Quarterly Journal of the Geological Society

Iguanodon Prestwich, a new Species from the Kimmeridge Clay, distinguished from I. Mantelli of the Wealden Formation in the S.E. of England and Isle of Wight by Differences in the Shape of the Vertebral Centra, by fewer than five Sacral VertebrS, by the simpler Character of its Tooth-serrature, &·c., founded on numerous fossil remains lately discovered at Cumnor, near Oxford

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Quarterly Journal of the Geological Society 1880; v. 36; p. 433-456
doi:10.1144/GSL.JGS.1880.036.01-04.36

34. IGUANODON PRESTWICHII, *a new Species from the* KIMMERIDGE CLAY, *distinguished from* I. MANTELLI *of the Wealden Formation in the S.E. of England and Isle of Wight by Differences in the Shape of the Vertebral Centra, by fewer than five Sacral Vertebræ, by the simpler Character of its Tooth-serrature, &c., founded on numerous fossil remains lately discovered at* CUMNOR, *near Oxford.* By J. W. HULKE, Esq., F.R.S., F.G.S. (Read April 28, 1880.)

[PLATES XVIII.-XX.]

These fossils, which Mr. Prestwich has kindly given me an opportunity of studying, are, for the extent of information they convey of nearly every part of the skeleton, the most important Iguanodont remains yet discovered at any one time in this country. The only others that may vie with them are those in the well-known Mantellian Maidstone block, in the British Museum, and some, said to represent the greater part of a skeleton, reported to have been found several years since at Hastings, preserved in a private collection, inaccessible, which in their entirety have not, so far as I can learn, ever been examined by an anatomist.

The Cumnor fossils appear to have formed part of one skeleton. They represent an animal between 10 and 12 feet long, which had not reached maturity. Its head was lizard-like, with large eyes and capacious nostrils. Its neck was very flexible and moderately long. Its trunk, particularly the thoracic region, was long, and borne on stout clawed limbs, of which the hinder were much stouter than the fore. The tail, of considerable length, tapered very gradually; and for more than half its length it was flattened laterally.

Unfortunately, as too frequently happens, the removal of the fossils by the unskilful hands of day-labourers has occasioned much damage and many losses. The bones had been already much crushed by the pressure of the beds; but many of the fractures are plainly quite recent. These injuries are not, however, without some compensating circumstances; for the broken surfaces afford in several instances an insight into structural details which may not be so well perceived in an entire bone. This is especially exemplified in the remains of the head, in which the persistence of the sutures and the broken surfaces discover structural details not to be seen in the skull of an old Iguanodon from Brooke, Isle of Wight, which I brought under the notice of the Geological Society in 1870, and which till very recently was the only fragment of an Iguanodon skull which had been identified and described. Taken together, the Cumnor and Brooke skulls give a nearly complete anatomy of this part. The Iguanodont dentition, particularly the maxillary, has never been so well shown as by these Cumnor fossils. I may instance also, as matters in which they have proved highly instructive, the variations of the form of the articular surfaces, and also of the length of the vertebral centra in different regions of the column, and the structure of the tarsus.

A conviction of the value of this skeleton for future reference has led me to describe with greater detail than would otherwise have appeared necessary all the more important and better-preserved bones.

Head (Pl. XVIII.).—This has been much crushed and broken. The most instructive pieces preserved are:—I. 1*, the basis cranii as far forward as the hypophysial fossa; I. 9, the back of the skull, and the sides nearly to the same extent as the base; I. 10, the frontal region; I. 3, 4, 8, parts of both mandibular rami; and I. 2, 5, 6, 7, portions of both maxillæ.

I. 1 (Pl. XVIII. fig. 3).—The occipital condyle has a reniform outline. Its horizontal diameter is 29 millims., and its vertical diameter 19 millims.; these figures, however, do not convey a correct idea of the extent of the articular surface in these directions, which is greater vertically than horizontally, an arrangement manifestly associated with greater angular mobility of the head up and down than from side to side at the occipito-atlantal joints. The condyle is composed mainly of the basioccipital bone; and only a small part at its upper lateral corners is contributed by the exoccipitals. At the under surface a well-marked constriction or neck separates the condyle from a pair of blunt pyramidal swellings, divergent downward extensions of the basisphenoid, corresponding in position to the posterior pair of similarly placed processes in extant lizards. Against these basisphenoidal swellings laterally the neck of the basioccipital expanding abuts, whilst mesially it sends downwards and forwards a short triangular process which is wedged in between them. This intercalated basioccipital process has a low but sharp median crest, which begins behind in a small pit, pierced by vascular foramina lying in front of the condyle.

When the front of the fossil is viewed there are apparent, 1st, below, in the middle line, a rough broken spot, about 12 millims. in diameter, where the præsphenoid has been split off; 2nd, above this a smooth vertical groove, ending above in the floor of the cranial cavity—it is obviously the posterior half of the hypophysial pit; 3rd, on each side of this an uneven fractured boss, the junction of ali- and basisphenoids. Each of these bosses overhangs the smooth antero-lateral surface of the descending basisphenoidal process of its own side; and there is immediately beneath it a winding groove, which rises from the undersurface of the skull through the hypophysial fossa into the cranial cavity; it marks the course of the internal carotid artery. A branch of this groove, ascending in a backward direction, enters the skull through the principal foramen of exit for the 5th nerve.

Pl. XVIII. fig. 4. The upper surface of the fragment exhibits (1) a mesial trough, the floor of the skull-chamber. This is 7·5 millims. wide near the foramen magnum; and here it is relatively deep. Anteriorly it widens through a space of 26 millims., and then deepening

* These numbers refer to labels attached to the bones.

forms a wide depression behind the hypophysial pit. Throughout this extent, 38·5 millims., the floor of the skull-chamber consists of a continuous unbroken piece, basioccipital, which ends taperingly in the depression behind the sella turcica, where the basisphenoid comes into view. Thus the basioccipital overlaps the basisphenoid on the upper as also at the under surface of the basis cranii.

Laterally the persistence of the sutures and the foramina of exit for the cranial nerves makes it possible to recognize in sequence from behind forwards (1) a stout exoccipital, articulating with the basioccipital by a broad serrated suture, and perforated at 10 millims. from the foramen magnum by an aperture (for 9th nerve?). At 6 millims. in front of this opening is another groove (for transmission of vagus?), which appears to pass out between the exoccipital and opisthotic elements. This, again, is followed by a very conspicuous groove, situated where the basioccipital attains its greatest breadth in the floor of the skull-chamber. In front of this, where the prootic might be expected, is the upper opening of a deep funnel-like pit, which descends within the bone into the basisphenoidal process visible at the under surface of the skull. The form of this pit does not suggest the transmission of blood-vessel or nerve, whilst its situation hints that it may be part of the auditory apparatus, possibly an air-channel connected with the middle ear. The fact that in old Iguanodons the inferior basisphenoidal processes are hollow sinuses * favours this conjecture. A wide groove, presumably for the 3rd nerve, separates the prootic and alisphenoid.

Pl. XVIII. fig. 5. Another fragment (I. 9) comprises the back of the skull and the sides nearly to the extent of the piece just described. The supraoccipital bone contributes the upper boundary of the foramen magnum, as in extant lizards. It is not excluded from this opening as in crocodiles—a point worthy of notice, because the general form of the occiput, so far as it can be recognized in this fossil, has a crocodilian likeness, as has also the occiput in my Brooke Iguanodon-skull. Immediately above the foramen magnum the supraoccipital stretches laterally outwards to what are apparently the roots of a stout suspensorium (for the attachment of the quadrate bone), now broken off and missing. This is a strong pyramidal projection, below constructed of the blended exoccipital and opisthotic, above of another and distinct part, parietal. Between these two parts of the suspensorium the broken surfaces show that an extreme lateral extension of the supraoccipital intrudes. Nearly at its mid-height this bone abruptly contracts to less than half its breadth below (22·5 millims), being here encroached on and overlapped by the suspensorial extension of the parietal. This narrowing of the supraoccipital is too symmetrical to be altogether due to the downward crushing of the parietal upon it; it has doubtless been increased by this, but is a natural conformation. The upper border of the supraoccipital is a smooth edge, which was connected with

* I learned this many years ago in a fragment of a very large old skull in the collection of the Rev. W. Fox.

the parietal by sutura harmonia. In their present mutilated state the back and sides of the skull form a rude pyramid, of which the base of the posterior face is notched by the foramen magnum, and the postero-external angle is formed by the truncated suspensorium.

The lower borders of the fragment correspond to the upper borders of the basis cranii. They, as also the inner surface, are too mutilated for description.

On the under surface of the base of the right suspensorium is a wide groove, directed forwards and inwards. It exactly corresponds to the groove in the Brooke skull to which I lately referred, and may have lodged the stapedial rod.

Pl. XVIII. figs. 1, 2. A third fragment of the skull (No. I. 10) comprises parts of the parietal and frontal regions and of the left temporal bar. The parietal bone is single; no trace of mesial suture joining two halves is discernible. This is mentioned because in the nearly allied *Hypsilophodon* such a suture has been thought to exist. The sides of the parietal fall off steeply from a sharp median crest, which divides in front, and, bending outwards, here forms the anterior boundary of the upper temporal opening. There is no parietal foramen.

The frontal is a very large bone. Its length contrasts strongly with the shortness of the parietal; and its breadth also is considerable. It consists of two halves, united by a very evident mesial suture. Its structure is very dense, without diploë. Deep sutural indentations in its right border show that the præ- and postfrontal bones approached each other very closely, and that the frontal formed but a small part, if any, of the upper border of the orbital opening. The direction of this opening is lateral, as in *Hypsilophodon Foxii*. The postfrontal bone, of which part is preserved on the left side, is large; its smooth orbital surface is of great extent; a long slender branch separated the orbital from the lateral opening; and a stronger branch directed backwards forms the anterior part of an upper temporal bar.

In the undersurface of the fossil are shown:—1st. A large lozenge-shaped mesial hollow—the vaulted inner surface of the skull—narrow behind, in its longer diameter sinuous, being convex in the parietal part and concave in the frontal. Its greatest width coincides with the parieto-frontal suture. It narrows anteriorly at a line drawn through the middle of the orbital surfaces; and in front of this it expands for the reception of the olfactory lobes, which must have been of large size—an inference confirmed by the large size of the nasal chambers, indicated by the great size of the nasal bones. 2nd. Laterally, on each side of the vault of the skull-chamber is the smooth orbital surface lately mentioned. Its outline is roughly rhomboidal. The two outer sides are sutural, as already mentioned, and afforded attachment to the præ- and postfrontal bones. The inner angle is rounded off, and the two inner sides make a continuous curve. Of this the posterior $\frac{3}{4}$ are broad and rough as if sutural, and the anterior $\frac{1}{4}$ is a thin, smooth, free crest.

Jaws.—Other very instructive pieces are fragments of both maxillæ and of both rami of the mandible. Of the maxillary fragments, No. I. 2 is the most important. Its outer alveolar border, 77 millims. long, has in this space the sockets of 9 teeth. Immediately above this free border the bone rapidly swells, acquiring greater bulk mainly by expansion of the outer wall, which in its ascent slants outwards as high as the level of the upper ends of the tooth-fangs, above which it again falls inwards towards the mesial line. The inner dentary wall, a thin plate, rises nearly vertically as high as the tops of the tooth-fangs, above which it bends outwards, and joins the outer wall of the bone.

Above the alveolar border the outer surface of the maxilla is pierced by a row of conspicuous foramina, as in *Megalosaurus* and *Teratosaurus*.

Viewed from above, this piece of the upper jaw shows at the inner side the smooth surface overlying the ends of the tooth-fangs, and outside this a broken edge. Nearly in the middle of this edge, sunken in the substance of the base, outside the tooth-fangs, is a remarkable oval pit, 13 × 7 millims. across at its mouth, and 7 millims. deep. Its surface is perfectly smooth. The outer margin of this pit is a thin smooth lip, which apparently formed the lower border of a conjugate anteorbital foramen. Behind, at its inner side in the dry skull, the pit seems to have freely communicated with the naso-buccal cavities. Behind the pit is a narrow groove, of which the outer border is a thin natural edge. I am disposed to view this as the sutural groove for the reception of the front margin of the jugal bone, which fixes this as the hinder part of the jaw, and shows it to belong to the left side. In front of the pit is another, wider groove, the significance of which is less obvious. In the piece No. I. 5, the corresponding part of the right maxilla, this groove descends from the pit forwards in the substance of the jaw outside the teeth. Near its origin it is joined by a lesser channel, which begins not far from the jugal groove near the back of the jaw, and passes forward skirting the inner border of the pit. Do this pit and the wide groove proceeding from it represent the glandular grooves which tunnel the hinder part of the maxilla in the crocodile? May the lesser groove have transmitted a branch of the 5th nerve? Less imperfect materials must answer these questions.

The fossils No. I. 3, 4, are considerable portions of the mandibular rami. They have the well-known Iguanodont form, and do not need particular description.

Dentition.—In every piece of maxilla or mandible holding teeth, the crowns of all which were in full wear at the animal's death have been broken off and lost; in most instances this damage is quite recent; but their fangs and the germs of many successional teeth remain, and these afford very complete information respecting the perfect form of the mature upper and lower teeth, and also of the manner of succession.

The crown has the compressed, ridged, serrate form characteristic of the family Iguanodontidæ.

Upper Teeth (Pl. XVIII. fig. 7).—The crowns of these are narrower in the antero-posterior direction, and the primary ridge in their outer stoutly enamelled surface is stronger than in the lower teeth, characters noticed by Melville, Mantell, and also by Owen, which may serve to distinguish these teeth when detached from the jaw. This ridge divides the outer strongly enamelled surface unequally, being much nearer to the anterior margin. At the free end of the unworn crown it ends angularly at the meeting of the anterior and posterior borders. Of these the former is nearly straight, whilst the latter bends towards the angle in a full sweep. The most prominent part of the ridge is nearly at the mid-length of the crown, and from here it declines towards a cingulum, which marks off the crown from the fang. The outer surface between the primary ridge and the front straighter border of the crown has the form of a wide, deep, smooth groove, whilst the space between it and the distant posterior curved border is sculptured by several minor longitudinal ridges, which start from the minuter cusps of the terminal serrature, and are separated from one another by narrow grooves. These secondary ridges are fewer, and the grooves between them narrower towards the middle of the crown, and they subside towards the cingulum. The serrature is limited to the free end and the front and posterior border of the distal half of the crown. In the half next the fang these borders are smooth uninterrupted ridges. The cingulum is a sinuous inconspicuous line crossing the outer surface of the tooth in a double curve, the two ends of which are convex towards the fang. One of these corresponds to the basal end of the primary ridge; and the other is nearer the distant border of the crown. The cusp between the curves is nearly equidistant from the two borders, but slightly nearer the primary ridge. In a tooth which has descended so far beyond the outer alveolar border that the cingulum is 5·5 to 6 millims. distant from it (No. 5 in I. 2, fig. 7), the outer surface of the exposed part of the fang is covered by wavy lines. The inner surface of the crown is gently convex, smooth, and even, and unsculptured, the terminal marginal serration being scarcely prolonged upon it. In a favourable light faint transverse markings are apparent on it. A longitudinal swelling subdivides this surface unequally; the correspondence of its position to that of the primary ridge on the outer surface makes this the thickest part of the crown.

The lower teeth (Pl. XVIII. fig. 6) have much broader crowns than the upper. In the angulation of the hinder margin of the crown, the curve and greater length of the anterior margin, the unequal division of the thickly enamelled inner surface by a primary ridge, they prefigure the teeth of Iguanodon from the Wealden-beds in S.E. England and the Isle of Wight. They differ, however, from these in one detail, the character of the serrature. The free edge of the small plate-like cusps of this is in such Wealden teeth minutely mamillated; but in these Cumnor teeth the margin of the lamella is even. I found this difference in teeth of very nearly the same size. Perhaps in relative simplicity of sculpturing the Cumnor Iguanodon's teeth more closely resemble the teeth in the dentary piece of a mandible obtained from near the horizon of the Purbeck cinder-bed at Swanage, figured by Prof. Owen in Foss. Rept. Wealden and Purbeck Formations, Suppl. v. pl. i. (1874).

Several broken teeth show that both upper and lower teeth have a large pulp-cavity (Pl. XVIII. fig. 8). It is now filled with calcite, which, by its whiteness, contrasts strongly with the dark dental tissues. The cavity passes far into the crown, towards the base of which it is widest; and it contracts greatly towards the end of the fang, which it pierces as a minute inconspicuous pore. The fang in both jaws tapers to a point. I particularly mention this because, though known and described already, it has been lately asserted that such tapering ending of the fang, with accompanying reduction of its pulp-cavity almost to its obliteration, is unusual in *Iguanodon Mantelli*.

Succession.—The replacement of older teeth as their crowns are worn out, by germs developed in reserve cavities lying nearer the inner surface of the jaw, is more completely illustrated by these Cumnor fossils than by any which had previously come under my notice. Four successional phases of upper and lower teeth are apparent. In the maxilla, I. 2, may be seen:—1, stumps ready to be shed, as that marked No. 5, where the cingulum is 5·5 to 6 millims. beyond the outer alveolar border; 2, teeth the crowns of which were in full use, as that marked No. 4, where the entire crown has emerged, the cingulum lying nearly in the plane of the alveolar margin; 3, germ-crowns, which have emerged only $\frac{1}{2}$ or $\frac{1}{3}$, and had not come into use, as Nos. 1, 3, 10, 12, 14; 4, quite small germ-crowns, which only just peep over the inner parapet. In these four phases the younger lie inside the older teeth, alternating with them, the arrangement being such that, when one of the oldest teeth is ready to fall out, a fully formed successional tooth moves outwards into its place.

The fragment of lower jaw, I. 3 (fig. 6), illustrates for the lower teeth, even more beautifully, the same four phases, the same grouping and progression. Nos. 1, 3, 5, are teeth nearly worn out; Nos. 2, 4, 6, teeth in full use; Nos. 7, 8, 9, crowns scarcely half emerged; and Nos. 10, 11, minute germs only just visible above the inner parapet.

An idea of the size of the teeth may be gleaned from the following measurements. The maxillary piece, I. 2, in a space of 75 millims, contains the sockets of an outer series of 9 teeth. The breadth (*i. e.* antero-posterior dimension) of a fully formed upper crown is 9·5 millims.; the length of a fang (I. 5) is 20·5 millims. The dentary part of the left mandibular ramus, I. 4, in the space of 94 millims., has the sockets of an outer series of 12 teeth; and the fragment of the right ramus, I. 3, contains sockets of six outer teeth in the space of 51 millims. The greatest breadth of the largest lower-tooth crown is 12·5 millims., that of other crowns varying between 10 and 11·5 millims.

The head of this Cumnor Iguanodon, so far as may be inferred from the pieces recovered, may have been about 20 cm. long, a size which may be considered moderate. In its general form it was obviously much more lizard-like than crocodilian. The preponderance of Lacertilian resemblance is not merely a superficial one; it is evident in many structural details. In the occiput the shape, so far as is shown in this fossil (and in this it agrees with my Brooke Iguanodon-skull), has certainly a greater resemblance to that of a crocodile than lizard; but this superficial likeness is outweighed by the lizard-like entrance of the supraoccipital bone into the foramen magnum, from which it is excluded in the crocodile. In the upper surface of the skull the shape and size of the upper temporal openings, the form of the parietal bone, the division of the frontal bone, the large size and form of the nasal bones, are all lacertilian correspondences. The form of the maxilla, the mode of articulation of the mandible by a suspended quadrate not wedged into the side of the skull, and the dentition are other lizard-resemblances. On the under surface of the skull the downward extension of a median process of the basioccipital bone is at first sight a crocodilian feature; but it differs from the crocodilian's basioccipital in direction and relations. However, whatever value may be attached to this superficial similarity, it is more than balanced by the divided palate, shown by the free exposure of the basioccipital and basisphenoid bones throughout their whole extent, and by the absence from the maxillæ of any trace of palatal extension, or of attachment of those bones which in the crocodile close the palate and separate the nasal and buccal passages.

Vertebral Column.—Sixty-four centra and a considerable number of pieces of neural arch and processes give very complete information as to the structure of every part of the vertebral column. Of the centra 25 are præsacral, 4 are sacral, and 35 are postsacral or caudal. For convenience of reference, they have been consecutively numbered in what appears to be their natural sequence in the column; but probably several are missing from in front and behind the sacrum.

Neck (Pl. XIX. figs. 1–4).—Of the 25 præsacral vertebræ, 7 have, either wholly upon the centrum, or jointly on this and on the arch, an articular process for the attachment of the lower branch of a forked riblet—a lower or capitular costal facet, parapophysis—which stamps them cervical. Some are much crushed; and in all the neural arch is much mutilated. All are opisthocœlous, the posterior surface cupped, the anterior convex. Both surfaces retain marks of a concentrically laminated intervertebral cartilage. The contour of the anterior surface is almost a rhomb, in which the infero-lateral sides include an angle of about 100°; the upper angle is cut off by the neural canal; and the supero-lateral and infero-lateral sides include an angle of about 80°. The horizontal exceeds the vertical diameter. The lateral non-articular surfaces of the centrum are concave longitudinally, and they are indented by a depression, which is deeper towards the front. Below this depression the opposite sides of the centrum meet in a median keel. The borders, where at each end the sides and articular surfaces meet, and the keel are rugose in all the cervical vertebræ, as in most of the succeeding præsacral centra.

The atlas and axis are lost. In No. 1 of the cervical series the lower transverse process or parapophysis, preserved only on the left side, is an oval facet 5 × 4 millims. in extent, which projects from the side of the centrum, near its anterior border, below the semi-diameter. Close behind it, agglutinated to the centrum by matrix, is a small hatchet-shaped bone, having on one margin an articular facet, the form and size of which so nearly agree with those of the parapophysis as to suggest, in connexion with its nearness to this, that it is a neck-riblet. The sides of this centrum are convex in the vertical direction. From the size and position of the parapophysis, I think it probable that this vertebra was next to the axis, or the third in natural sequence.

In No. 2 the parapophysis is higher on the side of the centrum; it is also more prominent than in No. 1. It is close to the anterior border of the centrum, just external to the neuro-central suture. From it there passes backwards a ridge which divides the side of the centrum into a smaller upper area lying between the ridge and neuro-central suture and a larger lower area between the ridge and inferior median keel. The depression (mentioned in the description of No. 1) is in the lower area; and its deepest part is in front. A large vascular foramen pierces the bottom of the depression. The middle of the centrum is constricted, the horizontal transverse diameter being here 29 millims., whilst at the ends it is 40 millims. The upper surface of the centrum contributes at each end a large triangular piece to the floor of the neural canal; but at the middle of the canal only a narrow piece of it appears between the neurapophyses.

In No. 3 the parapophysis touches the neuro-central suture, which in front spreads outwards on its upper surface. The neurapophysis in this, as in all the neck-vertebræ, has an extensive attachment to the centrum, its antero-posterior dimension nearly equalling that of the upper surface of the centrum. At each end it spreads out very conspicuously. The arch, of which more is preserved than in any other neck-vertebra, was evidently dwarfed. On its left side, just external to the præzygapophysis, are indications of an upper transverse process for attachment of rib-tubercle, now broken off, a diapophysis, in the level of the spring of the arch.

In No. 4 the parapophysial facet rests jointly on the centrum and neurapophysis; but the former constitutes the greater part.

In No. 5 the parapophysis is similarly situated; but in No. 6 it is on a slightly higher level, the centrum contributing the lesser part.

In No. 7 the parapophysial facet lies just above the neuro-central suture, on the dilated antero-external corner of the neurapophysis.

In No. 8 no distinct trace of rib-facet is perceptible here; and in No, 9 the facet has certainly risen above the base of the neurapophysis.

Accounting all cervical in which the supporting process for the attachment of the rib-head is wholly or partly on the centrum, the neck of this Iguanodon certainly contained not less than 9 vertebræ. From the foremost of these preserved, No. 1 (probably the third in natural sequence) to the 7th, and indeed through the 8th and 9th, which in general form most resemble cervical centra, a gradual increase in bulk of the vertebral column takes place from the head to the trunk, and a gradual ascent of the parapophysis is observable.

The following measurements show the dimensions of Nos. 2 and 3, the least distorted centra in this series:—

	No. 2.	No. 3.
	mm.	mm.
Length along upper surface of centrum	41·	40·5
" " lower " "	35·5	41·
Diameters.		
Anterior surface, vertical	25	26
" " horizontal	37	42
Posterior surface, vertical	30	31
" " horizontal	40	41
Horizontal diameter at middle of centrum	29	36

The typical cervical vertebræ are followed by a few in which the anterior articular surface becomes plane, and the posterior is less hollow. In these there is no rib-head facet upon the centrum; but in one (Pl. XIX. fig. 5), No. 11, which retains a large part of its neural arch, this facet is on the anterior margin of the (upper) transverse process, very close to the præzygapophysis. It is an oval, 17 × 19 millims., directed outwards, and indicates a rib of considerable stoutness. The transverse process—diapophysis—is broken off just beyond the rib-facet. It had a broad basal attachment to the arch in the level of its crown, extending from the præ- to the postzygapophysis, after the manner of the platform mentioned by Prof. Owen as characteristic of *Iguanodon Mantelli*. This platform is upborne by a strong buttress, which rises obliquely forwards to its under surface from the lower and back part of the neurapophysis near the neuro-central suture. In front of this buttress is the parapophysial facet, and behind it is a deep three-sided hollow. The præzygapophyses of this vertebra look upwards and inwards. A line drawn perpendicularly to the plane of the left præzygapophysis includes, with the spinous process, an angle of about 45°. The sides of this centrum (No. 11) are concave longitudinally and gently convex vertically. The keel is less strongly marked than in the cervical vertebræ. The length of the neural surface of this centrum is 50·5 millims., and the vertical diameter of the articular ends is 38 millims. The length of No. 10 is 42 millims.

In No. 13 the rib-head facet lies further outwards from the præzygapophysis upon the transverse process than in No. 11. This vertebra is therefore thought to have occupied a place in the vertebral column posterior to No. 11. The length of the centrum, measured along the neural surface, is 55 millims.; and the vertical diameter of the articular end is 46 millims. The sides are much crushed; but it is evident, notwithstanding this mutilation, that the horizontal diameter of the ends did not exceed the vertical as in the neck. The borders of the articular ends are prominent and slightly everted.

The anterior articular surface of all the præsacral vertebræ behind where the neck and trunk join (in which region it is plane) is slightly hollow; and this is also its shape in the tail. The posterior articular surface of all the vertebræ behind the neck is decidedly concave. This character—the greater concavity of the posterior articular surface—is of use in determining the direction of a dissociated centrum when other indications are lost.

The sides of the centrum, in what I may call the middle dorsal region, are gently convex in the vertical direction, and concave longitudinally. At its middle the centrum is slightly constricted. The constriction is much less than that represented in the figure of a thoracic vertebra of *Iguanodon Mantelli* given by Prof. Owen in the Foss. Rept. of the Wealden Formation, Suppl. II. t. 7. fig. 6.

In No. 11 the facet for the rib-head is 9·5 millims. distant from the præzygapophysis; in No. 13 it is 18·5 millims. from it; in No. 18 the interval is nearly the same. It appears from this that the outward movement of the capitular facet, from the root of the (upper) transverse process—diapophysis—to the free end of this, takes place through a larger series of vertebræ in this Iguanodon than in extant crocodiles, and that the middle thoracic region was longer in the Dinosaur. In a skeleton of *Crocodilus niloticus*, presented in 1875 to the Hunterian Museum by the Hon. E. F. C. Berkeley, at the 19th vertebra the capitular costal facet merges into the tubercular facet at the free end of the transverse process; and the rib articulating here retains scarcely any trace of division. In this skeleton the passage of the capitular facet from the centrum to the free end of the diapophysis is completed through a chain of 8 vertebræ, the 12th to 19th inclusive. In this Iguanodon's vertebral column the capitular facet, withdrawn from the centrum in No. 8, is still near the root of the diapophysis in No. 18. The large proportion of Iguanodont vertebræ in which the rib-head facet is close to the præzygapophysis, which I have obtained in the Isle-of-Wight Wealden beds, had long attracted my notice.

Behind No. 16 the bulk of the centrum much increases. Many of the centra in the front and middle of the trunk are much crushed; but, allowance being made for this mutilation, the excess of the horizontal over the vertical diameter, so noticeable in the articular ends of the centra in the neck, is clearly not repeated here.

In No. 17, where the centrum has escaped distortion, the anterior articular surface has a nearly circular outline; its horizontal and vertical diameters are each 51 millims. The vertical diameter of the posterior end is also 51 millims., the horizontal being somewhat greater, 57·5 millims. The borders of both ends are prominent, and slightly everted (as in the root of neck); and the rugosity of the adjoining part of the lateral non-articular surface is strongly marked. The sides of the centrum here, as in the anterior thoracic region, are gently convex vertically. The inferior median keel is less prominent here than in the last-mentioned region. The constriction of the middle of the centrum is also in these Cumnor fossils less than in those from the Wealden formation, described in the work to which reference was very lately made. The transverse horizontal diameter of No. 17 at its middle is 41 millims, at the anterior end 51 millims, and at the posterior end 57 millims. In this part of the column the præzygapophysis has a more horizontal direction than in the front of the trunk.

In the loins the centrum increases greatly in bulk, and this more by augmentation of its width and depth than by addition to its length. In No. 21, which I place here, the horizontal diameter of the anterior articular surface is 64 millims., and the vertical diameter 56 millims.; the same diameters of the posterior articular surface are 74 and 52 millims., the horizontal diameter in both instances preponderating. The average length of the centrum in this region is 54 millims. These proportions give to the lumbar contra an appearance of stoutness and shortness. The anterior articular surface is very flat, whilst the posterior surface is distinctly concave, the concavity being greater in the vertical than in the horizontal direction. The sides of the centrum are, in the vertical direction, more cylindroid than in the dorsal region. The inferior keel is more marked than in the posterior dorsal vertebræ, owing to a slight flattening of the surface on each side of it, which increases its prominence. The anterior articular processes look inwards and upwards. The posterior articular processes greatly overhang the plane of the posterior surface of the centrum. They are separated from one another by a deep groove. The neuro-central suture is almost the same length as the upper surface of the centrum; but the neurapophyses soon contract, principally by the forward slant of their posterior border. In No. 20 the lengths of the neuro-central suture and centrum are 50 millims., whilst at the height of 15 millims. the neurapophysis has an antero-posterior extent of only 32 millims. (Pl. XIX. figs. 6–8.)

The spinous processes of all the præsacral vertebræ have been broken off. So far as may be gleaned from the stumps remaining on some of the arches and from detached dissociated fragments, they had in the trunk a great antero-posterior extent; near their root their front margin is a thin edge; their posterior border is deeply grooved; they had a backward slant. In none of the trunk-vertebræ is there any indication of a capitular costal facet on the pier of the arch, as represented in the figure of the dorsal vertebra of *Iguanodon Mantelli* in the Fossil Rept. of the Cret. and Weald. Formations, p. 109, pl. 35; and the evidence afforded by these remains (it is not claimed to be complete) seems to show that the rib-head facet, when it left the neuro-central suture, passed directly from this to the (upper) transverse process, as in extant crocodiles. In the skeleton of *Croc. niloticus* the transfer occurs at the 12th vertebra, in which the capitular facet is on the diapophysis, whilst in the 11th vertebra it is on the neuro-central suture.

Sacrum (Pl. XX. figs. 1, 2).—The true sacral vertebræ (as defined by their ankylosis, the junction of the free ends of their lower transverse processes, and the connexion of these with the ilium) are four. Although now disconnected (ankylosis not having yet occurred, owing to the immaturity of the individual), the terminal surfaces of the centra fit each other so truly that their natural sequence is not, I think, open to doubt.

With the anterior surface of the foremost sacral centrum articulates another, in precisely the same manner as that in which the true sacral centra are joined together. It is the last lumbar vertebra, No. 23. By the identity of its mode of union to the first sacral centrum, and by the large support it affords to the first-sacral lower transverse process, it so closely resembles the true sacral vertebræ, and dynamically forms so obviously a part of the sacrum, that Drs. Melville and Mantell were not very culpable in regarding it as the first true sacral centrum.

The last lumbar (Pl. XX. figs. 1, 2, *ll*) is bulkier than any of the true sacral centra. Its form is depressed; its anterior articular surface is nearly plane, very slightly concave. It is smooth; and it was evidently capable of movement upon the next centrum in advance, to which it was attached by an intervertebral disk of the ordinary structure and form, the marks of which are still apparent. The vertical diameter of this face is 52·5 millims., and the horizontal diameter about 66 millims. Its posterior terminal surface is plane. It is marked by radiating impressions suggestive of intimate union to the next centrum by a thin film of ossifying cartilage. Its minimum horizontal diameter in the plane of the neural canal is 40 millims., and its maximum diameter, which is nearly on the level of its mid-height, is 71 millims. It will be seen from a comparison of these numbers how greatly the centrum expands behind. Here near the posterior border the centrum attains the maximum horizontal diameter of 91 millims., forming the anterior boundary of a deep notch in the articulated sacrum between the last lumbar and first sacral centrum, which afforded a very firm attachment to the first lower sacral transverse process. The sides of the last lumbar centrum, in the vertical direction, at first slope outwards from the neural surface until the level of the lower limit of the notch just described is reached. From here they bend rather abruptly inwards to an inferior median keel, at each side of which the surface is transversely nearly plane. Longitudinally the sides of the centrum are very concave; the concavity is increased by the prominence of the posterior margin. The neuro-central suture is relatively shorter than in the other lumbar vertebræ; the groove of exit for the last lumbar nerve limits it behind. At a short distance from its posterior limit the suture has a conspicuous indentation, repeated in the last true sacral vertebra.

The first true sacral centrum (No. 24) is much smaller than the last lumbar. In front, at its junction with this, it is much expanded, but towards its middle it rapidly contracts. The inferior median keel, conspicuous in the last lumbar centrum, is here scarcely noticeable. The form of the centrum is more cylindroid;

its neural arch plainly rested chiefly on this, its proper centrum, and was only to a very limited extent borne on the last lumbar. The length of the neuro-central suture is only about ⅝ of that of the upper surface of the centrum, the attachment being limited behind by the wide groove of exit of the first sacral nerve, which emerges over the side of the centrum rather behind its middle. Behind this nerve-groove is the rough sutural surface descending on the postero-lateral border of the centrum, of which the upper part afforded a limited attachment to the neural arch of the second sacral vertebra, and the lower part formed one side of the notch between it and this latter, where the second lower sacral transverse process was implanted. This process was evidently smaller than the first.

In the second sacral centrum (No. 25), the dimensions of the anterior and posterior terminal surfaces do not much differ. The centrum is evenly and slightly constricted at its middle. The non-articular part or side is cylindroid in the vertical direction, slightly flattened below the neuro-central suture, and again at its under surface, where longitudinally it is concave. It has no median keel. The groove of exit for the 2nd sacral nerve is slightly further back than the corresponding groove in the 1st centrum. The notch in the posterior border of the centrum for the second lower transverse process descends only a slight distance.

The third sacral centrum (No. 26) differs little from the second. Its under surface is somewhat flatter, and towards the posterior border it has a slight depression. Its lower transverse process is partly borne on the postero-lateral border of the second centrum. The groove of exit for the third sacral nerve is slightly nearer the posterior border of the centrum.

The fourth sacral centrum (No. 27) is distinguished from the others by the smoothness and concavity of its posterior surface, which evidently allowed the anterior caudal centrum to play upon it through the medium of an ordinary intervertebral disk. The neural arch rests on the whole length of its own centrum and slightly on the third centrum. The fourth sacral nerve emerged through the intervertebral foramen between it and the first caudal vertebra, and not across the side of its own centrum as in the first three sacral vertebræ. The under surface shows the same flattening and slight hollow noticed in the third centrum.

With the exception of the anterior surface of the last lumbar or false sacral vertebra, and of the posterior surface of the fourth sacral centrum, all the terminal surfaces of the sacral vertebræ are rough; their union with one another was evidently too intimate to allow of movement; and had the animal reached maturity they would probably have become coossified.

The length of the entire sacrum, including the last lumbar vertebra, is 29 centims., that of the last lumbar being 52 millims.; of the 1st sacral centrum, 50 millims; of the 2nd, 53 millims.; of the 3rd, 49 millims.; of the 4th, 50 millims.. When the centra are articulated the outline of the under surface of the sacrum is rendered sinuous by the constriction of the middle of the centra and the prominence of their terminal borders.

The neural canal correspondiug to the last lumbar and three foremost sacral centra is very capacious; at the fourth centrum it becomes abruptly contracted.

It will have been noticed that only the false sacral centrum (last lumbar) wholly supports it own neural arch, and that, as regards the four true sacral centra, the arch, whilst resting mainly on its own centrum, is also borne in part on the centrum next before it. This seeming advance of the arch, by which it comes to lie over the interval between two centra (first noticed, I believe, by Owen in a Wealden sacrum referred by him to *Iguanodon Mantelli*, formerly in the collection of the late Dr. Saull, and at his death acquired by the British Museum, and also found by him in a sacrum of *Megalosauras*), has its probable explanation in the persistence throughout life of an early embryonic phase. In the chick it has been ascertained that each permanent vertebra comprises the anterior and posterior halves of two consecutive protovertebræ. The neural arch, after this second segmentation of the vertebral column, comes to rest on the anterior half of the permanent vertebra. The intervertebral space between two permanent vertebræ corresponds to the middle of the centrum of a protovertebra.

In the Dinosaurian sacrum it appears as if the transformation of the proto- into the permanent vertebræ was not completed in the sacral region of the column; the second segmentation mapping out the permanent centra is effected, but the arches retain their primitive positions.

On comparing this Cumnor sacrum with the type fossil in the British Museum, to which I have very recently referred (No. 37685, Brit.-Mus. Catal.), some notable differences are evident. Of these, the smaller number of centra, 4 in the Cumnor sacrum (the British-Museum sacrum has 5 centra), is the most important. It is certain that 5 is the true number of centra in the latter; for they are firmly coossified in undisturbed natural sequence; but the reference of this fossil to *Iguanodon Mantelli* wants the confirmation which its association with other indubitable Iguanodon-remains might have afforded, and no such verified sacrum has since been found with which to compare it.

The proportions of the centra in the Cumnor and British-Museum sacrum No. 37683 are also very different, as the subjoined measurements show. In the former the centra are shorter and stouter, and they want the remarkable lateral compression and strongly carinate form so conspicuous in the latter, which is well represented in Prof. Owen's figure of this in his Foss. Rept. Wealden Formation, t. iii.

Measurements.

	Last Lumbar.	1st Sacral.	2nd Sacral.	3rd Sacral.	4th Sacral.	5th Sacral.
Wealden Sacrum. (No. 37685, Brit.-Mus. Cat.)						
Length along under-surface..............	mm. 71	mm. 62	mm. 80	mm. 65	mm. 76·5	mm. 76
Transverse horizontal diameter at middle of centrum	...	35	28	28	28*	65
Cumnor Iguanodon.	(No. 23)	(No. 24)	(No. 25)	(No. 26)	(No. 27)	
Length of centrum...	52	56*	52*	52*	52*	
Horizontal transverse diameter at middle of centrum	69·5	44	41·5	43	43	

That these differences of form have a specific value will be, I think, allowed by all. The fewer sacral vertebræ in the Cumnor sacrum have a somewhat higher import. Have we here an earlier phase in the development of the Dinosaurian sacrum than that exemplified in *I. Mantelli?* The earlier age of the Cumnor Iguanodon, as indicated by its gisement, Kimmeridge Clay, would be in harmony with this.

Tail.—Thirty-five postsacral vertebræ are recovered. It is probable that a couple of the foremost are missing, since all those procured have chevron-facets, and in extant lizards and crocodiles these are absent from a small number of the foremost caudal vertebræ.

In No. 28, probably the foremost of our series, the centrum is larger than in those which I have placed behind it. The anterior articular surface is nearly plane, very slightly concave, whilst the posterior surface, as in all the other caudal vertebræ, is distinctly concave. The sides of the centrum are, in the vertical direction, gently convex; they meet at the under surface of the centrum in a blunt wedge-form. In the longitudinal direction they are gently concave. The under surface at each end is encroached on by the chevron-facet, which is continuous with the terminal articular surface. In this vertebra (No. 28) the length of the neural surface is 50·5 millims., and the distance between the anterior and posterior chevron-facet on the under surface is 19 millims. A strong transverse process juts out from the neurapophysis at the height of 12 millims. above the neuro-central suture.

No. 29 (Pl. XIX. fig. 9) has a peculiar and distinctive obliquity, produced by the downward and backward slant of its under surface,

* Approximate measurements; small chips off edge prevent actual measurements of this dimension.

which meets the chevron-facet at an acute angle. (I have obtained similar caudal vertebræ in the Isle of Wight.) The sides of the centrum are vertically slightly convex. The narrow under surface is more encroached on by the anterior than by the posterior chevron-articulation. The transverse process arises rather lower than in No. 28. The spinous process has a strong backward slant.

Through the next four vertebræ, Nos. 30–33, the transverse process sinks on the arch towards the neuro-central suture, and it also becomes smaller. In No. 30 its size is greatly reduced, and it arises in the plane of the neuro-central suture, which is very indistinct. In No. 35 a slight swelling is the only vestige of the transverse process; and even this is absent from the succeeding vertebræ.

The suppression of the transverse process is soon followed by the disappearance of the neuro-central suture, which ceases to be recognizable in No. 37. Of the succeeding centra many have been much squeezed in by laterally applied pressure. To this they have yielded in such a manner as to suggest that the middle of the centrum was very imperfectly ossified, and perhaps permanently cartilaginous, as was thought characteristic of the caudal vertebræ referred to *Poikilopleuron*, but is now known to obtain in *Megalosaurus*. In No. 37, the 10th in the caudal series, the posterior chevron-facet is notched in front; and from this notch a slight groove passes forwards along the under surface of the centrum.

In No. 41 (Pl. XIX. fig. 11) the anterior chevron-facet has almost disappeared. On the side of the centrum is an angular longitudinal ridge; between this and the situation of the neuro-central suture is a shallow depression; and below the ridge a small better-marked hollow. The ridge is gradually lost in the succeeding centra. The reduction in bulk is attended with diminution of length of the centrum.

In the smallest vertebræ, towards the end of the tail, the centrum has a simple cylindroid form (Pl. XIX. figs. 12, 13). In these the arch is reduced to extreme simplicity, a mere hoop bearing an anterior and posterior pair of articular processes. The spinous process ceases in No. 51. A slight rugosity marks the situation of the chevron-joint, so conspicuous in the first half of the tail. The anterior chevron-facet first disappears. Both articular surfaces in all the caudal vertebræ are concave.

The change in form of the articular surfaces of the vertebral centra, traceable through the column, is highly instructive. In the neck these surfaces are convexo-concave, opisthocœlous; at the root of the neck the anterior ball is less convex, the posterior cup less deep; in the fore-trunk the anterior surface is plane, the posterior slightly concave; in the loins the anterior surface is very slightly concave, the posterior surface more so; and in the tail both surfaces are concave. Variation in length of centrum, shown by the annexed measurements, is not less worthy of notice; for it had been asserted that the length of centrum was constant for the same vertebral column, although this is not borne out by the skeletons of extant reptiles.

*Lengths of Vertebral Centra measured along their upper surface**.

Neck.		Trunk.		Tail.	
	mm.		mm.		mm.
No. 1 ...	43·	No. 10...	42	No. 28 *a*.	50·5
„ 2 ...	41·5	„ 13...	56	„ 28...	50·
„ 3 ...	41·5	„ 15...	56	„ 37...	53·
„ 6 ...	37·	„ 18...	58	„ 47...	47·
				„ 51...	39·5
				„ 55...	32·
				„ 57...	26·
				„ 58...	24·

Pelvis and Hind Limbs.—The sacrum has just been described; the other parts referable to the hip-girdle are portions of both ilia, of both pubes, and of one ischium. The limbs are represented by pieces of both femora, of both tibiæ and fibulæ, ossa tarsalia, metatarsals, and phalanges.

Ilia, No. iv. 1.—Part of the right ilium comprises the acetabulum and all that part of the broad flat plate which lies above and behind it. The greatest vertical dimension at the acetabulum is 135 millims.; the length of the mutilated præacetabular part is 110 millims.; the coxal articular surface is an oblong, 80 millims. long. It is widest behind, being here 43 millims. across. This surface, which is coarsely pitted (as if an epiphysial incrustation had been detached from it) is imperfectly divided at 45 millims. from its posterior limit by a slight projection. The part behind this is hollowed; that in front of it is nearly plane, or slightly convex. From the hinder and outer corner of the joint-surface a prominent angular ridge curves upwards and forwards over the joint, and gradually subsides on the smooth surface above it. A conspicuous sinuous line above the acetabulum probably marks the attachment of the capsular ligament. That part of the ilium which comprises the joint is the stoutest part of the bone. The inner surface of the ilium is sinuous. Above the acetabulum are the impressions of attachment of sacral ribs.

The pieces iv. 2, *a*, *b*, *c*, *d*, are fragments of the left ilium. Of these, iv. 2 *a* shows that the acetabular part was produced forwards as a long slender process, which was longer than the post-acetabular part of the bone.

Pubes.—The fossils iv. 16, iv. 17, correspond essentially with Wealden Iguanodont bones, now, I think, generally accepted as pubes. They are too mutilated for description. They show that the pubis formed part of the acetabulum as in Lizards.

Ischium.—The peculiar curve of the fossil iv. 18, and the process indicated on one margin near the stouter end, identify this as part of the long blade of an Iguanodont ischium.

Femur.—These large and strong bones are principally represented by their extremities. The head, iv. 3, iv. 4, has the subglobular

* The lengths of the sacral centra are already given in another Table.

form met with in Wealden thigh-bones. The condyles have been much split (iv. 12, 13, 10, 11) into many pieces; but the deep narrow anterior intercondyloid notch, characteristic of the femur of Wealden Iguanodonts, is plainly recognizable here. The medullary cavity was very large; and the portions of bone referable to the diaphysis show that this was a relatively thin tube of bone enclosing a very large quantity of unossified substance.

Tibiæ.—The pieces iv. 5, iv. 6, are the knee ends of the right and left tibiæ. They show an imperfect condylar division of the gonal surface, and that the præcnemial crest was remarkably large and strong. The fossil iv. 7, the distal end of the left tibia, agrees essentially in form with the same part in Wealden Iguanodons from the Isle of Wight. The entering angle in the antero-external surface, the salient angle in the postero-internal surface, and the malleolar division of the articular surface into a stouter and shorter inner and a narrower and longer outer half, each having a different aspect adapted to corresponding subdivisions of the proximal surface of the tarsus, are well illustrated by these fossils.

Tarsus.—This comprises two distinct bones, a larger inner bone, the equivalent of the astragalus (Pl. XX. figs. 5, 6), and a smaller and outer one, the representative of the calcaneum (Pl. XX. figs. 3–6).

The astragalus agrees substantially with the Wealden form *. It has a somewhat quadrilateral figure. The upper surface is the counterpart of the inner two thirds of the distal articular surface of the tibia as far outwards as the notch in this latter, but not including what may be conveniently called the outer tibial malleolus. It is divided into two parts, each of a rudely triangular outline. Of these the inner and larger, a wide shallow hollow, looks upwards, inwards, and backwards, whilst the outer division, a deep narrow trough, looks upwards, outwards, and backwards, when the bone is placed in the position it would take if it were articulated with the tibia, and the longer axis of the distal end of this latter were directed from without and behind forwards and inwards, the direction it probably had in progression.

The under surface of the astragalus forms the larger inner part of a wide articular pulley, convex from behind forwards, and gently concave from without inwards. This trochlear surface rises some distance on the front of the bone. The inner border of the bone is so deep that it deserves to be termed a surface. It is smooth; its outline is a rude crescent with blunted horns. Of these the posterior meets the hinder border of the bone (a thin lip with a downward and forward slant) in an angle which underlies the salient posterior angle of the tibia. The anterior surface forms the ascending lip or process, which fits into the retiring angle in the front of the tibia. The inner half of this lip rises gradually; and the outer falls abruptly. The outer border of the bone, much shorter and much thinner than the inner, is the outer boundary of the narrow trough-like part. Here the upper or tibial and the trochlear surface nearly meet.

* See Quart. Journ. Geol. Soc. vol. xxx. p. 24.

The Calcaneum (Pl. XX. figs. 3, 4), smaller than the astragalus, is (to borrow a simile from the older anatomists) a somewhat boat-shaped bone, wider behind than in front. It has an upper, an under, and an outer surface. The under surface is crescentic, strongly convex from back to front, and less convex transversely. It forms an arc of a circle, and was plainly part of a trochlear joint. The upper surface is subdivided by a prominent ridge, directed obliquely from behind forwards and inwards, into a posterior part, a deep trough parallel with the ridge, and an anterior part somewhat quadrilateral in shape, with the anterior corners rounded off, and the outer and posterior sides longer than the two others. The outer surface, vertical, is non-articular; below, behind, and in front it is slightly encroached on by the trochlear surface. Its lower border is an arc; its upper border is straight. Rather behind the middle this latter is interrupted by the outer end of the ridge mentioned as subdividing the upper surface. The inner border of the bone is thin and crenated; here, as lately mentioned, the upper and under surfaces nearly meet.

When the calcaneum is placed with the border which I have termed inner touching the outer border of the astragalus, and the upper or crural surfaces of the bones are viewed, it is evident that the deep trough in the calcaneum behind the oblique ridge in its upper surface forms the outward continuation of the trough in the outer half of the upper surface of the astragalus, and that it articulates with the outer tibial malleolus, which, as I have already said, is not borne on the astragalus. The quadrilateral depression in the upper surface of the calcaneum, lying in front of this tibial trough and of the oblique ridge, received the lower end of the fibula, the distal part of the shaft of which rests in a splint-like manner on the front of the tibia parallel with its outer border. Viewed from beneath, the convex under surface of the calcaneum is seen to complete the pulley, of which the astragalus forms much the larger part. The mutual adaptation of the two bones is so suggestive, that this alone would have justified the identification of the lesser bone with the os calcis, a bone previously unrecognized; but I fortunately obtained confirmation of the true skeletal position in a hind foot of *Hypsilophodon Foxii*, a closely allied form, in which I found the bones *in situ* joined to each other, as also to the tibia and fibula, in the manner described *.

In the articulation of its tibia with the calcaneum, as well as with the astragalus, the Iguanodon's foot differs from the hind foot in the three extant orders, Chelonia, Lacertilia, Crocodilia—in each of which the distal end of the tibia rests wholly on the astragalus, which latter, by an outer facet, is in contact with the fibula. But in the very point wherein the Dinosaurian foot differs from that of living reptiles, it closely resembles the foot of birds.

* Since this was written, by the courtesy of M. E. Dupont, the Director, I have had an opportunity of studying some of the very instructive Iguanodon-remains lately acquired by the Museum of Natural History at Brussels, and have been gratified by finding the bones in natural articulation as described.

In a communication to the Geological Society, in 1869, Prof. Huxley demonstrated the agreement of the Dinosaurian astragalus, which he had shortly before identified in *Megalosaurus,* with the distal condylar element of the bird's tibia, which Gegenbaur had shown to comprise the equivalent of the astragalus in extant reptiles.

In most birds, as is well known, the individual distinctness of the tibio-tarsal elements is soon lost by the accrescence of the tarsal part to the tibia, their individuality continuing longest in the keelless birds, of which the *Apteryx* furnishes an admirable example. In Dinosauria, Prof. Huxley showed that the astragalus remained a distinct part throughout the whole life. In the bird, as remarked by Gegenbaur, the combination of two tarsal elements in the single bone which is regarded as the equivalent of the astragalus, is hinted by the facility with which, at an early embryonic stage, the bone sometimes separates into two pieces in the attempt to detach it from the tibia. In this Cumnor Iguanodon, and also in the Wealden Iguanodon and in *Hypsilophodon*, the distinctness of the calcaneum is clearly preserved throughout life. It obtains also in *Megalosaurus*, and it may fairly rank as a Dinosaurian character. In Dinosauria the astragalus and calcaneum together are the homologue of the astragalus of the young bird.

In the grown bird the relation of the fibula to the calcaneum is not apparent; but it is otherwise in early embryonic existence, when the fibula and tibia are of equal length, and the distal end of the former reaches the mass of tissue out of which the proximal tarsal element is afterwards evolved. In the Iguanodont foot these early developmental phases are, as it were, permanently fixed.

Amongst the Cumnor fossils there are none which I can identify as elements of a distal tarsal row; and from the study of two hind feet of Iguanodon which I dug out in the Isle of Wight, and also of several feet of the allied *Hypsilophodon*, I suspect that such elements, if they ever had a distinct existence, soon lost it by fusion with the basal ends of the metatarsals. This coalescence of distal tarsal elements with the metatarsus is foreshadowed in *Compsognathus*, in which the former are represented by thin inconspicuous disks united to the metatarsals, a narrow line marking their primitive separateness. In *Iguanodon* probably such separateness is restricted to the embryo.

Metatarsus.—Parts of four bones are referable to this segment of the foot. Nos. iv. 24, 25, 26, are the distal trochlear ends probably of the two lateral and the middle metatarsals of the right foot; iv. 27 is the trochlea of the left middle metatarsal. Nos. 33, 35, 36, are fragments of their proximal ends and shafts.

The trochlea is wide and shallow. In the middle metatarsal it reaches higher on the front of the joint than in the lateral metatarsals, and the outer is rather stouter than the inner condyle. In the lateral metatarsals the condylar division, less marked in the outer one, is restricted to the plantar surface, and the front of the joint is convex transversely and in the direction of the long axis of the bone. In the inner metatarsal the inner condyle is narrow and prominent, the outer condyle broad and low.

Phalanges.—Of these 13 are preserved; iv. 29, 22, 39, are probably the 1st, 2nd, 3rd phalanges of the inner toe of the right foot; their greater length distinguishes them from iv. 42, 43, which are referable to an outer toe, the phalanges of which are distinguished for their shortness. The unguals are very strong, laterally compressed, and impressed with a deep submarginal nail-groove.

Shoulder-girdle and Fore Limb.—The only parts of the segment of the skeleton which can be certainly identified are the scapulæ and proximal ends of the humeri.

The Scapulæ, iii. 1, 2*a*, 2*b*, closely resemble those of Wealden Iguanodons from the Isle of Wight. The glenoid end shows the usual rough sutural coracoid surface, and the smooth concave glenoid part for articulation of the humerus. The coracoid part near its posterior border is furrowed by a conspicuous groove, which enters it from the thoracic aspect. The dorsal end of each scapula is missing, so that the length of this bone is unknown.

The fossil iii. 6 so closely resembles typical Iguanodont coracoids, that its nature can scarcely be doubted. Its form is simple, as in Wealden Iguanodonts; and, as in these, it is remarkable for its relatively small size.

No. iii. 4 is, I have no doubt, the proximal end of the left humerus. In its general form, and especially by the presence of a strong process at its posterior border, it closely imitates a very large humerus which I obtained several years since at Brooke Bay. No part of the shafts or distal ends of the humeri can be identified; nor can I speak with certainty of the bones of the forearm. Some imperfect bones, which I regard as metacarpals, are more slender, and appear to have been relatively longer than the metatarsals. A reconstruction of the fore foot out of these imperfect and dissociated remains must necessarily be so conjectural that I have not attempted it.

For this Kimmeridgian Iguanodon, the distinctness of which from the Wealden *I. Mantelli* is demonstrated (*a*) by the different shape of the thoracic vertebræ, the centrum of which is wedge-shaped in the Kimmeridgian Iguanodon, very constricted in the Wealden Iguanodon, (*b*) by the flattening of the under surface of the centra in the sacrum of the Kimmeridgian, which in the Wealden is keeled, (*c*) by the smaller number of sacral centra in the Kimmeridgian Iguanodon, and (*d*) by the relative simplicity of the marginal serrature of its teeth, I propose the specific name *Prestwichii*—*Iguanodon Prestwichii.*

EXPLANATION OF PLATES XVIII., XIX., XX.

All the figures are two thirds of the actual size, except those of the jaws, which are ×2, and figs. 8, 9, Pl. XX. which are diagrammatic.

Plate XVIII.

Fig. 1 (No. I. 10). View of undersurface of part of vault of skull. *f*, frontal bone; *pf*, postfrontal; *p*, parietal.

2. The upper surface of the same fragment. The lettering is the same.
3. Fragment of occiput. *fm*, foramen magnum; *so*, supraoccipital.
4. The under surface of a fragment of the base of the skull. *oc*, occipital condyle; *Bo*, basioccipital; *Bs*, basisphenoid; *c*, carotid groove; *hp*, hypophysial pit.
5. The upper surface of the same piece.
6. Fragment of the right maxilla (outer surface) showing three teeth:—1, a mature germ, not yet in wear; 2, a crown, which was in full use at the death of the animal; the free edge is not in the line of actual wear, but an accidental fracture; 3, a fang extended considerably beyond the border of its socket.
7. Another fragment of a maxilla, showing:—*s*, an empty socket; *f*, the fang of a tooth, of which the crown had been fully extended, and in full wear. It tapers to a blunt point; and the pulp-cavity, large at the junction of the fang and crown, is contracted to a small opening at the free end of the fang. *g*, a mature germ, at the base of which are remains of an almost completely extended fang.
8. A fragment of the dentary part of mandible. 1, 3, 5, fangs, of which the crowns must have been almost worn away; 2, 4, 6, crowns of teeth in full wear; 7, 9, 11, germs, of which about half is extruded beyond the inner parapet of the aveolus; 8, 10, smaller germs, of which only the tip is visible.

Figs. 6, 7, 8, are ×2.

Plate XIX.

d, diapophysis; *p*, parapophysis; *prz*, præzygapophysis; *psz*, postzygapophysis; *a*, anterior articular surface.

Fig. 1. Front view of cervical vertebra (ii. 3).

2. Posterior view of the same.
3. Side view of the same.
4. Inferior view of the same.
5. Side view of a thoracic vertebra (ii. 11).
6. Side view of a lumbar vertebra (ii. 20).
7. Anterior view of the same.
8. Posterior view of the same.
9. Side view of a caudal vertebra, from near sacrum (ii. 28). Centrum oblique (ii. 28).
10. Side view of a caudal vertebra (ii. 32) posterior in position to ii. 28.
11. Side view of a caudal vertebra from a part of the tail where the transverse process has disappeared (ii. 41).

12 (ii. 53) & 13 (ii. 58). Vertebræ from very near the end of the tail.

Plate XX.

Fig. 1. The last lumbar vertebra and the sacrum, seen from below.

2. The same, seen from above.
   In both, *l l*, last lumbar; 1*s* 2*s*, 1st & 2nd sacral centra; *ne*, neural canal; *ng*, nerve-groove.
3. The os calcis, its outer surface.

4. The same, its upper surface. *f*, the fibular portion; *t*, the tibial portion.
5. The astragalus (*a*) and os calcis (*c*), seen from below.
6. Front view of the bones of the legs, with the proximal tarsal series: *t*, tibia; *f*, fibula; *a*, astragalus; *c*, calcis.
7. Side view of same.
   This and the preceding figure are *restorations*.
8. The leg and proximal tarsal elements of a young fowl. The letters indicate the same parts as in fig. 6.
9. The hind limb of a chick, showing at this stage the fibula as long as the tibia, and the distinctness of the tarsal elements. After Gegenbaur.

Discussion.

Prof. Owen stated that a specimen existed in the British Museum showing the bones of the hinder limb of a Dinosaur, i. e. *Scelidosaurus*, which, though never referred to, gave much information as to the homologies of the bones. This paper, however, was most valuable, and he believed the author had established the specific distinctness of the form. He asked Prof. Seeley what genus in the Mammalia gave a dentition like that of the Triassic *Placodus*. He found it in *Ornithorhynchus*; but the broad, flat crushers were uncalcified in that sauroid Mammal.

Prof. Seeley spoke of the high value of Mr. Hulke's paper. Specimens existed in Belgium showing the bones of *Iguanodon* in situ, and gave independent evidence of the accuracy of the author's conclusions; but those who had seen them could not, as they had been shown in confidence, describe them. He thought the specimen on the table showed traces of Teleosaurian characters in the expanded frontal bone and in other parts of the skeleton. He would even attach more value than the author had done to the differences of the vertebral column, pelvis, teeth, and limb-bones from those of the ordinary *Iguanodon*; and he thought they might be generic, rather than dependent on age. He attached great importance also to the separation of the astragalus and the os calcis. Here there could be no doubt of specific distinctness from Wealden forms; and he believed that the differences were important enough to justify the author in placing the animal in a new genus.

Mr. Hulke said he had studied the specimens of *Scelidosaurus* much, and doubted whether the bones were truly not displaced. The Belgian specimens, however, gave the fullest evidence of the structure of the Dinosaurian tarsus.