A MONOGRAPH

OF THE

FOSSIL CHELONIAN REPTILES

OF THE

WEALDEN CLAYS AND PURBECK LIMESTONES.

BY

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ORDER—*CHELONIA.*

FAMILY—PALUDINOSA.

Genus—PLEUROSTERNON.[1]

IN acquiring the requisite materials for the present Monograph, I have had under examination numerous Chelonites from the Wealden series, the majority of which, as in most of the secondary rocks, were more or less fragmentary; indicating, indeed, with sufficient certainty, the order of Reptiles to which they had appertained, but not so perfect as to yield the characters required for determining the family of Chelonia to which they had belonged, much less their relations to the known species of tertiary and existing Tortoises and Turtles.

From the above series of Wealden Chelonites, I have selected for description and delineation those specimens which seemed best to illustrate the nature of the house-carrying Reptiles of the period; and propose to commence with the more perfect specimens which have been extracted from the fresh-water limestones of the Purbeck beds. For the opportunity of examining and figuring the best preserved examples of this kind, I am more especially indebted to William Cunnington, Esq., of Devizes, and to Charles Willcox, Esq., M.R.C.S., of Swanage, Dorsetshire.

[1] Derivation—*πλευρον* a rib, *στερνον* the breast-bone.

Genus—PLEUROSTERNON.

Char. Gen.—Testa depressa lata, complanata; sternum integrum, ossibus undecim compositum, per ossiculis marginalibus cum testâ conjunctum; scutis submarginalibus inter scutâ axillariâ et inguinaliâ positis.

As a general rule the vertebrate animals of the secondary strata manifest, in the modifications of their structure, a nearer approach to the archetype of their sub-kingdom than the tertiary and existing vertebrates do. This rule is exemplified in the present genus of Chelonian Reptiles by the accessory osseous pieces that enter into the formation of the plastron, and which are interposed, as an additional pair of bones, between those more constant parial elements called "hyosternals" (*h s*, Tab. III) and "hyposternals" (*p s*, ib.), and which alone articulate with the marginal pieces (*m*, *m*) in existing Emydians. At least, if we adopt the general homology of the parial elements of the plastron, indicated by the development of that part, viz. as being hæmapophyses, —an increased number of such pieces, making them to that degree more equal in number with the pleurapophyses of the carapace, offers an obvious tendency to a return to the normal type; and the fact of a genus or family of extinct secondary Chelonians manifesting such increase in the number of parial pieces, gives additional support to the conclusions as to the nature of the plastron, arrived at from a study of that part in the embryos of existing species.

By the name *Pleurosternon*, proposed for the remarkable extinct Chelonia about to be described, it is desired to intimate the characteristic furnished by the additional number of inferior rib-elements (hæmapophyses, or "cartilagines costarum" of Anthropotomy) composing the under-shell or plastron, which part naturalists, influenced by the views of Geoffrey St. Hilaire, have usually described under the arbitrary name of "sternum."

The extent of the ossification of the carapace and plastron, and the firm union of the roof and floor of the bony chamber by the medium of the side-walls, afforded by certain marginal plates, prove the genus not to belong to the *marine Chelonia*; the presence of the marginal plates, and the impressions of the horny scutes which covered the carapace and plastron, forbid its being referred to the *fluvial* tribe, represented by the *Trionyces*; the depressed shape of the carapace excludes it from the *terrestrial* tribe of true Tortoises; and we arrive, therefore, by the way of exclusion, to the association of the genus in question with the Terrapenes and other members of the family *Paludinosa* of the eminent Erpetologists, MM. Duméril and Bibron.

PLEUROSTERNON CONCINNUM. *Owen.* Tab^{æ} II and III.

The first specimen of *Pleurosternon* which will be described in the present Monograph is one from the fresh-water limestone of Purbeck, which was kindly transmitted to me by Wm. Cunnington, Esq., for that purpose. It consists of a nearly entire carapace and plastron.

The carapace, Tab. II, includes the nuchal plate, *c h*; the eight neural plates, *s* 1—*s* 8, which are connate with the neural spines of the vertebræ of the carapace; and the corresponding eight pairs of costal plates, except the eighth on the right side, *pl.* 1—8. The hindmost neural plates, and all the marginal plates, save the first of the left side connected with the nuchal plate, are wanting.

The length of the carapace, from the anterior margin of the nuchal plate to the posterior one of the eighth neural plate, is 13 inches; the breadth of the carapace, across the third costal plates, is 11 inches. The outer surface of the carapace is very slightly convex.

The nuchal plate, *ch*, is six-sided; the anterior and antero-lateral borders are of equal length, and are the longest of the six; the hind border is the shortest: the latter is angularly notched for the reception of the first neural plate, *s* 1. The front border is slightly convex, with a feeble median concavity. The greatest breadth of the nuchal plate, which is across the angles between the antero-lateral and postero-lateral borders, is 3 inches 4 lines; the length of the nuchal plate is 2 inches 3 lines. The outer surface of the nuchal plate is impressed by a triradiate groove, indicative of the junction of the two nuchal scutes with each other and with the first vertebral scute, *v* 1. The portion of the median series of bony plates answering to the first neural plate in ordinary Chelonia is divided by a transverse suture into two plates,—a circumstance which corroborates the homology of the neural plates with the median dermal bones of the Crocodilia, and opposes their interpretation as the vertebral spinous processes unwontedly expanded. The indented boundary between the first, *v* 1, and second, *v* 2, vertebral scutes crosses the first neural plate, *s* 1, immediately in advance of the dividing suture in question.

The second, *s* 2, to the eighth, *s* 8, nuchal plates inclusive are six-sided, with the antero-lateral sides or borders the shortest, and the postero-lateral ones the longest; the third, fifth, and eighth are crossed by the boundary impressions between the vertebral scutes. They progressively diminish in length to the seventh; the eighth resuming the normal length, unless the indentation between the fourth, *v* 4, and fifth, *v* 5, vertebral scutes conceal, as I suspect, a suture dividing the plate, *s* 8.

The first pair of costal plates, *pl.* 1, is impressed by the boundary lines dividing the second marginal scute, the first vertebral scute, *v* 1, the second vertebral scute, *v* 2, and the first costal scute, *c* 1; it unites with the nuchal, *ch*, and first and second marginal plates, with both divisions of the first neural plate, *s'*, with the anterior truncated angle of the second neural plate, *s* 2, and with the second costal plate, *pl.* 2; the second, *pl.* 2, to the seventh, *pl.* 7, costal plates, have the posterior angle of their mesial extremity truncated; they become slightly expanded at their lateral extremity; and, after the third, they gradually decrease in length. The second, fourth, and sixth costal plates, like the first costal plate, bear the impressions of the lines of union of the costal scutes with each other and with the vertebral and marginal scutes: the third, fifth, and seventh costal plates bear the impressions of the lines of union of the costal with the vertebral and marginal scutes. The eighth costal plate is impressed by the line of union between the fourth costal scute and the fifth vertebral scute, and by that of both these scutes with the fourth vertebral scute mesially, and with the tenth marginal scute laterally.

The exterior surface of all the above-described elements of the carapace is minutely wrinkled and granulated, except near the sutural borders, where it is impressed by numerous close-set fine lines, directed at right angles, or nearly so, with those borders. This two-fold pattern is best marked in the costal plates, in most of which the marginal lineated sculpturing extends over about one fourth of the entire breadth of the scute. There are no concentric impressions indicative of the lines of growth of the horny scutes.

The first marginal scutes meet at the middle line on the forepart of the nuchal plate, and do not leave there any median or nuchal scute in the present species. The first and second vertebral scutes are of equal breadth, the succeeding three progressively decrease in breadth: all are six-sided, and broader than they are long, the length and breadth being most nearly equal in the fourth vertebral scute, *v* 4.

The following are the dimensions of the principal vertebral scutes:

	First.		*Second.*		*Third.*		*Fourth.*	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Length, or antero-posterior extent	2	6	2	11	2	11	3	0
Breadth	4	10	4	10	4	7	3	6

Their shape is sufficiently indicated in the figure, Tab. II; as is also that of the costal scutes, *c* 1 to *c* 4.

In the carapace above described, the greater part of the marginal plates, the eighth costal plate of the right side, and the terminal neural plates, are wanting; but sufficient remains in natural juxtaposition to show that the carapace has been of a full oval figure, broadest anteriorly, with a very slight degree of convexity, and without any special elevations along the median line or at other parts.

The plastron, Tab. III, is a long, rather narrow, flat, oval plate; it was probably rounded anteriorly, but this border is fractured: it contracts from the lateral wall, *h s*, *p s*, with a gentle sigmoid marginal curve to the hinder apex, *x s*, which is emarginate by a notch with convex borders. The middle third of each lateral border of the plastron is connected, through the medium of three marginal plates, with the carapace. The length of the plastron, as far as it is entire, is 13 inches; its breadth, at the fore part of the lateral walls, is 6 inches 6 lines.

The entosternal element, *s*, is as broad as it is long; its anterior half is defined by two nearly straight borders, which converge at an angle of 45°; its posterior contour is nearly semi-circular; the length of the entosternal is 2 inches 4 lines. The episternal, *e s*, is bounded behind by two nearly straight lines, which meet at an open angle. The hyosternal is remarkable, as in other species of *Pleurosternon*, for the excess of its transverse over its antero-posterior diameter, as compared with the same element of the plastron in other *Paludinosa:* the median sutural border is irregularly wavy: the lateral border unites by suture with the fifth and part of the sixth marginal plates, the anterior border is united by suture at its median half to the entosternal and episternal bones; its lateral half is free, smoothly rounded, and indented by a deep and narrow notch. The outer surface of the bone is impressed by the line dividing the humeral from the pectoral scute, which line is crossed at right angles by the line dividing both the above scutes from the axillary and submarginal scutes.

The supplementary sternal elements, intercalated between the hyosternals, *h s*, and hyposternals, *p s*, and which, from their constancy in the present genus, I propose to denominate, for the convenience of description, the "mesosternals," and which bear the letters *p e* and *a b* in Tab. III, are transversely elongated, quadrate plates of bone, resembling in form the costal plates above, and being their correlatives in the plastron. They are not quite symmetrical in the present specimen, the left one having a greater antero-posterior breadth, and encroaching a little way beyond the median line to the right side of the plastron to join its fellow: at the outer end they articulate with part of the sixth and part of the seventh marginal plates. The mesosternal element is impressed by the line dividing the pectoral, *p e*, from the abdominal, *a b*, scutes; and by that dividing both these from the submarginal scutes. The hyposternals, *p s*, present nearly the same proportions as the hyosternals, *h s*; they unite externally with part of the seventh marginal plates; they are impressed by the straight transverse line dividing the abdominal from the femoral scutes, and by that dividing these from the inguinal scute. The xiphisternals, *x s*, present the form of an inequilateral triangle, and are impressed by the line dividing the femoral, *fe*, from the anal, *a n*, scutes. The forms and proportions of the perishable horny scutes that covered the bony plastron are indicated by the narrow, well-defined impressions of their boundary lines. The line dividing the intergular from the humeral scutes curves across the entosternal at about one third of the length of that bone from its anterior border. The humeral scutes, *h u*, covered the rest of the entosternal, *s*, part of the episternal, *es*, and the anterior half of the hyosternal, *h s*, bones. The pectoral scutes, *p e*, were transversely elongate, quadrate, and covered the posterior half of the hyosternals and the anterior third of the mesosternals. The abdominal scutes, *a b*, presented a similar form, and covered the rest of the mesosternals and less than half of the hyposternals. The femoral scutes, *fe*, were longer than they were broad; they joined the abdominal scutes by a straight transverse line; but that between them and the anal scutes, *an*, describes a curve, with the convexity backwards, and nearly equally divides the xiphisternals, *x s*. In addition to the axillary and inguinal scutes, there are three scutes interposed between the outer borders of the pectoral and abdominal scutes, and the under borders of the fifth, sixth, and seventh marginal scutes: these superadded scutes I propose to call "submarginal scutes." The *Platysternon megacephalum*, or Large-headed Terrapene of the Chinese swamps, presents a corresponding, but single, supplementary "submarginal scute," upon the under part of each lateral production of the plastron. The under surface of the fifth, sixth, and seventh marginal plates bears a crucial impression, indicative of the lines of junction between the marginal and submarginal scutes. The head of the left femur is preserved, near the seventh marginal plate, in the specimen above described.

For the species of *Pleurosternon*, which the above-described specimen, Tab^{æ} II and III, represents, I propose the name of *concinnum*.

PLEUROSTERNON EMARGINATUM. *Owen.* Tab^{æ} IV, V, and VI.

A nearly-allied species, *Pleurosternon emarginatum*, is represented in Tab^{æ} IV, V, and VI. It is from the same formation and locality, and differs from the foregoing chiefly in the contour of the free borders of the plastron. The anterior and posterior marginal plates being preserved in the specimen figured in Tab. IV, and almost all those of the right side in that figured in Tab. V, we obtain a nearly complete idea of the contour of the carapace in this broad and depressed extinct species of Emydian. The nuchal and first marginal scutes are unluckily wanting in the specimen with the upper surface of the carapace exposed, which prevents our determining whether the present species possessed or not the nuchal scute. The neural plate answering to *s* 1 in ordinary Chelonia is divided by a transverse suture in this species, as in *Pl. concinnum*, Tab. II; and the impression of the line of union between the first and second vertebral scutes crosses just in front of the suture of division. The second neural plate, 2, joins the first costal plate of the left side, but not that of the right; and it is pentagonal, the shortest side or border being that which joins the left first costal plate. The third, 3, to the seventh, 7, neural plates inclusive are hexagonal, and resemble in shape those in the *Pleurosternon concinnum;* the eighth neural plate is hexagonal, and is broader than it is long; the ninth neural plate, answering to that bearing the letter *s* 8 in Tab. II, is more expanded at its hinder part; the tenth neural plate, 10, is triangular, with a truncated apex and a broad rounded base, which articulates with the pygal and adjoining marginal plates.

The costal plates offer nothing particularly worthy of note, in comparison with those of *Pleurosternon concinnum.*

The second and third marginal plates bear not only the impressions of the lines dividing the corresponding marginal scutes from each other, but those dividing the marginal from the first costal scutes. The succeeding costal scutes do not encroach on the marginal plates, which consequently only show the impressions dividing the marginal scutes from each other. Some of the marginal scutes are slightly dislocated, and the posterior ones, from the ninth to the pygal scute inclusive, have their free borders mutilated.

The first vertebral scute, *v* 1, is narrower than the second and third vertebral scutes, instead of being broader, as in *Pleurosternon concinnum.* The second vertebral scute, *v* 2, is proportionally broader behind than is its homologue in *Pl. concinnum.* The fifth vertebral scute, *v* 5, has the three angles of its hinder border sharply produced in the interspaces between the last marginal scutes.

The character of the outer surface of the carapacial pieces resembles that in the *Pleurosternon concinnum.*

The more entire posterior border of the carapace, of which the inner surface is exposed in the specimen figured in Tab. IV, shows it to be slightly emarginate at the middle of that border; and there is sufficient of the anterior border of the same carapace preserved to show that it is more widely and deeply emarginate at the middle of that end.

With regard to the plastron, the lateral borders of the anterior freely-projecting portion are straighter, and those of the posterior portion more uniformly convex, than in the *Pleurosternon concinnum;* the terminal notch has its sides concave instead of convex. The impression of the line dividing the humeral, *hu*, from the pectoral, *pe*, scutes advances at the median plane so as almost to touch the entosternal, *s*. The mesosternals differ from those of the *Pl. concinnum* by the right extending a little to the left of the median line, but not more than may be expected from the admitted extent of variety in different individuals of the same species. The line between the femoral, *fe*, and anal, *an*, scutes is wavy, instead of being simply convex, as in *Pl. concinnum.* The impressions of the three accessory (submarginal) scutes, between the axillary and original scutes, on the right side of the plastron, Tab. VI, are well shown; they have not encroached so far upon the marginal plates as in the *Pl. concinnum.*

The length of the carapace of the *Pleurosternon emarginatum*, in the specimen figured in Tab. IV, is 21 inches 9 lines; the breadth of the carapace is 20 inches. In the specimen figured in Tab[ae] V and VI, the breadth seems to have been less; but allowance must be made for the partial dislocation inwards of the broad marginal plates, which, on the right side, overlap the ends of the costal plates. The entire length of the carapace of this specimen seems to have been about 17 inches; the breadth about 15½ inches.

PLEUROSTERNON OVATUM. *Owen.* Tab. VII.

The most beautiful and perfect example of the depressed Emydians, with the complex plastron, from the fresh-water limestone of Purbeck, is that from the collection of Charles Willcox, Esq., M.R.C.S., which, by the liberality of its possessor, has been figured, in Tab. VII, for the present Monograph.

The entire series of marginal plates is preserved with scarcely any dislocation or fracture, in natural connection with the costal plates: they show the carapace to have been nearly elliptical in figure, but a little more pointed, or less obtusely rounded behind than before; it is not emarginate at the anterior border, and was only very slightly so, if at all, at the posterior border. The *Pleurosternon concinnum* resembles the *Pleurosternon ovatum* in the absence of the anterior emargination of the carapace, which distinguishes the *Pleurosternon emarginatum*. The first vertebral scute, *v* 1, is, however, as in that species, narrower than the second, instead of being of equal breadth, as in the *Pl. concinnum:* it covers, also, a larger proportion of the first neural plate, *s* 1, which, moreover, is not divided into two, as in the two previously described species. The place of the fourth neural plate is occupied by the conjoined median ends of the fourth pair of costal plates, ossification having extended continuously from them into the dermal matrix overlying the subjacent neural spine, instead of commencing from that spine or from a separate centre; but this may be an individual variety. It leads, however, to a modification of form of the fifth neural plate, *s* 5, which is pentagonal, instead of being six-sided, as is usual, and as is the case with the two succeeding neural plates. The eighth neural plate expands posteriorly, and the expansion in this direction is progressive in the ninth and tenth neural plates; the eleventh or pygal plate, *py*, is narrower than the back part of the tenth neural plate, is quadrate, and shows, both by its shape, size, and median impression, that it belongs rather to the category of the dermal marginal plates, the series of which it completes posteriorly. The costal plates, *pl.* 1 to *pl.* 8, offer no modification worthy of notice. There are eleven marginal plates, 1, 1′, to 10, on each side of the carapace, in addition to the nuchal, *ch* and pygal, *py*, plates; they increase in breadth after the sixth; the first bears the impression of the triradiate line which marks the division between the first, *m* 1, and second, *m* 2, marginal scutes, and the first, *v* 1, vertebral scute.

There was no nuchal scute. The second, third, and fourth marginal plates were slightly overlapped by the first costal scute, *c* 1. The antero-posterior breadth, in comparison with the transverse breadth, is greater in the costal scutes of the *Pleurosternon* *ovatum* than in those of the *Pleurosternon emarginatum*. The number of marginal scutes was twenty-four, twelve on each side, *m* 1 to *m* 12.

The fore part of the plastron appears to have projected in advance of the carapace, as is indicated by the plate of bone marked *es*, in Tab. VII.

The length of the carapace of the specimen of *Pleurosternon ovatum* here described is 19 inches 6 lines; its breadth is 14 inches 6 lines. It is very slightly convex, with the margins a little raised. The feeble sculpturing of the outer surface of the carapace resembles in general character that of the other species of *Pleurosternon*.

This beautiful specimen is in the Collection of Charles Willcox, Esq., M.R.C.S.

PLEUROSTERNON LATISCUTATUM. *Owen*. Tab. I.

The species represented by the specimen of mutilated carapace, Tab. I, differs from all the other recognised species of the genus by its distinct nuchal scute, *ch*, by the small relative size of the first vertebral scute, *v* 1, and by the great relative size, more especially the superior breadth, of the three succeeding vertebral scutes, *v* 2, *v* 3, *v* 4. The boundary lines, indicating the forms and disposition of the horny scutes, are proportionally larger and deeper than in the other species of *Pleurosternon* described in the present Monograph.

The sutures uniting together the different elements of the carapace are more dentated or wavy than those in the other species, more especially the suture uniting the nuchal plate with the first neural plate and first pair of costal plates. The neural plates, from the first to the seventh inclusive, are similar in form, six-sided, with the antero-lateral sides the shortest; the eighth neural plate is the smallest, is four-sided, and broadest behind; the ninth and tenth neural plates are remarkable for their great breadth.

The transverse extent or length of the costal plates is considerable, in accordance with the great breadth of the carapace: the eighth costal plate, in this respect, differs considerably from its homologue in the other species of *Pleurosternon*. The second marginal scute is not produced backwards between the first vertebral and first costal scute, but, like the first and third marginal scutes, has its antero-posterior diameter much less than the diameter in the direction of the periphery of the carapace. The first, *c* 1, and fourth, *c* 4, costal scutes differ considerably in their forms and proportions from those in Tables II, V, and VII.

The outer surface of the osseous parts of the carapace of *Pleurosternon latiscutatum* is minutely punctated and rugose, except near the sutural borders of the several pieces, where it is impressed by rather coarse parallel striæ, directed at right angles to those borders.

Of this well-marked species of *Pleurosternon*, I have seen portions of the fossil carapace of several individuals, from the Purbeck limestone; the most complete of these fossils is represented, of half the natural size, in Tab. I. This specimen is now preserved in the Museum of the Philosophical and Natural History Society of Dorchester.

CHELONE COSTATA. *Owen.* Tab. VIII.

From the Wealden Clays of Tilgate Forest have been obtained many fragmentary Chelonites, indicative of species representing two of the actual families of the order, viz. *Paludinosa* and *Marina*; and such, therefore, as might be expected to be met with in the deposits of a large estuary. I propose to commence the description of these Wealden Chelonites by those which indicate a species of the marine family.

Portions of the carapace and plastron, and bones of the extremities of a large species of Turtle, some of them indicating individuals with a carapace nearly three feet in length, form part of the Mantellian collection, purchased by the British Museum: a few of these Chelonites have been figured in Dr. Mantell's 'Illustrations of the Geology of Sussex,' 4to, 1822.

The author of that work has not deduced any specific characters from these fossils, and the nature of most of the specimens hardly allowed their determination to be carried closer than to the marine family of *Chelonia.*

With regard to one of the specimens (Pl. VI, fig. 2), however, Mr. Clift's authority is quoted for its resemblance with the corresponding part of the *Chelone imbricata,* and Dr. Mantell acknowledges that "as Cuvier had referred the turtles of Melsbrock to the *Emydes,* we at first entertained doubts whether our approximation of this specimen to the *Cheloniæ* were correct. Mr. Clift's remark, however, tends to confirm the opinion that it belongs to a marine turtle." (Op. cit., p. 62.)

After a careful comparison of the specimens in the British Museum, I have come to the conclusion that the Wealden species differs from the *Chelone imbricata, Chelone carinata,* and other recent species, in as great a degree as do most of the extinct *Chelones,* in the greater extent of ossification of the costal interspaces and of the plastron.

A characteristic portion of the great Wealden Turtle is represented, of the natural size, in Tab. VIII of the present Monograph. It includes the second and third marginal plates, and considerable portions of the first and second costal plates, with the connate portions of the pleurapophyses, or vertebral ribs. These are remarkable for their breadth and prominence, and have suggested the name proposed for the present species of Wealden *Chelone.*

In the same plate are represented a mutilated right iliac bone, fig. 3, and the right femur of, probably, the same species of Turtle. These, also, are from the Wealden formations of Tilgate Forest, and form part of the Mantellian Collection now in the British Museum.

Figure 4, Tab. IX, gives a view of the inner surface of the left hyposternal, half the natural size of, probably, the same species of *Chelone*. It is imbedded in a slab of Wealden stone.

As compared with existing Turtles, the ossification of the plastron is more advanced or more extensive, the rays of bone from the outer and inner free borders of the hyposternal being shorter and their interspaces more filled up. A nearer approach is thus made in this Wealden species, as in some of the Eocene Turtles, to what may be regarded as the more general type of the Chelonian carapace.

PLATEMYS MANTELLI. *Owen.* Tab. IX, fig. 1.

Report on British Fossil Reptilia, 1841, p. 167.
EMYS DE SUSSEX, *Cuvier.* Ossemens Fossiles, 4to, tom. v, part ii, 1824, p. 232.
EMYS MANTELLI, *J. E. Gray.*

Amongst the Chelonian Fossils obtained by Dr. Mantell from the Wealden strata of the Tilgate Forest, in Sussex, were certain specimens, the resemblance of which to the flat species of Emydian, or terrapene, discovered by M. Hugi in the Jura limestone at Soleure, has been pointed out by CUVIER, (loc. cit.) , Both the Jura species and the Wealden Chelonites in question are referable to the 'pleuroderal' section of the great tribe *Paludinosa,* as arranged by Messrs. Duméril and Bibron;[1] and, in that section, to the genus *Platemys,* but so much of the skeleton has not, as yet, been discovered, as to afford a ground for a good specific character of the so-called *Emys Mantelli.*

The most intelligible fragment in the British Museum, is that element of the plastron—the hyosternal; which is figured in Tab. IX, fig. 1. The proportions of this bone indicate that the plastron of the *Platemys Mantelli* consisted of the ordinary nine pieces: where the accessory pair of mesosternal pieces is introduced, both the hyo- and hypo-sternals have relatively less antero-posterior extent than the fossil in question shows.

PLATEMYS, sp. dub. Table IX, fig. II.

A second species of Wealden *Platemys* is apparently characterised by a somewhat broader plastron, and by a greater relative thickness of the bones composing both this and the carapace. Without the latter difference, the proportionally broader plastron might be merely the sexual distinction of the female of the first species. Some difference, in the shape of the axillary notch of the hyosternal further induces me to regard the fragmentary Chelonites in question, of which a hyosternal is figured in Tab. IX, fig. II, as belonging to a second species of Wealden *Platemys.*

[1] Erpetologie, 8vo, 1835, tom. ii, pp. 172, 372.

PLATEMYS DIXONI. *Owen.* Table IX, fig. III.

A platemydian specifically distinct from either of the above is more unequivocally exemplified by the sternal element represented in Tab. IX, fig. III, the matrix having been carefully removed from the outer surface of this fossil, the linear impressions which have divided the humeral from the pectoral scute, and this from the abdominal scute, are clearly shown. The positions of these transverse grooves accord with those in the hyosternal of the Emydians, having the usual number (nine) of plastral elements: and the hyosternal character of the fossil is further shown by the oblique border cutting off the inner angle of the anterior end, for articulation with the entosternal element. (This end has been figured downwards in the plate.) The axillary groove is narrower than in the above-described species; and the whole bone seems to have been longer in proportion to its breadth. It is from the Wealden of Tilgate Forest, and is now in the British Museum. I propose to dedicate the Wealden terrapene, indicated by the above-described fossil, to my late esteemed friend, Frederic Dixon, Esq., F.G.S., author of the beautiful work 'On the Cretaceous and Tertiary Formations of Sussex.'

TABLE I.

HALF NAT. SIZE.

The carapace of *Pleurosternon latiscutatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

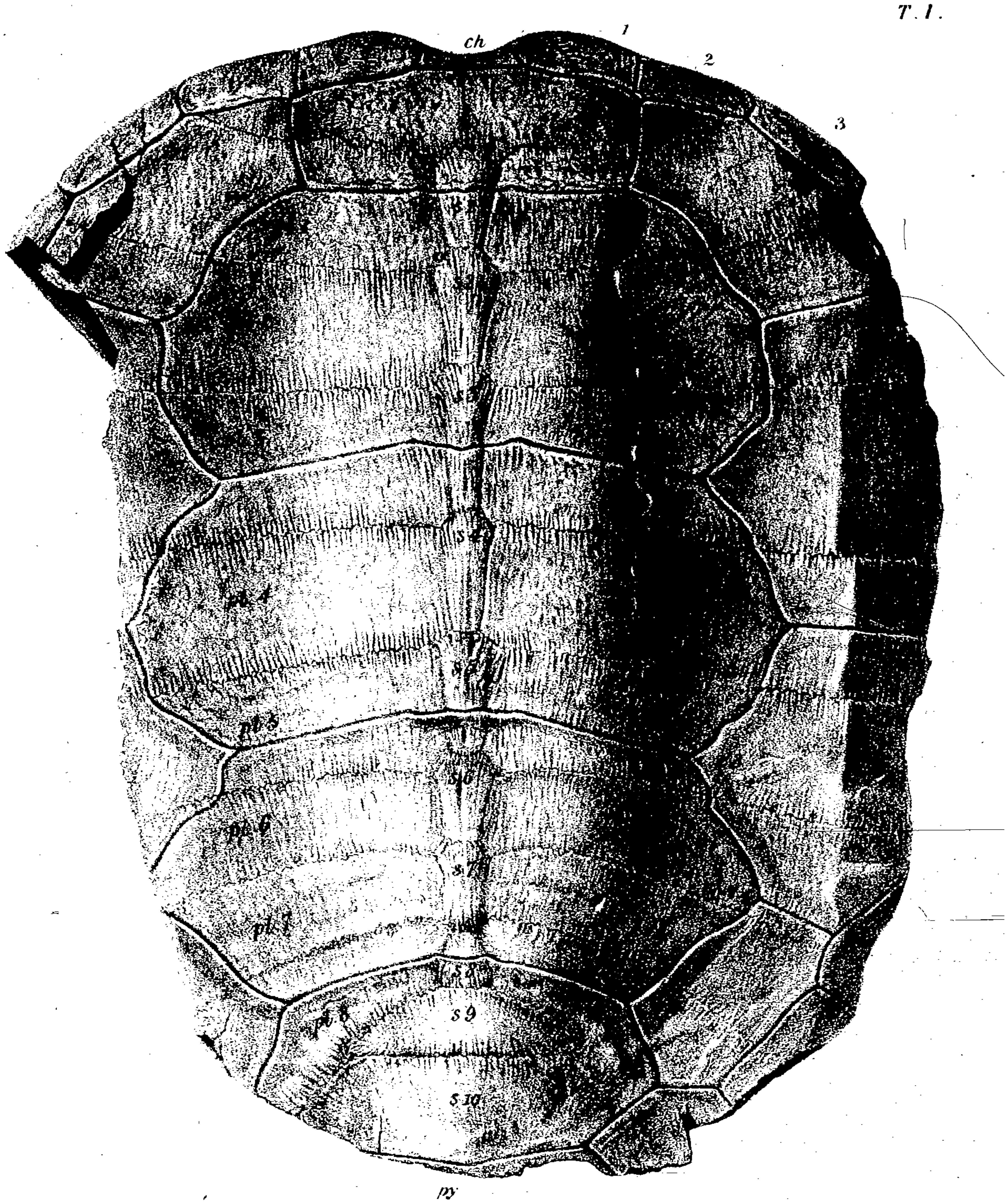
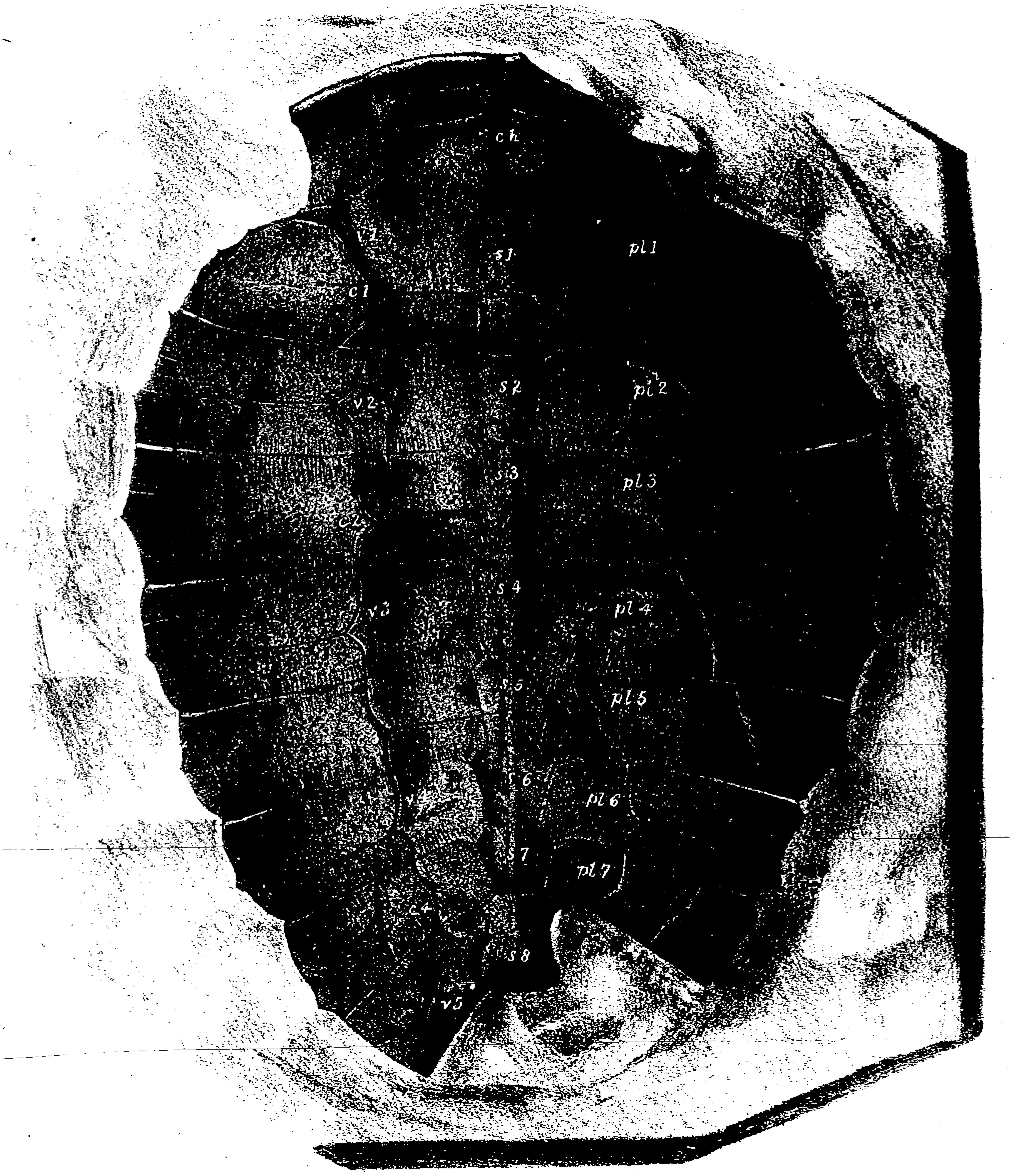

ch
1
2
3
s 9
s 10
py

TABLE II.

HALF NAT. SIZE.

The carapace of *Pleurosternon concinnum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of William Cunnington, Esq., of Devizes, Somersetshire.


ch
v1
s1
pl1
c1
s2
pl2
v2
s3
pl3
s4
v3
pl4
s5
pl5
s6
v4
pl6
s7
pl7
c4
s8
v5

1/2

TABLE III.

HALF NAT. SIZE.

The plastron of *Pleurosternon concinnum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of William Cunnington, Esq., of Devizes, Somersetshire.

1/2

. Dinkel. lith.

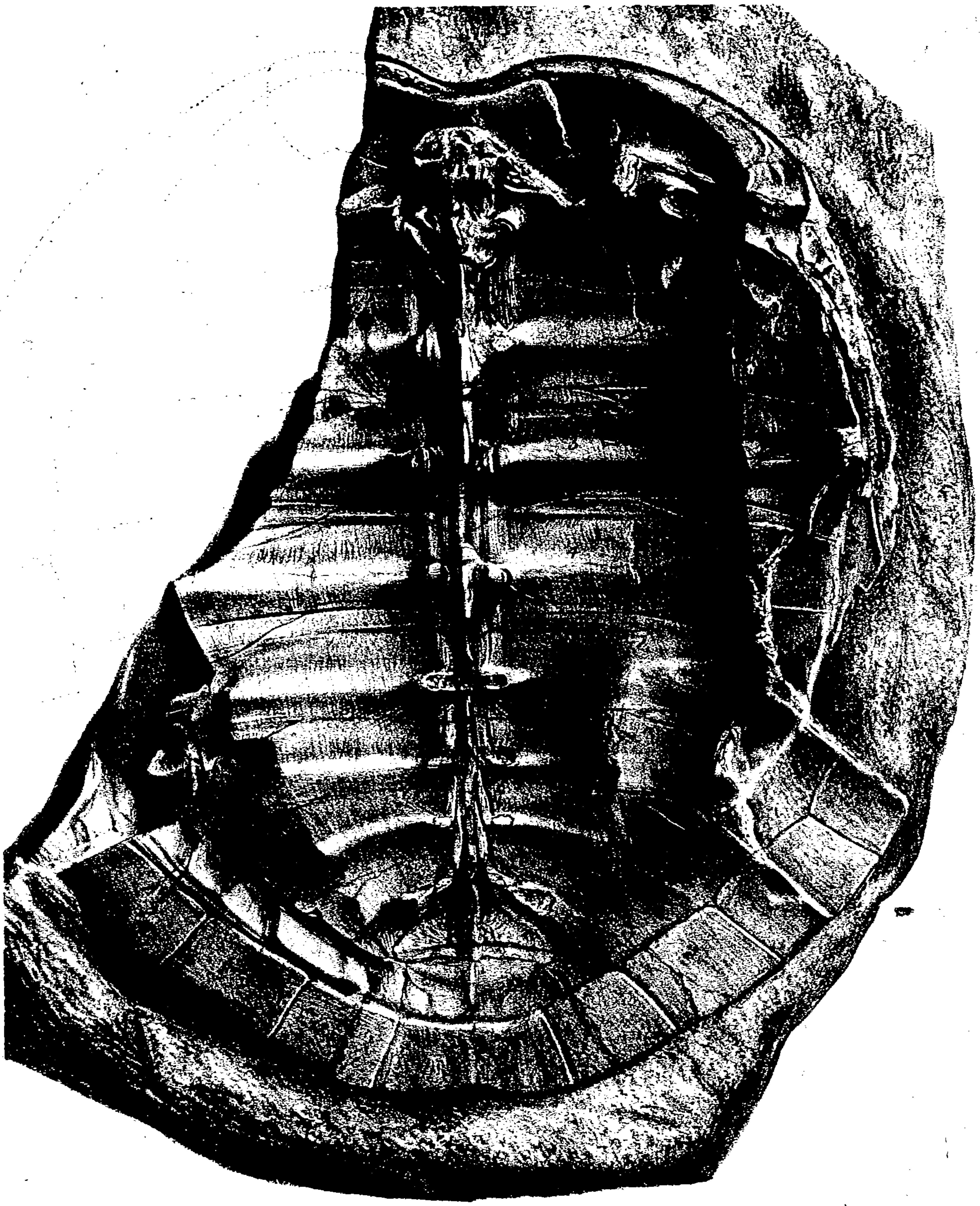
Day & Son Lith^rs to the Queen

TABLE IV.

ONE THIRD NAT. SIZE.

The inner surface of the carapace of *Pleurosternon emarginatum.* From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

T. IV.



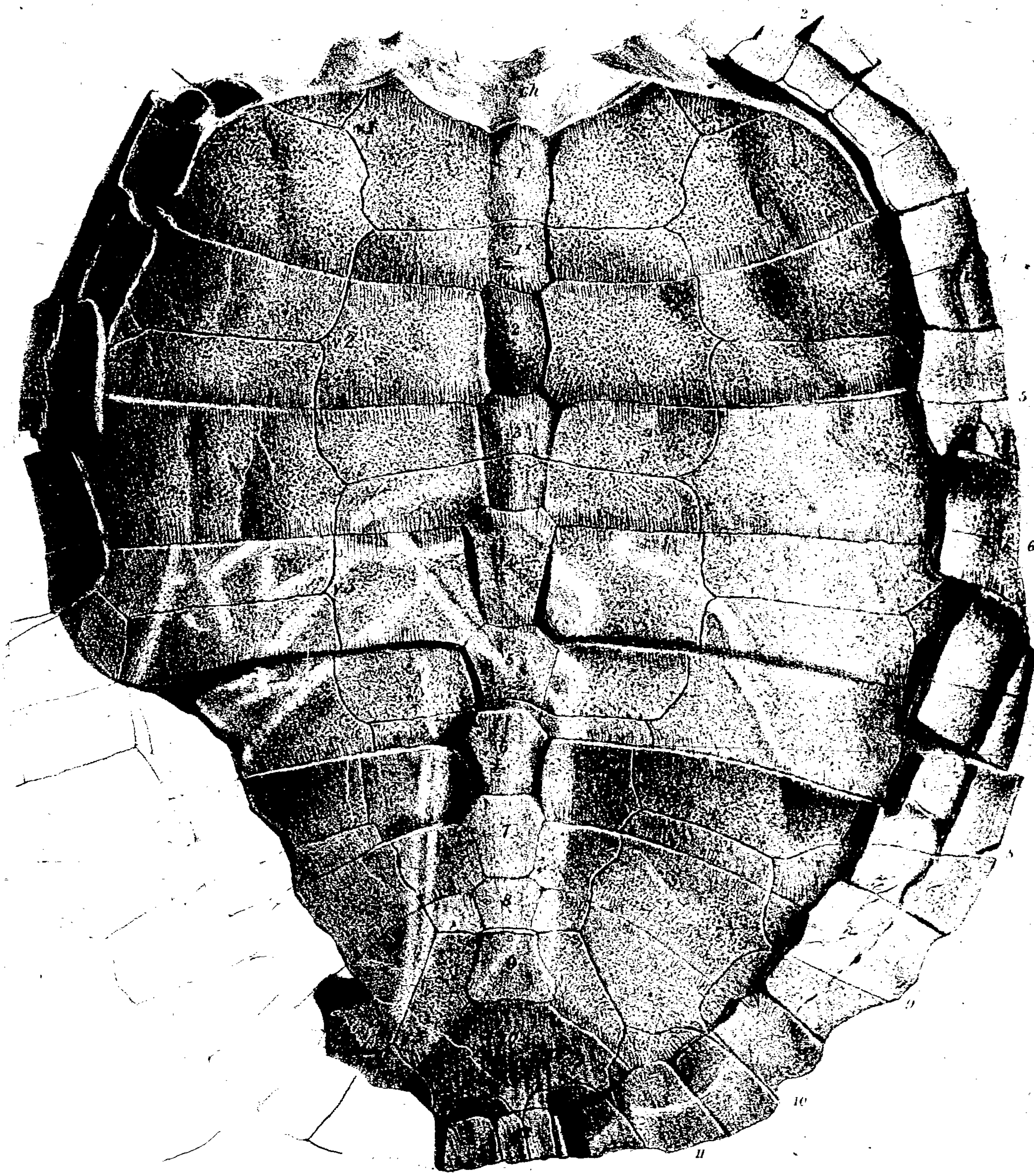
Dinkel ad nat. lith.

1/3

TABLE V.

HALF NAT. SIZE

The carapace of *Pleurosternon emarginatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.



1/2

TABLE VI.

HALF NAT. SIZE.

The plastron and marginal plates of *Pleurosternon emarginatum*. (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.

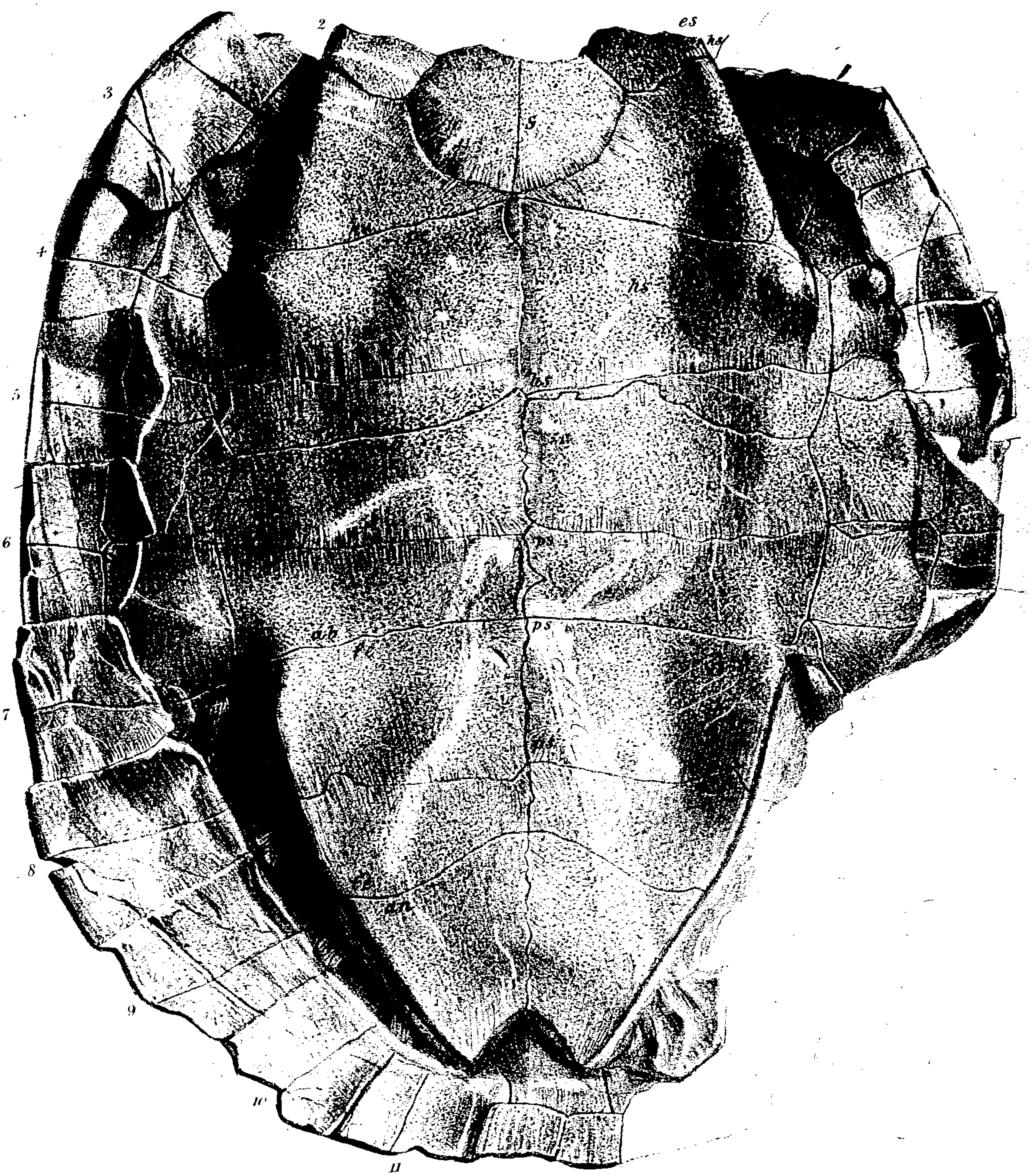
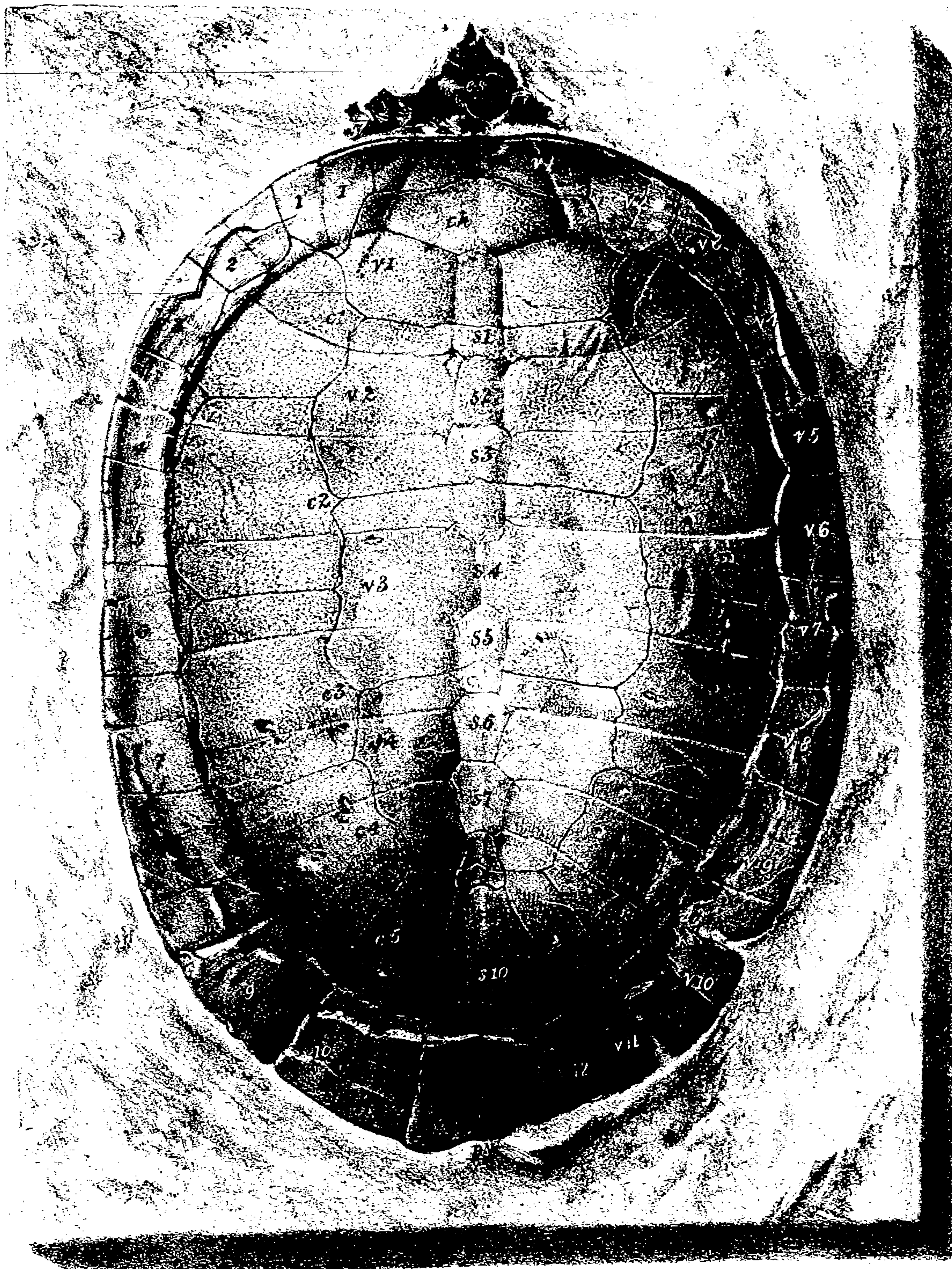

2
3
4
5
6
7
8
9
10
11
12
es
hs
s
ps
ah

TABLE VII.

ONE THIRD NAT. SIZE.

The carapace of *Pleurosternon ovatum.* (The letters and figures are explained in the text.) From the Purbeck Limestone. In the collection of Charles Willcox, Esq., M.R.C.S., Swanage, Dorsetshire.



1/3

Jos Dinkel, del et lith

TABLE VIII.

Fig. 1. Inner surface of a portion of the carapace of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 2. The right femur of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 3. The right iliac bone of *Chelone costata*, nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Nat size

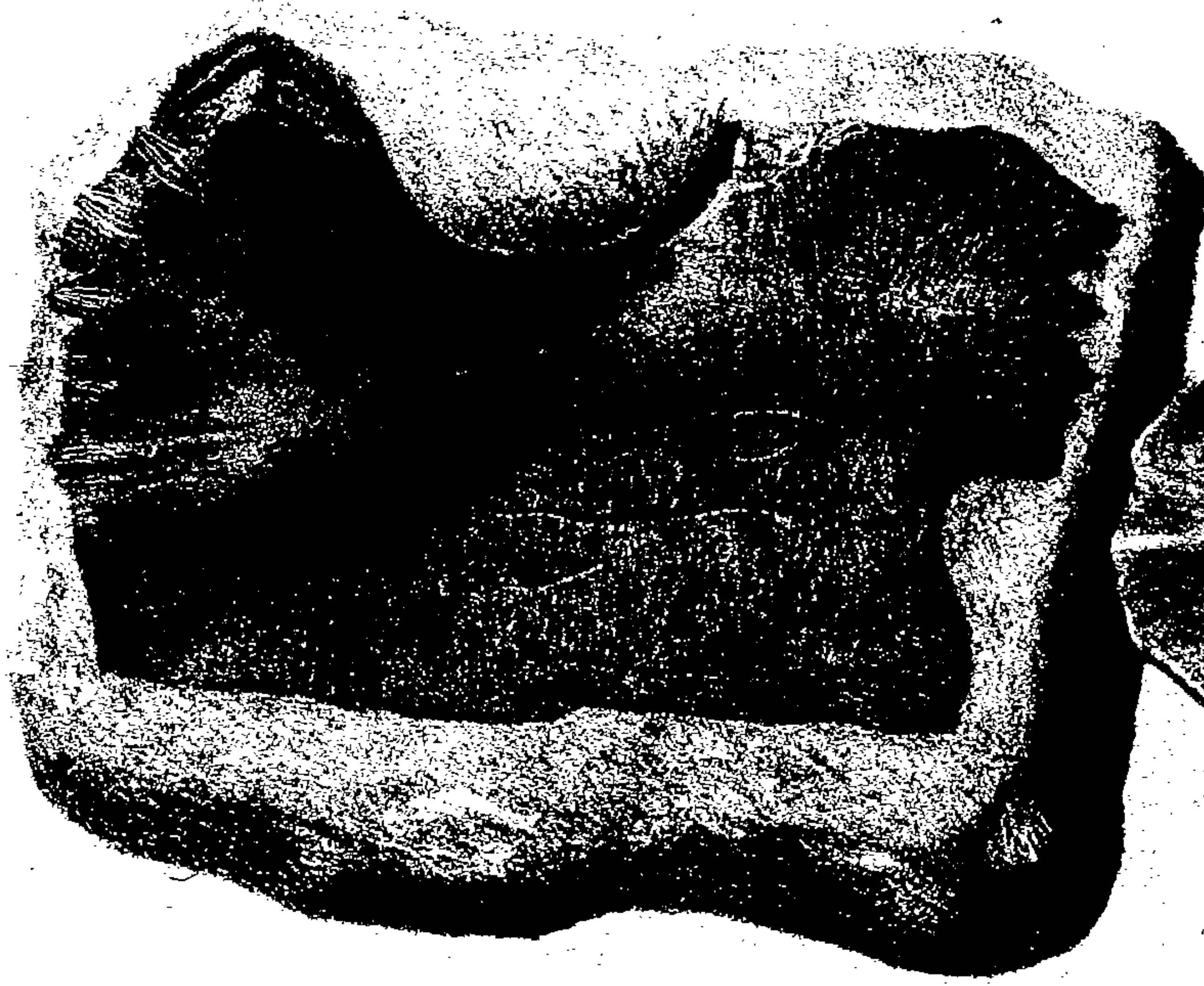
TABLE IX.

Fig. 1. The inner surface of the right hyosternal bone of *Platemys Mantelli;* half nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

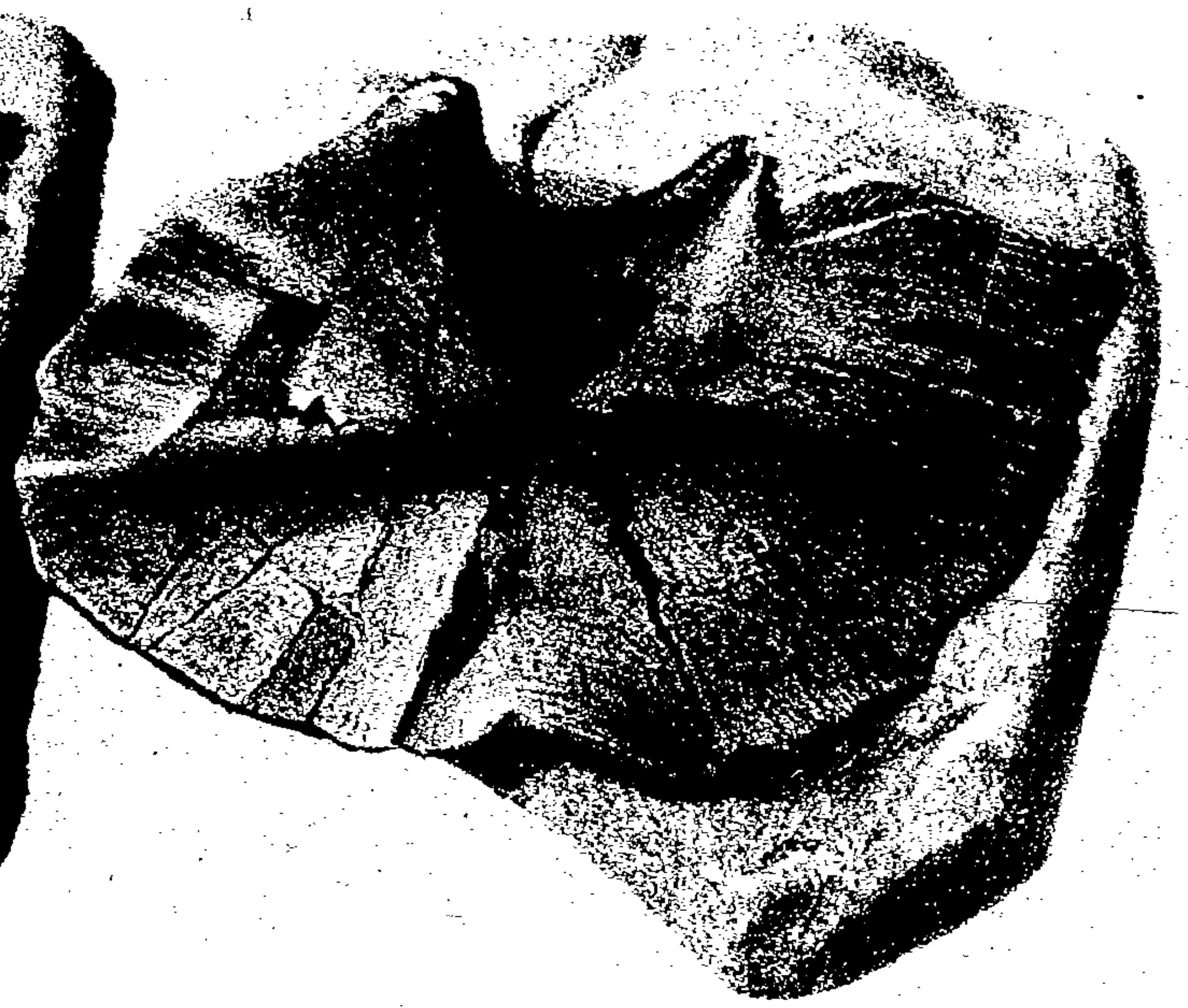
Fig. 2. The inner surface of a portion of a hyosternal bone of another species of *Platemys;* half nat. size. From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

Fig. 3. The left hyosternal bone of *Platemys Dixoni;* half nat. size; (figured upside down.) From the Wealden of Tilgate Forest. Mantellian Collection, in the British Museum.

1

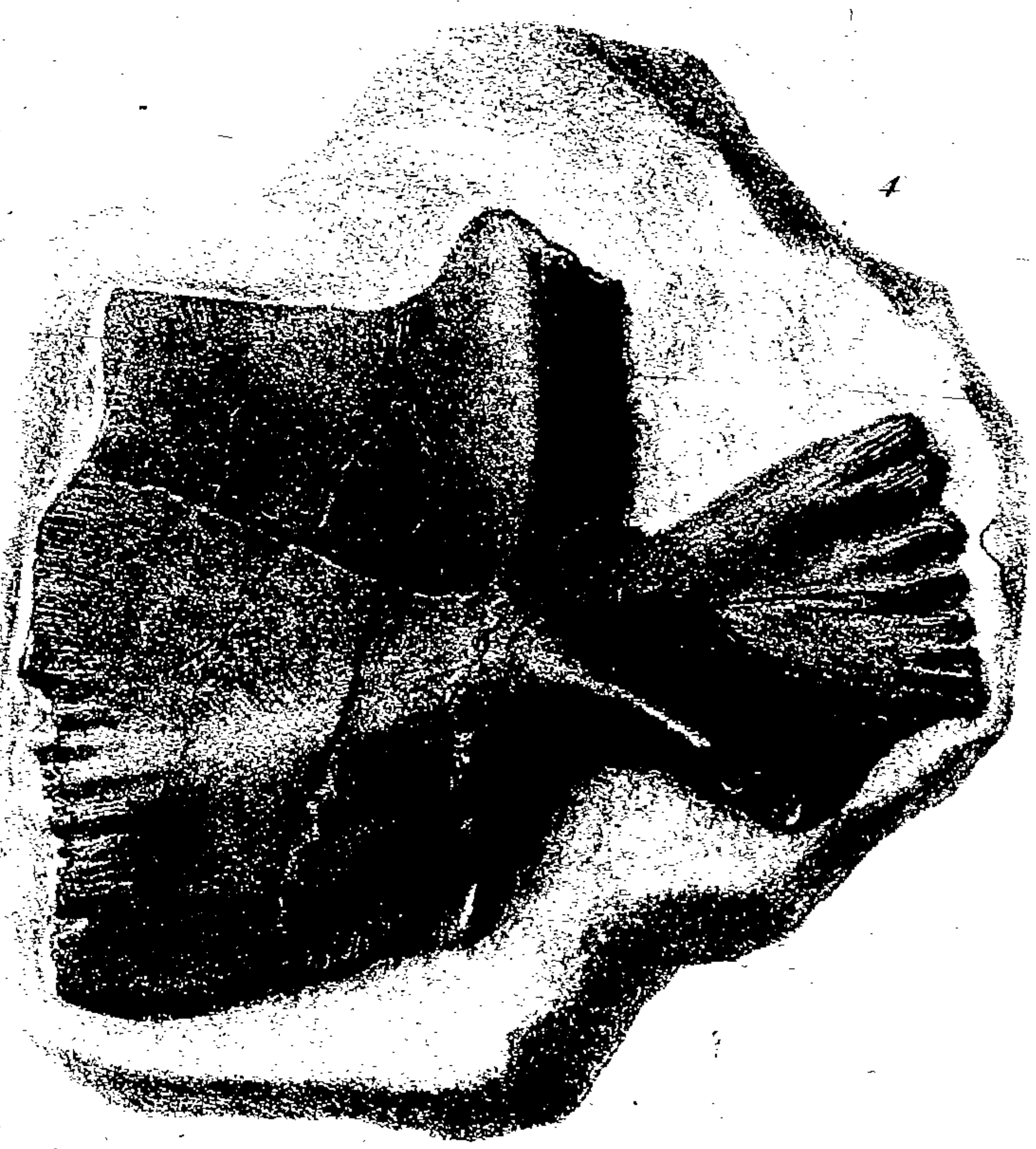


2



3

4



Half Nat. size.

TAB. X.

Iguanodon Mantelli, nat. size.

Fig.

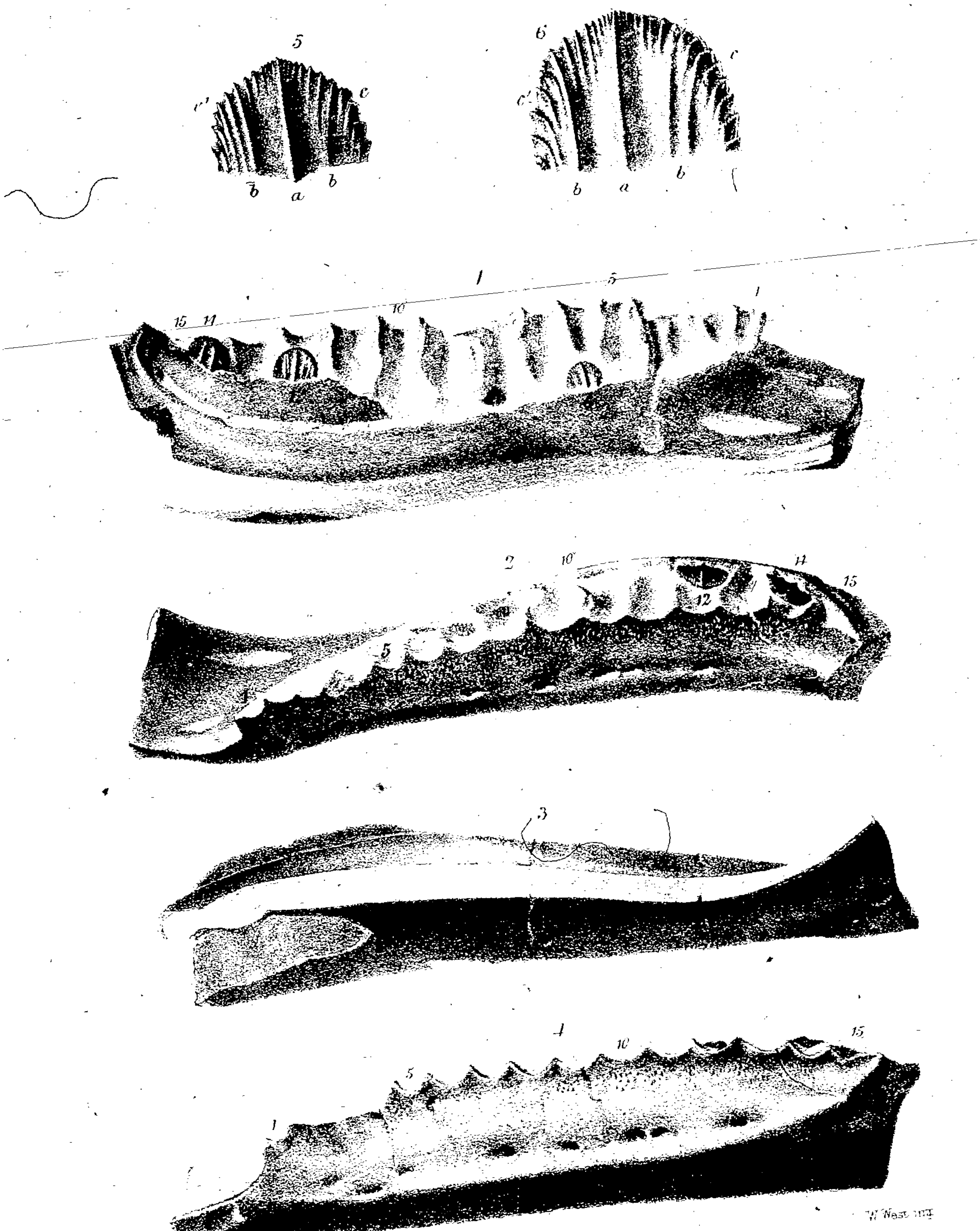
1. Inner side of part of the left mandibular ramus, showing part of thin inner alveolar wall (12), of a young Iguanodon.
2. Upper view of ditto.
3. Under view of ditto.
4. Outer side of ditto.

In each figure, 1 to 15 indicate the alveolar depressions in the outer wall.

5. Inner side of apex of crown of the successional tooth (6, fig. 1), magnified.
6. Inner side of apex of crown of the successional tooth (12, fig. 1), magnified.

Discovered by the Rev. W. Fox, M.A., in the Wealden, near Brixton, Isle of Wight.

T.X.



J. Dunkel del. et lith.

W. West imp.

MONOGRAPH

ON THE

FOSSIL REPTILIA

OF

THE WEALDEN FORMATIONS.

ORDER—*DINOSAURIA.**

(Cervical and anterior dorsal vertebræ with parapophyses and diapophyses; dorsal vertebræ with a neural platform; sacral vertebræ exceeding two in number; body supported on four well-developed unguiculate limbs.)

Genus—IGUANODON.

Dentes incrassati, marginibus lammellosis.

In a former Monograph 'On the Fossil Reptilia of the Cretaceous Formations,' 4to, 1851, p. 105, the vertebral characters of the dorsal and caudal regions of the spine of the Iguanodon were described and figured, as they were exhibited in the instructive specimen obtained by Mr. W. H. Bensted, from a Green Sand formation near Maidstone; in the present Monograph it is proposed to illustrate the characters of the rest of the skeleton, so far as undoubted parts of it have been obtained from the Wealden Strata, in which the first evidences of the Iguanodon were discovered by Dr. Mantell, and from which the most abundant and varied remains of this remarkable herbivorous reptile have since been obtained.

* Report on British Fossil Reptiles, 1841, in 'Trans. Brit. Association,' 8vo, 1842, p. 102. Pictet, 'Traité Elémentaire de Palæontologie,' 8vo, tom. ii, 1845, p. 52. From the Greek δεινὸς, fearfully great; σαῦρος, a lizard.

Description of part of the Skeleton of a Young Iguanodon. Tab. I.

IGUANODON MANTELLI, *Mantell.*

A considerable and very instructive part of the skeleton of a young Iguanodon, the entire body of which was probably under two yards in length, was discovered in the Wealden formations, about one hundred yards west of Cowleaze Chine, on the south-west coast of the Isle of Wight, in the year 1849.

The mass of Wealden stone in which this skeleton was imbedded, was broken into two parts in its extraction from the bed; and, as happened with the skeleton of the Dolichosaurus, described in a former Monograph,* the workmen disposed of one part to one collector, and of the other to another. Mr. Bowerbank was so fortunate as to become the possessor of that portion which contained the most important part of the skeleton, and which forms the upper division of the chief figure in the plate, Tab. I, where it is represented of the natural size.

This portion includes seventeen vertebræ, extending from the neck to near the pelvis inclusive: the pelvis apparently forms a continuation of the vertebral series, but is obscured by the principal bones of the right hind foot, *mt, pl,* 1 and 2. Some portions of ribs, *pl, pl,* and of a coracoid, 52, in the proximal part of the left femur, 65, the distal halves of the right tibia, 66, and fibula, 67, and a fragment of the left tibia, 66, are also imbedded in the same block of stone. The other portion of the block fell into the possession of Dr. Mantell, and is now in the British Museum. It includes eleven consecutive caudal vertebræ, with some of their hæmapophyses, *h, h;* the right femur, 65, the proximal halves of the right tibia, 66, and fibula, 67, and parts of the left tibia, 66′, and fibula, 67′. The bones of the right hind leg are almost completed when the blocks containing their opposite ends are brought into juxtaposition, as in Tab. I.

Of the seventeen vertebræ, in Mr. Bowerbank's specimen, the three anterior, 1, 2, 3, have been detached and carefully worked out: they appear to have immediately preceded the rest which remain imbedded in the block, and which are unequivocally consecutive; including the detached three, the seventeen vertebræ occupy an extent of thirteen inches.

The first three vertebræ, as imbedded and naturally cemented together, exhibit a slight upward curvature, and the five following vertebræ are bent in the same direction, but in a less degree: the rest present a moderate bend with the concavity downwards or towards the abdomen. The whole of this series, therefore, describes a gentle sigmoid curvature, like that which may be observed in the naturally articulated

* 'Fossil Reptilia of the Cretaceous Formations,' 1851, 4to, p. 22. Cuvier had to contend with similar difficulties; see 'Ossem. Foss.,' t. v, pt. ii, p. 148.

vertebral column of a young Alligator from the fourth cervical to the first lumbar vertebræ inclusive; which vertebræ are also seventeen in number in that reptile. Supposing the vertebræ of the young Iguanodon in question to be the homologous or nearly homologous vertebræ to those of the Alligator compared, the characters of the cervical vertebræ are given by the detached specimens, 1, 2, and 3, fig. 1, and figs. 2, 3 and 4, forming the anterior end of the series, and the degree of curvature shown by these vertebræ, which have been fixed together by the matrix, as they were naturally juxtaposed at the animal's death, and the slenderness of the portions of the ribs, *pl*, fig. 2, therewith preserved, add to the probability that they belonged to the neck.

In my 'Report on British Fossil Reptiles,' 1841, tom. cit., p. 126, I showed that the cervical vertebræ, which had been referred by Dr. Mantell to the Iguanodon, on the supposition that such vertebræ had ball and socket articular extremities, placed as in the neck-vertebræ of the Iguana, had, in fact, these articular surfaces situated in a reverse position to those in the Iguana and most existing Saurians, and that they agreed in that peculiarity with the vertebral characters which Cuvier had demostrated* in an extinct Saurian genus, subsequently called *Streptospondylus.* I had previously, however,† suggested the possibility that such Streptospondylian vertebræ from the Wealden might be the cervical ones of a large Saurian having plain-surfaced or concave vertebræ in the dorsal and lumbar regions. The authors of the paper 'On the Osteology of the Iguanodon,' in the 'Philosophical Transactions' for 1849, adopting this idea,‡ have applied it to the Iguanodon itself, but on no better grounds than a conjectural guess, which considerations of difference in other characters and proportions forbad my hazarding, when maturely considering the nature of the anteriorly convex vertebræ from the Wealden, in my 'Report.' Accordingly, in regard to the cervical vertebræ of the Iguanodon, I restricted myself to the following remark: "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." p. 126.

* 'Ossem. Foss.,' v, pt. ii, p. 153, pl. 8 and 9. † 'Report,' Op. cit., p. 96.

‡ P. 273. The reference to my observation is so made as to compel me to reproduce textually the passage in which the possible nature of Streptospondylian vertebræ was first indicated. "Since the vertebræ of the *Streptospondylus* lose their peculiar convexo-concave character by the gradual subsidence of the anterior ball, as they approach the tail, the cervical vertebræ of the *Cetiosaurus* may approach, more nearly than do the dorsal ones, to the convexo-concave structure of the Streptospondylian vertebræ. The fact that, hitherto, only cervical vertebræ of the great *Streptospondylus,* and only dorsal and caudal vertebræ of the *Cetiosaurus,* have been discovered in the Wealden formations, has induced me well to consider the grounds for assigning them to Saurians of distinct genera. But the general constancy of the vertebræ of the same Saurian in their antero-posterior diameter, forbids the supposition of a vertebra of six inches in length in the neck being associated with one of three inches in length in the back. Additional evidence of a very decisive character must at least be obtained before the great Cetiosaur can be admitted to have resembled the Pterodactyle in such disproportionate length of the cervical vertebræ." p. 96.

The following are the characters of the cervical vertebræ in Mr. Bowerbank's young Iguanodon:

The centrum partakes of the characteristic of that part in the dorsal region, in its lateral compression and the convergence of its sides to a very narrow inferior surface: but this wedge-shaped characteristic is exaggerated in the present vertebræ; the sides are naturally more compressed between the fore and hind articular ends; they are concave, not only lengthwise but vertically, and they meet below at a ridge from which a process—the hypapophysis—appears to have descended; for, though the ridge itself, *hy*, figs. 2 and 4, extends below the level of the articular ends of the centrum, it shows a fractured edge; and the hypapophysis is the characteristic of the cervical region in most saurian reptiles. As the neural canal retains its original capacity—the arch showing no marks of pressure,—the compression of the middle part of the sides of the centrum cannot be regarded as the effect of crushing; it is the same on both sides, and the expanded articular ends seem to exhibit their natural and symmetrical form,* as in fig. 4, Tab. I. This form differs from that in the dorsal region,† by being narrower in proportion to its depth, and repeats in this proportion the character of the same part in the caudal region;‡ but the contour of the cervical centrum is different from that of the caudal one: the anterior surface resembles an ancient shield, the sides slightly diverging as they descend to the parapophyses, and then more rapidly converging to the inferior ridge; the contour of the hinder surface, fig. 4, is an oval, a little flattened above at the larger end. The deep pit at the side of the centrum characteristic of the cervical and anterior dorsal vertebræ of the Streptospondyl is not present in the corresponding vertebræ of the Iguanodon. In these vertebræ the anterior articular surface is nearly flat vertically, very slightly concave at the middle, and as feebly convex above and below. Transversely the surface is slightly convex, and most so where it is continued, just above the middle of the surface, upon the parapophyses. The hinder surface is gently and pretty uniformly concave.

Both surfaces are devoid of that smooth or polished character which is observable in the Reptiles that have those surfaces coated by articular cartilage, and have their vertebral centrums articulated by synovial capsules; concentric striæ are plainly manifest near the border of the articular surface, whence I conclude that the vertebral bodies of the Iguanodon *were coarticulated by means of an intervertebral ligamentous substance, as in the class Mammalia.* That such substance intervened between these

* The assertion in the paper above cited, 'Phil. Trans.,' 1849, p. 303, that the three vertebræ here described "have been crushed and compressed almost flat laterally" has reference to an idea that they were homologous with the Streptospondylian vertebra described in my 'Report,' p. 92, the different form and proportions of which are explained by the authors of that paper on the assumption that that vertebra "has been compressed in an opposite direction," ib. p. 303.

† 'Mon. Cretaceous Reptiles,' tab. xxxvi.

‡ Ib., tab. xxvii.

most freely moveable cervical vertebræ, and, *à fortiori*, therefore, between the less moveable dorsal, lumbar, and caudal vertebræ, is further indicated by the interval separating the centrums in the three cervical vertebræ preserved with the natural co-adaptation of their zygapophyses, and with their natural upward curvature, in the specimen figured in Tab. I. The elasticity of the concentric ligamentous substance has permitted the vertebral bodies, in this upward flexure, to be more divaricated at their lower than at their upper borders.

Nothing in the characters of these unequivocal vertebræ of the Iguanodon affords any countenance to the conjecture that the broad and sub-depressed convexo-concave, or streptospondylian vertebræ, which I had stated might be a cervical modification of the vertebral column of the Cetiosaur, are from the cervical region of the Iguanodon. The parapophysis of the true cervical vertebræ of this reptile, figs. 2 and 4, *p*, is developed, in a great proportion from the centrum, in a less proportion from the neurapophysis, close to the anterior articular end of the centrum, which surface is continued upon the parapophysis. This process is short, obtuse, and terminates by a surface for the attachment of the head of the rib.

The neurapophyses, which are confluent at their summit, remain free below, where they are joined by suture to the centrum, embracing the upper third of the articular end. They contribute, as above stated, a small proportion to the parapophysis; ascend a short way vertically with a smooth and concave outer surface, then develope large zygapophyses, and, from the outside of the anterior of these, *z*, send out a diapophysis, *d*, for articulation with the tubercle of the rib. The neural arch is notched before, and more deeply behind; there is a ridge above each zygapophysis, and these ridges converge to the base of the neural spine. The broad, flat articular surface of the anterior zygapophysis, *z*, looks inwards and a little upwards and backwards; that of the posterior zygapophysis, *z'*, exhibits, of course, the opposite aspects; the outer border of both zygapophyses is rounded. The zygapophyses are not connected, externally, by a ridge continued forwards and backwards from the diapophysis, as in the dorsal vertebræ, where such ridges form the neural platform, Tab. XXXV, *n*, *n*. The neural canal is proportionally wider than in the dorsal vertebra of the older Iguanodon ('Monogr. Cretaceous Reptiles,' Tab. XXXVI), but this is no doubt due to both the comparative immaturity of the present specimen, and to the more advanced region of the spine formed by the vertebræ under consideration.

The bases of the neurapophyses do not extend so far inwards as in the dorsal vertebræ, but leave a median tract of the floor of the neural canal which is formed by the centrum itself: this part of the centrum sinks into a hollow, and is perforated by the myelonal veins.

The antero-posterior extent of the base of the neural spine is two lines, that of the neurapophysis, between the extremes of the anterior and posterior zygapophyses, being thirteen lines: the spine is much compressed laterally: it has been broken off near its origin in all the three detached vertebræ: there is a deep angular depression behind its base, between the two converging ridges from the posterior zygapophyses, probably for the implantation of an elastic ligament.

The proximal end of a slender pleurapophysis, *pl.* fig. 2, adheres by the matrix to the left side of the second and third of the three vertebræ above described; the neck of the rib is moderately long and rounded, truncate, and not expanded at its articular end; the tubercle is produced, and beyond that the rib becomes compressed: unfortunately only a small part of the body of the rib is preserved.

Of the succeeding vertebræ, imbedded in the matrix, the flat or slightly concave character is resumed in the anterior surface of the centrum of the third, counting backwards.

The modification of the articular terminal surfaces, slight as it is in the cervical vertebræ above described, may be readily understood to relate to the corresponding increase in the extent and facility of motion of that part of the spine. But such modification gives no support to the idea that the vertebra, No. $\frac{116}{2116}$ in the British Museum, provisionally referred to the *Streptospondylus major* in my 'Report on British Fossil Reptiles,' p. 92, but with the intimation of its being possibly a cervical vertebra of the *Cetiosaurus brevis* (ib., p. 96),—and referred by Dr. Mantell to the *Iguanodon Mantelli* in the 'Geology of the South East of England,' 8vo, 1833, p. 300, and by Dr. Melville to the same reptile, in the 'Phil. Trans.,' 1849, p. 301, Pl. XXVIII, fig. 4,—really appertained to the cervical region of the Iguanodon.

We have not, as yet, any evidence of so marked and sudden a change in the forms and proportions of a cervical vertebra, between the dentata and the fourth or fifth, occurring in any reptile or mammal, as would be the case were the vertebræ, described in p. 92 of my 'Report,' to belong to the Iguanodon; and the absence of such evidence prevents me now, as at the period when those vertebræ were first described, from hazarding or acceding to the hypothesis.

In the vertebræ succeeding those, 1, 2, 3, here regarded as cervical in the young Iguanodon, Tab. I, the sides of the centrum continue to be compressed, with a surface flat vertically, and concave longitudinally, and meeting below at a ridge, as far as the twelfth, counting backwards, and including the three detached cervicals: at the fourteenth vertebra the lower part of the centrum is broader, and is convex transversely. The parapophysis has ascended upon the neurapophysis in the fifth vertebræ, counting backwards; and in the sixth the contour of the articular terminal surface is oval, with the small end downwards: it is shown to be elliptical in the sixteenth vertebra.

The neurapophysial sutures are retained throughout the series of the seventeen successive vertebræ. In the seventh, sufficient of the neural arch is preserved to show the interzygapophysial ridge, forming the base of the expanded bony platform, *n*; a part of the neural spine, *n* 5, of this vertebra is preserved, to an extent equaling the vertical diameter of the rest of the vertebræ: it is compressed, but of considerable antero-posterior extent. The zygapophyses, *z*, *z'*, diminish in size, and their articular surfaces become more vertical as the vertebræ approach the pelvis. The left pleurapophyses, *pl*, *pl*, of the first five of the imbedded vertebræ, or those succeeding the three cervicals, seem to show a progressive and rapid augmentation of length, indicative of their formation of the fore part of the thorax, but the extremities of all their ribs appear to have been broken off: the inner surface, which is exposed, shows a longitudinal groove; traces of ribs continue to the seventeenth vertebra. There are impressions of spines of three vertebræ, beyond this, before we come upon the blended mass of the pelvis and hind foot. Before describing the pelvis, some notice is required of the peculiarities of those elements of the cervical and dorsal vertebræ which, from their development and retention of their primitive separation, are usually regarded as distinct bones, called "ribs."

Ribs of the Iguanodon. Tab. II.

These appendages, or elements, of the vertebral column are present throughout a great proportion of its extent, but become anchylosed, and reduced to the character and function of transverse processes in the lumbar, sacral, and caudal regions. They are free and largely developed in the thoracic-abdominal region of the spine, at the fore-part of which they have the same two-fold connexion with the vertebræ as in the Crocodilians. In the cervical region the rib is articulated by a "head," supported on a long neck, to a short sessile inferior transverse process or "parapophysis," and by a large "tubercle" to a superior transverse process or "diapophysis;" a portion of a cervical rib is slightly disarticulated and turned forwards in one of the hinder cervical vertebræ of the young Iguanodon, figured in Tab. I, fig. 2, so as to show most clearly the nature of this two-fold articulation; as the ribs increase in length, at the fore-part of the thorax, each is 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, as at Tab. XXXV, *p*, 'Mon. Cretaceous Reptiles'; and it was also articulated, as in the neck, by a tubercle, to the extremity of the diapophysis. In a certain number of the anterior thoracic vertebræ, the neck of the rib is co-extensive with the diapophysis, and is sometimes six or seven inches in length; afterwards the neck of the rib begins to shorten, and the head to decrease in size, and to have its place of articulation brought progressively nearer to the tubercle and to the end of the diapophysis, until it finally disappeared, and the posterior ribs became appended to the ends of the diapophyses.

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. $\frac{519}{2519}$), is 46 inches in length, its proximal or vertebral end is represented in Tab. II, figs. 1 and 2. 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 diapophysis, 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 2½ 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, and their connexion with continuous dermal ossifications, the lid of their bony box is almost wholly formed.

In fig. 3, Tab. II, is given a view of the upper surface of the head, neck, and tubercle, and expanded beginning of the shaft of a rib of an enormous Iguanodon, the part so represented measuring 10 inches in a straight line. A ridge is developed from the upper surface which, at the tubercle, expands into the overhanging plate of bone. In a more posterior rib, figs. 4 and 5, the tubercle is more distinctly developed, and continues so to be as the neck progressively shortens, as in figs. 6—10, Tab. II. Fig. 8 gives a view of an almost entire pleurapophysis, or "vertebral" rib, from about the middle of the thoracic abdominal cavity, the length of which, in a straight line, from the tubercle to the fractured end of the body, is 32 inches. The common form of the body of the rib is that exemplified in the transverse section of the rib, given at fig. 1. The number of thoracic abdominal vertebræ, supporting such free and more or less elongated ribs, was probably about fifteen.

SACRUM OF THE IGUANODON. Tab. III, IV, V and VI. (Half nat. size.)

The facts ascertained relative to the structure of that part of the vertebral column, answering to the "true vertebræ" in Human Anatomy, of the Iguanodon, had tended, at the period of preparing my 'Report on British Fossil Reptiles,' in 1840, to rectify the ideas on the Lacertian affinities of that reptile, suggested by its name, and had proved the Iguanodon to belong to a more highly organized section of the then-defined Saurian order than the Iguana and the rest of the Lizard-tribe. The two costal articulations, viz., for the head and tubercle of the rib on the anterior dorsal vertebræ,* and the corresponding modifications of some of the ribs themselves,† indicated the great extinct herbivorous reptile of the Wealden to have enjoyed a double circulation, aided by a four-chambered heart as perfect in structure as that of the modern *Crocodilia*.‡ The peculiar expansion and complexity of the neural arch, so superior to the structure of that part in the Crocodile, and so distinct from the Ophidian modification of the same part in the Iguana,§ pointed to the former existence of a primary group of the class *Reptilia*, superior to and distinct from both the crocodiles and lizards of the present period. But the confirmation of the ideas and the resolution of the questions thus suggested depended on, or at least rendered very desirable, the detection of corresponding modifications of other parts of the vertebral column, and especially of that part which more immediately transferred the weight of the hinder parts of the trunk and the tail upon the—for a reptile—enormously developed hind limbs.

No sacrum of any recent or fossil cold-blooded animal had at that time been recognised as including more vertebræ than the typical number—two—in the reptilian class; and no single vertebra, or set of vertebræ, had then been referred to the sacrum of the Iguanodon. The Mantellian Collection in the British Museum, according to its catalogue, in the hand-writing of its founder, contained no sacral vertebræ. I suspected, indeed, at an early period of my investigations of our Fossil Reptilia, some detached centrums, or vertebral bodies, of a young Iguanodontoid Saurian, in that Collection, No. $\frac{127}{2127}$, *e*, *g*, to belong, from certain characters hereafter to be noticed, to the sacral region of the spine; but the proof, from better preserved specimens, was still wanting.

Every collection, public and private, to which I could command access, was ransacked for a specimen that might agree with the suspected characters of the great desideratum towards completing the vertebral anatomy of the Iguanodon. Some years passed away, leaving fruitless this research; until, in 1840, in the course of a systematic examination of the private collections in this metropolis, and whilst engaged in the comparison of the reptilian fossils in the well-stored museum of J. Devonshire Saull, Esq., F.G.S., in Aldersgate Street, City, my attention was arrested by a bulky and weighty mass of anchylosed and fossilized vertebræ, with a long and rather flattened bone attached to one side, the examination of which left a conviction of their agreement in general form and characters with the supposed sacral vertebræ and iliac bones of the Iguanodon in the British Museum. The following is the description of this sacrum of the Iguanodon given in the part of my 'Report,' published in 1841, where it is

* 'Report,' 1841, pp. 126, 127.
† Ib., p. 133.
‡ 'Report, Brit. Foss. Rep.,' 1841, p. 203.
§ 'Hist. Brit. Foss. Reptiles,' 4to, 1850, p. 136.

compared with the sacrum of the *Megalosaurus*, which I had about the same time determined:

"This instructive specimen consists of five vertebræ 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 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 vertebræ 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 vertebræ 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 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 to 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 2½ 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," p. 130.

I looked forward to the more detailed description, with illustrative figures, of this unique specimen, when further worked out, as being likely to form one of the chief

* The true anterior limit of the sacrum is defined by this admeasurement.

novelties, and most important additions, to be submitted to the members of the Palæontographical Society, and other cultivators of geology, in my forthcoming 'Monographs on the Fossil Reptilia of Great Britain,' of which the 'Reports' to the British Association, in 1840 and 1841, were the basis.

In some particulars I have been aided, and in a few illustrations anticipated, by the labours of zealous contemporaries. Two associated authors, taking advantage of the indications given in my 'Report,' obtained Mr. Saull's permission to examine the sacrum of the Iguanodon which I had discovered, and had a drawing taken of it, which they published in the 'Transactions of the Royal Society,'* confirming, in the main, my description, but describing an attached lumbar vertebra, as a sixth sacral one.

As the characters of the order *Dinosauria* were mainly founded on this specimen four plates have, in this 'Monograph,' been devoted to the illustration of its remarkable structure.

Tab. III gives a view of the under surface, of half the natural size in linear admeasurement.

The last of the lumbar series, L, upon the interspace between which and the first true sacral vertebra the neural arch of that vertebra, *n* 1, Tab. IV, has advanced, has thereby become confluent with the sacrum proper, characterised by the junction of its transverse processes with each other, and with the iliac bones. The confluent lumbar vertebra has a much broader centrum or body, , than that of the contiguous sacral vertebra, especially at its middle part, which presents a subquadrate transverse section, the sides being vertical, excavated near the neurapophysis, and meeting the under surface at a right angle: the under surface is convex transversely, especially at its middle part, concave longitudinally. The anterior articular surface is quadrate, with the angles rounded off, and is broader than it is deep: it is slightly convex vertically, flat transversely, except near the periphery, which is convex: some remains of its water-worn and mutilated neural arch, showing the normal relation of its piers to the centrum, and its partial anchylosis to the advanced neural arch of the first sacral vertebra, are shown at *n n*, fig. 1, Tab. VI: the antero-posterior extent of the piers is short; the neural interspace between them and those of the first sacral vertebra is wide.

The body of the first proper sacral vertebra, *s* 1, Tab. III, differs from the foregoing by its sudden decrease in transverse diameter, especially at its middle part, the sides being concave lengthwise, and with the under surface compressed and produced into a low ridge. In consequence of the advanced position of its neural arch, the first pair of sacral nerves pass over the upper surface of the centrum about one third from its hinder end, and deeply groove that surface in their passage; the fore part of the advanced arch of the succeeding vertebra rests upon and has coalesced with the expanded hinder end of the first sacral vertebra. The transverse processes of this

* 'Philosophical Transactions,' 1849, p. 275, pl. xxvi.

vertebra, which consist of short pleurapophyses, *pl* 1, have been advanced, like the neural arch, to the interspace between the first sacral and last lumbar vertebræ, and have coalesced with both; the major part of the expanded head of the short and strong sacral rib being fixed to the sides of the expanded anterior end of its own centrum: after becoming slightly constricted, the ribs expands, like the overlapping cervical ribs in the crocodile, in the direction of the axis of the body, but the sacral ribs more firmly unite their portion of the vertebral column together by becoming confluent at their expanded extremities. Almost the whole upper surface of the short sacral rib has coalesced with a strong, vertically developed, antero-posteriorly compressed, diapophysis, *d* 1, Tab. IV. These processes are continued outwards from the whole side of the neural arch, and form a series of strong transverse ridges, *d* 1—*d* 5, Tab. IV, progressively increasing in length to the fourth, *d* 4; the fifth, *d* 5, being of nearly the same length as the fourth. The neurapophyses extend forwards and backwards beyond the base of the diapophyses, and coalesce with each other and with the centrums, so as to convert the interneural outlets for the nerves into foramina. The neural spines, probably short in comparison with those in the dorsal region, and apparently more or less blended together to form a continuous ridge, have been broken or worn away to their bases, which are indicated by the letters *n* 1—*n* 5, in Tab. IV. The bodies of the second, *s* 2, Tab. III, and third, *s* 3, sacral vertebræ are compressed, and continue to present the carinate inferior surface; that of the fourth sacral *s* 4, and fifth sacral *s* 5, progressively expand, and are convex beneath. In the first to the fourth sacral, inclusive, the sides of the centrum present a rounded depression a little behind their middle, the neural arches of the second, third, and fourth sacral vertebræ rest two thirds upon their own centrum and one third upon that in advance, dipping wedgewise into the interspaces of the centrums as they cross from one to another: the neural arch of the fifth sacral, like that of the first, rests in a larger proportion upon its own centrum, above which its piers meet, leaving a triangular neural surface before and behind their junction. The posterior articular surface of the body of the last sacral vertebra is shown in Tab. VI, fig. 2, *s* 5; it is slightly concave; the upper surface of the centrum above this end, and for about one-fifth of its length, Tab. V, fig. 2, *s* 5, is free, the neural arch of the first caudal vertebra having resumed its normal position in regard to its centrum. The posterior zygapophyses, *z' z'*, Tab. IV and Tab. VI, are in part preserved in the last sacral vertebra; the degree of diminution of the neural canal, as it extends, with partial expansions, through the sacral series, may be seen by comparing fig. 1 with fig. 2, in Tab. VI. The coalescence of the pleurapophyses and diapophyses circumscribes a series of four progressively expanding vertical canals on each side of the sacrum, the lower outlets of which are shown in Tab. III, and the upper ones, *o, o, o, o,* in Tab. IV: the nervous foramina, in the interspaces of the neural arches, open into these canals. There has been a tendency to ossification in the fascia extended between the upper borders of the strong boundaries of these foramina, of which the evidence remains, at *f*, Tab. III and IV, in a thick plate of bone, extending partly over the upper outlet of the second foramen. The coalesced extremities of the fourth and fifth sacral ribs have been broken away on the left side. These coalesced extremities form a continuous tract of bone, *pl* 1′—*pl* 4′, Tab. III, with a flattened outer surface, slightly concave lengthwise, to which the iliac bone is attached, and has remained attached probably through partial confluence on the right side of the present specimen. The organic architecture of this part of the vertebral column of the ancient gigantic reptile cannot be sufficiently admired in reference to the due strength of the part thereby attained.

The pressure transmitted by the thigh bones upon the iliac bones is resisted, and is transferred by the strong vertical buttresses, formed by the modified and coalesced pleur- and di- apophyses, upon the bodies and neural arches of the sacral vertebræ; but, by the altered relative position of the neural arches and pleurapophyses, the weight transmitted by one pair of buttresses does not bear exclusively upon a single vertebral centrum, but is divided equally between two centrums. In the young and perhaps more active Iguanodon, prior to the general anchylosis that afterwards pervades this complex mass, the further advantage of a certain elastic yielding of the parts must have been gained, by the implantation of the piers of the neural arch, and the heads of the short, buttress-like ribs, upon or over the joints between the vertebral bodies. A like advantage is gained by the same modification, in regard to the position of the neural arches and ribs, in the vertebræ of the carapace of the Chelonian reptiles, and in the sacral vertebræ of the Ostrich; the structure of the latter is interestingly analogous to that of the same part of the spine in the extinct Iguanodon.*

A considerable proportion of the right iliac bone remains attached to the sacrum of the Iguanodon above described. It is a strong, elongated, subtriedral bone, firmly adherent by an inner flattened surface to the confluent expanded ends of the five sacral ribs, *pl* 1—*pl* 5. The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb, and a second short, oblique, almost vertical, ridge, divides the bone into an anterior and a posterior portion. The anterior portion is again subdivided into a thick, strong, acetabular portion 62—62, forming the upper part of the cavity for the hip-joint, and a more slender portion extending forwards as far as the anchylosed lumbar vertebræ, and terminating in an obtuse point, 62′. The hinder portion of the ilium, 62″, is extended backwards beyond the surface of attachment to the sacral ribs, and probably terminated freely, as in most Lacertian reptiles; but the extremity of this part has been broken off.† The chord of the acetabular arc or concavity measures 8 inches. The major part of the acetabulum was contributed, as in most modern lizards, by the ischium and pubis. Upon the whole, the structure of the ilium accords more with the Lacertian than the Crocodilian type of the bone.

* See my 'Archetype of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27.

† In the Paper, 'Phil. Trans.,' 1849, by the authors who anticipated my illustrations of Mr. Saull's pelvis of the Iguanodon, I am stated, or at least the author of a 'Report on British Reptiles' is charged, p. 299, with having mistaken the anterior for the posterior part of the ilium. A reference to p. 135 of the

With the foregoing knowledge of the complex structure of the sacrum of the Iguanodon, the peculiarities of detached parts of those modified vertebræ become intelligible, and prove to be such as they were originally surmised to be.*

DETACHED BODIES OF THE SACRAL VERTEBRÆ OF THE IGUANODON, Tab. VII.

As such parts, especially the centrum or body, are not unfrequently found separated from the rest of the skeleton of immature individuals, it has appeared desirable to subjoin a description of the most common of these parts.

No. $\frac{127}{2127}$, Mantellian Collection, in the British Museum, is the centrum of a sacral vertebra of a sub-quadrate form, with a broad and flattened inferior surface, fig. 3, slightly concave lengthwise. The upper surface, fig. 4, 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, *n*, and posterior, *n'*, parts of the sides of this centrum, fig. 1, are raised, so as to form projecting sub-triangular rough articular surfaces, continued upon the margins of the neural 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, *o*, figs. 1, 4, 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: such outlet is necessarily in this unusual situation, because the holes of conjugation, as they exist in other vertebræ showing the ordinary position of neural arches, have here been obliterated by the impaction of the bases of the neurapophyses between the contiguous extremities of the bodies of the sacral vertebræ.

The anterior and posterior articular extremities of the present interesting fossil equally bespeak the peculiar character of the sacral vertebræ of the *Dinosauria*. They are impressed by coarse straight ridges and grooves radiating from near the upper part of the surface, fig. 2, 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 vertebræ are compacted together in the mature Dinosaurs.

	In.	*Lines.*
The length of this vertebral body	2	10
The height	2	6
The breadth of anterior articular end	3	0
The breadth of middle part	2	2

volume of 'Reports of the British Association,' 8vo, 1842, will show how gratuitous such a statement is in regard to the 'Report on British Fossil Reptiles,' therein published. The posterior extremity of the ilium is there, as here, expressly described as the one which has been broken off; it is well displayed in the Maidstone Iguanodon.

* 'Report on Brit. Foss. Reptiles,' 1841, p. 130.

	In.	Lines.
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 *Hylæosaurus*. It is obviously very distinct in form from the sacral vertebræ of the *Megalosaurus*. No other reptile than one belonging to the order characterised 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*, and it was probably the fourth of the series.

Caudal Vertebræ of the Iguanodon. Tab. VIII and IX.

The typical vertebræ of this region—those, viz., with hæmapophyses—are distinguished by the single hæmapophysial 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 equally great Wealden vertebræ 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 tail of the *Cetiosaurus*. The posterior terminal articular surface is rather more concave than in the dorsal vertebræ; but the difference is by no means so marked as in the plano-concave vertebræ of the *Cetiosaurus*. The diapophyses* Tab. VIII, *pl d*, of the anterior caudal vertebræ are comparatively short, but strong and are continued from the base of the neurapophysis, or from the contiguous part of the centrum, or from both parts.

The hæmapophyses, or chevron bones, Tab. VIII, *h*, are not anchylosed to the centrum,

* This process, in a certain proportion of the caudal series, is of the nature of a pleurapophysis, being developed from a distinct centre, and articulated, in the young Iguanodon, as in the young Crocodile, by suture to the rest of the vertebra. In succeeding vertebræ the homologous part is an exogenous process, which gradually subsides to a ridge, where it is of the nature of a diapophysis; and under such name, with the above explanation, it seems to me most convenient to distinguish the transverse process of the caudal vertebræ.

but articulate with two contiguous vertebræ, crossing, and being somewhat wedged into, the inferior interspace of those vertebræ; in two of the caudal vertebræ of the Maidstone Iguanodon, there are two closely approximated hæmapophysial surfaces, but in general the hæmal arch articulates with a single oblique triangular surface on each of the contiguous extremities of the co-articulated vertebræ; the hæmapophyses 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 hæmapophysial 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 vertebræ 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. $\frac{130}{2130}$, Mantellian Collection, Brit. Mus.), 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 vertebræ preserved in natural sequence and relative position in the Mantellian Collection, the spines are more than double that height, Tab. VIII. 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 vertebræ 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, *ns*, of the first of these vertebræ 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 (No. 2130) 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 vertebræ. 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 vertebræ. The following are the 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
From under part of centrum to upper end of posterior zygapophysis	5	6	5	8	4	0
From upper end of posterior zygapophysis 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 chevron bones, of which three are preserved in the slab containing the six caudal vertebræ, Tab. VIII, *h, h,* exhibit the perforated character, ib. H, which distinguishes them from those of the *Cetiosaurus* and of all existing Crocodiles and Lizards, not excepting the Iguana, in which the hæmapophyses 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.

The bases of the neurapophyses, *n, n,* are nearly co-extensive lengthwise with the centrum, *c,* and expand transversely so as nearly to meet where they rest upon the centrum, but they do not quite circumscribe the neural canal. They contract rapidly in antero-posterior extent, forming the notches of the conjugational foramina, or nerve-outlets, of which the posterior notch is the deepest.

Detached Caudal Vertebra of the Iguanodon. Tab. IX.

The characteristic and well preserved caudal vertebra obtained by Mr. G. B. Holmes, from the Stammerham quarry of Wealden Stone, near Horsham, Sussex, is represented in different points of view in Tab. IX, two thirds the natural-size. Fig. 1 gives a side view, showing the slightly concave almost flat surface of the side of the centrum; these lateral surfaces converge towards the under surface, the anterior and posterior angles of which are, as it were, truncated for the articulations, *h* and *h′*, of the confluent bases of the hæmapophyses; the diapophysis, *d,* springs out from near the back part of the vertebra, about the line of suture of the centrum *c,* and neural

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

arch *n*; the base of this arch equals about two thirds of the antero-posterior extent of the centrum to which it is attached, a little nearer the anterior than the posterior end. The arch sends forwards a pair of long zygapophyses, *z*, whose articular surfaces look inwards and a little upwards; a low ridge traverses two thirds of the summit of the arch, fig. 2, from the hinder third of which springs the neural spine, *n s*, which slightly gains in antero-posterior extent as it rises: but its summit is broken away: the posterior zygapophyses *z*, fig. 1, project from the back part of the base of the spine: their articular surfaces look outwards and a little downwards.

The figure 2, of the vertebra, viewed from above, shows the form and extent of the summit of the neural arch, which is rarely preserved in fossil vertebræ. Fig. 3 shows the anterior, and fig. 4 the posterior, surface of the vertebræ; the articular ends of the centrum are very slightly and irregularly concave, with the margin thickened and rounded off. The under surface of the centrum, fig. 5, is characterised by a median groove or channel between two parallel ridges which extend from the anterior *h* to the posterior *h'* hæmapophysial surfaces. Of these the posterior one is the largest.

The neural canal, figs. 3 and 4, *n*, is contracted; its area is a full transverse oval.

With respect to the terminal caudal vertebræ in which diapophyses and hæmapophyses have ceased to be developed, no specimen of Iguanodon has yet been discovered in which any such vertebræ have been so associated with the rest of the skeleton as to enable the conscientious observer to determine their character as unequivocally belonging to the Iguanodon. Two vertebræ, from the Wealden, near Battle, in the Museum of the Royal College of Surgeons, in which the diapophysis has subsided to a longitudinal ridge, crossing the upper third of the centrum in the smaller specimen, have been described in the 'Catalogue' as probably belonging to the Iguanodon; for it is most probable that the typical form of the body of the Iguanodon's vertebræ is modified or lost in such terminal and rudimental vertebræ; but as these are, in every case, the least characteristic bones of an extinct animal, their loss is of the least consequence, and any positive affirmation regarding them, on imperfect evidence, becomes the more gratuitous.

Skull of the Iguanodon.

Tympanic Bone. Tab. X.

Of the bones of the head of the Iguanodon, the characteristic one above named, a fragment of the upper jaw, and a larger proportion of the under jaw have been brought to light: the portions of the jaws, at least, are demonstrably those of the present species of herbivorous reptile, by the teeth which they contain: the great Cetiosaur and Streptospondyl may possibly have afforded the specimen figured in Tab. X, which, in the Mantellian Catalogue of the Fossils purchased by the British Museum, is assigned to the Iguanodon.

A reptile with vertebræ and ribs resembling in their chief characters those of the amphicœlian 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 immoveably 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 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; and it may be asked:—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 *alæ*," Dr. Mantell proceeds to state, "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 cellulæ* 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 5½ 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." Tab. X, p. 306.

After a careful inspection of the specimen, as it now may be seen at the British Museum, I have come to the conclusion that both extremities have been abraded or fractured: and that the form of the articular surface is not unequivocally demonstrated at either end. The parts described as "two lateral processes" appear to be the two piers *a*, *c*, of the auditory arch of the tympanic, which arch is composed of a broad thin plate of bone, and surrounds the "foramen auditorium externum," *e*, which is of a narrow oval form. Although the shape of this bone indicates that it was much less susceptible of movement than the tympanic bone usually is in Lacertian reptiles, there is no appearance of a sutural attachment in its longitudinal extent, with a parallel and co-extensive squamosal bone, as in the Crocodilia: the points of connection seem to have been restricted to the two expanded extremities.

LOWER JAW OF THE IGUANODON. Tabs. XI, XII, XIII.

At the beginning of the year 1848, Mr. George B. Holmes, of Horsham, obtained from the Stammerham stone-pit, or quarry, of Wealden, near that town, the right ramus of the lower jaw of a young Iguanodon, which is figured of the natural size in Plates XI and XII.

The accurate and beautiful drawings made by his daughter, Miss G. M. Holmes, from which these plates are engraved, were most liberally transmitted to me, at that time, for description. Learning, however, from Dr. Mantell, when I was about to communicate that description to the Geological Society, that he also had just received from Captain Brickenden, of Warminglid, Sussex, the lower jaw of a larger Iguanodon, which he was desirous to describe for the Royal Society of London, I declined to use the materials with which Mr. Holmes had favoured me, until Dr. Mantell's observations had appeared. His Memoir was accordingly published in the 'Philosophical Transactions,' Part II, 1848.

The most remarkable conclusion to which the author of that Memoir arrived, after a study of the above materials, was, that the Iguanodon had been endowed, not only with fleshy or muscular lips,* hitherto believed to be the peculiar characteristic of the mammalian class amongst air-breathing vertebrate animals, but with such lips greatly developed.†

The correlation or association of such muscular and sensitive appendages to the jaws with the necessity of deriving lacteal nourishment by the act of suction, during the infancy of the animal, has hitherto been so constant and exclusive in the air-breathing vertebrates, that a transition from the Reptilian to the Mammalian class, by the conjunction of fleshy lips with a scaly skin and cold blood, would be a most unexpected and extreme exception to one of the best established generalizations in Comparative Anatomy.

I shall, first, give a description of the portion of jaw from Stammerham, then compare it with the larger jaw obtained from Tilgate Forest, and finally endeavour to

* "The great size and number of the vascular foramina, &c., indicate the great development of the integuments and soft parts with which the lower jaw was invested." p. 197.

† "The sharp ridge bordering the deep groove of the symphysis, in which there are also several foramina, evidently gave attachment to the muscles and integuments of the under lip; and there are strong reasons for supposing that the latter was greatly produced, and capable of being protruded and retracted, so as to constitute, in conjunction with a large fleshy prehensile tongue, a powerful instrument," &c., p. 197. The author proceeds to infer from "the edentulous and prolonged symphysis, and the great development of the lower lip and the integuments of the jaws, as indicated by the number of vascular foramina, a striking analogy to the edentata." Ib., p. 198.

deduce such conclusions as to the nature of the soft parts that covered the lower jaw, as the characters of that bone may legitimately sustain.

The subject of Tab. XI, XII, is the dentary piece of the right moiety or ramus of the lower jaw. It is chiefly remarkable for the straightness and parallelism of the upper, *a b*, and lower, *c d*, borders; for the portion which the dentary piece contributes to the suddenly rising coronoid process, *f*, and for the abrupt slope downwards, at an angle of about 45°, of the short, edentulous, compressed anterior part of the bone, *b*, to the shorter symphysis, *e*, *d*, fig. 1; which latter part of the bone projects a little below the lower level of the ramus. The exterior surface of the ramus is, vertically, a little concave where it forms the alveolar wall, and then becomes moderately convex to the thick and rounded lower border, Tab. XII, fig. 4. A few foramina, *g g*, fig. 1, open at irregular intervals, in a longitudinal series, upon the concave part of the outer surface of the ramus, from 5 to 6 lines below the alveolar border; and a few foramina occur parallel with the sloping border, *b c*, at a similar distance from it. The general surface of the bone on the outer side of the jaw is smooth, but becomes more irregular near the symphysis; it presents several lines of fracture, but rises to form the coronoid process, *f*, without any trace of the suture which separates the coronoid from the dentary piece in the jaw of the Iguana. The relative position of that suture, indeed, to the termination of the dental series, in the Iguana, is such that the suture could not be repeated in the Iguanodon, so as to include the coronoid process, because the dental series is continued backward along the inner side of the base of that process. In the form, extent, and direction of the coronoid process, it closely resembles that of the Iguanodon, at least as regards so much of the process as is contributed in fossil by the dentary piece. If its extent were added to by a true coronoid element articulating with it behind, it would resemble the broader coronoid of the *Cyclodus* and *Varanus*. The presence of the process, though formed in an unusual way in the Iguanodon, gives the jaw a lacertine character, and makes it differ in a striking degree from that of the *Crocodilia*. It remains to be seen, however, in more complete specimens, whether the coronoid piece actually contributes any share to the process, or whether it be restricted, as in the Crocodilian reptiles, to the inner surface of the ramus, bounding the fore part of the wide entry to the mandibular canal.

The inner side of the dentary element of the mandible of the Iguanodon, Tab. XI, fig. 2, displays, as in the *Lacertia* generally, the alveolar recesses, and such traces of the teeth themselves as may have been preserved, which in the present case are limited to a few more or less advanced germs of successional teeth. This aspect of the jaw shows that the dentition of the great extinct herbivorous reptile was of the "pleurodont"* type, as in the Iguana and many other modern lacertine genera.

* 'Odontography,' p. 240; the term signifies the attachment of the teeth to one side or parapet of an open alveolar groove.

Eighteen alveolar fossæ for the lodgement of the contracted sub-cylindrical bases of the teeth are exhibited in Mr. Holmes's specimen; but all the teeth that were fully developed and had occupied those semi-cylindrical depressions have been lost. Greater or less portions of the protruding summits of six successional teeth are seen below the alveolar grooves of the old teeth, and of so much larger size as indicates a more rapid growth of the young Iguanodon, than in modern reptiles. In the different proportions in which the young teeth are developed, may be discerned an illustration of the same law of preservation of an adequate proportion of an ever changing series of masticatory organs, which is illustrated by the condition of the dental series in many modern reptiles and fishes. The teeth marked *k, k, k,* for example, of which the summits of the crown have but just begun to be calcified, alternate with those marked *l, l, l,* fig. 2, Tab. XI, in which the crowns are more advanced. One may see by the size of these teeth that they are destined for work in a larger jaw than that of the young Iguanodon in which they are cradled; one may likewise discern the unfitness of the actual alveolar grooves for the reception and retention of the large successional teeth, and thence rightly infer that the bone grows and goes with the growth and disappearance of the teeth themselves; the alveoli of the shed teeth being progressively absorbed as the osseous bed of the new teeth rises along with them. The same concomitant growth of the jaw-bone and the teeth has long been recognised in the mammalian class, and is strikingly exemplified in the elephant, in which the large complex molars succeed each other from behind forwards.

The surface of the jaw below the alveolar groove is smooth, but is traversed by a deeper and narrower groove continued from the entry of the mandibular canal, *i*, forwards just above, and nearly parallel with, the lower border of the ramus, becoming shallower and descending to that border as the groove, *d*, approaches the symphysis, *s*; the major part of this groove was probably covered by the splenial element, (opercular of Cuvier), in the entire ramus of the Iguanodon's jaw. Above the groove the inner surface of the dentary is slightly convex at its posterior half, and slightly concave at the anterior half. The edentulous, narrow, sloping margin of the jaw, *b, e,* has a slightly tumid roughness along its inner side, as if for the firm attachment of a callous covering in the recent animal. The actual symphysis of the jaw is about two thirds of an inch in extent, and a quarter of an inch in greatest depth, almost horizontal in position, but bent, with the concavity looking upwards; the inferior and anterior angle of the jaw, *d*, projects a little way beyond the fore part of the symphysis, and the back part of the symphysis is impressed with a longitudinal groove, fig. 2, *s*, parallel with, but above, the anterior end of the mandibular groove, *d*.

In the small extent of the mandibular symphysis the Iguanodon resembles the *Lacertilia*, and differs from the *Crocodilia*, even from the true crocodiles and alligators in which the symphysis is much less than in the gavials; but the position of the symphysis at the lower end of the anterior termination of the ramus, and the sloping edentulous character of that part are peculiarities in which the Iguanodon differs from all known modern reptiles.

Another character by which the Iguanodon differs from modern lizards, and especially from the Iguana, is the contour of the alveolar plate viewed from above, as in fig. 3, Tab. XII; it is thus seen to describe a gentle but graceful sigmoid curve, convex inwards at its hinder two thirds, straight in the rest of its extent, or slightly concave inwards, as continued by the edentulous symphysis. In the Iguana the hinder four fifths of the alveolar plate is straight; it bends inwards to the symphysis of the jaw at its anterior part. The form of the thick rounded lower border of the jaw of the Iguanodon is shown at fig. 4, pl. xi.

In the Iguana the mandibular groove runs nearer the base of the alveolar plate than the lower border of the ramus, and stops short before it has reached the middle of the dental series: in the Varanus the same groove extends from the anterior termination of the splenial piece along the lower border of the ramus as far as the symphysis; in regard to this groove, therefore, the Iguanodon resembles the Varanus and also the Cyclodus more than it does the Iguana. In the Crocodiles one sees only an oblong foramen at the fore-end of the splenial element. The inner plate or wall of the dentary bone in the Iguanodon bifurcates behind, as in most reptiles, where it articulates with the splenial, angular, and coronoid elements; the upper branch is shown at *h*, the lower one at *e*, fig. 2, Tab. X. What may have been the length of the entire jaw, as completed by the splenial, angular, surangular, and articular elements, must remain conjectural, until either this part of the mandible, or an entire upper jaw with the tympanic part of the same cranium, may be discovered.

In the Iguana the dentary element forms about three fifths of the length of the lower jaw; in the Cyclodus it forms rather more than half, in the Varanus a little less than half of the lower jaw; in the Crocodile it forms more than two thirds the length of the jaw.

As the dentary piece in the Iguanodon itself contributes to the formation of the coronoid process, it is probable that the entire jaw may more nearly resemble the Crocodilian than the Lacertian type in the proportion of the ramus formed by the dentary element.

The length of the corresponding element of probably a mature Iguanodon, figured in the 'Philosophical Transactions' for 1848, and now in the British Museum, is 21 inches; its vertical diameter, in a straight line, where the alveolar wall is best preserved, is 3 inches, 7 lines, so that it is relatively deeper than in the younger Iguanodon, and this probably in reference to a deeper implantation of the large teeth of mature age, and to the greater strength of the jaw required for the more vigorous mastication at that period of life. The coronoid process, Tab. XIII, *f*, being a part of the dentary bone, has also been preserved with the rest of that element in Capt. Brickenden's specimen, and shows the same abrupt curve upwards. The nervo-vascular foramina are more numerous than in the younger jaw, but are arranged, as in that jaw, along the outside of the alveolar wall, beginning near the base of the coronoid process, and extending down the edentulous sloping part of the jaw; their size is exaggerated in the figure given in the 'Philosophical Transactions,' and there is no particular anterior foramen, larger than the rest, and meriting, as in the mammalia, the name of "foramen mentale." The exterior marginal groove of the edentulous border is better marked in Capt. Brickenden's than in Mr. Holmes's specimen, but the alveolar wall has suffered more injury in the Tilgate specimen than in that from Stammerham; in the latter, indeed, it seems to be entire, and so much of the thin inner border is preserved as to show that there was not any internal alveolar wall co-extensive with the outer one. I cannot discern evidence of more than 18 dental depressions on the outer alveolar wall of the large lower jaw from Tilgate; the number, therefore, is the same as in the specimen from the younger Iguanodon, just as we find the same number of teeth in the same species of Crocodile at all ages of the individual, no additional teeth being added to the series from behind, like the true molars in the Mammalia, in the course of the change of dentition as the animal advances to maturity. So much of the inner surface of the dentary bone as is preserved entire in the Tilgate specimen, corresponds with the same portion in the younger specimen from Stammerham; no part is absolutely flattened: the part sustaining the upper division of the mandibular canal has been broken away.

If we pass now to the consideration of the inferences as to the nature of the soft or perishable teguments of the jaw, which are deducible from the characters of the bone itself, it may be first remarked, that the disposition of the vessels and nerves, supplying such teguments, differs according to their nature in different existing air-breathing vertebrate animals, and the jaw-bone exhibits corresponding differences in relation to such modifications of the mandibular vessels and nerves. To those who may not have ready access to Cabinets of Comparative Osteology, a glance at the plates of the well-known and widely distributed 'Ossemens Fossiles,' of Baron Cuvier, will show that the rami of the lower jaw in Mammalia usually present one large, rarely two or three, foramina, on the outside of each ramus at its fore-part; but that, in reptiles, as may be seen in the Crocodiles, Pl. 1; the Lizards, Pl. 16; the Tortoises, Pl. 11;* the nervo-vascular foramina are more numerous, smaller, and arranged, in a more or less linear series along nearly the whole extent of the outside of the ramus of the jaw.

The first modification relates to the concentration of the nervous and vascular influences upon thick, muscular, soft, sensitive, extensile and retractile lips, covering the jaws, and extending beyond their fore part, where such lips are most developed. The second modification relates to a more diffused and equable supply of the nervous and vascular, but especially the latter, influences, to salivary follicles opening along the

* The 4th edition, 1824, tom. v, pt. ii, is here cited.

alveolar parapet, and to rapidly worn and renewed horny scales covering the outside of the rami of the lower jaw. The like differences of the condition of the soft parts external to the upper jaw govern corresponding modifications of the nervo-vascular foramina of the bones of that part. It will be obvious, on the slightest reflection, that the horny scales or scutes covering the borders of the jaws in reptiles must be those that are subject to most abrasion, moistening, and other influences accelerating their decay; and in the living Saurians it may be generally seen that the marginal scales or scutes of the jaws exhibit the effects of such destructive influences contingent on their position. As these scales are more quickly worn away than those of other parts, so they are more rapidly renewed; their progress of growth is quicker, and their formative beds in the cutis have a greater supply of both vessels and nerves: the greater vascularity of this part of the integument is shown by injecting the head of a crocodile or lizard, and macerating away the cuticular scales. The labial muco-salivary follicles are arranged commonly in a linear series, and their orifices may be seen in a row along the narrow and shallow groove between the alveolar border and the scaly integument forming the margin of the mouth: these follicles, in most Saurians, perform the offices assigned to the more compact and localized salivary glands in Mammalia; and consequently require and exhaust a good supply of blood. The arteries emerging from the serial foramina resolve themselves each into a brush of small branches which are spent in the vascular matrices of the labial scales and on the secreting surfaces of the labial glands.

In the great Mosasaurus, as is shown in Pl. XVIII, of the 'Ossemens Fossiles,' of Cuvier,* the linear series of nervo-vascular foramina along the outside of the ramus of the lower jaw indicates plainly that such jaw was covered by a firm scaly integument protecting a long series of muco-salivary follicles, as in existing Saurians. In the great Megatherium and Mylodon the single or double large nervo-vascular outlets confined to the fore part of the mandibular rami equally attest the existence of fleshy and sensitive lips produced beyond the fore part of the jaw, and capable of being further protruded and retracted.

It needs only a comparison of the lower jaw of the Iguanodon with that of the Mosasaurus and of any recent reptile, and with that of the Megatherium and of any recent Mammal, to arrive at a correct conclusion as to whether the Iguanodon resembled the Saurians in the covering of its jaws, or presented the monstrous combination of mammalian lips with a reptilian skeleton.

I have only to add that the form of the anterior termination of the jaw of the Iguanodon is diametrically opposite to that of the Mylodon: in the former, the upper border slopes downwards and forwards at an angle of 45° to the straight inferior border; in the latter the inferior border bends upwards and forwards at nearly the same angle to the straight upper border. In the reduced figure of the lower jaw of

* Ed. 4to, 1824, tom. v, pt. 2.

the Iguanodon in Pl. XVII, fig. 4, of the memoir above quoted in the 'Philosophica Transactions' for 1848, the nervo-vascular foramina are not diminished in the same proportion as the jaw itself: they are accurately delineated both as to number and size, in Tab. XIII, fig. 1, *g*, *g*, of the present Monograph. The angle, also, at which the two rami of the lower jaw are conjecturally united in Pl. XVII, 'Phil. Trans.,' 1848, is much too acute; and the restoration of the lower jaw in the Mantellian collection, British Museum, accordingly leaves a transverse space equalling little more than one half the breadth of the upper jaw, to the description of which I next proceed.

FRAGMENT OF THE UPPER JAW OF THE IGUANODON. Tab. XIII, figs. 2, 3, 4.

After the tympanic bone and lower jaw, the most instructive and intelligible part of the skull of the Iguanodon, as yet obtained, is a portion of the upper jaw, consisting of so much of the back part of the left superior maxillary bone, with the alveolar groove, as includes ten dental recesses, seven of which contain teeth. This specimen was washed out of the submerged Wealden deposits off Brook Point, Isle of Wight, and is now in the British Museum.

The alveolar groove opens widely and obliquely upon the inner and under aspect of the fragment, *a*, *a*, fig. 3: the outer side or parapet, fig. 2, is formed by the chief osseous mass with the outer compact wall of the jaw, fig. 4, *b*, *b*; this wall sends off from its upper and outer side a process, *m*, directed backwards and a little outwards, with the end broken and blunted by attrition, or water-worn; the bone is then continued backwards, slightly expanding in the vertical direction, and terminating in a point, *p*, also obtusely rounded by attrition subsequent to fossilization. Both this extremity and the malar process show unequivocal evidence of sutural surfaces upon their outer and upper side; that upon the malar process is oblong and depressed; that upon the upper and outer part of the hinder end of the maxillary is broad, oblique, and divided into two parts by a longitudinal elevation. Between this extremity and the malar process the canal, *c*, for the nerves and vessels of the upper jaw enters the substance of the bone, immediately above the deep rounded groove that divides the process from the body of the bone; a fossa is continued forwards above the canal, for an inch and a half, in advance of the entry of the canal, and continues the separation of the process from the body of the bone in that direction.

The smaller anterior end of this fragment is of a trihedral figure; the inner and under side is formed by the dental groove, the inner and upper side is flat; the outer side is slightly convex. At the angle where the last two sides meet there is a narrow sutural or fractured surface continued forwards from the sutural depression upon the upper part of the malar process. A transverse section of the anterior extremity of the fragment, fig. 4, taken through the foremost tooth, 1, and its successor, 2, shows compact bone from three to four lines in thickness, forming the outer surface, *b, b*, and a similar layer from one to two lines thick, forming the inner surface, *i*, and increasing to near three lines in thickness, where it bends down to form the shallow inner boundary of the alveolar groove, *i, a*; the compact substance is not continued over the alveolar groove itself; the intermediate substance is an areolar osseous tissue, the meshes being most open along the inner and upper surface of the bone. The maxillary canal, *c*, exposed in this section is nearer the outer surface; it measures 14 lines by 8 lines in its diameters, sending off branches which perforate obliquely, outwards and forwards, the compact outer wall of the jaw. Of the three oval nervo-vascular foramina, *g, g*, preserved in the present fragment upon the outer surface, two are 4 lines, and the third 3 lines in long diameter; they are included in a space of 16 lines, are situate about an inch above the worn outer border of the alveolar groove, and are the last three of the series of such foramina. They correspond nearly in size and relative distance from the alveolar border with those at the back part of the similar series of nervo-vascular foramina in the lower jaw of the Iguanodon; and like them the obliquity of their course indicates the relation of the fragment to the anterior and posterior extremities of the jaw. The corresponding foramina are present on the same part of the bone in the more mutilated homologous portion of a dentigerous bone of the Iguanodon figured in Dr. Mantell's 'Memoir,' above quoted, Pl. XIX, and equally prove the part to which those orifices incline as they open outwards to be the anterior end of the fragment, and not the posterior end, as the anatomist conjectured of whose aid Dr. Mantell availed himself in the interpretation of this fragment.

The vertical extent of the slightly convex outer surface of the maxillary, in front of the malar process, in the present fragment, is 3 inches, but a portion has been broken away from the border, to which the smooth and flat inner surface of the maxillary converges as it ascends; it is possible, therefore, that the outer wall of the maxillary of the Iguanodon may have been continued relatively as high vertically as in the Iguana, Varanus, Tejus, and most other Lizards: anterior to this broken upper surface is a portion of a wide smooth depression, or of a canal laid open.

The alveolar groove, as it extends backwards, curves outwards, in the same degree as the alveolar groove does at the same part in the lower jaw, Tab. XII, fig. 3. The extent of the alveolar groove in the present fragment of the upper jaw is 8 inches; the antero-posterior diameter of the crown of the largest tooth is 1 inch; it seems to answer, therefore, to the posterior half of the dentary part of the lower jaw of the Iguanodon. The first tooth, 1, is a fully developed or old one, with its cement-covered base apparently continuous or confluent with the cancellous bottom of the groove, *d'*. The crown of the tooth, 2, which is about to succeed it, and which has in part undermined and excavated the old tooth, is on the inner and posterior side of its base; the crown of the new tooth is widely and deeply excavated, as shown in the section, fig. 4, 2, where the hollow base of the crown has suffered a slight fracture and displacement:

a thin layer of dentine has been formed beneath the enamel; the mineral matter now occupies the place of the original vascular pulp of the dental matrix. The flattened side of the crown of this tooth is turned towards the outer alveolar wall, the convex surface looks inwards and downwards; in the lower jaw the teeth, Tab. XI, fig. 2, *l*, *l*, have the reverse direction, as stated in Dr. Mantell's Memoir on the lower jaw, from Tilgate.* Next, behind the young tooth, 2, is the recess from which an old tooth has been expelled; and behind the recess is a fully formed crown of a tooth, 3, with the beginning of the fang, which tooth had come into use, but its grinding surface has been worn down by the rolling of the fragment after fossilization and extrication of the specimen from the matrix; a narrow recess follows this tooth, and then comes the fang and base of the crown of an old tooth, 4, partly undermined, and about to be pushed out by the crown of a successor, 5; next follows an empty recess; then the base of apparently a fully developed tooth, 6, the projecting crown of which has been broken away; close behind this tooth is the base of a narrower and smaller tooth, 7, followed by the recess for a similar sized tooth, which terminates the series.

We thus see that, as in the lower jaw of the Iguanodon and in the upper jaw of the Iguana and Tejus, the teeth decrease in size at the hinder end of the series; and that this end of the series in the Iguanodon inclines outwards, as does the same end of the alveolar series in the lower jaw, to which it was opposed.

As a similar portion of bone, recognised by Dr. Mantell as a "fragment of the upper jaw of an Iguanodon," when first discovered in 1838, in a quarry near Cuckfield, has been referred to the opposite end of the jaw, in the Memoir in which it is figured, 'Philosophical Transactions,' 1848, Pl. XIX, pp. 190, 191, with an appeal to the osteology of the recent Iguana, as confirmatory of that determination, I may be excused for concluding by a summary of the facts which seem to me to determine rightly the nature and relative position to the rest of the skull of the present very interesting part of the fossilized skeleton of the Iguanodon. The size of the teeth forbids the supposition that the fragment in question can have formed part of a pterygoid or palatine bone,—such a dentigerous bone, viz., as is shown in the skull of the Mosasaurus and, amongst existing Saurians, in the Iguana: both the shape of the pterygoid and the relative size of the teeth discourage the idea that the present fragment can be part of the homologous bone: it would be contrary to all known analogies to refer it to the palatine bone; and there remains, therefore, only the superior maxillary bone with which to compare it. Of this bone the specimen is evidently that part or extremity containing a natural termination of the alveolar groove; this is shown by the suddenly diminished size of the teeth and alveoli, and by the portion of bone, *p*, fig. 2, which is continued beyond the last alveolus.

The question next arises:—Does the fragment include the anterior or posterior end of the alveolar groove? In answer to this I may first remark, that the outer and inner

* Philos. Trans., 1848, p. 187.

sides of the fragment are determined by the relative depth of the walls of the alveolar groove, and by the relative position of the new and old teeth. In no pleurodont lizard is the deeper wall the innermost; and in no lizard or crocodile does the germ of a successional tooth appear on the outside of the base of the one it is about to succeed. The philosophy of Zootomy compels one to be guided by so great a number of observed instances, as is implied by the above generalized statement, as by a rule; and we know that the lower jaw of the Iguanodon conforms to that rule, by direct observation. In the upper jaw of the Iguanodon the successional tooth-germ is not situated directly on the inner side, but is also behind the tooth about to be displaced, at least in most of the specimens in the present fragment.

The extremity of the alveolar series, therefore, exhibited in the present fragment, must be either the fore end of the right maxillary bone or the back end of the left maxillary bone. The expansion and bifurcation of the bone, as it approaches towards the end of the alveolar series, are opposed to every analogy presented by the fore part of the maxillary in the Lacertian and Crocodilian reptiles. The foramina, grooves, and sutural surfaces become utterly unintelligible in this supposition; which is opposed, moreover, by the direction of the nervo-vascular outlets on the outer side of the bone, and by the curvature of the extremity of the alveolar series, as compared with the anterior extremity of that series in the lower jaw. In favour of the conclusion that the fragment in question is from the back part of the upper jaw, the expansion of the bone as it recedes from the triedral fractured end, *a*, *a'*, the direction of the nervo-vascular outlets, *g*, *g*, the altered direction of the alveolar groove, inclining, *e. g.*, outwards to be adapted to the hinder curve of the alveolar groove of the lower jaw, and the diminished proportions of the teeth at its obvious termination, all concur. And I may add that, supposing the Iguanodon, like the Iguana, to have had the dental series of the upper jaw prolonged forwards upon a premaxillary bone, the alveolar series of the maxillary would have been continued nearer to the end of the bone, and would have terminated more abruptly than it does in the present fragment.

Thus conducted to the conclusion that we have in the fragment in question the hinder part of the left superior maxillary bone, we have evidence that the Iguanodon differed (as, indeed, from the important differences in other parts of the skeleton might have been expected) from the Iguana and the Crocodiles, in having the alveolar end of the upper jaw produced backwards, beyond that outstanding backwardly inclined process, which gave attachment to the malar bone, such backwardly produced dentary end of the bone corresponding with that end, in the existing reptiles above cited, which articulates with the ectopterygoid ("os transverse" of Cuvier).

The dental series, thus brought more beneath the cranial part of the skull, would be more favorably placed for the operations of the masticatory muscles inserted into the lower jaw, and the backward prolongation of the dentary element, where it is developed into a coronoid process, is a departure from the ordinary reptilian structure of the lower jaw, in itself significant of some correlative modification of the upper jaw. So far as the valuable fragment in question illustrates the nature of that modification, we discern in it an approximation to the mammalian type of the superior maxillary bone, subservient probably to a greater development of the homologue of the masseter muscle than is found in any recent reptile.

As the lower jaw of the *Iguanodon* does not contain more than 18 teeth in each ramus, it may be concluded that the portion of the upper jaw above described, supported at least one half of the dental series of the left side. The total length of that series in the skull to which such portion of jaw belonged must have been about 16 inches. The length of the alveolar tract, in the largest example of a ramus of the lower jaw yet discovered, Tab. XIII, fig. 1, is 13 inches.

In a cranium of the *Iguana tuberculata,* which measures 2½ inches in length, the dental series occupies four sevenths of that length: according to the same proportions, therefore, the cranium of the Iguanodon, affording the above fragment of the upper jaw, would be 2 feet 4 inches in length. If the lower jaw of the Iguanodon exceeded the length of the cranium in the same proportion as in the Iguana, 2 feet 8 inches may be assigned to the total length of the skull of the Iguanodon, according to the evidences as yet obtained. But the unbiassed will feel that the rest of the structure of the Iguanodon, and especially of its teeth and vertebral column, differs in too great and important a degree from that of the Iguana to allow much confidence to be attached to the conclusions formed or suggested as to the Iguanodon, according to the osteology of the recent lizard, after which it has been called.

Teeth of the Iguana. Tab. XVIII. (Figs. 1—5, after Mantell, 'Phil. Trans.')

Respecting these characteristic parts of the great extinct Reptile, little need be added to the observations recorded in my 'Odontography,' in the 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' pp. 115—118, and the excellent descriptions by Drs. Mantell and Melville, in the 'Philosophical Transactions,' for 1848.

Fig. 1, is a fully formed and moderately worn tooth of the upper jaw, showing the outer side; *a,* is the submedian primary longitudinal ridge, *b, b,* the accessory ridges, *c, c,* the lamello-serrated margins of the crown, of which the anterior is the longest; *d, d,* the compressed subquadrate fang. Fig. 1 *a,* gives a view of the fore part of the same tooth, showing the varying proportions of the two diameters of the crown and fang. Fig. 1 *b,* gives the form of the grinding surface of the crown; *a,* is the primary ridge on the enamelled side; *b* and *c,* the two facets produced by the attrition of two opposed teeth on the lower jaw.

Fig. 2. The outer side of an old tooth from the left upper maxillary bone, of

which the crown is much worn down by the action of the opposite teeth below, and the fang much absorbed by the stimulus of the growth of a succeeding tooth. *a*, the primitive ridge; *b*, *b*, the accessory ridges; *c*, the angle of the anterior border. Fig. 2 *a*, the inner side of the same tooth, showing the cavity produced by absorption at the base *d*. Fig. 2 *b*, the grinding surface of the crown; *b*, *c*, the two facets produced by the attrition of two teeth of the lower jaw.

Fig. 3. The inner side of a successional tooth of the right ramus of the lower jaw, in which the crown is fully formed, with the beginning of the fang, but has not come into use, and shows the lamello-serrated margin entire; *a*, the primary ridge; *b*, *b*, the secondary ridges; *c*, the anterior border.

Fig. 3 *a*. The outer side of the same tooth, showing the widely open pulp-cavity, *p*.

Fig. 4, shows the outer side of a tooth from the left ramus of the lower jaw, the crown of which had recently come into use; *c*, the anterior margin of the base of the crown; *d*, the contracted end of the fang. Fig. 4 *a*, is an oblique view of the enamelled inner side and posterior angular border, *c*, of the same tooth.

Fig. 5, the outer side, fig. 5 *a*, the inner side, of a tooth from the left ramus of the lower jaw, in which all the serrated part of the crown has been worn down in mastication, and a great part of the fang renewed by absorption: the grinding surface shows the two facets *b* and *c*, produced by the action of the two opposing teeth of the upper jaw, and also the inequality due to the more rapid yielding of the softer unenamelled vaso-dentine, forming the outer half of the crown.

Fig. 6. The inner side of the germ of a tooth of the lower jaw of a young Iguanodon, probably from near the anterior end of the series. This tooth shows only the primary ridge, and the entire serrated margin of the crown.

Fig. 7. The outer side of a fully-formed and slightly worn tooth, from the upper jaw of a young Iguanodon.

Fig. 8. A magnified view of a longitudinal section of the upper part of the crown of a slightly worn tooth of an Iguanodon, illustrative of the microscopic structure described, pp. 116, 117, of the 'Monograph on Cretaceous Reptiles.' *e* is the thin layer of enamel which coats the outer side of the crown of the upper teeth and the inner side of that of the lower teeth; *d* is the hard or unvascular dentine, forming the corresponding half of the crown; *v* is the softer vaso-dentine, forming the inner half of the upper and the outer half of the lower teeth; *m*, the medullary or vascular canals: *c*, cement.

Fig. 9, is a transverse section of the outer part of an upper tooth, more highly magnified, of an Iguanodon, *d* the dentine, *e* the enamel. Fig. 9 *a*, a similar view of a transverse section from the inner half of the crown of the same tooth; *m*, the orifices of the medullary canals.

Bones of the Extremities of the Iguanodon.

These are remarkable for their superior development in proportion to the vertebræ of the trunk, as compared with the Iguana, the Crocodiles, and other existing Sauria. The scapular arch accords with the Lacertian type in being complicated with clavicles, and in the great breadth of the coracoid; but the scapula, in its length and simplicity, resembles more that of the Crocodiles than of the Lizards.

Scapula, Coracoid, and Humerus. Tab. XIV. One third the nat. size.

The scapula, Pl. XIV, figs. 1 and 2, is a long, flat, narrow bone, slightly bent backwards, gradually contracting in breadth and augmenting in thickness from its free extremity, answering to the base, *a*, to its articulated end, *d*, which suddenly expands and developes processes, *b*, *c*, before joining the coracoid, *f*.

These processes are two in number; one, *b*, is from the anterior border a little above the surface, *d*, for articulation with the coracoid; it is short and obtuse: the other, *e*, is still shorter, and comes off from the posterior border just above the articular surface, *c*, for the head of the humerus. The outer surface of the bone is slightly depressed between these processes, and becomes contracted beneath them where it forms the two articular surfaces, *d*, *c*, above mentioned.

The process, *b*, answers to the stronger and broader anterior process of the scapula of the Crocodile: the posterior process, *c*, seems to have no homologue in the modern Reptilia.

The scapula in the Amboina lizard, called *Istiurus*, sends backwards and upwards a process, but it is relatively longer than in the Iguanodon, and comes off higher up the scapula: the Psammosaurus and Grammatophora have no such process, and the entire scapula is much broader in proportion to its length. The scapula of the Iguanodon in general shape resembles that of the Crocodilia more than that of the Lacertian, but it is longer and more slender than in the Crocodile. The scapula, seen fractured across the femur in the Maidstone Iguanodon, see Tab. XXXIV, 'Monogr. Cretaceous Reptiles,' and figured in Dr. Mantell's Memoir, 'Phil. Trans.,' 1841, Pl. VIII, fig. 30, as an undetermined bone, repeats all the essential characters of the scapula so beautifully exposed, in natural connexion with the coracoid, in Mr. Holmes's specimen, figured in Tab. XIV, fig. 1.

The coracoid, fig. 2, *f*, more closely accords with the Lacertian type of that bone: it is a sub-semioval plate, broader than it is long, with the middle of its straighter border produced and thickened, and divided into two articular facets; one, fig. 1, *f*, for the scapula, the other, *g*, for the humerus: this articular part or "head" of the coracoid is marked off by a short constriction or "neck" from the broad plate or the "head," widens as it sinks, its dilated termination answering to a foramen at that part of the coracoid in the Iguana, Istiurus, and Grammatophora: a smooth rounded notch divides the back part of the head from the backwardly produced obtuse angle of the bone, fig. 2, *g*. There is no process extended forwards from the fore part of the "body" of the bone: a notch, fig. 1, *h*, which penetrates the bone at the fore part of scapular end of the bone, as in the Lacertians above-named; the lower and inner border of the expanded body of the coracoid describes a full semi-oval contour, which, in Mr. Holmes's specimen, fig. 2, is broken by a short and narrow notch, entering about the middle of that border.

In the comparative simplicity of the coracoid of the Iguanodon we may discern an affinity to the Crocodilian reptiles, and in its degree of expansion an affinity to the Lacertian order: this bone, as well as some other part of the skeleton, manifesting the intermediate position of the herbivorous Dinosaur, and its adherence to a more general type of Reptilian organization, than the modern forms of Reptile present.

An articular portion of the coracoid, measuring 10 inches in diameter, and discovered in the Wealden of Tilgate forest, is preserved in the British Museum.

The chief mark of difference from the Crocodilian structure of the scapular arch, and of resemblance to the Lacertian type, is the presence of a distinct pair of clavicles, the form of which is well shown in the instructive collection of parts of the same skeleton of the Iguana, discovered by Mr. Benstead, in his Green Sand quarry, near Maidstone. The only other bones to which the long and slender ones, marked "clavicle," in Tab. XXXIV, 'Mon. Cret. Reptiles,' can be compared, are the thoracic ribs and the fibulæ. 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 most recent lizards, the radius, which is the more slender of the two bones of the fore-arm, differs from the fibula in little more than in being somewhat shorter and thicker, there is still less reason for supposing the bone in question to have belonged to the fore arm.

The form of the ribs of the *Iguanodon* is well known; their characteristic proximal extremity, in the longer anterior pairs of thoracic ribs, is shown in Tab. II, and they become shorter and more curved as they advance from the middle to the anterior part of the chest.

Amongst the bones obtained by Dr. Mantell from the quarry-men of Tilgate forest, and submitted by him, in 1830, to the examination of Baron Cuvier, was one, 28 inches in length, now in the British Museum, which the great founder of Palæontology thought "might be a clavicle:"* portions of other homologous bones have been found, indi-

* This opinion is cited by Dr. Mantell in his 'Geology of the South-East of England,' 8vo, 1833 p. 308.

cating a total length of 3 feet. In a Memoir, communicated by Dr. Mantell to the Royal Society, and printed in the 'Philosophical Transactions' of 1841, the author dissents from the opinion of Cuvier; remarking, that, "In none of the skeletons of reptiles, or, indeed, any other animals to which he had access, are there any bones with which these fossils could be identified."* He regarded, therefore, the term clavicle as being manifestly inappropriate and liable to lead to misconception, and proposed to distinguish the bone in question by the term "*os Cuvieri*, as the Cuvierian element of the pectoral arch of the Iguanodon."† From a reference to myself, in the same page, it might be supposed that I had concurred in this view of the introduction of a new element in the scapular arch of the Iguanodon; but at the time when I assisted Dr. Mantell in the comparison of the bone in question, I was not aware that he entertained any such view of it as was afterwards expressed in the Royal Society's Transactions. "In a very small lizard in the Hunterian Museum, Mr. OWEN pointed out to me a bone attached to the coracoid and omoplate, that bore some analogy to the bone in question." The clavicle of the lizard alluded to (*Cyclodus nigroluteus*), bore sufficient resemblance, as I have before stated (Monogr. Cretac. Reptiles, p. 111), to the long and slender fossil under comparison, to confirm the conjecture of Cuvier; but it lent no support to the idea of the long and slender fossil in question being a peculiar superaddition to the Saurian skeleton. The bone is compressed, slender, and sub-trihedral 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

In the clavicles preserved in the Maidstone Iguanodon, the short pointed process is sent off at the angle where the shaft slightly bends as it expands into the sternal extremity; and the second process is a broad subquadrate flattened plate. In the Cyclodus lizard the clavicle is bent at an open angle, but nearer the middle of the shaft than in the Iguanodon; the known differences of form presented by the clavicles in the genera *Cyclodus*, *Istiurus*, *Grammatophora*, *Amblyrhynclus*, and *Iguana*, would have justified the expectation of some unexampled modifications of that variable bone in a great extinct Reptile belonging to a different order of the class.

* 'Phil. Trans.,' pt. ii, 1841, p. 138. † Ibid.

The most interesting and instructive information regarding the humerus of the Iguanodon, afforded by Mr. Holmes's discovery, in 1847, of that bone, associated with the scapula and coracoid, in the same block of stone, was its relative dimensions to the scapula and other bones of the skeleton. The bones, so discovered, are represented, two thirds of their natural size, in Tab. XIV. Being shorter than the scapula of the same individual, and much shorter than the femur, the proportions of the humerus in the Iguanodon resemble more those of the extinct marine crocodile, called *Teleosaurus*, than those of any modern crocodile or lizard, and they indicate, as I have observed in a former Monograph, in connexion with the long, compressed, and vertically extended tail, the aquatic habits of this gigantic herbivorous reptile.

The head of the humerus, Tab. XIV, fig. 4, *a*, is somewhat prominent, and projects inwards and backwards at right angles to the shaft, between two sub-equal tuberosities. From the external of these tuberosities, *b*, a deltoid ridge is continued nearly half way down the bone, and gives the greatest breadth to the shaft a little above its middle part, at *c*. Where it subsides, the shaft is bent a little inwards, becomes more rounded, contracts in diameter, and then gradually expands to the distal condyles, *d*, *d*. These are rounded and moderately prominent; the shaft above them offers a broad and shallow concavity anteriorly, fig. 5, and a moderately deep longitudinal depression behind, fig. 3, which is continued into that between them shown at fig. 6. In the length of the deltoid ridge the humerus of the Iguanodon approaches nearer to the form of that bone in the Crocodile than in the Iguana; but it resembles more the humerus of the Iguana in the degree of concavity of the fore part of the shaft above the condyles.

The radius and ulna, well shown in the Maidstone Iguanodon, in the British Museum, and figured in Tabs. XXXIII and XXXIV, of the 'Monograph on Cretaceous Reptiles,' offer few differences worthy of notice, except their greater relative strength, from the corresponding bones in the Iguana. The olecranon of the ulna is more prominent and is rounded, as in the great monitor (*Varanus niloticus*).

Pelvis and Pelvic or Hinder Extremities.

The pelvis consists, as in recent reptiles, of the sacrum, with a pair of iliac, ischial, and pubic bones. The iliac bones, which would seem to become anchylosed to the sacrum in old individuals, have been already described, and are represented in Tabs. III, IV, and V of the present Monograph, and in Tabs. XXXIII and XXXIV of the 'Monograph on Cretaceous Reptiles.'

Pubis.—This bone, which presents a simple spatulate form in the Crocodile, already begins to increase in breadth at its symphysial extremity in the extinct family with concave vertebræ; and in the larger existing species of lizards is expanded at both extremities, and has a very marked and recognisable 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, now in the British Museum, (No. $\frac{187}{3187}$, Mantellian Catalogue), 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 well 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, also in the British Museum, (No. $\frac{188}{3188}$, 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 the modern *Varani* and *Iguanæ*. 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 large Mammalia; but the bone is too short in proportion to the breadth indicated by the fractured symphysial end, to afford any probability of its having been a humerus of a land reptile, and much less of the Iguanodon, in which the form of the humerus is now well ascertained.

Femur of the Iguanodon. Tab. XV, figs. 1, 1*a* and 1*b*. One fourth the nat. size.

Several specimens of this remarkable bone,—the one that most impresses the observer with the magnitude of the extinct reptile to which it belonged,—are preserved in the British Museum. Of these the most entire and perfect specimen, the subject of the above plate references, measures nearly 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, *a*, is 17½ inches; two flat longitudinal facets meet near the middle of the anterior surface of the shaft at a rough and slightly elevated angle, *c*, which runs straight down to within thirteen inches of the distal end; the ridge there inclines towards the internal condyle and subsides. Two strong muscles, answering apparently to the *vastus internus* and *vastus externus*, are indicated by the surfaces converging to this ridge. The head of the bone is carried inwards, overhanging the shaft. 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 a peculiar process or ridge sometimes called the "third trochanter," *d*, but which does not answer to the part so called, and projecting from the outer side of the femur, in the Rhinoceros and some other mammalia. The part answering to the great trochanter, *b*, is characterised by its compression in the direction of the bone from *a* to *b*, and its great breadth in the opposite direction: it is flattened externally and is divided by a deep and narrow fissure from the neck of the femur. The line of the outer side of the shaft is slightly concave as it descends from the great trochanter, is then convex along the middle part of the shaft, and is again concave as it is continued into the somewhat expanded external condyle, *e*. This condyle is narrow in the direction from *e* to *f*, fig. 1, especially at its prominent fore part, which has been broken off in the specimen figured: it gradually expands towards its back part, and the femur of the Iguanodon is characterised by the depth, as compared with the breadth, of the rotular, (fig. 1*b*, *r′*) and popliteal, fig. 1*b*, *p*, channels or cavities which separate the outer condyle from the inner one *f*. The inner border of the femur below the process *d* gradually inclines and expands to a flattened antero-posteriorly extended, slightly concave surface, which then descends vertically to the articular surface of the condyle, which surface extends horizontally at nearly a right angle with the line of the shaft of the bone. The antero-posterior extent of the flattened inner condyle is 8 inches. The thickness of the compact external wall of the shaft varies from half an inch to an inch and a half. The medullary cavity, at its widest part, has an area of four inches by two inches in diameter. Both ends of this fine bone are somewat crushed and mutilated.

The characters of the articular extremities of the femur which are obscured by the mutilated condition of the large specimen above described, are beautifully shown in the femur of a young Iguanodon, in the private collection of Mr. Holmes, 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, the top of which may be compared to a trochanter, is separated by a deep and narrow vertical groove or fissure, from the main shaft of the bone, and falls into that shaf a little lower down: here the shaft expands and becomes rather flattened from before backwards, but is sub-quadrangular: a low ridge, produced by the union of two broad and flat surfaces, extends down the middle of the anterior surface of the shaft, and, inclining towards the inner condyle, gradually disappears. A little below the middle of the shaft the inner margin is produced into the angular ridge or low and long process, above described (*d*, fig. 1). The shaft of the bone has a large medullary cavity. The distal end is characterised by a deep and narrow anterior longitudinal groove, situated not quite in the middle, but nearer the external condyle; there is a corresponding deep 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.

The following are some of the dimensions of this femur:

	In.	*Lin.*
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

In five separate long bones, in the Mantellian Collection, having the general characters of the two bones above described and of those of the Maidstone Iguanodon, which are marked "femur" in Tab. XXXIV, 'Monograph of Cretaceous Reptiles,' 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 the differences above indicated illustrate the extent of the individual varieties of the same bone, so far as my opportunities of comparison have extended.

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 sub-median 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 vertebræ, while that of the Iguana equals the united length of only six of its dorsal vertebræ.

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.

Tibia and Fibula of the Iguanodon. Tab. XV, figs. 2—7. One fourth the nat. size.

By the side of the femur, figured in Tab. XV, fig. 1, were found two other bones, the largest of which corresponds with the tibia in recent Crocodiles and Lizards. The homologous bone, better preserved, of a somewhat larger individual, is figured in Pl. XV, fig. 2. The external part of the head of this bone is produced horizontally, andits back part expands and divides into two condyles, *e*, *f*, fig. 2; the circumference of the proximal articular surface is 30 inches. The longitudinally finely striated vertical surface of the shaft of the tibia 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 gradually contracts, and assumes, about 8 inches below the head, the sub-quadrilateral form; it is broadest from side to side; its circumference is here 15 inches. The anterior surface is flattened; the outer side is convex or rounded; the dense external walls of this bone are very thick, at least 1 inch. The proximal articulation is convex from behind forwards, but, at the middle, it is slightly concave from side to side.

	In.	*Lin.*
Its lateral diameter is	12	0
Its antero-posterior diameter is	13	6

The fibula nearly equals the length of the tibia; the well-preserved specimen figured in Tab. XV., figs. 4—7, forms part of Mr. Holmes's choice collection of Wealden Remains from the vicinity of Horsham: it has belonged to a younger individual Iguanodon than the femur and tibia figured in the same plate.

The tibia of the Iguanodon equals the united length of nine of the dorsal vertebræ, while in the Iguana it does not exceed the united length of five dorsal vertebræ, although it more nearly equals the femur in length than in the Iguanodon. The head of the tibia is more expanded and more complicated by the condyloid prominences, and by their deep and wide groove in the Iguanodon than in the Iguana.

The disparity of strength between the tibia and fibula is considerable, but the difference in the thickness of the lower extremities of the two bones is less than the proportions of the shaft would indicate. 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 lower and larger end is 5 inches across, the smaller one 3 inches across.

The fibula is more expanded towards the distal end and more flattened against the tibia in the Iguanodon than in the Iguana. It differs, also, from that of the Iguana in the well-marked, shallow, longitudinal concavity along the side of the lower half of the shaft which is next the tibia, as is shown in Tab. XV, fig. 4, (the views of the fibula in this plate have unfortunately been drawn on the stone upside down). The opposite side of the shaft is smooth and convex, as shown in fig. 3. In one diameter the fibula gradually contracts from the proximal to the distal end, as is shown in fig. 5; but in the opposite diameter it expands in a greater degree, and very suddenly, at the articular distal end. The form of the proximal surface is shown at fig. 7, that of the distal one at fig. 6.

The unusually perfect specimen, from which the figures 3-7 were taken, was obtained from the Wealden formation at the Tower-hill pit or quarry, near Horsham, by my esteemed friend G. B. Holmes, Esq., of that town, by whose accomplished daughter the original drawings of the bone were made. Another fibula of a small Iguanodon from a pit at Rusper, in the same gentleman's collection, equals the antero-posterior extent of the spines of eight dorsal vertebræ of the same individual. This bone is 13 inches long, 6 lines across the proximal end, and two inches across the distal end.

METATARSAL AND PHALANGEAL BONES OF THE IGUANODON. Tabs. XVI and XVII. Nat. size.

Of the great Iguanodon from the Horsham quarry, two metacarpal or metatarsal bones are preserved in natural juxtaposition, in Mr. Holmes's Museum: one exceeds the other by four inches in length, 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 'metatarsal' in the plate above cited) corresponds with the shorter of the two bones above cited.

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.

Of the uppermost or proximal phalanges, one tolerably perfect specimen has long been known to palæontologists. It probably belonged to the left fore-foot of the Iguanodon, and is from the Wealden iron-sand which forms the shore of the Isle of Wight, east of Sandown Fort. This specimen, Tab. XVI, fig. 1, is described by Dr. Buckland as a 'metacarpal bone' in the 'Geological Transactions,' vol. iii, 2d series, p. 425: it does not exhibit, however, any articular facet at the side of the proximal end for junction with a contiguous metacarpal; and at the distal end, instead of a uniform convexity, it presents the trochlear combination of a vertical convexity with a transverse concavity. The inference, therefore, as to the metacarpal bones of the Iguanodon being much shorter and thicker than in any living crocodiles or lizards, receives no support from the proportions of the present specimen.

The following is the notice of the original specimen, in the memoir above quoted.

"The first of these two new localities" (for fossil remains of the Iguanodon) "is on the south coast of the Isle of Wight, in the iron-sand which forms the shore, a little east of Sandown Fort, between high and low water. The most remarkable specimen I possess from thence is the gigantic metacarpal bone about to be described. The form of this bone nearly resembles one in the collection of Mr. Mantell, which Cuvier saw, and pronounced to be a metacarpal bone of the thumb of a reptile; but much exceeds it in size, measuring 6 inches in length, 5 inches in width at its largest diameter, and 16 inches in circumference at its posterior and largest extremity. Its weight is nearly six pounds.

"It is, I believe, the largest metacarpal bone which has been as yet discovered; and if we apply to the extinct animal from which it was derived, the scale by which the ancients measured Hercules ("*ex pede Herculem*"), we must conclude that the individual of whose body it formed a part, was the most gigantic of all quadrupeds that have ever trod upon the surface of our planet. The corresponding bone in the foot of the largest elephant is less than our fossil metacarpal by more than one half. The bone represented by Mr. Mantell (Pl. 14, figs. 4, 5, of his 'Fossils of Tilgate Forest') approaches the nearest of all those engraved by him in this work, to our bone from Sandown Bay. He considers his fossil to be most probably a metatarsal bone of the Iguanodon, and states that he has one such bone which measures 4½ inches in length, and 13 inches in circumference at the largest tarsal extremity. The colossal proportions of a fragment of a femur in his possession, from Tilgate Forest (Pl. 18, fig. 1 of the same work), which measures 23 inches in circumference in the smallest part, sufficiently accord with those of his metatarsal bone last mentioned, as well as our metacarpal bone from the same formation in the Isle of Wight, and give strong probability to the opinion that all these three fragments of the skeleton of a reptile of such extraordinary stature may be referred to the Iguanodon. It is obvious that these supposed metacarpal and metatarsal bones are much shorter and thicker in their proportions than the metacarpal or metatarsal bones of any living lizards or crocodiles; but when we consider the enormous weight which the foot of an animal whose femur was 23 inches in circumference must have sustained, a reduction of length and increase of bulk in the bones which supported such a colossal frame, must have been attended with many mechanical advantages."

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 by 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, and exhibit, as in most other saurians, the curved vascular groove on each side: they have an articular, slightly concave base, and terminate anteriorly in a round blunt edge; the outer boundary of the lateral grooves form at the posterior end of the groove, a laterally projecting process, making 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	2	3

at the posterior end it gradually diminishes to the distal end.

The phalanx is slightly bent downwards; the under surface being concave longitudinally, but convex from side to side. 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, and is interrupted on both sides by smooth shallow commencement of the curved vascular groove; this deepens and contracts as it extends forwards. The upper surface of the phalanx 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; this 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 its dimensions:

	In.	*Lines.*
Transverse diameter of bone	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

The largest phalanx of this kind which has hitherto come under my observation is one (Tab. XVI, fig. 2) which had been washed out of the same tidally submerged Wealden iron-sandstone, which forms the shore between high and low water to the east of Sandown Fort, Isle of Wight. This phalanx had been rolled and waterworn, like most of the saurian fossils from that locality. The margins of the articular base of the phalanx are thus rounded off, and those of the sides and extremity have been worn away, rendering the latter more obtuse. Nevertheless, in this state, the phalanx measures 6 inches in length and 4¼ inches in breadth, much surpassing in size the largest ungual phalanx of the elephant, mammoth, or mastodon. It would be unsafe, however, to infer from the size of a claw or the bone supporting it that of the entire animal; an ungual phalanx presents very different proportions to the rest of the limb and to the entire animal, in different species: that of a horse, *e.g.*, exceeds in size that of an elephant: and the ungual phalanx of a sloth is longer than that of the largest crocodile. In the general proportions, and broad subdepressed form of the bone here described, it resembles the more perfectly preserved ungual phalanges known by their association with other parts of the skeleton to have belonged to the Iguanodon. The outer boundary of each lateral vascular groove expands to form similar aliform projections, as at *b*, fig. 2; the grooves terminate rather abruptly, but do not penetrate the substance of the bone. The upper surface, between the lateral grooves, is convex and smooth; the under surface, shown in the figure, is rough, and impressed by irregular vascular grooves and foramina. In its size and proportions this phalanx agrees with the proximal one figured in the same plate, Tab. XVI, fig. 1; it may have belonged to the same individual, and certainly came from an Iguanodon of the same colossal proportions.

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 Iguanodon) which differs in a marked manner from the specimens just described, being as much compressed from side to side as some of the unquestionably Iguanodon's ungual phalanges are flattened from above downwards. One of these compressed phalanges must have been at least 4 inches in length; it now measures 3 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 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, though 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. It is highly probable that the terminal phalanges of the different toes of the Iguanodon were somewhat varied in form; but the compressed incurved phalanx supposed to characterise the fore-foot of that great herbivorous reptile, appears to me to present rather the form of the phalanx of a great carnivorous Saurian. 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 on the south coast of the Isle of Wight, 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.

Amongst the varieties of large fossil ungual phalanges discovered in the Wealden of Kent, Sussex, and the Isle of Wight, I should be more disposed to refer to a herbivorous Saurian that modification which is less incurved than the typical form in the Iguanodon, and which exhibits that straighter and more conical form of phalanx, Tab. XVII, figs. 1, 2, 3, (No. $\frac{384}{2384}$ "Horn of the Iguanodon" Mantellian Collection and Catalogue) described in p. 141 of my 'Report on British Fossil Reptiles,'* and the determination of which, as a phalanx, in that 'Report,' subsequent acquisitions of similarly modified phalanges, *e. g.*, figs. 4, 5, Tab. XVII, have served to confirm.

As, however, the original opinion of the indefatigable explorer of the Wealden, to whom we owe our chief knowledge of that formation in England, has continued to prevail in the numerous geological and palæontological works published since 1841, it is incumbent on me to enter more into detail relative to the fossil on the nature of which I found myself compelled to differ with its original discoverer.

A certain resemblance in outward form, which the fossil teeth of the Iguanodon present to those of the Iguana, has exercised, as I have already intimated, undue influence in the prevalent ideas as to the affinities of the gigantic herbivorous reptile of the Wealden to the small existing lizard, after which it has been named. The Iguanodon, indeed, is generally supposed to have been characterised by a singular structure, viz., a horn, like that which, in the existing order of Saurians, distinguishes one of the species of Iguana, (*Metopoceros*, or *Iguana cornuta*).

The following observations on the fossil which has given rise to that opinion, may tend in some degree to modify, and I believe to rectify the received ideas as to the nature and affinities of the Iguanodon.

The bone to which I allude is that which Dr. Mantell has described as the "horn of the Iguanodon" in the following words, which convey an accurate idea of its general form and size.

"We have," says Dr. Mantell, "to request the reader's attention to a very remarkable appendage with which there is every reason to believe the Iguanodon was provided. This is no less than a *horn*, equal in size, and not very different in form, to the upper horn of the rhinoceros. This unique relic is represented of the natural size, Pl. XX, fig. 8.† It is externally of a dark brown colour, and while some parts of its surface are smooth others are rugous and furrowed, as if by the passage of blood-vessels. Its base is of an irregular form, and slightly concave. It possesses an osseous structure, and appears to have no internal cavity. It is evident that it was not united to the skull by a bony union, as are the horns of the mammalia."

The only reason which I have, hitherto, been able to find adduced for the above determination of the fossil described as "the horn of the Iguanodon," is, that a species of Iguana has, on the middle of its forehead, an osseous conical horn or process covered by a single scale."‡

* 'Reports of the British Association,' 1841.

† 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.

‡ Loc. cit., cited from 'Shaw's Zoology.'

The first and most obvious objection to the fossil in question, (No. $\frac{384}{2384}$, Mantellian Collection, British Museum), being the bony core of a median frontal horn, is its *want of symmetry.* This is plainly manifest in two respects; first, by the obliquity of the base; and secondly, hold it as you may, by the inequality and difference of form of the two sides. If the fossil be viewed with the apex upwards and forwards, as in the position in which Mr. Dinkel has delineated it, Tab. XVII, fig. 1, when I desired him to draw it in the position in which it appeared least unsymmetrical, even then the left side is, by reason of the basal obliquity, longer than the right, and it is more convex in the vertical direction. This view exposes what I believe to be the left side of the phalanx.

With respect to the base of the bone, all its natural surface, with the exception of one small spot, has been chiselled or scraped away, and the central coarse cellular structure of the bone is thus exposed. That single smooth spot, however, indicates that the base had been articulated by a synovial joint, and the form of the rest of the mutilated basal surface nowise militates against the supposition of the conical bone having been *the terminal unsymmetrical ungual phalanx* of the outer toe of a great Saurian reptile.

The want of symmetry in the ungual phalanges of the outer and inner digits of a reptile's foot, in which phalanges one side becomes longer and more convex than the other, exemplifies the nature of that degree of want of symmetry which exists in the fossil in question, and which ought of itself to be decisive against the opinion of such fossil being the basis of a single median frontal horn.

Yet this idea has been so long fixed and so generally received, that, although the objection above advanced may unsettle it, yet additional reasons may be expected before it will be finally abandoned. For, to the objection of mere want of symmetry, it may be replied, that this particular example of the horn of the Iguanodon may exhibit an accidental deviation from the normal structure; although, indeed, an unsymmetrical horn has never been noticed in the horned Iguana (*Metopoceros*). Yet even at this stage of the argument it will not be hard to decide between *a phalanx* to which the unsymmetrical form presented by the fossil is natural, and *a horn* in which such dissymmetry would be monstrous. Independently, however, of general configuration there are other characters by which an unequal phalanx of a crocodilian or other large Saurian may be detected.

An ungual phalanx is a significant bone; it has relations which no other phalangeal or other bone of a foot possesses, and has modifications of surface, of form, and structure subservient to those relations.

First, it supports the strong horny sheath or claw which immediately presses upon the ground, and which accordingly needs constant and copious reparation. An ungual phalanx, therefore, besides its own "periosteum" is invested by a highly vascular and almost glandular "corium," which is the active renovator of the worn-down claw.

All ungual phalanges of Saurian reptiles are marked on each side by a large, more or less deep and smooth groove, curved with the convexity towards the upper side of the claw. These grooves convey the blood-vessels and nerves to the matrix of the claw, and, in some species, sink at their distal end into the substance of the claw-bone.

But, it may be said, the bony basis or core of a frontal horn likewise supports a corneous sheath, and is invested by the vascular cutis which secretes that sheath. Since, however, the corneous sheath of a horn, and especially of so small a one as that which arms the head of the *Iguana cornuta*, and, as has been imagined, also of the Iguanodon, is less constantly and rapidly abraded than a claw, so the indications of the vascularity and activity of the reproductive organ are much more feebly marked upon the horn-core than upon the phalanx. They are also marked in a different manner. The horn-core is incased by its horny sheath, its base alone being free from that covering. The renovation of the horn takes place, as is well known, chiefly at the base, and the numerous vascular impressions are distributed pretty equally round the base of the core.

In the Saurian claw-bone the upper surface and sides are invested by the claw, and the renovation of the corneous matter is required near the sides of the distal half of the osseous cone. Hence in the phalanges of the large Saurian we see the large vascular curved groove extending along each side, and the canals by which the vessels and nerves emerged from the bone upon its immediately investing vascular organ of the claw are most conspicuous on each side near the apex.

Now the fossil in question exhibits conspicuously the two lateral, curved, wide and deep vascular grooves, *c*, *c'*, *d*, *d'*, figs. 1 and 2, and each groove sinks at its distal end, *c'*, *d'*, into the substance of the bone; the large oblique foramina, *e*, by which the blood-vessels and nerves emerged to supply the secreting organ of the claw are also present in greatest number on each side of the apex of the bone: these characters I hold to be decisive of the phalangeal nature of the so-called horn.

The groove on the right side of the phalanx, (fig. 2, *c*) as seen in a view of its upper surface, which is determined by the convexity of the vascular grooves, is entire: it begins about two thirds of an inch from the base, is shallow at first, but gradually becomes deeper, until it sinks into the substance of the bone (at *c'*): it presents the usual gentle and regular curve, convex upwards; its length, following the curve, is 1½ inch; it sinks into the osseous substance nearly two inches from the broken apex of the phalanx; its breadth is between 2 and 3 lines.

On the left side, fig. 1, a portion of the vascular groove, *d*, *d'*, is obliterated by the loss of part of the compact outer layer of the upper surface of the phalanx, forming the median edge of the groove, but the lateral or outer, and the terminal half inch of the groove where it sinks into the substance of the bone, as at *d'*, figs. 1 and 2, is entire: enough remains, therefore, to show that the groove on the left side of the phalanx had the same degree and direction of curvature as that on the right side; but the left groove becomes shallower and wider towards its beginning, which may be traced as far back as the base of the phalanx, as in Mr. Saull's specimen. The vascular foramina, at and beyond the opposite termination of the left groove, are not less numerous and conspicuous than are those on the right side; but the left groove is somewhat in advance of the right, and sinks into the unsymmetrical phalanx one inch and four lines from the broken apex. At one fourth of an inch below the left vascular groove there is a shallow, smooth impression, *f*, fig. 1, along the distal half of the bone, indicating the extent to which the lateral margin of the claw reached on that side: there is no corresponding impression on the opposite side, which coincides with the dissymmetry of the phalanx, in showing it to have belonged either to an outermost toe of the left foot, or to an innermost toe of the right foot.

The exterior of the bone around its base is sculptured, as in other and normally shaped phalanges, by smaller but coarse longitudinal impressions, corresponding with the attachments and insertions of the articular capsule and ligaments. The part of the bone, proved by the direction of the large smooth lateral grooves to be the under side, is the shortest, and is most convex transversely. The upper side is the longest, and is narrower across than the under side.

	In.	*Lines.*	
The length of this phalanx is	4	6	(doubtless 5 in. when entire.)
The longest diameter of its base is . .	3	3	
The shortest diameter of its base is . .	2	2	
The distance between the distal terminations of the lateral grooves	1	0*	

What might be the chances, it may be asked, that the single small bone supporting the median frontal horn should be found fossil, on the hypothesis that the Iguanodon possessed, like the *Iguana cornuta*, such a dermal appendage? Supposing an extreme toe, outermost, or innermost, of the fore and hind feet of the great reptile to have had a claw shorter and straighter than the rest, it would be four to one that the bone of such claw should be found, than the unique bone of the horn. By great good luck, indeed, the latter might once turn up; but one could not expect the only bone of its kind, and one of the smallest in the skeleton of the Iguanodon, to be frequently found. Yet I have had not less than three "horns of the Iguanodon" submitted to my inspection since describing the one so called in the British Museum. And two of these supplemental examples of straight conical claw-phalanges are figured in Tab. XVII. The first, figs. 3 and 4, was discovered in the Wealden of the Isle of

* The two figures in Tab. XVII have been made with the most scrupulous accuracy from the original fossil now in the British Museum, and exhibit characters not before given in any published figure of the so-called "horn of the Iguanodon."

Wight, and is in the collection of Felix Knyvett, Esq., by whose kind permission it is here described and figured. It has an irregular, slightly concave base, broader than it is high, and has a well-marked deep vascular groove on each side: that to the left, *d'*, skins into the substance of the bone as it approaches the apex, where it communicates with several large vascular foramina: the right groove, *c*, resembles that in fig. 2, in being shorter and more curved; but it seems to have given off its branches to the claw-forming matrix before sinking into the substance of the bone: the upper surface between these grooves is narrower and less convex than the under one, in which respect this phalanx also resembles figs. 1 and 2. Fig. 3 gives a side view, the left, of the second example of straight conical phalanx, showing the narrowest transverse diameter of the bone, as in fig. 1. Fig. 5 is a smaller phalanx of the same unsymmetrical, conical form, with an irregular slightly concave basal articulation, and with impressions of the two lateral vascular grooves; that on the left side, *d'*, being the best marked, and sinking into the substance of the bone, as in the other specimens figured. It is from the Wealden of Battle, Sussex; and is also in the collection of Felix Knyvett, Esq.

Having thus, as I believe, determined the true nature of the supposed horn of the Iguanodon, and lowered the problematical fossil from its place on the forehead to the end of one of the toes of some great Wealden Saurian, it remains to inquire to which of the gigantic reptiles of that formation the present phalanx may be, with most probability, referred.

There are three forms of fossil phalanges from the Wealden strata. One is broad, depressed, subsymmetrical, rounded at the apex, with the outer boundary of each lateral vascular groove produced like two aliform ridges, and the grooves commonly terminating without sinking into the bone.

This form of phalanx Dr. Mantell to refers the hind foot of the Iguanodon: and that it belongs to the Iguanodon is shown by the instructive series of bones of the same individual, rescued by Mr. Bensted from the Green Sand quarry at Maidstone.

Another form of phalanx is the reverse of the above, being compressed, curved downwards, with the lateral grooves longer and shallower, and their lower or outer boundary is not produced into an aliform process. This form is figured in the 'Wonders of Geology,' pl. iii, fig. 1, as belonging to the fore foot of the Iguanodon.

The ungual phalanges on both the fore and hind feet of the Iguana resemble this second form more than they do the first; but by no means differ from each other, as those of the Iguanodon must have done on Dr. Mantell's hypothesis.

In the fore foot of the Crocodile the ungual phalanx of the first toe is broad and depressed, with lateral ridges, and more resembles the phalanx in the Maidstone Iguanodon: the ungual phalanx of the third digit of the Crocodile is of the same length as the first, but is thinner in both transverse and vertical directions, though least in

Considering the great numbers of teeth and bones of the Iguanodon that have been the latter: it is not more curved than the first. Still the difference, which is the greatest I can detect in comparing the different ungual phalanges of the same Crocodile, is much less than that which is manifested by the depressed and compressed phalanges hitherto deemed to characterise the hind and fore feet of the Iguanodon. I think it more probable, therefore, that the second form of Wealden phalanx appertains to a distinct species from the Iguanodon, and probably to a carnivorous Saurian.

The third form is that which, less depressed than the first and less curved than the second, has been described as *the horn* of the Iguanodon. The outer border of the lateral vascular grooves are very slightly produced, and the grooves themselves commonly sink into the substance of the bone, as they do in the great phalanges of the Cetiosaurus. Some of these straight conical phalanges, *e. g.*, those figured in Tab. XVII, figs. 1, 2, 3, and 4, seem to be too large for the *Hylæosaurus.*

But I shall refrain, at present, from indulging in conjecture, however probable, as to the species of reptile to which this third form of phalanx belongs, satisfied with the present evidence of the nature of the bone itself, and that, if it ever formed part of the skeleton of the Iguanodon, it belonged to the foot and not to the head: and I shall conclude by briefly summing up the characters which ought to be borne in mind when the idea of the little modern Iguana is associated, through similarity of sound, with that of the great Iguanodon.

Both articular ends of the vertebræ of the Iguanodon are nearly flat, thereby differing more from the concavo-convex vertebræ of the Iguana than those of any existing Crocodile or Lizard do.

The anterior ribs of the Iguanodon have a head, neck, and tubercle, and a double articulation with the cervical and dorsal vertebræ; those of the Iguana and of every other existing Lizard have no cervix or tubercle, and have only a single articulation with the cervical and dorsal vertebræ. In this important modification of the anterior ribs the Crocodile has a greater resemblance and closer affinity to the Iguanodon than the Iguana has.

The height, breadth, and outward sculpturing of the neural arch of the dorsal vertebræ of the Iguanodon, are characters wanting in the Iguana and all modern Lizards, but are remotely approximated to in the dorsal vertebræ of the Crocodile, which, however, are far from presenting the expansion and complexity of the dorsal neural arches in the Iguanodon.

Five vertebræ of unusual construction are anchylosed together to form the extended sacrum of the Iguanodon: in the Iguana the small and simple sacrum consists of only two slightly modified vertebræ; in this respect it more closely resembles other Lizards, and even the Crocodiles, than it does the Iguanodon.

For the important difference in the structure of the teeth of the Iguanodon and Iguana, I refer to my former Monograph ('Cretaceous Reptiles,' pp. 115—117), and to p. 30 of the present Monograph.

INTEGUMENT (?) OF THE IGUANODON. Tab. XV, fig. 8.

In that part of the specimen of the skeleton of the young Iguanodon, figured in Tab. I, which is in the Museum of Mr. Bowerbank, some portions of a layer of dark, finely granulated carbonaceous matter, were found imbedded between the ribs, near the middle of the side of the trunk, and slightly adhering to the discoloured matrix: this layer is very probably, as Mr. Bowerbank believes, a part of the integument of the Iguanodon. Of the best preserved portions of this substance, the largest is an oblong one, 8 lines in long diameter; another is 6 lines in diameter; and both are about 1 line in thickness. Supposing the Iguanodon to have been covered by epidermal scales like those of the Iguana, and of proportional size, a single scale would cover from four to six times the extent of corium which is shown by the largest of the above specimens, on the supposition that they are parts of the true skin of the Iguanodon.

The firmer and more enduring parts of the substance here displayed seem to have consisted of coarse fibres, irregularly interlacing each other; these form the darker parts which rise above the surface and give it, when viewed by the naked eye, a subgranular character; the depressions indicate the interspaces of the fibres, and contain fine particles of a substance of a lighter colour. I have not been able to detect any clear traces of ultimate organic structure in the black carbonized remains of the fibrous tissue.

So much of structure as is discernible accords well with that of the corium of a tough and thick skin; but no conclusions can be satisfactorily deduced from the small portions here preserved, as to the nature of the defensive covering, epidermal or osseous, of the corium of the Iguanodon. The experienced microscopist to whom I am indebted for the opportunity of inspecting these rare and interesting specimens, writes to me: "I have examined the skin with the greatest care with my microscope, but I cannot find any indications of scales." My own observations have led to the same result. The visible character, however, of the surface of the supposed fossil skin of the Iguanodon, is not inconsistent with that of the vascular corium of a reptile which nourishes an overlying epidermal scale, or osseous plate or scute, either of which parts, if present in the living animal, would be most probably much larger than the largest of the fragments that have been here preserved. The chief difference between the corium of a squamate and that of a loricate reptile, is its less thickness in the latter where it underlies bone, than where it supports a scale, as in the squamate species.

Allowing for the extreme shrinking and condensation of skin which has become carbonized in the present rare instance, and has resisted the common result of the dissolving agencies, I should infer from these fragments that they might have originally been of that thickness which is consistent with an external covering of epidermal material.

collected from different localities during the last thirty years, and the collocation of some of these remains so as to prove that the entire carcase of an Iguanodon had been imbedded in the matrix, as in the case of Mr. Bensted's discovery near Maidstone, fossil bony scutes, had they existed in any quantity in the skin of the Iguanodon, might reasonably be expected to have been found associated with the parts of the endo-skeleton. Such dermal bones have been discovered in connection with other remains of the *Hylæosaurus*, and we may, therefore, with more confidence assign its value to the negative evidence in the case of the Iguanodon, and conclude that the surface of its nuge body was defended by thickened epidermis, either coextensive with the chorion, or specially developed and multiplied in the form of scales.

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 so long overlooked; since the required evidence, as pointed out in my 'Report on British Fossil Reptiles,'* is only an associated vertebra and long bone of the same individual, or a comparison of the largest detached vertebræ 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.

It was obvious that the exaggerated resemblances of the Iguanodon to the Iguana misled the Palæontologists who had previously 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, 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 I have assigned for calculating the bulk of the Megalosaurus on the basis of the vertebræ,‡ apply with equal force to the Iguanodon.

* Reports of the Brit. Association, 1841, p. 142.

† Mantell, 'Geology of the South-east of England,' p. 314. Buckland 'Bridgewater Treatise,' p. 243.

‡ Reports of the Brit. Association, 1841, p. 109.

Now the largest vertebra of an Iguanodon which has yet been obtained does not, as has been before stated, exceed 4½ inches in length; the most common size being 4 inches. The intervertebral substance is shown, by the naturally juxtaposed series of dorsal vertebræ in the Maidstone Iguanodon, to be not more than one third of an inch in thickness. All the accurately determined vertebræ 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 vertebræ, six inches in length, removes the only remaining doubt that could have attached itself to this important element in the present calculation.* The anterior cervical vertebræ of the Iguanodon, when discovered, if they prove to differ in length from the known dorsal and caudal vertebræ, will be, in all probability, somewhat shorter, as they are in the Hylæosaur and in all known Crocodiles and Lizards. It remains, therefore, to determine the most probable number of the vertebræ of the Iguanodon, in order to apply their length individually to the estimate of the length of the entire body. The structure of the vertebræ 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 vertebræ would resemble that of the Crocodiles than that of the *Scincus* or other Lizards with unusually numerous dorsal vertebræ, and which possess ribs of a simple and uniform structure, and of nearly equal size. The most probable number of vertebræ of the trunk, from the atlas to the last lumbar inclusive, calculated from Crocodilian analogies, would be 24 vertebræ. This is the number indicated by the instructive portion of the skeleton of the young Iguanodon figured in Tab. I, and for the first time described in the present Monograph: it is also the number possessed by the Iguana.

Twenty-four vertebræ, 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 is about equal to 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 vertebræ, 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 about 2 feet 6 inches, and this is nearly the length of the head, as estimated on the data afforded by the portions of lower jaw described at pp. 20—30. In the description of the caudal vertebræ it has been shown that the Iguanodon could as little have

* Reports of Brit. Association, 1841, p. 92.

resembled the Iguana in the length of its tail,* as in the anatomical characters of any of the constituent vertebræ of that part: the changes which the series of six caudal vertebræ 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 relatively shorter in the Iguanodon than in the Crocodile. Assuming, however, that the number of caudal vertebræ of the Iguanodon equalled that in the Crocodile, and allowing to each vertebra with its intervertebral space 4½ 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 largest 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.

* See also the judicious remarks by Dr. Buckland to the same effect, 'Bridgewater Treatise,' p. 244.

TAB. I.

Chief part of the vertebral column, with some bones of the extremities, of a young *Iguanodon*; nat. size.

From the Wealden of Cowleaze Chine, Isle of Wight. In the British Museum, and that of J. S. Bowerbank, Esq., F.R.S.

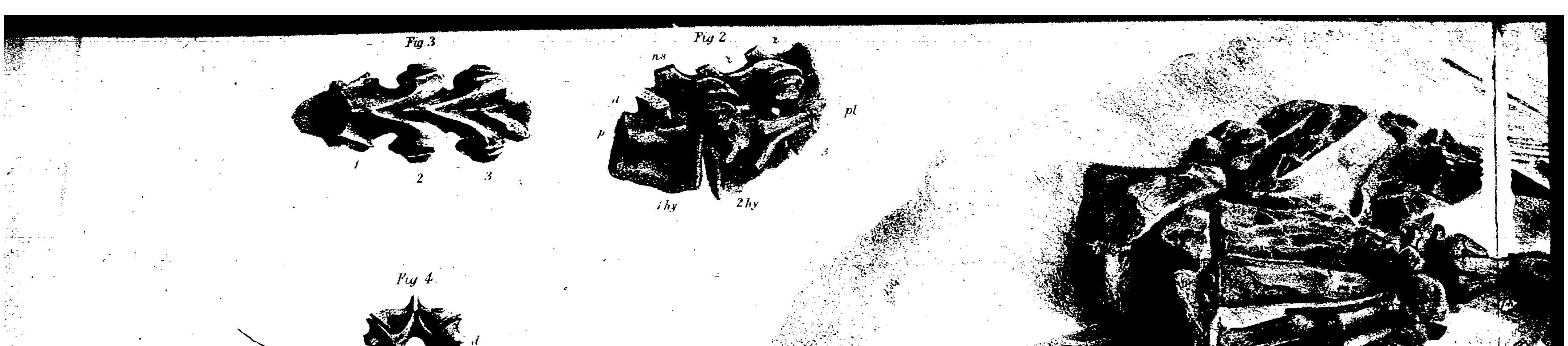
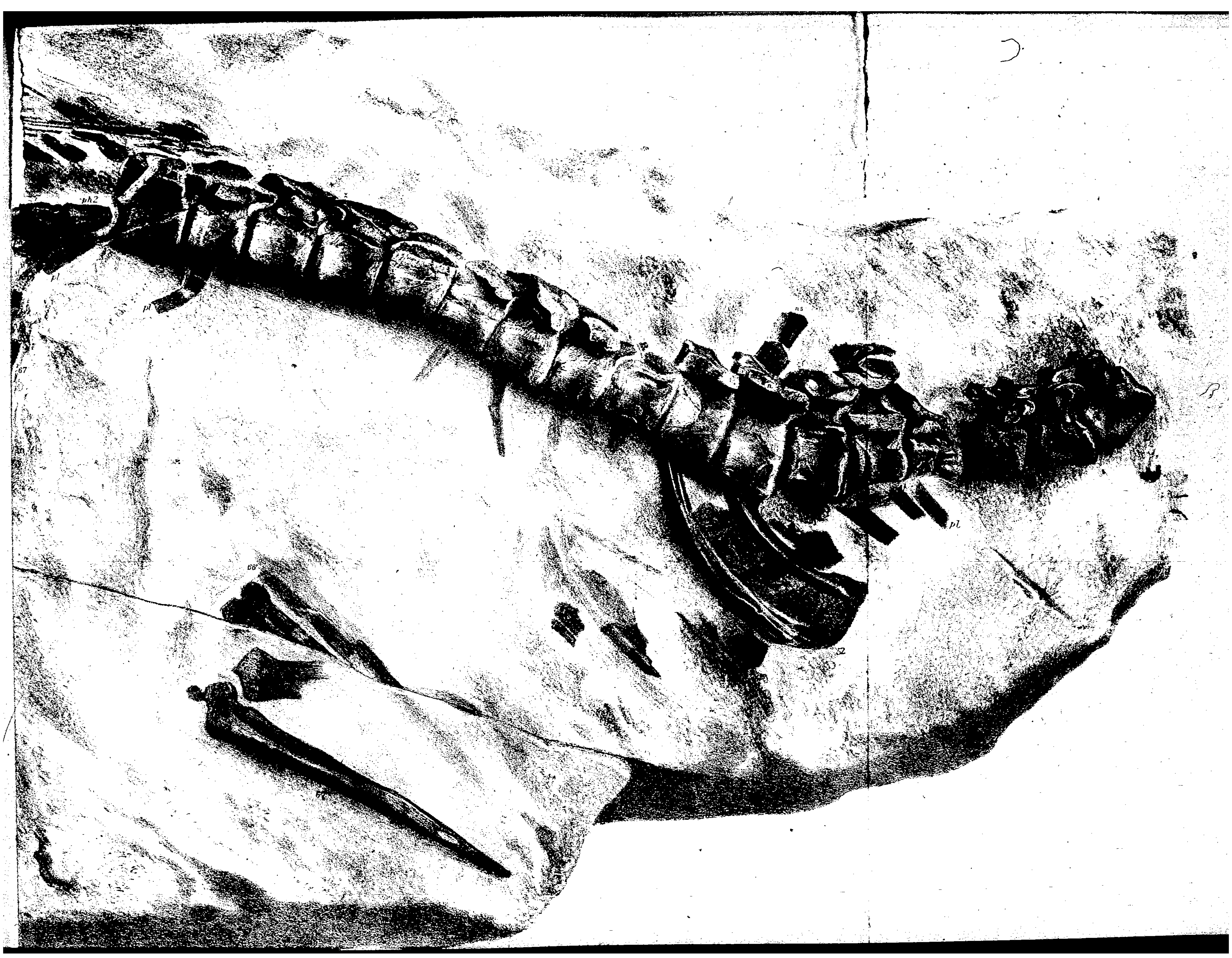


Fig.3
1
2
3
Fig 2
d
p
pl
1 hy
2 hy
Fig 4
d
p
hy



TAB. II.

Iguanodon Mantelli; one fourth nat. size.

Fig.

1. Upper or vertebral portion of a thoracic rib, front view.
2. Back view of the same rib.
3. Upper view of the vertebral end of a thoracic rib, showing the ridge continued upon the long neck.
4. A considerable portion of a succeeding thoracic rib.
5. Upper view of the vertebral end of the same rib.
6. A considerable portion of a succeeding thoracic rib.
7. Upper view of the vertebral end of the same rib.
8. An almost entire rib from about the middle of the thorax.
9. An anterior thoracic rib.
10. Upper view of the vertebral end of the same rib.

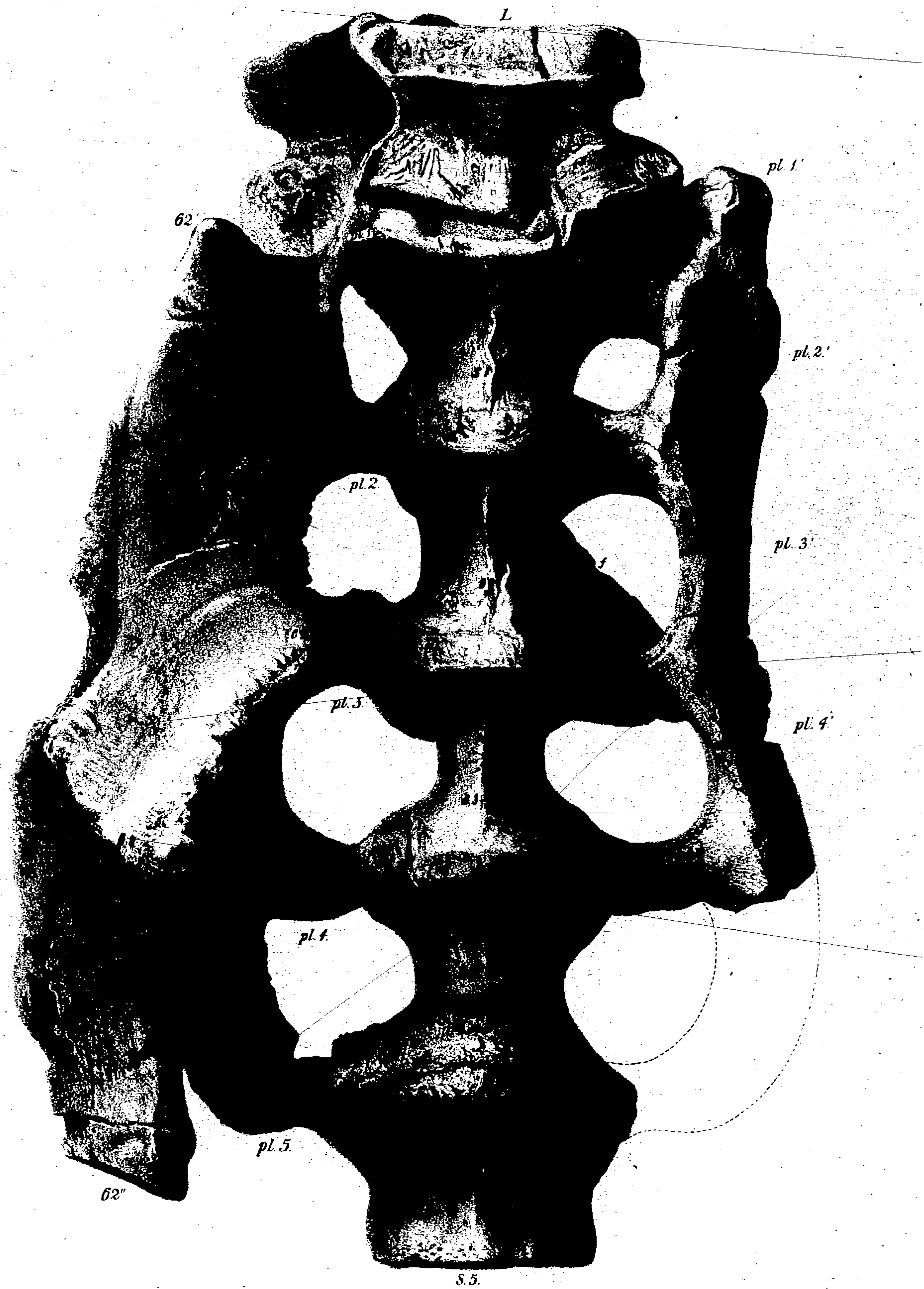
From the Wealden of Tilgate forest. In the British Museum.

Jos. Dinkel lith.

TAB. III.

The inferior or ventral surface of the sacrum, and some anchylosed bones of the *Iguanodon*; half nat. size.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.



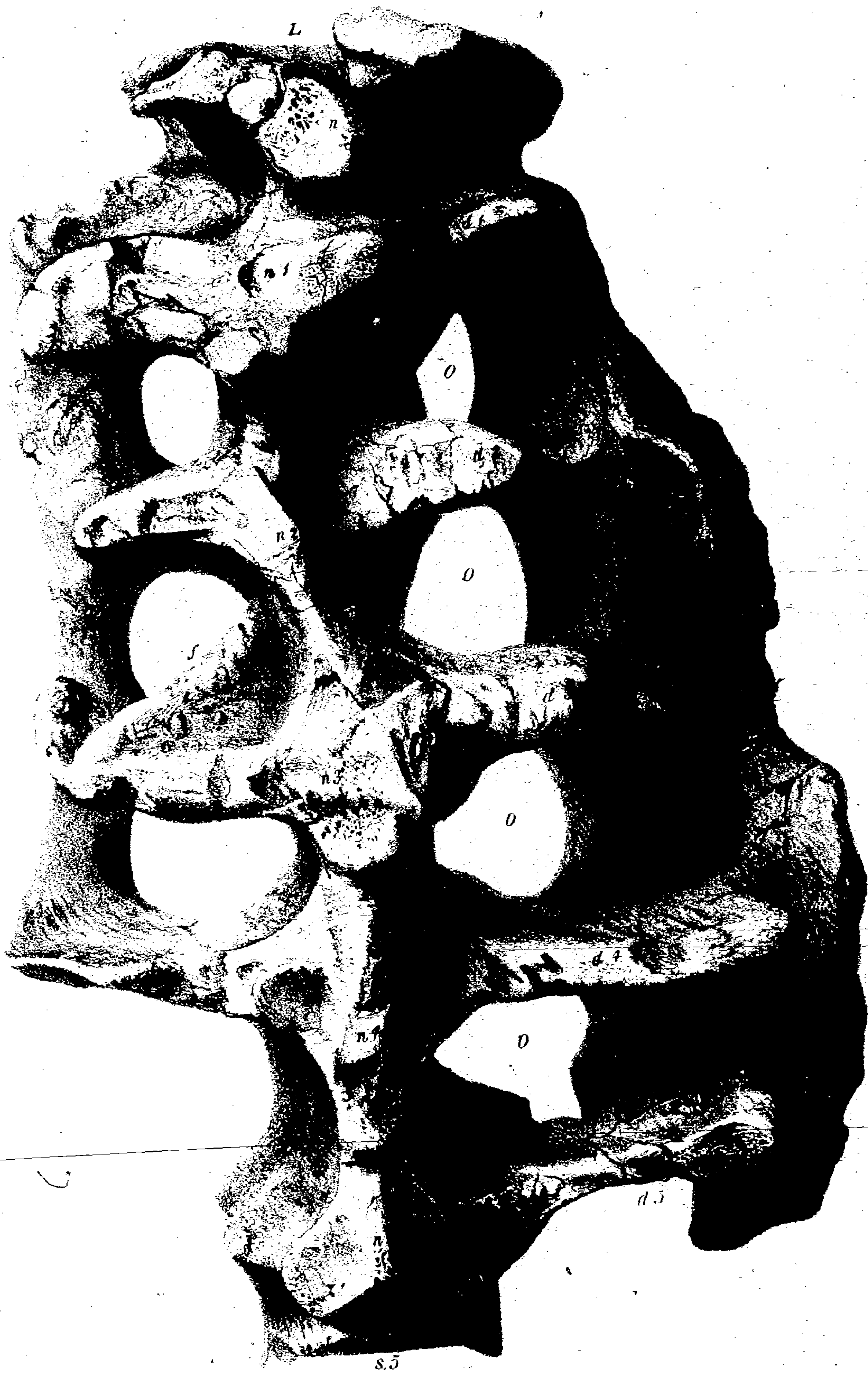
Jos. Dinkel Lith

Ford & West Imp

TAB. IV.

The superior or dorsal surface of the sacrum, and some anchylosed bones of the *Iguanodon*; half nat. size.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.



Jos Dinkel del.

TAB. V.

Fig.

1. Right side of the sacrum, and anchylosed ilium of the *Iguanodon*; half nat. size.

2. Left side of the sacrum, and anchylosed lumbar vertebra of the same *Iguanodon*.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.

Fig. 1.

Fig. 2.

Jos Dinkel Lith.

Ford & West, Imp.

TAB. VI.

Fig.

1. Front view of the last lumbar vertebra anchylosed to the sacrum of the *Iguanodon* ; half nat. size.

2. Back view of the sacrum with the anchylosed right iliac bone of the *Iguanodon*.

From the Wealden, near Brook-point, Isle of Wight. In the Museum of W. D. Saull, Esq., F.G.S.

Fig. 1.

Fig. 2

[illegible]es Dinkel, Lith. Ford & West, Imp.

TAB. VII.

The body of the fourth sacral vertebra of a young *Iguanodon*; nat. size.

Fig.

1. Side view.
2. Front view.
3. Under view.
4. Upper view, showing the place of the escape of the sacral nerves at *o o*.

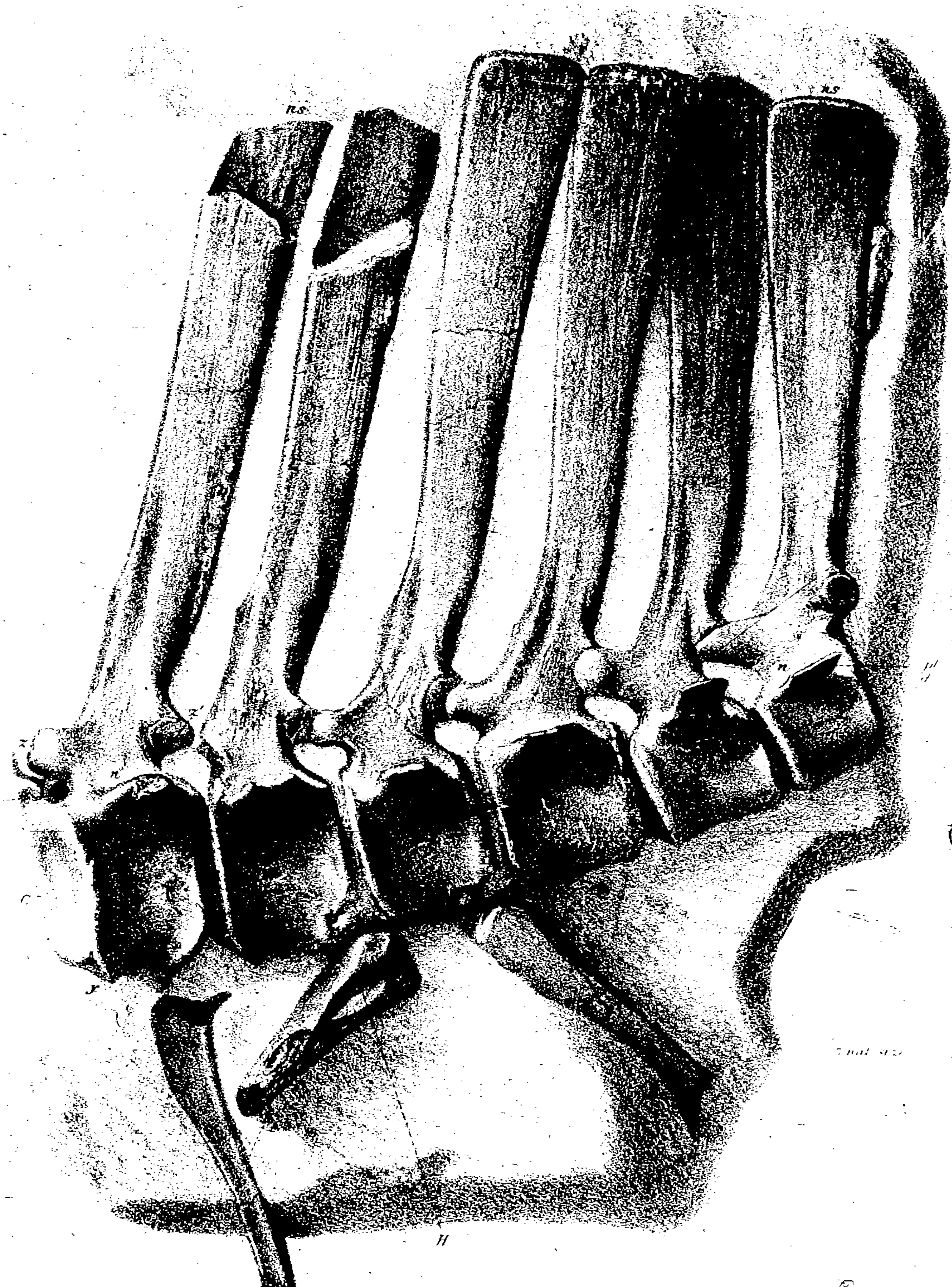
From the Wealden of Tilgate Forest, Sussex. In the British Museum.

T. VII.

TAB. VIII.

Six consecutive vertebræ from the fore part of the tail of the *Iguanodon Mantelli*; one third nat. size. An outline of a front view of the first of these vertebræ; restored and adjoined.

From the Wealden at Cuckfield, Sussex. In the British Museum.



nat. size

nat. size

TAB. IX.

A vertebra probably behind the middle of the tail of the *Iguanodon;* two thirds nat. size; the hæmal arch is wanting, and the neural spine is mutilated.

Fig.

1. Side view.
2. Upper view.
3. Front view.
4. Back view.
5. Under view.

From the Wealden at Stammerham, Sussex. In the Museum of J. B. Holmes, Esq.

Fig 2.

Fig 5.

Fig 1.

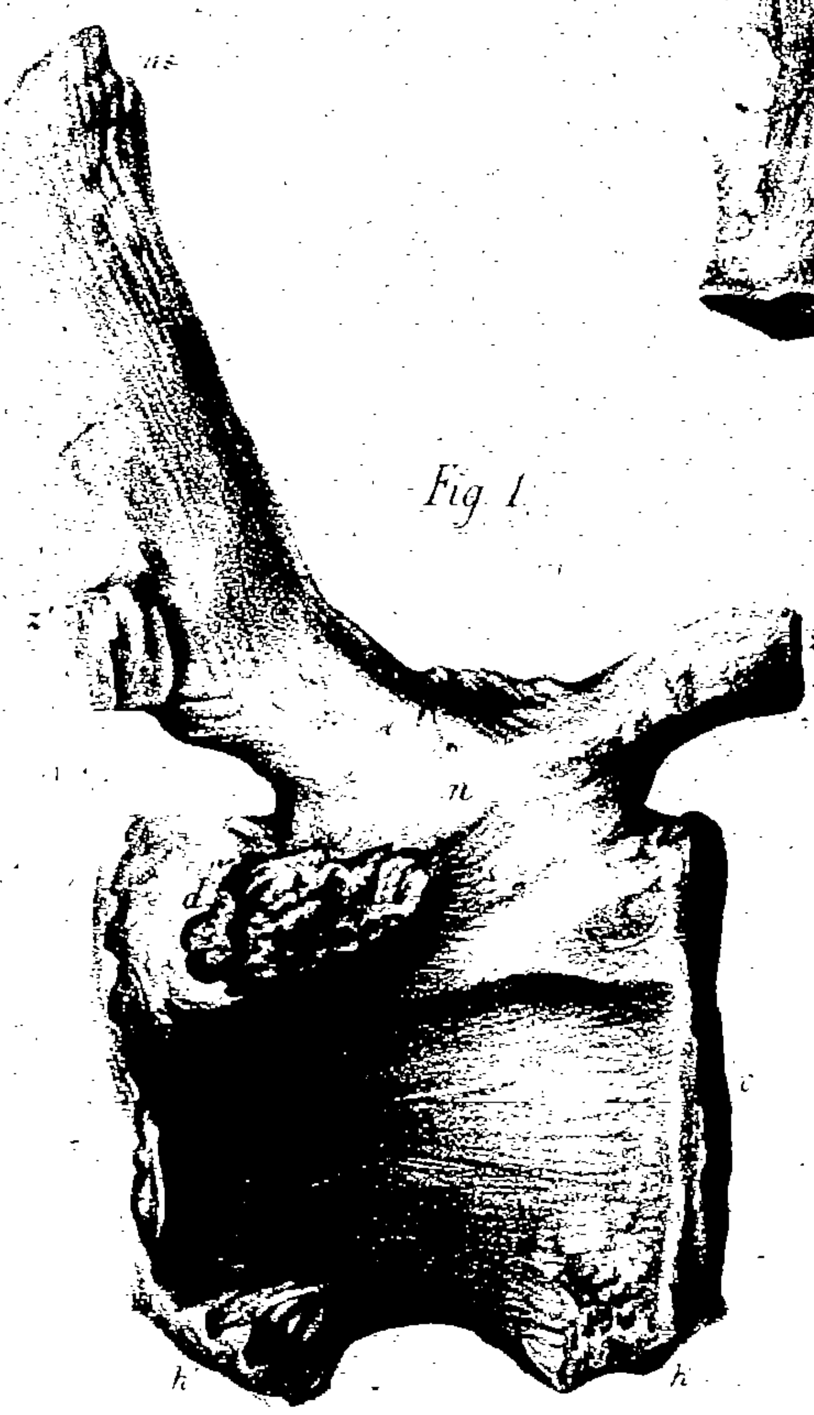


Fig 4.

Fig 3.

⅔ nat. size

TAB. X.

The tympanic bone of an *Iguanodon?* nat. size.

From the Wealden of Tilgate forest, Sussex. In the British Museum.

Jos. Dinkel lith.

TAB. XI.

The dentary part of the right branch of the lower jaw of a young *Iguanodon;* nat. size.

Fig.

1. Outside view.
2. Inside view, showing the alveolar depression, and the germs of some successional teeth.

From the Wealden of Stammerham, Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

Fig. 2.

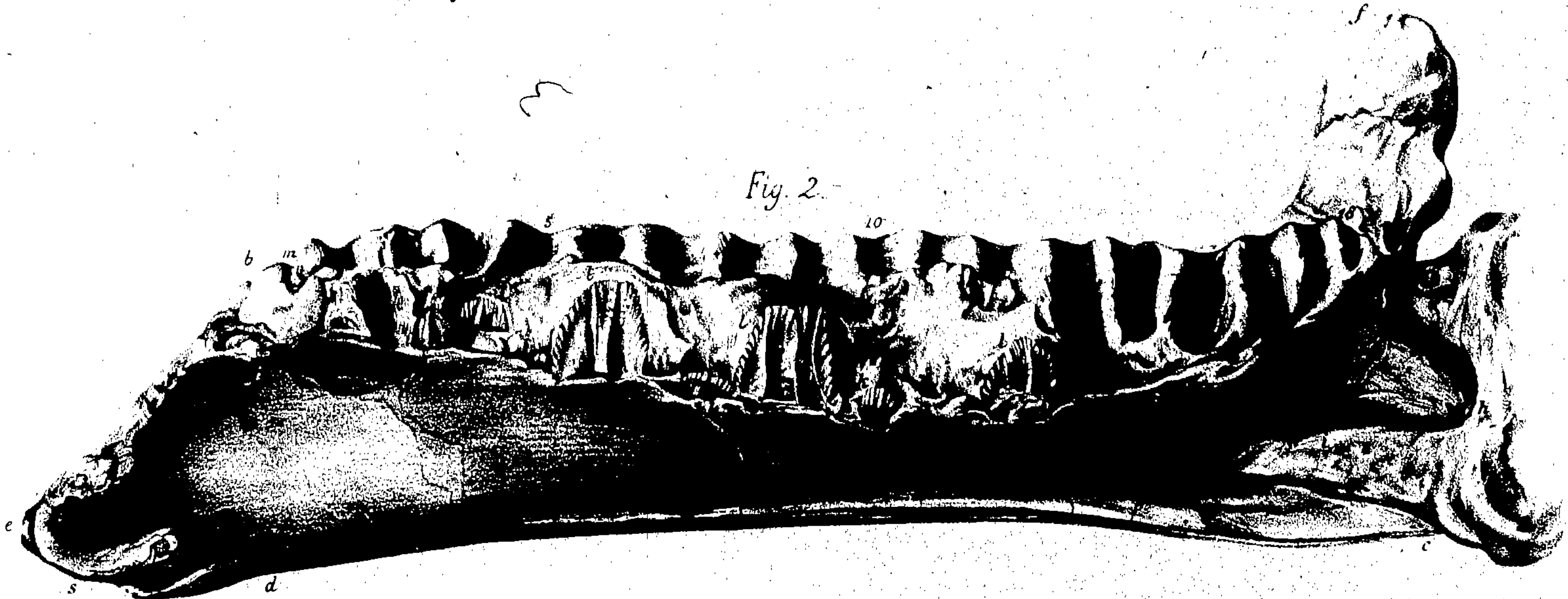
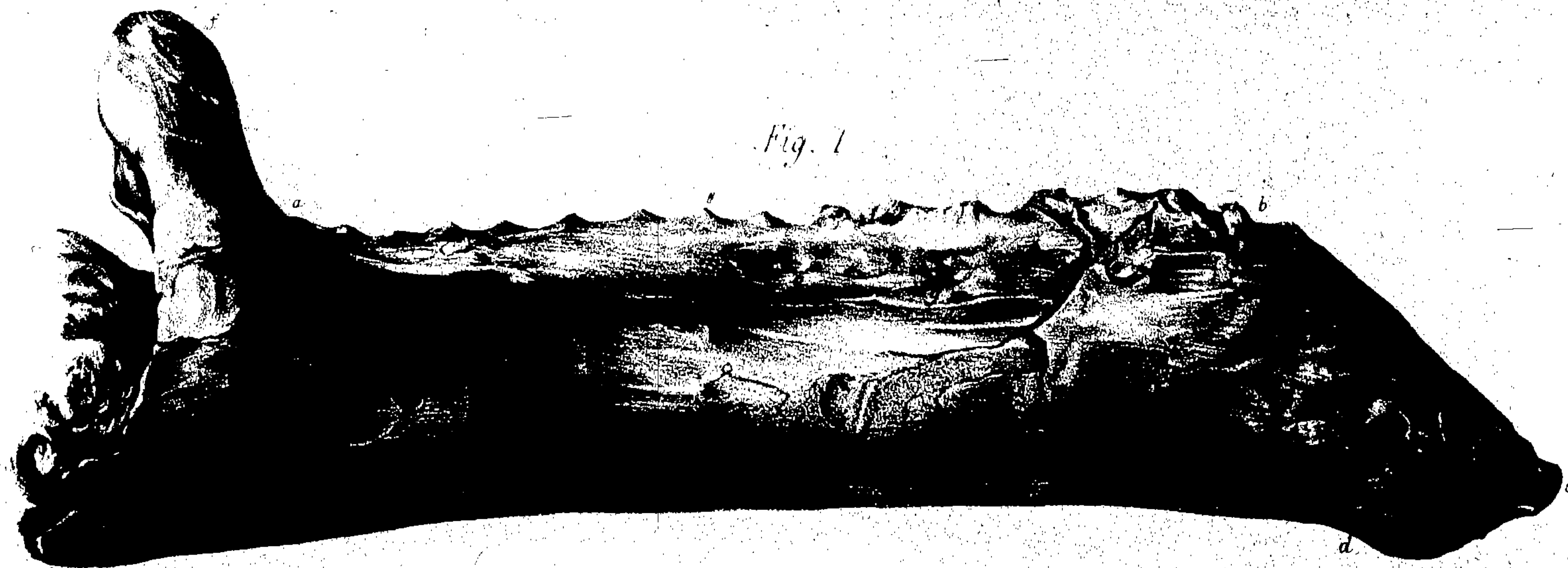


Fig. 1



Drawn from Nature by [illegible] on stone by [illegible] Erxleben

Day & Son Lithrs to The Queen

TAB. XII.

The same portion of lower jaw, as in Tab. XI, of a young *Iguanodon;* nat. size.

Fig.

3. Upper view.
4. Under view.

From the Wealden of Stammerham, Sussex. In the Museum of J. B. Holmes, Esq. of Horsham.

T. XII.

Fig. 3.

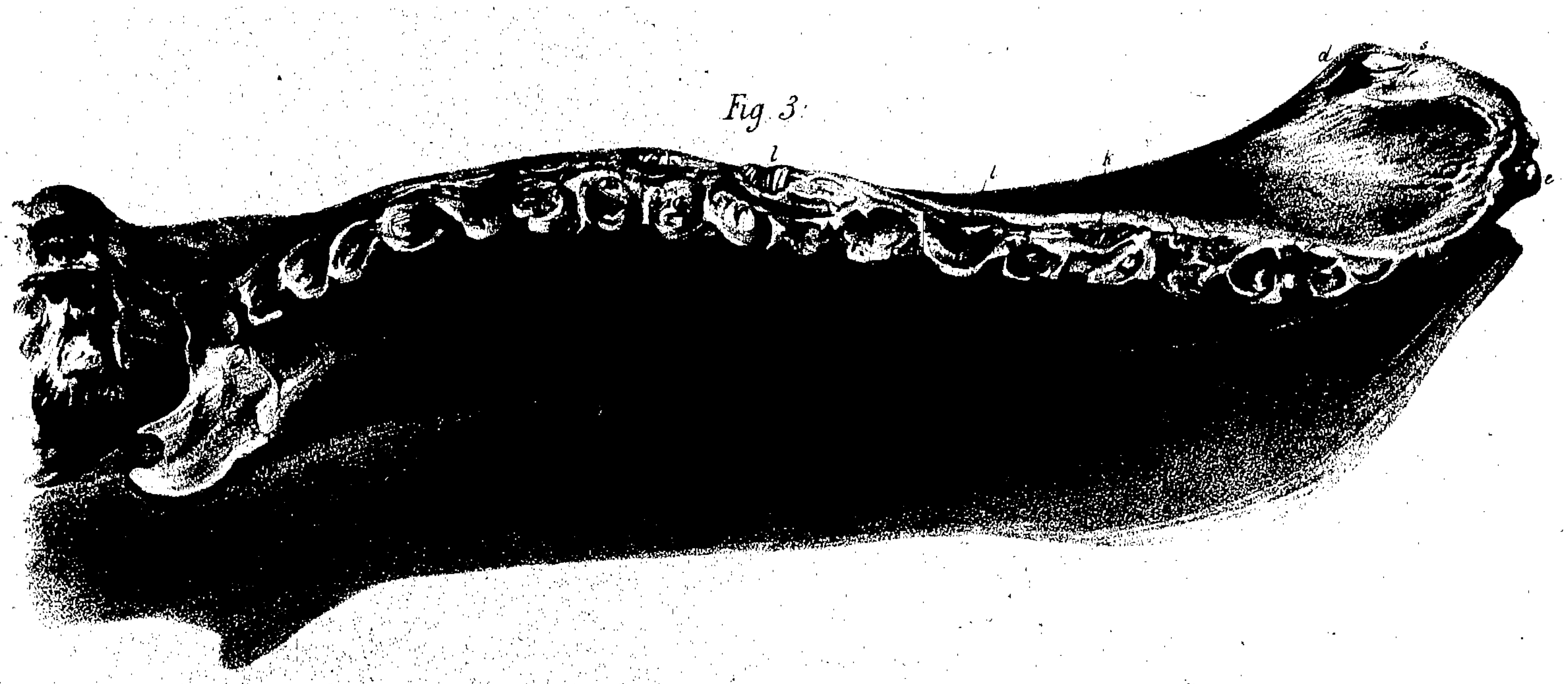


Fig. 4.

Draw from Nature by Miss Holmes.

Lith. to The Queen.

TAB. XIII.

Portions of the upper and lower jaws of the *Iguanodon;* nat. size.

Fig.

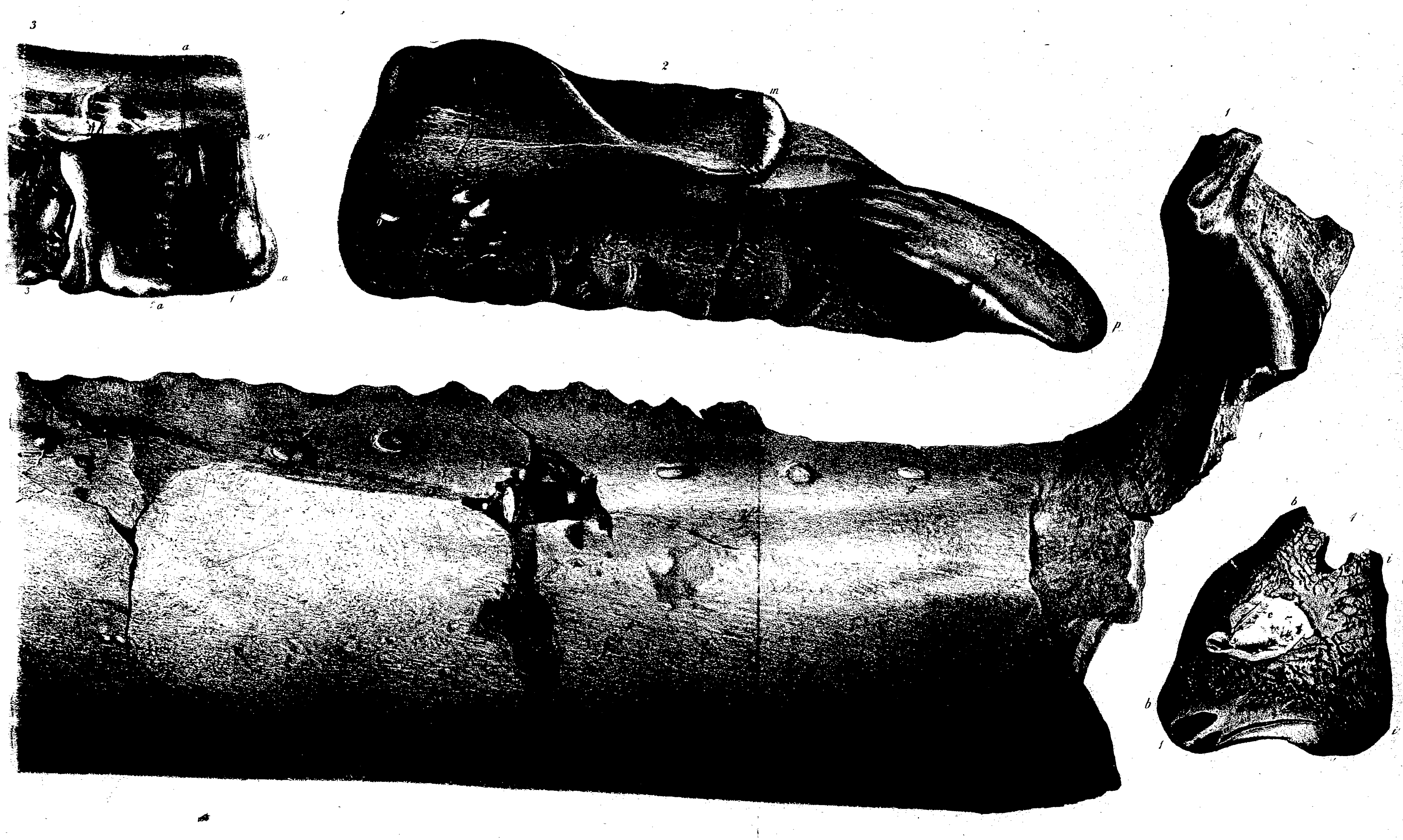
1. The dentary part of the lower jaw of a large, probably full-grown *Iguanodon:* nat. size.

   From the Wealden of Tilgate, Sussex. In the British Museum.

2. The outer side of a portion of the back part of the left superior maxillary bone of a probably full-grown *Iguanodon;* nat. size.
3. The inner side of the same specimen.
4. The cut surface of a vertical section taken through the fore part of the same specimen.

From the Wealden near Brook-point, Isle of Wight. In the British Museum.

T. XIII.



TAB. XIV.

Iguanodon Mantelli; one third nat. size.

Fig.

1. The scapula and coracoid (the upper end is downwards in the figure).
2. An end view of the same specimen showing the coracoid.
3. Front view of the humerus of the same individual.
4. Side view of the same humerus.
5. Back view of the lower half of the same humerus.
6. Condyles of the same humerus.

From the Wealden at Rusper, Sussex. In the Museum of J. B. Holmes, Esq.


Fig. 3
Fig. 6.
Fig. 4
Fig. 1.
Fig. 5.
Fig. 2

TAB. XV.

Iguanodon Mantelli; one fourth nat. size.

Fig.

1. Front view of the right femur: 1*a*, Outline of the head of the bone: 1*b*, Outline of the condyles of the bone.
2. Back view of the right tibia of a somewhat larger individual.

From the Wealden of Tilgate Forest, Sussex. In the British Museum.

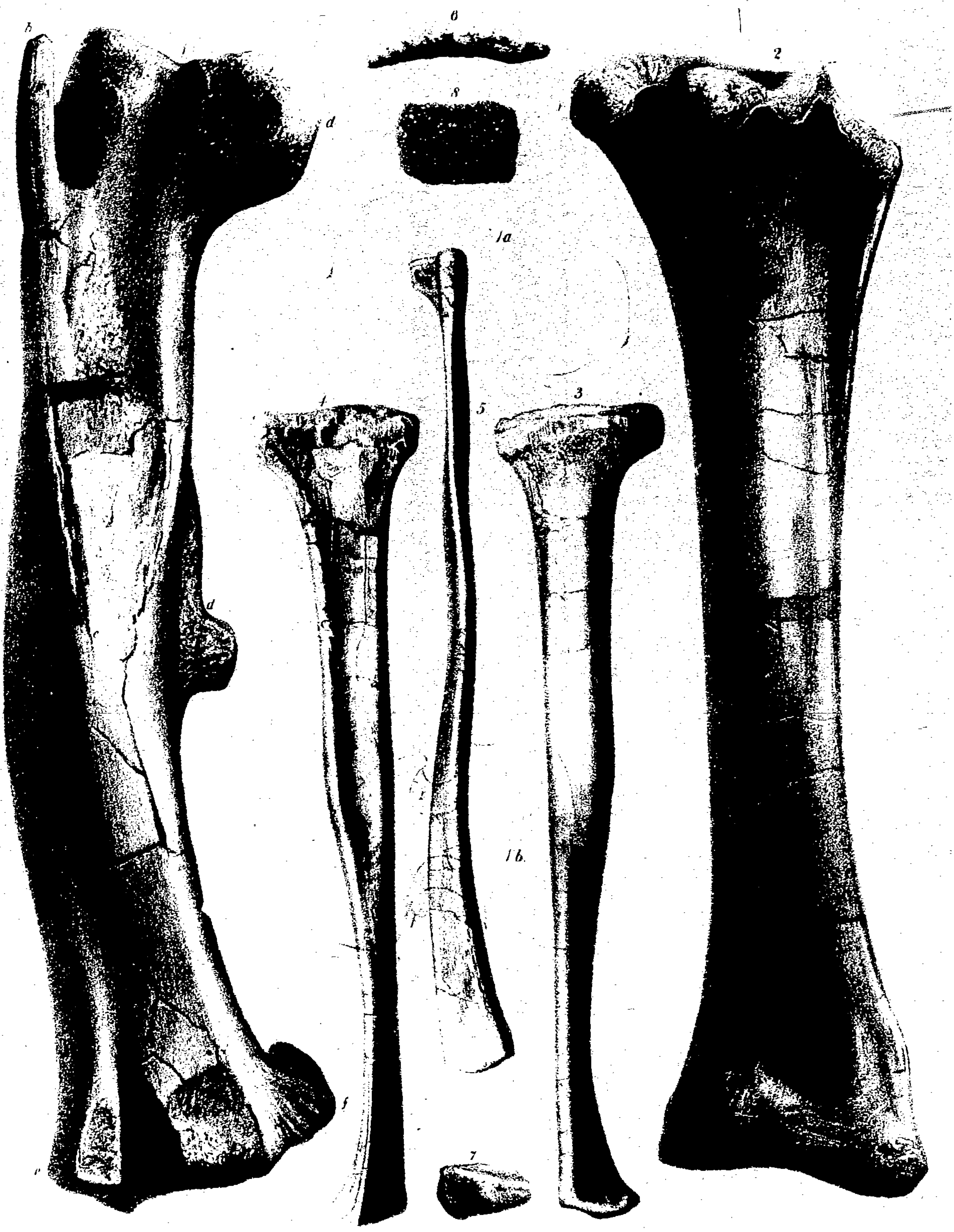
3. Outside view of the fibula of a younger Iguanodon.
4. Inside view of the same bone.
5. Front view of the same bone. (The upper end of the bone is downwards in these figures.)
6. Lower end of the same bone.
7. Upper end of the same bone.

From the Wealden of Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

8. A slightly magnified view of the surface of a piece of the corium or true skin of the *Iguanodon.*

From the specimen in Tab. I; from the Wealden of Cowleaze Clime. In the Museum of J. S. Bowerbank, Esq., F.R.S.

T. XV.



Frank West, Imp

TAB. XVI.

Fig.

1. A first or proximal phalanx of one of the toes of an *Iguanodon;* nat. size.
2. A last or ungual phalanx of one of the toes of an *Iguanodon;* nat. size.

From the Wealden of the South coast, Isle of Wight. In the Geological Museum of Oxford.

Jos Linzel, lith

T. XVI.

T. XVI A.

TAB. XVII.

Ungual phalanges of modified shape, probably from the extreme toe, outer or inner, of the hind foot of the *Iguanodon*.

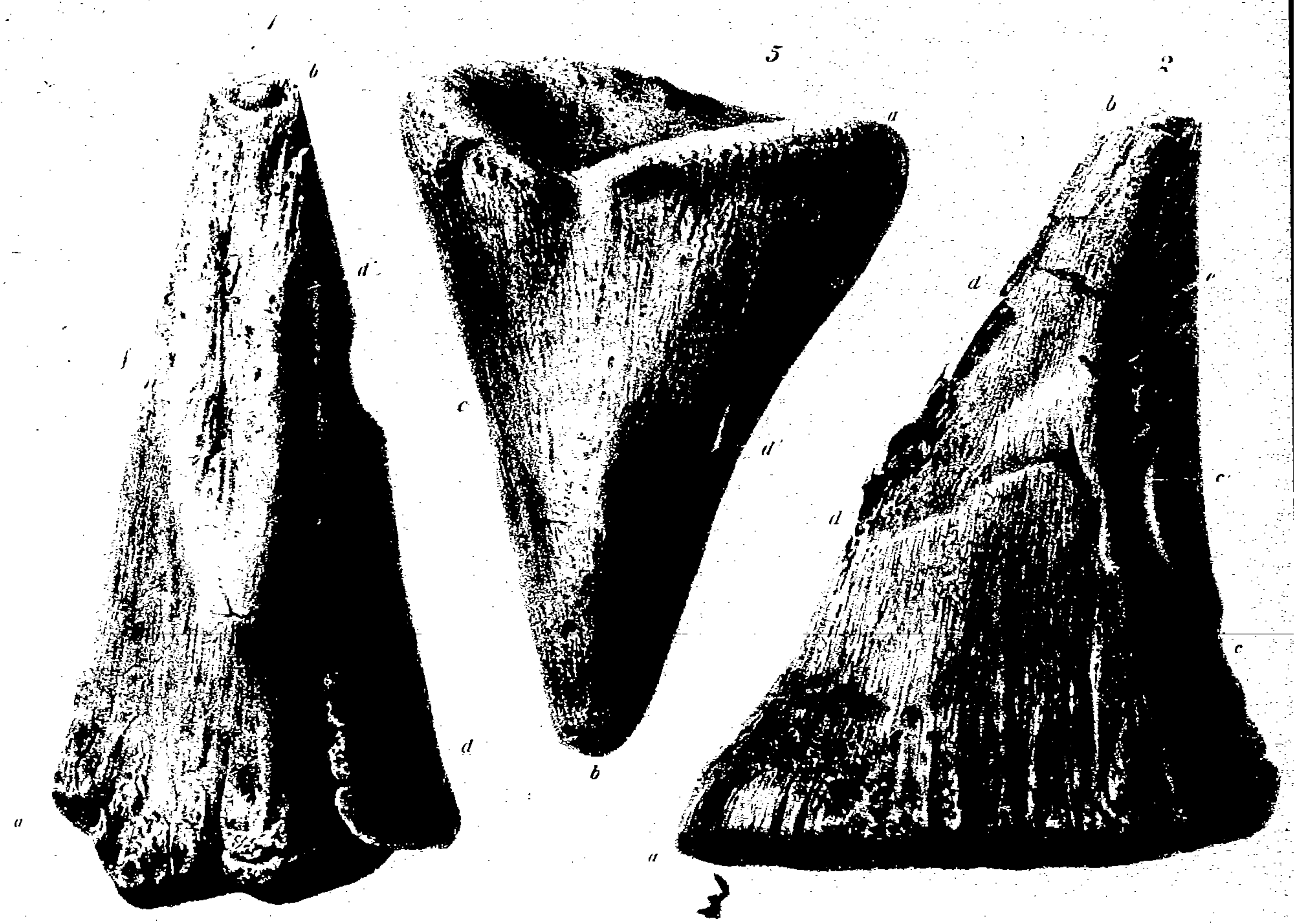
Figs. 1 and 2, are of the specimen called '*Horn of the Iguanodon*,' in the Works and Catalogue of Dr. Mantell.

From the Wealden, Sussex. In the British Museum.

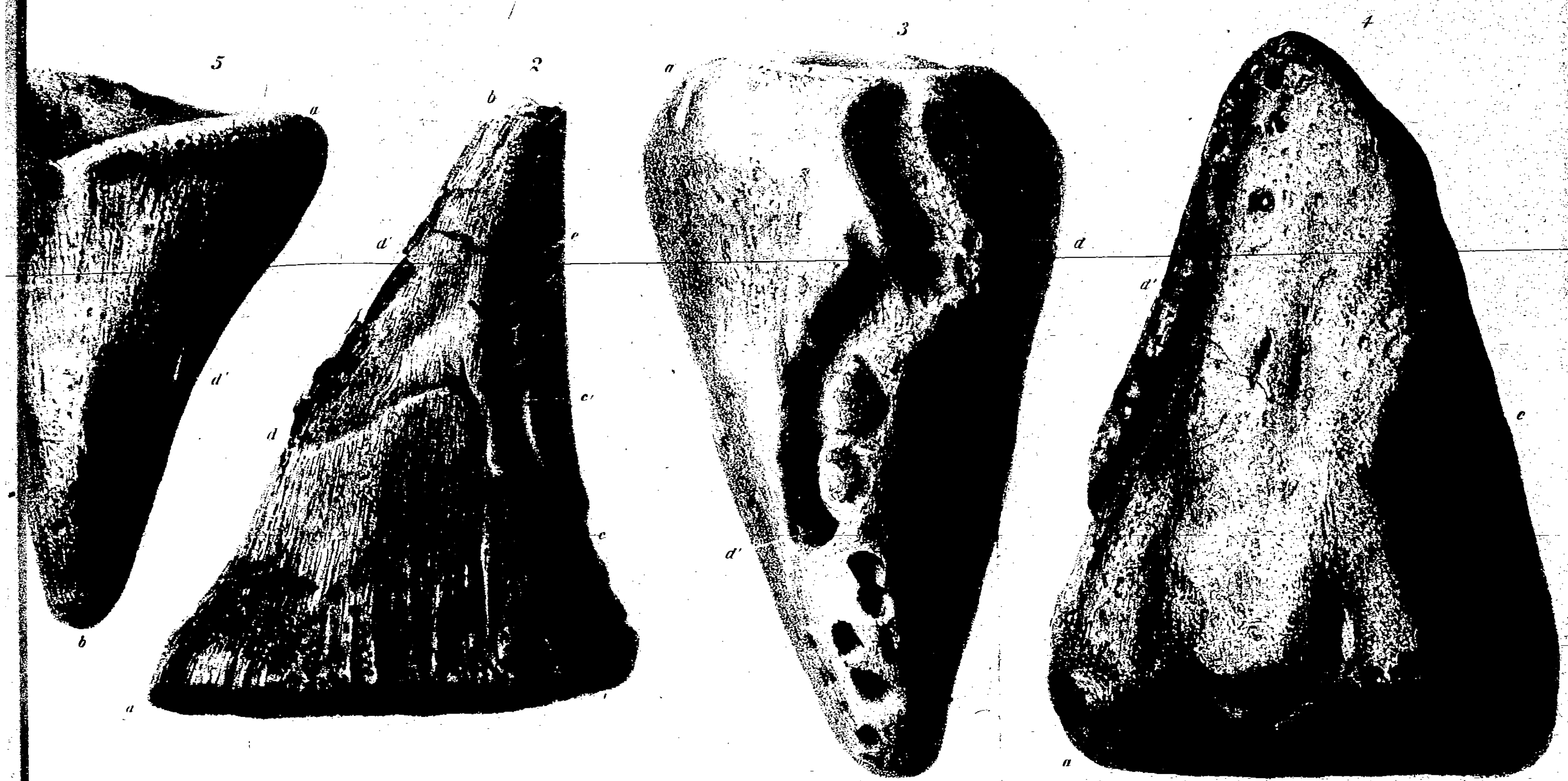
Fig.

3. Side view of a similarly shaped phalanx.
4. Upper view of the same phalanx.
5. Upper view of a smaller and similar phalanx.

From the Wealden of Battle, Sussex. In the Museum of Felix Knyvett, Esq.



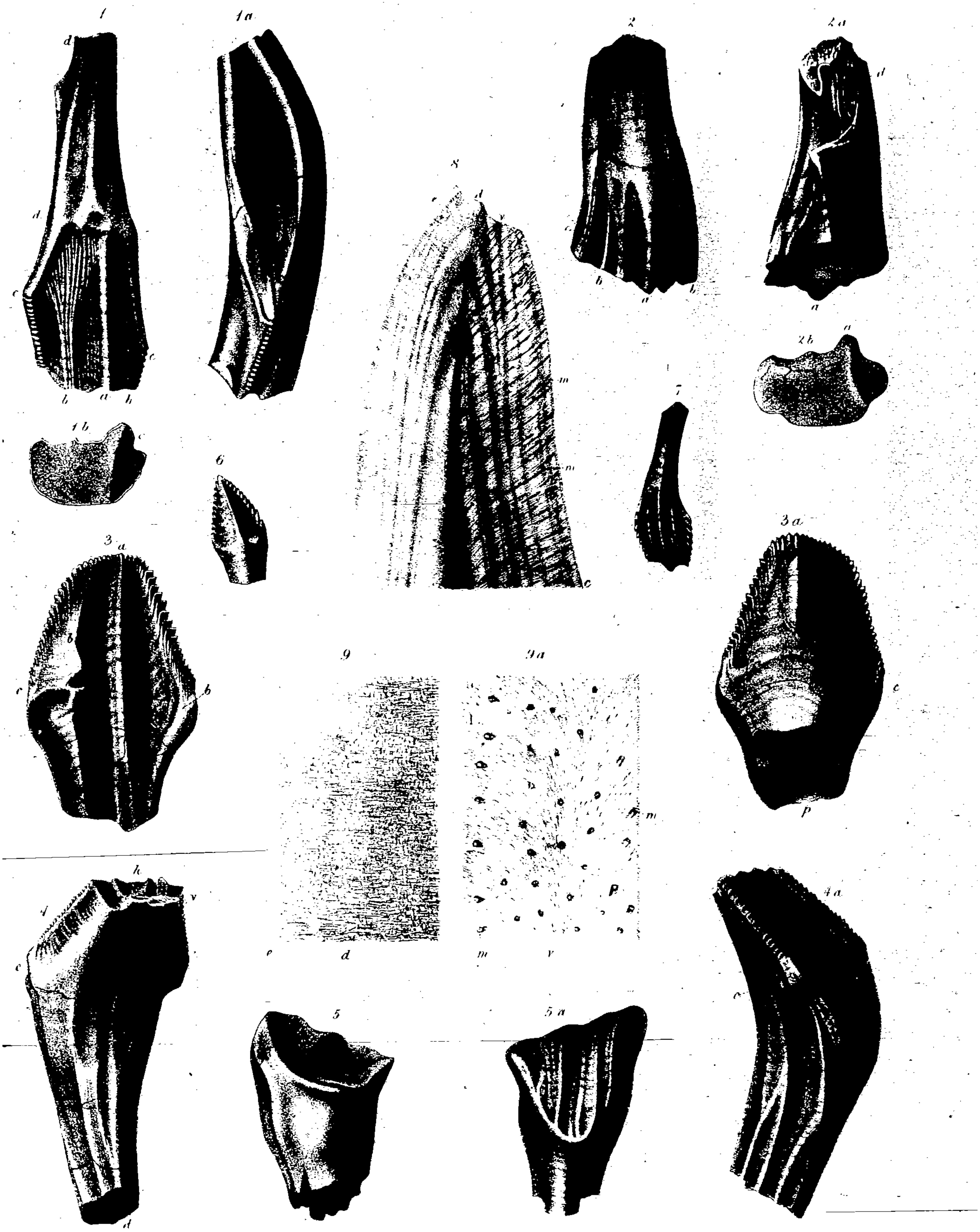
T. XVII.



TAB. XVIII.

Different views of the teeth from the upper and lower jaws of the *Iguanodon;* figs. 1—7, nat. size: figs. 8 and 9, highly magnified views of sections, showing structure.

From the Wealden of Tilgate Forest; and Cuckfield, Sussex. In the British Museum.



TAB. XIX.

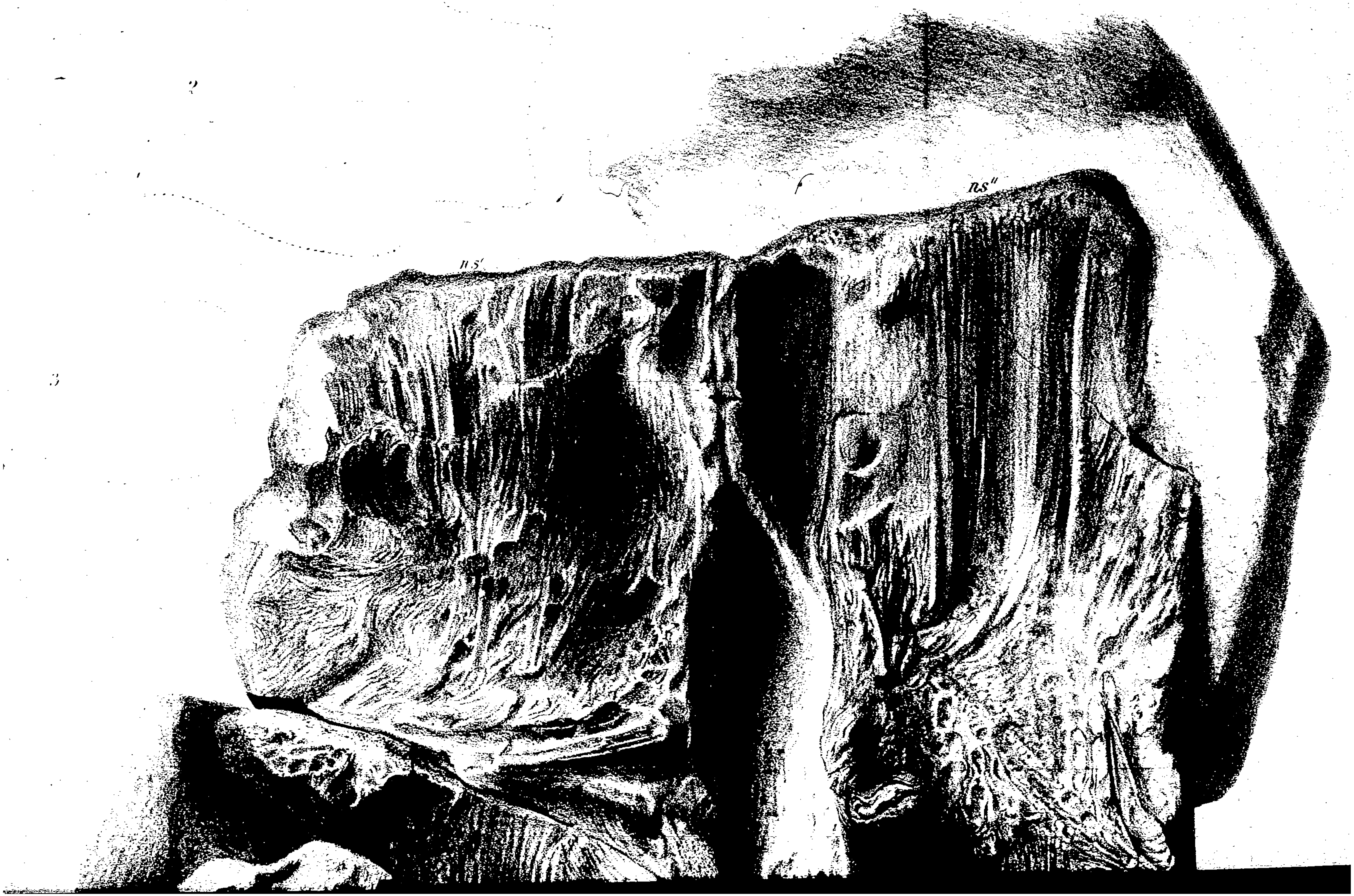
Megalosaurus Bucklandii; nat. size.

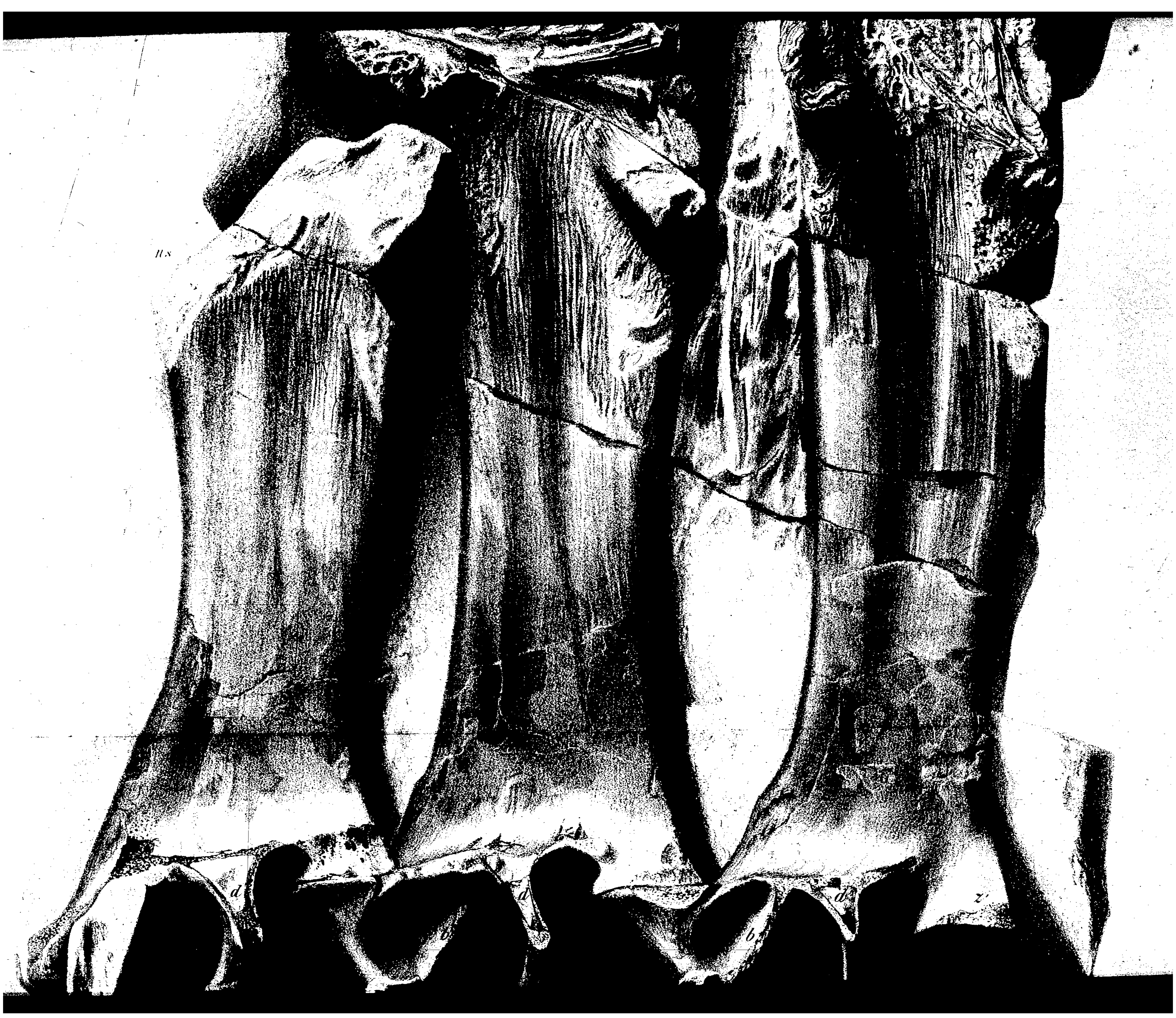
Three anterior dorsal vertebræ: *p*, parapophysis, or lower transverse process: *t*, accessory tubercle contributing some attachment to the head of the rib: *d*, diapophyses, or upper transverse process, fractured, which gave attachment to the tubercle of the rib: *b*, oblique buttress extending from the parapophysis to the diapophysis, and contributing to the support of the neural platform: *z*, the prozygapophysis, *z'*, the zygapophysis, forming the ends of the neural platform and articulating the neural arches of the vertebræ with each other. *ns*, the neural spine of the foremost of these vertebræ, *ns'*, the neural spine of the second vertebra; it expands at its extremity, overhangs the anterior shorter spine, and developes a strong bony plate from its back part which fixes it to *n''*, the similarly developed and modified spine of the third vertebra.

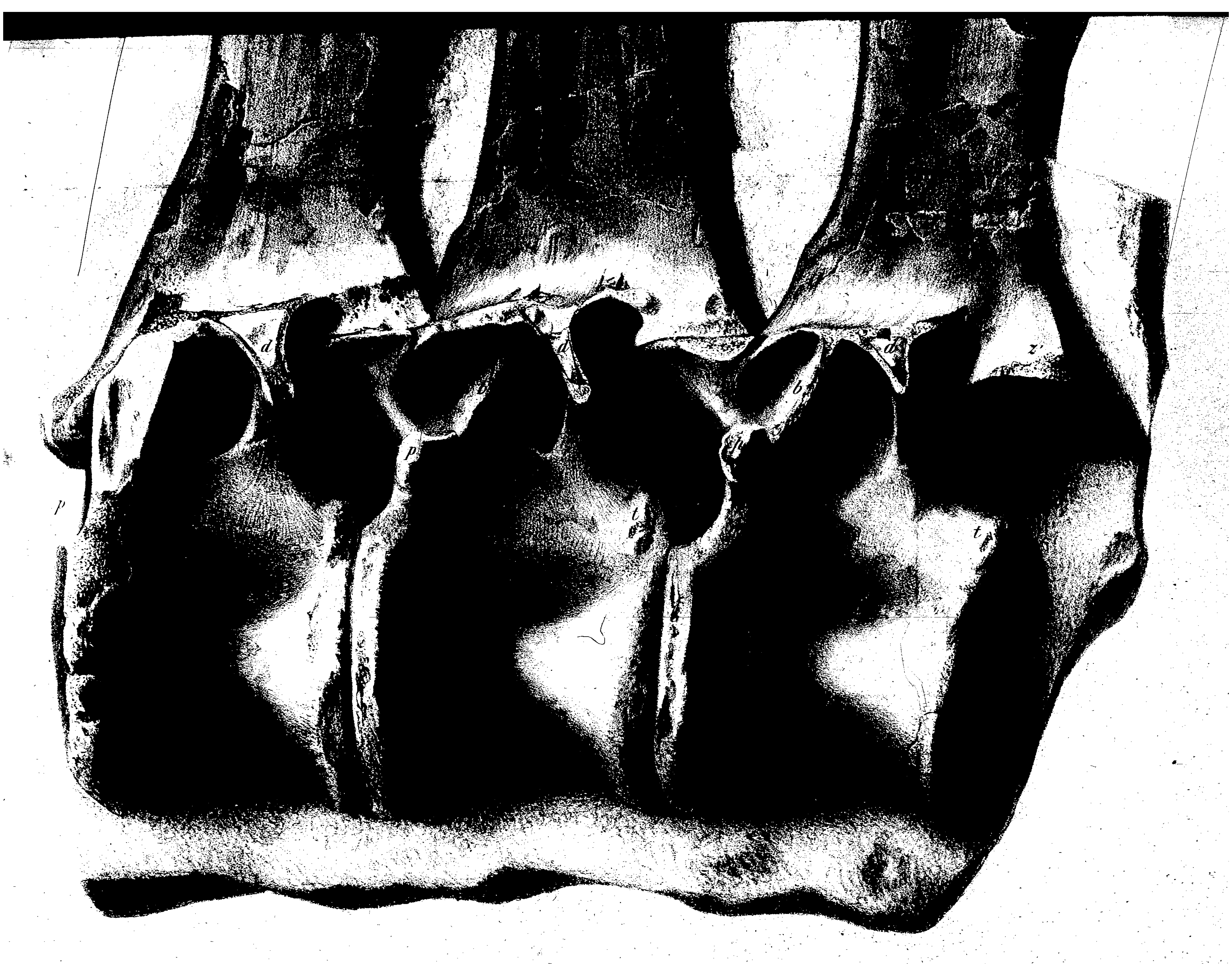
The extraordinary size and strength of the spines of these anterior dorsal vertebræ, indicate the great force with which the head and jaws of the Megalosaurus must have been used.

From the Wealden, near Battle. In the Museum of Samuel H. Beckles, Esq., F.G.S.

T. XIX.







Jos. Dinkel, Lith.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN FORMATIONS.

ORDER—*DINOSAURIA.*

Genus—MEGALOSAURUS,* *Buckland.*

Dentes laniarii, subcompressi, marginibus minuté serratis.

THE order or group of Dinosaurian Reptiles, briefly characterised in a preceding Monograph,† includes at least three well-established genera, resembling each other in having a large and complex sacrum, composed of five or more anchylosed vertebræ; in the height, breadth, and outward sculpturing of the neural arch of the dorsal vertebræ; in the twofold articulation of the ribs, or some of the anterior moveable ribs, to the vertebræ; and in having broad, and sometimes complex coracoids, and long and slender clavicles; whereby a Lacertian type of the pectoral arch is combined with a crocodilian type of the true vertebræ, and both with an ornithic type of sacrum.

These remarkable extinct Dinosaurs were of large, if not gigantic, size; with the trunk lifted, higher than in other reptiles, upon four unusually developed limbs; the principal bones of which are remarkable for the prominence and number of the apophyses relating to muscular attachments, for the size of the medullary cavity, and for the density of its compact bony wall: the limbs are terminated by metacarpal or metatarsal, and by phalangeal bones, which, with the exception of the ungual phalanges,

* Μεγας, great, σαῦρος, lizard.

† 'Palæontographical Society,' vol. 1855.

more or less resemble those of the horny pachydermal mammals, and attest, with the hollow long bones, the terrestrial habits of the species.

Of these gigantic *Dinosauria* the most formidable was that which its discoverer, that keen observer and original thinker, the Rev. Dr. Buckland, has called "Megalosaurus,*" in reference to the idea of its hugeness, which was suggested to both him and Baron Cuvier by certain of its limb-bones. "Si l'on pouvait donner," writes Cuvier, "le nom de *Lacerta gigantea* à un autre animal qu'à celui de Maëstricht, c'est l'espèce actuelle qui le mériterait; son seul fémur, long de trente-deux pouces anglais ou 0·805; annoncerait, en lui supposant les proportions d'un Monitor, une longueur totale de plus de quarante-cinq pieds de roi, et même, s'il y a de ces fémurs de quatre pieds et plus, comme on l'a dit, sa longueur serait encore plus étonnante."†

The locality where the first rightly recognised remains of the *Megalosaurus* were found was Stonesfield, near Woodstock, about twelve miles from Oxford. The formation is that calcareous schist, which, being quarried for roofing houses principally at Stonesfield, is called, in most English geological works, "Stonesfield slate." Its position is at the base of the great Middle Oolitic series, where it may be, perhaps, more accurately classed as an upper member of the Inferior Oolite.

To get at this slate, pits are sunk through forty-feet or more of superincumbent strata, chiefly consisting of that hard oolitic rock called "cornbrash" by the quarry-men. The schistose or slaty deposit is not more than six feet thick; and the scepticism with which the first announcement of bones of large animals in stony strata at that depth was received, is exemplified by the stress with which Cuvier thought it needful to insist on the fact that the Stonesfield slate was as regular a formation as it was an ancient one, and that there was no ground for supposing that the fossil bones which it contained had penetrated it by any fissure or other accidental opening.

The portions of skeleton originally discovered, and attributed by Dr. Buckland to his newly defined genus, *Megalosaurus*, consisted of a fragment of the lower jaw, a femur, a series of five vertebræ of the trunk, a few ribs, a coracoid bone, a clavicle, and some less certainly recognisable fragments.‡

Unfortunately, as Cuvier has remarked, those portions were not found together in one spot, nor, with the exception of the five vertebræ, were the bones associated two to two, or three to three, so as to make it probable that they belonged to the same individual; and, with regard to their zoological or anatomical relations, Cuvier further observes that these are of a somewhat equivocal and mixed nature, "encore ces rapports zoologiques sont-ils d'une nature assez equivoque et assez mélangée."§

* See 'Transactions of the Geological Society of London,' 4to, vol. i, 2d ser., pt. 2, 1824.

† 'Ossemens Fossiles,' 4to, vol. v, pt. 2, p. 343.

‡ 'Geological Transactions,' vol. i, 2d ser., p. 427.

§ Tom. cit., p. 345.

This side-blow to Dr. Buckland's determination has been repeated by later foreign palæontologists. M. Deslongchamps, for example, has remarked, "Qu'il n'y a de bien décidément constaté, comme Megalosaurus, que les dents; car les autres pièces osseuses, que l'on rattache à ce genre, y concordent à la vérité par la taille et parce qu'elles ont été trouvée dans les mêmes bancs, mais non dans le même bloc."* The Megalosaurus, in fact, was not the only gigantic reptile which the Stonesfield slate was then known to have contained; but, up to the present time, it has been the sole representative of the Dinosaurian order in that formation; and the combination of the characteristic modifications of the sacrum, scapular arch, and great limb-bones, in skeletons of the same individual of the Iguanodon, and equally proved to coexist in the Hylæosaurus, has added greatly to the probability of the disjoined complex sacrum, dorsal, and lumbar vertebræ, coracoid, and the large hollow femur, from the Stonesfield slate, which, though Dinosaurian, were neither Iguanodontal nor Hylæosaurian, having belonged to a distinct species of great Dinosaur: to no other reptile, indeed, could the portion of jaw, with teeth manifesting in their structure and mode of implantation the same transitional or annectant characters between the *Crocodilia* and *Lacertilia* as the above-cited parts of the skeleton present, be, with greater probability, referred, than to the peculiar Dinosaurian Carnivore to which the parts of the skeleton above defined certainly belonged.

To my own mind the above reasoning, strengthened by repeated instances of the occurrence of Megalosaurian teeth, with vertebræ, sacrum or portions of sacrum, coracoids, and femora, of the same species as those from Stonesfield ascribed to Megalosaurus, in Wealden and Oolitic formations of other localities, has produced a conviction that the parts to be described in the present Monograph do belong to one and the same species.

There is, moreover, a peculiar smoothness of surface and compactness of exterior osseous layers, common to the portions of toothed jaws with the other parts of the skeleton, that immediately suggest to the practised anatomical eye the idea of their being specifically identical. The microscopic character of the osseous tissue from the above-named bones is also the same; but on this evidence I should not lay much stress, since the difference is not, at least to me, appreciable between the Megalosaurus, Poikilopleuron, and Streptospondylus, in regard to the microscopic characters of the bone.

The bodies of the sacral vertebræ, as the five vertebræ of the *Megalosaurus* first discovered have proved to be,† are remarkable for their median constriction, and the almost cylindrical form of the transverse section of that part; and the repetition of these and some minor characters in vertebræ of the same size from other parts of the trunk, as, *e.g.*, in a detached dorsal and caudal vertebra obtained from Stonesfield

* 'Sur le Poikilopleuron Bucklandi,' 4to, p. 52.

† Report on British Fossil Reptiles, Part II, 'Trans. of the British Association,' 1841, p. 105.

with the original series of Megalosaurian remains, have sufficed for the determination of subsequently discovered and better-preserved specimens of detached vertebræ of the Megalosaurus from other localities.

Dorsal vertebræ.

The Megalosaurus departs, perhaps even more than does the Iguanodon, from the existing Crocodiles, Monitors and Lizards, in its vertebral characters. The articulating surfaces of the vertebral bodies are very slightly concave, indeed almost flat, presenting in that respect the type of the Amphicœlian Crocodiles: the non-articular surface is remarkably smooth and polished. The centrum is much contracted in the middle, presenting a deep concave outline of the under surface: the margins of the expanded articular extremities are thick and rounded off. The almost cylindrical section of the middle part of the vertebra arises from its 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; the centrum, however, slightly expanding above the fossa to support the arch.

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 of the centrum. 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 upper transverse processes (diapophyses) are developed, and from the middle of the upper surface the spinous process. A recent discovery has shown the extraordinary development of the latter apophysis in some of the anterior dorsal vertebræ.

In the Wealden deposits at Battle, Sussex, a large nodule of the ferruginous clay had been formed and consolidated around a portion of the skeleton of a *Megalosaurus* consisting of some anterior thoracic vertebræ. In the state in which this nodule was submitted to my examination, three almost entire and consecutive vertebræ, wanting the ribs, were preserved in natural juxtaposition. A figure of this unique specimen, discovered by S. H. Beccles, Esq., F.G.S., was, with his kind permission, given in a preceding Monograph.* In a second portion of the same nodule two almost entire and consecutive ribs of the right side were preserved: a smaller fragment contained the bodies and neural arches of two consecutive vertebræ in natural junction from a more anterior part of the chest than the series of the three vertebræ (*loc. cit.*, pl. xix). Two detached vertebræ, wanting the spinous process, from a hinder portion of the trunk, had been obtained either from, or near to, the above-described large nodule.

* 'Palæontographical Society,' 1855, t. 19.

The three vertebræ (*loc. cit.*, tab. xix) retain, what is rarely preserved in such complex parts of fossil Saurians, the entire neural spines, *ns*, and exhibit a disposition and proportions of those parts which have not before been noticed in any Dinosaurian, or in the dorsal vertebræ of any other reptile, recent or fossil.

That these vertebræ are from the fore part of the chest is indicated, according to the analogy of the *Crocodilia* and of the Iguanodon, by the articular surfaces for both the head and tubercle of the rib, and by the progressive ascent of the surface, *p*, for the head of the rib, as the vertebræ recede in position. By reference to the T. XIX, in the previous Monograph, *loc. cit.*, it will be seen that this surface slightly projects, and is situated upon the neurapophysial suture in the first, *p*, *ns*, but above that suture, supported wholly by the neurapophysis, in the third of those vertebræ, *p*, *ns'*. The megalosaurian character of all of the vertebræ is shown by the great, though regular and gradual constriction of the centrum between its articular ends, by the corresponding depth of the concave contour lengthwise, and by the almost circular form of the transverse section of the lower two thirds of the centrum. The non-articular surface of the centrum is smooth and polished, with some longitudinal grooves and ridges near the expanded ends, the bodies of which are thick and rounded. The side of the centrum is moderately hollowed below the neural suture, and swells out, becoming convex vertically, before bending round to the under surface. There is a rough tuberosity, *t*, at the upper and back part of the centrum, which may be contributed by the base of the neurapophysis.

The neural arch offers the same complex structure as in other *Dinosauria*: a compressed plate, *b*, extends obliquely backward from the parapophysis, *p*, to the diapophysis, *d*; the latter being supported by a stronger buttress extending outward from near the back part of the base of the neurapophysis, and being slightly inclined forward. Three deep depressions, probably receiving parts of the lungs in the living animal, divide these lamelliform buttresses from each other, and from the bases of the anterior, *z*, and posterior, *z'*, zygapophyses. The articular surface of the anterior one looks upward and slightly inward, that of the other, *z'*, downward and slightly outward, both being nearly horizontal. The neural platform extends from the outer margin of the prezygapophyses, *z*, to the fore part of the postzygapophyses, *z'*. The back part of the base of the neural spine is formed by two strong ridges, continued each from the whole upper part of the postzygapophysis, leaving an intermediate fossa for the implantation of a ligament: the base extends forward to the interspace between the prezygapophyses, being coextensive lengthwise with the vertebral centrum.

In the anterior of the three vertebræ the spine, *ns*, as it rises, slightly decreases in fore-and-aft extent, and then as gradually regains its dimension in that direction: after contracting transversely to a thickness of eight lines, when two inches above its base, it gradually expands to a thickness of one inch and a half at its summit, which forms a rough tuberosity, bevelled off obliquely from before upward and backward to within a third of its hinder border, which is flat: the whole height of this spine is nine inches, the vertical extent of the entire vertebra being thirteen inches six lines. The spine of the second vertebra, *ns*, 1, has a similar size and shape in the basal third of its extent, but it expands more gradually, especially transversely, and rises to a greater height, continuing to expand in every direction, but especially in the antero-posterior one; the fore part of its thick extremity being produced so as to overlap the horizontal part of the end of the shorter spine in front. The sides of the thick expanded end of this clavate spine are impressed by irregular decussating ridges, indicative of the attachment of strong tendons or ligaments; and, from the back part of the side, six inches below the summit, there projects a tuberosity: a less prominent tuberosity forms the border of the overlapping anterior part of the clavate end of the spine. The whole length of the spine is 13 inches 6 lines; the vertical extent of the entire vertebra being 18 inches 6 lines.

The neural spine of the third vertebra, *ns''*, is somewhat smaller than the foregoing at its most contracted part, three inches above its origin; but it expands, as it rises, attains a height of 14 inches, and is divided, like the foregoing, into a smooth part, and a summit impressed by the attachments of the nuchal ligaments or tendons. The base of the latter part developes a tuberosity from the fore part and back part of its outer side, and there are indications of ossifications in the interspace between it and the antecedent spine, which seem to have bound them immoveably together.

The proportions and external configuration of the spines of these anterior dorsal vertebræ, the sudden increase of the second spine, the further increase of the third, with the indications of the strength of the muscles or nuchal ligaments to which their expanded tuberculate summits have given attachment,—all recall characters of the spines of the anterior thoracic vertebræ of certain great Mammalia, and much more closely resemble those parts in the tiger or rhinoceros than in the crocodile, the gavial, or in any of the known existing Lizards. But the production of the summit of the second spine, so as to overlap part of that of the first spine, and the partial anchylosis of the second with the third spine, together with the great increase in the thickness of all the spines toward their summit, are characteristics in a great measure peculiar to the present extinct Dinosaurian; unless, indeed, it participated in them with some other members of the same extinct order of reptiles.

We cannot view this remarkable configuration of the anterior thoracic vertebræ of the Megalosaur without being impressed by an idea of the great strength of the muscles or ligaments—more probably of the energetically contracting muscles—which were implanted in those thick and lofty spines, from which, as from a fixed point, they acted upon the nuchal region of the head. The remarkable fossil, therefore, above described, yields some insight into the vigour with which such a head, consisting chiefly of the well-armed maxillary and mandibular apparatus, must have been made to operate on the bodies which the instincts of the Megalosaurus impelled it to grapple with and destroy in the reiterated predatory or combative acts necessitated for its own support and preservation.

Several specimens of dorsal vertebræ of the Megalosaurus, with the spinous process broken away, have come under my observation. The largest of these, preserved in the Geological Museum at Oxford, gives the following dimensions:

	In.	Lines.
Length of centrum	4	6
Height of ditto	4	3
Breadth of ditto across articular surface	3	9
Breadth of ditto across the middle part	2	6

The proportions and configuration of the neural arch agree with those of the more perfect vertebræ from the Wealden at Battle. The height of the spinous process of this vertebra, according to that marked *ns''* in T. XIX, *loc. cit.*, would not be less than 18 inches.

The upper part of the centrum is impressed by the spinal canal, which expands at each end, but chiefly behind. One or two vascular canals are sometimes present at the under part of the centrum, but are neither so large nor so regular as in the Plesiosauri.

Compared with the Iguanodon (see T. XXXV, of 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' Palæontographical Society, 1854), the sculptured sides of the neural arch are lower in proportion to their length in the Megalosaur: the anterior zygapophyses are more produced and more angular; the posterior ones are less produced. The depression anterior to the buttress, *d*, is bounded by the converging buttress or ridge, *b*, but this seems not to have been developed in the Iguanodon, in which the nearest approach to it is the elevated parapophysis in certain vertebræ, as in that figured in T. XXXV, *p*. There does not appear to have been, in the Iguanodon, the depression answering to that in front of the buttress, *b*, in T. XIX.

It would seem, from the mutilated lumbar vertebræ of the Megalosaurus in the Oxford Museum, figured in Dr. Buckland's original Memoir, pl. xlii, fig. 2, that the anterior oblique buttress, *b*, subsided in the vertebræ in that region.

Sacral vertebræ. Tab$^{\text{æ}}$. I, II, and III.

The sacrum of the Megalosaurus (T. I) consists of five anchylosed vertebræ, and it is remarkable, considering how small a proportion of the recognisable 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 Geological Museum at Oxford; a second sacrum, from Dry

Sandford, is in the Museum of the Geological Society; and a portion of a third sacrum (T. II and III), from the Wealden formation, is 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 vertebræ, 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 (249, ed. iv, 1836), in which Dr. Buckland's figure is reproduced as a "Suite de cinq vertèbres de Mégalosaurus" (p. 23). In truth, the sacrum was not known to be represented, at that time, in any Saurian by more than two vertebræ, 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 vertebræ."†

In contemplating this series of five anchylosed vertebræ, so new in Saurian anatomy, at the period of preparing, in 1840, the 'Report on British Fossil Reptiles,' for the British Association, my attention was first arrested by the singular position of the foramina (T. I, *f, f, f*) for the transmission of the nerves from the inclosed spinal marrow. These holes, which, in the plate illustrating Dr. Buckland's important Memoir, are represented above the bodies of the three middle vertebræ, are natural and are 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 existing Saurians is at the interspace of two vertebræ, 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, *i*, a thick and strong imperforate mass of bone, *p, d*, ascends to the neural platform, *d*, 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 vertebræ in the different classes of Vertebrata soon enabled me to recognise the peculiar condition and analogies of the five anchylosed vertebræ 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, pleurapophyses, or "vertebral ribs," the inferior laminæ or hæmapophyses, the superior laminæ or neurapophyses, are all subject to such changes; but the neurapophyses are much more constant in their place of attachment than the

* 'Transactions of the Geological Society,' 2d ser., vol. i, pl. 42. † Ib., p. 395.

other elements. In Mammals, 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 hæmapophyses depend, each pair from its proper centrum: in most other reptiles and mammals they are articulated to the interspace of two vertebræ, 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 Mammals I know of no exception to the rule, that each neural arch is supported by a single centrum: among reptiles the Chelonia* offer in those vertebræ 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 neurapophyses 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 vertebræ, 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 vertebræ of the Megalosaur retain the distinguishing characters which have been recognised in the dorsal and caudal vertebræ, 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, *c*; their expanded, thickened, and rounded articular margins, *i*; and also, though in a somewhat less degree, their relative length as compared with their breadth and height. The three anterior sacrals, T. I, 1, 2, 3, are, however, somewhat shorter than the two posterior ones, 4 and 5.

The following are the dimensions of the fifth sacral vertebra:

	In.	Lines.
Antero-posterior diameter of centrum	4	10
Vertical diameter of articular and of centrum	4	1
Transverse diameter of the same part	4	6
Vertical diameter of the middle of the centrum	2	6
Total height of the fourth sacral vertebra	11	0

* Cuvier describes the exceptional structure above alluded to in these reptiles, and likewise cites the Chondropterygians, 'Leçons d'Anat. Comparée,' ed. 1836, tom. i, p. 213.

† 'On the Nature of Limbs,' 8vo, 1849, p. 61, fig. 10.

The neural arches of the first three sacral vertebræ, *ns* 1, 2, 3, have been advanced so as to rest directly over the interspaces of the subjacent bodies; that of the fourth, *ns* 4, derives a greater proportion of its support from its proper centrum, *c* 4; 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 vertebræ the ordinary relations of the neural arch and centrum are again resumed. In the first four sacral vertebræ the base of the neural arch extends half way down the interspace between the bodies, and immediately developes from its outer part a strong and short transverse process, or parapophysis, *p*, which is 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 neurapophyses, and terminates above in a ridge of bone, *d*, *d*, at right angles to the suture; this ridge, with those of the other neurapophyses, extends longitudinally above the parapophyses the whole length of the sacrum, and forms the margin of the platform from which the spinous and accessory processes are developed: in the last sacrum the corresponding part forms a thick, obtuse process, or diapophysis, *d*, 5. The platform is further supported by a compressed ridge of bone extended from the upper part of the parapophyses, 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 vertebræ, immediately from the platform, but a shorter, vertical plate of bone, a metapophyses, *m*, 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 metapophyses in the third sacral vertebra is three inches and a half; they incline obliquely outwards, like the metapophyses in the dorso-lumbar vertebræ of the armadillos, and evidently tend to strengthen the connection between the sacral part of the trunk, and the pelvic base of articulation of the hind limbs. The spinous process begins to expand longitudinally, and when nearly opposite the summit of the metapophyses, 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 first four vertebræ; 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, the diapophysis, *d*, of the fifth anchylosed vertebra, resumes its more ordinary shape, and it is supported by two converging ridges of bone from the side of the neural arch below. The origin of the metapophysis, *p*, of the first sacral is placed higher than in 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 remaining vertebræ in this specimen are characterised 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, as in the Oxford specimen. The length of this series is one foot six inches and a half; the second and third sacral vertebræ are rather shorter than the rest. The first sacral vertebra, which was not anchylosed to the last lumbar, gives the following dimensions:—

	In.	Lines.
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 coextensive in length with the centrum, but rests on its anterior three fourths. A strong and short parapophysis 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 inch and a half. In the second sacral vertebra the neural arch has moved forward upon the interspace between the first and second sacral bodies, and developes from the lower part of its base a stronger, thicker, and longer parapophysis, 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 parapophyses 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 vertebræ 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 vertebræ is one inch.

T. II gives a side view of one of the sacral vertebræ, and a great proportion of the next vertebra, of the natural size, from the specimen of a portion of the sacrum of the Megalosaurus in the British Museum. The characteristic shape of the bodies of these vertebræ is better shown in the view of their inferior surface, T. III. But, in one of the vertebræ, *s* 3, the transversely rounded or convex surface begins to be modified into an almost carinate form of that surface. A similar difference of the inferior surface may be noticed in the third and fourth sacral vertebræ of the Iguanodon.*

The terminal articular surface of the last sacral vertebra, which articulates with the first of the caudal series, is shown in fig. 2, T. III.

* Palæontographical Society, 1854, 'Wealden Dinosauria,' Tab. III.

The five sacral vertebræ are not anchylosed in a straight line, but describe a gentle curve, with the concavity downwards; the series of parapophyses, or sacral ribs, forms a curved line in the opposite direction, in consequence of their different positions in the several vertebræ. The summits of the anchylosed spines being truncated, describe a curve almost parallel with that of the under part of the vertebræ.

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 the Iguanodon and 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.

In the caudal vertebræ the parapophyses are suppressed, and the single transverse process is formed by the diapophysis being lengthened out by the anchylosed rudiment of a rib. The hæmal arch was articulated to the lower part of the vertebral interspaces, but chiefly to the anterior vertebra.

Ribs. Tab. IV.

The ribs which, from their size, texture, and colour, as well as from their proximity in the matrix to other more characteristic parts of the Megalosaurus, belong most probably to the same species of reptile as the vertebræ above described, present a double articulation with the vertebral column.

The specimen, fig. 1, from the Stonesfield Oolite, and now preserved in the Museum at Oxford, has a small, almost flattened, obtuse head, *c*, for articulation with a parapophysis; the neck is long, and soon begins rapidly to increase in vertical thickness, being strengthened, also, by a longitudinal ridge on one side. It developes a thick, obtuse tubercle, *t*, larger than the head, for the diapophysis. The body of the rib gradually contracts, with a slight curve, to a point. The length of the body of this floating rib, is little more than twice that of the neck and tubercle, showing that it must have belonged to a hinder cervical or anterior dorsal vertebra.

A second specimen, fig. 2, from the Stonesfield slate, shows a longer body, a neck set on more transversely, and less expanded beneath the tubercle. The upper margin of the neck is sharp; the body of the rib is strengthened by a lateral ridge, and becomes compressed in such a direction that those ridges form its margins towards the lower end; this terminates so as to indicate its having been joined to an abdominal rib.

The upper portion of a rib from a larger specimen of Megalosaurus, and from a more expanded part of the thoracic abdominal cavity, T. IV, fig. 3, formed, with fig. 1, part of the original series of fossil bones, from the Stonesfield slate, described and referred to the Megalosaurus by Dr. Buckland.* It is remarkable, like the corresponding ribs of the Iguanodon,† for the length and strength of the part between the head, *c*, and tubercle, *t*, called the "neck;" but this presents a different form in transverse section, and a different direction from the neck of the rib in the Iguanodon. The outer border of the body of the rib does not expand below the tubercle, *t*, to form the shield-like plate which characterises the larger ribs of the Iguanodon;‡ the entire body of the rib is more slender, or narrower, but is, perhaps, stronger, from being less flattened and more quadrate, in transverse section; it is strengthened by two low lateral ridges. The relative thickness of the dense, compact outer wall of the rib, to the more open cancellous structure of the central part, which forms what might almost be termed a medullary cavity, near the middle of the body of the rib; and the form of the transverse section of the cervix and body of the rib, are shown in T. IV, fig. 3.

Cuvier, in his explanation of the figures introduced into the 'Ossemens Fossiles,' from the original Memoir of Buckland, describes three of the ribs, in the fourth edition (8vo, p. 93) as belonging to "un saurien voisin des crocodiles." It is, in fact, only in the Crocodilian order amongst existing reptiles, that the ribs present a head, neck, and tubercle, coincident with that two-fold articulation with the rest of the vertebra which is associated in the Crocodiles and Gavials with a higher grade of structure of both heart and lungs. The ribs, however, found associated with other parts of the skeleton, including a tooth of the Iguanodon, in the Maidstone quarry of Kentish rag-stone,§ demonstrated that the Crocodilian type of rib was associated with the Dinosaurian modifications of sacrum and limbs in that gigantic reptile: and there can be no reasonable doubt that the like association characterises the skeleton of the Megalosaurus. The minor modifications, above specified, of the huge ribs and fragments of ribs found with portions of jaw, limb-bones, and complex sacrum of answerable magnitude, in the same Oolitic stratum in Oxfordshire relate only to the generic distinctions of the Megalosaurus, as compared with the Iguanodon.

The scapula. Tab. V.

In the Wealden deposits at Stammerham, Sussex, a scapula of the Dinosaurian type, but differing from the known scapulæ of the Iguanodon and Hylæosaurus, has been discovered by G. B. Holmes, Esq., of the neighbouring town of Horsham, by whom I have been favoured with the drawing lithographed in T. V.

As remains of the Megalosaurus have been obtained from the same locality, some of

* Tom. cit., pl. 43, fig. 1.

† Palæontographical Society, 'Monograph of Wealden Reptiles,' No. 2, 1854, Tab. II.

‡ Tab. cit., figs. 1 and 2.

§ 'Palæontographical Memoirs,' 1851, Tab.

which form part of Mr. Holmes's instructive collection, it is possible that the blade-bone in question may belong to that genus; but I insert the description of it here with a full sense of the inadequacy of our present evidence for the precise determination of the scapula of the Megalosaurus.

The body of the bone is an oblong flattened plate, proportionally broader and shorter than in the Iguanodon; with the base rounded, not truncate as in the Hylæosaurus; and with the anterior border at first, as it descends, straight and then concave, not convex, as in the Hylæosaurus. The body of the scapula slightly decreases in breadth as it approaches the articular end, near which there is continued from the anterior border a long and slender process, at least three fourths the length of the entire bone, but the precise proportions of which cannot be determined in this specimen, because the extremity of the process is broken off. Near the base of the process a tuberous projection is developed, which touches the anterior angle of the articular end of the scapula, circumscribing an elliptical vacuity probably for the transmission of vessels. The thickened articular extremity shows indications of a division into two surfaces, one for the coracoid, the other for the humerus.

The coracoid. Tab. VI.

The coracoid is a long and large semioval plate of bone, 2 feet 6 inches in length, 1 foot 4 inches in greatest breadth; with the inner (mesial) border thin and regularly but very slightly convex, the upper border thin and strongly convex, the outer (lateral) border thick and made irregular by the development of processes, grooves, and articular surfaces. The latter are two in number: the largest and deepest, fig. 1, *o*, *l*, for the head of the humerus, the smallest and shallowest, *o*, *o*, for junction with the scapula.

This surface, which is hollowed out, groove-wise, chiefly in one direction, is supported by a very strong, thick, three-sided process, *n*, *o*, a little expanded towards its free end, and contributing by its hinder surface, *o'* to the formation of the glenoid cavity, in front of which it projects to meet the blade-bone. The length of this process is about 6 inches: its circumference is 13 inches; the length of the scapular articular surface, fig. 2, *o*, is 6 inches. A deep oblique notch, fig. 1, *n*, divides the scapular process, *o*, from the thin anterior part of the coracoid, *c*, *s*, the convex border of which is entire.

In some existing Lacertians, *e*, *g*, the Monitor and Iguana, a second process is sent off from this part, for articulation through the medium of an epicoracoid cartilage with the episternum; and the mutilated state of the first-discovered specimen of coracoid of the Megalosaurus, figured by Dr. Buckland in pl. xliii, fig. 3, vol. i, 2d series of the

'Geological Transactions,' produced a similar appearance, and led to the belief that the Megalosaurus resembled those Lacertians, in having both the scapular and episternal processes of the coracoid.

Not fewer than three entire or almost entire coracoids of the Megalosaurus have since been obtained, and are now in the British Museum, two of which show the true contour of the anterior part of the bone, as represented in T. VI, fig. 1, *c, s.* The Megalosaurus, therefore, resembled the Scincoid Lizards and the Crocodiles, in having only the scapular process in its coracoid; approaching, however, to those Lizards and the Lacertians generally in the great breadth of the bone, but more resembling the Crocodiles in the greater development of the scapular process as compared with that in the Scincoids. The glenoid cavity of the coracoid of the Megalosaurus, T. VI, fig. 2, *m*, is deeper and larger than in recent Saurians, or than in the Iguanodon. The longitudinal diameter of its outlet is 8 inches in the largest of the three coracoids (purchased by the British Museum of Mr. Stone, from Stonesfield); the greatest transverse diameter of the cavity is 4 inches 4 lines: the internal (central) border of the cavity is moderately sharp and entire; the external (peripheral) border becomes thicker as it recedes from the scapular process, and ends abruptly in an oblong tuberosity; the rest of the outer border beyond this part is thick and rounded, and is continued upon the obtuse process, *l*, forming the hinder boundary of the cavity. This process projects beyond the sharp, almost straight, outer border of the hinder part of the coracoid, which terminates in the hinder angle of the bone.

A strong ridge, like the spine of a scapula, begins to rise from the outer surface of the coracoid, about four inches behind the tubercular termination of the fore and outer part of the glenoid border: it is, at first, thick and rounded, but gradually becomes thinner and more prominent, and is bent outwards and backwards, rapidly subsiding near the hinder angle of the coracoid, and forming the external wall of a wide and deep groove; the internal wall of which is formed by the proper outer and hinder border of the coracoid, fig. 2, *l*. The large proportion of the exterior surface of the coracoid between this process and the anterior border of the bone is slightly concave; the opposite or inner surface being in a less degree convex, or nearly flat. Except a low thick ridge extending from within about four inches of the glenoid cavity to near the lower angle, enlarging as it approaches thereto, the inner surface, fig. 1, is even and almost smooth. Coarse striæ radiate from the articular part of the coracoid to its free expanded border. There is no foramen in any part of the coracoid; none certainly at the base of the scapular process or between this and the glenoid cavity, where such perforation, Cuvier states, may be found in all existing Lizards. If the scapula, T. V, above described should actually belong to the Megalosaurus, the notch or foramen at *e*, fig. 1, may fulfil the function of that which, in the Iguanodon, exists in the coracoid itself.

The clavicle. Tab. IV, fig. 4.

A slender sigmoid bone, nearly two feet in length, from the Stonesfield slate, now in the Geological Museum at Oxford, T. IV, fig. 4, was referred, by the discoverer of the *Megalosaurus*, to that species,* from its resemblance to the clavicle in certain Lizards, especially, as Cuvier remarks, who concurs in this determination with Buckland, to the clavicle of the great scincoid Lizard.† It is, however, less bent upon itself than in that existing Saurian, and bears a closer resemblance to the clavicle of the *Iguanodon*.‡ The more expanded median or pectoral extremity of the bone in question has one margin fractured, that which corresponds with the margin from which the two processes are developed in the clavicle of the Iguanodon: how far, therefore, the Megalosaurus resembled the Iguanodon in the form or even existence of those processes cannot at present be determined. The shaft of the clavicle presents a similar gentle sigmoid curve, but is relatively thicker and more bent than in the Iguanodon; its transverse section is subtrihedral: the outer or scapular end is more expanded; the sternal end is more rounded or convex. With respect to the present bone, Cuvier has remarked that according to the proportions of the clavicle in existing Lizards, it bespeaks an animal nearly sixty feet in length,§ but the proportions of the trunk to the limb-bones alter with the increasing bulk in different species of the same family or order, and we shall presently show that there are surer grounds for arriving at the true bulk of the Megalosaurus, than the comparison of its limb-bones with those the small existing Lizards affords.

The ischium. Tab. IV, fig. 5.

The subcompressed, three-sided bone, flattened and expanded at one end, thickened and less expanded at the opposite end, which formed part of a large cotyloid cavity, has most claims to be regarded as the ischium of the Megalosaurus. This bone, now in the Geological Museum at Oxford, formed part of the original series obtained from the Oolitic slate at Stonesfield, and described by Dr. Buckland.||

The longest diameter of the bone is 18 inches; the breadth of the almost straight, thin, mesial border, is about 14 inches, but the angles are somewhat mutilated; the narrow even flattened surface of this border appears to have joined, probably with some interposed fibro-cartilaginous matter, to the corresponding margin of the opposite ischium.

* Buckland, loc. cit., pl. 44, figs. 3 and 4.

† 'Ossemens Fossiles,' 4to, tom. v. pt. ii, p. 347.

‡ Palæontographical Society, vol. for 1851, 'Reptilia of the Chalk,' Tab. XXXIII; and vol. for 1854, p. 33.

§ 'Ossemens Fossiles,' p. 348.

|| Loc. cit., p. 427, pl. 43, fig. 4.

The femur. Tabs. VII and VIII.

The fine specimen of this bone, 32 inches in length, of which two views are given in T. VII, was discovered in the Oolitic slate at Stonesfield, originally formed part of the rich collection of Fossil Remains belonging to the Earl of Enniskillen, F.R.S., and has recently been transferred, with other parts of the Megalosaurus, from the same collection to the British Museum.

The head is subhemispheric, with the lower margin more freely projecting over or beyond the under part of the neck than appears to have been the case in the Iguanodon.* Viewed from behind, as in fig. 1, or in front, the head of the femur appears to be the convex termination or production of the somewhat expanded and posteriorly flattened upper end of the shaft; but, viewed from the inner side, where the great trochanter, *c*, is seen relieved from the shaft of the bone, the head of the femur has the appearance of being supported by a long and oblique neck, more slender than the shaft. The great trochanter is broad but not much produced, being, as it were, somewhat crushed down upon the shaft. The well-marked groove defining its upper part from the neck, reminds one of that which defines the same part of the upper trochanter in the Iguanodon; but the fissure is narrower and deeper in that Dinosaur than in the present genus. The inner trochanter, T. VII, *d*, is situated higher up, and is less produced than in the Iguanodon: it has also a broader base, which is extended further upon the hinder surface of the shaft of the femur. I have not seen any femora of the Megalosaurus in which the two trochanters were so nearly opposite one another, as is represented in the figures of that bone given in Dr. Buckland's original Memoir: the upper end of the specimen from which that figure was taken, had been more mutilated than in the original of the figures in T. VII. Below the inner trochanter the shaft of the femur assumes a subquadrate transverse section, with the angles rounded; and, near the lower end, begins to expand into the condyles. The anterior or rotular interspace, T. VIII, *g*, is much less deep, and is broader than in the Iguanodon; the posterior or popliteal interspace, *ib. h*, more resembles in size and depth that in the Iguanodon, but it is more flattened at the bottom. The outer condyle, fig. 1, *f*, has a moderately deep and wide longitudinal impression externally, which marks off the hinder projecting part of the condyle, which is relatively narrower than in the Iguanodon; the inner condyle, *e*, which is the largest and most prominent of the two, is almost flat upon its inner side. The figure, of the natural size, of the distal condyles, in T. VIII, taken from the best preserved specimen of the femur of the Megalosaurus in the British Museum will serve better than verbal description to convey a just idea of the modifications of this articular end of the bone in question.

* See T. XV, 'Monogr. Wealden Reptilia,' 1854, fig. 1.

The Tibia. Tab. IX.

The specimen, from which the reduced figures have been taken in the above plate, is the most perfect one of the tibia of the Megalosaurus which has hitherto come under my notice: it originally formed part of the collection of Megalosaurian remains from the Stonesfield slate, acquired by the Earl of Enniskillen, whilst an undergraduate at Oxford, and is now in the British Museum.

Fig. 1 gives a side view of the bone, with a top view of the upper articular surface. The divisions corresponding with the condyles of the femur project from the back part of the proximal end, which gradually contracts towards the fore-part where it assumes the character of a process, answering to the procnemial ridge in the tibia of birds, but it is a little inclined inward. The articular surface is a little concave at its middle part and becomes convex, in a moderate degree, upon the condyles. A thick cartilage appears to have covered the whole of this surface, and the softer bone in contact with the cartilage has been, as in most fossil reptilian long bones, more or less abraded, especially at the margins of the articulation. The backward position and production of the corresponding articular prominences or condyles in both femur and tibia, indicate that these bones were joined together at an angle, probably approaching a right one, when in their intermediate state between flexion and extension: and that motion of the tibia in the latter direction could not have taken place to the extent required to bring the two bones in the same line. A moderately developed longitudinal ridge, fig. 2, *c*, extends from the inner side of the upper fourth of the shaft of the tibia, the homologue of which is present in the tibia of the great Monitor. Below this the shaft of the tibia assumes a sub-trihedral figure, with the angles unequally rounded off, fig. 3; it very gradually decreases in breadth, from before backwards, to within a short distance of the lower end: the transverse diameter remains the same. The expansion of the lower articular end is chiefly in the latter direction, *i. e.*, at right angles with the long diameter of the proximal end: the inner angle of the distal end is the most produced. The form of the articular surface for the tarsus is a rhomboid, with two shallow depressions, but in the main is moderately convex.

The length of the bone above described is 26 inches: its shaft, like that of the femur, has a medullary cavity, but the compact walls are relatively thicker in the tibia.

The above-described bone, from the Oolitic slate of Stonesfield, presents all the main Dinosaurian characters, which have been described, in a preceding Monograph, in the tibia of the *Iguanodon*.* From that tibia the present bone differs in its

* Monog. cit., p. 39.

greater relative slenderness and its better developed processes, especially the inner, or entocnemial, ridge. The differences are of that degree which might be expected to be found in a limb-bone of another species or genus of large Dinosaurian reptile; and no reptile answering to that character has yet been determined, by fossil remains from the Stonesfield Oolitic slate, except the Megalosaurus. The modifications in question are such, moreover, as accord with the superior energy and activity which a carnivorous reptile like the Megalosaurus might be expected to possess in contrast with the heavier and more bulky herbivorous Iguanodon. There can be no reasonable doubt, therefore, that we have, in the subject of T. IX, the veritable leg-bone or tibia of the Megalosaurus.

Portions of metatarsal bones, most probably from their size and texture, those of the Megalosaurus, have been obtained from the Stonesfield Oolite and Sussex Wealden: one of these is figured by Dr. Buckland in Pl. xlix, fig. 6, of the volume of the 'Geological Transactions' containing his original Memoir on the *Megalosaurus*.

These fossils, however, which I have examined in the Geological Museum at Oxford, do not present sufficiently marked characteristic modifications to render a special description of them serviceable for the identification of future specimens of *Megalosauri*.

Ungual Phalanges. Tab. X.

Both teeth and vertebræ of the Megalosaurus have been discovered in the Wealden strata which contain remains of the Iguanodon and other large reptiles. Besides the claw-bones which, from their broad, obtuse, massive and slightly curved shape, I have referred to the herbivorous Iguanodon, there have been obtained, also from the Wealden, claw-bones which, by their sub-compressed, curved, and sharp-pointed shape indicate a carnivorous reptile; and some of these, by their size, might well belong to the Megalosaurus.

Without, however, the association of such claw-bones with other parts of the limb, recognisably Megalosaurian, a certain conclusion of their nature cannot be arrived at. The probability, however, of this latter type of ungual phalanx being that which the Megalosaurus would exhibit, decides me to give the requisite illustrations of it in the present Monograph.

T. X, figs. 1 and 2, give side views of an ungual phalanx, wanting the tip, and with a portion of matrix attached to the base. The length of this phalanx, if the point be restored according to the pattern of the smaller and better preserved specimen of the same kind, fig. 5, would be between 5 and 6 inches: the depth of the base of the phalanx is 2 inches 9 lines; the extreme breadth of the base being but 1 inch 5 lines.

The articular surface is deeply concave in the vertical direction, indicative of a strong joint and a certain extent of vertical motion, or of retraction and protrusion. Beneath the articular surface is a large rough process or protuberance for the insertion of a powerful flexor tendon. The margin of the articular pulley is slightly raised and roughened, for the attachment of the capsular ligament. The base of the claw-bone is longitudinally striated; the rest of the surface is smooth, and offers the same compact character and colour which are commonly found in the bones of the Megalosauri. On each side of the bone, nearer the lower border, and rather lower down on one side than on the other, is a deep smooth groove, running parallel with the lower concavity of the bone. These grooves indicate the position of the borders of the horny matter of the claw, and also, of the vessels supplying the reproductive matrix of that matter.

A smaller phalanx of the same type with one side imbedded in a block of Wealden sandstone, fig. 5, shows the whole length, and the sharp-pointed termination of the bone supporting the formidable claw.

Both the above-described specimens are in the British Museum.

Mandible and Teeth. Tabs. XI and XII.

The most important evidence of these highly characteristic parts of the Megalosaurus is the portion of the dentary element of the mandible or lower jaw, from the Stonesfield slate, preserved in the Geological Museum at Oxford, and forming part of the original series of bones described by Dr. Buckland.* This specimen is represented, of the natural size, in T. XI, fig. 1, from the inner side: a portion of the outer side of the same specimen is given in fig. 2. The entire depth of the ramus of the jaw is not, however, represented by this specimen: a broad and shallow groove along the under and inner surface of the bone indicates where the angular element of the mandible had articulated with this hinder portion of the dentary piece. The portion of the dentary element from a more advanced part of that bone, represented in T. XII, affords a truer idea of the vertical diameter of the mandibular ramus of the Megalosaur.

The first character which attracts the attention of the anatomist, in the Oxford specimen (T. X), is the inequality in the height of the outer and inner alveolar walls. This assures him of the saurian affinities of the gigantic reptile; a similar inequality characterising the jaws of almost all the existing Lizards. But in these the oblique groove, so bounded, to which the bases of the developed teeth are anchylosed, is much more shallow, and is relatively wider; and the teeth, in all their stages of growth,

* Loc. cit., pl. 40.

are completely exposed, when the gum has been removed. In the Megalosaur the greater relative development of the inner alveolar wall narrows the groove, and covers a greater proportion of the bases of the teeth, besides concealing more or less completely the germs of their successors. Moreover, instead of the mere shallow impressions upon the inner side of the outer alveolar plate, to which the teeth are attached in modern Lizards, there are distinct sockets formed by bony partitions connecting the outer with the inner alveolar walls in the jaw of the Megalosaurus.

These partitions rise from the outer side of the inner alveolar wall in the form of triangular vertical plates of bone, having their plane parallel with that of the inner wall; and from the middle of the outer side of each plate a bony partition crosses to the outer parapet, completing the alveoli of the fully-formed or more advanced teeth, the series of triangular plates, *t*, *t*, fig. 1, forming a kind of zigzag buttress along the inner side of those alveoli. The outer parapet rises an inch higher than the inner one.

Of the fully-developed teeth only one had been preserved *in situ*, in the specimen under description; the others appear rather to have slipped out, than to have been broken off, the anchylosis of the basal capsule of the tooth to the alveolar periosteum being but slight, and apparently taking place tardily in the Megalosaurus.

This tooth, T. XI, fig. 1, *a*, exhibits the average size of the fully developed teeth of the Megalosaurus that have yet been discovered. The shape of the crown is well exemplified in this figure, and in figs. 2, 4, and 5 of T. XII. It is sub-compressed, slightly recurved, sharp-edged and sharp-pointed; the edges being minutely serrated: the edge upon the convex or front border becomes blunted as it descends about two thirds of the way towards the base of the tooth; that upon the concave hinder border it is continued to the base. The lower half of the crown is thicker towards the fore-margin than towards the hind one, so that a transverse section gives a narrow oval form pointed behind, as in the lower section of fig. 5, T. XII: at the upper half of the crown the sides slope more equably from the middle thickest part to both margins, and the section is a narrow pointed ellipse, as in the upper section of the same figure. The crown is covered by a smooth and polished enamel which wholly forms the marginal serrations. The base of the tooth is coated with a smooth lighter-coloured cement, forming a thin layer, and becoming a little thicker towards the implanted end of the tooth. The remains of the pulp are converted into osteodentine in the basal part of the completely formed tooth. Moderately magnified, the surface of the enamel presents a finely wrinkled appearance. The marginal serrations present, under a somewhat higher power, the form shown in fig. 12, T. XI; their points being directed towards the apex of the tooth, a structure well adapted for dividing the tough tissues of the saurian integument. The main body of the tooth consists of dentine, of that hard, unvascular kind of which the same part of the teeth of existing Crocodiles and most mammals is composed. The dentinal tubules, in the Megalosaurus, are extremely fine and close-set, presenting a diameter of $\frac{1}{15000}$th of an inch, with interspaces varying between two and three times that diameter. They radiate from the pulp-cavity at right angles with the external surface of the tooth. The primary curvatures correspond with those of the dentinal tubules in the *Varanus*, figured in my 'Odontography,' pl. 67, fig. 2; but they are less marked, so that the tubules appear straighter in the Megalosaurus. After their origin they dichotomize sparingly, but the number of minute secondary branches sent off into the intermediate substance is very great. These secondary branches proceed at acute angles from the primary tubules; the divisions of the latter become very frequent near the periphery of the dentine, and the terminal branches dilate into, or inosculate with, a stratum of minute calcigerous cells, which separates the dentine from the enamel.* No part of the dentine is pervaded by medullary canals, as in the Iguanodon.

A series of teeth from individual Megalosauri of different ages has been selected from specimens in the British Museum, and in the Geological Museum at Oxford, progressively diminishing in size, but preserving the same characteristic form, from fig. 4 to fig. 9, inclusive, T. XI. Fig. 3 shows a specimen, imbedded in Stonesfield slate, which shows a somewhat more slender termination than usual. Fig. 11 is a much-worn and shed tooth, apparently of a small-sized Megalosaurus, in which both the point and the trenchant margins had been rubbed down to a smooth obtuse surface: it may have come from the hinder part of the dental series, where the teeth may have been smaller and less sharp, or more liable to be blunted by a greater share in the imperfect act of mastication than the teeth in advance.

Successional teeth, in different stages of growth, are shown in the original portion of jaw of the Megalosaurus in the Oxford Museum. Some more advanced, as at *b*, fig. 1, T. XI, show their crowns projecting from alveoli already formed by the plate extending across from the triangular processes before described. Vacant sockets from which fully formed teeth have escaped occur, generally in the intervals between these more advanced teeth. The summits of less developed teeth are seen protruding, as at *c*, *c*, at the inner side of the basal interspaces of the triangular plate, between them and the true internal alveolar parapet. There can be no doubt that, in the course of the development of these teeth, corresponding changes take place in the jaw itself, by which new triangular plates and alveolor partitions are formed, as the old ones become absorbed, analogous to these concomitant changes in the growth and form of the teeth, alveoli, and jaws, which take place in so striking a degree in the Elephant.†

The peculiarity of the Megalosaurus, as compared with the Crocodiles and Lizards

* The microscopic characters of the tooth of the Megalosaurus are represented in my 'Odontography,' pl. 70 A, in part of a transverse section of the middle of the crown, including the pulp-cavity and its osteo-dentine.

† See 'Odontography,' p. 625.

which have a like endless succession of teeth, is the deeper position of the successional tooth in relation to the one it is destined to replace, and the great proportion of the tooth which is formed before it is protruded. This interesting character is well exhibited in a portion of the jaw, kindly submitted to my examination by His Grace the Duke of Marlborough, and which is figured in T. XI, fig. 1. The anterior tooth, *a*, in this specimen, shows, at the inner side of its base, the commencing absorption stimulated by the encroaching capsule of the successional tooth below, the crown of which is completed externally, though not consolidated. On one of the fractured margins of this piece of jaw a part of the basal shell of an absorbed and shed tooth remains at *a*, fig. 3, with part of the root of the successional tooth which has risen into place, *b*; but which shows its base full of matrix, the pulp not having been calcified at that period of the tooth's growth. The crown of a third tooth, *c*, incompletely calcified, is exposed beneath, in the substance of the jaw. In fig. 1, the germs of several successional teeth are shown at *c*. In the proportion of the successional teeth which is calcified in the formative cavity in the substance of the jaw, the Megalosaurus offers a closer resemblance to the Mammalian class than do any of the recent or extinct Crocodilian or Lacertian reptiles. But the evidence of uninterrupted and frequent succession of the teeth in the Megalosaurus is unequivocal, and this part of the dental economy of the great carnivorous Reptile is strictly analogous to that which governs the same system in the existing members of the class. The different forms of the teeth at different stages of protrusion did not fail to attract the attention of the gifted discoverer of the *Megalosaurus*, in whose words I will conclude this part of my Monograph on the most formidable of extinct British Reptiles.

"In the structure of these teeth we find a combination of mechanical contrivances analogous to those which are adopted in the construction of the knife, the sabre, and the saw. When first protruded above the gum, the apex of each tooth presented a double cutting edge of serrated enamel. In this stage, its position and line of action were nearly vertical, and its form, like that of the two-edged point of a sabre, cutting equally on each side. As the tooth advanced in growth it became curved backwards in the form of a pruning-knife, and the edge of serrated enamel was continued downwards to the base of the inner and cutting side of the tooth, whilst on the outer side a similar edge descended but a short distance from the point, and the convex portion of the tooth became blunt and thick, as the back of a knife is made thick for the purpose of producing strength. The strength of the tooth was further increased by the expansion of its side. Had the serrature continued along the whole of the blunt and convex portion of the tooth, it would in this position have possessed no useful cutting power; it ceased precisely at the point beyond which it could no longer be effective. In a tooth thus formed for cutting along its concave edge, each movement of the jaw combined the power of the knife and saw; whilst the apex, in making the first incision, acted like the two-edged point of a sabre. The backward curvature of the full-grown teeth enabled them to retain, like barbs, the prey which they had penetrated. In these adaptations we see contrivances which human ingenuity has also adopted in the preparation of various instruments of art."*

SIZE OF THE MEGALOSAURUS.

A few words 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 vertebræ as the basis. The antero-posterior dimension is the most constant which the vertebræ present throughout the spine: in most Crocodilian and Lacertian reptiles the cervical vertebræ are a little shorter than the dorsal; but these are of equal length, and the caudal vertebræ maintain the same length, though decreasing in other dimensions, to very near the extremity of the tail.

As the dorsal vertebræ 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 vertebræ in Crocodiles, we may allow the Megalosaurus 23 vertebræ of the trunk.

The length of the body of a large dorsal vertebra of the Megalosaurus, in the British Museum, is 4½ inches: from the analogy of the Iguanodon I was led, in my original calculations,† to allow a probable thickness of the intervertebral substance one third of an inch: but if we multiply 23 by 5, not allowing for the probable shortness of the cervical vertebræ, we only then attain a length of 9 feet 7 inches. The subsequent discovery of the coadapted dorsal vertebræ, figured in T. xix, *loc. cit.*, shows that their bodies were not separated by soft substance of more than 1 line in thickness. If, moreover, setting aside the analogy of the Megalosaurus to the Crocodiles in the structure of the vertebræ, we take that species of Lacertian which it most resembles in the structure of the teeth, and found our calculation on the number of vertebræ of the trunk in such Lizard, then, the great carnivorous Varanian Monitor

* Buckland, 'Bridgewater Treatise,' vol. i, p. 237.

† Report on British Fossil Reptiles, 'Trans. Brit. Association,' 1841.

of Java having 27 vertebræ of the trunk, we do not, even calculating the same number of vertebræ 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 more nearly the natural length.

To this we must add 2 feet 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 vertebræ in length. In the Java Monitor the proportion of the head is less. In the Iguana the cranium does not exceed 6 dorsal vertebræ 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 vertebræ 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 vertebræ 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 vertebræ 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,—

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

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.

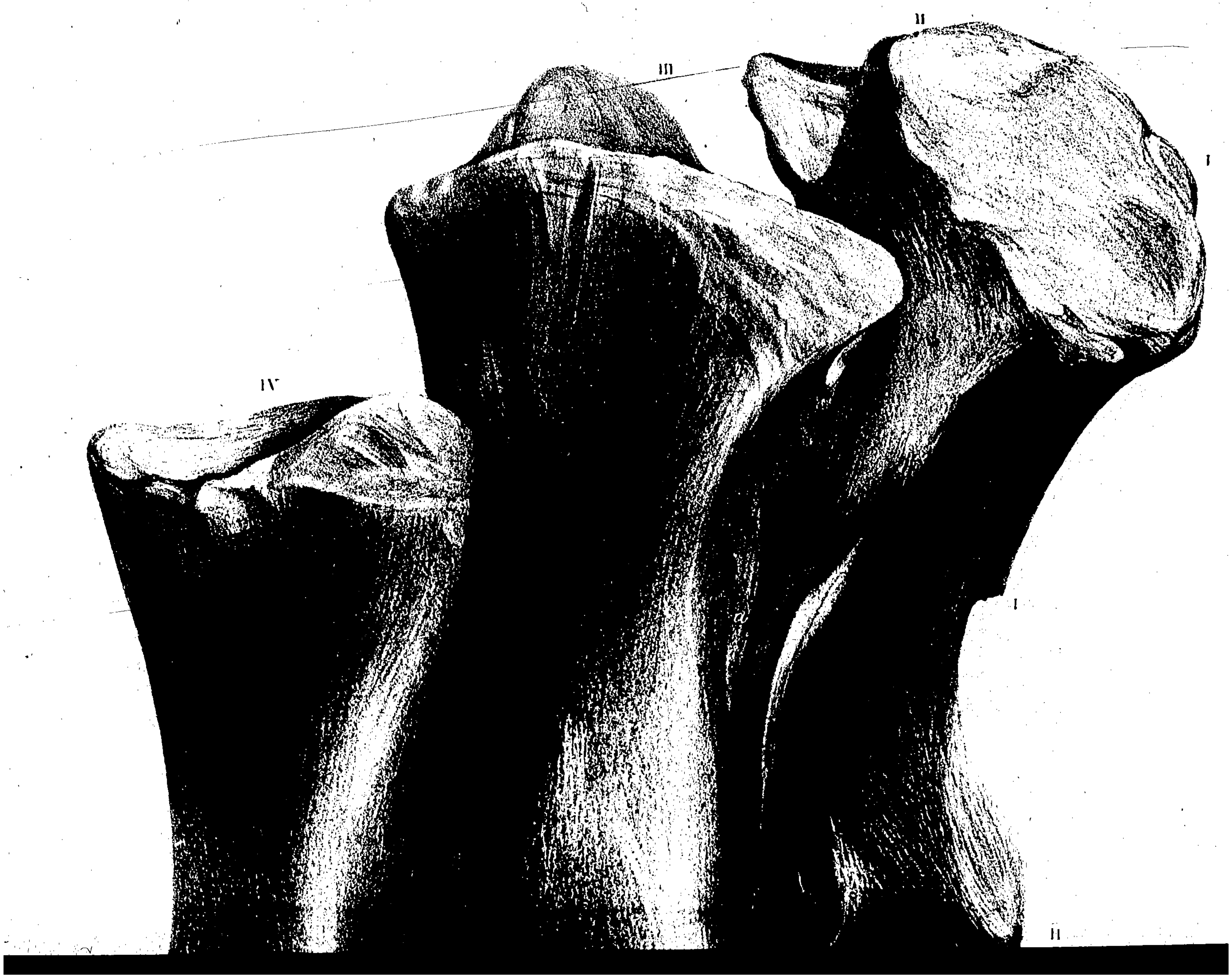
Strata and Localities of Megalosaurian Remains.

Besides the Stonesfield slate, the remains of the Megalosaurus have been found in the Cornbrash and Bath Oolite immediately above that slate, and in Oolites beneath it. A tooth of a Megalosaurus has been kindly communicated to me by Mr. Woodward, of the British Museum, which was found in the Inferior Oolite of Selsly Hill, Gloucestershire, which is separated from the Stonesfield Oolite by superimposed deposits of Fullers' earth one hundred feet in vertical extent. Vertebræ and parts of long bones of the Megalosaurus have been found in the Inferior Oolite at Kingham, near Chipping-Norton, and at Broadwell, near Merke-in-the-Marsh, Gloucestershire. But the formation in which the remains of the Megalosaur occur, in quantity only inferior to those in the Stonesfield slate, is the Wealden strata. Dr. Mantell 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. Some fragments of the metacarpus and metatarsus from this locality, were thicker than those of a large hippopotamus. Many teeth, of the same form as those found by Dr. Buckland, at Stonesfield, have been obtained from Wealden strata. Mr. Holmes, surgeon, at Horsham, possesses a good caudal vertebra, and some other parts of the Megalosaurus from the furruginous sand near Cuckfield, in Sussex. The magnificent specimen of dorsal vertebræ, T. xix, *loc. cit.*, was discovered by Mr. Beckles, F.G.S., in the Wealden formation near Battle. Remains of the Megalosaurus occur in the Purbeck Limestone at Swanage Bay. In some of the private collections in the town in Malton, Yorkshire, are teeth, unquestionably belonging to the same species as the Stonesfield Megalosaurus, from the Oolite in the neighbourhood of that town.

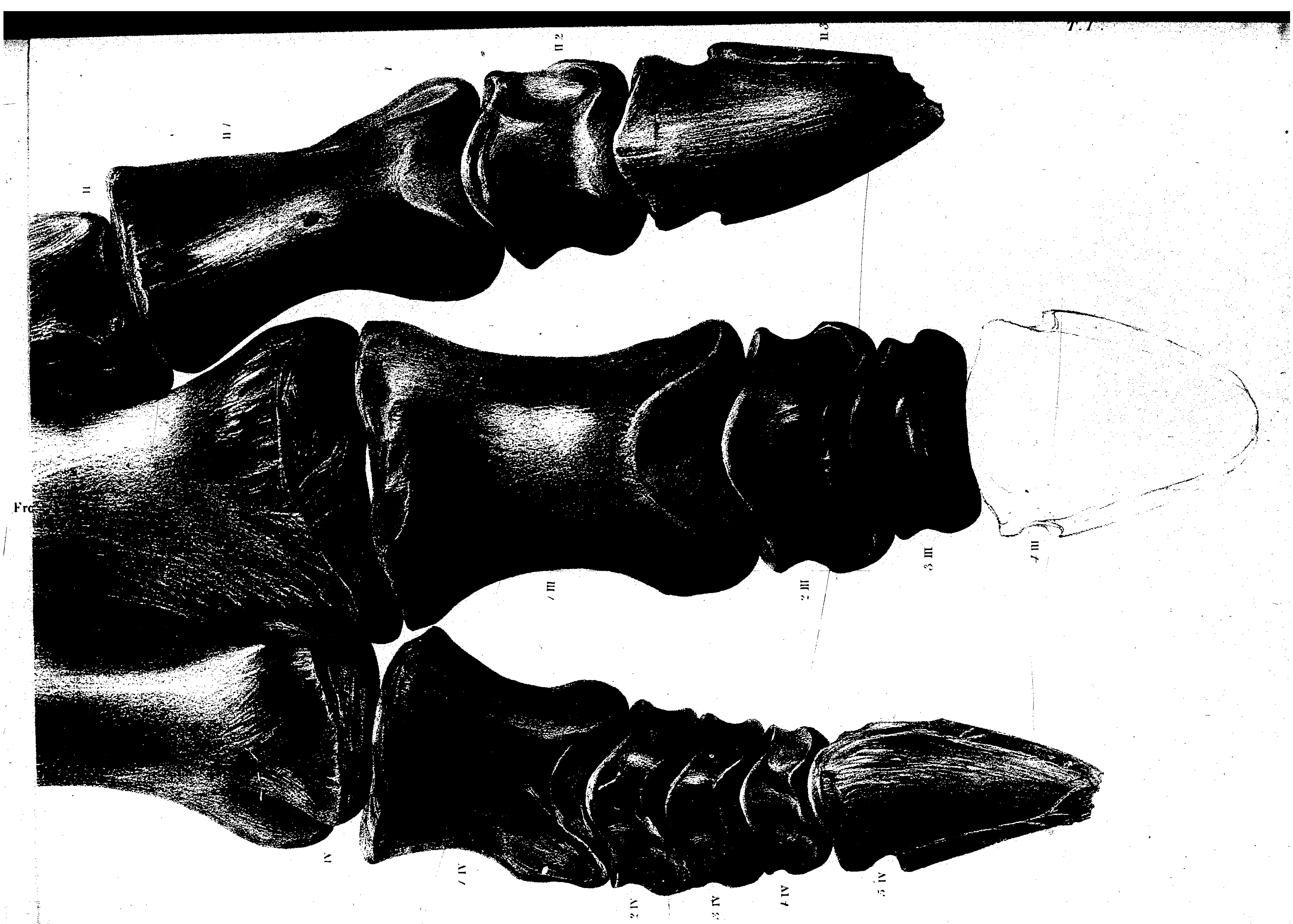
TAB. I.

Foot of a young Iguanodon, upper or front view; nat. size.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.



II
III
I
IV
a
I
II



TAB. II.

Metapodium of a foot of a young Iguanodon, nat. size.

Fig.

1. Proximal articular ends of the three principal bones, II, III, and IV, and of the anchylosed rudimental bone, I.
2. Under or back view of the same bones.
3. Distal articular ends of the three principal bones.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.

Fig.1

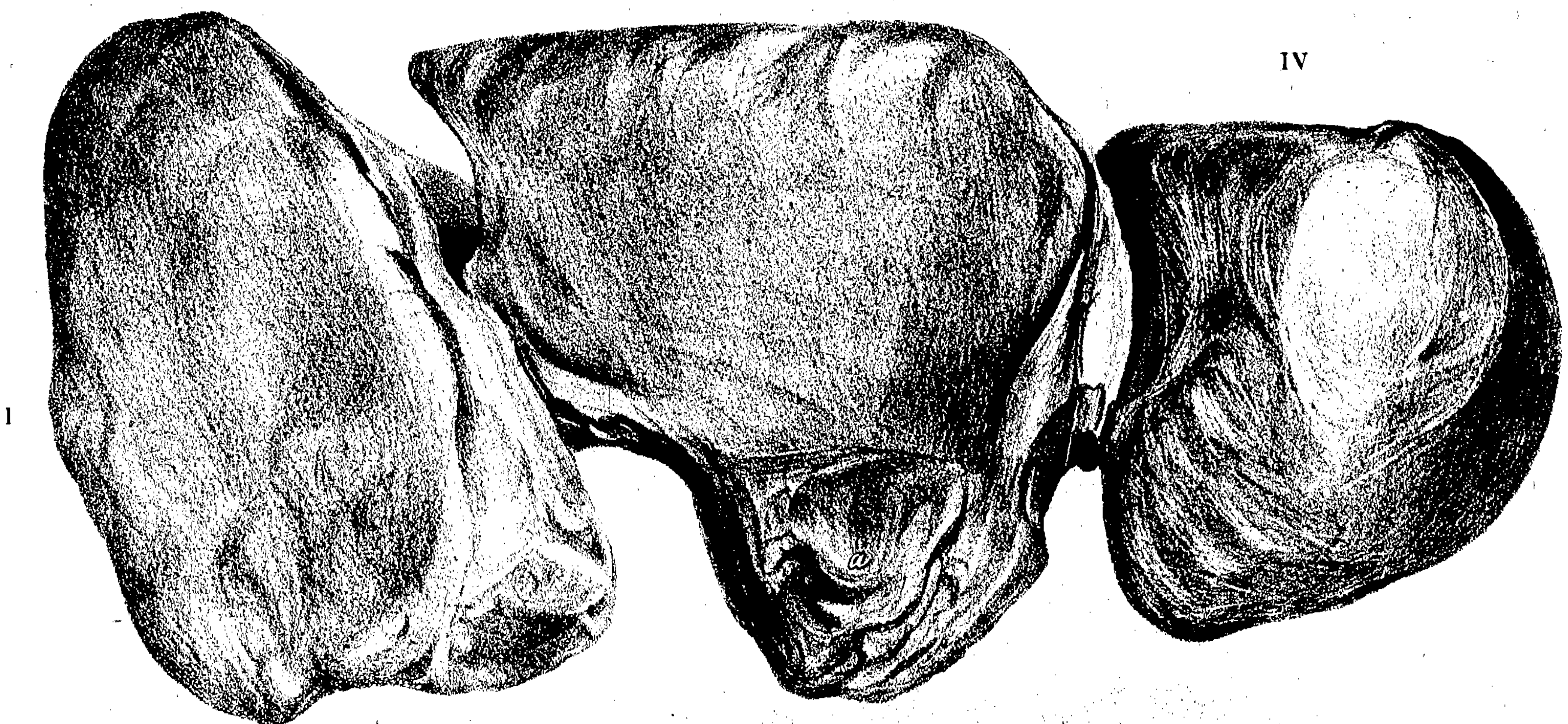
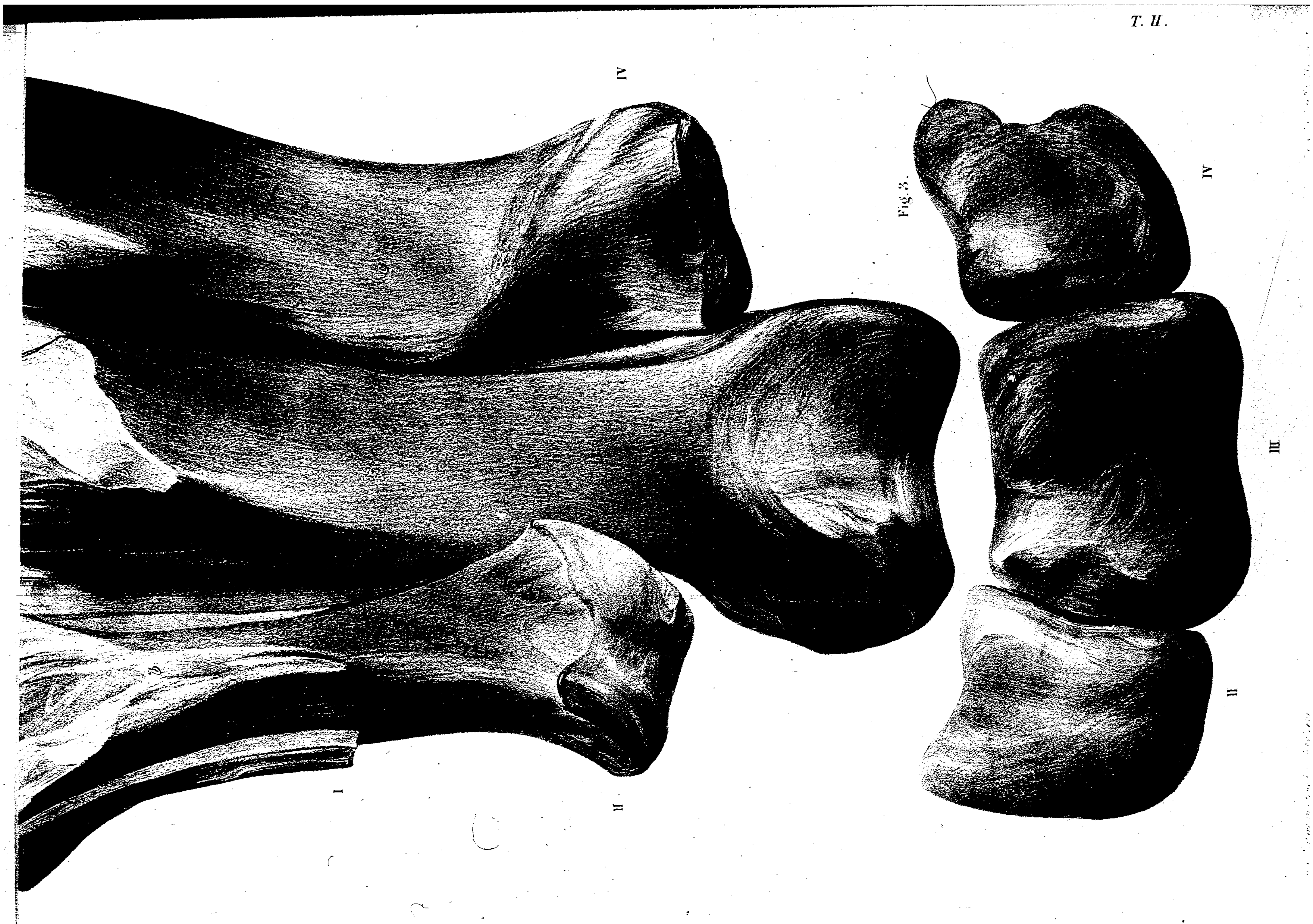


Fig.2.

T. II.



TAB. III.

Parts of the foot of a young Iguanodon, nat. size.

Fig.

1. Inner or tibial side view of the second toe, II, with rudiment of the first, I.
2. Inner or tibial side view of the first, second, and third phalanges of the middle toe.
3. Outer or fibular side view of the fourth or outer toe.

From the submerged Wealden Beds, South Coast, Isle of Wight. In the Museum of Samuel H. Beccles, Esq., F.G.S.

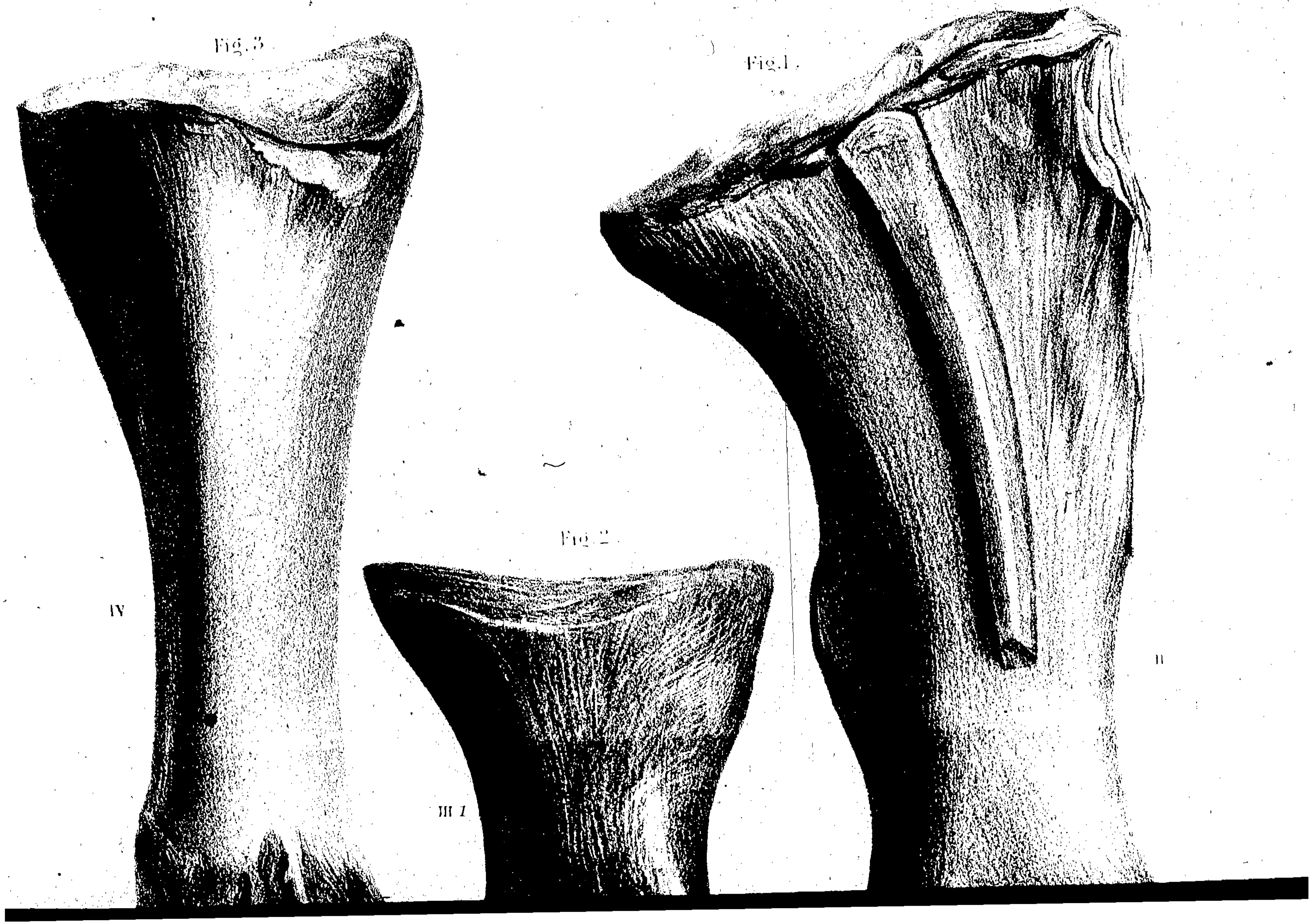


Fig.3
Fig.1.
Fig.2.
IV
III 1
II

T. III.

TAB. IV.

Portion of the skeleton of the Hylæosaurus, one fourth nat. size.

From the Wealden of Tilgate, Sussex. In the British Museum.


4
2
pl 3
10
52
52
51
51

T. IV

TAB. V.

Four anchylosed bodies of sacral vertebræ of a young Hylæosaurus, nat size.

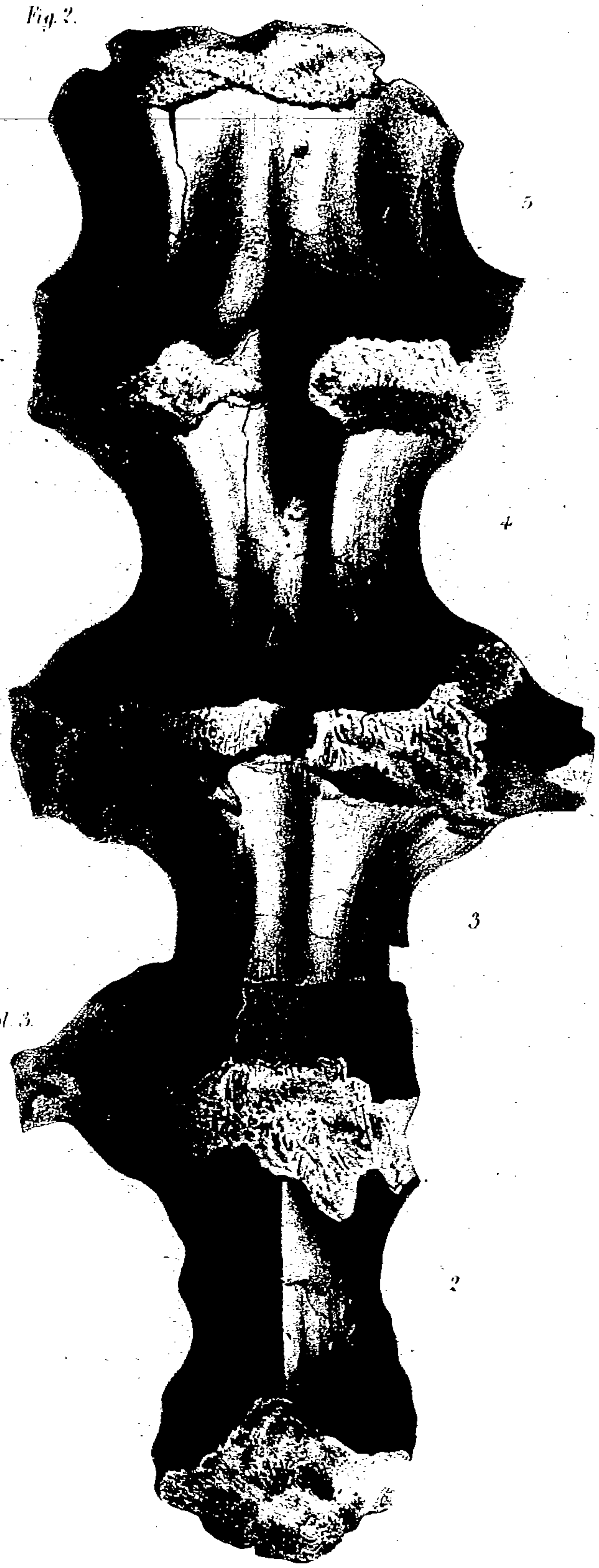
Fig.

1. Oblique side view, showing the expanded neural canal.
2. Under view.

From the Wealden of Tilgate Forest, Sussex. In the Collection of Captain Lambart Brickenden, F.G.S.

Fig 1.

Fig. 2.



Jos Dinkel lith
W West Imp

TAB. VI.

Portions of the sacrum of the Hylæosaurus, half nat. size.

Fig.

1. Under view of the third and fourth, with portions of contiguous anchylosed, sacral vertebræ.

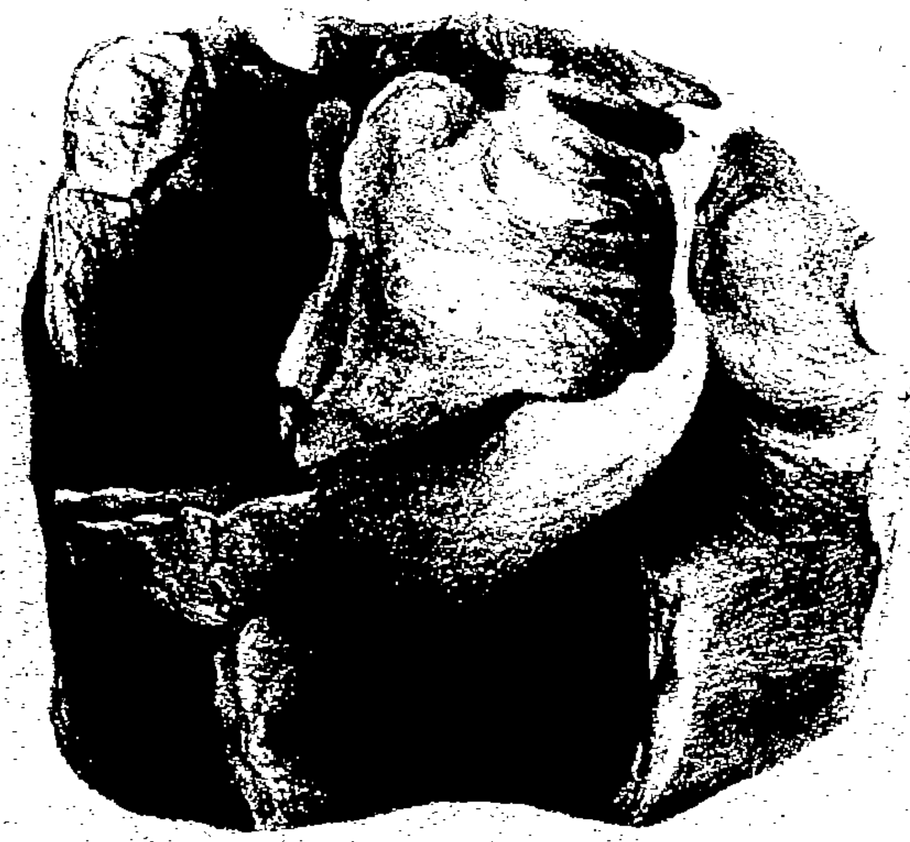
   From the Wealden of Tilgate, Sussex. In the British Museum.

2. Side view.
3. Under view.
4. Upper view of the third, with portions of the second and fourth, sacral vertebræ.

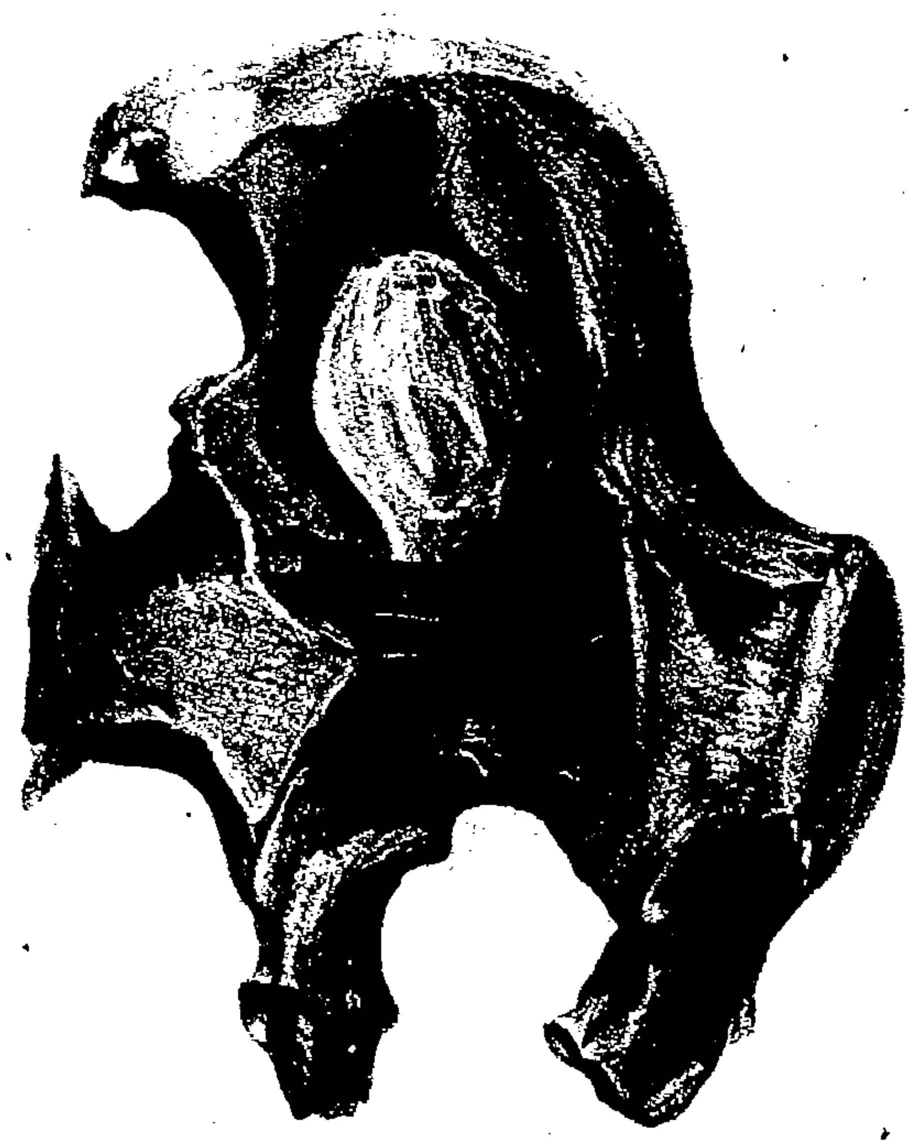
   From the submerged Wealden Beds, South Coast, Isle of Wight. In the British Museum.

1

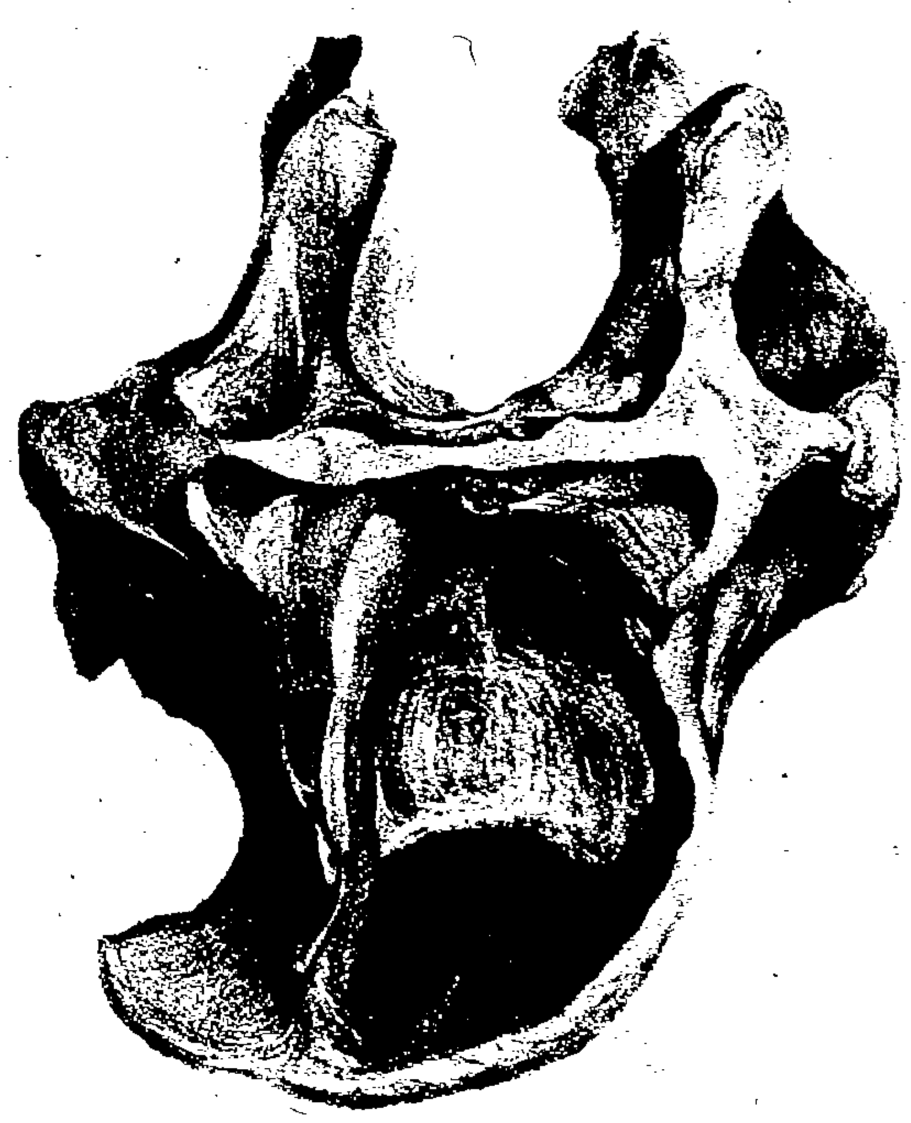
2



3



4



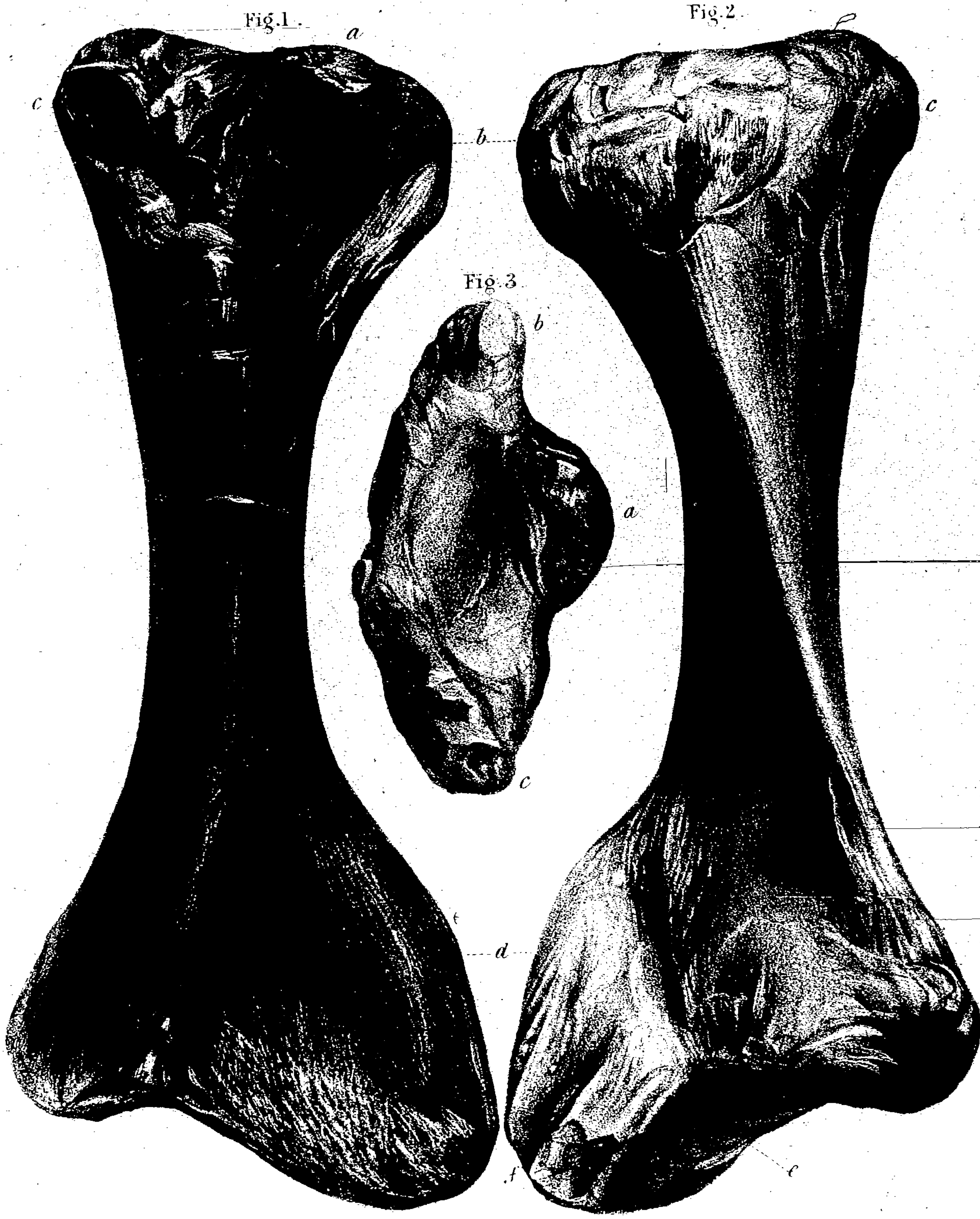
TAB. VII.

Tibia of the Hylæosaurus, half nat. size.

Fig.

1. Inner side view.
2. Outer side view.
3. Upper articular end.

From the Wealden at Bolney, Sussex. In the British Museum.



1/2 Nat. size.

TAB. VIII.

Fig.

1. Outside of a portion of jaw.
2. Inside of the same portion of jaw.
3. Upper view of the same.
4. The hinder fractured end of the same.
5. The fore fractured end of the same.

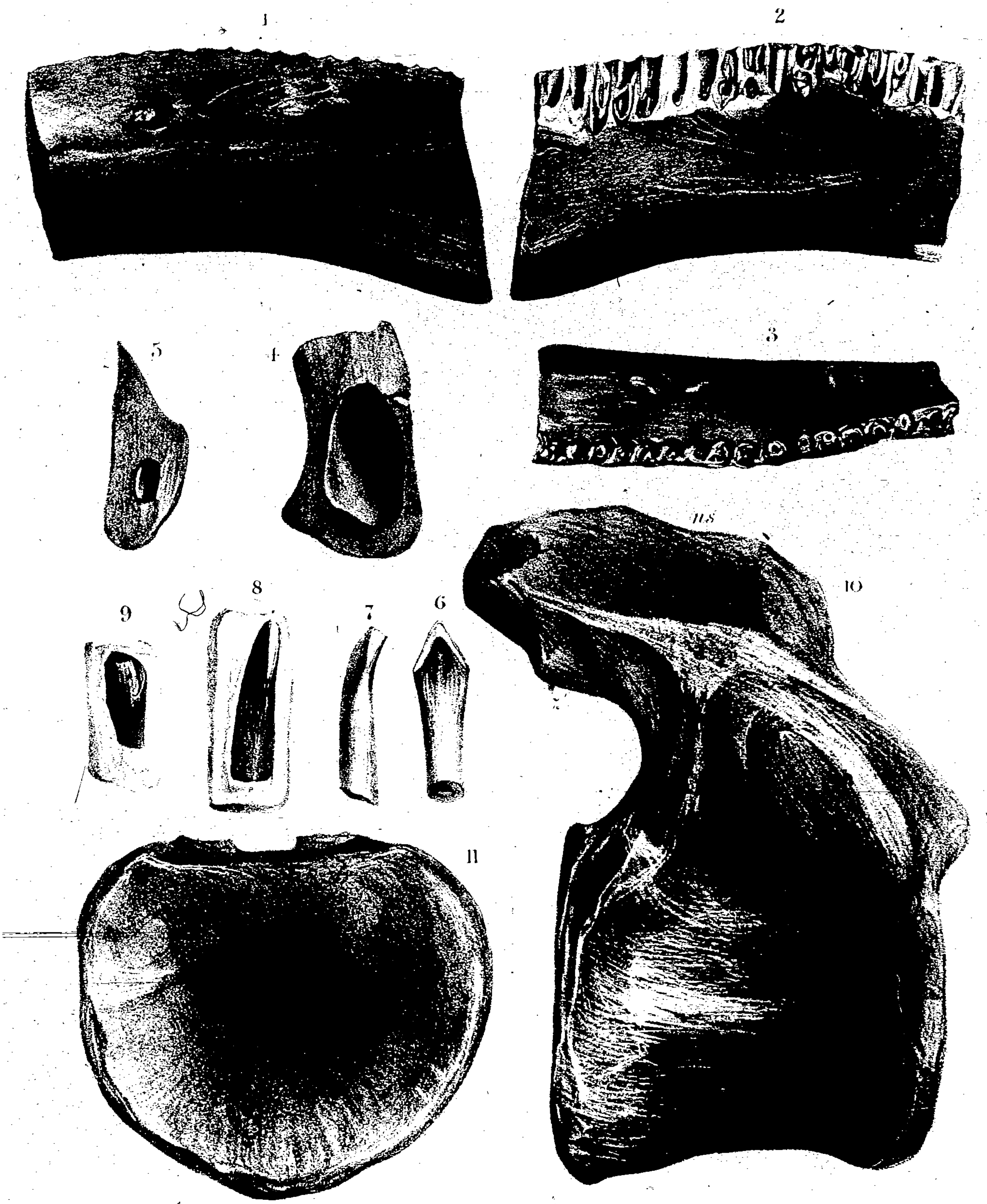
6 and 7. Two views of a tooth.

8. Side view of a tooth, imbedded in Wealden matrix.
9. A portion of a tooth, similarly imbedded.

The above specimens are referred, with probability, to the Hylæosaurus.

10. Side view of a dorsal vertebra of the Hylæosaurus.
11. Articular surface of the body of the same vertebra.

From the Wealden of Tilgate Forest, Sussex. In the British Museum.


1
2
3
4
5
6
7
8
9
10
ns
11

TAB. IX.

The osseous basis of a dermo-neural spine of the Hylæosaurus.

Fig.

1. A section, highly magnified, of the osseous tissue.
2. Hinder border of the spine (reversed).
3. Side view of the spine.

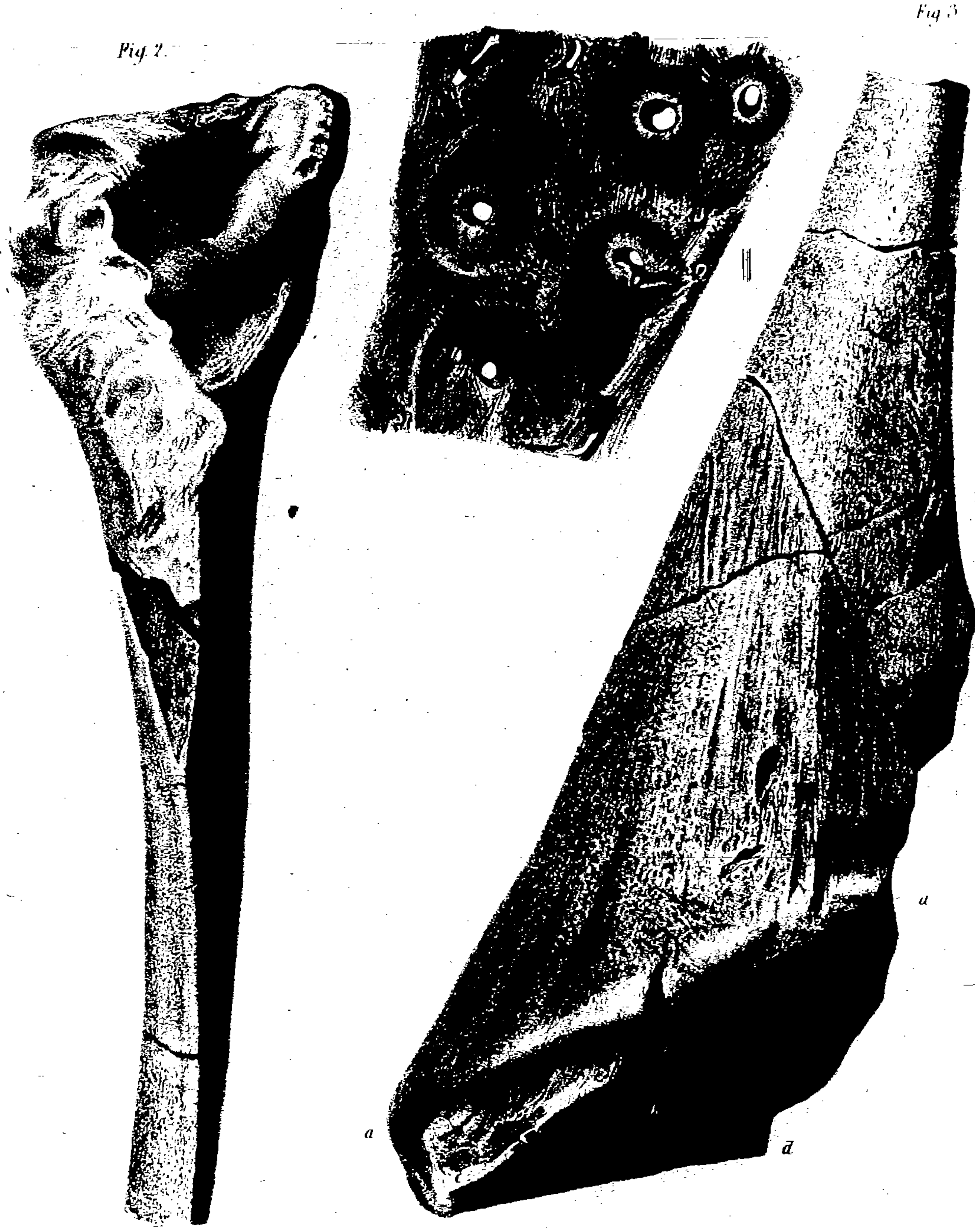
From the Wealden of Tilgate Forest, Sussex. In the British Museum.

T. IX

Fig. 1.

Fig. 2.

Fig. 3



Jos Dinkel lith

TAB. X.

Caudal vertebræ of the Hylæosaurus, one sixth nat. size.

Fig.

1. Ten vertebræ from the base of the tail.
2. Eleven vertebræ from near the end of the tail.
3. Under view of anterior caudal vertebræ, showing the form, and place of articulation, of the hæmapophyses.
4. Back view of a hæmal arch from the same (*h*) region of the tail (half nat. size).
4'. Under view of middle caudal vertebræ, showing the shape of the hæmapophyses, *h*.
5. Side view of a hæmal arch from a middle caudal vertebra (half nat. size).
6. Under view of caudal vertebræ beyond the middle of the tail.
7. Back view of a hæmal arch from one of these vertebræ (half nat. size).

The further modification of the hæmapophyses in the posterior caudal vertebræ is shown in fig. 2.

From the Wealden of Tilgate, Sussex. In the British Museum.

Fig. 1

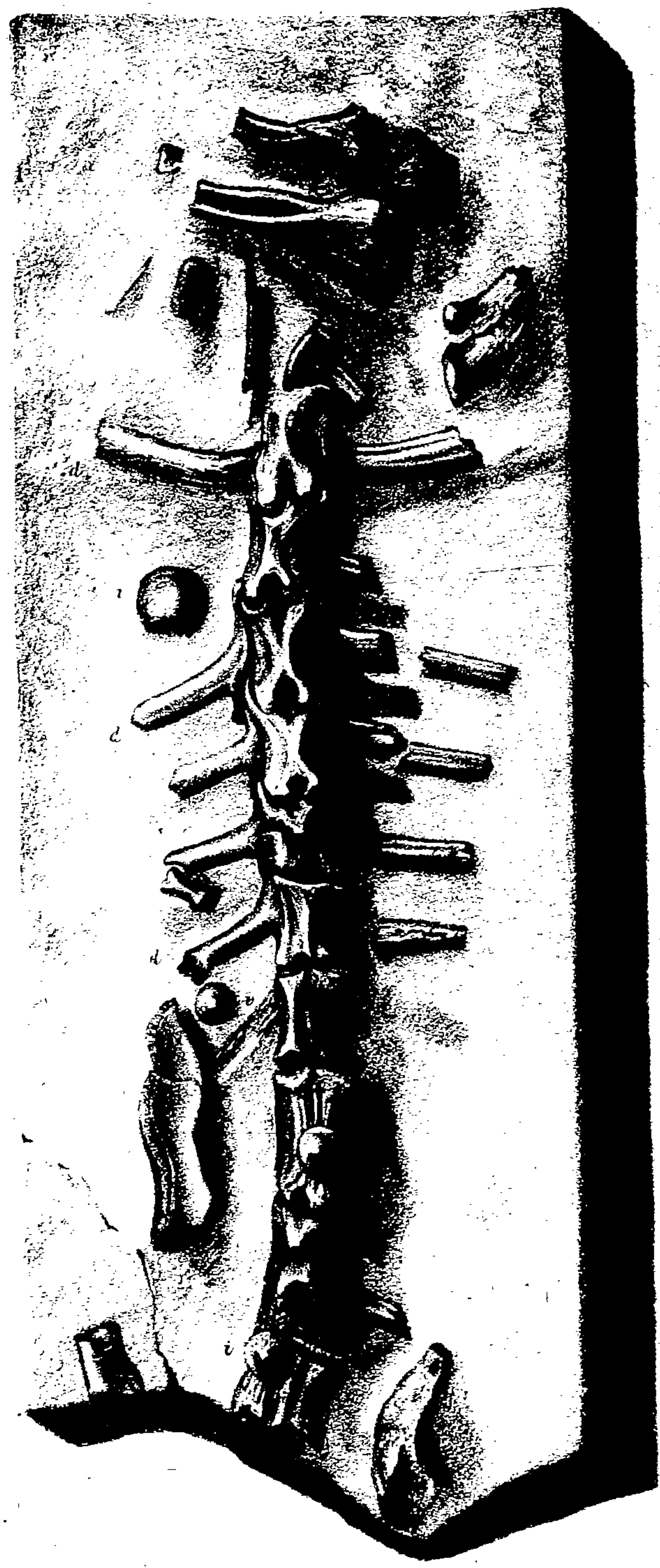


Fig. 2

Fig. 5

Fig. 6

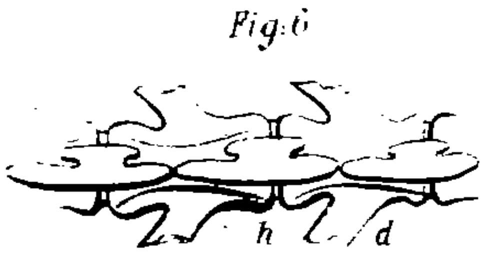


Fig. 7

Fig. 4

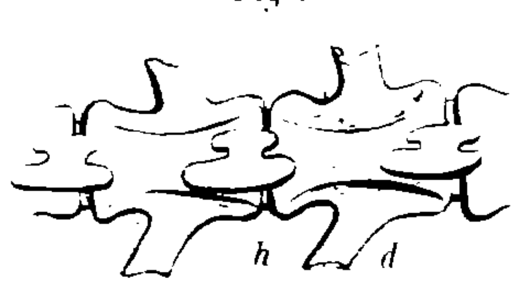
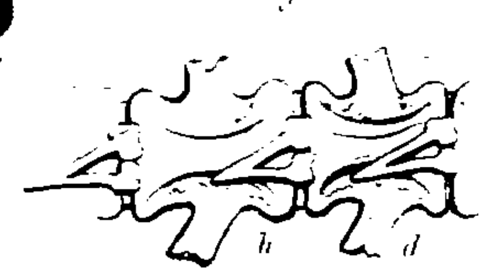


Fig. 4.

Fig. 3



TAB. XI.

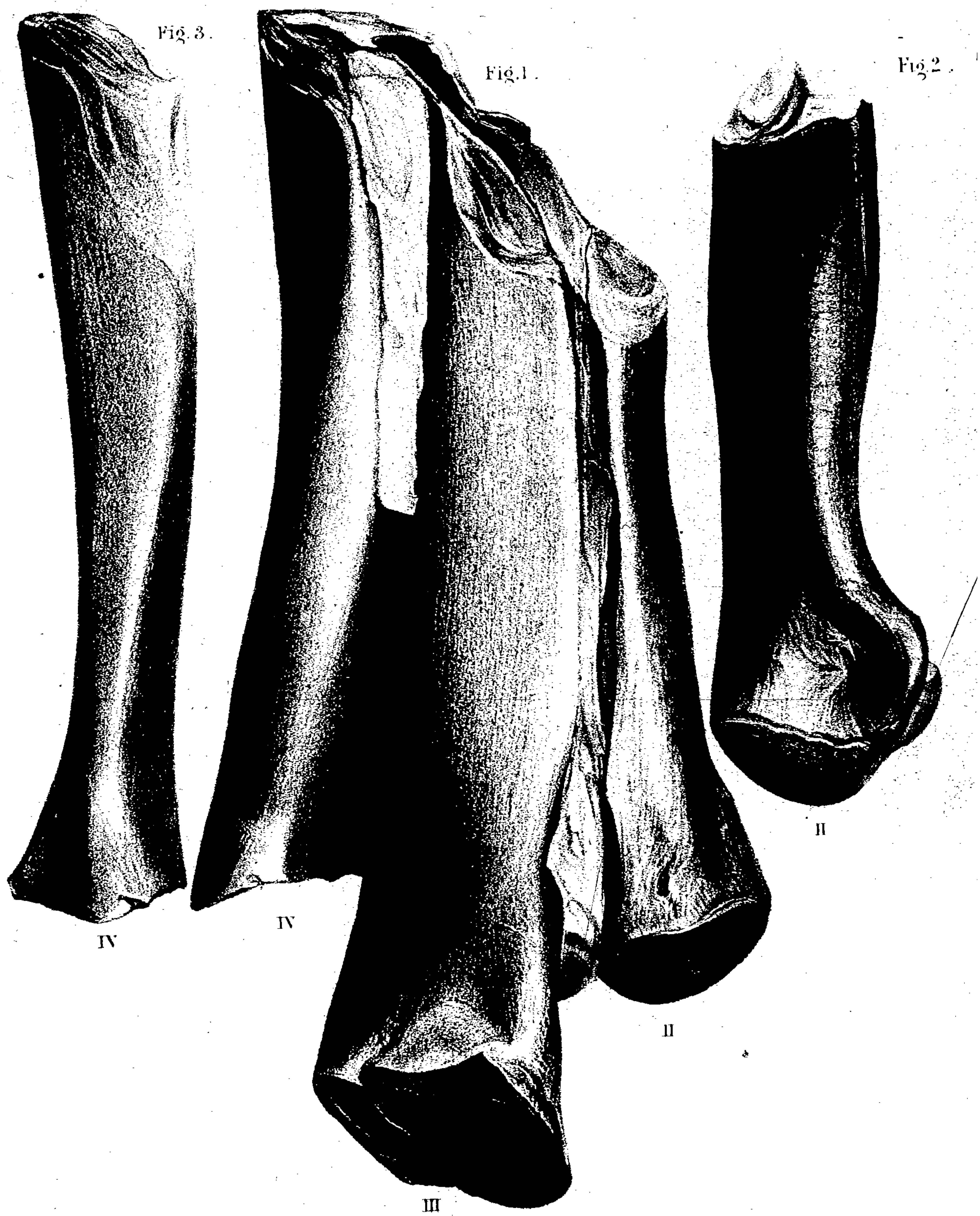
Metapodium of a foot of the Hylæosaurus.

Fig.

1. Front or upper view of the three normally developed metapodials.
2. Tibial side view of the innermost, answering to the second.
3. Fibular side view of the outermost, answering to the fourth.

From the Wealden of Tilgate, Sussex. In the British Museum.

T. XI.



TAB. XII.

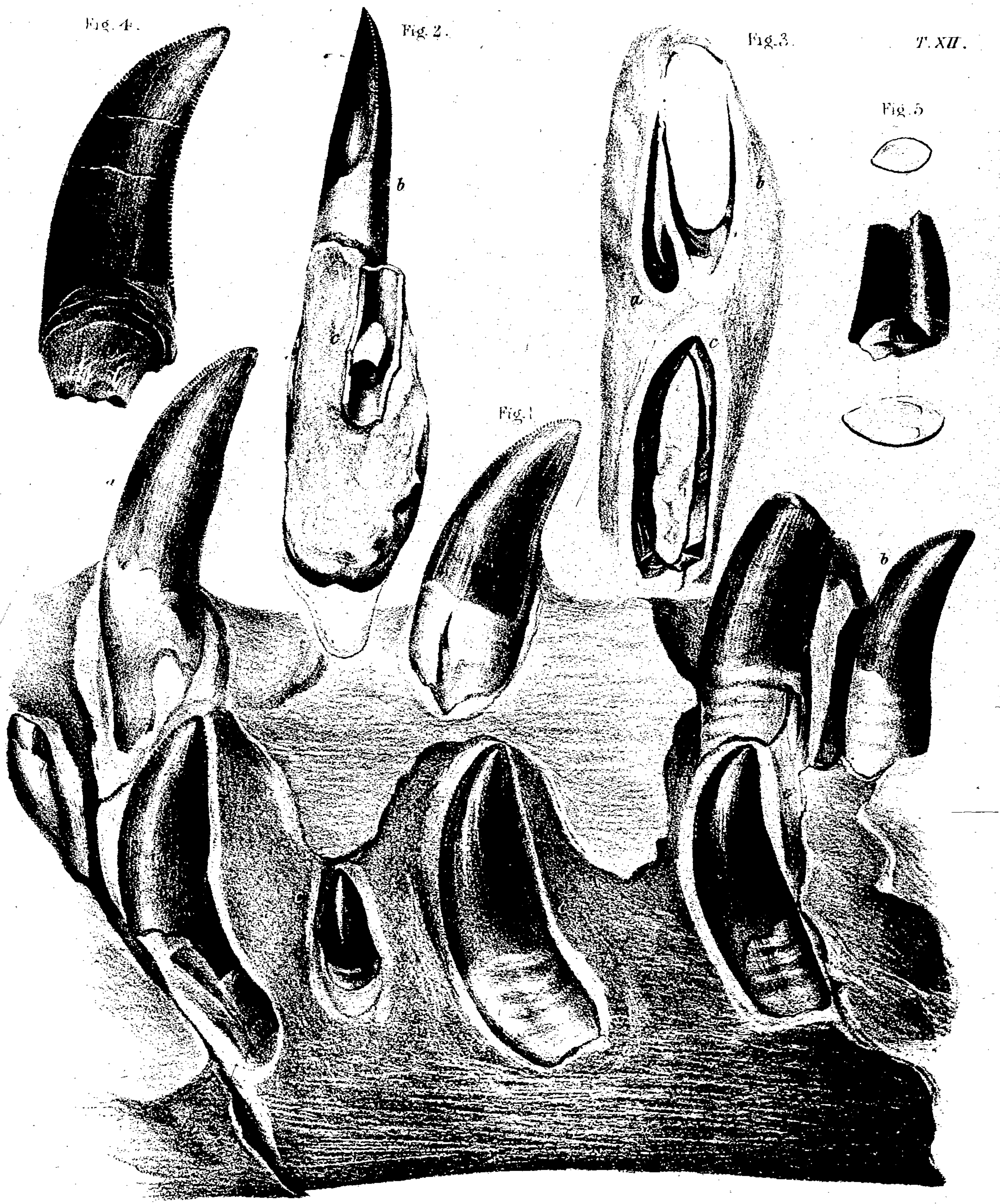
Figs. 1—3. A portion of the mandible with teeth of the *Megalosaurus Bucklandi;* nat. size.

Fig. 4. Side-view of a full-sized tooth of the Megalosaurus.

„ 5. A portion of a tooth of *Megalosaurus,* from the Inferior Oolite, of Selsly Hill, Gloucestershire. In the British Museum.

The foregoing figures are taken, with the permission of his Grace the Duke of Marlborough, from a specimen in his Grace's collection, from the Oolitic Slate, of Stonesfield, Oxfordshire.

T. XII.



MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN FORMATIONS.

ORDER—*DINOSAURIA*.

Genus—HYLÆOSAURUS,* *Mantell.*

THE third well-marked genus of Dinosaurian Reptiles, referred to in a former Monograph,† is founded upon a large portion of the skeleton of one and the same individual (T. IV), to which the name at the head of this section has been applied by its discoverer, Dr. Mantell.

In assigning to this genus a place in the Dinosaurian order, I have been guided by the structure of the vertebral column, especially the sacrum (T. V and VI); and, in placing it after the Megalosaurus, 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 a position higher, or nearer to the Crocodilian order. 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 *Crocodilia* is, however, manifested not only by the structure of the vertebræ 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 Hylæosaurus has not been made known, like the Megalosaurus, from detached parts of the skeleton successively discovered and analogically recomposed, but was

* ὑλαῖος, *sylvestris*, belonging to a wood, σαῦρος, lizard.

† Part iii, p. 1, Palæontographical Publications for 1856.

at once brought into the domain of palæontology by the discovery of the following parts of the skeleton in almost natural juxtaposition: viz., the anterior part of the trunk (T. IV), including ten of the anterior vertebræ in succession (3—10), supporting a small fragment of the base of the skull; the two coracoids (ib., 52), the coracoid extremities of both scapulæ (ib., 51), detached vertebræ, several ribs (ib., *pl*) more or less complete, and some remarkable parts of the dermal skeleton, including, apparently, enormous vertical plates or spines (ib., *d, d*), arranged, as is supposed, in the form of a median dorsal ridge or crest of singular dimensions.

This specimen is now in the British Museum. It was discovered in 1832, in a block of stone, measuring $4\frac{1}{2}$ feet by $2\frac{1}{2}$ feet, in the Wealden of Tilgate, Sussex.*

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 vertebræ 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 vertebræ are somewhat flattened below, so as to present an obscurely quadrate figure; most of the anterior dorsals (T. VIII, figs. 10 and 11) are more compressed and keel-shaped below; the sacral (T. V) and many of the caudal vertebræ (T. X) are longitudinally sulcated at their under surface.

The structure of the atlas and axis cannot be discerned in the British Museum specimen; the second (conspicuous) cervical vertebra (T. IV, 4)† has its sides subcompressed, its under surface rather flattened anteriorly, and the slight angular ridges separating it from the concave lateral surfaces are produced anteriorly into two feebly marked tubercles. The parapophyses, or 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 (T. IV, 6)† a parapophysis is, also, 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 a rib abuts; that and three of the succeeding ribs having their heads applied over the interspace of two contiguous vertebræ, as nearly throughout the thoracic region in Mammalia.

* 'Proceedings of the Geological Society,' December 5th, 1832, vol. i, p. 410.

† The Arabic numerals indicate the position which I believe the vertebræ to have had in the entire series forming the back-bone of the Hylæosaur.

The lateral compression of the centrum increases in the sixth (8) and seventh (9) (conspicuous) vertebræ, in which the under surface forms an obtuse ridge; in the eighth vertebra (10) this surface is broader and more rounded. In none of these vertebræ is a process developed from the under surface, as in the hinder cervical and anterior dorsal vertebræ of the Crocodiles; and in none of them is the anterior articular surface of the centrum convex, as in the Streptospondylus.

The most striking character of the vertebræ of the Hylæosaurus is the great development of the neural arch and its processes. The anterior articular processes extend (in the anterior dorsal and cervical vertebræ) over half the centrum next in front, and a broad diapophysis (upper transverse process) is developed from the side of the neurapophysis and along its anterior continuation: the diapophysis extends horizontally outwards, is notched anteriorly, and contracts to an obtuse point, against which the tubercle of the rib articulates: it is flat transversely, slightly concave lengthwise, and smooth below. The diapophyses increase in length and strength as the vertebræ 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 (T. IV, *pl* 3, and the ribs attached to 9 and 10). The rib (*pl* 2) which appears to be the second, and belongs to the cervical region, is short and pointed, not exceeding 4 inches in length. The neck and head of the rib corresponding with the seventh conspicuous vertebra, apparently the third free rib (*pl* 3), 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 entire length of this rib is 5½ inches. The neck of the fourth rib (*pl* 4) has the same length as that of the third, but is twice as thick and strong; the tubercle is broader but shorter. Beyond the tubercle the shaft of the rib is bent at nearly 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 diapophysis.

In the dorsal vertebræ 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 vertebræ 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 striæ 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 vertebræ of the Hylæosaur and the biconcave Crocodilian vertebræ is chiefly manifested in the development of the neural arch. The modification of this part in the cervical vertebræ has already been mentioned. In the dorsal vertebræ (T. VIII, fig. 10) 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 (*d*), from the middle line of which the broad spine (*ns*) is developed. A vertically compressed but strong diapophysis (*d*) is developed from the side of the neurapophysis, and is supported by a pyramidal underprop (*t*), extending upwards and outwards from the anchylosed base of the neurapophysis. There is a large deep and smooth depression (*p*) on each side of the base of the diapophysis. The anterior surface of the neural arch, above the anterior oblique processes, or prezygapophyses (*z*), is traversed by a vertical ridge, on each side of which there is a shallow depression.* The spinous process (*ns*) 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 vertebræ 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 vertebræ in the portion of the skeleton of the Hylæosaurus (T. IV):

	Vertebra No. 4.		Vertebra No. 6.		Middle dorsal.	
	In.	Lin.	In.	Lin.	In.	Lin.
Antero-posterior diameter of centrum	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 centrum	0	0	0	0	2	0

The differences between the vertebræ of the Hylæosaurus and Megalosaurus have been already pointed out, and are further shown in the admeasurements given above. The vertebræ of the Hylæosaurus 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 vertebræ of the Hylæosaurus 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 is superior in the expansion and strength of the platform and spinous process. From the vertebræ of the Poikilopleuron, an oolitic Saurian of about the same bulk, those of the Hylæosaurus differ in their more compact osseous structure, and in the absence of the large cells that characterise that structure in the vertebral bodies of the Poikilopleuron.

* This description is taken from Nos. 2586 and 2125 parts of the same vertebra in the British Museum.

The Sacrum (T. V and VI).

There is a portion of a sacrum of a small or young Dinosaur (T. VI, figs. 1 and 2, No. $\frac{484}{2481}$, British Museum), which, in the form and proportions of the bodies of the vertebræ, most resembles the present genus, and cannot be referred to either the 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 Hylæosaur 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 vertebral interspace; its strong transverse process, diapophysis and pleurapophysis combined, 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 and Iguanodon.

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 or metapophyses, such as the sacrum of the Megalosaurus is complicated with.

The following are admeasurements of the present portion of the sacrum of the Hylæosaurus:

	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.

The authors of a paper in the 'Philosophical Transactions' for 1849, who preceded me in the publication of the figures of the sacrum of the Iguanodon, first discovered by me in the collection of the late Mr. Saull, and described in my 'Report on British Fossil Reptiles,'* state that "the sacral fragment referred to the Hylæosaurus by Professor Owen cannot at present be found."

The fragment in question is the one above described. It has never, according to my observation, been absent from its place in the Hylæosaurian series of the British Museum, where it still bears the ticket and numbers, $\frac{484}{2484}$, under which its nature was first made known.†

In the paper in the 'Phil. Trans.,' above cited, the four confluent sacral vertebræ (T. V) are figured as "belonging either to the Hylæosaurus or Iguanodon" (p. 301). The apparent inability to recognise the specimen of Hylæosaurian sacrum, No. 2484, by comparison with which the sacrum (T. V) might have been determined, left the authors in the above state of doubt; yet the unequivocal Iguanodon's sacrum in Mr. Saull's museum suffices to differentiate the present specimen. It consists of the confluent bodies of four sacral vertebræ, answering to those marked *s* 2, *s* 3, *s* 4, and *s* 5, in T. III of my 'Monograph on the Iguanodon.'

The body of the second sacral vertebræ of the Hylæosaurus (T. V, 2) is carinate below, as in the Iguanodon. Above it is smoothly excavated to form the floor of a capacious neural canal (fig. 1, *n*), whence the nerves escaped, passing over the centrum, in consequence of the blocking up of the vertebral interspace by the articulation there of the shifted neural arch.

The third sacral vertebra (3) is not carinate below, as in the Iguanodon, but grooved along the middle line, and the increase of breadth is relatively greater in the centrum.

* 'Reports of the British Association,' volume of 1842, pp. 129—131. † Ib., pp. 113, 114.

This increase is still more marked in the fourth sacral vertebra (fig. 4), which is also longitudinally, but more widely, channelled along its under surface.

The breadth, as compared with the length, increases in the fifth sacral vertebra (5), shown to be the last, as in the Iguanodon, by the terminal articular surface for the first caudal vertebra. Like the preceding centrums, that of the fifth sacral vertebra in the Hylæosaurus is relatively broader and flatter below than in the Iguanodon: but the lateral compression beneath the wide outlets for the nerves, usually intervertebral in position in other reptiles, is well marked. These outlets are relatively wider in the Hylæosaurus than in the Iguanodon, and probably indicate greater activity, and a swifter rate of motion, in the smaller herbivorous Dinosaur.

The base of the pleurapophysis or rib-element—taking the place and function of an inferior transverse process in the Dinosaurian sacrum—may be discerned, wedged into the interspace between the second and third sacral vertebræ at *pl* 3, and again between the third and fourth vertebræ, at *pl* 4, fig. 2, T. V.

A third portion of the sacrum of the Hylæosaurus, which escaped the cognizance of the authors of the paper in the 'Philosophical Transactions' for 1849, is the specimen No. 28,936, British Museum. This consists of the third sacral vertebra, with part of the second and fourth anchylosed therewith, a great proportion of the neural arch, and a small part of the left ilium being included in this very instructive specimen. It is from the submerged Wealden of the Isle of Wight, and has been subject, like many of the fossils from that locality, to a certain degree of attrition by sea-waves on the beach.

The pleurapophysis (fig. 3, *pl* 3), continued from the obliterated interspace between the third and second vertebræ, quickly assumes the form of a broad and high plate, compressed from before backwards, and again becoming thickened when it abuts against the ilium (62).

The diapophysis (fig. 4, *d* 3), arising from the side of the neural arch, seems to form the upper part of the same broad, vertical, transverse wall of bone; but the suture between the pleurapophysial and diapophysial elements of this wall is clearly traceable, extending from the base of the neurapophysis upwards and outwards. The diapophysis at its upper part expands, and seems to bifurcate or abut against the side of the base of the neural spine. This spine forms, at the part of the sacrum here described, a continuous ridge of bone.

The fractured outer border of the ilium has been rounded and water-worn to its present form, which must not be taken as indicating its natural one. A large vacuity was bounded by the ilium and the two contiguous diapophysial plates (fig. 3), as in the sacrum of the Iguanodon: the large nerve-outlet, formed by the receding borders of contiguous neural arches, and the middle part of the centrum, opens into the large space above defined.

Caudal Vertebræ. T. X.

A proportion of the tail, to the extent of nearly six feet, and including about twenty-six vertebræ, discovered in a quarry in Tilgate Forest in the year 1837, is preserved in the British Museum (T. X). The diapophyses (*d, d*) present almost Crocodilian proportions, in regard to their length, at the interior part of this series, and may be discerned, though diminished to mere rudiments, in the small terminal vertebræ of the series. In the most perfect of the anterior vertebræ 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 diapophysis to form the prezygapophysis, or 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 up to the base of the neural spine; the antero-posterior extent of this process is 2 inches. The hæmal arches are from 4 to 5 inches in length near the base of the tail (figs. 3 and 4); they may be distinguished, like the diapophyses, by their convex external surface; their bases come into contact, as shown in fig. 4, but are not confluent as in the Iguanodon; they articulate to two separate hypapophyses. Between the pairs of these tubercles, which are placed at each end of the under surface of the centrum, there is a longitudinal sulcus. The diapophyses soon lose the slight anterior curve, stand straight out, decrease in length, and descend from the neurapophysis to the centrum as the vertebræ approach the end of the tail.

The hæmal arches 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. Fig. 4 shows the modification of the under surface of the caudal vertebræ, at the middle of the tail; and fig. 5 gives a side view of one of the hæmal arches from this part, of the natural size. The following admeasurements give the rate of decrease in length in the caudal vertebræ, taken at intervals of six joints:

	In.	Lin.
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 vertebræ 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 vertebræ 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 vertebræ (fig. 6): thus in the centrum 2 inches 2 lines long, the breadth was 1 inch 10 lines, and the height only 1 inch 3 lines. Here the bases of the short, but fore-and-aft extended, hæmapophyses appear to be confluent, as in fig. 7; but their peculiar shape would serve to distinguish them from a hæmal arch of an Iguanodon.

Bones of the Extremities.—Scapular arch.

The scapula of the Hylæosaurus (T. IV, 51) 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 scapulæ 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, the homologue of which exists in the scapula of the Iguanodon, and more developed in that of 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 scapulæ 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 connection 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.	Lin.
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* (T. IV, 52) 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 that in the Scinks and Chameleons. The antero-posterior extent of the coracoid in the connected portion of the skeleton (T. IV) is 8 inches; its transverse diameter 5 inches.

Tibia of the Hylæosaurus. T. VII.

One of the long bones of a limb, with a phalangeal bone, and a scapula, of the Hylæosaurus, were discovered in a quarry of Wealden stone at Bolney, in Sussex.

The long-bone is figured by Dr. Mantell as a humerus.* It bears a much closer resemblance to the tibia of the Megalosaurus,† but it is shorter and more expanded at its distal end in proportion to its length.

The proximal end (T. VII, fig. 3), which is 6½ inches by 3½ inches in its long and short diameters, shows a median tuberosity (*a*), divided by a depression from a second smaller tuberosity (*b*) (this has been crushed in the specimen), which have articulated with the condyles of the femur. Anterior and external to these the proximal end of the bone is produced into a strong "procnemial" ridge (*c*), the front surface of which is roughened for the insertion of a strong ligament. The shaft of the bone rapidly contracts to a trihedral form, with the angles rounded off; then as rapidly expands, and becomes, as it were, flattened out; more especially by the production of the outer

* 'Philosophical Transactions,' part ii, 1841.

† Monograph, 1856, T. IX.

border (*f*), which shows a broad and shallow articular depression for the distal end of the fibula. The distal articular surface for the tarsus presents the same form of an oblique, wide, and shallow notch (*e*), as in the Megalosaurus.

The largest diameter of this end of the bone is 7 inches; the circumference of the middle of the shaft is 7 inches. At the back part of the shaft, five inches from the proximal end, is the orifice of a canal for the medullary artery, which passes obliquely downwards. The entire length of the bone is 16 inches.

Metapodium of the Hylæosaurus. T. XI.

The specimen, No. 2556, in the British Museum, figured in T. XI, exhibits three metacarpal or metatarsal bones of the same foot, cemented, as naturally connected, by the Wealden matrix. The shape of the outer (IV) and inner (II) of these bones indicates that three alone constituted their segment of the foot, unless some styliform rudiment may have existed, which has left no mark of junction with the next fully developed metapodial* bone.

Those bones of the foot of the Iguanodon, described in a former part of the present Monograph, and figured in T. I, II, and III, afford a means of comparison with the present specimen, and show that it cannot belong to the corresponding foot of the Iguanodon, and that it is very improbable that it can belong to another (fore or hind) foot of the same species. It plainly indicates a foot of longer and more slender proportions, with a different configuration of the metapodial bones. The relative lengths of these bones show that they belong to a foot of the same side of the body as that of the Iguanodon above described.

The proximal ends of the three bones have been broken off obliquely, the outermost (T. XI, II) retaining the greatest proportion of the shaft: the innermost (ib., IV) retains its distal articular surface; the middle bone (ib., III) has a portion of the same surface. The distal end of the outermost bone is broken away.

By the analogy of the metapodium of the Iguanodon, the innermost metapodial of the present specimen answers to the second in the pentadactyle foot, the middle to the third, and the outermost to the fourth. The foot to which they belonged was functionally tridactyle, through the arrest of development or suppression of the first and fifth toes in the pentadactyle foot.

The metapodial (II) has a sub-compressed shaft, convex on the inner or free side (figs. 1 and 2), slightly concave towards the middle metapodial; with the anterior

* The term "metapodium" signifies the same segment in both fore- and hind-feet, and is requisite in treating of such segment when it cannot be determined whether it is of the fore-foot, metacarpus, or of the hind-foot, metatarsus.

margin sharp, but not produced at the middle of the bone, as in the Iguanodon: the distal articular surface is convex at its anterior half, trochlear at its posterior half, or with a median, rather oblique groove between two tuberosities.

The middle metapodial (III) differs from that of the Iguanodon in its uniformly almost flat anterior surface. The outer metapodial (figs. 1 and 3, IV) has a flatter and relatively broader outer surface than in the Iguanodon: the antero-internal border subsides about half way down the shaft: the internal border appears to be produced towards the middle metapodial, as in the Iguanodon. The distal end of the outer metapodial (IV) must have extended lower than that of the inner one.

The size and texture of the above-described bones of the foot accord best with the characters of the osseous texture in the Hylæosaurus, of which they are probably part of the hind-foot.

Jaw of the Hylæosaurus? (T. VIII, figs. 1—5).

No. $\frac{422}{2422}$, in the Reptilian Series of the British Museum, 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 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 3 inches long, 1 inch 7 lines deep at the hind part, and 1 inch 5 lines deep at the fore part; flattened and smooth at the inner side (T. VIII, fig. 2), but having the outer side (fig. 1) 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 (fig. 3) is formed by a regular series of pretty close-set sockets, with the internal alveolar wall imperfectly developed, and in part broken away, displaying their partitions; but with the outer wall entire, thin, and slightly crenate at its upper margin (fig. 1).

At the hind part of this fragment (fig. 4) the anterior extremity of the splenial 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 (fig. 5). 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 (fig. 2); 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, with oblique outlets, not depressions merely, as in the present mutilated fragment; and that it would have agreed with the Megalosaurus in presenting the sub-thecodont mode of implantation 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 my 'Odontography,'* I adopted the opinion of Dr. Mantell† respecting the present fossil, viz., that it belonged to a young Iguanodon; but subsequent considerations‡ induced me to refer it to the same species of extinct reptile as the teeth (T. VIII, figs. 6—9) belonged to.

Since the publication of my 'Reports on British Fossil Mammalia,' the lower jaw of the Iguanodon has been discovered, and leaves no room for doubt as to the generic and specific distinction of the present fossil. In the portion of jaw in question (T. VIII, figs. 2 and 3) there are eighteen alveoli in an extent of three inches: in the lower jaw of a young Iguanodon of the same size, there are but nine alveoli in the same longitudinal extent; whilst in three inches of the dentary border of the mandible of an older Iguanodon, there are but four alveoli. The form of the alveoli, as I had inferred from the known shape of the teeth of the Iguanodon, differs from that of the alveoli in the portion of jaw figured in T. VIII; but those alveoli accord with the shape of the fangs of the teeth next to be described.

* Part II, 1839, p. 248.

† 'Wonders of Geology,' vol. i, p. 393.

‡ "In the absence of this characteristic part of the tooth, an element in guiding our choice between the Iguanodon and Hylæosaur 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 Hylæosaur, 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 Hylæosaur 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 Hylæosaur the fangs are cylindrical; the sockets in the present fragment correspond with the latter form." (Report on British Fossil Reptilia, in the 'Reports of British Association,' 1841, p. 110.)

Teeth of the Hylæosaur? T. VIII, figs. 6—9.

At the period of preparing my 'Report on British Fossil Reptiles,' the teeth of the Hylæosaurus were unknown; but in the quarries where the bones of that reptile had been discovered, a few teeth had been met with of a peculiar form, respecting which Dr. Mantell wrote—"They 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."* The form and structure of these teeth (T. VIII, figs. 6, 7, and 8) deviate too much from those of the Crocodilian family to make at all probable a reference of them to the genera Poikilopleuron, Streptospondylus, or Cetiosaurus, which are much more closely allied to the Crocodilians than is the *Hylæosaurus*. In a later work,† 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 palæontologist, M. Fischer de Waldheim, by whom their resemblance to certain Saurian teeth from the Ural Mountains, belonging to the genus Rhopalodon, is indicated. From these teeth, however, the presumed Hylæosaurian teeth differ in having thick and flat instead of serrated coronal margins.

The fang of the tooth is subcylindrical, subelongate, smooth; as it approaches the crown it diminishes in one diameter, and slightly and gradually expands in the opposite diameter, forming a sub-compressed, slightly incurved crown, with the borders straight and converging at a moderately acute angle to the apex. These borders, in most specimens, are more or less worn, indicating the teeth of the opposite jaws to have been placed alternately, so as to meet and reciprocally occupy the angular vacuities left by the sloping borders of the crown: the enamel at these borders being worn away, and the dentine exposed.

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 enamel, with minute superficial longitudinal striæ, and surrounding a small central column of osteo-

* 'Wonders of Geology,' vol. i, p. 403.

† 'Geology of the South-east of England,' p. 293.

‡ P. 196.

dentine, consisting of the calcified remains of the pulp. 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 dentinal tubes are characterised 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, affording the usual characters of the texture of the bone in the higher reptiles.

From the form and structure of these teeth, it may be inferred that they have belonged to a Dinosaurian reptile; not so strictly phytiphagous as in the Iguanodon, but probably having a mixed diet.

In reference to the size of both the fragment of jaw and of the teeth, there is about the same proportion between them and the known remains of the Hylæosaurus, as between the jaw with teeth of the Iguanodon and the vertebræ and limb-bones of that colossal Dinosaur. The structure of the osseous substance of the portion of jaw figured in T. VIII closely accords with that of the known bones of the Hylæosaurus.

Having, therefore, demonstrated that the above-described mandibular and dental fossils of the Wealden do not appertain to the Iguanodon, nor to the Cylindricodon, it has appeared to me more to the interests of palæontology to refrain from adding to its catalogues a new name, which at present could signify nothing but the bare possibility that the grounds for approximating the fossils in question to the Hylæosaurus may prove not to be valid.

Dermal Scutes. T. X.

Unequivocal evidence that a dermal skeleton, analogous to that in the recent Crocodiles, was developed in the Hylæosaurus, has been afforded by the discovery of bony scutes in the mass of petrified vegetable matter removed in clearing the portion of the skeleton first described. Some of these detached bony plates still adhere to the caudal vertebræ, and may be observed to decrease in size as they approach the end of the tail (T. X, fig. 1, *i*, *i*). 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 Hylæosaur. The diameter of the largest of these scutes does not exceed 3 inches; the smallest present a diameter of 1 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, which I have described as characterising that surface, in the scutes of the Goniopholis.*

By the kindness of Dr. Mantell, I was favoured, when preparing my 'Report on Fossil Reptiles,' in 1840, with the means of submitting the structure of a dermal scute of the Hylæosaur to microscopical examination. This structure is represented in T. IX, fig. 1, and was described in my 'Report' as follows:

"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, opaque, 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? T. IX.

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, now in the British Museum, there are some large elongated, flattened, pointed plates of bone, three of which seem to follow each other in natural succession (T. IV, *d, d, d*). The length of the first of these plates is 17 inches, the breadth of the base 5 inches, equal to the antero-posterior diameter of two vertebræ: they decrease somewhat rapidly in length, the second being 14 inches long, and the third 11 inches long; but they slightly increase in breadth.

These remarkable bones were regarded by Dr. Mantell‡ as having formed part of a serrated fringe extended along the back of the animal, analogous to that of the Cyclura

* 'Reports of British Association,' 1841, p. 71.

† Ib., p. 115.

‡ 'Geology of the South-east of England,' p. 323; 'Wonders of Geology,' vol. i, p. 402.

Lizard. The chief objection, though not decisive, against this view is, 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, I once thought "might be paralleled by a similar concavity on the oposite side buried in the stone;"* but a separate specimen since obtained proves that side to have been convex (T. IX, fig. 3); and the anterior margin in the bones (*d*, *d*, T. IV) inclines from the middle line towards the concave side.

With regard to their relative position to the rest of the skeleton, it must be remembered that the ventral surface of this is exposed (T. IV); so that the under parts of the bodies of the vertebræ are towards the observer, and their spines imbedded in the matrix. The coracoids (52) and scapulæ (51) 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 vertebræ 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 characterise 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 Hylæosaurus 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 Hylæosaurus 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 vertebræ themselves in the Hylæosaurus. For the dorsal dermal spines in the Cycluar correspond in number with the spines of the vertebræ which support them, while the base of each of the hypothetical dermal spines of the Hylæosaur extends over more than two vertebræ.

In the Monotrematous quadrupeds (*Ornithorhynchus* and *Echidna*) the abdominal ribs are as much broader than the vertebral ribs as they would be in the Hylæosaurus, 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.

* 'Reports of British Association,' 1841, p. 116.

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 (T. IV) 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 Hylæosaurus, 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.

The peculiarly unsymmetrical figure of these problematical bones is strikingly shown in the specimen (T. IX, figs. 2 and 3, No. 28,861) now in the British Museum, discovered in the same quarry in Tilgate Forest, whence the above-described part of the skeleton of the Hylæosaurus was obtained.

It is a long triangular plate of bone (fig. 3), thickened at the base, becoming rapidly compressed or flattened beyond it, and gradually decreasing in thickness and breadth to the apex. Both the apex and one angle of the base have been broken away; but the bone can hardly have been under 8 inches across the base, and 15 inches in total length.

The base is surrounded by a low, obtuse, thick ridge (*a*), and is excavated by an irregular angular depression (*b*), the sides of which extend below or beyond the boundary ridge, at *c* and *d*; these productions not being opposite, but adding to the general oblique and unsymmetrical character of the apparently articular surface.

The body of the bone is moderately convex on one side (T. IX, fig. 3), and correspondingly concave on the opposite side, at the basal two thirds of its extent, beyond which the surface becomes convex transversely, but retaining its longitudinal concavity (fig. 2).

Several coarse vascular canals open upon and groove for a greater or less extent the outer surface of the bone, indicative of the periosteum being connected with a corium producing a thick epidermal covering; and this feature much inclines me to regard the bone as a true dermal spine. On the same hypothesis, the groove between the boundary ridge of the base and the projecting parts of the border of the basal depression, may have served for the implantation of dermal muscles, regulating the position of such spine.

But if these osteodermal spines formed a single series along the mid-ridge of the back, as the purely epidermal spines do in the Cyclura, they must have overlapped each other, and the unsymmetrical form must have related to such unusual disposition. In the *Xiphosurus velifer* of Cuvier, the fin-like crest along the dorsal aspect of the tail is supported by osseous spines: in the *Lophura* a dorsal crest is similarly supported; but the dermal spines are symmetrical. There remains the hypothesis, that there may have been two series of such spines, projecting one from each side of the dorsal region of the Hylæosaurus.

The shortness of the tibia, and the unusual development of its terminal processes for muscular attachments, indicate great strength of the hind limbs; and the glimpses which we thus obtain of this Wealden Dinosaur convey most strange ideas of its form and habits.

The remains of *Hylæosaurus armatus* have been discovered in the Wealden formation at Battle, Bolney, and Tilgate Forest, Sussex.

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OF THE

MONOGRAPH ON THE REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS.

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MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

ORDER—*LACERTILIA*.

Genus—NUTHETES,* *Owen.*

NUTHETES DESTRUCTOR, *Owen.*

FOR a knowledge of the fossil remains on which the present genus and species were founded,† I am indebted to Charles Wilcox, Esq., M.R.C.S., of Swanage, Dorsetshire, by whom the specimens submitted to me, including a portion of jaw with teeth, were discovered in the Purbeck formation, from the bed marked *k* 93 in Mr. Austen's 'Guide.'‡

The teeth are attached by partial anchylosis to depressions on the inner side of an alveolar wall, or according to the "pleurodont type." Their enamelled crowns are moderately long, compressed, pointed, slightly recurved, with a well-marked but finely serrated margin before and behind; the thickest part of the crown is not at the middle, but nearer the anterior border, as in the great Varanus (*Var. crocodilinus*) and in *Megalosaurus*; and they clearly resemble, in

* Abbreviated from νουθέτητης, *Monitor;* in reference to the resemblance of the teeth of the fossil to those of the modern Varanian Monitors.

† 'Quarterly Journal of the Geological Society,' 1854, p. 120.

‡ 'Guide to the Geology of the Isle of Purbeck,' by the Rev. J. Austen, M.A., Blandford, 1852.

miniature, the teeth of that great carnivorous reptile. To the question whether these Purbeck fossils might not be of a fœtus or young of Megalosaurus, the answer is, that the lower jaw of the Nuthetes differs from that of Megalosaurus in not having the inner alveolar wall developed in the same degree, and in not exhibiting any rudiments of alveolar divisions.* The inner wall is not produced in a greater degree than in the modern *Varani*. The largest teeth measure two lines in diameter at the base of the crown, which is more or less excavated on the inner side by the pressure of the matrix of a successional tooth.

The length of the largest fragment of the mandible was one inch and a half; the depth of the outer wall was six lines, that of the inner wall was from three to four lines. The exterior surface of the bone is smooth and polished, but shows under the pocket-lens very fine longitudinal linear markings; it is perforated by a series of nervo-vascular foramina along the alveolar wall, and is traversed near the lower margin by a line answering to the suture dividing the dentary from the angular piece in the jaw of *Varanus*.

The fossils give evidence of a carnivorous or insectivorous lizard of the size of *Varanus crocodilinus*, or great land-monitor of India. The specific name relates to the adaptations of the teeth for piercing, cutting, and lacerating the prey.

Of the vertebral characters I have not, as yet, received satisfactory evidence. *Nuthetes destructor* is referred solely on mandibular and dental characters to the "pleurodont section" of the order LACERTILIA. But, in the same division of the Purbeck strata, viz., from the "Feather Quarry," containing *Cyclas* and *Planorbis*, have been found long bones of a small Saurian and dermal scutes, agreeing, in regard to proportional size, with the jaw and teeth of *Nuthetes*. The bones present the characters of tibia and fibula, and are longer in proportion to their breadth than in any known recent form of Crocodilian; they are associated in the same slab with the scutes, which are subquadrate in form, about eight lines in one diameter and six lines in the opposite; smooth on the inside, impressed by minute, circular pits on the outside, and presenting more the character of the bony, dermal scutes of *Crocodilia* than of those of any known species of *Lacertilia* so defended. Additional evidence is needed to determine the relations of these small, pitted, dermal scutes to the bones and teeth of *Nuthetes*.

* 'Monograph on Megalosaurus,' vol. for 1856, p. 21.

Genus—Saurillus,* *Owen.*

Saurillus obtusus, *Owen.*

The fossils upon which the above genus and species were founded† were transmitted for my determination, in 1854, by Mr. W. R. Brodie, of Swanage, and were discovered by that persevering explorer of the Purbeck beds, in the "Dirt-bed," No. 93, of Mr. Austen's 'Stratigraphical List' above cited.

The most instructive specimen consisted of the right dentary element of the lower jaw, containing thirteen teeth. These are moderately long, conical, and obtuse; but are neither so long nor so recurved as in *Nuthetes*, nor are the crowns compressed, as in that genus. On the outer side of the dentary bone, not far below the alveolar border, are six nervo-vascular foramina in a longitudinal row, relatively as numerous and large as in Iguanodon, and indicating, as in that and other Saurian reptiles, the scaly covering of the jaws and the equally reptilian simple and subdivided condition of the salivary apparatus in *Saurillus*. The teeth are implanted according to the pleurodont type.

Supposing the fossil to have come from a mature individual, the size of the animal must have been nearly that of the common European lizard, *Lacerta agilis*. It was most probably insectivorous. The specific name, "*obtusus*," refers to the obtuse termination of the muzzle, as indicated by the form of the fore part of the jaw, and also to the blunt apices of the conical teeth.

Genus—Macellodon,‡ *Owen.*

Macellodon Brodiei, *Owen.* Tab. VIII, fig. 10.

In the slab of the fresh-water Purbeck stone containing the portions of upper and lower jaw, with teeth, on which the above genus and species were founded,§ there were also specimens of small, subquadrate, pitted, dermal scutes, and of a vertebral neural arch, corresponding proportionally in size with the teeth.

One specimen consists of the right superior maxillary bone, containing eight nearly entire teeth, and showing the places of attachment of thirteen or fourteen

* Abbreviation of *σαυρος*, *saurus*, a lizard.

† 'Quarterly Journal of the Geological Society,' No. 40, pp. 423 and 482.

‡ Μακελλα, *a spade*, ὀδους, a tooth.

§ 'Quarterly Journal of the Geological Society,' 1854, p. 422.

such teeth, the mode of attachment being by partial anchylosis to the bottom of an alveolar groove and to the side of an outer alveolar wall.

The crown of the teeth is broad, compressed, with sharp, subcrenate margins at the apical half, curving in most to a low point at the summit, and having a semicircular contour when this is worn away, as at *c*, fig. 10. A few of the anterior teeth are narrower, and the crenate margins converge, almost straight, to a sharper point, as in *a*, fig. 10. The older teeth have the crown reduced by attrition to the shape of a spade (*b*, fig. 10), suggesting the name of the genus. The enamel is marked by very fine, longitudinal ridges, the terminations of which give the crenate character to the unworn margins of the crown; a larger longitudinal rising marks the middle of the flattened surface, and is more conspicuous on the outer than the inner side of the crown in the lower jaw; it commences at a short distance from the base of the enamelled crown, and terminates at the apex. From this middle, thickest part of the crown the tooth narrows to the lateral margins, its transverse section across the middle of the crown resembling that of the upper part of the crown of the tooth of *Echinodon* (fig. 6, *b*).

In a portion of the upper maxillary bone of *Macellodon Brodiei*, the low palatal alveolar plate terminates internally in a smooth border, which had formed the outer boundary of an extended palatal vacuity, as in most lizards; this structure, with the unequal development, the succession, and pleurodont mode of implantation of the teeth, indicates the Lacertian affinities of *Macellodon*.

In a small slab from the lower part of the Purbeck stratum, called "dirt-bed, containing shells," Mr. Brodie discovered the dentary element of the lower jaw of *Macellodon*, containing thirteen teeth, and alveolar depressions for twenty; with this were associated the neural arch of a vertebra, portions of ribs, and some dermal, bony scutes. The teeth in place were anchylosed to depressions in an outer alveolar wall; a few at the fore part of the jaw were less expanded relatively to their length than the rest, which presented the Macellodont type of crown. They are separated by slight intervals, and the teeth are much smaller in proportion to the jaw than in *Nuthetes*. The dentary bone, figured of the natural size at Tab. VIII, fig. 10, presented the posterior notch for articulation with the angular and surangular elements; its outer surface is convex, and perforated at its anterior half by a linear series of nervo-vascular canals.

The neural arch associated with the above portion of lower jaw bears a greater proportional size thereto than in most lizards; it exhibits long diapophyses, as in the lumbar and anterior caudal Saurian vertebræ, supports a moderately long spine, and shows a small, circular, neural canal; the zygapophyses have been broken away from the exposed surface; and the centrum has been, apparently, detached from a sutural connexion with the arch, which would be rather a Crocodilian than a Lacertian character.

The dermal scutes agree in proportional size with the vertebra; they are subquadrate, smooth, and slightly concave on the inner surface; they are impressed with small, round pits on the outer surface; of two scutes in apparently natural juxtaposition, one slightly overlapped the other.

The length of the dentary bone of *Macellodon*, above described, is 9 lines, or 17 millimetres; the breadth of the neural arch across, and including the diapophyses, is 10 lines; the long diameter of a scute is 9 lines; its short diameter 6 lines. On the supposition, raised by the collocation in the same slab of these remains, that they may have been parts of the same animal, we should reconstruct, in idea, a Lacertian with a proportionally small and short-jawed head, and with a skin defended by crocodilian scutes; but I have seen similar scutes accidentally associated, in another block of Purbeck clay, with mammalian jaws and teeth, and they may have no closer relation to *Macellodon*.

The remains of small, lizard-like reptiles, with teeth more or less fitted for piercing, cutting, or crushing the chitinous coverings of *Articulata*, are such as might be expected in the marly shell-beds of the Purbeck series, which have afforded such abundant evidence of insect life;* and with them are associated remains of small, insectivorous mammals.† The numerous remains of plants in the same formation, some referable to *Cycas*, others to *Zamia*, illustrate also the interdependency between the insect class and the vegetable kingdom. Amongst the numerous and various Entomophaga organized to pursue and secure the countless and diversified members of *Insecta*, in the air, in the waters, on the earth, and beneath its surface, bats, lizards, shrews, and moles now carry on simultaneously their petty warfare, and in warmer climates in the same localities. In like manner, we now have evidence that lizards and mammals co-operated in the same locality, at the same task of restraining the undue increase of insect life during the deposition of the Lower Purbeck beds.

Genus—ECHINODON,‡ *Owen.*

ECHINODON BECKLESII, *Owen.* Tab. VIII, figs. 1—9.

The specimens figured in the above-cited plate were discovered by S. H. Beckles, Esq., F.R.S., in the thin, fresh-water stratum, containing shells§ and

* See the paper by Mr. Westwood, in the 'Quarterly Journal of the Geological Society,' 1854, p. 378.

† See my paper on *Spalacotherium*, ib., p. 426.

‡ Ἐχῖνος, *hedgehog*, and ὀδοὺς, *tooth*, "prickly tooth."

§ Species of *Valvata*, *Limneus*, *Cypris*, and *Physa*, apparently *Physa Bristovii*.

vegetable remains, high up the cliff, at Durdleston Bay, Isle of Purbeck. They consist of portions of the upper and lower jaws of a Saurian, allied, by the shape of the teeth, to *Macellodon*, but of much larger size, and with the thecodont implantation of the teeth. The crown belongs, in general shape, to that lamelliform, leaf- or scale-shaped type, of which the teeth of *Palæosaurus*, *Cardiodon*, *Hylæosaurus*, *Macellodon*, and even those of *Iguanodon*, are modifications. The teeth of the present genus are distinguished by the marginal serrations of the apical half of the crown, which increase in size from the apex to the base of that angular part of the tooth, the two basal points resembling spines, and terminating respectively, or forming the confluence of, the two thickened ridges (*r*, fig. 2, *c*) bounding the fore and hind borders of the basal half of the crown.

The crown is supported on a subcylindrical fang, and suddenly expands, both transversely (Tab. VIII, fig. 2, *c*) and antero-posteriorly (ib., *b*). In the former direction it as quickly begins to contract, and the outer and inner sides converge in almost a straight line to the apex; in the latter direction the crown continues expanding for about half, or rather more, of its longitudinal extent, with a slightly convex contour; it then rapidly contracts to the apex, the converging borders meeting at a right or somewhat acute angle, and being serrated as above described. The thickest mid-part of the crown forms a longitudinal rising, usually more marked on one side of the tooth; at the apical half the crown gradually becomes thinner towards the fore and hind margins; but at the basal half these margins are thickened, and cause the surface between them and the mid-rising to be undulated transversely. At the apical part of the tooth both the outer and inner sides are gently convex, the transverse section giving the thin-pointed ellipse, as in fig. 6, *b*.

The outer and inner enamelled sides of the crown each describe a curve at their base (fig. 3, *b*, *r*), convex towards the fang; these bases are somewhat thickened and rounded, so as to project from the fang; they converge at the fore and hind parts of the tooth, and unite at an acute angle (fig. 2, *c*, *r*), to form the long, basal points (fig. 3, *b*, *s*) of the serrated half of the crown. The foregoing characters apply to the majority of the teeth of *Echinodon*.

A portion of the left superior maxillary bone, imbedded in the matrix, with its outer surface exposed, is represented in Tab. VIII, fig. 1, and in outline, of the natural size at *a*. The anterior, probably premaxillary, part has been detached and broken. Three teeth, more or less fractured, project from sockets in the alveolar border of this part; their crowns are less expanded than in the typical maxillary and mandibular teeth. Part of the boundary of an external nostril is indicated at *n*. the larger maxillary fragment of the first two teeth present a similar form, and the entire crown of the second shows it to be longer, as well as more slender, than the posterior teeth; it resembles a canine tooth in both shape and position, the crown being subcompressed and slightly recurved, as well as sharp-pointed. It would serve well to pierce and retain a living prey.

The tooth succeeding the laniariform one presents the typical characters; beyond it the jaw-bone has been broken away in splitting the matrix, and the detached part adheres to the opposite layer (fig. 2). In fig. 1 are shown the impressions of four of the teeth preserved in the slab (fig. 2). Above the first impression (*o*, fig. 1) is the crown of a successional tooth, about to displace the tooth (*o*, in fig 2). The outer side of a type upper maxillary tooth is shown, magnified at fig. 1, *b*.

The remainder of the upper maxillary, with part of the palatine and pterygoid bones of the left side, are represented adhering to the other half of the split slab in fig. 2, and of the natural size, in outline, at *a*.. The extent of the inner alveolar wall, effecting, with the cross partitions, the lodgement of the teeth in sockets, is here demonstrated. The expanded crowns of the teeth come into contact. The inner surface of the crown is shown at *b*, in which the middle longitudinal rising is rather less prominent than on the opposite surface. The fore part of the crown is represented at *c*, showing the angle at which the obtuse basal borders of the enamelled crown meet there; the cement covering the fang is continued upon the crown within that angle.

The outer side of a portion of the right superior maxillary bone, with eight contiguous molars, is represented in fig. 3, and of the natural size, in outline, at *a*. There is a linear row of small foramina above the alveolar border. The median longitudinal rising of the crown of the teeth is more strongly marked on this, the outer, surface, as shown in the tooth magnified at *b*, fig. 3.

In fig. 4 is represented the inner surface of the posterior part of a right, superior maxillary bone, containing six contiguous teeth, with a less prominent or less defined median rising of the teeth in this fragment; the last three teeth gradually decrease in size. There is no discernible trace of the socket of another tooth beyond the sixth (*x*). A portion of the bony palate remains, which gives evidence of a large palatal vacuity, probably internal nostril, at *u*, and of a posterior palatal vacuity at *v*, probably corresponding with those in the Iguana.

The inner surface of a portion of a ramus of the mandible, with eight contiguous teeth, is represented at fig. 5, and in outline, of the natural size, at *a*.

The fore part of a right ramus, consisting chiefly of the dentary element, is represented in figs. 6—8, and of the natural size, in outline, at *a*. Fig. 6 gives the outer side, but the whole vertical extent of the bone is only preserved at the symphysial end. The apex of a young tooth projects from the fifth of the sockets here preserved; it is represented magnified at *a* and *b*.

There is a linear series of small, nervo-vascular foramina a little below the alveolar border. The crowns of the developed teeth have been broken away;

their fangs in the sockets are shown in fig. 7; the anterior teeth are narrower than the rest, as in the upper jaw. The crushed or broken state of the specimen at the opposite end prevents a determination of the total number of sockets in this ramus. On the inner side of the specimen (fig. 8), a considerable extent of the symphysis (*s, s*) is shown.

The posterior part of a broken and distorted dentary element of the left ramus of the mandible is represented in fig. 9, showing the last eight teeth, and the impressions of the crowns of as many in advance. A portion of the crown, displaced, of the fourth from the last is preserved, and likewise portions also of those in advance, which have been broken in splitting the slab, so that they appear smaller than they actually were. The last three teeth are entire, and show a gradual decrease of size, as in the portion of upper jaw (fig. 4). A magnified view of the inner surface of the last lower tooth is given at *a*, fig. 9.

From the characters of jaws and teeth above described, the extinct animal presenting them might be referred to the modern Lacertian group: but the structure of the vertebræ and limb-bones must be ascertained before the ordinal affinities of ***Echinodon*** can be satisfactorily determined.

The modifications of the mode of implantation of the teeth in the known limits of the Dinosaurian order affect the value of the thecodont character as a mark of affinity. The dentition of ***Echinodon***, in respect to the shape of the crowns of the teeth, appertains to the category embracing ***Macellodon, Cardiodon,**** ***Hylæosaurus***, and *Iguanodon*. From *Macellodon* the present genus differs in the swollen borders of the basal half and the stronger serration of the apical half of the dental crown. The similarly expanded crown of the tooth of *Cardiodon* has thicker and apparently not serrate margins, it is not divided into a basal and apical portion, and the apex is more obtuse. In *Hylæosaurus* the crown of the tooth is thicker and less expanded than in ***Echinodon***; the borders of the apical half are usually abraded by masticatory acts, show no marks of serration, and meet at an angle of 80°; but the crowns of the teeth were in contact, as in *Echinodon*. The more complex structure of the teeth of *Iguanodon* appears, nevertheless, to be due to additions superposed upon a type of tooth which is essentially like that of ***Echinodon***. The expanded crown is divided into a basal and apical portion; the marginal serrations of the latter are coextended with the increased thickness of the part into small lamellæ, themselves more minutely dentate. The middle longitudinal rising of the enamel, which in ***Echinodon*** has appeared to me to be stronger on the outer side of the upper teeth and on the inner side of the lower teeth, is exclusively developed, as the "primary ridge" on the corresponding aspects of the teeth of the upper and lower jaws in *Iguanodon*. In the small teeth, or those of the

* From the Oolitic Formation, called "Forest-Marble," near Bradford, Wilts. See my 'Odontography,' p. 291, pl. 75*a*, fig. 7.

young *Iguanodon*, the primary ridge is median and well-marked, and in the unworn tooth forms, or terminates at, the apex of the crown, increasing its resemblance to the Echinodont type of tooth. The difference of dental structure between *Echinodon* and *Iguanodon* is of the adaptive kind; relating in the former to animal food, in the latter to a mixed or vegetable diet. The entire dentition of *Echinodon* appears so well fitted to pierce the scaly covering of fishes, and retain the struggling prey, that I suspected the species to have been ichthyophagous, and, like the *Amblyrhynchus* of the Gallopagos Islands,* to have been aquatic in its habits.

My fellow-labourer in palæontology, Dr. Falconer, F.R.S., by whose labours that science has been so much enriched, suggested the name *Sauraechinodon* for the present Purbeck reptile; but as I am not aware that the more abridged form has been preoccupied, I have adopted *Echinodon* as sufficiently distinctive, having reference to the almost spiny character of the larger basal serrations of the apical half of the tooth.

The present species is dedicated to its discoverer, Mr. Beckles, of whose collection of Purbeck fossils the specimens here described form part; and I record with pleasure my grateful sense of the liberality with which they have been confided to me for elucidation.

* Darwin, 'Voyage of the *Beagle*,' vol. iii, p. 466.

SUPPLEMENT (No. I)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

ORDER—DINOSAURIA, *Owen.*

Genus—IGUANODON, *Mantell.*

IN the 'Monograph on the Iguanodon,' in a former volume of the publications of the Palæontographical Society,* the characteristic form of certain toe-phalanges was described; such phalanges, at least, were inferred to belong to the Iguanodon, with a high degree of probability, on evidence of association with other undoubted parts of the skeleton of that reptile, and more especially in the instance of the Maidstone skeleton;† but at that period the exact structure and number of toes of either fore or hind foot were unknown.

On the basis, however, of the determination of detached phalangeal bones in that Monograph, the present restoration of an entire—probably hind—foot, the carpus or tarsus excepted, of the Iguanodon, has been carried out; the ungual phalanges in the series of bones of this foot (T. I, II, III) closely corresponding in shape with the depressed and obtuse phalanges referred to that extinct animal in the above-cited volume, 1855, pp. 42—44. This most interesting and instructive framework of the foot of the great Dinosaurian herbivorous reptile was, moreover, found in a formation and at a locality where unequivocal vertebræ and other parts of the Iguanodon are common;

* 'Fossil Reptilia of the Wealden Formations,' Part ii, p. 40, t. xvi and xvii, (vol. for 1854.)

† 'Fossil Reptilia of the Cretaceous Formations,' Part i, p. 105, t. xxxiii, (vol. for 1851.)

so that it is with much confidence that the present contribution towards a complete reconstruction of the Iguanodon is now submitted to palæontologists.

The discovery and acquisition of the unique specimen, figured in T. I, II, and III, are due to S. H. Beckles, Esq., F.G.S., the author of the papers on the 'Ornithoïdichnites of the Wealden,'* and who first definitely called the attention of geologists to the singular "trifid," or tridactyle impressions in the Wealden of Sussex, of which he was the chief discoverer, and has been the most persevering investigator.

It seems a peculiarly appropriate reward for these researches, that the acquisition of the fossils demonstrating the tridactyle structure of one of the feet of the Iguanodon should have been reserved for Mr. Beckles. These fossils, moreover, were not fortuitously acquired, but were the fruit of special researches, assiduously carried on by Mr. Beckles on the south-west coast of the Isle of Wight, with a view to materials for completing our knowledge of the great Wealden reptiles.

Between Brook and Brixton, in the submerged Wealden bed, near low-water mark, indications of the entire skeleton of a young, perhaps half-grown, Iguanodon were detected. The bones of the foot which were most within reach had been very little disturbed. The metatarsus (T. II, fig. 2) was extracted in one piece; the phalanges of an outer toe (T. I, 1 IV—5 IV) were extracted in a second piece: they had been somewhat distorted at the time of imbedding, for the matrix had hardened around, and preserved them in that state. The phalanges of the toe of the opposite side of the foot (ib., 1 II—3 II) were extracted similarly cemented together by the matrix, but in their natural juxtaposition. Three of the phalanges of the middle toe (ib., 1 III—3 III) were also joined together by the matrix; the fourth, or ungual phalanx of this toe, was extracted separately; but Mr. Beckles's attention having been, unluckily, diverted to another subject at this time, the fossil got into the hands of an idle looker-on, who cast it into the sea. All the other bones of the foot Mr. Beckles caused to be carefully packed, and transmitted to me for description.

I employed a skilful lapidary to clear away the adherent matrix, and to separate the cemented phalanges of the distorted toe, for the examination of their articular surfaces, and the result of my comparisons were communicated briefly to the Geological Society of London, on the occasion of exhibiting the specimen at the meeting held June 17th, 1857.

As has already been stated, the bones, whether carpal or tarsal, which unite the foot proper to the limb, are wanting. The metapodium,† fortunately, yields the required proof of the precise number of toes.

* 'Quarterly Journal of the Geological Society,' January, 1851, and November, 1852.

† I use this word to signify the same segment in both fore- and hind-limbs: "metacarpus" is the specific term for the segment in the fore limb; "metatarsus" for that in the hind limb. But, in the gradual reconstruction of the skeleton of a strange reptile, it is requisite to have a term expressive of the more general kind of knowledge at first acquired. Metapodial is equivalent to metacarpal or metatarsal.

As a general rule, only the metapodials which bound or form the outer and the inner sides of that segment of the foot have the proximo-lateral articular surface confined to one side of the bone; the intermediate metapodials show such surface on both sides, for articulation with the contiguous metapodials. The metapodial (T. I, II, and III, IV), which will presently be shown to be the outermost, had its outer side rounded, and simply roughened for the implantation of ligamentous fibres; the metapodial on the opposite side (ib., II) also presented a convexity toward that border of the foot; but a small part of the middle of that convexity is articulated with a slender rudiment of a metapodial (ib., I), which forms the real boundary of that—the inner side of the foot. The upper portion of this metapodial, which resembles the "splint-bone" in the metapodium of the horse, has been fractured and partially dislocated before the induration of the matrix; the lower portion of the bone is in its natural position, and seems to have been anchylosed with the contiguous fully developed metapodium: the extremity of this lower portion, however, is broken away; so that, whether it ended in a point, like the rudimental metapodials in the horse, or supported a diminutive toe, like the metapodials of the spurious hoofs in the ox and musk-deer, cannot be at present determined.

As the fully developed toes which follow this rudiment have respectively three, four, and five phalanges, the analogy of both the fore- and hind-foot of the Iguanas and Monitors would indicate the small innermost metapodial (T. I, II, and III, I) to be the rudiment of the first toe (pollex or hallux), and the three fully developed toes to be the homologues of the second, third, and fourth toes of the feet in the Lizard tribe; the fifth toe being wholly suppressed in the Iguanodon. The analogy of the Crocodilian foot would lead to the same conclusion, since the second toe in that reptile has three phalanges, and the third toe has four phalanges, whilst in the hind-foot the fifth toe is suppressed. The fourth toe, however, in the *Crocodilia* differs from that in the *Lacertilia*, in having only four phalanges, and usually wanting a claw. Hence it would seem that, whilst the Iguanodon resembled the *Crocodilia*, as regards the hind-foot in that order, in the suppression of the fifth toe, it resembled the *Lacertilia* in having the fourth toe unguiculate, and with five phalanges: but it differs from both those Reptilian orders in the suppression of the first toe, and its representation by a hidden rudimental metatarsal, thus reducing the number of conspicuous and functional toes to "three."

The resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a "hind-foot;" but it cannot be assumed that the fore-foot may not have been similarly modified.

In the leading characteristics of the bony framework of the foot, whether fore or hind, it is interesting to find that the Iguanodon manifests a combination of Crocodilian and Lacertian characters, with superinduced Dinosaurian peculiarities, analogous to the plan of structure which I have had occasion to point out in other parts of its fossilized remains. So far as the Dinosaurian peculiarity of a reduced number of functional toes prevails, that order departs further from the general Reptilian type than do the existing Crocodiles and Lizards.

Having premised these general remarks on the fossils in question, I proceed next to point out the chief characters of the constituent bones of the foot.

The rudimental metapodial of the first or innermost toe (T. I, II, III, I) articulates by its proximal end with a notch, 9 lines in diameter, at the middle of the inner (tibial) surface of the second metapodial (II). It seems not to have been anchylosed at this part, from the circumstance that the slender bone has been broken, soon after death or interment, and the upper portion has been displaced obliquely from the lower half, which maintains, perhaps through anchylosis, its natural position; the displaced portion is cemented in that position by the hardened matrix to the contiguous large metapodial.* The rudimental metapodial, 9 lines by 6 lines in the two diameters of its proximal end, gradually becomes more slender as it descends; its lower half is trihedral, and stands rather sharply out from the large metapodial (II); its extremity is broken off; the large and small diameters of the lower fractured end are 5 lines and 3 lines. It is not probable that its presence was conspicuous beneath the integument which covered it, but it may have supported a rudimental toe and claw.

The second metapodial (ib., II) is 8 inches in length, 4½ inches in the longest diameter of the proximal end, 3 inches in that of the distal end. The bone expands at both ends, more suddenly at the distal one; it is convex on its free or tibial side, flattened on the side next the third metapodial, with the anterior border produced near the middle of the shaft into a process with a convex outline, and with a ridge projecting from the inner and back part of the proximal end. This ridge has been fractured. The outer or fibular angle of the back part of the proximal end is produced towards the next large metapodial, but has likewise been fractured. The articular surface at this end is flat, rather rough, showing vascular pits and other evidence of having been covered, in the recent state, by a layer of fibro-cartilage: by which it was articulated to the innermost tarsal or carpal bone. The distal articular surface is convex from before backwards, slightly convex transversely at its anterior half, with a middle concavity and lateral convexities, transversely, at the posterior half, which is somewhat broader than the fore part of the joint, and with the outer (fibular) angle produced.

The inner (tibial) side of the distal end of this metapodial has a broad and shallow depression for the attachment of a lateral ligament; the articular surface is two inches

* In the figure it is represented as restored to its natural position.

and a half higher than that of the adjoining (third) metapodial, and the proximal end is one inch and a half higher than that of the adjoining bone; but this is probably due to some dislocation of the metapodial before the matrix hardened around it.

The third metapodial (ib., III) is $11\frac{1}{2}$ inches in length. The proximal articular surface is slightly convex; a small portion of its back part (T. II, *a*) is continued upon the thick process (*b*) from the back part of the bone, which rises some way above the level of the horizontal surface, apparently about an inch; but the summit of this process has been broken off. This process subsides as it descends to the inner border of the shaft, about halfway down.

The inner and anterior angle of the proximal end is produced toward the second metapodial, rendering the side next that bone rather hollowed out, as for its reception when in its proper position. There is no process from the middle of the shaft near its fore part, as in the second metapodial. The distal end (T. II, fig. 3, III) expands into a broad trochlear surface, convex from before backwards, concave transversely; the fore-and-aft extent of the tibial side of this joint is the greatest; it appears to have been covered by articular cartilage, the extent of the cartilage being well defined by the transverse line at which the smooth surface rises a little above the level of the rough surface for ligamentous attachment.

The fourth metapodial (T. I, II, III, IV), which is here the third fully developed, and at the same time the outermost one, is 9 inches in length. Its proximal end (T. II, fig. 1, IV) is of a semi-elliptical form, concave towards the middle metatarsal, to which it articulates in the present specimen two inches below the proximal end of that bone; but there may have been some displacement of the bone prior to fossilization. The inner and posterior angle of the upper part of the shaft of the fourth metatarsal is slightly produced, as is also the same angle of the shaft below its middle. The front surface of the shaft is smooth and convex; the back part is almost flat, and is crossed obliquely near its lower end by a rough ridge.

The distal articular surface (ib., fig. 3, IV) is oblique, but in the opposite direction to that of the second metapodial (II); the transverse concavity of the surface is slight, and is also limited to the hinder half; the anterior fibular angle is produced. The extent of the articular cartilage of the joint is indicated by the raised line, as in the middle metapodial; the concavity on the inner side of the distal end is deep and well defined.

The innermost of the three toes (T. I and III, II 1, 2, 3), answering to the second in the hind-foot of the Iguana, includes three phalanges, and measures in total length 10 inches.

The first phalanx (II 1) is $4\frac{1}{2}$ inches in length; its proximal surface is obliquely sub-quadrate, very slightly concave, with the upper and outer (fibular) angle most produced, but rounded off; it is notched at the middle of the lower (plantar) border. Near this border, on the plantar aspect of the shaft, are two tuberosities for insertion of tendons. The distal articular surface is a trochlear one, convex vertically, and expanding as it descends; concave, but in a less degree, transversely; with the inner (tibial) side of greater extent. On both sides the articular border is slightly raised, forming the lower boundary of the wide concavity for the attachment of the lateral ligaments.

The second phalanx (II 2) is broader than it is long, its extreme breadth being 2 inches 4 lines. The proximal articular surface, with its concavity and convexity the reverse of those of the surface on which it plays, is triangular, with the angles largely rounded off. The under surface of this phalanx is somewhat flattened; the upper surface is contracted; the distal trochlea, very convex vertically, is flat transversely, at its upper half, slightly concave below; the modification resembling that of the phalanx supporting the unequal one in the other toes.

The third phalanx (II 3), which supported the claw, presents an oblique basal articular surface, flattened transversely and produced backwards above; slightly convex transversely below. The unequal part is sub-depressed, obtuse, obliquely bent downwards and outwards, but in a slight degree: the base of the bone is notched at each side, where the vascular canals relating to the growth of the claw commence; they impress the upper and lateral parts of the bone, which is $4\frac{1}{2}$ inches in length.

The proximal phalanx of the middle toe (T. I and III, III 1), answering to the third in the Iguana, shows its increase chiefly in breadth and thickness; its length is $4\frac{1}{2}$ inches. The proximal end, of a transversely oval form, is slightly and irregularly concave; its distal end is broader but less deep than that of the outer toe, and the shape of the trochlea is more symmetrical; the outer slightly exceeds the inner side in extent. The increase in the transverse over the longitudinal and vertical diameters is more marked in the second and third phalanges (III 2 and 3) of the middle toe; the latter phalanx shows the same flatness transversely, at the upper part of its distal trochlea, as in the corresponding phalanx of the outer toe. This structure indicates the next phalanx to have been an ungual one, resembling, as Mr. Beckles informed me, in its general character, the long terminal phalanx in the adjoining toes. It is indicated in outline in T. I, 4 III.

All the five phalanges of the outer toe (IV 1, 2, 3, 4, 5) are preserved; the entire length of the toe is $8\frac{1}{2}$ inches, being rather shorter than the inner, but apparently longer from the lower position of the metapodial bone (IV). In this proportion the Iguanodon differed from existing Lizards, and resembled the Crocodiles.

The proximal phalanx of the outer toe (IV 1), answering to the fourth in the Iguana's foot, is 3 inches in length, with a subtrihedral body, one side turned to the next toe, and one angle inwards and downwards. The proximal surface is flat; the distal one trochlear, but with the transverse concavity less deep than in the first phalanx of the inner toe. The three succeeding phalanges (IV 2, 3, and 4) are similar in character, but progressively decrease in size; they are very short in comparison to their breadth.

The ungual phalanx (IV 5) is relatively more slender than in the inner toe: its length is 4 inches; its basal breadth 1 inch 10 lines. The obliquity of the bone is slight, and in the opposite direction to that of the inner toe.

Should any rudimental or spurious claw have been supported by the metapodial of the innermost digit (T. II, fig. 2, I), the development of which toe is so remarkably arrested, it would probably present that form, and in regard to the fully grown Iguanodon, that size, which characterises the claw-phalanx which has been mistaken for the "horn" of the Iguanodon. It is probable that, in the fore-foot, the toe answering to the innermost in the Iguana's foot was better developed than its homotype in the hind-foot.

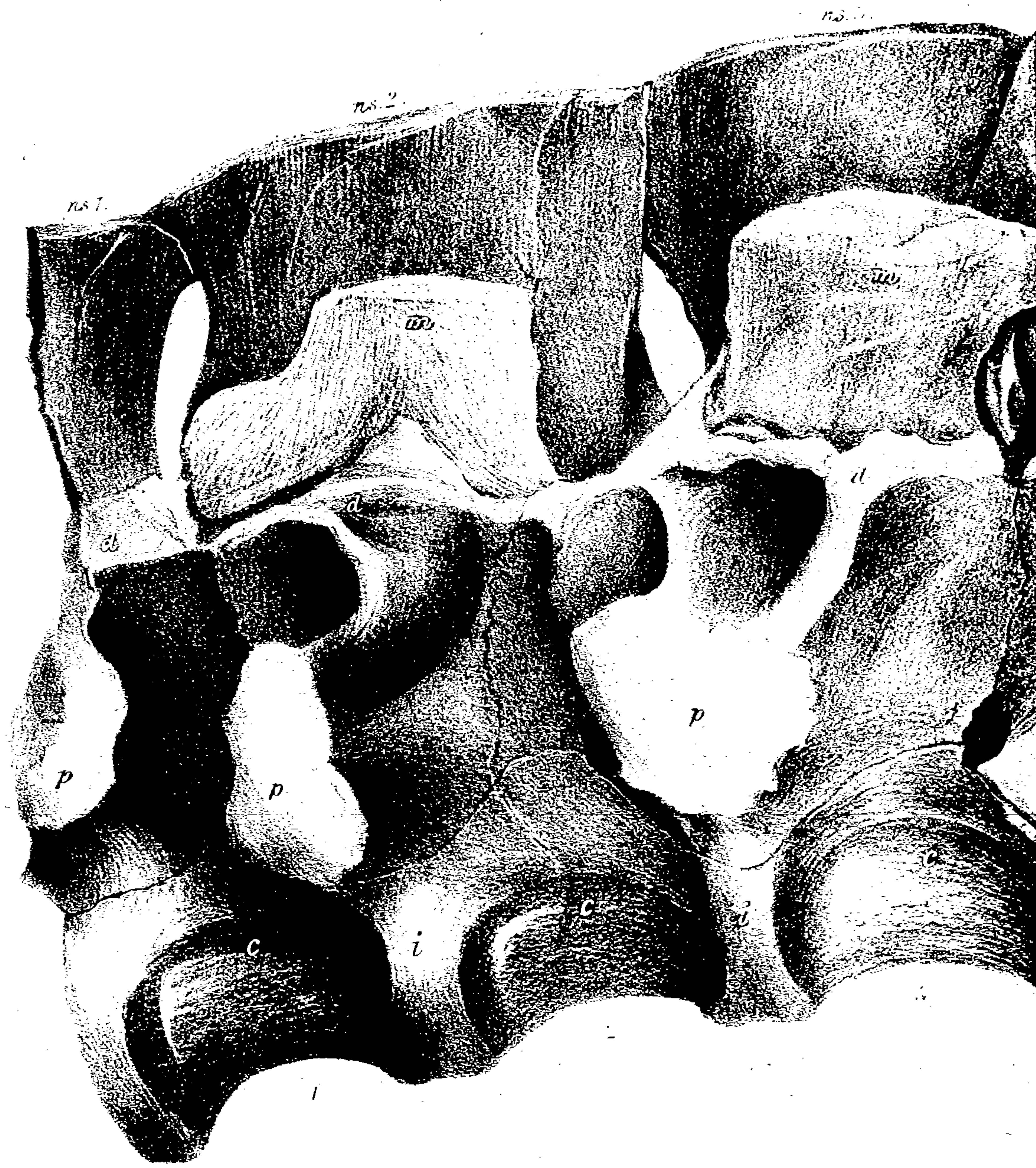
Not far from where the foot-bones were found, the femur, tibia, and fibula, of the same Iguanodon were extracted,—a circumstance which adds to the probability of their belonging to the same limb.

The modification of the present foot, whether of the fore- or hind-limb, of the Iguanodon is unique, according to present knowledge, in the class *Reptilia*. It exhibits an adaptation to terrestrial progression, and the support of a weighty superincumbent trunk, akin to that which we observe in the tridactyle foot of the heavy perissodactyle Pachyderms, represented at the present day by the Rhinoceros and Tapir.

TAB. I.

Sacrum of the Megalosaurus; half nat. size.

From the Oolitic Slate of Stonesfield, Oxfordshire. In the Geological Museum, Oxford.


ns.1.
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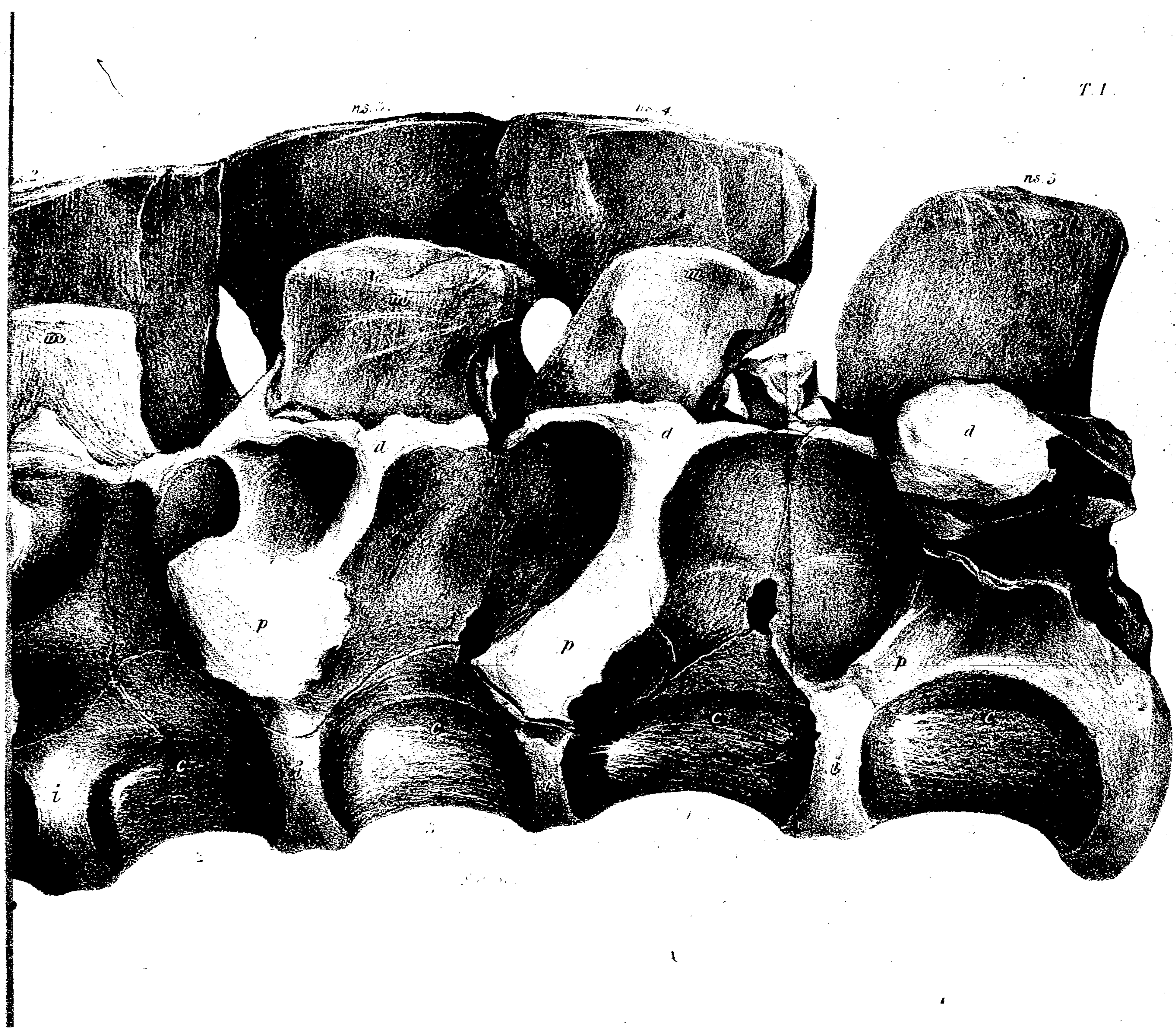
T. I.



TAB. II.

Portion of the sacrum of the Megalosaurus; nat. size.

From the Wealden, of Tilgate, Sussex. In the British Museum

T.II.

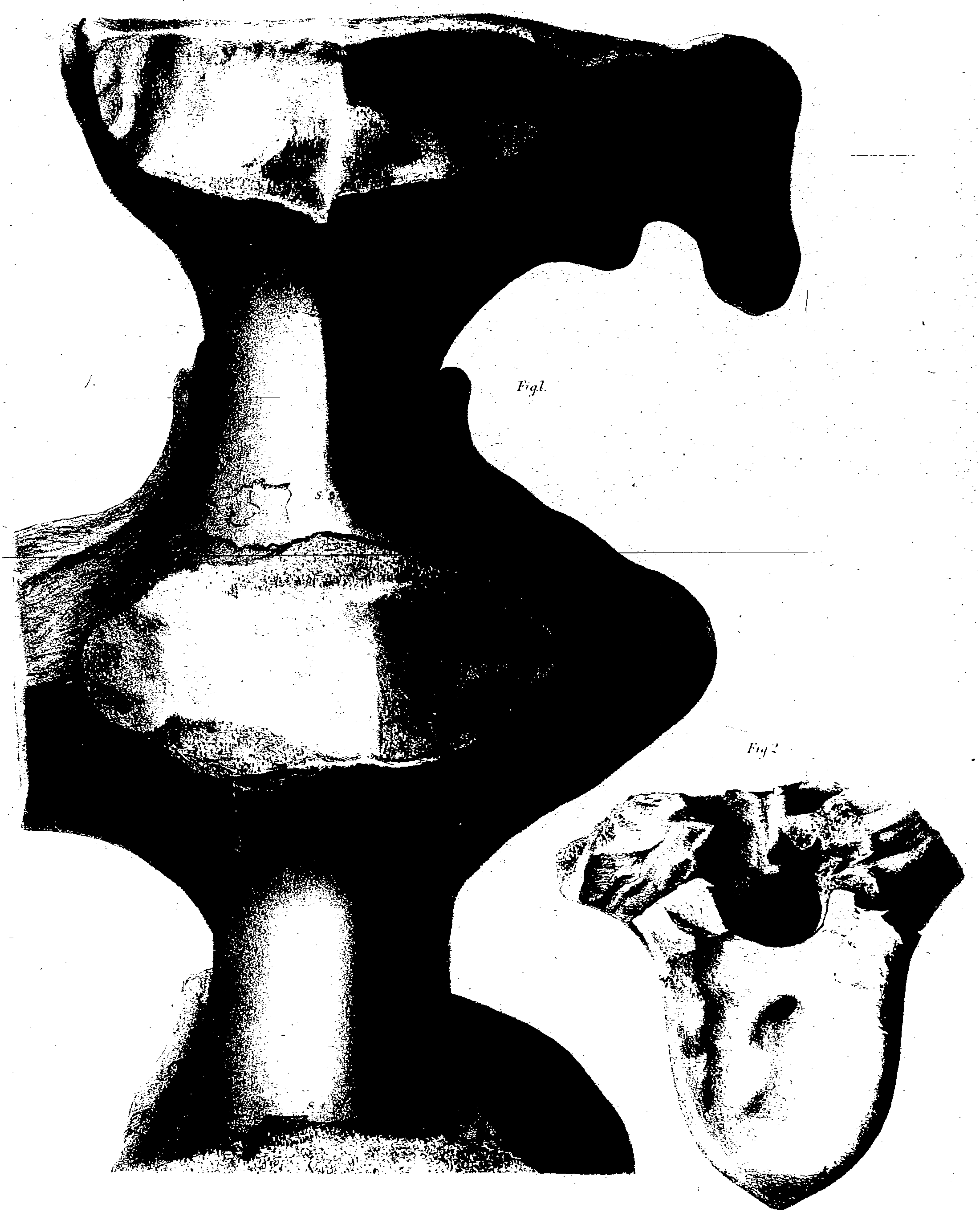
TAB. III.

Fig. 1. Under surface of the portion of the sacrum of the Megalosaurus; nat. size.

„ 2. End-view of the body of a sacral vertebra of the Megalosaurus; nat. size.

From the Wealden, of Tilgate, Sussex. In the British Museum.

T. III.



TAB. IV.

Megalosaurus Bucklandi; one fourth nat. size.

Fig. 1. Cervical, or anterior dorsal, rib.

„ 2. A succeeding dorsal rib: *c*, upper view of the head and neck.

„ 3. A posterior dorsal rib of a larger individual.

„ 4. The right clavicle.

„ 5. The right ischium.


Fig. 4
Fig. 2
c
t
Fig. 3
c
t
Fig. 1
c
t
Fig. 5

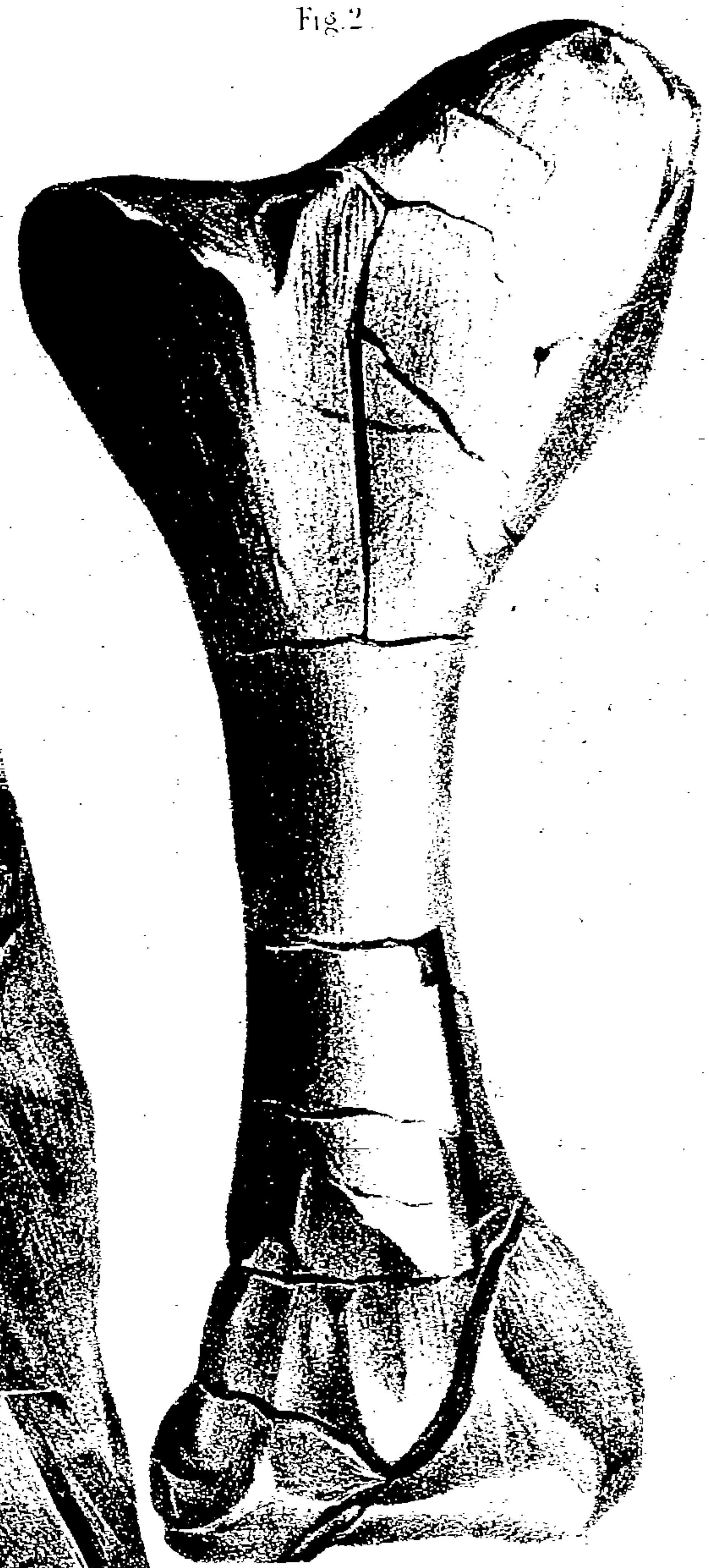
TAB. V.

The scapula of the Megalosaurus (?); one fourth nat. size.

From the Wealden, of Sussex. In the Museum of J. B. Holmes, Esq., of Horsham.

Fig. 1.

Fig. 2.



TAB. VI.

The coracoid of the Megalosaurus; one fourth nat. size.

Fig. 1. Inner surface.
" 2. Articular border.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

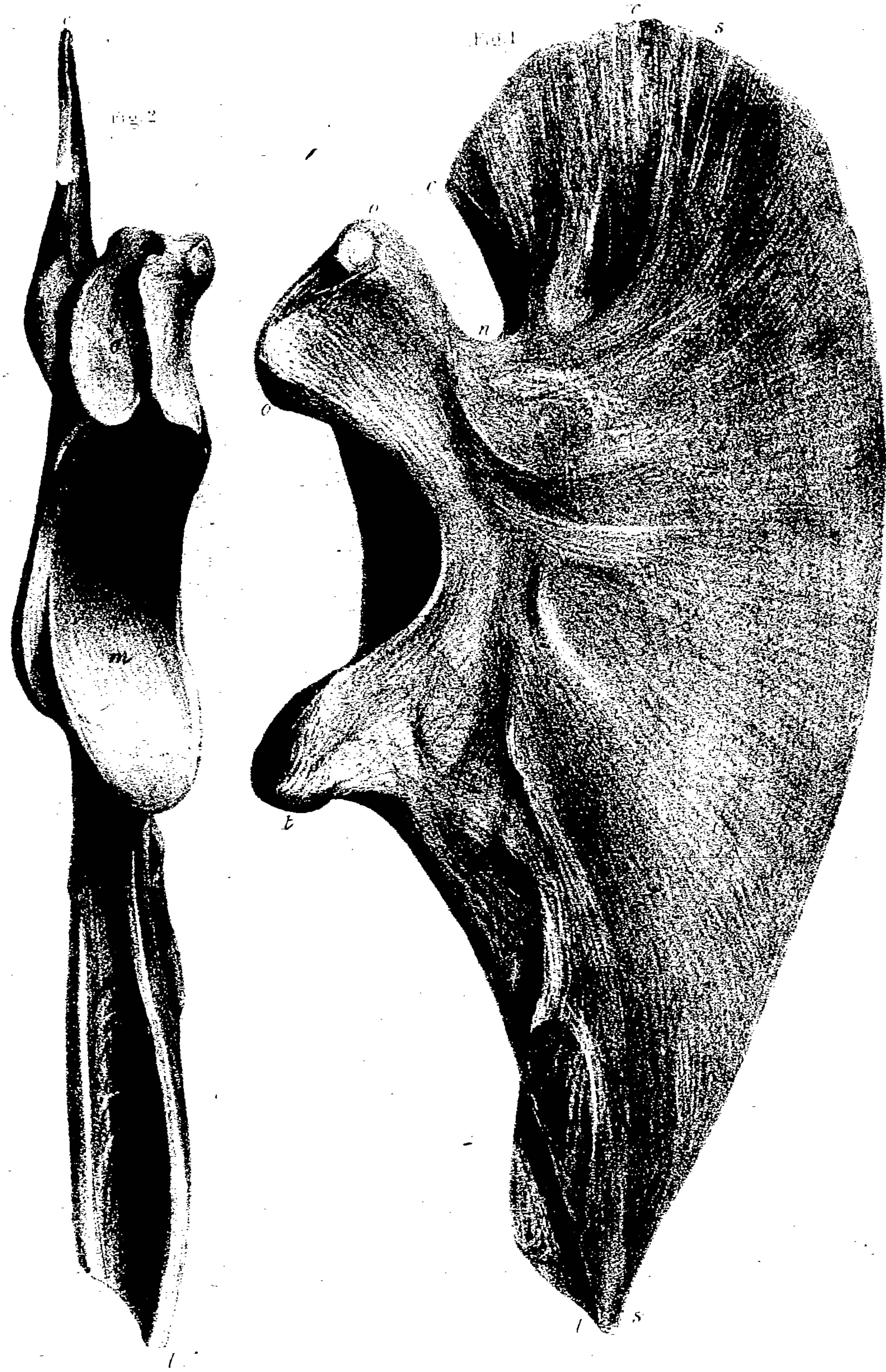


Fig. 2
Fig. 1
m

TAB. VII.

The femur of the Megalosaurus; one fourth nat size.

Fig. 1. Hinder surface.
„ 2. Inner surface.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

Fig. 1.

Fig. 2.

TAB. VIII.

Femoral condyles of the Megalosaurus; nat. size.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

T. VIII.

TAB. IX.

The tibia of the *Megalosaurus;* one fourth nat. size.

Fig. 1. Outer surface, with the upper articular end.
„ 2. Hinder surface, with the lower articular end.

From the Oolitic Slate, of Stonesfield, Oxfordshire. In the British Museum.

T. IX.

Fig. 1

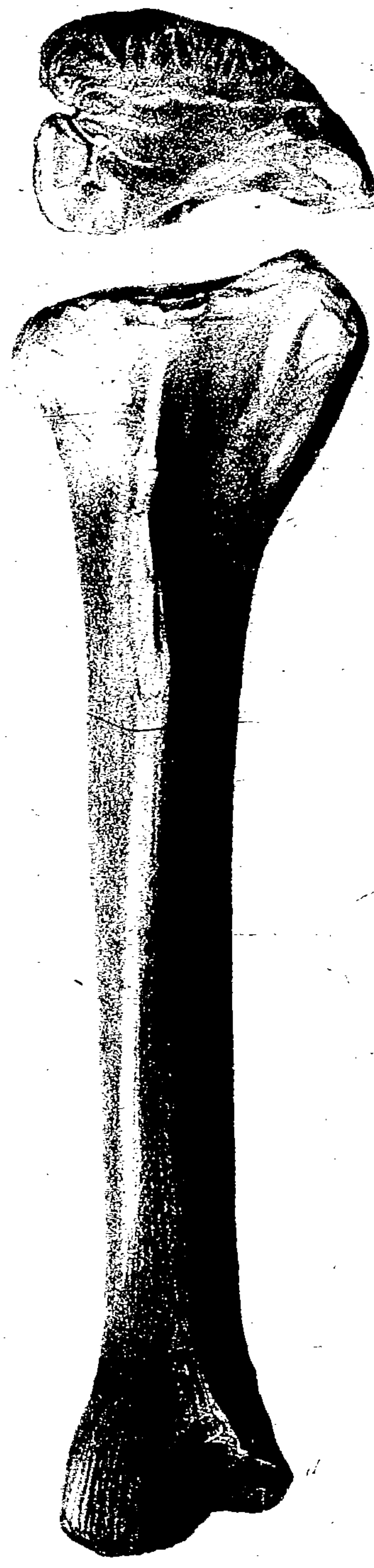


Fig. 2

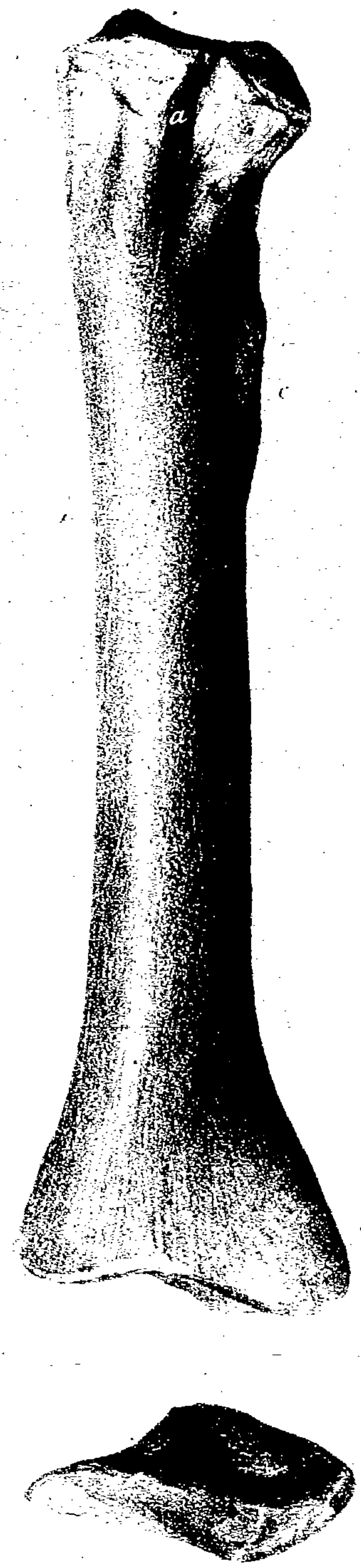


Fig. 3

TAB. X.

Ungual phalanges of Megalosaurus (?); nat. size.

Fig. 1. Inside view.
,, 2. Outside view.
,, 3. Upper surface.
,, 4. The fractured end of figs. 1 and 2.
,, 5. Side view of a smaller entire phalanx.

From the Wealden Sand, Tilgate, Sussex. In the British Museum.

Fig. 3.

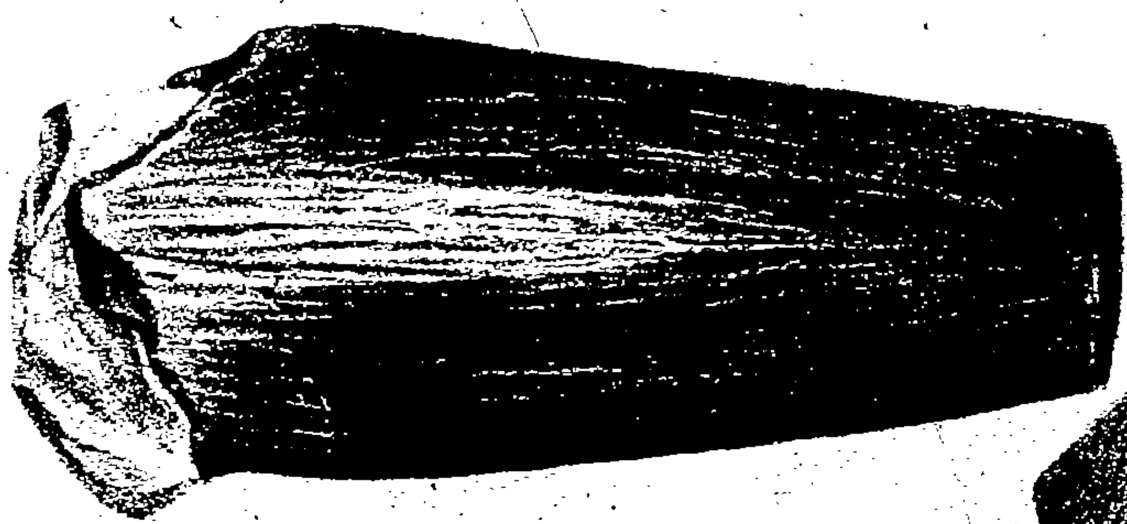


Fig. 1.

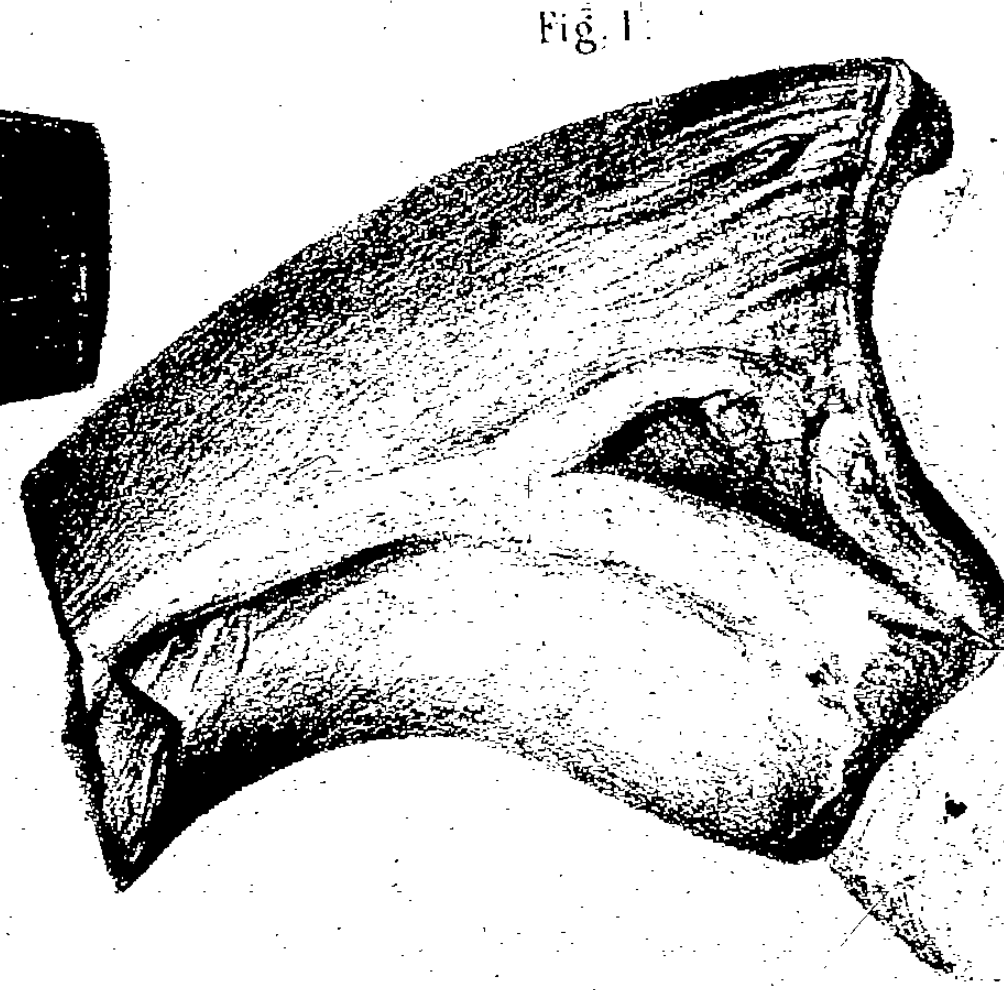


Fig. 4.

Fig. 5.

Fig. 2.

TAB. XI.

Megalosaurus Bucklandi, nat. size.

Fig. 1. Inside view of a portion of the dentary element of the mandible, with teeth.

„ 2. Outside view of part of ditto.

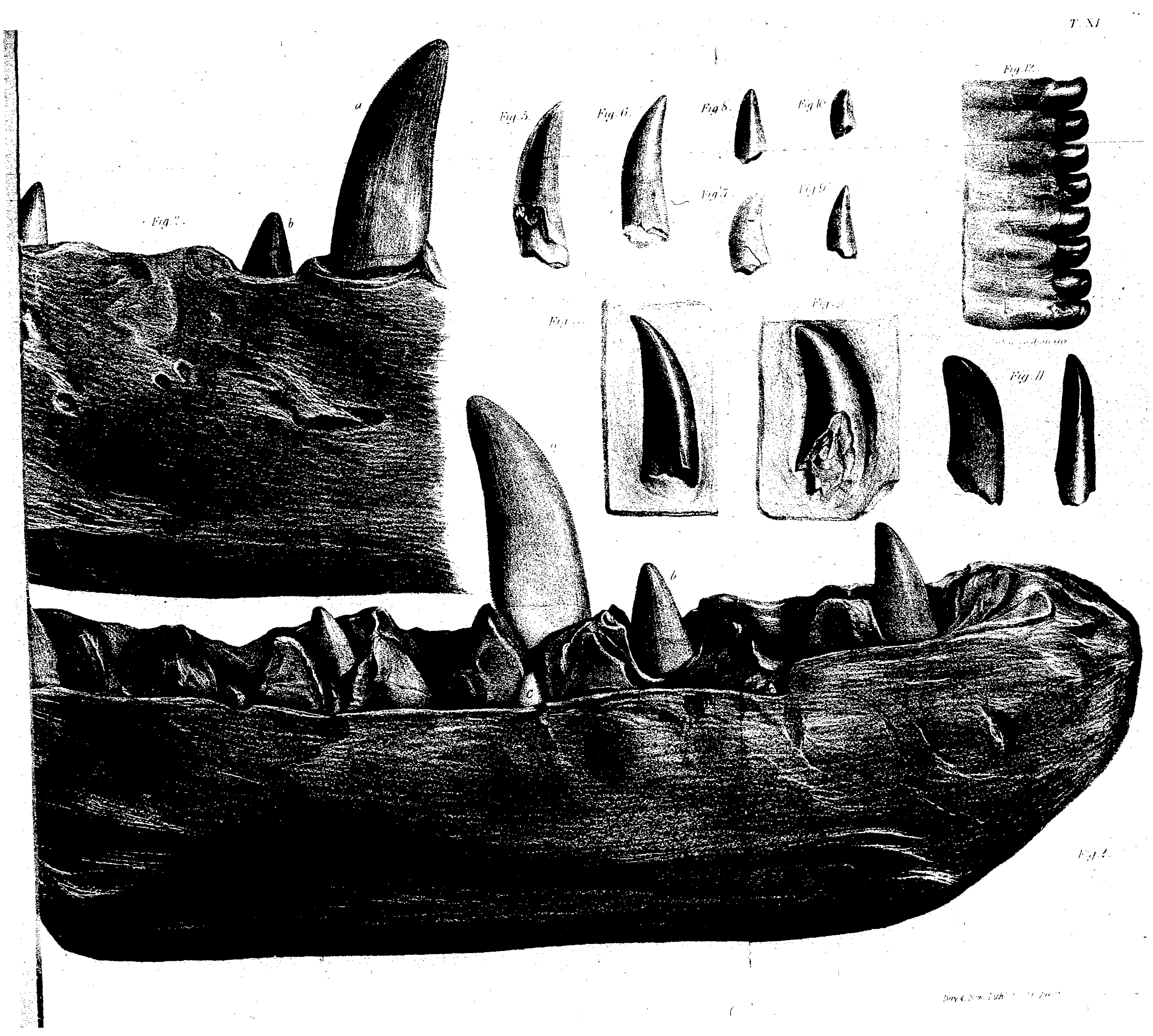
„ 3—11. Various teeth, the last much worn.

„ 12. Magnified view of the finely serrated border of the teeth.

Figs. 4, 7, and 9 from the Wealden, of Sussex; fig. 5 from the Cornbrash, of Oxfordshire; fig. 7 from the Bath Oolite, Somersetshire; the rest from the Oolitic Slate, of Stonesfield, Oxfordshire.

All the specimens, save fig. 1, in the Oxford Museum, are in the British Museum.

Fig. 2.



SUPPLEMENT (No. II)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

ORDER—*CROCODILIA.*

Genus—STREPTOSPONDYLUS, *Von Meyer.*

THIS name, from the Greek *στρέφω*, I turn, *σπονδύλος*, vertebra, was applied by M. Hermann v. Meyer to the Crocodilian reptile distinguished by Cuvier as the "second espéce de Crocodile de Honfleur,*" and characterised by the same great anatomist as "having the cervical and anterior dorsal vertebræ, with the articular ends of the centrum, convex in front and concave behind."† By this character was distinguished the "second Gavial of Honfleur" from a "first Gavial of Honfleur," in which the articular ends of the centrum were both slightly concave.

With regard to these kinds of fossil vertebræ Cuvier writes: "je nommerai l'un *système convexe* en evant, et l'autre *système concave.*"‡ To the former he referred a gavial-like skull with a shorter and more obtuse upper jaw, and a less depressed symphysis of the lower jaw;§ to the latter a more gavial-like skull, with longer and more slender jaws.||

* 'Ossemens Fossiles,' ed. 8vo, 1836. Explication des Planches, p. 78, pl. ccxxxviii, figs. 5, 6 et 7.

† Ib., t. ix, p. 309.

‡ Ib., p. 308.

§ Subsequently named *Steneosaurus rostro-minor*, by Geoffroy St. Hilaire.

|| *Steneosaurus rostro-major*, ib.

SUPPLEMENT (No. III)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

ORDER—DINOSAURIA, *Owen*.

Genus—IGUANODON, *Mantell*.

(*Mandible of a young Iguanodon.*)

I HAVE been favoured by the Rev. W. Fox, M.A., Rector of Brixton, Isle of Wight, with the inspection of a portion of the left mandibular ramus of an Iguanodon (Tab. X, figs. 1—4), including the entire series of alveoli. These are fifteen in number, and are clearly indicated by the angular risings of the outer alveolar wall, forming the intervals or divisions of the alveoli (fig. 4, 1—15). Between the summits of the angular processes the upper margin of the socket is deeply concave, and, the sockets being contiguous, a strongly marked crenate character is given to the border of the outer alveolar wall.

The longitudinal extent of the alveolar portion of the present ramus is 4 inches 3 lines. About an inch of the edentulous fore part of the ramus is preserved, but the symphysial end is broken away. At the opposite part of the fragment it has broken off, about three lines behind the last alveolus, from the rest of the jaw.

The teeth which occupied the alveolar depressions of the outer wall are gone. The germs of three successional teeth (ib., figs. 1 and 2, 6, 12, 14) are preserved. The summit of the hindmost (14) has risen to the level of the opening of the antepenultimate socket; the next in advance (12) has risen half way towards the outlet of the twelfth socket; the crown of the third just shows at the bottom of the sixth socket, counting from before backward. Each of these germ-teeth has the inner surface exposed of the summit of the crown, the anterior one showing the least proportion of the tooth. The primary longitudinal ridge (fig. 5, *a*) and the marginal serrations (*cc'*) are boldly and beautifully marked on the dark, lustrous enamel, the serrations being continued by grooves, some way upon the exposed inner side of the crown. The primary ridge more equally divides the summit of the crown here seen than in the part below, but the greater extent of the anterior area (*c*) is appreciable; the secondary longitudinal ridge (*b*) is discernible in both the anterior and posterior areæ of the crown, in the last two germs (fig. 1, 12, 14, and fig. 6. So much of the crown as appears in these teeth shows greater fore-and-aft breadth than the socket they would rise into, or rather than the socket of their predecessor, and the difference of breadth is so much greater in the basal part of the crown as to suggest much growth of the jaw in the progress of the germ to the state of a fully developed tooth in place. We thus obtain evidence of the immaturity of the specimen, and that it has not belonged to a distinct and diminutive species of *Iguanodon.*

Like all reptiles, the Iguanodon shed and renewed its teeth many times during the course of life; the new following the old teeth vertically, and being, therefore, in the growing animal, of a larger size than those they were about to displace. With the shedding of the deciduous teeth there was more or less absorption of their sockets, and with the rise of the successional teeth there was a concomitant formation of suitable, and, therefore, larger sockets.

In the Crocodile the number of teeth, or of sockets of one and the same set of teeth, does not vary with age, according to the observations of Cuvier.* Each tooth succeeds its forebear vertically, and none are added to the series, as in mammalia, from behind.

I believe myself able now to adduce evidence that the Iguanodon added this mammalian mode of succession to some other characters, which have been in previous Monographs pointed out, exemplifying its greater resemblance to the warm-blooded beasts than any existing form of reptile manifests.

The mandible of the young Iguanodon here described shows at the utmost fifteen sockets in the unquestionably entire series, occupying a longitudinal extent of four inches and a quarter. The mandible of the somewhat older Iguanodon, from the Wealden of Stammerham, Sussex, described and figured in my Monograph, 1855, Tabs. X and XI, shows eighteen alveoli, occupying a longitudinal extent of six inches.

* "Les dents offrent plusieurs remarques intéressantes dans le crocodile. La première, c'est que leur nombre ne change point avec l'âge. Le crocodile qui sort de l'œuf les a autant que celui de vingt pieds de long."—"Je me suis assuré de ce fait dans une série de huit têtes croissant en grandeur, depuis un pouce jusqu'à deux pieds." Cuvier, 'Ossemens Fossiles,' 4to, tom. v, pt. ii (1825), p. 90.

The mandible of the Iguanodon from the Wealden of Tilgate, Sussex, figured by Mantell in the 'Philosophical Transactions' for 1848, Pl. xvii, seems to have had at least twenty alveoli in a longitudinal extent of fourteen inches. The back part of the series is too much mutilated for precisely showing the divisions of the sockets; but the number, eighteen, which I originally estimated, from the figures of the fossil in the 'Philosophical Transactions,' is clearly below the number which may be estimated in the alveolar tract of the original specimen now in the British Museum.

From the foregoing facts, therefore, it may be concluded that the Iguanodon, in the progress of growth, from the period at which the dentigerous part of each ramus of the mandible is four inches in length to that in which the same part is fourteen inches in length, acquires four or five additional teeth in each series, which, from the rapidly decreasing depth of the three or four hindmost alveoli, I infer to be developed, like the true molars of mammals, in new and distinct alveoli behind those in place.

My obliging correspondent, Mr. Fox, who had been struck with the inferiority of number of the alveoli in his small specimen, compared with the indication of them in Mantell's plate of the larger jaw from Tilgate, supposed that it might indicate a distinction of species; but the whole evidence of the Iguanodon's mandibular structure, including the intermediate-sized specimen obtained by Mr. Holmes from Stammerham, appears to me to show only difference of age, and to bring to light a new and important characteristic of the dentition of the large extinct Herbivorous Reptile.

THE

PALÆONTOGRAPHICAL SOCIETY.

INSTITUTED MDCCCXLVII.

LONDON:

MDCCCLXXII—MDCCCLXXXIX.

SUPPLEMENTS Nos. 4—9

OF THE

MONOGRAPH ON THE FOSSIL REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS.

DIRECTIONS TO THE BINDER.

Supplements Nos. 4—9 of the Monograph of the Reptilia of the Wealden Formations will be found in the Volumes of the Palæontographical Society issued for the years 1871, 1873, 1876, 1878, 1879, ~~and 1888.~~

Supplements Nos. 1, 2, and 3, will be found in the Volumes for the years 1856, 1857, and 1862. Directions for binding these will be found in the Volume for the year 1864.

ORDER OF BINDING AND DATES OF PUBLICATION.

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,, ,, 5, pp. 1—18	I, II	1873	February, 1874.
,, ,, 6, pp. 1—7	—	,,	,,
,, ,, 7, pp. 1—7	I—VI	1876	December, 1876.
,, ,, 8, pp. 1—15	I—VI	1878	March, 1878.
,, ,, 9, pp. 1—19	I—IV	1879	May, 1879.

A MONOGRAPH

ON THE

FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENTS Nos. 4—9.

BY

SIR RICHARD OWEN, K.C.B., D.C.L., F.R.S.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

LONDON:

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PREFACE

TO THE

REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS

(SUPPLEMENTS Nos. 4—9).

In the volume of Monographs issued by the Palæontographical Society for the year 1887, the following, which have appeared in previous volumes, are noted at pp. 25 and 29 of the 'List of Members, Volumes, &c.,' as in course of separate publication :—

1. The Reptilia of the Wealden Formation (Supplements).
2. The Reptilia of the Kimmeridge Clay.
3. The Reptilia of the Mesozoic Formations, and
4. The Cetacea of the Crag.

The Supplemental Monographs first specified are chiefly devoted to the restoration of the extinct Reptile called *Iguanodon*, from some resemblance of its teeth to those characterising the Iguana lizard. Materials for this advance were first kindly supplied by Samuel Husbands Beckles, Esq., F.R.S., one of the correspondents on whom I pressed my wish. The rich series of remains, and their determinations as parts of the skeleton of an *Iguanodon*, form the subjects of the Supplement, No. 4, pp. 1—15, Plates I, II, III, in the Palæontographical Society's volume issued in 1872. The petrified bone, forming the core of the horny spine or claw with which the fore-leg of the more peaceable vegetable-feeding Reptile was armed, forms the subject of the 4to Plate II of that Monograph, and the large folding Plate I gives the bones of the fore-limb, also of the natural size. The geological period indicated by the rock from which these evidences were extricated is that termed the 'Wealden,' in the Upper or later Secondary Period.

Further and more exact knowledge of the dental characters of *Iguanodon* was gained by the reception of fossils from a Wealden formation at Stammerham, Sussex, transmitted to me by G. B. Holmes, Esq. These were noted and illustrated in the

Supplement, No. 5, communicated to the Palæontographical Society in the year 1873. A considerable portion of the lower jaw with teeth, transmitted by Mr. Beckles, supplied the ground for determining the side of the crown to which the characteristic ridges are limited, that, namely, which is turned toward the cavity of the mouth; the opposite or outer side of the tooth being smooth. The peculiar shape of the well-preserved symphysial end of the jaw supplied grounds of inference as to the form and movements of the tongue of the great extinct phytophagous or mixed-feeding dragon. Careful display of the tooth-bearing extent of this fossil specimen demonstrated the Reptilian character of the frequent succession and shedding of the teeth—a class-character contrasting with the Mammalian limitation of teeth to two sets, which accordingly bear the designation of the "deciduous" and the "permanent" series; the first formed, which characterise the immature mammal, being also known as "milk-teeth."

In 1873 the right ramus, or half of the lower jaw, added acceptable characters of the teeth of the *Iguanodon*, showing the entire number in the dentary part of the jaw, and the true relative positions of the smooth and the sculptured surfaces of the tooth-crown. This specimen, together with others from other Wealden localities, determined the Reptilian character of a more frequent succession of teeth than in the Mammalian class, a series of larger size being developed to correspond with the increased length of the jaws, and replacing the smaller teeth of the immature periods, which were shed.

Minor differential characters of the tooth-crown are pointed out, which, if observed only in detached fossil teeth, might have made foundations for distinct species or genera of extinct Reptiles.

A generic modification of the mandible, previously unnoted, is described as indicative (in addition to, and conformative with, the dental characters) of the vegetable or mixed diet of the great extinct Reptile, which of old once trod what now forms part of the Island of Great Britain.

Characters of the extinct Reptiles of the same period, indicative of a Dinosaurian family (*Prionodontia*) by association with the genus *Iguanodon*, are defined in this Supplement (No. 5), p. 10. The characters of the bony palate, more especially in relation to the position and conformation of the inner or hinder nostrils, are noted in the several Orders of *Reptilia*, those in the *Crocodilia* being especially defined.

Species representative of a genus, but showing a considerable range as to size, are most commonly known in the Mammalian class. A familiar example is manifested in the feline genus, where the attempt has been made to add needless complexity to zoology by coining a generic name for a small species, distinct from that given by Linnæus to it as well as to the lion and tiger. But the observed modifications of the dental system are too slight to obtain the suffrages of zoologists for a distinct term.

It is interesting to note that the complexities of structure, osteological and dental, manifested by the *Iguanodon*, and suggesting an analogy to a higher class, should be likewise extended by a manifestation of their presence in an unequivocal Saurian of the same geological epoch, with the same complex type of teeth as in the *Iguanodon*. The degree of correspondence in this generic character is shown in Plate I of this 'Wealden and Purbeck Reptilia Supplement,' No. 5, where the tooth-crown characteristic of the genus of the small species (*Iguanodon Foxii*), fig. 10, is shown by the side of a corresponding molar of the larger species (*Iguanodon Mantelli*, fig. 4). The portion of skull of the small kind (Plate I, fig. 9) supplies acceptably what the larger kind of *Iguanodon* still lacks.

In Plate II a lower molar of *Iguanodon Foxii* is figured, of the natural size (fig. 14) and magnified (fig. 15), facilitating the comparison with the mandibular molars of the natural size in the larger species (Plate I, fig. 3). In the same plate the hinder or occipital surface of the smaller species of *Iguanodon* (Plate II, fig. 1, nat. size) is contrasted with figures of the corresponding part of the skull in the existing *Iguana tuberculata* (Ib., fig. 3). The base of the skull is similarly illustrated in fig. 5 (*Iguanodon Foxii*) and fig. 7 (*Iguana tuberculata*). These parts of *Iguanodon Mantelli* must be obtained and adequately made known before palæntology can be legitimately encumbered with newly invented generic terms.

The kind and degree of modification of the tooth-crown justifying recognition of a distinct genus of extinct Reptile are manifested in fig. 21, showing the outer surface of an upper molar of *Scelidosaurus Harrisonii*. In the same plate are given three views, figs. 23, 24, 25, of the instructively preserved skull of *Hylæochampsa vectianus*.

R. O.

1*st February*, 1888.

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SUPPLEMENTS Nos. 4—9 OF THE MONOGRAPH ON THE FOSSIL REPTILIA OF THE WEALDEN AND PURBECK FORMATIONS.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN FORMATION.

SUPPLEMENT No. IV.

PAGES 1—15; PLATES I—III.

DINOSAURIA (IGUANODON).

BY

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FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,
ETC. ETC.

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SUPPLEMENT (No. IV)

TO THE

MONOGRAPH

ON THE

IGUANODON.

BONES OF THE FOREARM AND PAW. Plates I, II, III.

THE additional elements towards a reconstruction of the Iguanodon, which form the subject of the present supplementary monograph, have been contributed by SAMUEL HUSBANDS BECKLES, Esq., F.R.S., F.G.S., and their acquisition is due to his persevering labour, liberal indifference to expense, and intelligence directing the quest, resulting in the successful exhumation of the parts in question. They were associated with the greater part of the skeleton, of which, besides the subjects of the present Monograph, Mr. Beckles secured a dentary element of the mandible, fifty vertebræ, a sternum, scapula, and coracoid, one humerus and fragments of the other, one femur, one tibia and parts of the other, a tarsal bone, the three metatarsals, and phalanges of one hind foot, and some bones of the other hind foot.

Mr. Beckles was led to this excavation by a slight indication of bone in a Wealden clay (Hastings Series), about two miles to the west of St. Leonard's-on-Sea, Sussex. The area worked up was 200 feet square, or 10 feet by 20 feet, and 4 feet deep. The bed was below high water, and could only be wrought at during one tide in the day. Nevertheless the work of exposure was conducted with such energy that it was completed in a week. "The bones were imperfectly mineralized, and could only be secured by plaster of Paris, of which I used about thirty bags, each bag containing seven pounds. As a rule I applied the plaster with my own hands; but as the weather was severe, the wind being high and cold, with occasional sleet and snow, I was compelled to leave the manipulation of more than one bone to my navvies, and consequently one femur was destroyed, one jaw, one humerus, and one tibia, nearly destroyed. Had I not made a digging expressly for these bones, the interesting specimens you have in hand could never have been obtained."[1]

[1] Extract from a letter by Mr. Beckles to the author, of the 25th September, 1871.

The half or ramus of the lower jaw preserved is represented by the dentary element, containing many of the characteristic teeth of the great herbivorous reptile, and repeating the peculiar form of the fore part of the mandible which has been recognized in previously described and figured specimens of that bone.[1] Though dislocated, displaced, and somewhat scattered in the matrix, they impressed the discoverer with the conviction or certainty of their being parts of the skeleton of the same individual. A comparison of all the bones and fragments of bone submitted to me for determination give no indication of their having belonged to more than one animal, and all are referable to an individual of the same age and size.

The left radius and ulna are in the best state of preservation; the right radius and ulna are less entire; an os cuneiforme is recognizable in the carpal series, and there are metacarpals and a few phalanges of both right and left paws.

The radius is chiefly remarkable for its powerful spinous or spur-like appendage.

The antibrachial bones in the present collection confirm the ascription to 'radius' and 'ulna' of the two bones imbedded near the upper corner, opposite the right hand, of the great slab of the 'Maidstone Iguanodon;'[2] but Mr. Beckles' specimens having been worked out of the less intractable matrix—the Wealden clay—show the configuration and characters of the surface of the entire bone.

In the following description the surface or aspect of the bone corresponding with the olecranon and 'back' of the hand is termed 'anconal;' the opposite surface, or that answering to the 'palm' of the hand, is termed 'thenal;' the surface toward that side of the forearm where lies the radius is termed 'radial;' towards the opposite side 'ulnar.' 'Proximal' and 'distal' imply the ends of the bone respectively next to or furthest from the trunk of the animal.

ULNA. Plate I, 55.

The ulna is 1 foot 5½ inches in length;[3] 4 inches 8 lines across the radio-humeral articulation (at *a*, *b*, fig. 1); 3 inches 8 lines across the distal end; 2 inches 10 lines being the greatest diameter of the middle of the shaft.

The olecranon (*c*, fig. 1) extends 1 inch 9 lines above the humeral articular cavity (*d*, *d'*); it is obtuse, about 2 inches thick at the base, thence gradually contracting, to be continued into the ridge (*a*, fig. 1) extending along or forming the ulnar border of the

[1] More especially in the portion of the mandible of a young Iguanodon. Palæontographical Society's 'Monograph of the Fossil Reptiles of the Wealden Formations,' 4to, 1855, p. 20, Tab. XI, *e*, *s*.

[2] Ib., Tab. XXXIV, 'Monograph on the Fossil Reptilia of the Cretaceous Formations,' 4to, 1851. "The radius and ulna lie with their proximal ends next the right hand upper corner, the latter being distinguished by its prominent olecranon, which is rounded as in the Great Monitor," p. 112.

[3] The length of the ulna in the Maidstone Iguanodon is estimated at 1 foot 6 inches. 'Monograph,' *ut supra*, p. 114.

bone, to beyond the middle of the shaft, which then becomes rounded, and finally broadens to near the distal expansion of the bone (*k*, *k'*, fig. 1).

The humeral articular surface (figs. 1 and 2, *d*, *d'*) is oblong, and extends from above obliquely downward and forward to the strong anterior ridge (*e*), which, adding to its width, is then continued down to form (at *e'*) part of the cavity for the radius. The humeral surface is concave lengthwise, and also, in less degree, transversely; but both ulnar and radial borders become convex in that direction, or are rounded off and thick. The sharpest or best defined border is that which divides the lower part of the humeral articular cavity (fig. 2, *d'*, *f*, 'greater sigmoid' of Anthropotomy) from that (*g*) presented to the radius ('lesser sigmoid cavity,' ib.).

The length of the humeral cavity is 4½ inches; the breadth across the middle 2½ inches: the surface (*d'*, *f*, *g*, fig. 2) for the head of the radius appears to be directly continued over the well-defined lower part of the border (*d*, *f*) of the preceding cavity, directly downward, or with its plane in the longitudinal axis of the bone. This 'lesser sigmoid cavity' is semi-elliptical in shape, about 2 inches 8 lines in longest diameter, 1 inch 3 lines in the opposite direction; the upper border is straight, the lower one curved. The exact extent in the direction transversely to the head of the ulna, or in the long axis of the semi-ellipse, has suffered by fracture of the antero-inferior end or angle of the combined humero-articular cavities.

About half an inch below the radial surface the ridge (*e'*, fig. 1), continued downward from the above broken angle, expands to a rough tuberosity, which was joined by syndesmosis to a similar rough tuberosity (*r*, fig. 3) at the lower part of the anterior articular ridge of the radius.

At the proximal end of the ulna a thick, rough, long tuberosity, or tuberous ridge (fig. 2, *h*, *h*), from the radial side of the humero-radial articulation, is most prominent where it bounds or defines the radial division of that joint; below which it contracts and slightly bends to its termination (*h'*). This projection augments the breadth of the back part of the ulna below the base of the olecranon. At this part the ulna is almost flat, and the surface is roughened by thick irregular ridges, which mostly affect a longitudinal direction.

The general form of the bone at its upper three fourths is three-sided. The hinder side, continued from the above flat, rough expanse, maintains its character of flatness, gradually contracting to its termination 4½ inches above the distal end, where the shaft begins to be rounded.

The ulnar surface of the olecranon is moderately convex, lengthwise and across, for 3½ inches, or to below the middle of the humeral cavity. Then the surface begins rapidly to expand, by the development of the ulnar boundary (*e*) of the articulation for the radius, gaining a breadth of 4½ inches. The ulnar surface is here (fig. 1, *i*) moderately concave, both lengthwise and across; half way down the bone the concavity is changed to a surface flattened lengthwise, and moderately convex transversely.

The third or radial side of the shaft of the ulna has been somewhat crushed in, but seems to have been rather convex transversely, and is less sharply defined than are the other two surfaces. The thick rounded border between it and the hinder surface gradually subsides at the lower fourth of the shaft, and both blend into the somewhat flattened rough surface opposite the articular one at the distal expansion of the bone.

The thick rounded border between the ulnar and radial sides of the shaft contracts about the lower fifth of the bone, inclines forward, and extends into the beginning of the rugous margin (*k*, *k'*, fig. 1), which defines, by a convex curve, the lower or distal end of the bone.

The non-articular surface of this expansion is smooth anteriorly, where the radial facet of the shaft terminates; but is roughened by oblong tuberosities posteriorly, where the hinder facet of the shaft is lost upon it.

The articular surface for the distal expansion of the radius is of a crescentic shape, with the anterior horn the longest. It is rough and irregular on the surface, indicative of the ligamentous nature of the union. The smooth ulnar surface of the shaft terminates in the hollow of the crescent. The anterior horn extends 4 inches 3 lines above the distal end of the bone; the posterior horn 2 inches 6 lines above the same end. The general breadth of the syndesmotic surface is about 2 inches, contracting at each end of the crescent.

The compact bony wall of the ulnar shaft is from 6 to 9 lines in thickness; the fine cancellous centre, of an oval form in transverse section (fig. 4), is 1 inch 3 lines by 10 lines in its diameters.

In general shape, in the better definition of the joints for the humerus and radius, and in the development of the olecranon, the ulna of the Iguanodon resembles that of the larger living *Lacertia* more than that of the *Crocodilia*. From the ulna of the Iguana and of the large Nilotic Monitor it differs in the greater relative strength and more trihedral figure, the shaft of the ulna being compressed and two-sided in the smaller recent Lizards. There is the same concavity at the proximal part of the ulnar surface of the bone; but it seems relatively deeper in the Monitor. The chief difference in the Iguanodon is the thick tuberous extension on the radial side of the radial articulation, from which is continued that border which divides and defines the posterior and radial surfaces of the shaft.

Radius. Plate I, 54.

The length of this bone is 16 inches;[1] the greatest diameter of the proximal end (fig. 3) is 4 inches; of the distal end, from the upper border of the spur-surface (fig. 1, *m*)

[1] This appears to be its length in the Maidstone Iguanodon, but one end is covered by a crushed vertebra.

to the ulnar end of the distal articulation (ib. *n*) is 7 inches, 6 lines; from the lower border of the spur-joint (*o*) to the same part (*n*) is 5½ inches.

The proximal surface or 'head' (fig. 1, *p*), for articulation with the humerus, is semi-elliptical. The long diameter gives the breadth above quoted; the short diameter, at the middle of the ellipse, is 2 inches 4 lines; the truncate border or chord of the semi-ellipse is toward the ulna. From the posterior two thirds of this border the articular surface for the ulna (fig. 3, *q*) extends down, 1¼ inch, at right angles with the proximal surface. It is flat and rough, semi-elliptic in shape.

The proximal surface is almost flat, feebly undulate, with a linear roughness for ligamentous union with the humerus; it is continued at its fore part upon the ridge-like prominence of the bone (fig. 3, *r*, *r'*), which bends toward the ulna as it descends, terminating 2¼ inches below the humeral surface; this rough extension of the articular surface is separated from the flatter ulnar surface by a deep, smooth pit (ib. *s*), big enough to receive the end of the thumb. Beneath this articular surface the radius contracts to a breadth of 2 inches 5 lines, and a thickness of 1 inch 3 lines; and this subcompressed form, flat or subconcave toward the ulna, convex on the opposite side, but irregularly so on both sides, continues two thirds down the length of the shaft; which, then, gains in thickness and breadth, but especially and rapidly in the latter dimension by the extension of the distal end beneath that of the ulna.

The distal surface for articulation with the ulna commences about 9 inches from the proximal end of the radius in a pointed form (fig. 1, *t*), which rapidly expands to a breadth of 2¼ inches. This part of the distal ulnar surface is parallel, lengthwise, with the non-articular surface of the shaft of the radius, is almost flat or slightly convex and rough, and might be regarded as representing a partial interosseous syndesmosis; it is continued, however, at its lower broadest part into a smoother concavity upon the proximal side (ib. *u*, *v*) of the distal extension of the radius, and this concavity receives part of the distal convexity of the ulna (ib. *k*, *k'*). The distal end of the radius is excavated by two concavities for the carpal bones; that (ib. *w*) for the hemispherical part of the scaphoid is the deepest, and measures about an inch and a half in both transverse and fore and aft diameters; the shallower concavity (ib. *x*) for the convex part of the cuneiforme is continued into a slightly convex surface, extending to the apex of the distal extension ulnad (*n*) of the radius.

On the shaft of the radius may be noticed a rough, slightly prominent tuberosity (*y*), about 15 lines by 12, at the hinder or anconal margin, commencing about 4 inches from the proximal end. The shaft is not quite straight; the anconal surface below the tuberosity gains in thickness, and is slightly concave lengthwise; the thenal surface is thinner, and slightly convex lengthwise.

The exceptional feature of this radius is an oblong, irregularly flattened, rough surface, as if caused by fracture, occupying the radial aspect of the distal expansion (*m*, *o*); consequently, opposite the surface above described for articulation with the ulna. To this surface was joined, if not anchylosed, the base of a bone, corresponding with that which has been figured as the "horn" of the Iguanodon (*z*)[1]; the surface on the radius, like the co-adapted one on the base of the 'horn,' is 4 inches in long diameter, and 2 inches 4 lines in short diameter.

The unsymmetrical character of this supposed 'horn' led me to infer that it was one of a pair of bones, which I conjectured to be 'phalangeal.'[2] The rough flattened base of the original specimen, on part of which the cellular osseous texture was exposed, I believed to be due to the articular surface "having been chiselled or scraped away."[3] I now know that it was a natural surface due to separation from a close syndesmotic and partially anchylosed union with the distal end of the radius, as in the left antibrachial bones figured in Pl. I, fig. 1.

In the right radius of the Iguanodon, which has afforded the subject of the present Monograph, this horn-like appendage is anchylosed, and stands out from the radial side of the distal end like a process of the bone (Pl. II, fig. 1).

The length of the detached radial spine in the left fore-limb is 6 inches; the apex is not quite entire; the thenal surface (Pl. I, fig. 1, *z*) is less convex across and more convex lengthwise than the anconal surface (Pl. II, fig. 1, *z*). This surface is strongly convex transversely, slightly concave lengthwise, and is smooth along its distal half; it is roughened by thick and strong longitudinal ridges at its proximal third, and these are less developed at the corresponding part of the thenal surface.

The vascular channels indicate, as in a claw-phalanx, the system of supply of horny matter sheathing the bone.

The formidable spine, supported by this bony core, projected inward or from the radial side of the radius, with its distal border at right angles with the long axis of the bone, the proximal border (*z*) passing more obliquely to the apex of the spine-core.

The right ulna shows an exostosis at the back part of the shaft, near the base of the olecranon. Such instances of disease in Mesozoic reptiles are rare.

There is a slight difference in the shape of the proximal end of the right radius, which, nevertheless, belonged to the same individual Iguanodon, as the left one above described: the humeral surface, or 'head,' is 3 inches 5 lines by 2 inches 9 lines; the principal ulnar surface is 2 inches 3 lines by 1 inch 6 lines. The narrower surface for the ulna, extending upon the ridge-like process, with the digital depression dividing it from the broader ulnar surface, show the same characters, as at *r*, *s*, figure 3, Pl. I.

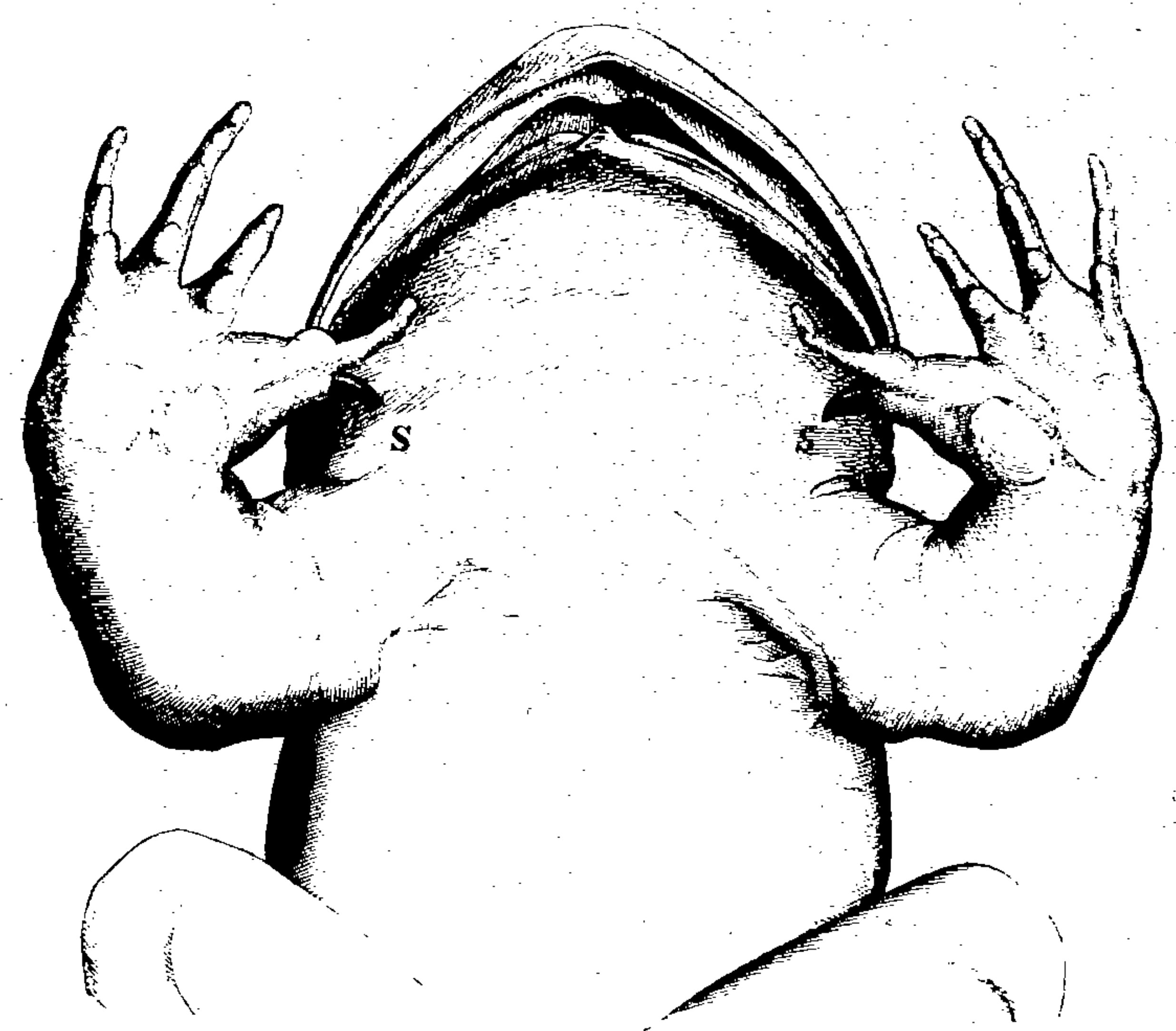
Fracture of the shaft of the right radius (fig. 5) shows a compact bony wall, 6 to 7 lines in thickness, surrounding a finely cancellous central tract: the shaft is sub-trihedral, approaching the cylindrical form prior to the distal expansion.

[1] MANTELL, 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.
[2] 'Monograph on the Fossil Reptilia of the Wealden Formation,' 4to, 1855, p. 46.
[3] Ib., ib.

The radius of the Iguanodon resembles that of Lizards—*Iguana tuberculata, Monitor niloticus,* for example—in the larger and more definite extent of the proximal surface for the ulna, than exists in the *Crocodilia.* But no living reptile—crocodilian, chelonian, or lacertian—is armed like the extinct herbivorous Dinosaur.

Of other examples in the animal kingdom of limbs with spinous weapons, the first that suggested itself was the monotrematous reptile-like Mammals. But in both *Orni-*

Fig. 1.



Sexual spines of fore-limbs; or 'Hand-spurs,' Male of large S. Amer. Toad (*Cystignathus fuscus*).

thorhynchus and *Echidna* they are limited to the hind limbs, and are attached to the tarsus, not to the tibia.

In the class of Birds are a few 'spur-winged' species—*Anser gambensis, Parra jacana, Palamedea cornuta, Hoplopterus, e.g.*—in which the weapons are attached to the radial side of the fore-limbs; not, however, to the radius itself, but to the base of the metacarpus.

My friend and colleague, Dr. Günther, has kindly supplied me with the following example of spines or spur-like weapons in an existing cold-blooded air-breather; but it is a member of the Batrachian order. In *Cystignathus fuscus* a sharp, conical, horny spine, figure 1, *s, s,* is supported by a bony core attached to the radial side of the metacarpal of the innermost or radial digit.

Many species of Fish support and wield with effect formidable spinous weapons, forming part of the pectoral fins, the homologues of the fore-limbs in Iguanodon and other terrestrial Vertebrates.

The monotrematous and batrachian instances show the spinous limb-weapons to be related to sex, and to be present, or fully developed, only in the males.

In the class of Birds the carpal spurs are common to both sexes, but smaller in the female.[1]

The question remains—were the radial spines of Iguanodon common to both sexes, or developed only in one, most probably the male?

In the Maidstone specimen such appendage, with a concomitant considerable distal expansion of the radius, cannot be discerned. In the best preserved ends of the anti-brachial bones, those, viz., furthest from the humerus (as the separated fragments of the matrix, have been restored in the Maidstone specimen), the closest resemblance traceable to the more complete bones before me is at the proximal ends; and especially, as originally determined by me, in the ulna, or lower placed bone. In this view the distal ends, especially of the radius, are partly concealed by an overlying vertebra, yet not to the extent to obscure the beginning of the radial expansion if it had existed. The shafts of both radius and ulna seem to be more slender than in Mr. Beckles' Wealden specimen. It may be that this is of a male Iguanodon and the Maidstone specimen of a female one.

A strange instrument truly in aid of the amorous embrace; yet, as in the instance of *Cystignathus*, and perhaps also the *Ornithorhynchus* and *Echidna*, not without a parallel!

If the radial spines, on the other hand, were developed in both sexes of the Iguanodon, and wielded for purposes of defence by the otherwise weaponless herbivore, one cannot fail to discern in them a formidable means of transfixing an enemy—the carnivorous Megalosaur, *e. g.*—in a close death-struggle.

Manus. Plate III.

With the right and left anti-brachial bones and spinous appendages several bones of both the fore feet were exhumed, but not enough for a complete restoration of either foot.

They give evidence that the fore-paw was pentadactyle, and that the terminal phalanges, at least of some of the toes, were short, obtuse, rough, serving for the support of horny matter in the shape of a hoof rather than of a claw. Such evidences of the carpal bones as were collected are more or less fragmentary; and, where a satisfactory union of those belonging to one and the same bone could be made, the homology of but one bone can be safely or with probability be suggested, that, viz., which answers to the large os cuneiforme in the carpus of Lizards.

The proximal surface of this bone is divided into a convex and concave surface; the former was apparently adapted to the concavity of the ulnar extension of the distal part of

[1] The Secretary of the Zoological Society, P. L. Sclater, Esq., F.R.S., kindly informs me that this is the case in the pair (male and female) of the spur-winged geese (*Plectropterus*) now living in the Society's Gardens.

the radius; the concavity was adapted to part of the distal end of the ulna, but leaving the ulnar end of the distal convexity of that bone (Pl. I, fig. 1, *k*) for probable adaptation to an os pisiforme. The distal surface of the unciforme shows the concavity for an os magnum, and a well-defined flatter surface for a small unciforme.

The metacarpal of the pollex (Pl. III, I, *m*) is 4 inches in length; 2 inches 5 lines across the broadest part of the proximal end; 2 inches across the corresponding part of the distal articulation. Both these dimensions are in the direction of the transverse breadth of the paw, the bone being subdepressed. The proximal articulation is a shallow, circular cavity continued radially upon a rough, angular production of that end of the bone. The opposite side of the articulation is produced into a broader roughened surface for syndesmotic union with the base of the next metacarpal.

The anconal surface of the bone (shown in Pl. III), for an inch or more in advance of the distal end, is roughened by longitudinal grooves and ridges: the surface then continues smoothly to the distal convexity; but shows, on each side near that surface, evidence of the powerful lateral ligaments connecting this metacarpal with the first phalanx.

On the radial side is a rough oval pit, an inch in long diameter, with the proximal border prominent and forming an angle in the radial outline of the bone. There is a similar projection on the ulnar side, but it forms the proximal end of a triangular tuberosity.

The thenal surface of the bone is more or less rough, and is divided by a low medial prominence into two facets.

The distal articulation is of an oval shape, convex in a greater degree than the proximal articulation is concave; it is 2 inches across transversely, 1½ inch in the opposite direction, or from the anconal to the thenal surface. The plane of both proximal and distal articular surfaces is not quite transverse to the axis of the bone, but rather oblique from the ulnar forward to the radial end. The least transverse diameter, at the middle of the shaft of this metacarpal, is 1 inch 8 lines.

The metacarpal of the pollex of both right and left fore-feet has been obtained.

The first phalanx of the pollex (ib. I, 1) is broader and more depressed, in proportion to its length than is the metacarpal which supports it. Its proximal concavity is smaller and more shallow than the convexity to which it is adapted, though this appearance may be in some degree due to the abrasion of the margins. That part which is preserved equally bespeaks the strength of the ligamentous attachment with the metacarpal; it is most produced on the radial side of the bone (*a*), as if ossification had extended there along the lateral ligament toward the metacarpal. The opposite or ulnar roughened surface is broader, more tuberous, but less produced.

The anconal surface of the bone is less regularly convex transversely than in the metacarpal; the mid part being raised so as to divide it from the surface on each side, which is flatter transversely and slightly concave lengthwise.

The smooth surface on the radial side is continued along a notch at the radial border of the phalanx, upon the palmar surface of the shaft, two thirds across. All the rest of that surface is grooved and roughened for ligamentous attachment.

The distal end of this phalanx is 2 inches in breadth; of this, a feebly convex, semi-oval articular surface occupies a transverse extent of 1 inch 5 lines; the breadth from the anconal to the thenal border of this surface gives that of the distal end of the phalanx, viz. 1 inch.

The series of bones does not include any phalanx adapted to or agreeing in size with this surface. By the analogy of *Sauria* and *Crocodilia*, I conclude the missing phalanx would be the terminal one. Of the proximal phalanx of the 'pollex,' Mr. Beckles' series includes both right and left.

The second metacarpal (Pl. III, 2, *m*), or that of the index digit, is 6 inches in length. The proximal end is subquadrate, 2 inches in breadth, deviating from flatness by a slight convexity, most marked towards the ulnar side, where it probably projected into the cleft between the trapezoides and os magnum.

There is no indication of a smooth synovial surface; the union throughout, or nearly so, seems to have been ligamentous; the longest diameter in the ancono-thenal direction is toward the ulnar side of the surface, and is 1 inch 8 lines.

Near the radial side of the base is a rough surface of limited extent, apparently for ligamentous connection with the adapted surface of the first metacarpal.

On the ulnar side of the second metacarpal a rough flattened tract projects, like an exostosis, from the whole length of that side of the bone. Its ancono-thenal breadth at the base of the metacarpal is 1 inch 6 lines; it decreases to a breadth of 6 lines where it passes into the rough surface for the lateral ligament on the ulnar side of the distal end.

The anconal surface of the shaft is smooth, becoming roughened by linear striæ as it bends upon the radial surface. The thenal surface of the shaft is ridged and grooved throughout; it is nearly flat transversely, moderately concave lengthwise. The distal articular surface is moderately convex, 1 inch 4 lines in diameter; there is a protuberance on each side of the thenal part of the distal end; the ulnar side of the bone is slightly convex; the radial one in a greater degree concave; thus, the second metacarpal is slightly bent toward the radial side of the paw.

The bone described belongs to the left foot. The proximal part of the same phalanx of the right foot is preserved.

The proximal phalanx of the second toe (ib., II, 1) is 2 inches 6 lines in length; 2 inches in breadth at the proximal end; 1 inch 9 lines at the distal end. The proximal articular surface has the smooth synovial character but slightly indicated. It is subcircular in form, about an inch in diameter, with a very feeble concavity; the rough peripheral tract on nearly the same plane, from 4 to 6 lines in breadth, indicates how large a proportion of the joint had been syndesmotic: the protuberance for the lateral ligament on the radial side projects beyond the plane of the articulation; that on the ulnar side has a more distal relation to the joint. The anconal and lateral surfaces of the shaft form a continuous convexity transversely. The thenal surface is flattened, but irregular; an oblique groove extends from the radial end of the proximal surface for about an inch onward toward the ulnar side; this groove, 4 lines in breadth, seems to be natural; the clay matrix could easily be picked out of it. Beyond the groove the short thenal surface is moderately smooth and slightly concave; a pair of hemispherical tuberosities project near the distal articulation, and are continued into the tuberosities on each side of that surface. The form of the surface is trochlear, that is, concave transversely, convex ancono-thenally; feebly defined in both directions. The breadth is 1 inch 3 lines; in the opposite diameter 10 lines. The well-defined anconal border projects a little above the level of the corresponding surface of the shaft; the breadth of the shaft at its middle is 1 inch 3 lines.

To the well-defined smooth trochlear surface of the above phalanx is adapted a surface of corresponding size, shape, and smoothness at the proximal end of a phalanx, 1 inch 3 lines in length, 1 inch $4\frac{1}{2}$ lines across that end (Pl. III, II, 2). The breadth of the distal articulation of this phalanx is 1 inch 2 lines; its ancono-thenal diameter is 6 lines, that of the proximal surface being 9 lines. Thus, the shape of this phalanx is subquadrate and subsphenoid; the apex of the wedge being cut off, so to speak, to form the distal joint. The upper surface of the short shaft is smooth, convex transversely, concave lengthwise. The under surface is flat, rough, and irregular, and is continued into rough prominences on each side of the shaft.

To the distal articular surface of the above phalanx is adapted the proximal one of the present (ib., II, 3, 3 *a*, 3 *b*), which is terminal, ending in a rough, obtuse, thickened border (3 *b*); the breadth exceeds the length in a greater degree in this than in the preceding phalanx; it equals 1 inch 3 lines, the length of the bone being 10 lines. The greatest ancono-thenal diameter of the proximal end is 9 lines, while that of the articular surface is but 6 lines; there is no trace of attachment for the claw. The non-articular surface of this obtusely wedge-shaped phalanx indicates by its roughness that it was imbedded in a callous sheath of the integument.

Thus we have evidence that the second digit of the fore-foot of the Iguanodon had three phalanges supported by a metacarpal; that it much exceeded in length the pollex or first digit, and that it was of less breadth, though with greater ancono-thenal thickness of the proximal phalanx.

The entire length of the four bones of the second digit is 10 inches 6 lines.

The metacarpal of the third or 'medius' (ib., III, *m*) digit is 6 inches 9 lines in length; the ancono-thenal exceeds the transverse diameter, except at the distal articulation, where the two are equal; the bone is most compressed laterally at the proximal end, which is strongly convex for being wedged or received into a groove-like cavity of the os magnum. The ancono-thenal diameter at this end of the bone is 2 inches; the transverse diameter at the anconal part is 1 inch 3 lines, but narrowing towards the thenal end. The radial side of the bone has a roughened tract, narrowing forward, and of the same extent as that on the contiguous surface of the second metacarpal; but it deviates from flatness at the parts, and in the degree in which that surface is convex in the attached bone. The two metacarpals were thus closely and ligamentously united, in a way and to an extent in which I have not observed the homologous bones in any recent Crocodilian or Lacertian. The anconal margin of the rough tract projects, ridge-like, along the proximal half of the bone. The anconal surface of the shaft begins, at an inch and a quarter from the proximal end, to be smooth, and is convex in both directions, but least so longitudinally. The ulnar surface of the shaft is roughened, but in a less degree than the radial one; the distal articular surface, single at its anconal half, where it is feebly concave, feebly concave transversely at its mid part, and much more convex in the opposite direction, has that curvature continued upon two lateral portions toward the thenal aspect of the bone, divided by an intervening channel.

The distal articular surface also inclines slightly to the radial side, where it projects beyond that surface of the shaft; it does not extend beyond the ulnar surface. It thus repeats the tendency to the bend radiad noticed in the second metacarpal, but here limited to the distal end.

The fourth metacarpal (Pl. III, IV, *m*) is 5 inches 6 lines in length; it is more compressed than the third, especially at the anconal part; the ulnar surface sloping anconad to meet the radial one, leaving the upper surface to be represented as a rounded border; thus, the shaft is trihedral, not quadrilateral. The proximal articular surface is 2 inches ancono-thenally by 1 inch 5 lines transversely. The chief part of the articular surface traverses that end of the bone in its long axis, with a strong convexity transversely, which passes into a flatter facet at the ulnar side; this ridge-like disposition of the chief articular prominence was probably wedged between the os magnum and unciforme. The ulnar flatter surface would articulate with the latter bone; in advance of this is a rougher tract, of small extent, for ligamentous articulation with a fifth metacarpal. The radial side of the fourth metacarpal is flattened and rough for junction ligamentously at its proximal part with the contiguous metacarpal; with an interval in the rest of the extent left by the concave curve, which this surface describes lengthwise, and which interval was probably filled up by looser ligamentous tissue.

The distal articulation, 1 inch 6 lines across, and the same in the opposite direction at the radial side, resembles in character that of the third metacarpal, but with an opposite obliquity tending to direct the toe which it supported more ulnad.

The corresponding metacarpal is preserved of the right fore-foot.

To either the third or the fourth digit belongs a proximal phalanx, 2 inches 6 lines in length, 1 inch 8 lines in transverse breadth of the proximal end, 1 inch 6 lines in the same breadth of the distal end, which supports a well-defined, smooth, shallow trochlear surface, 1 inch 1 line transversely by 10 lines ancono-thenally; it closely resembles the proximal phalanx of the second digit, but is rather narrower in proportion to its length, and shows greater disparity of size between the two distal tuberosities on the thenal surface. It may belong to the right paw.

A distal phalanx (ib., IV, 4), of the same character as that of the second toe, is longer in proportion to its breadth, and deeper ancono-thenally. The rough, obtuse termination is bounded below by a transverse groove indicative of an ungual callosity of a more definite form.

The fifth metacarpal of the right fore-foot (Pl. III, v, *m*, reversed) has been preserved. Its proximal surface is rather lozenge-shaped; the transverse diameter is 2 inches 3 lines; a circular, slightly concave, roughish articular surface is defined at the middle of the lozenge; the rougher tuberosities, extending beyond it on each side, form the truncate angles of the lozenge in that direction; a smaller extent of rough surface defines, in a feebler degree, the angles in the opposite direction. The length of this metacarpal is 1 inch 7 lines; the breadth of the distal end is 1 inch 8 lines. The upper surface is smooth, broad, and almost flat. The radial surface is continued into the thenal one, which is strongly concave lengthwise, and these combined surfaces are roughened by longitudinal ridges and grooves.

The ulnar surface slopes in that direction strongly from the upper one to meet the combined theno-radial surfaces; the distal articular surface is trapezoid in form, convex vertically, slightly concave transversely at its middle part, and continued upon a pair of tuberosities thenally; the toe which it supported would be directed obliquely to the ulnar side of the foot.

The skeleton of the fore-paw of the Iguanodon, carpus inclusive, may be set down as about 16 inches in length, and about 11 inches in extreme breadth, showing a like disproportion of size to the hind-foot which the humerus does to the femur.

In the Supplement,[1] No. 1, to the 'Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' I remarked, in regard to its subject, "the resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a 'hind-foot;' but it cannot be assumed that the fore-foot may not have been similarly modified."

We have now the desired evidence, and know that the fore-foot was pentadactyle, and that its chief speciality is in the stunted character of the terminal phalanges, at least of the second and third digits. The entire length of the bony framework of the fore-foot, without the carpus, is 1 foot 1 inch; its breadth across the proximal ends of the metacarpals is 9 inches: the length of the bony framework of the hind-foot, without the tarsus, is 1 foot 8 inches; its breadth across the proximal ends of the metatarsals is 9 inches.

The fore-foot is smaller in proportion to the hind-foot in the Crocodile; it is still smaller in the Iguana.

The length of the bony framework of the hind-foot in a *Crocodilus biporcatus*, with a

[1] Vol. of the Palæontographical Society, 4to, for 1858, p. 3.

vertebral column, from the first cervical to the last sacral inclusive, of the length of 3 feet 2 inches, is 8 inches, including the tarsus; the length of the fore-foot, including the carpus, in the same skeleton, is 5 inches 4 lines.

In the skeleton of an *Iguana*, with the same part of the vertebral column 9 inches 3 lines in length, the length of the hind-foot, including the tarsus, is 4 inches 5 lines; that of the fore-foot, including the carpus, being 2 inches 3 lines.

In most recent *Reptilia* the fore limbs are shorter than the hind ones; in some of the tailless Batrachians the difference is extreme. But there is nothing in the proportions or structures, especially in the approach to the ungulate type of the unequal phalanges of the fore-foot of the Iguanodon, to justify, encourage, or even suggest that the fore limbs so terminated did not take their share, as in the Iguanas and Crocodiles, in terrestrial locomotion.

The notion of the Iguanodon being a biped, and walking like a bird, would, were it true, lend countenance to the reptilian hypothesis of the Ornithicnites.

But this notion would imply, not only ignorance of the structure of the fore limbs of the huge reptile, but also forgetfulness or disregard of the correlated conditions of avian bipedal progression on dry land.

In proportion to the bulk and weight of the bird, and to its limitation to terrestrial locomotion, is the extent of the trunk-vertebræ grasped by the splints or side bones ('ilia'), which transfer the weight of the body upon the hind limbs. Thus, the ostrich has twenty coalesced sacral vertebræ.

We have no evidence that the Iguanodon had more than four sacral vertebræ, and our knowledge of their characters is derived, as might be expected from the remains of a cold-blooded prone quadruped, from detached and unanchylosed sacral centrums.

Observation of the genesis of the bird's sacrum showed,[1] among other points, the alternating disposition of the central and neural elements; and progressive research into the osteology of the extinct *Reptilia* led to the recognition of a correspondence in this particular of the sacrum of the large Dinosaurs with that of Birds. But this afforded no ground to the Discoverer of the sacral structure for affirming or predicating a closer affinity of the Iguanodon or Megalosaur than of the Pterodactyle to the feathered class.

In the strong ligament of the head of the femur in Birds—in the depth of the socket for its reception—in the strength and close adjustment of the knee-joint, in which the fibula takes its share—in the well-turned trochlear form of the distal end of the tibia—in the rejection of any intermediate tarsus between it and the foot, and in the consolidation of the metatarsal bones for a firm and close articulation with the tibia, we may discern a perfect adaptation to the requirements of the single pair of limbs to which the functions of support, station, and progression on land, are exclusively confided.

[1] Owen, 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27; Catalogue of the Osteological Series in the Museum of the Royal College of Surgeons,' 4to, 1853, p. 266.

The reverse of all these conditions is seen in the bones of the hind limbs of the Iguanodon and other Dinosaurian reptiles.

If one takes the pleasure of speculating on the genesis of *Didus* or *Dinornis*, guiding or reining the roaming fancy by facts, the geographical limitation of such ornithicnitoid species, and their primitive association exclusively with creatures of which they could have no dread, suggest the more obvious and intelligible hypothesis of derivation from antecedent birds of flight, whose wings they still show more or less aborted, according to Buffon's principle of transmutation by degeneration,—with a progressive predominance of the legs over the wings, ultimately resulting in a maximization of the terrestrial and abortion of the aerial instruments of locomotion.

PLATE I.

Iguanodon Mantelli (nat. size).

Figs.

1. Left radius and ulna, thenal or palmar aspect.
2. Left ulna, proximal end, showing articular surface for the radius.
3. Left radius, proximal end, showing articular surface for the ulna.
4. Section of shaft of ulna.
5. Section of shaft of radius.

From the Wealden Clay, Sussex. In the Collection of S. H. Beckles, Esq., F.R.S., F.G.S., &c.

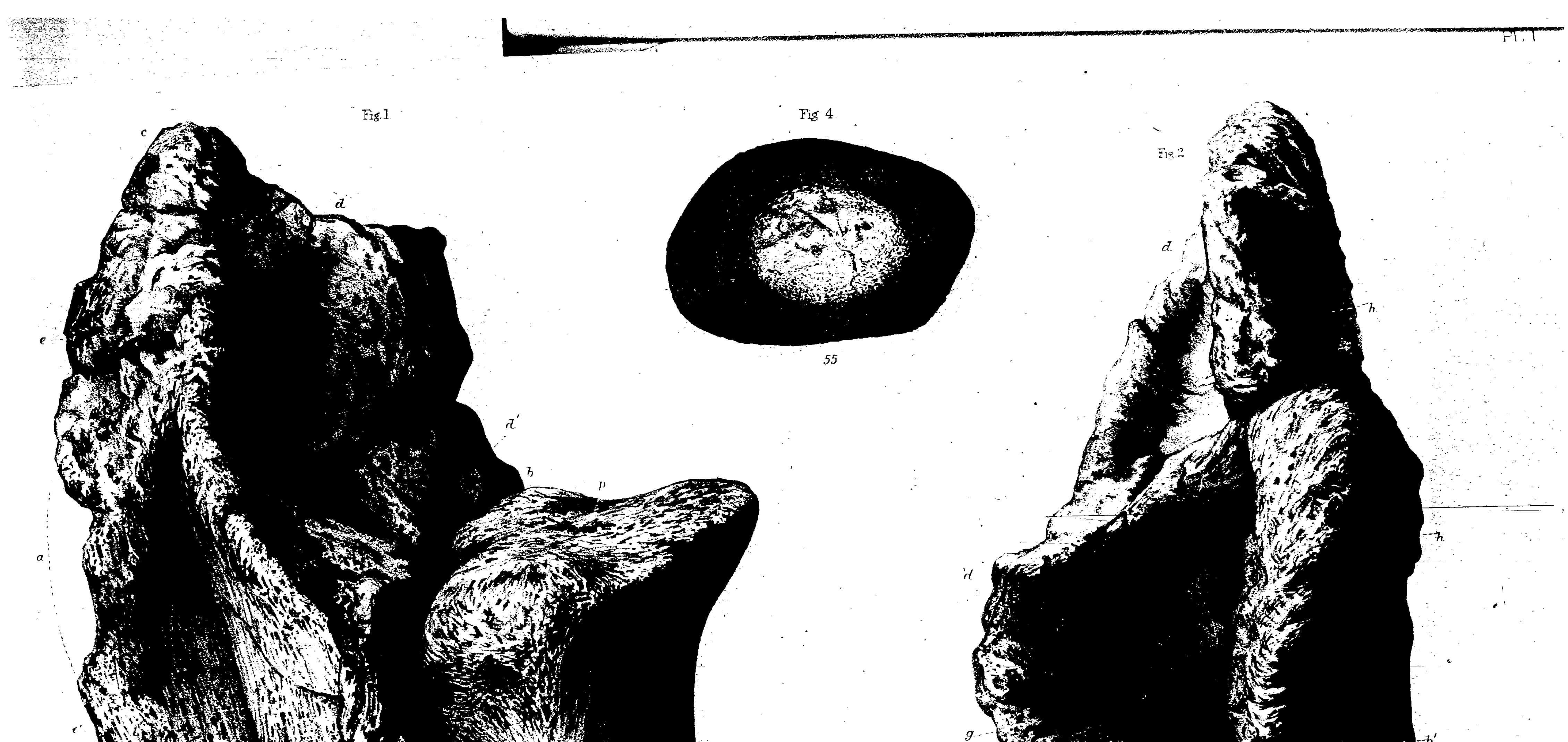


Fig.1
Fig 4
Fig.2
Fig 5.
55
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Fig 5.
Fig 3.

el et lith.

IGUANODON MANTELLI. δ. (?)

Mintern Bros imp

PLATE II.

Iguanodon Mantelli (nat. size).

FIGS.

1. Right radius, distal end, anconal or dorsal aspect.
2. Osseous core of radial spine, proximal or upper margin.

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Fig 2

Fig 1

Cl. Griesbach del et lith

Mintern Bros imp

IGUANODON MANTELLI.

PLATE III.

Iguanodon Mantelli (nat. size).

FIG.

1. Bones of left fore-foot.

 3 *a*. Ungual phalanx of second digit, proximal or articular surface.

 3 *b*. Ib., ib., distal surface.

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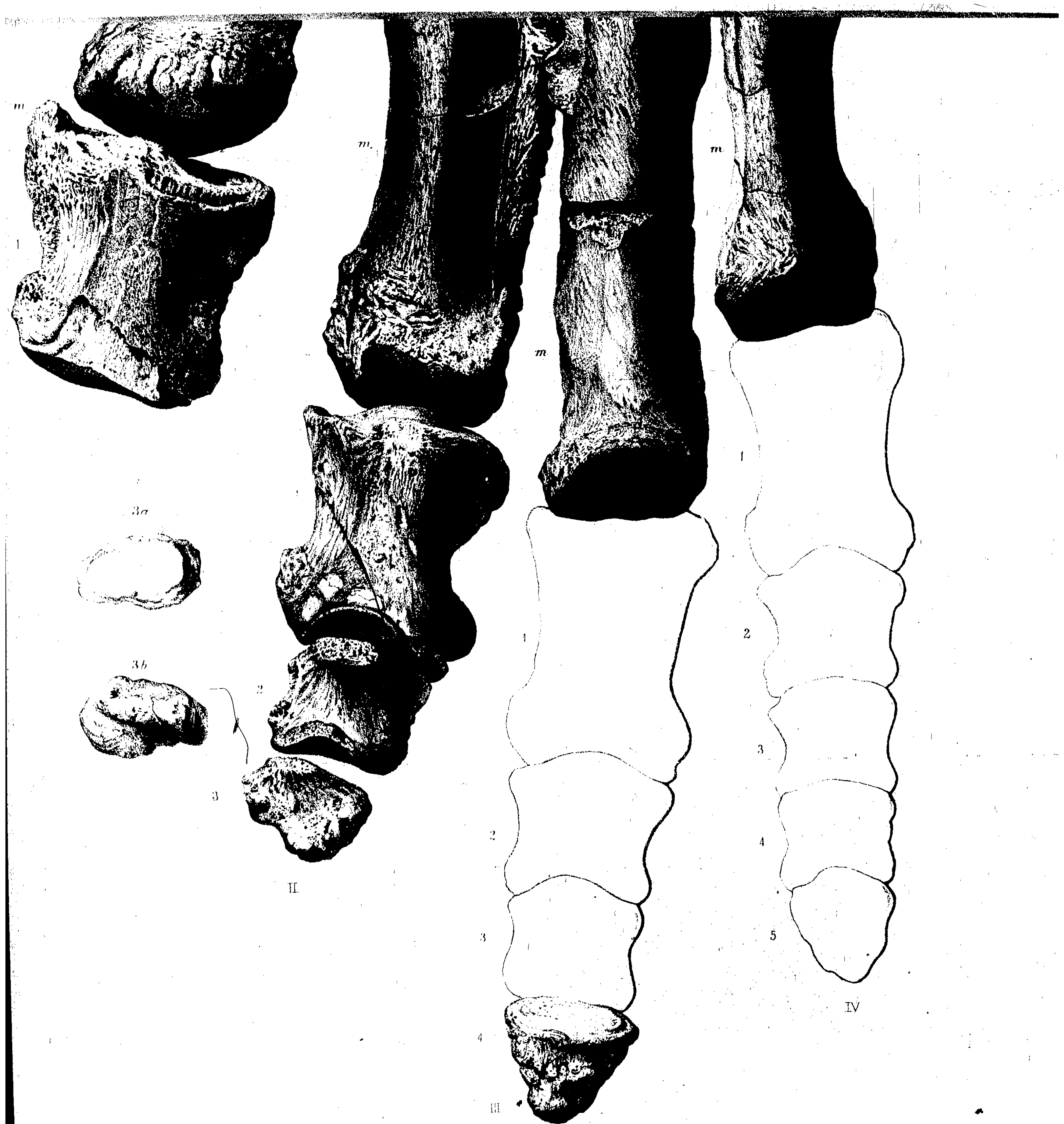
PL. III.



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IGUANODON MANTELLI.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. V.

PAGES 1—18; PLATES I & II.

DINOSAURIA (IGUANODON).

[WEALDEN AND PURBECK.]

BY

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SUPPLEMENT (No. V)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(IGUANODON.)

§ 1. Mandible and Mandibular Teeth. Plate I, figs. 1, 8.

The dentary element of the right mandibular ramus of the young Iguanodon ('Monograph on Wealden Reptilia, *Dinosauria*, Iguanodon,' part, ii, Plates XI, XII),[1] discovered in the Wealden of Stammerham, near Horsham, Sussex, by G. B. Holmes, Esq., demonstrated the fact that the sculptured surface of the crown in the teeth of the lower jaw was turned inward, the smooth surface outward, toward which aspect the entire tooth was moderately bent. Moreover, the alveoli in that jaw showed eighteen teeth to be the number supported in a close-set series and working position in the dentary element (ib., ib., p. 22).

The portion of mandible obtained by S. H. Beckles, Esq., from the locality of the limb-bones described in 'Supplement' No. IV,[2] is also the dentary element of the right ramus, of which a figure of the inner side is given in Plate I. On this surface the crowns of seven teeth nearly risen into place are seen; the worn crown and fang of a few of the preceding generation of teeth (*a*, *a*) have been preserved, and the summits of the crown of a few teeth of a third set (*c*) in succession are seen in the interspaces of the more developed teeth of the second set (*b*, *b*).

The length of the portion of mandible here preserved is eighteen inches; that of the corresponding part of the mandible of the Iguanodon discovered by Captain Brickenden in the Wealden of Tilgate (ib., ib., Pl. XIII) measured 20 inches. It is probable, therefore, that Mr. Beckles' specimen had nearly attained the full average size of the great herbivorous reptile.

The antero-posterior breadth of the teeth rising into place averages 9 lines; the largest mandibular teeth of Iguanodon (ib., ib., Pl. XVIII, figs. 3, 3 *a*) give 1 inch

[1] Pal. Soc. Vol. for year 1854.

[2] Ibid. 1871.

3 lines in the same dimensions. The crown-germs of the teeth in the Stammerham jaw (ib., ib., Pl. XI) average 6 lines; we thus learn that each successive series of teeth had an increase of size corresponding in a general degree with the growth of the jaw.

The subject of fig. 1, Pl. I, of the present Monograph shows at its interior or symphysial end the abrupt slope downward of the short, edentulous, compressed part, which curves inward to meet the corresponding part of the opposite ramus at a short symphysis, extending along an horizontal surface, parallel with the straight lower border of the mandible. The smooth canal thus formed above the symphysis indicates a relation of facility in regard to the movements of protrusion and retraction of a long, cylindrical, muscular tongue, probably used, like that of the Giraffe and Megatherium, for the prehension of the vegetable substances selected by the Iguanodon for food. It is a generic mandibular character.

The commencement of the coronoid process, contributed by the dentary, is the same in extent as that shown in the younger Iguanodon's jaw (ib., ib., Pl. XI, *a*, *f*), and indicates the position of the suture of the dentary with the surangular element.

The surface of the tooth-crowns here exposed shows the submedian primary vertical ridge, which, in detached teeth, indicates the hinder border of the crown by its proximity thereto. The secondary ridge is less strongly marked, and is best shown in the hindmost teeth. The anterior lamello-serrate border describes the usual convex curve; the posterior border being almost straight along its chief extent. The dental characteristics of *Iguanodon Mantelli*, as illustrated in previous plates (ib., ib., Pl. XVIII, Supplement, No. III, 'Iguanodon,' Pl. X),[1] are well maintained. The secondary ridge is, however, less developed than in the larger teeth of older Iguanodons. The alveolar border here, as in the smaller jaw (Pl. XII, fig. 3), describes a gentle sigmoid curve in the transverse direction, the convexity being inward in the hinder two thirds, then straight or slightly concave to the commencement of the symphysial slope. Three generations of teeth, *a*, *b*, *c*, are exposed in the present mandibular fossil (Pl. I).

In the inwardly convex part of the alveolar tract the teeth are placed 'en echellon;' the fore-and-aft plane of the anterior tooth (Pl. I, fig. 1 *b*), if carried back, would pass outside the succeeding tooth, and the crown of this stands in like relation to the next tooth behind. Thus, when fully in place, the crowns slightly overlap in the lower as in the upper jaw ('Monograph on Iguanodon,' Part No. I, Plate XI, fig. 2),[2] and eighteen teeth may range along an alveolar tract, which, if each tooth stood clear of the next, would not support more than fourteen. Room is also got for the full number along the working line by a certain alternation in the degree of attrition, as is well exemplified in the portion of mandible of a younger or smaller Iguanodon next to be described (Pl. I, fig. 8).

Three views of an upper tooth (Pl. I, figs. 2, 3, 4) and three views of a lower tooth

[1] Pal. Soc. Vol. for year 1862. [2] Ibid. 1854.

(ib., figs. 5, 6, 7) are taken from teeth of the same individual as that to which belonged the mandible (fig. 1) and the bones of the fore-foot described in 'Supplement,' No. IV.

I am indebted to A. J. Hogg, Esq., for the opportunity of examining and figuring the instructive specimen (Pl. I, fig. 8). It was discovered in the hard limestone, locally known as the "Under Feather," which is situated from four to five feet below the accumulation of shells of *Ostrea distorta,* called the "Cinder Bed," in the Middle Purbecks.

A reference to p. 22, fig. 4, of my 'Monograph on the Fossil Mammalia of the Purbeck Formations, British Mesozoic Mammals' (Palæontographical Society, vol. xxiv, issued for 1870), will show the position of the Middle Purbeck series in which the present interesting evidence of the Iguanodon was entombed. It is the first example of that genus, to my knowledge, from the Purbeck series.

In making this statement I refer, of course, to the unequivocal evidence of Iguanodon afforded by the dentition. A large phalangeal bone is figured by Buckland in Pl. XLI, 'Geological Transactions,' Second Series, as a "metacarpal" of Iguanodon. It was picked up "on the sea-shore, about half a mile north of the village of Swanwich" (ib., p. 428), and though "more or less injured by rolling on the sea-shore" has most claim to be referred to the hind-foot of the Iguanodon. It was most probably washed out of the cliffs of iron-sand and sandy clay described by Webster as dividing the Greensand of Ballard Down from the upper body of the Purbeck "limestone."

The portion of jaw here exposed (Pl. I, fig. 8), is the dentary element of a right mandibular ramus, about the size of the Stammerham specimen (Monogr. cit., vol. for 1854, Plates XI, XII), but is mutilated at both ends; it includes, however, in an alveolar tract of four inches, ten teeth, alternately young and old. The foremost, *b*, is a lanceolate and acuminate crown-germ, least advanced in size and lowest in position in the jaw. The second, *a*, is fully in place with the upper third of the crown worn away and supported by a long, slender, tapering fang, occupying the interspace between the first and third teeth. The latter shows the crown fully formed, with the apex risen almost to the level of the worn surface of the antecedent tooth, between which and the fourth it accurately fills the interspace. The fourth tooth, *a*, rises to a higher level than the second and has rather more of the crown worn away; much of its narrow fang is exposed. The crown of the fifth tooth—third of its series, *b*—fills, like the third tooth—second of the series *b*—the interval between the fangs of the fourth and sixth teeth. The sixth tooth rises a little higher than the fourth, and is rather more worn. The seventh tooth—fourth of the series *b*—is more complete and rises higher than the fifth or third; the apex of its crown is on a level with the worn surface of the sixth tooth: the outer part of the lower half of the crown and beginning of the fang of the seventh tooth has been broken away, showing the pulp-cavity in the latter. The eighth tooth—fourth of the series, *a*—is worn down to the contracted base and beginning of the fang. The ninth tooth has risen above it, has come into service, and the crown is supported by a strong root. Beyond this is part of the crown of a successional tooth of a third series, *c*.

The close interlocked fitting of these teeth of different stages and periods of growth is most instructively shown in the present specimen; former ones had given only a partial view of this arrangement, suggestive, however, of an Iguanodontal character of dentition, which is here demonstrated.

The primary and secondary ridges are more equally developed, and the tertiary ridges less conspicuous, in these lower teeth of a Purbeck *Iguanodon* than is usual in the larger or older Wealden specimens. If any Palæontologist should see in this a specific character he may, perhaps, accept the name of *Iguanodon Hoggii.*

§ 2. Skull and Teeth of *Iguanodon Foxii.* Plate I, figs. 9, 9 *a*, 10; Plate II, figs. 1, 5, 8—18.

This section of the present Monograph may be regarded as a Supplement to the paper by Professor Huxley, F.R.S., F.G.S., in the 26th volume of the 'Quarterly Journal of the Geological Society,' p. 3, Pl. I, figs. 1—4 (1870), in which its chief subject has been described and figured with characteristic care. The conclusions of the author as to the generic relationship of the species to which this unique fossil skull belonged, were not, however, satisfactory to its discoverer, and he, consequently, placed the specimen in my hands.

The desirability of throwing light upon the cranial characters of Iguanodon, supposing it should be admitted that there may be here a source of such, will serve, I trust, as an excuse with palæontologists generally, for my presuming to go over ground already trodden by so able a predecessor, and the result may be that the Rev. W. Fox will not stand alone in rejecting the ascription of his fossil to a genus "*Hypsilophodon.*"

The articular or condylar part of the basi-occipital (Pl. II, fig. 1, 1) is broken away, a portion of the broad basilar part of the bone (ib., fig. 5, 1) remains in articulation with the basi-sphenoid (ib., ib., 5). This element shows a median contraction with lateral emarginations, bounded anteriorly by the pair of pterapophyses (*t, t*). The left of these abuts in its natural position against the corresponding pterygoid, the hinder branch of which, diverging obliquely backward, is broad and moderately concave on its postero-internal surface; the end which would have abutted upon the inner and back part of the tympanic is broken off. There is no apparent "pre-sphenoid style" from the interspace of the pterapophyses.

The left half of the foramen magnum (Pl. II, fig. 1 *f*) is entire, showing a vertical diameter of 4 lines, a transverse one of 5 lines; the lower part shows the fractured surface from which the left exoccipital portion of the occipital condyle has been broken away: the basi-occipital part of the condyle is wanting. The super-occipital (ib., ib., 3) rises broadly and vertically from the upper half of the foramen, *f*, for an extent of 6 lines; a tract of matrix of 3 lines extent intervenes between the super-occipital, which here shows a jagged upper margin, and the hind border of the parietal, 7. It may be, as in *Varanus* (ib., fig. 2), that an unossified tract of the cranial walls has been left here; or an angular ridge, as in the Crocodile (ib., fig. 4, 3), may have been broken away. The direction of the occipital surface is more vertical than in Lizards. The mid-tract of the super-occipital is moderately convex transversely, the lateral tracts as moderately concave to the lateral borders of the occiput, which borders gently converge as they rise (Pl. II, fig. 1, 3). The exoccipitals (2) extend, connately with the par-occipitals (4), outward, slightly downward and backward, for an extent of 9 lines from the foramen magnum, preserving a vertical breadth of 4 lines.

In *Iguana* (Pl. II, fig. 3) the super-occipital (3) is a vertical crest, from which the sides slope forward and outward at an acute angle. In *Varanus* (ib., fig. 2) the super-occipital surface (3) is transversely convex and strongly inclined from the foramen magnum (*f*) upward and forward. The small Dinosaur, like *Dicynodon*, shows a crocodilian type of the occiput.

The left tympanic (ib., fig. 1, 28) has been dislocated inward, and lies with its upper end beneath the par-occipital abutment (4).

The pterygo-palatine structures accord with the lacertian type. The proportions of the pterapophyses (ib., fig. 5, *t*) are more like those of *Varanus* (ib., fig. 6, *t*) than of *Iguana* (ib., fig. 7, *t*); but the pterygoid of the small Dinosaur resembles that bone in the herbivorous Lizard. The right pterygoid (fig. 5, 24) retains part of the tympanic process (*a*) and of that (*c*) which abutted against the ectopterygoid (25); a portion of the right palatine (20) is preserved, of small size, showing an anterior and posterior emargination, as in *Varanus* (ib., fig. 6, 20). The hind end of the right maxillary with the abutting part of the ectopterygoid are broken away in the fossil. The right malar bone has left its impression on the matrix (Pl. I, fig. 9, 26).

The masto-postfrontal zygoma (ib., 8—12), in its breadth and relative position to the occiput and parietal, is crocodilian. The normal or lower (malo-squamosal) zygoma is indicated on the right side by the impression of the malar and a remnant of the squamosal; a larger proportion of which is preserved on the left side (Pl. II, fig. 1, 27) abutting against the tympanic (ib., 28). It is also shown in Pl. I, fig. 9 *a*, where the parts are drawn without reversing. The upper outlet of the temporal fossa is smaller than in Lacertians, larger than in existing Crocodiles; its proportions are those of some Teleosaurs and Dicynodonts, and are approached by those of the small Crocodilian from the same Wealden locality (ib., fig. 24, *t*, *t*).

The skull of *Scelidosaurus*, which gave the first considerable insight into the type of that part of the Dinosaurian skeleton, had, unfortunately, lost so much of the fore-end as prevented the application of the external narial test of its correspondence with one or other of the two existing divisions of Brongniart's *Sauria*. It could not, thereby, be determined, for example, whether the outer part or process of the fore-end of the nasal applied itself to the anterior edge of the ascending process of the maxillary, or to that of the premaxillary; in other words, whether the maxillary entered into the formation of the outer nostril, as in *Lacertilia,* or was excluded therefrom, as in *Crocodilia.*

The present Dinosaurian skull supplies this test and shows its correspondence with the Crocodiles; there is, nevertheless, a touch of the Lizard. For the body or jaw-part of the premaxillary (Pl. I, fig. 9, 22) sends upward not only the process from its hinder part (22^x), applying itself to the outer border of the fore-part of the nasal (15) and excluding therefrom the maxillary (21), but it also sends upward a more slender process from the fore-part, which terminates in a point wedged between the ends of the nasals and dividing the right nostril (*n*) from the left, after the lacertian type. Yet, again, the Crocodilian affinity is here manifested, for the premaxillaries are not confluent and the dividing process is not a single and symmetrical one, as in *Iguana, Varanus,* and most Lizards,[1] but is bisected by the medial suture or cleft dividing the right from the left premaxillary. The premaxillary thus, in the main, adheres to the type of that of the Crocodile, circumscribing all that part of the nostril which is not due to the nasal bone itself, and excluding the maxillary from the boundary of the respiratory opening. The application of the outer process of the fore-end of the nasal to the anterior edge of the ascending process of the maxillary[2] could only be predicated by one mistaking a crack of the premaxillary for the suture. The ascending process (Pl. I, fig. 9, 22^x) with which the nasal articulates at the outer part of its fore-end belongs to the premaxillary as well as does the inner process of the same end of the nasal bone.

The premaxillo-maxillary suture extends from behind the sixth obvious premaxillary tooth for the extent of nearly an inch, with a slight curve convex forward, between the two main elements of the upper jaw. The maxillary and premaxillary have been slightly separated from each other along this suture by the force which has fractured both bones; but the margins of the suture show its true nature and distinguish it from the fractures, especially those on the body of the premaxillary, one or other of which must be adopted for a suture on the hypothesis of the hinder ascending process (22^x) belonging to the maxillary bone.

Of the six premaxillary teeth in place the foremost alone (Pl. I, fig. 9, *i*) has the crown entire; its outer surface is convex across and lengthwise, most so along the middle, transversely, the main or mid-ridge of the Iguanodontal teeth being thus indicated. The margins are also slightly relieved (Pl. II, fig. 18, magn.) and converge at an acute angle to a sharp, slightly incurved, apex; the enamel is minutely punctate. Neither in the right nor the left deflected part of the premaxillary, anterior to the pointed tooth, is there any trace of socket or fang. It would seem that this end of the premaxillaries was edentulous, like the corresponding slope of the symphysial part of the mandibular rami to which it was

[1] *Hatteria (Rhynchocephalus)* is an exception ('Phil. Trans.,' 1862, plate xxv, fig. 5, 22, p. 467).

[2] "The outer, in like manner, applies itself to the anterior edge of the ascending process of the maxillary and forms a part of the outer boundary of the nostril."—Huxley, ut supra, p. 4.

applied. The outer surface of the deflected ends of the premaxillaries is pitted and finely punctate or rugose.

The fractured bases of the premaxillary teeth succeeeding the first show a transverse diameter nearly eqnal to the fore-and-aft one, and I can form no judgment as to the shape of their missing crowns, save on the analogy of the Iguanodon. They are close-set, and if those crowns extended antero-posteriorly they must have overlapped. This Iguanodontal arrangement is demonstrated in the undisturbed maxillary teeth, of which eight are recognisable; the hind border of one crown overlaps the fore border of the tooth behind.

The two anterior maxillary teeth have slipped in part from their sockets and do not show this arrangement. The first is the smallest antero-posteriorly, but its crown has been worn to the fang, and when entire would be larger in that direction. The second tooth is less worn, and yields in size to the third. In the fifth the full size of the crown, antero-posteriorly, is shown, and this tooth is selected for the magnified view in Pl. I, fig. 10.

The outer surface of the crown is bisected by a medial primary longitudinal ridge; behind this ridge the surface is smooth and concave transversely; in front of the ridge the similarly concave surface is accentuated by two low secondary longitudinal ridges. The same characters appear, in the degree in which the crown is unworn, in the other maxillary teeth.

In upper or maxillary molars of *Iguanodon Mantelli* the following varieties have been recognised and figured.

In the 'Monograph on the Iguanodon' (Palæontographical Society's volume for 1854, issued 1855, Pl. XVIII, fig. 2) the primary ridge is nearer the fore border of the crown than in fig. 10, Pl. I, of the present Monograph; there is a feeble indication of a secondary ridge on the anterior transversely concave facet. There are two secondary ridges in the posterior facet, as in fig. 10, and the crown is so worn down as to show no trace of marginal serrations.

In the upper tooth, fig. 1, Pl. XVIII (Monograph cit.), the crown is less worn and the marginal serrations appear beyond the line of extreme breadth. The anterior facet shows no secondary ridge; the two such ridges in the posterior facet run together in the terminal part of the crown.

In the 'Monograph on Iguanodon, Supplement No. II' (Pal. Vol. for 1858), "Cretaceous Reptilia," Pl. VII, fig. 2, three upper molars are shown *in situ* with the Iguanodontal overlap, viz. the hind border of a fore-tooth (*m*) over the fore-border of the next tooth (*n*): in these upper molars the primary ridge is sub-medial, and the front face smooth as in fig. 10, Pl. I, of the present Monograph; the two secondary ridges on the hind facet are feebly indicated. The marginal serrations are shown in the preserved terminal part of the crown, which is entire in the teeth marked *n* and *o*. Bisect the tooth *n* at the line at which it is worn away in figs. 9 and 10, Pl. I, and no serrations would appear. In some upper molars of Iguanodon the margino-serrate character is continued in a minute form nearer to the base of the posterior margin. I have figured a left upper molar of this variety in figs. 2, 3, 4, of Pl. I, and also to show the further variety of three secondary ridges on the hind facet of the crown.

But the upper molars in the subject of fig. 9 show, as in the enlarged view (fig. 10), a continuation of the relieved or raised lateral borders across the base of the crown, in a curved course, convex toward the fang. This basal ridge does not project beyond the origin of the primary ridge, but falls into that origin.

I have not observed this character, at least so definitely marked, in any upper tooth of *Iguanodon Mantelli*, and I regard it as indicative of a specific distinction of the smaller Iguanodon now under review, believing myself entitled to conclude as to its generic relationship from the characters of the dentition of the upper jaw above defined and illustrated.

It is true that one, at least, of the premaxillary teeth is canine-like with a crown "lanceolate and acuminate." But no portion of the skull of *Iguanodon Mantelli* has yet been discovered which would supply the means of testing its resemblance to or difference from the smaller species, in regard to this dental character. Consequently, prior to our knowledge of the skull and dentition of the smaller species, the discovery of a tooth answering in size to the ordinary upper molars of *Iguanodon Mantelli*, but with a "lanceolate and acuminate crown," would naturally suggest its reference to some other Dinosaurian genus of the Wealden, of the bulk of the Iguanodon. In giving a description of this tooth in the 'Supplement on Wealden Reptilia,' in the Palæontographical volume for 1857, issued in 1859 (p. 42), I therefore suggested that it might belong either to *Cetiosaurus* or *Pelorosaurus*. I now, however, from its resemblance to the entire premaxillary tooth in the small Iguanodon—as close as is the resemblance in the maxillary teeth—deem it more probably to belong to the larger species and to be a premaxillary tooth of *Iguanodon Mantelli*. As such, two views of this tooth of half the natural size are given in Pl. II, figs. 19 and 20, for comparison with the magnified view of the laniary of the smaller species (fig. 18). The surface of the crown (fig. 20) which answers to the outer one in fig. 18, and in *t*, fig. 9, Pl. I, is convex both lengthwise and transversely, and most so in the latter direction along the middle part; the main or mid-ridge of the maxillary Iguanodontal teeth being thus represented. On the opposite (inner) side of the crown (fig. 19, Pl. II) the surface is concave across the two thirds next the apex. One margin, the anterior according to the analogy of the small Iguanodon, is convex, the hinder margin along its terminal half is slightly concave. The crown expands antero-posteriorly above the root to nearly midway to the apex, towards which the borders then converge to a point with the different contours above noted. Both borders are trenchant, not serrate.

Now that we know that a laniariform, or 'lanceolate and acuminate,' premaxillary tooth was associated with molars of the Iguanodontal type, in a small exemplar of the genus, we may anticipate that the premaxillary part of the skull of *Iguanodon Mantelli,* when discovered, will show teeth, if they should be preserved there, of the laniary type exemplified in Pl. II, figs. 18, 19, and 20. The anterior mutilation of the skull of the *Scelidosaurus,* with maxillary teeth having the terminal and more expanded half of the crown serrate (Pl. II, fig. 21), precludes, at present, the determination whether the iguanodontoid molars of this genus were similarly associated with anterior laniaries. But the dentition of the small Purbeck Dinosaur (*Echinodon*), with a corresponding type of maxillary dentition (Pl. II, fig. 22), does include one or more laniaries in advance of molars of the serrate type, as in the small and large Iguanodons ('Monograph on the Fossil Reptilia of the Cretaceous and Purbeck Strata,' Pal. Soc. vol. for year 1858, p. 35, Pl. VIII, figs. 1, 1 *a*).

I next proceed to determine how far the dentition in the small skull repeats the iguanodontal character of overlapping arrangement of the crowns of the teeth.

The right tympanic and mandibular ramus are wanting in the fossil. The left mandibular ramus has been pushed obliquely to the right side, and its fore end has partly displaced the first and second molars, beyond which the projecting end has been broken away. The crowns of those teeth, so driven out of line, are thereby partly withdrawn from their sockets, so as to expose the basal half of their fangs. From this I infer that the force has operated upon the recent animal: for, if it had acted subsequent to fossilisation, through movement of the matrix, it would have broken the teeth, at that time cemented to their sockets. Howsoever that may be, displacement is obvious, and no inference can be drawn as to the original relative position of the crowns of these anterior teeth. As it is, the anterior edge of the crown of the third molar does not overlap in the slightest degree the posterior edge of the crown of the tooth before it; the reverse is the case if any overlap at all can be predicated.[1] In the undisturbed molars the hind edge of each tooth projects a little beyond the fore edge of the one behind it. This is the characteristic arrangement of the upper or maxillary teeth of *Iguanodon.* It is exemplified in the specimen figured in my second 'Supplement' to the Monograph on the genus (Palæontographical Society's volume for 1858, issued 1860), Pl. VII, fig. 2, in the undisturbed upper teeth, there marked *m, n, o.* The overlap by the anterior edge of the crown in the anterior four maxillary teeth of the posterior edge of the tooth in front, and the reverse arrangement in the rest of the maxillary series, where "the overlap seems to have taken place in the opposite direction," may be a character of *Hypsilophodon,* Huxley, but is certainly not a character of the present nor of any previous evidences of *Iguanodon.* In the small species discovered by Mr. Fox, as in the large type of the genus, the maxillary grinders not merely seem to overlap, but do so, in the way and degree exemplified in fig. 9, Pl. I, and in fig. 2, Pl. VII, of the former Monograph, above cited (Pal. Soc. vol. for year 1858), on the Iguanodon.

[1] "The anterior four teeth are rather smaller than the others; and this is especially true of the first tooth. The anterior edge of the crown of each of these teeth slightly overlaps the posterior edge of the crown of its predecessor."—Huxley, loc. cit., p. 5.

Four or five teeth may have occupied the alveolar interspace between the foremost of the series of ten maxillary teeth and the second tooth from the premaxillary one, *i* (Pl. I, fig. 9). Sixteen teeth of the pattern characteristic of the upper molars of *Iguanodon* would thus occupy the extent of the alveolar border of the upper jaw preserved behind the pointed tooth (*i*). The maxillary is broken away behind such sixteenth molar. The small Iguanodon may, therefore, have resembled the large one, in number or 'formula,' as in the characteristic and peculiar generic pattern, of its teeth. The arrow (10) points to the tooth which is the subject of the magnified view (fig. 10). A comparison of this figure with a similar magnified view of an upper molar of *Scelidosaurus* ('Monograph of a Fossil Dinosaur,' &c., Pl. V, fig. 3 [1]) shows the teeth of the two genera to be modifications of the same type. The exterior surface of the crown in *Scelidosaurus* (Pl. II, fig. 21) has a median and two marginal longitudinal elevations or ridges. The marginal ones diverge with the expansion of the crown, and end in points at its extreme breadth, rather more than half way between the base and apex of the crown. This apex and the points of the marginal ridges define a triangle, the converging sides of which are notched or serrate. The hollows between the medial and marginal ridges are smooth in *Scelidosaurus*, the anterior hollow is usually ridged in *Iguanodon*. In this genus the 'secondary' ridges are more feeble than the primary ones, and are plainly the seat of variety, as in the instances above cited. The upper molars of the small Iguanodon (Pl. I, figs. 9, 10) of the present Monograph exemplify the rule of the generic type: the first-cited figure of the two former Monographs shows the variety more approaching the type of the geologically older Dinosaurian (*Scelidosaurus*).

The molars of the Purbeck Dinosaur (*Echinodon*, Pl. II, fig. 22) repeat the pattern of those of *Scelidosaurus*, but the marginal serrations, being more numerous and relatively smaller, more resemble the serrations which Professor Huxley states "are so characteristic of the teeth of Iguanodon."[2]

The tooth, which I have referred, with probability, to the *Hylæosaurus*, shows the shape of crown on which the Scelidosaurian and Iguanodontal patterns have been superinduced; it expands from the base to two lateral angles, whence the sides converge to a third apical angle. If the converging borders of the terminal half of the crown had originally been notched or serrate, those projections had been worn away by use, in the tooth figured ('Monograph on the Fossil Reptilia of the Wealden Formations: Genus *Hylæosaurus*' in the Palæontographical Society's volume for 1856 [3]). I may remark, also, that this tooth is a mandibular one, and that a nearer approach to the serrident type may have been shown in the maxillary teeth of the *Hylæosaurus*. Howsoever this may prove to be, the conformity of cranial structure, as of fundamental tooth-type, between *Scelidosaurus*, *Echinodon*, and *Iguanodon*, now exemplified by the small skull (Pl. I, fig. 9), makes it convenient to associate the genera in a section of *Dinosauria*, which may be termed '*Prionodontia*,' *i. e.* serrident, or saw-toothed.

[1] Pal. Soc. vol. for year 1859. [2] Loc. cit., p. 5. [3] P. 21.

In this family the skull exhibits a more generalised type of structure than in the existing *Crocodilia* and *Lacertilia.*

The short, square, massive character of the cranium, and the greater extent of ossification of the rest of its walls, are retained in modern *Crocodilia;* but the majority of the characters, as the double or divided external nostrils, the divided frontals, the relatively large orbits, the pterygoids divaricated by intervening basi-sphenoidal pterapophyses, and the separated palatines, are characters retained by modern Lizards. In the majority of existing Laçertian genera, however, the nasals form a single bone, and the premaxillaries are confluent anteriorly. These bones retain their parial condition in *Crocodilia* as in *Prionodontia.*

The position of the portion of lower jaw—left mandibular ramus—preserved in the block of matrix with the skull, precludes the procedures of exploration requisite for detection of teeth or germs of teeth, with any regard for the safety of the rest of this unique specimen, although the temptation is great, in reference to the alleged absence of an Iguanodontal characteristic, namely, the serrations of the free edge in the teeth of this specimen. Not that the allegation has any real value as to the generic character of the Saurian so represented; since it is plain that the remnants of the crowns of the upper molars are not such as could show the Iguanodontal serration if it had existed, the apical part being wanting where alone, as a rule, the crown is marginally serrate in the upper molars of *Iguanodon Mantelli.* In this species, moreover, the serrations are more numerous, and affect a relatively greater extent of the margins of the crown in the teeth of the lower jaw than in those of the upper. Hence it might be expected that the mandibular teeth of the small species from the Cowlease Wealden would apply a decisive test, on the assumption that the absence of marginal serrations—all other Iguanodontal characters present—was decisive against a generic relationship with Iguanodon.

Mr. Fox has kindly transmitted to me the portion of the left mandibular ramus, 1 inch 7 lines in length, with a depth of 7 lines, where entire, which is the subject of figs. 8—11 in Pl. II. It includes the sockets and fangs of eight teeth, so closely set as to have necessitated the overlapping arrangement of the crowns, according to the Iguanodontal type, the hind margin of the anterior tooth covering the outer side of the fore margin of the tooth behind, in the lower as in the upper jaws. The proportion of transverse to fore-and-aft diameters of the fractured bases of the mandibular teeth (fig. 8) in this specimen is also Iguanodontal, suggestive of a bruising function. These eight teeth occupy an alveolar extent of 1 inch 3 lines.

The outer surface of the ramus (ib., fig. 9) is divided into an upper and lower facet by a low, obtuse, prominent angle or ridge extending horizontally, and giving the greatest thickness to that part of the jaw; a series of five vascular or neuro-vascular foramina extends a little above this ridge. The structure of the outer surface of the ramus, exhibited by the larger jaw of a young Iguanodon, also discovered by Mr. Fox, in the same Wealden deposits of the south-west coast of the Isle of Wight, closely accords with that shown by the present specimen (compare 'Monograph on the Fossil Reptilia of the Wealden,' Supplement No. 3, Pal. vol. for 1862, Pl. X, fig. 4, with fig. 9, Pl. II, of the present Monograph).

In like manner the inner surface of the smaller mandibular fragment (ib., fig. 10) shows a gentle convexity lengthwise and an almost level surface vertically, broken by a longitudinal groove near the lower border.

Concluding that, as in *Iguanodon*, the germs of successional teeth would lie on this side of the roots of the broken ones which had been in use, and that such germs would have the 'lanceolate and acuminate' portion of the crown, yielding the required test of conformity or otherwise in regard to marginal serration, I removed the inner (splenial) plate at parts which exposed three such germs (Pl. II, fig. 11, *a*, *b*, *d*), each demonstrating the character in question.

The inner side of the crown is traversed longitudinally by the submedial primary ridge, the coronal margin anterior to which shows four acute serrations, with grooves continued from their intervals some way down the surface. The extreme fragility of these precious evidences checked further attempts to expose more of that surface. My interpretation of the characters of the mandible and mandibular teeth, so far as they are exhibited by this specimen, is, that they demonstrate a reptile of the genus *Iguanodon*.

If the specimen belong to a full-grown individual, the greater relative size and the smaller number of the coronal serrations show it to belong to a distinct species of *Iguanodon*, for which the name of its discoverer is deservedly to be retained.

Still may remain the question whether, in the numerous successions of teeth which would ensue during the acquisition of the magnitude of *Iguanodon Mantelli*, the number of serrations might not be increased in greater proportion than the increase of the size of such serrations. That would be the sole modification needed to make them specifically as well as generically the teeth of *Iguanodon Mantelli*.

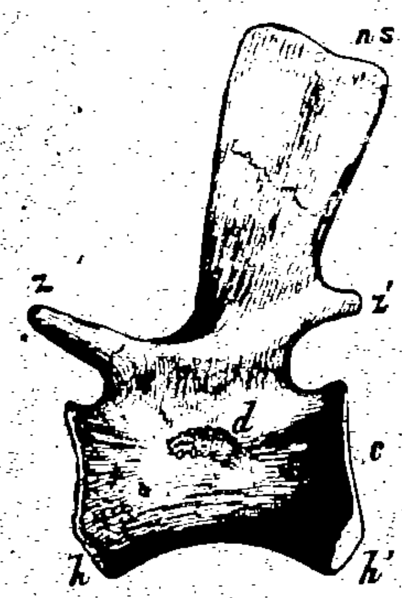
Of the above-described mandibular fossil Mr. Fox writes:—"This jaw was found within a yard of the skull. They were both in a mass of mud that had slided down from the cliff, and was being gradually washed away by the sea."

What is wanting in the exposed portions of the tooth-germs in the above specimen, viz. the continuation of the marginal serrations, of smaller size, upon the ridge bending from the margin at the broadest part of the crown upon the inner surface of the narrowing basal part of the crown, is fortunately supplied by an almost entire lower molar of *Iguanodon Foxii* (Pl. II, figs. 12—17), which came from a slab of Wealden stone containing a portion of a right mandibular ramus (Woodcut, fig. 1), with the symphysis, *s*, confined to the lower border of the sloping end (as at 5′, fig. 1, Pl. I); also a few ribs, a caudal vertebra of the pattern of those figured in Pls. VIII and IX

Fig. 1.

of the 'Monograph' on the Iguanodon of Pal. vol. issued for year 1854, and also "a distal phalanx of one of the toes." "I cannot tell," writes Mr. Fox, "where I have the bone itself, but its shape is exactly like that in *Iguanodon Mantelli*, very little curved in a downward direction, and rather broad.[1] In the little paper box, along with the fragment of jaw, you will find one very small tooth, quite perfect,[2] that came out of this slab in dressing."[3] This slab was found in the fallen cliff, about 150 yards east of "Barnes High," directly fronting the den of my *Polacanthus*, which I dare say you will remember seeing. The skull and broken jaw were found about 60 yards further eastward."[4]

FIG. 2.



In the accompanying Woodcut, fig. 2, of the caudal vertebra, nat. size, of *Iguanodon Foxii*, are added letters of reference corresponding with those on the figure of a caudal vertebra of *Iguanodon Mantelli* above quoted. The anterior or cervical vertebræ show the modification of the front ball and hind cup ('Monogr. on Wealden and Purbeck DINOSAURIA,' Part II, 1855, Tab. I, figs. 3, 4). If the sacral vertebræ should show the broad under surface, as in *s* 4, Tab. III, *Monogr. cit.*, a corresponding variability of vertebral shape in the same skeleton will characterise the present small kind of *Iguanodon* as it does the large kind.

The tooth (Pl. II, fig. 12) is 5 lines in length in a straight line; it is moderately curved, with the convexity (as the teeth *in situ* above described show) towards the inner surface of the jaw, the sculptured surface of the crown having the same aspect. The length of the fang is 3 lines, that of the crown is 2 lines, but the apex of this has been broken off. The breadth of the crown is $2\frac{2}{3}$ lines; the thickness of its base $1\frac{1}{2}$ lines. The fang tapers to its implanted end, which is hollow and filled with matrix, subcircular in form, $\frac{1}{2}$ a line in diameter; the dentinal wall is here very thin. The fang expands towards the crown, chiefly in the antero-posterior direction, and is shorter on the outer concave than on the inner convex side, the coronal enamel descending rather lower on the outer side. The inner side of the fang is broader and less convex across than the outer side, towards which the fang seems to be, as it were, rather pinched in.

The outer side of the crown (ib., fig. 17, magn.) begins with a feeble rise of the enamel from the level of the fang, such rise describing a slight convexity downward; this side of the crown is gently concave lengthwise, more strongly convex across; it is relieved by low ridges continued down from the apices of the chief serrations, most of them subsiding before gaining the basal line. The finer serrations on each margin of the crown, where

[1] The shape and proportions of the ungual phalanges vary in the toes of the fore and hind feet in *Iguanodon Mantelli*.

[2] Letter received 4th February, 1870.

[3] Ib. ib.

[4] Letter above cited. The skull and broken jaw are the subjects of figs. 9 and 9 *a*, of Pl. I.

it bends in from its broadest part, are conspicuous. Minute, short, irregular, longitudinal, linear risings of the enamel may be seen with the pocket lens in part of the interspaces of the longer and plainer ridges. The crown expands to its extreme fore-and-aft breadth about one third of its length from the fang.

The enamel on the inner side of the crown (ib. fig. 15, magn.) begins by a like definite rise from the level of the fang, but this runs straighter across before bending up to the margins of the expanding basal part of the crown. The continuation to the hinder border is more prominent and its termination is more abrupt, giving a slightly angular contour to that border, and making the surface of the crown between the border-ridge and the primary longitudinal ridge a little concave transversely. The basal rising subsides more quickly and completely upon the anterior border, which describes a gentle convex curve, and does not rise so as to render the inner surface of the crown between it and the primary ridge concave. Thus, the inner and outer sides of the crown being determinable by their difference of sculpturing, the fore and hind borders are shown by the above specified characters, and the detached tooth can be referred, as in the case of those of the larger *Iguanodon,* by like characters to its own ramus or side of the jaw; this, in the present tooth, is the right one. The inner side of the crown of this tooth of *Iguanodon Foxii,* as in the lower teeth *in situ,* has one chief median primary longitudinal ridge, increasing in strength from its origin at the basal rising of the enamel to the apex of the crown. On the front facet a short secondary ridge begins, next the primary one, near the apex of the crown, and terminates in the point or 'serration' next to that of the primary ridge. Another secondary ridge begins at the base of the crown, and runs nearly parallel with the primary one. The margin of the crown, anterior to this ridge, shows the usual smaller serrations. On the hind facet two secondary ridges commence at the up-bent part of the basal one, run parallel with the primary ridge, gaining in prominence and breadth, and terminate in the two stronger serrations behind the chief or apical one. Smaller serrations mark the hind border of the crown between the above and the end of the basal ridge.

Thus, all the complexities giving the generic characters of the lower teeth of *Iguanodon* are here manifested, as are those of the upper teeth in the skull (Pl. I, figs. 9, 10). The following differences from the larger teeth of *Iguanodon Mantelli* are of specific value: the defined rise of the basal border of the coronal enamel on both the outer and inner sides of the tooth, especially the latter; the relatively larger size and smaller number of the marginal serrations; the larger relative size and more definite median position of the primary longitudinal ridge.

The latter character, however, is reached in the range of variety to which the teeth of *Iguanodon Mantelli* are subject, as may be seen in the anterior 'acuminate and lanceolate' tooth in the Purbeck Iguanodon (Pl. I, fig. 8 *b*), and in the figs. 10, 15, 17, Plate VII ('Monograph on the Genus Iguanodon,' Supplement No. 2, Pal. vol. for 1858), exemplifying the characters of the upper and lower teeth of *Iguanodon Mantelli* and some of their varieties, due to age, wear, and position in the jaw.

From the above facts I conclude that the fossils discovered by Mr. Fox, and figured in Pls. I and II of the present Monograph, afford the much-needed exemplification of the cranial structure in the genus *Iguanodon,* and that they contribute to supply characters of the serrident family of *Dinosauria* which were not given in the fossil skull of *Scelidosaurus Harrisonii,* figured in Pls. V and VI of the Monograph on that Liassic Dinosaur, Pal. Soc. vol. for year 1859. The importance of this addition to the knowledge of Dinosaurian structures induces me to recapitulate and enforce the passing remarks, offered in the course of my descriptions, on statements which, if true, would leave such addition still a desideratum.

Serrations of the free edge of the crown, affirmed to be "*so* characteristic of the teeth of *Iguanodon*" (Huxley, *ut supra,* p. 5), are not in any degree characteristic of that genus. They are present in the teeth of older *Dinosauria* as of contemporary genera. The Liassic *Scelidosaur* and the Purbeck *Echinodon* alike manifest the modification. The true generic dental characteristic of *Iguanodon* is the superaddition to marginal serration of ridged and grooved sculpturing of one of the surfaces of the crown of the teeth; to wit, the outer one in the upper teeth, the inner one in the lower, the sculpturing being in so broad and definite a style that the ridges can be defined and distinguished. This character, combined with marginal serration, in the molars of the small Dinosaur in question, and this other character of the overlap of the expanded crowns in the one direction above described, are now submitted to impartial Taxonomists as the ground of the reference of the subject of the present section (§ 2) to Conybeare's genus.

So singular an anomaly in the arrangement of a molar series as the reversal of the order of overlapping at its two extremes might well support a generic distinction, but would need clear and indisputable demonstration for acceptance. *Iguanodon Foxii* affords no real ground for the ascription of such an anomaly.

As little does the fossil discovered by Mr. Fox support the assertion that its teeth have "no trace of the serrations on the free edge of their crown."

Prof. Huxley seems at one time to have been open to the evidence of the true character of the teeth in the unique skull from the Isle of Wight Wealden. But its discoverer had expressed his belief[1] that it might belong to a young Iguanodon, or to a new small species of that genus;—like the skeleton in which I had previously pointed out Iguanodontal characters.[2] So, in 1869, Prof. Huxley writes:—"A more critical comparison, however, has convinced me that the teeth of this reptile are perfectly distinct from those of the great Wealden Dinosaurian" (*ut supra,* p. 6). My own scrutiny, made in no critical spirit, but simply to find out the true state of the case, leads me to affirm these teeth to be specifically distinct, but not generically, from those of *Iguanodon Mantelli.* What the meaning of his term 'perfectly' may be, as predicated of this distinction, the author quoted nowhere defines.

[1] 'Proceedings of Sections, British Association,' Norwich, 1868.

[2] 'Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations—Dinosauria (Iguanodon),' Palæontographical Society's volume for year 1854, p. 2, Pl. I.

In a subsequent Monograph on the parts of "other skeletons of the animal in the same locality," I may test the grounds of the ascription of the tibia and fibula of *Iguanodon Foxii* to the ischium and pubis, and of the hypothesis of its bird-like bipedal progression.

In concluding the present Monograph I would express the deep obligations under which Palæontology is under to the persevering explorations carried on, in brief intervals of leisure, by the Rev. W. Fox, M.A., in the locality which has benefited by his judicious and benevolent spiritual care and supervision.

[APPENDIX TO SUPPLEMENT No. V MONOGRAPH ON *IGUANODON FOXII*, OW.]

SINCE the foregoing pages went to press, and long since the plates were completed and printed off, some additional observations have been recorded on specimens acquired from Mr. Fox's locality, which have been adduced in support of the title of my *Iguanodon Foxii* to generic distinction. The most important and decisive is that of my experienced fellow-contributor to the Monograph of the Palæontographical Society, Mr. BOYD DAWKINS.[1] *Hypsilophodon*, it appears, has seven digits in each fore-foot, and five developed ones on each hind-foot, whilst *Iguanodon* has but five digits on each fore-foot ('Monogr. Wealden Reptilia,' Supplement No. 4[2] (*Iguanodon*), 1872, Pl. III), and three developed digits on each hind foot (Ib. ib., Supplement No. 1[3] (*Iguanodon*), 1858, Pl. I). He justly, therefore, cites the distinction between *Hipparion* and *Equus* as warranting, or "sufficient for," the adoption of the same taxonomic distinction between *Hypsilophodon* and *Iguanodon*. It was unnecessary to remark (as the learned Society addressed by Mr. B. D. well knew) that two additional developed toes, with hoofs, are present in both fore and hind feet of the Miocene Horse, which toes are represented by splint-like rudiments of the metapodial elements in Pliocene and Modern equines, like the digit I in the above-cited plate of the Iguanodon's foot-skeleton.

Other observations, by Mr. HULKE, have not the same weight as those on the shape of the unequal phalanges of the fore-foot,[4] with me as those of Mr. Boyd Dawkins, seeing that some of the sacral vertebræ of the *Iguanodon*, those, *e.g.* marked *s* 4 and *s* 5 in the specimen of sacrum figured in Pl. III of my 'Monograph on Wealden Reptilia,' Part II[5] (*Iguanodon*), 1855, "are cylindroid and rounded below."[6] Such character might well be extended in a smaller species, but would not lead me to found thereon a generic distinction and name.

Moreover, in the series of eight vertebræ of which "the three last are firmly anchylosed, and the seventh and eighth form part of the sacrum," Mr. Hulke admits that "they are constricted in the middle, and their transverse processes, which spring from the junction of two vertebræ, are bent backwards, joining the dilated outer end of the transverse processes of the next vertebra, including a large subcircular loop."[7] This

[1] "Proceedings of the Geological Society of London," No. 273, November 19, 1873, 8vo (p. 2 of 'Abstracts').

[2] Palæontographical Society's volume for year 1871.

[3] Volume for year 1856.

[4] 'Quart. Journ. Geol. Soc.,' No. 116, June 25th, 1873, p. 528.

[5] Volume for year 1854.

[6] Proceedings, Nov. 19th ('Abstracts,' p. 2).

[7] Ib., ib., p. 1.

description might have been taken from the type example of the sacrum of *Iguanodon Mantelli,* figured in the Pal. Society vol. for 1855, above cited; and it adds to the satisfaction I feel in the additional knowledge of the osseous structure of the great herbivorous Dinosaur, which we may inferentially derive from the additional or better preserved parts of the smaller species; but which light it is sought to obscure by the *Hypsilophodon* curtain.

I have a strong belief and expectation that when specimens of the palatal structure of *Iguanodon Mantelli* are obtained they will resemble those of *Iguanodon Foxii,* figured in my Pl. II of the present Monograph, 'proved' and marked for 'Press' in June, 1873. The 'stout body' of the pterygoid is there shown in fig. 5 (*at* 24); the posterior process (*s*) joining the large 'pterapophysis' or basisphenoidal fork (*t*); the root of the branch (*a*), which Mr. Hulke[1] terms the 'quadratic process' = my 'tympanic process,' and the extension of the outer concave border to join the 'ectopterygoid' (*c*); also the separation, medially, of both pterygoid and palatines. Such, I repeat, may be expected to be, in the main, the palatal character of the great herbivorous Dinosaur. That expectation is further and strongly supported by the significant correspondence between *Iguanodon Mantelli* and *Iguanodon Foxii* in the characteristic and peculiar relations of the teeth to the jaws. "As in *Iguanodon Mantelli* the outer wall of the tooth-groove sends inwards partitions, which practically separate the teeth from one another, and must have afforded them a very firm support; but I doubt if these partitions actually reached the inner wall and became confluent with it."[2] I have no doubt, from the shape and length of the root or fang of the lanidriform tooth (Pl. II, figs. 19, 20, of the present 'Monograph') that it was "contained in a distinct separate socket." The difference, therefore, in the mode of implantation of teeth in the same jaw, as in the shape of vertebræ in the same sacrum, and in the shape of unequal phalanges in the fore and hind feet, are characters common to both *Iguanodon Mantelli* and *Iguanodon Foxii.*

R. O.

December 4*th*, 1873.

[1] 'Abstracts of Proceedings,' p. 1.

[2] 'Quart. Journ.' (June, 1873), p. 525.

PLATE I.

Genus IGUANODON.

FIG.

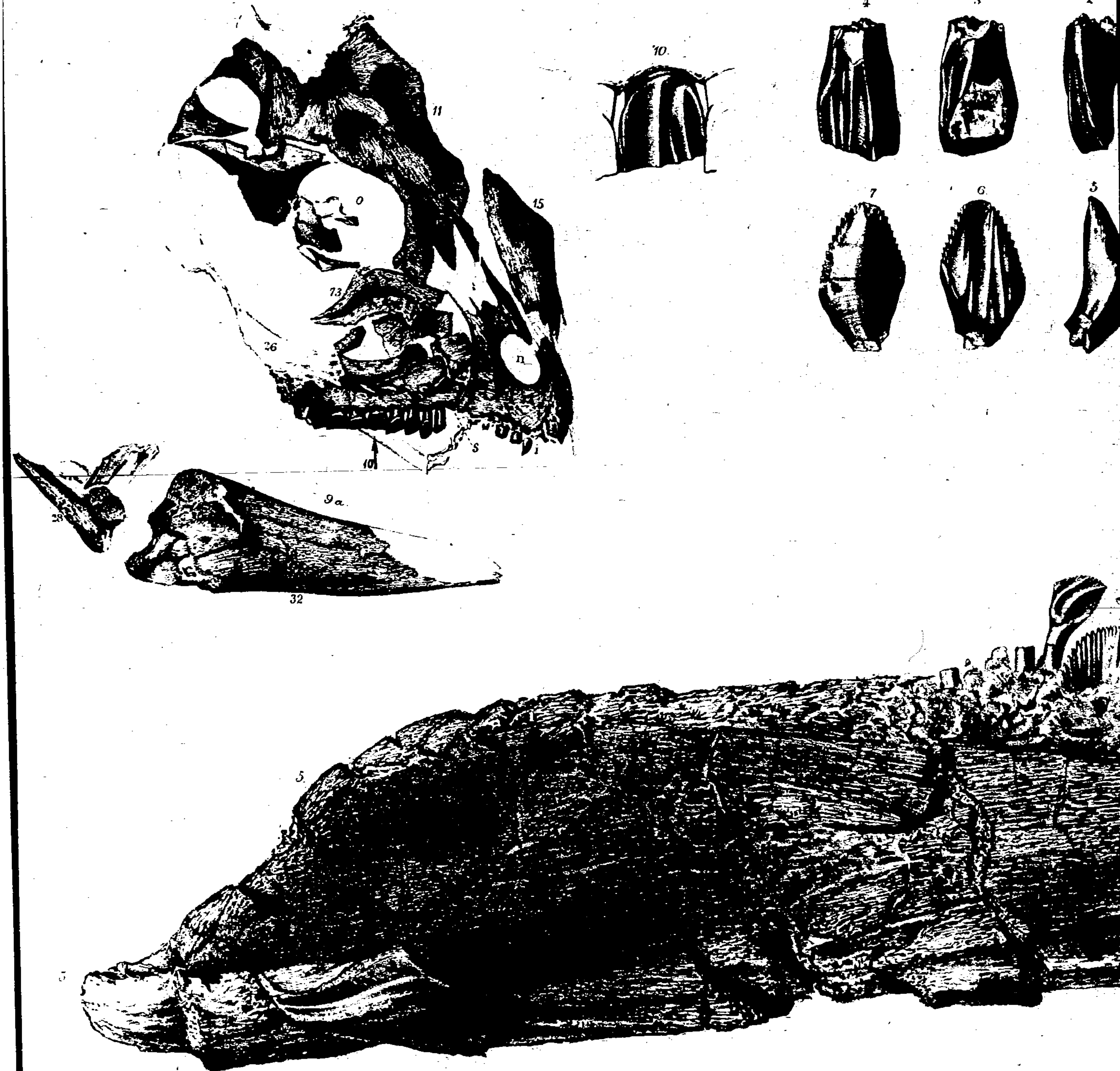
1. Inner side-view of the dentary element of the right mandibular ramus, *Iguanodon Mantelli;* nat. size.
2. Anterior surface of a worn upper molar of a younger *Iguanodon Mantelli.*
3. Inner surface of the same tooth.
4. Outer surface of do.
5. Posterior surface of a lower molar of the same *Iguanodon Mantelli.*
6. Inner surface of the same tooth.
7. Outer surface of do.
8. Inner side-view of a portion of the right mandibular ramus of a younger *Iguanodon Mantelli;* nat. size.
9. Major part of the skull of *Iguanodon Foxii;* nat. size.

9 *a.* Portion of left tympanic and mandibular ramus of the same skull; nat. size (drawn without reversing).

10. Outer side-view of a worn, right, upper molar of the same skull; magn. 5 diams.

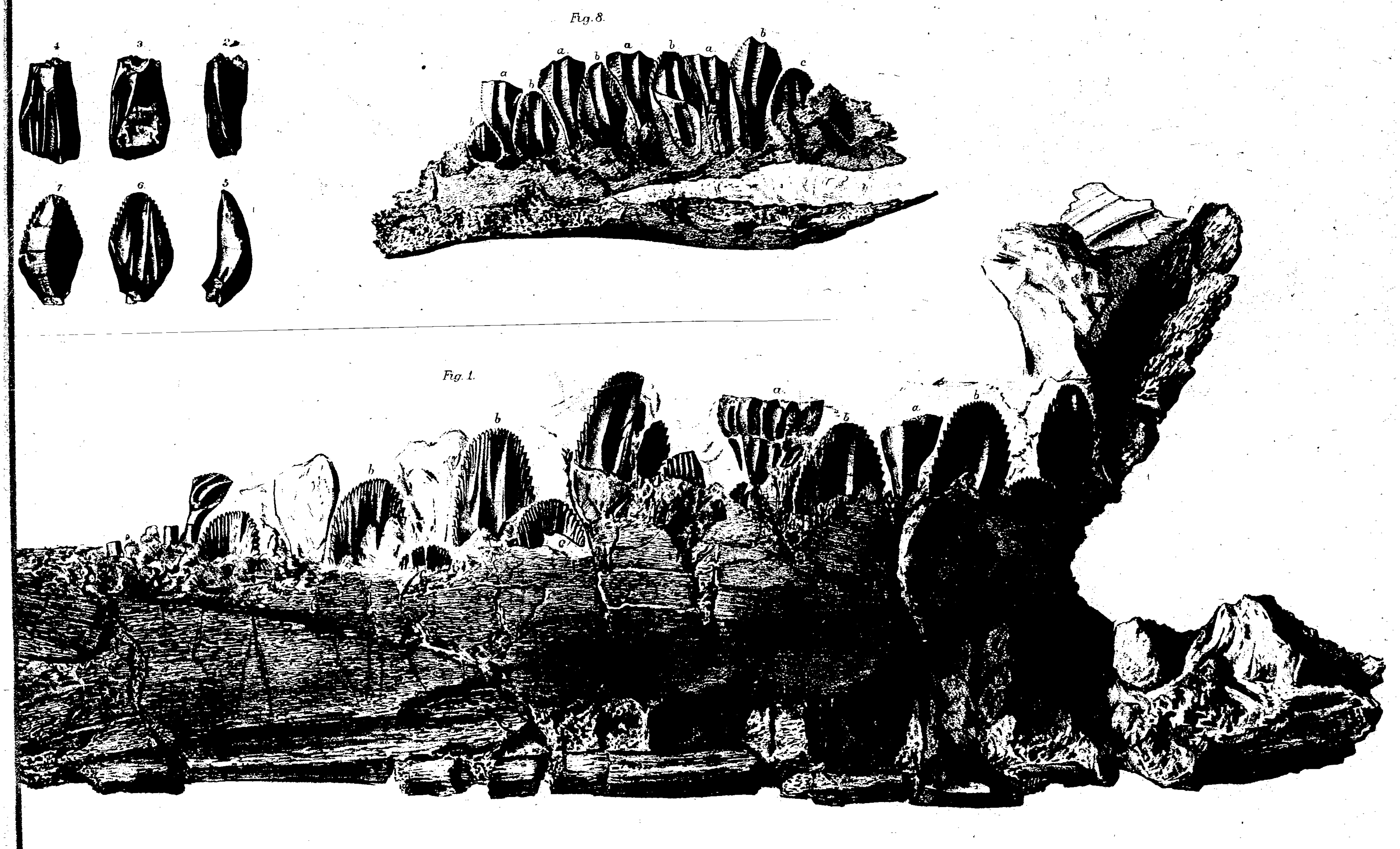
Figs. 1—7, from the Wealden Clay of Sussex, are in the Collection of S. H. Beckles, Esq., F.R.S., F.G.S., &c. Fig. 8, from the Middle Purbeck of Swanage, is in the Collection of A. J. Hogg, Esq. Figs. 9, 9 *a*, 10, from the Wealden of the Isle of Wight, are in the Collection of the Rev. W. Fox, M.A., of Brixton, in that island.

Fig. 9.



C.L Griesbach del. et lith.

Pl. I



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IGUANODON MANTELLI

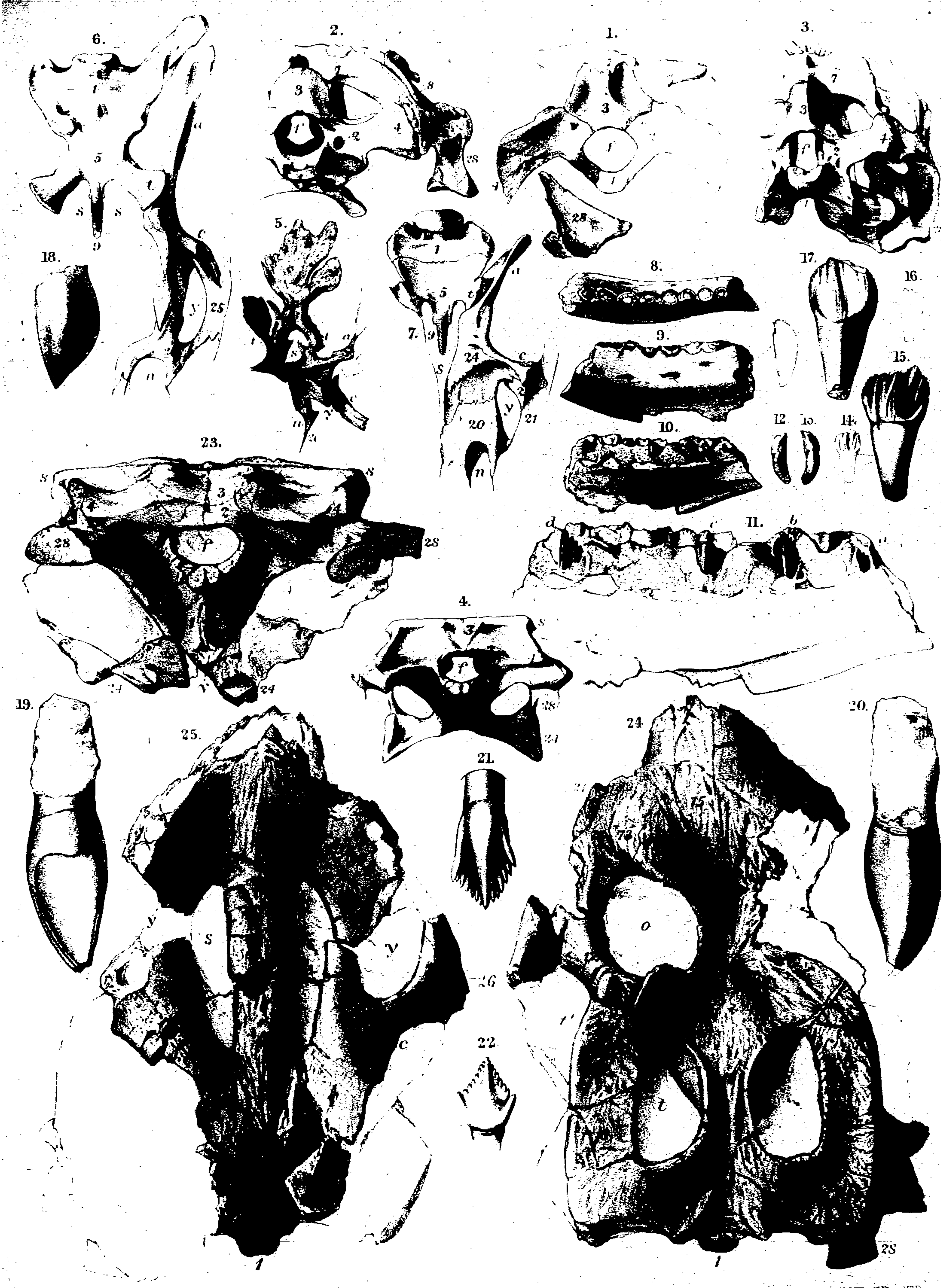
PLATE II.

Genera IGUANODON and HYLÆOCHAMPSA.

FIG.

1. Occipital surface of skull, *Iguanodon Foxii.*
2. Do. *Varanus salvator.*
3. Do. *Iguana tuberculata.*
4. Do. *Crocodilus acutus.*
5. Part of the base of the skull, *Iguanodon Foxii.*
6. Do. *Varanus salvator.*
7. Do. *Iguana tuberculata.*
8. Portion of right mandibular ramus, upper view, *Iguanodon Foxii.*
9. Do. outer side view, do.
10. Do. inner side view, do.
11. Do. do., magn. 2 diams., do.
12. Mandibular tooth, fore side, *Iguanodon Foxii.*
13. Do. hind side, do.
14. Do. inner side, do.
15. Do. do. magn. $2\frac{1}{2}$ diams., do.
16. Do. outer side, *Iguanodon Foxii.*
17. Do. do. magn. $2\frac{1}{2}$ diams., do.
18. Crown of upper laniariform tooth, *i*, outer side, magn. 5 diams., *Iguanodon Foxii.*
19. Upper laniariform tooth, inner side, half nat. size, *Iguanodon Mantelli.*
20. Do. outer side, do. do.
21. Upper molar, outer side, magn. 2 diams., *Scelidosaurus Harrisonii.*
22. Lower molar, inner side, do. *Echinodon Becklesii.*
23. Occipital surface of skull, nat. size, *Hylæochampsa vectianus.*
24. Upper surface of skull, do. do.
25. Under or palatal surface of skull, nat. size, do.

The fossils here figured, with the exception of figs. 19, 20, 21, 22, are from the Wealden of the Isle of Wight, and are in the Collection of the Rev. W. Fox, of Brixton, in that Island.



C. L. Griesbach del et lith.

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MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. VI.

PAGES 1—7.

CROCODILIA (HYLÆOCHAMPSA).

[WEALDEN.]

BY

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FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE,

ETC. ETC.

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SUPPLEMENT (No. VI)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(HYLÆOCHAMPSA.)

ORDER—*CROCODILIA.*

Genus—HYLÆOCHAMPSA, *Owen.* (PLATE II of SUPPLEMENT No. V, figs. 23, 24, 25.)

THE subject of the present 'Supplement' was discovered by the Rev. W. Fox, M.A., in the Wealden of the south-west coast of the Isle of Wight. It is the hinder part of a skull of a small or young Crocodilian, showing the occipital surface (Plate II, fig. 23), the upper openings of the temporal fossæ (ib., fig. 24 *t*) with the orbits (*o*); and so much of the palate (ib., fig. 25) as permits of instructive comparisons with that seat of divers modifications in other *Reptilia*. A few sockets of teeth are shown at the hind end of both right and left maxillary bones.

These indicate the teeth to have been relatively as large as in *Goniopholis;* and, although it is hazardous to conjecture the shape of the crown of a Crocodilian tooth from the cylindrical root, as indicated by its socket, yet it seems to me probable that the teeth of the present small Crocodilian resembled more those of *Goniopholis* [1] than of *Suchosaurus* [2] or of *Poikilopleuron.* [3]

The outer surface of the cranial bones shows a different pattern of sculpture from that in *Goniopholis;* instead of small circular pits there are short irregular ridges, which, at some parts, the postfrontals, for example, have a tendency to diverge from a reticulate

1 'Report on British Fossil Reptiles,' 8vo, Part II, 1841, p. 69.
2 Ib., ib., p. 67.
3 Ib., ib., p. 84.

centre; a number of short ridges and clefts radiate from the raised part of the border of the temporal outlet; but all these accentuations of the surface are rather feeble.

As I know of no corresponding specimen of a skull of any Wealden Crocodilian like the present, and as it offers generic modifications of parts which are comparable with Crocodilians of older and newer formations, I propose to describe the specimen as representing a new genus and species under the name of "*Hylæochampsa vectiana*."[1]

The occipital surface (Plate II, fig. 23), excluding therefrom the tympanics, 28, and pterygoids, 24, is of a triangular form, with the base upward; the apex is pierced by the foramen, *v*. The breadth of this surface, taken at the mastoidean angles, 8, 8, is, to so much of the vertical diameter as includes the foramen, *f*, as three to one. The basioccipital, 1, contributes the middle four fifths of the condyle, the upper angles of which hemispheroid tubercle, due to the exoccipitals, are broken off. The centre of the condyle is feebly impressed; it projects, and is, as it were, sub-pedunculate. The basioccipital curves from the condyle forward and downward, then descends vertically to the foramen, *v*, and is ridged along the mid-line. The extent of the occiput below the foramen magnum, *f*, exceeds the part above the foramen. The exoccipitals, 2, are the largest elements of this cranial segment; they meet above the foramen, excluding the superoccipital, 3, therefrom for an extent of nearly three lines. The suture appears to be continued upward through the superoccipital, 3; but this may be due to fracture. The superoccipital develops a tuberosity at each upper angle, near its junction with the mastoid, 8. Each exoccipital swells at its outer border into two tuberosities, representing the paroccipitals of *Chelonia*, and contributing to the articulation for the tympanic, 28. The direction of the bilobed paroccipital border, 4, is oblique from above downward and inward. The tuberosity forming the angle of the mastoid, 8, projects distinct from the upper paroccipital one, 4.

In the relative extent of the paroccipital tuberosities and in the direction of their border *Hylæochampsa* resembles *Teleosaurus*, and differs from *Crocodilus*, in which the masto-paroccipital border extends from above downward and outward (ib. fig. 4), making the greatest breadth of the occipital surface to be at the paroccipitals, not at the mastoids.

There is no vacuity between the mastoid and superoccipital; a linear suture, slightly concave upward, alone divides them on the occipital surface.

The articular surface of the tympanic, 28, projects as usual, backward, beyond the plane of the occiput; the medial half only of that surface is preserved in the present fossil; it is almost vertical and very slightly convex.

The upper platform of the cranium behind the orbits (Plate II, fig. 24) is subquadrate, with the anterior angles rounded off. It is perforated by the pair of upper temporal openings, *t*, which are oblong-ovate, with the outer border almost straight, the inner one curved, and with the hinder or basal border slightly raised; the anterior border is depressed and continued upon the side of the cranium proper, forming the inner wall of

[1] Gr. ὕλη, wood or weald; χάμψα, an Egyptian name of the crocodile. The specific name relates to the locality of the fossil.

the temporal fossa. A flat surface of bone (8, 12), equalling the breadth of the temporal opening, lies exterior to it; a narrower concave tract (11) divides the openings; the posterior surface (7) is broader than the lateral ones.

In *Teleosaurus* and allied genera (e. g. *Metriorhynchus*, *Teleidosaurus*, *Steneosaurus*, *Pelagosaurus*, &c.) the upper temporal openings are relatively larger and the surrounding flat tract of bone is of less extent than in *Hylæochampsa*, which herein more resembles the tertiary and modern *Crocodilia*, although the form of the openings is teleosauroid.

The general form of the upper cranial surface posterior to the orbits resembles, in *Hylæochampsa*, more that in *Crocodilus*, *Metriorhynchus*, and *Pelagosaurus*, than that in *Teleosaurus cadomensis* and in *Gavialis*, in which latter the breadth exceeds the length.

The orbits in *Hylæochampsa* (Pl. II, fig. 24, *o*) are circular and better defined by the post-frontal (12) from the lateral outlets (*t'*) of the temporal fossæ than in *Crocodilus*, and herein they more resemble the orbits in *Teleosaurus*; but they are less horizontal than in *Tel. cadomensis*, and incline less to the vertical position than in *Tel.* (*Pelagosaurus*) *temporalis*; their outline is obliquely upward and outward. The prefrontal (14) and lacrymal (73) swell out a little anterior to the orbit, whence the maxillary (21) and nasals (15) continue to form the upper jaw. This recalls the character of that part of the skull in the Gavial rather than in the Crocodile.

These modern or procœlian representatives of the order *Crocodilia* differ from the *Lacertilia* in the greater extent or degree of ossification of the palate.

The 'pterygo-maxillary vacuity'[1] is large, and is bounded, as in Lizards (Pl. II, figs. 6 and 7, *y*), by the pterygoid (24), the ectopterygoid (25), the palatine (20), and, in most genera, *Iguana*, e. g., by the maxillary (21). But the 'palato-maxillary' vacuity[2] (figs. 6 and 7, *n*) between the vomer, maxillary, and palatine, does not exist in *Crocodilia*; nor is there a trace in that order of an 'interpalatine vacuity.'[3] The 'interpterygoid' vacuity in *Lacertilia*[4] appears to be represented by the much smaller opening which serves as the 'palato-naris,' or hinder orifice of the nasal air-passages in modern Crocodilian genera.[5]

In his description of the Caen Gavial (*Teleosaurus cadomensis*, Geof.) Cuvier indicates a large vacuity, more advanced in position than the hinder nostril of modern Crocodiles, and more resembling the 'interpterygoid vacuity' of Lizards (Pl. II, fig. 7, *s*). This he regarded in the Caen Gavial as the 'palato-naris.'[6]

[1] See my 'Anatomy of Vertebrates,' vol. i, p. 157, fig. 98, c, y; "grand trou palatin" of Cuvier, 'Ossemens Fossiles,' 4to, tom. v, pt. ii, p. 133, pl. vii, fig. 4 *r*; also "trou ovale assez grand," p. 259, pl. xvi, fig. 3, *Varanus niloticus*.

[2] 'Anat. of Vertebrates,' tom. cit., fig. 98, D, *n*.

[3] Ib., ib., fig. 98, D, *m*.

[4] Ib., ib., fig. 98, D, *s*.

[5] Ib., ib., fig. 98, C, *n*.

[6] "La fosse nasale postérieure;" described as "très-grande," and marked with the letter *s* in fig. 4, plate vii, 'Ossemens Fossiles,' tom. cit.

The smaller and more posterior orifice, resembling the 'palato-naris' of *Crocodilus* and *Gavialis*, and which De Blainville and Bronn affirmed to be the true hinder nostril in the Teleosaurs, Cuvier calls "le trou des artères," and marks with the letter *t* in pl. vii, tom. cit.

The real nature of this foramen in the Teleosaurs is pointed out in my paper "On the Eustachian Canals in Crocodiles,"[1] and the accuracy of Cuvier's determination of the 'palato-nares' in the Teleosaur, is now accepted.[2]

In some Teleosaurians (*Tel. temporalis*, Bl., *Pelagosaurus typus*, Bronn) the 'palato-naris,' instead of being broader than long, as in *Tel. cadomensis*, is narrower and is produced forward into a point, on the same transverse parallel as the pterygo-maxillary vacuities, which are thus reduced in size and, as it were, pushed aside.

In *Hylæochampsa* (Pl. II, fig. 25) the vacuity (*y*) on each side of the bony palate is formed or bounded behind by the pterygoid (24) and ectopterygoid (25) and in front by the palatine (20), and probably by a small part of the maxillary (21), though here a portion of the antero-external part of the boundary is broken away. But sufficient remains to show that the vacuity is natural and is homologous with the "grand trou palatine" in *Teleosaurus cadomensis*, and with that called "grand vide palatine" or "trou palatine postérieur" by Eudes-Deslongchamps in *Teleosaurus temporalis* (*Pelagosaurus typus*); consequently with those which I have termed 'pterygo-maxillary' and symbolised by the letter *y* in my 'Anatomy of Vertebrates,' loc. cit. The vacuities in the interspace between the two 'pterygo-maxillary' ones, bounded externally by the pterygoids and palatines, answer to the "fosse nasale postérieure" of Cuvier in *Teleosaurus cadomensis*,[3] and to the "grande fosse ptérygoïdienne, qui limite en avant les arrière-narines" of Eudes-Deslongchamps in *Teleosaurus temporalis*;[4] consequently, also, to that which I have called 'interpterygoid' and symbolised by the letter *s* in *Iguana*.[5]

It is plain that the palatal or posterior opening of the nasal passages offers no trustworthy homological character in *Reptilia*. It is anteriorly situated in *Chelonia* and *Lacertilia*, where those passages are vertical or nearly so; it is at the hindmost part of the bony palate in modern Crocodiles, and in a more advanced position, though still in the hinder half of the palate, in the mesozoic or 'amphicœlian' Crocodiles. In each of these cases it has a distinct anatomical conformation. In *Chelonia* and most *Lacertilia* (*Varanus*, e. g.) its boundary includes parts of the vomer (13), palatine (20), and maxillary (21);[6]

1 'Philosophical Transactions,' 1850, p. 521, pls. xl—xlii.

2 E. d'Alton and H. Burmeister, 'Ueber der Fossile Gavial von Boll in Wurtemburg,' &c., 8vo, plates in fol., Halle, 1854, in which the small hinder foramen is called "die vereinigten Mundungen der Eustachischen Röhren und gewisser Sinusse im Innern der Ossis occipitis."

3 Tom. cit.

4 'Notes Paléontologiques,' 8vo, 1869, p. 146, pls. ix—xxiv, vi.

5 Op. cit., fig. 98, D.

6 Op. cit., fig. 98, B.

in *Iguana* it includes, with the same bones, also a part of the premaxillary; in *Crocodilus* proper it is wholly surrounded by the pterygoids; in *Teleosaurus* the palatines combine with the pterygoids to complete it anteriorly.

With regard to the opening answering to the hinder nostril in *Teleosaurus*, we find in *Varanus* that the halves of the divided vomer also contribute to bound or form the pointed anterior prolongation of the vacuity,[1] in the formation of which, as the pterygoids take the most constant and always the chief share in *Lacertilia* and *Chelonia*, and as the vacuity so bounded does not in these reptiles serve as the hinder or palatal opening of the nostrils, the term 'interpterygoid' appeared to me to be most conveniently applicable.

In the skull of the *Varanus niloticus* figured by Cuvier[2] the presphenoid is prolonged so as to seem to divide the 'interpterygoid vacuity' into a pair; the point of the bone, however, in nature inclines upward, and does not join anteriorly either the palatine or vomerine bones. In the larger monitor (*Varanus indicus*) and in *Iguana* the presphenoid (Pl. II, figs. 6 and 7, 9) has a like relation to the interpterygoid vacuity (ib., *s*), but is not so far produced.

Von Meyer, in his figure of the base of the skull of *Belodon Kapffi*,[3] represents the interpterygoid vacuity as divided by a longitudinal production, apparently, of the pterygoids, the lateral parts or plates of which form with the palatines the outer border of such vacuity. The homologues of the 'pterygo-maxillary vacuities' are much reduced in size, are external and posterior to the 'interpterygoid' openings, and are exclusively formed by the pterygoid and ectopterygoid, which, uniting externally to those openings as well as internally, are interposed between the maxillary and the 'pterygo-maxillary vacuity.' Von Meyer, as usual, puts no figures or letters of reference upon the bones and orifices, nor refers thereto by means of such symbols in his text.

Assuming, however, that the usually careful and accurate delineator of fossil specimens has correctly represented the palatal characters of his *Belodon Kapffi*, it offers the nearest resemblance to the characters of that part of the skull of *Hylæochampsa*.

In the proportion of this part of the skeleton of the Wealden Crocodile transmitted to me by Mr. Fox an extent of three inches of the hinder part of the bony palate is preserved (Pl. II, fig. 25). In this extent four vacuities are more or less completely shown; they are in two pairs. Of the medial pair (Pl. II, fig. 25, *s*, *s*) the left is entire, and the right lacks but a small part of its antero-external border; of the lateral pair (ib., *y*, *y*) the left wants a part of its antero-external border; but of the right, only a small part of the inner and hinder border is preserved.

The left pterygoid (24) is entire in its relations to the above vacuities, only the postero-lateral branch (answering to *a*, figs. 6 and 7) being broken off. The external branch (figs. 25, 6, 7, *c*), extends as usual, outward and forward to articulate with the ectopterygoid

[1] Cuvier, tom. cit., pl. xvi, fig. 3, &c. &c. [2] Ib., ib.

[3] 'Palæontographica,' zehnter Band, pl. xxxix, p. 227 (1863).

(ib., ib., 25); this abuts by its outer end against the hinder end of the maxillary (ib., ib., 21) and the contiguous part of the malar (ib., ib., 26), the fore part of the pterygoid (24) bounding with the ectopterygoid the hinder half of the pterygo-maxillary vacuity (*y*). The fore part of the pterygoid, continued along the inner border of that vacuity, articulates with the palatine (20), which, with the maxillary (21), completes the fore part of the boundary of *y*. We have thus the homologue of the 'great palatal opening' of CUVIER,[1] and of the 'posterior palatal opening' of EUDES-DESLONGCHAMPS in the *Teleosaurus cadomensis*,[2] which answers to the vacuity *y* in the *Lacertians*, figs. 6 and 7, Pl. II.

The medial pair of openings (Pl. II, fig. 25, *s, s*), bounded externally by the palatines and pterygoids, and internally, as it seems, by medial processes of the same bones, answer to the 'fosse ptérygoidienne' (VI) of EUDES-DESLONGCHAMPS in *Teleosaurus temporalis*,[3] and to the 'fosse nasale postérieure' of CUVIER in the *Teleosaurus cadomensis*.[4] But in *Hylæochampsa* this pterygoid fossa, or posterior nostril, is divided by so strong a longitudinal bony bar that the pair of vacuities might be taken at first sight to answer to the 'grands trous palatins' in the *Crocodilus rhombifer*.[5]

Such a determination is, however, incompatible with the coexistence of the vacuities (*y, y*) in *Hylæochampsa* and the concomitant recession of the maxillaries (21) from the outer boundaries of the openings(*s, s*, Pl. II, fig. 25).

We have thus another and most remarkable modification of the bony palate to add to those which have led that acute observer EUGENE EUDES-DESLONGCHAMPS to remark, in reference to the extinct *Crocodilia* of the Caen Oolite and other Mesozoic localities, "chaque espèce présente des modifications particulières."[6]

But although it may be admitted that the pair of medial openings (fig. 25, *s, s*) answer to the single medial opening (CUV., t. c., Pl. VII, fig. 4, *s*) in *Teleosaurus*, it does not absolutely follow that they served in *Hylæochampsa* the office of palato-nares. It might be contended that the small single orifice at the mid-line of the extreme hind border of the bony palate (ib., *e*) fulfilled that function, as the similarly sized and situated orifice performs in recent *Crocodilia*. The still smaller orifice (fig. 23, *v*) placed at the hind surface of the skull might in that case be homologized with the median Eustachian outlet,[7] and not with the vascular foramen,[8] in *Crocodilus*.

It should, however, be borne in mind that the true hinder nostril in procœlian

[1] 'Ossemen's Fossiles,' tom. cit., p. 133, pl. vii, fig. 4, *r*.

[2] 'Notes Paléontologiques,' p. 139, pl. xi, fig. 3, VII.

[3] Ib., ib., pl. xii, fig. 10, VII.

[4] Tom. cit., p. 133, pl. vii, fig. 4.

[5] Marked *h* in fig. 2 of plate iii of the 'Ossemens Fossiles,' tom. cit., and marked *y* in 'Anat. of Vertebrates,' tom. cit., p. 157, fig. 98, c.

[6] Op. cit., p. 147.

[7] "On the Communications between the Tympanum and Palate in the *Crocodilia*," *ut supra*, pl. xl, fig. 1, *e*.

[8] Ib., ib., *v*.

Crocodiles is divided by a pterygoid partition; although CUVIER makes the absence of this division, or inconspicuousness of the septum, a character of the skull of procœlian Gavials.[1] *Hylæochampsa* may show this partition in an exaggerated degree, and the orifices *s*, *s*, and not the orifice *e*, would be the hinder nostril.

Whatever alternative may commend itself to competent Palæontologists, the palatal characters which distinguish *Hylæochampsa* from all other known Reptiles, recent or fossil, are unaffected.

I have had no opportunity of studying the palatal characters in *Goniopholis*, *Suchosaurus*, or any other Wealden Crocodile than the subject of the present Monograph.

[1] "La cloison qui divise les narines ne se montre pas à leur ouverture postérieure." 'Oss. Foss.,' tom. cit., p. 106.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. VII.

PAGES 1—7; PLATES I—VI.

CROCODILIA (POIKILOPLEURON)

AND

DINOSAURIA? (CHONDROSTEOSAURUS).

[WEALDEN.]

BY

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ETC. ETC.

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SUPPLEMENT (No. VII)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(POIKILOPLEURON AND CHONDROSTEOSAURUS.)

ORDER. *CROCODILIA.*

FAMILY. CŒLOSPONDILIA.[1]

Genus—POIKILOPLEURON. *Eudes-Deslongchamps.*[2] Plate I.

THIS genus was established on fossils discovered in the Oolitic building-stone at Caen, Normandy, and the characters which have led to the recognition of evidences of the genus in our own Wealden deposits are the shape and texture of the vertebræ, and more especially the latter. By these were determined a caudal vertebra from the Wealden of Tilgate, in the Mantellian collection, now in the British Museum: which vertebra differed from the type-specimens on which the genus was founded, only by a slight inferiority of size.

M. Deslongchamps assigns the length of a 'décimètre,' or thereabouts, to his vertebræ, say 3 inches, 10 lines. The Wealden specimen, which has been fractured across the middle of the centrum, gives a length of that element of 3 inches, 8 lines; or about 9 centimeters. The vertical diameter of the articular end is 2 inches, 3 lines (58 mm.), the transverse diameter is 2 inches, 2 lines (55 mm.); the transverse diameter of the middle, contracted part of the centrum is 1 inch, 4 lines (36 mm.).

[1] This term refers to the large vacuity in the centre of each vertebral body, simulating a medullary cavity; ossification is here arrested at the middle, not, as in the *Amphicœlia*, at the two ends of the centrum.

[2] 'Mémoires de la Société Linnéenne de Normandie,' vol. vi, 1838, p. 37.

The external free surface of the vertebra is marked with faint striæ, otherwise it is almost smooth. Both terminal surfaces are of a full elliptical form, with the long diameter vertical; they deviate from flatness by a slight concavity. The centrum gradually contracts from the two extremities toward the middle: a diapophysis extends from the upper and hinder part of the side, below which there is a shallow groove, slightly bent with the convexity downward. The neural arch has coalesced with the centrum, and the base of the diapophysis extends from the hinder upper half of the centrum upon the base of the arch. A longitudinal sulcus traverses the anterior half of the under surface of the centrum. The hypapophysial surface is a single obliquely bevelled plane indicative of the confluent bases of the hæmapophyses, and this is the character of the hæmal arch preserved in the Caen specimen.

In my 'Report on British Fossil Reptiles'[1] I did not recognise grounds for specifically differentiating the Wealden *Poikilopleuron* from the *Poik. Bucklandi* of the Caen Oolite. Besides the Tilgate locality I was able to note, after examination of a series of fossils belonging to S. H. Christie, Esq., from the submerged Wealden Beds, Isle of Wight, the "half of a dorsal vertebra from Brook Bay, which agrees in size, in the form of the articular extremity, in the degree of median constriction, and especially in the large size of the medullary" (chondrosal) "cavity at the middle of the bone, with the vertebral characters of *Poikilopleuron*."[2]

Species. *Poikilopleuron pusillus*, Ow. Plate I.

This species is, to me at present, represented by eight vertebræ, an ungual phalanx of the rapacious type, and part of a medial symmetrical bone to which are articulated portions of a pair of rib-like bones, as to the nature of which the nearest guess I can make is that they represent part of the series of abdominal ribs with their sternum.

All these bones show a compact osseous texture with a smooth or polished exterior, and a section of one of the dorsal centrums exposed, what a fractured caudal one indicated, viz. a large central chondrosal vacuity, such as characterises the centrum of the Oolitic crocodilian genus *Poikilopleuron* of Eudes-Deslongchamps.

The reptile, of which the present are fossilised remains, was discovered by the Rev. W. Fox, M.A., in the south-west Wealden of the Isle of Wight; it is much smaller than the type of the genus *Poikilopleuron* from the Caen Oolite, or the Wealden vertebræ above referred to *Poik. Bucklandi*. It may be objected that the present specimens are from a young individual of the same species; but they show no signs of immaturity, and the caudal hypapophyses indicate the bases of the piers of the hæmal arch not to have been confluent as in the *Poikilopleuron Bucklandi*, and as in *Iguanodon*.

The vertebral centrums are long in proportion to their breadth and depth, and

[1] 'Reports of the British Association,' 1841, p. 84. [2] Ib., p. 87.

the non-articular surface is so concave lengthwise as to give the appearance of the centrum being constricted between the terminal articular surfaces. These are almost flat.

In one trunk-vertebra, the sides of the centrum converge to a carinate inferior surface. In another (Plate I, figs. 1—3) that surface is less narrow (ib., fig. 2). In both the suture of the neural arch is traceable, but the arch has remained attached: it shows a small facet (fig. 1, *p*) for the head of the rib at the fore part of the base of the neurapophysis. A horizontal (diapophysial) ridge (ib. *d*) extends from the prezygapophysis to the upper surface of the postzygapophysis, broadening as it recedes. The neural spine is compressed, but rises from nearly the entire length of the neural arch. The outer surface of the centrum is compact, smooth, and glistening; and on making a vertical longitudinal section the more definite generic character of the large chondrosal vacuity was exposed, as in fig. 3, *ch*, 3.

In the series of five vertebræ, including the three hinder lumbars and the sacrum (ib., fig. 4), the costal surface has been transferred to the diapophysial ridge, *d*, which now extends outward from a contracted base midway between the zygapophyses, the terminal articular surface being supported by a lower buttress-like ridge, *f*. The under surface of the centrum is here broader than in the preceding vertebra, and is transversely rounded: the carinate character in the dorsal vertebræ, giving space to the abdominal cavity, has here disappeared. In some of the present series the deeply concave side of the centrum has yielded to pressure, and the compact outer wall has been fractured and pressed in upon the chondrosal or *quasi* medullary cavity. In the last lumbar vertebra the diapophysis, depressed and subelongate, shows a narrow costal surface, *d'*, for a small or short 'false rib.'

The two hindmost vertebræ in this series of five are sacral (*s* 1, *s* 2). They have the crocodilian character of limited number, and the non-dinosaurian character of retaining their neural arch in normal junction with the centrum. The doubt expressed as to the ordinal affinities of *Poikilopleuron*,[1] in my 'Report,' is here dispelled. The diapophysis, short, but broad and deep (*s* 1, *d*), terminates in a large flattened semi-oval surface for the sacral rib. The corresponding surface upon an equally large diapophysis in the second sacral has rather less vertical extent (*s* 2, *d*). The centrums appear to have coalesced, but the primitive line of separation of the terminal expanded surfaces is traceable.

The neural spines are broken away in all this series of vertebræ, but their narrow elongate bases indicate the same character as in the detached more anterior vertebra from a smaller individual (figs. 1 and 3, *ns*).

The two caudal vertebræ (figs. 5—8) are from the terminal part of the tail where both transverse and spinous processes have disappeared. The low neural arch has coalesced

[1] "Subsequent discoveries may prove it to belong, like the *Megalosaurus*, to the *Dinosaurian* order; but, as the *Poikilopleuron* is, at present, known, it seems to have most claim to be received into the cœlospondylian family of the Crocodilian order," 'Rep. Brit. Assoc.,' 1841, p. 85.

with the centrum, and this, retaining its length, as in the sacral and lumbar region has diminished by loss of transverse and vertical extent. The under surface is canaliculate (fig. 7), and both the anterior and posterior expanded ends of the boundary ridges of the lower groove have articular surfaces, *h*, *h*, for a hæmal arch.

In Plate I, fig. 9, the compressed subtriangular portion of an abdominal sternum (?) is marked *hs*; the pair of abdominal ribs which articulate by expanded thinned-off ends to the sides of *hs* are marked *h*, *h*.

The ungual phalanx (ib., figs. 12, 13) is remarkable for its degree of curvature, its strong lever-process, and the deep lateral grooves.

The value of this little specimen and fruit of Mr. Fox's persevering researches in the Wealden deposits of his vicinity is its demonstration of the limited crocodilian number of trunk-vertebræ deprived of reciprocal motion upon each other, and with transverse processes thickened and terminally expanded for junction with the pelvis.

I repeat, with some stress, this character because the experienced and accomplished palæontologist of the United States, JOSEPH LEIDY, M.D., while rightly recognising the "half of a vertebral body" from a Cretaceous formation at Middle Park, Colorado, as of a *Poikilopleuron*, remarks :—"*Poicilopleuron* was probably a semi-aquatic Dinosaurian, an animal equally capable of living on land or in water, and perhaps spending most of its time on shores or in marshes."[1]

But the cited capacity is enjoyed by *Crocodilia* equally with *Dinosauria*; and *Poikilopleuron* may well have spent, like its neighbour and contemporary *Teleosaurus*, least of its time on shores or in marshes, if the latter were accessible to it in its Oolitic or Cretaceous localities.

The fossil described and figured by LEIDY adds nothing to the evidence previously extant of the affinities of *Poikilopleuron*; and if I plead for the retention of the orthography of the estimable discoverer of the genus, I more strongly protest against the addition of a new generic term for which LEIDY's fossil yields not a single character.[2]

The geological conditions under which Deslongchamps discovered his *Poikilopleuron* led him to remark: "aussi dut-il passer une grande partie de sa vie dans les eaux et probablement dans les eaux marines: puisque ses os sont restés dans un calcaire qui doit évidemment sa formation à des débris marins."[3]

Amongst the rounded pebbles discovered in a position suggestive of their having been in the stomach of the *Poikilopleuron*, as such pebbles are commonly found in the stomach of a Crocodile or Alligator, Deslongchamps detected the tooth of a Cestraciont Fish,[4] very significative of the element whence the *Poikilopleuron* derived its food.

Our actual knowledge of the skeleton of *Poikilopleuron* is sufficiently complete to

1 'Contributions to the Extinct Vertebrate Fauna of the Western Territories,' p. 268, 4to, 1873.

2 Ibid., pl. xv, figs. 16—18, "Antrodemus."

3 Op. cit., p. 51.

4 Mem. cit., p. 65, "elle provient très-probablement d'une des derniers proies qu'il avait avalées."

give the answer to the question, "Whether the cavernous structure of its skeleton was related to pneumatic functions, as in Birds, flying Reptiles, and some others?"[1] The central cavity is completely closed; no pneumatic orifice or canal penetrates thereto: it had no communication with pulmonary or other air-cells. Nor is the alternative limited to marrow.[2] Primitive "chondrine," to which ossification had not extended, most probably filled the vacuity in the vertebral body shown at *d*, fig. 2, plate ii, of the 'Mémoires de la Société Linnéenne de Normandie,' sixième volume, 4to, 1838; as in figures of Plate I, fig. 3, of the present Supplement, and in fig. 16 of Leidy's plate xv, op. cit.

ORDER. *DINOSAURIA* (?)

Genus—CHONDROSTEOSAURUS.

Species. *Chondrosteosaurus gigas*; Owen. Plates II—V.

The flatness of the under surface of the vertebra figured in Plates II—V recalled the character of that of *Bothriospondylus suffossus*,[3] and, with the predominance of the transverse over the vertical diameter, suggested that it also might have come from the sacral series.

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

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

The portion of neural canal preserved (Plates III and IV, *n*) gives the vertical diameter of the centrum. There is no indication in the concave articular surface of that diameter having been diminished by posthumous pressure. The gentle transverse con-

[1] Id., p. 279.

[2] "Dans les deux séries, le corps des vertèbres est creusé d'une grande cavité médullaire (fig. 2 *d*, et v. *b*); le tissu spongieux n'existe qu'aux deux bouts; il y a de chaque coté, dans la gouttière laterale un trou pour le passage des vaisseaux nourriciers," p. 78; "ces vertèbres présentent à l'intérieure une grande cavité médullaire analogue à celle des os longs." Mem. cit., p. 83.

[3] 'Monogr. on Brit. Foss. Reptilia of the Mesozoic Formations,' Part II, Pl. III, Pal. Soc. vol. for the year 1875.

cavity of so much of the broad under surface as is preserved (Plate II) is evidently natural. The deep depression (Plate V, fig. 1, *f*) on each side of the centrum between the par- and di-apophyses recalls a vertebral character of the genus *Bothriospondylus*.

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

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

The base of the diapophysis (Plate V, fig. 1, *d*) at the part of the neurapophysis preserved gives a fore-and-aft extent of 3¼ inches, and a vertical diameter of 2 inches, from which the size of the tubercle of the rib may be inferred.

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

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

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

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

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

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

Species. *Chondrosteosaurus magnus*, Ow. Plate VI.

Syn. *Bothriospondylus magnus*, Ow.

A mutilated centrum from the same formation and locality as that of *Chondrosteosaurus gigas* has been kindly transmitted to me for the purpose of the present Monograph, by its discoverer, the Rev. Wm. Fox, M.A.

Sufficient of the concave articular surface is preserved to show its correspondence in size with that of the foregoing vertebra, but its proportions are reversed, the vertical diameter plainly appearing to surpass the transverse one. This vertebra, it is true, has come from a more posterior part of the column. The parapophysis has disappeared, at least from the position from which it projects in the subject of Plate II: if such process was present its origin has risen to near the base of the neural arch. So much of the free surface of the centrum as remains is concave lengthwise; all trace of flattening of the inferior surface has disappeared. The curve of the free surface toward the fore end of the centrum indicates that vertebral element to have been shorter absolutely, and much more so relatively to the hinder cup, than in *Chondrosteosaurus gigas*. It is hard to suppose that so extreme a degree of modification of shape and proportion should be present in an anterior and a middle dorsal vertebra of the same spine or in the same species, as is exemplified by the subjects of Plates III and VI; I therefore refer them, provisionally, to distinct species. The present vertebra agrees more closely in proportions with that of which a side view is given in a former Monograph.[1]

The extreme modification of structure in both that vertebra and the subjects of the present Monograph lead me to refer them to a distinct genus from *Bothriospondylus*; but it is a nearly allied one.

I had a vertical longitudinal section made of a rolled and worn centrum, of smaller size than the type of *Chondrosteosaurus gigas*, but of similar proportions. It is figured three fourths of the natural size in Plate V, fig. 2. The black tint indicates the ossified proportion of the vertebral substance; the lighter tint the chondrosal proportion, filled in the fossil by Wealden marl.

[1] 'British Fossil Reptilia of the Mesozoic Formations,' Part II, Pl. VIII, Pal. Soc. vol. for the year 1875.

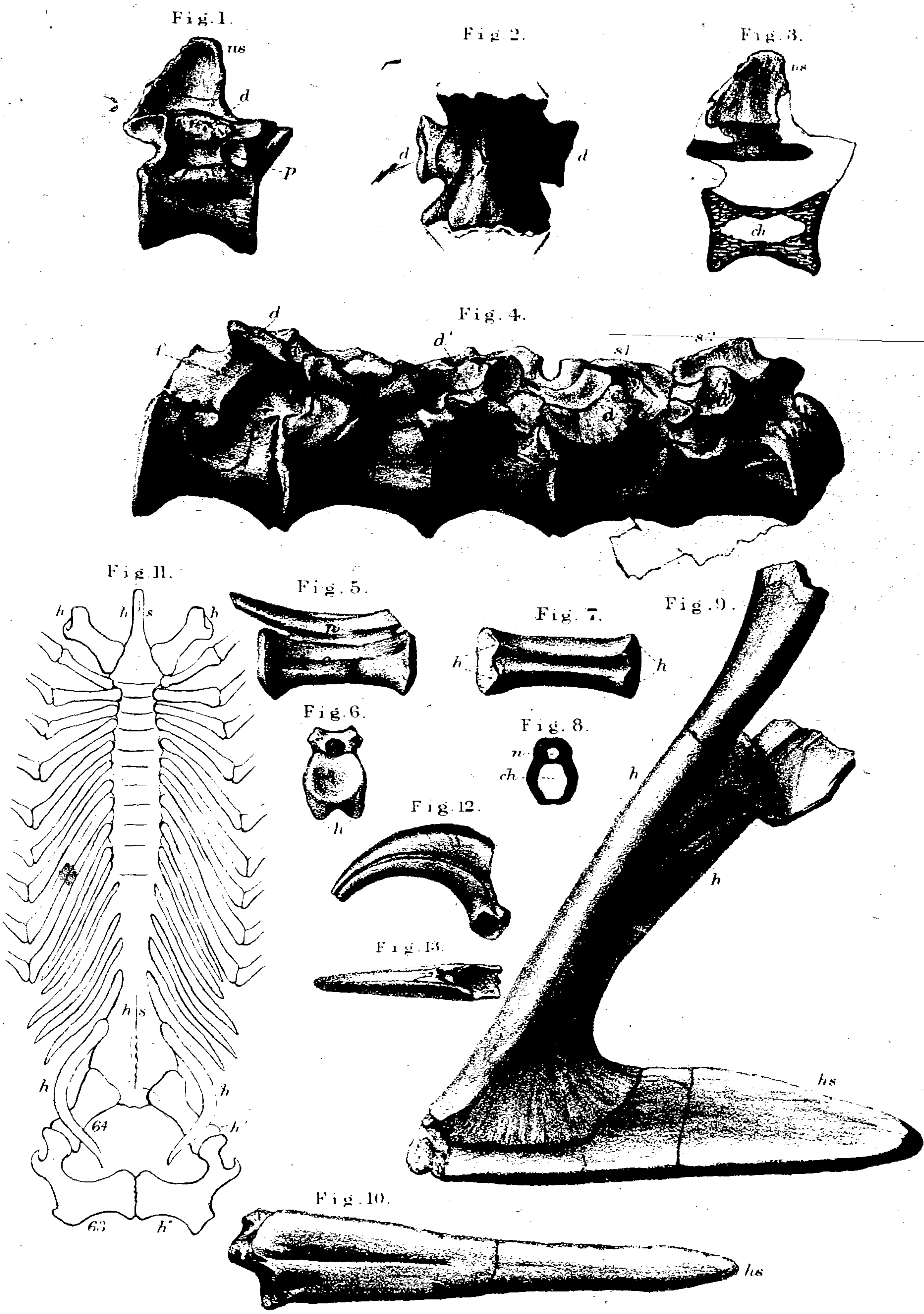
PLATE I.

Poikilopleuron pusillus.

Fig.

1. Side view of a dorsal vertebra.
2. Under view of a dorsal vertebra.
3. Vertical longitudinal section of the same.
4. Side view of lumbar and sacral vertebræ.
5. Side view of a caudal vertebra.
6. End view of the same.
7. Under view of the same.
8. Vertical transverse section of the middle of the same.
9. Abdominal hæmapophysis and hæmal spine.
10. Under surface of abdominal hæmal spine.
11. Reduced view, in outline, of neural or upper surface of the series of abdominal hæmapophyses and spines of a *Crocodilus biporcatus*.
12. Side view of ungual phalanx.
13. Upper view of the same.

The fossils are of the natural size, are from the Wealden of the Isle of Wight, and are in the Museum of the Rev. W. Fox, M.A., F.G.S.



C. L. Griesbach del. et lith.

Poikilopleuron pusillus.

Mintern Bros. imp.

PLATE II.

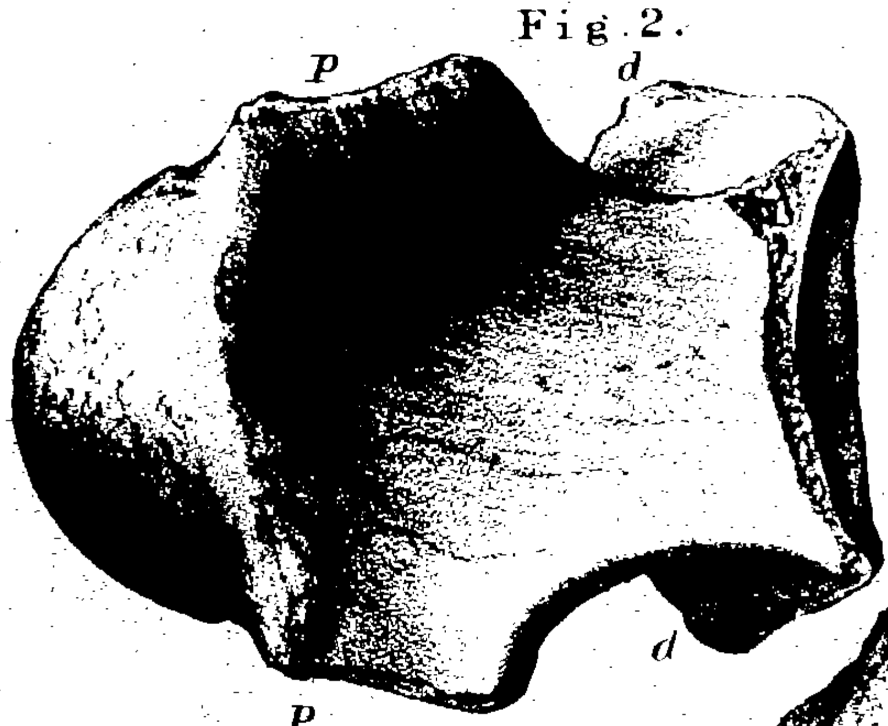
Chondrosteosaurus gigas.

FIG.

1. Under view of the centrum of an anterior trunk-vertebra: nat. size.
2. Reduced view of restored under surface of the same vertebra.

From the Wealden of the Isle of Wight. In the British Museum.

Fig. 2.



C. L. Griesbach del. et lith.

Chondrosteos

Pl II.

Fig. 1.

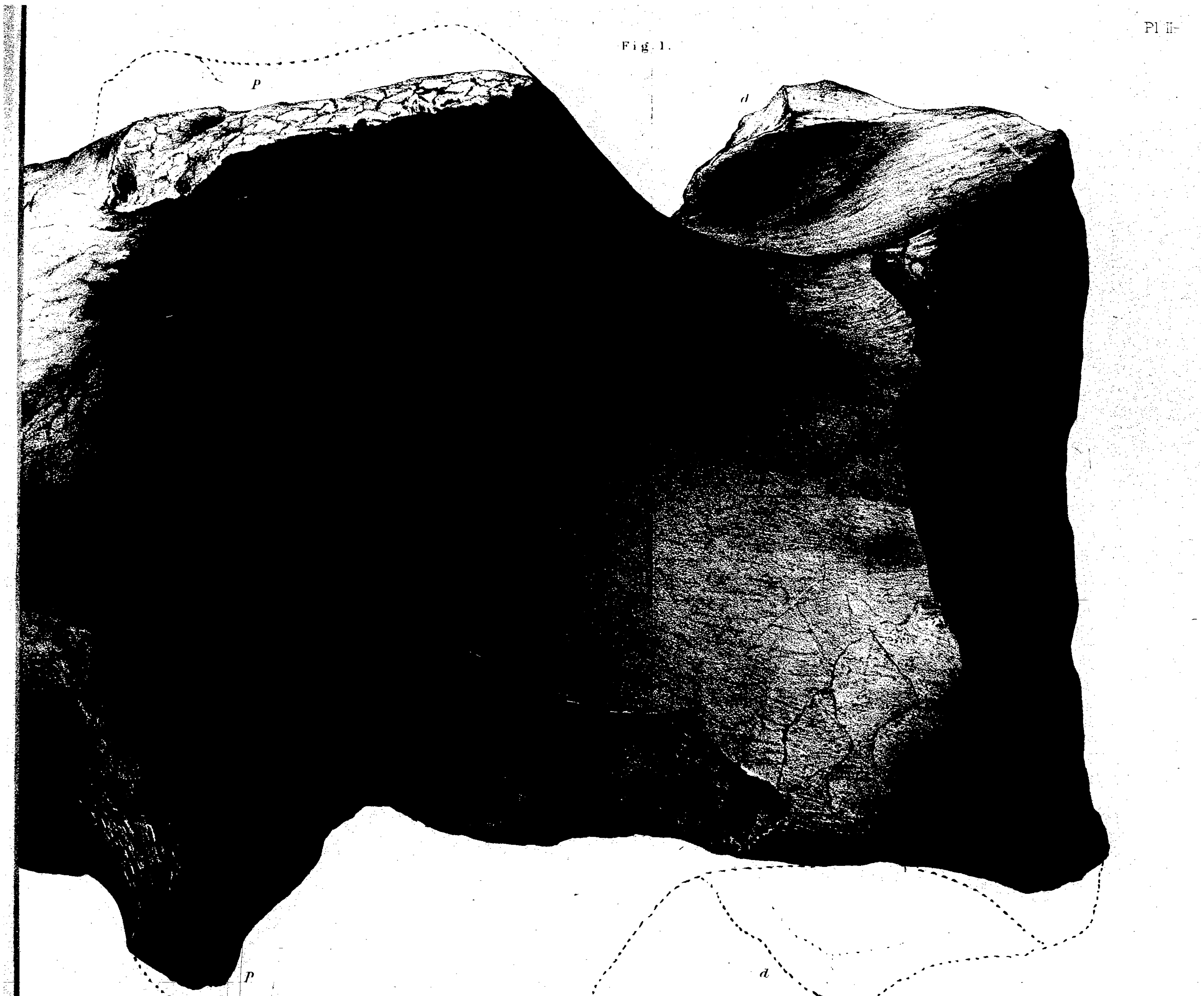


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PLATE III.

Chondrosteosaurus gigas.

Hinder articular surface of the centrum of an anterior trunk-vertebra: nat. size.

From the Wealden of the Isle of Wight. In the British Museum.

Fig. 1.

Chondrosteosaurus gigas.

PLATE IV.

FIG.

1. Neural surface of centrum of anterior trunk-vertebra of *Chondrosteosaurus gigas:* two thirds nat. size.
2. Hind surface of anterior trunk-vertebra of an Eagle (*Haliætus albicilla*) : nat. size.
3. Neural surface of the centrum of the same vertebra : nat. size.

The subject of fig. 1 is from the Wealden of the Isle of Wight. In the British Museum.

Pl. IV

Fig. 2.
Fig. 1.
Fig. 3.

sbach del et lith

Mintern Bros imp

Figs. 1. Chondrosteosaurus gigas; 2. 3 Haliaetus albicilla.

PLATE V.

Chondrosteosaurus gigas.

FIG.

1. Side view of centrum of an anterior trunk-vertebra: half nat. size.
2. Vertical longitudinal section of centrum of anterior trunk-vertebra: three fourths nat. size.

From the Wealden of the Isle of Wight. In the British Museum.

Fig. 1.

Fig. 2.

G. H. Griesbach del. et lith. Mintern Bros. imp.

Chondrosteosaurus gigas.

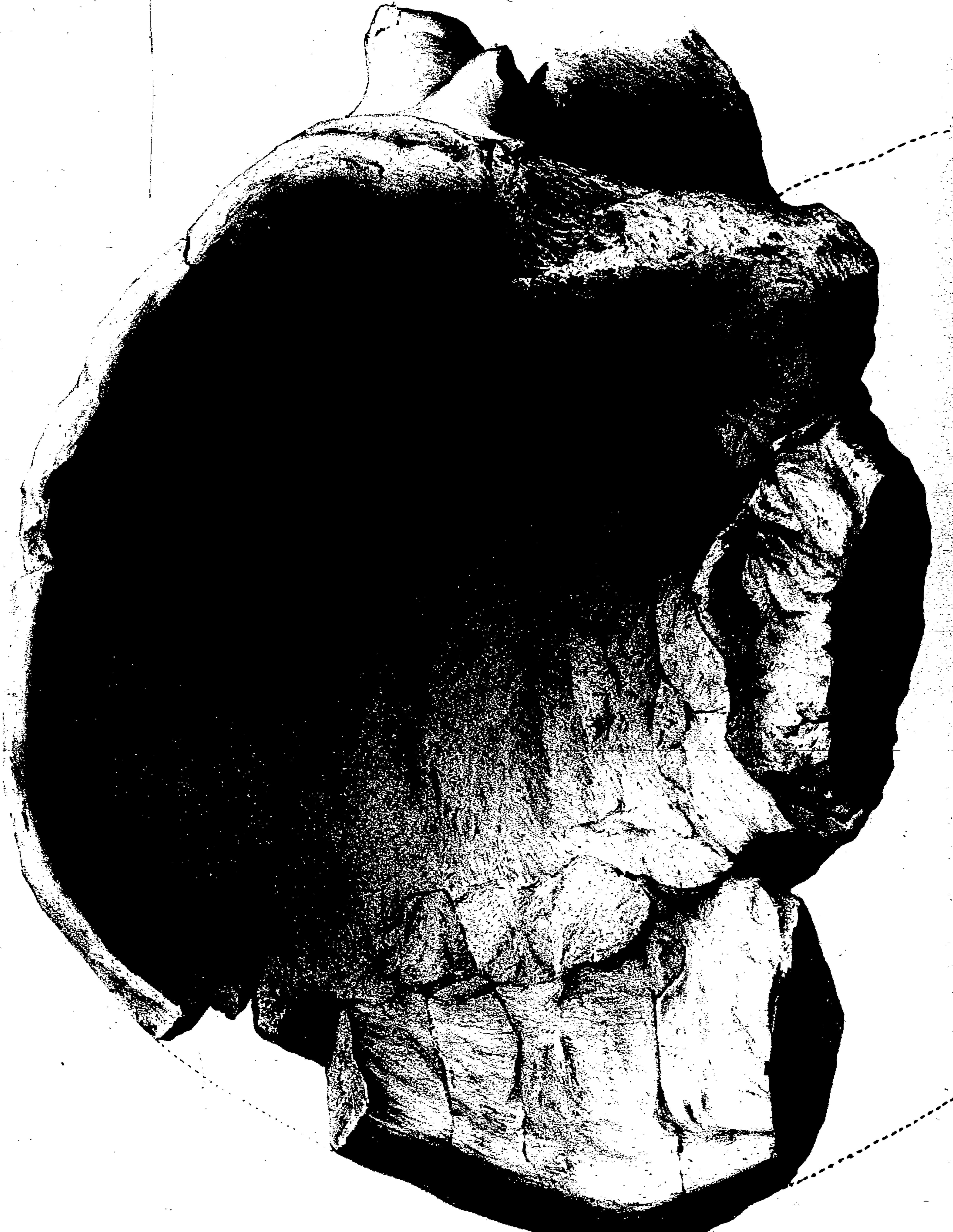
PLATE VI.

Chondrosteosaurus magnus.

Hind surface of a trunk-vertebra: nat. size.

From the Wealden of the Isle of Wight. In the Museum of the Rev. W. Fox, M.A., F.G.S.

Fig. 1.



C. L. Griesbach del. et lith.

Mintern Bros. imp.

Chondrosteosaurus magnus.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. VIII.

PAGES 1—15; PLATES I—VI.

CROCODILIA (GONIOPHOLIS, PETROSUCHUS, AND SUCHOSAURUS).

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SUPPLEMENT (No. VIII)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(GONIOPHOLIS, PETROSUCHUS, AND SUCHOSAURUS.)

ORDER. *CROCODILIA.*

Genus—GONIOPHOLIS, *Owen.*[1]

Species—*Goniopholis crassidens.*[2] Plates I—IV.

THE knowledge of this remarkably well-defended Amphicœlian Crocodile has been chiefly derived from a study of the specimen now in the British Museum, obtained in 1837 by ROBERT TROTTER, Esq., F.G.S., from a quarry of Purbeck stone in the vicinity of Swanage.[3] Confirmation and additional characters of the genus have been afforded by more fragmentary remains obtained by MANTELL from the Wealden of Tilgate, and by G. B. HOLMES, Esq., from the Wealden of Cuckfield and the vicinity of Horsham.

The first indication of the genus was given by detached teeth, one of which is figured in Plate I, fig. 3, from the Tilgate quarry, and which presented a more robust form of crown than that of *Suchosaurus* and other *Crocodilia*, then known, of that formation; the proportions being rather those of the teeth of the procœlian broad-faced Crocodiles[4] and Alligators[5]

[1] 'Report of the British Association,' "On British Fossil Reptiles," Part II, 1841, p. 69.

[2] Ib., ib., p. 69.

[3] A reduced view of this group of parts of the same skeleton is given in Mantell's 'Wonders of Geology,' vol. i, pl. i, 3rd edit., 1839. The quarry belongs to the 'Limestone Series' of the 'Middle Purbeck.'

[4] Cuvier, 'Ossemens Fossiles,' 4to, tome v, part ii, pl. i, figs. 4 and 5.

[5] Ib., Ib., figs. 6, 7, 8.

of the Tertiary and modern times.[1] The resemblance was carried out by the unequal size of the teeth in the same jaw, as shown by portions of *maxillæ* and *mandibulæ* subsequently acquired. But the Wealden teeth differed in the longitudinal ridges of enamel traversing the exterior of the crown; such ridges being numerous, close-set, and neatly defined. Two of the ridges, longer than the rest, traverse opposite sides of the tooth, about midway between the fore and hind outlines in the side-view. In the larger teeth (Pl. I, fig. 3) they extend from the base to the apex; in the smaller teeth (ib., figs. 4 and 6) these opposite ridges are limited to the apical half of the crown, to which they may give somewhat of a trenchant character. At the back part of the series (ib., fig. 7) the dental crown becomes obtuse, as it is shown to do in a former Monograph (tom. cit.), in *Alligator Hastingsiæ* and *Crocodilus Spenceri*.

On these characters the present genus and species were originally founded,[2] and the fortunate preservation of two teeth in the lower jaw of the dislocated parts of the skeleton from the Purbeck stone determined its generic, if not specific, affinity with the Wealden type of *Goniopholis crassidens*.

In the notable slab from Swanage the parts which first and more especially attract attention are the numerous, large, bony, dermal plates or scutes. These are scattered irregularly over the slab, and in their number and relative size bring the species much nearer to the extinct Teleosaurs than to any of the existing Crocodiles; they differ, however, from both the dorsal and ventral scutes of the Teleosaur in their more regular quadrilateral figure (Pl. IV, fig. 1); they are longer in proportion to their breadth than most of the Teleosaurian scutes, and are distinguished from those of other Crocodilians, recent and fossil, by the presence of a conical, obtuse process (ib., *a*), continued from one of the angles, transversely to the long axis of the scute: it is analogous to the peg or tooth of a tile, and fits into a depression on the under surface of the opposite angle of the adjoining scute; thus serving to bind together the plates of the imbricated bony armour, and repeating a structure which is characteristic of the large bony and enamelled scales of many extinct Ganoid Fishes. Some of the scutes in the Swanage specimen are 6 inches in length and 2½ inches in breadth; the average length is that shown in the figure.

The exterior surface of the scute is impressed by numerous deep, round, oblong, rarely angular pits, from two to four lines in diameter, and with intervals of about two lines, defined by convex, reticularly disposed ridges of the bone; but a larger proportion of the border of the scute is overlapped by the contiguous scute than in the Teleosaur, and this part (Pl. IV, fig. 1, *c*) is smooth and thinner than the rest of the scute. The whole of the inner surface of the scute (Pl. III, *b*) is smooth; but on

[1] See "Monograph on Reptilia of the London Clay," in the volume of the Palæontographical Society, issued for the year 1849.

[2] 'Report,' loc. cit.

close inspection it is seen to be everywhere impressed by fine, straight lines, decussating each other at nearly right angles, and indicating the structure of the corium in which the scutes were imbedded. Thus, from the size and strength of these dermal bones, their degree of imbrication, and the structure for interlocking, we may conclude that the *Goniopholis* was better mailed than the Teleosaur, which Cuvier regarded as "l'espèce la mieux cuirassée de tout le genre."[1]

In the slab in question the vertebræ were all at right angles to the exposed plane, and fractured across the middle, one extremity being buried in one of the halves of the slab, and the other in the opposite half. By permission of the Trustees of the British Museum, I proceeded, in 1841, to remove the matrix from the two extremities of the same vertebra, and so demonstrated that both articular ends were equally but slightly concave (Pl. II, figs. 8, 9).

	Inches.	Lines.
The length of the body of the vertebra examined was	2	0
Vertical diameter of the articular extremity	1	9
Transverse diameter of the articular extremity	1	8
Ditto of middle of the body	0	11
Ditto of entire vertebra, including the transverse processes	10	0
Height of entire vertebra, including spinous process	4	4
From the lower part of the centrum to the base of the transverse process	2	6

The suture which joins the neural arch to the centrum is conspicuous; it forms an ascending angle or curve at its middle part. In the degree in which the body of the vertebra expands to form the subconcave articular surfaces, in its smooth, non-articular surface, and in the circular transverse contour at the lower part of the centrum, *Goniopholis* resembles *Streptospondylus* more than it does *Teleosaurus*.

The diapophyses of the lumbar and anterior caudal vertebræ are long, straight, and comparatively slender; those of the sacral vertebræ are relatively thicker, and the spaces enclosed by their expanded extremities are smaller than in either the Teleosaurs or Crocodiles. The antero-posterior extent of the two sacral vertebræ is three inches two lines.

The ilium is broader than in the existing Crocodilians; the bifurcation of the proximal end of the ischium is more marked, and the iliac branch is more regularly rounded; the pubic branch is longer, more slender, and its articular end is more regularly convex; the distal or lower part of the ischium expands into a relatively broader plate. This character is still more conspicuous in the pubis, which equals the ischium in breadth, and begins to expand much nearer the proximal extremity than in the existing Crocodiles. In these modifications of the pelvis, as well as in the biconcave

[1] 'Ossemens Fossiles,' tom. v, pt. 2, p. 139.

structure of the vertebræ, the Crocodilian of the Purbeck limestone, like others of the Mesozoic epoch, was probably more marine than existing Crocodilians. The caudal vertebræ were provided with long, narrow, unanchylosed chevron bones.

The portion of the mandible preserved in the Purbeck slab belongs to that part of the left ramus included between the articular extremity, which is broken off, and the hind commencement of the dental series, of which two teeth (Pl. I, fig. 7) remain. This portion of jaw measures 1 foot 6 inches in length, and 5 inches in greatest depth. In these proportions, and the curve of the lower margin, it deviates from the Oolitic Teleosaurs and Steneosaurs, and resembles the modern Crocodiles; and although not quite equalling these in the robust proportions of the jaw, yet it much exceeds in this respect the Crocodilians with more slender teeth.

Portions of the skeleton of a *Goniopholis*, kindly submitted to my examination by G. B. Holmes, Esq., of Horsham, by whom it was discovered in a Wealden stratum at Cuckfield, Sussex, include the fore-part of the premaxillaries (Pl. I, figs. 1 and 2). This shows a semicircular anterior contour, and a single subcircular nostril (fig. 2 *n*), placed rather nearer the termination of the muzzle than in existing Crocodiles; but yet above; not terminal, as in *Teleosaurus*, nor subterminal, as in *Steneosaurus*. There is not enough of the bone preserved to show whether there was a constriction of the upper jaw behind the nostril, as in the Gavial. The incisive foramen is not immediately beneath the nostril, as in the modern and Tertiary Crocodiles. The outer surface of the premaxillaries is convex, rather irregular, with vascular foramina and wrinkled impressions. The margins of the symphysis (*s*) are a little produced. There are four alveoli in each premaxillary, as far as the bone is preserved; they are proportionately larger, more numerous, and closer together than in the corresponding part of the *Streptospondylus* or *Steneosaurus brevirostris*.[1] The first and smallest socket is in contact with the second, which is the largest; the intervals increase beyond this socket (Pl. I, fig. 1). The palatal surface shows a pair of large and deep approximate fossæ, and a second pair of smaller fossæ, apparently for lodging the crowns of the anterior teeth of the lower jaw.

The subject of fig. 5, Pl. I, is from the Purbeck stone, and of a somewhat larger individual than the Cuckfield specimen.

In a mandibular fragment from Cuckfield (Pl. I, fig. 8) the cylindrical fang of a well-preserved tooth is invested by smooth cement; the coronal ridges begin at the basal line of the enamel, and proceed nearly parallel to the apex of the cone. In a tooth with a crown one inch long and half an inch across the base four ridges are included in a space of one line's breadth; a few of the ridges are interrupted to preserve the parallelism of the rest. Towards the apex a number of shorter and finer ridges are present on each side of the two chief ridges, to which they obliquely converge. At the extreme apex of an unworn tooth the ordinary ridges terminate in fine, slightly wavy lines, forming a subreticulate surface.

[1] 'Ossem. Fossiles,' 4to, t. v, pt. 2, pl. x, fig. 6.

In the Jurassic Crocodilian (*Madrimosaurus*, V. Meyer) the coronal ridges of the teeth are more numerous, are smaller at the base of the enamel, and more of the ridges are interrupted than in *Goniopholis*; the entire tooth also seems to be shorter and thicker.

The three vertebræ represented in figs. 1—5, Pl. II, were obtained by Mr. Holmes from the same bed of Wealden clay, at Cuckfield, as the teeth and scutes, figured in Pl. III, characteristic of the genus *Goniopholis*, to which, therefore, I refer them. They correspond with the fourth, fifth, and sixth cervical vertebræ of the recent Crocodile, having a parapophysis (*p*) similar in form, extent, and position, with traces of a short and thick hypapophysis, *hy*, at the fore part of the under surface; but that surface of the Wealden vertebra is less convex, the whole centrum is relatively broader, and the more important difference of the concavity of the hinder as well as of the fore articular end manifests the distinct family of *Crocodilia* to which the *Goniopholis* belongs. The depth of the concavity of these surfaces exceeds that in *Teleosaurus*. The free surface of the centrum is smooth. The neural arch articulates with the whole length of the centrum by the neurapophysial surfaces of the form shown in fig. 5, *np*. The neural canal (ib., *n*) slightly widens behind. Two vertical, venous canals open into the neural one. Fig. 6 is the side-view of a cervical centrum from the Purbeck beds, having the general proportions of those of *Goniopholis*, but differing in the smaller size of the parapophysis. Figs. 7—9 are views of the centrum of a dorsal vertebra of the Purbeck *Goniopholis*, fig. 9 showing the texture as displayed by a vertical longitudinal section. It is compact or minutely cancellous throughout; whereas the centrums in the *Teleosaurus* exhibit a more open, reticulate texture, with a cavity near the centre; this cavity is still larger in *Poikilopleuron*.

One of the posterior caudal vertebræ of the Cuckfield specimen, after the subsidence of the diapophyses and the great reduction of the zygapophyses, shows the spinous process rising from the hinder part of the neural arch, as at *g*, Pl. III.

The coracoid (ib., *h*) differs from that of the existing Crocodiles in its greater relative breadth at the neck or part marked *h*, in the more gradual and minor expansion of its mesial end, and in the more regular convexity of its scapular border. It exhibits the same perforation near this border as in the modern Crocodiles.

The humerus associated with the remains of *Goniopholis* from the Wealden of Cuckfield has the usual Crocodilian form and sigmoid flexure. Compared with one from a *Crocodilus biporcatus*, with the same-sized cervical vertebræ, it is a somewhat thicker and stronger bone. It has a broader and thicker ulnar tuberosity, and the angle at which the process is bent down upon the shaft is less marked, more rounded off. The radial crest is a triangular, compressed ridge, but is not produced beyond four lines from the surface of the shaft; the distal part of the bone is proportionately thicker antero-posteriorly than in the modern Crocodiles, and the longitudinal, irregular ridges at the margin of the articular surface are stronger; there is a similar ridge above the inner condyle.

The femur of the *Goniopholis* (Pl. III, *o*) is relatively longer, and is less bent than in the existing Gavial or Crocodile. The tibia (*m* and *n*, the latter bone presenting its narrower side to view) is also both longer and thicker.

Dermal Scutes.

In the slab of Wealden stone from Cuckfield, containing the parts of the dislocated skeleton shown in Pl. III, there were imbedded, not only the long, quadrate, toothed scutes (*a*, *b*), like those in the Purbeck slab (Pl. IV, fig. 1), but a second form of scute (ib., *d*) of which no examples had been preserved in the Purbeck specimen. Of this second form detached specimens were obtained from the same formation and locality, of which one is figured in Pl. IV, figs. 2, 3, 4. These scutes are hexagonal, marked, as in the toothed kind, on the outer surface, by hemispheric, circular or subcircular pits, and on the inside by fine, linear, decussating lines, on an otherwise smooth and plane surface. They have no articulating process, but have a strongly marked sutural surface on the thick margin (ib., fig. 3), showing them to have been united together, like the neural and costal plates of the carapace, and like the elements of the plastron, in the Terrapene and Tortoise. The section (fig. 4) shows the depth of the external pits, the texture of the scute, and its level and even under surface, *d*.

From the association of hexagonal sutural scutes with the quadrate, oblong, toothed scutes in the specimen (Pl. III), it can hardly be doubted that they formed part of the same exo-skeleton, and are probably from the ventral region. Some slighly modified shapes are shown in the scutes marked *f* in Pl. III.

In the sixth part of the sixth volume of the 'Palæontographica' of H. v. Meyer, the author has described and figured part of the dermal skeleton of what he believes to have been a Saurian reptile, consisting of bony plates, for the most part hexagonal, and united by marginal sutures. These plates, however, do not present the uniformly pitted character of the external surface, as in *Goniopholis*, but here and there in the series they show a few irregular, large depressions; the more constant markings are smaller, apparently vascular foramina, and linear, usually radiated, impressions, in character more like the markings of the dermal ossifications of the Labyrinthodont Reptiles. The specimen described is from the "Dachsteinkalk," under the Winkelmaas Alpe, near Runpalding, in Bavaria, and it is referred to the *Psephoderma Alpinum*.

Species—*Goniopholis simus*, Ow. Plate V.

This species is founded upon the entire skull, *minus* the lower jaw, imbedded in the limestone of the Swanage quarry, of which skull a reduced view of the upper surface is given in Pl. V, fig. 1; and of so much of the under surface (ib., fig. 2) as could be brought to light by exploratory operation on that part of the imbedding slab.

The skull in its general shape corresponds with the broad-faced species of the Procœlian Crocodiles;[1] and in the festooned contour of the alveolar borders, with those having teeth of uneqal size, and with a crown of mainly the proportions of the teeth in the present Amphicœlian genus.

The conclusion conveyed by the latter expression is not, indeed, based upon the discovery of vertebræ in such contiguity with the present skull as to support an inference as to their having formed part of the same skeleton; but it is a probable one from the association of such vertebræ with the foregoing nearly allied species of *Goniopholis*; and such probability is strengthened by the nature of the cranial modifications by which the skull under review differs from those of the Procœlian species most nearly resembling it in shape.

The temporal vacuities (ib., fig. 1, *t*) are relatively larger than in *Crocodilus* proper, or broad-faced Procœlians, and are subquadrate in form. The palatonaris (ib., fig. 2, *n*) is not only larger, but is more advanced in position, so as to come wholly into view on the bony palate, and on the same plane therewith; and here, moreover, they receive for completion of their anterior contour, the hinder ends of the proper palatine bones (ib., ib. 20), three fourths only of the border being contributed by the pterygoids (ib., ib., 24). The Eustachian aperture (ib., ib., *e*) is likewise on the palatal, not the occipital, plane.[2]

In these characters is manifested the nearer affinity of the Purbeck Crocodilian to the Amphicœlian Teleosaurs[3] than any Tertiary or modern genus presents.

The following are amongst the modifications of minor import in the skull of the present species of *Goniopholis*. The external nostril (Pl. V, fig. 1, *n*), horizontal in position, is more nearly terminal than in modern Crocodiles, or than in *Goniopholis crassidens* (Pl. I, fig. 2, *n*). It is formed by the premaxillaries exclusively; the nasal bones terminating about an inch behind the nostril. In Procœlian Crocodiles a graduated series of developments of the nasal bones may be traced. They may be short, as in *Gavialis gangeticus*, or extend to near the nostril, as in *Crocodilus cataphractus*, rather nearer in *Crocodilus intermedius*, still nearer in *Crocodilus Hastingsiæ*, be produced close

1 Cuvier, 'Ossem. Foss.,' tom. cit.

2 'Phil. Trans.,' MDCCCL, pl. xi, fig. 1 *e*.

3 Ib., p. 522.

to the aperture as in *Crocodilus champsoïdes*, penetrate a short way into the aperture, as in *Crocodilus suchus*, or, by continuous ossification of the septum in old individuals of *Crocodilus niger* and *Alligator lucius*, extend seemingly across the nostril. These characters, barely of specific value, have been used in the fabrication of genera of existing Crocodiles and Alligators,[1] in all of which the orbits are larger than the upper temporal apertures.

In *Goniopholis simus* the orbits (Pl. V, fig. 1, *o*) are rather smaller than the apertures (ib., ib., *t*).

Each pterygoid(fig. 2, 24,) articulating by a crenate suture with the narrow hind end of the palatine (ib., 20), which diverges from its fellow to form the fore part of the palatonaris, loses vertical thickness and gains in breadth as it extends backward. It there articulates by a tract of an inch in length with the basisphenoid. The Eustachian canal (ib., *e*) opens at the midspace between the basisphenoid and basioccipital. The latter arches down in advance of the condyle, and the venous foramen is conspicuous on this tract.

As the pterygoids are relatively less than in the Procœlians, so the palatines are relatively larger, especially in anterior breadth. After contributing their share to the palatonaris, they come into contact and the medial suture is continued forward to an extent of 3 inches 5 lines. The anterior breadth of the pair is 3 inches 4 lines. The medial suture of the palatal plates of the maxillaries was traced forward two inches or more in advance of the palatines, and laterally the plates were exposed to the same breadth as the palatines proper. The palato-maxillary suture, 20′—21′, is strongly sigmoid, describing as it leaves the midline a convexity forward and then a concavity. It was not thought expedient to endanger the unique specimen by further excavation in reference to the comparatively unimportant premaxillo-maxillary palatal suture.

The bony palate, as far as it was exposed, is smooth; the upper surface of the skull is rugose and pitted. The pits are circular or subcircular, from 1 to 2½ lines in diameter, situated chiefly on the swollen sides of the maxillaries and on the cranial part of the skull, including the expanded upper and outer surface of the squamosals; and the tympanic pedicles are smooth, and terminate in the usual transversely extended concavo-convex articular surface.

The tooth called "anterior canine" is preserved, somewhat mutilated, in each premaxillary. Sockets of smaller premaxillary teeth are faintly traceable. The tooth termed "posterior canine" projects from the anterior part of the outswollen and convex border of the maxillary. From portions or traces of the other teeth or sockets I estimate that there were from sixteen to eighteen teeth on each side of the upper jaw. In the largest and least mutilated crowns of these teeth the dental characters of the genus *Goniopholis* are shown.

In the 'Catalogue of the Osteological Series, Mus. Coll. Surgeons,' 4to, 1853, p. 164, is described the specimen No. 752, as "The skull of a Crocodile from Bengal,

[1] 'Trans. Zool. Soc.,' vol. vi, p. 125.

wanting the lower jaw, of a species (*Crocodilus palustris?*) which is frequently found inhabiting the larger ponds. It differs from the *Cr. biporcatus* of the Ganges in having shorter maxillary and premaxillary bones in proportion to its length, and in having much less developed prefrontal ridges; the palatal suture between the maxillary and premaxillary bones is transverse, not curved. The anterior extremities of the palatine bones are narrower and more pointed. The number of alveoli is—premaxillary 5—5, maxillary 14—14."

The doubt indicated (?) arose from the inadequate characterisation by Lesson, of the species described by him in the 'Zoologie' of the 'Voyage aux Indes Orientales de Bélanger;' but there is no reference of the specimen, No. 752, to the *Crocodilus rhombifer*, as is affirmed by the author of the "Synopsis of the Species of Recent Crocodiles," 'Trans. Zool. Soc.,' vol. vi, p. 140. I did not regard my doubt as justifying the sinking of Lesson's "*palustris*" into a synonym, and of imposing a new specific, much less generic name. But the osteological character of the palatal region of the skull, pointed out in my 'Catalogue,' appears to be the chief of those relied upon by the author of that 'Synopsis' for his genus *Bombifrons*, of which the first character is:—"The premaxillary suture straight, or rather convex forwards" (loc. cit., p. 139). The other characters are not of specific value.

The sutures of the premaxillary bones, I may remark, are of three kinds; one is medial and unites the pair; it is the "interpremaxillary suture:" the second is lateral, uniting the outer or dental plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary suture:" the third is transverse, more or less, and unites the palatal plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary palatal suture." Its modifications, added to other differences, when determined to be constant, may aid in differentiating the species of *Crocodilus* proper, of *Alligator*, and of *Gavialis*.[1]

The convenience of these three genera of Procœlian *Crocodilia*, although they agree in palatonarial and vertebral characters, will probably ensure their retention; but *Tomistoma, Oopholis, Halcrosia, Palæosuchus, Rhynchosuchus, Ramphostoma, Mecistops, Bombifrons, Palinia, Molinia, Caiman, Jacare*, &c., into which they have been subdivided, exemplify the evil of "encumbering the science with a multitude of names" (loc. cit.,

[1] Prof. Marsh, in his 'Introduction and Succession of Vertebrate Life in America,' 8vo, 1877, writes (p. 21):

"The beds of the Rocky-Mountain Wealden have just furnished us with a genuine "missing link," a Saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias."

When the cranial characters of this Crocodilian are made known it will be of moment to compare the temporal apertures on the upper surface and the palato-nasal apertures on the under surface of the skull. When the dental characters of the same fossil are described and figured we may be able to determine whether they are those of the broad-faced procœlian Crocodiles and Alligators or those of *Goniopholis*.

p. 128),—an evil which, if the "names" do not represent "generic distinctions," cannot be laid to the charge of the "Palæontologist."

At least, the "small fragments of the fossil skeleton" (ib., p. 128) on which the genus *Goniopholis* was originally founded have subsequently been proved, by acquisition of other parts, to have indicated accurately that well-marked and interesting addition to the recorded modifications of the Crocodilian type. Those of the vertebral and cranial structures have, indeed, proved to be not only of generic, but of family value.

Genus—Petrosuchus, *Owen*.[1]

Species—*Petrosuchus levidens*. Plate VI.

This genus and species of Crocodile is founded on the portion of skull and mandible, figured in Plate VI. The skull is imbedded in the same limestone of the Middle Purbecks, now quarried at Swanage. It was discovered in a block with the upper surface (ib., fig. 1) exposed. This surface is partially weathered, but shows here and there a faintly wrinkled natural sculpturing. The upper temporal apertures are larger than the orbits. In front of these the skull contracts more rapidly than in *Goniopholis*, and presents, as far as it is preserved, a slender form of face approaching to the proportions of that in the modern *Crocodilus cataphractus*,[2] and in the Tertiary *Crocodilus champsoïdes*;[3] but the more rapid contraction in front of the orbits is gavial-like, and there are other characters indicative of a nearer affinity than in *Goniopholis* to the Teleosaurian group. This affinity is decisively marked by the larger relative size and more advanced position of the palatonaris (ib., fig. 2, *n*), into the formation of which the diverging hind ends of the palatines (ib., fig. 2, 20) enter in a larger proportion than in *Goniopholis*. The basisphenoid (ib., ib., 5) is more produced, and the pterygoid (ib., ib., 24) contracts a more extensive sutural union therewith. Each palatine bone (ib., ib., 20), where they diverge at the palatonaris, shows a protuberance on its under surface. The Eustachian outlet is seen at *e*.

The portion of the left mandibular ramus (Pl. VI, fig. 3) includes the dentary element (32), nine inches in length, with portions of the angular (30) and surangular (29); that of the angular including six inches of its extent. Of this element two inches extend forward in advance of the hindmost point of the dentary; and, guided by the proportions of the *Crocodilus champsoïdes*, I estimate the total length of the

1 Gr. πέτρος, rock, and Σοῦχυς, an Egyptian name of the Crocodile.

2 Cuvier, 'Ossem. Foss.,' 4to, tom. v, part ii, pl. v, figs. 1 and 2; Gray, 'Trans. Zool. Soc.,' vol. vi, pl. xxxii, fig. 2.

3 Pal. vol. for the year 1849, 'Fossil Reptilia of the London Clay,' t. iii.

mandible of *Petrosuchus levidens* to be 16 inches, or thereabouts, indicating that from four to five inches are wanting at the fore part of the subject of fig. 1.

The vertical extent of the ramus behind the mandibular vacuity (ib., fig. 3, *v*) is 1 inch 9 lines; the vacuity itself is 1 inch 6 lines in long diameter, 6 lines in short diameter; its long axis is nearly parallel with that of the ramus. The lower, like the upper jaw, appears to have been long exposed on its imbedding block of stone. Little of the outer layer of the bone is preserved, and this is limited to parts of the angular and surangular. It here shows a more decided reticulate sculpture, the meshes being in the form of subcircular pits of from 1 to 2 lines in diameter.

The vertical breadth of the dentary at the terminal point of the angular is 1 inch 3 lines; it loses, as usual, in this diameter as it advances, but irregularly, owing to a gentle undulation of the alveolar border. This is convex where it supports the anterior group of teeth opposed to the premaxillary and foremost upper canine teeth; it is then slightly concave to the mid-third part, where the border is more feebly convex; beyond this, after a feeble concavity, it gradually rises to the surangular piece (29).

Of the foremost group of teeth seven are preserved; the third counting from the foremost being the longest and broadest, with the crown curving upward and a little backward; the length of this tooth is 1 inch 4 lines, its extreme breadth is 3 lines, about half of the total length forms the exserted crown, but the point is not entire. The first and fifth of this series are the next in size, but do not exceed an inch in length, the intermediate teeth are smaller; two or three sockets of still smaller teeth may be traced in the concave part of the border. In the following convex part, seven teeth are preserved, with shorter and relatively thicker crowns than in the foremost group; but none of them showing the robust proportions of the teeth of *Goniopholis*. Behind this group the indications of teeth and sockets are faint. I estimate the number of teeth in the present ramus at about twenty; which is the number in the mandibular ramus of *Crocodilus champsoïdes:* a margin of two or three more or less being allowed for a perpetually changing set of teeth.

The inequality of the size of the teeth and concomitant festooned course of their alveolar series is Crocodilian, as contrasted with the Gavialian and Teleosaurian types. But the temporal and palatonarial openings indicate the generic distinction of *Petrosuchus*, with its transitional character between the Teleosaurian and Tertiary Crocodiles.

Portions of dermal scutes, with the pitting as on the mandible, but with wider intervals, are preserved on the slab in which the above-described fossil is imbedded.

Genus—Suchosaurus, *Owen.*[1] Suchosaurus cultridens[2] (Pl. IV, figs. 5—8).

In the Wealden formations have been found detached teeth and vertebræ, indicating the existence, at that period, of a large Amphicœlian Crocodile specifically and generically distinct from both *Goniopholis* and *Petrosuchus;* for, since the discovery of associated bones and teeth of the former genus has made us acquainted with its vertebral characters, an exhaustive analysis of the other reptilian fossils of the Wealden series leave only the form of Saurian tooth, Pl. IV, figs. 5 and 6, wherewith to associate the equally peculiar form of Saurian vertebra, ib., figs. 7, 8. This vertebra is readily distinguishable, by the length of the centrum and the compressed wedge-shaped character of its middle part, from all other known Saurian (Dinosaurian or Crocodilian) vertebræ of the Wealden period. The specimen (No. $\frac{188}{2138}$, Mantellian Collection of Wealden fossils in the British Museum) is the centrum of a dorsal vertebra, with both articular extremities slightly and equally concave; though narrower at the middle than at the ends, it is more uniformly compressed than in other Crocodilian vertebræ, the sides converging to an inferior obtuse ridge, which is very slightly concave in the antero-posterior direction. The sides are not flat in the vertical direction nor slightly concave, as in many of the Iguanodon's vertebræ, to which the present form approximates; but are gently convex, so that a pencil laid vertically upon the sides touches it only by its middle. A more decided difference between the present Crocodilian vertebræ and those of the Iguanodon is, that the former are longer in proportion to their height and depth. The external surface at the middle of the body of the vertebra is very finely striated, so as to present a silky appearance; near the margins it is sculptured by coarse, longitudinal grooves and ridges.

The base of the neurapophysis which, when anchylosed, leaves an evident trace of the suture, is nearly equal in length with the body of the vertebra; it does not wholly include the neural canal, but leaves the impression of the lower third of that canal upon the upper surface of the centrum. On the outside of the neurapophysis are two slightly developed, broad, obtuse ridges, converging towards each other from the outer side of each angle or end of the base of neurapophysis; the ridge corresponding with the posterior of these in the Iguanodon's vertebra rises more vertically, and is in higher relief. The neurapophysial suture slightly undulates in its horizontal course, and rises in the middle instead of descending upon the centrum, as in the Plesiosaurs.

The present vertebra is alluded to at p. 70, and figured at pl. ix, fig. 11, of Mantell's

[1] 'Report,' ut supra, p. 67 (Gr. Σοῦχος, an Egyptian name of the Crocodile, and σαῦρος, lizard).
[2] Ib., ib.

'Illustrations of the Geology of Sussex,' 1827, as a lumbar vertebra of the *Megalosaurus*. But in the 'Geology of the South-east of England,' the same author, speaking of this vertebra, observes, "It cannot, I now think, be separated from those figured in the same plate as belonging to a Crocodile;" p. 297, *note*. The body of the Megalosaurian vertebra has a pretty deep, longitudinal depression between the neurapophysial suture, wanting in the Tilgate vertebra here described. This, however, is not the only distinction; below the depression the centrum of the Megalosaur swells out, and is as convex below as it is laterally in the transverse section, so that the outline of a transverse section would describe five sixths of a circle; a similar section of the vertebra of *Suchosaurus* would be triangular, with the apex rounded off. The Megalosaurian vertebra is more contracted at the middle, and swells out near the articular ends, surrounding those articulations with a thick convex border; in *Suchosaurus* the lateral meet the marginal surfaces at a somewhat acute angle; but the silky striated surface of the Suchosaurian vertebra, and the smooth and polished surface of the Megalosaurian one, would effectually serve to distinguish even fragments from the middle of the body of each.

The following are dimensions of the vertebra of the large Wealden Crocodilian above described:

	No. 138.	
	Inches.	Lines.
Antero-posterior diameter of the body	3	10
Vertical diameter of its articular end	3	2
Transverse diameter of its articular end	2	9
Transverse diameter of the middle of the body	2	0

The fossil teeth from the Wealden (Pl. IV, figs. 5, 6), which I provisionally associate with the foregoing vertebra, approach by their more slender and acuminate form to the character of those of the Gavial, but differ from the teeth of any of the recent species of that genus of Crocodilians, as well as from those of the long and slender-snouted extinct genera (*Teleosaurus*, *Steneosaurus*, &c.). The crown is laterally compressed, subincurved, with two opposite trenchant edges, one forming the concave, the other the convex, outline of the tooth. In the Gavial the flattening of the crown and the situation of the trenchant edges are the reverse, the compression being from before backwards, and the edges being lateral.[1] The tooth of the Suchosaur thus resembles in form that of the Megalosaur, and perhaps still more those of the Argenton Crocodile; but I have not observed any specimens of the Wealden Crocodilian teeth in which the edges of the crown were serrated, as in both the reptiles just cited. The teeth of the Suchosaur also present a character which does not exist in the teeth of the Megalosaur, and is not

[1] The tooth attributed by M. Deslongchamps ('Mémoires de la Société Linnéenne de Normandie,' vol. vi, p. 39) to the *Poikilopleuron* agrees in form with those of the Gavial, and differs in the characters cited in the text from those of the *Suchosaurus*.

attributed by Cuvier[1] to those of the *Crocodile d'Argenton.* The sides of the crown are traversed by a few longitudinal, parallel ridges, with regular intervals of about one line, in a crown of a tooth one inch and a half in length; these ridges subside before they reach the apex of the tooth, and more rapidly at the convex than at the concave side of the crown.

Hitherto these teeth have not been found so associated with any part of the skeleton of the same species as to yield unequivocally further characters of the present extinct Crocodilian. From the above-mentioned well-marked differences between these teeth and those of all other known species, I regarded the extinct Crocodile in my 'Report on British Fossil Reptiles' as forming the type of a distinct genus and species, and proposed for it the term *Suchosaurus cultridens.* It indicates a nearer affinity or transition to the Dinosaurian order than does any of the mesozoic *Crocodilia,* known by their cranial as well as by their dental, vertebral, and dermal characters.

Of those species so recognised, including the Purbeck and Wealden kinds now added, the following are common characters. A greater development, than in Tertiary Crocodiles, of the dermal bony armour, which consists, without exception, of both dorsal and ventral scutes, the scutes in each series well connected with each other, and in *Goniopholis* exceptionally so.

A less development of the osseous surface for the origin of the muscles of the mandible indicated at the upper surface of the cranium by the larger 'temporal vacuities,' and at the under surface by the smaller pterygoid plates. Horizontal plane, larger size, advanced position and palato-pterygoid formation of the palatonares.

Amphicœlian vertebræ.

These common characters of mesozoic *Crocodilia* suggest considerations of their relation to the prey of such *Crocodilia* and also to the coexistent marine reptiles of which those *Crocodilia* themselves became the prey.

Similarly, if the common characters of the tertiary and existing *Crocodilia* be summed up they become suggestive of analogous considerations.

A minor development than in mesozoic crocodiles of the dermal bony armour, consisting, with few exceptions, of the dorsal scutes only, and these relatively smaller, thinner, and less closely knitted together, may relate to the absence of the Mosasaurs, Pliosaurs, Polyptychodonts, &c., against the assaults of which the contemporary crocodiles of those Saurians required a better defensive armour.

The greater development of the osseous surface for the origin of the muscles of the mandible, indicated at the upper surface of the cranium by the smaller, or obliterated, 'temporal vacuities,' and, at the under surface, by the more expanded alæ of the pterygoids, accords with the stronger jaws and dentition, as an adaptative to seize and subdue a stronger and more resisting kind of prey than that on which the mesozoic crocodiles habitually fed.

[1] Cuvier, 'Ossem. Fossiles,' 8vo. tom. ix, p. 331.

The oblique plane, posterior position, small size, and exclusively pterygoid formation of the palatonares, together with the procœlian vertebræ, lead one to think of the contemporary coming in, with the neozoic crocodiles, of active, warm-blooded, air-breathing mammals.

But the considerations suggested by such correlations require the wholesome sifting of discussion; and I, therefore, propose to reserve them for a communication to the Geological Society of London.

I will only add that any additional evidences of the cranial characters of Purbeck Crocodiles will be gratefully received.

PLATE I.

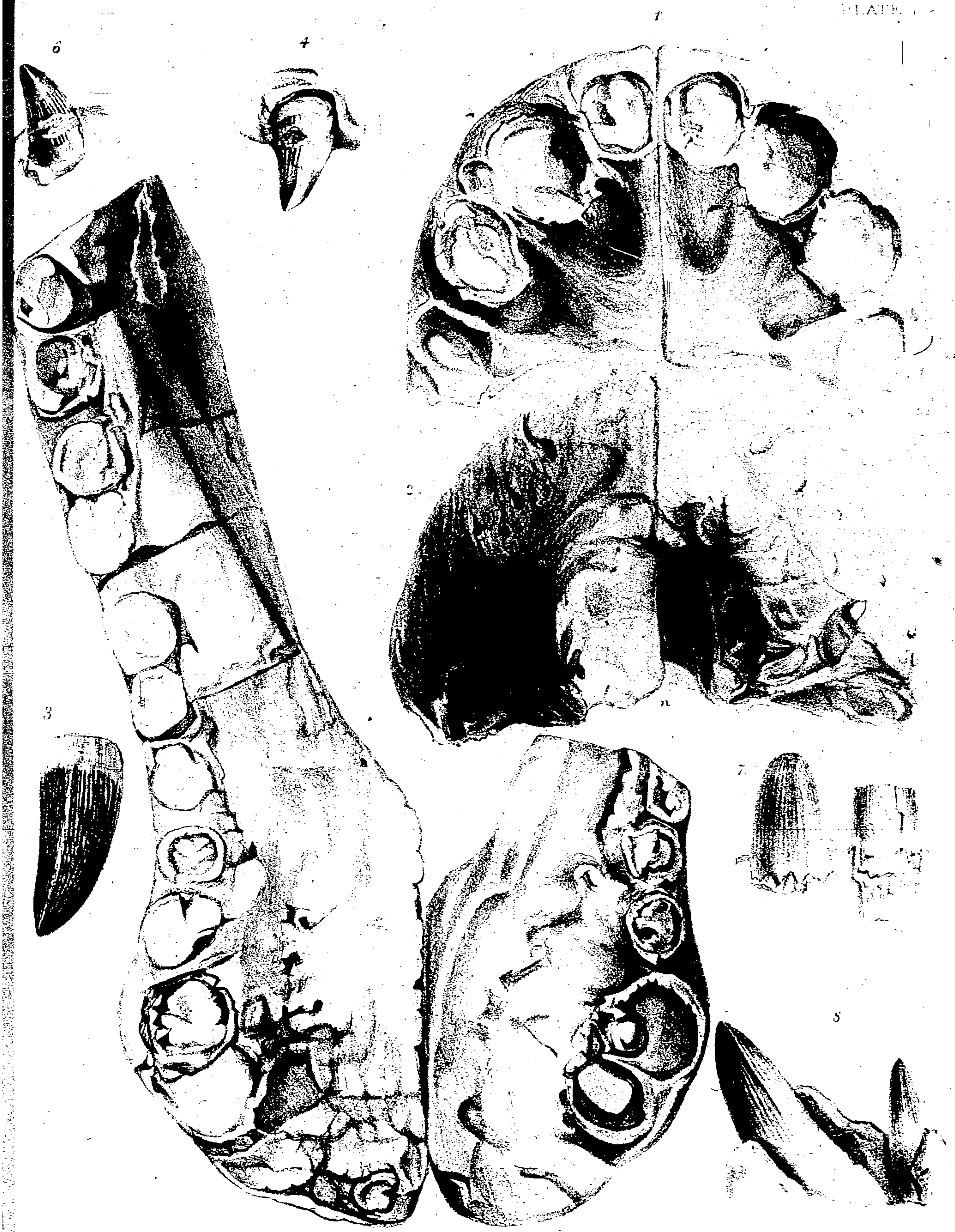
Goniopholis crassidens.

FIG.

1. Premaxillary extremity of skull, palatal surface.
2. Premaxillary extremity of skull, outer surface.
3. Crown of large maxillary tooth.
4. Crown of small maxillary tooth.
5. Symphysial extremity and part of ramus of mandible, upper or oral surface.
6. Crown of small mandibular tooth.
7. Two hindmost mandibular teeth.
8. Large and small mandibular teeth from near the middle of the series.

The subjects of figs. 1—4 are from the Wealden of Cuckfield.
The subjects of figs. 5—8 are from the Limestone Series of the Middle Purbeck.

All the figures are of the nat. size.



From nat. on stone by J. Erxleben

GONIOPHOLIS CRASSIDENS

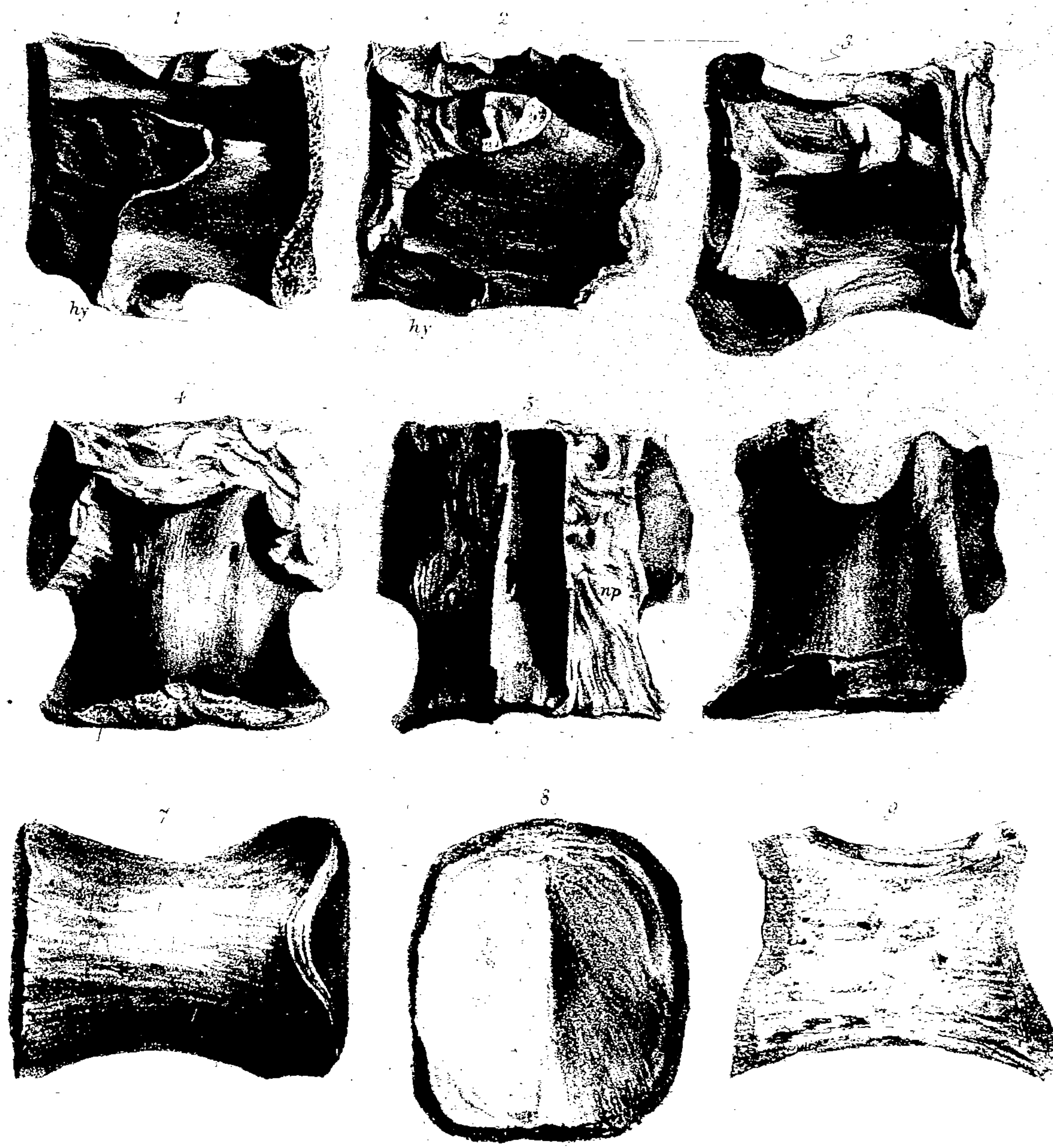
PLATE II.

Goniopholis crassidens.

Fig.

1. Side view of centrum of third cervical vertebra.
2. Side view of centrum of fourth cervical vertebra.
3. Side view of centrum of fifth cervical vertebra.
4. Under view of centrum of third cervical vertebra.
5. Upper view of the same.
6. Side view of centrum of sixth cervical vertebra.
7. Under view of centrum of dorsal vertebra.
8. Front view of centrum of dorsal vertebra.
9. Vertical longitudinal section of centrum of dorsal vertebra.

The subjects of figs. 1—6 are from the Wealden of Cuckfield.
The subjects of figs. 7—9 are from the Limestone Series of the Middle Purbeck.



From nat. on stone by J. Erxleben.

W. West & Co. imp.

GONIOPHOLIS CRASSIDENS.

PLATE III.

Goniopholis crassidens.

A slab of Wealden Stone with bones, teeth, and scutes: two thirds nat. size.

From the Wealden of Cuckfield.

From nat. on stone by J. Erxleben.

GONIOPHOLIS CRASSIDENS

PLATE IV.

Goniopholis crassidens.

Fig.

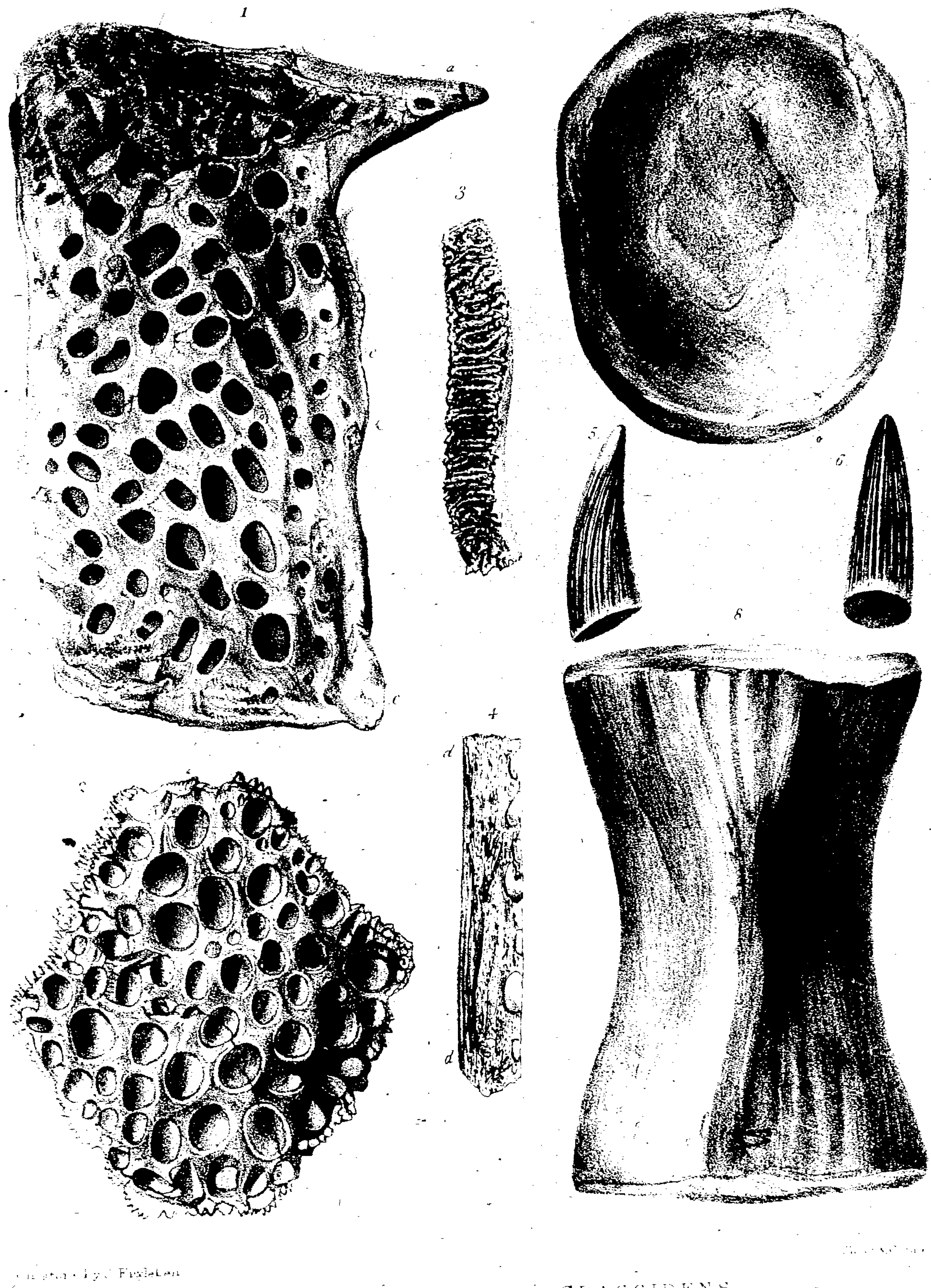
1. Dorsal scute, outer surface.
2. Ventral scute, outer surface.
3. Sutural margin of ventral scute.
4. Section of ventral scute.

Suchosaurus cultridens.

5. Side view of crown of tooth.
6. Hind view of crown of tooth.
7. Hind articular surface of centrum of dorsal vertebra.
8. Under surface of centrum of dorsal vertebra.

The subject of fig. 1 is from the Limestone Series of the Middle Purbeck.
The subject of figs. 2—4 is from the Wealden of Cuckfield.
The subjects of figs. 5—8 are from the Wealden of Tilgate.

All the figures are of the natural size.



1–4 GONIOPHOLIS CRASSIDENS
5–8 SUCHOSAURUS CULTRIDENS

PLATE V.

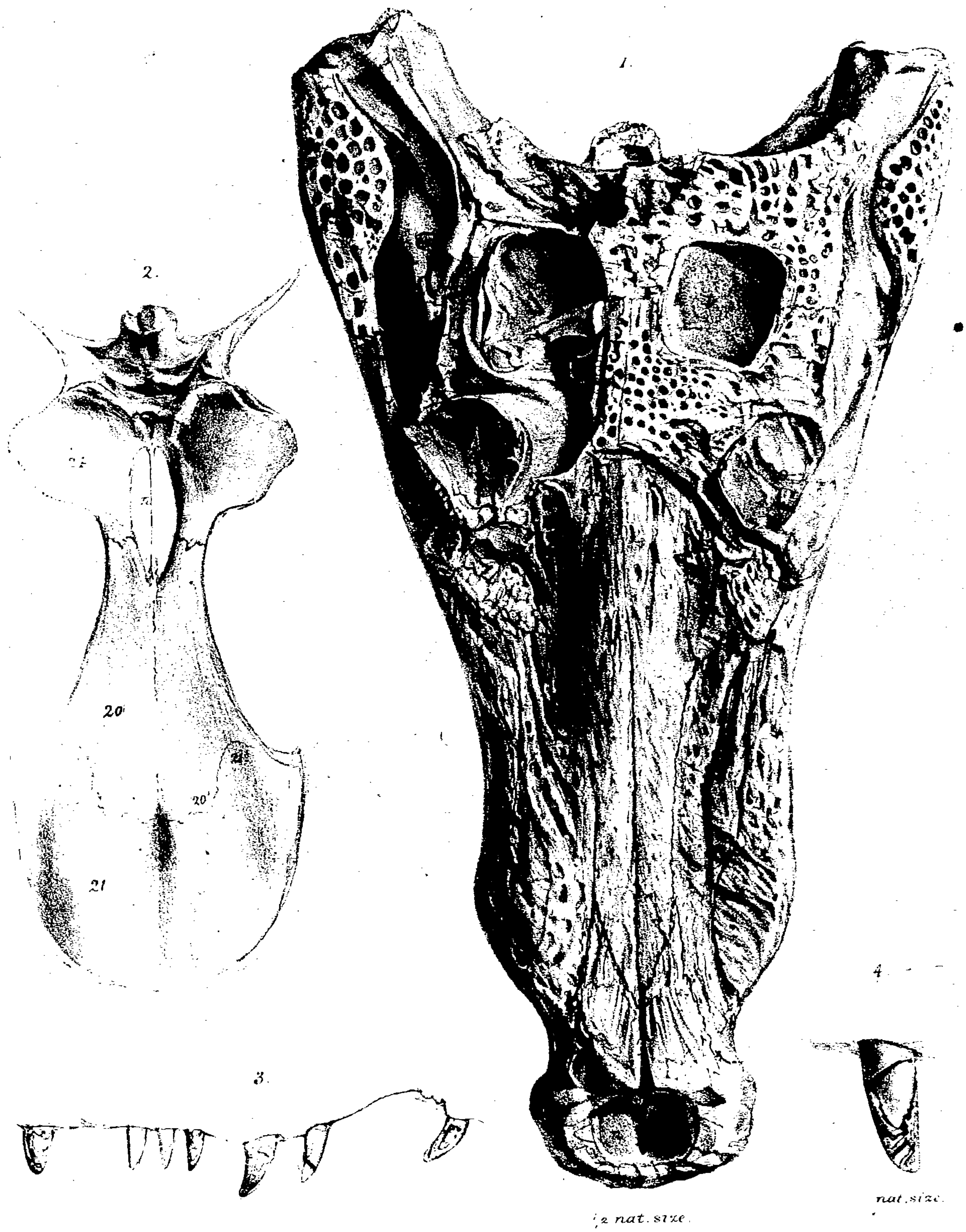
Goniopholis simus.

FIG.

1. Upper surface of skull.
2. Portion of the palatal surface of skull.
3. Portion of the left alveolar border and teeth of upper jaw.
4. The largest (2nd canine) of the upper series of teeth.

From the Limestone Series of the Middle Purbeck.

Figs. 1—3 : half nat. size ; Fig. 4 : nat. size.



From nat. on Stone by J. Erxleben

GONIOPHOLIS SIMUS.

W. West & Co. imp.

PLATE VI.

Petrosuchus levidens.

Fig.

1. Portion of skull, upper surface.
2. Portion of skull, palatal surface.
3. Portion of right ramus of mandible.

From the Limestone Series of the Middle Purbeck.

All the figures are of the nat. size.

From nat. on Stone by J. Erxleben

PETROSUCHUS LEVIDENS.

W. West & Co imp.

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF THE

WEALDEN AND PURBECK FORMATIONS.

SUPPLEMENT No. IX.

PAGES 1—19; PLATES I—IV.

CROCODILIA

(GONIOPHOLIS, BRACHYDECTES, NANNOSUCHUS, THERIOSUCHUS, AND NUTHETES).

BY

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ETC. ETC.

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SUPPLEMENT (No. IX)

TO THE

MONOGRAPH

ON

THE FOSSIL REPTILIA

OF

THE WEALDEN AND PURBECK FORMATIONS.

(GONIOPHOLIS, BRACHYDECTES, NANNOSUCHUS, THERIOSUCHUS, AND NUTHETES.)

ORDER. *CROCODILIA.*

THE subjects of the present 'SUPPLEMENT' are from the same division ('Feather-bed') of the fresh-water deposits of the Middle Purbeck series as the Mammalian fossils described in the under-mentioned volume,[1] and were disinterred by the skilful and enterprising explorer of that geological series, SAMUEL HUSBAND BECKLES, Esq., F.R.S., to whom the discovery of most of those fossils is due.

The whole of Mr. Beckles' gatherings from the Purbeck shales having been acquired by the British Museum, many slabs with indications of organic remains have been carefully worked out, and the chief parts of the subjects of Plates I—IV have thus been brought to light

At the first aspect, detecting in the scattered groups of scutes specimens showing the peg (Pl. IV, fig. 3, *a*) and groove (ib., fig. 4, *b*), it seemed as if remains of some young specimens of *Goniopholis* were so exposed. The condition, however, of two of the skulls (Pl. III, figs. 1 and 3) enabled a comparison to be made which determined their specific and, by their dentition, generic distinctions from both *Goniopholis* and *Petrosuchus*. The number of maxillary and mandibular specimens, of which several are figured in Pl. III, exemplified a degree of constancy in size which begat a conviction that such was a character of the species; and, diminutive as were the REPTILIA which have supplied the subjects of both plates, their characters were indisputably those of the Order *Crocodilia*. One of them, by the size and shape of certain teeth, came nearer to *Goniopholis*, another

[1] 'Monograph of the Fossil Mammalia of the Mesozoic Formations;' in the Volume of the Palæontographical Society for the year 1870.

by the same character resembled *Petrosuchus*, but the differential characters were such as could not have been obliterated by growth or age.

A third form of Crocodilian made a nearer approach in one of the species (Pl. I, fig. 2) to the average size of the broad-faced genera. A fourth (ib., fig. 1) corresponded in size with the subject of fig. 2, but offered no character by which it could be legitimately removed from the genus *Goniopholis*. I commence with the description of this small but well-marked species.

Genus—GONIOPHOLIS, *Owen*.[1]

Species—*Goniopholis tenuidens*. Plate I, fig. 1.

The dental character of the Amphicœlian genus *Goniopholis* consists of the numerous close-set, fine, longitudinal ridges of the enamel, two of which, larger and sharper than the rest, traverse opposite sides of the tooth from the base to the apex of the crown, midway between the convex and concave lines of the curvature of the tooth, that is, at the fore and back parts of the crown.[2]

The general shape and proportions of the tooth-crowns indicate distinctions of species of *Goniopholis*. The type of the genus is characterised by the thickness and subcircular section of the crown, and the obtuseness of that in the posterior teeth.[3]

In *Goniopholis simus*[4] the proportion of breadth to length of crown is less than in *G. crassidens*, and this difference is more marked in the specimen from the Feather-bed of Purbeck which forms the subject of fig. 1, Pl. I.

This specimen consists of the chief part of the dentary and co-articulated splenial elements of both rami of the same mandible, partially dislocated at the symphysis. The alveolar tract includes the incisive (*i*) and molary (*m*) convexities, without an intervening laniary rising. The incisive convexity includes five sockets, a tooth being retained in the first, third, and fourth on the right, and in the first and third sockets on the left dentary. The foremost tooth has a crown of 6 mm. length and barely 2 mm. of basal breath; each has partially emerged from a socket larger than itself, and exhibits a portion of a tooth in succession to one which has been lost or shed. The socket is separated by an interval of 2 mm. from the second. This shows a subcircular aperture of 5 mm. in diameter. The third socket opens at 2 mm. distance from the second. The tooth (*b*) in the right dentary shows the inner, longitudinally concave side of the crown, with a basal breadth of 6 mm.

[1] 'Reports of the British Association,' 8vo., 1841, "On British Fossil Reptiles," part ii, 1841, p. 690.

[2] Loc. cit., pp. 69, 70.

[3] 'Supplement (No. viii) to the Monograph on the Fossil Reptilia of the Wealden and Purbeck Formations,' Palæontographical Volume for the year 1878, p. 1, pl. i, fig. 7.

[4] Ib. Ib., p. 7, pl. v.

and a total length of 16 mm. One may count about a dozen fine longitudinal linear ridges between the fore and hind stronger ones (ib., fig. 1 *b* and *b'*, magn.). The corresponding tooth (ib., fig. 1 *a*, magn.) in the left dentary shows the outer longitudinally convex side of the crown, with about sixteen fine ridges. These teeth answer to, or interlock with, the premaxillary or anterior canines of the upper jaw. The fourth tooth (ib. *c*) is less than the third; its crown projects 10 mm. from the right dentary; the fractured base of the corresponding tooth in the left dentary is 4 mm. in diameter. Seven close-set sockets follow along the feebly concave part of the alveolar tract. The tooth of the twelfth socket at the beginning of the second convexity is preserved in both rami; its crown is 8 mm. in length, 4 mm. in basal breadth, with an obtuse summit, showing the feeblest indication of an apical point. This point is rather better seen in the crown of the next tooth, which has not wholly emerged.

The total number of teeth is sixteen in each of the dentary elements here preserved, and by analogy to the *Goniopholis simus*,[1] the whole, or nearly the whole, of the dental series or sockets, in one dentary element is here exhibited.

The outer surface of the dentary is pitted by small subcircular, not close-set, impressions, except on the outer alveolar plate of the molary rising, where a few longitudinal pits indent the otherwise smooth surface of the bone.

The length of the symphysis is 25 mm., the depth 10 mm. The extreme breadth of the incisive part of the mandible is 32 mm.

The length of the preserved alveolar part of the dentary is 85 mm. (3 inches, 3 lines); the length of the entire mandible might have been between 5 and 6 inches.

Fragmentary evidences of the *Goniopholis tenuidens* in other slabs of matrix do not indicate any individual of a larger size than is exemplified by the above-described portion of lower jaw.

The mandible of *Goniopholis crassidens*, with an extreme depth of 4 inches, attained the length of 2 feet. Of this length the alveolar part of the dentary element occupied, as in most broad-faced Crocodiles, one half. The length of the alveolar part of the mandible of *Goniopholis tenuidens* being 3 inches, the total length of the jaw may be set down at one fourth of that of the type species of the genus.

Genus—Brachydectes, *Owen*.[2]

Species—*Brachydectes major*. Plate I, fig. 2.

In this genus and species a left mandibular ramus, 9 inches 6 lines in length, shows an alveolar tract of but 3 inches 9 lines in length. In the proportion of the jaw, therefore, appropriated to the lodgment of the teeth this Crocodile differs from the rest of the

[1] 'Supplement' (No. viii), *ut supra*, p. 8.

[2] Gr. βραχύς, short; δηκτής, biter.

family. The ramus has a less relative depth than in *Brachydectes minor*, fig. 3; it measures in extreme vertical extent, taken at about one fourth of the length from the angle, 1 inch 9 lines, or little more than one sixth the entire length of the ramus, whilst in *Br. minor* the extreme depth of the mandible, which is about midway between the two ends, is nearly one fifth of the entire length of the ramus. This proportion might, however, be deemed an immature character of the smaller specimen, but there are other differences in the jaw of *Brachydectes major* not attributable to age and consequent growth. There is no longitudinal ridge on the angular element. The angle itself is more produced. This process repeats, indeed, the low position characteristic of the genus *Brachydectes*, but the line descending thereto from the articular element is straight, not concave, as in *Br. minor*, and the curve from the angle to the convex border of the angular element (fig. 1, 30) is deeply concave. Moreover, the outer surface of the deep hinder part of the ramus is sculptured with close-set deep pits, giving a strongly reticular character to that part of the bone.

The alveolar tract shows, as in *Brachydectes minor*, a laniary convexity (*l*) as well as an incisive one (*i*); both, however, are slight. In the latter the crown of the third or fourth incisor is preserved; it is 20 mm. in length, 6 mm. in basal breadth. The enamel of the exposed outer side is smooth; the fore part of the crown is obtuse, the hind part trenchant, with a faint appearance of minute denticulation. This is the only tooth preserved in the present jaw. There are faint indications of ten or twelve alveoli behind the tooth; two of these in the laniary curve (*l*) indicate teeth proportionally as large as the canine in *Brachydectes minor*. The outer surface of the laniary convexity is smooth. The rugged irregularly and minutely pitted character is continued to the alveolar border of the incisive convexity. The sutures between the dentary and hinder elements of the mandible are not clearly definable. Certain parts of the outer surface which were wanting made it doubtful whether any vacuity between the surangular, angular, and dentary elements existed; and the condition of the jaw of the smaller species weighs in favour of assigning an uninterrupted outer wall of the mandible as an additional differential character of the genus.

The proportion of the incisor tooth approaches that of the third in *Petrosuchus*,[1] but the latter is longer in proportion to the basal breadth. The dental series, and consequently the dentary element, are relatively longer in *Petrosuchus* than in *Brachydectes*.

A second specimen of the left dentary bone repeats closely the same size and characters of the corresponding part of the mandibular ramus above described. The teeth are wanting. Behind the alveolus of the 'anterior canine' are indications of seven or eight following alveoli, not more. The better preserved outer plate of the bone demonstrates the absence of the vacuity which is present in *Petrosuchus*, *Goniopholis*, and *Crocodilia* generally.

[1] 'Supplement' (No. viii), pl. vi, fig. 3.

Species—*Brachydectes minor*. Plate I, fig. 3.

This species first indicated the genus in the exploratory operations; it is represented by the left mandibular ramus (Plate I, fig. 3), which is remarkable, as in the larger species, for the small proportion which the alveolar tract bears to the entire length of the bone, and for the entireness of the outer wall. The alveolar tract is undulated, showing an incisive and a laniary convexity with intervening and hinder concavities.

The incisive convexity holds five teeth, close set, the two hindmost rather larger than the rest; but no single tooth is so much larger as to suggest the name of 'canine.' The laniary convexity shows one large canine with a broad, straight, laterally compressed crown. It is preceded by a smaller tooth, rather less than the hindmost incisor, and separated therefrom by a space which may have held two or three small teeth. The alveolar tract behind the canine seems to have lodged three or four teeth, the crowns of which are lost.

The whole length of the alveolar tract is 23 mm. (1 inch); that of the entire ramus is 85 mm. (3 inches 2 lines). The dentary element bifurcates behind as usual; the upper prong joining the surangular, the lower and longer one the angular, but without defining or leaving any vacuity; the union where such vacuity would have been left in ordinary Crocodiles is situated well within the anterior half of the ramus. The posterior elements are correspondingly of unusual length; their breadth is also proportionally greater than in previously known Crocodilian mandibles. The length of the surangular element (29′) is 48 mm. (1 inch 10 lines); its depth (vertical breadth) is 13 mm. (6 lines). The upper border describes a feeble convexity; beneath the articular surface of 29 the surangular curves downward and backward, meeting the lower border at a point wedged between the articular and angular elements.

The articular exposes the outer antero-posterior concave border of the joint. From this it descends obliquely backward and joins the angular in forming the process (30′), which here projects directly backward, its termination being much below the joint, and nearly on the level of the lowest part of the lower border of the jaw. The angular element extends forward from the angle, with its lower border at first straight or feebly concave, and then moderately convex to its junction with the dentary; a ridge projects along the greater part of this course a little way above the lower border. A portion of the splenial element shows above the fore part of the surangular, and supplements the inner alveolar wall at the hind part of the dentary.

From the lower jaw of *Theriosuchus* (Plate III, figs. 5, 14, 16) the present differs in the shortness of the dentary element and alveolar series, in the greater depth and verticality of the outer surface of the ramus, and the narrower inferior border. It also offers a generic distinction in the number and shape of the teeth.

The proportional length and slenderness of the dentary and the absence of any laniary convexity succeeding the incisive one, together with greater number and the shape of the teeth of *Nannosuchus* (Pl. II, figs. 8 and 9) offer a more striking contrast with the mandible and teeth of *Brachydects.*

No specimens have been brought to light which show characters of *Brachydectes minor* on a larger scale than is represented by the mandibular ramus above described.

Genus—Nannosuchus,[1] *Owen.*

Species—*Nannosuchus gracilidens.* Plate II, figs. 1—10; Plate III, figs. 1 and 2.

In this genus the teeth have long, slender, sharp-pointed crowns, slightly recurved, mostly sub-circular in transverse section, impressed by a few clear or narrow and shallow grooves. The dental series is pretty uniform as to size and shape of crown, but less so than in the Teleosaur and Gavial; the teeth are also less numerous and wider apart.

The claim to generic distinction indicated by the armature of both upper and lower jaws was established by an additional dental character revealed in the following specimen.

The fore part of the mandible (Plate II, fig. 1) exhibited a tooth *in sitú* (fig. 1 *c* and fig. 2 enlarged), answering to that termed the 'anterior canine' in *Crocodilia,* but presenting characters which I had not before observed in those or other *Reptilia.*

The crown is long in proportion to the basal breadth, conical, recurved, and pointed. It is traversed along the middle of the outer surface by a ridge, or rather a low angle of the enamel, simulating a ridge; between this and the trenchant hind border is included one third of the outer surface of the crown. This tract is smooth, and, transversely, is feebly depressed or concave, giving a trenchant character to the hinder longitudinally concave edge of the crown. The two thirds of the outer, transversely convex, surface of the crown is traversed by close-set linear grooves, and intervening ridges, which mostly subside at the apical half of the crown, leaving about one third of the apex smooth. This tooth appears to be the fourth counting backward; the length of the crown is 10 mm., the basal breadth 3 mm. An enlarged view is given of the outer side of the crown in fig. 2.

The foremost tooth, also preserved (fig. 1, *i*), shows a coronal length of 5 mm., a basal breadth of 1 mm.

The crown of a fifth tooth rises close behind that of the fourth, with a basal breadth of 2 mm, and a length of 5 mm.; it is conical, but is straight. The outer side, uniformly convex, is traversed along the basal half by fine ridges and intervening grooves; it may be that the whole of this crown has not emerged.

[1] νάννος, dwarfish, Σοῦχος, an Egyptian name of the Crocodile.

The portions of mandible, the subject of fig. 1, consist of the right and left dentary elements, of which the major part is preserved, the rest indicated by impressions on the matrix. The preserved parts include the symphysial expansion, the joint being slightly dislocated through pressure, which has acted obliquely. The right dentary shows its outer side, the left dentary its lower border, and beyond the symphysis a small proportion of the outer surface, while the inner one is partly covered by the smooth splenial element (31).

The breadth of the symphysial part of the right dentary is 15 mm.; the length of the under part of the symphysis is 18 mm. At 33 mm. from the fore end the (vertical) breadth of the ramus diminishes to 10 mm., beyond which it gradually increases to 15 mm., where the bifurcation of the bone begins. The entire length of the part preserved is 114 mm. (nearly 4½ inches).

The exterior of the symphysial part of the dentary is pitted by numerous minute subcircular depressions. As the bone contracts the depressions enlarge and elongate, then take the form of longitudinal grooves of irregular depth; but these become limited to the lower half of the outer side of the dentary, the part above, which forms the outer alveolar plate, being smooth, with a few faint, short, longitudinal linear impressions.

The symphysial expanse of the right dentary shows five sockets, of which, as above stated, the first, fourth, and fifth retain their teeth. The implantation of these teeth in complete sockets confirms the indication by the sculpturing of the bone that the jaw has belonged to a member of the Crocodilian order.

The first tooth was the smallest; the second and third, judging from the sockets, gained in size; the fourth is the largest, and represents, as above remarked, the tooth opposing or interlocking with the premaxillary canine above; the fifth abruptly loses size. Of the succeeding teeth little more can be divined from the present specimen than that they were small or, at least, slender. The convex curve, lengthwise, of the outer alveolar border is very feeble, and seems to have helped to lodge the hinder teeth; it is divided by a long feeble concavity from the symphysial or incisive convexity. There is no laniary rising.

Two smooth bones (31, *x*) contribute to the inner wall of the ramus, as exposed on the left side. If the lower one (*x*) represents the splenial, the upper one (31) would be an unusually developed inner plate of the dentary. If this, however, should be, as its posterior expansion indicates, according to the analogy of the modern Crocodiles, the splenial element (31), then the lower bone (*x*), would represent an angular element unusually produced forward. The longitudinal line of demarcation between these smooth inner questionable elements is not an accidental crack.

The Crocodilian character of the present jaw is supported by the scutes (Pl. II, fig. 4) and impressions (fig. 5) of scutes, by a vertebra (fig. 3), portions of ribs with a bifurcate proximal end, and by a metacarpal bone, all on the same slab of matrix.

The vertebra is Amphicœlian; the neurapophysial suture is unobliterated; it is from the part of the trunk where the rib articulation has risen wholly above the centrum. This element is 13 mm. in length; the non-articular surface is smooth and entire, gradually and slightly expanding to the articular ends; the one exposed being subcircular, 10 mm. in diameter.

Of the scutes preserved the largest are oblong, quadrangular, with a tooth-like process from the anterior and outer angle, from the base of which is continued a raised smooth tract along the anterior border, from 4 to 3 mm. in breadth. The breadth of the entire scute is 17 mm.; the length is 35 mm. Some smaller scutes are pentagonal.

We have here, therefore, evidence of an Amphicœlian Crocodile, with the dermal armour after the type of that of *Goniopholis*, but generically distinct by the characters of the mandibular dentition. If the dentary bone constituted three fourths the length of the mandible this may be reckoned to have been about 6 inches in length, and the entire Crocodile may have been 6 feet in length.

The portion of mandible of which the under surface of the dentary and splenial elements are exposed, forming the subject of fig. 6, Plate II, is shown by certain teeth in place and others scattered near in the same slab, to belong to the same genus and species as that represented by fig. 1, and to have come from an individual of similar size. Both are the largest evidences of *Nannosuchus* shown in the numerous series of Reptilian fossils from the portions of the 'Feather-bed' formation now under review.

The symphysis, 21 mm. in longitudinal extent, forms a fifth part of the preserved extent of the dentary; the breadth of this part of the jaw is 30 mm.; that behind the symphysis is 27 mm. The rami, as far as they are preserved, diverge to a breadth of 70 mm.

The alveolar part of the symphysis describes an incisive convexity, and the sockets indicate one or two teeth of larger size and thicker proportions than those of the rest of the dental series. The crowns of two of these teeth, which had become detached, are fortunately preserved, near the fore part of the jaw. The largest (fig. 7, magn.) represents the 'anterior canine,' and is the homologue of fig. 1 *c* and fig. 2, magn. It shows the well-marked characteristics of that tooth in *Nannosuchus*, and, besides the difference of sculpturing, the crown is more strongly curved than in *Goniopholis* or *Retrosuchus*. The second detached tooth near the incisive alveoli shows both root and crown. The latter is but half the length of that of the 'canine;' more of the convex side is exposed than in fig. 2; it is traversed by fine longitudinal ridges. The teeth which are in place show a smaller size and more slender pointed crown. There is no evidence of any tooth equalling in size the largest of the symphysial or incisive series.

The numerous minute circular pits sculpturing the symphysial expansion change, as in the specimen (fig. 1), to coarser and larger longitudinal impressions as the rami recede and pass backward; and the surface near the alveolar border showing the feeble molary convex curve is smooth.

The dental character of *Nannosuchus* is more fully exemplified by smaller specimens, of which two, forming parts of the lower jaw, will be first noticed.

The subject of fig. 8, Pl. II, includes the dentary and angular elements, partially dislocated, of the right mandibular ramus. Two of the molary series of teeth are *in situ*, showing long, slender, feebly recurved crowns, each 5 mm. in length; other teeth of similar shape and with finely striate enamel are on the same slab.

In a smaller dentary (Pl. II, fig. 9) the sockets of eighteen teeth are visible. The proportions and outer markings agree with those of the larger specimen.

The humerus (fig. 10), preserved near the jaw, shows the usual Crocodilian characters, with more slender proportions than in *Crocodilus niger*; it rather resembles that of the Gavial.[1]

The characters of *Nannosuchus* yielded by the foregoing specimens are supplemented by those of the skull represented of the natural size in Pl. III, fig. 1. The teeth preserved *in situ* and detached, but in contiguity with the alveolar border, are generically those to which they would be opposed assuming the skull to be that of a *Nannosuchus*. The inferiority of size is not shown by any other distinctive character to indicate a species other than that founded on the lower jaws above described.

As in those, the teeth of the upper jaw are divided by intervals usually greater than their basal breadth. Each premaxillary (fig. 1, 22) had four teeth at least; the maxillary had not fewer than ten teeth.

The characters of length and slenderness of crown in the teeth of this small Crocodile suggested a comparison of its skull with that of *Petrosuchus*,[2] but the differential characters exceed in importance those of size. The upper jaw of *Nannosuchus* does not contract so rapidly, or in so great a degree in advance of the orbits, as in *Petrosuchus*; it is also shorter as well as broader; no amount of growth could have converted it into the slender elongate shape which approximates *Petrosuchus* to the gavial-like *Crocodilus cataphractus*.

The hind border of the parieto-mastoid platform is undulate; gently convex at the middle, where it is formed by the parietal (ib., 7), concave on each side, where it is carried out by the mastoids (ib., 8).

In *Crocodilus niger* this border is straight; in *Croc. palustris* it is undulate, but the middle parietal convexity is much less than the lateral, concave, mastoidean curves, owing to the relatively narrower extent of the parietal bone. The lateral borders of the supra-cranial platform, due to the mastoids (ib., 8) and post-frontals (ib., 12), present, in *Nannosuchus*, a gentle sigmoid curve. In most modern *Crocodilia* these borders are straight, running parallel in *Croc. niger*, slightly convergent forwards in *Croc. cataphractus* and *Croc. intermedius*.

The breadth of the platform is to that of the skull, taken across and including the

[1] 'Catalogue of Osteology, Mus. Coll. Chir.,' 4to, 1853, p. 153, No. 691.

[2] Supplement (No. viii) in Palæontographical Soc. Volume for 1878, Plate VI.

zygomatic arches, as 8 to 10 in *Nannosuchus;* in *Croc. niger* the platform is little more than half the breadth of the skull taken across the hind part of the parieto-mastoid or upper temporal apertures; in *Croc. palustris* the platform occupies half the breadth of the skull taken at the same part.

The upper temporal apertures (T) have the same relative size as in *Petrosuchus,* but they differ in shape, being less circular, the longer diameter being longitudinal, or in the skull's axis. As far as the orbits are preserved these do not exceed in size the upper temporal apertures. This character of the Mesozoic Crocodile is retained in the present dwarf species. A super-orbital bone strengthened the upper eyelid; it retains its connections with the frontal (11), post-frontal (12), and pre-frontal (14) in the left orbit (*o*); but has become slightly detached in the right orbit (*o′*). The nasal bones (15) terminate in a point distant from the external nostril by rather more than the diameter of that aperture, which accordingly is single and exclusively bounded by the premaxillaries. In this character *Crocodilus cataphractus* and *Croc. intermedius* resemble *Nannosuchus;* but the upper jaw is longer and more slender in proportion in both these existing Crocodiles than in the Purbeck species; in both, also, the upper temporal apertures are relatively smaller than in *Nannosuchus.*

In the character of the nasal bones and conformation of the external nostril *Nannosuchus* resembles *Goniopholis,*[1] but the supra-temporal apertures are more oblong and the maxillaries are not so out-swollen as they approach the premaxillaries. The facial part of the skull, from the front border of the orbit forwards, equals the extent of the skull from the same part to the occiput in *Nannosuchus;* in *Goniopholis* the facial part of the skull, so defined, is one third longer than the extent behind. The mutilated state of the unique skull of *Petrosuchus*[2] prevents a similar comparison being made.

The sculpturing of the upper surfaces of the exposed parts of the skull in *Nannosuchus* presents the common Crocodilian character of minute subcircular pits, leaving a reticulate disposition of the intervening bone.

Genus—THERIOSUCHUS,[3] *Owen.*

Species—*Theriosuchus pusillus.* Plate III, figs. 3—16; Plate IV.

This Crocodile, somewhat smaller in size than the preceding species, approaches nearer to the type of the broad-faced Alligators in the proportion of the antorbital part of the skull.

The dentition is more modified than in any other known Crocodile, recent or extinct, and approaches that which characterises the Theriodont order of Triassic Reptilia.

[1] Supplement, &c., No. viii, Plate V, fig. 1, *t*.

[2] Supplement, &c., No. viii, Plate VI, fig. 1.

[3] Gr. θηριον, wild beast; σοῦχυς, crocodile.

The premaxillary teeth are five in number in each bone; the three middle ones subequal, the first and fifth smaller. The maxillary teeth are divisible into laniaries and carnassials or trenchant molars. The first maxillary tooth is small (Pl. III, fig. 5); the second and third gain quickly in size, the latter (*a*) assuming the character of a canine; the fourth tooth (*b*) is a still larger canine; the fifth (*c*) and sixth (*d*) decrease in size somewhat suddenly, but in length rather than breadth of crown, and terminate the series projecting from the convex part of the alveolar border of the maxillary. The tooth *c* or *d* may be said to terminate the laniary series. Beyond *d* the teeth lose length and slightly gain in breadth; the crown assumes a triangular, laterally compressed, or lamellate form, and the enamel is transversed on the outside by fine but distinct lines (ib., fig. 6, *e*). Of these sectorial or carnassial molars some of the detached specimens of maxillary (figs. 7 and 11) indicate as many as eight or nine. The broad base or root of each tooth is not inserted into a separate and complete socket, but is lodged in a recess of the outer alveolar wall; moreover, the partitions between these recesses are low or partial, and the teeth appear to have been applied thereto, without being so completely confluent therewith, as in the pleurodont mode of fixation of the teeth in certain Lizards. Hence, in some of the specimens of the maxillary bone the incisors and canines only are retained, being rooted each in its own complete socket; while the molars have fallen out, and their partially separated recesses are shown, as in figures 7 and 11.

In the lower jaw the foremost tooth is rather larger than those which interlock with the middle premaxillary or 'incisor' teeth above; but not any of the succeeding laniary teeth attain the size of the upper canines. The twelfth tooth, counting backwards, assumes the lamellate, triangular shape of striate crown characteristic of the superior sectorials; and the inferior ones were lodged, like those above, in a common depression of an outer alveolar wall, developing the ridges dividing such depression into the dental recesses, as shown in fig. 16, Pl. III. This approximation to a Lacertian dental character might seem ground for something more than a family section of the order *Crocodilia;* but the quasi-pleurodont attachment of the hinder teeth in *Theriosuchus* is only an extension of the character affecting some of the teeth in existing species of Crocodile.[1]

In the cranial platform of *Theriosuchus* the medial parietal part of the hind border is less convex and the two outer parts are more concave by reason of the further backward production of the mastoids than in *Nannosuchus.* The lateral borders of the sculptured part of the platform are more convex than in that genus. This is owing to the greater proportion of the outer and posterior angles of the platform which is abruptly depressed

[1] It is noted in the *Alligator niger.* "No. 765. The right ramus of the lower jaw, from which the posterior part of the inner alveolar wall has been removed, showing the five posterior teeth lodged in a common alveolar groove." 'Osteological Catalogue, Museum of the Royal College of Surgeons,' 4to, vol. i, p. 167 (1853).

below the level of the sculptured surface of the mastoid, and which becomes smooth like the contiguous and lower-placed tympanic. This character, shown in the subject of fig. 3, Pl. III, usefully indicated fragmentary parts of the skull of other individuals of the species, such as are figured in fig. 1, 12′, Pl. IV. The supra-temporal vacuities are relatively larger than in *Nannosuchus*. The intervening tract of the parietal, rather more canaliculate than in *Nannosuchus*, is divided by a mid ridge in two of the cranial specimens, and partially so in the more complete skull.

No palpebral ossicle is preserved in the orbit (*o*). The pointed ends of the nasals are produced so as to divide the outer nostril into two, as in some specimens of *Crocodilus niger;* were this a character of generic value, it might unite *Theriosuchus* with *Halcrosia*, Gray.[1]

The alveolar part of the maxillary in which the canines are developed make a corresponding convex extension of its outer border, as in *Goniopholis*.

The extent of the 'symphysis mandibulæ' and the angle of divarication of the rami are shown in fig. 4, Pl. III.

The matrix was removed as far as practicable from the palatal surface of the skull (fig. 4) and exposed a portion of the basisphenoid (5), of the pterygoids (24), of the palatines (20), and palatal plates of the maxillary (21); the pterygo-maxillary vacuities (*y*) and the hind portion of the palatonares (*n*) were brought into view. What seems to be a portion of the hind part of a mandibular ramus was so wedged down upon a part of the palatal surface that, in regard to the fragile character of this unique skull, it was deemed unadvisable to attempt its removal.

In Pl. IV a portion of the skeleton of *Theriosuchus pusillus* is figured. It is of one individual. In the slab of matrix in which it is imbedded the fore part, marked A, A, is continued on from the hind part with an interval of the extent marked B. At this interval the slab has been broken across, but the parts appear to have been naturally readjusted before the specimen was fixed in its present frame. The position in which the two portions of the skeleton are figured relates to the convenience of size of the Plate.

The skull has been displaced and fractured, but the contiguity of the preserved portion with the vertebral column supports the conclusion that it formed part of the skeleton of the same individual. It thus serves to determine the species to which the subject of Plate IV belonged.

The part of the skull includes the parieto-mastoid platform (7, 12′) with the tympanic (28) and the squamosal (27). The articular surface of the tympanic for the mandible shows the Crocodilian character. The median or sagittal ridge of the parietal is well marked, and is continued along the mid-frontal. This character is partially effaced by mutilation in the more entire skull (Pl. III, fig. 3). It is well shown in the frontal bone indicating the largest of the specimens of *Theriosuchus* (Pl. III, fig. 8).

[1] 'Trans. Zool. Soc.,' vol. vi, p. 135.

The vertebral centrums of the trunk show the shallow Amphicœlian character of those of the *Goniopholis* and Teleosaurians. The smooth under or dermal surface of part of the two median rows of the dorsal scutes are shown in the fore half of the skeleton. In the hind half the upper or epidermal surface of the scutes is exposed, showing in most the submedial longitudinal ridge. This is wanting in certain, probably lateral, scutes, of which a group is exposed at the fore part of the anterior portion of the skeleton. One of these unridged, but toothed, scutes is figured at fig. 3, Pl. IV.

Of the limb-bones preserved may be recognised the right scapula (51) and humerus (53), the left humerus (53) with the radius (54) and ulna (55), followed by some dislocated metacarpals and phalanges of the fore-foot.

In the hind portion of the skeleton (fig. 2) the right femur (65), tibia (66), fibula (67), with the four metatarsals and scattered phalanges, are preserved.

All the limb-bones show the ordinal Crocodilian characters, but the proportion of the fore to the hind limb is that of the Procœlian division, not that of the Teleosaurs.[1] In this respect, as in the proportions of the maxillary bones and teeth, the advance to Tertiary types of Crocodilia is manifested. As in these the *Theriosuchus* was better adapted for locomotion on dry land than were the Teleosaurs.

In *Theriosuchus* the breadth and shortness of the antorbital part of the skull in proportion to the part behind exceeds that in any modern broad-snouted Crocodile. Even in the young 'Crocodile à deux arrêtes,' figured in Pl. I of Cuvier's 'Ossemens Fossiles,'[2] a transverse line across the fore part of the orbits equally bisects the skull, omitting the mandible. In *Theriosuchus* the same line leaves in advance six thirteenth parts of the length of the skull.

This proportion suggested at first view the immature state of the individual to which the subject of fig. 3, Pl. III, had belonged; but of the numerous evidences of *Theriosuchus pusillus* none were larger than those figured in Pl. IV, and in figs. 3, 4, 8, 14, 16, of Pl. III: several other fragmentary evidences had come from smaller individuals.

I conclude, therefore, that, as in the case of most species notable for their diminutive size, immature characters of the larger species of the genus are associated with such dwarfishness of the adults. The only known mammals of the Purbeck period characteristic, moreover, like the dwarf Crocodiles, of the fresh-water 'Feather-bed' deposits, are of diminutive size, and the carnivorous Saurians seem to have been thus adapted in dimensions and force to their prey.

I estimate the average length of a mature *Theriosuchus* at 18 inches. The length of the skull, taken as that of the mandible, is 3 inches 6 lines. In the articulated skeleton of a modern Crocodile the angle of the lower jaw extends to the third cervical vertebra.

[1] Compare Tab. XI, 'Monograph on the Fossil Reptilia of the London Clay,' part ii, *Crocodilia* and *Ophidia*, Palæontographical volume, 4to, 1850.

[2] Quarto, tom. v, 2de partie.

In *Alligator lucius* the trunk from the third cervical to the last sacral vertebra inclusive is nearly equal to two lengths of the skull; the length of the tail is $2\frac{1}{3}$ lengths of the skull. The trunk of *Theriosuchus* so defined includes two lengths of the skull. The tail, as indicated by fig. 2, Pl. IV, equalled $2\frac{1}{3}$ lengths of the skull.

In the long-jawed Gavials and Teleosaurs the trunk includes about $1\frac{1}{4}$ length of the skull; but the tail is proportionally longer than in the short- and thick-jawed Crocodiles.

Crocodilian vertebræ. Plate I, figs. 4—12.

Of the numerous scattered vertebræ in the different slabs of the Purbeck matrix those specimens have been selected for figuring which exemplify the Crocodilian characters of different portions of the vertebral column.

The subject of fig. 4, Pl. I, is from the neck or fore part of the trunk, in which the hypapophysis (*hy*) has not subsided on the under surface of the centrum; the processes for the head ('parapophysis,' *p*) and tubercle ('diapophysis,' *d*) of the proximally bifurcate rib are well developed. The pre- (*z*) and post- (*z'*) zygapophyses, together with the neural spine (*n.s.*), complete the series of developments of this complex type of Crocodilian vertebræ.[1]

Figs. 5 and 6 are two consecutive, but slightly dislocated, vertebræ from the hinder part of the trunk. The long and broad diapophyses show the notch (*d*) where the simple and short hinder ribs were articulated, each by a single joint, with the rest of their osseous 'segment' or vertebra.[2]

Figs. 7 and 8 are side views of mutilated hinder trunk vertebræ.

Fig. 9 gives a back view of one of the sacral vertebræ, showing the robust processes represented by coalesced pleurapophyses. The suture is traceable by which the latter articulate with both centrum and neural arch.[3]

Fig. 10 is a caudal vertebra, with the hæmal arch and spine (*h*); a front view of the latter is given in fig. 11; the vertebra is from that part of the tail where the pleurapophyses cease to be developed.[4]

Fig. 12 shows the completely ossified substance in a section of a dorsal centrum.

Fig. 13 probably belonged to *Brachydectes minor.*

All these and other detached vertebræ indicate the dwarfed proportions of the *Crocodilia* characteristic of the fresh-water deposits of the 'Feather-bed.' Many

[1] No. 687, Osteological Catalogue, 1853.

[2] No. 689, op. cit., p. 153.

[3] It accords with the character of the sixth cervical vertebra in *Gavialis gangeticus* ('Catal. of Osteology, Mus. Coll. Chir.,' 4to, vol. i, p. 152, No. 684), save in the minor devolopment of the hypapophysis, which indicates a position in the vertebral column somewhat further back.

[4] See No. 686 of the same series and 'Catalogue,' loc. cit.

correspond in size and shape with those shown *in sitû* in *Theriosuchus*, Pl. IV. The subjects of figures 4—10 I am disposed to refer to *Nannosuchus*.

CROCODILIAN SCUTES. Pl. II, fig. 4, 5, 11, 12.

In almost every slab containing Crocodilian remains are scutes, or portions or impressions of scutes. They include the 'peg-and-groove' type, the hexagonal with sutural margins, and the ordinary quadrate with bevelled edges, either plain or single-ridged. All show the Crocodilian pitted or reticular sculpturing on one side, the smooth surface on the opposite.

The scutes exemplified in Plate II, figs. 4 and 5, partly by portions, partly by impressions, may be referred both by contiguity and proportional size to the larger examples of *Nannosuchus gracilidens*. Some scutes of this type, of rather larger size, and with the smooth, overlapped, anterior border relatively broader and more elevated than in *Goniopholis crassidens*,[1] may belong to the smaller species of *Goniopholis* (*G. tenuidens*) or to the larger kind of *Brachydectes*. A smaller-sized peg-and-groove scute would fit *Brachydectes minor*; the smallest and most numerous of all are commonly associated with evidences of *Theriosuchus pusillus*.

The most instructive scutal fossils are those which exemplify the relative position and mode of interlocking of the articular mechanism. Of these are figured two groups, one showing the outer (ib., fig. 11), the other the inner (ib., fig. 12) surfaces.

These specimens afford grounds for additions to the original description of the peg-and-groove modification of Crocodilian armature.

To the "process continued from *one of the angles* vertically to the long axis of the scute"[2] may be added "from the anterior and external angle;" and for "the depression on the opposite angle of the adjoining scute" may be written "on the under surface of the posterior and external angle of the scute in advance."

When the medial dorsal series of scutes are seen in natural connection from the outer surface the articulating peg is concealed, as in the two hinder pairs of the three shown in fig. 11, Pl. II. When the inner surface of a similar series is exposed, as in fig. 12, the mode of application of the pegs and grooves comes into view.

The scutes of the two medial rows along the back of these Purbeck Crocodiles join each other at the medial line by a close contact of the inner borders—a kind of 'harmonia' or toothless suture. Ventral scutes usually show thicker, more sutural, margins. The dorsal scutes upon the tail lose the peg and groove, are longest in longitudinal diameter, and mostly support a longitudinal submedial ridge on the outer surface; at least in *Theriosuchus pusillus* (Pl. IV, fig. 2).

1 'Supplement,' No. viii; Pal. Vol., 1878, p. 2, Pl. IV, fig. 1.

2 'Report on British Fossil Reptiles,' 1841, p. 70.

Genus—NUTHETES, *Owen.*[1]

Species—*Nuthetes destructor.*

In a former 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones' the above genus and species were founded on portions of jaw and teeth, kindly transmitted to me by Charles Wilcox, Esq., of Swanage, Dorsetshire.

In Mr. Beckles' collection further evidence of *Nuthetes destructor* is afforded by the portions of jaw (Pl. II, figs. 13 and 14) and by numerous detached teeth, ranging in size from a length of enamelled crown of 5 mm. to 20 mm. (fig. 15, *c*), and with variations in the proportion of length to basal breadth (comp. fig. 15, *d*, *e*, with *a*, *b*).

The teeth in the mandibular fragment accord in size and shape with those of the original or type specimen;[2] they are laterally compressed, strongly recurved, and combine a basal fore-and-aft breadth of 3 mm. with the length of 5 mm. (straight). They likewise show the "excavation or longitudinal depression on the side of the base."[3] The coronal enamel does not extend over this depression, but is continued along its margins, and to a greater extent on that next the convex border of the crown than on the opposite side. In the portion of jaw, originally figured, with seven more or less perfect tooth-crowns, two of these indicate a longer and more slender shape than the rest. Several detached teeth of this type have been exposed in portions of the 'Feather-bed Marl' in the Becklesian series. Some of these, exemplifying difference of size, are figured in Plate II, fig. 15.

In all these tooth-crowns the characteristic fore and hind finely denticulate ridges are discernible, as shown in the magnified view (fig. 16); the rest of the enamel is smooth and even, as in the type of *Nuthetes destructor*. Of this species I am disposed to regard the specimens above described as indicative of the range of size according to growth of individuals rather than as exemplifying specific modifications of the genus.

DERMAL BONES ('GRANICONES').

In many portions of the matrix of the 'Feather-bed' are ossicles of a conical shape, the cone showing various degrees of elevation, with a granulate surface, the base being flat and smooth, or faintly and minutely pitted. These 'granicones' I regard as dermal bones.

[1] 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones,' Palæontological Society's volume, issued for 1858, p. 31. 1861.

[2] 'Quarterly Journal of the Geological Society,' 1854, p. 120.

[3] Ib., ib.

In fig. 18, Pl. II, is represented a 'granicone' with a basal breadth of 8 mm., and a length or height of cone of 14 mm. In Fig. 19 the base is oblique, reducing the shortest side of the cone to a height of 8 mm. In this, as in some of the similarly shaped 'granicones,' part of the basal margin is raised or prominent, sometimes formed by a single series of close-set granules, as in Fig. 20. Those on the surface of the cone are less regularly disposed, but at some parts affect a longitudinal arrangement (Fig. 21.) The apex shows various degrees of obtuseness, which finally reduces the granulate or exterior surface of the cone to a moderate convexity, but the conical shape is the rule. The smallest of such 'grani-cones' has a basal breadth of 3 mm., a length of 5 mm.

Slices of these enigmatical fossils prepared for the microscope demonstrated the absence of the structures characteristic of piscine dermal bony cones and spines. Moreover, the geological deposit (a subdivision of the Purbeck series) containing the granicones is a fresh-water one, and their structure was equally distinct from the ganoid dermal defences of the *Sturionidæ* or other fishes habitually frequenting lakes or rivers. The dermal scutes of *Theriosuchus* are notable for the greater number of the canaliculi, and the more regular 'lay,' or disposition, of the 'lacunæ' or bone cells, than in Lacertians; also by the wider 'sinuses' or unossified tracts. In the dimensions, size, shape, and number of the 'canaliculi;' in the minor regularity of the 'lay' of the lacunæ, and in the less proportion in both number and dimensions of the sinuses, the bony tissue of the granicones resembled that in Lacertians; and in this conclusion from microscopical characters,[1] combined with the evidence of the association, and the contiguity of the granicones, with the unquestionable fossil remains of *Nuthetes destructor*, I derive the grounds for referring them to that extinct genus and species.

Among modern Lizards the singular '*Moloch horridus*' of Australia exemplifies dermal scutes most nearly resembling these 'granicones' in shape; but the horny exterior is supported by dense fibrous tissue, not bone. It may be that we have in them a formal exemplification of the dermal armour of *Nuthetes destructor*. If so, the association of a Lizard of such forbidding physiognomy with small Marsupials having their nearest of kin in Australia would be worthy of note.

At the conclusion of my former Monograph on Mesozoic (Wealden and Purbeck) *Crocodilia*, allusion was made to the differences they presented in characters of the bony palate, extent of attachment of mandibular muscles, vertebral articulations, and dermal armature, from the Neozoic *Crocodilia*; differences which suggested the relation of such modifications in the Tertiary and existing Crocodiles and Alligators to freer or more frequent life on dry land, and greater power of grappling with and drowning large terrestrial mammals.

One of these reptiles having seized and submerged a tiger or buffalo, admits the water into its wide, unlabiate mouth, by the spaces to which the thickness of the part of the prey gripped keeps asunder the upper and the lower jaws. Thus, the part of the mouth

[1] See 'Journal of the Royal Microscopical Society,' vol. i, No. 5, p. 233, pls. xii and xiii.

not occupied by the prey is filled with the fluid in which the mammal is being dragged and drowned. "The closure of the exterior nostrils"[1] would not prevent the water entering the 'glottis.' A special arrangement is requisite for this purpose, and such arrangement, as it exists in Neozoic Crocodiles, is incompatible with the relative position of "the posterior nares" and the glottis in the Mesozoic Crocodiles. The question is, with a closure of the external nostrils and the exclusion of water admitted by the mouth into the nasal passage, how is the water to be prevented from getting into the windpipe? We know how this is effected in the Cetaceans; and modern Crocodiles have as efficient a mechanism to the same end though on a different plan, but requiring a size and position of the palatonares which constitutes one of the best marked cranial characters differentiating the Mesozoic and Neozoic *Crocodilia*.

In all the Crocodiles contemporary with "large and active mammals"[2] there is a double valvular structure at the back of the mouth, which prevents the water having access to the mouth, from entering either the hinder nostril or the glottis. A membranous and fleshy fold hangs, like a curtain, from the hind border of the roof of the mouth, and answers to our 'velum palati:' the other valve is peculiarly crocodilian; it is a broad, gristly plate, which rises from the root of the tongue, carrying with it a covering of the lingual integument; and, when the palatal valve is applied to it, they form together a complete partition wall, closing the back of the mouth, between which and "the posterior nares" it is situated, shutting off both the latter aperture and the glottis from the mouth.

To make this mechanism available, the hind nostril is reduced in size, and such reduction is shown in the skull. The palatonaris is also placed far back, and its plane instead of being horizontal is tilted up at the angle which makes the operation of the two parts or folding doors of the partition most effective in closing the oral chamber posteriorly.[3] If the submergence of the Crocodile, with its "large mammalian"[4] prey, should last so long as to render it needful for the reptile to take a fresh breath, it can protrude its prominent snout from the surface of the river, and inhale a current of air which will traverse the long meatus and enter the glottis by the chamber common to nose and windpipe, which is shut off from the mouth by the above-described structures. We have no ground for inferring such from the bony palate in amphicœlian Crocodiles; the difference in its size and position are such as to have deceived both Bronn and De Blainville as to the position and homology of the palatonares in *Teleosaurus*.[5]

The subjects of the present Monograph bear unexpectedly, and in an interesting degree, on another objection, raised during the discussion at the Geological Society of

[1] 'Quart. Journ. of Geol. Soc.,' May, 1878, p. 429.

[2] Loc. cit., p. 425.

[3] 'Proceedings of the Zool. Soc.,' October 25th, 1831, p. 139.

[4] Ib. ib., p. 426.

[5] 'Abhandlungen über die Gavial-artigen Reptilien der Lias-formation,' fol., 1841, pp. 12, 16, 24.

London, on the topics touched upon at the conclusion of the preceding Monograph, and subsequently submitted in greater detail to that body. The objection was, that "warm-blooded animals did actually exist contemporaneously with the Mesosuchian Crocodiles."[1] As the only examples of the Mammalian class of which I was cognisant were the subjects of the undercited Monograph,[2] and a few other species of like diminutive size, it did not seem to me to affect a question exclusively bearing upon "large Mammalian quadrupeds."[3] It seems, however, that the Crocodiles which most abounded, if we may judge from the proportion of their fossil remains in the fresh-water deposits of the 'feather-bed' subdivision of the Purbeck series, were related in size to their contemporary diminutive Mammals. The Spalacotheres, Peralestes, Stylodons, Triconodons, &c., may well have been the prey of the dwarf Crocodiles of the locality. For these were reduced to dimensions which forbade them to disdain such succulent morsels, and at the same time they were suitably armed and limbed for the capture of the little Marsupials.

[1] Hulke, 'Quarterly Journal of the Geological Society,' May, 1878, p. 428.

[2] "On the Fossil Mammalia of the Mesozoic Formations," Palæontographical Soc. Volume for 1870.

[3] 'Quart. Journal,' *ut supra*, pp. 425, 426.

PLATE I.

Genus—Goniopholis.

Fig.

1. Dentary portions of the mandible of *Goniopholis tenuidens*: 1 *a*, outer side of anterior canine; 1 *b*, inner side of anterior canine: *b′*, the same magnified.

Genus—Brachydectes.

2. Side view of left mandibular ramus of *Brachydectes major*.
3. Side view of left mandibular ramus of *Brachydectes minor*.

Order—Crocodilia.

4. Front view of an anterior trunk-vertebra.
5. Upper (neural) view of a posterior trunk-vertebra.
6. Upper (neural) view of a following vertebra.
7. Side view of a trunk-vertebra.
8. Side view of a trunk-vertebra.
9. Back view of a sacral vertebra.
10. Side view of a caudal vertebra.
11. Front view of hæmal arch and spine of do.
12. Longitudinal vertical section of the centrum of a trunk-vertebra.
13. Side view of three dorsal vertebræ of *Brachydectes minor*?

The figures are of the natural size save where otherwise expressed.
From the Middle Purbeck; in the British Museum.

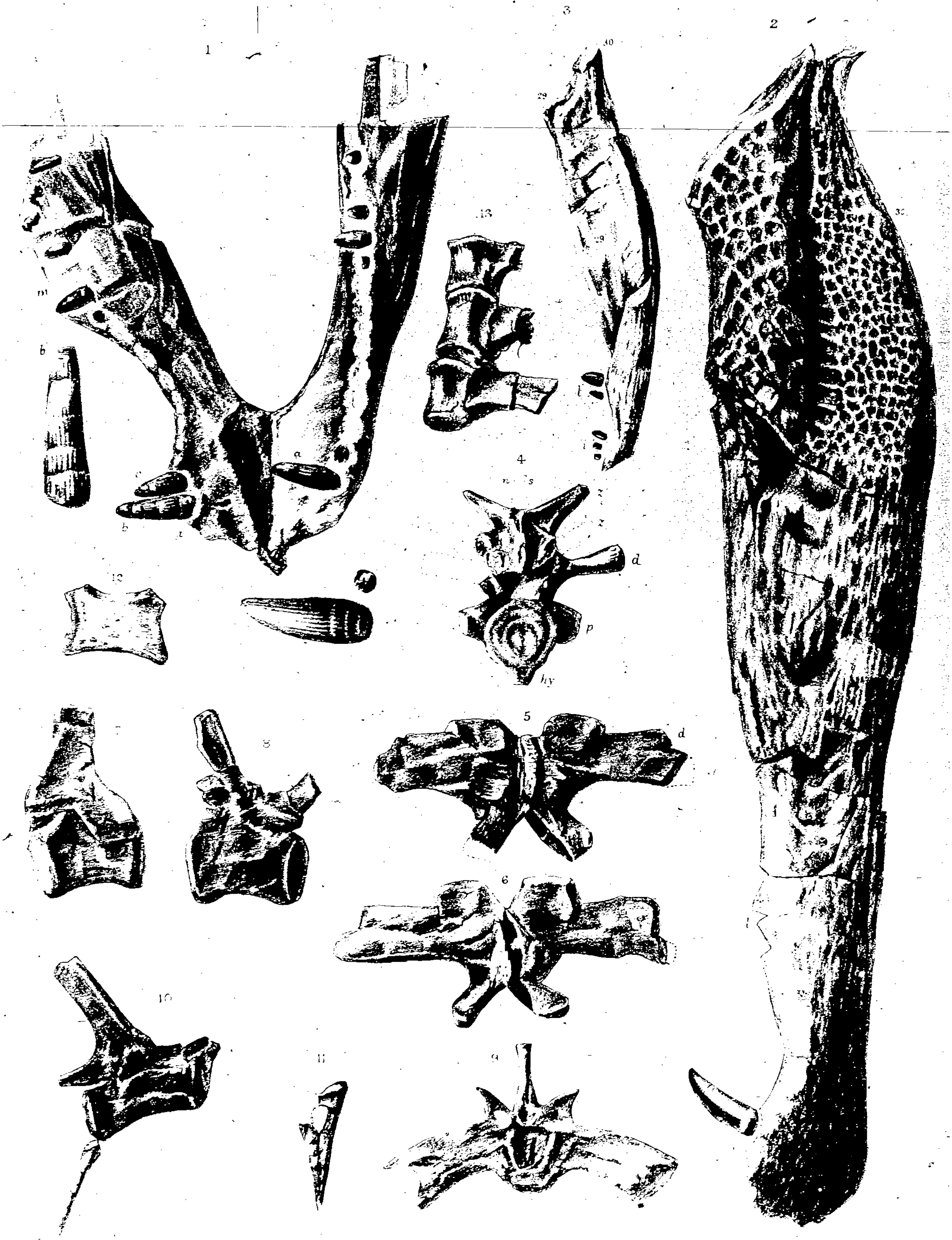

PLATE II.

Genus—NANNOSUCHUS.

FIG.

1. Dentary portions of mandible of *Nannosuchus gracilidens.*
2. Outer side of right anterior canine of do., magn.
3. Oblique view of a trunk-vertebra of do.
4. Portion and impression of a dorsal scute of do.
5. Portion of a larger dorsal scute of do. (the subjects of figs. 3, 4, and 5, are on the same slab as fig. 1).
6. Under view of dentary portions of mandible of *Nannosuchus gracilidens.*
7. Detached anterior canine of probably the same mandible.
8. Outer side view of right ramus of mandible of *Nannosuchus gracilidens* (the ends are drawn too far apart).
9. Portions of dentary elements of mandible of do.
10. Humerus of do.

Incertæ species.

11. Outer view of three pairs of dorsal scutes.
12. Inner view of four pairs of dorsal scutes.

Genus—NUTHETES.

13 and 14. Portions of mandible and teeth of *Nuthetes destructor.*
15. Five detached teeth of do.
16. Side view of crown of a tooth of do., magn.
17—21. Dermal bones or 'granicones,' probably of *Nuthetes.*
22. Section of a granicone, magnified 12 diameters.
23. Ib. ib. magnified 500 diameters.

Genus—THERIOSUCHUS.

24. Anterior caudal vertebra, with articular end in outline.

The figures are of the natural size save where otherwise expressed.
From the Middle Purbeck; in the British Museum.

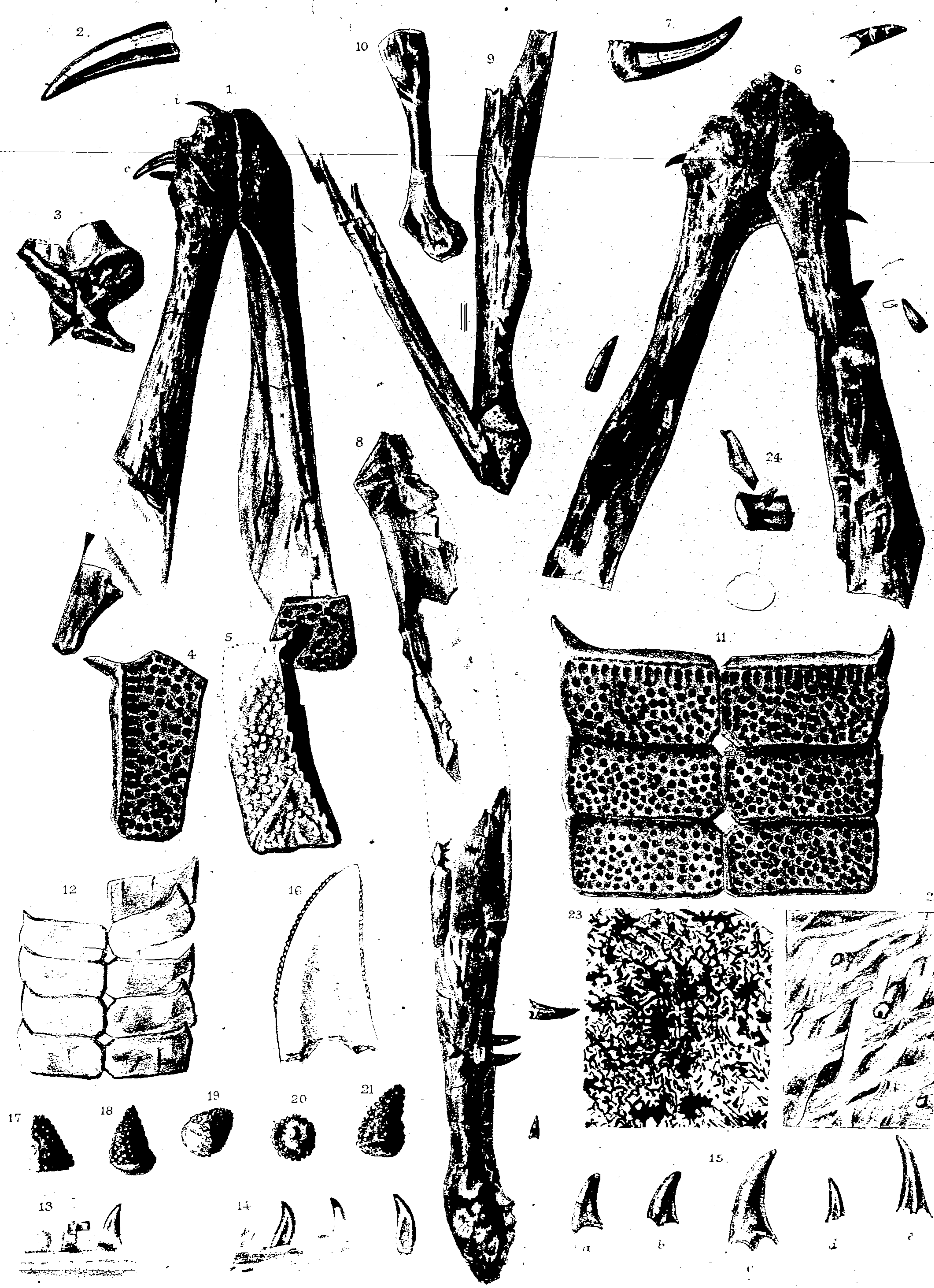
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PLATE III.

Genus—Nannosuchus.

Fig.

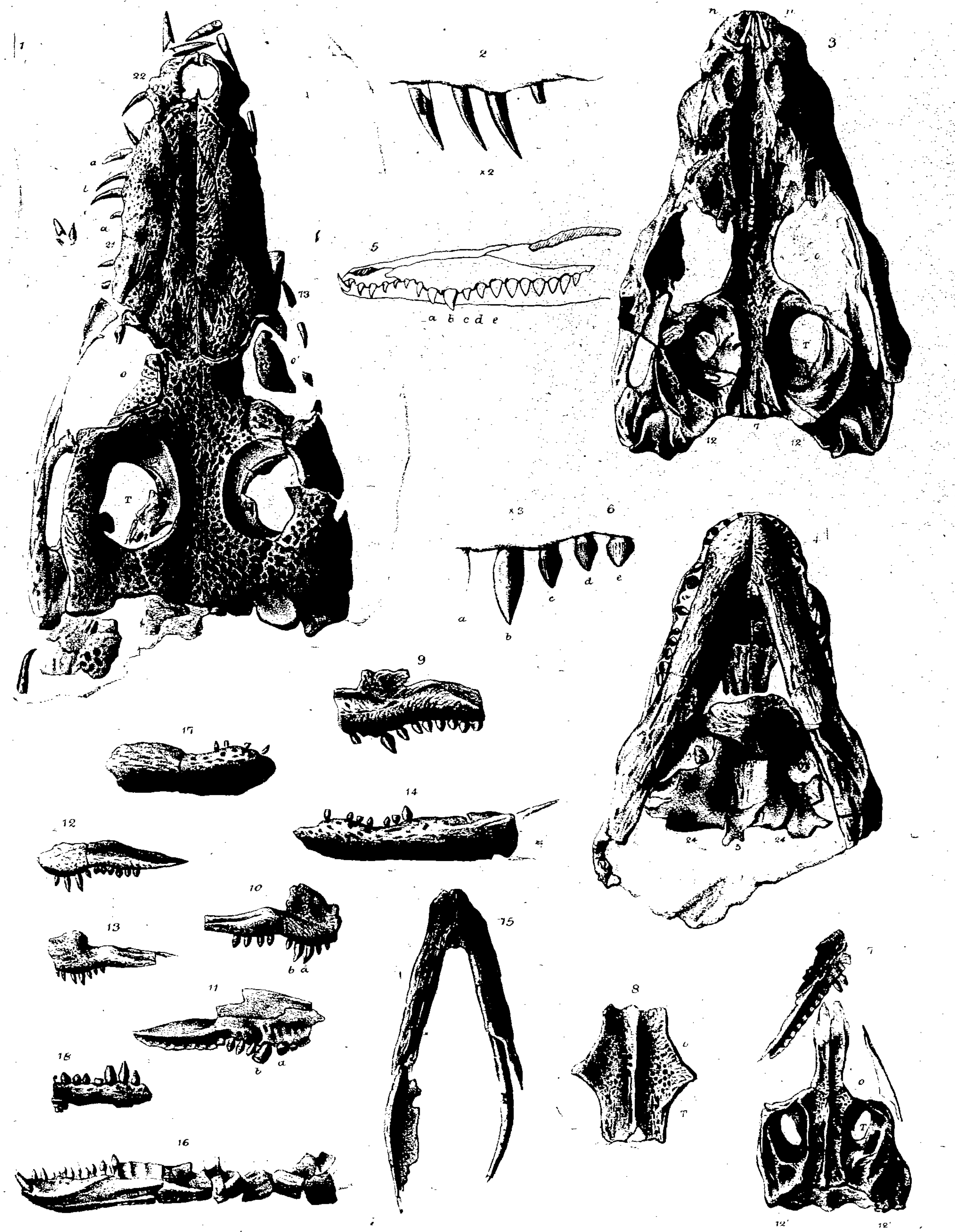
1. Upper view of skull of *Nannosuchus gracilidens.*
2. Crowns of four teeth, *a, b, c, d,* in fig. 1, magnified 2 diameters.

Genus—Theriosuchus.

3. Upper view of skull of *Theriosuchus pusillus.*
4. Under view of the same skull.
5. Side view of facial part of the same skull.
6. Crowns of five teeth, *a, b, c, d, e,* in fig. 5, magnified 3 diameters.
7. Upper view of cranium and inner view of left maxillary, *Theriosuchus pusillus.*
8. Frontal bone, *Theriosuchus pusillus.*
9. Part of left maxillary, ib.
10. Part of right maxillary, ib.
11. Left maxillary, inner side view, ib.
12. Right maxillary, young individual, ib.
13. Right maxillary, young individual, ib.
14. Left dentary, side view, mature individual.
15. Dentary and angular parts of mandible, under view, ib.
16. Dentary and fragments of mandible, inner side view, ib.
17. Fore part of right dentary, side view, ib.

The figures are of the natural size save where otherwise expressed.

From the Middle Purbeck; in the British Museum.



C.L. Griesbach lith. W. West & Co. imp.

1, 2, Nannosuchus; 3-16, Theriosuchus

PLATE IV.

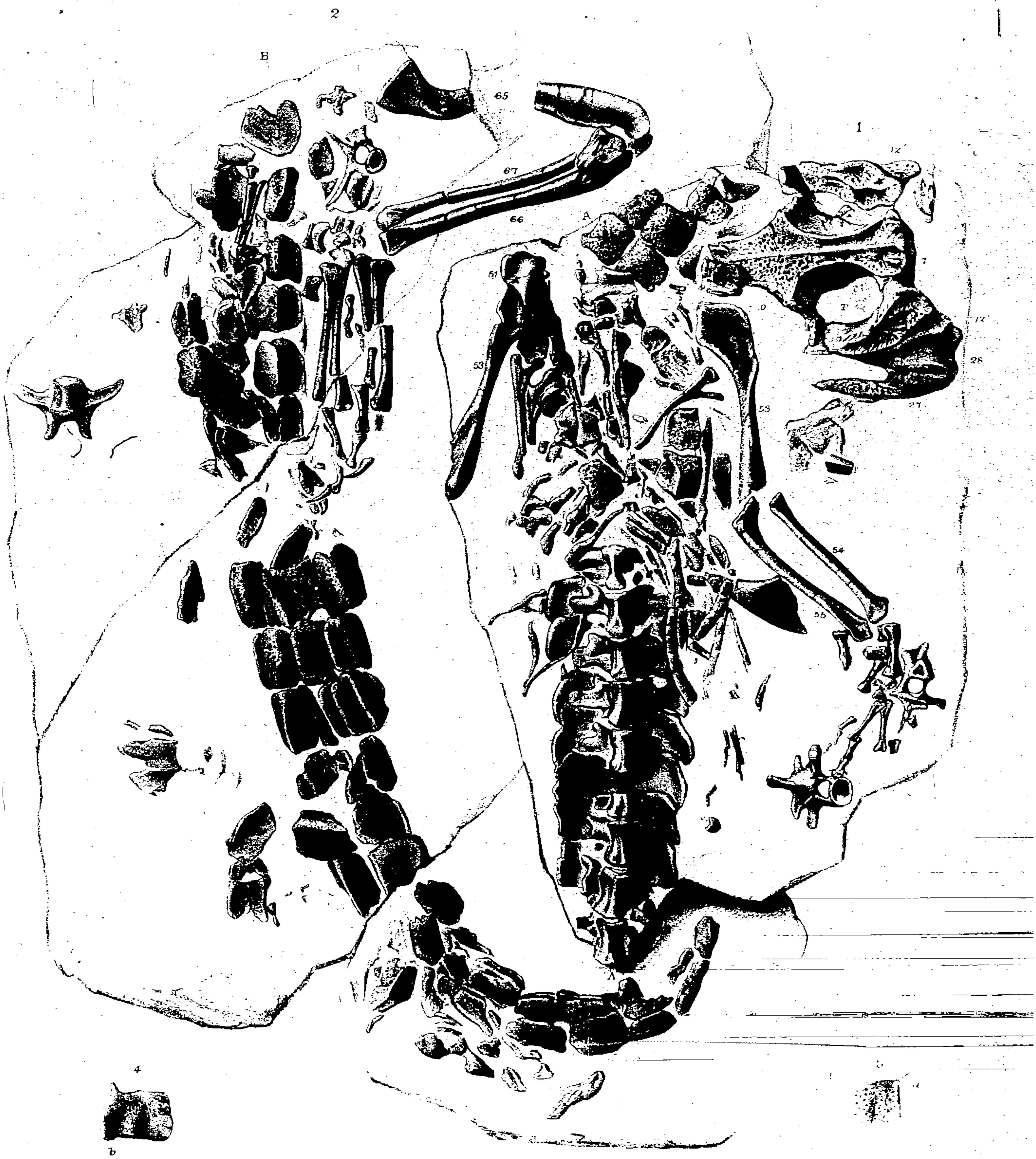
Theriosuchus pusillus.

Fig.

1. Portion of skull, trunk-vertebræ, and bones of fore limbs.
2. Bones of right hind limb and ridged caudal scutes of the same skeleton.
3. An unridged scute with peg, *a*.
4. Under surface of a scute, showing peg and groove, *b*.

All the figures are of the natural size.

From the Middle Purbeck; in the British Museum.



C.L. Griesbach lith.

Theriosuchus