46. *On the* Dinosauria *of the* Cambridge Greensand. By Professor H. G. Seeley, F.R.S., F.G.S. (Read December 18, 1878.)

[Plates XXXIV., XXXV.]

Introductory Note.

The remains of Dinosaurs were for many years very rarely met with in the Cambridge Upper Greensand; and several important parts of the skeleton have never yet been found. But a considerable collection of more than 500 bones is now preserved in the Woodwardian Museum alone; and since the greater number of these fossils have been discovered in larger or smaller sets of naturally associated remains, each of which is obviously a portion of the skeleton of a single individual, they afford evidence on which it is possible to establish many species which belong to several genera. Occasionally the series of remains is sufficiently large to give grounds for a conjectural reconstruction of the animal; but more frequently the bones are limited to a few caudal vertebræ; and even the larger sets of associated bones come chiefly from the caudal and sacral regions of the vertebral column. With the exception of *Macrurosaurus*, already described*, and also known from a long sequence of large caudal vertebræ, all the remains indicate animals of small or of moderate size, varying between the magnitudes of a sheep and an ox. The majority of the species were characterized by possessing comparatively short tails; though one animal, at least, had a tail in which the vertebræ were more than usually elongated. These remains possess a peculiar interest in being the latest known representatives of the Dinosauria in British geological deposits; and they help to define the limits within which the osteological structure of the order varied and persisted in that organic type.

The literature of British Upper Cretaceous Dinosauria is very scanty. Professor Owen, in 1860, figured in the Palæontographical Society's monograph (2nd Suppl. to *Iguanodon*, pl. vii. figs. 15–17) two Dinosaurian teeth from the Cambridge Greensand, one of which resembled *Hadrosaurus*, while the other was like *Iguanodon*. I have never seen either specimen, and, so far as I am aware, no other Dinosaurian teeth have ever been met with; they were, I believe, the property of Mr. Beddome, of Trinity College, who, when at Cambridge, made considerable collections of vertebrate fossils. These teeth would now be invaluable, because I am not acquainted with any English Greensand skeleton which I should be disposed to identify with either *Iguanodon* or *Hadrosaurus*; and the teeth, without actually pertaining to those genera, may perhaps indicate the directions of the affinities of some of the Cambridge species. The next contribution to knowledge is Professor Huxley's classical paper on *Acanthopholis*, from beds just above the Greensand at Folkestone†.

* Quart. Journ. Geol. Soc. vol. xxxii. p. 440. † Geol. Mag. vol. iv. p. 65.

That brief memoir clearly sets forth the leading characteristics of an armoured genus which is well represented at Cambridge. It may, perhaps, have been that other Dinosaurs were protected by armour undistinguishable from that of *Acanthopholis*, and that some of the Cambridge Dinosaurs were not weighted with these dermal plates. There is, I think, evidence to show that the plates were arranged in some of these species in one median row placed over the neural spines of the vertebræ, with lateral rows of plates, which I infer to have been relatively few and large, and placed somewhat after the manner of the scutes of a Crocodile*, but in the tail and limbs to have conformed to the plan of the land Chelonia.

As doubts have from time to time been expressed as to whether some of the fossils of the Cambridge Greensand might not have been derived from the waste of underlying deposits during its accumulation, and consequent uncertainty has been freely expressed by some writers as to the possibility of bones collected from day to day being naturally associated portions of the remains of one animal, it may perhaps here be useful to state once for all what the evidence is upon which the association of these vertebrate fossils is accepted as a basis for specific and generic characters. Almost every phosphatite digging presents fossils with a mineral character peculiar to the locality, so that a trained observer who has carefully watched these workings for years finds it possible to identify the localities of many specimens on this evidence almost with certainty; and the chances of imposition by wilful deception are small. Then, in the cases of some Plesiosaurs and Ichthyosaurs, I have been present at the workings when associated portions of skeletons have been found, so that I can state from my own knowledge that naturally associated portions of single animals are met with; and often we have had to wait for months for the neck of an animal of which the body has been found, until the overlying rock was removed so that the bones could be collected. The circumstance that private collectors rarely obtain associated sets of bones is explained by the necessity of being on the spot and watching the workings several times a day, so as first to obtain the bones direct from the diggers, and, secondly, to obtain any that the diggers may have overlooked, after the phosphatic nodules have been washed in the mills, when the fossils are detected if they are strong enough to resist attrition. For a long time associated series were limited to portions of one region of the body, because the collector was content with the produce of a single washing; and it was not until Mr. William Farren employed Mr. Pond, an experienced foreman of phosphatite-washers, to devote his whole time to visiting the phosphatite-washings about Cambridge, with the purpose of collecting the whole of the fossil Vertebrata, that it was proved that the bulk of the remains occur as naturally associated

* A brief account of some 376 Dinosaurian bones from the Cambridge Greensand is given in my 'Index to Fossil Remains of Aves, Ornithosauria, and Reptilia,' 1869, pp. xvii, 18–24. The bulk of the remains were then referred to three new species of *Acanthopholis*; and since that date the *Macrurosaurus semnus* has been described and figured in the Journal of this Society.

portions of skeletons of single animals, and that scattered or isolated bones are comparatively rare. It rarely happens that any pit yields more than three or four skeletons. These are almost always of different species; they generally occur at considerable intervals of time; and if an animal happens to lie in the line in which the rock is being worked its remains are collected in a few minutes, while if it is at right angles to the working it will have to be watched for bit by bit as the excavation progresses. In arranging these Dinosaurian and other fossils in the Woodwardian Museum, I have occasionally had to reject an accidental Ichthyosaurian or Plesiosaurian fragment found with a Dinosaur; but I hardly ever remember evidence of two Dinosaurian skeletons being mixed together. And when this has occurred the circumstance could be traced to the fossils having been indiscriminately purchased and mixed by the engineer at the works, or only collected after having been triturated in the mills.

There is no doubt that some of the bones in the Cambridge Greensand have suffered from attrition, and it is probable that the apparently worn condition of the bones has led to the belief that they were derived from some older formation; but not only is a similar fauna unknown in any older formation, but it occurs well developed on this horizon at Gosau, in Austria. Moreover, the bones are much less worn than is often the case with specimens from the Wealden deposits of Sussex; and no one has ever suggested that the Wealden fossils are derivative. And in so far as the Cambridge Greensand specimens are worn, it is probable that the greater part of the abrasion has been produced in the washing-mills at the several diggings after the specimen had been dug out from the bed. In many cases, however, this explanation will not apply; and bones occur which have roughened edges, roughly fractured surfaces, and considerable holes penetrating into their substance. These circumstances led me to institute experiments on the effects of exposure of bones to the air and subsequent maceration as influencing their condition of preservation; and I have found the articular ends especially to suffer from exposure, while under maceration the bones become so brittle that they are fractured with slight movement. In the case of land animals, such as Dinosaurs, both these conditions may well have exercised an influence; and what has hitherto been regarded as evidence of wear seems to me better explained in this way. Many associated bones are decomposed, past all recognition, on the exposed neural surfaces; while the ventral surfaces which rested on the sea-bed yield valuable distinctive characters.

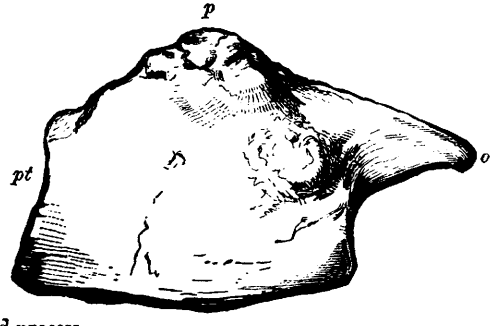
I venture now to submit to the Geological Society some account of the structure, affinities, and systematic position of this Dinosaurian fauna; and I desire to express my grateful sense of the kindness of Prof. Hughes in affording me facilities for studying the Woodwardian Dinosaurs, and my indebtedness to the Council of the Royal Society for assistance in carrying on this investigation. On the present occasion I offer descriptions of a few only of the typical Dinosaurs of the deposit.

Part I.

Note on the axis of a Dinosaur from the Cambridge Greensand, preserved in the Woodwardian Museum of the University of Cambridge (fig. 1).

The more important bones which are absolutely distinctive of the Dinosaurian skeleton, such as the pelvis, astragalus, &c., have not been met with from the Cambridge Greensand; and though there have been obtained from that formation a large number of isolated and associated bones, which belong to several extinct genera, each having more or less in common with the described types of Dinosaurs beyond all question referable to the group, there is probably no bone more characteristic of the order than a badly preserved example of the second cervical vertebra. This solitary specimen is the result of more than a quarter of a century of zealous research,

Fig. 1.—*Axis of* Acanthopholis ?, *nearly nat. size.*



o. Odontoid process.
p. Pedicle of centrum supporting the neural arch, below which are the articulations for the rib.
pt. Posterior articular surface of centrum.

carried on by many collectors under opportunities which have never been surpassed; and therefore, though it only confirms, under certain generic differences, the characters of the axis from the Wealden described by me some time ago *, it seems worthy of a brief memorandum as showing that the Dinosauria retained this typical characteristic to so late a geological period as the Cambridge Upper Greensand.

The state of preservation of the fossil would suggest to me that it was probably found in the neighbourhood of Haslingfield. The neural arch is not preserved, and but little remains of the external hard film of bone; but although this is lost, and the cancellous tissue is almost everywhere exposed, the close resemblance of its form to the centrum of the Wealden axis strongly suggests that this condition is more likely to have resulted from prolonged exposure to the air, or from maceration, coupled perhaps with the action of solvents in the water, than to have been produced by attrition, though the marks of wearing are also observable. Therefore the specimen

* Quart. Journ. Geol. Soc. vol. xxxi. p. 461.

is more valuable as an evidence of form of the centrum than might at first sight appear, obscured though its surface is with small adherent masses of phosphatite, marl, oysters, and the shelly base of a *Gorgonia*-like polypary.

The striking features of the specimen are:—(1) the evidence that the neural arch was supported on pedicles of the centrum (fig. 1, *p*); (2) that the upper tubercle for the rib, usually called a diapophysis, was supported on this pedicle, and not on the neural arch itself; (3) the form of the odontoid process, which is compressed from below upward, and is almost a third of the length of the vertebra; (4) the form of the centrum, which is wide and depressed in front, and narrower, deeper, and subhexagonal behind; (5) the obliquity of the posterior articulation, which extends further backward at its ventral than at its neural border; and (6) the absence of all indications of a separate wedge-bone element beneath the anterior articulation,—the last point being perhaps the most interesting of all, because the Upper-Greensand Ichthyosaurs and Plesiosaurs similarly cease to have this ossification marked either by form or suture in the axis, although it is a characteristic separate element of the skeleton in the species which represent those orders in the older Secondary rocks.

The extreme length of the vertebra is $2\frac{1}{2}$ inches. The length along its neural border is about $2\frac{3}{10}$ inches; but, owing to the excavation of a large vertical space for the atlas below the odontoid process, the length along the ventral surface is only $1\frac{8}{10}$ inch. The neural canal is smooth, relatively large, and excavated in the centrum as a half-cylinder, which is $\frac{8}{10}$ inch wide in the hinder part of the vertebra.

The anterior articulation for the atlas is vertical and subreniform, concavely impressed below the odontoid process, so that its ventral margin was prominent. This concave area is $\frac{8}{10}$ inch wide, and is margined laterally by slight eminences, external to which the bone is again concave. The odontoid process (fig. 1, *o*) is slightly worn at its extremity and on its neural surface, but extends forwards in a broad wedge shape, also compressed from below upwards to some extent. The transverse measurement of the anterior face of the vertebra is $1\frac{1}{2}$ inch, while its vertical measurement, from the neural canal downwards, is $\frac{9}{10}$ inch.

The posterior articulation, as already remarked, is inclined forward (fig. 1, *pt*), is well cupped concavely, is a regular hexagon in outline, and is wider than the part of the centrum anterior to it. Its articular margins are a little worn; but it measured fully an inch from the neural to the ventral surface, and each side of the hexagon was about $\frac{6}{10}$ inch long.

The basal surface appears to have been flat from front to back, though its anterior margin is slightly worn. The articulations for the rib were placed much as in the Wealden specimen already described (Q. J. G. S. vol. xxxi. p. 461), except that in the Greensand fossil they are both relatively rather higher on the side of the centrum, and the parapophysis extends rather nearer to the anterior articular margin.

This specimen may be referred provisionally to Prof Huxley's genus *Acanthopholis*, though there is no certain evidence of its generic determination; its occurrence would justify the anticipation that this type of axis will be found to characterize all Cretaceous Dinosaurs. It is, however, remarkable that in *Zanclodon* the relations of the axis and the centrum of the atlas are entirely Crocodilian, and that the forms of the bones are so absolutely similar to the same elements in a Crocodile as to add a new element to the affinities of the Dinosauria, as indicated by this portion of the vertebral column.

Part II.

On the Vertebral Characters of Acanthopholis horridus, *Huxley*; *from the base of the Chalk Marl near Folkestone* (figs. 2 & 3).

Prof. Huxley's account of the remarkable Cretaceous Dinosaur named *Acanthopholis** is the basis for all future comparisons in estimating the affinities of the allied types which I am about to describe, some of which belong to species of the same genus, and others to genera all more or less nearly related. The most striking of the remains from the Cambridge Greensand are often portions of vertebral columns; and as the vertebræ of *Acanthopholis* have not hitherto been figured, it becomes necessary to add to the original description of the genus some account of these remains, part of which are in the Museum of the Geological Survey, while others are in the British Museum. As these remains were found at the same time they probably belong to one individual. Altogether there are hardly more than six or eight vertebræ, which give characters of the dorsal and early and later caudal portions of the series.

Dorsal Vertebræ.—The dorsal vertebra of *Acanthopholis* was briefly described by Prof. Huxley (Geol. Mag. 1867, vol. iv. p. 66). It is preserved in the Museum of the Geological Survey.

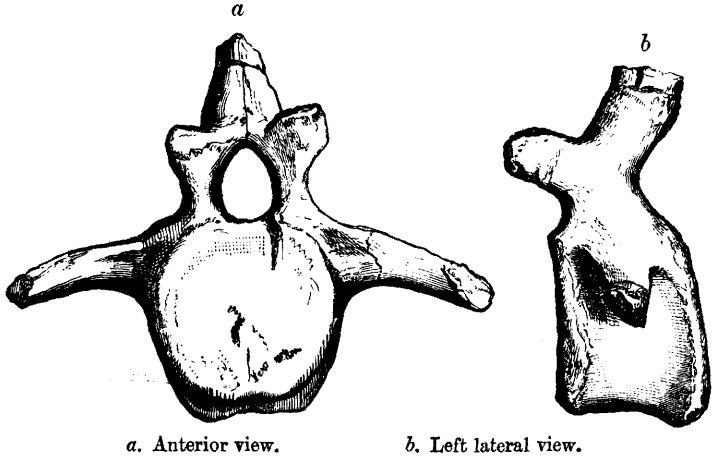
The anterior articular end of the centrum is 2 inches deep from the neural canal to the base, is vertically ovate in outline, $1\frac{9}{10}$ inch wide in the middle, and $1\frac{4}{10}$ inch wide at the upper part below the pedicels for the neural arch. The margin of the centrum is imperfectly preserved, and the flattened face is slightly concave.

The length of the centrum is $2\frac{1}{10}$ inches. The sides and base of the centrum are rounded from above downward. There is a very faint median ridge at the base, making the bone less concave from front to back than at the sides. The width of the middle of the centrum from side to side is $1\frac{9}{10}$ inch, and the width at the base of the neural arch in the middle of the centrum is $1\frac{5}{20}$ inch; the depth from the base of the neural canal to the base of the centrum is $1\frac{6}{10}$ inch. The neural canal is narrow with parallel sides; in front it is $\frac{5}{10}$ inch wide, and causes the centrum to project slightly below it anteriorly. The canal is deeply excavated in the bone. The condition of preservation of the specimen gives no indication of a suture with the neural arch, which probably existed.

* Geol. Mag. 1867, vol. iv. p. 65.

Early Caudal Vertebra (fig. 2).—The early caudal vertebra might be about the third. It has the centrum rather short, with the articular surface subcircular in front, and larger and subquadrate behind. The neural arch is moderate, with the compressed spine directed upward and backward; and the prezygapophyses extend outward in a V-shape, anterior to the face of the centrum. The transverse anchylosed caudal ribs are compressed from above downward, and directed outward and a little downward.

Fig. 2.—*Early Caudal Vertebra of* Acanthopholis horridus, *one half nat. size.* (From a specimen in the British Museum.)



a. Anterior view. *b*. Left lateral view.

The centrum, as in the early caudals of *Scelidosaurus*, has an aspect of leaning obliquely forward, partly owing to the articular surface for the chevron bones causing the posterior articulation of the vertebra to extend below the anterior articular margin, and partly in consequence of a real obliquity, as indicated by the angles made by the articular faces with the neural canal. The margins of the articular faces are apparently worn a little or roughened by decomposition. The antero-posterior measurement of the centrum is $1\frac{6}{10}$ inch below the neural canal, $1\frac{2}{10}$ inch through the middle of the concave articular faces, and nearly $1\frac{7}{10}$ inch towards the inferior visceral margin, so as to suggest a convex curve for the inferior outline of the tail.

The anterior articulation is somewhat markedly concave from above downward, has a thick rough rounded border, and is as nearly as possible circular, with a diameter of about $1\frac{9}{10}$ inch. The posterior articulation is subquadrate, but a little wider than deep, the width being about $2\frac{2}{10}$ inch. The depth from the neural canal to the facets for the chevron bones $1\frac{8}{10}$ inch, and to the base of the centrum rather over 2 inches. The least depth of the centrum from the middle of the neural canal to the middle of the basal visceral surface is $1\frac{8}{10}$ inch. The chevron facets, though prominent,

are not clearly defined; a broad median concavity on the basal surface of the centrum may indicate that they were separate. This chevron region is $1\frac{8}{10}$ inch wide, and not more than $\frac{4}{10}$ inch long; it is oblique, looking downward and backward.

The sides of the centrum are somewhat flattened, are obliquely inclined, and converge towards the base, which is about an inch wide, and defined chiefly by the rounded ridges in the line of the chevron bones. The sides are slightly convex from above downward, and moderately concave from front to back.

The transverse processes have their superior surfaces on a level with the base of the neural canal. At their union with the centrum they expand in every direction so as to have a nearly circular base and to spread to the width of the centrum. As preserved, the process is about $1\frac{7}{10}$ inch long. It is compressed from above downward, being twice as wide as deep, and tapers a little outward, being $\frac{7}{10}$ inch wide at the end. The posterior margin is more curved than the anterior margin; and while the superior surface is more flattened from side to side, the inferior surface is the more convex.

The neural canal is vertically ovate, about $\frac{8}{10}$ inch high and more than $\frac{5}{10}$ inch wide.

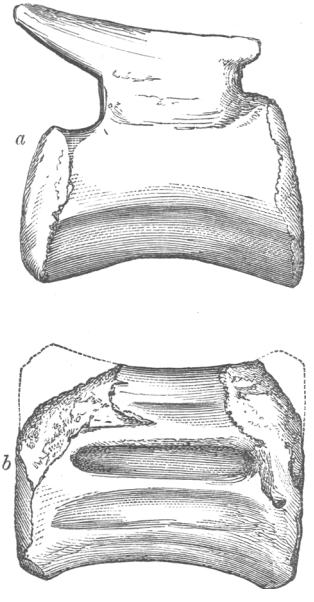
The neural arch is moderate, with the neurapophyses compressed from side to side and directed forward, so that the præzygapophyses project anteriorly to the front of the centrum; these processes were strong and subcylindrical; their articular ends appear to have been about $1\frac{8}{10}$ inch apart anteriorly, and to have converged backward in a Λ-shape, being deeply divided in front. Above the zygapophyses, of which the posterior are not preserved, the neural spine is directed obliquely backward, and becomes more compressed from side to side; it is fractured at less than 2 inches above the base of the neural canal, where it appears to be $\frac{8}{10}$ inch long and less than $\frac{5}{10}$ inch wide, and of an almond-outline in section, being sharper in front than behind.

Middle Caudal Vertebræ.—Centrum about $1\frac{1}{2}$ inch long, with the articular ends subcircular, wider than deep, the anterior apparently the larger, but both about $1\frac{2}{10}$ inch deep and wide (fig. 3). There is a rather deep, narrow, concave, median groove (see fig. 3, *b*) on the base of the centrum, about $\frac{3}{20}$ inch wide, which does not enlarge towards the ends. The sides are made subangular by two imperfect lateral ridges (see fig. 3, *a*), of which the lower is but slightly developed, and the upper one has in the middle the rudiment of a transverse process. The neural arch is compressed from side to side, prolonged backward beyond the centrum into a neural spine with parallel superior and inferior margins, more than $\frac{1}{2}$ inch deep and rising $1\frac{2}{10}$ inch above the base of the centrum, and compressed posteriorly from side to side. Anteriorly it is prolonged into two stout zygapophyses, which, as preserved, do not extend in front of the centrum.

The latest caudal vertebra preserved is in the Museum of Practical Geology. It has the centrum $1\frac{11}{20}$ inch long, and the neural arch rather shorter. The articular ends of the centrum are sub-

hexagonal and moderately concave. The depth of the anterior face is rather less than an inch; the width from side to side in the

Fig. 3.—*Middle Caudal Vertebra of* Acanthopholis horridus, *nat. size.* (In the Museum of Practical Geology.)



a. Right lateral view. *b.* From beneath, showing median longitudinal groove.

middle of the centrum is $1\frac{1}{10}$ inch. The upper outline of the neural arch is straight and oblique. The depth from the posterior end of the neural arch to the base of the centrum is $1\frac{9}{20}$ inch, while in front the corresponding measurement is $1\frac{7}{20}$ inch; the width over the anterior zygapophyses is $\frac{11}{20}$ inch. The posterior end of the neural arch (which is imperfectly preserved) tapers. The length of the union between the neural arch and centrum is $\frac{8}{10}$ inch. The ridges on the sides of the centrum are only developed towards the articular ends.

This vertebral column is quite distinct from that of any other genus, though, as indicated by Prof. Huxley, it closely approaches to *Scelidosaurus*. There is a close general correspondence in the form of the dorsal centrum, though in the lower part of the back *Scelidosaurus* appears to have the body of the vertebra more compressed from side to side. The early caudal vertebræ in *Scelidosaurus* are longer, and more oblique, and have the neural spine less inclined backward. The later caudal vertebræ in *Scelidosaurus* are much more elongated than in *Acanthopholis*, have the body more constricted, and have no trace of the inferior median groove or of the lateral ridges of *Acanthopholis*, while the form of the neural arch is altogether different. The basal groove, form of the caudal centrum,

and lateral ridges are rather indicative of resemblance to *Iguanodon*. The dermal armour, however, must not be neglected, as suggesting a not improbable and near relationship to *Hylæosaurus*. The Dinosaur from the Gosau beds (Upper Greensand), which Dr. Bunzel refers to *Scelidosaurus*, is closely allied to *Acanthopholis*, though it cannot be included in that genus.

Part III.

On the Skeleton of Anoplosaurus curtonotus, *Seeley, a Dinosaur from the Cambridge Greensand, contained in the Woodwardian Museum of the University of Cambridge.* (Plates XXXIV. & XXXV.)

At the close of the year 1872 Mr. Henry Keeping secured for the Woodwardian Museum, from one of the phosphatite-washings near Reach, an associated series of Dinosaurian bones, which, though indicating an animal of no large size, makes a considerable addition to our knowledge of the Cretaceous modifications of that organic type. In all there are about 77 bones or fragments of bones, which may be referred to under the following osteological headings :—

1. Anterior extremity of left ramus of lower jaw.
2. Five or six centrums of cervical vertebræ.
3. Twelve or thirteen centrums of dorsal vertebræ and fragments of ribs.
4. Six centrums of sacral vertebræ and fragments of sacral ribs.
5. Eight centrums of caudal vertebræ.
6. Four neural arches of vertebræ, chiefly dorsal.
7. Evidence of both coracoids.
8. Proximal end of scapula.
9. Proximal and distal ends of right humerus.
10. Proximal and distal ends of left femur; and other fragments, among which are metatarsal bones, phalanges, and fragments of the left tibia.

All the specimens are more or less broken and worn; they are incrusted with Oysters and *Plicatulæ*; but having lain in the sea where the phosphates were not abundant, are in a pale state of mineralization, and have few adherent masses of phosphate of lime upon them. Like the other Cambridge-Greensand fossils which have come under my notice, they show no signs of being derivative, and appear to me to be of Upper Greensand age.

The Lower Jaw.—The fragment of jaw (Plate XXXV. fig. 1) is $2\frac{3}{8}$ inches long. It is fractured posteriorly, inferiorly, where the inner margin of the bone is thin, and anteriorly, so that it affords no evidence of the nature of the symphysial union of the rami other than that it was very short and narrow. The jaw becomes less deep from behind toward the anterior extremity, as in other Dinosaurs, and teeth were apparently continued almost, if not quite, to the anterior end. The alveolar margin is nearly straight, being but very slightly convex externally, and similarly concave internally. It is compressed from side to side, $\frac{3}{8}$ inch thick posteriorly, and $\frac{5}{16}$ inch thick anteriorly; it may have been vertical. As preserved,

the external alveolar wall is higher than the inner wall, and appears always to have been higher. In the length of $2\frac{1}{4}$ inches are the sockets or spaces for thirteen teeth; the sockets appear to have been nearly half an inch deep, and parallel to the inner surface of the jaw, so that the teeth were directed outward. The sockets were apparently nearly circular; but owing to this outward direction they appear as though they were transversely oblong. The inner surface of the jaw is approximately parallel to the outer surface; it consists of two areas—a long flat superior space, the plane of which is twisted a little outward anteriorly, about $\frac{5}{8}$ inch deep, and limited inferiorly by a sharp straight angular ridge; and below this is a channel attenuated anteriorly, the side of which bends under the superior area (see Pl. XXXV. fig. 1 *a*). The thickness of the bone becomes reduced below the ridge, being hardly more than $\frac{1}{8}$ inch thick where fractured along its inferior border, which is directed inward. As preserved, the groove is not more than $1\frac{1}{2}$ inch long, hence the symphysis could not have occupied more than an inch in front of the groove.

Externally the specimen consists of an inferior part, convex from above downward, corresponding to the internal groove, and therefore extending longitudinally from behind forward, bulging out so as to widen the jaw to $\frac{5}{8}$ inch, and dying away in front, where the jaw is moderately convex from the alveolar margin downward. Above this longitudinal inferior convexity the bone is very slightly channelled in length, being slightly concave from above downward. Along this space are several vascular perforations at irregular distances, which become small and more numerous towards the anterior extremity of the specimen. The extreme depth of the fragment as preserved, at the posterior fracture (Pl. XXXV. fig. 1 *a*), is about $1\frac{1}{8}$ inch.

This form of jaw has hitherto been described in no British Dinosaur; but on some future occasion I expect to be able to show that an animal with a similar mandible has left its remains in the Gosau beds of Austria, which are also of Upper Greensand age.

The Vertebral Column.

Cervical Vertebræ.—None of these vertebræ have the neural arches preserved, and all have the margins of the centrums and the tubercle for the rib worn. This gives rise to some uncertainty as to whether the sixth vertebra is not rather a first dorsal, as I incline to believe. The five vertebræ (Plate XXXIV. fig. 1) are similar in size, and measure $7\frac{1}{4}$ inches in length when placed in close succession, without making any allowance for the intervertebral cartilages. The earliest vertebra preserved has the centrum somewhat depressed; but the centrums increase slightly in depth as they succeed each other backward, and decrease slightly in length. The first (fig. 1, 1), as preserved, is fully $1\frac{1}{4}$ inch long, with the anterior articular surface worn, so that neither its width nor depth can be given with certainty; though, as widened by the diapophysis, it is obviously wider and does not appear to be so deep as the posterior articular end. The diapophysis is large, and placed low on the side

of the centrum just behind the anterior articulation; the transverse width over the diapophyses appears to have been at least $1\frac{3}{8}$ inch. Behind the diapophyses the centrum is constricted regularly, so as to measure 1 inch from side to side. The sides and base are concave (Pl. XXXIV. fig. 1 *a*) from front to back; but the sides have a somewhat vertical aspect and the base a broad and flattened aspect, owing to these regions being separated by slight angles at the margin of the posterior articulation, though the base is moderately convex from side to side, and rounds into the superior lateral regions. The ovate posterior articulation has had its margin rubbed; it is flattened, but moderately concave, much as in Teleosaurs, and is $\frac{15}{16}$ inch deep and $1\frac{1}{8}$ broad, as preserved. The neural arch may have extended the whole length of the centrum; the neural canal is shallow, widened posteriorly, and contains small nutritive foramina in the middle.

The second vertebra preserved (fig. 1, 2) has the base of the centrum more rounded, and consequently the diapophysis appears to be rather higher on the side of the centrum. The centrum is less constricted from side to side behind the diapophyses, the sides of the centrum are more convex in depth, the centrum is shorter, and the articular surfaces appear to be larger. The following are the measurements of the specimen as preserved:—

Along the base of the centrum $1\frac{3}{16}$ inch, less along the neural canal; width over remains of diapophyses $1\frac{3}{8}$ inch; depth of anterior articular face 1 inch; width behind the diapophyses $1\frac{1}{8}$ inch; width of posterior articulation $1\frac{1}{4}$ inch; depth of posterior articulation $1\frac{1}{16}$ inch.

The external margins of the bases for the neural arch are compressed so as only to measure $\frac{15}{16}$ inch from side to side.

In the succeeding cervicals (fig. 1, 3, 4, 5) the differences are slight, except from the increased depth of the centrum, which in the fifth measures $1\frac{1}{8}$ inch deep posteriorly, as preserved. The anterior articulation of the centrum is in all cases nearly flat; but the posterior face is moderately cupped, often with a central depression. The base of the neural canal, too, becomes more deeply channelled; it is impressed in the middle with the nutritive foramina, and the tubercle for the rib rises higher on the side of the centrum. Since the first vertebra preserved is posterior to the axis, this animal must have possessed at least seven cervical vertebræ; but there were probably not more than eight, since not more than one vertebra appears to be missing from between the last cervical and first dorsal of the series.

Dorsal Vertebræ (Pl. XXXIV. fig. 2).—There are thirteen dorsal vertebræ, or vertebræ from between the neck and the sacrum. They appear to be in sequence, and therefore, if the number were similar to that in the Crocodile, the gap between the dorsal and sacral series must be very small. In the Crocodile the series can readily be divided by the relations of the ribs into three groups, comprising, after the eight cervical, three pectoral, seven dorsal, and six postdorsal or lumbar. Nothing corresponding to this division can be recognized in the fossil, because only the centrums of the vertebræ are preserved.

These centrums are exceedingly similar in form, but increase slightly in length as they pass down the back, and when placed together in sequence, with their articular faces in contact, form an upward arch, which is unlike the straight horizontal column of the Crocodile, and suggests, I think, that the body may have been carried in a semi-erect position, as was certainly the condition in so many of the Dinosauria. The form of the centrum, which is well rounded on the underside (fig. 2*a*), is remarkably Teleosaurian. The position of each vertebra in the series is determined by length, size of the articular ends, and shape, width, and degree of excavation of the area which forms part of the neural canal, there being a marked increase in width and depth on nearing the sacrum, while the neural area widens posteriorly on nearing the neck.

The first centrum of the series is fractured transversely, as though by a stroke of the workman's pick, and only the posterior half is preserved. It shows the articular area for the neural arch to be exceedingly broad, and the posterior face of the centrum is very slightly concave, being much less impressed in the middle than in the cervical region. The second dorsal measures $1\frac{2}{10}$ inch from front to back, has an aspect of slight compression from side to side, where it measures 1 inch in the middle of the centrum, becoming a little wider towards the neural arch. The depth of the centrum from the neural canal is $1\frac{3}{20}$ inch. The posterior articular face is almost absolutely flat. The third dorsal is rather better preserved; it measures $1\frac{5}{20}$ inch in length, is rather more flattened at the sides and ends, and has the neuro-central suture so uniform that the back of the vertebra can only be recognized by the nutritive foramina in the neural canal being placed slightly behind the middle line. The fourth dorsal slightly increases in length, and is more compressed below the neuro-central suture, so that the articular faces of the centrum become vertically elongated, measuring, as preserved, $1\frac{3}{10}$ inch in depth and $1\frac{3}{20}$ inch wide. The fifth to the twelfth centrums are about $1\frac{1}{2}$ inch long, and have the sides of the neural canal rather narrower than in the earlier dorsal region, the sides being subparallel, with a slight expansion at both the anterior and posterior ends. The neuro-central suture is slightly convex from back to front, is marked with transverse grooves, as in Teleosaurs, and in the seventh centrum the lateral compression reduces the transverse measurement in the middle of the suture to $\frac{17}{20}$ inch. Towards the end of the dorsal series the articular face of the centrum is more nearly circular, and it becomes flat at one end, and somewhat concave at the other. There is no certain evidence on the matter; but I am inclined to regard the somewhat larger end with the concavity as anterior, on the ground that the neuro-central sutural surface is somewhat wider towards the concave end. Hence there would seem to be an approach towards a procœlous articulation in the lower part of the back, which may be a functional development consequent upon a semierect mode of progression. The last dorsal is much longer in the neural than in the visceral measurement, the extreme length being $1\frac{13}{20}$ inch. There is no important change in the

size or form of the articular face. When placed together, end to end, without allowance for intervertebral cartilages, the series of dorsal vertebræ measures 19 inches; but this does not represent the entire length of the dorsal region, because at least one vertebra is missing between the last dorsal and first sacral, and at least one between the first dorsal and last cervical.

Neural Arch.—The most perfect specimen of a dorsal neural arch is figured (Pl. XXXV. fig. 14). It measures $1\frac{11}{20}$ inch from the sutural surface uniting with the centrum, to the slight transverse platform (*a*) from which the compressed neural spine (*e*) rose; though now broken away, the platform was horizontal, small, convex from front to back, concave from side to side, with the outer prolongation notched out posteriorly and directed a little upward. Its anterior border reaches no further forward than the middle of the neurocentral suture. There is the usual strong buttress below this transverse process, compressed from side to side, and terminating in an elevated vertically ovate articulation for the rib (*b*), looking outward and a little upward, $\frac{3}{10}$ inch wide and $\frac{5}{10}$ inch long, above which the buttress is constricted, and below which it widens and disappears. The prezygapophyses are broken away (*d*); but the posterior zygapophyses (*c*) are flat ovate facets looking obliquely downward and outward, converging inferiorly so as almost to unite, but remaining separated by a groove. The arch over the neural canal is remarkably high and narrow.

Dorsal Ribs.—The dorsal ribs are represented by a number of fragments, but none are sufficiently perfect to give any idea of their length. The fragments are all more or less curved. The two specimens figured (Pl. XXXV. figs. 11, 13, 12) give some idea of the difference in size of the specimens and of the typical characters which they present. They are especially remarkable for having the under or visceral surface compressed and the dorsal surface expanded like the crosspiece of a capital T. This would suggest a great development of intercostal muscles, and would have led me to anticipate for the animal some form of dermal armour; but since no trace of armour was found with the remains, the explanation of this form of rib has yet to be discovered.

Sacral Vertebræ (Pl. XXXIV. fig. 3).—The sacral vertebræ, as preserved, are six in number, and the series is apparently complete; but they do not become anchylosed into a sacrum, though the articular surfaces were evidently in intimate juxtaposition. It is impossible to affirm that this condition is proof of the immaturity of the individual, though such a conclusion is natural. As placed together, end to end, the series of vertebræ measures $8\frac{1}{2}$ inches in length. As in the other regions of the vertebral column, there is no trace preserved either of neural arches or of the short sacral ribs in union with the centrums, except the impressed surfaces for their articulation upon the sides of the centrums. In the absence of the usual aids for determining the order of succession of the bones, I have arranged them in sequence by means of the form of the neural canal and the mutual adaptation of the articular surfaces. Like the sacral ver-

tebræ in other Dinosaurs, these centrums are of dissimilar forms, and are unlike the dorsal vertebræ, which all have the visceral surface well rounded, as in Crocodiles.

The first sacral (fig. 3, 1) is $1\frac{6}{10}$ inch long along the neural canal, and about $\frac{1}{10}$ less along the visceral border. The base and sides are flattened, though the sides are moderately concave in length, and slightly convex from above downward, in which direction they converge. The base is defined by well-rounded shoulders, which merge into the sides; it is slightly concave in the middle towards the two ends. The anterior articular surface is much the smaller of the two, is vertical, flattened, slightly concave from above downward, and subquadrate, being wider above than below. From the neural canal to the base is $\frac{9}{10}$ inch. The width of the centrum just below the neural canal is $1\frac{2}{10}$ inch, while the width at the base is about $\frac{7}{10}$ inch. The neural canal is very large, deep, widens rapidly behind, and gives off the first pair of sacral nerves anterior to the posterior articular surface, where the transverse measurement is $1\frac{1}{4}$ inch. In front the neural canal is about $\frac{6}{10}$ inch wide; posterior to the excavations for the sacral nerves the width is probably nearly double. The posterior articulation is angularly crescentic, being concave above in the line of the neural canal; it is $\frac{8}{10}$ inch deep, $1\frac{1}{2}$ inch wide at the upper margins of the neural groove in the centrum, and about $\frac{8}{10}$ inch wide at the base. The surface is flat, but marked with grooves, which radiate towards the sides and base. The length of the wall for attachment of the neural arch is less than an inch; it is compressed from side to side, and increases in width in front. There is no indication of a rib to the ilium having originated from the centrum of this vertebra.

In the second sacral (fig. 3, 2) the centrum attains its greatest width, and the neural canal acquires its largest size; but in form the vertebra is unlike the first, especially being depressed and much broader than long, with a rough parallelism between the convex visceral surface and the concave neural canal. The extreme length of the centrum is $1\frac{13}{20}$ inch; but it is somewhat less in the median line, since the posterior face is concave from side to side. The base is flattened, but rounds into the sides, which slope obliquely outward, more rapidly towards the posterior than towards the anterior end. In front the flat articular face of the centrum is $\frac{8}{10}$ inch deep; it is of subcrescentic outline, extending superiorly up each side of the neural canal, where the horns are $\frac{1}{2}$ inch wide. The posterior articulation is an arc of a large circle, as wide at the sides as in the middle, where it is $\frac{8}{10}$ inch deep. The pedicles for the neural arch reach from the anterior face of the centrum backward $\frac{9}{10}$ inch, and diverge outward; they are $\frac{1}{2}$ inch wide, and narrow posteriorly. They are bounded behind by the large canals for the sacral nerves, larger on the left side than on the right; these canals are directed obliquely forward. Behind and chiefly below these grooves are the large, subcircular facets, $\frac{3}{4}$ inch in diameter, for the sacral ribs, which look outward, backward, and somewhat upward, extending to the posterior articular surface of the centrum, and by their transverse extension making

the side of the centrum concave from front to back. The transverse width of the centrum at the notches for the sacral nerves is $1\frac{3}{4}$ inch; the transverse width over the front of the facets for the sacral ribs is about $2\frac{1}{4}$ inches; the width of the neural canal between the pedicles for the neural arch, as preserved, is $1\frac{1}{4}$ inch.

The third sacral vertebra (fig. 3, 3) is smaller, with the centrum similarly depressed, the neural canal almost as large, the anterior intervertebral articular surface convex from side to side, and the posterior articulation similarly concave, the latter being relatively deeper; the length of the centrum in the median line is $1\frac{1}{2}$ inch. The base is flattened, slightly convex in the middle portion, and measures $1\frac{17}{20}$ inch transversely. This great width, like the flattening, results from the fact that the whole of the side is occupied by surfaces for the attachment of sacral ribs. The two pairs of these surfaces are divided by the grooves for the sacral nerve, which are only half as wide as those in the second vertebra; these grooves are $\frac{8}{10}$ inch from the anterior articulation, and are directed outward, a little backward, and vertically downward between the facets for the sacral ribs as a canal $\frac{3}{20}$ inch wide. The anterior of these rib-facets is the larger; it is an inch deep, and not quite so long, being subquadrate; the surfaces look outward, forward, and very slightly upward, and extend to the anterior articular surface of the centrum. The posterior facet is fully as deep, but not more than half an inch in length; it extends back to the posterior articulation, and looks outward and backward. The greatest transverse measurement is 2 inches at the middle of the centrum. The neural arch appears to have been attached to both the anterior and posterior ends of the centrum by pedicles, which are coextensive with the length of the facets for the sacral ribs. The superior and inferior margins of the articular faces of both ends of the centrum are subparallel, about $\frac{8}{10}$ inch deep; but the anterior articulation has the greater transverse measurement, and increases in depth a little towards its lateral limits. The width of the neural canal, as preserved, is $1\frac{1}{10}$ inch, but becomes less posteriorly.

The fourth sacral vertebra (fig. 3, 4) has greatly decreased in size. There is a vertical elevated ridge in the middle of the anterior articular surface of the centrum, on each side of which the flattened surfaces are slightly concave; the outline of the articulation is reniform, it is more than $\frac{8}{10}$ inch deep, and was about $1\frac{3}{10}$ inch wide. The under surface of the centrum has a conspicuous rounded median ridge, most marked posteriorly, and on each side the halves of the base are flattened and converge inferiorly. The posterior articular surface of the centrum is relatively narrow (because there is only one pair of facets for sacral ribs, and they are immediately behind the anterior articulation); it is $\frac{9}{10}$ inch deep in the middle, and $1\frac{7}{20}$ inch wide at the upper third; the surface is concave from side to side, and most impressed in the upper part of the middle line. The neural canal widens in its hinder third, where it gives off a pair of sacral nerves, which are directed slightly backward as they pass out. The anterior lateral facets for the sacral ribs are large, extend back behind the middle line of the centrum, and were directed forward and out-

ward. The neural canal again becomes narrower behind than it was in front.

In the fifth sacral vertebra (fig. 3, 5) the centrum reverts very much to the form and proportions of an early dorsal, being compressed at the sides, having the base well rounded, and the margins of the articular surfaces well elevated. It is $1\frac{1}{4}$ inch long, and has the body of the vertebra relatively deep in proportion to the width. The anterior articulation is half an oval, with a prominent tubercle below the neural canal, and on each side of this tubercle is a depression; the surface is otherwise flattened, but slightly convex from side to side; it is $\frac{9}{10}$ inch deep in the middle, and about $1\frac{2}{10}$ inch wide in the upper third. The posterior articulation is more nearly subquadrate; it is rather deeper, about as wide, is flattened, but concavely impressed in the median line below the neural canal. The facet for the sacral rib is small, and limited to the upper third of the side of the centrum. The neural canal has now become much smaller than in the first sacral, and the nerves are given off very high up, more than $1\frac{2}{10}$ inch from the base of the posterior articulation, and hardly more than a quarter of an inch anterior to it.

The sixth and last sacral centrum (fig. 3, 6) approximates in characters to an early caudal; but the neural canal is more deeply excavated than in the caudal region, while the large size of the attachment for the neural arch and the form of the anterior articulation show it to be sacral. It is $1\frac{2}{10}$ inch long in the line of the neural canal, and less in the basal measurement. The anterior articulation is less than an inch deep, and is widened transversely by the large facet for the sacral rib to about $1\frac{2}{10}$ inch, but the transverse measurement over those facets is $1\frac{6}{10}$ inch. Below the neural canal, which is only $\frac{3}{10}$ inch wide in front at the base, is a prominent tubercle, with a concavity on each side, as in the fifth vertebra, below which the surface is similarly marked with slight grooves, such as are usually seen in cartilaginous surfaces between which there is no motion. The posterior surface is more nearly circular, and measures more than an inch in depth and $1\frac{3}{10}$ inch wide; in its centre is an elevated tubercle, as usual in caudal vertebræ, and around this the surface is concave and marked with faint concentric lines. The base of the centrum is well rounded, but its sides are pinched in concavely below the facet for the last sacral rib; this facet appears to have been transversely elongated and to have looked outward. The attachment of the neural arch appears to have extended the whole length of the centrum, and to have been wider than in any of the other sacral vertebræ.

This sacrum gives evidence of only four sacral ribs (Pl. XXXIV. fig. 4). The first, attached between the second and third centrums, and the second, between the third and fourth centrums, were massive, the former being $1\frac{1}{2}$ inch in diameter at its origin and the latter rather less. These were the true sacral elements, and would correspond to the sacrum of the Crocodile or Teleosaur. The third and fourth sacral ribs are small; the former is given off from the fifth, and the latter from the sixth sacral vertebra. The great enlargement

of the neural canal in the sacral region, where it becomes much wider than the entire diameter of a dorsal centrum, and the absence of any corresponding pectoral enlargement is strongly suggestive, not only that the hind limbs were relatively more developed than the fore limbs, but that progression was carried on by means of the hind limbs; and the slight increase in size of the centrums from the neck to the sacrum would support such a conclusion.

Caudal Vertebræ (Pl XXXIV. fig. 5).—The eight caudal vertebræ, when placed together in close succession, measure $8\frac{1}{2}$ inches in length, and when so placed arrange themselves in a curve, which has the convex side downward, while the dorsal and sacral regions form a curve in the opposite direction; and this curve of the tail appears to be correlated with the elevation of the root of the tail well above the ground.

Each centrum is just over an inch long, the last of the series being of the same absolute length as the first, though the vertical and transverse measurements have become greatly reduced. The first caudal of the series exactly corresponds in size with the posterior articular face of the last sacral vertebra.

The anterior face of the second centrum is flattened, but slightly concave, is of subcircular outline, nearly $1\frac{2}{10}$ inch wide and nearly $1\frac{1}{10}$ inch deep. The posterior face (fig. 5 *a*) is subtriangular, owing to the sides converging inferiorly and terminating in the oblique facet for the chevron bone, which is more than half an inch wide, and rounds upward into the intervertebral articular surface. This surface is $1\frac{1}{10}$ inch wide in its upper third, and nearly $1\frac{2}{10}$ deep to the base of the chevron articulation: it is much more concave than the anterior articulation, and the depression is similarly deepest just above a slight mamillate eminence in the centre of the intervertebral surface. The antero-posterior measurement of the centrum is 1 inch. The base of the neural arch has come away on the left side, leaving a large pit $\frac{3}{4}$ inch long and $\frac{4}{10}$ inch wide. On the right side the pedicle has remained attached, and shows that from this broad base a small compressed lamina ascended, directed inward, to form the arch over the neural canal. At the sides of the centrum are, on each side, an ovate facet more than half an inch long and of less depth, placed midway between the anterior and posterior articular faces of the vertebra. These facets gave attachment to the transverse processes or caudal ribs; they have an elevated border, and the upper fourth is formed by the pedicle of the neural arch, while the remainder of the facet is on the upper part of the side of the centrum. In subsequent vertebræ this facet decreases in size, descends a little in position, and is placed nearer to the posterior end of the centrum. The sides of the centrum converge inferiorly towards a flattened narrow base, which is about $\frac{4}{10}$ inch wide, and owes its existence and imperfect definition to the chevron bone attached to the base of the posterior articular surface. The ventral surface of the first centrum is considerably more convex from side to side. In the sixth caudal the width and depth of the centrum are about an inch; the antero-posterior extent of the narrow lamina of the neural arch is $\frac{9}{20}$ inch; the transverse process appears to be short, thick, and

directed a little backward. The base is better defined by an obscure angular ridge, and midway on the side, below the transverse process, is another angular ridge. The articular ends of the centrum are more concave than in the earlier vertebræ. The first six vertebræ (fig. 5) are in natural sequence; then the series is broken by the loss of probably four vertebræ. The remaining two centrums preserved were followed by at least four more, so that the tail may have included at least sixteen vertebræ, and have measured at least as many inches.

The last centrum preserved has the anterior face $\frac{19}{20}$ inch wide and $\frac{15}{20}$ inch deep, with the outline flattened above and convex below. The posterior face is $\frac{9}{10}$ inch wide and $\frac{8}{10}$ inch deep. There is an indication of division in the chevron facets. The underside of the centrum becomes rounded, and the size of the transverse process, still high on the side, is reduced to a mere tubercle. The neural canal is narrow and slightly channelled in the centrum, and the base of the small neural arch was less than $\frac{4}{10}$ inch long.

The Scapular Arch.

Coracoids.—The right coracoid is only preserved in a fragment, but the left is fairly perfect (Pl. XXXV. fig. 2). It was an expanded subquadrate bone of the usual pattern, thick at the articular surfaces for the humerus and scapula, and thin at the two other edges, the anterior and upper of which is broken. The underside of the bone is concave, the upperside gently convex. It is $3\frac{4}{10}$ inches wide from the scapular to the inferior margin. The surface to which the scapula was attached (fig. 2, *b*) is convex in length, as preserved, and imperfectly ossified. It measures about $1\frac{1}{2}$ inch in length, is $1\frac{1}{10}$ inch thick at the junction with the humeral surface, and becomes compressed as it ascends. The humeral surface (fig. 2, *a*) is subquadrate, $1\frac{2}{10}$ inch long, and of about the same thickness; it is smooth, truncating the bone transversely, and nearly flat. Below the humeral articulation the bone is emarginate on the external surface, and the emargination resembles the appearance that would be produced by drawing the thumb over the angle of a plastic substance. The portion of the anterior border which looks downward is $2\frac{1}{2}$ inches long, as preserved, and thin, thickest at the corner nearest the humerus, and becoming attenuated as it ascends. The other upperside, which is somewhat broken, is about $2\frac{1}{4}$ inches long. The coracoid foramen is placed about the middle of the scapular margin, and extends obliquely inward, upward, and backward; it is about $\frac{3}{10}$ inch in diameter, and penetrates into the scapular margin as it emerges on the inner side of the bone.

Scapula.—The scapula is known from an important fragment, comprising the articular end of the right side of the bone (Pl. XXXV. fig. 3). It is imperfectly preserved at the anterior border, but is 3 inches wide. The humeral surface (*a*) is flat, $1\frac{1}{4}$ inch long, and about as wide; it is rounded posteriorly, and convex on the inner surface from side to side. The coracoid surface (*c*) is divided into two portions, and is somewhat compressed from side to side. The inner surface of the bone is concave from above downward. The pos-

terior outline is moderately concave, while the anterior outline is more concave, rounding distally into a convex outline, which is partially broken away. The specimen is $3\frac{1}{2}$ inches long, and, where fractured, the ascending shaft is $1\frac{1}{2}$ inch wide, $\frac{9}{10}$ thick, and more compressed on the inner than on the outer margin. The distinctive feature of the bone which separates it from other scapulæ is the development towards the humeral side of a massive quadrate spinous process (fig. 3, *b*), which increases the thickness of the bone to $2\frac{1}{4}$ inches. It is $\frac{1}{2}\frac{9}{0}$ inch wide, margined posteriorly by a sharp ridge, anteriorly by a rounded ridge, is rounded inferiorly almost as perfectly as a pulley surface, and flattened externally till it merges, after about 2 inches, in the free end of the scapula. It extends to within about half an inch of the humeral articulation, and is directed obliquely forward across the bone.

The Fore Limb.

Humerus.—Only the right humerus is preserved (Pl. XXXV. figs. 4, 5). It has been fractured by a blow from a digger's pick, which has removed the middle portion of the shaft and broken away the radial crest. The distal articular end is imperfect, owing to decomposition of the bone before fossilization, and its decayed surface, like the body of the shaft, is overgrown with *Plicatulæ*. The humerus is larger than might have been anticipated in an animal otherwise giving indications of a semierect position. It was probably not less than 9 inches in length, evidently possessed a long and compressed radial crest, which reached at least halfway along the bone, had the proximal end massive and the distal end fairly expanded, while the lower part of the shaft was constricted in the usual manner. As preserved, the specimen at the proximal end (fig. 4) is nearly flat on the ventral surface, with the slightest indication of concavity from side to side. The extreme width from side to side is rather less than 3 inches, as preserved; but the bone was somewhat wider, since no part of the radial crest is preserved, though its limit is indicated by a slight reflection downward of the margin of the fragment at the fracture (fig. 4, *a*). The radial crest appears proximally to have been about half an inch thick, and to have extended to within about three fourths of an inch of the proximal end of the bone. It is separated from the articular head by an oblique region, which is somewhat compressed, less than 1 inch long, a little concave in length, and rounded from side to side. The head of the bone (fig. 4, *b*) is subovate, but the margins of the articular surface are a little worn or decayed. It is slightly convex in its long diameter, from the ulnar to the radial side, which measures about $1\frac{9}{10}$ inch, and rather more convex from the dorsal to the ventral side, where it measures about $1\frac{6}{10}$ inch. Its margin bulges convexly on the dorsal aspect, but not so markedly as in some other Dinosaurian types, such as *Hadrosaurus*; it is even less than in the humerus attributed to *Hylæosaurus*, and is perhaps more nearly like *Scelidosaurus*, though the resemblance would appear to be closer to another and undescribed Dinosaurian genus from the Lias. The proximal articular surface is smooth, though marked by irregular

shallow grooves, which may indicate that it possessed a terminal articular cartilage, though developed to a less extent than in the Ceteosaurians of the Lower Secondary rocks. Towards the ulnar side the articular surface becomes narrow and prolonged, like the stalk of a fig (fig. 4, *c*); but this portion is inclined at an angle of about 45°. It is nearly flat in its long measurement, which is more than an inch, and slightly rounded in its narrow measurement, which appears to have been less than three quarters of an inch. It gives an extreme length of articular surface to the head of about $1\frac{7}{10}$ inch. Externally the ulnar margin is well rounded from side to side, about $\frac{6}{10}$ inch thick, and by its compression forms on the dorsal surface a concave longitudinal channel, which descends some little distance on that aspect of the bone. Below the articular head of the bone the shaft is convex from side to side, but becomes rapidly compressed, so that 2 inches below the articular surface its thickness is scarcely 1 inch. The fragment is unfortunately only about 2 inches long; it shows indications of the lateral margins rapidly converging, is marked on the dense external layer with longitudinal striæ, and shows at the fractured end fine cancellous tissue, but no trace of a medullary cavity.

Distal end.—The distal end (fig. 5) apparently formed an angle with the proximal end in the usual way, so far as can be judged by comparison of the proximal and distal fractured surfaces of the humerus. The distal fragment is $4\frac{1}{2}$ inches long, and at its proximal end has a subtriangular section, measuring nearly $1\frac{1}{2}$ inch in the greatest long diameter, from the ulnar to the radial sides, and about 1 inch in the greatest short diameter, which is towards the ulnar side from back to front. It will thus be seen that the bone is compressed towards the lower radial margin, and the strong crest which is there indicated is the distal termination of the radial crest. The long axis of this section is at an angle of about 45° to the axis of the distal articulation. The ventral side is here flattened, but has a slight indication of a longitudinal concavity. The dorsal aspect is divided into two areas by a rounded angular bend, that of the ulnar side is the shorter and less convex. The shaft continues to decrease in thickness towards the distal end, where it measures, just above and between the condyles, $\frac{9}{10}$ inch, and it more rapidly increases in width, though, from the radial condyle being broken away, it is impossible to state accurately what the width was, though it could not have been less than 3 inches.

Metacarpal bone.—This small well-preserved specimen I am inclined to regard as the fifth or outer metacarpal of the left fore limb. It is $1\frac{4}{10}$ inch long, and has the proximal articulation subtriangular, $\frac{9}{10}$ inch wide and $\frac{8}{10}$ inch deep, with the apex of the triangle below. The articular surface is nearly flat, but slightly oblique, as shown in the figure (Pl. XXXV. fig. 9).

The bone is compressed from above downward, $\frac{6}{10}$ inch wide in the middle of the shaft and $\frac{4}{10}$ inch deep. It terminates distally in an oblong surface, which is convex from above downward and from within outward, and has the upper outer corner rounded away. The surface is fully $\frac{8}{10}$ inch long and $\frac{6}{10}$ inch deep.

The Hind Limb.

The Femur (Pl. XXXV. fig. 6) is very imperfectly preserved, having been considerably fractured by the workmen. A portion of the proximal end is preserved, which is about $3\frac{1}{4}$ inches long, and displays a small piece of the outermost part of the proximal articulation (*a*), showing it to have been comparatively smooth and slightly convex from front to back, in which direction the measurement was rather more than 1 inch. The bone was flattened behind, but was not flattened on the external aspect at the proximal end. Here it is convex from within outward, and also rounds into the posterior surface. In front there is a strong proximal trochanter (fig. 6, *b*), somewhat of the type seen in *Iguanodon*, but more compressed; it is closely adherent to the shaft without being anchylosed to it. The cleft on the posterior side is more marked than on the anterior side, and extends for $1\frac{3}{4}$ inch below the proximal articular surface. This trochanter is broken away in its upper part, but its base is $\frac{7}{10}$ inch wide and nearly $\frac{3}{10}$ inch thick. The inner half of the proximal end of the bone is broken away.

The distal end is represented by a small portion of the shaft, also of a left femur, and therefore presumably the same bone. It is from just above the distal condyles, and shows on the posterior surface the usual groove between the condyles, which is placed, as usual, nearer to the inner than to the outer side of the bone. The fragment, which is only $1\frac{1}{2}$ inch long, is 2 inches wide at the distal end, and the greatest antero-posterior measurement is $1\frac{3}{20}$ inch, while in the condylar groove (fig. 7, *a*) the measurement is $\frac{17}{20}$ inch. The front is flattened, with a slight tendency to a median longitudinal depression. The inner side is slightly flatter than the outer side; but both are well rounded, and round into the two halves of the posterior surface. There is no indication of any expansion of the bone at the distal end, and it is improbable that the strong external muscular process seen in some genera was here developed.

The bone had a large medullary cavity; it is dense at its circumference, and finely cellular internally. I estimate the length of this femur to have been about 12 inches. Its distinctive features are the compression and position of the proximal trochanter. Its imperfect preservation renders comparison with other types at present difficult.

The Tibia.—The left tibia is represented by two fragments of the shaft, which give no indications of the forms of either the proximal or distal articular ends. The distal end decayed before fossilization, but the proximal end and middle of the shaft appear to have perished under blows from the diggers' picks. Proximally the larger fragment is triangular, being flattened behind and obliquely compressed from side to side so as to form a strong cnemial crest, which is directed outward in front of the proximal end of the fibula. The oblique inner and anterior surface of the bone is flattened. The external or fibular side (Pl. XXXV. fig. 8, *a*) is gently channelled from front to back. The width of the fragment, as preserved, from

side to side posteriorly is $1\frac{3}{20}$ inch, from front to back at the external border $1\frac{3}{10}$ inch, and from the cnemial crest to the inner posterior border $1\frac{6}{10}$ inch. The two posterior angles of the bone are rounded, and the cnemial crest, which is gently concave in the outline of its length, becomes more compressed proximally.

The distal fragment becomes flattened in front and convex from side to side behind, with the fibular side flattened and front inner margin angular. The bone curves a little forward towards the distal end. Its measurement from side to side is reduced to $\frac{8}{10}$ inch, and from back to front to $\frac{13}{20}$ inch. The medullary cavity is very large; its wall is thinner in front than elsewhere.

The tibia was more slender than might have been expected, and appears to have been of about one fourth the size of the tibia of *Hadrosaurus* figured by Leidy. It closely resembles in form the same element of the skeleton in some Dinosaurs from Gosau.

Metatarsus.—The metatarsus is represented by the proximal halves of three bones somewhat rubbed, and a distal end of another. The fractures show them to have had medullary cavities; but they are too imperfect for description. There is also a phalange (Pl. XXXV. fig. 10).

Part IV.

On the Axial Skeleton of Eucercosaurus tanyspondylus, *Seeley, a Dinosaur from the Cambridge Greensand, preserved in the Woodwardian Museum of the University of Cambridge* (figs. 4 & 5, pp. 616, 620).

Introduction.

The remains of a large land-animal, for the reception of which it becomes necessary to institute the genus *Eucercosaurus*, are limited to an associated series of nineteen vertebræ and a neural arch, obtained from one of the more recently opened workings in the Upper Greensand, at Trumpington, near Cambridge. The state of preservation is not very satisfactory, the bones being often incrusted with phosphate of lime, and several of them considerably decomposed, as the consequence of long maceration. Some of them have also been a little worn, and a few broken, during their discovery, by the picks of the excavators.

There is no indication of the skull or neck; but both may be inferred to have been small, since the four dorsal vertebræ preserved show a considerable and decreasing difference in size towards the neck. At first sight there may seem to be just a possibility that the eighth vertebra may not belong to the same animal; but against that suggestion is the evidence of similarity of form and similar condition of preservation.

I am led, by the forms of the vertebræ, to anticipate that the animal carried itself in a more or less erect position, supported on the hind limbs, and that, following the usual osteological law exemplified in the vertebral column of man, the growth of the lower

dorsal region was in proportion to the increase of pressure consequent upon its having to support the number of vertebræ above it. No single centrum is well preserved in this dorsal region of the body; but the neuro-central suture is marked by transverse ridges, and the underside of the centrum in the earlier part of the series is characterized by an angular or squeezed condition of the visceral aspect. This pinched appearance becomes lost as the series is traced backward, and in place of the inferior keel a well-rounded visceral surface is developed. The neural arch preserved is strong, but not high; the transverse processes are given out horizontally from it, and the ribs may have been articulated to them exclusively. The sacral region is represented by three vertebræ, but of such forms as to suggest that there were probably five or six; and the tail, represented by twelve vertebræ, presents the unusual condition of the vertebræ becoming elongated as they pass downward in the series. The chevron bones, as indicated by facets for them, were at first unusually large; but where the centrum has developed the hexagonal outline, which it afterwards attains when more elongated, the chevron bones must have been small, since no definite facets for them can be seen on the slightly rubbed articular ends. It is mainly on the evidence which this specimen gives of a strong sacrum and a long tail, such as could have acted as a balance to the weight of the anterior part of the body, that I am disposed to affirm the erect or semierect position of this Trumpington Dinosaur. The modifications which the vertebral column in consequence presents are of a type met with in no other Dinosaurian genus from the Cambridge Greensand. There is no approximation towards any of the typical American Dinosaurs, and there may be some uncertainty as to its relative position in the Dinosaurian order; but it is probably affiliated to the Iguanodont family. Yet the ridges which give the remarkable compressed hexagonal aspect throughout the vertebræ of the tail are so far similar to the ridges on the short caudal vertebræ of *Acanthopholis*, as to suggest that the difference of form may be mainly a functional development consequent upon the different ways in which the bodies of the animals were carried.

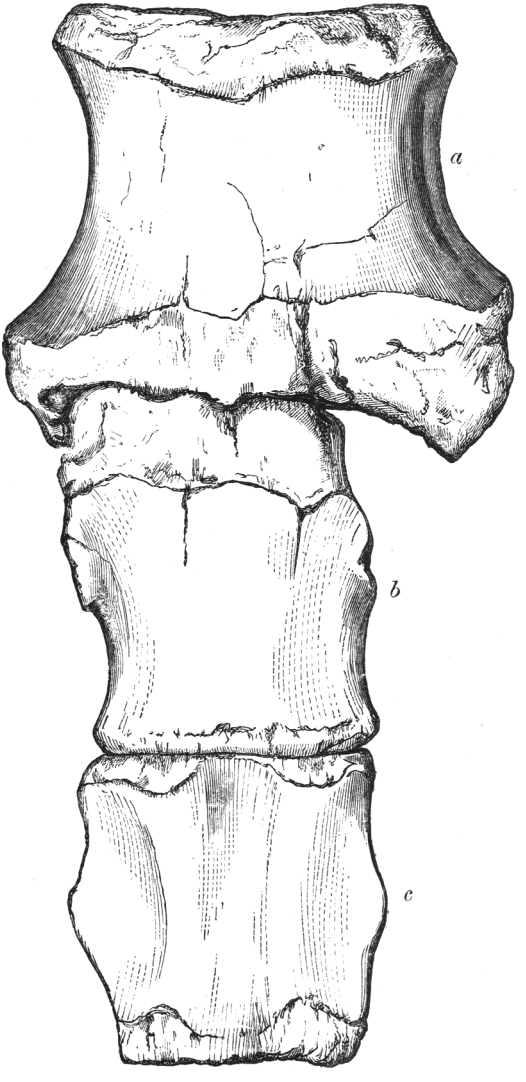
Dorsal Vertebræ.—The first three vertebræ are from the early part of the dorsal region. The centrum of the earliest preserved is about $1\frac{6}{10}$ inch long. The anterior articular face is broken, and the posterior articular face is nearly flat, without a central depression. It is $1\frac{1}{2}$ inch wide and $1\frac{4}{10}$ inch deep to the worn visceral keel. Its outline was subtriangular. The sides of the centrum are concave from back to front, moderately convex from above downward as usual, and terminate in a sharp keel on the visceral surface. The greatest width of the centrum in the middle just below the neuro-central suture is $1\frac{2}{10}$ inch. The attachment of the neural arch was wide, $\frac{13}{20}$ inch, and is marked by somewhat irregular grooves subparallel to the articular ends. The second vertebra is of the same length, has the articular surfaces more or less incrusted with phosphatic matrix, and differs chiefly in having the sides of the centrum more inflated, so that the articular ends

have a rounder lateral outline, and in having the visceral keel, which is about $\frac{4}{10}$ inch wide in the middle, defined by a groove on each side. What I take to be the posterior articular face of the centrum is decidedly concave. Both of these specimens appear to have suffered from rubbing in the mill at the washing from which they were obtained. Several vertebræ are missing between the second and the third of the series preserved. The third centrum is $1\frac{7}{10}$ inch long dorsally, and rather less at the visceral margin, showing that the back was probably arched convexly. The sides of the centrum are much more inflated, and the visceral keel has disappeared from the middle of the base of the centrum, though it is still indicated by strong rugosities at the two ends. The side of the centrum adjacent to the articular ends continues this rugose condition round the side by means of short wavy ridges. The visceral surface was somewhat rubbed before fossilization; but the articular ends, as preserved, are nearly circular. The anterior face is $1\frac{9}{20}$ inch deep, slightly cupped, with a central boss. The posterior face is $1\frac{6}{10}$ inch wide, moderately cupped, but without any central elevation. The articular margins are a little worn, but appear to have been rounded. Again, several vertebræ are missing between the third and fourth. All trace of the visceral keel has now disappeared, and the centrum has again become slightly deeper than wide, and has a somewhat compressed aspect at the sides, owing to its depth. The rugose marks for ligamentous attachment are relatively stronger and longer than in the earlier vertebræ. There is a small nutritive foramen more than a third down the side and intermediate between the two ends. Similar foramina occur in the previously described vertebræ. This centrum is $1\frac{8}{10}$ inch long on the neural surface, and apparently less on the visceral surface, though one end of the specimen had decomposed from maceration before it was fossilized. The articular ends are slightly concave, and the posterior end is nearly 2 inches deep and $1\frac{17}{20}$ inch wide, as preserved. The lines of the neuro-central suture are nearly obliterated by decomposition, but the least width of the centrum in the middle is $1\frac{6}{10}$ inch.

Sacrum.—Of the sacrum three vertebræ are preserved. They so far closely correspond with sacral vertebræ of *Anoplosaurus* as strongly to suggest that in this genus also there were at least six elements in the sacrum. The two bones, which have the forms of second and third vertebræ (fig. 4, *a*, *b*, p. 616), fit together by natural surfaces, and show that the sacral elements were in the closest possible bony union, short of anchylosis, the coadapted intercentral surfaces being irregular. There is, however, some difficulty in adapting the third sacral vertebra to the articular surface of the fourth (?) (*c*); so that it would seem more probable that another vertebra should have been introduced between them. But the anterior end of the fourth (?) centrum was destroyed by decomposition before fossilization, and the posterior surface is partly destroyed by fracturage since it was exhumed. And when the three centrums are placed together in sequence resting on the visceral surfaces as they pro-

bably lay on the sea-bed, the whole of the neural surfaces are seen to be so much decomposed that the vertebral form is scarcely recognizable.

Fig. 4.—*Three Sacral Vertebræ of* Eucercosaurus tanyspondylus, *nat. size.*



The vertebra which from its resemblance to the fourth sacral of *Anoplosaurus* (fig. 4, *c*) I regard as holding that place in the series measures rather more than $1\frac{7}{10}$ inch in length, and has a broad shallow channel on the median part of the visceral surface, deeper, however, than in *Anoplosaurus*. This is bounded laterally by two broad well-rounded ridges, into which it merges, and which terminate inferiorly the comparatively flat sides of the centrum. At what I take to be the anterior end these ridges are a little more divergent than at the posterior end. The base of the centrum has no sharply defined border, but is about $\frac{9}{10}$ inch wide at the articular ends. What remains of the sides of the centrum is only sufficient to show that these were moderately concave from front to back, and comparatively flat and divergent from below upward. Only a small fragment of the neural canal is preserved, enough to show that the depth from this surface to the base of the centrum towards the middle of the vertebra was about $1\frac{1}{4}$ inch. The sides appear to have diverged outward anteriorly, as though to give attachment to small sacral ribs; but behind the indication of this anterior inflation, of which there is no trace in *Anoplosaurus*, there appears to have been a broad rounded prolongation of the side upward towards the neural canal, as though for the passage of an intervertebral nerve. There is nothing to indicate the deep excavation of the centrum for the expansion of the spinal cord in the sacral region; but only evidence that the vertebral nerve, when given off, was prolonged downward instead of upward. The small fragment of neural surface is flat.

The centrum which corresponds best in form with the second sacral of *Anoplosaurus* (fig. 4, *a*) has become naturally fractured and enlarged before fossilization, as a consequence of maceration and absorption of phosphatic material. It is broad and deep, expanded at the posterior end, but with the base and sides so well rounded as to form about two thirds of a circle. The anterior end, which is roughened from decomposition and the natural rugoseness of the articular face, is vertically semiovate, being, as preserved, $2\frac{1}{10}$ inches wide below the neural canal, and $1\frac{7}{10}$ inch deep. The posterior end widens as though to give attachment to strong sacral ribs, and measures from side to side nearly $2\frac{7}{10}$ inches, while as preserved it is only $1\frac{1}{2}$ inch deep; hence the crumpled irregular articular face is transversely subreniform. The indications of the neural surface are comparatively flat, widening posteriorly, and widest just in front of the sacral ribs, where it may be presumed that sacral nerves were given off.

Of the third sacral element (fig. 4, *b*) nothing remains but the basal portion of the centrum. It is $1\frac{19}{20}$ inch long, $1\frac{4}{10}$ inch wide posteriorly at the sides, which are flat and vertical, and rounded into the nearly flat base, which is slightly concave from front to back and slightly convex from side to side. On a level with the base, at the anterior ends of the sides, are large facets fully an inch long for sacral ribs. The articular ends appear to have the same rugged faces noticed in the preceding sacral element.

Caudal Vertebræ (fig. 5, p. 620).—The tail appears to have comprised three types of vertebræ. Of the earliest caudal there is one, of the middle caudal four vertebræ, and of the later caudal region five. To these I have added provisionally two later caudals in the same condition of mineralization and of similar size, also from the Trumpington pit, which show exactly the same characters, but were found subsequently.

The first caudal is distinguished by a short deep centrum with a rounded visceral surface, flattened articular ends, no chevron bones, small neural arch, and apparently poorly developed transverse processes, which are abraded. The centrum is about $1\frac{1}{2}$ inch long, less along the neural canal and more at the inferior border. The articular face is $1\frac{1}{2}$ inch deep in front, and, as preserved, of the same width, though originally wider. A transverse depression runs across it in the middle so as to divide the surface into superior and inferior portions meeting at a slight angle. The neural canal appears to have been about $\frac{1}{2}$ inch in diameter. The neural arch, as preserved, extends the whole length of the centrum, is depressed in front, and appears to have been fractured at its upper and hinder prolongation. All trace of the transverse process is removed by abrasion; it was given off on a level with the base of the neural canal.

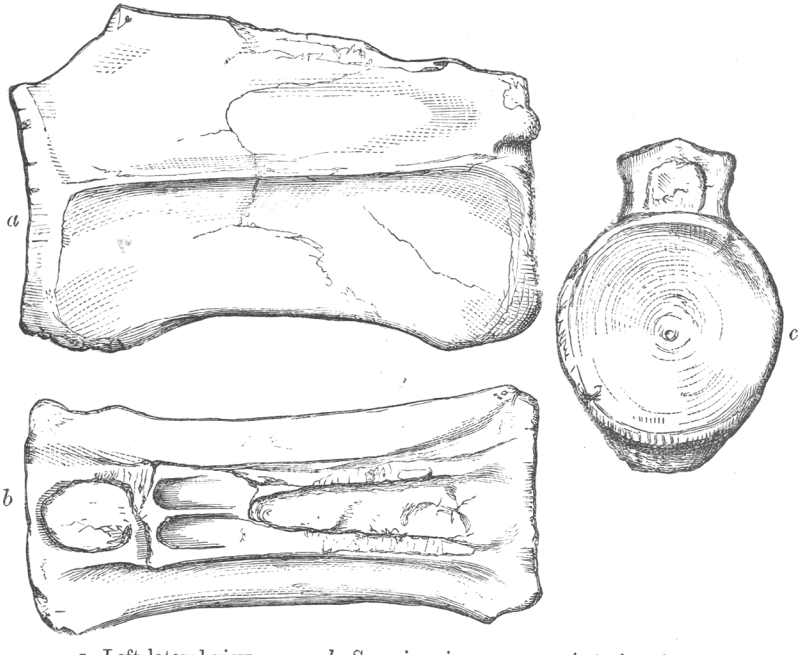
The four middle caudal vertebræ successively increase in length, have the sides of the centrum compressed, and the base narrow and rounded, largely encroached upon by the facets for the chevron bones. These vertebræ have strong transverse processes given off, so as to extend outward and a little forward. These transverse processes are flattened and apparently hollow, like the rest of the neural arch, and perhaps the body of the centrum. They rapidly become small, and in the fourth are reduced to transverse ridges which are already below the level of the neural canal. The first centrum, as preserved, is $1\frac{19}{20}$ inch long. The posterior articular face of the centrum is decomposed, and the anterior face obscured with matrix; but the facet for the chevron bone is a large equilateral triangular area with rounded angles, about $\frac{8}{10}$ inch long. The space is concave, as though the bone had decomposed; but the decomposition does not extend onto the rounded articular margin of the centrum. The depth of the centrum from the base of the neural canal is rather less than $1\frac{1}{2}$ inch. The space between the two facets for the chevron bones on the base of the centrum is less than $\frac{6}{10}$ inch long. The transverse process is about $\frac{2}{10}$ inch thick and $\frac{8}{10}$ inch wide, 1 inch from inner border of the neural canal; it is directed slightly upward, and its hinder margin inclines forward. The sides of the centrum are flattened, though slightly convex from above downward, and fairly concave from side to side. In the next caudal the centrum is 2 inches long at the base. The posterior articular surface is flat and subtriangular, $1\frac{1}{4}$ inch broad and about the same depth, with straight converging sides, which are truncated inferiorly by the large facet for the chevron bone, which is nearly $\frac{7}{10}$ inch long. The transverse processes are more nearly horizontal, but are broken abruptly; the neural arch appears to have the laminæ

very thin. The following vertebra, which is the eleventh of the whole series, is fully $2\frac{1}{10}$ inches long. The anterior facet for the chevron bone is not decomposed, and presents a flat oblique surface. The flattened ends of the centrum are slightly concave. The base, instead of being narrow and rounded, now begins to be defined by two slight parallel ridges.

The twelfth vertebra is about $2\frac{1}{4}$ inches long. Here the neural arch is much more elongated, and the centrum less deep, so that the transverse-process ridge, which extends the whole length of the vertebra and is slightly convex in length, divides the side into two subequal regions, of which the lower is chiefly formed by the centrum, and the upper by the neural arch. The articular ends are subcircular, rather wider than deep, and moderately cupped concavely. The articular face is about $1\frac{2}{10}$ inch in diameter. Several vertebræ are here missing, and the remainder of the series from 13th to 19th have an elongated prismatic form. Those numbered 16 and 17 are the specimens which were brought to the Museum on a separate occasion from the others. All these vertebræ agree in every thing except length, relative development of the facet for the chevron bones, and preservation. All have the articular face of the centrum subcircular and concavely cupped. The sides are divided by a median ridge into two areas on each side, of which the upper pair are rather the smaller and more deeply excavated. At the base there is a narrow, slightly channelled region defined by parallel sides; and a similar region, somewhat wider and shorter, runs along the upper surface of the neural arch, so that the vertebræ have a compressed hexagonal aspect. The 13th is rather over $3\frac{1}{2}$ inches long; the 14th $2\frac{6}{10}$ inches long. The 15th (imperfect) shows the anterior end of the neural arch, but is not sufficiently well preserved to show whether the zygapophyses interlocked. The 16th vertebra (fig. 5, p. 620) is nearly $3\frac{7}{10}$ inches long, and is the best preserved in this region. It has the anterior face of the centrum subhexagonal, but with the upper pair of lateral elements shorter than the lower pair, $1\frac{1}{4}$ inch wide at the outer angle, and about as deep to the rounded surface, where a chevron bone may still have been attached. The posterior articular face is of the same size. The extreme depth of the centrum in front is $1\frac{4}{10}$ inch. The median ridge on the side of the centrum is concave in length, so that the diameter of the bone in the middle of the ridge is 1 inch. The lateral spaces above and below this ridge are $\frac{8}{10}$ of an inch high in the middle of the centrum; the narrow base is less than $\frac{1}{4}$ inch wide. The width of the neural arch posteriorly is about $\frac{1}{2}$ inch; along it in the superior median line runs a slight ridge. The neural arch has a more pinched aspect than the part of the centrum below the median lateral ridges. The 17th vertebra is $2\frac{3}{4}$ inches long; it shows that the chevron bones still exist, but that the articular faces of the centrum have become slightly smaller, though hardly more deeply cupped. The 18th and 19th vertebræ are represented by fragments which add nothing to our knowledge beyond showing that the central part of the centrum was either hollow or occupied by a

spongy tissue of the most delicate character. Throughout the whole of these specimens the external surface is remarkably dense, and seems to have resisted decomposition to an unusual degree; while the cartilaginous surfaces have more frequently suffered

Fig. 5.—*Sixteenth Caudal Vertebra of* Eucercosaurus tanyspondylus, *two thirds nat. size.*



a. Left lateral view. *b*. Superior view. *c*. Anterior view.

decay. The isolated neural arch is much invested with phosphate of lime, but does not differ essentially from the neural arch attached to an early caudal vertebra, except that the transverse processes and platform are above the level of the neural canal. This proves the arch to be either cervical or dorsal. The indications of the facets of the zygapophyses show that the centrum was probably $1\frac{7}{10}$ inch long, so that the arch would correspond in size with the third dorsal vertebra described. The posterior zygapophyses measure 1 inch transversely, and are notched out to a moderate extent posteriorly; the facets are small and look obliquely downward and outward. The anterior facets are broken away, but appear to have been limited laterally by remarkable tubercles. The transverse processes were compressed concavely, notched out in front of the posterior zygapophyses, and extending outward from the vertical laminæ of the neural arch, which are imperfectly preserved. The transverse processes, like the neural spine, are fractured.

All the parts which are most characteristic of the Dinosaurian genera, such as the bones of the extremities, the pelvic and pectoral arches, and the teeth, are unfortunately wanting. We are hence compelled to rely on the forms of the vertebral centrums in estimating the affinities of this genus; and there are very few genera in which associated sets of vertebræ from the several regions of the body enable one to make a satisfactory comparison.

No other Dinosaurian genus known to me has the tail-vertebræ so hexagonal, compressed, and elongated as in *Eucercosaurus*. Perhaps the tail of *Hylæosaurus* is least dissimilar, and the compressed visceral side of the earlier dorsal centrums may probably be taken to indicate an affinity towards the Iguanodont family.

Part V.

On the Skeleton of Syngonosaurus macrocercus, *Seeley, a Dinosaur from the Cambridge Greensand, preserved in the Woodwardian Museum of the University of Cambridge* (figs. 6–8, pp. 624–626).

Introduction.

Syngonosaurus is founded upon a series of nineteen vertebræ, which represent the neck, back, sacrum, and tail; and in some respects these vertebræ offer evidence of affiliation to several Dinosaurian types, especially to *Eucercosaurus*. The early dorsal vertebræ, however, are remarkably compressed from side to side, not merely at the base, but throughout the body; and ossification has progressed so far that, notwithstanding the somewhat battered condition in which the remains are preserved, the neural arches are constantly united to the centrums. In the lower dorsal region the compressed condition of the centrum is only recognized in the great vertical depth of the bone. The ridge on the visceral surface gradually disappears, till it is represented by a mere tubercle below the anterior and posterior articular ends. The ridge, however, reappears in the sacrum, where the depth of the centrum becomes greatly diminished, in the usual manner. The caudal vertebræ at first had centrums with the articular faces oblique, slightly procœlous, and in close juxtaposition, indicating the tail to have been stiff. The chevron bones formed a single large facet, which appears to have obliquely truncated the lower half of the posterior face. The facet is represented by a sutural surface, probably indicating that these bones were large as well as firmly adherent. Ten vertebræ are preserved from the back, four from the sacrum, and five from the earlier part of the tail. These tail-vertebræ have the centrum much compressed from side to side below the transverse processes; but the visceral surface, though narrow, is well rounded. The other associated bones are imperfect fragments of a metatarsus badly preserved; and in the absence of better evidence of their pertaining to this vertebral column, I do not feel that they can be satisfactory evidence of the extremities. There are eleven pieces of dermal armour, large elongated plates, some of which

appear to have been symmetrical and median, others to have been placed laterally. Each plate has a sharp elevated ridge. But there is no positive evidence that the armour was found with the bones. The circumstance was not stated when the collection was purchased by the University; but after the remains were exhibited in the Woodwardian Museum, Mr. W. Farren mentioned to me that both sets of bones came to him at the same time and from the same washing, and might therefore perhaps have been associated portions of one animal. This species was indicated in my 'Index' 1869, pp. xvii & 24, as *Acanthopholis macrocercus*.

The Vertebral Column.—The vertebral column steadily enlarges from the neck to the lower part of the back. In the earlier dorsal region the articular faces of the centrums are slightly concave; but in the lower part of the back they are flat at both ends. In the early part of the tail the articulation appears to indicate a stiff condition; but in the lower part of the tail the articular faces are fairly concave. Notwithstanding the worn state of the specimens, they all agree so perfectly in character, and are so different from any other remains that have been found, that no doubt can be entertained as to their being portions of a single animal. It is impossible to tell how much of the abrasion was produced in the washing-mill, and how much before fossilization; but as the bones show evidence of fracture and decomposition, it is probable that much of the worn appearance which they present has resulted from decay consequent upon maceration and exposure of the upturned surfaces.

Cervical Vertebra.—Although this specimen is sufficient to give important characters of the cervical region, it has neither articular end preserved, and shows but little of the neural arch. The centrum was about $1\frac{6}{10}$ inch long and $1\frac{2}{10}$ inch deep. It is compressed from side to side, and has the base narrow and rounded. The neural arch is defined from the centrum by a deep groove; below this groove and behind the upper part of the anterior articular face is an indication of the large tubercle for the rib, which must have been fully half an inch in diameter. The posterior articular face of the centrum was triangular. The platform of the neural arch reached to a height above the base of the centrum of $2\frac{2}{10}$ inches. The transverse process for the upper head of the rib was directed outward and forward; it is fractured, and is there $\frac{1}{2}$ inch deep. The neural canal was large, and nearly 1 inch high.

Dorsal Vertebræ.—The next four vertebræ belong to the early dorsal region; they differ from the cervical chiefly in being a little larger, wanting the tubercle for the rib-articulation, and in the increasing depth and width of the centrum. The neural arch also, which is partly preserved in three out of the four, is directed more obviously outward. But all these vertebræ have the same compressed centrum, with comparatively flattened sides, converging to a narrow rounded base and subtriangular articular terminal ends. When the neural arch is broken away, it is seen to have united with the centrum by rugose transverse ridges, arranged on a facet which

extends the length of the centrum, and looks obliquely outward and upward. The length of the centrum in this region varies between $1\frac{1}{2}$ inch and $1\frac{7}{10}$ inch. The articular ends widen at the upper margin from little more than 1 inch to $1\frac{4}{10}$ inch, and the depth is about $1\frac{4}{10}$ inch. The sides are slightly concave from back to front, and their curve is prolonged upward, continuous with the neural arch, which is always distinguished by the deep groove already referred to. The succeeding four belong to the lower dorsal region; in them the centrum increases in size and depth, and its side becomes rather more convex. It still retains the basal ridge, which becomes sharper, and sometimes disappears, being marked by a tubercle at each end. In the earliest of these four vertebræ, the height from the base of the centrum to the platform of the neural arch is rather more than $2\frac{1}{2}$ inches, and the length of the centrum is $1\frac{3}{4}$ inch, while its depth from the neural canal is about $1\frac{4}{10}$ inch. In the largest and, apparently, last or last but one of the four, the width of the centrum at the anterior articular face, as preserved, is $1\frac{8}{10}$ inch, while the depth of the centrum is about the same. From the decreasing height of the neural arch this vertebra may be supposed to be near to the sacral region. It is $1\frac{8}{10}$ inch long in the dorsal measurement, and less ventrally. The height to the platform of the neural arch from the middle of the base is $2\frac{3}{4}$ inches.

The transverse processes are about $\frac{1}{2}$ inch thick, but are fractured. The neural spine and zygapophyses are also broken away, but the zygapophyses look inward as well as upward. The ninth dorsal vertebra differs so much from those with which it is associated, and recalls so strongly the dorsal region of *Acanthopholis*, that I am inclined to regard it as having become accidentally mixed with the other remains. It is in the same state of mineralization, but is much longer, had a perfectly rounded base, was most compressed below the neural arch, and had circular articular ends, with a central pit, so that I feel no doubt that it ought not to be included in the definition of *Syngonosaurus*.

Sacrum.—The sacrum (fig. 6, p. 624) has lost the neural arches, and consists, as preserved, of two portions, each of which includes parts of two vertebræ, so that there were certainly no fewer than four, and may have been more. The last dorsal described corresponds in size and character with the first sacral of the larger fragment, which has a similar flat, subtriangular, articular end (fig. 6, *a*), which is $1\frac{7}{10}$ inch broad at the upper part, as preserved. The sides are convex from above downward, and meet in a sharp keel in the middle of the base. The suture between the first and second vertebra is entirely obliterated. The depth from the neural canal to the middle of the base is $1\frac{1}{2}$ inch; in the second vertebra it becomes reduced to $1\frac{1}{4}$ inch. The fragment is $3\frac{6}{10}$ inches long, which I estimate to be within a tenth of an inch of the length of two vertebræ. The base of the second vertebra is much more convex than that of the first, and the median keel is all but obliterated. The width of the centrum in the middle is rather less than $1\frac{1}{2}$ inch in the first sacral vertebra, and somewhat more in the second. The state of preservation is such that there are

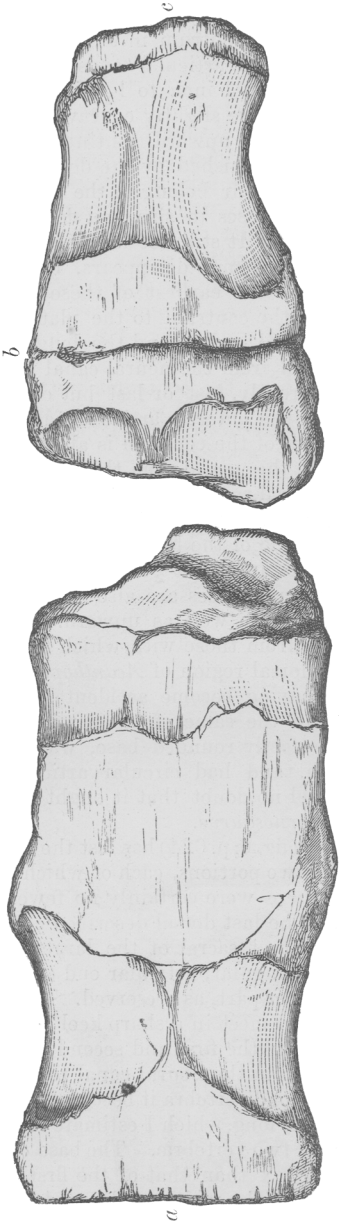


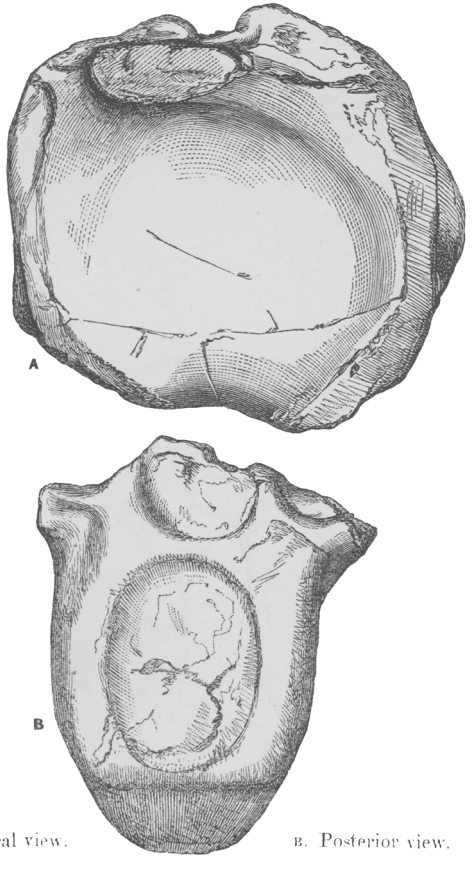
Fig. 6.—*Sacral Vertebræ of* Syngonosaurus macrocercus, *ventral aspect, nat. size.*

a. Anterior articular surface of first sacral preserved.
b. Suture between third (?) and fourth (?) sacral vertebræ.
c. Posterior articular surface of fourth (?) sacral vertebra.

no indications of facets for the attachment of sacral ribs, unless they be in the fractured and decomposed sides of the second sacral element. The other sacral fragment is smaller, and consists of the hinder portion of a vertebra with a flattened underside, which unites by a visible suture (fig. 6, *b*) with the fourth sacral, which is $1\frac{7}{10}$ inch long. At the junction of these two vertebræ there is laterally a large flattened surface of $1\frac{1}{4}$ inch, and extended to the bases of the centrums, to which one of the principal sacral ribs was obviously attached. The fourth sacral is very narrow, measuring only 1 inch from side to side in the middle, and having well-rounded sides and a rounded base. Neither vertebra shows any portion of the neural canal; and the posterior face of the fourth, which seems to have become separated from the sacral vertebra next succeeding, was flat, small, subcircular, and hardly more than 1 inch in diameter (fig. 6, *c*).

Caudal Vertebræ.—The five caudal vertebræ are not consecutive. The two earliest (fig. 7) have the centrums with oblique articular

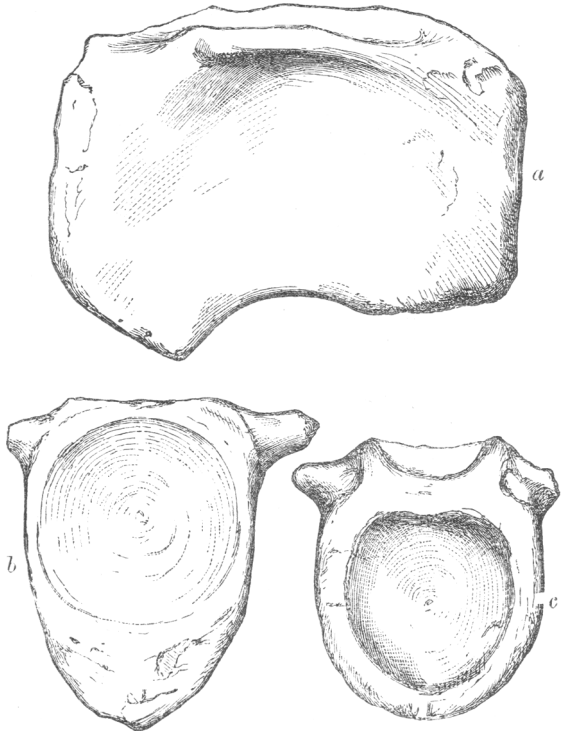
Fig. 7.—*Second Caudal Vertebra of* Syngonosaurus macrocercus, *nat. size.*



A. Right lateral view. B. Posterior view.

surfaces, which in front are cupped and behind are flattened. The angle of inclination of the articular faces is about 55°. The length of the centrum along the neural canal is fully 2 inches. The margins of the articular faces are worn. The centrum is compressed from side to side, and at the base the sides round together. The transverse process is given off on a level with the base of the neural canal as usual, but is broken, and only a small fragment of the neural arch is preserved, so as to arch over the spinal cord in front, forming a foramen about $\frac{6}{10}$ inch in diameter. Above the transverse process the neural arch is somewhat pinched in, as is the centrum below. The depth from the neural canal to the base of the centrum is about $1\frac{8}{10}$ inch; the width from side to side is about $1\frac{4}{10}$ inch. The base of the articulation posteriorly is truncated by an oblique triangular facet for the chevron bone; but it is uncertain whether this condition also marks the anterior facet. A vertebra is probably missing from between the second caudal and the third; for the third, fourth, and fifth become rather more elongated, the third (fig. 8) measuring $2\frac{4}{10}$ inches long. It is more compressed from side to

Fig. 8.—*Third Caudal Vertebra of* Syngonosaurus macrocercus, *nat. size.*



a. Right lateral view. *b*. Posterior view. *c*. Anterior view.

side below the transverse process, has a narrower rounded base, and terminates at each end in a large subcircular concave cup, which is $1\frac{2}{10}$ inch in diameter; below this, at the posterior end, is a large shield-shaped, subtriangular, rugose facet for the chevron bone, which is $\frac{9}{10}$ inch deep and fully 1 inch wide. The measurement from the neural canal to the base of this facet is $1\frac{7}{10}$ inch.

Except that they are longer, these vertebræ recall closely the forms of some of the earlier caudal vertebræ of *Eucercosaurus*; but the shape which was there seen to be characteristic of one or two vertebræ only, here seems to extend throughout the series; and though the centrum has in the last caudal preserved become reduced to little more than half the depth of the earliest, there is no indication of changing character, and the transverse process remains strong. The resemblance is close as far as it goes; but in the sacrum and dorsal regions the character is quite different, and *Eucercosaurus* has neither the compression of the body of the centrum nor the sharp keel, except in the earliest dorsal preserved. These points of resemblance indicate close affinity, but do not suggest generic identity.

Bones of the Extremities.—With this vertebral column were found four metatarsal bones. They are rather more than half the size of the complete metapodium which I figured in the 'Annals of Natural History' for November 1871, and regarded as probably pertaining to the fore limb. The first left metatarsal is fairly perfect, $2\frac{4}{10}$ inches long, $1\frac{3}{20}$ inch wide proximally, and $1\frac{8}{10}$ inch deep at the proximal end, which is imperfectly preserved. Its sides are concave, and it widens distally to $1\frac{9}{10}$ inch, where the articular face is concave from side to side, well rounded from above downwards, and about $\frac{9}{10}$ inch deep. The other three are the proximal ends of the second, third, and fourth metatarsal bones. When the four are placed together they measure rather over 5 inches from side to side, which is a greater width of foot than I should have anticipated for *Syngonosaurus*; but, in the absence of the larger bones of the hind limb, it is impossible to affirm or deny their claim to belong to this animal. There are also two phalanges which, from their shortness, may be first and second: but these also are so large, relatively to the metatarsus, as to suggest doubt as to their natural association with them. The first is $2\frac{6}{10}$ inches wide and $1\frac{8}{10}$ inch deep at the proximal end; it is $2\frac{1}{10}$ inches long and $1\frac{1}{2}$ inch thick. The second phalange is $2\frac{1}{10}$ inches wide and $1\frac{3}{10}$ inch deep at the proximal end, is $1\frac{3}{10}$ inch long, and is compressed towards the distal end, so as to be there less than an inch thick. The indication of the fore limb is limited to the proximal end of the humerus; but the greater part of the bone is lost. The proximal end of the right humerus is not quite perfect on the radial side, but is $2\frac{6}{10}$ inches wide and $1\frac{6}{10}$ inch deep over the middle of the head. The ulnar side of the head is modified after the pattern of the crocodile, and a sharp ridge is prolonged down the two inches preserved of the ulnar side of the bone, which is compressed. The whole proximal part of the shaft rapidly becomes compressed distally, and as rapidly narrows from side to side; the articular head shows the character-

istic Dinosaurian convexity on the middle of the dorsal surface, but appears to be less concave than usual on the ventral aspect. Some doubt may well attach to the association of this bone with the vertebral column.

There are twelve subovate pieces of dermal armour reputed associated with the skeleton. They vary from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches in length, are about 2 inches wide, and have a strong elevated angular crest and fold running down the length of the plates, which have the lateral halves a little concave. The margins are thin and show no signs of overlapping, except at the posterior ends; and the external surface is roughened, with an irregular pitted appearance, similar to that seen in *Acanthopholis* and *Scelidosaurus*. The dermal surface is usually smooth and concave; but one symmetrical plate has the under surface deeply excavated, evidently for a muscle, and may therefore be inferred to be one placed over the neural spine of a vertebra; it is, however, in a slightly different state of mineralization, and possibly may not belong to the series. It must remain for the present an unsettled question whether *Syngonosaurus* was really armoured, though the probabilities lean in that direction. The only existing reptiles in which dermal armour of the pattern found among the Dinosaurs is met with are the Chelonians; and in that order, both on the limbs and tail, dermal bones, covered with a horny sheath, are found, which differ from those of Dinosaurs chiefly in size.

Part VI.

On the Dorsal and Caudal Vertebræ of Acanthopholis stereocercus, *Seeley, a Dinosaur from the Cambridge Greensand, preserved in the Woodwardian Museum of the University of Cambridge; with some notice of a second species of* Anoplosaurus *collected with these remains.*

Among the smaller series of Dinosaurian bones collected for the Woodwardian Museum by Mr. W. Farren, is a collection of twelve vertebræ and a fragment of a dermal spine, which were catalogued in my Index to Aves, Ornith. and Rept. 1869, pp. xvii and 24, as *Acanthopholis stereocercus*. Looking at the specimens anew, I have no doubt that the remains are not all referable to one species. The first, which is in bad preservation, is a cervical; it has, apparently, got into the washing-mill and become worn. It is so far similar to *Anoplosaurus* as to suggest that it really belongs to the neck of a second species of that genus. The next two are dorsal; then follows a postsacral of remarkable form, which is succeeded by an early caudal. The next three caudal vertebræ I do not now regard as pertaining to the same species, and separate them as belonging to a second and undescribed species of *Anoplosaurus*. They want the median groove on the base of the centrum, which is characteristic of the caudals of *Acanthopholis*, and in all essential characters they have the general facies of caudal vertebræ of *Anoplosaurus*; but differ from the species already described in the ver-

tebræ being of relatively much greater length, and distinguished by carrying the neural canal in a deep groove in the centrum. The remaining three vertebræ present the characters of *Acanthopholis*, and may well have belonged to the same animal as the preceding five bones.

Dorsal Vertebræ.—The two dorsal vertebræ present the characters already described in dorsals of *Acanthopholis* and *Anoplosaurus*, but have the articular faces of the centrums more deeply concave than in any form hitherto described. It may therefore be enough to say that the dorsal measurement in both is a little greater than the visceral measurement; that the aspect is Teleosaurian, slightly compressed, and well rounded on the base. There are several small nutritive foramina in the middle of the side. The neural canal is a long groove with parallel sides, and its width is less than the width of the lateral surfaces from which the pedicle for the neural arch is broken away. The better-preserved and slightly longer of the two vertebræ is $1\frac{17}{20}$ inch in extreme length, has the posterior articular face $1\frac{1}{2}$ inch deep and rather narrower, while the anterior articular face is nearly circular, with the measurement of $1\frac{1}{2}$ inch. The greatest compression of the centrum from side to side, where its transverse measurement is 1 inch, is below the neural canal.

Postdorsal.—A bone which I am disposed to regard as a last lumbar or, more probably, postsacral vertebra, is distinguished by a large neural canal, and a centrum which is oblong and defined by six sides. The body of the vertebra is $1\frac{7}{10}$ inch long, with a flattened base, flattened sides, and subquadrate articular ends. The anterior end, as preserved, is $1\frac{2}{10}$ inch deep and more than $1\frac{1}{2}$ inch wide. The posterior face is somewhat smaller; both are concave surfaces, with a somewhat large obscure central boss. The base at each end is $1\frac{2}{10}$ inch wide, and about $\frac{9}{10}$ inch wide in the middle. There is no indication of its lateral ridges being connected with facets for chevron bones; the sides are similarly gently concave from back to front, and show a thickened mass at the base of the neural arch, as though a slight transverse process might have there originated, or a facet existed for a small osseous attachment. It is impossible from the fractured fragments of the pedicle of the neural arch to judge what the characters of that portion of the vertebra were. The least width of the neural canal in the middle is $\frac{13}{20}$ inch.

The early caudal vertebra is in good preservation and shows unusual characters. The neural arch is anchylosed to the centrum, the short transverse processes are well indicated, and the facets for the chevron bones are unusually large for this genus, and divided from each other. The centrum is $1\frac{11}{20}$ inch long dorsally, $1\frac{1}{2}$ inch long ventrally. The transverse processes are short, vertically compressed, rather oblique, and placed posteriorly on the upper third of the centrum; they measure from front to back about $\frac{6}{10}$ inch at their bases. Below these transverse processes, the sides of the centrum, which are flattened, converge towards the visceral surface; but the base can only be defined at the articular ends by the width of the

facets for the chevron bones, which is rather less than an inch, because the middle of the base is occupied by a deep groove, more than $\frac{1}{4}$ inch wide, which is boat-shaped, tapering away between the chevron facets. These facets are convex from front to back, and each is slightly concave from side to side; they round into the articular ends of the centrum, and are markedly distinct from each other at the posterior end, where they are longest. The length of the base of the centrum, between the anterior and posterior pairs of facets, is $\frac{13}{20}$ of an inch. Above the transverse process is a pair of short strong ridges, developed at the posterior end, which are horizontal and just above the base of the neural canal. The neural arch is small, narrow, and depressed; its posterior end was removed by fracture, but anteriorly it is less than $\frac{1}{2}$ inch wide, and the extreme measurement, from its summit, as preserved, to the base of the centrum is $1\frac{8}{10}$ inch. The articular faces of the centrum are subhexagonal, and somewhat deeply impressed in the centre, especially the anterior face, which is $1\frac{2}{10}$ inch high and $1\frac{4}{10}$ inch wide. While the posterior face is not quite so high, it is a little wider, and is less markedly hexagonal, owing to the influence of the transverse processes in developing an angle on the upper third of the side.

The next vertebra preserved is from a much lower position in the tail; it has essentially the same type of character, and measures $1\frac{9}{20}$ inch in length along the neural canal, but is so much smaller in vertical and transverse measurements, that the anterior face is barely an inch wide and almost $\frac{17}{20}$ inch in greatest depth. The posterior face has the same depth, and may have been a little wider. The articular faces are moderately concave, subhexagonal, and prolonged downwards into articular facets for the chevron bones, which are larger behind than in front. They are divided by a deep narrow groove, which runs along the middle of the base. On the middle of each side is a blunt somewhat rounded ridge, which helps to give the centrum its hexagonal aspect by dividing the side into two subequal regions, two of which converge downwards, and the other two converge upwards. Below these ridges, and nearer to the basal ridges, are two other moderately developed longitudinal ridges; and above also, on a level with the neural canal, are two more short ridges, sufficiently elevated to give a channelled, pinched appearance to the base of the neural arch, since another ridge runs along that region on each side. The neural arch is small, and its pedicle, $\frac{7}{10}$ inch long, is placed nearer to the anterior than to the posterior end, as in *Acanthopholis horridus*. The neural arch has a median ridge, which rises a little as it extends backwards; the arch is fractured, both at the anterior and posterior ends, and the neural canal is small. The height from the middle of the base of the centrum to the middle of the neural arch is $1\frac{3}{20}$ inch. The next vertebra shows all these characters, except that the neural arch is broken away, and indicates that the channel for the spinal cord was slightly excavated in the centrum. The lateral spaces between the ridges are also rather more concave. The length of this cen-

trum is nearly $1\frac{2}{10}$ inch; the width of the articular face is fully $\frac{8}{10}$ inch. The last vertebra of the series is $\frac{9}{10}$ inch long. It, too, has lost the neural arch, and has the articular ends more deeply excavated and much wider than high. From the relatively small size of the base, its outline is subpentagonal. The neural canal is very small, and the arch absent from the posterior third.

In instituting the species on these remains, I rely on the four vertebræ last described for its type, without in any way doubting the natural association of the dorsal vertebræ with these caudal elements. Still, as three caudal vertebræ of *Anoplosaurus* had become accidentally mixed with them, and the cervical vertebra belongs to that genus also, it seems to me unsafe to attribute the dorsal vertebræ unreservedly to *Acanthopholis*, although we know that that region of the body presents no essential difference from the same region in *Anoplosaurus*. As compared with the tail of the type species, *Acanthopholis horridus*, Huxley, this species is distinguished by having the middle caudals much more robust, with a deeper basal groove and strongly developed facets for the chevron bones, while the neural arch is bounded by lateral ridges, which are absent in the type species. The later caudals are relatively more robust than in the type, and distinguished by progressively decreasing in length, by retaining well-developed chevron facets to the last, and by having the neural arch less developed and defined by a deep groove at its base.

Anoplosaurus major.

The Cervical Vertebra.—I have already suggested the possibility of this centrum pertaining to a second and larger species of *Anoplosaurus*. The centrum is depressed and broad in front, and leans obliquely forward, more so at the posterior than at the anterior articular surface. This condition would probably suggest that the neck was carried in an upraised position. The base of the centrum is $1\frac{1}{2}$ inch long, while the neural canal was somewhat less. The base is flattened, apparently with a slight median ridge, but is slightly convex from side to side, and the base makes about a right angle with the nearly vertical lateral spaces behind the articular tubercle for the rib. The vertebra measures from side to side $1\frac{1}{10}$ inch, but the width over the tubercles, as preserved, is $1\frac{9}{10}$ inch. The tubercles are on the middle of the side of the centrum, close to the anterior articulation, and are about $\frac{1}{2}$ inch in diameter. Immediately behind the tubercles the centrum has a pinched aspect. The anterior face is transversely ovate, 1 inch deep, as preserved, but the underside is a little worn; it is moderately cupped, and was about $1\frac{1}{2}$ inch wide. The posterior articular surface is somewhat deeply cupped, $1\frac{3}{20}$ inch in depth and $1\frac{3}{10}$ inch wide. The neural canal is very wide, being $\frac{7}{10}$ inch in diameter. The bases of the laminæ of the neural arch are compressed, and extend along the length of the centrum; they appear to be confluent with the centrum, and show no certain indication of suture.

Although the caudal vertebræ which indicate the second species of

Anoplosaurus are not such as one would choose for the foundation of a new species, they differ from *Anoplosaurus curtonotus* in the absence of the basal ridges, which causes the base to be flattened, and in having flat sides, which are only broken by the tubercle which represents the transverse process, and which, prolonged into a ridge, divides the side into two areas. The facets for the chevron bones were so small that they have become obliterated by the wear to which the specimens have been subjected, and appear to have only marked the posterior ends. The best-preserved specimen has the centrum slightly oblique, $1\frac{6}{10}$ inch long, with the articular ends hexagonal, the posterior end being nearly $1\frac{4}{10}$ inch wide, $1\frac{1}{10}$ inch deep. The other two vertebræ are $\frac{1}{10}$ of an inch longer, and the faint ridges of the base and sides are less developed; so that the species is distinguished from the type of the genus by the more elongated form of vertebræ, and by retaining the two basal angles after the transverse tubercular process had disappeared, as well as by the deep excavation of the neural canal in the centrum, and by the presumably larger size of the adult animal. It may be a convenience, pending the discovery of better materials, to indicate this species as *Anoplosaurus major*.

A small fragment of a nearly smooth dermal plate, probably referable to the *Acanthopholis*, was collected with these remains, but is too imperfect to yield any useful characters.

Part VII.

On a small series of Caudal Vertebræ of a Dinosaur from the Cambridge Greensand (Acanthopholis eucercus, *Seeley*), *contained in the Woodwardian Museum of the University of Cambridge.*

This note is founded on the small assemblage of six caudal vertebræ catalogued in my 'Index to the Secondary Reptiles in the Woodwardian Museum,' as Series vi. (p. 24). They indicate a close resemblance to the tail-vertebræ of *Acanthopholis horridus*, Huxley, but differ in the more elongated form and more constricted condition of the centrum, in the somewhat different development of ridges upon the side of the centrum, in the rapid diminution in length of the centrums, which in the type species remain all of about the same length, and in the greater size of the bones now described, which appear to indicate a rather larger species. The collection was purchased by the University from Mr. Farren; and I see no reason to doubt his statement that the vertebræ were found associated, and form part of the skeleton of one individual.

The earliest specimen preserved is an early caudal. It is robust, about $2\frac{1}{4}$ inches long, and $1\frac{7}{10}$ inch deep in the anterior articular face, which is subcircular and fairly concave; the posterior articulation is broken, but was subhexagonal, not so deep in vertical measurement, and similarly cupped. The body of the vertebra is subcylindrical, with six more or less marked longitudinal ridges, two on the base, slight and rounded, separated by an interspace of less than half an inch, which interspace is a slightly impressed median channel, most marked towards the two ends of the centrum.

The sides of the vertebra are well rounded; but at the upper third, behind the middle of the centrum, is another pair of longitudinal ridges, which become produced into very short transverse processes, compressed from above downwards, and imperfectly preserved; the third pair of ridges are those which form the bases of the neural arch, between which and the transverse processes the upper part of the side of the centrum is concave. These pedicles, from which the neural arch is broken away, are compressed from side to side, diverge a little as they extend backwards, reach to near the anterior margin, and extend backwards for about $1\frac{2}{10}$ inch. The outside transverse measurement of these ridges in front is $\frac{8}{10}$ inch, behind it is about $1\frac{2}{10}$ inch.

Several vertebræ appear to be missing between the centrum described and the second of the series, which has unfortunately been fractured longitudinally and vertically, so that it is little more than half a centrum. The fracture shows the bony tissue to be arranged in short, irregular, parallel longitudinal laminæ, about $\frac{1}{16}$ of an inch apart. The centrum is longer along the ventral than the neural surface, the superior measurement being less than 2 inches, and the inferior measurement about $2\frac{1}{4}$ inches, indicating that the tail was curved in an opposite direction to the back, as might be expected. The anterior articulation is much wider than deep, the vertical depth being $1\frac{1}{2}$ inch, and the outline reniform, since the neural canal impresses the centrum concavely. The posterior articulation is much more deeply excavated above; the antero-posterior measurement through the middle of the articular faces is $1\frac{7}{10}$ inch. The greatest vertical measurement ($1\frac{8}{10}$ inch), from the hinder ridge of the neural arch to the facet for the chevron bone, is about equal to the greatest transverse measurement in the upper third of the centrum.

The subcylindrical centrum, which enlarges towards the two ends, is modified hexagonally by eight longitudinal ridges, two on the base, faint and parallel, becoming strong posteriorly, where they terminate in the oblique facets for the chevron bone. The side of the centrum below the neural arch is divided into three regions by two moderately elevated longitudinal ridges: the lower region is flat, and measures $\frac{8}{10}$ inch from above downwards; the middle region is slightly concave and about half as wide; while the upper region is more concave, and has a depth of $\frac{6}{10}$ inch. The upper of these lateral ridges becomes prolonged outward behind the middle line into a slight vertically compressed transverse process. The neural canal is still large, but the arch is smaller; its pedicles are very slight, are on the inside of the neural ridges, and only measure about $\frac{8}{10}$ inch in length.

The third vertebra of the series has the centrum $2\frac{1}{10}$ inches long on the inferior margin, and is smaller in all measurements. The transverse tubercle has now disappeared, and the lateral ridges are obscure. The ridges which terminate in the facets for the chevron bone are well developed posteriorly, and terminate in two distinct surfaces, which look obliquely downwards and backwards. The neural arch is small, and extends to within half an inch of the an-

terior articulation; it has no trace of a neural spine or lateral process.

The fourth vertebra is much smaller and more constricted. It is fully 2 inches long. The transverse measurement in the posterior articulation is $1\frac{4}{10}$ inch, while the depth is about an inch. The outline is subtriangular, and the cup is deeply excavated. There appears to be only one chevron facet; and, though larger posteriorly, a similar small facet also impresses the anterior articulation. This surface is flat, broadest in the upper part, but not so deep as broad. The least transverse measurement in the middle of the centrum is 1 inch. A median lateral ridge on the side of the centrum is well marked; above it the side of the centrum is concave in both measurements; below it the side of the centrum is convex vertically in the middle part. The neural arch is very small, and is margined at its base by ridges, which appear to mark its junction with the centrum. The vertical measurement through the vertebra from the neural canal to the base is $\frac{8}{10}$ inch just behind the neural arch.

The fifth vertebra is $1\frac{6}{10}$ inch long, and distorted by the development of the chevron element only on the left side. Normally, the centrum would be hexagonal, with a median longitudinal ridge on the side. The width in front, about $1\frac{1}{10}$ inch, is considerably more than the depth; posteriorly the measurements are less. The neural arch is small and compressed, with its upper margin horizontal.

The sixth vertebra is as long as the fifth, and has the facet for the hypapophysis developed in front and behind; but the ridges are absent from the middle of the underside of the centrum. The lateral ridges, on the other hand, are greatly developed and nearly parallel to each other; this gives the centrum a depressed appearance. The anterior articular face is the wider, while the posterior face is the deeper, being more than $\frac{8}{10}$ inch deep, the anterior face being fully $\frac{6}{10}$. The neural canal is still about $\frac{1}{4}$ inch wide.

Conclusions concerning the classification and organization of these Dinosaurs may conveniently be deferred until the whole of the remains have been described and figured; but these and other studies strongly enforce a conviction that the Dinosauria are far more nearly related to the Triassic and older Secondary Crocodilia than the evidence of their affinities hitherto adduced would have prepared us to anticipate.

EXPLANATION OF THE PLATES.

All the figures are of the natural size.

PLATE XXXIV.

The vertebral column of *Anoplosaurus curtonotus*.

Fig. 1. Left lateral aspect of third to seventh cervical centrums, showing how the bodies of the vertebræ increase in depth from before backward, and indicating at the upper anterior corner of each an attachment for a cervical rib.

1 *a*. Visceral aspect of third (?) cervical vertebra, showing flattened and rounded under surface, and expansion towards the anterior end.

Fig. 2. Left lateral aspect of fourteenth to eighteenth centrums of the series, showing the somewhat compressed appearance of upper parts of the bodies of the last five dorsal vertebræ.

2 *a*. Visceral aspect of the last dorsal vertebra, No. 18.

2 *b*. Posterior (?) articular end of the same centrum, No. 18.

3. The sacrum, showing the neural or superior surface, and giving evidence of the great expansion of the spinal cord in the region of the second and third sacral vertebræ. The outlets for the escape of the sacral nerves at the sides of the centrum are best seen in the first three vertebræ.

4. Dorsal surface of vertebral end of a sacral rib, showing the massive end for attachment to the sides of the centrums of the second and third vertebræ. Its worn upper surface gave attachment to the neural arch.

5. Left lateral aspect of a sequence of six early caudal vertebræ numbered 25 to 30, showing decreasing depth of the centrum posteriorly, and diminishing size in the surface for the attachment of the sacral rib which remains in union with the 30th vertebra. The chevron facet, *c*, also diminishes in size.

5 *a*. Posterior articular surface and facet for the chevron bone of the vertebra No. 26.

Plate XXXV.

Fig. 1. Internal aspect of anterior end of the left ramus of the lower jaw, showing the broken inferior border and the imperfectly preserved sockets for the teeth on the superior border.

1 *a*. Outline of the fractured posterior end of the same specimen.

2. External aspect of left coracoid, showing the coracoid foramen, and (*a*) articular surface for the humerus, and (*b*) the surface for union with the scapula. The broken superior margin of the bone is also shown.

3. External surface of proximal end of right scapula, showing the constricted upper part of the bone, (*a*) the articular element in the glenoid cavity for the humerus, (*b*) the greatly elevated spine, and (*c*) the compressed articular surface for the coracoid.

4. Superior surface of proximal articular end of right humerus, showing (*a*) the fractured radial side of the bone, (*b*) the articular head, and (*c*) the extension of the proximal articulation onto the compressed ulnar border.

5. Distal portion of the same bone with only a minute trace of the distal articular surface. It shows the widening outline of the distal end, but not the radial crest, which is concealed behind the bone.

6. External aspect of proximal end of left femur, showing (*a*) the curved proximal articular surface, and (*b*) the proximal styloid anterior trochanter, which is fractured proximally.

7. Outline of the distal end of the shaft of the same bone, showing (*a*) the intercondylar groove on the inferior surface.

8. External or fibular-posterior aspect of two portions of the shaft of the left tibia, showing (*a*) the groove behind the cnemial crest in which the fibula was carried.

9. Probably the metacarpal bone of the fifth digit, superior aspect, left foot.

10. Phalange, probably of the fore limb.

11. Lateral view of proximal end of a dorsal rib, showing the compressed vertical condition of the bone and its flattened superior surface. These characters are also shown in fig. 13, which gives the outline of the fractured end of the bone.

12. Transverse section of another dorsal rib, showing the expanded upper surface widened as though to carry dermal armour.

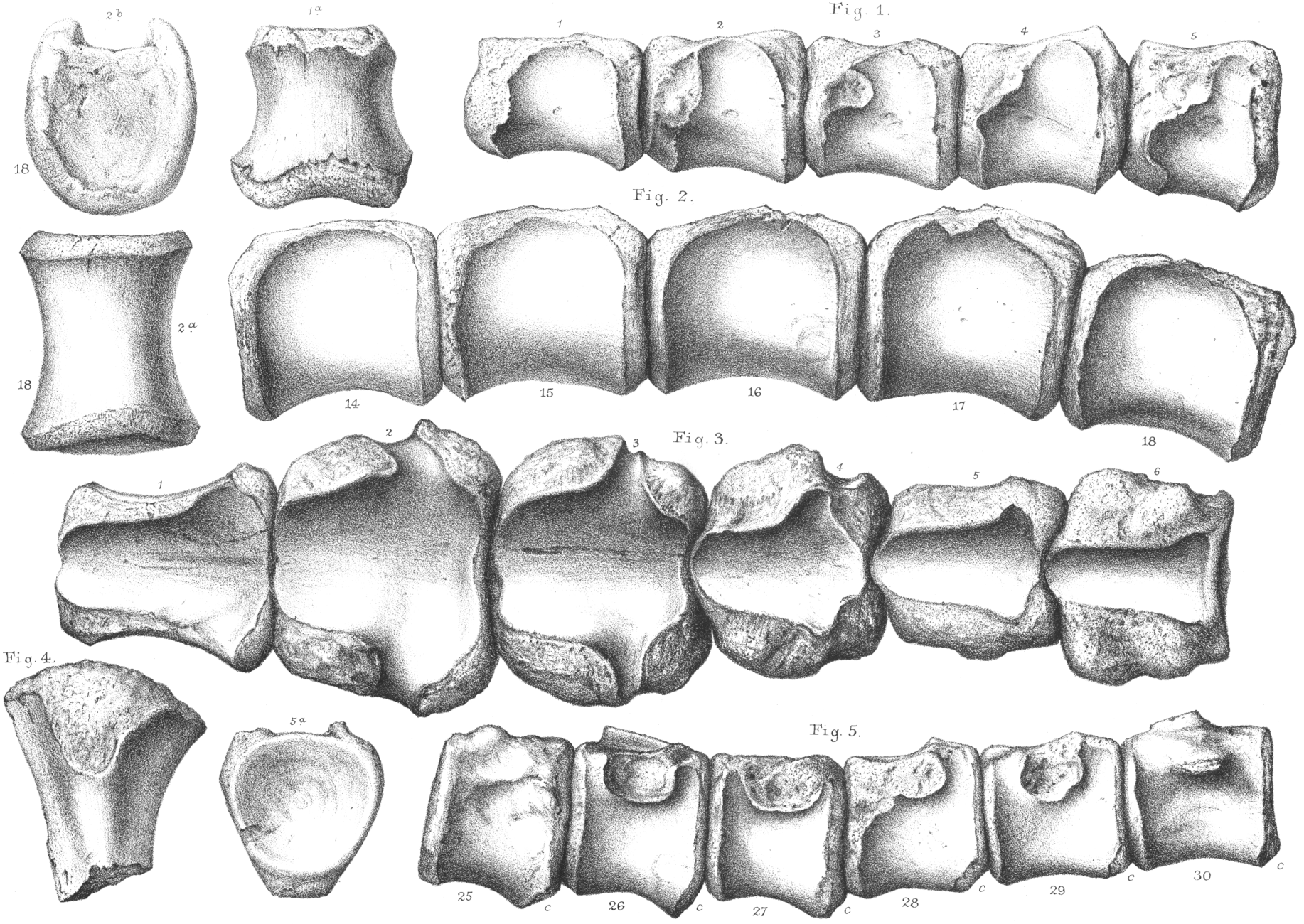
14. Right lateral aspect of neural arch of dorsal vertebra, showing (*a*) the fractured base of the transverse platform, (*b*) the lower articular surface for the dorsal rib, (*c*) postzygapophysis, (*d*) fractured prezygapophysis, (*e*) fractured base of neural spine, (*f*) articular surface for union with the centrum.

Discussion.

Mr. Charlesworth dwelt on the importance of practical experiments on the effects of exposure and maceration on bones, such as those carried out by the author of this paper.

Mr. Hulke bore testimony to the great value of Prof. Seeley's researches; but said he always felt doubt on the safety of putting together the *disjecta membra* obtained by diggers and coprolite-washers. He also expressed doubt as to the generic distinctness of *Anoplosaurus* and *Acanthopholis*. Of the truly Dinosaurian character of most of the specimens brought forward by the author of the paper there was no doubt whatever.

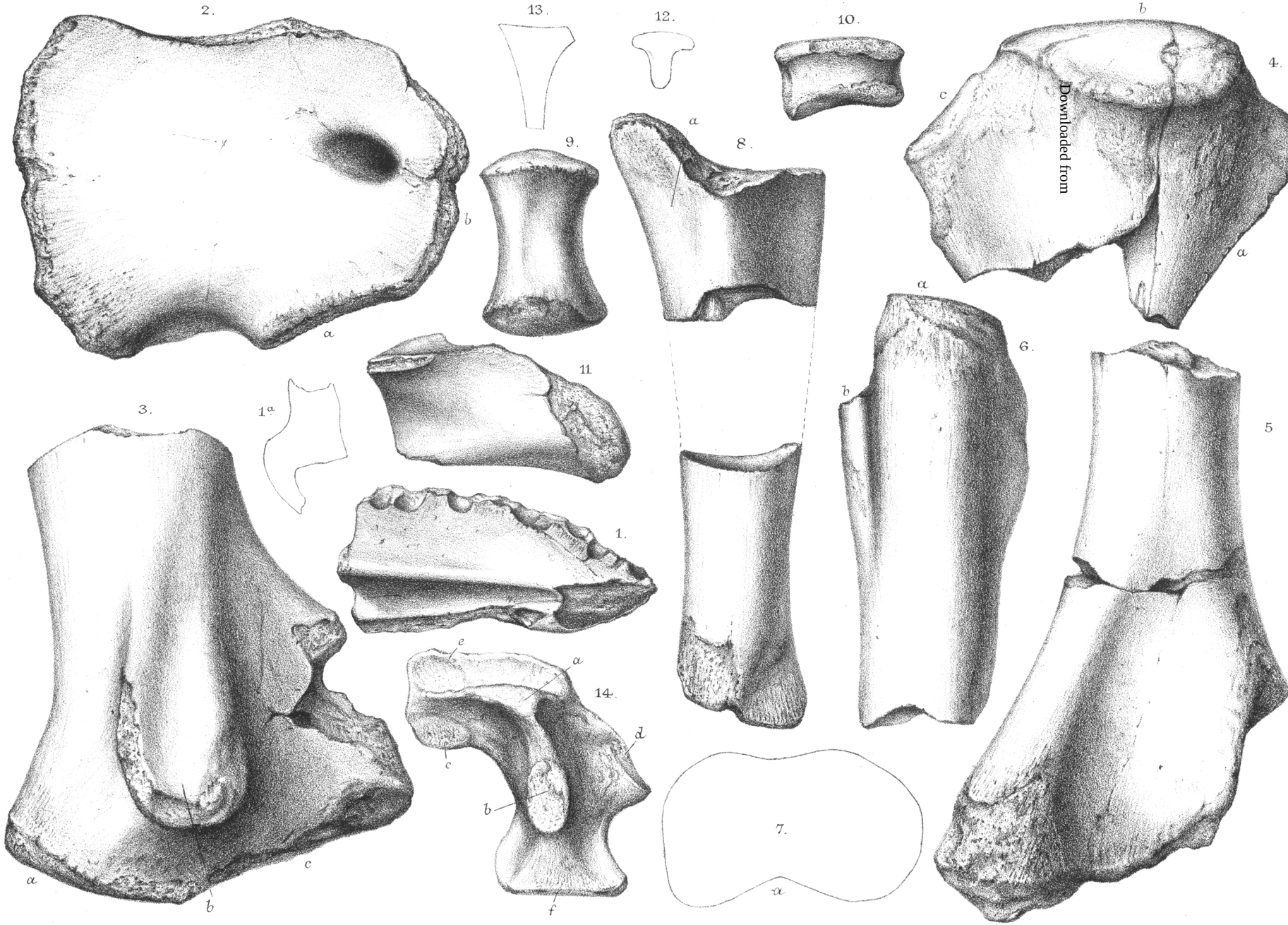
Prof. Seeley was aware of the difficulty of dealing with such specimens, but had given his reasons for associating the scattered bones laid before the Society.



C. Berjeau lith.

Mintern Bros imp.

ANOPLOSAURUS CURTONOTUS.



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ANOPLOSAURUS CURTONOTUS.

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