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An Excerpt from the Report on British Fossil Reptiles

Dinosaurians

RICHARD OWEN, ESQ., F.R.S., F.G.S., &C., &C.

Source: Owen, Richard, "Report on British Fossil Reptiles, Part II" from the *Report of the Eleventh Meeting of the British Association for the Advancement of Science,* Plymouth, England, July 1841, John Murray, publisher, London, 1842, pp. 60–204. [Note: This excerpt includes only pp. 102–144. First use of the word "dinosaur."]

This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum composed of five anchylosed vertebrae of unusual construction, by the height and breadth and outward sculpturing of the neural arch of the dorsal vertebrae, by the twofold articulation of the ribs to the vertebrae, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only, by broad and sometimes complicated coracoids and long and slender clavicles, whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch; the dental organs also exhibit the same transitional or annectent characters in a greater or less degree. The bones of the extremities are of large proportional size, for Saurians; they are provided with large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal Mammals, and attest, with the hollow long-bones, the terrestrial habits of the species.

The combination of such characters, some, as the sacral ones, altogether peculiar among Reptiles, others borrowed, as it were, from groups now distinct from each other and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe or sub-order of Saurian Reptiles, for which I would propose the name of *Dinosauria.*[1]

Of this tribe the principal and best established genera are the *Megalosaurus,* the *Hylaeosaurus,* and the *Iguanodon;* the gigantic Crocodile-lizards of the dry land, the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious *Sauria,* as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria,* or Marine Lizards.

Megalosaurus

Of the gigantic Lacertians in question, the most remarkable are the *Megalosaurus, Iguanodon,* and *Hylaeosaurus,* the worthy fruits of the laborious researches of Prof. Buckland and Dr. Mantell. With respect to the *Megalosaurus,* the great carnivorous terrestrial Lizard of the Wealden and Oolitic period, the lucid descriptions of its discoverer in his original Memoir and the "Bridgewater Treatise," and the judicious remarks of Cuvier on its natural affinities, leave little to be added, save the observations on the sacrum, to the present brief record of the strata and localities in which the remains of the *Megalosaurus* have been found.

The most complete collection of the bones of this genus has been derived from the oolite of Stonesfield, where the original specimens were first discovered. Dr. Buckland now possesses in his valuable collection portions of a lower jaw, the principal fragment containing a tooth fully developed, and the germs of several others; detached dorsal, caudal, and a series of five sacral vertebrae, ribs, two coracoid bones, a clavicle, humerus, radius, an ilium, an ischium, a femur, fibula, metacarpal and metatarsal bones.

These parts have not been discovered so associated together as to prove them to belong to the same animal; but the peculiar characters of some of the bones, which distinguish them from the other oviparous reptiles of the same strata, and the agreement in texture and proportionate size of the others, render their reference to the *Megalosaurus* highly probable.

The essential characters of the most authentic of these remains prove the *Megalosaurus* to have been closely related to the Lacertian division of the Saurian order; but the teeth, the vertebrae, and some of the bones of the extremities, indicate its affinities to the Crocodilian group, and all these parts manifest more or less strongly the peculiar characters of its own remarkable family. In the instructive and characteristic portion of the lower jaw, the sockets, like the teeth, are compressed, and are separated by complete partitions; but they are so much wider than the teeth, as to suggest the existence of a greater proportion of ligamentous gum at the upper part of the alveolar tract in the recent animal than in the Crocodiles. "The outer rim of the jaw rises almost an inch above the inner rim, and forms a continuous lateral parapet, supporting the teeth externally; whilst the inner rim throws up a series of triangular plates of bone, forming a zigzag buttress along the interior of the alveoli. From the centre of each triangular plate, a bony septum crosses to the outer parapet, thus completing the alveolus."[2] There is a slight groove and ridge along the inner side of the sockets, and it is at this groove, at the interspace of each triangular plate, that the apices of the new teeth protrude. The teeth have compressed, conical, pointed crowns, with trenchant and serrate anterior and posterior edges. They appear straight when they first protrude, but are bent in the progress of growth; in the course of development the crown of the tooth is solidified, and the anterior margin at the base of the crown becomes smooth and convex. The smooth enameled surface of the tooth presents fine polished wrinkles.

In all existing Lizards the teeth are anchylosed, either to the side of an outer alveolar parapet, according to the pleurodont type, or to its summit, according to the acrodont type. The double parapet, inclosing and concealing the germs and the bases of the full-grown teeth, is a remarkable approach in the present gigantic Dinosaur to the Crocodilian structure, the similarity in this respect no doubt resulting from a similar necessity in the carnivorous Megalosaur for a firm lodgment of the destructive maxillary weapons. The higher development of the outer alveolar parapet bespeaks the affinity of the *Megalosaurus* to the Lizards: in the form of the teeth it approaches nearest to the Varanian family, which at the present day includes the largest, and most carnivorous species of Lizard.

Vertebrae

The Megalosaur deviates more decidedly from the existing Monitors and Lizards in its vertebral characters. These are afforded, at present, by the sacral, a few costal and caudal vertebrae. The articulating surfaces of the body of the vertebra are nearly flat or slightly concave, as in the coelospondylian[3] Crocodiles. The non-articular surface is remarkably smooth and polished. The body is much contracted in the middle: the margins of the expanded articular extremities are thick and rounded off. The middle contracted part of the body is nearly cylindrical, being nipped in, as it were, by a more or less deep longitudinal fossa on each side, just below the base of the neural arch, but again slightly expands to support that part. The length of the base of the neurapophysis is nearly equal to that of the centrum: the suture is persistent, as in Crocodiles; its course is undulating, and it rises in the middle. The neurapophysis ascends and inclines outwards, to form, at a height above the centrum equal to three-fourths its vertical diameter, the margin of a broad platform of bone, from the sides of which the transverse processes are developed, and from the middle part the spinous process. A strong ridge or buttress of bone extends from the posterior angle of the base of the neurapophysis obliquely forwards to the under part of the transverse process; behind which ridge there is a deep depression, separating it from the posterior articular process. These processes are relatively smaller than in the *Iguanodon,* and do not project beyond the hinder end of the centrum. The spinal platform descends in a gentle curve from the posterior to the anterior oblique processes: the base of the strong and thick spinous process follows this curve along the middle line of the platform; its antero-posterior extent was $4\frac{1}{2}$ inches, in a vertebra having the centrum of the same length, with a vertical diameter of 4 inches, and measuring $7\frac{1}{2}$ inches from the under part of the centrum to the posterior part of the base of the spine.

Sacrum

The sacrum of the *Megalosaurus* consists of five anchylosed vertebrae, and it is remarkable enough, considering how small a proportion of the recognizable bones of this rare reptile has been found, that the present characteristic part of the vertebral column of three different individuals should have been obtained: one sacrum, from Stonesfield, is in the museum of Dr. Buckland at Oxford; a second sacrum, from Dry Sandford, in the museum of the Geological Society; and a third sacrum, from the Wealden formation, in the British Museum.

I have studied each of these specimens with much attention, which a recognition of their remarkable structure has well repaid.

It would seem that Cuvier did not regard the five anchylosed vertebrae figured in Dr. Buckland's original memoir, as the sacrum of the *Megalosaurus.* They are briefly alluded to in the second and fourth editions of the 'Ossemens Fossiles,' and in the description of the Plate, in which Dr. Buckland's figure is reproduced as a 'Suite de cinq vertèbres de *Mégalosaurus.*' In truth the sacrum was not known to be represented, at that time, in any Saurian by more than two vertebrae, and therefore Dr. Buckland mentions this part in his original memoir as "five anchylosed joints of the vertebral column, including the two sacral and two others, which are probably referable to the lumbar and caudal vertebrae."[4] In contemplating this series of five anchylosed vertebrae, so new in Saurian anatomy, my attention was first arrested by the singular position of the foramina for the transmission of the nerves from the inclosed spinal marrow. These holes, which, in the plate illustrating Dr. Buckland's important memoir[5] are represented above the bodies of the three middle vertebrae, are natural, and accurately given: the smooth external surface of the side of the vertebra may be traced continuing uninterruptedly through these foramina, over the middle or nearly the middle of the centrum, into the surface of the spinal canal.

But the normal position of these foramina throughout the vertebral column in all other reptiles is at the interspace of two vertebrae, whence by French anatomists these holes are termed 'trous du conjugaison.' In the sacrum of the Oxford Megalosaur, however, it is evident that above the anchylosed intervertebral space a thick and strong imperforate mass of bone ascends to the base of the spinous process, leaving it to be conjectured either that the nerve had perforated the middle of the neurapophysis, or that these vertebral elements had undergone in this region of the spine a change in their usual relative position to the centrum. Previous researches into the composition and modifications of the vertebrae in the different classes of Vertebrata soon enabled me to recognize the peculiar condition and analogies of the five anchylosed vertebrae of the *Megalosaurus;* with a view to illustrate which I shall premise a few observations on the different relative positions which the peripheral vertebral elements may take in regard to the central part or body. The lateral vertebral elements, or ribs, the inferior laminae or haemapophyses, the superior laminae or neurapophyses, are all subject to such changes; but the neurapophyses are much more constant in their place of attachment than the others. In Mammalia the ribs for the most part are joined to the interspace of two centrums; in Reptiles each pair is attached to a single centrum. In Fishes, and the Mosasaur among Reptiles, the haemapophyses depend, each pair from its proper centrum; in other Reptiles and Mammalia they are articulated to the interspace of two vertebrae, leaving a half-impression on each of the contiguous centrums. The neurapophyses present a degree of constancy in their relation to the body of the vertebra corresponding with the importance of their function. In Mammalia I know of no exception to the rule, that each neural arch is supported by a single centrum: in Birds no exception has hitherto been recorded; but among Reptiles the Cheloniae[6] offer in those vertebrae, in which the expanded spinous processes contribute to form the carapace, the interesting modification analogous to those noticed in the lateral and inferior vertebral elements, viz. a shifting of the superior laminae from the middle of the body to the interspace of two adjoining centrums; whereby that part of the spine subject to greatest pressure is more securely locked together, and a slight yielding or elastic property is superadded to the support of the neural arch.

The same modification is introduced into the long sacrum of birds; each neural arch is there supported by two contiguous vertebrae, the interspace of which is opposite the middle of the base of the arch above, and the nervous foramen is opposite the middle of each centrum. It is this structure, beautifully exemplified in the sacrum of the young Ostrich, which Creative Wisdom adopted to give due strength to the corresponding region of the spine of a gigantic Saurian species, whose mission in this planet had ended probably before that of the Ostrich had begun.

The anchylosed bodies of the sacral vertebrae of the Megalosaur retain the distinguishing characters which have been recognized in the dorsal and caudal vertebrae, in regard to the smooth and polished surface of their middle constricted part; the cylindrical, or nearly cylindrical transverse contour of this part below the lateral depression; their expanded, thickened and rounded articular margins, and also, though in a somewhat less degree, their relative length as compared with their breadth and height. The three middle sacrals are, however, somewhat shorter than the two terminal ones.

	In.	Lin.
Antero-posterior diameter of centrum of fifth sacral	4	10
Vertical diameter of centrum of fifth sacral	4	1
Transverse diameter of centrum of fifth sacral	4	6
Vertical diameter of the middle of the body	2	6
Total height of fourth sacral vertebra	11	

The neural arches of the first three sacral vertebrae rest directly over the interspaces of the subjacent bodies; that of the fourth derives a greater proportion of its support from its proper centrum; and that of the fifth, which rests by its anterior extremity on a small proportion of the fourth centrum, is extended over nearly the whole length of its own centrum, so that in the caudal vertebrae the ordinary relations of the neural arch and centrum are again resumed. In the four first sacral vertebrae the base of the neural arch extends half way down the interspace of the bodies, and immediately developes from its outer part a strong and short transverse process (broken and rounded off in the fossil). From the base of this process the neurapophysis expands upward, forward and backward, is joined by vertical suture to similar expansions of the contiguous neurapophysis, and terminates above in a ridge of bone, at right angles to the suture; this ridge, with those of the other neurapophyses, extends longitudinally above the transverse processes the whole length of the sacrum, and forms the margin of the platform from which the spinous and accessory processes are developed. The platform is further supported by a compressed ridge of bone extended from the upper part of the transverse process, like a buttress, to the middle of the horizontal ridge. On each side of the buttress there is a depression, which is deepest in front. The spinous process is not developed, as in the dorsal vertebrae, immediately from the platform, but a shorter, vertical plate of bone, of nearly the same longitudinal extent as the true spine, is developed on each side of, and parallel with its base; the height of these accessory spines in the third sacral vertebra is three and a half inches. The true spinous process begins to expand longitudinally, and when near the summit of the accessory spines, is joined by vertical suture with the similarly expanded neighbouring spines, so that the sacrum is crowned by a strong continuous vertical longitudinal ridge of bone, at least along the four first vertebrae; the broad spine of the fifth being rounded off anteriorly, and separated by a narrow interspace from that of the fourth. Besides this modification of the spine, and the more normal position of the neural arch of the fifth anchylosed vertebra, the origin of the transverse process has been suddenly raised to the level of the spinal platform, and it is supported by two converging ridges of bone from the side of the neural arch below. The origin of the transverse processes of the first sacral is also placed higher than the three middle ones, in which the several peculiarities of structure above described are most strongly marked.

The specimens of sacrum of the *Megalosaurus* in the British Museum, and that of the Geological Society, present the same structure as that above described in the original specimen at Oxford. Part of the fifth sacral vertebra is wanting in the specimen from Dry Sandford. The rest are characterized by the same smooth and polished surface, rich brown colour, contraction of the middle of the body, its cylindrical form transversely, and the longitudinal fossa below the annular part. The length of this series is one foot six and a half inches; the second and third sacral vertebrae are rather shorter than the rest. The first sacral vertebra, which was not anchylosed to the last lumbar, gives the following dimensions:—

	In.	Lin.
Antero-posterior diameter of centrum	5	0
Vertical diameter of anterior articular end	4	0
Transverse diameter of anterior articular end	4	6

The neural arch seems not to have been co-extensive in length with the centrum, but rests on its anterior three-fourths. A strong and short transverse process extends obliquely upwards and backwards from each side of the arch; the antero-posterior diameter of the base of this process is two inches, its vertical diameter one and a half inch. In the second sacral vertebra the neural arch has moved forward upon the interspace between the first and second sacral bodies, and developes from a lower part of its base a stronger, thicker and longer transverse process, directed outwards and forwards. The third neural arch has its base transferred directly over the interspace of the second and third centrums; the diameters of the base of its transverse processes are three inches and two and a half inches: they incline slightly backwards. The fourth neural arch descends lower down upon the interspace between the third and fourth centrums. The fifth neural arch, as in the Oxford specimen, extends a little way across the interspace between the fourth and fifth centrums, but nearly resumes its ordinary place. The second and third sacral vertebrae are not so regularly convex below in the transverse direction, but their sides converge so as to give a slight indication of a broad obtuse ridge. The diameter of the spinal canal in the first and last sacral vertebrae is one inch.

The five vertebrae are not anchylosed in a straight line, but describe a gentle curve, with the concavity downwards; the series of transverse processes or sacral ribs, forms a curved line in the opposite direction, in consequence of their different positions. The summits of the anchylosed spines being truncated, describe a curve almost parallel with that of the under part of the vertebrae. The contour of the hinder part of the body of the present gigantic carnivorous lizard, doubtless raised high above the ground upon the long and strong hind-legs, must have been different from that of any existing Saurians. In these the relatively shorter hind-legs, being directed more or less obliquely outwards, do not raise the under surface of the abdomen from the ground; it is the greater share in the support of the trunk assigned to the hind-legs in the Megalosaur which made it requisite that, as in land mammals, a greater proportion of the spine should be anchylosed to transfer the superincumbent weight through the medium of the iliac bones upon the femora.

The femur, like the teeth and vertebrae, exhibits a mixture of the characters of the Monitor and the Crocodile. It is arched in two directions, being at first concave in front, and then behind. Its articular head is directed forwards, and has behind it a compressed and rather salient trochanter; it thickens towards the distal end, and there terminates in two unequal condyles. Near its upper third it has an expansion on both the inner and the outer side, like the one which is seen on the internal side of the femur in the Crocodile. The femur of the Monitor is less arched. The medullary canal is wide, which removes the Megalosaur from the Crocodiles, and indicates, as Dr. Buckland has well shown, its aptitude for a more terrestrial life.

The ribs, which from their colour, texture, and proximity of deposit, belong most probably to the *Megalosaurus,* present a double articulation with the vertebral column; the head is supported on a long and strong compressed neck, thickest at its under part; the tuberosity is large. One of the small cervical false ribs is preserved, the free extremity of which gradually tapers to a point.

The scapula is a thin, slightly bent plate, of equal breadth, except where it is expanded and thickened towards the humeral end, but thinning off again towards the articular margin. The chief support of the humerus seems to have been afforded by a large and broad coracoid. The antero-posterior diameter of one of these bones, taken across the median, thin, slightly convex margin, is two feet three inches. The thickened process for the articulation with the scapula has a deep and narrow notch in front, and the deep and wide glenoid cavity for the humerus behind it; the posterior boundary of this cavity projects outwards in the form of an obtuse process. A short but strong process projects from the anterior part of the coracoid analogous to that which in the Varanian Monitors and most other Lizards abuts against the epicoracoids, and which bespeaks the existence of the epicoracoids in the *Megalosaurus.* The characteristic coracoid bone illustrates most unequivocally the affinities of the *Megalosaurus* to the Lacertian group of reptiles; but compared with the coracoid of a Varanian Monitor, four feet nine inches in length, it is sixteen times as large. This magnitude in a reptile, Cuvier justly observes, is quite appalling; for, other proportions being the same, the *Megalosaurus* must have exceeded seventy feet in length.

A long and slender bone, nearly two feet in length, most resembles the clavicle of certain lizards, especially, as Cuvier remarks, those of the great Scincus. It is slightly arcuated longitudinally, subtrihedral in the middle, flattened and expanded at the two extremities. If it be really a clavicle, it forms as characteristic an indication of the Lacertian affinities of the *Megalosaurus* as the coracoid. According to the proportions of the clavicle in existing lizards, Cuvier observes that it bespeaks an animal nearly sixty feet in length.

A subcompressed, three-sided bone, flattened and slightly expanded at one end, thickened and more suddenly extended transversely at the opposite end, which formed part of a large cotyloid cavity, is most likely an ischium; its length is 18 inches; its breadth, at the middle of the shaft, 5 inches; at its articular end 9 inches, the thickness of this end being 4 inches. The ascending shaft of this bone is slightly twisted, convex and smooth on the outer side, flat and rough on the inner side.

Other bones, not improbably belonging to the *Megalosaurus,* are preserved in the British and Oxford Museums, and in the private collections of Messrs. Holmes and Saull; but further evidence of their Megalosaurian character must be obtained before a description of them can be profitably applied to the reconstruction of the skeleton of the present carnivorous Dinosaur.

A few words, however, may be added, touching the size of the *Megalosaurus;* for it appears to me that the calculations which assign to it a length of 60 and 70 feet are affected by the fallacy of concluding that the locomotive extremities bore the same proportion to, and share in the support of, the body, as they do in the small modern land lizards.

The most probable approximation to a true notion of the actual length of the *Megalosaurus*, is that which may be obtained by taking the length of the vertebrae as the basis. The antero-posterior dimension is the most constant which the vertebrae present throughout the spine: in most Crocodilian and Lacertian reptiles the cervical vertebrae are a little shorter than the dorsal; but these are of equal length, and the caudal vertebrae maintain the same length to very near the extremity of the tail.

As the dorsal vertebrae of the *Megalosaurus* agree, in the important character of the mode of articulation of the ribs, with the Crocodiles, it may be regarded as most probable that they also corresponded in their number. This does not exceed 14 in recent Crocodiles, nor 16 in any of the known extinct species; taking, then, the latter number, and adding to it 7, the usual number of the cervical vertebrae in Crocodiles, we may allow the *Megalosaurus* 23 vertebrae of the trunk.

The length of the body of a large dorsal vertebra of the *Megalosaurus* in the British Museum is $4\frac{1}{2}$ inches: from the analogy of the *Iguanodon,* in which several dorsal vertebrae have been discovered in their natural juxtaposition, it is probable that the thickness of the intervertebral substance did not exceed one-third of an inch: but if we multiply 23 by 5, not allowing for the probable shortness of the cervical vertebrae, we only then attain a length of 9 feet 7 inches. If, however, setting aside the analogy of the *Megalosaurus* to the Crocodiles in the structure of the vertebrae, we take that species of Lacertian which it most resembles in the structure of the teeth, and found our calculation on the number of vertebrae of the trunk in such lizard, then, the great carnivorous Varanian Monitor of Java having 27 vertebrae of the trunk, we do not, even calculating the same number of vertebrae to have occupied each a space of five inches in the *Megalosaurus,* obtain a length of trunk exceeding 11 feet 3 inches.

I should consider the first calculation, or about 10 feet, to have been the most probable natural length.

To this we must add I foot 10 inches for the known length of the sacrum. Thus 12 feet will be a fair or even a liberal allowance of length from the occiput to the beginning of the tail. In Crocodiles the skull equals about 12 dorsal vertebrae in length. In the Java Monitor the proportion of the head is less. In the Iguana the cranium does not exceed 6 dorsal vertebrae in length.

We may consider therefore 5 feet, taking the Crocodile as the term of comparison, as probably not below the length of the head of the Megalosaur. With regard to the tail, this includes between 36 and 38 vertebrae in Crocodilians, but varies from 30 to 115 in the small existing Lacertians, in many of which it is a prehensile organ, aiding them in climbing and other actions suitable to their size. It is very improbable that the tail should have presented such unusual proportions in the great Saurian under consideration, and indeed very few caudal vertebrae of the Megalosaur have been as yet discovered, and none exceeding 4 inches in length. Allowing the Megalosaur to have had the same number of vertebrae as the Crocodile, and multiplying this number 36 by $4\frac{1}{2}$, a length of 12 feet 6 inches is thus obtained for the tail. A calculation on this basis thus gives, in round numbers,

Length of head	5 feet
Length of trunk, with sacrum	12 feet
Length of tail	13 feet
Total length of the *Megalosaurus*	30 feet

Upon this mode of obtaining an idea of the bulk of the present extinct reptile I am disposed to place the greatest reliance, and conceive that any error in it is more likely to be on the side of exaggeration than of curtailment. From the size and form of the ribs it is evident that the trunk was broader and deeper in proportion than in modern Saurians, and it was doubtless raised from the ground upon extremities proportionally larger and especially longer, so that the general aspect of the living Megalosaur must have proportionally resembled that of the large terrestrial quadrupeds of the Mammalian class which now tread the earth, and the place of which seems to have been supplied in the oolitic ages by the great reptiles of the extinct Dinosaurian order.

Besides the Stonesfield slate, the remains of the *Megalosaurus* have been found in the Bath oolite immediately below that slate, and in the cornbrash above it. The other formation, in which the remains of the Megalosaur occur, next in importance to the Stonesfield slate, is the Wealden strata. Dr. Mantell has discovered in the ferruginous clay of the Forest of Tilgate a fine vertebra, and a portion of the femur of the *Megalosaurus,* 22 inches in circumference. Many teeth have been discovered altogether of the same form as those found by Dr. Buckland. Some fragments of the metacarpus and metatarsus from this locality, were thicker than those of a large hippopotamus. Mr. Holmes, surgeon at Horsham, possesses a good caudal vertebra, and some other parts of the *Megalosaurus* from the ferruginous sand near Cuckfield in Sussex. Remains of the *Megalosaurus* occur in the Purbeck limestone at Swanage Bay. In some of the private collections in the town of Malton, Yorkshire, are teeth, unquestionably belonging to the same species as the Stonesfield *Megalosaurus,* from the oolite in the neighbourhood of that town.

The tooth from the New Red Sandstone of Warwick figured in the Memoir by Messrs. Murchison and Strickland,[7] and referred to the *Megalosaurus,* belongs to another genus of Lacertian, more nearly allied to the *Palaeosaurus* of the Bristol conglomerate.

Hylaeosaurus

A second well-marked genus of Dinosaurian Reptiles is founded upon a large portion of the skeleton of the reptile to which the name at the head of this section has been applied by its discoverer, Dr. Mantell.

In assigning to this genus its present place in the Dinosaurian order, I have been guided by the structure of the vertebral column, especially the sacrum, and by the following considerations. The distinct alveoli in the jaws of the *Megalosaurus,* and the resemblance of its teeth to those of two extinct Crocodilians, viz. the Argenton species and the *Suchosaurus,* seemed to claim for that great carnivorous Dinosaur the next place to the Crocodilian order, among which the *Streptospondylus,* as has been shown, seemed to make the closest approximation to the *Megalosaurus,* in the great height, complexity and strength of the neural arch of the vertebrae. In the present genus, which there is good reason for believing to have resembled the Lizards more than the Crocodiles in its dental characters, an affinity to the Loricate Sauria is manifested not only by the structure of the vertebrae and ribs common to it with other Dinosaurs, but likewise by the presence of dermal bones, or scutes, with which the external surface was studded.

The *Hylaeosaurus* has not been made known like the *Megalosaurus,* from detached parts of the skeleton successively discovered and analogically recomposed, but was at once brought into the domain of Palaeontology by the discovery of the following parts of the skeleton in almost natural juxtaposition: viz. the anterior part of the trunk, including ten of the anterior vertebrae in succession, supporting a small fragment of the base of the skull; the two coracoids, the coracoid extremities of both scapulae, detached vertebrae, several ribs more or less complete, and some remarkable parts of the dermal skeleton, including, apparently, enormous vertical plates or spines, arranged, as is supposed, in the form of a median dorsal ridge or crest of singular dimensions.

In the fragment of the cranium may be distinguished the pterygoid elements of the sphenoid bone, the inner margins of which touch anteriorly and then recede as they pass backwards, leaving a heart-shaped posterior nasal aperture, the apex of which is turned forwards. The breadth of this aperture is 1 inch 3 lines: its posterior position gives another character, by which the present Dinosaur, and probably the larger genera, of the same order, resembled the Crocodiles more than the Lizards.

The bodies of the vertebrae are shorter in proportion to their breadth than in the *Megalosaurus* or *Iguanodon.* They have not so smooth and polished a surface as in the *Megalosaurus,* nor are they so contracted in the middle, or so regularly rounded below from side to side; a few of the anterior vertebrae are somewhat flattened below, so as to present an obscurely quadrate figure; most of the anterior dorsals are more compressed and keel-shaped below: the sacral and caudal vertebrae are longitudinally sulcated at their under surface.

The structure of the atlas and axis cannot be discerned in the Mantellian specimen; the second (conspicuous) cervical vertebra has its sides subcompressed, its under surface flattened, and the anterior part of the slight angular ridges separating it from the concave lateral surfaces, are produced anteriorly into two feebly-marked tubercles. The inferior transverse processes are developed from each side of the anterior part of the body of the vertebra; they are subcircular, very slightly prominent, about 7 lines in diameter.

In the fourth (conspicuous) vertebra, a large proportion, but not the whole, of a costigerous transverse process is developed from each side of the anterior part of the body, with the costal surface directed obliquely outwards and forwards. There is a small costal surface at the side of the expanded posterior extremity of the same vertebra, against which a part of the head of the fourth rib abuts; that and three of the succeeding ribs having their heads applied over the interspace of two contiguous vertebrae, as nearly throughout the thoracic region in Mammalia. The lateral compression of the centrum increases in the sixth and seventh (conspicuous) vertebrae, in which the under surface forms an obtuse ridge; in the eighth vertebra this surface is broader. In none of these vertebrae is a process developed from the under surface as in the hinder cervical and anterior dorsal vertebrae of the Crocodiles.

The most striking character of the vertebrae of the *Hylaeosaurus* is the great development of the neural arch and its processes. The anterior articular processes extend (in the anterior dorsal and cervical vertebrae) over half the centrum next in front, and a broad upper transverse process is developed from the side of the neurapophysis and along its anterior continuation: this transverse process extends horizontally outwards, is notched anteriorly, and contracts to an obtuse point against which the tubercle of the rib articulates: the transverse processes are flat transversely, slightly concave lengthwise, and smooth below: they increase in length and strength as the vertebrae extend along the trunk; and the ribs, which they contribute to support, exhibit a still more rapid increase: the ribs present, as in the other Dinosaurs and Crocodiles, a bifurcated vertebral end for the double articulation above described.[8] The neck and head of the rib corresponding with the seventh conspicuous vertebra is 2 inches 2 lines in length; the tubercle, or upper head, is 10 lines long; the breadth of the rib at the point of bifurcation is 1 inch 1 line. The neck of the eighth rib has the same length as that of the seventh, but is twice as thick and strong; the tubercle is broader but shorter. Beyond the tubercle the shaft of the rib is bent at right angles with the neck. This soon begins to shorten, and the shaft of the rib to lengthen, until it becomes attached solely to the transverse process.

In the dorsal vertebrae the body increases in all its proportions, excepting its length. The lateral compression now manifests itself at the upper part of the centrum just below the neurapophysial suture; the under surface of the posterior dorsal and lumbar vertebrae is convex transversely, but in a less degree than in the *Megalosaurus,* and in some, it is obscurely carinated. The external surface at the middle contracted part of the vertebra is moderately smooth, but the minute striae give it a somewhat silky lustre; it is longitudinally but irregularly ridged and grooved near the articular ends. These are both slightly concave at the centre, more slightly convex near the circumference. The difference between the vertebrae of the Hylaeosaur and the bi-concave Crocodilian vertebrae is chiefly manifested in the development of the neural arch. The modification of this part in the cervical vertebrae has already been mentioned. In the dorsal vertebrae each neurapophysis rises vertically, contracting in the axis of the vertebra, expanding transversely or outwardly, until it has attained a height equal to that of the centrum; there it expands into a broad and flat platform, from the middle line of which the broad spine is developed. A vertically compressed but strong transverse process is developed from the side of the neurapophysis, and is supported by a pyramidal underprop, extending upwards and outwards from the anchylosed base of the neurapophysis. There is a large, deep and smooth depression on each side of the base of the transverse process. The anterior surface of the neural arch, above the anterior oblique processes, is traversed by a vertical ridge, on each side of which there is a shallow depression.[9] The spinous process is of unusual thickness, its transverse breadth at the base measures 1 inch: this modification may probably relate to the support of great dermal spines. The spinal canal in the dorsal vertebrae is cylindrical, and expanded at both extremities; its diameter at the middle is 7 lines, at the expanded outlets 10 lines, in a posterior dorsal or lumbar vertebra. Here the bases of the neurapophyses begin to shorten, and leave a small proportion of the upper surface of the centrum uncovered at both ends, chiefly at the posterior end.

The following are dimensions taken from three of the vertebrae of the *Hylaeosaurus:*

	Second conspicuous cervical		Fourth conspicuous cervical		Middle dorsal	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of body	1	10	2	2	2	9
Vertical diameter of its articular end	0	0	1	6	2	6
Transverse diameter of its articular end	2	0	2	2	3	0
Transverse diameter of middle of body	0	0	0	0	2	0

The differences between the vertebrae of the *Hylaeosaurus* and *Megalosaurus* have been already pointed out, and are further shown in the admeasurements given above: the vertebrae of the *Hylaeosaurus* differ from those of the *Iguanodon* in their greater transverse diameter, and in the breadth of their under part; those of the *Iguanodon* are flatter vertically along their whole sides, which converge to a narrower ridge at the under part. The vertebrae of the *Hylaeosaurus* differ from those of the *Streptospondylus* in the sub-biconcave character of the articular ends of the centrum, and in its comparative shortness and thickness: the separated neural arch might be distinguished from that of the *Streptospondylus* by the simplicity of the supporting buttress of the transverse process; and, although equal in height, yet it is superior in the expansion and strength of the platform and spinous process.

Sacrum

There is a portion of a sacrum of a small or young Dinosaur (No. 484/2484, Mantellian Collection), which, in the form and proportions of the bodies of the vertebrae, most resembles the present genus, and cannot be referred to *Megalosaurus* or *Iguanodon.* It includes two entire and parts of two other vertebral bodies, anchylosed together, and to the bases of the neurapophyses; which, as in the *Megalosaurus,* are transferred to the upper and lateral parts of the interspaces of the subjacent bodies. These are moderately, but regularly, contracted in the middle and chiefly laterally, being more flattened below, where likewise each is traversed by a longitudinal sulcus. At the middle of each lateral concavity there is a vascular perforation. I am uncertain which is the anterior part of this interesting series; but, by the analogy of the *Megalosaurus,* conclude that vertebra which supports the greatest proportion of its neural arch, to be posterior to the adjoining one which supports the remaining small proportion. On this basis also I assume that the anterior sacral vertebra is deficient, if we may allow five to the Hylaeosaur as to the other Dinosaurs.

The second sacral vertebra, then, is here broken across the middle of the body, exposing its solid minutely cellular central structure: its neural arch is too mutilated for profitable description: its base rests nearly equally on the second and third sacral bodies. The third neural arch, which exhibits a similar relative position, has its base extended half way down the interspace; its strong transverse process extends outwards and forwards, and is at first contracted, then expands both transversely and vertically, most so in the latter direction, and is twisted obliquely, so that the lower end is directed downwards and forwards, and the upper and thicker end is bent obliquely backwards, until it meets and becomes anchylosed to the anterior production of the transverse process of the next vertebra behind: an elliptical space is thus produced, the axis of which is nearly vertical, and into this space the neural canal opens; the nerve being transmitted over the middle of the body of the vertebra, as in the sacrum of the *Megalosaurus.*

The upper and inner part of the base of the broad, oblique transverse process, or sacral rib, abuts against the base of the spinous process. There is no appearance of accessory spines such as the sacrum of the *Megalosaurus* is complicated with.

The following are admeasurements of the present portion of the sacrum of the *Hylaeosaurus:*

	In.	Lin.
Length of the body of the third vertebra	2	0
Breadth of its articular end	2	0
Breadth of its middle part	1	4
Breadth of its inferior groove	0	4
Length of the transverse process	1	10
Antero-posterior diameter of the middle of process	0	4
Vertical diameter of base of process	1	6
Vertical diameter of expanded extremity	3	0
From the lower part of centrum to the origin of the spinous process	2	6

The spines appear to be anchylosed into a continuous ridge.

The anterior surface of the transverse process appears undulated by wide shallow depressions and intervening elevations.

Caudal Vertebrae

A proportion of the tail, to the extent of nearly six feet, and including about twenty-six vertebrae, discovered in a quarry in Tilgate Forest in the year 1837, is preserved in the Mantellian Collection. The transverse processes present almost Crocodilian proportions, in regard to their length, at the anterior part of this series, and may be discerned, though diminished to mere rudiments, in the small terminal vertebrae of the series. In the most perfect of the anterior vertebrae they are compressed vertically, but with convex, not flattened sides, and rounded edges, presenting an elliptical transverse section, and preserving the same breadth to their truncated extremity: they extend outwards, and are slightly bent forwards: the breadth of this vertebra between the extremities of the transverse processes is 11 inches. The neurapophysis is curved forwards from the base of the transverse process to form the anterior oblique process: its length from the extremity of this process to that of the posterior one is $3\frac{1}{2}$ inches. The neurapophysis presents a simple convex external surface to the base of the spine: the antero-posterior extent of this process is two inches. The chevron bones are from four to five inches in length near the base of the tail; they may be distinguished, like the transverse processes, by their convex external surface; their base is open, not confluent as in the *Iguanodon,* and articulated to two distinct tubercles. Between these tubercles, which are placed at each end of the under surface of the centrum, there is a longitudinal sulcus. The transverse processes soon lose the slight anterior curve, stand straight out, decrease, in length, and descend from the neurapophysis to the centrum as the vertebrae approach the end of the tail.

The chevron bones also decrease in length, but they expand in the antero-posterior direction at their unattached and dependent extremity, which is defined by a slight convex outline. The following admeasurements give the rate of decrease in length in the caudal vertebrae, taken at intervals of six joints:—

	In.	Lines
Length of body of presumed 8th caudal	2	6
Length of body of presumed 14th caudal	2	4
Length of body of presumed 20th caudal	2	2

The sides of the slender posterior vertebrae are distinguished by a slight median expansion below the base of the rudimental transverse process, so that the surface, instead of being gently concave lengthwise, undulates by virtue of the middle elevation. I have not met with this character in the corresponding vertebrae of other Saurians. In the vertical direction the sides of the centrum in the posterior caudals converge at almost a right angle to the inferior groove. The greater breadth of the centrum, in proportion to its height, may still be discerned in the terminal caudal vertebrae: thus in the centrum 2 inches 2 lines long, the breadth was 1 inch 10 lines, and the height only 1 inch 3 lines.

Dermal Scutes

Unequivocal evidence that a dermal skeleton, analogous to that in the recent Crocodiles, was developed in the *Hylaeosaurus,* was afforded by the discovery of bony scutes in the mass of vegetable matter removed in clearing the portion of the skeleton first described. Some of these detached bony plates still adhere to the caudal vertebrae, and may be observed to decrease in size as they approach the end of the tail. From their form, which is elliptical or circular, and from the absence of any surface indicating the overlapping of an adjoining scute, it may be inferred, that the bony plates in question studded in an unconnected order the skin of the Hylaeosaur. The diameter of the largest of these scutes does not exceed three inches; the smallest present a diameter of one inch. They are flat on the under surface, convex with the summit developed into a tubercle in the smaller specimens, but which is less prominent in the larger ones: the outer surface is studded all over by very small tubercles: the inner surface presents the fine decussating straight lines, already noticed in the scutes of the *Goniopholis.*

By the kindness of Dr. Mantell, I have been favoured with the means of submitting the structure of a dermal scute to microscopical examination.

The medullary canals, which are stained brown, as if with the hematosine of the old reptile, differ from those of ordinary bone in the paucity or absence of concentric layers. They are situated in the interspaces of straight opake decussated filaments, which frequently seem to be cut short off close to the medullary canals. Very fine lines may be observed to radiate from some of the medullary canals: irregularly shaped, oblong and angular radiated cells are scattered through most parts of the osseous tissue, but they present less uniformity of size than do the Purkinjian cells in ordinary bone. The most striking characteristics of the dermal bone are the long straight spicular fibres which traverse it and decussate each other in all directions, representing, as it seems, the ossified ligamentous fibres of the original corium.

Dermal Spines?

On the left side of the thorax, partly overlying the left scapula and vertebral ribs, in the large slab of stone containing the anterior part of the skeleton, there are some large elongated, flattened pointed plates of bone, three of which seem to follow each other in natural succession. The length of the first of these plates is seventeen inches, the breadth of the base five inches, equal to the antero-posterior diameter of two vertebrae: they decrease somewhat rapidly in length, the second being fourteen inches long and the third eleven inches long; but slightly increase in breadth.

These remarkable bones are regarded by Dr. Mantell[10] as having formed part of a serrated fringe extended along the back of the animal, analogous to that of the *Cyclura* Lizard. This ingenious suggestion carries with it so high a degree of probability, that I had not thought of comparing the bones in question with any other part of the skeleton, until my attention was arrested by observing a want of symmetry in the form of the most perfect of them. They are nearly flat, but along the middle present a slight degree of concavity towards the observer, which, however, may be paralleled by a similar concavity on the opposite side buried in the stone; but the anterior or convex margin inclines from the middle line towards the concave side. With regard to their relative position to the rest of the skeleton, it must be observed that the ventral surface of this is exposed; so that the under parts of the bodies of the vertebrae are towards the observer, and their spines imbedded in the matrix. The coracoid and scapular arch are placed, as might be expected in a skeleton little disturbed and lying on its back, with their under surfaces towards the observer, and covering, like a buckler, a portion of the vertebrae and ribs. In this position we might look for a portion of the apparatus of the sternal or abdominal ribs, in the hope of discerning the modifications of these variable parts which might characterize a genus differing in many peculiarities from other known Saurians. Now it is with the apparatus of abdominal ribs, which present such a diversity of characters in other Saurians, that it may be useful to compare the long flattened bones in question, as well as with the supporting bones of a dorsal crest, in the event of a future discovery of a skeleton or portion of skeleton of the *Hylaeosaurus* including these bones. The objection to their being abdominal ribs, which may be founded on their great relative breadth as compared with those ribs in other Saurians, and especially with the vertebral ribs of the *Hylaeosaurus* itself, deserves due consideration; but the same objection applies to the bones in question as compared with the superadded spines in the Lizard with a dorsal fringe, or with the spines of the vertebrae themselves in the *Hylaeosaurus.* For the dorsal dermal spines in the *Cyclura* correspond in number with the spines of the vertebrae which support them, while the base of each of the hypothetical dermal spines of the Hylaeosaur extends over more than two vertebrae.

In the *Monotremata* (*Ornithorhynchus* and *Echidna*) the abdominal ribs are as much broader than the vertebral ribs as they would be in the *Hylaeosaurus,* on the costal hypothesis of the detached bony plates here suggested; and, after the close repetition, in the *Ichthyosaurus,* of another of the remarkable deviations in those aberrant Mammals from the osteological type of their class, viz. in the structure of their sternal and scapular arch, the reappearance of the monotrematous modification of the sternal ribs in the present extinct reptile would not be surprising. The want of symmetry and the difference of size and form, above alluded to, in the four succeeding spine-shaped plates, agree better with the costal than the spinous hypothesis.

Whether the bones in question be dorsal spines or abdominal ribs, they have evidently been displaced from their natural position in the partial disarticulation of the entire skeleton prior to its immersion in the mud that has been subsequently hardened around it; but the degree of displacement has not been greater in the one case than in the other.

In offering, with due diffidence, a choice of opinions respecting the nature of these singular bones, I have been actuated solely with the view of accelerating the acquisition of the true one, which, it is obvious, will be more likely to be attained by the choice being present to the mind of subsequent fortunate discoverers of these remains of the *Hylaeosaurus,* than if they were solely preoccupied by the hypothesis of the dorsal fringe. For example, it may lead to more careful noting of the constancy or otherwise of the unsymmetrical inclination of the convex margin of the spine, and whether they form, or are disposed in, pairs; which, on the costal hypothesis, may be expected, in the event of another skeleton being discovered.

Bones of the Extremities

Scapular Arch

The scapula of the *Hylaeosaurus*[11] is longer and narrower than in the Monitors and Iguanas, adhering in this respect to the Crocodilian type, but most resembling in the shape of its blade or body, that of the genus *Scincus.* It differs, however, from the scapulae of all known reptiles, and indicates an approach to the Mammalian type, by the production of a strong obtuse acromial ridge, separated by a deep and wide groove from the humeral and coracoid articular surfaces. The blade of the scapula is long, flattened, slightly convex on the inner and proportionally concave on the outer surface: the anterior margin is convex, the posterior one concave; the upper extremity or base truncate, slightly convex, with the posterior angle a little produced, the anterior angle rounded off. On the outer side of the scapula two broad convex ridges descend and converge to form the beginning of a thick and strong spine, at fourteen inches distance from the base; this then expands into the thick acromial ridge, which extends transversely, and is continued forwards as a long subprismatic process from the anterior angle of the head of the scapula. This process, which appears likewise to be present in the scapula of the *Iguanodon,* perhaps also in the *Megalosaurus,* is broken off in the present specimen about four inches from the neck of the scapula, with which it forms a right angle. The acromion is perforated at the base of its anterior prolongation by a foramen analogous to the supraspinal one in the scapula of the Edentate Mammalia. Besides the scapulae preserved in the connected part of the skeleton, there is, in the Mantellian Museum, a nearly entire and detached scapula of larger size, discovered, in connexion with many other bones of the skeleton, in a layer of blue clay near Bolney in Sussex, and indicating the connected part of the skeleton first discovered in 1832 to have belonged to an immature individual. The dimensions of this scapula are as follows:

	In.	Lines
Length of the scapula	18	0
Breadth of its base	8	0
Breadth of its neck	3	9
Thickness of its base	1	0
Thickness of its neck	2	6
Breadth of subacromial groove	2	0
Breadth of humeral articulation	4	0
Breadth of coracoid articulation	2	6

The *coracoids* present a much more simple form than in the *Megalosaurus,* and resemble those of the Scink and Chameleon, thus deviating in their great breadth, like the coracoids of the Enaliosaurs, from the Crocodilian type. In the portion of the skeleton the right coracoid is slightly bent out of place and thrust under the left one; and there is no trace of a sternal or entosternal bone in their interspace. The median margin of the coracoid describes an uninterrupted and full convex curve commencing at the angle dividing it from the scapular articular surface; but it is separated by a concavity or emargination from the articular surface for the humerus. It is perforated by a moderate sized elliptical canal, about two inches from the humeral articulation, and in this respect resembles the same bone in the Iguana, Monitors and Lizards, and differs from the Scinks and Chameleon. The antero-posterior extent of the coracoid in the connected portion of skeleton is eight inches; its transverse diameter five inches.

A humerus, and a phalangeal bone found with the scapula, near Bolney, are figured by Dr. Mantell in the Memoir of 1841.

Teeth of the *Hylaeosaur?*

With regard to the *Hylaeosaurus* Dr. Mantell observes, in his latest geological work, "the teeth are unknown; but in the quarries where the bones of that reptile were discovered, I have found teeth of a very peculiar form, which appear to have belonged to a reptile, and are entirely distinct from those of the *Megalosaurus, Iguanodon,* Crocodile and *Plesiosaurus,* whose remains occur in the Tilgate strata."[12] The form and structure of these teeth, which will be presently described, deviate too much from those of the Crocodilian family to make at all probable a reference of them to the genera *Poikilopleuron, Streptospondylus,* or *Cetiosaur,* which are much more closely allied to the Crocodilians than is the Hylaeosaur. In the 'Geology of the South-east of England,' Dr. Mantell attributes these teeth, on the authority of M. Boué, to the *Cylindricodon,* a name by, which Dr. Jäger distinguishes one of the species of his genus '*Phytosaurus.*' I have been favoured by Dr. Jäger with one of the bodies supposed to be the teeth of the *Cylindricodon* of the Wirtemberg Keuper, but it is merely the cast of a cylindrical cavity, consisting entirely of that mineral substance, without a trace of dental structure. The difference of form between the Wealden teeth now under consideration, and those on which the *Phytosaurus cylindricodon* of Jäger was founded, is pointed out in detail in my Odontography, and has been likewise appreciated by the estimable Palaeontologist, M. Fischer de Waldheim, by whom their resemblance to certain Saurian teeth from the Ural Mountains, belonging to the genus *Rhopalodon,*[13] is indicated. From these teeth, however, the presumed Hylaeosaurian teeth differ in having thick and flat instead of serrated coronal margins. The following is Dr. Mantell's original description of the teeth in question:

"These teeth are about an inch and a quarter in length, and commence with a subcylindrical shank, which gradually enlarges into a kind of shoulder, terminating in an obtuse angular apex, the margins of which are more or less worn, as if the teeth had been placed alternately so as to meet at their edges, as in pl. ii, fig. 3. They are obscurely striated longitudinally, and have a thick coat of enamel: the crown of the tooth is solid, but the shank is more or less hollow. All the specimens appear as if they had been broken off close to the jaw; but they may have been separated by necrosis occasioned by the pressure of the supplementary teeth."[14]

The following is the result of a microscopical examination of these teeth. The tooth consists of a body of dentine covered by a thick coating of clear structureless enamel, and surrounding a small central column of true bone, consisting of the ossified remains of the pulp, which presents the usual characters of the texture of the bone in the higher reptiles. The dentine differs, like that of existing Lacertians, from the dentine of the *Iguanodon* in the entire absence of the numerous medullary canals which form so striking a characteristic of the more gigantic Wealden reptile. The main calcigerous tubes are characterized by the slight degree of their primary inflections; they are continued in an unusually direct course from the pulp-cavity to the outer surface of the dentine, at nearly right angles with that surface, but slightly inclined towards the expanded summit of the tooth. They are chiefly remarkable for the large relative size of their secondary branches, which diverge from the trunks in irregular and broken curves, the concavity being always towards the pulp-cavity. In most parts of the tooth, the number of these branches obscures even the thinnest sections.

The ossified pulp exhibits the parallel concentric layers of the ossified matter surrounding slender medullary canals, and interspersed with irregular elliptical radiated cells.

Jaw of the *Hylaeosaurus?*

No. 422/2422, in the Mantellian Collection, is a portion of the right ramus of the lower jaw, with characters distinguishing it from that of any other known Saurian; as, for example, its degree of curvature, indicating the lower jaw to have been bent down in an unusual degree, and the remarkable inequality of its external surface. This fragment is about three inches long, one inch seven lines deep at the hind part, and one inch five lines deep at the fore-part; flattened and smooth at the inner side, but having the outer side raised by the termination of a strong angular ridge at its lower and hinder part, and by a rough convex longitudinal ridge extending along its upper part; the surface of the jaw being concave above and below this ridge. The lower margin is thick and convex; the upper one is formed by a regular series of pretty close-set sockets, with the internal alveolar wall broken away, displaying their partitions; but with the outer wall entire, thin and slightly crenate at its upper margin.

At the hind part of this fragment the anterior extremity of the opercular piece is preserved; the rest is formed exclusively by the dentary piece: the area of the wide conical cavity in the interior of the jaw is exposed at the back part of the fragment; its apical termination is near the fore part. A succession of large vascular canals open obliquely forwards in the concavity above the upper oblique longitudinal ridge. The whole of the outer surface is minutely ridged and punctate.

The depth of the sockets bears a smaller proportion to that of the jaw than in modern Lacertians or Crocodiles, being about one-fourth of that depth: the partitions of the sockets, which are very regular in their breadth and depth, though they are more prominent than in the pleurodont Lizards, yet exhibit a fractured margin; there is no trace of a smooth natural surface of the bone in the interspace of the sockets; and at the part where the inner wall has been least mutilated, it nearly completes the socket and incloses the long and slender fang of the tooth. Whence, I conclude, that the entire jaw of the extinct reptile would have exhibited a series of true sockets, not depressions merely, as in the present mutilated fragment, and that it would have agreed with the *Megalosaurus* in presenting the thecodont mode of attachment of the teeth.

The crowns of all the teeth are broken off; the small sockets of reserve, exposed at the inner side of the base of the old sockets, do not contain any evidence of the species to which this fossil has belonged. In the absence of this characteristic part of the tooth, an element in guiding our choice between the *Iguanodon* and *Hylaeosaurus* is given by the breadth of the interspaces of the sockets; these must bear relation to the breadth of the crowns of the teeth, if we suppose that they were in contact throughout the series, as in Lacertians. Now the teeth of the *Iguanodon,* and those which I have referred to the *Hylaeosaurus,* differ in a marked degree in the breadth of the crown. The complicated and expanded crown of the Iguanodon's tooth is supported on a narrower stem; and the stems or fangs, if the crowns were in contact without overlapping, must have been separated by interspaces of proportional breadth, viz. twice their own breadth; but the thickness of the crown of the tooth of the *Iguanodon* renders it very unlikely that they did overlap each other. Now the crowns of the teeth of the Hylaeosaur are expanded to such an extent, as, if in contact to require an interspace of the fangs, not broader than the fangs themselves; and the interspaces of the fangs in the fragment of jaw under consideration correspond with crowns of this breadth. The fangs of the teeth in the *Iguanodon* are conical, and more or less angular; in the teeth presumed to belong to the Hylaeosaur the fangs are cylindrical; the sockets in the present fragment correspond with the latter form.

In my Odontography[15] I adopted the opinion of Dr. Mantell[16] respecting the present fossil; but subsequent examination and consideration of its characters have led me to a different conclusion. It might, nevertheless, be urged that the teeth of the young *Iguanodon* may exhibit such modifications as would affect the validity of the objections here offered; but these, I think, establish the greater probability that the jaw, in question originally contained teeth of the form of those that I have referred to the *Hylaeosaurus.*

The remains of the *Hylaeosaurus* have been discovered in the Wealden formation in the following localities: Tilgate Forest, Bolney and Battle.

Iguanodon mantelli, Cuv.

The bones of an enormous reptile, successively discovered in the Wealden strata by Dr. Mantell, interpreted by their discoverer with the aid of Cuvier and Clift,[17] named *Iguanodon* by Conybeare,[18] lastly found in juxtaposition to the extent of nearly half the skeleton, in the greensand quarries of Mr. Benstead, offer not the least marvelous or significant evidences of the inhabitants of the now temperate latitudes during the earlier oolitic periods of the formation of the earth's crust.

With vertebrae sub-concave at both articular extremities, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterized in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch and unusually large bones of the extremities excavated by large medullary cavities and adapted for terrestrial progression;—the *Iguanodon* was also distinguished by teeth, resembling in shape those of the Iguana, but in structure differing front the teeth of every other known Reptile, and unequivocally indicating the former existence, in the Dinosaurian Order of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

Of this remarkable Reptile, the results of personal examination of almost all the recognisable remains that have hitherto been collected in public or private museums, are here given.

Teeth

The value of the ordinary external characters of the teeth of the oviparous Vertebrata has never perhaps been placed in so striking a point of view as in the leading steps to the discovery of the *Iguanodon,* which cannot be better recounted than in the words of Dr. Mantell.

After noticing the ordinary organic remains which characterize the sandstone of the Tilgate Forest, and his discovery, in the summer of 1822, of other teeth distinguished by novel and remarkable characters, the indefatigable explorer of the Wealden proceeds to state,[19]—

"As these teeth were distinct from any that had previously come under my notice, I felt anxious to submit them to the examination of persons whose knowledge and means of observation were more extensive than my own. I therefore transmitted specimens to some of the most eminent naturalists in this country and on the continent. But although my communications were acknowledged with that candour and liberality which constantly characterizes the intercourse of scientific men, yet no light was thrown upon the subject, except by the illustrious Baron Cuvier, whose opinions will best appear by the following extract from the correspondence with which he honoured me:—

"'Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles; à l'apparence extérieure on pourrait aussi les prendre pour des dents de poissons, analogues aux tetrodons, ou aux diodons; mais leur structure intérieure est fort différente de celles-là. N'aurions-nous pas ici un animal nouveau, un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal unique, jusqu'à présent, dans son genre. Le temps *con*firmera ou *in*firmera cette idée, puisqu'il est impossible qu'on ne trouve pas un jour une partie de la squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance.'"

["'These teeth are certainly unknown to me; they are not from a carnivorous animal; however, given their lack of complication, the serration on the edges, and the thin film of enamel which covers them, I am led to believe that they belong to the order of reptiles. Their external appearance could also suggest fish teeth similar to tetrodons, or to diodons; but their interior structure is very different from these. Do you not agree that it looks as if we have here a new animal, a herbivorous reptile? And just as today in the terrestrial mammals, it is among the herbivores that one finds the species of larger size, so in the reptiles of former times, when they were the only terrestrial animals, would not the largest of them have been nourished by vegetation? Part of the large bones that you possess would belong to this animal, which is unique, as of now, in its kind. Time will prove or disprove this idea, since it seems impossible that one will not find eventually a part of the skeleton joined together with portions of the jaws bearing the teeth. It is this last objective especially that it is a question of seeking with the utmost perseverance.'"]

"These remarks," Dr. Mantell proceeds to say, "induced me to pursue my investigations with increased assiduity, but hitherto they have not been attended with the desired success, no connected portion of the skeleton having been discovered. Among the specimens lately collected, some, however, were so perfect, that I resolved to avail myself of the obliging offer of Mr. Clift (to whose kindness and liberality I hold myself particularly indebted), to assist me in comparing the fossil teeth with those of the recent Lacertae in the Museum of the Royal College of Surgeons. The result of this examination proved highly satisfactory, for in an Iguana which Mr. Stutchbury had prepared to present to the College, we discovered teeth possessing the form and structure of the fossil specimens."

The important difference which the fossil teeth presented in the form of their grinding surface was afterwards pointed out by Cuvier,[20] and recognized by Dr. Mantell,[21] and the combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain, by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This I have endeavoured to do in my general description of the Teeth of Reptiles,[22] from which the following account is abridged.

The teeth of the *Iguanodon,* though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted, while the crown is expanded, and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel, but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive ridge; these are separated from each other and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations, which, at first sight, appear to be simple notches, as in the Iguana, present under a low magnifying power the form of transverse ridges, themselves notched, so as to resemble the mammillated margins of the unworn plates of the elephant's grinder; slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown: the longitudinal ridges are continued further down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; it then diminishes in breadth, but its thickness goes on increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillae, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur: such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon.*

The apex of the tooth soon begins to be worn away, and it would appear, by many specimens, that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations: the adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathrariae* and similar plants, which are found buried with the *Iguanodon,* is pointed out by Dr. Buckland, with his usual felicity of illustration, in his 'Bridgewater Treatise,' vol. i, p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface, and now another dental substance is brought into use to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

The marginal edge of the incisive condition of the tooth and the median ridge of the molar stage are more effectually established by the introduction of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguana and other reptiles, and more easily worn away: this is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the calcigerous tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp-cavity, and are confined to the dentine forming the corresponding walls of the tooth: their diameter is 1/1250th of an inch: they are separated by pretty regular intervals equal to from six to eight of their own diameters; they sometimes divide once in their course. Each medullary canal is surrounded by a clear space; its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The calcigerous tubes present a diameter of 1/25,000th of an inch, with interspaces equal to about four of their diameters. At the first part of their course, near the pulp-cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. When viewed in a longitudinal section of the tooth, the concavity of the primary curvature is turned towards the base of the tooth: the lowest tubes are inclined towards the root, the rest have a general direction at right angles to the axis of the tooth; the few calcigerous tubes, which proceed vertically to the apex, are soon worn away, and can be seen only in a section of the apical part of the crown of an incompletely developed tooth. The secondary undulations of each tooth are regular and very minute. The branches, both primary and secondary, of the calcigerous tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the calcigerous tubes, occasioned by this modification of their secondary branches, is represented by the irregularly dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth: very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, is the only structure I have been able to detect in it.

The remains of the pulp in the contracted cavity of the completely formed tooth are converted into a dense but true osseous substance, characterized by minute elliptical radiated cells, whose long axis is parallel with the plane if the concentric lamellae, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the Iguanodon's teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and, that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enameled edge by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just after a review of the external characters of the dental organs of the *Iguanodon,* their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact:—

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument, during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence."—*Buckland's Bridgewater Treatise,* vol. i. p. 249.

Head

Two fragments of jaw with alveoli, in the Mantellian Collection, are referred by its founder to the *Iguanodon:* in neither of them, unfortunately, is a tooth with the characteristic crown preserved: the size of these specimens proves them to have belonged, if to this genus, then to young individuals. The smaller fragment is described in this Report under the head of *Hylaeosaurus,* on account of the cylindrical, equal, and straight form of the remaining fangs. These parts correspond with the fangs of the teeth which I suppose to belong to the *Hylaeosaurus,* rather than with those of the *Iguanodon,* which are angular, curved, taper towards a point, and support crowns so expanded, as to require greater intervals between their fangs than in the fossil. It is just possible that these differences may depend on age.[23]

Tympanic Bone

A reptile with vertebrae and ribs resembling in their chief characters those of the coelospondylian Crocodiles, and with distinctive peculiarities, in which the Lacertians by no means participate, might reasonably be conjectured to resemble the Crocodiles in the form of the tympanic bone; and if the reptile in question used its teeth for masticating hard vegetable substances, we might with more reason expect that the bony pillar supporting the lower jaw should be firmly and immovably fixed through its whole length, like the tympanic bone of the Crocodilians, and not be loosely suspended to the skull by a single extremity, as in the Iguana and other Lacertians. A very remarkable bone discovered in the Tilgate strata, figured by Dr. Mantell in the 'Geology of the South-east of England,' pl. ii, fig. 5, the resemblance of which to the 'os quadratum,' or tympanic bone of birds, was first suggested by Dr. Hodgkin, is assigned to the *Iguanodon* by Dr. Mantell. He accurately describes it "as forming a thick pillar or column, which is contracted in the middle, and terminates at both extremities in an elliptical and nearly flat surface." In the Iguana and other reptiles the lower end of the tympanic bone is terminated by a convex trochlea, which is received into a corresponding cavity in the lower jaw. Is the modification of the bone in question, assuming it to belong to the *Iguanodon,* indicative of a peculiarity of the joint of the lower jaw as remarkable as the structure of the teeth, and correlated to their masticatory uses? "Two lateral processes, or *alae,* pass off obliquely, and are small in proportion to the size of the column; on placing these bones beside the os tympani of an Iguana, we at once perceive that the relative proportions of these parts are reversed; for in the recent animal the pillar is small and the lateral processes large. From the great size of the body of the fossil, and the extreme thinness of its walls, the *tympanic cellulae* must have been of considerable magnitude, and have constituted a large portion of the auditory cavities. Pl. ii, fig. 1, (fig. 5 is meant,) accurately represents the most perfect specimen in my cabinet; it is 6 inches high, and $5\frac{1}{2}$ inches wide at the longest diameter of the extremity of the body. It exceeds in magnitude the corresponding bone of the *Mosasaurus,* and is fourteen times as large as the same bone in an Iguana 4 feet long." *Loc. cit.,* p. 306.

Vertebral Column

The vertebrae of the *Iguanodon* have their bodies terminated by flat or slightly concave articular surfaces,[24] and their sides flat or slightly convex vertically, moderately concave lengthwise or in the axis of the vertebra; the sides converge more or less towards the under surface, and the body accordingly presents more or less the form of a wedge, with its edge obtuse or flattened in the dorsal vertebrae, but slightly concave, and with its anterior and posterior angles truncated in the caudal vertebrae.[25] The contour of the terminal surfaces is nearly circular, with the vertical slightly exceeding the transverse diameter. The neural arch of the dorsal vertebrae presents the complicated exterior, the great height and superior expansion, which characterize these vertebrae in other Dinosaurs: the base of each neurapophysis equals, or nearly equals, the antero-posterior extent of the centrum, but immediately contracts in this direction from the posterior margin, which then curves backwards as it inclines towards the opposite neurapophysis, and the conjoined laminae are developed beyond the posterior end of the centrum to an extent varying in the different regions of the spine. In the dorsal vertebrae the bases of the neurapophyses are developed transversely inwards, so as to meet and join each other below the spinal canal: the haemapophyses present an analogous structure through a great part of the tail, the bases of each pair, as well as the apices, being united together, and the chevron bones, thus formed, are perforated instead of being notched for the passage of the great blood-vessels. The neurapophyses are commonly anchylosed to the centrum, with a persistent trace of the suture. The transverse processes are straight, and of great length in the vertebrae from the middle of the trunk, indicating there a considerable expanse of the abdominal cavity, adapted for the lodgement of the capacious viscera of a herbivorous feeder. The spinous processes rise to a considerable height in the dorsal, as well as in the anterior caudal vertebrae. The exterior surface of the vertebrae is impressed with fine striations, which are mostly longitudinal in the centrum; so that fragments may thus be distinguished from the characteristically smooth and polished vertebrae of the *Megalosaurus.* The antero-posterior diameter of the largest vertebrae of the *Iguanodon* which I have yet seen is $4\frac{1}{2}$ inches; the most usual size is 4 inches.

Having premised these general characters of the vertebrae of the *Iguanodon,* there next remain to be considered the modifications by which they are distinguished in different regions of the spinal column. Hitherto I have not met with any specimen of a cervical vertebra; the comparatively small fractured vertebra, Nos. 437/2437 and 438/2438 , "Axis of the Iguanodon," Mantell. Catal., is an ordinary, or more posterior, cervical vertebra of a large Crocodilian Reptile, which, if not belonging to the *Poikilopleuron,* indicates a species distinguishable from all other known Saurians.[26] The large cervical vertebrae with ball-and-socket articular surfaces, agreeing with the *Iguanodon* in size, have been shown to have these surfaces the reverse in position to those in the Iguanae and modern Saurians, and to belong to the genus *Streptospondylus.* The desirable knowledge, therefore, of the anatomy of that region of the spine in the *Iguanodon,* which in other Saurians is usually distinguished by its well-marked and varied characters, remains to be acquired.

Costal or Dorsal Vertebrae[27]

Towards the middle or anterior part of this region the bodies of the vertebrae are laterally compressed, and meet below at an obtuse ridge. Through, apparently, a considerable proportion of the dorsal region of the spine, the neurapophyses rise vertically to a height equal to that of the centrum, and expand into a broad and strong platform, the upper surface of which is slightly concave transversely, and arched from behind downwards and forwards in a regular curve; this platform is supported by a strong vertical buttress on each side, and sends upwards from the whole of its middle line a thick, broad and high spinous process. Two oblique, flat, articular processes look downwards and outwards from the posterior angles of the platform; and the corresponding anterior oblique processes, having their flat articular surfaces looking upwards and inwards, and inclining to each other at a right angle, terminate the contracted anterior part of the platform, and do not project beyond it as two distinct processes separated by a median fissure. They are not continued beyond the anterior end of the body of the vertebrae, and consequently the posterior processes overhang the hinder surface of the centrum in order to rest upon the oblique processes of the vertebra next behind. In the anterior dorsal vertebrae the body supports a large and well-marked articular surface on each side, for the head of the rib; and a long and strong transverse process is developed from each neurapophysis against the end of which the tubercle of the rib abuts, as in the Crocodile. In the hinder costal vertebrae the long transverse process is gradually narrowed to its extremity, which is abruptly truncated, and has a right-angled notch at the anterior part; the curtailed neck of the rib, no longer expanded into a head or joined to the body of the vertebra, is fitted into this notch, and the broad and flat surface, at right angles to the neck, is adapted to the extremity of the transverse process.

We seek in vain, in the existing Iguana, for such modes of articulation of the ribs as have here been described, while they are common to Crocodiles with the Dinosaurs. The fact of the complete inclosure of the spinal canal by the meeting and confluence of the bases of the neurapophyses beneath it, was first brought to my attention by the appearances in the body of a dorsal vertebra of the great Horsham *Iguanodon,* in the collection of Mr. Holmes. This centrum, which measures $4\frac{1}{2}$ inches in length and 5 inches across its articular extremity, presented only a slight trace of the impression of the spinal canal at the anterior part of its upper surface, the rest being occupied by a slightly concave, continuous, rough articular surface. The deficiency of this vertebra was supplied by a fine specimen in Mr. Saull's collection of the separate neural arch of a dorsal vertebra of a corresponding size, which seemed to have been detached from a natural articulation. I saw with much interest that the bases of the neurapophyses met and joined each other below the spinal canal along the posterior half of their longitudinal extent, presenting at their under part a continuous slightly convex surface, which must have left a corresponding concave rough articular surface upon the upper part of the centrum, like that exhibited by the Horsham vertebral body. The base of each neurapophysis, which is longer than it is wide, describes a slight curve, convex in the antero-posterior direction, downwards or towards the centrum. The spinal canal is nearly cylindrical, very slightly expanded at the two extremities; its diameter I inch 5 lines. The chief buttress of the spinal platform rises from the posterior and outer part of the base of the neurapophysis, and ascends almost vertically, slightly inclining forwards; it is compressed, with its plane transverse to the axis of the vertebra; it expands as it blends with the under part of the broad platform, half-way between the anterior and posterior boundaries of that remarkable part of the neurapophysis. A second buttress rises from the anterior part of the base of the neurapophysis, and ascends vertically to the upper and outer end of the anterior oblique processes. The base of the transverse process is situated above the converging point of the two buttresses. In the interspace of the two buttresses of the anterior dorsal vertebrae there is a large oval articular surface, convex at the anterior and concave at the posterior part, which has afforded a lodgement to the head of an enormous rib. The oblique or articular processes, directed as described in the general observations on the vertebrae of the *Iguanodon,* converge and meet at nearly a right angle. There is a wide depression at the posterior broad part of the base of the spine, and a wide and deep fossa between the posterior buttress and the posterior oblique process. The base of the spine, as it extends forwards along the middle of the broad platform, descends with a graceful curve to the interspace of the anterior oblique processes. The platform recedes on each side from the base of the broad spine with a regular concavity to its plane; its surface is coarsely striated transversely.

The following are dimensions of this interesting fossil:

	In.	Lin.
Length of the base of the neurapophysis[28]	4	6
From the base of the neurapophysis to the middle of the base of spinous process	5	0
From the base of the neurapophysis to the posterior part of the base of spinous process	6	0
From the base of the neurapophysis to the anterior part of the base of spinous process	3	6
Antero-posterior extent of base of spinous process	6	6
Transverse diameter of spinal platform	8	6
Transverse diameter of conjoined bases of neurapophyses[29]	4	0
Extent of spinal platform beyond hind part of base of neurapophysis	4	0

The spinous process is broken off near its base in this specimen, which is otherwise remarkably entire, considering that it was washed out of the submerged beds of the Wealden and cast on the south shore of the Isle of Wight. It was found near Culver Cliff.

The characters thus obtained from two different parts of the vertebrae of two Iguanodons from distant localities, certified to belong to that genus from the association of one of the parts, viz. the vertebral centrum, with many other characteristic bones of that reptile, have their value increased from the circumstance of the obscure and unsatisfactory manner in which the vertebral characters are exhibited in the celebrated specimen from the Maidstone quarry. The eight vertebrae originally forming a continuous series in this specimen are from about the middle of the back; the antero-posterior diameter of each is $3\frac{1}{2}$ inches. Little more can be determined from these or from the detached and crushed dorsal vertebrae in this specimen, except the flattening of the sides of the vertebrae and their convergence to the lower surface, the slight concavity of both articular extremities, the height of the neural arch, and the strength and length of the transverse and spinous processes.

With the evidence afforded by the previously described specimens, the characters afforded by the following detached vertebrae from the Tilgate strata may with confidence be applied to the further elucidation of the osteology of the *Iguanodon.*

An anterior dorsal vertebra (No. 160/2160, Mantellian Collection), having the following dimensions of the centrum,

	In.	Lin.
Antero-posterior diameter	3	11
Vertical diameter of articular end	4	1
Transverse diameter of articular end	3	2

measures, from its under surface to the posterior part of the base of the spinous process, 8 inches. The broad and high neural arch is anchylosed with the centrum, but the nearly straight line of suture is indicated by numerous puckered rugae and striae. The transverse process extends from the side of the neurapophysis; its base is vertically oval, measuring $2\frac{1}{2}$ inches by 2 inches. The neurapophysis expands above this surface into a broad platform, with a thick rough external free border, probably fractured. The platform is supported by a buttress-like ridge, rising vertically from the posterior angle of the base of the neurapophysis, and expanding as it ascends to blend with the under part of the overhanging platform. Behind this buttress is a wide and deep depression, and the neurapophysis extends backwards to form the posterior articular processes which project $1\frac{1}{2}$ inch beyond the hind surface of the centrum. The antero-posterior extent of the neurapophysial platform is 6 inches; the dimensions of the oval articular surfaces of the oblique processes are 2 inches by $2\frac{1}{2}$ inches; the inferior margins of the posterior processes are separated by a groove. A smaller anterior ridge extends along the anterior part of the neurapophysis. The base of the spinous process extends from the posterior triangular interspace of the oblique processes forwards and downwards along the curve of the supporting platform; the thickness of the spine, which is 1 inch at the posterior part of the base, gradually diminishes towards the fore part of the vertebra. The anterior oblique processes form the sides of an angular depression in front of the base of the spine.

The spinal platform of the *Iguanodon* differs from that of the *Megalosaurus* in its greater relative antero-posterior extent; arising from its being extended further back; the platform is also raised higher above the centrum.

No. 556/2556, Mantellian Collection, is a dorsal vertebra, posterior in situation to the preceding, and from an individual of the same size. The neural arch is anchylosed, but the sutural line is obvious. The surface for the head of the rib on the side of the neurapophysis is smaller, and a transverse process begins to be developed above that surface, throwing its aspect somewhat downwards. The costal surface is separated in this as in the preceding vertebra by a strong vertical ridge or buttress from the wide depression below the posterior part of the base of the spine. The angle between the oblique processes is rather more open. The spinous process of this vertebra, almost entire, is detached from the neural platform, but is cemented to the same mass of stone: it is 9 inches in height and 3 in breadth, or antero-posterior extent; the summit is, however, wanting. The following are other dimensions of the present vertebra:

	In.	Lines
Antero-posterior extent of the body	3	10
Vertical diameter of the body	3	9
Transverse diameter of the body	3	7

The sides of the centrum are as usual concave lengthwise, but are slightly convex vertically, and converge to the lower surface, which is formed by an obtuse ridge.

In a dorsal vertebra of the Horsham *Iguanodon* in Mr. Holmes's collection, from apparently the middle of the back, the spinous process, which is 8 inches in length, expands gradually in breadth and thickness as it ascends to its truncated summit, the antero-posterior diameter of which is 4 inches, its transverse diameter or thickness being 1 inch 6 lines.

In a series of eight posterior dorsal vertebrae, measuring together 1 foot, and consequently from a young *Iguanodon* in Mr. Holmes's collection, the spinous process of the most anterior one is, in antero-posterior diameter, 7 lines, but increases in the other vertebrae to 15 lines, which shows a somewhat rapid change of character.

Sacral Vertebrae

The highly remarkable and characteristic structure of the sacrum of the *Megalosaurus*, and the strong indications of close affinity between this gigantic carnivorous reptile and the still more colossal herbivorous *Iguanodon*, which the structure of their costal vertebrae, of their ribs, and of the larger bones of their extremities afford, made it very desirable to ascertain whether the *Iguanodon* deviated in the same manner from other Saurians, existing and extinct, in the extent and structure of the sacral region of the spine.

The collection of the remains of the *Iguanodon* in the British Museum does not include this characteristic part of the skeleton; it does not form part of the series of bones obtained by Mr. Holmes from the Wealden Quarry at Horsham; but in the collection of rolled bones of the great Wealden Saurians—*Cetiosaurus*, *Streptospondylus*, and *Iguanodon*—in the museum of Mr. Saull, there is a fine specimen of the sacrum with one of the iliac bones attached, which, in the proportions of the vertebrae and the form of the ilium, agrees with the known characters of the *Iguanodon*.

This instructive specimen consists of five vertebrae anchylosed together by the articular surfaces of their bodies and by their spinous processes, which seem to form a continuous thick median ridge of bone. The five vertebrae measure 17 inches in length. The articular extremity of the terminal sacral vertebra is very slightly concave and subcircular, measuring 3 inches in both vertical and transverse diameter. The bodies of the dorsal vertebrae are compressed at their middle part, and broader below than in the dorsal region, and concave in the direction of their axis, the concavities being separated by the broad prominent convex transverse ridges formed by the anchylosed and ossified intervertebral spaces. The contour of the under part of the sacrum thus forms an undulating line. The lateral and inferior surfaces are separated by a more angular prominence of the centrum, the under surface is less convex transversely, and the whole centrum is shorter in proportion to its depth and breadth, than in the *Megalosaurus.* The neurapophyses present the same remarkable modification in regard to their relations to the body of the vertebra as in the *Megalosaurus,* having shifted their position from the upper surface of a single centrum to the interspace of two, resting on proportions of these, which are more nearly equal, as the vertebrae are nearer the middle of the sacrum. The nerves were compelled therefore to escape from the spinal canal over the body of the vertebra, more or less near its middle, and they impress the upper surface there with a smooth canal.

The strong, vertically compressed, transverse processes, or sacral ribs, rise from the bases of the neurapophyses, and their origin extends upwards upon the spine, and downwards upon the sides of the contiguous vertebral bodies and intervertebral space; in the specimen described they are firmly anchylosed to all these parts, extend outwards and expand at their extremities, four of which meet, join, and form an elongated tract of varying breadth to which the ilium is firmly attached. The length of the largest penultimate transverse process was 5 inches 8 lines, its vertical breadth at the middle 3 inches, its thickness here 1 inch. The adjoining (last) transverse process was 5 inches in length; the interspaces of the transverse processes equalled from $2\frac{1}{2}$ inches to 2 inches. The sacrum increases in breadth posteriorly; its transverse diameter, including the anchylosed ilia taken at the posterior part of the acetabulum, is 13 inches, at the anterior part of the sacrum only 8 inches. The proportion of the spine thus grasped, as it were, by the iliac bones, which transmit the weight of the body upon the thigh-bones, corresponds with the mass which is to be sustained and moved; and the size and structure of the sacrum indicate, with those of the femur and tibia, the adaptation of the present great herbivorous Saurian for terrestrial life.

No. 127/2127, Mantellian Collection, is the centrum of a sacral vertebra of a subquadrate form, with a broad and flattened inferior surface, slightly concave antero-posteriorly. The upper surface is excavated by a wide and moderately deep canal, indicating the unusual size, for Reptiles, of the sacral portion of the spinal chord. The anterior and posterior parts of the sides of this centrum are raised, so as to form projecting sub-triangular rough articular surfaces, continued upon the margins of the spinal canal, evidently for the attachment of the neurapophyses and the heads of the strong sacral ribs. The interspace of these anterior and posterior neurapophysial surfaces is formed by a smooth oblique groove, connecting the smooth surface of the spinal canal with that of the free lateral surface of the vertebra, and indicating the place of exit of the sacral nerves, which is necessarily in this unusual situation, because the ordinary holes of conjugation must have been obliterated by the impaction of the bases of the neurapophyses between the contiguous extremities of the bodies of the sacral vertebrae.

The anterior and posterior articular extremities of the present interesting fossil equally bespeak the peculiar character of the sacral vertebrae of the *Dinosauria.* They are impressed by coarse straight ridges and grooves radiating from near the upper part of the surface, like those on the corresponding part of a cetaceous vertebra when the epiphysial articular extremity is removed. These inequalities are here, doubtless, preparatory to that anchylosis by which the sacral vertebrae are compacted together in the mature Dinosaurs.

	In.	Line
The length of this vertebra	2	10
The height	2	6
The breadth of anterior articular end	3	0
The breadth of middle	2	2
Antero-posterior diameter of anterior costal surface	1	7
Antero-posterior diameter of posterior one	1	0
Breadth of spinal canal	1	5
Breadth of canal of sacral nerve	0	4

From its separated condition, the body of the sacral vertebra here described must have belonged to a young Dinosaur of a size far exceeding that of the *Hylaeosaurus.* It is obviously very distinct in form from the sacral vertebrae of the *Megalosaurus.* No other reptile than one belonging to the order characterized by the peculiar structure of the sacrum already described, could have yielded a detached vertebral centrum with the remarkable modifications of the one under consideration. The modifications detected in the entire sacrum of the *Iguanodon* in Mr. Saull's collection, justify the reference of the vertebra above described to the sacrum of a young *Iguanodon.*

Caudal Vertebra

These are distinguished by the single haemapophysial surface at each end of the narrow inferior surface of the centrum. The sides of the centrum are flat, or even slightly concave in the vertical direction, though less so than in the antero-posterior direction. In a caudal centrum, for example, in the Mantellian Collection, measuring 4 inches in length, and 5 inches 4 lines in depth at the middle of the side, if a pencil be laid vertically along that part, an interval of between 1 and 2 lines separates its middle part from the bone. Those great Wealden vertebrae which, on the contrary, have the middle of the side of the body prominent, and the lower half only converging towards the under surface, are from the middle and posterior part of the tail of the *Cetiosaurus.* The posterior terminal articular surface is rather more concave than in the dorsal vertebrae; but the difference is by no means so marked as in the plano-concave vertebrae of the *Cetiosaurus.* The transverse processes of the anterior caudal vertebrae are comparatively short, but strong, and are continued from the base of the neurapophysis.

The haemapophyses, or chevron bones, are not anchylosed to the centrum, but articulate with the interspaces of the vertebrae; in a few of the anterior ones to two distinct but closely approximated surfaces on each contiguous vertebra, but in the rest of the caudal vertebrae to a single oblique triangular surface on each of the contiguous extremities of the centrum; the haemapophyses being here confluent at their vertebral as well as at their distal extremities.

A caudal vertebra exhibiting this modification in Mr. Holmes's collection measures, in the vertical diameter of the articular surface, 4 inches 9 lines; in its transverse diameter, 4 inches 6 lines; the breadth of the inferior surface of the vertebra is 3 inches 3 lines. The interspace between the anterior and posterior haemapophysial surface is 9 lines; it is concave in the axis of the vertebra. The diameter of the spinal canal is reduced in this vertebra to 9 lines. The transverse processes are of very small size. The spinous process is broken off. We have seen that those of the sacral vertebrae appear to have been short. There is reason to think that the spinous processes increased in length for a certain distance as they receded from the sacrum, and then diminished. Thus, in a caudal vertebra (No. 130/2130, Mantellian Collection), evidently anterior in position by its size, by its oblique processes, and by the place of development of its transverse processes from the base of the neural arch, the spinous process is 5 inches in height, while in the six caudal vertebrae preserved in natural sequence and relative position in the Mantellian Collection, the spines are more than double that height. That the vertebra (No. 2130) is not a more posterior caudal vertebra from a larger *Iguanodon* is shown by the relative thickness, as well as position, of its transverse processes, as compared with the six caudal vertebrae above mentioned, for their transverse processes sensibly diminish in every diameter, and especially in vertical thickness, from the first to the sixth; and, moreover, it is evident that, in this short series, the spines decrease in height both forwards from the third as well as backwards, but more so in the latter direction. Thus the spine of the first of these vertebrae is 14 inches high, of the third 15 inches, and of the sixth 13 inches. These spines increase in breadth toward their summits, which are truncated, and in contact with each other, partly from this expansion, partly from the posterior ones being slightly bent forwards. One cannot witness this change of character in so short a segment of the tail without a conviction that this appendage must have been relatively shorter than in the Iguana.

The first spine, besides being somewhat shorter, is more rounded off at its anterior margin than the third, a difference which is still more obvious in the detached caudal above described; but above its origin a thin trenchant plate is extended for a short distance from the middle of the anterior margin: this character, which calls to mind one that is present in a greater proportion of the vertebral column in the Crocodilians, is more strongly developed in the second and third vertebrae. The neurapophysial suture is more nearly obliterated in the sixth than in the first of this instructive series, or in the more anterior and detached caudal vertebra. The following are dimensions of the detached anterior caudal (No. 1), and of the first (No. 2) and last (No. 3) of the series of six:

	No. 1		No. 2		No. 3	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum	2	8	2	8	2	7
Vertical diameter of articular surface	3	6	3	3	2	6
Transverse diameter of articular surface	3	5	3	2	2	6
Front under part of centrum, to upper end of posterior articular process	5	6	5	8	4	0
From upper end of posterior oblique process to the summit of spine	5	0	14	0	10	6
Antero-posterior diameter of base of spine	1	3*	1	7	1	4
Antero-posterior diameter of summit of spine	2	0	2	2	2	6

* The anterior basal ridge of this vertebra is broken away.

The transverse processes disappear in the posterior caudal vertebrae. The chevron bones, of which three are preserved in the slab containing the six caudal vertebrae, exhibit the perforated character which distinguishes them from those of the *Cetiosaurus* and of all existing Crocodiles and Lizards, not excepting the Iguana, in which the haemapophyses are anchylosed at their distal or spinal end only, and remain separate and articulated to two distinct surfaces, at their proximal ends. The length of the superior and inferior vertebral spines, and the shortness of the transverse processes, prove the form of the tail to have been flattened laterally and of great breadth in the vertical direction, at its basal portion at least.

Ribs

These appendages of the vertebral column are largely developed in the thoracic abdominal region of the spine, and had the same two-fold connexion with the vertebrae as in the other Dinosaurs and the Crocodilians. At the anterior part of the costal region of the spine, the rib was joined by a large head to a shallow cavity, situated at first on the side of the centrum and then on the side of the neurapophysis; and it was further articulated by a tubercle to the extremity of the transverse process. In a certain number of the anterior vertebrae, the neck of the rib was co-extensive with the transverse process, and sometimes six or seven inches in length; afterwards the neck of the rib began to shorten, and the head to decrease in size, and to have its place of articulation brought progressively nearer to the end of the transverse process, until it finally disappeared, and the posterior ribs became appended to the ends of the transverse processes.

In the Iguana, as in other Lizards, the ribs have but one mode of articulation, viz. to a simple tubercle developed from the side of the centrum.

One of the largest double-jointed ribs of the *Iguanodon,* in the Mantellian Collection (No. 519/2519), is 46 inches in length. The neck is less distinct from the tubercle and body than in other ribs, which seem to have been situated further back; it expands more gradually to the tubercular articulation with the transverse process, and is at this part 5 inches in breadth; it bends with a deep oblique curve for about one-fifth of its length, and then is continued in a nearly straight line to its extremity: this is slightly expanded and truncated, for the attachment doubtless of a bony sternal rib. The convex or outer margin of the rib is bent backwards so as to overhang the sub-compressed shaft of the bone along its upper or proximal third part.

The proximal extremity of one of the ribs from the middle of the trunk of the Horsham *Iguanodon,* presents an ovate head $2\frac{1}{2}$ inches in the long diameter; the neck is 7 inches long, straight, compressed, and topped by a well-marked tubercle, where it joins the body of the rib. This part is also compressed; and its external margin, besides being bent backwards, is also developed in the contrary direction, so as to assume the form of a slightly convex plate of bone 2 inches broad, attached at right angles to the shaft of the rib, which it overhangs on both sides. This structure is characteristic also of some of the ribs in the other Dinosaurs, and is interesting as indicating the commencement of that peculiar development of the corresponding part of the ribs in the Chelonian reptiles, by which the upper part of their bony box is almost wholly formed.

Bones of the Extremities

Scapular Arch

The scapula has not hitherto been discovered so associated with other unequivocal portions of the skeleton of the *Iguanodon* as to permit the characters of this bone in that species to be confidently recognised. The bone (No. 194, Omoplate of *Iguanodon,* Mantell. Catal.) agrees with the undoubted scapula of the Hylaeosaur, and with that of certain Lacertians, especially of the genus *Scincus*[30] in the production of a long and slender pointed process, continued at nearly, right angles with the body of the bone, from the anterior part of the articular surface for the coracoid ; but it differs from the scapula of the Hylaeosaur in the presence of two short processes given off from the lower part of the base of the long process, and in the absence of the thick and strong transverse acromial ridge which overarches the glenoid depression, and in the deeper concavity of the posterior margin of the ascending plate or body of the bone. This part, in its shape, relative length and breadth, is intermediate between the Crocodilian and Lacertian type of the scapula, at least as exemplified in the Monitors and Iguanas, where it is broad and short. The Scincs and Chameleons, in the more Crocodilian proportions of their scapulae, resemble the Hylaeosaur and the great species of extinct Saurian, most probably the *Iguanodon,* to which the present bone belongs.

Coracoid

The thick articular portion of this bone, with its characteristic perforation, here continued to the articular margin by a narrow fissure, dividing the scapular from the humeral articulation, has been found of different sizes in the Tilgate strata, and has been, with much probability, likewise referred to the *Iguanodon.* One of these portions of coracoid, which measured 10 inches in diameter, was found in the same block of stone with other unequivocal remains of *Iguanodon.*

Clavicle

The doubts which are attached to the determination of the previous parts of the scapular arch are fortunately dissipated from the consideration of this bone by the preservation of both the right and left clavicles in the Maidstone *Iguanodon.* The presence of the fibula in the same block of stone, and its discovery in close proximity with the tibia and femur in the Wealden strata, satisfactorily prove that the present remarkable bone cannot have formed part of the hinder extremity. And since, in other reptiles, the radius differs from the fibula in little more than in being somewhat shorter and thicker, there is still less reason for supposing it to belong to the fore-arm.

The form of the ribs of the *Iguanodon* is well known, and they become shorter and more curved as they advance from the middle to the anterior part of the chest. The determination, therefore, which Dr. Mantell regarded as most probable,[31] must be held to be the true one. The largest entire clavicle from the Wealden strata measures 29 inches in length, and there is a portion of another in the same collection one-third larger. The largest fibula of the *Iguanodon* that has been found measures 28 inches. The bone is compressed, slender, and subtrihedral at the middle part, expanded and flattened at the two extremities, bent with a slight double curve in a graceful sigmoid form. The broadest end, which, from the analogy of the Cyclodus lizard, must be regarded as the median or pectoral extremity, gives off two processes, the first appearing as a continuation of the thinner margin of the bone, twisted and produced obliquely downwards; the second process is given off nearer the expanded sternal end, towards which it slightly curves.

	In.	Lin.
The breadth of the expanded sternal end of a clavicle, 29 inches in length, is	3	7
The breadth of the scapular end	4	3
From this extremity to the base of the first process	19	0
The breadth of the narrowest part of the shaft	1	7

Humerus

This important bone has not been hitherto satisfactorily determined; it differs less from the femur in form in Reptiles than in Mammalia. In the Crocodilians it is shorter than the femur, especially in the extinct piscivorous species, with biconcave vertebrae and more strictly aquatic habits. In Lizards it is more nearly equal with the femur, and the similarity of the size of these bones we may conceive to have been greater in the gigantic terrestrial Dinosaurs.

In the modern Crocodiles, the chief distinction in the form of the humerus is the ridge at the upper third of the bone: in Lizards this distinction is almost lost. If we find the femur of the *Iguanodon* distinguished from that of all other reptiles by the presence of a peculiar process from the inner side of the bone, there are not wanting grounds to expect that the humerus may present a similar character.

As the reasons for suspecting that some of the large bones, hitherto uniformly regarded as the femora, may be the humeri of the *Iguanodon,* will best appear in the description of the femur, I shall now proceed to the consideration of the large bones with which the femur is articulated.

Ilium

The iliac bone of the *Iguanodon*[32] resembles in form that of the Monitor more than that of the Iguana: in the portion of the pelvis in Mr. Saull's collection it measured 14 inches in length. It commences anteriorly by a thick obtuse extremity slightly bent outwards; this part is supported by the thickest and strongest of the sacral ribs, which slightly inclines backwards: the ilium quickly increases in vertical as well as transverse extent, forming at its lower part the usual portion of the acetabulum; the concavity terminating behind in a broad obtuse prominence: behind this part the ilium rapidly contracts, by a deep inferior emargination, to a comparatively slender process extending backwards and gradually diminishing to an obtuse point, well shown in the detached ilia of the Maidstone

Iguanodon, but here broken off. The chord of the acetabular arc or concavity, in Mr. Saull's specimen, measured 8 inches.

In the Maidstone *Iguanodon* the left ilium lies detached, with its symphysial articulation or inner surface uppermost, indicating by the extent of that surface, which equals the antero-posterior diameter of nearly five of the dorsal vertebrae of the same individual, the length of the sacrum peculiar to this and other Dinosaurian reptiles. Its slender posterior portion terminates in a subacute point: the anterior extremity of the right ischium, which has the opposite surface exposed, bends slightly outwards in the form of a thick tuberosity.

	In.	Lin.
The length of this bone is	16	0
Its depth	5	0
From the anterior tuberosity to the posterior angle of the acetabulum	18	0

Pubis

This bone, which presents a simple spatulate form in the Crocodiles, already begins to increase in breadth at its symphysial extremity in the extinct family with concave vertebrae; and in the larger existing species of Lizards is expanded at both extremities, and has a very marked and recognizable character superadded, in being bent outwards with a considerable curvature.

A massive fragment of a broad osseous plate, bearing a segment of a large articular cavity at its thickest margin, and thence extended as a thinner plate, bent with a bold curvature, and terminated by a thick rounded labrum, offers characters of the Lacertian type of the pubis too obvious to be mistaken. This specimen is from the Tilgate strata; and, since the modifications of the ilium of the *Iguanodon* in the Maidstone skeleton approximate to the Lacertian type of the bone, and especially as manifested by the great *Varani,* in which the recurved character of the pubic plate is most strongly marked, we may, with much probability, assign the fossil in question to the pelvis of the *Iguanodon.*

This fine portion of pubis is of an inequilateral triangular form, 16 inches in its longest diameter, 9 inches 6 lines across its base or broadest part, 6 inches 8 lines across its narrowest part. The fractured surface of the bone, near the acetabulum, is 3 inches 3 lines thick. The acetabular depression is 7 inches across, a proportion which corresponds with that of the acetabular concavity in the ilium, and with the size of the cavity in which the head of the Iguanodon's femur must have been received. One angle of the cavity, corresponding with the anterior one in the *Varanus,* is raised; a broad and low obtuse ridge bounds the rest of the free margin of the cavity. The smooth labrum exchanges its character near one of the fractured edges of the bone for a rough surface, which indicates the commencement of the symphysis. In the apparent absence of the perforation below the acetabular depression, the present bone agrees with the Crocodilian type.

Ischium

A second fragment of a large lamelliform bone (No. 188/2188, Mantellian Catalogue) presents, in its general form and slightly twisted character, most resemblance to the ischium, with traceable modifications intermediate to those presented by the extinct *Goniopholis* and modern *Varani* and *Iguanae.* The loss of the acetabular extremity, which is broken away, prevents a certain determination of this bone; the only natural dimension that can be taken is the circumference of the neck, or contracted portion between the acetabular end and the expanded symphysial plate: this circumference gives 7 inches. The slight twist of the bone upon this part as it expands to form the broad symphysial plate,—a character which is well marked in the ischium of the *Goniopholis,*—gives it a superficial resemblance to the humerus of some of the large Mammalia; but the bone is too short in proportion to the breadth indicated by the fractured symphysial end, to afford a probability of its having been the humerus of a land reptile, and much less of the *Iguanodon,* in which the form of the femur is well ascertained; unless, indeed, there be actually more discrepancy between the femur and humerus in size and form in the Dinosaurs, than has, hitherto, been recognized in the Reptilian Class.

Femur

The Maidstone *Iguanodon* does not satisfactorily determine the question of the principal bone of the fore and hind extremities, for whilst the clavicles, many anterior dorsal vertebrae, and anterior ribs, would lead one to suppose that the two long bones found in their proximity might be humeri; on the other hand the presence of the iliac bones, with some caudal vertebrae in the same slab, give equal probability to their being femora. The bones in question (1 and 2 in the figure of the Maidstone *Iguanodon,* published by Dr. Mantell in his 'Wonders of Geology,' vol. i, pl. ii.) have the same general characters, viz. the flattened trochanter at the proximal end, the compressed ridge-like process at the middle, and the two condyles with the deep and narrow fissure at the distal end, which are presented by the larger detached bones, described by Dr. Mantell as femora, from the Tilgate strata. They are otherwise too much crushed and buried to yield materials for more minute comparison: each of these bones measures 33 inches in length.

In five separate long bones, having the general characters of the two above-mentioned in the Maidstone *Iguanodon,* numbered consecutively and marked 'Femur' in the Mantellian Collection, Nos. 1 and 3 differ from Nos. 4 and 5 in the greater inward production of the head, making the concavity of the line descending from the head to the median internal ridge somewhat deeper. The lower angle of this median ridge is more produced in Nos. 1, 2 and 3, than in Nos. 4 and 5. The whole inner contour is more regularly concave in No. 5, than in Nos. 1 or 3. Of these five bones, No. 2 was found associated with a tibia and fibula; and if, therefore, the differences above indicated should be more than mere individual varieties of the same bone, we might conclude Nos. 4 and 5 to be humeri. Such conclusion appears more probable from the circumstance of two of the longest and largest of the bones, having the general characters of the femur of the *Iguanodon,* which were obtained by Mr. Holmes from the quarry of the Wealden stone at Horsham, belonging both to the right side.

Now the other bones obtained in proximity with the above were all parts of one large individual, and it is much more probable, therefore, that we have here a right humerus and femur of the same individual, than two right femora of different individuals. One of the differences noticed in the Tilgate specimens, viz. the degree of obliquity at which the neck joins the shaft, is discernible in these; and close to that bone, which shows the characters that we have supposed to belong to the femur, were found bones corresponding with the tibia and fibula.

Regarding then this as the femur, it presents the following characters:—it measures 3 feet in length: its circumference at the middle of the shaft is 18 inches: the contour of the rounded inward-projecting part of head is $17\frac{1}{2}$ inches: two flat longitudinal facets meet near the middle of the anterior surface of the shaft at a rough and slightly elevated angle, which runs straight down to within thirteen inches of the distal end: the ridge there inclines towards the internal condyle and subsides. Two strong ***vasti internus et externus*** muscles are indicated by this ridge. The head of the bone is carried inwards, overhanging the shaft in a greater degree than the corresponding part does in the humerus. The line of the inner side of the shaft describes a graceful sinuous curve, being first concave, then slightly convex at the middle, where there is an indication of the projecting ridge which has been broken off: below this it is concave to the flattened antero-posteriorly extended, slightly concave surface, which descends vertically to the articular surface of the condyle, which surface proceeds horizontally at nearly a right angle with the line of the shaft of the bone. The antero-posterior extent of the flattened condyle is 8 inches. The thickness of the external wall of the shaft varies from half an inch to an inch.

Both ends of this fine bone are crushed and mutilated.

By the side of the femur were found two other bones, the largest of which corresponds with the tibia. The external part of the head is considerably produced horizontally; the circumference of the proximal articular surface is 30 inches. The longitudinally finely striated vertical surface of the shaft of the bone commences at the anterior part of the proximal end along a well-defined curved line, which runs transversely across the bone, convex downwards in the middle and concave downwards at each end: the bone rapidly contracts, and assumes, about 8 inches below the head, the subquadrilateral form; it is broadest from side to side: its circumference is here 15 inches. The anterior surface is flattened; the outer or radial side convex or rounded; the dense external walls of this bone are very thick, at least 1 inch. The length of this bone is 27 inches, but it wants the distal end. The proximal articulation is very convex from behind forwards, but, at the middle, it is slightly concave from side to side.

	In.	Lines
Its lateral diameter is	12	0
Its antero-posterior diameter is	5	6

The disparity of size between the tibia and fibula is considerable, but the disparity in the thickness of the two extremities of the bone is less than in the bone which is described and figured as the fibula by Dr. Mantell. On the middle of one of the flat sides of the fibula is an oblong rough surface slightly raised, measuring 3 inches by 2 inches. The articular extremities of the fibula are tuberculate; the larger end is 4 inches across, the smaller one 3 inches across. The shaft is subcompressed.

A few yards from the three preceding bones was found the, presumed, humerus, which measured 35 inches in length, being very nearly equal in size with the femur. Its proximal extremity is crushed and mutilated: the shaft is compressed from before backwards; concave behind: the submedian ridge, or compressed process is developed from the inner side of the shaft at the usual situation, and corresponds in form with those of the bones Nos. 4 and 5, Mantellian Collection. The distal condyles are divided anteriorly by a narrow longitudinal furrow, which penetrates deeply between them. As the absence of the deep fissure between the condyles of the femur is repeated in the humerus of the Iguana, so may its presence be repeated in the humerus of the *Iguanodon.*

The inner condyle projects backwards beyond the outer one, which is distinguished by being traversed by a longitudinal groove. This bone differs from the femur in the shorter neck supporting the head, in its more prominent median process, and in the uniform though slight concavity of the inner margin of the shaft.

The preceding observations were made during an inspection of the fossils in Mr. Holmes's interesting collection in the summer of 1840. I have subsequently been favoured by a letter from that gentleman, containing the following clear and valuable observations on the two large bones in his collection, which support the view I had taken of their nature.

"I have also examined the two large bones concerning which so much doubt exists. They both appear to belong to right extremities, but as the one which has the trochanter, and which by way of distinction I shall call No. 1 (humerus?), is so much crushed in the direction of the rough ridge, so strongly marked in the other, I cannot say with any degree of certainty whether it possessed the same form or not. There is, however, this difference at any rate. The head of No. 1 is so much mutilated that little can be said about it, but it is very clear that the neck is shorter than that of No. 2 (femur ?), and there is a variation of nearly one-half in the degree of obliquity from the perpendicular of the shaft of the bone in which the two heads are set on; that of No. 2 being more so than the other. They also differ in another respect. In measuring from the inferior part of the head, supposing both bones to be placed in an erect position, to the superior portion of the condyle, which is the best way in which I can ascertain their relative length; No. 2 is longer in the shaft than the other bones, which, if they both belonged to the same individual, (and I think there is no sufficient reason to doubt it) would, according to thy conjecture, make it appear that one is the femur and the other the humerus.

"The question next arises as to which of the bones either name is to be appropriated. No. 1 has the trochanter, which is very similar in shape to the femur marked No. 5 in the British Museum. No. 2 has none in its present mutilated state, but on examining the posterior part of the shaft, where on the internal side one might expect to meet with some remains of the base of the trochanter, I find the surface of the bone concave, and it diverges much more than I should suppose it would do if it had merely been continuous with the returning surface from the anterior part of the bone, if there had been no trochanter interposed to disturb the otherwise greater rotundity of the shape.

"This leads me to suppose that it once had one, and that it probably might have been formed like that in Nos. 1 and 2 in the British Museum. If they were not the bones of distinct animals, this might perhaps have been the case." Dated Horsham, Nov. 2nd, 1841.

The characters of the articular extremities of the femur which are obscured by the mutilated condition of the large specimen, are beautifully shown in the femur of a young *Iguanodon,* obtained from a pit near Rusper, four miles north of Horsham. The rounded portion of the head extends inwards; it is indented at its anterior part by the commencement of a longitudinal broad channel, which extends down upon the shaft: the articular surface is not confined to the inwardly produced head, but extends over the whole proximal horizontal surface of the femur, expanding as it approaches the outer part of the head. The articular surface is circumscribed by a well-defined linear groove, which separates it from the longitudinal striated surface of the shaft of the bone. At the posterior and external angle of the articular proximal end of the bone, a longitudinal column, separated by a longitudinal groove from the main shaft of the bone, falls into that shaft a little lower down the distal end: here the shaft expands and becomes flattened from before backwards. The distal end is characterized by a deep and narrow anterior longitudinal groove, situated not quite in the middle, but nearer the internal condyle: there is a corresponding longitudinal groove on the posterior part of the distal end, which is wider than the anterior one, and in the middle of the bone, separating the two condyles, but inclining beneath, and, as it were, undermining the backward projecting part of the internal condyle; this is much more prominent than the external one, which is traversed or divided by a narrow longitudinal fissure. The articular surface is irregular and tuberculate.

	In.	Lines
The lateral diameter of proximal end	2	8
The lateral diameter of distal end	3	0
Antero-posterior diameter of outer part of proximal end	2	0
Antero-posterior diameter of outer part of internal condyle	2	3

The femur of the Iguana differs as widely from that of the *Iguanodon* as does that of the Monitor or any other Lacertian reptile. The forms of the head and trochanter of the femur of the Iguana are just the reverse of those in the *Iguanodon.* The head of the femur in the Iguana is flattened from side to side, and its upper convex surface is extended from before backwards, making no projection over the gentle concave line leading from its inner surface down to the inner condyle. In the *Iguanodon* the head is rounded and rather compressed from before backwards; and is produced, as in Mammals, over the inner side of the shaft.

In the Iguana the trochanter is compressed from before backwards, and is separated by a wide and shallow groove from the oppositely compressed head: in the *Iguanodon* the trochanter is singularly flattened from side to side, and is applied to the outer side of the thick neck, from which it is separated by a deep and narrow fissure. The Iguana has no submedian internal process, and its distal condyles are slightly divided by a shallow depression.

The circumference of the femur of the *Iguanodon* very nearly equals one-half its length: the circumference of the femur of the Iguana only equals one-fourth its length: yet the femur of the *Iguanodon* equals the united length of eleven of its dorsal vertebrae, while that of the Iguana equals the united length of only six of its dorsal vertebrae.

The femora of the Iguana stand out, like those of most other Lacertians, at right angles with the vertical plane of the trunk, which is rather slung upon than supported by those bones: but it is evident from the superior relative length and strength of those bones in the *Iguanodon,* from the different conformation of the articular, especially the proximal extremities, and from the ridges and processes indicative of the powerful muscles inserted into the bone, that it must have sustained the weight of the body in a manner more nearly resembling that in the pachydermal Mammalia. As in some of the more bulky of these quadrupeds, the indication of the 'ligamentum teres' is wanting in the head of the femur of the *Iguanodon.*

The tibia of the *Iguanodon* equals the united length of nine of the dorsal vertebrae, while in the Iguana it does not exceed the united length of five dorsal vertebrae, although it more nearly equals the femur in length than in the *Iguanodon.* The head of the tibia is more expanded and complicated by deep and wide grooves in the *Iguanodon:* the fibula is less expanded towards the distal end and less flattened against the tibia in the *Iguanodon.*

The fibula of the small *Iguanodon* from the pit at Rusper, equals the antero-posterior extent of the spines of eight dorsal vertebrae of the same individual. This bone is 13 inches long, 2 inches across the proximal end, and 6 lines across the distal end.

Of the great *Iguanodon* from the Horsham quarry two metacarpal or metatarsal bones are preserved in natural juxtaposition: one exceeds the other by four inches, and measures 2 feet 6 inches; the breadth of its distal end is 3 inches 3 lines; the shaft is compressed and subtrihedral; its texture is spongy at the centre. The proximal end is expanded, with a nearly flat articular surface, the contour of which is broken by two longitudinal indentations: the distal end offers a well-sculptured trochlear articulation for the first phalanx. The bone of the Maidstone *Iguanodon* (marked 7 in the figure above cited in the 'Wonders of Geology') corresponds with the above-described bones of the foot.

Some of the phalanges, probably the middle ones, appear to have been singularly abbreviated; but they have not yet been discovered in such juxtaposition with undoubted Iguanodon's bones as to justify a more precise description of their characters under the present head.

The distal or ungual phalanges of the *Iguanodon,* although doubtless offering certain modifications of form in different toes, are shown by those preserved in the Maidstone *Iguanodon,* and others of much larger dimensions, found associated with the bones of the great *Iguanodon* of the Horsham quarry, to have had a less incurved, broader and more depressed form than in other known Saurians. Two of the largest ungual phalanges of the Horsham *Iguanodon* in Mr. Holmes's collection, are broad, subdepressed, with the curved vascular groove on each side, as in most other Saurians, with a slightly concave articular base, and terminating forwards in a round blunt edge; the outer boundary of the lateral grooves forms, at the posterior end of the groove, a laterally projecting process, rendering this part of the phalanx broader than the articular extremity or basis. The following are dimensions of the largest of the two phalanges:

	In.	Lines
Length	5	4
Breadth	3	2
Breadth at articular end	3	0
Depth at articular end	2	3

The last dimension gradually diminishes to the distal end.

This phalanx is slightly bent downwards; the under surface being concave, longitudinally, but convex from side to side; less so than on the upper surface. The under surface is rough; the upper surface nearly smooth, except at the margin of the articular surface, on the projecting sides and at the distal extremity, which is sculptured by irregular vascular grooves and holes. The phalanx has a slight oblique twist to one side, and is somewhat thinned off to that side on which the curved groove is longer than on the other side.

In Mr. Saull's museum is an ungual phalanx of an *Iguanodon,* which nearly equals those from Horsham, and presents the same subdepressed form. The base is slightly convex transversely; more concave vertically: the articular surface is faintly divided by a median vertical rising: the rounded edge of the articular surface is slightly raised, interrupted on both sides by the smooth shallow commencement of the curved vascular groove: this deepens and contracts as it extends forwards. The upper surface is convex longitudinally and transversely; the lower surface is rather more convex transversely than the upper, but is slightly concave longitudinally. The upper and lateral surfaces, for about an inch near the base, are deeply sculptured by large irregular longitudinal grooves and ridges; the rest of the upper surface is impressed by fine interrupted longitudinal impressions; but having, on the whole, a smooth appearance. The laminated superposition of the exterior, compact portion of the bone is shown by the separation of portions of the layers of about one line in thickness. The under surface is more deeply impressed by cavities having reticulate elevations. The right aliform process begins 10 lines from the articular surface, the left about 14 lines from the same part: their base is bounded below by slight impressions, and above by the lateral canals, which appear to sink into the bone. A few distant vascular grooves mark the upper surface of the bone, but more numerous larger ones are situated near the lateral canals and at the broken anterior end of the phalanx. The following are the dimensions of this bone:

	In.	Lines
Transverse diameter	3	5
Transverse diameter of broken end	2	2
Vertical diameter of base	2	7
Vertical diameter of broken end	1	6
Length to broken end	4	4

It was probably more than 5 inches long when entire.

The largest of the phalangeal bones in the collection of Wealden Reptiles in the British Museum, which from its breadth, slight degree of obliquity and vascular canals is referable to the *Iguanodon,* is less than those just described. The phalanx in question (No. 384/2384, Mantellian Collection) is conical, $4\frac{1}{2}$ inches long, probably 5 inches when entire; but the apex is broken off: the longest diameter of the base or articular surface is 3 inches 3 lines: it is slightly and obliquely compressed, and very slightly curved, and from this circumstance, as well as from the obliquity of the base and its unsymmetrical figure, it probably belonged to the small outer or inner toe at the margin of the foot. Only a small part of the natural smooth articular surface is left, the rest appears to have been scraped away, so that the coarse cancellous structure of the middle of the bone is exposed. The free surface of the bone near the base is deeply sculptured by irregular longitudinal furrows, which served for the implantation of the articular ligaments. The rest of the free surface is tolerably smooth, except at the sides near the apex, where there are numerous oblique outlets for the large vessels and nerves supplying the secreting organ of the claw. The two lateral longitudinal curved grooves which characterize the claws of most Saurians are here well developed; they commence, one at, the other near, the base; are at first shallow, then deepen, and finally sink into the substance of the bone about $1\frac{1}{2}$ inch from its fractured apex. Below one of these canals there is a shallow smooth impression; corresponding no doubt with the margin of the claw. The under surface of the phalanx indicated by the concavity of the curved grooves is more convex transversely than the upper surface: the distance between the converging lateral grooves in this surface is one inch.

Among the few other phalangeal bones from Dr. Mantell's collection in the British Museum, there is one (figured in the 'Wonders of Geology,' pl. iii, fig. 1, as belonging to the fore-foot of the *Iguan-*

odon) which differs in a marked manner from the specimens just described, being as much compressed from side to side as the *Iguanodon*'s ungual phalanges are, for the most part, flattened, from above downwards. One of these compressed phalanges must have been at least four inches in length; it now measures three inches, with the extremity broken off; it is 2 inches 8 lines in vertical diameter at the base, and only 1 inch 2 lines in the greatest transverse diameter. The phalanx is more curved downwards than any of the true *Iguanodon*'s phalanges, and it is traversed by a longer and shallower groove, the lower margin of which is not produced into a lateral aliform process, nor does the distal end of the groove sink into the substance of the bone.

The ungual phalanges on both the fore and hind feet of the Iguana resemble this phalanx in form more than they do those of the *Iguanodon.* In the fore-foot of the Crocodile the ungual phalanx of the first or innermost toe is broad and flat, with lateral ridges, much resembling the depressed phalanges of the *Iguanodon.* The ungual phalanx of the third digit is of the same length, but is thinner in both transverse and vertical directions, but is less so in the latter. It is not more curved. Still the difference (and this is the greatest that I can perceive, in comparing the different ungual phalanges of the same individual Crocodile (*Croc. acutus*)) is much less than that which is manifested between the depressed and the compressed phalanges hitherto referred to the *Iguanodon.* In the great proportion of the skeleton found near Maidstone are two phalanges which correspond in form with those enormous specimens found near Horsham, and with the small depressed claw-bones from Tilgate Forest, unquestionably belonging to the *Iguanodon,* and supposed by Dr. Mantell to be peculiar to the hind-foot of that Saurian.

Size of the *Iguanodon*

From the comparison, which the few connected portions of the skeleton of the *Iguanodon* enable us to make, between the bones of the extremities and the vertebral column, it is evident that the hind-legs at least, and probably also the fore-legs, were longer and stronger in proportion to the trunk than in any existing Saurian. One can scarcely suppress a feeling of surprise, that this striking characteristic of the *Iguanodon,* in common with other *Dinosauria,* should have been, hitherto, overlooked; since the required evidence is only an associated vertebra and long bone of the same individual, or a comparison of the largest detached vertebrae with the longest femora or humeri. This characteristic is, nevertheless, one of the most important towards a restoration of the extinct reptile, since an approximation to a true conception of the size of the entire animal could only be made after the general proportions of the body to the extremities had been ascertained.

But it is very obvious that the exaggerated resemblances of the *Iguanodon* to the Iguana have misled the Palaeontologists who have hitherto published the results of their calculations of the size of the *Iguanodon;* and, hence, the dimensions of 100 feet in length arrived at by a comparison of the teeth and clavicle of the *Iguanodon* with the *Iguana,* of 75 feet from a similar comparison of their femora, and of 80 feet from that of the claw-bone, which, if founded upon the largest specimen from Horsham, instead of the one compared by Dr. Mantell,[33] would yield a result of upwards of 200 feet for the total length of the *Iguanodon,* since the Horsham phalanx exceeds the size of the largest of the recent Iguana's phalanges by 40 times!

But the same reasons which have been assigned for calculating the bulk of the *Megalosaurus* on the basis of the vertebrae, apply with equal force to the *Iguanodon.* Now the largest vertebra of an *Iguanodon* which has yet been obtained does not, as has been before stated, exceed $4\frac{1}{2}$ inches in length; the most common size being 4 inches. The intervertebral substance is shown, by the naturally juxtaposed series of dorsal vertebrae in the Maidstone *Iguanodon,* to be not more than one-third of an inch in thickness. All the accurately determined vertebrae of the *Iguanodon* manifest the same constancy of their antero-posterior diameter which prevails in Saurians generally; the discovery of the true character of the supposed Lacertian vertebrae, six inches in length, removes the only remaining doubt that could have attached itself to this important element in the present calculation.[34] The cervical vertebrae of the *Iguanodon,* when discovered, if they prove to differ in length from the known dorsal and caudal vertebrae, will be, in all probability, somewhat shorter, as they are in the Hylaeosaur and in all known Crocodiles and Lizards. It remains, therefore, to discover the most probable number of the vertebrae of the *Iguanodon,* in order to apply their length individually to the estimate of the length of the entire body. The structure of the vertebrae and the ribs, and especially the variation in both structure and size which the ribs of the *Iguanodon,* already obtained, demonstrate to have prevailed in the costal series, render it much more probable that the number of the costal vertebrae would resemble that of the Crocodiles than that of the *Scincus* or other Lizards with unusually numerous dorsal vertebrae, and which possess ribs of a simple and uniform structure, and of nearly equal size. The most probable number of vertebrae of the trunk, from the atlas to the last lumbar inclusive, calculated from Crocodilian analogies, would be 24 vertebrae; which is also the number possessed by the Iguana.

Twenty-four vertebrae, estimated with their intervertebral spaces at 5 inches each, give 10 feet; if to this we add the length of the sacrum, viz. 17 inches, then that of the trunk of the *Iguanodon* would be 11 feet 5 inches; which exceeds that of the Megatherium. If there be any part of the skeleton of the Iguana which may with greater probability than the rest be supposed to have the proportions of the corresponding part of the *Iguanodon,* it is the lower jaw, by virtue of the analogy of the teeth and the substances they are adapted to prepare for digestion. Now the lower jaw gives the length of the head in the Iguana, and this equals the length of six dorsal vertebrae, so that as 5 inches rather exceeds the length of the largest *Iguanodon*'s vertebra yet obtained, with the intervertebral space superadded, on this calculation the length of the head of the largest *Iguanodon* must have been 2 feet 6 inches. In the description of the caudal vertebrae it has been shown that the *Iguanodon* could as little have resembled the Iguana in the length of its tail,[35] as in the anatomical characters of any of the constituent vertebrae of that part: the changes which the series of six caudal vertebrae present in the length and form of the spinous processes, and in the place of origin of the transverse processes, indicate the tail to have been shorter in the *Iguanodon* than in the Crocodile. Assuming, however, that the number of caudal vertebrae of the *Iguanodon* equalled that in the Crocodile, and allowing to each vertebra with its intervertebral space $4\frac{1}{2}$ inches, we obtain the length of 12 feet 6 inches for the tail of the *Iguanodon.* On the foregoing data, therefore, we may, liberally assign the following dimensions to the *Iguanodon:*

	Feet
Length of head, say	3
Length of trunk with sacrum	12
Length of tail	13
Total length of the *Iguanodon*	28

The same observations on the general form and proportions of the animal, and its approximation in this respect to the Mammalia, especially the great extinct Megatherioid or Pachydermal species, apply as well to the *Iguanodon* as to the *Megalosaurus.*