OBSERVATIONS

ON

THE OSTEOLOGY

OF THE

IGUANODON AND HYLÆOSAURUS.

BY

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WITH

NOTES ON THE VERTEBRAL COLUMN OF THE IGUANODON;

BY

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XV. *Additional Observations on the Osteology of the Iguanodon and Hylæosaurus.*

By Gideon Algernon Mantell, *Esq., LL.D., F.R.S., F.L.S., Vice-President of the Geological Society, &c.*

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In the last memoir which I had the honour of placing before the Royal Society, allusion was made to the discovery of some remains of the Iguanodon that tended to elucidate the structure of certain parts of the skeleton of that gigantic terrestrial animal, which from the imperfect data previously obtained, had not been satisfactorily determined.

I now beg to submit to the consideration of the Society the results of a careful examination of these fossils, and of other illustrative specimens in the collections of my friends, in the hope that this addition to the previously recorded knowledge of the osteology of the Wealden Reptiles, will be found to possess considerable physiological interest and importance.

The fragmentary and isolated condition of the osseous relics found imbedded in the fluviatile deposits of the South-East of England, affords a sufficient excuse for error in the interpretation of a piece of bone, or in the reference of an entire bone to a particular genus or species. My own mistakes in this respect I shall unreservedly point out, and I would fain hope that other labourers in the same department of natural history, but of far higher authority, will not hesitate, after the noble example of the illustrious Cuvier, to make similar admissions; for it is only by substituting truth for error, and facts for hypotheses, that correct principles of palæontology can be established.

The fossils in my possession consist of several bones of the extremities and pectoral arch, and of cervical, dorsal, and caudal vertebræ of the Iguanodon, equal if not surpassing in magnitude any previously discovered; and portions of the sacrum of individuals of different ages; together with dermal and other bones of the Hylæosaurus, Goniopholis, &c. The recent acquisition of some of these relics excited in my mind a desire to renew the attempt to construct the skeleton of the colossal reptile whose remains were first brought to light by my early geological researches in Tilgate Forest. I therefore repaired to the British Museum, and by the kind permission of Mr. Konig, re-examined many of the fossils described in my former works. I also availed myself of the liberality of Capt. Lambart Brickenden, Mr. Baber, Mr. Saull, &c., to inspect their several collections, and chisel out and figure or describe such specimens as threw light on the especial object of my present inquiries.

In the difficult and tedious investigations necessary to arrive at any certain conclusions as to the distinctive characters of the vertebræ belonging to different parts of the spine of the same species of fossil reptile—in which there is no clue to guide us through the labyrinth but analogy—I was so fortunate as to obtain the invaluable aid of that profound anatomist and physiologist, Dr. A. G. MELVILLE, without whose co-operation it would have been impossible for me, from the pressure of professional engagements, to have instituted the requisite comparison of the specimens with the corresponding bones of allied recent and fossil species; or to have arrived at the determination of the true place in the vertebral column of certain isolated vertebræ presenting remarkable dissimilarities in their characters, and which had formerly been assigned by myself and others to distinct genera of Saurians.

As the present communication may be regarded as supplementary to my former attempts to illustrate the osteological structure of the Wealden reptiles, I propose, for the convenience of reference, to notice the various subjects under review, in the order adopted in my memoir published in the Philosophical Transactions for 1841.

IGUANODON. *Angular Bone of the Lower Jaw.*—With the gigantic femora, tibiæ, and vertebræ, hereafter described, were found associated numerous fragments of large ribs, vertebral processes, &c., and a portion of a long arched bone of so peculiar a shape as to defy all my attempts to determine its place in the skeleton, till the sagacity of Mr. WATERHOUSE (of the British Museum) recognized its accordance with the angular bone of a reptile; an opinion which a careful comparison of the fossil with recent types has satisfactorily confirmed. The specimen is 10 inches in length, and proves to be the right angular bone of the lower jaw of a large Iguanodon; it exhibits the deep longitudinal channel, and the post-opercular notch, peculiar to that maxillary element in Saurians, but is not sufficiently perfect to afford an instructive delineation; the length of the jaw to which it belonged was probably from 3 to 4 feet.

Vertebral Column.—The structure of the middle dorsal and anterior caudal vertebræ, was first established by the figures and descriptions given in my various geological works, and by the references to these parts of the skeleton in the Maidstone specimen; for although the vertebræ in that celebrated fossil are more or less distorted by compression, their distinctive characters are not obliterated, but may be recognized by due attention.

The elaborate and critical examination of all the Saurian vertebræ from the Wealden collected by myself and others, given in the masterly reports on the British Fossil Reptiles by Professor OWEN, undertaken and published at the expense of the British Association of Science since the appearance of my memoir in the Philosophical Transactions for 1841, has supplied many important diagnostic details of great value to the cultivator of this department of palæontology. But the determination of the cervical, anterior dorsal, lumbar, and terminal caudal, has not hitherto been satisfactorily accomplished. For although in my earlier attempts to interpret the mutilated and generally isolated relics of gigantic Saurian skeletons which were from time to time exhumed in the Wealds of the south-east of England, certain large vertebræ of dissimilar forms were vaguely assigned to the Iguanodon—

more from their constant collocation with undoubted bones of that reptile, and the absence of any remains of the extremities of other species or genera to which they could have belonged, than from any legitimate anatomical deductions—yet almost all these bones have since been referred to distinct genera by Professor OWEN*.

Among the fossils lately obtained from the Isle of Wight, are certain cervical, anterior and middle dorsal, and posterior caudal vertebræ, which so closely approximate in their essential characters to the other elements of the spinal column of the Iguanodon, as to leave but little doubt that they belong to that animal. And although in the absence of any connected portions of the anterior part of the spine absolute certainty cannot be obtained, the close typical affinity of the bones in question supports this view of the subject, rather than that which assigns them to distinct genera of reptiles, of which no other less questionable vestiges have been discovered in the Wealden formation.

I will now briefly state the result of a careful examination and comparison of all the materials to which we could obtain access; the anatomical details, and the description of the essential osteological characters upon which our opinions are based, have been drawn up by Dr. MELVILLE, and his subjoined report will, I doubt not, be regarded by the scientific palæontologist as the most valuable part of this memoir.

Cervical vertebræ, Plate XXVIII. figs. 4, 6.—In my Geology of the South-East of England† (published in 1833), several large convexo-concave vertebræ from Tilgate Forest are described as presenting the true lacertian type, being concave anteriorly, and convex posteriorly, as in the Iguana, Monitor, Crocodile, &c., and this statement is repeated in my memoir of 1841‡. But Professor OWEN, from a more accurate examination of one of these bones (now in the British Museum), in which the posterior oblique processes remain, discovered that the relative position of this vertebra in the skeleton must have been the reverse of that which I had assigned to it; the *convexity being anterior* and the *concavity posterior*. A similar deviation from the ordinary Saurian structure had long since been detected by CUVIER in a fossil crocodilian found at Honfleur, and figured and described in the "*Ossemens Fossiles*" (tome v. p. 155); and which, though referred by GEOFFROY to the genus *Steneosaurus*, has since been named by Von MEYER *Streptospondylus* (reversed spine); a most objectionable name, since the same character prevails in several fossil genera, as well as in many existing Mammalia. The fossil vertebræ from Tilgate Forest, above mentioned, are assigned by Professor OWEN to the genus *Streptospondylus* of Von MEYER, as *S. major*§.

But notwithstanding this decision, and the adoption of Professor OWEN's interpre-

* See Reports on British Fossil Reptiles, vol. for 1841, pp. 88–94. † Page 307.

‡ Philosophical Transactions, p. 141, Pl. IX. fig. 4.

§ British Association Reports, 1841, p. 91. The eminent author appears however to have entertained some doubts whether the appropriation was correct, and the vertebra in question might not belong to his genus "*Cetiosaurus*;" but he dismisses the suspicion with the remark, "that the general constancy of the vertebræ of the same Saurian in their antero-posterior diameter forbids the supposition of a vertebra 6 inches in length in the neck, being associated with one 3 inches in length in the back," p. 96.

tation of these vertebræ in my subsequent geological works*, yet I could not divest myself of the idea that this inference might be erroneous, from the fact that all the convexo-concave vertebræ of the Wealden were cervical; it was indeed this circumstance, and the extreme rarity of this type, which deterred the Rev. W. D. Conybeare and myself, at the very commencement of my exploration of the Wealden, from assigning them to the Iguanodon†.

The inspection of a large anterior dorsal vertebra of the convexo-concave system, recently obtained by me from the Isle of Wight (Plate XXVIII. fig. 5), first suggested to Dr. Melville the idea that this bone, as well as the cervicals above described, belonged to the Iguanodon; and he has spared neither time nor trouble to determine the correctness of this solution of the problem. To him, therefore, alone is due the credit of having first correctly interpreted the characters of this important part of the skeleton, should future discoveries confirm our present view of the subject.

The gradual transition from the anteriorly convex cervical vertebræ with their deep posterior concavity (see Plate XXVIII. fig. 4^a and fig. 4^b), to the plano-concave vertebræ of the posterior dorsal and lumbar regions, appears, at least in the absence of the only certain evidence—a naturally connected spinal column—to warrant the conclusion that all these vertebral elements are referable to the same gigantic herbivorous Saurian‡. If this opinion be correct, the adult Iguanodon must have approached in the structure of its vertebral column, as well as in its maxillary and dental organs and hinder extremities, to that of the Rhinoceros and other large pachyderms; for in them the convexo-concave type characterizes the cervical and anterior dorsal regions of the spine§.

Anterior dorsal vertebra, Plate XXVIII. fig. 5.—In this specimen from Sandown Bay, the convexity is relatively less than in the cervical, and appears to indicate a gradual transition to the flat or but slightly elevated face of the middle dorsal, as shown in the fine vertebra found at Brook Bay with some enormous bones of the extremities of an Iguanodon; see Plate XXIX. fig. 8||.

* Medals of Creation, p. 725. Wonders of Geology, 6th edit. p. 414.

† See Geology of the South-East of England, p. 307.

‡ A reference to Cuvier's Oss. Foss., tome v. p. 156, will show that even in the typical form of the genus *Streptospondylus* the same disappearance of the convexo-concave character in the middle and posterior dorsals, takes place.

§ If the discrepancy in the relative proportions and configuration of the cervical, dorsal, and caudal vertebræ be regarded as presenting objections to this view, let it be remembered that in the spinal column of our domestic Mammalia an equal dissimilarity prevails; for example in the Ox, in which the cervical are convexo-concave, and the convexity gradually disappears in the posterior regions of the spine; and the bodies of the distal caudal, instead of being solid throughout as in the anterior vertebræ, *have a large medullary cavity in the centre*, as in the fossil reptile, called *Poikilopleuron*.

|| In my memoir of 1841, a fragment of a vertebra, which Baron Cuvier supposed to be part of the atlas of an Iguanodon, is described as such; and the cast of the spinal canal in calcareous spar is regarded as that of the medulla oblongata (Philosophical Transactions, Plate IX. fig. 1). This specimen has since been cleared of the sandstone with which it was partially invested, and proves to be the neural arch of a crocodilian cervical vertebra.

Sacral and caudal vertebræ, Plate XXX.—The most important and novel announcement in relation to the osteology of the Wealden reptiles in Professor OWEN's Reports, was the exposition of the structure of the sacrum in the three remarkable extinct genera of his order Dinosauria; namely, the Megalosaurus, Hylæosaurus, and Iguanodon; a peculiarity of mechanism which had escaped the penetration of all previous observers. No one appears to have suspected that in these reptiles the pelvic arch was composed of a greater number of anchylosed vertebræ than in the living Saurians; and that the position of the neural arches was transposed from its usual place over the middle of the body of the vertebra, to the ossified intervertebral spaces formed by the anchylosis of the contiguous vertebræ; the foramina for the transmission of the sacral nerves from the spinal chord being situated above and behind the middle of the body (see Plate XXX. figs. 15, 16)*.

Fragments of the pelvic arch, consisting of the body of one sacral vertebra, with a portion of the contiguous bones anchylosed to each extremity, are not uncommon in the Wealden deposits; and so long since as 1826, Sir R. MURCHISON transmitted to Baron CUVIER a specimen of this kind (from Loxwood in Sussex†), with several lumbar and caudal vertebræ. Upon these relics the illustrious founder of palæontology only remarked, that the united bodies of the vertebræ "seem to indicate that the animal to which they belonged made such feeble use of its tail that the caudal vertebræ were occasionally anchylosed together." Neither did the magnificent specimen of the sacrum of the Megalosaurus, consisting of a series of five united vertebræ, made known by the present DEAN OF WESTMINSTER in 1824, suggest the correct interpretation of this part of the skeleton of the Dinosaurians. The announcement of Professor OWEN was therefore to me of especial interest, since it elucidated the nature of many fossils in my collection which had previously been undeterminable.

The present investigation rendering it necessary to acquire an accurate idea of the characters of the vertebræ composing the pelvic arch of the Iguanodon, I obtained permission of Mr. SAULL to have the fine specimen of a sacrum in his museum (described in Report of Brit. Assoc. p. 131), more completely developed at my own expense, as its true characters were in some measure obscured by the coating of hard calcareous grit with which, as is generally the case with the Isle of Wight Wealden fossils, it was partially invested. This interesting and instructive relic is figured as it now appears in Plate XXVI.; half the natural size in linear dimension.

This sacrum consists of *six* anchylosed vertebræ (not of *five* as described in the Reports on Brit. Foss. Reptiles, p. 130), with the right iliac bone attached. The relative size and proportions of the several bones composing the sacral arch are now well displayed. The body of the first or anterior vertebra (Plate XXVI. 1) is large, strong, and expanded, forming a powerful buttress in front; the bodies of the two posterior vertebræ (Plate XXVI. 5, 6) are likewise large and strong; but the second, third, and fourth, are constricted laterally in the middle (Plate XXVI. 2, 3, 4), and

* See Reports on Brit. Foss. Reptiles, 1842, p. 105.

† Geological Transactions, vol. ii. (New Series), p. 105, Plate XV. figs. 4, 6.

are more slender than either the anterior or posterior; by this modification of the elements of the sacral arch, both lightness and strength were obtained.

A similar construction is present in every specimen of the sacrum that has come under my observation, whether of young and small, or of old and large individuals; in all, the same relative proportions in the size of the vertebræ are present, as in Mr. SAULL's fossil.

A portion of the sacrum of a young Dinosaurian consisting of four vertebræ,—the two posterior and two of the middle series—recently discovered in Tilgate Forest and presented to me by Captain LAMBART BRICKENDEN, is represented of the natural size in Plate XXVII. This fossil beautifully exhibits the forms of the bodies of the vertebræ, and the attachment of the neural arches to the anchylosed intervertebral spaces. The vertebræ differ so much in their proportions and configuration from those in the fossil figured in Plate XXVI., as to render it doubtful whether this specimen may not be a portion of the sacral arch of the Hylæosaurus: this subject will be more fully considered by Dr. MELVILLE in the subjoined report*.

Another highly interesting series of the sacral vertebræ, with four consecutive anterior caudals of the same reptile, found by PETER MARTIN, Esq., at Charlwood in Surrey, are figured in Plate XXX. figs. 15, 16, 17, one-fourth the natural size. The portions of the sacrum consist of the anterior, three middle, and one of the posterior vertebræ, all of which are more or less mutilated (Plate XXX. figs. 15, 16). The implantation of the neural arches in the intervertebral spaces, the coalescence of the expansion above, and the foramina for the transit of the sacral nerves (fig. 15, *z*), are well shown: and the relative size of the last sacral and first caudals is seen in the series of four anterior caudal vertebræ (fig. 17). The absence of a chevron bone at the junction of the two first caudals (fig. 17, *x*), and the presence of this element in the succeeding interspaces (fig. 17, *i*, *i*, *i*), seem to indicate that the first of this series is the second caudal; as the deep concavity of the posterior anchylosed sacral vertebra renders it probable that the anterior face of the first caudal—the bone which unites the tail to the pelvis—was more or less convex; as is the case in the Crocodile, Gavial, &c.†

Pelvis.—Of the pelvic bones, the *Iliac*, of which both the right and left are preserved in the Maidstone specimen, and the right Ilium in the sacrum figured in Plate XXVI., are alone determined. There are portions of large bones in my former

* Among the water-worn masses of bone so abundantly strewn along those parts of the southern shores of the Isle of Wight, which are bounded by cliffs of the Wealden strata, I had often met with specimens in which the body of a very large vertebra is anchylosed to one so disproportionately small, that I could not explain their origin, until Professor OWEN's description of the structure of the sacrum suggested their true nature. These fossils are in fact one of the large vertebræ either of the anterior or posterior end of the sacrum united to one of the slender middle vertebræ. A specimen of this kind in the highly interesting collection of Mr. BABER, is of enormous size; the anterior face of the largest vertebra being 7½ inches by 6½ in diameter. This fossil is also interesting on another account, for on one side of the body of the largest vertebra there is an abnormal enlargement (or exostosis): I have observed similar bony tumours on the sides of the bodies of other vertebræ.

† See Wonders of Geology, sixth edition, p. 419.

collection which unquestionably belong to the pelvic region of some great Saurian, most probably of the Iguanodon, but at present all the elements of this part of the skeleton have not been found in a state sufficiently recognizable to admit of their positive identification.

Caudal vertebræ.—The characters of the anterior caudals are so well known that it is unnecessary to describe them; but on the somewhat angular caudals, originally referred by me to the Iguanodon, and subsequently ascribed to the *Cetiosaurus* by Professor OWEN, and now restored to the former reptile by Dr. MELVILLE, I will offer a few remarks. In the first place, in confirmation of the opinion that these vertebræ belong to the Iguanodon, I would especially call attention to the fact, that with the unquestionable Iguanodon sacrals found at Loxwood, and examined by Baron CUVIER (as previously mentioned, *ante*, p. 275), were several caudals belonging to the same individual, and these possess the angular form, and more or less grooved base, as may be seen by reference to the Geological Transactions, vol. ii. New Series, pl. 15. figs. 1, 3. I can vouch for the accuracy of the figures from having carefully examined the specimens at the time they were being drawn by that able artist, Mr. SCHARF.

I would next call attention to the spine of the Hylæosaurus, which exhibits in the several modifications of its vertebræ, as great a discrepancy in the elements of the dorsal and caudal regions, as our proposed restoration of the spinal column of the Iguanodon. In the highly instructive specimen from the Weald of Sussex, represented on a small scale (one-sixth linear) in Plate XXXII. fig. 22, a nearly uninterrupted chain of vertebræ is preserved, commencing with the first caudals. The marked angular character of the middle and distal vertebræ is most obvious; and the difference between these bones and the anterior caudals, and the corresponding modifications in the form of the chevron bones, are as great as those presented by the vertebræ we have ascribed to the different regions of the spine in the Iguanodon.

If this chain of vertebræ of the Hylæosaurus had not been found in connection with unquestionable bones of that reptile, namely, the dermal scutes and spines, no one could have established their relation; and the tail of this Wealden reptile would have run the risk of being for ever separated from the body to which it originally belonged, and would probably have been honoured with a distinct generic appellation.

The chevron bones in the Hylæosaurus present a remarkable variation in form, as is shown in Plate XXXII. fig. 22. The most anterior (fig. 22 *g*) has a double head for articulation with the body of the vertebra; in the next variety (fig. 22 *f*) the two articulating facets are confluent as in the Iguanodon; in the distal (fig. 22 *e*) the chevron bones are so much elongated in a horizontal direction in a line with the axis of the body, as to be in contact with each other in the centre; this part of the tail must therefore have formed a very strong elastic subcylindrical chain or chord.

Pectoral arch.—I now arrive at the consideration of that part of the skeleton respecting which, happily, no controversy can arise, and that has been established by my own discoveries and investigations. By a reference to my former paper*, it

* Philosophical Transactions, 1841, Plate VIII. fig. 19.

will be seen that the clavicles of the Iguanodon were recognized from two of these bones occurring in the Maidstone specimen; and that a coracoid bone, 10 inches wide, was also ascribed to the same reptile*, from several examples having been found with undoubted bones of the Iguanodon: but the latter reference was only provisional, since there was no connecting link to unite this element to the other parts of the pectoral arch. A scapula, 18 inches long†, for a similar reason was placed in the same category; but with the precautionary remark, "that neither of the specimens was found in natural apposition or connexion with other portions of the skeleton, but only imbedded in the same mass of rock." I have often vainly attempted to find such a correspondence between the articulating facets of the coracoid and scapula above mentioned, as would warrant the conclusion that they originally belonged to the same genus of Saurians. By the fortunate discovery of a perfect scapula (Plate XXX. fig. 10) which fulfils these conditions, and can also be proved to belong to the Iguanodon, both the bones forming the shoulder-joint are now for the first time determined.

This specimen is delineated one-fourth the natural size in Plate XXX. fig. 10; when obtained it was firmly imbedded in the hard Tilgate sandstone, and broken into several pieces: I succeeded in extricating the whole from the rock, and in reuniting the dissevered parts, so as to demonstrate the perfect form of this most interesting fossil. It is the right scapula, and is 13 inches long, $5\frac{1}{4}$ inches wide at the humeral and 4 at the upper or spinal extremity; like that of the Crocodile it is slender, flat, and slightly arched; at the humeral end it becomes thick and expanded to form the apophysial surface that united with the coracoid, and the outer half of the glenoid cavity to receive the head of the humerus; it is flat and very thin at the upper or spinal end. This bone differs essentially from the scapula of the Iguanas, Monitors, &c., and approximates to that of the Crocodiles and Scinks; the minute scapula of the Chameleons presents the same simple character.

Upon placing this scapula in juxtaposition with a coracoid of the form assigned to the Iguanodon‡, it will be manifest that the two bones must have belonged to the same scapular arch; as is shown in Plate XXX. figs. 10 and 11. The close resemblance between this form of pectoral arch and that of the Hylæosaurus will be seen at a glance by reference to the figures of the latter§. The scapula of the Iguanodon differs from that of the Hylæosaurus in having the body more arched and slender, and the neck more contracted; and in the absence of the strong acromial ridge which characterizes the latter. The coracoid (Plate XXX. fig. 11) differs chiefly in its greater external convexity and inner concavity, and in the apophysial scapular surface being separated from the glenoid facet by a deep notch (Plate XXX. fig. 11 *e*) for the passage of vessels, instead of having a simple perforation as in the Hylæosaurus. In both these reptiles, however, there is a closer affinity in the structure of the pectoral arch, than I have observed between other extinct forms.

* Philosophical Transactions, 1841, Plate IX. fig. 11. p. 138.

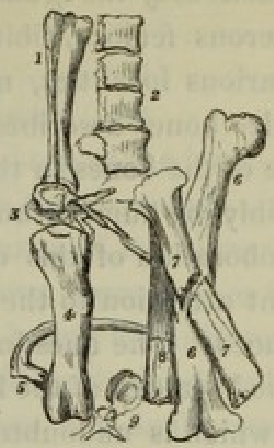
† Ibid. Plate IX. fig. 10.

‡ Ibid. Plate IX. fig. 11.

§ Ibid. Plate X. fig. 8.

While examining the scapula above described, I was reminded of the fractured portions of two long flat bones in the Maidstone specimen which I had often in vain attempted to decipher. One of these bones* lies across the right femur, as shown in the annexed diagram (fig. 1). Upon repairing to the British Museum, the identity of these bones was immediately apparent; they prove to be the right and left scapulæ; consequently the coracoids above mentioned, which are adapted to this form of scapula, also belong to the Iguanodon†.

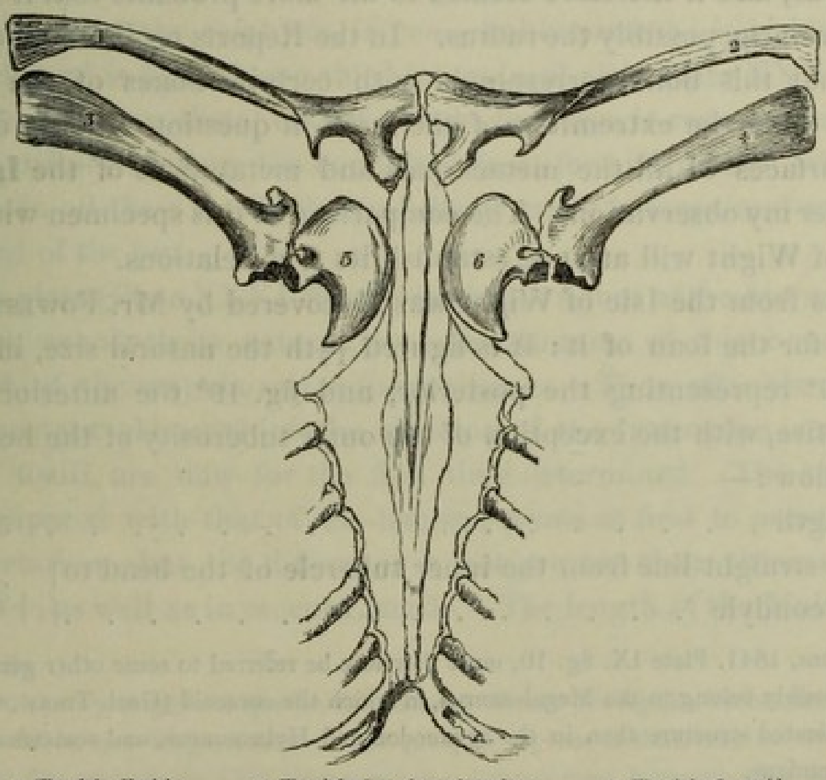
Fig. 1.
Part of the Maidstone Iguanodon.



1. Two metacarpal bones.
2. Four consecutive dorsal vertebræ.
3. A detached dorsal vertebra.
4. *Humerus.*
5. A detached rib.
6. The right femur.
7. *Scapula* lying across the shaft of the femur.
8. Distal end of the corresponding *Scapula.*
9. A detached dorsal vertebra.

As the *clavicles, coracoids,* and *scapulæ,* are now determined, the structure of the pectoral arch of the Iguanodon may be regarded as established; and although the sternum is at present unknown, and the relative position of the several parts can only be conjectured, I have ventured to attempt the restoration of this important part of the skeleton of the extraordinary being on whose osteology I have bestowed so much time and labour. The annexed outline represents the arrangement which appears to me the most natural.

Fig. 2.
Restoration of the Pectoral Arch of the Iguanodon.



1. The right Clavicle.
2. The left Clavicle.
3. The right Scapula or Omoplate.
4. The left Scapula.
5. The right Coracoid.
6. The left Coracoid.

* Figured in Philosophical Transactions, 1841, Plate VIII. fig. 30.

† The Scapula with a long slender process extending from the head of the bone, which is figured in Philo-

Bones of the Extremities.

Humerus of the Iguanodon, Plate XXXI.—It may be worth remarking, that although numerous femora, tibiæ, and other bones of the hinder extremities were discovered in various localities, no certain remains of the fore-legs had occurred except the slender bones described by me as metacarpals*. Professor OWEN† suggested that some of the bones in the British Museum, which I had considered as femora, might possibly be humeri, and the observations of a correspondent are quoted by him in corroboration of this opinion; but I feel confident that no one who will give sufficient attention to the subject, can for a moment admit the validity of the reasons adduced. The question however is now decided by the discovery of a bone found in the Wealden of the Isle of Wight, associated with other remains of the Iguanodon; and which is undoubtedly a humerus, because it cannot possibly be referred to any other part of the skeleton, and possesses all the essential characters of the principal bone of the anterior extremity of a gigantic reptile. Most fortunately, too, it can be proved to belong to the Iguanodon; for it is identical with a well-preserved, but much smaller bone, in the Maidstone specimen (Plate XXXI. fig. 20).

In my memoir of 1841, this last bone is figured‡, with the remark that "it probably belongs to the brachial extremity; it is imbedded near the two metacarpals, but I have not been able to determine its character satisfactorily." The relatively very small size of this bone appeared to be an insuperable objection to the regarding it as the humerus, and it therefore seemed to me more probable that it was one of the bones of the fore-arm, possibly the radius. In the Reports on British Fossil Reptiles §, it is stated that this bone corresponds with certain bones of the foot found at Horsham; but both the extremities of the fossil in question entirely differ from the articulating surfaces of all the metacarpals and metatarsals of the Iguanodon that have come under my observation. The comparison of this specimen with the humerus from the Isle of Wight will at once establish its true relations.

The humerus from the Isle of Wight was discovered by Mr. FOWLSTONE, to whom I am indebted for the loan of it: it is figured $\frac{1}{12}$th the natural size, in Plate XXXI. fig. 19; fig. 19^a representing the posterior, and fig. 19^b the anterior aspect. This fine bone is entire, with the exception of the outer tuberosity of the head; its dimensions are as follow:—

Greatest length	3 feet.
Length in a straight line from the inner tubercle of the head to the inner condyle	$31\frac{1}{2}$ inches.

sophical Transactions, 1841, Plate IX. fig. 10, must therefore be referred to some other genus of the Wealden reptiles; it may possibly belong to the Megalosaurus, in which the coracoid (Geol. Trans., vol. vi. pl. 43, fig. 3) is of a more complicated structure than in the Iguanodon and Hylæosaurus, and somewhat resembles that of the Iguanas or Varanians.

* Philosophical Transactions, 1841, Plate VIII. fig. 14.

† Reports on British Fossil Reptiles, 1841, p. 138.

‡ Philosophical Transactions, Plate VIII. fig. 5.

§ Page 140.

From the outer tubercle of the head to the external condyle	33	inches.
Circumference of the head	23½	
——— round the condyles	21½	
Circumference of the shaft at the deltoid crest	19½	
——— one-third from the distal extremity	16	

The medullary cavity only extends to within one-third of the top of the bone; it is 3 inches in diameter: the greatest thickness of the wall of the shaft is 1 inch.

The head of the bone presents the usual posterior protuberance of the humerus in Lizards, but the epiphysis of this, as well as of the distal extremity, is wanting, as is the case in all the long bones of the Wealden reptiles. At about 3 inches from the top the ridge or crest for the insertion of the deltoid muscle (*d*) is considerably developed, and extends 15 inches down the shaft, which rapidly contracts below, and finally expands to form the condyloid extremity. The articular face of the latter (Plate XXXI. fig. 19^d) is divided into two nearly equal condyles; the inner or ulnar segment (*e*) is traversed by an anterior furrow, which is more strongly marked in the humerus of a younger individual (Plate XXXI. fig. 18^d *e*): the posterior or olecranal fossa (*g*) is simple, and somewhat deeper than the anterior. On the whole, the aspect of this humerus more closely corresponds with that of the Crocodiles than of the ordinary Lizards.

I have for many years possessed the head or proximal extremity and the lower or condyloid end of two humeri, which must have belonged to very young Iguanodons. The former is of a left humerus: it is 8 inches in circumference, and with the exception of the absence of the epiphysis, is remarkably perfect; it is identical with the large specimen, and is figured one-third its natural size, Plate XXXI. fig. 21. The specimen of the lower or distal end of a right humerus is represented, Plate XXXI. fig. 18; it beautifully displays the condyloid facet for articulation with the bones of the fore-arm. In all these fossils the medullary cavity is large, and extends to within about one-third of the top.

In the same plate (Plate XXXI. fig. 20) is given a figure of the humerus in the Maidstone specimen, one-sixth its natural size; the situation of this bone is pointed out in the outline* of the scapula and adjacent bones. Thus after the lapse of fifteen years two important elements of the skeleton of the Iguanodon contained in that most valuable fossil, are now for the first time determined. The small size of the humeri, as compared with that of the femora, seems at first to present an objection to this interpretation; but the difference is not greater than obtains in many other fossil Saurians†, as well as in recent Lizards. The length of the Maidstone humerus

* *Ante*, p. 279, fig. 1.

† "C'est un fait à peu près général que les membres antérieurs des reptiles crocodiliens et lacertiens sont plus courts et plus faibles que les postérieurs; chez quelques espèces la différence est très-prononcée. Mais nos reptiles fossiles des environs de Caen annoncent une disproportion beaucoup plus forte encore entre ces membres: le Pœkilopleuron, le Sténéosaurus de Quilly, les Téléosaurus, en fournissent la preuve. Ces derniers surtout avaient les membres antérieurs d'une excessive petitesse; les deux paires de membres différaient entre elles plus peut-être qu'elles ne diffèrent les Gerbilles et les Kangaroos."—Deslongchamps, *Mémoire sur le Pœkilopleuron Bucklandii*, p. 81.

is about 20 inches, that of the contiguous femur 33 inches; but as the latter is somewhat flattened and extended by compression, the difference is probably not more than one-third. The Isle of Wight humerus is 3 feet long; the largest femur I have seen is 4 feet 8 inches; the average size of the femur in the adult was probably about 4 feet; this bone therefore presents the same proportionate length as the Maidstone humerus.

Hinder extremities.—The femur, tibia, fibula, metatarsals, phalangeals, and ungueals, have long since been discovered and determined*; but the bones of the tarsus as well as of the carpus are still unknown. I should have passed over these parts of the skeleton without remark, but that some of the femora, tibiæ, &c. which I have recently obtained are of such enormous proportions, as to require notice in proof of the colossal size which some individuals must have attained.

In the course of last autumn I procured from the cliffs near Brook Point,—a locality well known to the British geologist from the fossil forest exposed at its base†,—portions of two corresponding femora, tibiæ, and several vertebræ, fragments of ribs, &c. of Iguanodons. The most entire bone is the left femur; it consists of the shaft from above the popliteal space to the root of the outer trochanter‡: the head and condyles are both wanting; the inner trochanter remains: the length of this fossil is 3 feet; circumference of the shaft 27 inches. The greatest thickness of the wall of the shaft is 2 inches; the diameter of the medullary cavity 5 inches by 3; in all the femora which I have examined the medullary canal extends from above the condyles to within one-third of the top of the bone§. Of the right femur, which from its correspondence in size is probably referable to the same individual as the left, two large portions of the shaft were alone obtained. Now if we take as a scale of proportions one of the large femora in the British Museum, the bone above described, if perfect, would give the following admeasurements:—

Total length	4 feet 8 inches.
Circumference of the head exclusive of the outer trochanter . . .	3 — 2
——————— the shaft at the base of the middle trochanter .	2 — 1
——————— the distal end round the condyles	3 — 6

One of the tibiæ found with the above, consists of about two-thirds of the shaft, with the distal or tarsal extremity nearly entire: the following are its dimensions:—

* Philosophical Transactions, 1841, Plate VIII.

† See my "Geological Excursions round the Isle of Wight," p. 277.

‡ Philosophical Transactions, 1841, Plate VIII. fig. 1, for an outline of the perfect form of the femur of the Iguanodon.

§ In this enormous bone the internal structure is beautifully preserved; sections properly prepared exhibit the peculiar form and proportions which Mr. Bowerbank considers to be characteristic of the reptilian type. That eminent microscopic observer has kindly favoured me with his measurements of the bone-cells in portions of this femur. The general average of the proportions of the length and diameter of the cells is as one to eleven and a quarter; the length being $\frac{1}{600}$ and the diameter $\frac{1}{6750}$th of an inch.

Length along the middle of the shaft	27	inches.
Length to the distal inner process	32	
Circumference of the distal or tarsal end	25	
———————— middle of the shaft	18	
———————— upper part	20½	

Probable length of this tibia when entire, 4 feet.

A fragment of the shaft of a tibia found with the above, is 23 inches in circumference. The distal end of another tibia, from Sandown Bay, is 27 inches in circumference. As a contrast to these gigantic remains, I may state, that bones of the extremity occasionally occur so small, yet so compact, as to suggest the probability that they may belong to distinct species; but at present I have not been able to detect other characters which would warrant such an inference. A left femur in my possession, from Rusper in Sussex, is 14½ inches long; circumference of the shaft 6 inches; this therefore is but one-fourth the size of the specimen from Brook. The lower portion of a thigh-bone, which in the characters of its condyloid extremity entirely agrees with all the recognized femora of the Iguanodon, is but 3¼ inches in circumference round the condyles, and but 2¼ round the shaft immediately above them; the total length of this femur, when entire, could not have exceeded 4½ inches.

In general the circumference of the shaft of the thigh-bone immediately below the base of the inner trochanter, is nearly equal to half the length of the entire bone; for example, the large right femur from Sussex in the British Museum, which is 3 feet 8 inches long, is 21 inches round the shaft. But there are exceptions to these proportions; thus the femur from Brook Point, presented by me to the Hunterian Museum of the Royal College of Surgeons, is relatively shorter, for it is only 3½ feet long, while the circumference of the shaft is 24 inches. The thigh-bone of the Maidstone fossil is of more slender proportions. The tibia is about one-tenth shorter than the corresponding femur; and the fibula somewhat shorter than the tibia. With the view of affording a general idea of the dimensions of the known parts of the skeleton of the Iguanodon, to which the largest femur in my possession belonged, the following list, calculated from the average size of numerous specimens, is subjoined: the length of the corresponding bones in the Maidstone fossil is added for comparison.

	Iguanodon from the Isle of Wight.	Maidstone Iguanodon.
Femur, length of	4 feet 8 inches.	2 feet 9 inches.
Tibia	4 — 1	2 — 6
Fibula	3 — 8	
Humerus	3 — 2	1 — 8
Clavicle	4 —	2 — 4
Scapula	3 — 4	2 — 1
Metacarpals	2 — 2	1 — 2
Ilium	3 — 10	2 — 4
Metatarsals	1 — 11	1 — 2
Ungueal bones	5¾	3½

Dermal bones, Plate XXXII.—Several dermal bones have been discovered since my last communication on this subject, some of which are clearly referable to the Hylæosaurus, while others may with great probability be assigned to the Iguanodon, from their obvious difference from those found associated with the bones of the former reptile. Some dermal spines or tubercles resembling that which I figured and described as the horn of the Iguanodon in my "Fossils of Tilgate Forest," have been found at Hastings, and in the Isle of Wight. One remarkably fine example of a conical dermal tubercle or horn, in which the core or base is ossified, was obtained from the Wealden at Ridgway near Weymouth, by Mr. Shipp of Blandford, and several bones of the Iguanodon were found in the same locality; it is figured in Plate XXXII. fig. 24. Several somewhat angular bones, of coarse texture, 5 or 6 inches long, which resemble in form the spinous warts seen in the *Amblyrhynchus* and other Iguanidæ, have likewise been obtained from Sandown Bay. In the absence of proofs derived from direct connection or contiguity with known parts of the skeleton, it is useless to attempt appropriating these dermal appendages to particular Saurians. But in the case of the Hylæosaurus the dermal bones peculiar to that animal are easily recognizable; for not only have I found them in the typical specimen of this reptile discovered in 1832*, but likewise in the beautiful series of vertebræ already referred to†, Plate XXXII. fig. 22; in which the discoidal and oval scutes are situated on each side the spinous processes of the vertebræ.

The same fossil contains, at the anterior part, portions of large angular spines resembling those described in my former memoir‡. As the correctness of my opinion that the large flat spines in the first-discovered specimen of the Hylæosaurus were dermal, and extended down the back as a dorsal fringe, has been questioned by Professor Owen§, I beg to state, that since my former communication I have submitted sections of one of these spines to microscopical examination, and if identity of internal structure be of any value, my interpretation is substantiated; for the same remarkable organization is present as in the admitted dermal scutes, namely, "straight spicular fibres decussating each other in all directions, and seeming to represent the ossified ligamentous fibres of the original corium‖."

Summary.—The facts described in this communication will, I trust, be regarded as a valuable addition to our knowledge of the osteological structure of one of the most remarkable herbivorous terrestrial quadrupeds that ever trod the surface of our planet. With the exception of the cranium, sternum, and the bones of the fore-arm, carpus, and tarsus, the entire skeleton may now be considered as determined. In the present memoir the pectoral arch and the arm are for the first time described

* Geology of the South-East of England, Pl. V.

† *Ante*, p. 277.

‡ Philosophical Transactions, 1841, p. 150, Plate X. figs. 1, 2, 3, 4.

§ See Reports on British Fossil Reptiles, 1841, p. 115.

‖ See Wonders of Geology, sixth edition, p. 438. Mr. Bowerbank, Mr. Williamson, and other eminent microscopical observers, to whom I gave specimens of the spines, concur in the statement that the structure of these bones is identical with that of the dermal scutes, Plate XXXII. fig. 23.

and correctly assigned, and the true characters of the vertebral column demonstrated, so far as the data hitherto obtained afford the means of re-connecting its disjointed elements.

The physiological inferences resulting from this investigation confirm, in every essential particular, those which I had the honour to submit to the Society in my late memoir on the maxillary and dental organs of the Iguanodon. By the determination of the principal bone of the arm, we now discover that the fore-limbs of the colossal original were more reptilian in their relative proportions with other parts of the skeleton, than could *à priori* have been surmised. But this comparatively feeble development of the anterior extremities tends to confirm the opinion which I formerly advanced, that the fore-feet were long and slender, and served as prehensile instruments; while the hinder limbs and feet were strong and massive, as in the Hippopotamus.

Thus, after the lapse of more than a quarter of a century, I conclude my attempts to restore the skeleton of the gigantic Saurian, of whose former existence a few isolated and water-worn teeth were the sole known indications, when, in 1825, I ventured to communicate to the Royal Society, through my friend the late Davies Gilbert, Esq., P.R.S., "A Notice of the Teeth of an unknown Herbivorous Reptile discovered in the Strata of Tilgate Forest in Sussex."

19 *Chester Square, Pimlico,*
15*th January*, 1849.

Notes on the Vertebral Column of the Iguanodon.

By A. G. Melville, *M.D., Edin. M.R.C.S.*

The atlas and axis of this gigantic reptile have not hitherto been discovered, but we may expect, as in the corresponding vertebræ referred to the *Steneosaurus rostrominor* (G. St. Hilaire), the pleural complement of the axis to have a double attachment, above to the superior transverse process derived from the base of the neural lamina, and below to an exogenous tubercle—inferior transverse process—on the lower part of the centrum of the atlas, or in addition, to the contiguous portion of the axis. In the recent Crocodiles, the cervical rib of the axis is displaced from its own centrum, and has an upper and lower attachment to the odontoid process or true centrum of the atlas. It will be a matter of great interest to ascertain if in any of the extinct Crocodilidæ or Dinosauria, the rib-like processes of the atlas are attached to their proper centrum, and not displaced forwards on the hæmal element of the occipital vertebra, or so-called body of the atlas, as in the existing Crocodiles; a displacement which repeats the normal attachment of the ribs in fishes to the inferior or hæmal elements of the bodies of the vertebræ.

The posterior surface of the body of the axis must be deeply concave, as we shall presently see.

The large cervical vertebræ from the Wealden strata, with reversed convexo-concave joints (*Streptospondylus major*, O.), (Plate XXVIII. fig. 4), enter into the composition of the cervical region of the spinal column of the Iguanodon. We are forced to this conclusion by the following circumstances:—1st, an anterior dorsal vertebra (Plate XXVIII. fig. 5.) from the same deposits, with similar but less marked deviations in the form of the articular facets, and with a configuration of the neural arch, so far as perfect, identical with that existing in more posterior dorsal vertebræ with plano-concave joints, well-recognized as belonging to this great herbivorous reptile, links together these apparently discrepant vertebral types: 2ndly, the amount of variation here assumed is parallel to that which exists in its affine among the Crocodilidæ, the *Steneosaurus rostro-minor** ; and similar changes in the form of corresponding articular facets occur in the spinal column of the Ruminants, Solipeds, and other Pachyderms: 3rdly, other alterations in the sculpturing of the neural arch of equal value with the modifications in the form of the articular aspects of the body, are concomitant with these changes in the different vertebræ just mentioned, and are equalled in kind and degree by those which occur in the series of neural arches of the spine in the recent Crocodiles: 4thly, these convexo-concave cervical vertebræ are found in such collocation with other well-determined bones and vertebræ of the Iguanodon as to leave no reasonable doubt of their belonging to that animal: 5thly, the number of these vertebræ of different ages and sizes in our collections is such as we might have expected on that supposition; and 6thly, if these be not the cervical vertebræ of the Iguanodon, we have the (assumed) *Streptospondylus major* with nothing but a neck, whilst the Iguanodon, as yet known, is wholly destitute of that region of the spine: is it not, therefore, more probable that the neck of the so-called Streptospondylus belongs of right to the Iguanodon, especially as the bones of that reptile, tested by the fortunate discovery of the Maidstone specimen, constitute the great majority of the osseous relics from the deposits of the Weald? in other words, the Iguanodon is the reptile *par excellence* characteristic of the Wealden formation.

The Streptospondylian form of the body of a vertebra can no more characterize a genus of Reptiles than the Amphicœlian or Cœlospondylian modifications; each is common to a group of species constituting not only distinct genera and families, but also orders and subclasses. Nay, the Streptospondylian type is not even persistent throughout the elements of the same spinal column; it disappears towards the middle of the dorsal region in the *Steneosaurus rostro-minor*, the best known example of this structure, and that in which it was first recognized by Baron Cuvier. The genus *Streptospondylus* of V. Meyer ought therefore to be abolished, and the residual generic appellation *Steneosaurus* (G. St. Hilaire) be retained to designate Cu-

* Vide Cuvier, Oss. Fossiles, vol. ix. 8vo edit.

VIER's first Gavial of Honfleur. The Amphicœlian and Procœlian forms are generally continued through the whole length of the vertebral column; the Streptospondylian modification in the last sacral replaces, and in the first caudal is superadded to, the Procœlian form of the vertebral bodies characteristic of the living Crocodiles.

In the Report on British Reptiles much stress is laid on the uniformity in length of the bodies of the same vertebral series in Reptiles; this indeed holds good within certain limits among the less complicated smaller existing Lacertæ, but will lead us into error if rigidly applied to the more highly organized extinct Saurians and Crocodiles. The relative length of the vertebra must always be taken exclusively of the articular convexity, whether that be in front or behind, as is the practice in stating the absolute length of the spine or of its individual regions. Deterred by the great length of these cervical vertebræ referred to the *Streptospondylus major*, when compared with the shortness of the dorsal or lumbar vertebræ assigned by him to the *Cetiosaurus brevis*, Professor OWEN was unwilling to associate them together as belonging to the spinal column of the same species, which, however, appears to be really the case, as I shall afterwards have occasion to demonstrate.

The body of the cervical vertebra, Plate XXVIII. fig. 4, though somewhat crushed, well displays the peculiar characters of this region of the spine. Its dimensions are as follow:—

	inches.
Length of body between the centres of the articular facets . . .	$3\frac{3}{4}$
Extreme length, including convexity	$5\frac{1}{2}$
Length of body (inferiorly), exclusive of convexity	$3\frac{1}{2}$
Height of body posteriorly	$3\frac{1}{2}$
Width of posterior concave surface	5
Extent from the extremity of one transverse process to the other .	9
Transverse diameter of the spinal canal	$1\frac{3}{4}$

The centrum (a) is depressed, and yields a subpentangular section with the apex below; it is broader than high, but the width is nearly equal to the length. The anterior articular facet (a') is convex, the posterior (a'') deeply concave with thin edges; both have a wide oval contour. The lateral aspect presents a deep concavity beneath the root of the neural lamina, bounded inferiorly by a ridge (e) faint and expanding behind, but developed in its anterior third or half into a flat oblong facet (*parapophysis*), for articulation with the head of the rib. Below the transverse ridges the surfaces of the opposite sides, concave outwards, rapidly converge to a broad median carina widening behind, which does not appear to be developed downwards in front into a distinct spine as in Crocodiles. How much of the body is contributed by the expanded bases of the neural laminæ cannot be readily determined, the sutures being obliterated; from the great width of the vertebral foramen in the neck, it is most probable that they do not meet mesially, and exclude the centrum from entering into the composition of that foramen, as is the case in the dorsal region of the spine.

The neural lamina (*b*) contracts above its base, and again slightly expands ere it coalesces with its fellow, the posterior notch as usually being the deepest; a small tract of the body is also, as it were, left uncovered in front and behind to nearly as great an extent as in the lumbar vertebræ hitherto assigned to the *Cetiosaurus brevis*; this character therefore is of no value either generically or specifically. The spine (*neuracantha*) is represented only by a ridge contracting and subsiding towards the anterior edge of the neural arch. The strong sub-prismatic upper transverse process (*d*) (*plagiapophysis*) springs from the upper part of the neural lamina (*neuropoma*), and curves backwards, bending slightly downwards towards its outer extremity, which furnishes a large articular rounded surface for the tubercle of the rib. Internally it is cut away obliquely downwards and inwards for the lodgement of the posterior oblique process (*met-arthrapophysis*) which lies between it and the crown of the neural arch, resting on the oval articular facet (*f*) of the anterior oblique processes (*pro-arthrapophysis*), which is thus situated on the upper surface of the transverse process; those of opposite sides are widely separate, look towards each other, and are only inclined slightly towards the horizon, their inner margins being separated by a narrow groove from the sides of the neural laminæ.

The long, thick and compressed peduncles of the posterior oblique processes (*g*), spring from the hinder border of the neural arch on each side of the mesial line, and diverge as they pass backwards, projecting much beyond the articular cup of the body. Their section is ovate, the lower edge being the thickest; each is slightly twisted on its axis towards the extremity, which is bevelled off obliquely to the upper margin for the oval articular surface, looking downwards and slightly outwards.

We may conjecture that this vertebra is one of the most posterior cervical from the high origin of the transverse process, for in the series of five vertebræ behind the atlas and axis in the Crocodile, this process rises gradually from the base of the neuropome to the middle of its height, and reaches the crown of the neural arch at the third dorsal.

The large vertebra with a wedge-shaped body and convexo-concave articular facets, Plate XXVIII. fig. 5, we regard as one of the more anterior of the dorsal region of the spine; in it the inferior transverse process has abandoned the side of the centrum, and is placed on that of the neural lamina. In the first dorsal of the Crocodile, the perapophysis is still below the neuropomal suture; in the third and fourth, the corresponding surface is subdivided by that sutural line; and in the fifth it quits the centrum altogether, but is not placed on the side of the neural arch. No specimen has yet been met with of a dorsal vertebra belonging to the Iguanodon with the perapophysial surface or tubercle wholly or partially on the centrum, although that character may have been presented by the two or three first dorsal.

The anterior convexity (a') of the above-mentioned vertebra is much less developed than in the cervical, and the concavity behind (a'') is correspondingly shallow. The section of the body would present a deep triangular outline with the apex below corresponding to a thick median crest. The body is constricted in the centre so that the sides are concave parallel to its axis, but convex vertically, owing to the great prominence of a broad longitudinal ridge, equivalent to that bearing the perapophysial surface in the cervical; above and below which there is also a deep concavity. The spinal canal (*j*) has a transversely oval outline, and enlarges considerably towards each extremity. The neural lamina (*b*) contracts suddenly, though slightly, and chiefly from behind forwards above its expanded base, so that the posterior notch is much the deeper; its external surface is impressed by a deep and rough irregular fossa (*l*) for the insertion of the head of the rib, bounded behind by a sharp prominent ridge ascending obliquely forwards from near the posterior and inferior angle of the base of the neuropome, and passing outwards on the under surface of the plagiapophysis (*d*). In front, this perapophysial surface (*l*) is defined by a thin margin arching backwards to meet the above-mentioned buttress-like ridge at the root of the transverse process, which is detached, but springs with an inclination upwards from the side of the spinal platform. The spinous, anterior, and posterior oblique processes, are unfortunately wanting; but the anterior oblique processes do not approximate to each other so closely as in the more posterior vertebræ, in which they are merely separated by the trenchant anterior edge of the spine; from this we may infer that the long peduncles of the met-arthropophyses in the cervical vertebræ have coalesced at their bases to support the more strongly developed spine, but that their apices bearing the articular facets are still separated by a wide notch, more or less filled up by the base of the neuracantha (*c*), which decreases in width as it extends forwards to the anterior edge of the neural arch; its line of attachment sweeping downwards at the same time from the excavation of the spinal platform in front for the reception of the oblique processes of the preceding vertebra. The expanded bases of the neural laminæ are defined by the direction of the superficial striæ, and doubtless coalesce more or less completely in the mesial line, commencing in front, to exclude the centrum from any share in the formation of the vertebral canal. The dimensions of this most instructive specimen are subjoined.

	inches.	lines.
Length of the body between the centres of the articular surfaces .	4	3
Greatest width of body	4	3
Greatest height of body	6	6
Antero-posterior diameter of neural lamina where narrowest . .	2	9
Width of spinal canal	1	9
Height of spinal canal	1	4

The next vertebra to be described, Plate XXIX. fig. 8, differs from that just mentioned, in the flatness of the anterior articular surface (a'), and in the almost complete obliteration of the posterior concavity (a''), in the less central constriction of the body, and in the absence of its inferior median ridge. Notwithstanding the situation of the perapophysial surface on the side of the neuropome, the above characters all point to a more posterior position in the dorsal series; and we may suppose either that the anterior convexity of the body subsided much more rapidly than the head of the ribs changed its point of attachment, or that several vertebræ presenting a similar configuration of the neural arch, but with a progressively diminishing convexity, occurred at the anterior part of the dorsal region, which would indicate a less rapid transition between the different forms of the vertebræ, and consequently a greater number of them than in the Crocodiles, which might indeed have been expected in a herbivore with a bulky trunk, as shown by the huge ribs in the Mantellian collection.

The dimensions of this very perfect and interesting fossil are as follow:—

	inches.	lines.
Extreme length of the body	4	$3\frac{1}{2}$
Extreme width of the body	3	3
Extreme height of body (measured on anterior surface)	4	10
Antero-posterior diameter of neural lamina where narrowest	2	9
From mesial line anteriorly to extremity of transverse process	8	
Antero-posterior diameter of transverse process at root	2	9
Between extreme points of anterior oblique processes	3	4
Width of spinal canal (posteriorly)	1	2

The body is much contracted in the centre, so that the sides are deeply concave lengthwise, but convex vertically; they converge towards each other below, thus a vertical section presents a wedge-shaped outline with convex sides. The neuropomal sutures are obliterated, but the share contributed to the body by the expanded bases of the neural laminæ is equal to that indicated by the detached neural arch in Mr. Saull's collection. The neural lamina (*l*) is coextensive with the supporting centrum, but it contracts slightly as it ascends, and so that the posterior notch is still the deepest. The spinal platform is also excavated in front for the reception of the posterior oblique processes; the base of the spine (*c*) increases in thickness as it passes backwards and rises on the thick hinder portion of the platform. The anterior articular facets (*f*) are oval, look towards each other, and their inferior margins meet nearly at right angles, separated only by a slight notch, and further back by the thin anterior edge of the spine. The strong trihedral transverse processes pass outwards and upwards with an inclination backwards from the sides of the spinal platform, and are as it were twisted on their axes, so that the upper surface slopes forwards and downwards internally, but backwards and downwards externally; both edges are thin; below it is supported by a more strongly developed diagonal buttress-like ridge, passing outwards beneath, and gradually subsiding into the transverse process, giving it an increased thickness. This ridge separates two fossæ on the free aspect of the neuropome; the anterior is more or less obliterated by a rough excrescence, which articulates with the head of the rib (*l*); the posterior is remarkably deep, partly roofed over by the base of the plagiapophysis, and separated from that of the opposite side by the pinched up lower edge of the coalesced peduncles of the met-arthrapophyses, which are unfortunately detached. The spinal canal is nearly circular, and expands slightly in front, where it assumes a transversely oval outline.

In a corresponding anterior dorsal vertebra, No. 2160 of the Mantellian Collection, Plate XXVIII. fig. 7, belonging to a younger and smaller individual, the posterior articular processes are present (*g*), and the perapophysial surface (*l*) is well-defined, but has in the Report on British Reptiles been regarded as the base of the transverse process, whilst the true origin (*d*) of that process is stated to be 'the rough external free border' of the spinal platform, 'probably fractured.' A comparison of figs. 7 and 8 will remove any doubt as to the accuracy of the interpretation here adopted. The wedge-shaped form of the centrum in the above-mentioned vertebræ cannot be regarded of higher value than as indicating their anterior position in the dorsal series; in the Crocodile, the compression of the centrum and the development of an inferior carina ceases in the fifth dorsal, in which also the head of the rib is attached to a facet on the transverse process a little external to its base, while the tubercle is fixed to its extremity, as is the case in the vertebra, Plate XXIX. fig. 9; which from its close resemblance to those just described we have ventured to assign to the Iguanodon, notwithstanding those slight modifications which have induced Professor Owen to regard similar ones as belonging to the genus Cetiosaurus, but which we believe to be simply indicative of position in the same vertebral column, as we have wholly failed in detecting any such differential characters, after repeated examination, as would warrant us in considering this vertebra as specifically, and still less generically, distinct.

This vertebra (Plate XXIX. fig. 9) differs from those above described in the relative shortness and in the cylindrical form of the body, which is much constricted in the centre, so that the surfaces are deeply concave parallel to the axis, but convex in the opposite direction. Its length is 3 inches 6 lines; the width of its anterior subcircular articular facet is 6 inches 1 line, inclusive of the thick rough everted edge, and its height 5 inches 4 lines. The posterior surface is transversely oval; both surfaces are somewhat concave, but the hinder more distinctly so, especially in its upper half, whilst the corresponding part of the anterior aspect is raised into a faint mesial convexity; the adjacent surfaces of contiguous vertebræ are thus coadapted. The spinal canal is 1 inch 1 line transversely where narrowest, but enlarges anteriorly. The neuropomal sutures are obliterated, but the direction of the superficial striæ or rugosities indicate the great expansion of the bases of the neural laminæ, which leave only a narrow tract widening behind the centrum to form the floor of the spinal canal. The neuropome rises from its base nearer the anterior than the posterior surface, and thus the intervertebral foramen is chiefly constituted by the posterior notch. Where most contracted the neural lamina measures 2 inches 6 lines in antero-posterior extent, at its base it is 2 inches 10 lines; seven lines of the body are left exposed behind, and about three in front. But who will venture to base generic distinctions on such trivial characters as these? The enormous spine rises from nearly the whole length of the platform, which presents a median notch in front, separating the projecting anterior oblique processes, whose oval facets are almost horizontal, being inclined to each other only at a very obtuse angle. The strong transverse processes project outwards, with a slight inclination upwards from its lateral edges, their upper surfaces sweeping gently upwards to the lateral aspects of the spine. The antero-inferior edge of the plagiapophysis is thick, and about 2 inches external to its base bears the rough facet for the head of the rib (*l*), beyond which this process contracts suddenly in antero-posterior extent to lodge the neck of the rib; its extremity is however lost. The thickness of the transverse process diminishes to its posterior edge, and below the diagonal buttress already mentioned in the preceding descriptions, supports it, and is prolonged outwards on the slender portion of the process. The posterior deep fossa behind the buttress exists also, but the anterior is obliterated, the outer surface of the neural lamina being only slightly convex from before backwards, and subconcave vertically.

The spine ascends obliquely backwards and is of nearly equal width throughout; in its basal half it diminishes rapidly in thickness towards its anterior thin margin, which is prolonged forwards to the edge of the platform; in its upper moiety it contracts slightly behind; the posterior border presents a deep groove, obliterated in the upper third by a rough ridge rising from its floor; the apex is broadly truncated and the hinder angle removed; the anterior border is carinate below, but above exhibits a well-marked excavation, becoming wider and deeper above. The greatest diameter of the transverse process at its root is 2 inches 9 lines; between the articular surfaces of opposite sides, for the head of the rib, it measures 8 inches 5 lines. The length of the spine anteriorly is 12 inches 5 lines, its greatest antero-posterior diameter is 3 inches 4 lines, and its greatest thickness 2 inches 3 lines. The greatest width of the centrum is equal to 4 inches 5 lines. The extreme height of this vertebra is 1 foot 8 inches.

Undoubted lumbars of the Iguanodon have not hitherto, so far as I am aware, been recognized, although some of the vertebræ preserved in the Maidstone specimen may belong to that region of the spine. The presence of an articular facet on the transverse process for the attachment of the rib is the distinctive character between the posterior dorsal and lumbar vertebra; unfortunately these processes being readily detached are usually absent. However, we may expect certain modifications in the neural arch of, and also a more robust, perhaps, shorter body in, the vertebræ of the lumbar region. As in Crocodiles, the transverse processes would continue to spring at the level of the spinal platform, but the absence of the rib would cause a further simplification in the sculpturing of the neural lamina, and thus the supporting diagonal buttress of the transverse process would wholly disappear. The neural laminæ themselves would have a less antero-posterior extent than in the more anterior element of the column, and hence the *notches* and uncovered tracts of the body would be more marked than in the dorsal vertebræ, where great strength and size are required in the arch to support the huge ribs of this herbivorous, and it may be, *ruminating*

Saurian. Moreover, the nerves escaping through the intervertebral foramina of this region are larger than those of the dorsal segment of the spine, as they contribute to the formation of the lumbar and sacral plexuses; the vertebral foramen would probably also be wider, since the spinal chord enlarges in that region to form the posterior expansion or ganglion of the *sinus rhomboidalis*, which extends through the anterior half of the canal of the sacrum: the expanded bases of the neural laminæ would therefore leave a portion of the centrum uncovered mesially, to form the floor of the canal and support directly the medulla spinalis.

I can perceive no difference between the posterior dorsal or lumbar vertebræ (No. 2133, 2115)* assigned by Professor OWEN to the *Cetiosaurus brevis*, and that last described as corresponding in some respects to the fifth dorsal in the spinal column of the Crocodile, than a diminution in the relief of the buttress supporting the transverse process. In No. 2115 the neural arch is broken away, and the tract of the centrum left uncovered behind to form the floor of the intervertebral foramen, is of greater extent than in No. 2133, indicating a more posterior situation in the vertebral series. The approach to the quadrangular form of the body of this vertebra is no proof whatever of a specific and still less of a generic distinction; otherwise the first sacral vertebra, which is more decidedly quadrate, if found separate, would be equally entitled to a generic value; but its association, in the sacrum from Mr. SAULL's collection (Plate XXVI.), with other vertebral bodies of a very dissimilar character, and with the ilium of the Iguanodon, prevents our falling into an error of such magnitude. We may therefore reasonably conclude, that these vertebræ, to wit, Nos. 2133, 2155, belong to the Iguanodon, and that the latter, in the form of the body, approached the first sacral, and was one of the proper lumbar series. The vertebra, No. 2109, attributed in the above-mentioned report to the (so-called) second species of Cetiosaurus found in the Wealden formation (*C. brachyurus*), is also a posterior dorsal or lumbar vertebra of the Iguanodon; the neural arch is much mutilated. The only other element of the skeleton of that species is a caudal vertebra, No. 2161, which also belongs to the Iguanodon; being in fact one of the most anterior of the caudal series, and contrary to the character of the genus to which it was referred, it presents one of the most interesting and instructive examples of the rough surface on the sides of the upper aspect of the centrum, left by the removal of the unanchylosed neural arch. The so-called *Cetiosaurus brevis* being thus founded only on two vertebræ which belong to the Iguanodon, must be expunged from the list of extinct reptiles.

The angular posterior caudal vertebræ referred in the Report on British Reptiles, to the *Cetiosaurus brevis*, I am also inclined to assign to the Iguanodon for the following reasons:—1st, a similar vertebra, as far as can be ascertained, exists in the Maidstone specimen, and in this case an admixture of bones of distinct animals cannot even be suspected; 2ndly, the numerical ratio of the vertebræ of this kind

* Mantellian Collection in the British Museum.

occurring in the Wealden, to those from the same deposits and localities belonging to other regions of the spinal column, all referable to the Iguanodon, excepting the few megalosaurian and crocodilian vertebræ, is such as long ago to have induced Dr. MANTELL to regard them as characteristic of that Saurian; and the occurrence of such vertebræ with those of the sacrum and other bones of the Iguanodon in Western Sussex, described by CUVIER, has already been commented on* :—3rdly, as I shall presently show that the four large anterior caudal vertebræ in the Mantellian Collection, also assigned by the author of the Report to the *Cetiosaurus brevis*, cannot be transmuted into the vertebræ in question by any changes occurring in a consecutive series, there is left for that animal only some terminal caudal vertebræ; while to complete the tail of the Iguanodon just those are wanting; 4thly, but independently of the evidence furnished by the Maidstone specimen, we have seen examples which point out the series of changes by which these angular vertebræ are produced from those of the middle caudal region. These changes, again, are not greater than those that take place in the tail of the Hylæosaurus † and other extinct reptiles, as well as in that of many mammalia.

Let us look for a moment at the vertebræ of the tail of the Mosasaurus as contrasted with those of other regions of the spinal column in that reptile, and we shall then be prepared to admit far greater modifications than are here assumed. Could we *à priori* correctly restore the vertebral column of any animal from scattered fragments, belonging to different individuals, without making allowance for the changes occurring in the series of segments composing that column?

In the form of the terminal caudal vertebræ we may expect to find a very great similarity even in remote genera, and hence it is unsafe to base a generic character on their peculiarities. The genus Cetiosaurus (restricted to the species *medius* and *longus* from the oolite) is founded chiefly on such trivial distinctions, and we may refer to it any caudal vertebra of considerable dimensions with plano-concave or biconcave facets not referable to other known and perfectly determined genera, such as the Ichthyosaurus and Plesiosaurus, of which we have fortunately nearly perfect skeletons, and hence cannot be led astray in the labyrinth of fragments from which we are compelled, in most instances, to construct the lost denizens of the former lands and seas of our globe.

In the caudal vertebræ of the Iguanodon, the body is wedge-shaped; the sides, which are faintly concave lengthwise and flat, or but slightly convex vertically, converge towards each other below; in the three or four most anterior, they present a concavity beneath the base of the short caudal rib, which is wedged between the centrum and the root of the neural lamina; in a very instructive example in Dr. MANTELL's Collection, the pleural element has dropped out from one side, leaving a deep cavity now filled by matrix ‡. The caudal ribs disappear towards the middle of the tail, after which the bodies of the vertebræ have a subhexagonal form, Plate XXX. figs. 12, 13;

* *Ante*, p. 277. † See Plate XXXII. ‡ Philosophical Transactions, 1841, Plate VIII. fig. 37 *o*.

the angles of the upper or basal surface of the centrum, which support the impacted roots of the ribs, are therefore removed, and replaced by planes converging towards each other above, and forming with the primary surfaces a longitudinal ridge on each side, which descends gradually to its centre in the terminal vertebræ, at the same time becoming more prominent as the body assumes a more hexagonal figure. In the vertebræ immediately adjoining the sacrum, the anterior articular surface is flat or slightly concave in its lower moiety, but convex above, whilst behind the reverse is the case, and thus the vertebral surfaces are coadapted; in the middle caudal elements, the body has plano-concave facets; the anterior then becoming depressed in the terminal vertebræ, which are thus biconcave. The expanded bases of the neural laminæ leave a portion of the centrum uncovered mesially, above they contract and leave considerable tracts of the body exposed; the posterior notch is twice the depth of the anterior. The elongated space ascends obliquely backwards, increasing in width, but is abruptly truncated; the hinder border is in its upper half, while from the lower moiety of the anterior margin a thin plate extends forwards, its base reaching to the deep notch which separates the pro-arthrapophyses; these receive between them the closely approximated corresponding posterior processes which look outwards, and are developed on the hinder part of the base of the spine, their thin posterior edge being separated by a shallow notch. The free aspect of the neuropome is flat in the axis of the vertebra, but concave in the opposite diameter, the concavity passing upwards into the lateral surface of the spine.

The spinal canal is circular, widening slightly at each extremity. The chevron bone is not developed at the two first caudal intervertebral spaces in the fossil, Plate XXX. fig. 17, *x*, which represents four vertebræ belonging to the same individual as the fragments of the sacrum, figs. 15 and 16: there is a marked increase in the size of the body to the third, and then it diminishes; that of probably the second caudal is but little contracted inferiorly, whilst in the third it is carinate, and encroached on posteriorly by the semicircular surface descending obliquely forwards, and giving attachment to the anterior facet of the expanded base of the chevron bone, which is wedged into the intervertebral space, truncating the opposed angles of the contiguous vertebræ. The laminæ of the chevron bone (*angiopoma*) coalesce at their distal extremity, and develope a long inferior spine (*angiacantha*); they also meet above the hæmal canal to form the expanded wedge-like base, the anterior facet of which is the largest. The angiopomal impressions are never in pairs, but always united into a single subtriangular rough irregular surface, the posterior of which is most extensive; the narrow tract separating them is deeply concave lengthwise, carinated in the more anterior caudal vertebræ, but deeply sulcated in the more posterior elements. The chevron bones are continued further back than the ribs, and the angiopomal impressions are present on many of the hexagonal terminal vertebræ; the posterior are the largest and partly subdivided by a slight median ridge. The dimensions of the first caudal of the above series are subjoined.

	inches.	lines.
Height of anterior surface of body	3	6
Width of anterior surface of body	3	7
Length of the body (inferiorly)	2	1
Width of spinal canal in centre		$5\frac{1}{2}$

In the Crocodile the chevron bone commences at the second caudal and terminates at the twentieth, but the rib ceases at the fifteenth, the number of vertebræ composing the tail being forty-two.

The four huge caudal vertebræ already mentioned as assigned to the *Cetiosaurus brevis**, exhibit very peculiar characters, fully detailed by Professor OWEN, and are especially distinguished by the absence of projecting posterior articular processes; 'the posterior articular surfaces being impressed upon the sides of the posterior part of the base of the spine,' while the anterior oblique processes 'reach beyond the middle of the vertebra next in front, and pinch, as it were, the back part of the base of the spine so as to impress upon it the surfaces representing the posterior articular processes.' If then these anterior caudal vertebræ are characterized by the absence of the posterior oblique processes, and as in the succeeding elements of the series the invariable tendency is to the disappearance of articular processes whether in front or behind, the terminal angular vertebræ (Plate XXX. figs. 12, 13) in which the posterior oblique processes are still well-developed, projecting from the back part of the base of the spine, cannot belong to the same species as those just described, without violating those analogies which have hitherto held good; for we cannot well admit the reappearance of posterior oblique processes, after they have once subsided, in a more posterior part of the same caudal series. Other discrepancies equally marked forbid their association.

There remain then to represent the *Cetiosaurus brevis*, in the specimens under consideration, only the above four caudal vertebræ, which are truly so whale-like in their form, as to be pre-eminently worthy of that generic appellation. Probably they are portions of one or other of the species of that genus from the Oolites, indicated by Professor OWEN, chiefly from the more posterior caudal vertebræ.

The close resemblance which these unique caudal vertebræ† present to two remarkable ones figured by CUVIER‡ from the oolite of Honfleur, was long ago recognized by Dr. MANTELL. They are thus described: 'à corps cylindrique, presque aussi long que large, marqué de chaque côté d'une petite fossette, à faces planes, circulaires, à canal médullaire fort étroit, à partie annulaire non articulée ; l'apophyse épineuse haute, et droite ; les transverses au niveau du canal médullaire, grosses cylindriques, dilatées verticalement au bout ; et, ce qui est très remarquable, *les*

* *Ante*, p. 294.

† An outline of one of these vertebræ is given in Dr. MANTELL's Memoir, Philosophical Transactions, 1841, Plate IX. fig. 13.

‡ Tome v. pl. 22, figs. 1 and 2. Oss. Foss. ed. 1824.

articulaires postérieures petites, pointues, rapprochées, et donnant dans deux petites fossettes entre les antérieures et au-devant de la basse de l'épineuse.' 'Elles doivent appartenir à une espèce de Sauriens très-voisine des Plésiosaurus.' Ocular inspection can alone safely indicate the propriety of associating these vertebræ together as belonging to the same species or genus. Probably the mutilated remains of a large Saurian, from the lower greensand at Hythe, may belong to this genus, and also the teeth of the provisional '*Polyptychodon*' occurring in the same formation. The Wealden deposits intercalated between two marine formations, contemporaneous with them in a certain sense, may well contain a few vertebræ of the great Saurians which swarmed along the shores of the bays indenting the "Country of the Iguanodon," or even entered occasionally the mouths of its mighty rivers. If these four caudal vertebræ are specifically different from any found in the more ancient oolite, to prevent confusion, and to remove the objection that may well be raised against the *nomen triviale* '*brevis*'—for who will venture to indicate the relative length of an animal with no known affine, from four of its anterior caudal vertebræ?—we propose to name the species to which they belong, *Cetiosaurus Conybeari*, in honour of the Dean of Llandaff, one of the earliest, ablest, and most distinguished geologists and palæontologists of England.

The massive sacrum of the Iguanodon (Plate XXVI.) is composed of a series of six vertebræ anchylosed together in a nearly straight line; the neural arches unite at an early period above the intervertebral foramina, and form a tunnel over the spinal canal, while the short spinous processes coalesce into a thick median ridge. The bodies of the second, third, and fourth vertebræ, are only half as broad as those of the first and two last, which are of nearly equal width, but all have the same length. The free articular surface (a') of the first sacral is flat or rather slightly convex, especially in the vertical diameter, and presents an oval contour; the posterior facet of the sixth (a'') is subcircular and slightly concave, but deepest above.

The body of each is more or less constricted in the centre, so that their surfaces are deeply concave lengthwise; this contraction, and the marked expansion towards the articular facets, is most striking in the smaller middle vertebræ, least so in the first; and the more or less rounded transverse ridges at the lines of anchylosis give the inferior surface of this chain an undulating outline. The neural lamina of the first sacral about its root is much contracted in the antero-posterior diameter, and chiefly from behind forwards, so as to leave a large tract of the body exposed posteriorly, while the anterior notch is comparatively shallow. The neural laminæ of the four succeeding vertebræ are displaced slightly forwards, so that the anterior extremities of their bases rest upon and excavate the postero-superior angles of the body in front, and are also, perhaps, partly wedged into the intervertebral space; each however impresses and is mainly attached to its own centrum; and that of the last sacral is restored almost to its normal position, projecting only slightly beyond the anterior aspect of the body, leaving a portion of its upper surface uncovered behind, to form the floor of the large intervertebral foramen. The preceding foramina intervertebralia, instead therefore of being situated more or less over the union of two contiguous bodies, are thrown forwards in the same ratio as the neural laminæ, encroach on the centrum in front, and generally occur over the junction of its posterior and two anterior thirds. In the first sacral the body has a subquadrangular section; the lateral aspects are impressed by a fossa beneath the root of the neuropome, and meet the inferior surface nearly at right angles, which are rounded off; the lower aspect is but slightly convex transversely; sometimes it presents a median ridge separating two very shallow concavities, perforated by vascular foramina. The anterior oblique processes project considerably beyond the margin of the neural arch, and are nearly horizontal, and separated from each other by a wide notch. The bodies of the three succeeding vertebræ, as already mentioned, are narrow, constricted in the centre, compressed laterally in the lower moiety, and rounded transversely below, with a more or less distinct longitudinal mesial ridge, sometimes replaced by a groove in the third. In other cases they appear to be flattened inferiorly, without our being able to regard them as distinct, so that there appears to be a considerable range of variation attributable to age and sex, &c. Each lateral surface presents a small digital fossa (Plate XXX. fig. 16) towards the middle of its height and nearer its posterior extremity, as if the centrum had been pinched up between the thumb and fore-finger. Above the fossa the centrum expands, the anterior angle (Plate XXX. fig. 14*) of the expanded portion being, as it were, removed and flattened out by the base of the neural lamina, and also, perhaps chiefly, by the sacral rib, which is wedged deeply into the intervertebral space; the posterior angle (Plate XXX. fig. 14§), like that of the first sacral, is removed, but to a much less extent than the anterior; between them is the smooth, semilunar, oblique notch (Plate XXX. figs. 14, 15, 16, *z*), impressing the slightly elevated parapet which bounds externally the wide, deeply concave floor of the spinal canal. In the two posterior sacral vertebræ the bases of the neural laminæ begin to expand inwards, so as to cover the upper surface of the centrum, in the last sacral meeting in the centre and leaving only a small triangular tract in front and behind exposed; thus the calibre of the canal is diminished. The bodies of the two last vertebræ expand to nearly the same diameter as the first, but the lateral surfaces converge more or less rapidly to an inferior mesial convexity, varying in breadth and prominence. By the relative size of the two extremities of the spinal canal in the sacrum, we are enabled most readily and certainly to determine its position. The bases of the strong sacral ribs (Plate XXVI. *h*, *h*, *h*, Plate XXX. figs. 15, 16 *h*) are compressed in the antero-posterior diameter and impacted in the intervertebral spaces, descending nearly to the inferior surface of the centre, and rising high upon the neural laminæ, which are also excavated to give an additional surface of attachment. The neural laminæ also send out vertical processes (*plagiapophyses*) which are superimposed upon the sacral ribs, and early coalesce with them to form the thick partitions, which extend outwards, gradually increasing in length to the last; and enclose between them the large circular sacral foramina. The inferior angles of the free extremities of the five posterior ribs expand and coalesce to form a band completing the sacral foramina without (Plate XXVI. h''). The thickest and strongest of these septa is the second, it is also inclined slightly backwards; the second or third posterior ones have a tendency forwards. The corresponding compressed rib-like process of the first sacral is perhaps chiefly formed by the transverse process, and does not appear to have reached the band above-mentioned. The vertical septa extended as high as the base of the spinal ridge, and appear to have had a convex upper edge and a concave lower one. Curious bony buttresses (Plate XXVI. 3*) of a triangular form seem to have partly roofed over some of the sacral foramina; these are most probably remains of a lateral expansion of the side of the spinal platform, at right angle hence to the vertical portion of the transverse process. These parts are, however, so much mutilated that we must have more perfect specimens for examination ere many interesting points can be fully elucidated. The band above-mentioned is curved longitudinally in its anterior two-thirds, with a concavity looking downwards and outwards, the posterior part of the arc being twisted slightly from within outwards on its axis; the portion contributed by the two posterior ribs is convex externally, passing into the concavity at a very obtuse angle. The bands of opposite sides are much more closely approximated in front than behind, but are most remote opposite the angle just mentioned.

This instructive specimen of the sacrum also points out the true position of the *Ilium* (Plate XXVI. A), the form of which is well seen in the two detached examples in the Maidstone Iguanodon*. The slender anteriorly prolonged extremity, which is supposed in the Report on British Reptiles to be the posterior, is only an exaggerated condition of the short spine projecting forwards from the ilium in the smaller Lacertæ. From the form and position of the head of the femur, I am inclined to think that no part of the surface of the acetabulum is present in this mutilated specimen; it is perhaps fractured (A'''') across the neck or contracted portion, beneath which it would expand to contribute to the formation of the acetabular fossa.

The beautiful and interesting fragment of the sacrum of a Dinosaur, consisting of the four posterior vertebral bodies anchylosed together, Plate XXVII. figs. 2, 3, presents certain differences in the form of the centrum, which are perhaps due to age and sex; but I am inclined with Dr. MANTELL to regard it as probably belonging to the Hylæosaurus, which must have presented a nearly similar structure of the pelvis. The sacral fragment referred to the Hylæosaurus by Professor OWEN, cannot at present be found to institute the necessary comparison with the present specimen. The age and size of the individual appear to have had no very obvious relation to the occurrence of anchylosis in the sacral column, as we meet with examples of very dissimilar size both anchylosed and separate. There is the same disproportion between the central and extreme elements of this chain as we have seen in the sacrum

* Philosophical Transactions, 1848, Plate VIII. fig. 28.

of the Iguanodon, but the bodies are relatively broader and flatter, and not so much pinched up beneath the intervertebral notches; but a reference to the Plate will furnish a better idea of these differences than can be conveyed in words.

Since the observations on which the above remarks are chiefly founded were made, Dr. MANTELL has informed me, that according to the account given by the fisherman who collected the cervical, anterior and middle dorsal, first sacral, and anterior caudal vertebræ—all of which I had assigned to the Iguanodon—they were found not only in the same limited area, but in such collocation as to give rise to the conviction in the mind of one who had certainly no theory to support, that they constituted portions of the same 'backbone,' and were associated with bones of the hinder extremity of the Iguanodon of proportionate size, now in Dr. MANTELL's Collection, and partly described in this memoir. Although unwilling to lay any undue stress on this circumstance, it will, we conceive, raise in the minds of future observers such presumptive evidence in favour of the opinions here advanced, as may, independently of the mere intrinsic value of the argument from analogy, lead them to view favourably our proposed restoration of the vertebral column of the Iguanodon.

The time is perhaps not far distant, when the exertions of the many collectors of the Wealden fossils will yield the materials for continuing these interesting researches, and modifying or confirming our conclusions. And, although, we feel it is difficult to convey to the minds of others that conviction of their accordance with nature, which has been impressed on our own after the repeated examination of a more extensive and instructive series of specimens than has, perhaps, fallen under the observation of any other palæontologists, we may be permitted meanwhile to indulge the hope that a step has been taken in the right direction, to reconstruct the skeleton of the marvellous Reptilian Herbivore, whose earliest known remains were first exhumed from the Wealden formation of Sussex, during the infancy of Palæontology.

DESCRIPTION OF THE PLATES.

PLATE XXVI.

Sacrum of the Iguanodon; in the Collection of W. D. SAULL, *Esq., F.G.S.*
(One-half linear, the natural size.)

Figs. 1, 2, 3, 4, 5, 6. The six anchylosed vertebræ composing the Sacrum; 1, is the first or most anterior vertebra.

a'. Anterior articulating facet.

a''. Posterior ———————.

h. Sacral ribs.

h'. Confluence of the sacral ribs at the outer extremity of the left side.

h''. Sacral foramina.

* Expansion of bone from the rib across a sacral foramen.

A. The right ilium.

A′. Anterior prolongation of the same.

A″. Posterior extremity of the ilium, of which several inches are wanting.

A‴. Crest or upper margin of the same.

A⁗. Remains of the neck of the ilium.

PLATE XXVII.

This fossil consists of the four distal anchylosed vertebræ of a sacrum belonging either to the Hylæosaurus or Iguanodon (*natural size*). Collected by Captain Lambart Brickenden, F.G.S.

Fig. 2. The inferior or visceral aspect.

Fig. 3. The side or lateral aspect.

3, 4. The two middle slender vertebræ.

5, 6. The two larger and posterior vertebræ.

h. Sacral ribs.

j. The spinal canal.

k. Line of intervertebral anchylosis.

b. Bases of the neural laminæ.

PLATE XXVIII.

Vertebræ of the Iguanodon.

Fig. 4. Cervical vertebra from Brook Bay: this specimen is somewhat compressed vertically, so as to appear wider and more elliptical transversely than natural.

4^a. Inferior view.

4^b. Upper view.

4^c. Lateral view.

The several parts in this and the other vertebræ are indicated by the following signs:—

a. The body or centrum.

a′. The anterior articulating surface of the same.

a″. The posterior ———————————.

b. The neural arch.

c. The spinous process.

d. Superior transverse process.

e. Inferior transverse process.

f. Anterior oblique process.

g. Posterior oblique process.

h. Rib or costal process.

i. Chevron bone.

j. Spinal canal.

k. Line of intervertebral anchylosis.

l. Articulating surface for the head of the rib.

Fig. 5. Anterior dorsal vertebra from the Isle of Wight.

5^a. Anterior view.

5^b. Posterior aspect.

5^c. Lateral view.

Fig. 6. Cervical vertebra, in Mr. Saull's Collection, lateral view: the anterior convexity has been chiseled away.

Fig. 7. Middle dorsal vertebra, in British Museum.

7^a. Lateral view.

7^b. Anterior view.

PLATE XXIX.

Dorsal Vertebræ of the Iguanodon.

(one-fourth linear, natural size.)

Fig. 8. Middle dorsal vertebra. Isle of Wight; found with fig. 4, Plate III.

8^a. Posterior aspect.

8^b. Anterior aspect.

8^c. Lateral view.

Fig. 9. Posterior dorsal vertebra found with the above.

Cervical Vertebræ of a very young Iguanodon.

(natural size.)

Fig. 9*. A series of three convexo-concave vertebræ from the Wealden of the Isle of Wight.

9^a*. The upper or dorsal aspect, showing the spinous and oblique processes of the neural arches; the vertebræ are somewhat displaced, and injured by compression.

9^b*. Lateral view of the same.

9^c*. Lateral view of one of the vertebræ detached.

This interesting series of cervicals (for the loan of which I am indebted to J. S. Bowerbank, Esq.) was associated with other portions of the skeleton of a very young individual, consisting of a connected suite of fourteen dorsal vertebræ of the usual type, several ribs with portions of the dermal integument, metatarsal, phalangeal, and ungueal bones, and several others which are at present too much concealed by the investing sandstone to admit of their identification.

These vertebræ are especially instructive, because they establish the true characters of the cervical region of the spine of the Iguanodon in a very young state.

Unfortunately the bodies of the vertebræ have been crushed and compressed almost flat laterally, and the natural form of the inferior part of the centrum is destroyed, the visceral aspect presenting a sharp ridge, and thus assuming a different contour to that of the adult cervical figured in Plate XXVIII. fig. 1, which has been compressed in an opposite direction. Nevertheless, the close analogy between these vertebræ is sufficiently obvious; the structure of the neural arch (as seen in fig. 9^{a}*) is identical; and the only essential difference in the bodies of the respective vertebræ, is that the anterior articulating facet (a') is much less prominent in the young specimen than in the adult: but as the posterior facet (a'') is deeply concave, it is probable that in the recent state the anterior facet possessed a cartilaginous convex epiphysis, by which the ball-and-socket joint was completed: as in the skeleton of the young *Gavial* the facets of the sacro-coccygeal vertebra are flat, though very convex in the adult*; so in the Iguanodon, the ball and socket of the cervicals may not have been fully developed and ossified till the reptile arrived at maturity.

Fig. A. A *concavo-convex* dorsal vertebra from Tilgate Forest: natural size.

I have introduced this figure to prove the existence in the Country of the Iguanodon, of small Lizards having the spinal column constructed of vertebræ anteriorly concave, and posteriorly convex, as in the living Iguanas, Crocodiles, &c.: the very reverse of those above referred to the Iguanodon.

A, is a lateral view; and A′ the anterior aspect, showing the deep socket for the reception of the head of the antecedent vertebra.

PLATE XXX.

Fig. 10. The right *Scapula* or Omoplate of the Iguanodon: from Tilgate Forest (one-fourth natural size).

10^{a}. Inner aspect.

10^{b}. The external aspect.

a. The upper or spinal end.

b. The humeral extremity.

c. The coracoid facet or articulating surface.

d. The glenoid facet, forming half the cavity for the reception of the head of the humerus.

Fig. 11. The right *Coracoid* of the Iguanodon; drawn of a size to correspond with the scapula.

s. Scapular facet or surface to articulate with the scapula.

d′. Glenoid facet, forming with the corresponding part of the scapula, the glenoid socket.

e. Notch for the passage of vessels.

* See Wonders of Geology, 6th edit. p. 418.

Fig. 12. Posterior caudal vertebra of the Iguanodon.

12[a]. Anterior aspect.

12[b]. Lateral view.

Fig. 13. Distal caudal vertebræ of the same; one-half natural size. This specimen and the preceding are from Tilgate Forest.

Fig. 14. A middle sacral vertebra of the Iguanodon from Brook Bay; one-half natural size. In the collection of J. BABER, Esq., of Knightsbridge.

14[a]. Lateral view.

14[b]. Upper or spinal aspect.

Figs. 15, 16, 17. Represent portions of a chain of sacral and caudal vertebræ of the same Iguanodon: from Charlwood in Surrey. In the cabinet of P. MARTIN, Jun., Esq., of Reigate.

Fig. 15. The two anterior sacrals; *z*, foramen for the transit of the sacral nerves.

Fig. 16. An entire middle sacral, with portions of the adjoining vertebræ anchylosed at each end.

Fig. 17. Four consecutive anterior caudals with remains of the chevron bones (*i*).

PLATE XXXI.

Humeri or Arm-bones of the Iguanodon.

Fig. 18. Inferior portion of the right *Humerus* of a young Iguanodon; one-third natural size.

18[a]. Front or anterior view.

18[b]. Lateral view.

18[c]. Posterior view.

18[d]. The condyloid articulating surface seen from below.

Fig. 19. Right Humerus, one-twelfth natural size: from the Isle of Wight; in the possession of Mr. FOWLSTONE of Ryde.

19[a]. Posterior view.

19[b]. Front or anterior aspect.

19[c]. Articulating surface of the proximal extremity of the bone seen from above.

19[d]. Distal or condyloid articulating surface seen from below.

Fig. 20. Right Humerus of the Iguanodon, from the Maidstone specimen in the British Museum; one-sixth natural size: the posterior aspect only is exposed.

Fig. 21. Upper extremity of the Humerus of a very young Iguanodon: from Tilgate Forest; one-third natural size.

21[a]. Posterior aspect.

21[b]. Anterior view.

21[c]. Articulating surface of the proximal extremity seen from above.

The principal points in the above specimens are indicated by the following letters.

a. The head.

b. Inner tuberosity.

c. Outer tuberosity.

d. Deltoid crest, or ridge for the insertion of the deltoid muscle.

e. Inner condyle.

f. Outer condyle.

g. Olecranal furrow or depression.

PLATE XXXII.

Vertebræ and Dermal Bones of the Hylæosaurus.

Fig. 22. Posterior portion of the spinal column of the Hylæosaurus, from the Weald of Sussex; one-sixth natural size.

The *series of nine vertebræ* anterior to the three terminal ones in this specimen, lies imbedded on the stone in a position the reverse of that of the other portions of the spinal column; the hæmal aspect of the bodies of the vertebræ, with the corresponding chevron bones (*i*, *i*, *i*), being uppermost.

22^a. Outline of the form and arrangement of the chevron bones in the distal part of the column.

22^b, 22^c, 22^d. Illustrate the modifications of form in the chevron bones in the anterior part of the specimen.

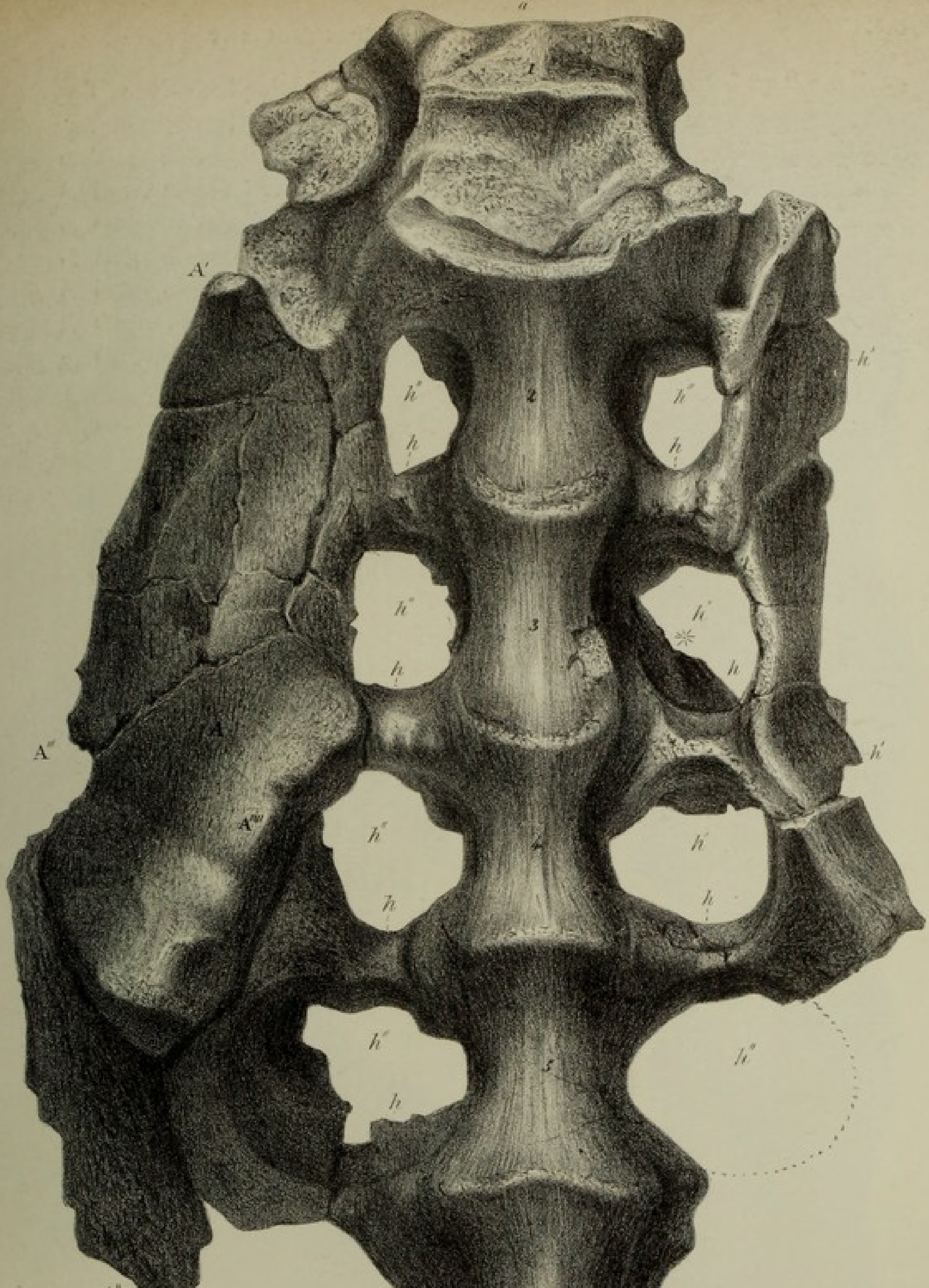
22^e. Distal chevron bone.

22^f. Middle ———————.

22^g. Anterior ———————.

Fig. 23. Dermal bone from the middle portion of fig. 22; one-half natural size.

Fig. 24. Dermal tubercle or horn of the Iguanodon; natural size: from Ridgway, near Weymouth.



Sacrum of the Iguanodon

(½ linear the natural size)

West, del. Printed by J. Basire. J. Dinkel, lith.

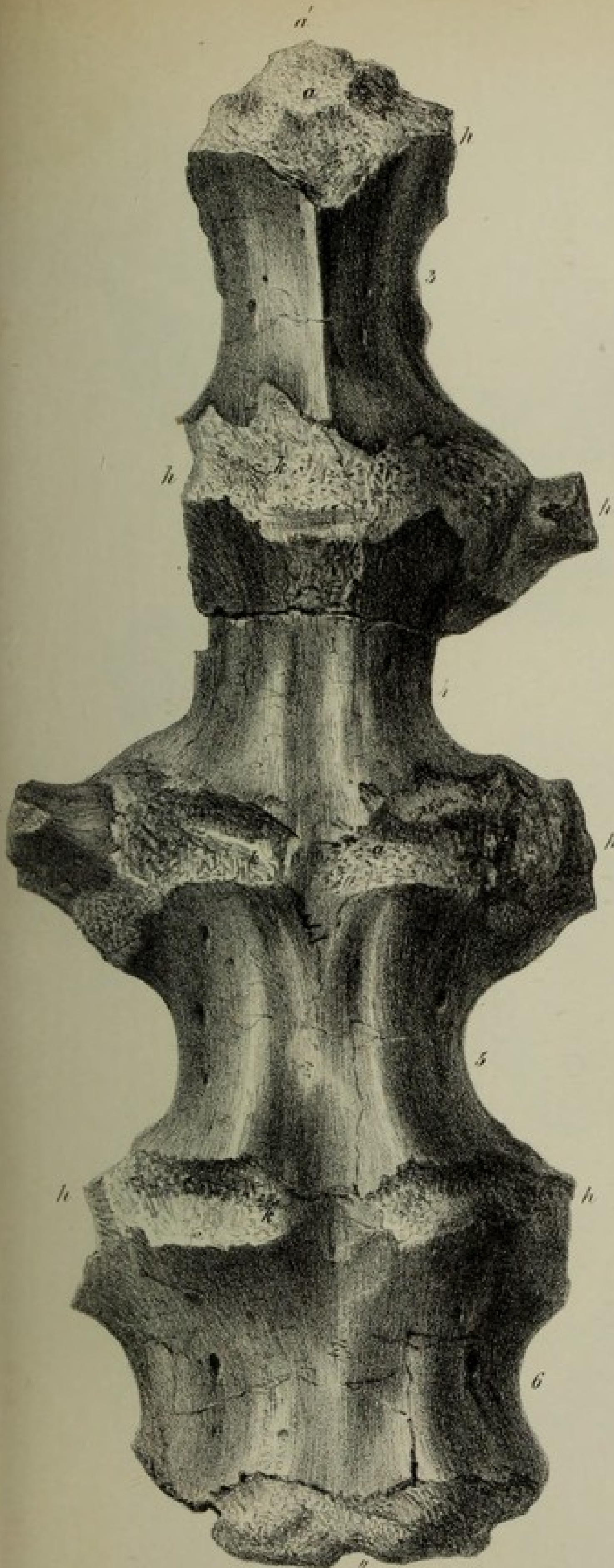


Fig. 2.
Visceral aspect.

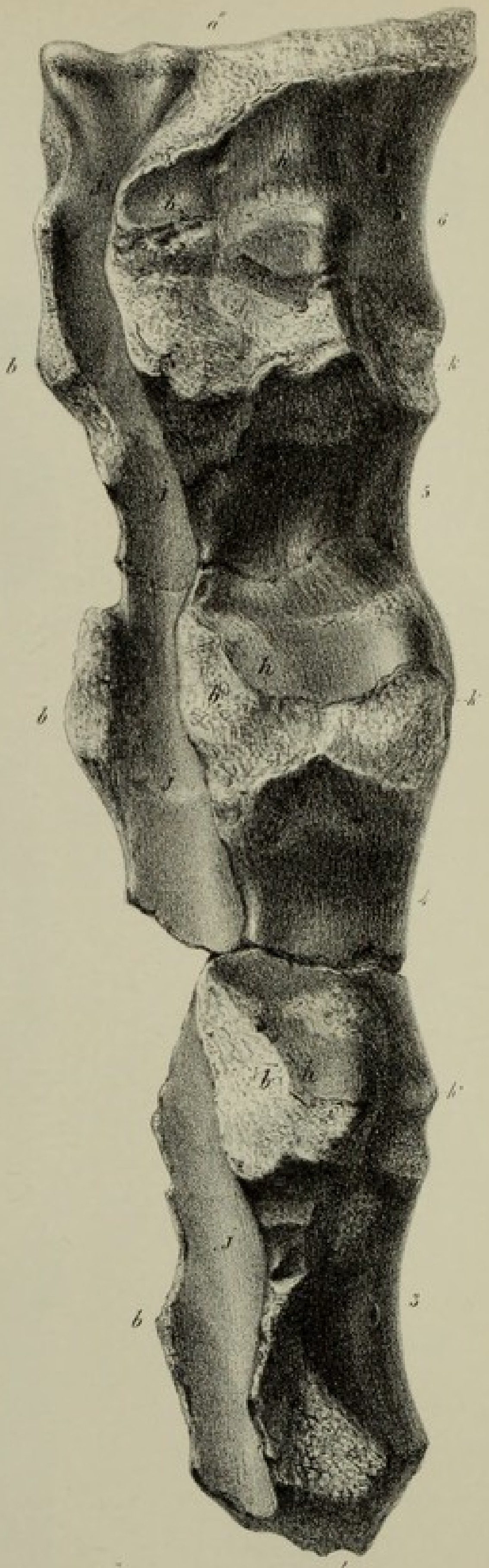
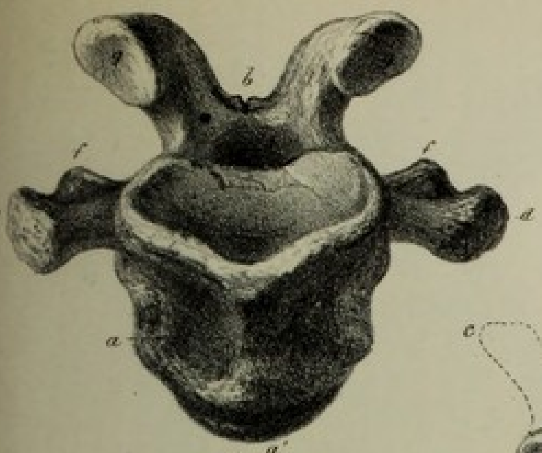


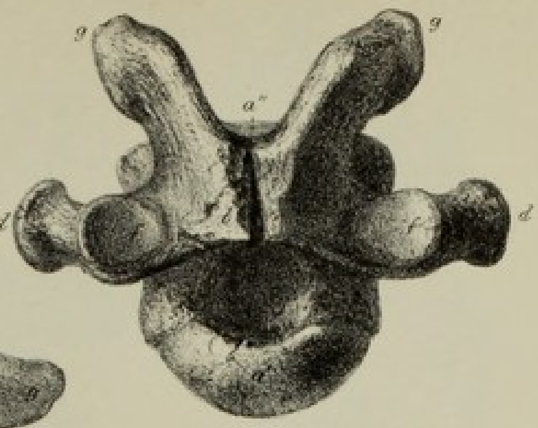
Fig. 3.
Lateral aspect.

Part of the Sacrum of the Hylæosaurus? nat. size.

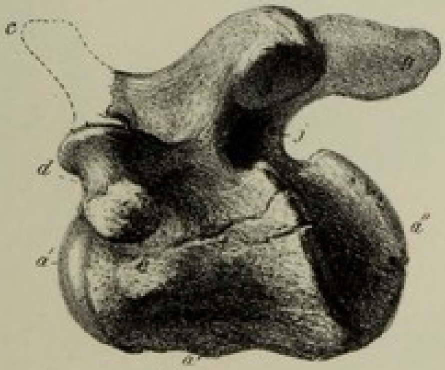
Dinkel & West, del. Printed by J. Basire. J. Dinkel, lith.



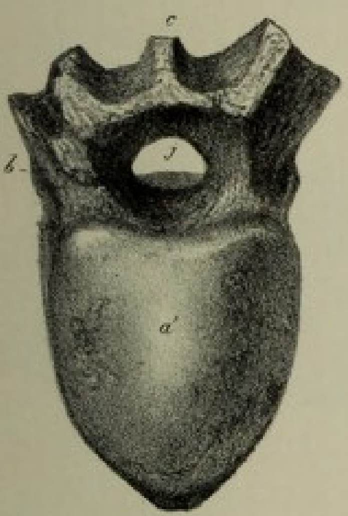
4a
¼ nat. size.



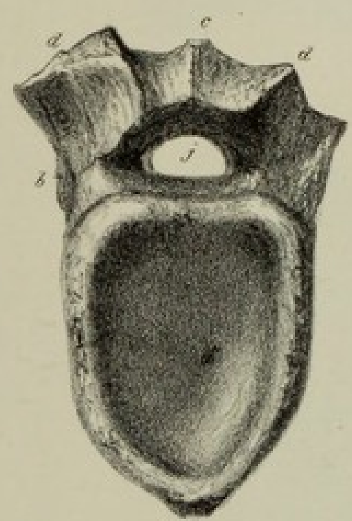
4b
¼ nat. size.



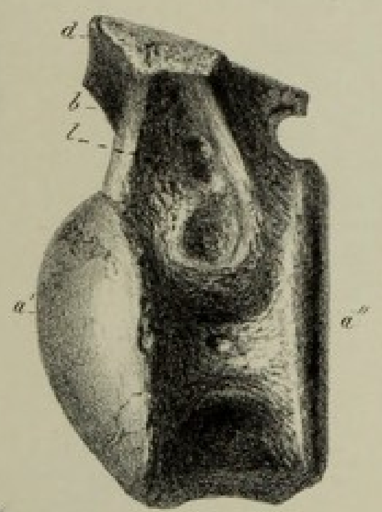
4c



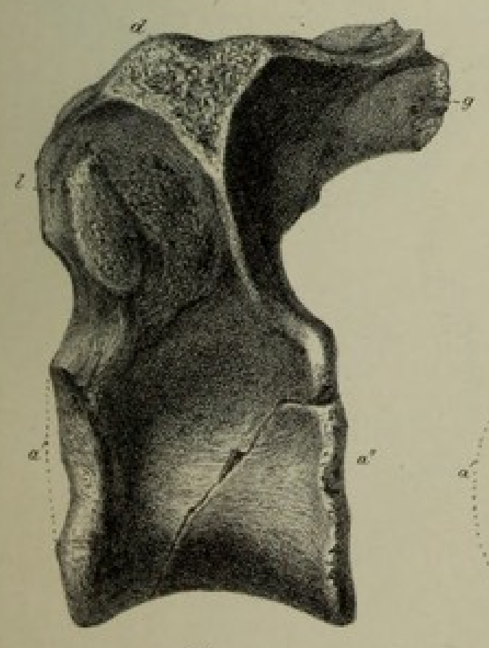
5a
¼ nat. size.



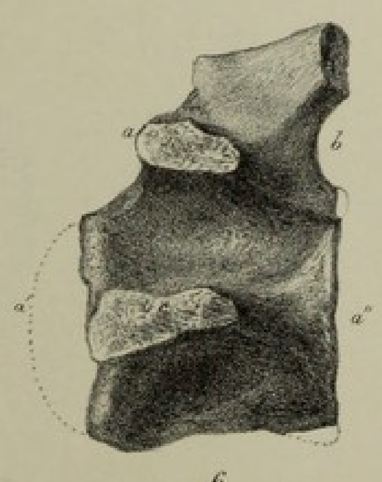
5b
¼ nat. size.



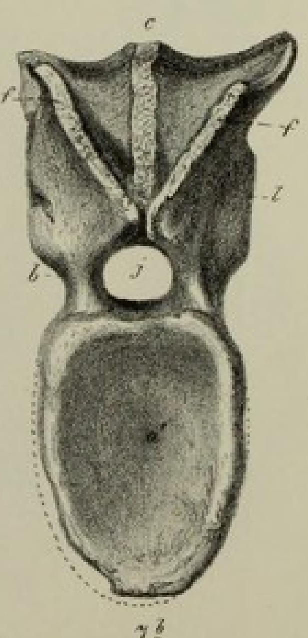
5c



7a
¼ nat. size.



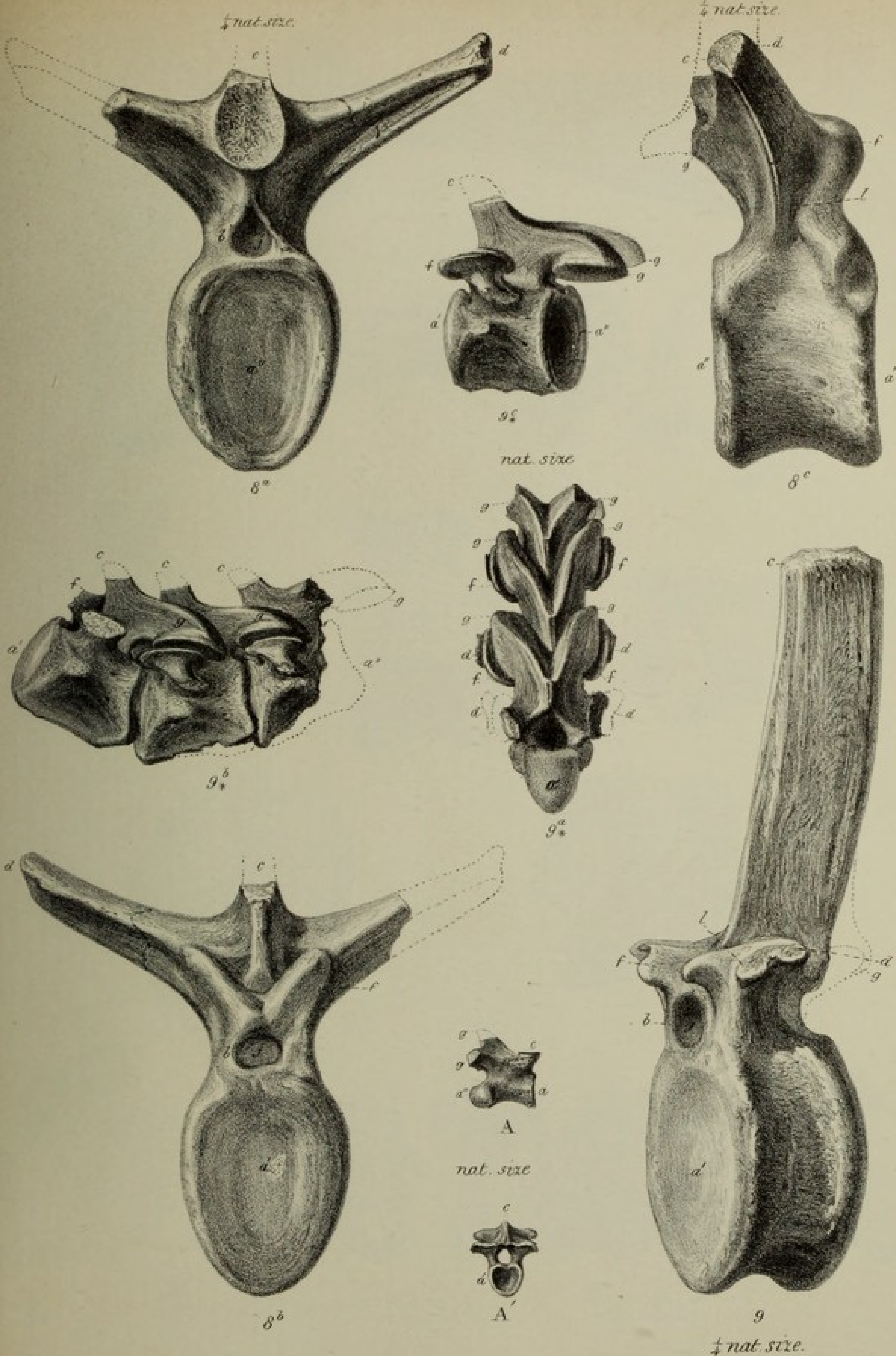
6
¼ nat. size.



7b
¼ nat. size.

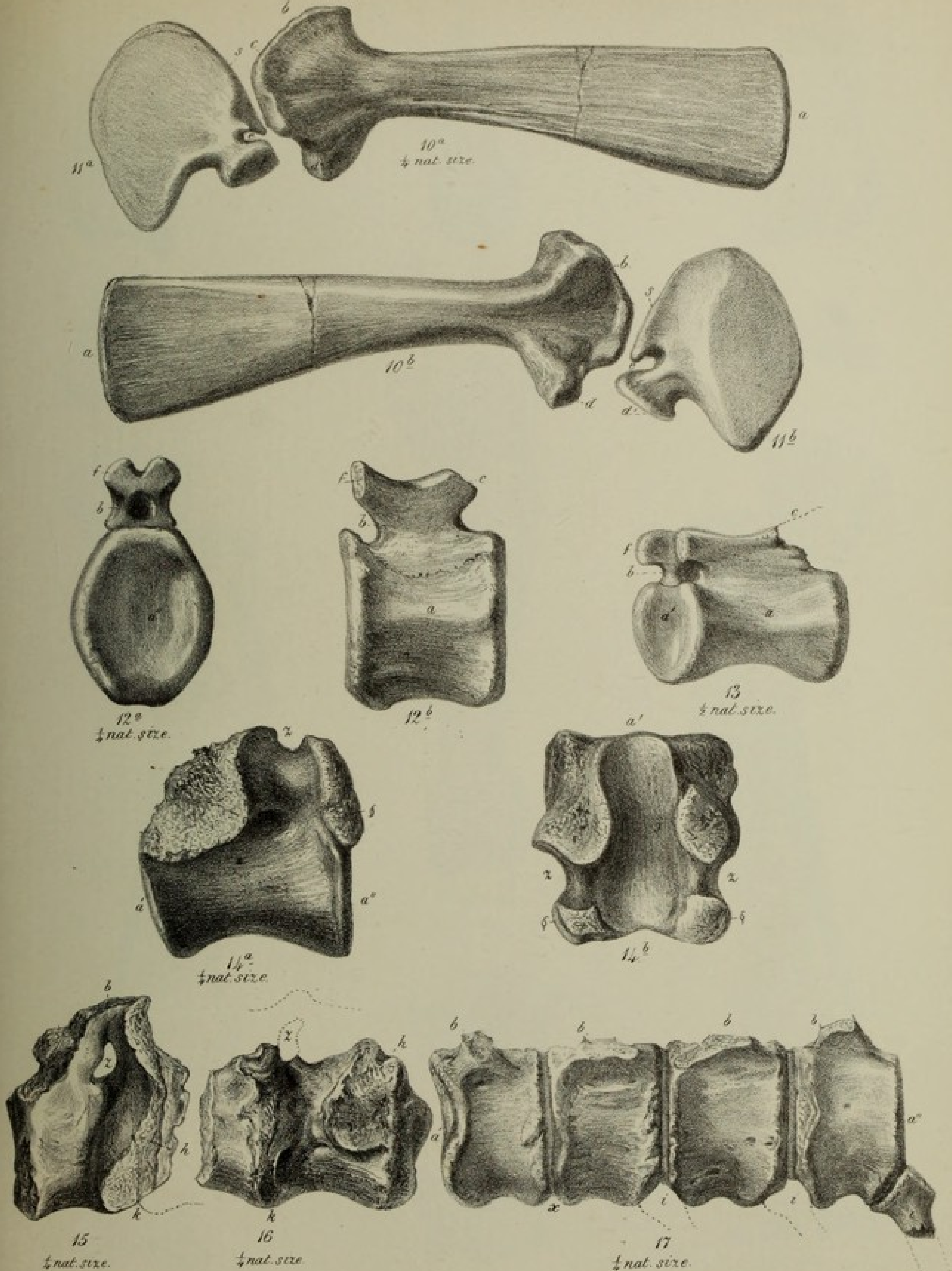
Vertebræ of the Iguanodon.

J. Dinkel, del. et lith.



Vertebræ of the Iguanodon.

J. Dinkel lith.

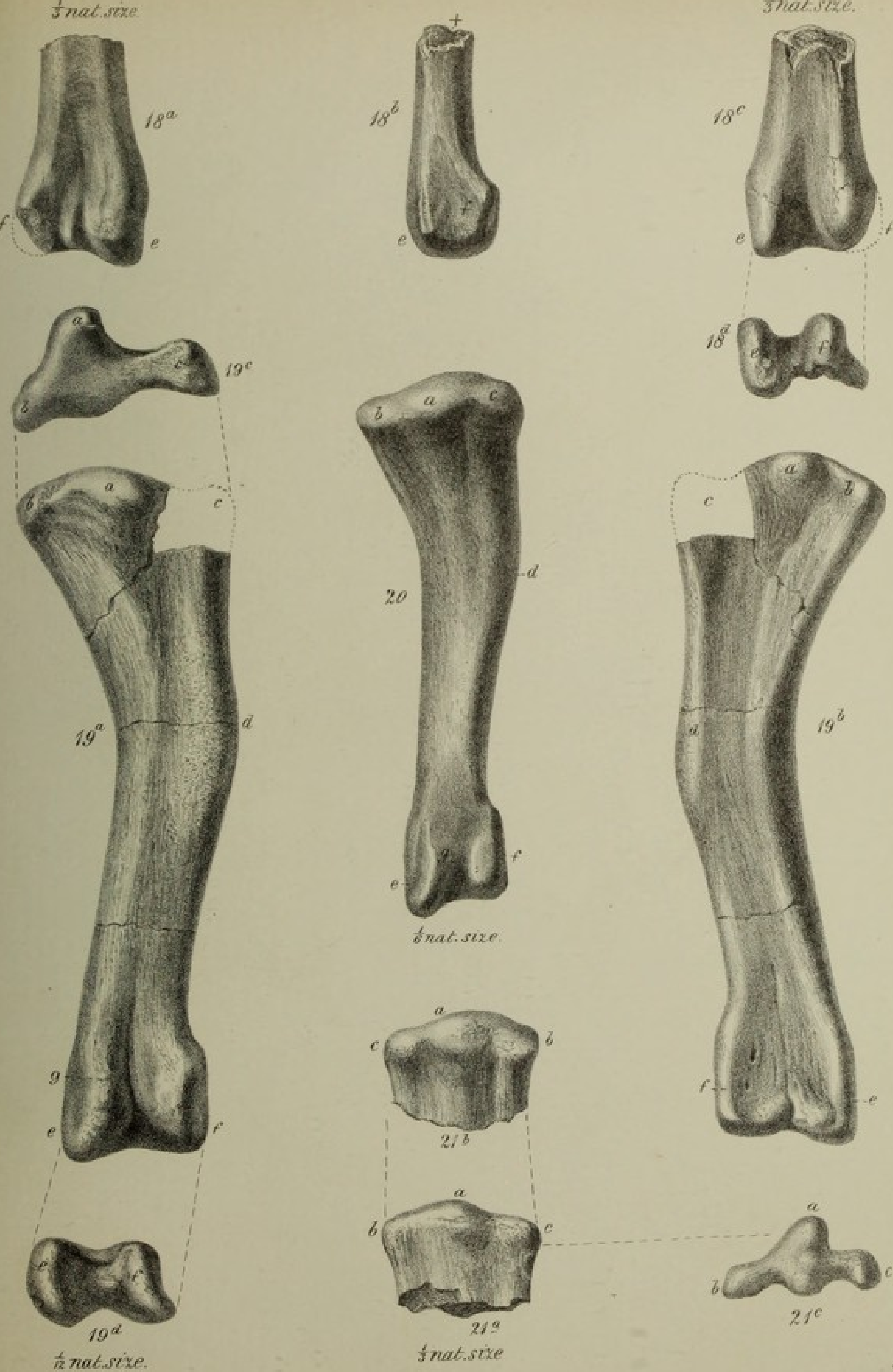


Scapula, Coracoid and Vertebræ of the Iguanodon.

G. Scharf del.

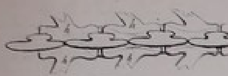
Printed by J. Basire.

J. Dinkel lith.



Humeri of the Iguanodon.

G. Scharf, del. Printed by J. Basire. J. Dinkel, lith.

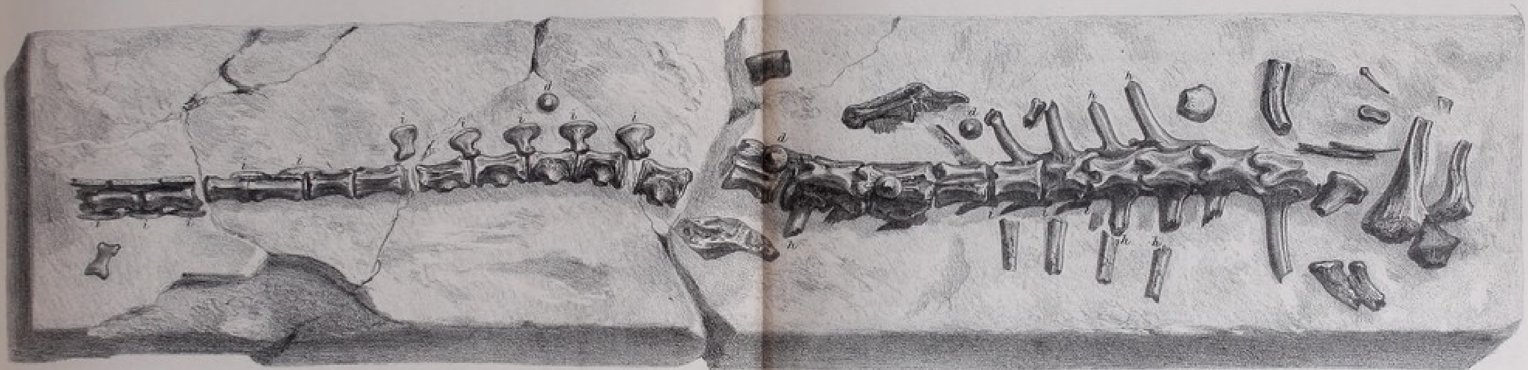


22a

22b

22c

22d



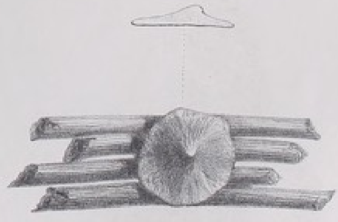
22

24

22f

22e

22g



23

Posterior portion of the Spinal Column of the Hylæosaurus.
(½ natural size)

Printed by J Basire.

i. i. Chevronbones. h. h. Transverse processes. d. d. dermal bones.

J. Dinkel, del et lith.