Order. **DINOSAURIA.**

Genus—**Bothriospondylus.**

Species—*Bothriospondylus suffossus,* Owen ('Dinosauria,' Plates 61—63).

The subjects of the present section might be deemed to have more interest for the Anatomist, by reason of the singular modification of vertebral structure which they exhibit, than for the Palæontologist, as affording evidence of an additional specific or generic form to the already known numerous extinct Saurian Reptiles of the Mesozoic formations.

The vertebra, for example (Pl. 61), which, by the presence of pre-(p) and post-(p') parapophyses with expanded rough syndesmotic articular surfaces, is a sacral one of the Dinosaurian type, presents so singular a degree of depression, or horizontal flattening, of the centrum, as to suggest artificial and posthumous pressure as its cause; and it is true that some of the lumbar or dorsal vertebrae therewith associated show unmistakable marks of such violence. But, as the side view of the present vertebra, ib., fig. 4, shows, at c, c', there is no such evidence of fracture of the peripheral compact layer of the bone with distortion, causing more or less departure from symmetry in the centrum, as accompanies every instance of crushing out of shape in the present series of vertebrae (compare figs. 1 and 4, e.g., with fig. 5, in Pl. 63). There is also evidence of a transitional assumption of the depressed form of centrum, in another sacral one (Pl. 62, figs. 4, 5, 6), which, from having the syndesmosal surface on a single parapophysis (p) on each side, was part of a terminal vertebra of the sacral series.

Four views (Pl. 61, figs. 1—4) are given of the vertebral centrum which appears to correspond with that marked 5 in 'Dinosauria,' Pl. 38. In the sacrum of the *Hylæosaurus* there figured the vertebra No. 5 offers the greatest breadth and flattening of the under surface, which is also notable for the absence of the longitudinal ridges, parial or single, marking the under surface of the succeeding or preceding centra.

The under surface of the present sacral (Pl. 61, fig. 1) is less accentuated than the Hylæosaurian one compared with it, and the venous canals are relatively smaller than in it: they also issue irregularly, instead of being symmetrically disposed as are the large pair in *Hylæosaurus*. The under surface, as shown in the side view (ib., fig. 4, c), is feebly undulate lengthwise, the concave curves being mainly due to the expansion of the articular ends (ib., fig. 3). The under surface of the centrum is as moderately convex across, becoming flat near the free portions of the side of the centrum (ib., figs. 1, 2, 4, c'), and very slightly concave through the distal expansion of the parapophyses (ib., fig. 1, p p'). But the distinctive peculiarity of the present centrum from the known sacral ones
of other Dinosaurs is the continuation of the free surface, over the side of the centrum (fig. 2, c') between the origins of the parapophyses (p, p') into a long, low and deep cavity (ib., figs. 2 and 4, f, f), overarched by the part of the side of the centrum supporting the neurapophyses (ib., figs. 2 and 4, np), which appear to have been confluent therewith, and to have been removed, with the rest of the neural arch, by fracture.

This displacement exposes the floor of the neural canal (ib., fig. 2, n), the breadth of which indicates a sacral enlargement of the myelon, and consequent development of the pair of limbs deriving their nerve-supply therefrom. The issue of a large pair of these nerves is indicated by the continuation of the neural surface outward at o, o, behind the broken bases of the neurapophyses (np) which have not extended so near to the end b, as to the opposite end, a, of the centrum.*

Owing to the abrupt continuation of the lateral surface of the centrum into the depressions, f, f, characteristic of the present genus of Dinosaur, the free surface of the side of the centrum presents the form of a smoothly rounded, longitudinally concave, ridge (ib., figs. 2 & 4, c). It may be that the approximation of the roof and floor of the lateral fossae has been increased by pressure. Yet the horizontal surface, f, could hardly have been bent from the vertical side-surface of the centrum, c', without some fracture of the compact outer layer of bone; and, further, if the flat form of the centrum had been due to such cause, the seemingly natural undulate configuration of the under surface, with its expansion at the two ends, would not have been unobliterated and unmodified in the degree exhibited by the fossil specimen.

The outward production of the fore part of each side of the centrum (fore parapophysis, p) has a longitudinal extent of an inch and a half, a vertical one at the articular surface of seven to eight lines. The surface is rough and slightly concave; it may have contributed less than one half of the vertical extent of the sacro-iliac joint at this part. The fractured or roughened surface above this parapophysis indicates a corresponding diapophysial production of the neural arch for extension of the joint. Longitudinally the pre-parapophysial surface slightly inclines toward the front articular surface, a, of the centrum. This surface is flat, very rough, and irregular, indicative of having been broken away from a partial confluence with the opposed surface of a contiguous sacral element; the lower part showing here and there a smoothness as of the original free surface of this end of the centrum. Above this surface large unossified vacuities are shown in the cancellous texture of the bone. The vertical diameter of the articular end of the centrum is one inch three lines; the transverse diameter is three inches six lines. The lower margin is not entire, but has been eroded or worn away for an equable extent of about four lines; along the transverse curve it has not been broken off that end of the centrum.

The post-parapophyses (p') are shorter antero-posteriorly, thicker vertically; and the articular surfaces of this pair converge at a greater angle to the posterior surface, b, of the

* Compare the figure of the sacral vertebra of Iguanodon, Pl. 12, fig. 4, o, o, p, 288.
centrum (ib., fig. 3) than in the anterior pair. The upper rough or fractured surface (fig. 3, n, n) may have coalesced with the fore part of the neural arch of the succeeding sacral vertebra, if such arch, as in other Dinosaurs, has crossed the interval between its own centrum and that of the next sacral. A greater extent of the hinder surface of the present centrum (fig. 3, c), at its lower half, shows freedom from anchylosis than on the fore surface.

The Reptile indicated by the portion of the vertebra above described is referable by the characters which such fossil shows to the Dinosaurian group. In the Crocodilia the confluent outstanding parts of centrum and neurapophyses, affording attachment to the pelvic arch, are single on each side of the sacral vertebra, and the neural arch retains its normal position in connection with its centrum.*

In Megalosaurus the lateral abutments for iliac attachments have diapophysial bases, or spring exclusively from the neural arch.† Pre- and post-parapophyses are indicated in the sacral vertebrae of Iguanodon by the slightly produced or outstanding parts of the side of the centrum articulating with the two displaced neural arches (compare figs. 1 and 2 of Pl. 61, with figs. 3 and 4, ‘Dinosauria,’ Pl. 12). In the sacral vertebra of the Hylæosaurus, above referred to, the duplex parapophyses have about the same development as in Bothriospondylus.

Not any of these earlier described Dinosauria have the flattened form and lateral cavities characteristic of the sacral vertebrae of the present genus; whence I infer, from the different relative expanse of the neural canal, as shown in the figures of the vertebrae above compared, that the hind limbs were relatively less in Bothriospondylus than in Iguanodon. They, probably, came nearer to Crocodilian proportions.

A second more mutilated sacral centrum of Bothriospondylus (Pl. 62, figs. 4, 5, 6) shows the modification of that marked 4 in the sacrum of Hylæosaurus (‘Dinosauria,’ Pl. 38, figs. 1 and 2), in having the parapophysial expansion limited to one (p) on each side of the centrum. In the present genus its base occupies the anterior half of the lateral surface, instead of the smaller proportion shown in Hylæosaurus; it is also more depressed, and the entire centrum is flatter, though not in so great a degree as in the subject of Pl. 62 above described. Both ends of the present centrum are flat, and show a greater proportion of the smooth unconfluent condition than in the subject of Pl. 62, fig. 3. The supporting parts of the neural arch forming the roofs of each lateral cavity (Pl. 62, figs. 4 and 5, f) are broken off together with the arch itself, and but a small part of the neural surface (ib., figs. 4 and 5, n) is preserved.

This mutilation exposes the whole depth of the lateral excavations (ib., fig. 4, f, f) of the centrum, undermining, as it were, the base of the neural arch; and these show that the breadth of the centrum beneath that arch is reduced, about midway between the two ends, a and b, to half an inch, the breadth of the centrum at the fore end, a, being, when

* See ‘Crocodilia, Pl. 11, fig. 6, sacral vertebra of Crocodilus Hastingsie.
† See ‘Dinosauria,’ Pl. 25.
entire, 3 inches 3 lines. At the opposite or hinder end the breadth was less, and the height apparently greater, whence it may be inferred that this vertebra was near to the hinder end of the sacrum.

The right half of the anterior, flat, smooth but irregularly indented, articular surface of the centrum is nearly entire. Extending, as far as the origin of the pre-parapophysis, $p$, which is preserved, and wanting only part of its upper surface, the entire transverse extent can be estimated, as above noted.

The under surface of the centrum (Pl. 62, fig. 6) is more convex across than in the subject of fig. 1, Pl. 61, concomitantly with its greater extent in the present vertebra. The longitudinal contour of the under surface (Pl. 62, fig. 5) is more uniformly concave. The margin of both articular ends is eroded. The aperture of the lateral excavation (ib., fig. 4, $c$) is 1 inch 5 lines in longitudinal extent; but the cavity is continued 10 lines further above the pre-parapophysis (ib., $p$); the depth of the excavation at the middle of the vertebra is 1 inch 3 lines. The smooth compact crust of the centrum passes, without fracture, over the free lateral tract (ib., fig. 5, $c$). The vertically convex border of the floor of the cavity is somewhat thicker than in first-described sacral vertebra, but similarly shows a natural condition and contour. The upper surface of the floor of the cavity shows a fine crack (outside the letter $f$ in fig. 4) as if the inner half of that floor, with the adjoining part of the centrum ($p$) supporting the base of the neural arch had been slightly depressed.

The proportion broken away from the left side of the present vertebra is indicated in outline in figs. 4 and 6.

The subject of figs. 1, 2, 3, Pl. 62, transmitted at the same time with the vertebrae above described, and from the same locality, I refer, from the superficial characters of the under surface and of one of the terminal surfaces of the centrum, to the same genus and species of Dinosaur, and it probably formed part of the same individual.

The flattened surface of the centrum, at $a$, fig. 2, in the irregular impressions of its otherwise smooth surface closely accords with the one, $b$, of the subject of fig. 5, to which it adapts itself sufficiently closely to suggest that it may have been ligamentously articulated thereto. The opposite surface (ib., fig. 1 and fig. 2, $b$) is not so impressed, is slightly convex and smoother, and indicates a joint with the succeeding vertebra admitting of more movement. I infer, therefore, that the present specimen is the centrum of the last sacral vertebra, and that the end articulating with the first caudal vertebra had resumed more of the usual vertical proportions of the centrum. The parapophysis ($p$), with the irregular syndesmosal surface, has a greater extent, both vertically and lengthwise. Above it extends the narrow fractured surface of the broken off base of the neurapophysis. The floor of the neural canal (fig. 1, $n$) is preserved, which is concave lengthwise as well as across, sinking somewhat into the substance of the centrum. Its diameter midway between the two ends is 7 lines.

The lateral excavations of the centrum appear to have ceased at this vertebra, and
probably were not resumed in the caudal series. It has been fractured and somewhat distorted by posthumous violence: but this has not affected the contour of the under surface of the centrum (ib., fig. 3), or the vertical proportions of this element, any more than in the case of the two previously described sacrals.

In four centra of dorsal or dorso-lumbar vertebrae of Bothriospondylus suffossus, forming part of the same series transmitted from the Kimmeridge Clay of Swindon, the characteristic excavations are conspicuous and with longer apertures than in the sacral vertebrae, where these are interrupted by the broad articular parapophyses. No trace of the latter processes are present in the trunk vertebrae of which the type is selected for the subjects of Plate 63.

The centrum is subcompressed (fig. 2); its sides moderately concave lengthwise (fig. 1), with one end feebly convex, $\alpha$, the opposite end rather more concave, $\beta$. I regard the latter as the hinder one, and the trunk-vertebrae to be, as in Streptospondylus, of the opisthocoelian type. The free surface of the centrum is smooth, save near the articular ends, where there are low longitudinal risings and shallow channels. The under surface (ib., fig. 4) is perforated by two or more small vascular (venous) canals near the articular ends.

The fore end (ib., fig. 2) has a somewhat irregular surface. The hind one, which has suffered less from compression (ib., fig. 3), shows a similar coarse pitting and rising at the central part of its surface, the peripheral part being smoother than that at the middle, which has yielded to pressure, the large cancelli there having been crushed in.

The bases of the neurapophyses (Pl. 63, np), commencing about three lines from the anterior end of the centrum, are continued to the posterior end. They have been ankylosed to the centrum and broken away. Posthumous pressure has crushed this specimen laterally and obliquely. Part of the floor of the neural canal is exposed (at $n$, $n$, fig. 5), and is continued outward, at $a$, where the spinal nerve has had issue. The narrowness of the tract of the centrum, between the lateral excavations, $\alpha$, $\delta$, giving support to the coextensive parts supporting the neural arch, is a singular characteristic of the present genus, and made it difficult to conceive that a mere plate of bone like that between $\alpha$ and $np$ in fig. 1, Pl. 63, would relate to the support of a neural arch. It recalled the structure of that part of the vertebra in the thoracic-abdominal region of a Chelonia. What the character of such arch may have been we have yet to learn, in the present species, from better preserved specimens. Not a fragment recognisable as belonging to such portion of the vertebra could be found among the fossils sent up from the Kimmeridge locality at Swindon.

Two rather more crushed and distorted centra show, nevertheless, an increase of transverse diameter indicative of their having come from a region of the spine near the sacrum. The centrum shows the same opisthocoelian type, the same wide and deep lateral excavations, undermining, as it were, the neural arch, an absence of transverse processes, and the fractured bases of ankylosed neurapophyses.
The "Swindon Brick and Tile Company's Works," whence, through the kindness of the managing director, James K. Shopland, Esq., the above-described fossils were obtained, are situated on land adjoining the Wilts and Berks Canal. The vertebrae were found, associated with remains of *Pliosaurus brachydeirus*, in the Kimmeridge clay, at a depth of fifteen feet. The clay here is of a deep black-blue; and a mass of lignite, seemingly derived from a crushed trunk of a tree, and burning like ordinary coal, was here discovered.

**Order. DINOSAURIA.**

**Genus—** *Omosaurus.*

Species—*Omosaurus armatus*, Owen (‘Dinosauria,’ Plates 64—75).

Shortly after the foregoing pages on *Bothriospondylus* had been penned I was favoured with the subjoined note,* announcing further discovery of larger bones in their Kimmeridge Clay works, followed by a liberal offer on the part of the Company † of such of these fossils as might be found worthy of being added to the Geological Collection in the British Museum. Mr. William Davies, of that Department, was thereupon instructed to inspect the diggings, and, on his 'Report' of the appearances, was authorised to take the requisite steps to remove and transmit to the British Museum as much of the matrix as gave evidence or promise of containing organic remains. This operation

*  

**"SWINDON BRICK AND TILE COMPANY,**  
**"SWINDON, WILTS; 23rd May, 1874."**  

"**DEAR SIR,**  
"I last year had the pleasure of sending you some Saurian Remains discovered in this Company's Kimmeridge Clay Pits, and I beg to inform you that we have just laid open other remains considered to be unusually large and fine, which are left in situ, carefully covered over.  
"As exposure to light and air will, I fear, cause the remains to split and crumble, I should suggest your coming or sending some one to inspect them at once; the clay adjoining I will leave unworked until Wednesday next.  
"I am, &c.,  
"JAMES K. SHOPLAND."  

**"PROFESSOR OWEN, British Museum."**

† It is due to their enlightened liberality and prompt co-operation in applying to the advance of science whatever, in the course of the works, might aid therein, to subjoin the names of the Directors of the Company:—J. C. Townsend, Esq., Thomas K. Shopland, Esq., Henry Kinneir, Esq., Richard Rowley, Esq.
was carried out with Mr. Davies' experienced skill and judgment.* Some tons weight of matrix was transmitted to the British Museum, and occupied, during the remainder of the year, the practised chisel of Mr. Barlow, the mason-sculptor of the Geological Department, under the guidance and supervision of Mr. Waterhouse, Mr. Davies, and myself. The result was the extrication from these masses of the bones of one and the same individual dragon, or Saurian, and these form the subject of the present section.

They were found at a depth of ten feet from the surface soil covering the clay deposit, which deposit, where it surrounded the bones, presented unusual density and almost intractable hardiness, and was traversed by fissures or cavities occupied by infiltrated spar, presenting in parts a septarian character. This condition of the matrix suggested that it might, in some degree, be due to the decomposition and exudation of the soft parts of the large reptile when buried in the clay sea-bed into which it had sunk; gaseous emanations might give rise to fissures or vacuities in the surrounding tenacious mass, into which the stalagmitic spar might subsequently infiltrate during the long ages of the condensation, petrifaction, and upheaval of the deposit; but cracks and cavities, from whatever cause, do become so occupied, as in the present local accumulation, and have received the name of 'septarian doggers.'

In the borings lately carried on at Netherfield, near Battle, Sussex, 660 feet of 'Kimmeridge Clay' were traversed before the 'Oxford Clay' was reached, without interposition of 'Coral Rag' or 'Coralline Oolite.'† This testimony to the time during which Kimmeridgian strata had been accumulated to such vertical extent gives free scope for surmise and speculation as to the long ages during which Pliosaurs, Cetiosaurus, Bothriospondylus and other enormous reptiles, lived and died in a world of which they seem to have been masters, as far as grades of organic life and power, acting at that epoch, have been determined. Other lines of variation and modification of the dragon type, besides the new one about to be defined, probably remain to be determined by ulterior research, and to reward the labour, skill, and science of investigators and collectors of Kimmeridgian remains.

Of the Dinosaurian genus and species, for which the name Omosaurus armatus‡ is proposed, parts of the vertebral column, the pelvis, a femur, and tibia, and almost all the bones of the left fore limb, have been worked out. The scapular arch, sternum, skull and teeth, and bones of the hind feet, are still desiderata. That not a single tooth

* See the processes described by him in his instructive 'Catalogue of Pleistocene Vertebrata in the Collection of Sir Antonio Brady,' 4to., 1874, p. 71.

† A thickness or vertical extent of 1050 feet is assigned to the combined 'upper' and 'lower' divisions of the Kimmeridge Clay, by the Rev. J. F. Blake, M.A., F.G.S., in his instructive memoir on this formation in England, 'Quarterly Journal of the Geological Society,' vol. xxxi, p. 196.

‡ 'Πρόσων, humerus, Σαυρός, lacertus: suggested by the unusual development of the muscular crests and processes of the arm-bone, perhaps in relation to the formidable weapon with which the fore limb appears to have been armed.
should have been met with in any part of the ossiferous matrix is much to be regretted, but one indulges the hope that teeth of *Omosaurus* may be one day recovered and be found implanted in their jaws.

**Cervical Vertebra.**—A portion of a neural arch and spine (‘Dinosauria,’ Pl. 64, figs. 1 and 2), with the right prezygapophysis, $z$, the left postzygapophysis, $z'$; the roof of the neural canal, $n$, and the entire neural spine, $n$ $z$, might belong, from the shortness of the latter, to a caudal vertebra. But, from the indicated capacity of the neural canal and the aspects of the articular surfaces of the zygapophyses, I infer the specimen to have belonged to a vertebra from the cervical region.

The length of the neural arch is 7 inches 6 lines; the height of the neural spine is 3 inches 6 lines; its fore-and-aft breadth, at the middle, is 2 inches; at the free end 3 inches; the thickness, transversely, is 1 inch: this is at the hind border, near the summit; it slightly decreases toward the base, and the whole spine thins toward the fore part. The summit, which is rugged, gains in extent by being produced backward.

The diameter of the neural canal appears to have been $1\frac{1}{2}$ inches. The prezygapophysis, $z$, projects about half an inch in advance of the base of the diapophysis, $d$, $d$, which here has an antero-posterior extent of 2 inches 6 lines. The outer border of the prezygapophysis is slightly raised above the base of the diapophysis; the articular surface of the prezygapophysis looks upward and slightly inward; it is not quite flat, but feebly convex. The articular surface of the postzygapophysis, $z'$, is in the same degree concave. This surface looks downward and a little outward.

In the figure of the upper surface of a cervical vertebra of a large Monitor Lizard (*Varanus niloticus*, Cuv., ib., fig. 4) I have indicated by dotted lines the course of the fractures which have reduced the corresponding vertebra of the huge Dinosaur to the condition shown in Fig. 2. The relation of the origin of the diapophysis, $d$, to the prezygapophysis, $z$, is the same in both the recent and fossil Saurian; but the breadth across the zygapophyses was relatively less to the length of the neural arch in *Omosaurus*.

The fragmentary condition of this solitary evidence of the region of the vertebral column supporting the skull seems to point to some strange violence by which the head of the Omosaur has become severed from the trunk, and its frame-work probably borne to some part of the old sea-bed at a distance from the rest of the body.

**Dorsal Vertebra.**—Amongst the characters of the Order *Dinosauria* is a lofty and buttressed neural arch in a great proportion of the trunk-vertebræ; the characters of the articular ends of the centraums relate to species or to parts of the vertebral column of the same species. The ordinal character is illustrated in the *Iguanodon* (‘Dinosauria,’ Pl. 3); in the *Megalosaurus* (ib., Pl. 24); in the *Hylæosaurus* (ib. Pl. 37), et seq.
This character is strongly marked in dorsal vertebrae of the present genus, and with modifications which could hardly have been illustrated or made clear without the above-cited figures of the vertebrae of previously defined Dinosaurian genera. In these, however, the degree of complexity of the neural platform varies; it is least marked in the smaller and more crocodiloid genus *Scelidosaurus* (*Dinosauria, Plates 51 and 52*).

The vertebra of *Omosaurus*—the subject of ‘*Dinosauria,* Plates 65, fig. 1, and 66’—has come from the middle of the trunk. This is inferred from the position of the surface, *p,* for the head of the rib, which has risen from the centrum, or base of the neural arch, to near its summit, where, with its diapophysial productions, *d, d,* the arch expands to a breadth of 14 inches 6 lines; the breadth (in the same direction, transversely) of the centrum being 5 inches 3 lines. The vertical diameter of the middle of the articular surface of the centrum is 4 inches 9 lines; the height of the vertebra to the base of the neural spine is 11 inches. This spine has been worked out entire only in the above-described cervical and caudal vertebrae; but there are indications justifying an estimate of its length in the dorsal series, at from 6 to 8 inches.

Thus, the dorsal vertebra, affording material for the present description, which has a breadth, as above shown, of one foot two and a half inches, had a height of at least one foot and a half.

The fore-and-aft dimension of the centrum (*Pl. 66, fig. 3*) is 4 inches. The anterior surface (*ib., a*), where it varies from flatness, is toward convexity, but in the feeblest degree; the posterior surface (*ib., b*) is very slightly, but more equably, concave. The free surface of the centrum is moderately concave longitudinally; slightly depressed at *f,* beneath the base of the neural arch. The tissue throughout the vertebra is more compact than in *Cetiosaurus* ('*Dinosauria,* Pl. 76).

The neurapophyses (*Pl. 65, fig. 1, n p*) have coalesced with the centrum; they quickly narrow transversely, above their base, to a thickness of half an inch, more gradually contract in fore-and-aft dimension (*Pl. 66, fig. 2, n p*) to two inches and a half. Over-arching the neural canal (*Pl. 65, fig. 1, n*), they meet and coalesce about one inch and nine lines above the centrum, whence their compact coalesced mass rises above the crown of the arch, expanding to a height of five inches (posteriorly, *Pl. 66, fig. 1*) before giving off the neural spine (*ib., n s*).

At three inches above the base the outer surface of the neurapophysis is excavated by a smooth oval cavity (*ib., fig. 2, p*), 1 inch 9 lines in vertical, 1 inch 6 lines in transverse, diameter, and about 8 lines in depth. To this cavity was adapted the ‘head of the rib’: for this part there is no parapophysis, or outstanding process. Below the capitular cavity the outer surface of the neurapophysis is divided from the hinder surface by a low obtuse ridge or angle (*ib., ib., e*); a broader ridge (*ib., ib., a*), also low and obtuse, rises along the middle of the outer surface of the neurapophysis, and expands to form the lower margin of the costal pit. In advance of this pit the
neurapophysis extends forward to form the prezygapophysis (ib., and Pl. 65, fig. 1, z). The ridge (e), rising to the costal pit, forms or extends its hind border and is thence continued, expanding or thickening, into the ridge which forms the diapophysial buttress, f. The ridge (Pl. 66, fig. 3, a) does not, in this vertebra, combine with the ridge, e, to form the buttress, as in the Iguanodon ('Dinosauria,' Pl. 3), but appears as a shorter independent ridge. A median ridge (Pl. 65, fig. 1, r) rises from above the interspace of the prezygapophyses to the neural spine, n s. Another median ridge (Pl. 66, fig. 1, s) extends along the back of the neural arch and rises to the interspace of the postzygapophyses, z', z'. The chief expanse of the summit of the neural arch in the antero-posterior direction is a zygapophysial one (Pl. 66, fig. 2, z z'); in the transverse direction it is a diapophysial expansion (ib., fig. 1, a, d).

Each diapophysis is three-sided; the broadest facet is on the upper side, forming with the zygapophyses the neural platform. External to the zygapophyses this surface is 2½ inches from before backward; it is flat. The postinferior surface (Pl. 66, fig. 1, f d) is in that direction concave, most so below the postzygapophyses, z', and growing shallower to the tumid extremity, d, of the transverse process. The least fore-and-aft diameter of this surface of the diapophysis is 2 inches 3 lines, that of the antero-inferior surface is 1 inch 5 lines; this is feebly concave across, and is divided lengthwise for part of its extent by the zygapophysial ridge (Pl. 65, fig. 1, i).

The free end of the diapophysis is swollen and tuberous; a well-marked facet (Pl. 65, fig. 1, d, and Pl. 66, fig. 2, d) cuts the lower part obliquely; it is of a rhomboid shape, nearly flat, and is roughened for the ligamentous attachment of the 'tubercle of the rib'; it measures 2½ inches by 1 inch 9 lines.

The postzygapophyses (Pl. 66, fig. 1, z z') are formed by an expansion backward of the neural platform, the pair of processes being indicated by a medial notch; they are more clearly defined by their flat articular surfaces, which are subtriangular in shape, the angles being rounded off; their longest diameter is 2 inches; they look outward and downward.

The prezygapophyses (Pl. 65, fig. 1, e z) have been mutilated in the present vertebra, but the extent of their basal origin, 2 inches, may be traced; they are more distinct productions of the neural platform, which abruptly sinks to the level of their medial borders.

The anterior basal ridge (ib., z) of the neural spine begins at this lower part of the platform, which it divides into a pair of hollows. The spine rises freely from the broader upper level of the platform. Its base here has a fore-and-aft extent of 3 inches 8 lines. The hind border of the spine is rather sharp; the thickest part of the body of the spine is 9 lines; its free termination was probably, from the analogy of a caudal vertebra subsequently to be described, swollen and tuberous.

A vertebral centrum and a portion of the neural arch, from the same region of the spinal column, repeat the characters, so far as they are shown, of the less fragmentary
vertebra above described and figured. Two views of the centrum, of half the natural size, are given in Plate 65, figs. 2 and 3. The capacity of the neural canal (fig. 2, n) is worthy of note; it is rather Mammalian than Saurian, and implies a great development and vigour of the muscular system.

**Lumbar Vertebrae.**—The last lumbar vertebra (Dinosauria, Pl. 72, 1) appears to be confluent with the first sacral (ib., 1). Its centrum is 3 inches in longitudinal extent; the side is slightly depressed below the base of the neural arch, from which extends a lumbar rib (ib., l, p 1) 9 inches in length; this is 1½ inches in breadth at three inches distance from its free extremity.

This lumbar rib, and also that of the antecedent lumbar vertebra, are straight and extend transversely to the axis of the vertebral column. The distance in a straight line from the hæmal surface of the lumbar centrum to the end of the last lumbar rib is 1 foot 3 inches.

**Sacral Vertebrae.**—These are five in number (ib., s1—s5), coalesced together, and seemingly with their pleurapophyses. The antero-posterior extent of the five sacral centra is 1 foot 4½ inches, each centrum averaging 3½ inches in length. After the first they increase in breadth and decrease in the transverse convexity of the hæmal surface, the middle ones showing traces there of a shallow longitudinal hæmal channel with thick low convex borders. The interspace between the heads of the third pair of sacral ribs (ib., pl 3) is 7 inches, between the fifth pair it is 6 inches.

Fractures of the mass of matrix enveloping the pelvis exposed the close cetiosaurian texture of these vertebrae and the shape, in some degree, of the neural canal in a portion of the sacrum. One (fifth) sacral vertebra was thus divided lengthwise through the centrum, neural arch, and spine, and yielded the following dimensions:—Vertical extent 1 foot 5 inches; ib., length of neural spine, 6 inches; antero-posterior diameter of do., 3 inches 6 lines. This spine for a great part of its length was not in contact with the antecedent neural spine. The neural canal partially depresses the upper surface of the centrum of each sacral vertebra, probably in relation to venous sinuses rather than to ganglionic enlargements of the myelon. The vertical diameter of the neural canal where it dips down into the centrum is 2 inches 3 lines; in the ordinary course of the canal, it is 1 inch 2 lines; but, as the fracture affording this view was not exactly along the middle of the vertebra, the canal might gain more depth at that part.

The central part of the sacral centrum shows a rather coarser cancellous texture than the rest, or than is seen in any part of the centrum of an anterior caudal vertebra (Pl. 75, fig. 1).

What appears to be the first sacral rib (Pl. 72, pl. 1) is slightly dislocated hæmad, and probably, at the same time, bent forward obliquely from above downward and backward in a greater degree than natural, the hæmal end of the articular surface
projecting a couple of inches in advance of the second sacral rib (ib., pl. 2). The long or vertical diameter of the head or articular end of this rib-plate is 6 inches; at 3 inches of its outward course it expands to a breadth of 7½ inches by a convex extension of the fore border, which appears to have articulated like a rib-tubercle with the neural arch, and to have been underlapped by part of the ilium (Pl. 72, a). Beyond this point the rib-plate, as it approaches the acetabulum, diminishes in breadth but increases in thickness and seems to develop from its hæmal side a broad, transversely convex ridge or buttress (ib., pl. 1) 5 inches long by 2½ broad at the distal end, which abuts upon the fore and hæmal angle of the acetabulum, e. A process of the antacetabular part of the ilium (ib., a) is continued inward and hæmad to articulate with the upper border of this first broad, sacral rib; an oblong vacuity, 4 inches by 2 inches, intervenes between this process of the ilium and the acetabulum. The second sacral rib (ib., pl. 2) is indicated by the part of the plate posterior to pl. 1.

The proximal portion of this seemingly single broad and bifid pleurapophysis is applied to the greater part of the sides of the two anterior sacral centrums (ib., s 1, s 2), showing it to be the confluence of two pleurapophyses, the part described as the convex side or buttress being the distal articular end of the anterior of these.

On this view the next independent sacral rib would be the third (ib., pl. 3); its proximal end is expanded and applied by a similar, but not so great, obliquity to the side of the third sacral centrum (ib., s 3); having a breadth of 3 inches with a thickness of nearly 2 inches, but contracting to a narrow rounded hæmal border, retaining above this part a thickness of 1 inch, then expanding to a breadth of 3 inches to abut upon the hæmal border of the acetabular part of the ilium, filling the interval between the like extremities of the second and fourth sacral ribs. The direction of the third pair is nearly transversely outward. The length of the interspace between the second and third ribs is 6 inches; the fore-and-aft breadth is 3½ inches; it narrows towards the acetabulum, where the distal expansions of these ribbed buttresses come into contact and seemingly coalesce with each other, and similarly narrows to their proximal expansions, thus showing an elliptical shape.

The head of the fourth sacral rib (ib., pl. 4) is applied to the whole side of the corresponding centrum (s 4), and is 3½ inches in fore-and-aft diameter; from this the rib contracts to the form of a subvertical thick plate, and then expands to a breadth of 4 inches applied to, and confluent with, the lower border of the acetabulum and a considerable extent of the medial surface of the ilium rising therefrom.

The fifth sacral rib, with the head reduced to 2½ inches in fore-and-aft extent, is applied to the side of the last sacral centrum (s 5). This rib, contracting at first like the previous ones, then expands as it extends outwards and slightly backwards, chiefly in the vertical direction, to be applied for an extent of 5 inches to the part of the acetabulum to which the ischium is articulated. A considerable part of the right ischium (ib. 63) is retained, dislocated a few inches from the articular facets (ib., b, e).
KIMMERIDGIAN DINOSAURS.

and thrust a little mesiad and forward. This bone will be subsequently described showing the proportion of the acetabular cavity contributed by it.

Anterior to the pelvis is a dislocated group of eight hinder trunk-vertebrae, each retaining more or less of its neural arch and processes. On the right side of the pelvis a complete dorsal vertebra is exposed, measuring 1 foot 5 inches in length and 13 inches in breadth, between the diapophyses. The centrum is 3 inches 9 lines in length, 5 inches in breadth, 4½ inches in height, to the base of the neural canal; the hinder outlet of this is pyriform, the apex about 2½ inches in vertical, and 1½ inches in transverse, diameters. From the floor of the neural canal to the base of the spine is 8 inches; the length of the spine is 5 inches.

Beyond this dorsal vertebra is the body of a caudal one, showing a greater degree of concavity of the fore surface of the centrum, which has a breadth of 6 inches.

Behind the sacrum is a dislocated group of four caudal vertebrae, mainly agreeing in character with the subject of Pls. 67 and 68.

CAUDAL VERTEBRAE.—The vertebra of Omosaurus which has been most perfectly wrought out of the matrix is one from the base of the tail; it was in the same block with the sacrum, not far from the hind part of the pelvis.

This anterior caudal vertebra forms the subject of ‘Dinosauria,’ Pls. 67 and 68, of the natural size; and I here subjoin, also, the following admeasurements:

<table>
<thead>
<tr>
<th>Description</th>
<th>In.</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height or vertical extent of the entire vertebra</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Breadth of ditto</td>
<td>14</td>
<td>6</td>
</tr>
<tr>
<td>Length at the zygapophyses, giving extreme length of neural arch</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Centrum, length, lower surface</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>&quot;          &quot; upper surface</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>&quot;          &quot; breadth, anterior surface</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>&quot;          &quot; posterior surface</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>&quot;          &quot; height, anterior surface</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>&quot;          &quot; posterior surface</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Neural canal, vertical diameter</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>&quot; transverse diameter, least</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Neural arch, breadth at upper level of centrum</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>&quot; across prezygapophyses</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>&quot; postzygapophyses</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Pleurapophysis, length from base to apex</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>&quot; depth from tubercle to under surface</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&quot; thickness, extreme, at base</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>&quot; at tubercle</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>&quot; below tubercle</td>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>
A comparison of such of the above admeasurements as have been recorded of trunk-vertebrae shows that the caudal ones become shortened, at least, at the basal part of the tail. As the length of this appendage would depend upon the number of vertebrae, and especially of those reduced nearly to the centrum, which might again gain in length, it would be premature, on present evidence, to hazard an opinion on this dimension in *Omosaurus armatus*. But the size of the outstanding parts for muscular attachments indicates great power in the tail, which would probably be exercised, as in the largest living Saurians, in delivering deadly strokes on land, as well as in cleaving a rapid course through the watery element.

The centrum is transversely elliptical, with both upper and under surfaces sloping from before downward and backward from the terminal articular planes, these being vertical. Of them the anterior (Pl. 67, fig. 1, a) is flat, with a slight convexity toward the periphery and a shallow transverse groove at the centre; the posterior surface (Pl. 68, fig. 1, i) is more decidedly, though but slightly concave; the deepest part here, being along a central transverse groove, with a slight upward bend, like that on the opposite surface. A rugged border for the attachment of a capsular ligament projects from two to five lines beyond the articular tract. This, though smoother than any part of the free surface of the centrum, has evidently, by its inequalities or sculpturing, related to a syndesmosal joint, as in the *Chelone* and *Mammalia*, not to a synovial one as in *Crocodilia*. Between the fore and hind borders of the centrum the lower surface is antero-posteriorly concave (Pl. 68, fig. 2), the concavity narrowing as it approaches the line of confluence of the pleurapophysis (ib., ib., pi). This line begins below, half way between the under and upper surfaces of the centrum, and extends upward, approaching obliquely the fore surface (ib., a) to overlap and be lost (by ankylosis) in the base of the neurapophysis; a feeble trace of the primitive separation of this element may be discerned at the hinder outlet of the neural canal (ib., fig. 1, p\(\prime\)l). The pleurapophysial line of confluence is more distinctly traceable; the base of the pleurapophysis, representing the head of the caudal riblet, is broadest below, and there extends nearer the posterior than the anterior surface of the centrum; but, as it rises, it narrows and leaves a larger proportion of the post-lateral surface of the centrum free. The "tubercle" (\(\phi\)) of the rib is a well-marked rough prominence at which the upper border of the rib descends at an open angle with the "neck" to its obtuse apex. The under border of the riblet is gently concave lengthwise. No diapophysis has been developed, in this vertebra, to afford abutment to the tubercle.
Each neurapophysis at its confluence with the centrum gives a triangular horizontal section (Pl. 67, fig. 3, np), the base of the triangle, 1 inch 5 lines, being anterior, the obtuse apex behind. The inner, shorter side, next the neural canal, is parallel with its fellow and the trunk's axis, the outer side, 2 inches 9 lines in extent, slopes from the broad fore part backward and mesiad to the hind margin of the neural arch.

From the upper and anterior forwardly sloping part of each neurapophysis the prezygapophysis (z) is developed; it is short, thick, obtuse, with a flat articular surface, looking upward, inward, and slightly forward; subcircular, an inch in diameter. From the narrower hind part of the neural arch the common base of the pair of postzygapophyses (z', z") rises, expanding to form their articular surfaces, which look in directions opposite to those in front. The hind surface of the common base of these articular expansions has a wide and deep vertical channel.*

The neural spine (ns) is subquadrate at its base, with the lateral angles broadly rounded off (Pl. 68, fig. 2, ns). The line of attachment of the base of the spine rises from before backward (ib., fig. 3). A median anterior ridge (Pl. 67, fig. 1, x) strengthens the lower half of that surface, as a similar but thicker ridge (Pl. 68, figs. 1 and 3, x) does the posterior corresponding tract. Where these ridges cease the spine begins to expand into its rough obtuse summit, chiefly transversely, so as to give it an elliptical contour extended in that direction (Pl. 67, fig. 2).

The foremost of the caudal vertebrae remains in the block of matrix with the sacrum. The present I take to be the second of the series. There is no trace of hypapophysis for a hæmal arch in either of these caudals (the under surface of the centrum of the second is figured in Pl. 67, fig. 4). In Scelidosaurus the first or foremost caudal alone is devoid of hæmal arch; in the second caudal the lower part of the hind border is touched by the smaller anterior facet on the base of the hæmapophysis.

In the few succeeding caudal vertebrae, with diminution of general size, the vertical extent and the length of the pleurapophyses decrease in a greater ratio. A larger proportion of the side of the centrum is left free below the rib's confluence therewith; and this free surface of the centrum shows, as in the specimen selected for Pl. 69, an upper (c) and a lower (c") depression. The transverse extent of the centrum decreases without corresponding loss of vertical extent. The hind surface of the centrum (ib., fig. 2) becomes more concave, without corresponding increase of convexity of the fore surface. The contour of the hind surface approaches the subhexagonal.

The anterior and posterior ridges of the neural spine subside; the fore ridge is longest retained, but shrinks toward the base of the spine, as at r, fig. 1. In the subject of this Plate, as in three other caudals extracted from the matrix, the neural spine has been bent to one side, as shown in Pl. 69, fig. 2. This distortion I conceive to be due to movements of the matrix after the fossil had been inclosed thereby and become petrified therewith. For,*

* It is possible that a similar facet may have been ligamentously attached to the rough surface extended from the lower margin of the terminal surface.
being thus supported at every point by the matrix, during the slow and continuous partial pressure, the spine has yielded and bent without breaking. In one instance the sustaining neural arch has suffered partial fracture at the side (ib., fig. 1), toward which the spine has been bent.

A thickening at the outer side of the neurapophysis, feebly indicated in the larger anterior caudals (Pl. 68, fig. 2, np), becomes more prominent near the base of the prezygapophysis, as at np, figs. 1 and 2, Pl. 69, in the succeeding smaller vertebrae, in which the hypapophyses are more distinctly marked.

These articular protuberances (ib., figs. 1—3, hy) form a pair at the hind border of the inferior surface of the centrum; the articular tracts at the fore border of that surface are barely defined, or may be indicated by an extension backward of the rough marginal syndesmochial tract.

The caudal vertebra in Pl. 69 is figured a little more than half the natural size. The answerable caudals in the great Monitor Lizard (Varanus niloticus) are given, of the natural size, in figs. 4 and 5.

The hæmal arch in the caudal vertebra, with a centrum 5½ inches in vertical extent, has the same length. The hæmapophyses (ib., fig. 2, h) are 2½ inches in length before coalescing to form the spine (ib. ib., h), which is 2½ inches in length in the subject of the Plate; it was probably longer when quite entire. But the length of the arch and spine was plainly less in proportion to the vertical extent of the rest of the vertebra than in Cetiosaurus longus. The hypapophyses are accordingly relatively smaller, and are limited to a narrower transverse extent of the inferior surface of the centrum (ib., fig. 3, hy) than in Cetiosaurus, or in the recent Varanus (Pl. 69, fig. 4, hy). In Cetiosaurus brevis the hypapophysial facets (h, h) are broader and wider apart than in Cetiosaurus longus.

In Iguanodon the reverse conditions prevail. These surfaces have become confluent, and present a single bilobed facet to the similarly confluent surfaces on the bases of the right and left hæmapophyses ('Dinosauria,' Pl. 13). Both neural and hæmal spines are relatively longer in Iguanodon; and the neural spine springs from a smaller proportion of the hind part of the neural arch at a much greater distance behind the prezygapophyses than in Omosaurus. The caudal vertebrae differ less from each other in Omosaurus and Cetiosaurus than they do in either of these genera as compared with Iguanodon.

As in the case of Cetiosaurus longus and other previously described Dinosaurian subjects, I have selected the best preserved specimen of an average-sized vertebra for figures of the natural size, the requisite comparisons being much facilitated, and accurate results ensured, by such life-size figures.

Humerus.—Of the skull, teeth, or scapular arch of Omosaurus I have not as yet received evidence. The humerus and some other bones of the left fore limb ('Dinosauria,' Pl. 70) have been relieved from the matrix in a more or less complete state.
The humerus (ib., figs. 1—5) is remarkable for its breadth, especially at the proximal half, compared with the length. The articular surfaces at both ends have been more or less abraded. That at the proximal end (figs. 1 and 2, a and fig. 3, a) shows the elongate oval form, with the larger end, c, toward the ulnar aspect, narrowing to the beginning of the great radial crest, b', b', as in Crocodilus, Varanus, and most existing Saurians; as in these, also, the head projects somewhat toward the anconal surface (as at a, fig. 2); but the prominent part of the shaft continued therefrom is less marked than in Cetiosaurus longus (p. 585, fig. 4).

The radial tuberosity (Pl. 70, figs. 1 and 2, b) is not developed distinctly as such, but, as in Crocodilus and Varanus (ib., fig. 6, b), is the beginning of a plate or crest of bone, answering apparently to both the deltoid and pectoral in Mammals, which plate extends considerably radiad, but with less inflection palmad, than in Crocodilus or Varanus, so that more of its breadth is seen in a direct palmar view, as in fig. 1, than in the Pterodactyle or the above existing Reptiles. It has a certain forward or palmar bend, and subsides a little below the middle of the shaft.

From the proximal beginning, b, of this great crest, a broad tuberous rising (ib., fig. 2, a) projects anconad, and is continued, narrowing obliquely distad, to terminate or subside at the radial side of the shaft, close to the termination of the crest b'. The tuberosity and ridge, a, a', might be regarded as 'deltoidean,' as distinct from the 'pectoral' b, b', save that its position is anconal instead of palmar. There is a rudiment or indication of this 'anconal ridge' in the humerus of the Crocodile, and a shorter one in Varanus. In the latter existing Saurian it gives origin to a muscle answering to the external 'head' or portion of the 'triceps extensor cubiti' in Mammals.

The ulnar tuberosity extends ulnad and distad as a thick tuberous ridge, which terminates more abruptly than the radial crest, at c, figs. 1 and 2, about seven inches beyond the proximal end. The broad surface of the humerus between the crests is rather concave across on the palmar surface, somewhat more convex on the anconal surface, which is interrupted by the 'anconal or tricipital tuberosity and ridge.'

The shaft at its narrowest part presents in section the form given in fig. 5, Pl. 70, being almost flat, palmad and convex, anconad, transversely. It soon begins to expand into the distal end of the bone. The crest, e, simulates the 'supinator' one in Mammals, and is not perforated, as is the answerable disto-radial crest in some existing Saurians. Such perforation is very small in Varanus (ib., fig. 6, e'). There is no indication of this vascular or nervous canal in Omosaurus, and the crest is relatively shorter than in Varanus. The ulnar expansion, f, of the distal end is thick and tuberos.

Sufficient of the radial condyle, g, remains to show its Saurian extension palmad, and its convexity in Omosaurus (ib., fig. 4); the precise form and extent of the less prominent ulnar condyle or trochlea is not definable.

The texture of the shaft of this humerus, as exposed by the fracture across its middle
narrowest part, is compactly dense; there is a small medullary cavity (fig. 5) which seems to have but a short longitudinal extent.

A deep anconal depression (ib., fig. 2, i), marks that aspect of the distal expansion in a greater degree than in any Crocodilian, Lacertian, Dinosaurian, or Pterosaurian humerus that, as yet, has come under my notice; it gives to this part of the humerus of *Omosaurus* something of a Mammalian character.

The following are admeasurements of the humerus:

<table>
<thead>
<tr>
<th>Description</th>
<th>Ft.</th>
<th>In.</th>
<th>Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>2</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Breadth across radial or pectoral crest</td>
<td>1</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>&quot; distal end</td>
<td>0</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>&quot; middle of shaft</td>
<td>0</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Girth of &quot;</td>
<td>1</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Length of base of radial or pectoral crest</td>
<td>1</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>&quot; ulnar crest</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

The figures of this bone on Pl. 70 are reduced to one fourth of the natural size.

Although I should have hesitated to found a genus or generic term on a solitary limb-bone if such distinction had not been supported by the vertebral characters, yet the features were so much more strongly marked in the present than in previously described or figured humeri as to have afforded a better excuse for such taxonomic deduction, which ought to rest, and, as a rule, can only safely do so, on characters afforded by associated parts of the skeleton or teeth.

Mutilated as are the humeri discovered with unquestionable vertebrae of *Cetiosaurus longus* in the Geological Museum of Oxford, justifying the conclusion that they belonged to the same individual, they are unmistakably distinct in character from that bone in *Omosaurus*.

Although the radial or pectoral ridge be broken away in the subjects of figs. 4 and 5, p. 585 (*Cetiosaurus*), its base has a minor relative extent than in *Omosaurus*; the shaft beyond that ridge expands more gradually into the distal end; the entire length of the bone—4 feet 4 inches in *Cetiosaurus longus*—is greater in proportion to the breadth or thickness of the shaft.

The slender character of the humerus is more marked in that bone which chiefly represents Mantell's genus *Pelorosaurus* (*Dinosauria,* Pl. 49), in which the radial or pectoral crest (ib., fig. 2, d) subsides above the middle of the shaft, encroaching, as in the Crocodile, *Varanus*, and Pterodactyle, upon the palmar surface of the bone. The humerus of *Iguanodon* (*Dinosauria,* Pl. 19) is still less robust in proportion to its length, not to mention its inferior size as compared with associated dorsal vertebrae, than in *Omosaurus*. 
In *Hylæosaurus* we find the nearest approach to *Omosaurus* in the proportion of the length of the humerus giving attachment to the great tuberous crests from the radial and ulnar sides of its proximal part. But in the Isle of Wight specimens referred, with doubt, to that Dinosaur, the radial crest is more strongly, and, in reference to its Saurian nature, more typically twisted palmad than in the huger Kimmeridgian genus. It shows a tuberous thickening anconad of its distal end, in the place of the ridge, *a*, fig. 2, Pl. 70, in *Omosaurus*.

**Radius.**—This antibrachial bone in *Omosaurus* (ib., figs. 7—11) has a subcompressed shaft, expanding moderately and almost equally into the two articular ends, as far as their degree of conservation shows; but it is probable that the more mutilated distal end (fig. 10) when entire would give a somewhat greater breadth than the proximal one or 'head.' This (ib., fig. 9) is of a narrow subelliptic shape. A small part of the concave articular surface, *a*, for the radial condyle of the humerus, is preserved. The anconal surface of the shaft (fig. 7) is feebly divided at its distal two thirds into two facets by a low rising, hardly to be called a ridge, beginning at the middle of that surface at its proximal third and inclining as it descends toward the radial border of the distal end. The concavity of both borders, and especially of the ulnar one, narrows transversely the shaft, but this preserves more equably its ancono-palmar thickness (see the section of the middle of the shaft in fig. 11). The lateral facet (fig. 8, *v*) at the proximal end for articulation with the ulna is more convex than is usual in *Reptilia*.

The surface (ib., fig. 8, *e*) for the insertion of the biceps tendon is well defined. The thenal prominence (ib., figs. 8 and 10, *f*) extending or deepening the cup, *g*, for the scaphoid, is strongly developed, and is thicker than usual, as far as it is preserved. Its outer surface is roughened, as if for the ligamentous attachment of some bone, such surface extending to the angle, *g* (fig. 8), at the broadest part of the distal end of the radius.

**Ulna.**—The proximal extension of the articular cup (Pl. 70, fig. 13, *a*) upon an anconal or olecranal production marks this bone as strongly as in *Varanus* (ib., fig. 15, *a*) but the excavation (*c*) of the shaft below the proximal end is differently situated. It would seem as if the ulnar or outer border of that depression in *Varanus* (ib., fig. 15) had been moved or extended palmad in *Omosaurus*, toward the narrower, palmar, surface of the bone; and to such an extent that part of this excavation comes into view from the ulnar side, as at *e*, fig. 14. This excavation is continued distad for more than half the length of the bone (*c, c'). Below this part the shaft assumes a subtriedral form; and its anconal border bends toward that aspect as it approaches the carpus. The articular surface for this segment of the fore limb is wholly destroyed.

**Manus.**—Of the carpal bones have been extracted a left scaphoid, left cuneiform, and left unciform. Of these three large wrist-bones the scaphoid is the smallest, as in
**Varanus**, not the largest, as in *Crocodilus*, in which it is connate with the trapezium and trapezoides.

The proximal surface for the radius is more uniformly and less boldly convex; the opposite articular surfaces for the trapezium and lunare is more deeply concave. The outer (ulnar) surface is elongate, narrow, and is the smallest on the bone; it seems barely to have touched the cuneiform, which is here, as in *Varanus*, the largest of the carpals.

The free broader radial surface of the scaphoid is flattened and roughened, and seems to have continued, distad, the corresponding surface of the radius itself, which is on the radial side of the distal end of that antibrachial bone (Pl. 70, fig. 8, g).

The length (transverse extent) of the scaphoid is 5 inches; the extreme (anconeopalmar) breadth is 3 inches; the extreme proximo-distal extent (on the rough flat surface) is 1 inch 10 lines.

The cuneiform is a massive cuboidal bone, with a proximal surface less concave for the ulna than in *Varanus*, but with as deep an opposite (distal) concavity for the division of the unciforme which supports the fourth digit. There is an approach to the crocodilian character of the bone in the increase of the distal part or surface. The transverse extent of the bone there is 4 inches 9 lines; that of the proximal surface being 4 inches; the anconeal diameter of the bone is 3 inches 9 lines; the proximo-distal diameter is 3 inches 10 lines.

The unciform seems, as in the Crocodile, to have supported both fourth and fifth metacarpals, not to have been divided to afford articulations for these bones on separate portions. Its transverse extent in *Omosaurus* is 6 inches 4 lines; the other dimensions closely correspond with those of the cuneiform carpal.

The digits of a hind foot are longer, as a general rule, than those of a fore foot in existing Saurian Reptiles, and the same proportion has been demonstrated in the fore and hind feet of some extinct Dinosauria.* The proportions, at least, of the metatarsals in *Hylaosaurus* and *Scelidosaurus* support a belief that those of the metacarpals would be as in the homologous bones of *Iguanodon*.

Of the five metapodial bones of *Omosaurus* which have been wrought clear out of the matrix not any show a length as compared with the breadth which exceeds that of the metacarpal of the first digit in the fore-foot of *Iguanodon* ('Dinosauria,' Pl. 48, fig. 1, w); and the homologues of the intermediate metacarpals are shorter in proportion to their breadth than in *Iguanodon*.

I conclude, therefore, that the above metapodials of *Omosaurus* are metacarpals, that the digits were not unequal in length, and that the whole fore-foot was more massive and elephantine in its proportions, in *Omosaurus* than in *Iguanodon*.

A metacarpal ('Dinosauria,' Pl. 71, figs. 3—6) has a flattened proximal surface (ib., fig. 5) of a subtriangular shape, slightly convex near its radial (r) and anconal (a) peri-

* *Iguanodon*, 'Dinosauria,' Pl. 45; *Hylaosaurus*, 'Dinosauria,' Pl. 44; *Scelidosaurus*, &c.
phery slightly concave toward the palmar border \((p)\), which is broken away, the articular surface being continued a short way upon the ulnar \((u)\) side of the shaft for junction with the second metacarpal.

The articular surface is pitted with small deepish depressions, as in most great Saurians, where the joint surfaces seem to have been more synodesmosal than synovial. The transverse and ancono-thanal diameters of the proximal surface are equal, each being 3 inches 6 lines; but, had the ulnar border been entire, the transverse diameter would have somewhat exceeded the other.

The short thick shaft of this bone is three-sided; one side extends obliquely from the ancono-ulnar \((\text{fig. 3, } a, u)\) angle to the radio-palmar \((r, p)\) angle, with a transverse convexity; the second, or palmar, side \((\text{fig. 4, } p)\) is less convex across; the third, or ulnar side, is flat across at the middle part, and somewhat concave near the two expanded ends of the bone. All these surfaces are concave lengthwise, the palmar one least so; but the proximal half of this \((\text{fig. 4, } p, p')\) has been crushed.

The distal articular expansion \((\text{fig. 6})\), almost flat transversely at its anconal part \((a)\), begins to be concave at the middle of the distal surface \((b)\), and this deepening to the palmar one \((p)\) divides the joint there into a pair of convex troclear condyles. The radial \((r, \text{fig. 6})\) of these, when entire, would have been the most prominent of the two.

The metacarpal \((\text{Pl. 71, figs. 1 and 2})\) which supported the fourth digit has a proximal articular surface of a more definite triangular figure \((\text{Pl. 67, fig. 5})\); the anconal border \((a)\) being the longest, and the angle between the radial \((r)\) and ulnar \((u)\) borders being rounded off. The articular surface is continued upon both these sides of the shaft, but further for the articulation with the mid-metacarpal than for that with the fifth.

The anconal surface \((\text{Pl. 71, fig. 1})\) of the shaft is almost flat and lies more on the plane of that surface of the entire metacarpus than in the marginal metacarpal above described \((\text{fig. 3})\). The radial and ulnar surfaces of fig. 1 converge palmad to the narrow convex palmar surface which forms the rounded angle of the proximal triangular tract \((\text{ib., fig. 6, } w, r)\). Both radial and ulnar surfaces of the shaft are concave lengthwise and across \((\text{ib., fig. 2, } r)\). The transverse concavity of the distal articular surface is feebly indicated, and the bifid character of the joint is scarcely marked, though fractured surfaces suggest that a pair of low palmar prominences may have been broken away; but the joint is much less troclear than in the first metacarpal \((\text{ib., fig. 6})\).

A metacarpal of similar type to the preceding has suffered too great mutilation of both ends to serve for profitable description; it is not a corresponding metacarpal of the right fore-foot, but may be either a second or third, though from the slight superiority of length I should judge it to have been the second metacarpal of the same left fore-foot as the subjects of \(\text{Pl. 71} \) belonged to.

A metacarpal with a subtriedral shaft, and an oblique twist at its basal half through an extension radiad of the radial angle, upon which angle the flat proximal articular surface has extended for the metacarpal on that side, is evidently a fifth metacarpal bone.
The distal surface (Pl. 67, fig. 6) is oblong and almost flat save where it becomes convex on being continued from the basal upon the radial surface; it is feebly concave transversely at its middle half, but this is not continued, deepening, so as to divide the palmar part of the joint into a pair of trochlear condyles. The length of this metacarpal is 5 inches 9 lines; the breadth of the proximal end is 4 inches; of the distal end 3 inches 2 lines; the breadth of the middle of the shaft is 2 inches 3 lines.

The largest of the proximal phalanges extracted gives a length of 5 inches 5 lines; with a breadth of the proximal end of 4 inches, and a breadth of the distal end of 3 inches 7 lines. The breadth of the middle of the shaft is 3 inches; and this seems not to have been more than 1 inch 7 lines in ancono-thenal diameter, but the thenal surface is partially crushed in. The anconal surface is smooth and flat save toward the expanded articular ends. The proximal surface, moderately concave, appears to have been adapted to a distal articular surface of the simple character of the metacarpal last described (Pl. 67, fig. 6). The distal surface of the phalanx is moderately trochlear, i.e., with a feeble transverse concavity along its middle half; it is strongly convex throughout in the opposite (anconothenal) direction. The size of this proximal phalanx indicates it to have belonged to one of the larger middle digits.

Of the instructive terminal phalanges, the most entire forms the subject of figs. 4 and 5 of Pl. 68. The small proportion preserved of the thin, smooth, punctate, articular surface shows a partial depression at b, fig. 4; but the bone is so slightly abraded where that smooth crust is wanting as to afford a fairly true figure of its general shape, which is almost flat, with a feeble sinuosity. The anconal border (a) is most produced; consequently that surface of the phalanx is longest; but it is little more than half as long as it is broad. The thenal surface is made concave lengthwise by the thenal production of the terminal lobes of the distal end (Pl. 68, fig. 5). There is no appearance of these being articular. I regard them as the free termination of a last or ungual phalanx, and to show a modification of that end like the terminal phalanx of the second toe in Iguanodon (\textit{Dinosauria;} Pl. 48, i i, 3).

Not any of the fragments of phalanges suggested a structure for supporting a terminal claw, such as exists in \textit{Megalosaurus}. The fore-foot of \textit{Omosaurus}, as represented by the bones above described, was a short, broad, massive member, relating chiefly to progressive motion, and suggests the huge species, if not, like \textit{Iguanodon}, phytophagous, to have been a mixed feeder.

\textbf{Ilium.—}The mass of matrix with the portion of the skeleton of \textit{Omosaurus} figured in Pl. 72, reduced to one ninth of the natural size, includes, with the sacrum, both the iliac bones and a large portion of the right ischium. The left ischium and both pubic bones, one of which was almost entire (Pl. 73, figs. 4 and 5), were wrought out of the block in the course of exposing the rest of the pelvis upon which they were lying dislocated.

The length of the ilium is 3 feet 5 inches; that of the antacetabular portion is 1 foot
9 inches; that of the postacetabular portion is 9 inches, but the end of this is broken off on both sides; the breadth of the superacetabular portion is 7 inches; the length of the acetabulum is 1 foot 1 inch; the breadth of ditto is 9 inches; the extent of the unwalled part of the cavity is 7 inches.

Besides the pelvis and the detached vertebræ above noted the right femur and probably the shaft of the fibula were left in the mass in the relative positions exposed in Pl. 72, in which the pelvis is seen from the hæmal (ventral or lower) aspect.

The ilium (ib., 62—62") is an oblong, broad, and thick bone, ankylosed by a neuromedial tract, two feet in length, to the expanded ends of the five sacral ribs (ib., pl. I—V).

The hæmal surface is divided into an acetabular tract (62), an antacetabular production (62') of greater antero-posterior extent, and a shorter postacetabular production (62")).

The lateral or external surface, or superacetabular tract, extends neural and outward to terminate in a thick rugged convex border (r), which is continued forward, subsiding as a ridge upon the outer or neural surface of the antacetabular prolongation, (62'); the ridge is lost about nine inches from the fore-end of the antacetabular plate, and gives a triedral form to this part of the ischium. The ridge, continued from r, answers to that in the ilium of the Iguanodon noted at p. 287.* But the proportions of the antacetabular and postacetabular productions are reversed in the Kimmeridgian as compared with the Wealden Dinosaur.†

The length of the antacetabular part of the ilium in Scelidosaurus more resembles that in Omosaurus, but it is narrower and extended more in the axis of the trunk, or is less inclined outward. The corresponding part of the ilium in Cetiosaurus resembles in breadth that of Omosaurus. In this the acetabular cavity (62) is thirteen inches in longitudinal, nine inches in transverse extent. Its outer and hinder border subsides at e, and the cavity is continued upon the superacetabular surface of r, the break in the boundary being somewhat analogous to the cleft in the more developed border of the Mammalian acetabulum for the passage of vessels to the intra-acetabular synovial mass. The lower or hæmal part of the cavity is completed by the ischium (ib., 63), which articulates syndesmatically with the surface (b, e). There is no surface for the articulation of a pubis with the ilium, the Omosaurus in this respect corresponding with the Crocodilia. In the breadth also of the ilium as compared with the length that bone of Omosaurus comes nearer to the Crocodilian than to the Lacertian type.

And, again, in the extent to which the ilium is prolonged in front of the acetabulum the Crocodiles‡ depart less from the Dinosaurs than do the Lizards. In Lacerta

* "The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb."

† Compare ‘Dinosauria,’ Pl. 10, fig. 1, 62' and 62", with Pl. 72.

‡ Cuvier, ‘Ossements Fossiles,’ 4to, 1824, vol. v, pl. iv, fig. 15, a.
*nilotica, e.g.*, the ilium is prolonged in front of the acetabulum to an extent equalling only that of the acetabular excavation of the same bone.

**Ischium.**—This bone (Pl. 72, 63, and Pl. 73, figs. 1—3) offers the structural type of that in *Chelonia* and certain *Lacertilia* (*Uromastyx*, e.g., Pl. 73, figs. 8 and 9, 63), in its 'tuberosity' or posterior process (c); but, in its slenderness or relation of breadth to length, it exceeds that in any Lacertian or other (to me) known forms of existing Reptile.

Of the iliac articular end of the right ischium but little is exhibited, the bone (63, Pl. 72) having been pressed forward and behind the part of the acetabulum from which it has been dislocated. The process (c) answering to that so marked in *Uromastyx*, in the more perfect left ischium (Pl. 73, fig. 8), comes off nearer the articular end than in the Lizard. The rest of the bone is simply styliform and straight, having no process crossing, as in Birds, the obturator interspace between ischium and pubis. The smooth concavity on the under or hæmal surface of the expanded end, articulating with the ilium, contributes about a fourth part of the cavity for the head of the femur. The end of the process (c) is rough, thickened, of an elongate subtriedral form, 2½ inches by 1 inch; the opposite or fore-end of the expansion has a rough syndesmotic surface for the attachment of a similarly roughened end of the pubis. The breadth of the ischium, including these processes, is 13 inches; from this part the bone quickly contracts to a narrow plate. The hind margin of this plate (ib., fig. 1, e) is moderately thick and rounded, whence the bone thins off to an edge in front (ib., f). The hæmal surface is flat or feebly concave, transversely, and is smooth (Pl. 73, fig. 1). The upper or neural surface is, transversely, rather convex, save where it extends upon the acetabular part (a, d), and here it is rather concave. The body of the bone gradually contracts to a breadth of 2½ inches; it then slightly expands to its symphysial end (ib., g, and fig. 3), which has a breadth of 4 inches, with a thickness of 2 inches. Restoring a part wanting between the preserved body of the ischium and the symphysial end, to the extent indicated by the dotted lines in Pl. 73, fig. 1, the total length of this pelvic bone in *Omosaurus* would be 2 feet 6 inches.

**Pubis.**—This bone (Pl. 73, figs. 4—7) presents the type of the pubis in Lacertians (ib., figs. 8 and 9) in the pectineal process (c), and the perforation (d), but adheres to the Crocodilian type in presenting one articular surface only at the proximal end (a) for the ischium, and (seemingly) contributing no share to the acetabular cavity. A Chelonian character is shown in the length of the bone between the head (a) and the process (c).

The articular end (a) has been better preserved than the corresponding one of the left ischium (ib., fig. 1). It presents a narrow, elongate, synchondrosal, roughish facet, 6 inches in length, 1 inch 7 lines in breadth, with a moderate convexity in the long axis (ib., fig. 6). The posthumous abrasion of the articular surface checks an absolute statement as to the precise configuration of this ischio-pubic joint in the recent *Omosaur*, but
the proportion, if any, contributed by the pubis to the acetabulum must have been very small, for no trace of such appears.

The pubis as it recedes from this joint gradually narrows to a breadth of 3 inches 4 lines, then more rapidly expands to form the perforated pectineal plate (c). This plate or process becomes, as in Lizards and Tortoises, thickened and tuberous at its free prominent border, which describes a bold convexity before subsiding into the slender continuation of the pubis (e,f). The margin of e continued thereto by the dotted line, in figs. 4 and 5, is a fractured one; and the angle of the border (e) to which the dotted line is continued shows also fracture; the extension of bone along that line is inferential. Proximad of such fracture the anterior border of the pubis is entire and sharp, a continuation of that which partly circumscribes the oblique pectineal hole or channel (d).

From the pectineal expansion the pubis contracts to a breadth of 2 inches, then expands to its symphysial end (g), which, when entire, must have had a breadth of from 5 to 6 inches. The abraded surface (ib., fig. 7) gives a fuller ellipse than that of the ischium (ib., fig. 3), but, as in that bone, indicates a symphysial junction with the opposite pubis. The hind border of the pubis (f) is rounded and thicker than the fore border (e).

The neural surface (ib., fig. 5) is feebly canalicate lengthwise in part of its extent, and this character is shown, though still more feebly, in the pubis of Uromastyx (fig. 9, 64). But the accentuation of this surface in the broader half of the pubis of *Omosaurus*, as shown in fig. 5, is due to crushing and fracture seemingly in relation to the original prominence of the part of the pectineal process (e, fig. 5), which has been pressed to flatness with slight concavity.

I conclude from the length of both ischium and pubis that they diverged from each other, viz., from their outer to their inner or symphysial ends, at an angle nearer that in Crocodilians than in Lacertians. There is no evidence or indication that these hæmaphyses were disposed otherwise than in the rest of the Reptilian class, meeting, each pair, at the medial line, with a space between ischia and pubes, answering to a common and uninterrupted obturatorial vacuity. This space, in *Dicynodon*, is obliterated by continuous ossification.

The length of the pubis in *Omosaurus* is 3 feet 6 inches, the extreme breadth is 9 inches; the least breadth of the pre-pectineal part (b) is 3 inches 6 lines; the extreme thickness of this part is 1 inch 3 lines.

**Femur.**—To the right of the pelvis lies the femur of the same side, with the hinder surface exposed (Pl. 72, 65). The head (a) of the bone is at a distance of 1 foot 8 inches from its socket (e) and a little posterior to it. The distal end lies exterior to and a few inches in advance of the right ilium. The terminal articular surfaces of the shaft are, to some extent, worn away, but sufficient remains to show that the chief convexity or head (a) projected some inches within the inner longitudinal border of the shaft, the proximal surface sloping slightly distad to the rough convex angle,
representing a trochanter (f), from which a thick rough ridge is continued, gradually subsiding upon the shaft.

The breadth of the proximal end of the bone is 1 foot 1 inch; at 1 foot distance from that end the shaft is contracted to a breadth of 8 inches, and at its middle part to one of 6 inches. Notwithstanding the posthumous pressure which has shattered this part of the crust of the femur, one may infer that the shaft was naturally subcompressed from before backward.

At three fourths of the distance from the head of the bone the shaft again begins to expand, attaining at the distal end a breadth of 13½ inches. There is a distinct oblong protuberance (g) at the inner and back part of the shaft, 1 foot 6 inches beyond the head, corresponding to that more developed prominence which has received the name of 'third trochanter' in Iguanodon and Scelidosaurus. There is also evidence of a longitudinal ridge (a) continued from the back part of the trochanter, about 9 inches down the shaft, inclining toward the middle of the hinder surface.

The popliteal cavity (e) is moderately concave, chiefly transversely through the backward production of the outer condyle (g). This is of less breadth posteriorly than the inner condyle (f) but is more convex as well as more prominent. The outward extension of the femur (h) beyond this prominence is somewhat unusual.

Tibia.—This bone is represented by its proximal end and three fourths of the shaft (Pl. 74, figs. 3—6). The shaft is more slender in proportion to the head than in Hylæo- or Scelido-saurus, and yields a full subelliptic section (ib., fig. 6). Part of the articular surface for the inner femoral condyle may be recognised at a, and that for the outer condyle at b, fig. 3, Pl. 74. A procnemial plate (c), with a base of 7 inches in extent, projects forward 4 inches beyond the articular part of the head of the bone. As wrought out of the matrix this plate shows a sharper free border than probably was natural; its obtusely rounded summit, c, has retained its condition as an epiphysis. The diameter of the head of the tibia in the direction of the procnemial prominence (a, c, fig. 5) is 11 inches. The preserved longitudinal extent of the tibia is 2 feet. The two diameters of the fracture (f, fig. 3) are 4 inches 6 lines and 3 inches 6 lines. The indication of a medullary cavity at the fracture (f) are hardly so definite as in fig. 6, and such as it is, the cavity was short; for at the fracture (e) the corresponding central portion of the shaft shows an open osseous tissue with wide chondrosal interspaces.

In the obliquely fractured and partly crushed end of the shaft the trace of medullary cavity has disappeared. The osseous tissue of the rest of the shaft is compact. Notwithstanding the degree of crushing, the beginning expansion in the tibio-fibular direction and of contraction or flattening in the rotulo-popliteal direction is unmistakable, and has led me to conclude that the distal, more flattened end of the bone is that which is wanting in the present specimen.
Other parts of Hind Limb.—Exterior to the right femur and overlain by it is the shaft or slender part of a bone, 16 inches in length and 3 inches in breadth; it bears the proportion of a fibula to the tibia above described.

No recognisable tarsal, or other bone of the hind-foot, has been detected in the indurated matrix forming the bed of the Omosaur. But Professor Phillips, in his instructive ‘Geology of Oxford,’ states, "Three metatarsals in the Oxford Museum, apparently of Megalosaurus, lying in their original apposition, have been obtained from the Kimmeridge Clay of Swindon and seem to indicate a tridactyle foot (diagram lxviii)." I subjoin a copy of the cut of these bones (Fig. 1), deeming it more probable that they belonged to the genus of Dinosaur now known to have left remains in that formation and locality, than to the Megalosaurus, of which no indubitable evidence has yet been obtained from Kimmeridge Clay, either at Swindon or elsewhere. A is an outline of the proximal, B of the distal, ends.

These bones exemplify the 'leptopodal' character of the Dinosaurian foot, due to the reduction of thickness or breadth by suppression of two of the toes, and a consequent departure from the short, thick, or broad 'pachypodal' character of the pentadactyle hind foot of the existing and extinct terrestrial Cheonia and of some Lacertia.

Dermal Spine.—One osseous spine ('Dinosauria,' Pl. 74, figs. 1 and 2; Pl. 75, figs. 2 and 3) has been successfully wrought out of the matrix; but though a close search was made for other evidences of a dermo-skeleton none have been found.

The spine in question is 1 foot 6½ inches in length, and not more of the tip seems to be wanting than might extend this dimension to 1 foot 7 inches, or, at most, 1 foot 8 inches; the long diameter of its base (Pl. 75, fig. 2) is 5 inches; the shaft gradually tapers to a point. The spine is rounded and slightly compressed; the narrower diameter is shown in Plate 74, fig. 1, the greater breadth in ib., fig. 2. The surface, smoothest toward the base, becomes slightly broken by fine longitudinal, quasi fibrous, markings; and this sculpturing becomes coarser as the spine contracts. At every part may be seen small orifices, apparently vascular; few in number along the basal two thirds, but more frequent near the point. These indicate a periosteum in relation to the supply of a horny sheath, of which we have here the petrified bony core. The texture of the osseous substance is dense (Pl. 75, fig. 3).

The base is obliquely truncate, with a boldly sculptured border, broadly and deeply notched as if for strong ligamentous attachments, the whole basal surface being coarsely roughened; it is also channelled, seemingly, by two vessels entering the substance of the

* 8vo, 1871, p. 215.
spine, one, perhaps, an artery, the other a vein (Pl. 75, fig. 2). The spine is traversed by a central medullary or chondrosal canal, in diameter one third that of the smaller diameter of the spine (ib., fig. 3). The rough imperforate part of the base, like its coarse periphery, suggests adaptation to syndesmotic junction with some other bone. But with what part of the frame?

There is a want of symmetry at the obliquely truncate base, which suggests this spine to have been one of a pair.

In Scelidosaurus the dermo-neural spines at the neck and fore-part of the back are similarly 'somewhat unsymmetrical in form,' showing a parial arrangement along, that part of the trunk, but they are succeeded by symmetrical dermo-neural spines having a medial position along the rest of the trunk and tail.

The osseous spines, probably dermo-neural, of Hylæosaurus, show a length in proportion to the adjacent vertebral centra of somewhat exceeding the present spine of Omosaurus; they are, likewise, obliquely truncate at the base, and unsymmetrical in shape, but in a greater degree; and they are much more compressed ('Dinosauria,' Pl. 37, d).

In the Hylæosaurian specimen in the British Museum, which turned the scale in favour of the dermo-neural hypothesis, an irregular angular depression is described and figured at the base; and this repeats, though single, the pair of depressions or canals above noted, and reputed vascular, in the base of the spine of Omosaurus. The low, obtuse, thick ridge girting the base of the spine in Hylæosaurus is, however, simple, unnotched; the provision for attachment of the spine, in Omosaurus, betokens a greater power of resistance against displacement. The superior strength of the spine, due to its full elliptical shape in transverse section, suggests its application as a weapon to be wielded for attack rather than as one of a merely defensive palisade of spines.

Considering the number of vertebrae—dorsal, sacral, caudal—which have been recovered in more or less completeness from the intractable mass of some tons weight, including the rest of the above described recovered parts of the skeleton of the Omosaur, it might reasonably be expected that, had the trunk and tail been defended by dermal spines, as in Scelidosaurus and Hylæosaurus, especially by spines similar in number and arrangement to the dermal ridged scutes of the more Crocodilian Dinosaur of the Lias, evidences of such appendages to the trunk-skeleton should have been found in the grave of the great Kimmeridgian dragon.

But we are, now, not limited to the head, the trunk, or the tail in quest of positions of armour afforded by dermal bones to extinct members of the Reptilian class.

In the great Mantellian Iguanodon, or at least in the male of that species, a pair of spines supported by unsymmetrical conical bony cores were wielded for offensive action by the fore-limbs (p. 508, Pls. 46, 47). The form and proportions of the Iguanodontal carpal spine, especially in its degree of compression, are more like those of the spine in Omosaurus than are any of the dorsal spines in Hylæosaurus. 'True, the conical spine-
core in *Iguanodon* is shorter in proportion to its basal breadth than is the problematical spine in *Omosaurus*.

It is significant of the nature of this one unsymmetrical osseous spine that the bones of one of the fore limbs, the left, and that limb only, should have been preserved, and in a more complete state than any other part or limb of the present remarkable Dinosaurian framework; the spine in question lay not far from the radius and carpus.

Two spines of similar form to that of *Omosaurus*, but of larger size, were discovered near each other in a pit of Kimmeridge clay at Wootton Bassett, Wiltshire, and formed part of the well-known collection of William Cunnington, Esq., F.G.S., now in the British Museum. Whatever contiguous bones may have been dug out of the same part of the pit were not preserved. These two spines form a pair, and resemble each other as much as would the right and left radius, or the right and left ulna, of the same Dinosaur. They differ from the (carpal?) spines of *Omosaurus* in having a sharp edge, which in a transverse section, like that of fig. 4, Pl. 77, would terminate one end of the long diameter of the ellipse. The lethal power of the weapon was augmented by this character of the sword added to that of the pike. The degree of obliquity, the coarse marginal notching, and vascular perforations of the base, are as in *Omosaurus*; but the expansion is greater, yielding dimensions of 8 inches and 6½ inches in long and short diameters; there is a slight submedial ridge dividing the basal articular surface into two shallow channels. The long diameter of the shaft, four inches beyond the least produced part of the base, is 3½ inches, being nearly the same as in *Omosaurus*. The edge of the spine is along the same line as the most produced part of the base. The shaft has a central cavity, as in *Omosaurus*. Should these prove to be a pair of carpal spines they indicate a species of Dinosaur distinct from *Omosaurus armatus*. They will be further described and figured in a subsequent part of the present work.

**Order Dinosauria.**

**Genus—Cetiosaurus.**

Species—*Cetiosaurus longus*, Ow. (Plate 76, and Woodcuts 2—11).

Until a comparatively recent period the generic or family characters of the great extinct Cetiosauroid Reptiles were founded on a few scattered bones of the trunk and limbs.† The texture of these fossils mainly differentiated them from the corresponding vertebrae and limb-bones of previously determined genera or species of Saurians. No

*Gr. κότειος, cetaceous; σαῦρος, Lizard; "Report on British Fossil Reptiles," Part ii, in 'Reports of the British Association,' &c., for the year 1841; also 'Proceedings of the Geological Society of London' or June, 1841 (vol. iii, p. 457).

† *Ante*, p. 405; provisionally referred to the order *Crocodilia*. 
portion of the skull, not one tooth, had been discovered so associated with Cetiosaurian bones, at the date of my "Reports on British Fossil Reptiles,"* as to throw any additional light on the ordinal affinities of the new genus. I had not, then, grounds for dissociating it from the Crocodilian group or order. The grand accession of evidences of the osseous framework of one of the species† added to the original Collection of Buckland, preserved in his Museum at Oxford, by his eminent successor, Professor Phillips, F.R.S., by whom they have been instructively elucidated in his excellent work on the "Geology of Oxford,"‡ has proportionally advanced the means of determining the ordinal relations and affinities of the genus. The inferences which may be drawn in favour of the Dinosaurian characters of the sacrum will be subsequently discussed. But the demonstration of the sacral characters of the more recently discovered Cetiosauroid genus Omosaurus adds to the grounds for referring the type-species of Cetiosaur to the Dinosaurian group of Reptilia.

It is characteristic of the accidents that attend the quest and acquisition of the remains of extinct Vertebrates, that skull, jaws, and teeth should have escaped the careful operations to which we are indebted for the present means of restoring both Cetiosaurus longus and Omosaurus armatus. Of the former reptile a single doubtful and mutilated tooth was all that Prof. Phillips could refer with any degree of probability to that species.

That the side-pits of saurian vertebrae have no essential relation to largely cancelled, pseudo-pneumatic structure of the bones is shown by their presence in the anterior trunk-vertebrae of the genus for which the uniformly close though coarse osseous texture, as in the whale tribe, suggested the generic name Cetiosaurus.

The first indication of this type of Saurian was, however, afforded by an inspection of a limb-bone, submitted to me by Dr. Buckland in 1838, when I was engaged in collecting materials for my "Report" to the British Association "On the Fossil Reptilia of Great Britain." Buckland had referred to this fossil in his "Bridgewater Treatise," 1st edit., 1836, in the following terms:—"There is in the Oxford Museum an ulna from the Great Oolite of Enstone" (Enslow probably meant), "near Woodstock, Oxon., which was examined by Cuvier and pronounced to be cetaceous; and also a portion of a very large rib, apparently of a whale, from the same locality."

This limb-bone I could not match with any then known to me in the Cetaceous order. Yet, save a thin compact outer crust, the osseous structure was, where exposed, like that in the humerus of a Whale or Grampus; there was no medullary cavity. In shape the resemblance, though remote, seemed nearest to that of the outer metatarsal of a Monitor Lizard.§

* "Reports of the British Association for the Advancement of Science" for the years 1839 and 1841.
‡ 8vo, 1871.
§ Prof. Phillips, who had obtained, in 1870, from the Great Oolite at Enslow, the three metatarsals
Shortly after I was able to differentiate certain saurian vertebrae from those ascribed to the genera Iguanodon, Hylæosaurus, Megalosaurus, and Poikilopleuron, not only by superiority of size, but by differences in form, proportions, and structure.* The latter character applied, more especially, to these huge unknown fossil bones in the comparison with Poikilopleuron, in the vertebrae of which four-footed reptile ossification is incomplete and large chondrosal vacuities are left in the substance of the centrum, which, in the fossils, become filled with spar.†

From the similarity of texture of the vertebrae of the new genus of Saurian so indicated to that in the limb-bone from "Blechingdon," Enslow, I suggested that it might belong to Cetiosaurus.‡ The cetaceous hypothesis of the huge Oolite Vertebrate was thereupon abandoned, and my determination was adopted in the second edition of the 'Bridgewater Treatise,' and also by Lyell, who gives a reduced cut of the fossil in his 'Manual of Geology,' ch. xx.

In 1848 Dr. Buckland informed me of the discovery of a femur, 4 feet 3 inches in length, which, from the correspondence of its texture with that of the metatarsal from Blechingdon, and also with that of some fragmentary long bones from Blisworth, Northamptonshire, I referred to the genus Cetiosaurus, and to the species from the Great Oolite called Cetiosaurus longus.§

More recently (1868—70) a considerable proportion of the skeleton was discovered in the quarries of the Great Oolite of Enslow Rocks at Kirtlington Station, eight miles north of Oxford, the bones of which more nearly approached in size to the type specimen of Cetiosaurus longus.¶ I, therefore, visited Oxford for the purpose of studying these remains.

Such of the trunk-vertebrae as were sufficiently entire appeared to have come from the fore part of that region, and showed the opisthocelian character of those vertebrae as in certain Dinosaurs.

In the best preserved anterior dorsal vertebra the parapophysis, short but large in vertical extent, shows remains of the articular surface for the head of the rib. The diapophysis, supported by a strong buttress-like ridge, is directed upward and outward at an angle of 45° with the neural spine. The distance between the articular surface for of each hind foot of a Cetiosaurus, wherewith he was able to compare the above fossil long bone, "incomplete at both extremities," considers the determination of it as a metatarsal of large size to be "probably true."—'Geology of Oxford,' &c., 8vo, 1871, p. 285.


† The chief of these cavities, being in the centre of the vertebrae, was termed 'medullary' (loc. cit., p. 459); but I have since had reason to conclude that it was occupied in the living Saurian by unossified chondrine.


§ Ib., ib. Also ante, p. 413.

¶ "Vertebrae 8, 9, and 11 inches in diameter," "monstrous ribs," "femora upwards of 5 feet in length."—'Athenæum,' April 2nd, 1870.
the ‘tubercle’ and that for the ‘head’ of the rib is ten inches, which indicates the extent of the ‘neck’ of the rib at this fore part of the thorax. The neural spine is strengthened by lateral buttress-like ridges rising from the neural platform; it is of a massive quadratoform and seems to have terminated obtusely. The zygapophyses are supported by buttress-like vertical ridges.* All the characters of this massive vertebra bespeak the great strength of the back-bone of the enormous saurian. The total vertical extent of the above vertebra, which is incomplete at the wider part of the centrum, is 2 feet 4 inches; the breadth at the diapophyses is 1 foot 6 inches.

The vertebra which is the subject of ‘Dinosauria,’ Pl. 76, from a hinder position of the trunk than the above-described, exemplifies the cetiosaurian characters of texture (fig. 2, p) also of a contracted antero-posterior extent of the neural arch as it rises from the centrum,† and of a partial subsidence of the anterior ball. This vertebra has been crushed and fractured; the right side is pressed obliquely backward for an inch or so beyond the left side, so that the length of the centrum, measured as it has been squeezed out of shape, exaggerates its original or natural longitudinal diameter. This would not exceed, according to my estimate eight inches. The vertical diameter of the centrum has also been pressed down beyond its original extent. I estimate the ball or fore part at 6½ inches, the cup behind at 7 inches, in height. The neural arch, as in the type-vertebrae of Cetiosaurus longus,‡ is retained in anchylosed union with the centrum to the extent shown in Plate 76, viz., eight inches.

A vertically grooved median ridge appears to commence at the back part of the base of the spine. This process is wanting; it probably would have added a foot to the present vertical extent of the vertebra, which is sixteen inches. Minor projecting parts have been equally broken away, and, as usual, lost in the quarrying or extricating operations. Such fractures occur on both sides of the prominent rim of the hinder cup of the centrum (as at p, fig. 2, Pl. 76). The singularly naturally compressed upper and middle part of the centrum (ib. f) underlying the neural canal and forming a vertical plate or medial wall of bone, three to four inches in height, and but six lines to eight lines in thickness, has been in part broken away, exposing that canal. The fore and hind outlets of the neural canal are squeezed into a narrow, vertically lengthened, oval shape (ib., fig. 2, n).

The neurapophysis rises by two buttress-like columns (ib., fig. 1, n, n) which converge as they ascend and overarch the lateral depression f. The base of the neural arch is coextensive with the centrum, save in so far as the anterior ball may have projected

* "On Cetiosaurus from Oolitic Formations," 'Proc. Geol. Soc.,' 1841, l. c., p. 459. Cetiosaurus longus is defined as in the ‘Report,’ and distinguished from the Cetiosaurus brevis of the Wealden Formations, pp. 101, 102, which will probably prove to be referable to a distinct cetiosauroid genus.

† In the account, illustrated by woodcuts, given by Phillips in his excellent ‘Geology of Oxford,’ pp. 246—294, a vertebra, supposed to be lumbar, the subject of the diagram lxxxvii., p. 257, has assigned to it the following admeasurement—"Greatest length from front to back (crushed) 4½ in." I have found no trunk-vertebrae of the Cetiosaurus from the Kirtlington Oolite so short as this.

‡ "In all these vertebrae the neurapophyses are anchylosed to the centrum," &c.—‘Report,’ p. 102.
beyond; but the neurapophysis soon shows, as it rises, the 'short antero-posterior extent,' which is among the characteristics of the genus. One advantage of the fractures, which must otherwise have been got by sections, is the demonstration of the cetiosaurian texture of the bone (Pl. 76, fig. 2, p). The resemblance of this close but somewhat coarse osseous tissue to that of cetaceous bone, especially in the larger Whales, and which seems to characterise the whole skeleton of the present genus of gigantic saurians, might well excuse the idea that the huge long bone first observed was cetaceous.

The unbroken surface of the vertebra has a fine fibroid character; the interrupted lines affecting a longitudinal course on the centrum and a vertical one on the neurapophysis. How far any exposure of the arch at the base of the spine may have formed a part answering to the 'platform' in the antecedent vertebra, and as in most Dinosaurs, the broken state of the specimens does not allow of determination.

Near the borders of the articular ends of the centrum, which are more or less rubbed away, stronger sculpturing is indicated, as if in relation to ligamentous attachments.

The lower border of the lateral depression, $f$, is more obtuse, less definite, than in Bothriospondylus (Pl. 63, fig. 1); the vertical convexity of the side of the centrum changes in Cetiosaurus more gradually into the concavity of the depression.

The sternum of Cetiosaurus longus is a transversely elliptical plate with an almost flat, slightly undulate upper or inner surface (fig. 2); 19 inches broad, 15 inches long, 1 inch to 1½ inch thick, increasing to 2½ inches at the coracoid articular surfaces, though, probably, the entire expanse of the border here is not preserved. The hind border shows prominences for the attachment of three pairs of sternal ribs, $r$, $r$, the hindmost pair in contact, as in Monitor niloticus.

In this Lizard the sternum has a rhomboidal form, with a low median ridge on the outer or under surface, a deep hollow on the opposite surface, and considerable thickening of the articulations for the coracoids. Were these bones fully ossified in that Lizard they would correspond in breadth with those of Cetiosaurus; there are, however, two tracts retaining the primitive sclerous state, and an antero-medial part which has not gone beyond that of gristle, in the coracoid of the recent saurian. We have, therefore, in Cetiosaurus, as in some other ancient
saurians, notably of the order *Dinosauria*, a degree of lacertian structure combined with a crocodilian advance of vertebral and concomitant cardiac and pulmonic structures.

The scapula of *Cetiosaurus* (fig. 3) is more crocodilian than lacertian in its proportions. It is an elongate plate, expanded at both ends, but most so and most abruptly at the articulations for the coracoid, c, and humerus, h, h. The more gradual
expansion of the base or free extremity is chiefly due to the hinder border, and this describes a concavity, while the fore border is nearly straight. The outer surface (left) is slightly depressed lengthwise behind a longitudinal ridge near to and parallel with the anterior border. The inner surface (right) has a longitudinal rise near the middle,
which bifurcates to strengthen the humeral and coracoid surfaces, and to add to the thickening of the articular end of the bone. Phillips notes the modification of structure of the basal three inches of the blade, indicative of coarse or partial ossification of an original cartilaginous superscapula, the proportions of which element would thus be more crocodilian than lacertian. The resemblance of the blade-bone of Cetiosaurus to that of Scelidosaurus has already been noted. But the production of the anterior or humeral angle of the articular end is somewhat greater, approaching that in Hylæosaurus. The length of the scapula of Cetiosaurus longus is 4 feet 6 inches, the breadth of the articular end is 2 feet 2 inches, the least breadth of the body of the bone 10 inches.

The humerus of Cetiosaurus seems far from exhibiting the outstanding plates and ridges for muscular attachments, such as we see in Omosaurus (Pl. 70, figs. 1 and 2) and the larger existing lizards (Hydrosaurus, Monitor), which run swiftly on land; they are even more feebly indicated than in the Crocodiles, but much of this inferiority may be due to posthumous injury and abrasion in the present huge fossils.

The head of the humerus, fig. 4, a, is an elongate, semi-oval, narrow convexity, broadest at the middle, which projects toward the hinder or anconal surface of the bone, as in Lizards and Crocodiles; the degree of the projection is shown in the outline of the proximal end of the bone, at e, fig. 4, a.

The ridge from the radial side of the proximal third of the shaft (fig. 5, b), answering to the 'pectoral' or 'deltoidal' one in the Mammals, commences, as in the Monitors, near the head, not, as in the Crocodiles, abruptly at some distance below; it has suffered abrasion in the Kirtlington specimen, yet seems not to have stood out in the same relative degree as in Omosaurus, or as in the Monitor, in which, as in the Crocodile, it is bent toward the fore or palmar side of the bone.

The shaft of the humerus in Cetiosaurus is subcompressed, subtrihedral, through an obtusely angular longitudinal low ridge or prominence, on the anconal side (fig. 4), continued from below the head to near the distal end, inclining toward the radial side. There is no trace of the distal ridge from that border of the shaft which, in Monitors, answers to the 'supinator' ridge in Mammals (Pl. 70, fig. 6, c). The more prominent of the two distal articular convexities, that, viz., for the head of the radius, is feebly indicated; the back part of the convexity for the ulna is traceable at the worn distal end of the bone (fig. 5, d).

The pectoral and supinator ridges are still more feebly in-
dicated in the humerus of a small or young *Cetiosaurus*, figured by Phillips at p. 273, Diag. ci.

The length of the Kirtlington humerus (op. cit.), figs. 4 and 5, is 4 feet 3½ inches; extreme breadth of the proximal end 1 foot 8 inches; of the distal end 1 foot 3 inches; diameters at the middle of the shaft 8 inches by 4 inches.

The proportion of the ulna (fig. 6) to the humerus appears to be nearly that in the Monitor. The shaft is more distinctly three-sided, the anconal surface being strengthened by a median longitudinal rising or ridge not present in *Monitor*. As in this Lizard the palmar concavity excavates the whole of the upper half of that surface of the shaft except at the outer and inner ridged boundaries. The margin toward the radius is concave, the opposite one nearly straight, feebly convex. Both ends of the ulna of the Kirtlington Cetiosaur are wanting; it measures in this state upwards of 3 feet in length. In the section, fig. 5, a, the palmar side, a, is 12 inches across; the facet, b, of the anconal side is 11 inches; the narrower facet of the same side, e, is 7 inches. No recognisable bones of the fore foot of the *Cetiosaurus longus* appear as yet to have been discovered; but the proportions of the known parts of the fore limbs are such as to make it more likely that they took their share in a quadrupedal mode of progression than that they were borne aloft, with the trunk, on the hind legs like the folded wings of a bird.

The first almost entire femur of *Cetiosaurus longus* was obtained mainly through the personal care and supervision of Hugh E. Strickland, M.A, then (1848) of Merton College, from one of the divisions or thin bands of the 'Great Oolite' underlying the Cornbrash near Enslow Bridge, north of Oxford. The length of this femur is 4 feet 3 inches.

In 1868 the femur of a larger individual of *Cetiosaurus*, and in 1870 the other bones of the same individual, here described and referred to the species *Cetiosaurus longus*, were discovered in the same quarries, close to the railway-station for Kirtlington, eight miles north of Oxford. Professor Phillips having notice of the first discovery took the requisite steps, with his wonted energy, to prosecute the quest and secure for his science the evidences of the monster dragon.

The thigh-bone, first come upon, "was found to be lying on a freshly bared surface of the Great Oolite, nearly in the line of a natural fissure, and covered by the laminated clay and thin oolitic bands which there occupy the place assigned to the Bradford Clay of Wiltshire." *

This bone was 5 feet 4 inches in length. In the course of the quarrying works the opposite femur and many other bones of the same skeleton were brought to light. The majority of these "did not actually touch the Oolite, still less were embedded in it, though single exceptions occurred of each circumstance."

"The strata covering the solid Oolite were thus noted, March 21st, 1870:
"Thin skerry beds of Forest-marble and shaly clay.

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<td>&quot;Brown, yellow, and grey layers, argillaceous, sandy, and oolitic&quot;</td>
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<tr>
<td>&quot;Grey and argillaceous bed, with selenite&quot;</td>
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<td>&quot;Grey and greenish bed loosely oolitic, with Terebratula maxillata, Avicula, Astarte&quot;</td>
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<td>&quot;Clay and loosely aggregated oolitic parts, with selenite and abundance of carbonized wood, some shells, and most of the bones&quot;</td>
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<tr>
<td>&quot;Clay below&quot;</td>
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"Great Oolite with undulated and waterworn surface. The two lower bands 'die out' to the southward, and there some of the bones came in contact with the rock, and others were engaged in it."

Phillips, ut supra, p. 251.

The most striking of the remains here discovered was the fellow femur (right) of the one (left) found in the previous year. The anterior surface of the latter (left) is shown in cut, fig. 7. It is 5 feet 4 inches in length, the diameter of the middle of the shaft is 1 foot, that across the condyles 1 foot 5 inches. The shaft is naturally subcompressed, but the flattening has been exaggerated by posthumous pressure to which the closely cancelled texture of the interior of the shaft has yielded, with fracture of parts of the denser outer crust; but there is no sufficient indication of the head, a, having been pressed so as to project inward, from any original disposition of that prominence forward, such as characterises the femur in modern Crocodiles and Lizards. The relation of the head to the shaft of the bone is thus more mammalian than saurian in the gigantic Cetiosaur. But the 'neck,' b, is short, or almost nil; the trochanterian angle, c, not produced above the level of the neck or head. The trace of any prominence for muscular attachment at the inner part of the shaft, d, is feeble; by no means such as appears in Scelidosaurus or Iguanodon. The distal end expands to the condyles, e, f, but in a minor degree than in the Monitor.

The cut, fig. 8, shows the postero-external surface of the right tibia of Cetiosaurus longus. The prominence, a, is that which receives the outer condyle of the femur; the border, b, in the view of the proximal end, gives the contour of the antero-internal part, which is rather flatter than in Monitor; c shows the production above the procnenemial ridge at the fore part of the bone; d is the part which was articulated to the distal epiphysis supporting the outer malleolus. The proportions of the tibia to the femur are
less than in Monitors or Crocodiles; the length of the bone (fig. 8, a, d) is 3 feet 10 inches; the breadth of the end adapted to the femur (fig. 7) is 1 foot 7 inches; that of the distal end is 1 foot.
As Professor Phillips remarks, "the terminal surfaces are strongly marked by the pitted adherence of cartilage, . . . . . which gives the appearance of deficient epiphyses." *

In a full-grown Monitor niloticus the distal epiphysis, which affords the articular

* P. 282-3. He adopts an idea that the convex part of the anterior surface of the distal portion of the shaft of the tibia in the Crocodilie is the homologue of the ascending process of the astragalus of Megalosaurus, but "separated from its base and ancylosed to the tibia; while in Megalosaurus the connection remains, and the ascending process is not joined by synostosis to the tibia" (op. cit., p. 283). Scelidosaurus instructively exemplifies the homology of the distal epiphysis of the tibia in Dinosaurs with that in the Monitor and the Bird, and demonstrates the separate existence of the bone answering to the astragalus, &c., in both Crocodiles and Lizards, but which is not ossified in the tarsus of Birds (p. 499, cut, fig. 4).
surface to the astragalus, is unanchylosed, the line of suture closely resembling that in the distal end of the present fossil.

Of the foot-bones, "three metatarsals of each foot were secured." The largest appeared to be the first or innermost, the slenderest the third or outermost of the series. "Perhaps there were only three metatarsals, since the specimens we possess exhibit opposite pairs of three and no more" (Phillips, op. cit., p. 285).

That these bones are homologous with those determined as the second, third, and fourth of the pentadactyle foot in *Scelidosaurus* and *Iguanodon* I deem more probable than that they answered to the metatarsals of the first, second, and third digits in *Crocodilus*.

If a first or a fifth digit existed in the hind foot of *Cetiosaurus*, their shortness or rudimental condition may have prevented their recognition.

In the description of the osseous characters then known of the largest species of Whale-Lizard, I remarked:

"These enormous *Cetiosauri* may be presumed to have been of aquatic and, most probably, of marine habits, on the evidence of the coarse cancellous tissue of the long bones which show no trace of medullary cavity."*

In reference to their affinities:

"In the great expanse of the coracid [fig. 9] and pubic bones, as compared with the Teleosaur and Crocodiles, the gigantic Saurians in question manifested their closer affinity to the *Enaliosauria*"†—closer, that is, than the Teleosaurs or Crocodiles show; but "their essential adherence to the Crocodilian type is marked by the form of the long .

* 'Report,' *ut supra*, p. 102.
† *Ib.*, *ib.*
bones of the extremities, especially of the metatarsals: and, above all, by the toes being terminated by strong claws." Here, in 1842, the clawless character of the limbs of Plesio- and Ichthyo-sauri was the dominant idea, to the exclusion of the then novel group of Dinosauria, "characterised by a large sacrum composed of five ankylosed vertebrae of unusual construction," &c.*

The question to be determined in respect to Cetiosaurus is the admissibility of the genus by the sacral character to the Dinosaurian order. This character, in 1842, I put in the van, relating as it does, physiologically, to terrestrial progression more after the manner of Mammalian quadrupeds than of existing four-footed Saurians, whether Crocodiles or Lizards; an extent of the trunk being thereby transmitted, through a co-extensive ilium, upon hind limbs, the chief bones of which are 'medullary' in Dinosauria.

The ilium (fig. 10) of the Cetiosaurus longus, from the Kirtlington quarry, is estimated by Phillips as probably equal to six vertebrae. He writes:

"The extreme length of one (ilium) is 42, of the other 45 inches, probably equal to six vertebrae,"† —such sacral vertebrae being estimated each at a little over 7 inches in length.

These vertebrae are briefly noticed as follows:—"Several bones of this portion are in the collection, but there is great difficulty in so placing them as to acquire a just notion of the structure or to present a satisfactory drawing. In some degree it (the sacrum) must have approached that of Hylaeosaurus."‡ I found a nearer approach to the sacrum in Scelidosaurus.

In either comparison the length of the sacrum is not to be estimated as equal to that of the ilium. In Scelidosaurus, e.g., in which the number of sacral vertebrae is 'four,' the parts of the ilium anterior and posterior to the sacro-iliac symphysis, or surface of junction with such vertebrae, give to that pelvic bone almost twice the length of the sacrum. The length of this part of the spine in Scelidosaurus is 10 inches, whilst that of the ilium is

18 inches, "a part, apparently a small one, being wanting from both extremities" of the iliac bone. But, on this basis, we may allow to the ilium of 45 inches length a sacrum of 24 inches, or one of four vertebrae, each 6 inches in length. It is not probable that a saurian with iliac bones between 3 and 4 feet in length, and thigh-bones between 5 and 6 feet in length, would have a sacrum reduced to the crocodilian formula of two vertebrae.

Admitting, then, that more numerous sacrals, such as the Tortoises show, are not the sole and may not be the chief character of Dinosauria, and that the generalisation signified by that term is a passing one, denoting a step in the progress of knowledge of the extinct Reptilia; and supposing that it should be now limited to saurian genera, combining, with four or more sacrals, the alternating or interlocking arrangement of the autogenous vertebral elements—as in Bothriospondylus, Megalosaurus, Iguanodon, Hylaeosaurus, Omosaurus—the question to be solved is:—"Does such arrangement characterise the sacrum of Cetiosaurus?" Have we, in the absence of any certain or definite knowledge of the cranial and dental characters of the genus, grounds for determining its ordinal relations to the Dinosaurs, Crocodiles, Sauropterygians, Ichthyopterygians, Lacertians, &c.? I am disposed to wait for such additional evidence, admitting, meanwhile, the faculty of terrestrial progression in a superior degree to that of the amphibious Crocodiles; nevertheless, the habitual element of the Cetiosaurus may have been, and I believe to have been, the waters of a sea or estuary. And I may here repeat the remark on the initial evidence of the species:—"The main organ of swimming is shown, by the strength and texture and vertical compression of the caudal vertebrae, to have been a broad vertical tail; and the webbed feet, probably, were used only partially, in regulating the course of the swimmer, as in the puny Amblyrhynchus of the Galapagos Islands, the sole known example of a saurian of marine habits at the present period."*

In fact, to the characters of the caudal vertebrae of Cetiosaurus longus known to me at the date of the above-quoted 'Report,' viz.—"post-zygapophyses represented by hollow pits," "slight concavity of both articular ends of the centrum, moderate compression of the sides between the expanded ends, which are subcircular,† the under surface concave lengthwise, marked by parial articular surfaces, showing the haemal arches to be articulate therewith over the vertebral interspaces,"‡ the discovery of the grand proportion of the skeleton of the individual at the Enslow quarries adds a demonstration that the haemal arch in an anterior caudal vertebra (fig. 11) attained a length of 1 foot 2 inches; and that the neural spine "probably rose twelve inches above the canal,"§ giving a total vertical extent of upwards of a yard to such anterior caudal. The vertebrae probably exceeded in this dimension at the middle of the tail.

The modifications of the caudal vertebrae in parts of the tail of Cetiosaurus longus, as exemplified by specimens from the Great Oolite described and figured by Phillips ('Geology of Oxford,' 8vo, 1871), are similar to those in the instructively preserved

Dinosaur from the Dorsetshire Lias (Scelidosaurus Harrisonii, Ow.), now in the British Museum.

The broad subquadrate coracoid, with rounded angles, of the Cetiosaurus longus from the Enslow quarries (fig. 9) repeats the characters of that bone in the type of the species (‘Report,’ p. 102). In the Oxford giant the bone measures “from the glenoid cavity to the extremity near the scapular margin (incomplete) 18 inches; if complete, probably 20; breadth between scapular and sternal margins, 18.5 inches; greatest thickness 5.0.” (Phillips, op. cit., pp. 270, 271.)

The scapula of Cetiosaurus resembles that in Scelidosaurus, with rather less concavity of the anterior border, and rather more concavity of the posterior one. It surpasses the humerus in length in a minor degree than in Scelidosaurus, and in a still less degree than in Iguanodon.

In the characters of the dermo-skeleton Cetiosaurus would seem not to agree with Scelidosaurus. It is very improbable, if there had been such agreement, that not any skin-scutes or spines should be shown in connection with the large proportion of the skeleton of one and the same individual brought to light on the excavated oolite of Enslow Rocks at Kirtlington. *

The same negative evidence in all the various finds of fossil remains on which the genus was based suggested, in 1841, the idea that the tegument of Cetiosaurus might be smooth, or unarmed, as in Cetacea and Enaliosauria. But, as has been shown in antecedent contributions to the ‘History of British Fossil Reptiles,’ a new interest will attach itself to the future occurrence of an osseous spine, seemingly dermal, in contiguity with the parts of the fore-limb which were wanting, or not discovered, in the Kirtlington example of Cetiosaurus longus.

In Scelidosaurus the number of vertebrae between the skull and sacrum is twenty-three or twenty-four; in Iguanodon the same region includes more than seventeen vertebrae: in this genus there are five sacral vertebrae; in Scelidosaurus four. In no Dinosaur has the number of caudal vertebrae been so satisfactorily or approximately demonstrated as in Scelidosaurus. Thirty-five of these vertebrae were obtained in consecutive articular association in the individual fossil skeleton in the British Museum. If we allow the Cetiosaur, on this analogy, twenty-four vertebrae between the skull and sacrum, averaging 5 inches each in length, and add an inch for the intervertebral connective tissues, we get a total length of trunk at 12 feet. Four sacral vertebrae would add two feet. Taking the number of the caudal vertebrae at that shown in Scelidosaurus,

and the reduction of length in the ten terminal ones not to be more than is there shown, the length of the tail of *Cetiosaurus longus* may be set down at 17 feet. Thus we get an approximative idea of the length of this Cetiosaur, *minus* the head, as 31 feet. The fortunate discovery of the skull or lower jaw, or a mandibular ramus, would supply the ground for completing an idea of the size of the whole animal. As the femur of *Cetiosaurus longus* found in 1868 in the Enslow locality exceeded in size that found in 1848, so the subject of cut, fig. 7, may ultimately prove not to represent the extreme size attained by individuals of the species; and the length of 7 inches shown by the typical caudals would found an estimate of 35 or 36 feet for the length of trunk and tail of *Cetiosaurus longus*.

As evidence of this species have now reached me from four counties—Yorkshire, Northamptonshire, Buckinghamshire, and Oxfordshire—I submit that there is no case, according to the 'canons of zoological and botanical nomenclature' adopted by the 'British Association for the Advancement of Science,' * for suppressing the original name proposed by the discoverer of the species, and substituting one which is in one degree misguiding. I would also plead for a retention of the orthography of the generic name.†

In my "Report on British Fossil Reptiles," Part ii,‡ I referred to the palæontologist, who, in 1869, was deservedly characterised as "that remarkable man whose recent death all who are interested in the progress of sound palæontology must deplore, Herman von Meyer,"§ in the following terms:—"In the tabular arrangement of extinct Saurians founded by M. Herm. v. Meyer on the development of their organs of motion, the *Megalosaurus* and *Iguanodon* are grouped together in Section B, with the following character:—Saurians with locomotive extremities like those of the bulky terrestrial Mammals: '(Saurier mit Gliedmassen ähnlich denen der schweren Landsaügethiere).'- *Palæologica*, p. 201. No other grounds are assigned for their separation from other Saurians." The needful quest of such grounds led to the discovery of characters which, with the essential unlikeness of the limb-bones of the two cited genera to those of any mammal, the inappropriateness of the name given to the family, and the evidence of the claims of the reptiles under review to form a group higher than a subordinate section of an order, weighed with me in defining the characters of such higher group, and to propose for it the name *Dinosauria*, a step which I still deem to be in the interests of "sound palæontology."

In support of the statement that "Prof. Owen, nine years afterwards, conferred a new name upon the group and attempted to give it a closer definition," Professor Huxley refers to Von Meyer's paper in the 'Isis' for 1830, admitting that he had "not verified

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* Report of the Committee,' &c., for the year 1842.
† In framing this name the diphthong in *kreios* was dropped, as in 'pliocene,' 'miocene,' &c.
‡ 'Reports of the British Association,' 8vo., 1841, p. 103.
the citation,” which his readers are left to conclude would have justified his definition of my work in relation to the *Pachypoda* of Von Meyer. A quotation could not, in fact, be given for the purpose Professor Huxley had in view. I therefore supply the omission, with the remark that the occasion of eulogizing a deceased palæontologist might be better improved than by making it a ground for reflecting on a living one.

In the ‘ *Isis von Oken,*’ Band xxiii, Heft v, 1830, 4to, p. 518, Hermann von Meyer proposed the following distribution of Fossil Saurians according to the structure of their hind-limbs:—

“ *Saurier mit Zehen, welche denen der lebenden am ersten noch entsprechen würden, und zwar*

“ a. **Vierzähige.**


“ Geosaurus, *Cuvier* (?)

“ Teleosaurus, *Geoffroy* (?)

“ *Aeolodon, H. v. Meyer.*

“ *Streptospondylus,*

“ Metriorhynchus,

“ *Macrospondylus,*

“ Lepidosaurus,

“ *Mastodonsaurus, Jaeger* (?)

“ b. **Fünfzähige.**

“ *Protorosaurus, H. v. Meyer.*

“ *Saurier mit flossenartigen Gliedmassen.*

“ Ichthyosaurus, *Conybeare.*

“ Plesiosaurus, *Conybeare.*

“ Mosasaurus, *Conybeare.*

“ Phytosaurus, *Jaeger* (?)

“ *Saurocephalus, Harlan* (?)

“ *Saurier mit Gliedmassen, ähnlich denen der schweren Landsäugethiere.*

“ Megalosaurus, *Buckland.*


“ *Saurier mit Flughaut.*

“ Pterodactylus, *Cuvier.*"
The artificiality of these limb-characters has been pointed out, and has been accepted by the adoption, e.g., of the ordinal distinction of the Ichthyopterygia from the Sauropsyrgia;* also of the order Labyrinthodontia,† as represented by Mastodonsaurus and Phytosaurus, which latter genera, included in v. Meyer’s Section, a, ‘Vierzehige,’ are excluded from my order Crocodilia,‡ Whether any apology be necessary for the substitution of the latter term for a defined ordinal group including half of the representatives of von Meyer’s “(a) Vierzehige” I leave to the judgment of unbiased palæontologists, and proceed to cite the more definite ascription of taxonomical value to the groups above defined proposed by von Meyer, in his useful compilation called ‘Palæologica,’ 8vo, 1832. In this work the author prefixes to the class Reptilien (p. 101), as to that of Mammalia (p. 44), his division of such classes into Orders. Those which he adopts for the ‘Reptilien’ are—

“A. Chelonier.

b. Saurier.

c. Batrachier.

d. Ophidier.”

This was the latest step in Palæontological ordinal classification with which I had to contrast the ideas of the Reptilian orders acquired during the researches of which the results were condensed in my ‘Reports to the British Association’ of 1840 and 1841.

Von Meyer’s subdivision of the Saurian order is based, as in his previous sketch in the ‘Isis,’ upon the structure of the limbs:

“A. Saurier mit Zehen, ähnlich denen andern lebenden Sauriern und zwar I. Vierzehige. II. Fünfzehige.”

“b. Saurier mit Gliedmassen ähnlich denen der schweren Landsäugethiere. 1. Megalosaurus, Buckland. 2. Iguanodon, Mantell.”


In the characters of his subordinate group b, Von Meyer (ib., p. 210) condenses the descriptions and accepts the determinations, clavicle included, of Buckland and Mantell. There is no sign of his having examined any of the fossils on which these descriptions and determinations were based. He is struck with a resemblance of the metapodial bones of Megalosaurus in Buckland’s plates with those of a hippopotamus; and with the size of one of these bones, “zweimal so breit als im Elephanten” of the Iguanodon; and may have deemed their feet, in like manner, to have been tetradactyle or pentadactyle.

* “On the Orders of Fossil and Recent Reptilia.” From the ‘Report of the British Association for the Advancement of Science’ for 1859, 8vo, p. 159.

† Ib., p. 158.

‡ Ib., p. 164; and “Report on British Fossil Reptiles,” op. cit. for 1841, 8vo, p. 63.
Such supposed character seems to have suggested to Von Meyer the name *Pachypoda*, which he subsequently applied to them, the proportions of the entire foot which would support such term being to him unknown.

The feet of Dinosaurs are, in fact, characterised by their narrowness or slenderness rather than by their breadth or thickness. The functional toes (hind feet), are, in the typical species of Von Meyer’s *Pachypoda* reduced to three,* and do not exceed four (*Scelidosaurus*, e.g.) in any veritable member of the order. But had Von Meyer known the structure of the Dinosaurian foot, and it had been such as to have been truly defined by his ‘family term,’ this term must have given way to the “Pachypoda” proposed and accepted in 1821 for a similar group of *Mollusca*; as the same term, proposed for a family of *Coleoptera*, in 1840, had, in like obedience to taxonomic rules, sunk to the condition of a synonym under the law of priority, even when not affected by inapplicability of the name to its objects.†

Every specimen accessible in 1840, of Megalosaurus, Iguanodon, Hylæosaurus, having been examined and compared by me and the structure of the sacrum elucidated by observations on its development in birds,‡ vertebral characters, with dental ones, were substituted for those of the ‘Family’ above cited from the ‘Isis’ and ‘Palæologica,’ in the definition of the Order *Dinosauria*, quoted by Professor Huxley in his paper on this group.§ Of this definition the Professor asserts that “every character which is here added to von Meyer’s diagnosis and description of his *Pachypoda* has failed to stand the test of critical investigation.”¶ This statement is not accompanied with any evidence in its support, but by a suggestion that I had dealt unjustly with von Meyer in proposing the name and substituting the alleged inaccurate characters of the reptilian group *Dinosauria*. If I have to offer, in relation to the main end and aim of my labours, any remark which may seem critical, it will be accompanied by its grounds. Thus, in regard to the characters proposed by Professor Huxley for the Order *Dinosauria—*

> “1. The dorsal vertebrae have amphicoelous or opisthocoelous centra. They are provided with capitarian and tubercular transverse processes, the latter being much the longer” (loc. cit., p. 33).

If by ‘amphicoelous’ be meant ‘biconcave,’ as the term ‘amphicoelian’ has been applied to dorsal vertebrae of *Teleosaurus* (‘*Crocodilia,* Pl. 4, fig. 6) and of *Ichthyosaurus* (ib., fig. 7), no such vertebrae exist in the dorsal region of *Dinosauria*. The term ‘amphiplatyan’ would more truly express the configuration of the terminal articular

* E.g. *Hylæosaurus, *Dinosauria,* Pl. 44; *Iguanodon,* ib., Pl. 45.

† *Pachypus* was given to a genus of *Coleoptera* in 1821; this, in like manner, reduced the *Pachypus* applied to a genus of mammals in 1839 to a synonym.


¶ Ib., p. 33.
surfaces of the centrum in such dorsal vertebrae as are figured in 'Dinosauria,' Pls. 65 and 66 of the present Work, and in corresponding vertebrae of Iguanodon, Megalosaurus, Cetiosaurus, Hylæosaurus, Scelidosaurus, Bothriospondylus, figured in previous plates. Not that the flatness of both ends of the centrum is absolute, but the deviation is slight and usually, when in the direction of concavity, confined to the hinder surface (as in the Dinosaurian vertebra, fig. 5, Pl. 4, above cited). Neither must it be supposed that the dorsal series may be 'amphicoelous' in one Dinosaur, or 'opisthocoelous' in another.

The centrum in some Dinosaurs, Tapinocephalus, e.g., shows at the middle of its flat articular surface a foramen one sixth the diameter of such surface. It is the base of a small conical cavity, the apex of which meets that of the cone of the opposite side,—a beaded remnant of the notochord appearing to have traversed the vertebral column. In other species examined by me certain cervical vertebrae and a few consecutive dorsal vertebrae are 'opisthocoelous,' i.e. have the 'ball' in front (fig. 4, Pl. 4, above cited); and the convexity, in certain of these, does not wholly subside until the lumbar region is reached. But whence did Professor Huxley derive his knowledge of the 'opisthocoelous' character in 'pachypodal Saurians'? If from the original definition of the Dinosaurian group,* that character, as there limited, seems to have stood the test of time.

The discoverers of the Iguanodon and Megalosaurus believed the ball to be behind, and von Meyer accepted this view of the conformity of the Dinosaurian with the Crocodilian dorsal centraums. In fact, the way to distinguish the fore from the hind end of a fossil saurian vertebra seems not to have been known to their describers until the test was defined in 1841. This knowledge, howsoever acquired by the writer of the "Character 1," here discussed, is applied by him in error to Dinosauria: in them the ball subsides at the beginning of the dorsal series.† I would further remark, that, as there are many modifications and characteristics of the so-called 'capitular transverse processes' and 'tubercular transverse processes,' in the varied series, including Dinosaurian, of vertebral structures, the advantage of single substantive terms is exemplified by the convenience and helpfulness to precise description which such terms afford, adjectively, in predicating of 'parapophyssal' and 'diapophyssal' modifications.

And if by 'capitular portion of the transverse process' Professor Huxley may mean 'parapophysis,' and by 'tubercular portion of the transverse process' 'diapophysis,' ‡ I have then to object that the 'dorsal vertebrae' of Omosaurus do not all possess the two kinds of processes. In the subjects of Pls. 66 and 67 the head of the rib is received by a pit, not articulated to a 'capitular process.' The dorsal vertebrae, of which the ribs

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† Ib., ib.
have not 'distinct capitula and tubercula,' have no 'capitular portions, or transverse processes;' in fewer words, no parapophyses.

In reference to Professor Huxley's "Character No. 2," I submit that a Saurian with sacral vertebrae reduced to two in number is not a Dinosaurian.

"3. The chevron bones are attached intervertebrally and their rami are united at their vertebral ends by a bar of bone."* This is a character of Iguanodon† and of Scelidosaurus‡ but not of Cetiosaurus§ nor of Omosaurus,∥ "Char. 3" is one of a genus, not of the Order Dinosauria.

"5. The skull is modelled upon the Lacertian, not on the Crocodilian type." For the instances in which the Dinosaurian skull departs from the Lacertian, and approximates to the Crocodilian type, I refer to pp. 520—530, and 'Dinosauria' (Pls. 50, 60). These instances confirm and add to the combination of Crocodilian with Lacertian characters, propounded, in 1841, as exemplifying the more generalised Saurian type of the extinct order Dinosauria.

"6. The teeth are not anchylosed to the jaws, and may be lodged in distinct sockets." They become anchylosed in Hylæosaurus, and the manifold modifications of the dental system in Dinosauria concur with those of the skull and jaws themselves in exemplifying the mixed or more generalised character of the group.¶

"7. There is no clavicle." This is probable from the crocodilian affinities shown in the skull and vertebrae; and the character founded on the bone, so called, in my early diagnosis of Dinosauria, must be suppressed: but I have not yet seen a specimen of a Dinosaur in which the scapular arch was shown in its natural condition and integrity.

Before continuing my remarks on some of the Professor's remaining twelve characters of Dinosauria, I would observe, in reference to comments upon the step taken of substituting that name of the Order for one of a Family which, for reasons above given, could not have stood in Taxonomy, that the further insight into the structure of Mammalia tersely expressed in the names and characters of the Orders in the 'Règne Animal' was gratefully accepted by all single-minded cultivators of Biology, although some of such orders were the same or nearly the same as those defined and otherwise named in the 'Systema Naturæ.' Cuvier was not deterred from fixing this additional step in the advance of Zoology by the opportunity it might open to an objector for charging him with unfairness or injustice to Linnaeus; nor was Linnaeus much moved by like remarks to which he was subjected by critics of that era in reference to his names for groups of plants more or less similarly defined, before him, by John Ray, and others.

† Monogr. 'Wealden Reptilin,' part ii, Pal. vol. for 1854, p. 15, t. viii. (Iguanodon Mantelli) ib. ib., t. i, Iguanodon Foxii (if this be not an immature specimen).
‡ Monogr. 'Fossil Dinosaur of the Liás,' Pal. vol. for 1860, p. 8, t. vii.
§ Phillips, 'Geol. of Oxford,' p. 259, fig. 2, 8vo, 1871.
∥ Ante, p. 55, pl. xvi.
To return, however, to my proper task, more especially in reference to the affinities of the *Dinosauria*.

The first clue to the homology of the supposed clavicular bone of the *Iguanodon* was given by Professor Leidy in the 'Proceedings of the Academy of Natural Sciences of Philadelphia,' December 14th, 1858. In the description there given of the fossil remains of a Reptile, which he calls 'Hadrosaurus,' from the marl of New Jersey, which marl, from the affinity of this Reptile to the *Iguanodon*, he surmises may be of the Wealden or Green-sand period, Leidy finds, with the ilium, "a bone which I suspect to be the pubic, but which appears to correspond with that of the Maidstone *Iguanodon*, described as the clavicle" (p. 9). In a subsequent illustrated Monograph,† Leidy repeats his homology of the bone in question and notes—"an ilium and a supposed pubic bone, imperfect" (p. 71). Of the latter a figure is given ("Pl. VIII, fig. 13"), and the accomplished Author truly remarks:—"It bears a general resemblance to that indicated by Professor Owen and Dr. Mantell as the clavicle of the *Iguanodon*; but appears to me rather to resemble the pubic bone of the *Iguana* and *Cyclura* than the clavicle of the same animals."‡

Professor E. D. Cope, Corr. Sec. Academy of the Nat. Sciences, Philadelphia, communicated to the Academy, in 1867, a paper "On the Extinct Reptiles which approached the Birds," of which an 'Abstract' was given in the 'Proceedings of the Academy' for December of that year. In this 'Abstract' the Professor is reported as stating that "he was satisfied that the so-called clavicles of *Iguanodon* and other *Dinosauria* were pubes, having a position similar to those of Crocodilia."§ There is no reference, therein, to Professor Leidy, nor to the paper by Professor Huxley "On the Classification of Birds" which was published in the 'Proceedings of the Zoological Society,' 1867, p. 415.||

In the lecture "On the Animals which are most nearly Intermediate between Birds and Reptiles," delivered by Professor Huxley at the Royal Institution of Great Britain, 7th February, 1868, he states:—"I hold it to be certain that these bones—the so-called 'clavicles'—belong to the pelvis and not to the shoulder-girdle, and I think it probable that they are ischia; but I do not deny that they may be pubes."

Thanks to the rapidity by which, through science, sea and land can now be traversed, we get the results of research by our American fellow-labourers within a fortnight, usually, after publication.

I have no doubt of the legitimacy of Professor Huxley's delusion—"I could not possibly have known anything about them when my 'Lecture' was delivered;" but

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* 'Philos. Trans.,' p. 138, 1841.
† 'Cretaceous Reptiles of the United States,' p. 97, pl. viii, fig. 13: in the 'Smithsonian Contributions to Knowledge,' No. 192, vol. xiv, 4to, 1865.
§ 'Proceedings of the Academy of Natural Sciences of Philadelphia,' p. 234, 8vo, 1867.
the claimed originality of his views of problematical pelvic bones by no means called for any reflection on postal arrangements between Great Britain and the United States. The impossibility might merely mean an oversight which left the writer ignorant of both Cope’s and Leidy’s anticipations, as appears to have been the case with regard to von Meyer’s paper in the ‘Isis’ of 1830.

In the “Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds,” with confirmatory testimony by Professor Phillips, of Oxford,* Professor Huxley adopts the ischial homology of the bone in question, and illustrates it by a diagram, “Fig. 3, Dinosaur,” p. 27 (tom. cit.), in which the supposed “ischium” is directed from the acetabulum downward and backward, parallel with the pubis, with which it articulates by the process (c, figs. 4 and 5, in Plate XX, “Omosaurus”), so as to “interrupt the obturator space,” and define, as in Birds, an anterior part of that space as an “obturator foramen” (loc. cit.).

To an advocate of the affinity of Dinosaurs to Birds and of the derivation of Birds from Dinosaurs, such determination of the bone in question gave great help, and the consequent diagram has been mainly subservient in gaining suffrages to the idea—I may term it sensational—of the kinship of the Iguanodon with the Cassowary, carried to the inference of a common bipedal mode of progression.

The value of the genus Omosaurus, as of every well-determined new Dinosaur, to the Palæontologist desirous, irrespective of foregone conclusions, to lay the basis of lasting views of affinity on fixed homologies, is here great. The bone, Pl. 72, 63, which completes the acetabulum, shows by the extent and position of its articulation with the ilium, from which it has been but slightly dislocated, that it is the ischium. The recovery of the parial bone to the extent shown in Pl. 73, fig. 1, shows that the shaft gives off no process; also that an extension of the iliac articular end beyond the acetabular surface of the ischium, and behind it, is the sole production, transverse to the axis of the bone, which can be homologised with a non-articular process in the ischia of other Vertebrates.

The ischia of Omosaurus being thus determined, the homology of the other pair of pelvic bones (Pl. 73, figs. 4 and 5), wrought out of the mass of matrix overlying the hæmal surface of the sacrum and ilia, was plain. They confirm the opinion of Professor Leidy as to the nature of the bone; and, so far as their dislocated condition indicated their natural direction, it supports the conclusion of Professor Cope that they had “a position similar to those in the Crocodilia,” i. e., directed forward and downward, as shown by Cuvier. in the ‘Ossemens Fossiles,’ tome v (1824), Pl. IV, fig. 15, a, Pl. V, fig. 6, and as exemplified in the diagram, Cut fig. 13, p 6.

So much of the homological ground being thus cleared, we may pass to the question of the kinship or affinities it brings into view.

In birds, as a rule, the pubis is a long simple style without process (fig. 15, ‘Bird’); the

exceptions are chiefly seen in the wingless forms, *Apteryx*, e. g., and the Cassowary, in which latter bird the expanded acetabular and of the pubis projects forward, at \( \hat{b} \), beyond the joint, \( a \), in a pointed form, about six lines in length. The proximal end of the pubis

![Figure 12, 13, 14](image)

enters into the formation of the acetabulum in all birds. The distal end terminates, in most birds, freely; in some it is ankylosed to the ischium; in the Ostrich it joins its fellow to form a symphysis pubis:* in all it is directed backward and downward.

In the Monotremes the pubis (fig. 15, *Ornithorhynchus*) sends off from its fore part, about one third of its length from the acetabular end, \( a \), a low and broad process, \( c \), giving attachment to the outer part of the base of the marsupial bone. It joins its fellow at the expanded distal end, \( s \), and joins at \( f \), the corresponding end of the ischium,

* For other modifications, which, however, give no help in the present inquiry, see my 'Anatomy of Vertebrates,' vol. ii, pp. 35, 36.
thus dividing the obturator interspace into a pair of foramina. As in all mammals the bone is directed downward (hæmad) and a little backward.

In Crocodilia the pubis (fig. 13, p 6), as in birds, is a simple style slightly expanded distally where it articulates with a cartilaginous abdominal sternum,* but it joins not there, directly, either its fellow or the ischium. It contributes no part to the acetabulum, but is attached at its proximal end to an anteriorly produced part of the same end of the ischium (ib. is).

In Chelonia the pubis is remarkable for its breadth, due to its distal expansion; proximally it contributes to the acetabulum, articulating there with both ilium and ischium, and at or near half way to the distal end, it sends forward a broad and termi-

* 'Anat. of Vertebrates,' vol. i, p. 68, fig. 56, 5.
nally thick pectineal process;* it unites distally with its fellow, and in some species also, as in Monotremes, with the ischium, dividing the obturator space. The average proportions and common character of the pubis in Lacertilia are given in Cut, fig. 15, Monitor; the perforation a marks the closer resemblance to the Dinosaurian pubis (fig. 12, pb).

Notwithstanding the difference in the proportions of breadth and length, the pubis in Iguanodon and Omosaurus, in its essential characters, is more like that in the Tortoise than in any bird. But these proportions are among the most variable characters of the bone, and we have not far to seek in the Lacertian order before finding, as in Uromastix, a pubis combining with the pectineal process (Pl. 73, figs. 8 and 9, 6), as slender a body thence continued as in the Dinosauria. Only, in Omosaurus, the proximal end of the bone seems not to contribute any share to the acetabular cavity; and, if this should be the case with other Dinosaurs, those extinct reptiles would combine, in their pelvis, as in some other parts of their skeleton, characters now restricted respectively to the Crocodilian and to certain members of the Lacertian groups of the class.

Thus, the ischium, in Omosaurus, has no other 'process' save the stunted homologue of the proximal extension supporting the pubis in Crocodilia.

In Chelonia, as in Uromastix, there is a distinct posterior process (marked c in figs. 8 and 9, Pl. 73); but in certain Lizards (Varanus niloticus, e.g.)† it is reduced to a mere rudiment, and in the Chameleon it ceases to exist. Thus, the Omosaurus resembles the Crocodilia and some Lacertilia in the simplicity of its ischium, and markedly departs from the type of birds in respect to this bone.

But it is alleged that the ilium gives evidence of the avian affinity of Dinosaurs which we have now proved to be wanting in the rest of the pelvis. Among the 'points of difference between any existing Reptile and any existing Bird,' the following is put by Professor Huxley in the foreground.

"1. In the Reptile the ilium is not prolonged in front of the acetabulum." "In the bird the ilium is greatly prolonged in front of the acetabulum."

"Now, in all the Dinosauria which I have yet examined, the ilium extends far in front of the acetabulum."‡

To the first of these averments it needs only an elementary acquaintance with comparative osteology to reply, that in all Crocodilian Reptiles the ilium is prolonged in front of the acetabulum, and to an extent nearly equal to that in which it is produced behind the acetabulum. Reference to the well-known figure in the 'Ossemens Fossiles,' which I here reproduce (woodcut, fig. 13, ii) exemplifies this fact: Cuvier has been careful to mark with the letter 'a' the antacetabular part of the ilium which the advocate of the avian affinities and bipedal progression of the Dinosauria denies to it and to all other Reptiles, Dinosauria

* 'Anat. of Vertebrates,' vol. i, fig. 116, a.
† Cuvier, 'Ossemens Fossiles,' tom. cit., pl. xvii, fig. 40, e.
excepted. The ilium in Pterodactyles yields the same ground as that of Dinosaurs for predicking kinship with Birds.

The true characteristic of the ilium in Dinosaurs is the distinction of the super-acetabular (Pl. 72, r) from the antacetabular (ib. 62) parts of the bone, with the anterior extension and subsidence, in some species, of the former upon the dorsal surface of the latter. This complexity of the ilium is wanting in both birds and pterodactyles.

As to the proportions of the ant- and post-acetabular extensions of the ilium, they vary in known Dinosaurs: the post-acetabular production (Pl. 72, 62") is shorter in Omosaurus than in Scelidosaurus, and is shorter in Scelidosaurus than in Iguanodon.

From the importance assigned by Professor Huxley to iliac characters, in the conclusion he advocates, a non-anatomical reader might infer not only that no other Reptiles, but that no other warm-blooded Vertebrates save Birds, had the ilium extended, as in Dinosaurs, far in front of the acetabulum.

And yet an impartial quest of the affinities of these huge terrestrial Reptilia would impel the seeker, having such end solely in view, so to extend his comparisons. In Mammals "the ilium is prolonged in front of the acetabulum," which, as in Reptiles, "is either wholly closed by bone or presents a fontanelle."

In the spiny Monotremes (woodcut, fig. 15, Echidna) the ilium (q) extends far in front of the acetabulum (a), and furnishes only an arched roof of that cavity, the inner wall of which (i) remains membranous, as in the Bird. The pubis (a), after extending hämad (forward or downward) to the pectineal process (c), bends there to be continued backward, as in Ornithorhynchus. As a rule all Mammals resemble Birds in a backward extension of more or less of both pubis and ischium, from their iliac articulations.

Thus the character asserted to be peculiar to Dinosaurs among Reptiles exists in both the Pterosaurian and Crocodilian orders of that cold-blooded class; and, amongst warm-blooded Vertebrates, it is common to Mammals with Birds.

In my 'Anatomy of Vertebrates' I remarked, "the transference of the weight of a horizontal trunk upon a single pair of legs necessitates an extensive grasp of the trunk-segments. When the legs require to be pulled far and strongly back, as in diving and cursorial motions, the origins of the requisite muscles are extended far behind the limb's centre of motion, as in the pelvis of Grebes, Loons, Ostriches, and Emus. When the bird slowly stalks, or hops, or climbs, or uses its legs chiefly in grasping and perching, the pelvis is short and broad, especially behind; its breadth may even exceed its length, as in Cyclarius guanensis."*

The antacetabular part of the ilium in Birds is usually the longest, but its outer surface is not divided or interrupted by the super-acetabular plate and ridge peculiar to Dinosaurs. To the degree in which the pelvis is produced behind the acetabulum (as in woodcut, Fig. 14, b), such production helps to transmit the weight of the body upon the legs in a relative position thereto more favorable to the support of such weight; if the pubis

were directed forward instead of backward, it would detract from this relation of the pelvis to bipedal progression. Nevertheless, the balance of the parts so carried in the Bird preponderates forward; the weight of the body with the head and fore-limbs is greatest in advance of the acetabula.

Among the modifications which are associated with the backwardly produced ilia, ischia, and pubes, in relation to the terrestrial progression peculiar to Birds, may first be noted the great extent of the axial trunk-bones welded into one mass where they are grasped by the bones transferring such mass upon the heads of the femora.

In no Birds are the sacral vertebrae so few as in Dinosauria; and in those Birds which, from their size and terrestrial habits, are cited to exemplify Dinosaurian affinities, and which best lend themselves to test the question of the locomotion of the great extinct Reptiles, the number of the sacral vertebrae is from 18 to 20. The several species of Dinornis had from 17 to 20 sacrals; 12 is the average number in Natator, 12 in Grallæ and Gallinaceæ, 11 in Altrices. The highest number of sacral vertebrae yet found in Dinosauria is 5:* in Dicynodontia it is 6. The Sloths have 6 (Aï) or 8 (Unau) sacral vertebrae. The extinct Megatherioids, from the great share taken by the massive hind limbs in supporting the body while the fore limbs were engaged in disbranching trees, have a correspondingly closer resemblance to Birds in the structure and proportions of their pelvis than any known extinct Reptiles present. The Mylodon had not fewer than 11 anchylosed sacral vertebrae.†

In Birds, the trunk, properly so called, as distinguished from the neck, is singularly short; its production in advance of the pelvis is reduced to the utmost, consistently with its visceral relations.

The number of vertebrae between the neck and pelvis, i.e. of such as bear pairs of moveable ribs, averages 8, and never exceeds 10; and of these anchylosis commonly fetters the major part.

Between such vertebrae and the skull the 'cervicals' are as exceptional in excess, numerically; and this concurs with the exceptional reduction of number in the 'dorsals;' both being in special physiological relation to bipedal support and progression.

The numerous cervicals have peculiar joints, governing the sigmoid flexure and oscillating sway of the long and slender neck; whereby, in walking, both neck and head, in Birds, may be brought more directly over the supporting columns of the hind limbs as these change their position. These limbs, moreover, have their specialties in relation to their peculiar work in the vertebrate series.

The femur (Fig. 14. (Dinornis), f) is relatively short; the tibia (t) relatively long; the fibula (fb), styliform and short, takes no share in the ankle-joint, but co-operates with the tibia in a special manner to extend and strengthen the articulation of the leg with the thigh. The femoral condyles are concomitantly modified to effect the accessory femoro-fibular

* They may in an exceptional instance extend to 6, but demonstrative evidence of this excess has not come to my knowledge.

† 'Description of the Skeleton of an Extinct Gigantic Sloth,' &c., p. 64, pls. i, x, 410, 1842.
joint. Nothing of this exists in Dinosaurian or other Reptiles. Still more special is the modification in Birds by which the leg is united with the foot. No break in the column charged with the sustaining function peculiar thereto in the Bird is allowed beyond the absolute necessities of bending movements of such column when subserving locomotion.

The tarsal segment is suppressed; the metatarsal segment (mt) is aggrandised, lengthened out and confluently compacted; the metatarsals of three toes are welded into one bone.

The joint of the leg with this bone is closely and tenaciously trochlear, strictly limiting the movements of the foot to one plane. The long and slender phalanges stretch forward at right angles to the metatarsus, and diverge to form a suitable base for the columns to which has been assigned such an unique task—so peculiar a work—as is performed by the hind limbs on the feathered class.

Certain Dinosaurs welded carpal spines and some Mammals bore tarsal ones. It would be as germane on that ground to derive Chauna or Palamedea from Iguanodon or Omosaurus, as Platypus from Phasianus.

What are the known structures in Megalosaurus, Iguanodon, and other Dinosauria, which, corresponding with those in Birds, would justify the conclusion or suspicion that the ischium and pubis, besides being long and slender, as they are demonstrated to be in Omosaurus, were directed from their acetabular ends backward parallel to one another? It is certain that the ischium in Iguanodon had not the 'obturator' process characteristic of the same bone in Birds, and as certain that there must be a mistake about the matter when the same is predicated of the pelvic bone, erroneously called ischium, in the immature or small kind of Iguanodon which has been termed 'Hypsilophodon' in ignorance of the true structure of the mandibular teeth.

That the pelvic bones, truly homologous with ischia, were "united in a median ventral symphysis,"* is most probable from the shape and surface of the somewhat expanded distal extremities of the unquestionable ischia in Omosaurus. But such union does not exist in Birds. If it should be found in all Dinosauria, it is one of the majority of characters in which that order differs from the class of Birds and agrees with its own class, viz. the Reptiles.

Of the comparatively few sacral vertebrae in Dinosauria the 'costal portions of the transverse processes' (pleurapophyses) abut chiefly against the part of the ilium contributing to the cup to be upborne by the thigh-bone; there are no postacetabular abutments against other parts of the ilia, or against the comparatively broad ischia, as in Birds. In the latter pelvic character we have again to quit the Reptilian class and to indicate the repetition of it in certain bird-like Lissencephalous Mammals.†

The augmentation of number of sacral vertebrae beyond that—two—in Crocodiles and Lizards, whose bellies trail upon the ground or are but little raised therefrom by the out-

† 'Anat. of Vertebrates,' ii, pp. 397—402, figs. 263, 264, 266—268.
sprawling fore and hind limbs in running along, relates in Land-tortoises to a more vertical position of the leg, and to the greater weight which the entire hind limb has to sustain in the progression of those Reptiles.

In Dinosaurs (woodcut, Fig. 12) the thigh (\( f \)), as well as the leg (\( t_6 \)), were probably less obliquely disposed, in quadrupedal locomotion, than in any existing Reptiles, save, perhaps, the Chameleons. The four or five sacrals, interlocked, as in Birds and Tortoises, by alternating centrums and neural arches, have been recognised as physiologically related to correspondingly developed hind-limbs and a concomitant carriage of their huge elongate trunk, in a way approaching to that in the large gravigrade Mammals.*

It is requisite, in the present test, to determine as nearly as may be the relative length of the pre-pelvic part of the trunk to the pelvis in Dinosaurs.

It may be presumed that those who represent the pubic-ischial elements of such pelvis, as being disposed in the avian fashion, intend the inference that, so far, the pelvis of the Dinosaurs related to the same bipedal mode of progression as in Birds, and that the trunk was similarly borne along, prone, upon the single pair of hind-legs.†

If, however, our knowledge of the dinosaurian pelvis being rectified, it should be averred that the trunk of the Iguanodon or Megalosaur might be otherwise carried than in Birds, that it was reared upright and so balanced, as in Man, upon a pair of hind, or in that case lower limbs, it may then be necessary to enter upon a series of comparisons between the dinosaurian and human skeletons in connection with such upright mode of progression.

At present I shall not spend time in analysing the grounds of such view; but, returning to the avian comparison, I may remark that the number of free vertebræ between the sacrum and skull, in Iguanodon, is 24, of which 7 are cervical, 17 dorso-lumbar; in Megalosaurus present evidence supports an estimate of 23 such free vertebræ allowing 7 to the neck; in the parts of the skeleton of the same individual Hylæosaurus, in the British Museum, 10 vertebre in natural succession include the hinder cervicals and succeeding dorsals, but the more or less complete vertebræ scattered in the same mass of matrix support an estimate of the vertebral formula not less in number than in Iguanodon; whilst, as such vertebre are shorter in proportion to their breadth than in either Iguanodon or Megalosaur, there may have been more than 24 between the skull and sacrum. In Scelidosaurus 16 dorso-lumbar vertebre are shown in succession in the blocks of lials in which they have been exposed, and 6 at least, if not 7 cervicals, are also evidenced in the same instructive skeleton of one individual Dinosaur.

† "Not a ground-crawler, like the alligator, but moving with free steps chiefly, if not solely, on the hind limbs, and claiming a curious analogy, if not some degree of affinity, with the ostrich." Phillips, 'Geology of Oxford,' p. 196. Such an idea, if it ever 'suggested itself' to my mind, was never expressed, and must have been instantly dismissed through considerations akin to those detailed in the text.
The proportion of the skeleton of *Cetiosaurus longus* in the Oxford Museum and that of the allied Dinosaur (*Omosaurus armatus*) in the British Museum demonstrate the absence of ankylosis in the dorso-lumbar region of the spine, and of any of the modifications of the hindmost vertebrae which, in Birds, add to the mechanical bracing of the trunk upon the pelvis: they show no lengthened pleurapophyses, having free proximal articulations to anterior sacral vertebrae; but, on the contrary, as in Mammalian quadrupeds, the lumbar ribs are short, coalesced with their vertebrae, and project as straight outstanding transverse processes, not opposing the lateral movements of the trunk upon the pelvis, but, with the antecedent vertebrae, negativing the notion of any action of muscles, proceeding from the pelvis and thigh-bones to grasp fast a trunk, and uplift it, together with the fore-limbs, neck, and head, clear of the ground, as during the hypothetical bipedal march and course of the huge dinosaurian Reptiles.

The ascertained conformity of organisation in known *Dinosauria* supports the conclusion that a long, bulky, bendible body stretched forward from the pelvis and hind limbs throughout the order.

In Birds the bony 'vertebral' and 'sternal' ribs of the few vertebrae of their short dorsal region are spliced together by a mechanism of which no trace has hitherto been discovered in the corresponding more lengthened region of the spine of *Dinosauria*; there is a like absence, in these cold-blooded vertebrates, of the ankylosis of centra, and of ossified tendons or neurapophysial splints—avian structures—which limit, to the essential minimum, any movement between one prepelvic vertebra and another. Every modification of the Bird's skeleton concurs to facilitate the carriage of the prone trunk, as one compacted mass, upon the vertical pair of limbs, and not one of these modifications exists in Reptiles recent or extinct.

What, then, we next ask, were the arrangements in the neck to diminish the difficulty which the known structure and proportions of the trunk oppose to the bipedal progression of *Dinosauria*?

Nothing of such exists in the length of the neck, nothing in the number or in the freedom of flexibility in opposite directions of the cervical vertebrae; on the contrary, those vertebrae in *Dinosauria* which are anterior to the bearers of the long and free ribs are few in number, with the little flexibility allowed by their reciprocal joints checked by the disposition of their short and mostly imbricate ribs. The neck of the Dinosaur was short, straight or nearly so, and strengthened by the overlapping pleurapophyses for the carriage of a massive head projecting forward almost in a line with the body: never could such head be carried back, by a graceful sigmoid bend of a long neck, so as to be poised above the centre of support afforded exclusively by a hind pair of limbs.

Such head, with its powerful jaws and their dense and weighty dental armature, needed the development and structure of a pair of fore-limbs, to sustain it with the fore part of the trunk, and take the required share in bearing along the bulky dinosaurian quadruped. *Omosaurus* adds a pregnant instance of the requisite anterior pair of supports.
What the Dinosaur needed for its mode of terrestrial locomotion the Bird has not; and what the Bird possesses for its mode of terrestrial locomotion the land Reptile is devoid of.

I have alluded to the modifications, extreme and beautiful they are, of the hind limb-bones of the Bird for the functions concentrated therein; the suppression, viz., of the tarsal segment; the simplification, unification, consolidation of the segments above and beneath it; the tibia alone (woodcut, Fig. 14, t) articulating with the metatarsus, ib., mt, by a finely fashioned, close-fitting, interlocking joint.

As in all warm-blooded quadrupeds and the majority of cold-blooded ones, recent and extinct, the articular ends of the tibia are ossified independently of the shaft, are in the condition of epiphyses in the young Bird (Fig. 16, Dinornis, p t), and retain longer that condition in the Reptile (Fig. 16, Varanus, p t, and Scelidosaurus, p t). The attachment of the distal epiphysis with the shaft of the tibia (t) is made firmer in the biped (Dinornis, p t) than in the quadruped (Fig. 16, Ruminant, p t); and the extent of the attachment is greater, is more irregular or interlocking in the warm-blooded quadruped than in the cold-blooded one; it is still greater in the Bird, in which a process, longer than that in the Ruminant, ascends upon the front of the diaphysis, closely fitting to a groove there, and clamping, as it were, the articular epiphysis to the main shaft of the leg bone. The bigger the Bird the greater the share of locomotion allotted to the hind pair of limbs in standing, walking, or running, the longer is the clamping process and the later is the period of the coalescence of the epiphysis with the shaft. The Ostrich among existing Cursores, and the Dinornis amongst
extinct ones exemplify this relation. In the metatarsus of the Bird the shafts of the ento-, meso-, and ecto-metatarsi are severally ossified from separate centres, but the proximal epiphyses of the three bones are ossified from one centre, and form a single cap of bone where the shafts are still distinct.* Such cap (Fig. 16, Dinornis, p w) may be arbitrarily homologised with one or more bones of the distal tarsal series in Reptiles (Fig. 16, Scelidosaurus, b, e; in Varanus, b, e) and in Mammals (Fig. 16, Ruminant, b, n, e). It seems more natural to regard it as answering to the epiphysial cap, covering the ends of the two chief metatarsals, of the Ruminant (ib. ib., pm, iii, iv), and I associate such instances of complex osteoagy of the metatarsus with the high conditions of organisation differentiating the warm-blooded classes, Aves and Mammalia, from the cold-blooded Reptilia.

In the Ruminant, as in the Bird, the single epiphysis and multiple diaphyses coalesce into one so-called 'cannon bone.'

In the Dinosauria the hind limbs are not adapted, as in the Birds, for transference of the entire weight of trunk, neck, head, and fore limbs, from the leg upon the foot by due development and modifications of the main leg-bone, the tibia; but the fibula is continued to the ankle-joint, and takes a larger share in its formation than is usual in Mammals. Both leg-bones have their distal epiphyses (Fig. 16, 2 f, p t. Scelidosaurus, Varanus). The tarsal segment is represented, usually by four ossicles: one, a, answers, by its connections, to the astragalus, naviculare, and entocuneiform bones of the Mammal; a second, b, represents the calcaneum with the lever process slightly if at all developed; there are, also, a cuboid, c, and an entocuneiform, e. The metatarsals, whether they be three or four in number, never coalesce, but retain their primitive distinctness throughout life. The sole ground taken to bridge over this significant difference in the structure of leg and foot in the Bird and Dinosaur is to affirm that the distal epiphysis, pt, of the tibia in the Bird is the homologue of the astragalus in the Mammal and Reptile (Fig. 16, a).†

"If the whole hind-quarters, from the ilium to the toes, of a half-hatched Chicken could be suddenly enlarged, ossified, and fossilised as they are," ‡ the ilium would be distinguished from that of a Dinosaur by the major number of its sacrovertebral attachments and by their greater extent, by the absence of the ridge continued from the super-acetabular plate upon the antacetabular one; the pelvis would be distinguished by the presence in the ischium of an obturator process wanting in the Dinosaur (Fig. 12, is), and by the absence of a pectineal process of the pubis present in the Dinosaur (ib., pb), by the parallelism of the ischium and pubis, and by the backward extension of both bones (compare Figs. 12 and 14). The differences grow and multiply as the comparison proceeds; as, e. g., by the non-extension, in the Chick, of the fibula (Fig. 14, fb) to the ankle-joint and by the larger and more complex distal epiphysis of its tibia (Fig. 16, Dinornis), by the

‡ Ib., loc. cit., p. 30.
absence of a tarsus, by the backward direction of the innermost or first toe (Fig. 16, i), as contrasted with the parallel position of that toe with the second toe in the reptilian foot (Fig. 16, Scelidosaurus, Varanus). If the entire skeleton of an immature Chick, Ostrich, or Moa were enlarged, whether suddenly or gradually, to the dimensions of that of a Cetiosaur, and were so ossified and fossilised, the characters of the dorsal vertebrae, of the cervical vertebrae, of the skull, and the absence of an anterior pair of limbs with fore-paws organized to be applied to the soil and take their share in the support and progression of a long and bulky trunk and massive head as in the Dinosauria, would be decisive against the reference of such imaginary gigantic Chick to any known representative of the Dinosaurian order of Reptiles. But, to the Biologist who rejects the principle of adaptation of structure to function, the foregoing facts and conclusions will have no significance.

By a modification of the hind-limbs the Bear, and by addition of a longer sacrum to plantigrade feet the Ground-sloth, may assume a crouching bent-kneed attitude and hold the fore-limbs free to grapple with a foe or a tree.

Such is the plasticity of some mammalian structures that, by due training, a Bear, a Dog, or a Monkey may be taught to dance and walk erect for a brief space. It may be doubted whether a cold-blooded, small-brained Reptile could by any training be brought to exemplify the mode of motion conceived in the quotation at p. 609, note †. But that, like the Chlamydosaur with its long-toed, wide-spread, hind feet, the huge Dinosaurs might assume the fighting posture of the Bear, when occasion called them to wield their carpal weapons, is conceivable without commission of physiological or anatomical solecism.

The woodcuts, p. 603, Figs. 12, 13, 14,* give the pelvis and hind limb of a Moa (Dinornis) and of a Crocodile (Crocodilus) for comparison with the corresponding parts of a Dinosaur (Omosaurus): the position, proportions, and structure of the foot of which are guaranteed by those of Iguanodon and Scelidosaurus.

In the Crocodile the foot may be applied flat to the ground and the thigh turned out nearly at right angles to the body; but, in some phases of progressive motion, the limb can assume the position delineated: the same may be predicated of the Dinosaurian Reptile. The Bird occasionally rests on the foot, with the metatarsus flat to the ground: but the thigh cannot be turned outward at the angle, which is possible in the Dinosaur and Crocodile. When an accessory trochanter is present in the femur of a Dinosaur (Iguanodon, Scelidosaurus), it projects from the inner border of the shaft, not from the outer one, as in the restoration given in Fig. 3, p. 27, 'Quart. Journal Geol. Soc.,' vol. xxvi, 1870.

* The letters have the same signification throughout; ii, ilium; a, antacetabular plate; b, postacetabular plate; ib (in the Dinosaur) marks the superacetabular plate; is, ischium; p, pubis; f, femur (of this only the lower part of the bone is given, so as not to conceal parts of the pelvis important in the comparison); t, tibia; b or fb, fibula; as, astragalus; ca, calcaneum; cb, cuboides; i, inner or first toe; ii, second toe; iii, third toe; iv, fourth toe; v, rudiment of fifth toe.
When the question as to the power of predicking homologies both special and general, as in the case of the bones of the vertebrate skeleton,* became finally accepted, the hypothesis of the successive incoming of specific forms or modifications of the vertebrate archetype through the operation of secondary causes was the only one which could adapt itself intelligibly to the facts. In enunciating my conviction that 'nomogeny,' i.e. natural laws, or secondary causes, had so operated "in the orderly succession and progression of such organic phenomena," I laid myself open to comments from opposite quarters. On the one hand, the admitted ignorance of the nature and mode of operation of such secondary cause or causes led to the rebuke by a Successor in the chair of the Hunterian Professorship, to wit, that, as to the secondary origin of species, my 'trumpet gave an uncertain sound.' On the other hand, an able, theological critic blew the following note of alarm:—"It is not German naturalists alone who are contributing to diffuse scientific Pantheism. We have in England an anatomist, Richard Owen. To call him an atheist because of his scientific conclusions would be an impertinence; nevertheless, in a lecture on 'The Nature of Limbs' which was delivered at the Royal Institution of Great Britain in February last, and has since been published, he brings all his scientific knowledge and demonstrative skill in support of what is called the Theory of Development, and which has become popularly known by its introduction into the book called the 'Vestiges of Creation.' This theory of development, as our readers may know, assumes that God did not interpose to create one class of creatures after another as the consequence of each geological revolution; but that, through the long course of ages, one class of creatures was developed from another. Now, Richard Owen undertakes to demonstrate scientifically (and his demonstration is very rigorous) that the arms and legs of the human race are the later and higher developments of the ruder wings and fins of the vertebrated animals—that is, those which have a true backbone; and he shows in the splint bones of the foot of a horse, bones analogous to those of the fingers of the human hand. Therefore he concludes that God has not peopled the globe by successive creations, but by the operation of general laws."†

The sole ground for Professor Flower's depreciatory remark is my acknowledgment of being "as yet ignorant"‡ of the nature or way of operation of such general or secondary laws; and I regret to say that after all that has been advanced since 1849 in the endeavour to elucidate the way in which one species may be transmuted into another, I am still in need of light.

Assuming that the ornithic modification of the vertebrate archetype was one of those under which the 'vertebrate idea' became embodied in the course of progression from

* 'Hunterian Lectures,' Royal College of Surgeons, 1844; 'Reports of the British Association for the Advancement of Science,' 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1846; and 'Discourse on the Nature of Limbs,' 8vo, 1849.
† 'Little Lectures on Great Topics,' 12mo, 1849.
‡ 'On the Nature of Limbs,' p. 86.
"its old Ichthyic vestment,"

* two questions present themselves:—Out of what antecedent vertebrate modification was the avian one evolved? How, or under what conditions or secondary influences, was such evolution effected?

The hypothesis of the bipedal locomotion of the *Dinosauria*, the advocated homology of their os pubis with the ischium of the bird, and the alleged restriction of the avian antacetabular production of the iliac bone to the *Dinosauria* among Reptiles, have been superadded to the proved fact of a correspondence of structure between the shorter sacrum of the Dinosaurs and the longer sacrum of Birds as grounds for the conclusion that Birds are transmuted Dinosaurs, and that the feathered class made their first step in advance under the low form of *Struthiones* or *Cursores*, incapable, as yet, of flight. The kind and amount of modification required to evolve an Ostrich out of an Iguanodon may be appreciated by the osteological comparisons already submitted in the present section of this work. To revert only to the structure of the fore-limb. In losing its power of aiding in the quadrupedal progression, and of grasping or otherwise applying the hand, it has as yet, in the hypothetical first form of Birds, gained no other faculty. At best it may help in the swift course of the ostrich by flapping motions similar to those of better birds during their flight; or the more minute monodactyle hand may just serve to scratch the back of the head, as in the New Zealand Kivi. In their larger extinct relatives, the Moas, it is still doubtful whether more of the framework of a fore-limb existed than the supporting scapular arch, and that of the simplest character.

In all these gradations of structure of a limb unavailable for flight or any other mode of locomotion we see no approach in the scapula to the Dinosaurian types of that bone; it retains in all Cursorials the strictly avian sabre-like shape and pointed free extremity, without expansion and truncation there such as obtains in the alleged ancestral *Reptilia*.

† The coracoid still further departs from any well-determined Dinosaurian type of the bone, and as closely adheres to that of the Birds of flight, save such decrease of breadth and of relative size as accords with its necessity to bear upon the sternum in the mechanical mode of inspiration peculiar to Birds with Pterodactyles.

What could be the conceivable conditions of the life of an Iguanodon or Megalosaurus which rendered a fore-limb useless or cumbersome, and concomitantly called for lengthened and strengthened hind-limbs and a more vigorous and exclusive exercise of these in the acts of locomotion? The abettors and acceptors of the exposition of the operation of the secondary mode of origin of species by way of 'natural selection' are amenable to the call for an explanation of such conditions, especially if such mode of origin be hypothetically applied to the kinds of Birds deprived of the power of flight. But such explanation would have to square with the fact that a loss of one pair of limbs had been associated, on the assumption of the Dinosaurian ancestry, with an advance of the mechanical structure

* 'On the Nature of Limbs,' p. 86.

† Compare, for example, the scapula of the Apteryx, 'Transactions of the Zoological Society,' vol. ii, pl. xxx, fig. 2, p.; and figs. 3 and 4, with Cut, fig. 3, p. 586.
of the organs of circulation, and a progress in the extent and perfection of the lungs, together resulting in the higher temperature, with more numerous and minute coloured discs, of the blood. For these conditions of the vital organs characterise alike both winged and wingless Birds, and the resultant unvarying warmth of the body is accompanied by a clothing of down and feathers, the most exquisite and complex of all tegumentary coverings, common to the Kivi and Ostrich with the Eagle and Swift.

But there are other hypotheses of the way of operation of secondary genesis of species anterior in date to that of Darwin. The influence, viz., of exercise and of disuse in altering the proportions of parts mooted by Lamarck;* the hypothesis of ‘degeneration’ propounded by Buffon;† and the effects of congenital changes in parts of the body, mainly depended upon by the author of ‘Vestiges,’ in his endeavour to explain the way of operation of the secondary law of the origin of species.

The comparative ease is so refreshing, after the labours of induction and dry description, in supposing a case, that I may be forgiven for indulging in a suggestion of a possibility of the few still extant wingless or flightless birds having originated, not from any lower cold-blooded vertebrate form, but from higher active volant members of their own warm-blooded feathered class. Consideration of extinct kinds, in the restoration of which I have been occupied, has strengthened the supposition.

Here, in yielding to this indulgence, I own to finding more help from the Lamarckian hypothesis than the Darwinian one, and I am ultimately led to propound the Struthionidae as exemplifications of Buffon’s belief in the origin of species by way of degeneration; on other grounds than those on which my anonymous Critic, above cited (p. 614, †), views the Papuan and Boschisman in relation to an antecedent higher, indeed perfect, form of man.

Let us suppose, for example, an island affording abundant subsistence to vegetarian birds, and, happily for them, to be destitute of creatures able or desirous to destroy such birds. If the food was wholly, or chiefly, on the surface the power of traversing such surface would be of as much advantage to the bird as to the herbivorous quadruped. As flight calls for more effort than course; so cursorial progression would be more commonly practised in such a happy island for obtaining the daily food. The advent or proximity of a known element of danger might excite the quicker mode of motion; the bird would then betake itself by a hurried flight to a safer locality. If, however, certain insular birds had never known a foe, the stimulus to the use of the wings would be wanting in species needing only to traverse the ground in quest of food. In the case of New Zealand, for example, the roots of wide-spread ferns, being rich in farinaceous and amylaceous principles, the habit of scratching them out of the ground would lead to full development of the muscles of the leg and foot. So, such daily habitual exercise of legs and feet by unscared Rasorials would lead in successive generations to strange developments of hind-limbs;

* ‘Philosophie Zoologique,’ 2 vols., tom. i, chaps. iii, vi, vii, 8vo, 1803.
† ‘Histoire Naturelle,’ tom. xiv, p. 311, 4to, 1766.
whilst the disuse of the wings during the pre-Maori æons would lead to their atrophy. The Lamarckian hypothesis has, in fact, this advantage over others of like kidney, that physiology testifies to the relation of growth to exercise, and of waste to disuse, and so far votes in favour of the conditions evoked by Lamarck as *vera causa* in transmutation. We recognise in the stunted wings of the Dodo evidences of its affinity; as, for example, by their close conformity, save in size, and in the prominence of their processes for muscular attachments, to the scapula, coracoid, brachial and antibrachial bones, carpus, metacarpus, &c., of the perfect instrument of flight in truly winged birds, and such conformity of structure is agreeable with the hypothesis of the origin of the Mauritian species of ground-pigeon through descent or degeneration. The differences which the wing-bones of the Dodo present when compared with their homologues in the *Iguanodon* is in the same degree adverse to the hypothesis of its evolution from any such reptile, in the direction of ascent and improvement. The same course of argument applies to the impennate Awk, the Cassowary, Rhea, Ostrich, &c., as to the wingless birds of the Mascarene, Polynesian, or Melanesian Islands.

Confidence in the impartial exercise by Biologists of the logical faculty leads to the conclusion that their science will accept the view of the Dodo as a degenerate Dove rather than as an advanced Dinother. But whence the dove? Are we then, I will not say driven, but rather guided, to the old belief that the winged bird was "created" in the sense of being miraculously made, at once, out of dust, agreeably with the alternative hypothesis conceived by my critic? Or, is a belief in a Dove's coming to be through the operation of a secondary law still legitimate and germain to our truth-seeking faculties? Not necessarily relegating an honest inquirer to the bottomless pit of Atheism, if he should happen to ask:—Were there no volant vertebrates of earlier date and lower grade than the "Fowls of the Air"?

Without knowing or pretending to know the way of operation of the secondary cause, the vast increase of knowledge-stores of biological phenomena makes it as impossible to comprehend them intelligibly in any degree, on the assumption of primary or direct creation of species, as it was impossible for Copernicus to understand and explain the vast accession of astronomical facts in his day, on the belief of the subservient relation of sun to earth, of the posteriority of the creation of the luminary to that of the light-receiver, and of their respective relations of motion, as received in his day. To the objection, how, on his assumption of the diurnal rotation of the earth, loose things remained on its surface, Copernicus could offer no explanation. Neither has the Biologist been able, as yet, to explain how the Ramphorhynchus became transmuted into the Archeopteryx. It is open, of course, for any one to deny such change. What seems to me to be legitimate, in giving an account of the labours that have resulted in a certain accession to the knowledge of extinct forms of cold-blooded, oviparous, air-breathing Vertebrates, is the indication of the respective vicinity of certain groups of such now much reduced class to the warm-blooded oviparous Vertebrate air-breathers which in our times so greatly prevail in life's theatre.
Every bone in the Bird was antecedently present in the framework of the Pterodactyle; the resemblance of that portion directly subservient to flight is closer in the naked flyer to that in the feathered flyer than it is to the fore-limb of the terrestrial or aquatic Reptile. No Dinosaur has the caudal vertebrae reduced as in Birds; many Pterodactyles manifest that significant resemblance. But some Pterodactyles had long tails and all had toothed jaws. A bird of the oolitic period* combined a long tail of many vertebrae with true avian wings, and it may have had teeth in its mandibles. It is certain that a later extinct bird,† though of an early tertiary period, far back in time beyond the present reign of birds, had tooth-like processes of the alveolar borders of both upper and lower jaws.

Fact by fact, as they slowly and successively drop in, testify in favour of the coming in of species by 'nomogeny,' and speak as strongly against 'thaumatogeny'‡ or the multiplication of miracle on the alternative hypothesis of the writer of 'Little Lectures on Great Things.' He and his school invoke a cataclysm to extinguish the Palæothere, and an inconceivable operation to convert dust into the Hippothere; yet a slight disproportion of the outer and inner of the three hoofed toes of each foot of these quadrupeds is their main difference. My critic again invokes a cataclysm to extinguish the race of Hippotherian species and again requires the miracle to create the Horse. Yet the loss of the small side-hoofs that dangled behind the main mid-hoof in the Hippothere is the chief organic distinction between Hippotherium and Hippos. Every bone, every tooth, present in the eocene and miocene predecessors of modern Horses is retained in them, with slight changes of shape and proportion. The second and fourth metacarpals which bore hoofed digits of moderate size in eocene days, bore them of diminutive size in miocene days; and now, when such dangling spurious hoofs are gone, their metacarpal and metatarsal suspensors still remain, hidden beneath the skin, and ending in a point where, of old, was a well-turned joint.

It has become as impossible to square the hypothesis of "the peopling of the globe during the long reign of life thereon, by successive and special creations" with the known vital phenomena, as it was impossible to explain the sum of astronomical facts, accumulated in the fourteenth century, by the cumbrous machinery of cycles and epicycles, necessitated under the assumption of the globe as the fixed, central, and largest body of the Universe. Biology seems now to be at the Copernican stage; and if the rejection of the incoming of species by primary creative acts should exercise an influence on the progress of that science akin to that of astronomy after the abandonment of the faith in the earth's fixity, Biologists may confidently look for as rapid a progress through acceptance of Nomogeny.

What, then, may be the meaning of the reduction of bulk in the fore-limbs of certain Dinosaurs? Does that reduction indicate a step in the conversion of such Reptiles into

* Archeopteryx, 'Philosophical Transactions,' 1863.
‡ 'Anatomy of Vertebrates,' 8vo, vol. iii, p. 814.
Birds? Do we get an explanation of the small fore-limbs by the picture which Professor Phillips, under Huxleyan guidance, vividly presents to us "of the grand and free march on land chiefly, if not solely, on the hind-limbs?" Or, is the fact of the disproportion of size between the arms and legs in the Megalosaurus and Iguanodon susceptible of other than the Oxfordian hypothesis?

As a matter of fact, such disproportion is shown by Crocodilian Reptiles still in existence; whilst extinct Crocodiles of more aquatic habits and marine sphere of life had the fore-limbs as much reduced in size as in any known Dinosaur.* Of this Teleosaurian character the physiological explanation which has been advanced is, that the course of such Crocodile through water, due to the action of the long, laterally flattened tail, would be facilitated, or less impeded, by such reduction of size of the fore-limbs; those limbs taking no share in the forward dash of the piscivorous reptile in pursuit of its prey, and, if of any use in the water, being limited in natatory evolutions to assist in a change of direction; the fore-limbs, in fact, being mainly if not wholly required to help in the progress of the amphibious beast upon dry land, or to scratch out the nest in the sand. Actual observation of a swimming Crocodile or Lizard testifies to the fore-limbs being then laid flat and motionless upon the sides of the chest. All known Dinosaurs have the Crocodilian swimming organ; the Iguanodon exemplifies the compressed vertically broadened tail in an eminent degree. And just as such appendage was essential to the proportion of the active life of these huge cold-blooded amphibians which was spent in the watery element, so such far-produced caudal fin must have been a cumbrous impediment to the way of walking upon dry land pictured in the Work and Paper above cited.†

In the ratio in which the fore-limbs approach the hind ones in size may be inferred the proportion of time spent by the huge reptile on land, and the importance of the share taken by these limbs in such quadrupedal mode of progression: when the Dinosaur betook itself to water its fore-limbs would be, most probably, disposed as in the Crocodiles.

If, then, the hypothesis that the reduced fore-limbs of Dinosauria receive the most intelligible, and therefore acceptable, explanation, admitting the principle of adaptation of structures to functions and reciprocally, agreeably with the analogy of such living animals as are most nearly allied to them in organization; the notion that Birds, under their wingless conditions, were derived from Dinosaurs may be safely left to the judgment of whomsoever may be disposed to bring unprepossessed and impartial judgment to the consideration of the hypothesis.

Genus—Omosaurus.

(Continued.)

Species—Omosaurus hastiger, Owen. ('Dinosauria,' Plates 77 and 78.)

If the grounds assigned in a former part of this work (p. 577) for the probable homology of the unsymmetrical spine figured in Plates 74 and 75, which spine was found with the bones of the fore-limb of Omosaurus armatus, should be deemed to warrant such conclusion, a similar one may be provisionally accepted as applicable to the pair of spines of similar size and character discovered in the same division of the Kimmeridge Clay, in the Great Western Railway Cutting at Wootton Bassett, Wiltshire, briefly referred to at p. 577.

Many large Saurian fossils were collected from the sections of Kimmeridge Clay at that time exposed; but none have reached me save the subjects of the present Monograph, which were there obtained by William Cunnington, Esq., F.G.S., and have passed with the rest of his collection into the possession of the British Museum. The apical portion of each spine has been broken away, but the degree of decrease from the base affords satisfactory grounds for the restoration given in Plate 78, the ratio of decrease being less in the present species than in the almost perfect spine of Omosaurus armatus (Plate 74).

The base of the spine (Plate 78, b) expands from the body, a, more suddenly and in a greater degree in Omosaurus hastiger. It is suboval in form and, as in Omos. armatus, its plane is oblique to the axis of the spine. The long diameter of the base is 9 inches, the short diameter is 7 inches.

The articular surface is divided into two unequal facets by a low ridge of the base (Plate 77, fig. 1, r, r) parallel with the long diameter of the base; each facet is feebly convex lengthwise, less feebly concave transversely. The surface for attachment is roughened by low short ridges diverging from the long ridge, r, and is irregularly pierced by vascular canals; the borders are thick and irregularly notched.

The body of the spine is continued more directly from one end (Plate 78, figs. 1, 2, 3) of the oval base, a, fig. 2, sloping and expanding more gradually to the opposite end of the base, b, fig. 2.

The body of the spine is a full oval in transverse section (ib., fig. 4), pointed at each end, where the two opposite edges, d, e, are cut. The anterior edge (fig. 1, d), begins about 6 inches beyond the anterior produced part of the base; the posterior edge (fig. 3, e) begins about 2 inches from that end of the base. Both edges extend along the preserved portions of each spine, and were probably continued to, or near to, the pointed
end. An additional advantage as a lethal or piercing weapon must have been derived from this two-edged structure.

In the right spine (fig. 1) the length preserved is 14 inches; in the left spine (fig. 3) the length preserved is 10 inches. Each spine may be estimated to have been upwards of 20 inches in length when entire.

The transverse section taken from the broken end of the left spine (fig. 4) gives 4 inches and 3½ inches in the two diameters; the broken end of the better preserved spine gives 3 inches and 2¾ inches in the two diameters; the spine approaches to a circular section as it nears the pointed end. The texture of the outer inch is a compact bone susceptible of a high polish; it becomes finely cancellous within a few lines of the central cavity, the section of which at the part cut, viz. 8¾ inches from the base of the spine, gives 1 inch 6 lines, and 1 inch 3 lines, in the long and short diameters.

The close correspondence of the present fossil in general form, in basal modifications for attachment, and in texture, with the spine, probably left carpal, of Omosaurus armatus, will be obvious on comparison of Plates 77 and 78 with Plates 74 and 75 of a former part of this work, treating of that species; and such correspondence may be deemed to support the provisional reference of the carpal (?) spines from the Kimmeridge Clay of Wootton Bassett to the same genus as that from the Kimmeridge Clay of Swindon; they manifestly indicate a distinct species on the above hypothesis of their nature. The osseous core of the carpal spine in Iguanodon (p. 508, Plates 46, 47) differs chiefly in its relative shortness or speedier diminution from the base to the apex.

After a comparison of these fossils with all the examples of carpal and tarsal spines in existing vertebrates, I found the nearest resemblance to the basal expansion, by which the spine of Omosaurus has been attached, in the tarsal spine of the Platypus (Ornithorhynchus paradoxus, Plate 77, fig. 2, twice natural size). There was the same proportion of breadth to the body of the spine; the same sudden expansion to form the base; the same medial rising in the long axis of the base, and furrows extending therefrom to the margin. But these radiating furrows are more numerous, and the spine, though it is hollow as in Omosaurus, has that cavity converted by terminal apertures into a canal, and this canal is traversed, as in the poison-fang of certain Ophidian Reptiles, by the duct of a gland. The affinity shown by the Monotrematous Mammals to the Reptilia in certain parts of the skeleton is well known, and is closer in the structure of sternum, coracoids, and clavicles, than in any Bird.
Order. **DINOSAURIA.**

*Genus—Chondrosteo saurus.*

Species—*Chondrosteo saurus gigas,* Owen. ('Dinosauria,' Plates 79—82.)

The flatness of the under surface of the vertebra figured in Plates 79—82 recalled the character of that of *Bothri ospondylus suffossus* (p. 551, Plate 61), and, with the predominance of the transverse over the vertical diameter, suggested that it also might have come from the sacral series.

The hemispheroid convexity, however, of the anterior end, notwithstanding abrasion of the articular surface itself, and the proof of its truly indicating such form given by the more perfect preservation of that surface in the opposite concave articular end (Plate 80), too plainly pointed to a much more forward position of this remarkable vertebra in the backbone series of the huge Reptile which it represents.

That the vertebra is from the fore part of the trunk may be inferred from the presence, on each side, of both a paraphysis (Pl. 79, p) and a diapophysis (ib., d), indicative of the bifurcation of the proximal end of the rib into a capitular and a tubercular articulating process.

The portion of neural canal preserved (Plates 80 and 81, n) gives the vertical diameter of the centrum. There is no indication in the concave articular surface of that diameter having been diminished by posthumous pressure. The gentle transverse concavity of so much of the broad under surface as is preserved (Plate 79) is evidently natural. The deep depression (Plate 82, fig. 1, f) on each side of the centrum between the par- and di-apophyses recalls a vertebral character of the genus *Bothriospondylus.*

The paraphysis (Plate 79, fig. 1, p) projects from the level of the under surface: it commences behind, four inches from that end of the vertebra, as an extension of the lower border of the centrum, curving outward and gaining vertical thickness as the process advances (Plate 82, fig. 1, p), the fore part of the base of the process occupying the lower vertical half of the centrum, and terminating very near to the beginning of the anterior articular ball.

The neurapophysis (Plates 80, 81, 82, ns), which has coalesced with the centrum, begins to rise about two inches in advance of the hinder cup. The part of the broken base there preserved yields a transverse thickness of 3½ inches. Anterior to this the upper surface of the centrum has been abraded to the level of the neural canal, but sufficient is preserved to show that the neurapophysis loses thickness at the middle of the vertebra, and appears to regain it as it approaches the anterior ball (Plate 81, fig. 1).

The base of the diapophysis (Plate 81, fig. 1, d), at the part of the neurapophysis pre-
served, gives a fore-and-aft extent of 3 1/4 inches, and a vertical diameter of 2 inches, from which the size of the tubercle of the rib may be inferred.

Restoring the margin of the posterior concavity and the articular surface of the anterior convexity, the length of the centrum of this vertebra would be 1 foot 3 inches.

The whole of the side of the centrum is occupied by a deep oblong depression which, probably, lodged a corresponding saccular process of the lung. On one side this depression was partially divided by a thin oblique plate (Plate 82, fig. 1, f, f). I deem it much more probable that the large cancelli obvious at every fractured surface of this vertebra (ib., fig. 2) were occupied in the living reptile by unossified cartilage, or chondrine, than by air from the lungs, and consequently have no ground for inferring that the whale-like Saurian, of which the present vertebra equals in length the largest one of any Cetacean recent or fossil, had the power of flight, or belonged to either Pterosauria or Aves.

The neural canal (Plate 81, n) indicates a centre of origin of motory nerves subservient to less energetic, more sluggish, movements than in the volant groups; movements probably exercised more commonly in the aqueous than the gaseous atmospheres; and it leads to the inference that, when emerging, the huge frame was sustained by the solid earth on limbs of dinosaurian proportions.

The neural canal at the middle of the vertebra yields 1 inch, 3 lines in diameter, and expands to that of 2 inches at its hinder outlet; it is here, therefore, one fourth the transverse diameter of the vertebral centrum.

In a corresponding vertebra of an Eagle (Plate 81, fig. 2) the posterior outlet of the neural canal, n, is 4 lines in diameter, that of the end of the centrum, there, being 6 lines in diameter: the relative size of the myelon, here indicated, harmonises with the rapid and powerful exercise of muscles of flight deriving their motive energy from an adequate nervous source. The contrast in the relative size of the myelon and vertebra between the Eagle and the Chondrostosaurus is shown by figs. 1 and 3, n, in Plate 81.

The specimen here described and figured was obtained from the submerged Wealden deposit on the south coast of the Isle of Wight, and was purchased for the British Museum.

The extreme modification of structure in the vertebrae of Chondrostosaurus contrasted with that of the subjects of Plates 61—73 leads me to refer them to a distinct genus from Bothriospondylus; but it is a nearly allied one.

I had a vertical longitudinal section made of a rolled and worn centrum, of smaller size than the type of Chondrostosaurus gigas, but of similar proportions. It is figured three fourths of the natural size in Plate 82, fig. 2. The black tint indicates the ossified proportion of the vertebral substance; the lighter tint the chondrosal proportion, filled in the fossil by Wealden marl.
Species—Chondrosteosaurus magnus. (‘Dinosauria,’ Plates 83—85.)

In the subject of Plate 84 sufficient of the concave articular surface is preserved to show its correspondence in size with that of the subject of Plate 80, but its proportions are reversed, the vertical diameter plainly appearing to surpass the transverse one. The present vertebra, it is true, has come from a more posterior part of the column. The parapophysis has disappeared, at least from the position from which it projects in the subject of Plate 79; if such process was present its origin has risen to near the base of the neural arch. So much of the free surface of the centrum as remains is concave lengthwise; all trace of flattening of the inferior surface has disappeared. The curve of the free surface toward the fore end of the centrum indicates that vertebral element to have been shorter absolutely, and much more so relatively to the hinder cup, than in Chondrosteosaurus gigas. It is hard to suppose that so extreme a degree of modification of shape and proportion should be present in an anterior and a middle dorsal vertebra of the same spine or in the same species, as is exemplified by the subjects of Plates 80 and 84; I therefore refer them to distinct species. The present vertebra agrees more closely in proportions with that of which a side view is given in Plate 83.

The centrum is shorter in proportion to both breadth and height than in Chondrosteosaurus gigas. The rise in the position of the parapophysis shows the vertebra (Plate 83) to have come from a more posterior part of the spinal column than the subjects of Plate 79, and of fig. 1, Plate 82. The outlet of the side-pit is shorter and deeper (vertically); yet the long diameter of the aperture is about one third that of the centrum; its compact lining layer of bone is entire. The fore end of the centrum shows the convexity, the hind end the concavity, characteristic, with the chondrosal texture of the bone (Plate 85), of the present remarkable genus. The neurapophysial bases extend to within an inch and a half of the hind margin of the centrum; they rise at the beginning of the convexity of the fore end. This convexity has suffered abrasion, and the widely cancellous structure is exposed, as shown in Plate 85.

It seems not needless to remark, in reference to such fossils, that the primal basis of the vertebrate skeleton may be converted into sclerine or chondrine, and that ossification may begin in either ‘membrane’ or ‘cartilage.’ In some vertebrates, chiefly if not exclusively cold-blooded, more or less of the bone may remain unossified, retaining the antecedent stage, with some slight modification of tissue, to which, as in selachian vertebrae, the term ‘chondrine’ has been applied. Such partially ossified bones, when petrified, show corresponding cavities, usually filled with matrix or spar.

But this condition of fossil bones may depend on other osteogenetic changes. After substitution of bone-earth for gristle, or the conversion of the entire cartilaginous mould
into bone, the central part may be absorbed and marrow be substituted for bone. Then, in the course of fossilisation matrix or spar may be substituted for marrow. Or the absorption of previous solid bone, such as that of a chelonian humerus or femur, may go further; the marrow may also be absorbed, the wall of the bone may be perforated, or 'tapped,' and air be admitted from a contiguous portion of lung. But in the course of fossilisation the non-ossified parts of the substance of the bone become filled by the same mineral infiltration whether the cavities in the recent state contained chondrine, marrow, or air.

The inconsiderate conclusion that fossil bones with large vacuities and thin compact osseous walls and partitions must have been bones of volant vertebrates led to the supposition that certain fossil eggs belonged either to Pterodactyles or Birds, because the bones of the unexcluded embryo showed the hollow or tubular character. Such eggs in a portion of stone from a quarry in the Island of Ascension were submitted under this impression by Lyell, in 1834, to my examination. The characteristic scapula and coracoid of a chelonian embryo were detected in the petrified contents of the fossil egg. To the objection, based on the hollowness of those limb-bones, against the reference of those bones to the reptilian genus, I showed, by dissection of a newly hatched Chelone preserved in spirits in the Hunterian Museum, that the cavity of such bones was filled with chondrine, not with air, and I explained to my friend that the thin outer shell of bone was a transitory embryonal character, and that the femora, humeri, and other bones became massive and solid in the adult turtle.* Now, the earlier chondrosal stage in the existing genus was not overpassed but retained as the normal adult osteal character of the extinct huge and heavy reptiles of the genus Chondrosteosaurus.

It is a relief to banish the marvellous and awful vision of flying Dragons with vertebrae of the size of those of Chondr. gigas and Chondr. magnus!

Order. **DINOSAURIA** (?).

**Genus**—Cardiodon.

**Species**—Cardiodon rugulosus.

In the Wealden and Upper Oolitic, as in other mesozoic formations, the evidences studied in the process of restoring the Reptiles of those periods come to hand, for the most part, fragmentarily. Bones without skull, jaws, or teeth may indicate genera before unknown, such as Omosaurus and Chondrosteosaurus; or scattered teeth unassociated therewith may suggest reptiles as huge but be generically distinct from the known

teeth of Iguanodon, Hylæosaurus, or Megalosaurus. A happy accident may one day bring to light the connection of the subjects of the present subsection with those of the foregoing of which the dental characters are unknown.

In this state of doubt it is convenient to indicate the new fossil by a distinct generic term, and such has been suggested, for the subjects of figs. 2—5 of Plate 85, by the heart-shaped form of the crown of the fossil tooth. The crown, being 1 inch in length, 8 lines in breadth, and 5 lines in thickness, might well have come, according to the proportions of the teeth of Hylæosaurus (Plate 39), and Scelidosaurus (Plate 46), from a Dinosaur with trunk-vertebrae of the size of those of species of Chondrostosaurus.

In the teeth of Cardiodon the 'crown' suddenly expands above the 'neck,' and thins off to the fore and hind borders (Plate 85, fig. 3), and contracts to a subacute apex (ib., fig. 2). The enamel rises into wavy longitudinal ridges with widish intervals, where it is minutely rugous. The fang is cylindrical, coated with smooth cement.

The original or typical specimens of Cardiodon rugulosus were from the 'forest marble' of Wiltshire.*

* See my 'Odontography,' 4to, p. 291, pl. lxxv a.