VIII. *Researches on the Structure, Organization, and Classification of the Fossil Reptilia.*—VII. *Further Observations on* Pareiasaurus.

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[PLATES 17–23.]

Introduction.

IN 1889 I examined the fossil Reptilia described by Professor GAUDRY from the Permian rocks of Autun, and those from Orenburg, described by EICHWALD, and obtained subsequently. These remains give no evidence of Pareiasaurians in Europe, though they add to knowledge of the Theriodontia.

Later in the year I visited Cape Colony, and examined the Museums of Cape Town and Graham's Town. Every facility for study was placed in my way by the trustees and officers of those museums, but it soon became evident that almost every specimen of obvious scientific interest had been already deposited in the British Museum, in London. There were indications of a few new generic types, but the portions of individual animals which were associated had the bones disconnected and few in number; and of types allied to *Pareiasaurus* I saw only one imperfect bone, a proximal end of a femur, collected for the South African Museum. If further evidence was to be obtained, it could only be by collecting new specimens.

Dr. W. G. ATHERSTONE, F.G.S., aided me with advice. Sir GORDON SPRIGG, K.C.M.G., facilitated my work; and arrangements were made by which I had the advantage of the companionship of Mr. THOMAS BAIN or of Dr. ATHERSTONE in my journey through the Colony. Much of the success which attended my efforts is due to this combination of circumstances, and, so far as actual collecting of fossils went, to Mr. BAIN's hereditary interest in types of life first made known by his father, to his friendly help in unremitting daily labour, and to his great local knowledge.

The Geological Horizons of South African Reptiles.

The geological horizons of the fossils hitherto collected and described have not been generally recorded, for the divisions of the rocks into subordinate strata are not

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obvious to the north of the Zwarteberg Mountains. After making traverses from Prince Albert north to Fraserberg, and south from Aliwal North to Graham's Town, and examining the shales at Kimberley which have yielded *Mesosaurus*, there appeared to me to be good reason for division of the Karroo rocks into five zones, characterised by the different types of Reptilian life which they yield, though the zones are not sharply defined from each other.

Professor HUXLEY described, from East London, a remarkable genus, *Pristerodon.* This is apparently found in the Lower Karroo rocks, but I did not visit the locality. *Oudenodon* has been recorded from the same horizon. *Anthodon,* which is probably not to be distinguished from *Pareiasaurus,* is recorded from the "Bushman's River, half way between Graham's Town and Port Elizabeth," so that it would come from the Lower Karroo beds if they are correctly laid down upon Mr. DUNN's Geological Map.* If the shales at Kimberley are Lower Karroo rocks, then, from the occurrence of *Mesosaurus* on that horizon, those rocks may be termed Mesosaurian. The Lower Karroo zone extends to the north of the Zwarteberg Mountains from the Ecca Conglomerate, and runs east and west. It may be a part of the next zone.

The second zone is that of the Pareiasaurians. It extends from south of Fraserburg Road Station to the foot of the Nieuwveldt Mountains, covering a breadth of about 50 miles of country, without evidence of a physical break at the bottom of the series. From this horizon come all the described remains of *Tapinocephalus* and *Pareiasaurus,* and those collected by myself, except the jaws of *Pareiasaurus Russouwi,* which has teeth like *Anthodon,* and is from the top of the overlying volcanic series.

The third zone is that of Dicynodonts. Almost all the Theriodonts hitherto described, the Endothiodonts and Dicynodonts, are recorded from localities which I infer to be on this horizon, partly from observation upon the lie of the strata in travelling between Balmoral and Aliwal North, but chiefly from Mr. DUNN's map. I have no evidence whether *Procolophon* is from this zone or the next zone above.

The fourth zone yields a highly specialized group of Theriodonts of new genera. I examined it at Aliwal North and at Lady Frere, and infer it to be on or about the base of the Indwe Coalfield.

The fifth zone is that of the Zanclodonts. It is seen on the Krai River and extends towards Barkly East. It comprises the Stormberg rocks. The fossils from it are *Massospondylus* and *Euskelosaurus.*

I saw no marine fossils in these strata. And the only shells, probable freshwater types, are from the zone of *Pareiasaurus,* found long since by Mr. T. BAIN.

Such fishes as I found at Klip Fontein and Colesberg were allied to types from the Permian, Trias, and Rhætic of Europe.

The plant remains from the coal of Cyphergat and Molteno, include *Tæniopteris, Glossopteris, Alethopteris, Sphenopteris,* which seemed to me specifically identical with

* Mr. T. BAIN states that many bones have lately been found on this horizon in working the Prince Albert Goldfield.

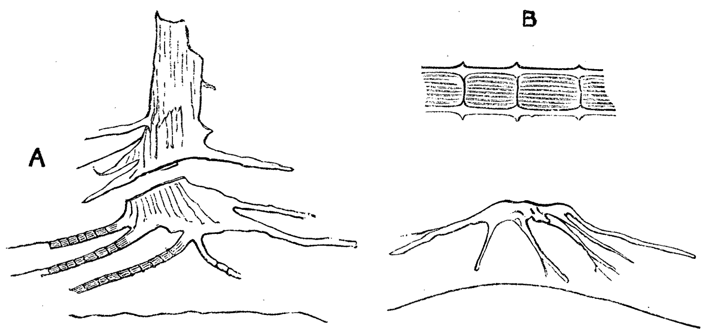
those from the Damuda horizon of the Gondwana group of India. This relationship of the flora already urged by Dr. W. T. BLANFORD as common to India, South Africa, and Australia, goes towards showing that the lowest beds of the Karroo are probably not older than Lower Permian, and that the Zanclodont beds are not newer than Upper Trias.

The Reptilian fossils from the Permian rocks of Russia have most in common with the Theriodonts from the *Pareiasaurus* beds.

Mr. ALFRED BROWN of Aliwal North showed me a *Lepidodendron* (and many other plants) from a sandstone like that which yields the *Euskelosaurus.* It was associated with *Glossopteris.* I had no opportunity of determining its horizon.

Near Cyphergat I was so fortunate as to see forest trees standing *in situ* as they grew, in sandstone just above the coal. They are so remarkable as evidence of a terrestrial surface, and in their characters, that I transcribe the following note. The trees are on two horizons, and show successive forest growths immediately above one

Fig. 1.



A. A new type of tree, showing the expanded base of the trunk and the roots jointed like *Calamites;* with successive growth of one tree above another.
B. The diagram shows the structure of the roots.

another. The uppermost tree (fig. 1) retained 80 centims. of the stem in a vertical position. It was 25 centims. wide at the base of the trunk. The trunks gave off many roots which extended laterally for from one to five feet on each side of the stem as exposed. The roots if found separately from the trunk might have been mistaken for *Calamites.* They were slender, divided transversely by constricting nodes. There was a narrow, sharp, slightly elevated transverse ridge above each nodal constriction, formed of the carbonised surface layer. This thin layer of coal in the internode was nearly smooth externally, only showing faint traces of the internal structure. Beneath this film of coal, the internal sandstone cast was longitudinally ribbed, with regular parallel grooves as in a *Calamite.* There was no indication of transverse division of the trunk where the wood was solid, though its surface was weathered.

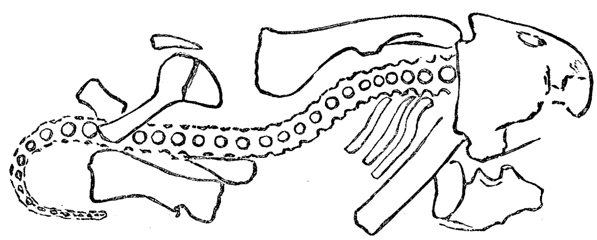
Masses of prostrate trunks of trees of exogenous growth are common in the

Karroo rocks especially about Colesberg. Wherever I saw them the prostrate trunks were parallel to each other.

The Localities of Pareiasaurus.

The original fragment of skull of *Pareiasaurus bombidens*, described by Sir R. OWEN, came from Mr. LUTTIG's farm, situate at about the junction of the Lower Karroo rocks with the Upper Karroo group, as drawn upon Mr. DUNN's map. The specimen subsequently described by myself ('Phil. Trans.,' 1888) is from Palmiet Fontein,* north-west of Tamboer, at the foot of the Nieuwveldt range, near the junction of the *Pareiasaurus* beds with the overlying Dicynodont beds. I accordingly selected this region of the Karroo as one in which *Pareiasaurus* might be searched for. At Tamboer Fontein, north of Fraserburg Road Station, Mr. J. S. MARAIS gave me a skeleton of *Pareiasaurus* which showed the structure of the palate, nineteen presacral vertebræ, sacral vertebræ, a few caudal vertebræ, parts of the pelvis, shoulder-girdle, and limb-bones, among which the ulna, tibia, and fragments of the humerus were instructive in guiding subsequent search. This fossil is afterwards referred to as the Tamboer specimen, and identified as *P. bombidens* (OWEN). Eventually, under the guidance of Mr. SEREL MARAIS, I saw a large skeleton in the rock on the side of a hill at Bad, and made a sketch of the aspect and

Fig. 2.



Aspect of the skeleton of *P. Baini* as it appeared in the rock at Bad after the outline had been cleared, and the superficial bones removed from the head.

position of the exposed indication of the remains, which is here given, because it enabled me subsequently to reconstruct the fossil. An expedition was organised; and, with the aid of Mr. J. S. MARAIS and his sons, Mr. SEREL MARAIS and his sons, and Mr. THOMAS BAIN, the specimen was quarried from the hillside under my direction on the 12th August, 1889. I marked every block of stone and fragment with colour as it was removed, so that the pieces of stone might be eventually fitted together again. In the process of excavation it was manifest that the specimen included all essential parts of the skeleton, and indicated a massive animal with short, solid, heavy, and expanded limb-bones, with long ribs devoid of the lateral ridges seen in *P. bombidens*, and with a little dermal armour in the median dorsal region.

* Formerly transcribed in error as Palinut Fontein, from the Brit. Mus. Register.

On arrival at the British Museum, I fitted the fragments together, and built up the animal and matrix into a solid mass, with the aspect which it had upon the mountain side when first discovered at Bad. This work was finished at Christmas, 1889. In January, 1890, Mr. RICHARD HALL, assistant mason in the Geological Department of the British Museum, commenced to remove the matrix, and has developed the skeleton with a skill, patience, and success which have never been surpassed. I have endeavoured to preserve the bones in natural connection by matrix; but, having first exposed the limb-bones in their original connection with each other, it has been judged desirable to separate these parts of the skeleton and articulate the bones in position as now shown. Very few parts of the skeleton are absent, and nothing of importance, except, possibly, the abdominal ribs.

After collecting this fossil, I passed north to Steenkamps Poort, Fraserberg, where Mr. J. VAN RENEN, R.N., gave me a few dermal scutes of *Pareiasaurus*, which are in better preservation than those upon the specimen from Bad.

Finally, after crossing the Nieuwveldt range, the Reverend P. D. RUSSOUW, of Fraserberg, gave me part of the maxilla and mandible of a new species of *Pareiasaurus*, which closely resembles *Anthodon* in dental characters. The specimen was found by the brothers L. and O. ERASMUS in red beds north of their farm at Klipfontein. After careful search in the rock, I was unable to detect any other parts of that skeleton, though the fossil is manifestly broken.

On these materials the following observations are made:—

The skull of Pareiasaurus bombidens (OWEN). (Plate 20).

The British Museum fossil already described as *P. bombidens** shows the general form of the skull, but its roof bones were too imperfect to exhibit all the external characters.

The occipital region was unknown, except for what appeared to be a portion of a single basi-occipital condyle. There was no evidence of the internal structure of the skull, and no part of the palate was shown. except the surface of the basi-sphenoid and adjacent region of the pterygoid bones, while the lower jaw, although well preserved as to form, was imperfect.

The most remarkable cranial character exhibited in the cast of the skull of *P. serridens* (OWEN) in the British Museum, was the forward extension of longitudinal palatal ridges, parallel to each other; and there also appeared to be other ridges on the palate, of which the described specimen of *P. bombidens* gave no evidence. It is still uncertain whether these two fossils belong to different genera, but the nature of the ridges on the palate can now be explained from the new specimens. In the Tamboer fossil, which I refer to *P. bombidens,* the cranial bones had lain so long exposed to atmospheric action that all the upper part of its skull

* 'Phil. Trans.,' vol. 179, B, Plate 12.

had disappeared, though enough remains of the maxillary bones containing teeth, and the under-lapping lower jaw which has its superior margin in contact with the palate, to demonstrate close resemblance to the fossil figured, 'Phil. Trans.,' 1888, B., Plate 15. As the maxillary teeth have not hitherto been so well shown as in the Tamboer animal, it may be stated that no tooth shows the slightest indication of being ground down with use. The crowns are enamelled, thick, convex in front, compressed from within outward towards the cutting margin, expanded from back to front in the lower part of the crown. Every crown is vertically ovate, smooth, and free from ridges on the external surface; but on the inner surface there are slight grooves which correspond to the external divisions between the denticles.

The extremity of every tooth terminates in three denticles of nearly equal size and length, very slightly divided from each other, forming a three-pronged chisel. There are two other shorter denticles on each side of the tooth. The first pair of these lateral denticles widens the crown below the middle, and the next pair widens it still more, nearer to the base. Thus each tooth which is fully exposed has seven unworn denticles.

Thirteen teeth are counted in the maxillary region as preserved. The crown contracts towards the base to a circular root wedged firmly into the jaw, apparently by cement, so that no separation between tooth and jaw can be seen ('Phil. Trans.,' 1888, B., Plate 16, fig. 2). The crowns decrease in size as they extend backward. The largest are nearly 2·5 centims. high in front, and they are too wide to be contained in linear succession, so that the posterior border of each tooth overlaps the anterior border of the next adjacent tooth.* About a centimetre of the root of each is exposed.

The palatal bones are exposed on both their inferior buccal, and superior nasal aspects. The nasal surface of the palate is smooth. The bony floor of the anterior nares is similar to that seen in the type already described; but behind the ascending process of the premaxillary bones, here broken away, there is a median reniform depression or vacuity, 2 centims. wide. There is no conclusive evidence that the premaxillary bones extend upon this suprapalatal surface. A pair of bones, defined by a well-marked median suture, extends backward and forms a median ridge about 10 centims. long. This ridge declines posteriorly owing to another pair of bones coming up from behind what may be the premaxillary pair. Further back still is a more distinct pair of ossifications which rise above the palatal plate in talon-like processes, while their posterior border rests upon the basi-sphenoid bone, and forms the anterior border of the triangular outlet for the posterior nares at the back of the palate. These bones are manifestly the pterygoids. It is not evident whether the posterior nares are completely surrounded by the pterygoid bones as they appeared to

* [Complete rotation of the teeth in this way to a transverse position, would give the denticles an arrangement only to be paralleled among Mammalia, forming many parallel rows of tubercles. —July, 1892.]

be in *P. bombidens* ('Phil. Trans.,' B, 1888, Plate 15). I have no doubt that the anterior pair of bones which lie between the premaxillaries and the pterygoids are the vomera. They contribute, with a narrow horizontal palatal plate of the maxillary bones, to circumscribe the large anterior comma-shaped (,) palatal vacuities (Plate 20, fig. 1). The sutures cannot be clearly traced, but these bones probably meet in the median line in front of the pterygoids. The palatines are not clearly defined, but must be placed laterally posterior to the palatal vacuities. Behind the palatine, and between the pterygoid and malar regions, there is a postero-lateral expansion of the horizontal plate of the palate, but no proof that it corresponds to the transverse bone. The anterior palatal vacuity is only complete on the right side, where it terminates in a rounded posterior comma-like head, divided from the corresponding vacuity on the opposite side by a bony interspace 6 centims. wide. The vacuity is 11 centims. long and 4 centims. wide. This structure of palate is best compared to the condition in Mammals, though approximated to in Rhynchocephalia, Teleosauria, &c.

There is no trace of a division between the posterior nares, which form a channel between the brain-case above and the palatal plate below. The surface of the palate in the mouth is studded over with small, cylindrical, pointed, enamelled teeth; and there is a large number of recurved teeth, packed more closely, which are arranged in parallel rows upon elevated ridges, and suggest the palate of an osseous Fish rather than the palate of any existing Reptile. The arrangement of these teeth is as follows:—First, there is a median longitudinal channel in the palate, measuring more than 20 centims. to the posterior nares; it is wide in front, constricted in the middle, and widens posteriorly to 2·5 centims. Teeth are arranged parallel to this channel. Two rows of teeth appear to originate upon the inner margin of the vomerine bones. They are at first large, and then small, the small teeth being developed as far back as the vomerine bones, or for about 10 centims. External to these short rows are two other rows, about 2 centims. apart, which extend backward to the outer angles of the posterior nares, from which point two small short rows of six or seven teeth each, converge forward down the median channel. The inner of these rows is 12 centims. long, and the outer 18 centims. long. External to the double or treble parallel ridges is a shallow V-shaped depression on each side of the palate, which is wide anteriorly towards the palatal vacuities, and narrows posteriorly to a deep groove. The whole of these spaces are covered with scattered teeth. They are bordered externally by two short ridges, about 9 centims. long, carrying close-set teeth; they unite posteriorly, enclosing a narrow space, which is more than a centimetre wide anteriorly. These double ridges diverge forward and outward to the posterior angle of the maxillary bone, and are regarded as carried upon the palatine bones. External to the outermost ridge there is a very deep channel, with a vertical border, flanked externally by a convex surface, margined on its hinder border by an oblique row of teeth diverging forward and outward. An excavation runs far under this plate, and rises into a channel above, which has the T-shaped form of the auditory chamber in *Ichthyosaurus;* and, behind that, what I regard as the opisthotic bone diverges outward and backward.

The palate, as a whole, gives the impression of carrying four parallel rows of teeth in the middle, and three oblique rows on each side. The inner longitudinal rows number about 35 teeth; the outer longitudinal rows contain 50. There are about 20 teeth in each of the pairs of lateral oblique rows except the hindermost, in which there are a dozen. The rows of teeth are approximately in the same horizontal plane, but the palatine rows ascend a little as they extend outward.

I am acquainted with no other South African genus of Reptile in which teeth are developed to the same extent in rows on the palate. There is an interesting though distant approximation to this condition in the palate of *Procolophon,* which may probably be referred to a division of the same ordinal group. Teeth occur upon the palate in rows in *Endothiodon,* but in that genus there are no teeth on the aveolar border. It is only in *Hyperodapedon* that the individual teeth on the palate are anything like as numerous, or the rows as numerous. The only genera in which teeth have been recorded on the vomers, palatines, and pterygoid bones are *Champsosaurus* and *Ophiosaurus.** In Rhopalodon teeth are figured upon the pterygoid bones.

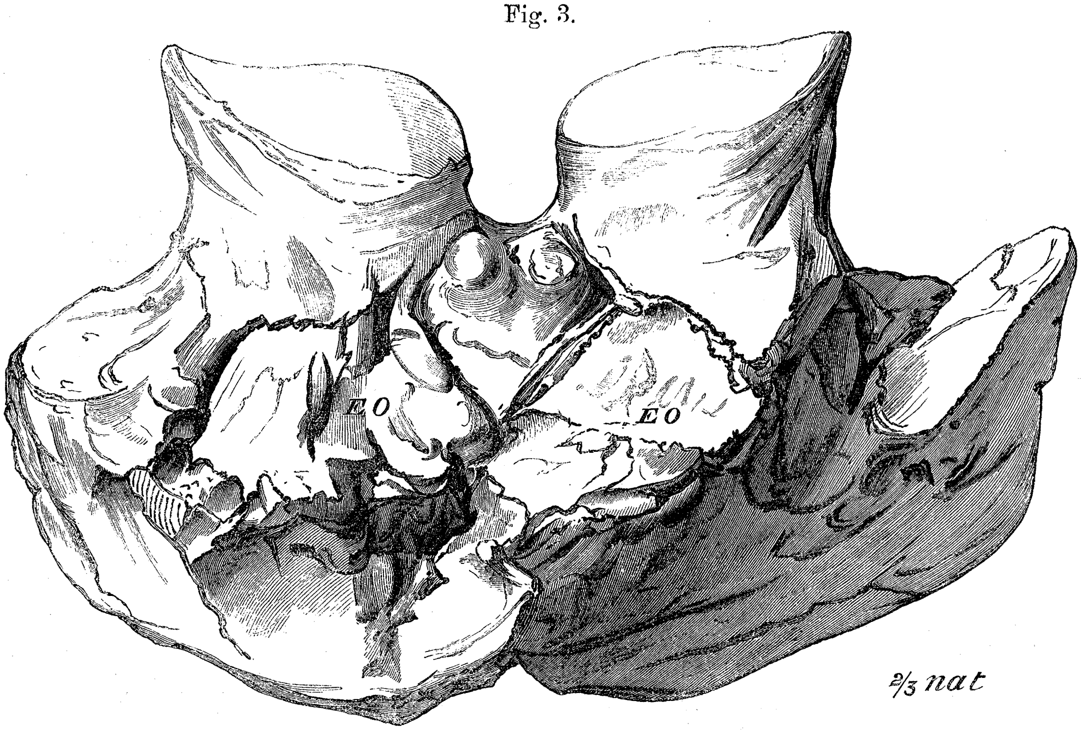
The basi-sphenoid extends backward behind the palate, as an oblong mass, with concave sides and a concave median channel. Its rounded lateral ridges descend anteriorly, and expand into buttresses which support the palate on each side of the posterior nares. The specimen gives no certain evidence that the pterygoids overlap the inferior surface of the basi-sphenoid in the way which the specimen figured ('Phil. Trans.,' 1888, B, Plate 15) appeared to indicate, though the bone is fractured in an almost identical way. The posterior transverse sutures on the basi-sphenoid are evident, but curve forward in the middle line, instead of backward, and indicate the close structural union between the basi-sphenoid and basi-occipital bones. There is an indication of the presphenoid imperfectly preserved.

The basi-occipital region has the inferior part of the condyle prominent and defined inferiorly by a groove which separates an infero-lateral process on each side. Its inferior margin is partly obscured by a large intercentral bone (Plate 20, *w*), similar to that figured 'Phil. Trans.,' 1888, Plate 20, behind the interclavicle, and it was probably the close union of this element with the basi-occipital which suggested my interpretation of the imperfectly preserved condyle as rounded inferiorly, *loc. cit.*, p. 70. The ex-occipital bones are not preserved, but there is a transverse suture imperfectly exposed which shows the position they occupied; and the posterior articular aspect of the basi-occipital is a large V-shaped concavity. This concavity defines two lateral areas, which extend backward 2·5 centims. beyond the transverse line, on the superior surface. The margin of this articular border is obscured by its close union on the right side with the displaced wedge bone. From other evidence, subsequently referred to in the skull of *P. Baini*, it will be shown that the vertebral articulation

* G. A. BOULENGER, 'Zool. Soc. Proc.,' 1890, p. 665.

of the skull with the vertebra was not transversely ovate or formed only by the basi-occipital bone; nor did it terminate in two condyles as this specimen might have suggested, but was circular and terminated posteriorly in a conical cup. This conical cup is probably a primitive condition of the small pit which occurs between the ex-occipitals and basi-occipitals of such a reptile as *Chelone*, and which is seen as a relic of the notochordal condition more or less marked in the centre of the condyle in *Ichthyosaurus*, and many other reptiles. The persistence of this unossified condition of the occipital condyle is particularly suggestive in relation to the double condyles which are developed upon the basi-occipital bone in Labyrinthodontia. For if the ex-occipital bones extended backward so as to contribute to the occipital condyle (as

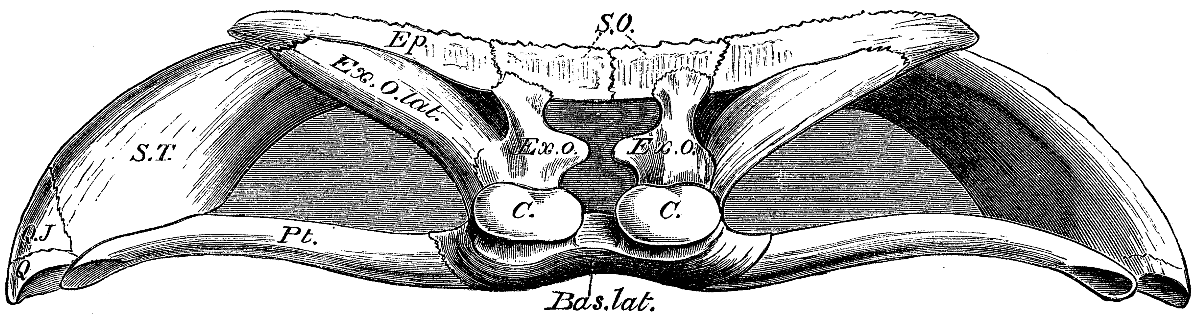
Fig. 3.



Superior aspect of the basi-occipital bone of *Mastodonsaurus giganteus*, showing the two condyles formed by the basi-occipital bone. The letters *EO*, are placed upon the surfaces which gave attachment to the ex-occipital bones. (From a cast of the type in the Natural History Museum.)

they do in numerous reptiles both existing and fossil), the Labyrinthodont articulation would approximate nearer to the condition in *Pareiasaurus*. But the Labyrinthodontia are not amphibian in this respect, since they retain the primitive mode of union of the vertebral column with the skull, by means of the basi-occipital bone only, to which *Ichthyosaurus* offers a nearer parallel than is found in *Pareiasaurus*. [It is exceptional for the skull to unite with the vertebral column by the basi-occipital bone only, but two condyles like those of *Mastodonsaurus* or *Actinodon*, formed by the basi-occipital bone, are in better osteological harmony with the structure of Reptiles, than would be two condyles formed by the ex-occipital bones, under circumstances in which the basi-occipital element was not ossified. I can see no reason to doubt that the basi-occipital element is ossified in the Labyrinthodontia; or that it gives attachment to the ex-occipital bones in *Mastodonsaurus*, and *Trematosaurus* in the way shown in the preceding figure of the former, and by Dr. E. FRAAS's figure of the latter genus, which is here reproduced.

Fig. 4.



Occipital aspect of the skull of *Trematosaurus* (after E. FRAAS) showing the two condyles (*C.*) formed by the basi-occipital bone and the ex-occipital bones placed vertically (*Ex. O.*) upon it.

The Labyrinthodontia considered as true Reptilia illuminate the affinities of many fossil groups of animals in a way which was not obvious so long as they were regarded as formed upon a distinct plan from the reptilian stock.—12th July, 1892.]

Vertebral Column of P. bombidens.

The vertebral column figured, 'Phil. Trans.,' B, 1888, Plate 12, did not show the ventral surfaces of the dorsal vertebræ, while the lateral surfaces which gave attachment to the ribs, were more or less obscured by matrix; so that the parapophysis and diapophysis which appear in the dorsal vertebræ, figs. 1 and 2, Plate 18, as separated, as shown in this Tamboer specimen, are connected by bone, which is, however, sometimes deeply constricted in the middle of the articular region, but never separates the facets as in those two figures, which are restored. Nineteen presacral vertebræ are preserved. Except the first four, they are all in natural connection with each other, and with the sacral region. There are also three caudal vertebræ from the proximal part of the tail, and two small caudals, which prove the tail to have been longer than was evident from the first specimen. There is no sharp distinction between the cervical and dorsal regions, though the transverse processes which give attachment to the ribs, extend laterally beyond the border of the centrum in its dorsal part, and are less elevated in the neck.

This character would give eleven vertebræ as dorsal, and eight as cervical. In the cervical region there is on each a distinct tubercle, which may be termed a parapophysis, but the diapophysial facet was supported on a process which extended transversely, was elevated and compressed from back to front in a way not indicated in the original specimen, or in the restored figure, fig. 1, Plate 17.

The sixth vertebra preserved (second of consecutive series) has also two distinct facets for the ribs, but in the third, these facets are scarcely divided from each other, and in later vertebræ I detect no division at all in the deep vertical rib facet of the dorsal region, though it sometimes assumes a form like a figure 8 in *P. Baini.*

The bodies of the vertebræ lengthen in antero-posterior measurement. In the consecutive series they are 6·7 centims. in the first two, 7·2 centims. long in the succeeding two. On the base there is a slight median ridge which becomes less prominent after the fourth. The size of the articular face of the centrum slightly increases in the hinder part of the cervical region, and there is an increase in the side to side compression, which changes the wide flattened ventral surface of the earlier vertebræ to a constricted rounded base in the succeeding vertebræ, greatly reducing the transverse measurement behind the rib facet. The distance from the base of the parapophysis to the summit of the transverse diapophysis, appears to go on increasing with the succession of the early vertebræ. In the twelfth vertebra there are two articular facets connected by a concave margin as in the earlier vertebræ. It appears as though the inferior articulation augmented in size at the expense of the diapophysis, that in the early vertebræ the articular facets are distinct from each other, or only united by a slender ridge, but that, in the latter part of the dorsal series, they are carried on processes which rise from a more massive base, and terminate in a vertical articulation more or less constricted transversely in the middle. The earlier facets for the ribs all look downward as well as outward, but towards the end of the series the facets are more nearly vertical, and below the buttresses, which carry the zygapophysial facets. This specimen shows the mode of union of the vertebræ with the ribs.

No ribs are sufficiently preserved to demonstrate their length. They are expanded vertically at their proximal ends, and grooved on the middle of the posterior aspect, in harmony with the constriction between the two portions of the articulation, though no dorsal rib preserved shows a notch between its superior and inferior articular surfaces, such as would define the head from the tubercle.

The other bones preserved, include the articular end of the scapula, with the anchylosed coracoid and precoracoid, which are remarkably small. Their small size helps to define the species. The bones are anchylosed together, or the sutures are too obscure to be traced. The articular cavity for the humerus is fully 10 centims. deep and about 9 centims. wide in the middle. The parts of the scapular arch formed by the scapula and coracoid meet at about a right angle. The division between the bones appears to be indicated by a longitudinal groove. At the anterior corner of the bone there is a deep depression external to the articulation, helping to define the precoracoid, which appears to unite with the scapula by a sigmoid suture, which descends into the scapulo-precoracoid foramen.

Portions of the blade of the scapula were found, but they add nothing to the distinctive characters of the type.

The articular parts of the left ilium* and ischium were found, and a right pubis, which may belong to another animal. The ulna shows the distinctive character of the species in a slender lower end of the shaft, which is imperfect distally. The distal end of the humerus is also imperfect. The tibia has a deep furrow in front, but is similar in character to the large specimen already figured, 'Phil. Trans.,' B., 1889,* Plate 25, which may belong to *Tapinocephalus*. I do not describe these fragmentary remains because the corresponding bones, seen in the skeleton of *P. Baini*, are more perfect.

Skull of Pareiasaurus Baini (Plates 17, 18, 19).

The skull is a little distorted as the result of earth movement in folding the rocks, by which it has become slightly oblique and slightly lengthened. When a median line is drawn along the palate, the quadrate articulation on the left side is an inch or two further back than that on the right side. The lateral measurement from the median line of the premaxillary suture to the hinder border of the supra-quadrate bone in the middle of the cheek is $18\frac{1}{2}$ inches on the right side, but $20\frac{1}{2}$ inches on the left side. There is thus an elongation of the left side of the head, and a gap exists in the jaw on that side about 4 inches long, which may be partly due to this cause.

The extreme length of the skull in the median line, from the alveolar border to the occipital border, measured on the palate, is $15\frac{3}{4}$ inches; but owing to the convexity of the ascending median internasal bar of the premaxillary bones, the head extends about an inch further forward. The extreme width of the skull posteriorly, over the quadrato-jugal region, as preserved, is $20\frac{1}{2}$ inches. Hence its length is to its breadth nearly as four to five. In *P. bombidens* the length of the skull is about 15 inches, and its breadth about 17. Therefore, since the skull of this new specimen is proved to be elongated by *post mortem* tension, by about 2 inches at least, it was of a broader and relatively shorter type than that referred to *P. bombidens.*

The alveolar margin of the jaw descends below the level of the palate to a depth of nearly 2 inches in front, and its depth decreases posteriorly to about 1 inch, at the posterior termination of the maxillary dentition. This vertical internal alveolar surface of the premaxillary and maxillary bones is slightly concave in depth, and in length its concavity follows in a general way the concavity of the alveolar outline.

The number of teeth in the alveolar border on the right side does not exceed sixteen, of which not more than two appear to be contained in the premaxillary bone. All these are inclined inward as in other specimens, suggesting a relation to

* [An examination of these remains enables me to identify the bone figured, 'Phil. Trans.,' 1889, B., Plate 23, as a tibia of *Pareiasaurus*. Its resemblance to the ulna is remarkable, in view of the resemblance of the femur to a humerus; but the bone had not the epiphyses, which were supposed to have been lost; and the distal end (Plate 23, fig. 3) fitted on to the astragalus.—1892.]

the outwardly inclined summits of the crowns of teeth in the mandible like that seen in the existing Lizard genus *Moloch*, and the fossil *Iguanodon*. But there is no evidence that the crowns met each other, or were worn by mutual attrition as in those types. Most of the crowns are unfortunately broken. In front of the jaw they measure about $\frac{5}{8}$ inch from side to side, while further backward their width is less than half an inch. The fractured crowns are crescent-shaped, convex in front in harmony with the inflated form of the crown, and concave internally. The general height or depth of the crown of a tooth was about $\frac{3}{4}$ of an inch, but no specimen is now quite so long, owing to loss of terminal denticles. Each tooth appears to have been serrated at the margin with seven denticles as in the Tamboer specimen, though no single tooth is sufficiently preserved to show the lengths of the several denticles. These teeth, as compared with those in the Tamboer fossil, have the aspect of being more slender, smaller, less inflated transversely, overlapping each other less, with the terminal denticles of the crown less prolonged. On the inner surface the denticles are well defined by grooves. The total length of the dentigerous border on each side, measured convexly round the outer contour of the maxillary and premaxillary bones, is $9\frac{1}{2}$ inches; at the bases of the crowns of the teeth the measurement is about half an inch less. The number of teeth on the left side is not counted with the same certainty, owing to fracture and distortion; but thirteen are preserved in the jaw, indicating the absence of three in a part of the jaw which is missing. The bases of three teeth have a longitudinal extent of less than an inch and a half. The maxillary teeth are all in the same plane from front to back, though the alveolar border possibly recedes slightly upward, towards the premaxillary region in front. An elevated ridge, of which there is no trace in the Tamboer specimen, defines the alveolar border in front; and, immediately behind the termination of the alveolar border, the bones which prolong its contour backward descend in level. The whole of the posterior lateral border is formed by the quadrato-jugal bone, which is external to, and in contact with, the distal end of the quadrate bone, but descends below the level of its articular condyle, with a thick inferior margin, which is rounded from side to side; it develops a small descending tubercular process opposite to the quadrate condyle.

Palate (Plate 19, fig. 1).

The general plan of the palate is substantially similar to that shown by the Tamboer fossil, only the rows of teeth are closer together, and the interspaces between the rows are freer from teeth. The palate is about an inch longer than in that specimen, rather narrower in the middle, and much narrower in front. The width of the transversely ovate vomerine region of the palate is $4\frac{1}{2}$ inches. There is a single anterior choana which is larger and more elongated than in the Tamboer fossil, and is placed behind the vertical premaxillary border. In that specimen the transverse width between the approximating anterior ends of the lateral comma-shaped vacuities is $2\frac{1}{2}$ inches; in this skull the width is 2 inches, and the transverse measurement of the vomerine mass is 5 inches.

The anterior pair of teeth on the palate in the vomerine region is the largest; they are well defined from the parallel rows which extend to the lateral margins of the posterior nares. Both alike have a V-shaped series of teeth in front which become smaller and smaller behind, tapering as they extend backward, but the longitudinal teeth are smaller and more vertical; and neither show the curve in length, or the recurved direction, which characterizes the teeth in the Tamboer fossil. The length of the inner row is about 2 inches, there is a second row external to it imperfectly developed, as in the Tamboer specimen; but in this fossil from Bad the rows do not extend backward so far. The inner pairs of longitudinal rows of teeth are supported upon ridges which increase in elevation as they extend backward. The transverse width in front is $1\frac{1}{2}$ inch; behind it is $2\frac{3}{4}$ inches. These ridges are not so strongly elevated in the Tamboer fossil, in which they are 2 inches wide in front and 3 inches wide behind. In both cases the width of the median groove between these rows is about the same. But while the ridges, descending posteriorly from the innermost of these rows, converge forward in the Tamboer fossil, a similar pair of ridges in this specimen converges backward. Posterior to the palatal opening of the posterior nares two ridges are prolonged obliquely outward in the Tamboer fossil on each side, and to these the Bad fossil has nothing analogous. The floor of the interspace between the longitudinal rows which converge forward, and the shorter palatine rows which diverge outward shows in *P. Baini* no traces of teeth, while in the *P. bombidens* the palatine rows are an inch shorter, with the ridges less elevated but wider, and flanked laterally by rows of teeth which cover the whole intervening space of the palate. In this fossil from Bad the teeth are not only smaller but less numerous. Otherwise the palates in the two species are essentially the same in plan. The lateral pairs of tooth rows, owing to their greater length, have an appearance of diverging outward less rapidly in *P. Baini*. There are slight differences in proportion in the areas posterior to the palate, the length being rather greater in the Tamboer fossil, while the width is less. The aperture for the palato-nares is larger in *P. Baini*, but the basi-sphenoid in both is similarly channelled, and unites by a V-shaped suture with the basi-occipital. Both specimens have similar descending basi-sphenoid processes such as are developed in *Plesiosaurus* below the occipital articulation.

There are two lateral vacuities on the palate on each side. The first pair extend from immediately below the anterior border of the orbit to the quadrate, so that they are defined externally by the maxillary and malar bones, internally by the palatine and pterygoid bones, and have the quadrate bone behind. On the left side this vacuity is 5 inches long, and as preserved it is 4 inches wide behind and narrower in front. It extends into the skull between the external armour of bones behind the orbit and the internal plate, which ascends with that branch of the pterygoid which passes outward and laps against the quadrate. This cavity evidently contained the muscles which descended to the coronoid region of the lower jaw. There is no evidence that it ascended to a median ridge of the brain case. The vertical depth of the skull in this position measured from the external surface to the back of the palate was about 6 inches. Behind the quadrate bone a second pair of posterior vacuities reach to the roof of the brain case. There are thus, upon the under-side of the head, the comma-shaped vacuities in front like those of Lizards, the single median pterygo-sphenoid vacuity, a pair of vacuities in front of the quadrate articulation, and another pair behind the quadrate.

The Quadrate Bones (Plate 19, fig. 1).

The quadrate bones are vertical, compressed, oblique plates, which extend outward and backward. They are $5\frac{1}{2}$ inches high, and in contact throughout with the external temporal shield. They each terminate downward in a compressed articular surface, which is placed transversely, 3 inches wide, less than 1 inch from front to back, somewhat convex, and margined posteriorly by a slight transverse ridge just above the condylar articular surface. On its inner border the articulation descends a little below the transverse process of the pterygoid bone, which extends to the quadrate bone. The width of the interspace between the inner margins of these condylar articulations, as preserved, is $9\frac{3}{4}$ inches, and the extreme transverse width across the condyles exceeds 16 inches. Externally, the quadrato-jugal bone descends about $2\frac{1}{2}$ inches below the level of the condylar surfaces, which may be imperfect. In its posterior aspect the quadrate looks as though bent angularly, for a vertical ridge, over its upper portion, defines a narrow posterior area from a wider internal area. There is some indication of a vertical suture in this angular bend; it shows the quadrate to be triangular, and its superior border lies between the squamosal and the internal plate of the pterygoid. There is a foramen seen on both sides which passes obliquely through the bone in the line of junction of the quadrate with the squamosal, about $1\frac{1}{2}$ inch above the condylar surface. A somewhat similar perforation is seen in the quadrate bone of *Belodon*. This posterior area of the quadrate bone is concave from side to side above, and flatter distally where it widens. The internal pterygoid part of the plate has a similar thickness, but it decreases in depth as it extends forward and inward. The quadrate bone has the general character of that figured ('Phil. Trans.,' 1889, B, Plate 10, fig. 4), which I identify as referable to *Pareiasaurus*, or a near ally.

Post-pterygoid Vacuities (Plate 19, fig. 1).

The transversely extended basal mass of the pterygoid, posterior to the dentigerous ridges and external to the palato-nares, forms a strong rounded ridge, which has a concave contour posteriorly, as it extends behind the quadrate plate to the margin of the articular condyle. This posterior border of the pterygoid is the anterior portion of the large vacuity on each side, bounded internally by the basi-sphenoid bone, and posteriorly by the bones named opisthotic and squamosal, so that it probably contained the auditory apparatus.

The lateral walls of this area are mutually inclined together so as to form a pair of oblique pent-house cavities in the back of the head, which are chiefly in front of the hinder borders of the quadrate bones, and extend forward as far as the hinder opening of the palato-nares. A longitudinal oblique depression lies in the upper surface of the transverse pterygoid process on both sides, and there is some appearance of a narrow plate of bone rising from the pterygoid and extending on the upper border of the quadrate plate backward to its junction with the opisthotic. There is a roughness on each side in the opisthotic region at about the junction of the pterygoid, basi-sphenoid, and basi-occipital bones, but no trace is visible of a bone having been attached to it.

The pterygoid bones develope a triangular mass at the hinder border of the palate, the posterior edge of which bears a small row of teeth, and it curves round so as to make an elevated ridge, which terminates externally abruptly, like the external lateral margin of the pterygoid bone in Crocodiles and Lizards, but its preservation is imperfect on both sides. It is reflected a little downward; its under surface is flat, with a tendency to concavity, and its antero-posterior surfaces are also concave. It ends upward in a ridge, which may be the columella, though the preservation is too imperfect to demonstrate that structure.

There is nothing to define the bony mass external to this lateral truncation, from the palatine bone. But there is a lateral perforation external to the outward termination of the palatine rows of teeth, and this appears to separate two distinct ossifications, suggesting the possible existence of the transverse bone.

The Occipital Region (Plate 18, fig. 2).

The back of the skull shows the occipital articulation, the foramen magnum, and the bones which arch over the back of the brain case, and connect it with the lateral armature of the head. Two vertebræ, which I regard as atlas and axis, were in contact with the back of the head, though not quite continuous with the occipital condyle, and were associated with two semi-circular intercentral bones, already figured in *P. bombidens* ('Phil. Trans.,' 1888, B, Plates 12 and 20, fig. 1), which are more developed, but otherwise recall the sub-vertebral bones long since figured in the neck of *Ichthyosaurus.*

The basi-occipital articulation does not differ appreciably in form from an ordinary articular surface of the centrum of a vertebra. The transverse measurement of its face is $3\frac{1}{4}$ inches, its depth is $3\frac{5}{8}$ inches; so that it is transversely ovate, with a margin round it, and a well-defined central concavity. I have not observed a similar condition in any Reptile; but this fish-like concavity does not in this case show evidence of organic affinity, though it certainly presents a primitive condition of the occipital condyle. The foramen magnum is transversely ovate, about $1\frac{1}{4}$ inch wide, and less than 1 inch high. The brain was evidently small posteriorly, and the walls of the brain-case show at first no augmentation in size, and the bone which forms the lateral walls of the foramen extends forward horizontally for an inch before it rises vertically in a sharp crest to the roof bones of the skull. The back of the head thus presents the greatest possible contrast to the vertical occipital plate of the Dicynodontia. Sutures between these bones are more or less problematical. The upper half of the articular occipital cup appears to be formed by the two ex-occipital bones; but there is no such clearness of the sutural lines as should be desired to affirm this condition. Supposing the ex-occipitals to be correctly identified in the cup, they also form the massive lateral pedicles of the foramen magnum which are like the ordinary neural arch of a vertebra.

The supra-occipitals are but doubtfully indicated by a longitudinal marking, which may be a suture at the upper flat wall of the foramen magnum. It would indicate a width of $1\frac{1}{4}$ inch for this convex plate, which has a slight median ridge prolonged to the border of the foramen magnum, where its width is reduced to 1 inch. I am disposed to suggest that the whole of the vertical plate, which lies between the occiput and the parietal armour, is formed by the interparietal bone, as in the Dicynodonts; but the sutures are too obscure to justify me in offering a definite opinion on this point. The two sides of the bone converge backward, and meet in the vertical median ridge already described (Plate 18, fig. 2); and it is just possible that the occipital plate of Dicynodonts is the result of a flattening of these surfaces backward, which in *Pareiasaurus* are inclined to each other. This vertical inter-parietal ridge, but for its direction, is exactly like the condition of a marine Chelonian; and the bones which extend outward from the foramen magnum on the line of the brain case are separated by similar vacuities from those above, which form the superficial armour

There is no doubt that the bones which extend laterally from the ex-occipitals to the squamosal region present a closer resemblance to such reptilian types as Lizards, Rhyncocephalians, and Crocodiles than has been found in Dicynodont reptiles. The direction of those bones is outward and backward, with a twist. They are prolonged laterally at the upper margin of the foramen magnum, as though they were posterior zygapophyses, and defined by a concavity which extends downward and forward towards the basi-sphenoid, as though it would contain the outlets for cranial or inter-vertebral nerves. The superior surface of the bone narrows as it diverges outward, and then the mass ascends vertically with a concave curve to the roof of the head The transverse width of this basin at the back of the head is 6 inches; its height above the occipital condyle to the flat roof is $2\frac{1}{2}$ inches; its lateral boundaries extend back beyond the vertical border of the occipital articulation for about an inch.

The Roof of the Skull.

The bones which cover the skull are a thin plate from half an inch to one inch thick, comparable to that seen in the genus *Lacerta*. The bone is marked with elongated pits, or grooves, which have no relations to the positions of the sutures, but produce an ornament which, on the whole, is as Crocodilian as it is Labyrinthodont. The only vacuities in the upper surface of the head are the two nares, the orbits, and the parietal foramen. The sutures between the constituent elements of this cranial armature are less distinctly shown than in the specimen of *P. bombidens* already figured ('Phil. Trans.,' 1888, B, Plates 13, 14). There are several points, however, in which the structure of that specimen is made better known by the evidence from this skull. The nasal bones are narrow, and convex between the nares (Plate 17), the superior margins of which diverge backward, upward, and outward, so that the bones are exposed in a V shape between them, in a way not previously seen in this genus. The premaxillary bones ascend as a wedge between the nasals. The ascending process, about $1\frac{1}{4}$ inch wide at the base, appears to be narrower at its upward termination, which I place $5\frac{1}{2}$ inches above the alveolar border. It forms a snout remarkably convex from above downward, as in *Procolophon* and some Theriodont Reptiles. Where the premaxillary is fractured superiorly in *P. bombidens*, the fracture is much longer than wide; in *P. Baini* the similar fracture shows the converse proportions, the bone being 1 inch wide and half an inch long.

A groove indents the bones internally, and passes down to the median choana, which is not visible in the *P. bombidens*. The roof of the nasal vacuities is formed by the nasal bones; their posterior border is made by the maxillary, and the anterior border is formed by the premaxillary. There are two tubercles above the nares, forming distinct bony prominences, with the summits about 3 inches apart (Plate 18). The length of the nasal bones from front to back is 6 inches, they terminate in a transverse suture. Internally there are lateral excavations, which appear to indicate space occupied by the olfactory organs. The frontal bones appear to be $4\frac{1}{2}$ inches long in the median line, they are divided by a median serrated suture; and the transverse suture which separates them from the parietal diverges backward, allowing the frontals to extend back laterally, so as to form the upper lateral borders of the orbits. The parietal bones are about $4\frac{1}{2}$ inches long and appear to be separated from each other by a median suture, with the exception of a small median portion behind the parietal foramen, that part being in contact with the vertical roof of the brain case, while the shield in front has no such connection. The width of the parietal region is about 7 inches. Behind it the roof bone has a concave posterior border above the occipital region, so that it is in the position of the supra occipital or interparietal bone, but appears to be quite distinct from the bones so named in connection with the foramen magnum. On each side of it, is a lateral ossification which has been commonly named the epiotic. I find myself unable to compare these roof bones with those in the walls of the brain case, and they rather seem to correspond to the dermal ossifications, which so singularly parallel the cranial bones in Sturgeons, or the elements roofing over the vertebral neural canal ('Phil. Trans.,' 1889, B, p. 290). It would appear as though in some animals the same set of bones originate simultaneously in different ways, one forming deep-seated cartilaginous elements, and the other superficial dermal elements, both of which may afterwards persist in the skull. The length of the parietal foramen is seven-eighths of an inch; its width barely three-quarters of an inch. It is narrower in front than behind, placed just behind the orbits, has a slightly elevated border, and the internal boundary is excavated in all directions, but especially backward. Its hinder border is $5\frac{1}{2}$ inches from the concave margin of the interparietal plates of the cranial shield. The length of the cephalic shield to the fracture through the premaxillary bone is $16\frac{1}{2}$ inches; the width between the orbits at their superior borders is about $7\frac{1}{2}$ inches. The sides of the head, from the angle where they meet the flat roof, have an oblique depth of 11 inches. As compared with *P. bombidens* the head is relatively wider in all parts in proportion to its length. The lateral expansions of the cheeks are greater. On the internal surface of the shield many sutures are traced, which cannot be observed on the external surface. The maxillary bones show strong prominences, which extend laterally from the sides of the nares, and ascend obliquely towards the orbit. They give a rugged aspect and breadth to the snout; which does not appear to show the lachrymal groove seen in *P. bombidens*, and in *Endothiodon uniseries.*

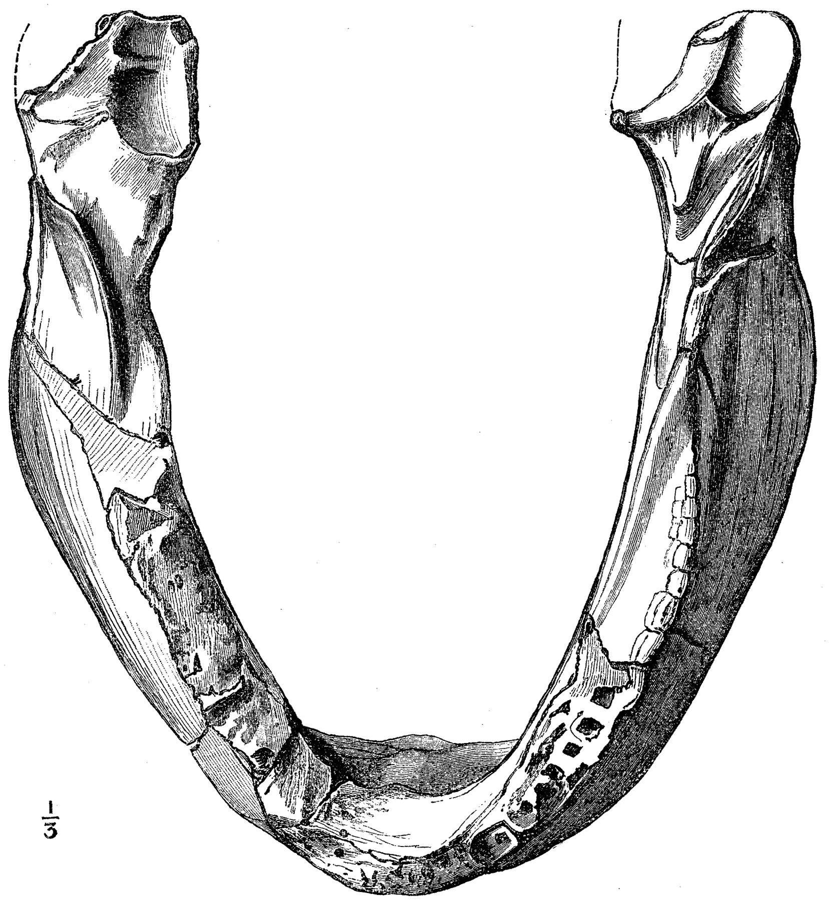
The Lower Jaw.

The lower jaw was found displaced obliquely on the palate. In all other examples of the genus, the lower jaw has been contained within the maxillary border of the skull. When the lower jaw of *P. Baini* is articulated to the condyles of the quadrate bones, it is found to be as long as the head, though it is possible that distortion has displaced the quadrate bones forward. If the lower jaw were contained within the vertical alveolar plate of the skull then the lateral processes of the pterygoid bones would fit into depressions between the slight coronoid processes of the lower jaw.

The mandible does not differ materially in form from that already described in *P. bombidens.* The chief differences appear to be, first that the articular surface for the quadrate bone is less expanded transversely, while the descending "mastoid" processes on the inferior margin of each side of the mandible, which were previously only known as convexities ('Phil. Trans.,' 1888, B, Plates 14, 15), are placed somewhat further forward (Plate 17). The jaw shows all its characters, except that the crowns of most of the teeth are lost. It manifests no evidence of crushing.

It forms a symmetrical horse-shoe (fig. 5), with the rami united by suture in front. As they diverge outward and backward, the jaw is somewhat twisted, so that its inferior border is carried out laterally beyond the alveolar border. Thus the alveolar contour is a much smaller and more lanceolate curve than the outline of the base of the lower jaw. Posteriorly, the articular extremities approach a little towards each other. The external measurement along the teeth, from the median suture outward and backward, is about 8½ inches. There appear to be sixteen teeth in each ramus, though the alveolar margin on the right side posteriorly is not quite perfect. The teeth are closely placed together; they are hollow as preserved, with quadrate roots which appear to be wedged into the jaw by cement. On the left side posteriorly a few crowns are preserved, and, like the less well preserved crowns on the right side, are smooth with an irregularly striated external surface, and are inclined outward.

Fig. 5.



Mandible of *P. Baini* seen from above. It shows the bilobed articular condyles behind, and the positions of the teeth in front of the slight compressed coronoid ridge.

No crown gives evidence of denticles, being incomplete, so that there is no proof that the dentition was the same in both jaws. The transverse width of the jaw over the hinder termination of the teeth is 8½ inches. The total length of each ramus, measuring from the middle suture round the convex external side of the jaw, is 17 inches. The length, measuring in a straight line from the front of the alveolar border to the back of the articulation as preserved, is about 15 inches.

The alveolar border has a width of seven-eighths of an inch, or less. Below its posterior termination there is an excavation on the inner side, which communicates, apparently, with the interior cavity of the jaw. External to this cavity, at a point which may correspond in position with the coronoid bone, the lateral prolongation of the alveolar border becomes thin and somewhat elevated, and is thus prolonged to the external margin of the articulation. Towards the articulation behind the sub-coronoid pit, the bone widens to receive the condyles of the quadrate bone. The articular surface consists of two longitudinally ovate concavities, of which the external one is the shorter, and the inner one is supported upon a ledge of bone, which is reflected inward, as in the jaws of Birds and many of the lower Mammals. These internal margins are not perfectly preserved, but appear to indicate an interspace of $7\frac{1}{2}$ inches between the articular surfaces. The transverse width over each condylar articulation is $2\frac{3}{4}$ inches, and to this width each concavity contributes about equally. Posteriorly the width may be reduced to about half, because the external concavity is only $1\frac{1}{2}$ inch long, and the inner concavity nearly $2\frac{1}{2}$ inches long, and it forms the posterior extremity of the jaw. These two areas are divided by a sharp median ridge. The transverse width between the external margins of the articulations is 13 inches.

The depth of the jaw in front, below the crowns of the teeth, is about 4 inches; and, as in ***P.*** *bombidens*, the jaw is compressed from front to back, and descends in the line of the symphysis in a short talon process, which is inclined backward. The inferior border of the jaw is concave in length, between this anterior process and the infero-lateral processes, which descend with a mastoid shape to a depth of $7\frac{1}{2}$ inches beneath the teeth, which is nearly double the least lateral depth in the middle of the side of the ramus. This inferior mastoid process has a broad elongated base, and contracts in the antero-posterior direction, somewhat in the form of a bovine teat, rounded at the extremity. I see no reason to doubt that the descending process is the angular bone; it is inclined a little inward at first, and then a little outward. On the inner side of the jaw, above the middle of this process, and $3\frac{1}{2}$ inches below the superior margin, is a large foramen, $1\frac{1}{4}$ inch long, and nearly $\frac{1}{2}$ inch deep. The inner side of the jaw is remarkable for its flatness and smoothness. The suture defining the dentary bone appears to have a sigmoid contour on the inner side of the jaw, extending from the back of the alveolar margin forward, then back to near the foramen just described, and finally curves round the descending process. It does not appear to extend behind this process, on the external surface of the jaw.

Comparison with Structures in other Animals.

Although this specimen leaves but little to be desired in knowledge of the skull, it may be more convenient to defer a final discussion of its characters till the matrix has been removed from the skull of *Tapinocephalus*, and from other specimens now awaiting development.

As a whole, the skull has proved to have more in common with the Lacertilia and Rhyncocephalia than was evident when the skull of *P. bombidens* was described ; but its resemblances to the extinct Reptilia are closer than with existing types.

The structure of the palate is dissimilar to that of Dicynodont reptiles, and the difference of aspect is partly suggestive of Mammalia in the closed palate, and posterior position of the palato-nares. But in Mammals the maxillary bones meet on the palate in the median line, which is not the case in this type ; and the pterygoid bones do not usually form the posterior boundary of the palato-nares in the same way. Hence the condition of the palate in this sub-order is better compared with that in Lizards and *Sphenodon*, in which the several bones have less dissimilar positions and relations to each other, and to the palatal vacuities. The value, however, of these resemblances is better appreciated when the varying position of the palato-nares is compared in the Crocodilia from the secondary rocks, and in the Edentata. From this comparison, I infer that no conclusive evidence of affinity can be found in the structure of the palate seen in *Pareiasaurus*, unless the resemblance amounted to absolute coincidence of condition. I am not aware that this is the case in any type, recent or fossil, with which this genus can be compared. Dr. VICTOR LEMOINE has figured in *Champsosaurus*, a fossil with slender snout, in which pterygoid bones, palatines, and apparently the vomer, carry small teeth comparable in a general way to those of this fossil. The resemblances of that type with other Saurians have been fully discussed by Mr. DOLLO. I should regard the teeth as having but little value in classification. They are developed on the bones of the palate in *Protorosaurus*, which may offer a less distant analogue of *Pareiasaurus* than any existing reptile.

The fossil animals with closed palate with which comparison may be made, include such types as *Loxomma, Belodon, Nothosaurus;* but none of them approach so closely to the fossil as to demonstrate very near affinity; and in many respects *Belodon, Nothosaurus, Placodus,* and other European allies of Triassic age offer closer resemblances than are found among Carboniferous Labyrinthodonts, or newer genera of secondary age.

The back of the skull in its singularly open vacuities on each side of the brain case is in the strongest contrast to Dicynodont Reptilia, and this condition is not entirely unparalleled in Plesiosaurians, such as *Murænosaurus,* and Ichthyosaurians, such as *Ophthalmosaurus,* though neither have the back of the skull so open as in *Pareiasaurus,* which in this respect is better comparable to *Sphenodon.*

The perforation external to the quadrate is also an interesting resemblance to *Sphenodon,* but it is found in Ichthyosaurs, in which the condition of the post-orbital arch more nearly parallels the fossil. The form of the quadrate bone appears to be more like that of *Plesiosaurus* and *Dicynodon,* than any other type. While its relation to the pterygoid bone and perforated condition are more suggestive of *Belodon,* in which the pterygoid makes an angle with the inner margin of the quadrate, and in which the condyles of the quadrate bone are not dissimilar.

The external surface of the skull is interesting from showing the large parietal foramen, which appears to be in the parietal bone. The sculptured external surface of the bones has not shown mucous canals, such as characterize some Labyrinthodontia, but they do not appear to be developed in the American fossil named *Eryops megacephalus*, which offers an instructive parallel to the development of lateral armour below and behind the orbit. I have had no opportunity of examining the bones of *Eryops*, but, in so far as can be judged from figures, it appears to me not improbable that the relationship between *Eryops* and *Pareiasaurus* may be much closer than would follow from the reference of *Eryops* to Batrachia, by Professor COPE, and of *Pareiasaurus* to the Anomodont alliance by myself.

The presence in the roof of the skull and in the cheeks of elements found in the Labyrinthodontia, I still regard as indicating a close relationship between Labyrinthodonts and this fossil; only it now seems to me impossible to retain the Labyrinthodontia in close association with the Amphibia, and that by transferring the order to the Reptilia, the anomaly of this correspondence in skull-structure is removed.

There is an indication of collateral affinities with the Saurischian Dinosauria, in the Rhyncocephalian characters of the interior of the skull, but it cannot be profitably discussed till further evidence is available.

Jaws of Pareiasaurus Russouwi (Plate 19, figs. 3 and 4).

I am indebted to the Reverend P. D. RUSSOUW, of Fraserberg, for a fragment of the jaws of a small species of *Pareiasaurus*, which shows the maxillary bones with the adjacent dentary and angular elements of the lower jaw. The fragment is only 9 inches long. It exhibits the suture between the premaxillary and maxillary bones, with indications of two alveoli in the premaxillary bone, which is imperfectly preserved. There is some indication of an indefinite character of a thin sub-nasal plate, but the specimen neither establishes its limits nor its existence. The fragment of the maxillary preserved is about 8 inches long. It is broken above, but shows the base of the right nasal vacuity, and of the ascending process between this vacuity and the orbit, but the inferior orbital border is broken away. The bone is slightly curved in length, and probably contains all, or nearly all, the teeth. Externally, these are broad, flat, chisel-shaped crowns terminating in many sharp striated denticles, apparently seven (five are exposed), though the striæ are absent from the enamelled face of the tooth (Plate 19, fig. 3). This condition is so dissimilar to the condition seen in the convex teeth of *P. Baini*, and both make so suggestive an indication of the denticulated dentition of Theriodont reptiles, like *Galesaurus planiceps*, that it is not without interest in its bearing on the general affinities of these fossils.

The lower jaw shows just the same descending process of the angular bone, which is found in the other species of the genus. The alveolar border laps within the palate, so that the crowns of the teeth are in contact with the upper margin of the palate.

Their roots are exposed by fracture, and the crowns curve slightly inward, possibly from compression. There is a transverse constriction at the base of the crown on the inner side, so that in front the thickness of the tooth from within outward is probably much greater than that of its root below. The crowns are relatively short and strongly denticulated all round. Only fourteen teeth appear to be preserved in a consecutive line. On the hinder of these the denticles radiate in a fan, and appear to be sixteen in number on each tooth, though they are not completely exposed on both sides of any tooth. There are pits like pulp cavities on the inner sides of the bases of the roots, such as are often seen in *Ichthyosaurus*, and one of the later teeth shows a successional crown with the denticles fully developed (Plate 19, fig. 4). They have sharp cutting edges, but do not show the vertical fluting seen on the enamelled external surface of the maxillary teeth, and the grooves between the denticles are different to those on the inner side of those teeth in *P. Baini*. The close resemblance of these teeth to those figured by Sir R. OWEN in *Anthodon serrarias*, although admitting of specific distinction, does not allow of generic separation, so that it would appear to follow that *Anthodon* is probably indistinguishable from *Pareiasaurus*. There may be ground for keeping the types separate if *Anthodon* should prove to want the descending process of the angular bone which is here preserved, but till that demonstration is made the genera may be united. This identification has the effect of extending the range of *Pareiasaurus* from the lower Karroo rocks to near the summit of the upper Karroo series.

The Shoulder Girdle in Pareiasaurus Baini (Plate 17).

In *P. bombidens* the shoulder girdle was shown to lie immediately behind the head, but its preservation is imperfect. In *P. Baini* the scapular arch is almost complete so far as the forms of its bony elements are concerned. It consists of an anterior arch formed by the T-shaped interclavicle and two clavicles which articulate with the meso-scapular process of the scapula, and two bones which may be termed epi-clavicles or supra-clavicles, like those of Labyrinthodonts and Fishes, which have not hitherto been recorded so far as I am aware in any Reptile other than Labyrinthodont. The posterior scapular arch consists on each side of the precoracoid bone above, coracoid below, and scapula behind. The clavicular arch curves round backward convexly, and it is possible that the lateral margins of the interclavicle met those of the coracoid. The extended scapulæ are prolonged backward over the ribs towards the pelvis (Plate 17).

The scapula and coracoid combine to form the articulation for the humerus, which is deeper than broad, with a notch on its upper anterior border, in front of which is the precoracoid foramen, which passes through the bone obliquely backward to the scapula.

The elongated scapula is nearly flat in its blade, comparatively straight on its under side. On the left side of the body the measurement from the precoracoid foramen to the hinder extremity of the scapula is $22\frac{1}{2}$ inches. On the right side, where the preservation is not so good, the antero-posterior measurement is $21\frac{1}{2}$ inches; the difference in the measurements may be due to distortion of the bones by twisting. The inferior border of the scapula is slightly concave in length, with the concavity increasing a little forward towards the greatly expanded articular end of the bone.

The posterior extremity is truncated, slightly thickened, convexly rounded above and below, where it becomes a little thinner. In the middle where thickest the measurement is under 2 inches, but the larger part of the expanded blade of the scapula is not more than 1 inch thick.

The superior border is much more concave in length than the inferior border, so that at 3 inches from the posterior extremity the vertical depth of the bone is 8 inches; and at 9 inches from that extremity the vertical depth is about $4\frac{1}{2}$ inches. In its proximal half the scapula deepens again, chiefly by depression of its inferior border. Just as the lower portion of the posterior end is prolonged furthest backward, so the upper part of the anterior end, which makes the border of the humeral articulation, is prolonged furthest forward. The massive character of the proximal end for the humerus has already been figured ('Phil. Trans.,' 1888, B., Plate 12, fig. 15C) in *P. bombidens*. The depth of the humeral articulation is 5 inches, and corresponds to the thickness of the bone. The articular surface is moderately concave, and has a sharp articular margin, slightly notched on its lower border. An anterior oblique suture separates the scapula from the coracoid.

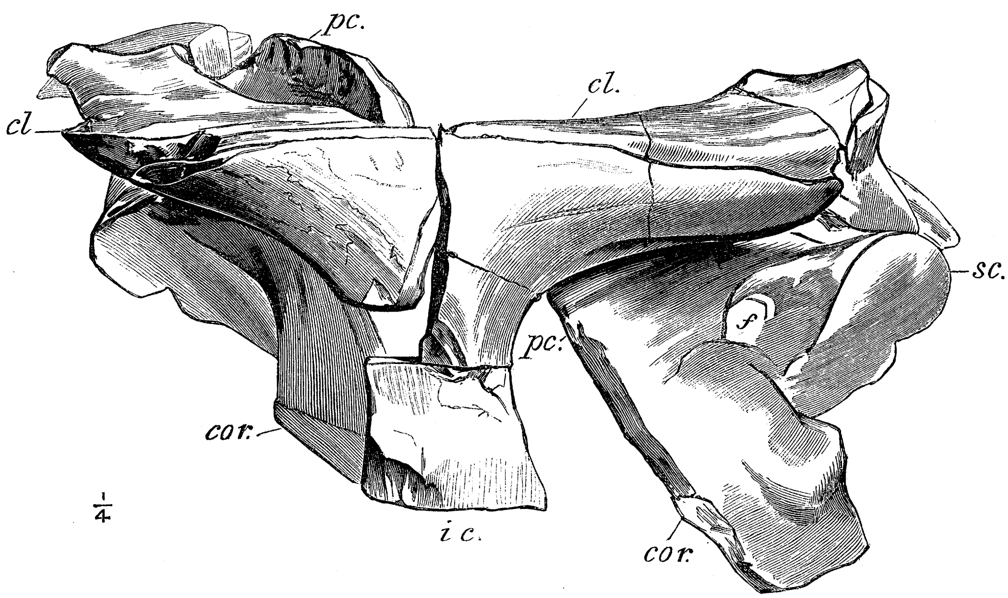
The mesoscapular process (Plate 17) developed superiorly to receive the extremity of the clavicle, has a vertical border in front, and augments the thickness of the bone to fully 4 inches. It is about 6 inches in extreme length, and three-quarters of an inch wide in the middle, becoming narrower front and back, but expanding transversely as it descends. Its surface for the clavicular articulation is perfectly flat. It somewhat resembles the process on the anterior border of the scapula in some Dinosaurs. The general configuration of the bone, with its elongated form and terminal ends, can be compared better with the condition in Dinosaurs, such as the *Triceratops* restored by Professor MARSH, than with other animals.

The sutural union of the scapula with the coracoid and precoracoid is not very distinct. The depth of the bone at the suture is about 9 inches.

The precoracoid bone (Plate 17, *pc.*, and fig. 6, *pc.*) holds the usual position with regard to the coracoid seen in figured specimens of Anomodont reptiles, referred to *Procolophon*, and to the Dicynodontia. It is placed above the coracoid in vertical position. From the precoracoid foramen to the anterior border is 7 inches and in the direction of the suture with the coracoid, which is not quite straight, the measurement is a little more. On the visceral surface these two bones combine to form a flattened but slightly concave basin, which is continuous with the adjacent part of the scapula.

The coracoid appears to have formed a wide, flattened base upon which the weight of the shoulder girdle was supported. It is possible that the specimen is imperfect at the base since the bone is there $2\frac{1}{2}$ inches thick, and narrows anteriorly. The posterior half of the coracoid forms the great semi-cylindrical concavity for the humerus, which is notched at the basal margin, both in front and behind, but marked inferiorly by an elevated border, similar to the edge of the scapular part of articulation. The bone becomes rapidly thinner in front, so that at the anterior border, which is convex in outline, the thickness is more than half an inch, and it is thin toward the junction with the precoracoid. It terminates toward the interclavicle in a sharp border, rounded from above downward. There is no certain evidence whether it met the interclavicle at the margin, or passed behind it as in *Ichthyosaurus.** The clavicular arch

Fig. 6.



Clavicular arch of *Pareiasaurus Baini*, seen from the front, in natural union with the shoulder girdle as found. *ic.* interclavicle, *cl.* clavicles, *sc.* scapula, *pc.* precoracoid, *cor.* coracoid, *f.* foramen.

consists of a clavicle, interclavicle, and epi-clavicle. The interclavicle (*ic.*) is a strong T-shaped bone, broadly expanded at the superior transverse bar, and giving attachment upon this flattened surface to the clavicles (*cl.*), which extend outward and backward in a curve to the scapulæ (*sc.*). There is no indication that the clavicle was embedded in the interclavicle in the way shown in *P. bombidens.* The transverse bar of the interclavicle measures round the convex curve 19 inches; its median depth, as preserved, in about 9 inches. The interclavicle was prolonged downward and backward in a flat, wide, median bar, comparable to that seen in the interclavicle of *Procolophon* and *Keirognathus.* It therefore may be anticipated in all Anomodonts, though not

* [A similarly thin median margin to the coracoid is found in *Mesosaurus*, which may possibly imply overlap of those bones.—July, 1892.]

hitherto found in *Mesosaurus*. This bar is at first compressed from front to back, and then thickens in the median line as it extends distally, but preserves the sharp concave lateral margin. Its transverse width, where narrowest, is 3 inches, but at the distal fracture it is nearly 4 inches wide and $1\frac{1}{2}$ inch thick in the middle. This gives a total depth for the median bar of the interclavicle as preserved, of $8\frac{1}{2}$ inches, which is nearly half its transverse width. There are obscure indications as if of separate centres of ossification for the several parts of the bone. The form of this bone is unlike that already figured in *P. bombidens*. Only the base of the descending process in shown in *P. bombidens*, and that process is much narrower than the corresponding part of this specimen ('Phil. Trans.,' 1888, B, Plate 12, fig. 1).

The clavicles only just meet in the median line without blending. The clavicle is much more convex on its external border than concave on its inner border, so that it gradually increases in width to upwards of 3 inches, as it extends outward and backward. At the outward termination of the interclavicle, the bone shows a little angular prominence, beyond which the border becomes concave, and then it is obvious that there is a sort of branch or posterior division in the clavicle, since the bone becomes channelled in the median line opposite the mesoscapular articulation. The channel is prolonged into a notch. One limb of the clavicle terminates upon the elevated scapular process, and the free end possibly gives attachment to the epi-clavicle, which is a flattened bone in close contact with the external superior margin of the scapula, prolonged parallel to its superior contour, almost to its hinder extremity, gradually decreasing in thickness, and becoming narrower (Plate 17, *ec.*). The anterior end of this bone is well defined from the clavicle, but it is not evident whether it is attached to the inner fork of that bone, which is a thick, strong process, obliquely truncated, and apparently articular, fully 2 inches in vertical measurement though less in width.*

The mode of development and dimensions of the precoracoid, and its relation to the coracoid, is a distinctive ordinal character, which this type shares with *Procolophon* and Dicynodonts. The preservation of the precoracoid foramen suggests that in Crocodilia and their extinct allies, the precoracoid is blended with the coracoid. There is some ground for inferring that in the Sauropterygia the precoracoid and coracoid are undivided, though no foramen in the precoracoid portion is seen, since in *Procolophon* precoracoid and coracoid combine, by a transverse suture, to form a bone similar in its form to the bone called coracoid in *Plesiosaurus*.† In Nothosaurians the precoracoid does not appear to be ossified. The clavicular arch in *Plesiosaurus* (*Eretmosaurus*) *arcuatus* is seen to be made up of a median interclavicle and lateral clavicles, which rest upon the scapulæ. Mr. A. N. LEEDS has shown me a combined clavicle and interclavicle which was carried anterior to the scapulæ in one of the

* The epi-clavicle appears to be shown in Sir R. OWEN's figure of the shoulder girdle of *Kistecephalus*. 'Cat. Foss. Rept., South Africa,' Plate 69, fig. 8, *b*.

† Nature of the shoulder girdle and clavicular arch in Sauropterygia ('Roy. Soc. Proc.,' vol. 51).

remarkable Elasmosaurian types of Sauropterygia from the Oxford clay, grouped under *Muræenosaurus*. There is no trace of any close correspondence to this kind of shoulder girdle in existing reptiles.

The clavicular arch finds its nearest parallel among Labyrinthodonts, owing to the apparent possession of the epi-clavicles or supra-clavicles seen in genera like *Actinodon*, described by Professor GAUDRY. The clavicular arch of *Eryops* in the relative development of clavicle and inter-clavicle, together with the scapular arch in contact with it, as figured by Professor COPE, offers by far the nearest parallel to *Pareiasaurus*. That type at present has not been demonstrated to be Labyrinthodont, and I conceive that it may be not improbably included within the *Pareiasauria*, partly on the evidence of its pelvic characters, but also on evidence of the shoulder girdle, limbs, and, to a less extent, of the vertebral column. Everything depends upon the characters used for classification. The relations of the coracoid, precoracoid, and scapula towards the humeral articulation, seem to me to make a more useful basis for classification than the imperfect ossification of the vertebræ or size of the intercentrum; and the anterior direction of the ilium, with its posterior angle, and the median symphysis of the pubis and ischium, which parallels the condition in *Pareiasaurus* and other Anomodonts, I can only account for by referring *Eryops* to the Reptilia, and provisionally to the *Pareiasauria*.

The Vertebral Column in Pareiasaurus Baini (Plates 17, 23).

There appear to be eighteen presacral vetrebræ. The distinction between cervical and dorsal region is not well marked, but ten vertebræ may perhaps be counted as cervical and eight as dorsal in *Pareiasaurus Baini*. The characters of the cervical vertebræ are not completely shown, owing to attachment of ribs and matrix. The first two vertebræ were completely embedded in the matrix at the back of the head.

The atlas as preserved is represented by a centrum, which is little more than two-thirds the dimensions of the same element in succeeding vertebræ, its neural arch is not in contact with the centrum. In the specimen figured ('Phil. Trans.,' 1889, B., Plate 12), as *Dicynodon* (*Tropidostoma*) *Dunni* (*loc. cit.*, p. 250), the first vertebra free from the skull was described as not having a neural arch. That specimen appeared to have an ossification, which is longer than a vertebra, between that centrum and the back of the skull.*

The anterior face of the atlas in *Pareiasaurus Baini* is small and somewhat convex, for adaptation to the cup of the occipital condyle. The measurement from front to back is about $1\frac{1}{2}$ inch. There is a groove in the position, which I take to correspond to the neural canal. The bone is transversely ovate, being $3\frac{3}{4}$ inches wide and $2\frac{3}{4}$ inches deep. The absence of the anterior articular cup is a remarkable difference from the usual condition in extinct Reptilia, and so far as it goes is rather suggestive

* By removing the cervical vertebræ from the skull two vertebræ were found in this position, while their mode of union with the skull is dissimilar to anything previously known.

of a Stegacephalous type, but at present there is no conclusive evidence that it differs from the condition in Dicynodonts.

The second vertebra is remarkable for its wedge-shaped neural spine, which extends forward so as to be in a line with the front of the atlas, thus reproducing the condition of the neural arch in the second free vertebra of the species of *Dicynodon* already referred to (p. 338).

The neural spine is over two inches wide behind, channelled vertically on the posterior surface, where it is thickened and expanded transversely towards the summit, on which the channel is produced forward. The antero-posterior extent of the summit of the spine is 3 inches; its wedge-like form is inclined downward and forward. The arch, as a whole, is comparatively slender. It has large, thin, flat, horizontal facets (only preserved on the left side) in the position of prezygapophyses, extending in advance of the articular face of the centrum. A slight prezygapophysis is developed in the vertebra of *Tropidostoma Dunni* (*loc. cit.*, p. 251).

On the side of the centrum, well separated from this facet by a concavity, is a moderately elevated lateral tubercle, close to the anterior articular margin of the centrum. It is ovate, less than an inch deep vertically, and half an inch wide transversely. This appears to be the facet for the rib. There is no indication of a second facet or tubercle. Similarly, on the centrum of the third vertebra, there appears to be but one articular facet for the rib, which is also of small size. In the fourth vertebra the rib facet is carried on a small short transverse process. The fifth, sixth, and seventh vertebræ show the transverse process to have considerable lateral extension, and each process appears to support the rib facet on the under side, without evidence of division into two articular surfaces, such as appear to be shown by the specimens of *P. bombidens*. The neural spines in the cervical region incline a little forward. In the fifth the expanded summit of the spine is transversely ovate, and concavely cupped; it measures $2\frac{1}{4}$ inches from front to back, and $3\frac{1}{2}$ inches from side to side. The summits are expanded in all the neural spines, but they are not so much compressed from front to back in the posterior half of the presacral series, as in the first half. They appear to be most elongated in the earlier part of the neck. The extremities of the spines are not absolutely in contact with each other, being covered by small plates of dermal armour. As the vertebræ extend backward, their vertical measurement increases a little, chiefly owing to increased elevation of the neural spines in the lower dorsal region.

The centrums of the dorsal vertebræ are conspicuously compressed from side to side, with the lateral surfaces flattened, and with intercentral ossifications well developed on the visceral surface, but not obviously larger than in *P. bombidens.* If the intercentrum were regarded as distinctive of dorsal vertebræ, ten or eleven might be counted in that region, leaving seven or eight as cervical. The relatively flattened under-surface of the centrum in the earlier series is in marked contrast to the compressed rounded base of the centrum in the dorsal region.

The distance from the front of the atlas to the front of the first sacral vertebra is about 40 inches. The length of the sacrum, which is nearly identical in extent with the blade of the ilium, may be taken at 14 inches. The length of the tail, as preserved, is 37 inches, of which 21 inches lie behind the posterior border of the pelvis.

The later cervical ribs, which were completely preserved on both sides, have on the left side a length of 24 inches. They are expanded at the proximal end for articulation to the crescentic transverse processes; are curved, flattened, and maintain a nearly uniform width and thickness to the end, which is truncated and rounded.

The mode of attachment of the ribs suggests that of certain Plesiosaurs, Nothosaurs, Lacertilians, Rhynchocephalians, but the form of the ribs, flattened from above downward, is rather Mammalian and Chelonian. In *Eryops* the intercentrum is enormously developed, so as almost to exclude the centrum from the visceral surface. But in that genus and in *Dimetrodon* the articulation of the ribs as described by Professor COPE is approximately similar.

Sacrum (Plates 17, 21, 22).

Owing to its state of preservation, apparently, the sacrum of *P. bombidens* already figured ('Phil. Trans.,' 1888, B) shows but one vertebra attached to the ilium, by an enlarged and expanded sacral rib. *P. Baini* modifies that conception. There is a presacral or sacro-lumbar vertebra, with a large longitudinally expanded transverse process, which extends in front of the principal sacral vertebra, with the transverse process below its sacral rib, so as to support the anterior angle of the blade of the ilium. And there are two other vertebræ behind the principal sacral vertebra, which may be termed sacro-caudal. Their sacral ribs extend behind the principal sacral rib, at a slightly higher level, so as to support the upper, outer, and hinder border of the blade of the ilium. Owing to the strain which the fossil has undergone in the rock, the sacral ribs are separated from the ilium by an interval of half an inch to an inch on each side; and but for this displacement the ilium would have been in close contact on each side with four sacral vertebræ; though the sacral ribs are not quite complete on both sides in the present condition of the specimen.

The neural spines of the sacral vertebræ are exceptionally strong. The first is about 4 inches high, and at the summit 3 inches wide and fully $2\frac{1}{2}$ inches from front to back; truncated and flattened superiorly, with the circumference slightly rounded, roughly cartilaginous above, with a slight central depression. This condition is in contrast to the concave summits of the neural spines seen in one or two dorsal vertebræ, from which the protecting scutes have been lost.

The anterior portion of the neural spine is regularly convex from side to side; the posterior aspect of the spine has two flattened sides, meeting at an open angle. The outer corners form, as they descend, the rounded ridges of the posterior zygapophyses. The neural spine is constricted in size as it descends in front, and the surfaces become flattened laterally, so as to excavate the neural arch behind the anterior zygapophyses. The transverse measurement over the articular facets of those processes is rather more than over the posterior pair, which have a width of $7\frac{1}{4}$ inches. Laterally there is a notch between the zygapophyses, and the transverse width is there less than 5 inches. Below the prezygapophysis is the transverse process, or sacral rib, which rises from the anterior border of the side of the centrum, well above its base, and expands vertically and transversely. It carries the facet of the prezygapophysis on its anterior part. That facet is transversely ovate, flattened and looks upward and slightly forward. The antero-posterior measurement of the massive base of this transverse process on the left side is nearly 4 inches. It seems to be somewhat narrower on the right side; and the sacral rib, which extended transversely outward, was smaller. This rib in the first sacral vertebra measures fully 7 inches in length, from its attachment to the side of the centrum. As it extends outward it becomes constricted from side to side, the anterior border being deeply concave, and the posterior border, which is at first straight, is subsequently prolonged backward. The upper surface of this rib is convex, the inferior surface much flatter, with the outer part horizontal, and measuring 6 inches in antero-posterior extent. It terminates outward in an oblique articular surface directed upward and outward for contact with the ilium. The neural canal is exposed by fracture (Plate 22); it is somewhat triangular in section, $1\frac{3}{4}$ inch wide above, and nearly $1\frac{1}{4}$ inch deep, terminating downward in a point.

In the second sacral vertebra the neural spine is somewhat smaller, for, although it reaches the same superior level, it has less height, appears to have less width, and the neural arch is altogether smaller; and, owing to the slight development of the posterior zygapophyses, the postero-lateral ridges which descend from the neural spine are slight and sharp. I infer the transverse measurement over the first pair of sacral ribs to have been about 16 inches from the measurement in the median line outward; but, in the second pair, the transverse measurement was 14 inches. The ribs are massive, and the antero-posterior extent at the side of the vertebra is 4 inches. The corresponding measurement of the external margin is about 9 inches on the right side, and was probably as much on the left side, though a slight fracture only enables $8\frac{1}{2}$ inches to be measured. These sacral ribs are directed outward and backward, as in *P. bombidens*, and as in that species they extend over the length from front to back of about three vertebræ, but the bones differ somewhat in form and character in the two species. Seen from above, the rib is remarkable for its transverse width and flattened form, measuring 4 inches from front to back, so that its superior aspect is quadrate; and, as preserved, there is no indication of the anterior notch between the sacral rib and ilium, seen in *P. bombidens*. There is also a transverse posterior compression above, which divides the thickened anterior part of the rib from the more compressed posterior part. The external articular surfaces for the ilium are about $2\frac{1}{2}$ inches thick, slightly sinuous in front, both above and below, and convex posteriorly, where the depth of the articulation is greatest.

The third and fourth sacral vertebræ are similar to each other. Their neural spines, instead of having a vertical or slightly forward inclination, begin to show a slight incline backward, in harmony with the caudal series. They are smaller than those in front. The transverse measurement of the summit of the neural spine is $2\frac{1}{2}$ inches, and the antero-posterior measurement 2 inches. The posterior surface of the neural spine is flattened. The fourth neural spine is, to a large extent, broken away, consequent on development of the specimen; for the left hind limb rested transversely across the vertebræ in this position, as indicated in the figure of the skeleton before it was disturbed (p. 312). The transverse measurement over the sacral ribs of these vertebræ gives a width of from 12 to 13 inches. They are comparatively slender, directed transversely outward, slightly backward, and articulate with the ilium in a position which is higher, or nearer to the dorsal surface, than that of the second or great sacral rib. In the *P. bombidens* already figured there is a flattening of the upper surface of the ilium ('Phil. Trans.,' 1888, Plate 12, fig. 2), which may indicate the position in which the third sacral rib was placed. At its external termination, in *P. Baini*, this rib is fully $2\frac{1}{2}$ inches wide, but it contracts as it approaches the body of the vertebra to a width of little more than 1 inch. It is only completely preserved on the left side. On the right side portions of the third and fourth ribs are seen. They expand as they approach the ilium. The iliac margin of the fourth sacral rib measures fully $3\frac{1}{2}$ inches from front to back, and this rib is stronger than the third. It is compressed in front and thickened behind, so as to show in transverse section a comma-shaped form.

The measurement from the anterior face of the first sacral centrum to the posterior face of the fourth centrum is $12\frac{1}{2}$ inches. The sacrum is co-extensive with the antero-posterior limit of the superior expanded plate of the ilium, and lies entirely in front of the middle of the articular face of the acetabulum for the femur (Plate 21). The narrowing of the transverse processes posteriorly is correlated with the mode of approximation of the iliac bones superiorly towards each other.

The visceral surfaces of the centrums of the sacral vertebræ are rounded transversely. The first is the largest, and slightly the deepest, owing to the sacral rib being given off in a more elevated position than in succeeding vertebræ. The antero-posterior measurements of the sacral centrums are: in the first, $2\frac{1}{2}$ inches; the second, $3\frac{1}{2}$ inches; the third, rather less than 3 inches; and the fourth, $2\frac{3}{4}$ inches.

Between the inferior junction of the last lumbar and first sacral centrums, is a large transversely ovate intercentrum, measuring $3\frac{1}{2}$ inches transversely, and $1\frac{1}{2}$ inch from front to back. Its under surface is flat, smooth, and convex from side to side, so that it gives a flattened aspect to the junction between the centrums. A similar, but rather smaller intercentrum is present between the two succeeding vertebræ, which are possibly anchylosed together. It is uncertain whether an intercentrum was developed between the third and fourth sacrals. The three posterior sacral vertebræ have diminutive zygapophyses, the facets of which must have less than half an inch in diameter; but the prezygapophyses of the second have the facets $1\frac{1}{2}$ inch in diameter, and this I regard as showing that the union between the second and first took place late in life, so that the first sacral vertebra is rather to be termed sacro-lumbar. In all cases, the posterior margins of the centrums appear to be slightly more prominent, and wider than their anterior margins.

This specimen illustrates the difficulty in determination of the number of sacral vertebræ in other Anomodonts in which preservation is less perfect.

I obtained evidence in South Africa from a specimen entrusted to me by the Directors of the Albany Museum, that in the genus *Procolophon* (see p. 365) there are also four sacral vertebræ; that is to say, four vertebræ with sacral ribs modified for attachment to the ilium. Sir R. OWEN has shown that in *Platypodosaurus* there are five sacral vertebræ, and it is probable that some variation in number of vertebræ in this region is found in different sub-ordinal groups. The correspondence between the number in *Pareiasaurus* and *Procolophon*, combined with the general similarity of plan in the structure of the skull, and of the shoulder girdle, have suggested to me the convenience of placing *Procolophon* as a family or division of the Pareiasauria, instead of grouping it as a distinct order in the way previously suggested.

Caudal Vertebræ.

The length of the tail, as preserved, is about 37 inches, but its extremity is incomplete, having been exposed on the surface of the hill, and the terminal vertebræ lost among the *débris* carried away by the rains. When complete, its length may have been three feet six inches. Twenty-six caudal vertebræ are preserved. The neural arch is developed to the end of the series. Chevron bones appear with the fifth post-sacral vertebra, and appear to have been continued to the end of the tail. The vertebræ are at first wider than deep, but they afterwards became compressed from side to side, for, after the sixth, the transverse processes become shorter and shorter till they disappear in small lateral tubercles. In harmony with this condition, facilitating lateral movement, the tail was bent round towards the side of the pelvis when the fossil was discovered.

The first two vertebræ of the tail were found displaced to the left, resting flat on the articular faces of the centrums, so that there was a slight gap between the body and the tail, which, however, was in a continuous line in the two series of vertebræ. These displaced vertebræ are obliquely crushed, and in both the neural arch and transverse processes are imperfect. The transverse processes are wide, compressed from above downward, and attached along the entire width of the arch. The centrum was about three inches wide, a little less high, with a concave channel for the neural canal, and a sharp posterior articular margin to the base of the centrum. In the second vertebra the deep attachment for the transverse process is conspicuous; the neural spine is directed backward, with a sharp median keel in front, so that its section is irregularly triangular. There appears to have been an interspace between the bodies of the early caudal vertebræ of about half an inch.

The neural canal is always very much larger on the posterior aspect than in front, where it is relatively small, and wider than high. In the fourth centrum the width in front is $2\frac{3}{4}$ inches, the depth 3 inches. It is well excavated for the neural canal. The strong neural arch extends laterally beyond the margin of the centrum, and terminates outward in a sub-triangular blunt process.

The strong neural spine is $3\frac{1}{2}$ inches long, $2\frac{3}{4}$ inches wide, a little constricted in front of the postzygapophyses. The prezygapophyses are here broken away, but in the succeeding vertebræ they are strong anterior elements, inclining a little forward, so that they help to define a lateral concavity of the arch, which is completed above by the neural spine. The measurement over the pre- and post-zygapophyses exceeds $3\frac{1}{2}$ inches. Each zygapophysial facet is nearly circular, more than an inch wide. The transverse process is attached to both the neural arch and the side of the centrum. The base of the centrum is transversely rounded and shows no sign of inferior ossifications on its margins. In subsequent vertebræ the transverse processes are nearer to the anterior border of the centrums. The processes become more compressed from front to back, but still have deep bases, and are obviously shorter than in earlier vertebræ. The prezygapophyses become less developed with the appearance of the chevron bones, which are attached to the inferior posterior edge of the centrum, and directed backward. In the fifth vertebra one chevron is preserved, and in the sixth both are anchylosed together at the articulation, and subsequently fractured. In the following vertebræ the chevron bones are conspicuously strong. In the seventh they form a V shape, are about 3 inches wide at the vertebral articulation, anchylosed together, $4\frac{1}{2}$ inches long, and at the free end conspicuously truncated. They are possibly slightly curved from front to back. At about the twelfth vertebra, the centrum, which has diminished in front to back measurement, is less than 2 inches wide. The neural spine is perfectly preserved in the fifteenth vertebra, it is over 2 inches long, less than 1 inch wide, and from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch thick, terminating in a slightly expanded truncate-rounded surface. It is inclined obliquely backward, compressed from side to side, with a sharp ridge back and front. The zygapophyses now become directed upward and outward, so as to lap round the neural spine, without showing conspicuous facets.

The tubercles representing the transverse processes have become small, and though the chevron bones continue to be strong, at the twentieth vertebra the bone is only $1\frac{1}{4}$ inch in length, and articulates by a broad surface with the centrum of the preceding vertebra, below the body of the succeeding vertebra. As this chevron facet is only slightly inclined to the face of the centrum it gives a different aspect to that produced by chevron bones in most animals. The transverse truncation of the extremity of the chevron bone, by a broad flat semi-circular surface, defined by a strong border, is a condition which distinguishes this bone in the later caudal series.

On the twenty-sixth vertebra, the last of the series preserved, the tubercle which represents the transverse process has disappeared. The decrease in size of the last five vertebræ is so gradual that there may have been several more in the complete series. The last vertebræ have the margins of the centrums well elevated and rounded as though there were a freedom of movement towards the extremity which did not exist higher up the series. The length of the last eleven vertebræ preserved is $9\frac{1}{2}$ inches, the earliest of these is 1 inch long, the latest less than $\frac{3}{4}$ of an inch. Five vertebræ are probably missing from the end of the tail.

The vertebral column has more features in common with that of *Sphenodon* than with any other order of existing Reptiles. That type has a small atlas and a large neural arch to the second vertebra. The cervical ribs have deep attachments, and imperfectly divided heads, which closely parallel the condition in the fossil. The dorsal vertebræ are deeply cupped in a manner which is not altogether unlike the tubular central depression seen in these fossils. Comparison cannot be made in detail; the neural arches are different, the caudal chevrons are attached between the vertebræ, instead of to the anterior centrum. Sauropterygia and Nothosauria, especially in the large-headed short-necked forms, show considerable resemblance to the vertebral conditions of *Pareiasaurus*, though they never have the neural arch so wide; and in Sauropterygia, at least, the attachment for the dorsal rib is not so deep, nor does the articular surface ever appear so nearly divided into two facets, as is seen in some dorsal vertebræ of *Pareiasaurus Baini*. I much regret that the difficulty of excavation compelled me to abandon the search for abdominal ribs. Their occurrence in Rhynchocephalia, Protorosauria, Nothosauria, Sauropterygia, and Chelonia, in which they may be regarded as making the foundation for the plastron, strongly suggests their occurrence in Anomodontia, especially as they are already known to be well developed in some species of the genus *Mesosaurus*.

Dermal Armour of Pareiasaurus Baini.

The only dermal armour found on the specimen of *P. bombidens* consists of small scutes which were chiefly disposed laterally above the sacral and caudal vertebræ. I examined the specimen now described while it was still in the rock, but failed to observe any evidence of scutes in this region, and none have been met with by Mr. HALL in chiseling away the matrix. *P. Baini*, however, shows a few convex pitted scutes, 2 inches in diameter, with sharp margins which were found just behind the head.

Three rows of scutes appear to have extended down the median line of the back, and are still preserved in contact with the neural spines. Each scute is about 2 inches wide by $1\frac{3}{4}$ inch long. The median row was placed on the summits of the neural spines and above the interspaces between them. In contact with these, laterally, there is a pair of scutes extending transversely outward; so that in the antero-posterior direction three scutes may be counted corresponding to each vertebra. And the effect is a median longitudinal stripe of close-set scutes, flanked by two lateral rows; and this dorsal armature I suppose to be a specific character of this species. The neural spines of the sacral vertebræ had the appearance of being much larger when the specimen was in the rock, but I am unable to say whether this was due to dermal armour upon them, which has since disappeared, or resulted from investing rock.

The scutes from Steenkamps Poort, given to me by Mr. VAN RENEN, are rather larger, thinner, relatively longer, and marked by a radiating ornament. They probably indicate another species, and were associated with a considerable number of fragmentary bones of which I have only a caudal vertebra, remarkable for the short antero-posterior extent of the centrum.

Pelvis of Pareiasaurus Baini (Plates 17, 21, and 22).

The pelvis is a little crushed, so that its vertical depth has been slightly decreased, but the arrangement of the bones in the fossil is substantially as in life. The extreme longitudinal extent of the bones is about 29 inches. The striking features of the pelvis are, first, the anterior direction and superior development of the iliac bones; and, secondly, the complete anchylosis of the ischium and pubis to form a posterior ventral sheet of bone through which there are no openings like the obturator perforations in Mammals. The blade of the ilium is flat externally, and slightly concave from above downward. The inferior anterior angle curves a little outward, and the superior posterior angle curves a little inward; so that the expanded blades of the bones of the opposite sides of the body are inclined to each other, and if prolonged upward would meet at some height above the vertebral column, as in many Mammals and Birds. In Saurischian-Dinosaur Reptiles, which alone among Reptilia approximate towards the Anomodont types in pelvic characters, the iliac bones usually diverge from each other, as they extend towards the dorsal surface, or are vertical.

In general form the blade of the ilium is irregularly oblong, measuring about $12\frac{1}{2}$ inches in length on its superior margin. In front, its contour is rounded as it ascends to the straight and nearly horizontal superior margin, and it is slightly concave behind. The rounded anterior part of the upper margin looks obliquely upward and outward, is thickened, has its edge horizontal transversely, and this border was apparently cartilaginous. The bones on the two sides of the animal are very similar, and the slight imperfections of the one side are completed by the better preservation of the other side. The transverse external measurement over the anterior angles of the iliac bones is 23 inches. The depth of the ilium in front is 5 inches, $5\frac{1}{2}$ inches in the middle, and the depth increases posteriorly as the bone descends with a concave curve towards the acetabulum for the head of the femur.

On the internal surface of the ilium of *P. bombidens*, figured 'Phil. Trans.,' 1888, B Plate 19, a groove is seen near the lower border of the bone, which I did not discuss in describing the specimen. This appears to indicate a bone on its inner surface which comes between the ilium and the sacral rib. A similar groove is shown in *P. Baini* (Plate 21). I am not aware of any similar structure in other animals, and the state of the fossil does not make the significance of this condition quite clear; but since the groove in *P. bombidens* extends to the acetabulum it seems to suggest that the pubis may extend on the inner face of the ilium. In that case the two anterior sacral ribs would articulate with the pubis, and only the posterior two would be in contact with the blade of the ilium.

The depth of the ilium posteriorly is about 9 inches, and its length along the upper border of the acetabulum may be only about 7 inches. Its articular border is thickened and prominent. The acetabulum is of irregular sub-triangular form, about 7 inches wide above and 5 inches wide below, with the infero-lateral borders concave. Three well-developed prominences correspond, first, to the border of the ilium in front, secondly, to the ischium behind, and, thirdly, to the pubis at the base of the acetabular cavity. The transverse width or thickness of the ilium is considerable, especially in the acetabular region. The least transverse width, over the pelvis, measured internally, between the posterior angles of the iliac bones, is less than 11 inches.

The form of the anterior aspect of the pelvic opening between the sacrum and pubes is very nearly circular. It is 11 inches deep from the base of the centrum to the anterior ventral margin of the pubis. The lateral parts of the curve are made by the sacral ribs, which are directed downward and backward, and form the upper arch, meeting the pubes, which make the inferior part of the circle.

The anterior entrance to the floor of the pelvis is sharply defined from its posterior part by an angular bend, which reflects the front downward (Plate 22, fig. 1). The anterior 4 inches of the pubic bones are nearly vertical, concave from side to side, and slightly convex from below upward (Plate 21). This bone is shown to be the pubis by the foramen (*f*) which passes horizontally through it behind the acetabulum. *Eryops megacephalus* (COPE) appears also to have the pubis directed downward in front, with the foramen similarly placed. This vertical portion of the pubes in *P. Baini* makes very nearly a right angle with the flat interior floor of the basin of the pelvis, which is somewhat channelled on each side, owing, probably, to compression of the rock. The ossification is exceptionally complete, so that sutures between the several bones, if not obliterated, are more or less conjectural.

Externally the form of the pelvis is remarkable; for the pubic bones extend from the ilia downward and backward as vertical plates, broad and rounded from side to side, with a convex inferior contour, which is parallel to the anterior margin of the acetabulum. The inferior processes in front of the base of the pubes are thickened, as though they were callosities for supporting the body (Plate 21). They are $2\frac{1}{4}$ inches wide, have a transverse direction, and measure 14 inches from left to right. The two sides of the pelvis converge inferiorly, to meet in a median keel, which extends from front to back, and has the same relation to the transverse ridge in front as the staff in a T has to its cross bar. The under surface of the bone is greatly excavated between these ridges. Each of the inferior surfaces of the pelvis is oblong, measuring 14 inches long, and 9 inches wide at the hinder part of the acetabulum, and 8 inches wide at the posterior margin of the bone, which is sinuous. The ischium is thickened at the outer posterior border, which has a slight convex curve upward, in harmony with the rest of the outer superior part of the bone.

There is a longitudinal division in the middle of the length of the ventral plate of the pelvis on each side, but I am unable to determine whether this is a suture or a plane of fracture due to slight ventral compression. If it is a suture it indicates that the whole of the longitudinal ventral keel, and some breadth of bone on each side of it, is a median ventral ossification (*ip.*) or a backward prolongation of the pubes, and that the symphysis pubis extends along the whole antero-posterior extent of the base of the pelvis. The ischium in this case would be external and parallel to the pubis on each side. There are uncertain indications of a division descending from near the external outlet of the pubic foramen, and at a distance of 5 inches behind the front of the pubis, this division plane is 4 inches from the median line of the ventral keel. It approaches to within 3 inches of the median line further back at a distance of 4 inches from its posterior extremity, where it curves outward.

The median ventral keel is not more than half an inch wide in the middle of its length, but it widens transversely to about 3 inches in front, and rather more behind. The keel is concave in length, except at its flattened and expanded extremities. These thickened inferior processes have the aspect of growth resulting from mechanical causes, and may indicate effects of the great weight of the body in stimulating ossification upon cartilaginous surfaces.

The external border of the ischium is concave in length, but irregular in form. In front a sharp ridge is developed on its inferior margin, and above that ridge the bone is excavated. There is a small tuberosity on the margin towards the posterior extremity.

The acetabular surface of the ilium looks downward, because it extends outward laterally beyond the bones which are attached to it (Plates 17 and 21). As in *Phocosaurus* the surface of the ilium which supports the head of the femur is thickened and projects into the acetabulum, being slightly defined as a large crescentic surface. A similar crescentic process is seen in the Russian Theriodont figured by EICHWALD. Behind the middle of this articular surface is a pit which may be for the attachment of the ligamentum teres.

As a whole the pelvis has a Mammalian aspect, but no genus can be named in which it is closely paralleled. If the Pinnipedia have a pubis and ischium similarly prolonged backward, those types have no corresponding median symphysis, or similar development of sacral ribs ; and it is among the more specialised terrestrial Mammalia that comparison would show the nearest resemblance to the conditions of the pelvic elements here discussed. The ischio-pubic region, whenever it forms a median symphysis, is less developed among Mammals than in these fossils. If the *Hyrax* has the ilium prolonged far forward, the ischio-pubic region has less backward development, and on the whole, the resemblances are as close with Carnivorous types like Bears and Tigers, with Deer, with Edentates like *Orycpteropus*, or with Echidna, in which the presence of prepubic bones constitutes a remarkable difference from the bone extending along the inner side of the ilium in *Pareiasaurus*. The most striking features of Mammalian character, which have interest when considered collectively, are its relation to the sacrum, the development of the ilium in front of the acetabulum, and the presence of a small posterior process to the ilium above the acetabulum; the longitudinal parallelism between the superior borders of the expanded ischium and ilium; and the downward direction of the pubic bones at a right angle with the ilium, to enclose a basin. On the whole, the Pareiasaurian pelvis may, perhaps, have the nearest analogue among Edentates; and the characters are equally marked whether the pelvis is examined from above or below or the side.

The form and forward position of the ilium, thus united to the sacrum, make comparison of that bone with existing Reptiles or Amphibians impossible. The only fossil animals which approximate in any way in these pelvic characters are the division of Dinosauria termed Saurischia, in which the ilium is usually directed forward with an expanded blade; but the pubes in that order, although meeting with a median symphysis, have their chief development in front of the acetabulum, and downward rather than inward, and have no posterior development of the pubic bones below the ischia, such as occurs in Ornithischian Reptiles. Therefore the resemblance of the Pareiasaurian pelvis to the higher Ornithomorpha cannot be held to indicate close affinity though it may be of some value in explaining, by collateral descent, similarity of form in other parts of the skeleton.

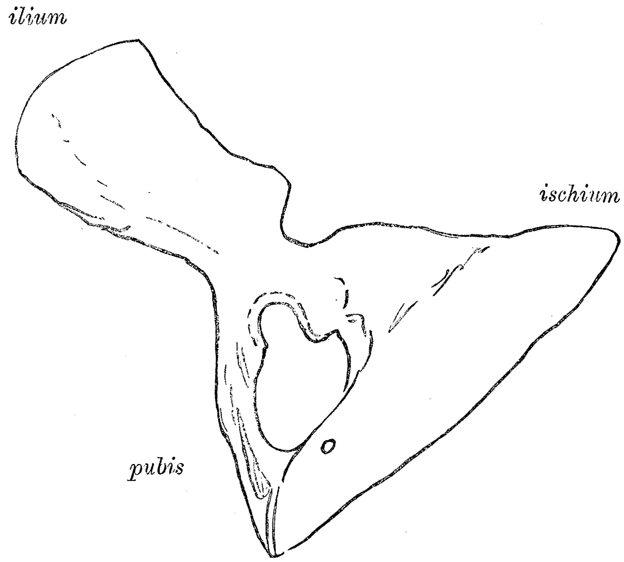
Such resemblances as are seen in Amphibia are limited to comparison of the inferior bony basin of *Pareiasaurus*, with a continuous sheet of cartilage in the inferior part of the pelvis of *Urodela*; but in the majority of amphibious types the pubic bones are remarkable for development forward; and the Amphibian pelvis, in general character, does not suggest Mammalian comparisons, although the illium extends forward in Anura.

Perhaps the most singular correspondence, after the obvious and close resemblances of this type with the Dicynodont Reptiles of South Africa, is with the American fossil described by Professor COPE as *Eryops megacephalus*.* The pelvic bones do not appear in *Eryops* to be united to the vertebral column, and in that genus it is obvious there was no such development of strong sacral ribs as in *Pareiasaurus*. The pelvis is compared by Professor COPE in its inferior compression to the corresponding parts in the Anura; the ilia are said to be "shorter and worn as in the Urodela." The genus is grouped by COPE with the Ganocephala. My only knowledge of this

* E. D. COPE, 'Proc. Amer. Phil. Soc.,' vol. 19, Plate iv., figs. 11–14, 1881.

American type is derived from Professor COPE'S writing and figures; and although the vertebral column obviously differs in many details, and especially in the great development which the intercentrum attains, so as to occupy the visceral surfaces in the dorsal region, there are many resemblances between *Pareiasaurus* and *Eryops*, so that the relation between them may be closer than has been supposed, and, perhaps, justify the grouping of *Eryops* among true Reptiles, in the order Pareiasauria. The mode of attachment of the ribs appears to be similar. The external characters of the skull are not unlike. The shoulder girdle is almost identical in essential points. And

Fig. 7.



Pelvis of *Eryops megacephalus*, after COPE, drawn in a position to compare with the os innominatum of *Pareiasaurus* and Anomodonts.

if the pelvis is inclined so as to bring it into harmony with the Dicynodonts already figured, I can see no difference of plan to separate it from the pelvis of an Anomodont Reptile. There has been no demonstration given of the Labyrinthodont organization of *Eryops* or of the Amphibian organisation of its immediate allies, and, therefore, instead of interpreting resemblances to *Eryops* as Labyrinthodont characters, it seems to me more legitimate to regard those characters as probably Pareiasaurian, especially as they are nearly all common to other Anomodonts.

The Limbs of Pareiasaurus Baini.

On the right side of the animals the limbs are well preserved, and were in their natural positions in contact with the pelvis and shoulder girdle, though the bones have undergone some amount of compression. On the left side they were exposed on the surface of the country, and there is not the same demonstration of natural association. The bones had decayed with exposure, though, from not being distorted, the fragments are instructive. The imperfect left femur was found, and upon the sacral region of the skeleton were the imperfect left tibia and fibula and proximal tarsal bone. It is, perhaps, just possible that these bones may belong to another animal, but since they complete the osteology of the skeleton, and no other remains occurred near, there is no sufficient ground for questioning the association. Of the left fore limb only the distal end of the humerus was found, and although it is wider than the corresponding part of the right humerus, and the vertical depth of the condyle is less, the differences in measurement may be the result of distortion

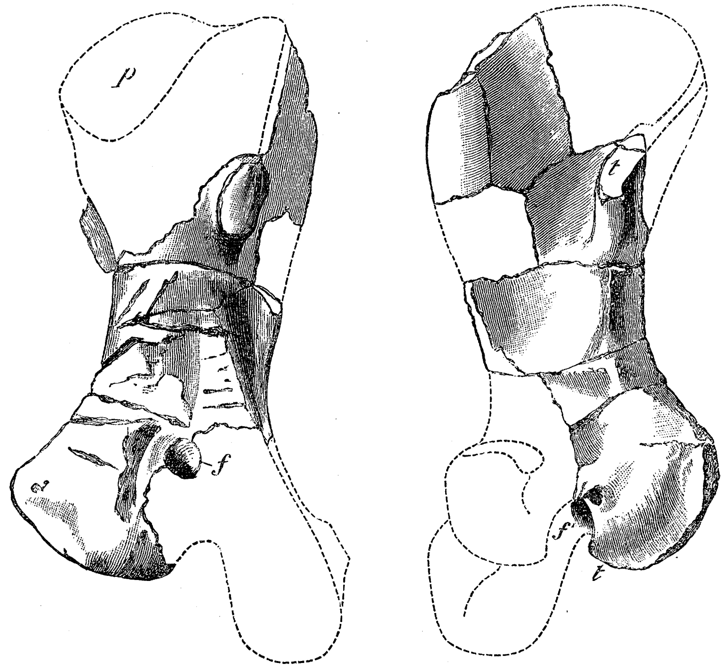
The Hind Limb of Pareiasaurus Baini.

The femur was found flexed forward, almost horizontal, with its head in the acetabulum; the tibia and fibula were in connection with its distal end, and almost vertical. The digits extended forward and somewhat outward. As soon as the extent of the foot was uncovered I made a sketch as evidence of the relations of the bones when found, and on this evidence they have been put together. The hind limb is slightly shorter than the fore limb, and its digits are rather smaller. The measurement along the bones, from the head of the femur to the extremity of the clawed digits, hardly exceeds 31 inches.

Femur (Plates 17, *f.*, 22, fig. 2).

The right femur, owing probably to its horizontal position, is vertically compressed. Presuming that the left femur, which was lying upon the surface in many fragments when I found it, belongs to the same individual, it gives remarkable evidence of the distortion which a bone may undergo; so that it may often be difficult to be sure of the specific identity of specimens affected in this way. Both bones are about 17 inches in length, though the extreme measurement of the compressed right femur exceeds that of the other, as preserved, by more than half an inch. Its superior surface is greatly flattened, and apparently widened out by compression, so that the immense external proximal crest of the bone, directed downward on the left side, is here spread out laterally. The bone has much the aspect of a humerus, from the manner in which this crest is reflected downward so as to define on the left side a large concave space on the under surface of the articular head. I do not remember any very close parallel to this condition, for, although the external crest is well-marked in *Echidna*, and slightly preserved at the proximal end of the bone in some Mammals such as the Squirrel, the Mole, and the Aye-aye, only in *Ornithorhynchus* is there a concave area behind the head of the bone, and in that type it is much less developed than in this fossil. The articular head of the bone is convex from within outward. Both its inferior and superior surfaces are convex. It is about 3 inches deep in the middle, flattened or slightly concave, becoming narrow on the inner border, which is rounded. It is prolonged as a slightly concave cartilaginous surface along about 5 inches of the downwardly reflected external crest, which is from 1 inch to $1\frac{1}{4}$ inch thick where the cartilage surface ends. The bone then becomes more compressed and rounded from side to side. In the crushed specimen from the right side, the extreme transverse width of the proximal end is 10 inches; the least width in the lower third of the shaft is $5\frac{1}{2}$ inches; the maximum width of the distal end, as preserved, is $7\frac{1}{2}$ inches. From the evidence of the uncrushed left femur, these measurements are in excess of the true proportions, and due to distortion of the bone. The

Fig. 8. Fig. 9.



Imperfect eft femur of *P. Baini* with the restored parts indicated by dotted lines. Fig. 8.—The superior aspect shows *p* the proximal articulation (restored); *f* a foramen which passes between the condyles. Fig. 9.—The inferior aspect of the left femur, showing *t* the internal proximal trochanter which defines a basin on the head of the bone; *f*, inter-condylar foramen; *c*, distal condyle.

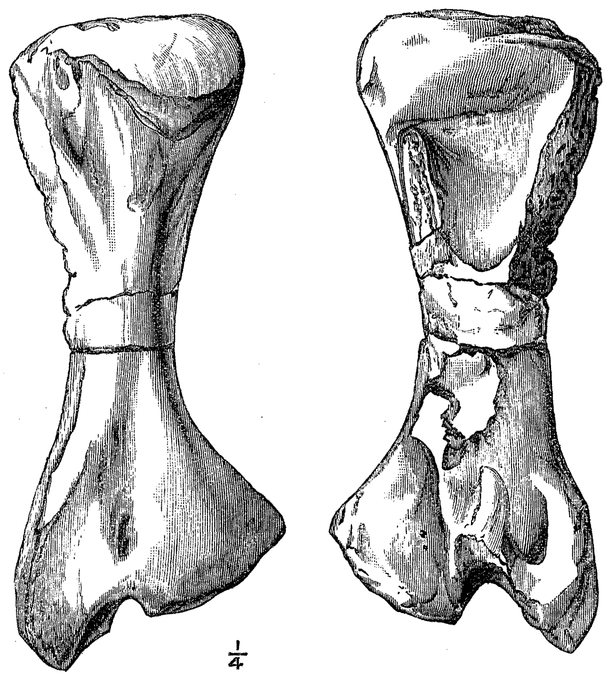
superior surface on the left side forms an arch from side to side, which on the right femur is flattened. On or about the summit of the arch is a large rough ovate tubercle, about $3\frac{1}{2}$ inches from the proximal end of the bone (fig. 8). This tubercle has a rugous surface, is $2\frac{3}{4}$ inches long, $2\frac{1}{2}$ inches wide.*

There was something approaching to a rounded median longitudinal ridge on the superior surface of the bone, as in the femur of a Pareiasaurian originally termed *Propappus*; but, towards the distal end, this convex superior surface becomes

* [There is something approaching this condition in the limb bone of *Saurodesmus Robertsoni* from Elgin; and the proximal end of that bone so far resembles *Pareiasaurus*, in its external crest and internal trochanter as to suggest that the bone may be an Anomodont femur.—July 15, 1892.]

flattened and widened. The bone is imperfect distally on its outer side, and on the right side it is somewhat compressed from side to side. On the superior surface there is a median distal groove, which leads down to a foramen about half an inch long and rather narrower; this has the same position as the foramen at the distal end of the femur of *Propappus* (Fig. 10). It is a true canal, and not a notch like that seen at the distal end of the femur in certain Ornithischian Reptiles, such as *Orthomerus* and *Iguanodon.* An inch and a half below the foramen, a median notch in the bone (Fig. 9), as in *Propappus* (Figs. 10, 11), defines the distal internal articular surface for the tibia *c*, from a smaller external surface for the fibula (Plate 22, fig. 2, c^2). The distal condylar articulation for the tibia is oblique, as in *Propappus,* but instead of

Fig. 10. Fig. 11.



$\frac{1}{4}$

Right femur formerly referred to *Propappus*; now figured for comparison with (Plate 22, fig. 2) the femur of *P. Baini*, which shows that the fossil is referable to that genus, or a near ally.

being convex, as in that specimen, its surface is flat, but with a compressed margin quite as well defined. The depth of this surface as preserved is $5\frac{1}{4}$ inches. Proximally it is $2\frac{1}{2}$ inches wide, and distally more than 3 inches wide. At 4 inches from the internal border this surface is margined by a sharp ridge, but as in *Propappus,* a ridge crosses obliquely in the space between the condylar articulation and this vertical inner border. The notch between the condyles is large and obliquely excavated towards the outer side of the bone, as in *Propappus.* The cavity as preserved is 3 inches wide, over 3 inches deep, but narrows superiorly to about 1 inch. At the base of this concavity is the small circular foramen, which has not been completely excavated, but apparently passes through the bone, like the similar foramen in *Propappus.*

The better preservation of this fossil shows that the external condyle of *Propappus* is largely broken away. It is divided from the internal condyle by a channel 2 inches wide. It is a small area, 4 inches long by $2\frac{1}{4}$ inches wide, which narrows distally to a width of 1 inch. External to it is a smooth oblique area, an inch wide, with a sigmoid twist which passes from the lateral to the horizontal position on the under side of the bone. The superior surface is rounded on the external margin, and apparently on the internal margin. The measurement from the oblique articular head to the most distal point on the same side of the bone is 12 inches, so that the femur of *P. Baini* is nearly half as long again as that on which *Propappus* was founded Above the articular condyles, the under surface of the bone is flattened from side to side, between the external border and the ridge traversing the bone, which is distinctive of Pareiasaurians. Within 4 inches of the proximal end of the femur of *P. Baini*, on the inner side, is a compressed trochanteroid ridge, with a sharp border, which border extends distally towards the tibial articulation (Plate 22, fig. 2).

This process, which is crushed in the right femur, has the external surface slightly concave in the left femur. I regard the process as representing the lesser trochanter of the Mammalian femur. The process extends downward about 2 inches beyond the great concavity on the under side of the bone, which it helps to define. The ridge, which is prolonged distally from this process, is about $5\frac{1}{2}$ inches long. At the base of the concavity the transverse section of the uncompressed shaft in the left femur is semi-ovate. The trochanter measures about 3 inches from above downward, and probably 4 inches to the margin of the fractured lateral ridge.

As preserved, the femur of *Pareiasaurus Baini* has a much more elongated proximal articulation than that of *Propappus*, and there are many minor differences of proportion, but those differences only emphasise the general resemblance between these types; and, until other parts of the skeleton justify the revival of the name *Propappus*, that type may be referred to as *Pareiasaurus* (*Propappus*) *minor*.

It is evident that the femur of *Sphenodon punctatum* is formed on a different plan, in not having any trace of the external crest at the proximal end of the bone, which is one of the more important differences of the Lacertilian from the Mammalian femoral type.

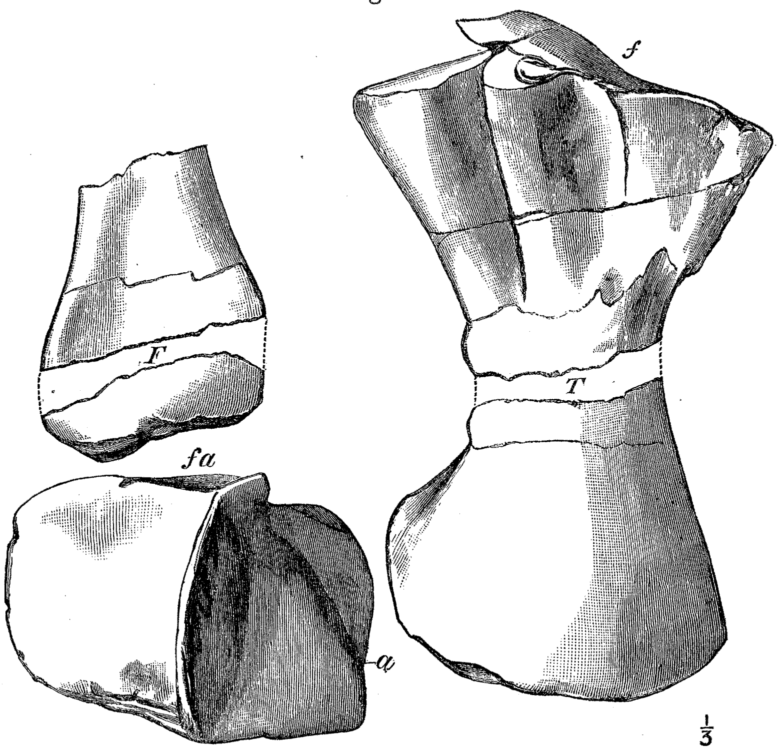
The resemblance of the femur is not appreciably closer with Urodele Amphibia in form, for this fossil shows no trace of the front-to-back compression of the articular head. It is most nearly paralleled in form, among Reptiles, by the femur in fresh-water Chelonia.

The Tibia (Plate 17).

The right tibia and distal end of the fibula were found in natural association, in contact with the femur above and the astragalus below. The tibia is very similar, in general character, to the bone figured in 'Phil. Trans.,' 1889, B, Plate 25, which may be referred to *Tapinocephalus*. It differs in proportion from the tibia which I obtained in association with the Tamboer specimen of *P. bombidens*.

The tibia is a massive bone, strong and relatively short, expanded proximally, contracted towards the lower third of the shaft, and oblique distally, where it descends in an inner anterior border to articulate with the tarsus. It is $9\frac{1}{2}$ inches long in front, where its distal end is convex from side to side, and about 6 inches wide. The proximal surface is truncated, transversely expanded, $7\frac{1}{2}$ inches wide, 4 inches deep on the inner side and $2\frac{1}{2}$ inches deep on the outer side. Two longitudinal grooves descend in front from the proximal end, defining a median elevated ridge, which is situate below a median elevation on the superior articular surface.

Fig. 12.



Bones of the right hind leg, in natural position as found, but separated from each other. *T*, tibia; *f*, proximal articulation for the femur. *F*, distal end of fibula, showing compressed articular surface for the proximal tarsal; *fa*, *a*, astragalo-calcaneum, showing oblique surface of astragalus for the tibia, and transverse surface of calcaneum for the fibula. (The segments *F* and *T* are not wanting.)

That eminence probably fitted between the condyles at the distal end of the femur. The larger part of the articulation corresponds with the larger femoral condyle, just as the smaller part corresponds with the smaller femoral condyle. Distally, the bone has a crescentic surface, similar to that in the tibia figured ('Phil. Trans.,' 1889, B, Plate 23) as ulna.* The external border measures 7 inches transversely, while the internal border measures 8 inches. This difference is owing to the existence of a notch at the distal extremity, similar to that already described in the tibia which

* In Plate 22 of the same Paper, Fig. 4, described as proximal surface of ulna, should be described as proximal surface of tibia.

was referred by Sir R. OWEN to *P. bombidens* ('Phil. Trans.,' 1889, B, Plate 25). The bones may have had cartilaginous extremities, for, though they were in close contact when found, yet the surfaces do not quite coincide in extent. The posterior surface of the tibia is flatter than the anterior surface; but, while flattened, it is traversed by a slight ridge, which passes from the upper fibular border obliquely downward and outward to the distal margin. It helps to give a concave aspect to the surface, where the shaft is reduced to a width of 3 inches at its least measurement. Seen from the side, the bone has a slight sigmoid curve, leaning forward a little proximally, curving back a little distally.

The Fibula.

The distal half of the fibula is preserved (Fig. 12). The fragment is $4\frac{1}{2}$ inches long, and attains its greatest width, $3\frac{3}{4}$ inches, a little above the distal articulation. It is a slender bone, compressed from front to back, slightly crushed, flattened in front, and more convex behind. It was probably 4 inches shorter than the tibia, or about 7 inches in length, for it is in contact with the calcaneum by a narrow surface which rises in level much above the attachment for the tibia, as is evident from the figure of the proximal tarsal bone. The anterior articular margin of the fibula is straight and oblique, inclining downward and outward, but its posterior margin is curved obliquely, making the articular surface concave on the side towards the tibia, and convex on the wider outer part of the articulation. The distal end of the fibula on the left side is also preserved. The bone shows no distinctive features.

The Proximal Row of the Tarsus.

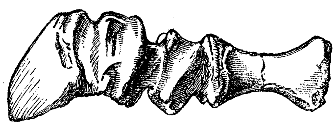
The tibia and fibula are both articulated to one large bone. There is nothing resembling this condition in Urodela, which have the fibula articulated with the fibulare, which has been identified with the calcaneum, and the outer side of the tibia articulated with the intermedium, which has been identified as the astragalus. But while this condition characterizes *Cryptobranchus*, in *Menobranchus*, according to HYRTL, there are only two bones in the proximal row, of which the fibulare gives some attachment to the tibia, though less than that afforded by the intermedium in *Menopoma*. If the fibulare and intermedium were conjoined an astragalo-calcaneum might be produced, which would have much in common with the large tarsal ossification seen in this fossil. I am inclined to accept the determination of the tibiale as corresponding to the sesamoid of the Mammalian tarsus as identified by GEORGE BAUR. And a small bone in this position was probably developed beneath the inner margin of the tibia in *Pareiasaurus*. BAUR has given ('Morphol. Jahrbuch,' vol. 11, Plate 27) an instructive series of figures of early stages in the development of the Human tarsus, in which the astragalus alone holds a not dissimilar place to the large bone in this fossil, which may be composed on the external side of the large calcaneum, and on the inner side by the astragalus. On the whole, the structure in *Pareiasaurus* is distinctive of that type.

The bone has an oblong form, is about $5\frac{3}{4}$ inches wide, and $4\frac{1}{2}$ inches deep. It is compressed from front to back, vertical in position, divided into two areas in front by a vertical ridge of which the inner area is oblique, and gives attachment in front to the distal surface of the tibia. This portion is the astragalus. The posterior surface of the bone is concave. A slight neck divides the cartilaginous tibial surface from the superior fibular articulation. The part of the bone beneath the fibula is $3\frac{1}{2}$ inches wide and $3\frac{1}{4}$ inches deep. It does not extend quite so far distally as does the portion beneath the tibia. The anterior face of this subquadrate part of the bone is moderately concave. Its external border is vertical, flat, cartilaginous, more than $1\frac{1}{4}$ inch wide proximally, and narrower distally. The posterior face is similar to the anterior surface, except that its concavity is rather more irregular, owing apparently to a foramen, which appears to lie in the line of union between the calcaneum and astragalus. A foramen in this position is found in some Urodeles such as *Menopoma* and *Salamandra*. The posterior aspect of the portion termed the astragalus is more irregular, owing to the development of a slight tuberosity on its upper part. When the bones are looked at from the distal surface the descending portion of the tibia extends beyond the astragalus, without visible support, as though a third tarsal were attached to it, and this circumstance has led me to place the compressed sub-ovate tarsal bone vertically in this position, though I cannot be sure that it was sufficiently near when found to justify the association, for some of the bones of the foot were depressed in position an inch or two, and were not discovered till the bones of the fore leg had been removed from the hill side in which the animal rested. Only four or five small tarsals of the distal row were recognised. The shale was here soft, so that they are no longer in natural association. They are irregularly shaped bones with convex surfaces, two of them with rounded margins, and aspect almost like pebbles. It is not possible to determine their true positions and nomenclature.

Digits of the Hind Limb (Plate 17).

There appear to have been five digits in the hind foot. The metatarsals are short broad flattened bones, with transversely ovate articular ends, somewhat resembling in form the phalanges of some Plesiosaurs. The phalanges, including the claw, appear to have been three in number. The claw was long, broad, depressed, with sharp lateral margins, and terminates in a point. The other two phalanges are relatively short. The first metatarsal is 2 inches long, $1\frac{7}{8}$ inch wide proximally, and about 2 inches wide distally. The transverse measurement or thickness of the flattened articular ends is more than an inch. The bone is flattened above, rounded at the sides, and at the distal extremity in front, and concave in the middle. The first phalange is fully half an inch long, the second more than three-quarters of an inch long. These bones have their articular surfaces somewhat saddle-shaped as in the well ossified extremities of similar bones in terrestrial animals. Their transverse measurement is slightly less than in the metacarpal bones. The bones become deep at their infero-posterior border, which has a rounded margin. This arrangement is associated with the power of the claws to bend downward, though this claw form is not that of a Carnivorous type of animal. The claw phalange, as preserved, is nearly $2\frac{1}{2}$ inches long and about

Fig. 13.



Middle digit of right hind limb showing metatarsal bone, two short phalanges, and the terminal claw phalange.

2 inches wide behind. Its superior surface is convex; its inferior surface inflated in the middle of the bone, with lateral channels, and a posterior articular cavity, while it is concave in length. Portions of three other digits were found at an inch or two lower level. They show metatarsal bones and phalanges. The five digits, as arranged, measure 8 inches across with the bones placed in close contact, while the length of the foot is only 6 or 7 inches.

The Fore Limb of Pareiasaurus Baini.

The right humerus is complete, as are the ulna and radius of the same side of the body. The carpus comprises a large proximal bone, and small distal bones, which were somewhat displaced, and are not completely preserved. Some of the digits are in natural connection with each other. They appear to be five in number, and are longer than the digits of the hind limb. The total length of the fore limb, measured in a straight line along the bones from the head of the humerus to the extremity of the claws, did not exceed 36 inches; so that it is 5 inches longer than the hind limb.

The Humerus (Plates 17, 23, fig. 1).

The head of the right humerus when found was in its natural articular position in the glenoid cavity of the scapular arch. It is somewhat compressed from above downward, in so far as can be judged from the fragment of the left humerus, which is in an uncompressed condition. The transverse width of that bone, as preserved, is 12 inches. The width of the distal articular surface is only 6 inches. This convex articulation is almost limited to the under surface of the bone, where its outline is concave from side to side, convex from above downward; and it is inflated so that its convex superior border extends fully 5 inches along the vertical extent of the bone. On each side of the distal articular surface, the bone is prolonged distally, but especially on the inner side, where it terminates in a truncated cartilaginous surface, now partly broken away with the adjacent bone. On its external or radial border, the bone is much compressed from above downward, and forms a comparatively thin plate which extends outward and upward beyond the articulation. There is a slight indication as of a distal prolongation of the ridge which, descending from the radial crest, crosses to the ulnar side, and is divided by a deep concavity from the rounded distal condyle. The state of preservation of this distal fragment does not show whether there was a supra-condylar foramen, such as is usually developed in or about this position, though the bone has the oblique flattened external border looking downward and inward as in the humerus of Dicynodonts. The external border is very much broader than the internal side of the bone.

The length of the right humerus is rather less than 17 inches; the transverse width of the proximal end is between 12 and 13 inches. The distal end as preserved has a transverse width of 8 inches, and the distal articular surface is 5 inches wide. The thin crest on the radial side is depressed and squeezed downward, and the ulnar tuberosity is obliterated by fracture or crushing, so that the aspect of the two specimens placed side by side is dissimilar. But with the reduced width of the bone, the height of the distal articulation on the right side is augmented from $5\frac{1}{2}$ inches to $6\frac{1}{2}$ inches, so that what is lost in width is gained in height. With this deformation there is not much variation in the length of the articular surface, or in the way in which its rounded superior margin encroaches on the bone above. In both specimens the contours follow the same curves, and a similar concavity excavates the bone between the base of the radial ridge and the distal articular convexity. The least measurement from the proximal to the distal articular surfaces is $11\frac{1}{2}$ inches.

The proximal end of the bone is not less disfigured by compression than its distal end. The superior surface is flattened, with an angular ridge dividing off the area of the radial crest, which is 5 inches wide, and meets the upper surface of the bone at an open angle. The crest is connected with the head of the bone by a narrow band, but becomes developed and thickened as it extends distally, forming a strong tuberosity of triangular form, more than $2\frac{1}{2}$ inches wide, which helps to define a concavity on the under side of the humerus, which is deeply excavated below the radial crest.

The width of the upper end of the bone exceeds its length. On the inner side it is produced beyond the articular head. The articular head of the humerus appears originally to have been saddle-shaped, but is deformed by compression, and is now about 8 inches wide by less than 4 inches deep. The middle portion originates a convexity on the upper anterior side of the shaft, which extends for some way towards its middle (Plate 23). The part of the shaft which lies between the proximal and distal ends is less than 3 inches long, and its width and thickness are about 4 inches by 3.* This form of bone is remarkably different from that referred to *P. bombidens* in the South African Catalogue of Sir R. OWEN, and it is still more unlike the humerus of *Titanosuchus ferox* ('Phil. Trans.,' B, 1889, Plate 20). I have nothing to add to the affinities of the bones already stated in a previous memoir. The great development of the convex distal condyle makes one of the most striking characters which distinguish this type of humerus.

Right Ulna and Radius.

As preserved in the rock, the radius had an oblique position with regard to the ulna, its proximal end crossing outward so as to be lodged in the notch in front of that bone. This I have taken to be the original connection of the two bones, which were in natural contact when in the rock, and separated by the mason's chisel. As among Mammals the radius extends no further proximally than the inferior border of the articular surface of the ulna. Its extreme length in a straight line is $9\frac{1}{2}$ inches. The extreme length of the ulna is 15 inches. The difference is due to the circumstance that the ulna is produced proximally so as to form an ascending concave articulation for the distal condyle of the humerus, and is prolonged proximally for some distance beyond this articulation, as in many Mammals. A similar type of ulna has already been described ('Phil. Trans.,' B, 1889, p. 265, Plate 22, figs. 1, 2, 3) and referred to *P. bombidens* by Sir R. OWEN.†

Some approximation is made to a like condition of the bone in the existing *Cryptobranchus*, and a still closer resemblance is seen in the fossil *Eryops megacephalus*, as figured by E. D. COPE ('Proc. American Phil. Soc.,' 1881). The radius is essentially anterior and the ulna posterior at their proximal ends, but distally they are side by side, and combine to form an elongated and comparatively narrow articulation for the carpus, which was mainly attached to the radius. This is in harmony with Mammalian conditions.

The ulna has a flattened aspect. It is enormously expanded at the proximal end, and slightly expanded at the distal end. The radius has a rather more slender sub-cylindrical shaft, but has the articular ends much expanded.

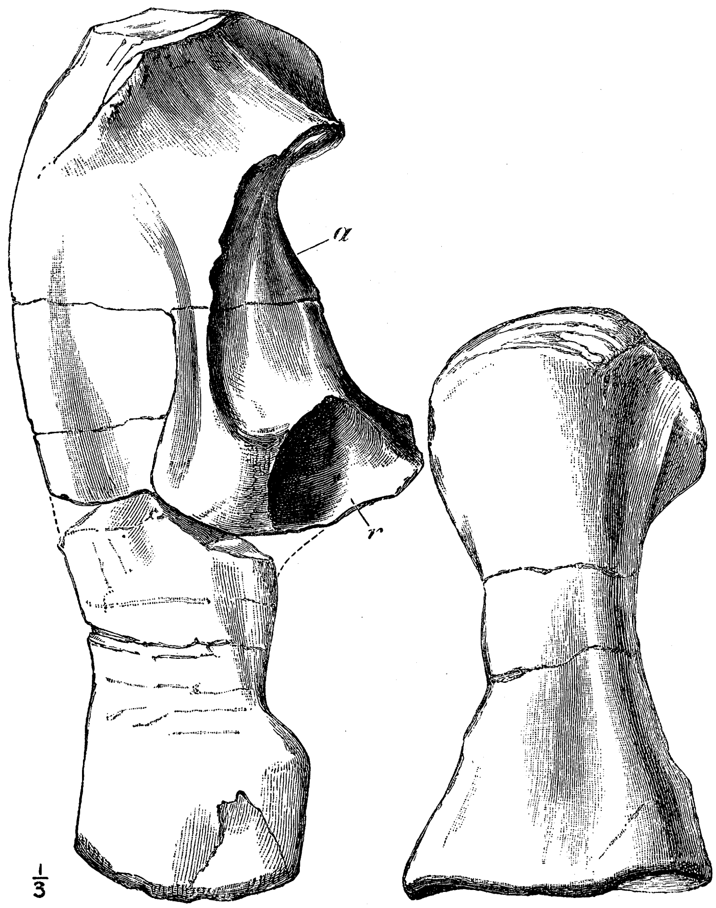
In front the ulna measures 7 inches from the distal end to the lowest point of the proximal articulation. The greatest length of that articulation is less than 6 inches, and the bone extends proximally beyond the articular border for $2\frac{1}{2}$ inches. The distal end is $3\frac{3}{4}$ inches wide, and two inches thick. The distal surface is oblique, descending at the front margin in harmony with the radius. The surface is narrower

* It ought to be mentioned that in chiseling out the specimen, the continuity between the two ends of the bone was lost by removal of the matrix owing to the loss of the fragment left unshaded in Plate 17. I have placed them together, to the best of my belief, as they were in the rock, but it is impossible to be certain that the original contact was as it is drawn.

† 'Cat. Fos. Rept. South Africa,' p. 12.

in front than behind, rounded a little from back to front, and roughly cartilaginous. The anterior inner distal angle is excavated to fit apparently against the posterior angle of the radius, which partly underlapped the bone. The least transverse measurement of the shaft is $2\frac{1}{2}$ inches, at about 3 inches from the distal end. The bone then widens both to the front and back, and developes an elevated crest at the base of the proximal articulation; and this ridge is prominently elevated so as to greatly increase the transverse width of the bone, and make its external or posterior

Fig. 14.



Right ulna and radius slightly separated, showing *a* proximal articular surface of the ulna, *r* excavation in the ulna which received the proximal end of the radius.

lateral surface concave. It also defines an anterior lateral concavity which receives the proximal end of the radius. This concavity further divides the anterior termination of the proximal articulation into two parts, which fork on each side of the radius. The transverse measurement over this sub-radial expansion of the proximal articulation of the ulna is about 3 inches. Its anterior border is prolonged on the face of the shaft. It terminates in front in a sharp edge which is concave from above downward.

The articulation may be a little distorted, but is a semicircle in contour. Its sides are sub-parallel, but gently concave in the part which is nearest the radius. The measurement from one extremity of the articulation to the other is 6 inches in a straight line. A median longitudinal ridge extends down the articular surface, and divides it into external and internal parts. The internal portion is the larger, and is excavated under the olecranon tuberosity.

The proximal surface of this tuberosity is transversely convex, and its posterior aspect is roughly cartilaginous. The lateral surface is concave from above downward, and widens as it extends on to the concave lateral surfaces of the bone.

The contour of the posterior border of the ulna is convex in length at the proximal end, and concave at the distal end. It is rounded transversely, is about an inch wide, increasing somewhat towards the distal end; but at the proximal end its width of nearly 4 inches coincides with the transverse width of the terminal cartilaginous extremity. The proximal half of the ulna is much the thicker, wider, and heavier portion.

The distinctive specific characters of the ulna appear to be width of the shaft, and the development of the proximal tuberous process beyond the articulation. For in the *P. bombidens* from Tamboer the width of the shaft appears to be less than $2\frac{1}{4}$ inches, while its thickness is about $1\frac{1}{4}$ inch. Like all the other bones of the skeleton these are dense, but become cancellous towards the centre.

The radius has an elongated dice-box form. The distal articulation is nearly 5 inches long and 3 inches wide anteriorily. It is sub-reniform, being narrower behind where overlapped by the ulna. The distal surface is concave, with a border produced in front and at the sides. A strong ridge, ascending from the anterior distal angle up the front of the bone, helps to define a flattened lateral surface superiorly; the bone is rounded from side to side. The proximal end is sub-triangular, $4\frac{1}{2}$ inches from front to back, and $3\frac{3}{4}$ inches from within outward. The posterior articular border is slightly concave, while the remainder of the outline is a half ellipse. The superior articular surface for the humerus covers the whole of the truncate extremity of the bone, and is moderately concave.

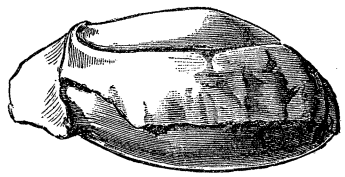
The least transverse measurement of the shaft in the middle is $1\frac{1}{2}$ inch; and its least antero-posterior measurement is 2 inches.

The Carpus.

The carpus appears to consist of two rows of bones, but it is not perfectly preserved. The principal carpal was beneath the radius. It is a large transversely ovate bone, convex above, so that its surface corresponds to the concave distal end of the radius. This articulation is about 4 inches long by 3 inches wide. The anterior surface is convex from side to side with a curve like that of the radius, it is flat vertically, smooto, and 1 inch deep.

On the right side it was met by a second ossification, now displaced, beyond which there may have been others. On its inferior border are two small carpals of the second row, which appear to have had a close union with the proximal carpal. Each bone is more than an inch in each measurement. The distal surface of the principal

Fig. 15.

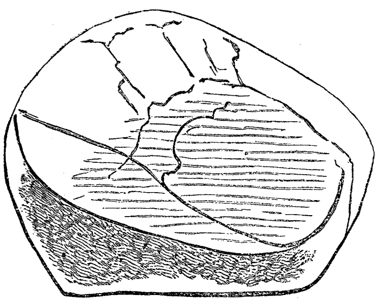


Principal carpal bone of the right side.

carpal is convex. I regard it as formed of the scaphoid and lunar bones as in *Theriodesmus*, but whether the two bones below are the centralia, as seems probable, must remain for the present uncertain.

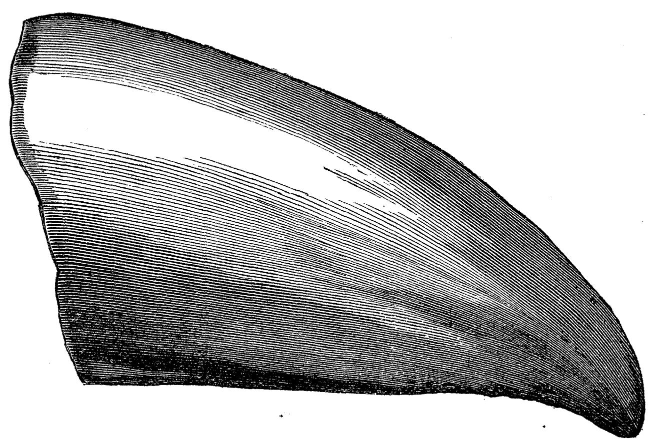
The metacarpal bones appear to be smaller than the metatarsals, but they have the same form; yet the fore foot was rather the larger. It had a transverse width of 10 inches, and a length of 9 inches. All the phalanges are similar to those of the

Fig. 16.



Form of articular end of claw phalange from the fore limb.

Fig. 17.



Terminal claw phalange of the right fore foot. Natural size.

hind limb, but the bones are a little longer and larger. The longest external claw is nearly 4 inches long, 2 inches wide at the proximal end, and $1\frac{1}{2}$ inch deep. The bones were in very hard rock, and the foot was not exposed as a whole in quarrying it. Therefore, in arranging the remains to indicate five digits, I have been influenced by the fact that portions of ten digits were found on the right side of the animal, and no digit on the left side; and that the digits with large claws were in close contact with the extremity of the ulna. I have no certain evidence of more than three phalangeal bones in any digit, but it is possible that one digit may have had four.

[*On the Skeleton of* Procolophon, Plate 23, fig. 3.

In illustration of the views expressed at p. 343, as to the systematic position of *Procolophon* in the Pareiasauria, the following account is given of the unique vertebral skeleton of a species of that genus (probably *P. trigoniceps*, OWEN) from Donnybrook, Queenstown District, Cape Colony.

The head is missing, and the vertebral column is exposed in a sinuous curve, with the neck and extremity of the tail bent round towards the right side. As preserved, the specimen shows eighteen pre-sacral vertebræ. It is, therefore, possible that but few are missing. Perhaps, the first four or five of those preserved may be accounted cervical, but the specimen is fractured on the left side so that the bodies of the early vertebræ are partially removed, and their external characters, except as to length and depth, are imperfectly seen. The neural arch, however, is well preserved, and in the earliest vertebra shows a large neural canal, wider than high, surmounted by a neural arch which has a strong neural spine, with a form not dissimilar to that in *Pareiasaurus*. There is a vertical excavation at the base of the spine in front just above the neural canal. The sides of the neural spine look forward and outward, and the posterior surface is flattened. The summit of the spine is large and truncated. The zygapophyses extend outward, and are relatively large as in *Pareiasaurus*. Immediately behind the prezygapophyses of the first vertebra, a process is seen which I suppose to have given attachment to a rib. Between this process and the posterior zygapophysis, the side of the vertebra is concave. The spines of the succeeding vertebræ are very nearly vertical, but inclined a little backward, with their summits nearly circular, though rather longer than wide, and the interval between them small. The neural spines are broken away from the subsequent vertebræ, but the base of the neural arch soon becomes remarkably wide, relatively to its antero-posterior extent; and in about the ninth vertebra preserved, as in the tenth, the position of the costal tubercle, behind the prezygapophysis, for the articulation of the dorsal rib, exactly reproduces the condition figured in *Pareiasaurus bombidens* ('Phil. Trans.,' 1888, B., Plate 12), except that the notch between this process and the postzygapophysis appears to be relatively larger. The neural arch is here more uniformly vertical on its hinder surface, at the base of which there is a small vertical foramen in the median line. One or two ribs, separated from the vertebral column in its anterior portion, show the same remarkably deep attachments which are evident both in that species and in *P. Baini*, without any indication of division into two separate articular facets, so that the proximal portion of the rib was vertically deep and compressed from front to back, showing that the process to which it was attached was vertical, although it has not been exposed. The ribs are long, strong, apparently ovate in section with a groove along the posterior surface, which is not seen in *P. Baini*. On the left side, indications of thirteen dorsal ribs are counted. It is uncertain whether a rib was attached to the vertebra immediately in advance of the sacrum. No rib is preserved, yet there is some appearance of a tubercle below the prezygapophysis of that vertebra.

The sacral ribs are rather shorter than the last of the dorsal ribs, but they are much more massive. The first appears to be the largest, directed outward and backward; the second directed outward, is smaller; the third is given off from a much smaller vertebra; it is flattened, and expands as it extends outward. The fourth sacral rib is slender, and is like a caudal rib, except that on the right and left sides it is directed forward so that its extremity is in contact with the extremity of the sacral rib of the third pair.

On both sides the ilium is broken and displaced. It lies in a horizontal position on the right side, and appears to be deeper than long, and more produced backward than forward, though this may be the effect of displacement subsequent to fracture. In form it is more like *Phocosaurus* than *Pareiasaurus*.

Eight long caudal ribs, cylindrical and curved backward, can be counted on the right side attached to vertebræ, and behind these there appear to have been about nine vertebræ. I am unable to say whether caudal ribs were prolonged to the end of the tail, though two are seen at about the thirteenth and fourteenth. The caudal neural spines are at first inclined forward; towards the end of the series they appear to have been very small, and are not preserved.

The only limb bone seen is the nearly perfect femur, which lies on the left side adjacent to what appears to be a fragment of the ilium, and is directed posteriorly. Its proximal end is convex from side to side, on the superior surface, with a large rounded head to the bone. The internal trochanter (which is external as the specimen lies) is enormously large, and greatly widens the bone proximally below the articular head. The indication of the length of the femur preserved is $1\frac{2}{10}$ inch, the width of the proximal end is half an inch; but the width of the elevated ball of the condyle does not exceed $\frac{3}{10}$ of an inch. The shaft is hollow, and at the distal fracture $\frac{7}{10}$ of the inch from the proximal end, is $\frac{2}{10}$ of an inch wide. In details of form this bone is as unlike *Pareiasaurus* as are the bones of the fore-limb figured 'Phil. Trans.,' 1889, B, Plate 9, fig. 9. But in plan, the femur, like the vertebræ, approaches nearer to *Pareiasaurus* than to any other type with which comparison has been attempted.

The length of the vertebral column measured round the curve is about 9 inches, of which the tail does not exceed $3\frac{1}{2}$ inches. The length of the sacrum is about an inch. The longest ribs in the anterior part of the body do not exceed $1\frac{1}{4}$ inch. The last dorsal rib and earliest caudal are about $\frac{7}{20}$ of an inch long. The curvature of the dorsal ribs is small, as though they had enclosed a wide abdominal cavity.

I am indebted to the Trustees of the Albany Museum for the opportunity of developing this skeleton from the matrix, and studying its characters in this country.
July, 1892.]

Summary.

The skeleton, as now mounted, is substantially in the position in which the bones were preserved in the rock, except that the right fore limb has been articulated, and the head has been slightly raised. The shoulder girdle was probably lower in front, for it had been forced upward so as to dislocate the neck. The extreme length of the animal, as now developed and articulated, from the snout to the extremity of the tail, measures, as preserved, 115 inches, so that the total length may not have exceeded 10 feet. Owing to dislocations, my measurements taken at Bad, before the skeleton was disturbed, were about 6 inches longer.

I suggest the name *P. Baini* for this fossil, in association with that of THOMAS BAIN, Esq., Geologist, who was my companion through the Karroo; and who had previously transmitted to the British Museum many of its best South African Fossil Reptiles, including the *Pareiasaurus bombidens*.

The conclusions to be drawn from this specimen are an extension of those indicated by the more fragmentary remains, previously described in 1888. I have not been able to add anything to the Labyrinthodont characters of the skull, but the evidence of the structure of the skull now given seems to me sufficient to transfer certain of the Labyrinthodontia from the Amphibia, with which the group has been placed, into association with the Reptilia. Very little is known of the structure of the skull in the higher Labyrinthodont types allied to, as *Loxomma.*

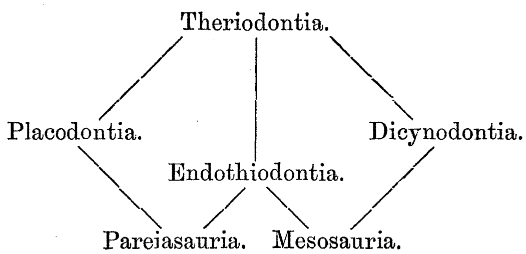
The internal structure of the skull in *Pareiasaurus* has more in common with *Sphenodon*, *Belodon*, and some Dinosaurs like *Diclonius* than could have been anticipated; but these resemblances may have their chief value as a common inheritance from a Labyrinthodont ancestry. The palate has shown unexpected divergence from that of the Dicynodontia towards that of *Hatteria*. The occipital condyle is essentially Reptilian, and has nothing in common with the condition in Amphibia.

The vertebral column appears to have more resemblance to that of *Hatteria* than was obvious in the skeleton of *P. bombidens*, and also shows well-marked differences from the Dicynodontia, but there is not sufficient evidence of its agreement with any true Labyrinthodont. The shoulder girdle is identical with that of the Anomodont Reptiles already described, although the presence of the epi-clavicular bones is a character which may be common to Labyrinthodonts, but there is no evidence of such a shoulder girdle, similar in plan and details of bony structure, outside the limits of the Anomodontia, unless the genus *Eryops* should be rightly so placed. The pelvis finds its nearest parallel among Anomodonts, but is more Mammalian in aspect, though there are some indications of peculiar distinctive details of structure, especially in regard to the os pubis. The limbs are about intermediate in type between those of Mammals and Urodela, though the close resemblance which some elements in the fore limb, humerus, ulna, and radius, show to bones figured by Professor MARSH in *Stegosaurus* and *Triceratops*, are interesting as showing collateral affinity.

Systematic position of Pareiasaurus.

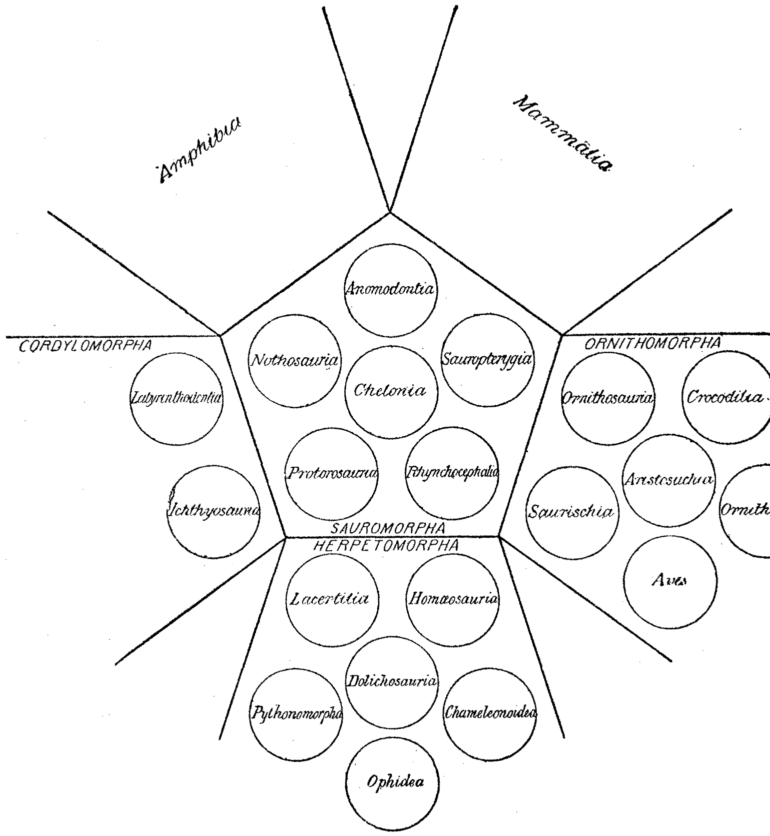
In place of the eight divisions of the Anomodontia enumerated in Memoir VI. on the Anomodont Reptilia and their allies, I now suggest six divisions, which are made up, first, by grouping Procolophonia as a division of Pareiasauria; secondly, by including under the Theriodontia, Gennetotheria, Cotylosauria, and probably Pelycosauria. To the four groups thus obtained I add Endothiodontia and Mesosauria, named after the types *Endothiodon* and *Mesosaurus*. These divisions may be arranged as follows:—

Anomodontia.



This group is in morphological value rather to be regarded as a sub-class than as an order. I find the affinities of the allied groups which may be associated with the Anomodontia more or less characteristic in Protorosauria, Nothosauria, Sauropterygia, Rhynchocephalia, and hence have combined them under the term Sauromorpha. This class, through its constituent orders, has affinities with the Amphibia, Cordylomorpha, Herpetomorpha, Ornithomorpha, and Mammalia. Expression may be given to these relations in the following tabular grouping (p. 368), where the Anomodontia stands at the divergence of Amphibia and Mammalia. The Sauropterygia is placed at the divergence of Mammalia and Ornithomorpha. The Rhynchocephalia are similarly intermediate between Ornithomorpha and Herpetomorpha. The Protorosauria are probably at the divergence of the Herpetomorpha and Cordylomorpha; and the Nothosauria mark the divergence of Cordylomorpha and Amphibia. All these types have affinities with the Chelonia. In this grouping an attempt is made to summarise the results in classification which seem to follow from an examination of the mutual relations and affinities of *Pareiasaurus* with South African Reptilia and other animals.

I would express my thanks to Dr. H. Woodward, F.R.S., for the interest taken by him in the long work of chiseling the specimen out from the intractable matrix in the workshops of the Geological Department of the British Museum. And I express my thanks to the Government Grant Committee for assistance in the exploration which enabled me to obtain this skeleton among other fossils in Cape Colony.



Explanation of Plates (17–23).

PLATE 17.

The skeleton of *Pareiasaurus Baini*, one-third of the natural size, drawn from the left side, showing the skull, vertebral column, ribs, clavicular arch and shoulder-girdle, and pelvis, but without the limbs. The limbs are drawn from the right side of the animal reversed, being more perfectly preserved on the right side than on the left; and they are separated from the skeleton to show the articular surfaces of the shoulder-girdle and pelvis.

The mandible is articulated to the condyles of the quadrate bones.

The inter-clavicle (*i.c.*) remains united to the clavicles (*cl.*), with the precoracoid (*p.c.*) and coracoid (*c.*) towards its lateral margin. The epi-clavicle (*e.c.*) lies along the superior margin of the scapula. The scapula (*s.*) is supported upon long dorsal ribs, which are flattened, and ovate in section.

The dermal scutes (*d.s.*) upon the summits of the neural spines are seen between the scapula and pelvis.

In the pelvis, *il.* is the ilium; *p.* the position of the pubis; *is.* the position of the ischium.

In the fore-limb *h.* is placed upon the missing fragment of the humerus; *u.* is the ulna; *r.* the radius; *car.* the carpus; *mc.* metacarpal bones; and *ph.* phalanges.

In the hind-limb, *f.* is the femur; *t.* the tibia; *fi.* fibula, imperfect at its proximal end; *ac.*, astragalo-calcaneum; *tar.*, small bones of the tarsus; *m.*, metatarsal bones; and *ph.*, phalanges of the hind limb.

PLATE 18.

Fig. 1. The skull of *Pareiasaurus Baini*, seen from above, showing the wedge-like form of the head with a flattened crown and oblique cheeks; the sculpture of the bones, the parietal foramen, the position of the orbits in the middle length of the side of the head, and the anterior nares divided by the internasal septum of the nasal and premaxillary bones, which bulges forward between them; one-third natural size.

Fig. 2. Outline of the posterior occipital aspect of the skull, showing the occipital condyle *oc.*, with the foramen magnum, and lateral vacuities at the sides of the brain case. The position of the cheeks diverging and descending is seen to give an appearance of depth to the side of the head.

PLATE 19.

Fig. 1. Palatal aspect of the skull of *Pareiasaurus Baini*, showing the positions of the teeth in the premaxillary and maxillary bones. The vomerine, palatine, and pterygoid bones are covered with double parallel rows of teeth, which converge backwards towards the vacuity of the palato-nares. *B.o.* is the base of the occipital condyle; *c.* the condyle of the quadrate bone; one-third natural size.

Fig. 2. External aspect of a maxillary tooth from the Tamboer specimen; natural size.

Fig. 3 and fig. 4 are from the jaws of *Pareiasaurus Russouwi* from the top of the Nieuwveldt range, midway between Klip-fontein and Fraserberg; natural size.

Fig. 3 is the external aspect of a maxillary tooth, with the denticles nearly on the same level, and the tooth flat; natural size.

Fig. 4 is a mandibular tooth from the same specimen seen from the inner side of the jaw, showing the radiating denticles. A successional tooth of similar character is seen below; natural size.

PLATE 20.

Fig. 1. Palate of the Tamboer specimen referred to *Pareiasaurus bombidens*, showing teeth scattered in the interspaces between the rows. This palate is continuous with the maxillary bones; *w.* is an intercentrum below the basioccipital.

Fig. 2. The same palate seen from the side, so as to show the superior and inferior surfaces of the bones, and position of the maxillary and mandibular bones.

Fig. 3. A single tooth from the palate, showing its cylindrical curved character.

PLATE 21.

Sacrum and pelvis of *Pareiasaurus Baini*, seen from the ventral aspect. $s.^1$, $s.^2$, $s.^3$, $s.^4$, sacral ribs; *il.*, ilium; ? *pp.*, ossification only seen on the left side, which appears to be an anterior prolongation of the pubis on the inner side of the ilium (also seen in *P. bombidens*, 'Phil. Trans.,' 1888, B, Plate 19, figs. 1 and 2); *f.* is the foramen, which passes longitudinally through the pubic bone; *p.*, the pubis, reflected downwards and forming inferior callosities; *ip.*, a median inter-pubic ossification, which is only defined on the ventral surface; *a.*, acetabulum; *is.*, ischium; one-third natural size.

PLATE 22.

Fig. 1. Anterior aspect of sacrum and pelvis of *Pareiasaurus Baini*, showing the large size of the neural spine and second pair (*s.*) of sacral ribs and the depth given to the pelvis by the downward reflection of the pubis (*p.*) and interpubic ossification (*ip.*). The pubic foramen (*f.*) is well seen on the left side. The anterior angles on the iliac bones (*il.*) are seen to extend outward.

Fig. 2. Infero-posterior aspect of right femur: *art.*, proximal articulation; *t.*, internal trochanter; $c.^1$, $c.^2$, flattened distal condyles.

PLATE 23.

Fig. 1. Right humerus of *Pareiasaurus Baini*, seen from the superior aspect; one-third natural size.

Fig. 2. Middle caudal vertebræ of the same specimen, of the natural size.

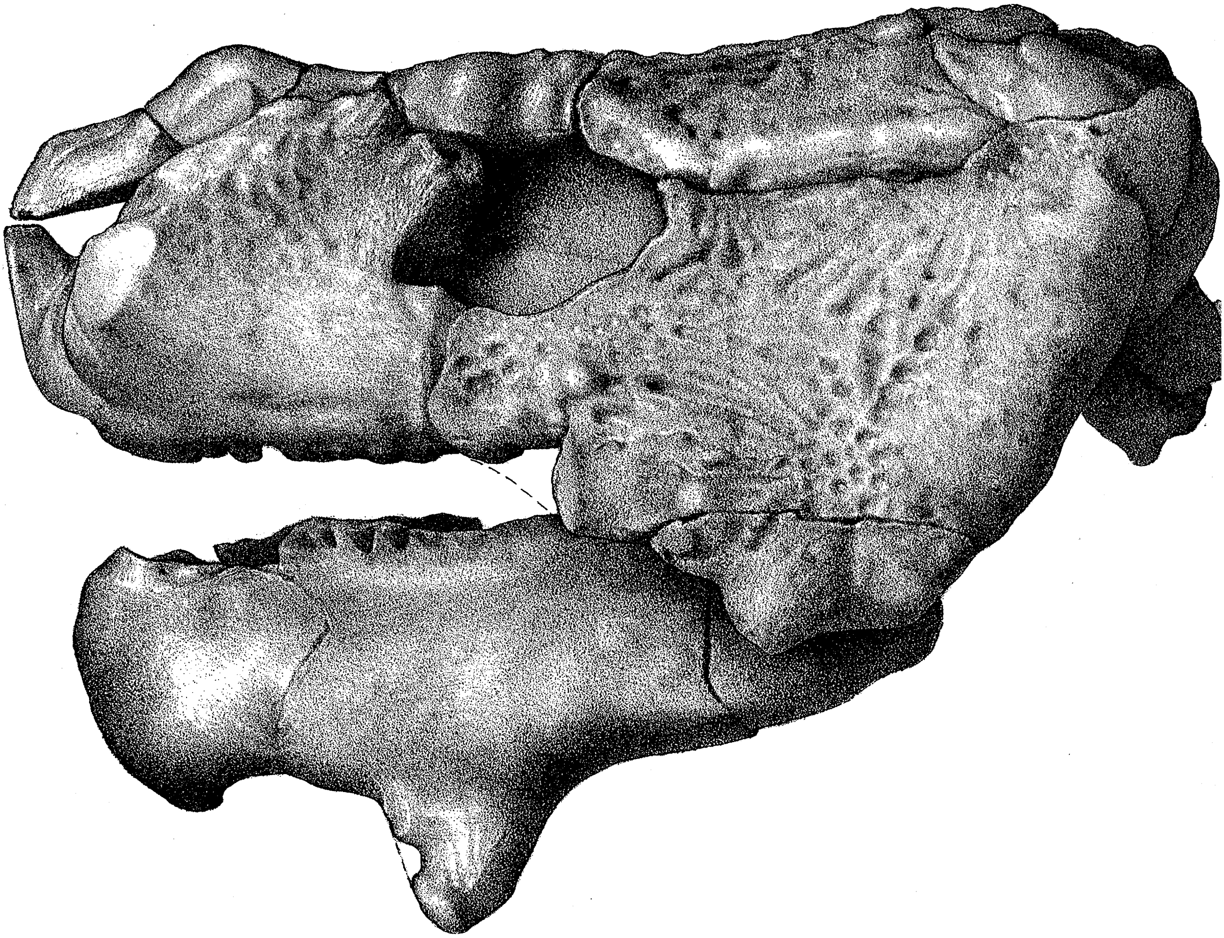
Fig. 3. Dorsal aspect of the vertebral skeleton of *Procolophon*, of the natural size, for comparison with *Pareiasaurus bombidens* ('Phil. Trans.,' 1888, B, Plate 12, fig. 2).

The cervical region is at the lower part of the figure.

The caudal region is the upper part of the figure.

The displaced ilium is on the right side, and the femur on the left side.

The anterior extremity and skull are figured 'Phil. Trans.,' 1889, B, Plate 9.

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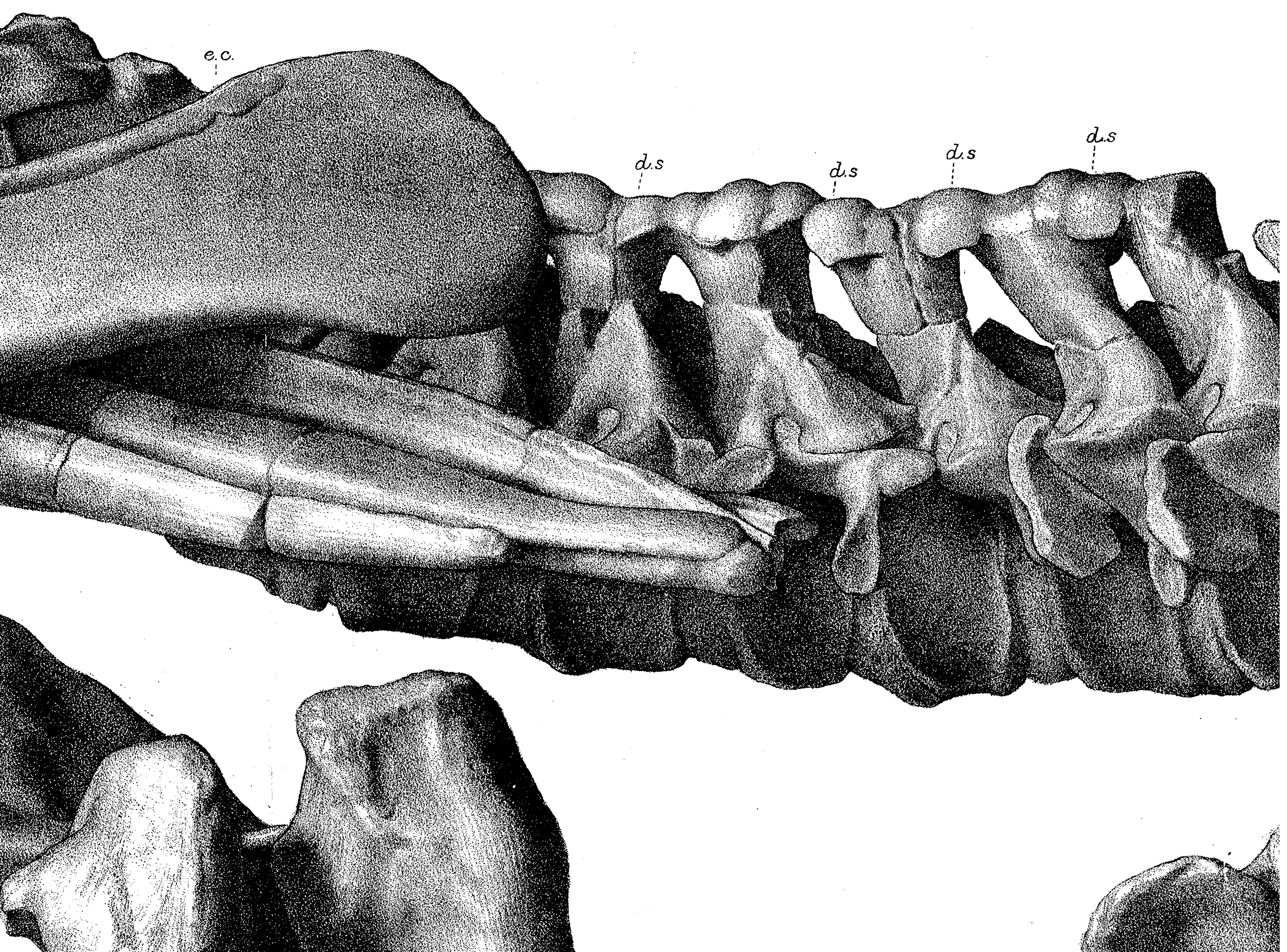
e.c.
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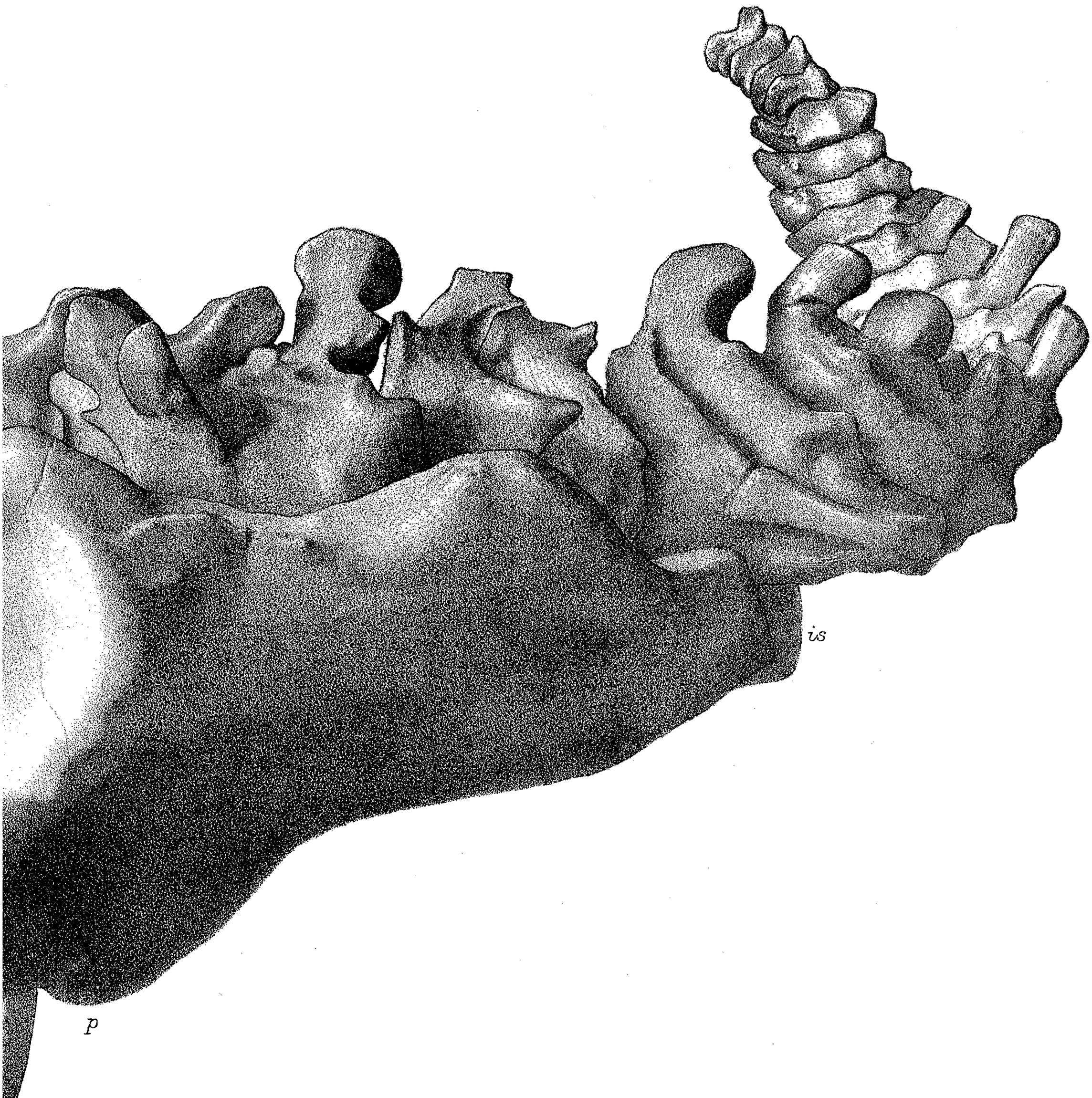
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G. M. Woodward, ad nat. lith.


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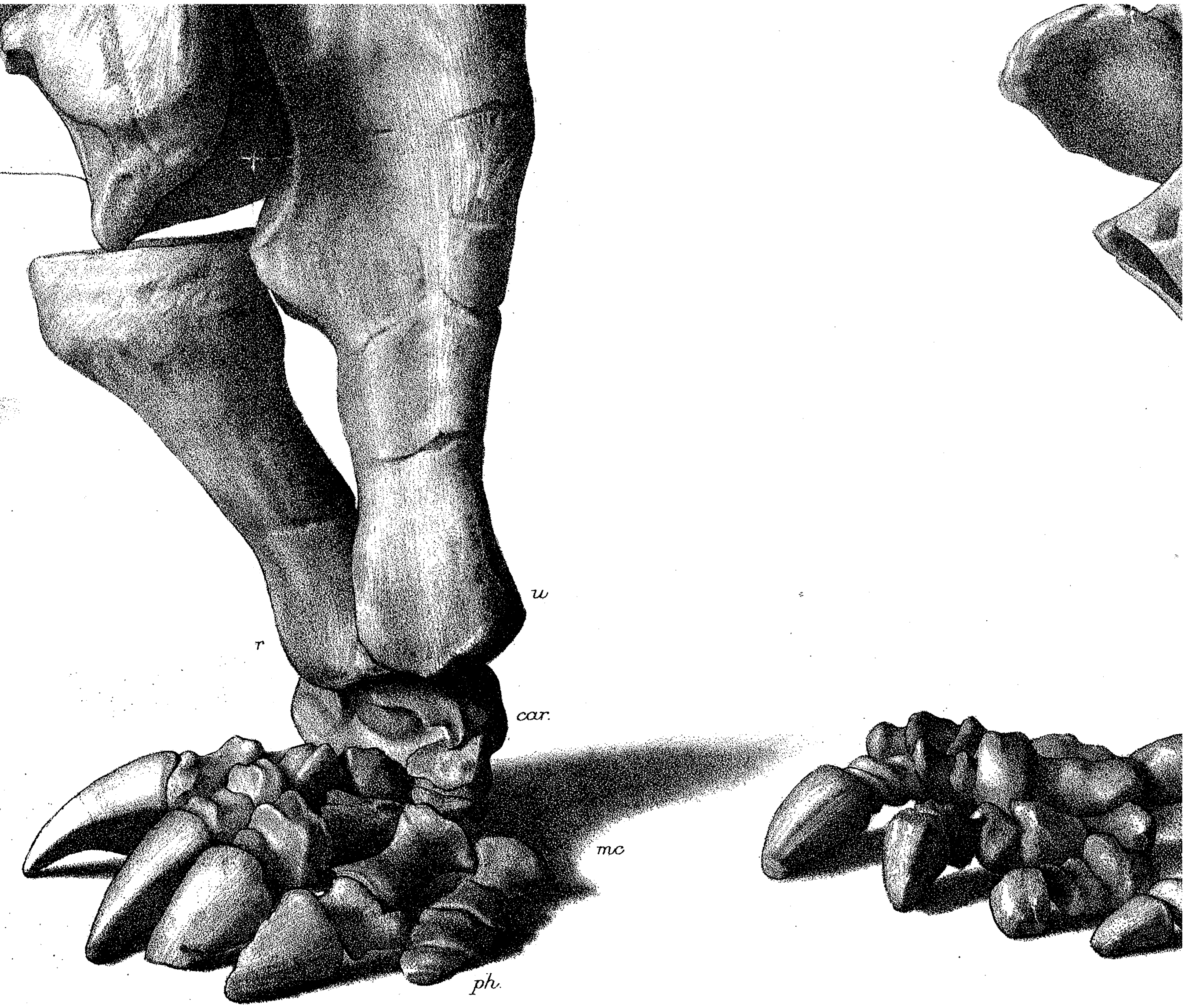
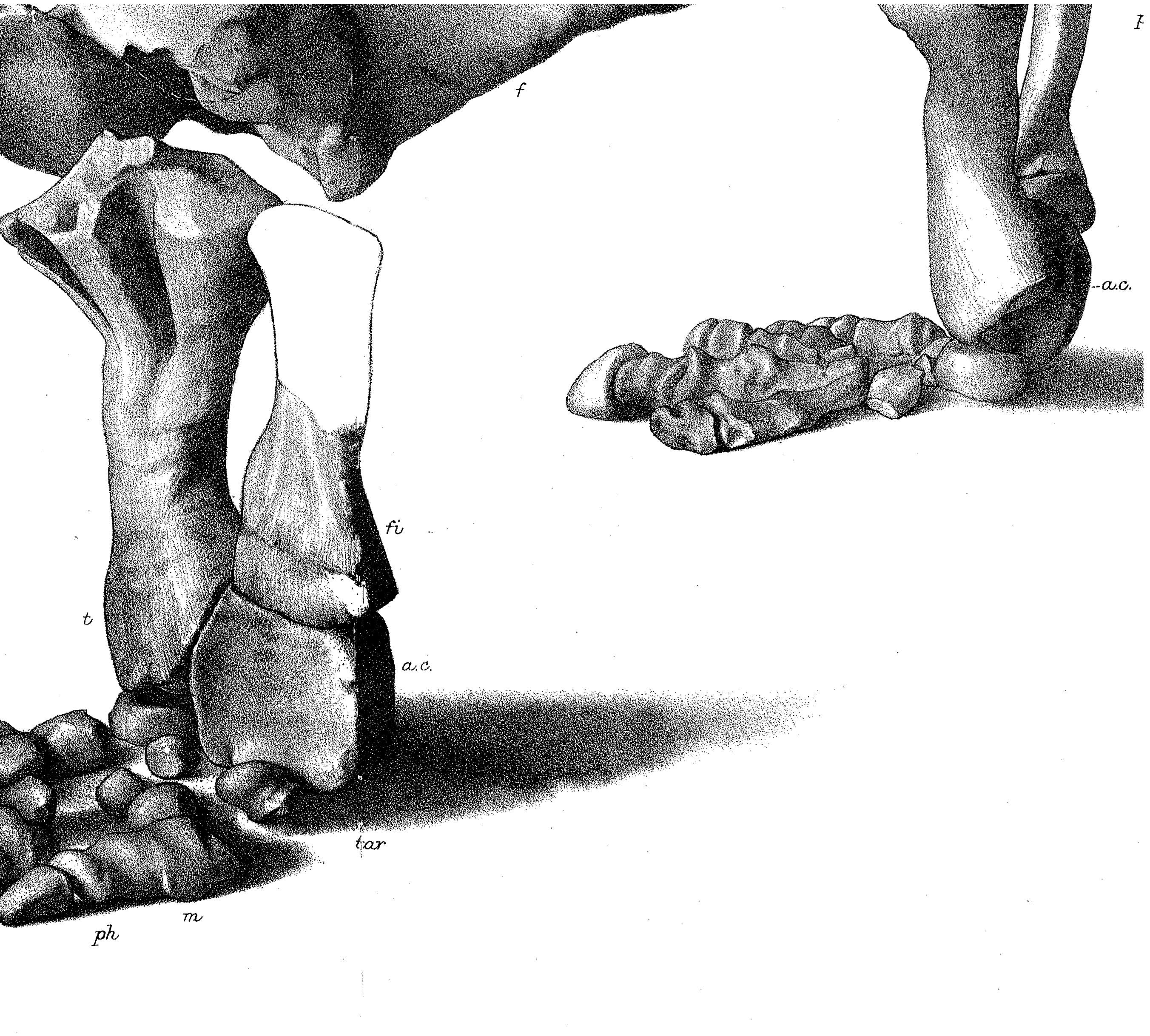


Pareiasaurus Baini.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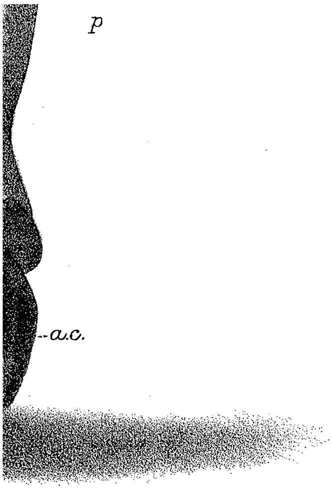


West, Newman, imp.

Fig. 1.

1/3

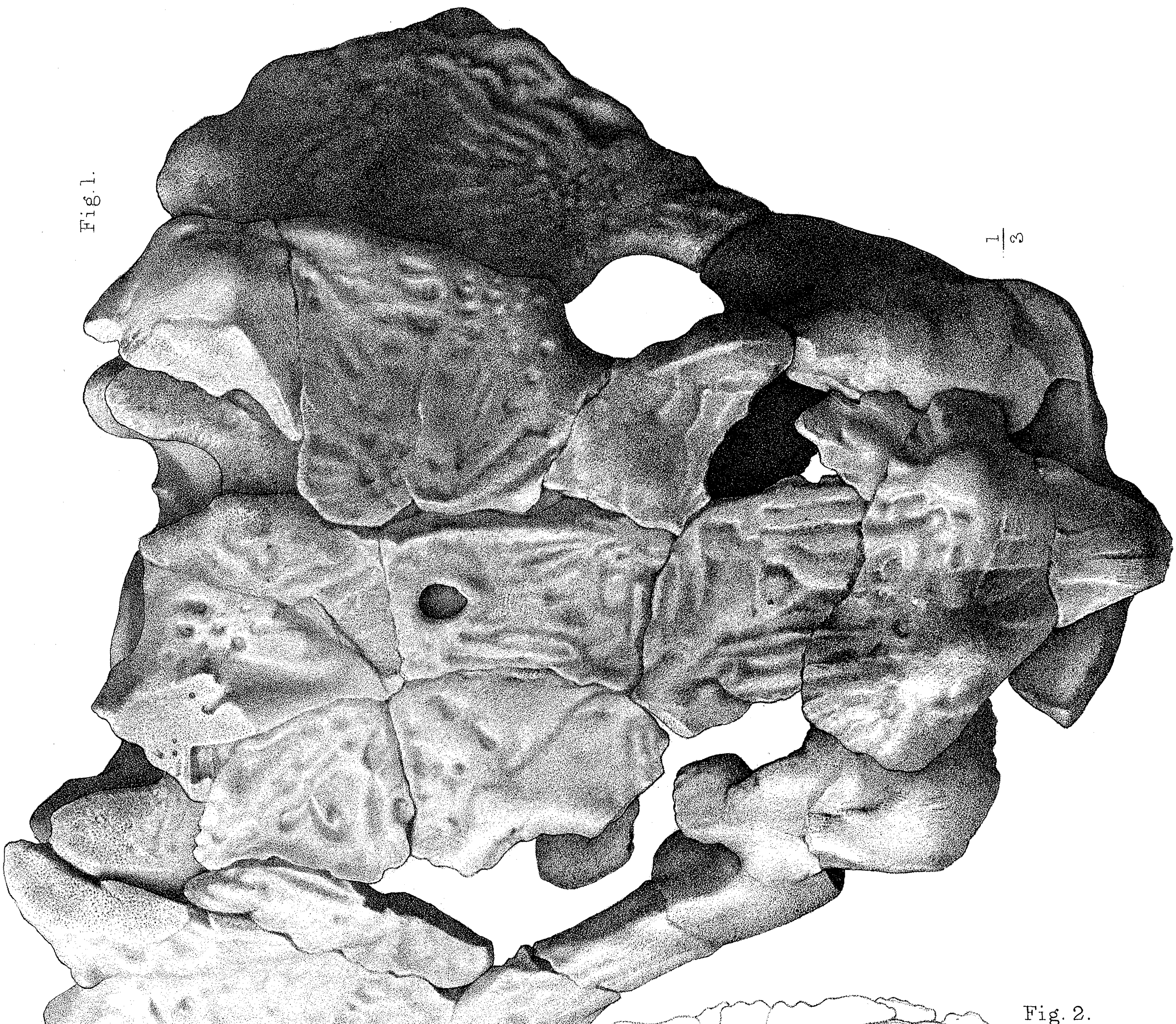
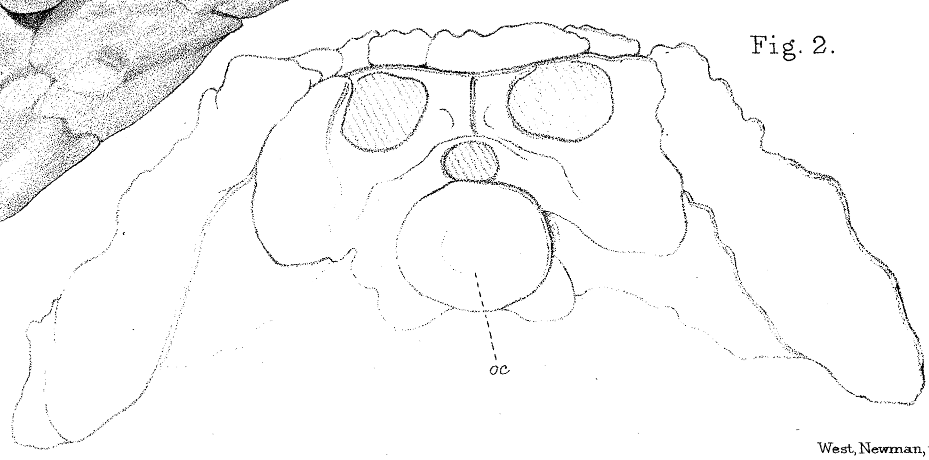


Fig. 2.



G.M.Woodward, ad nat. lith. West, Newman, imp.

Cranial Armature, Pareiasaurus Baini.

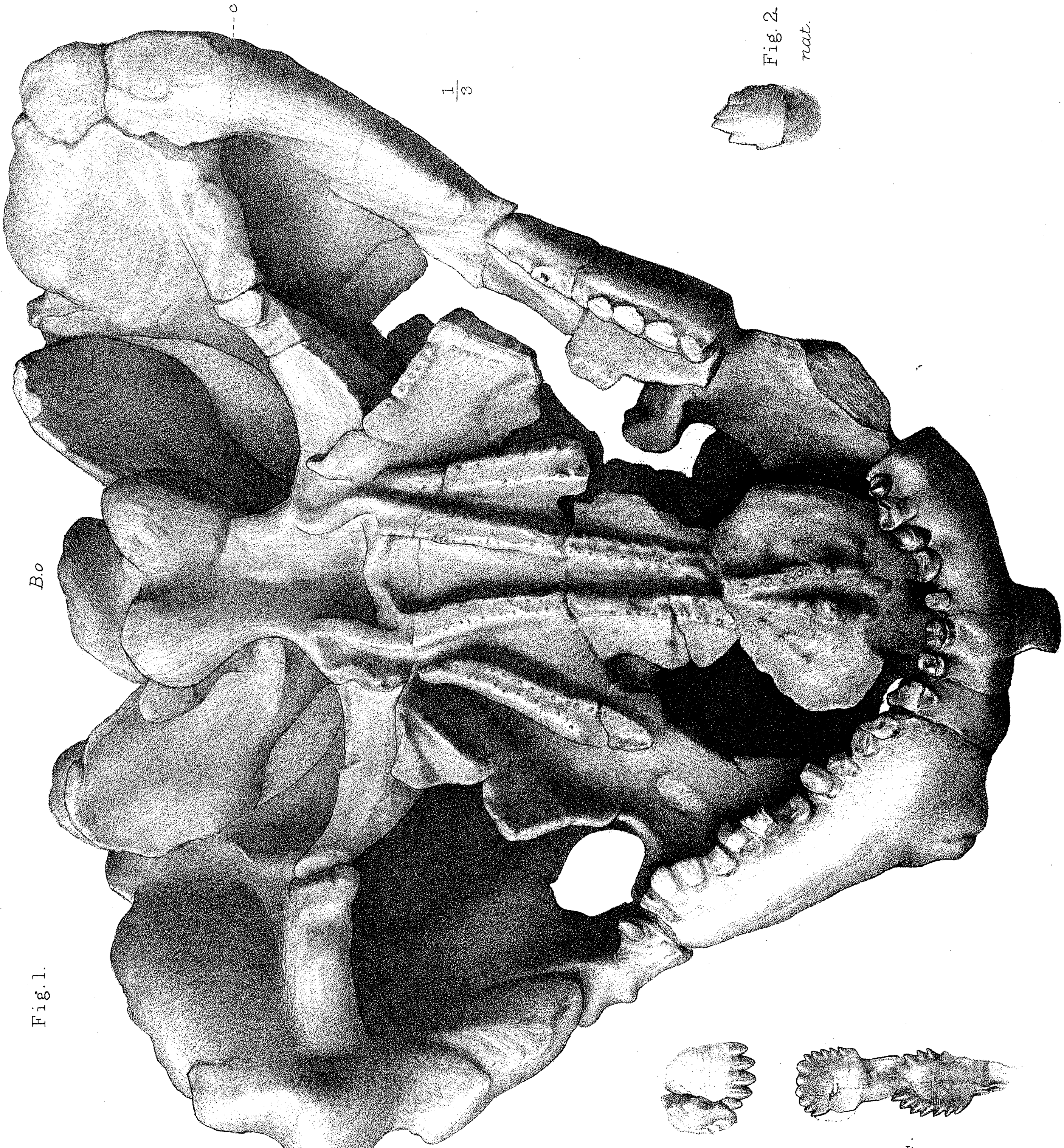


Fig. 1.

Fig. 2 *nat.*

Fig. 3.

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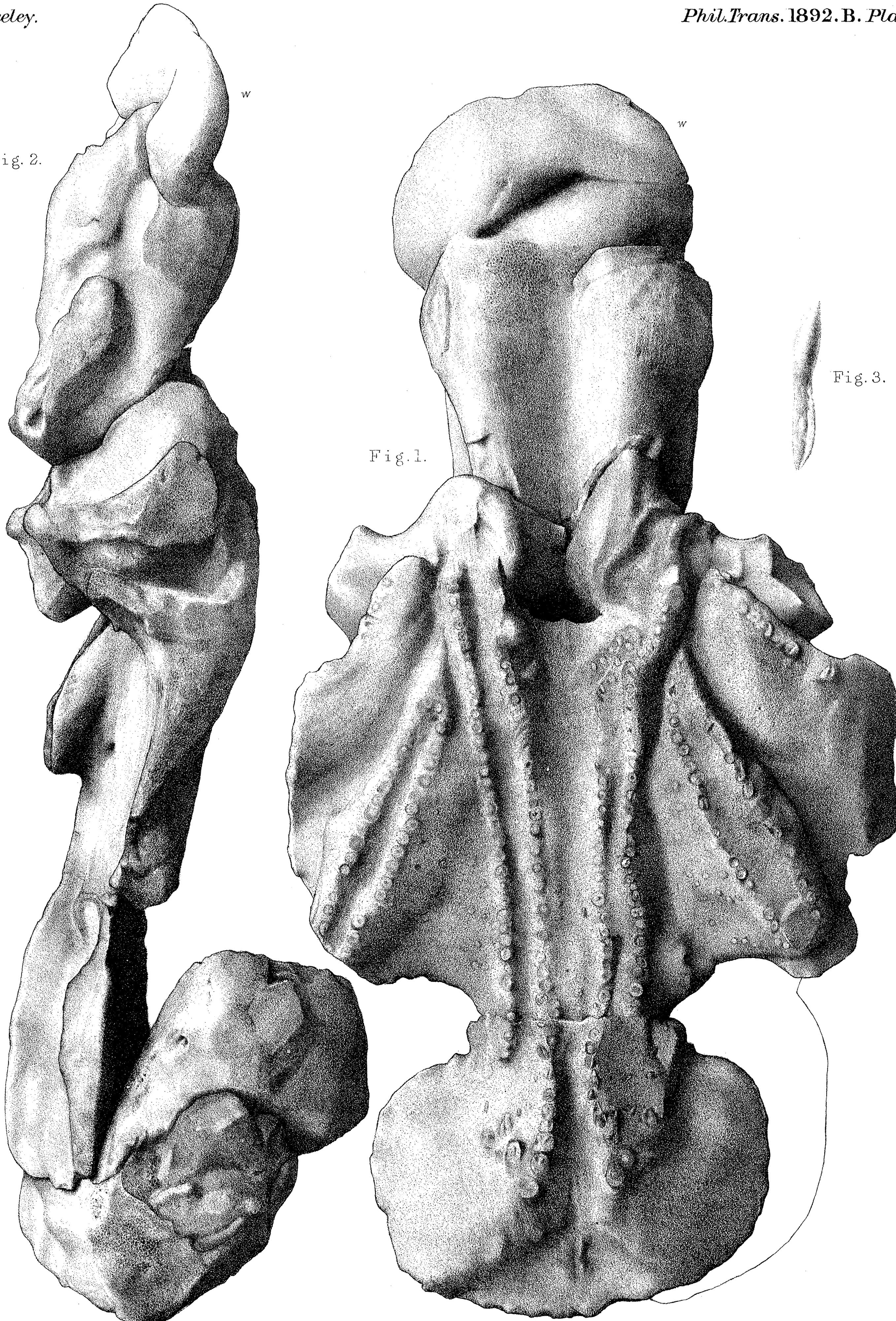
Fig. 4.

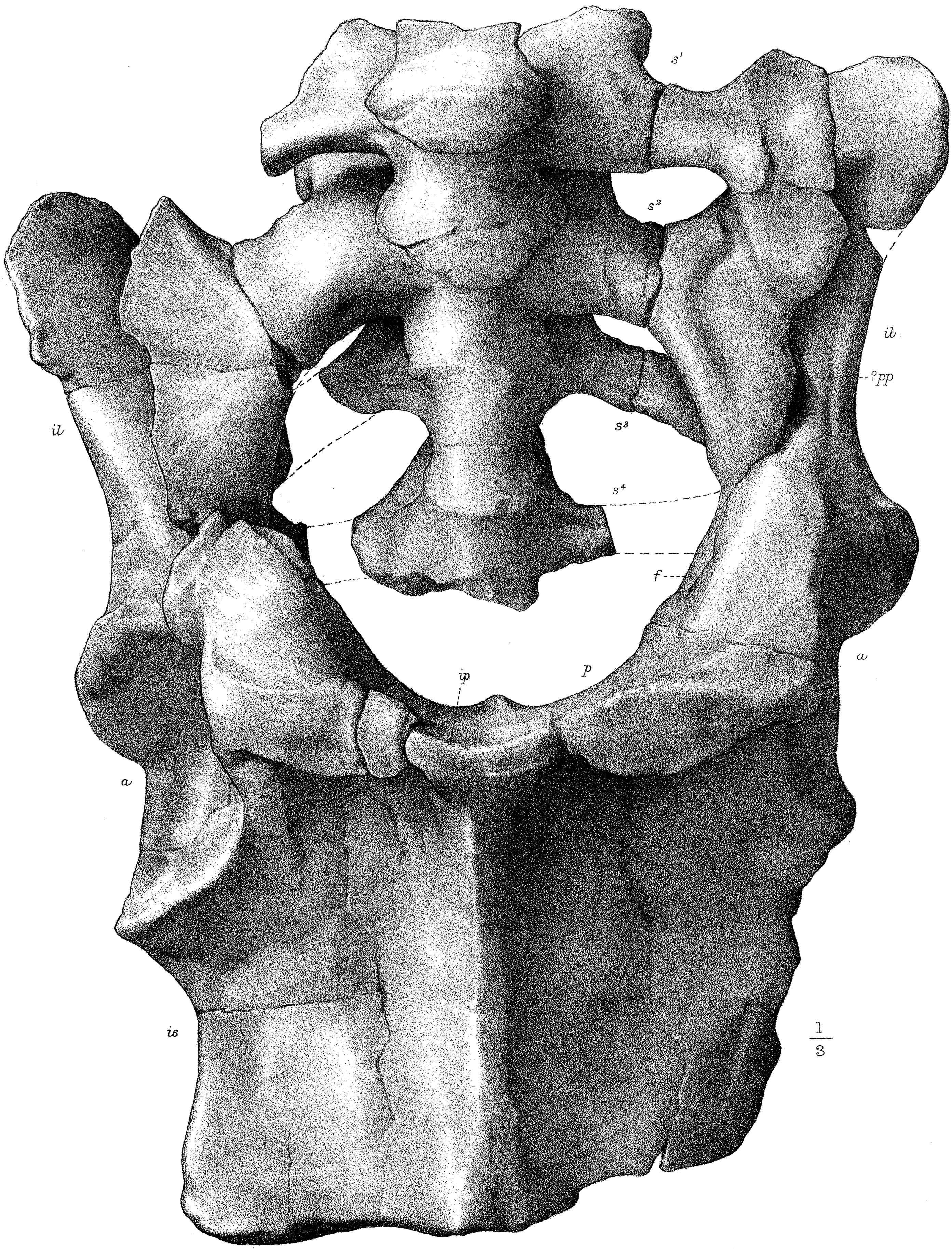
G. M. Woodward, ad. nat. lith. West, Newman, imp.

Palate and Dentition, Pareiasaurus Baini.



G.M.Woodward, ad.nat.lith. West, Newman, imp.

Palate of Pareiasaurus Bombidens.



G. M. Woodward, ad. nat. lith. West, Newman, imp.

Sacrum and Pelvis, Pareiasaurus Baini.

Fig. 1.

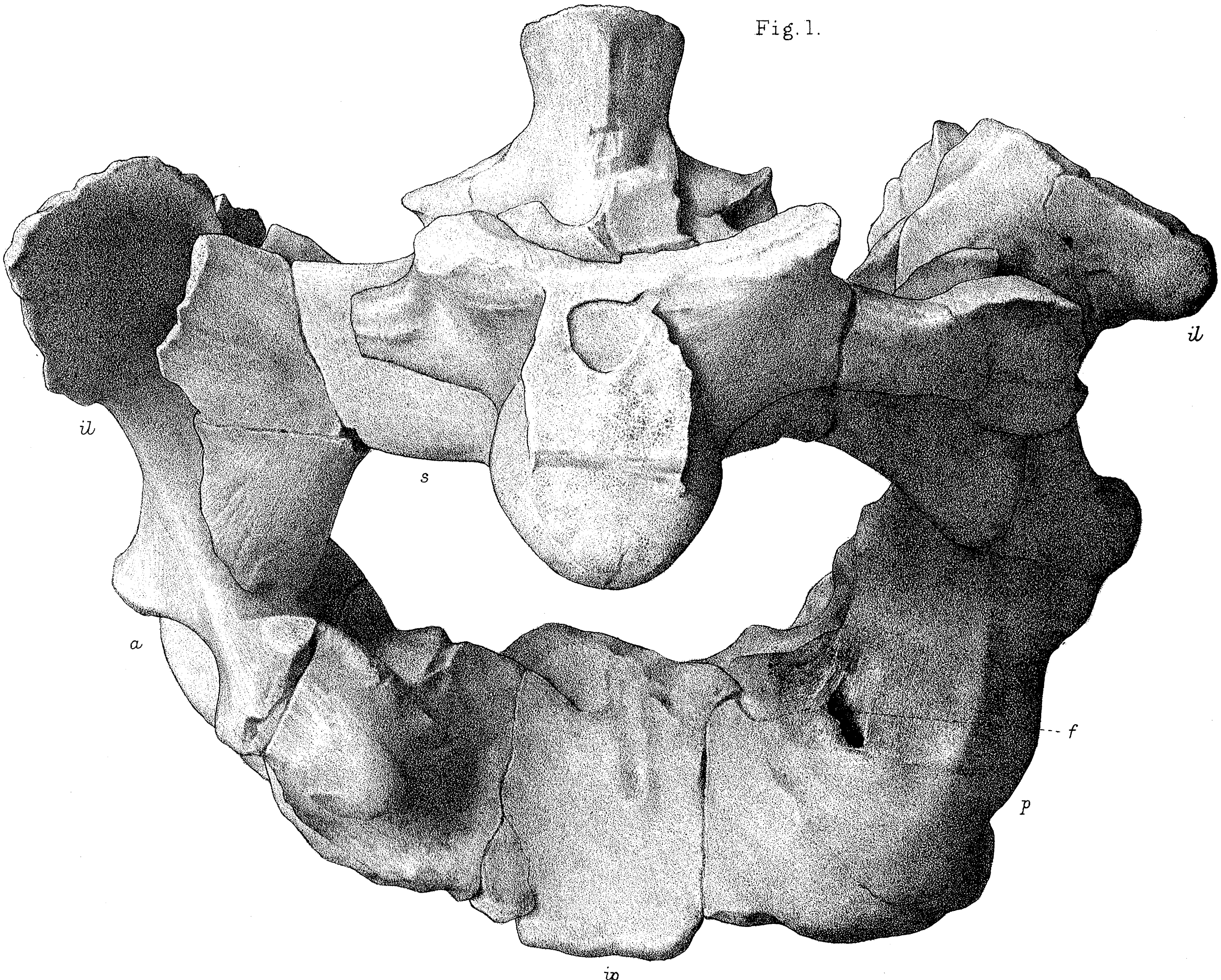
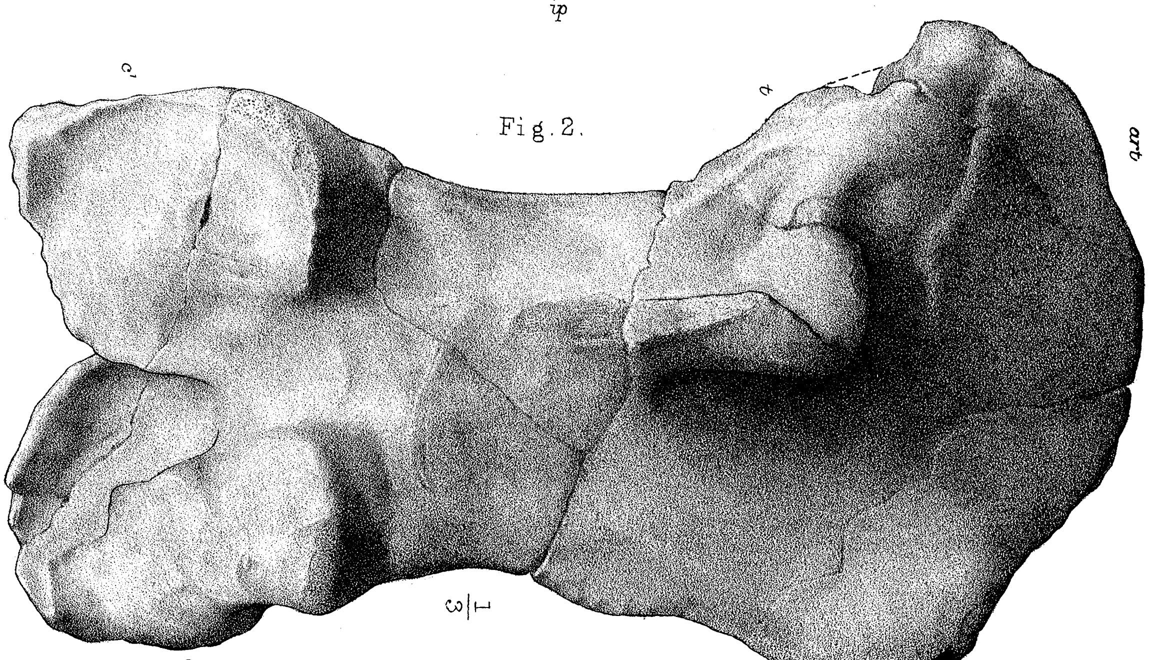
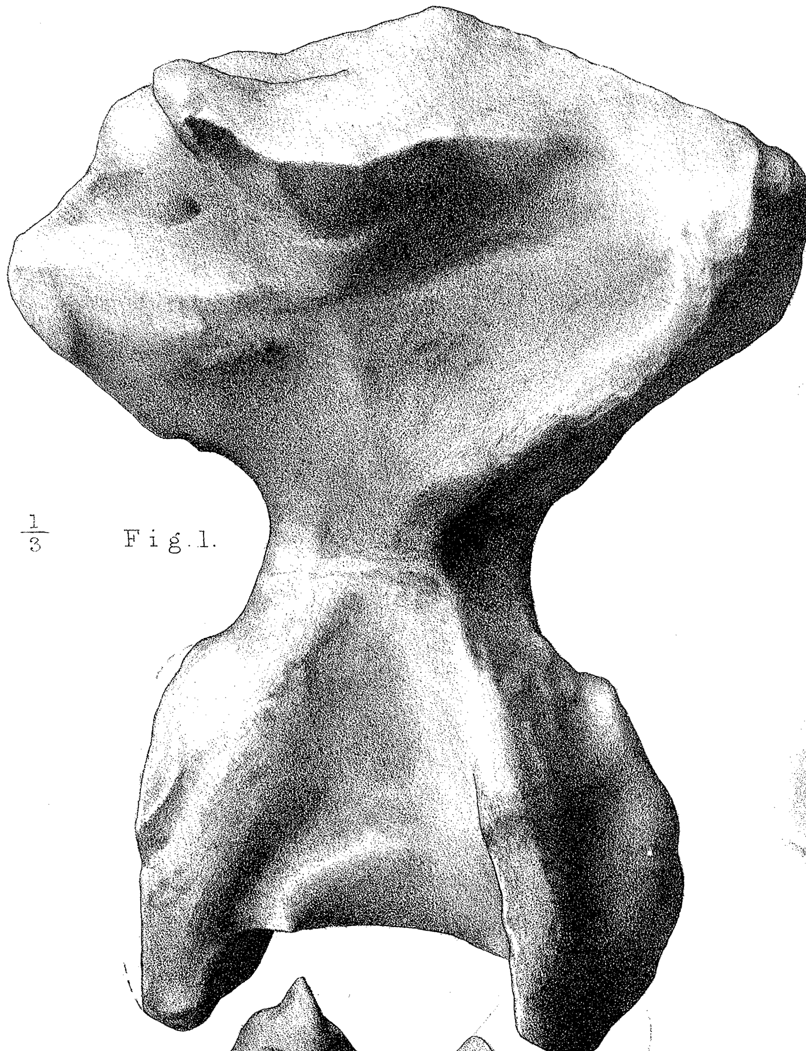


Fig. 2.



G. M. Woodward, ad. nat. lith. West, Newman, imp.

Pelvis and Femur, Pareiasaurus Baini.



$\frac{1}{3}$ Fig. 1.

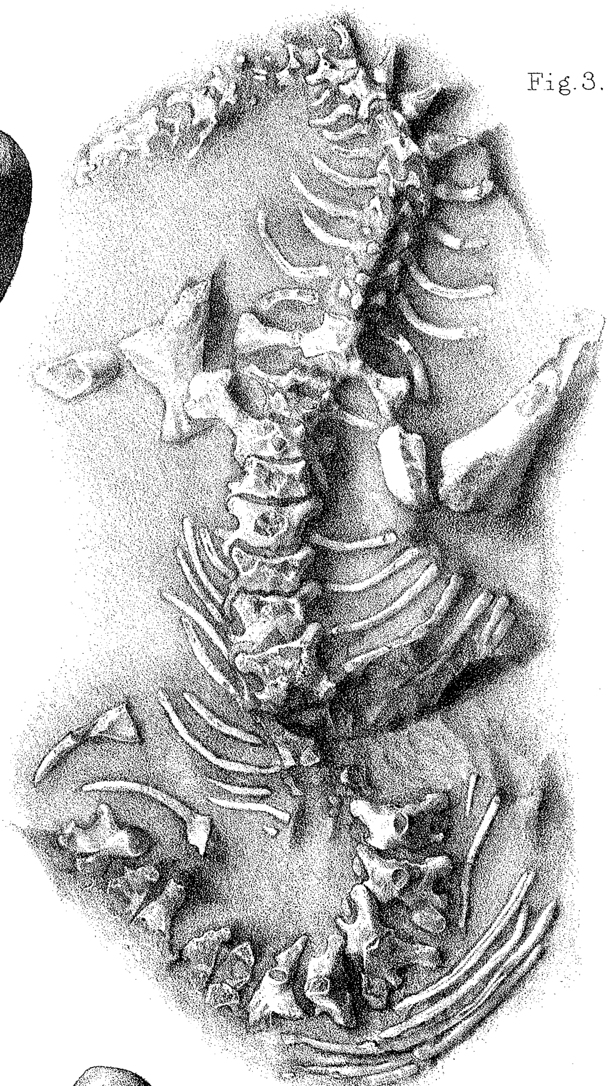


Fig. 3.

Fig. 2.

G. M. Woodward, ad. nat lith.

West, Newman, imp.

Bones of Pareiasaurus & Procolophon.

G. M. Woodward, del. et lith.

West, Newman, imp.

Pareiasaurus Baini.

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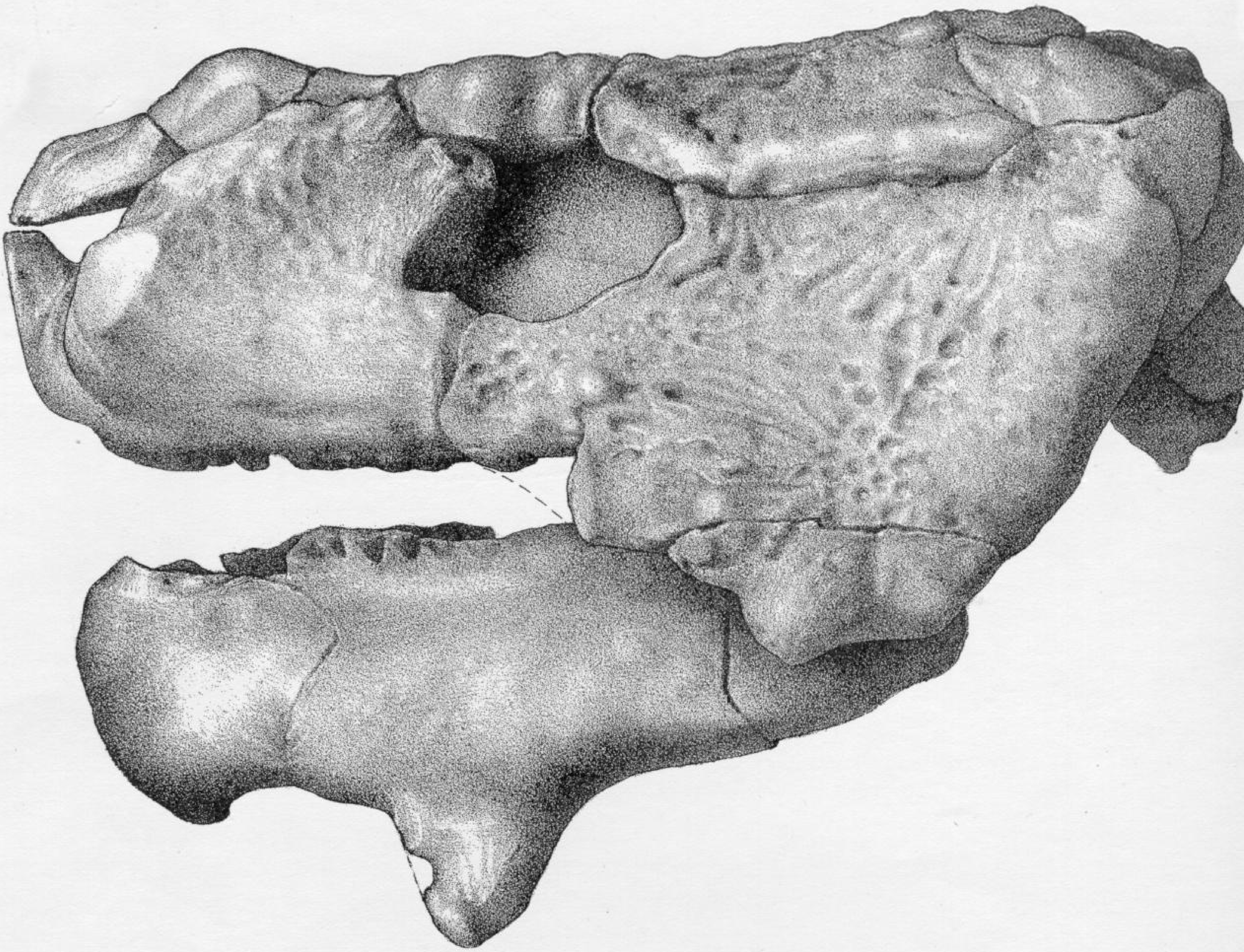

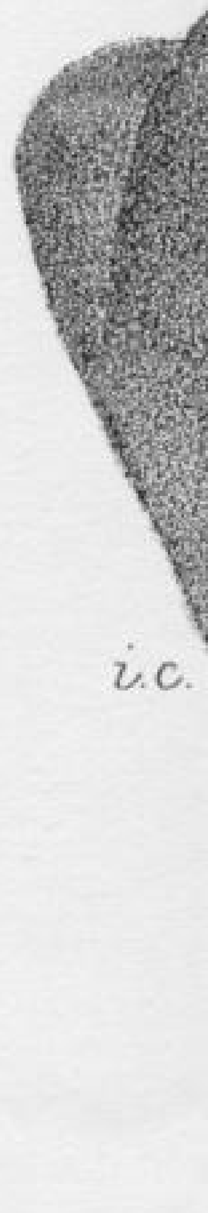


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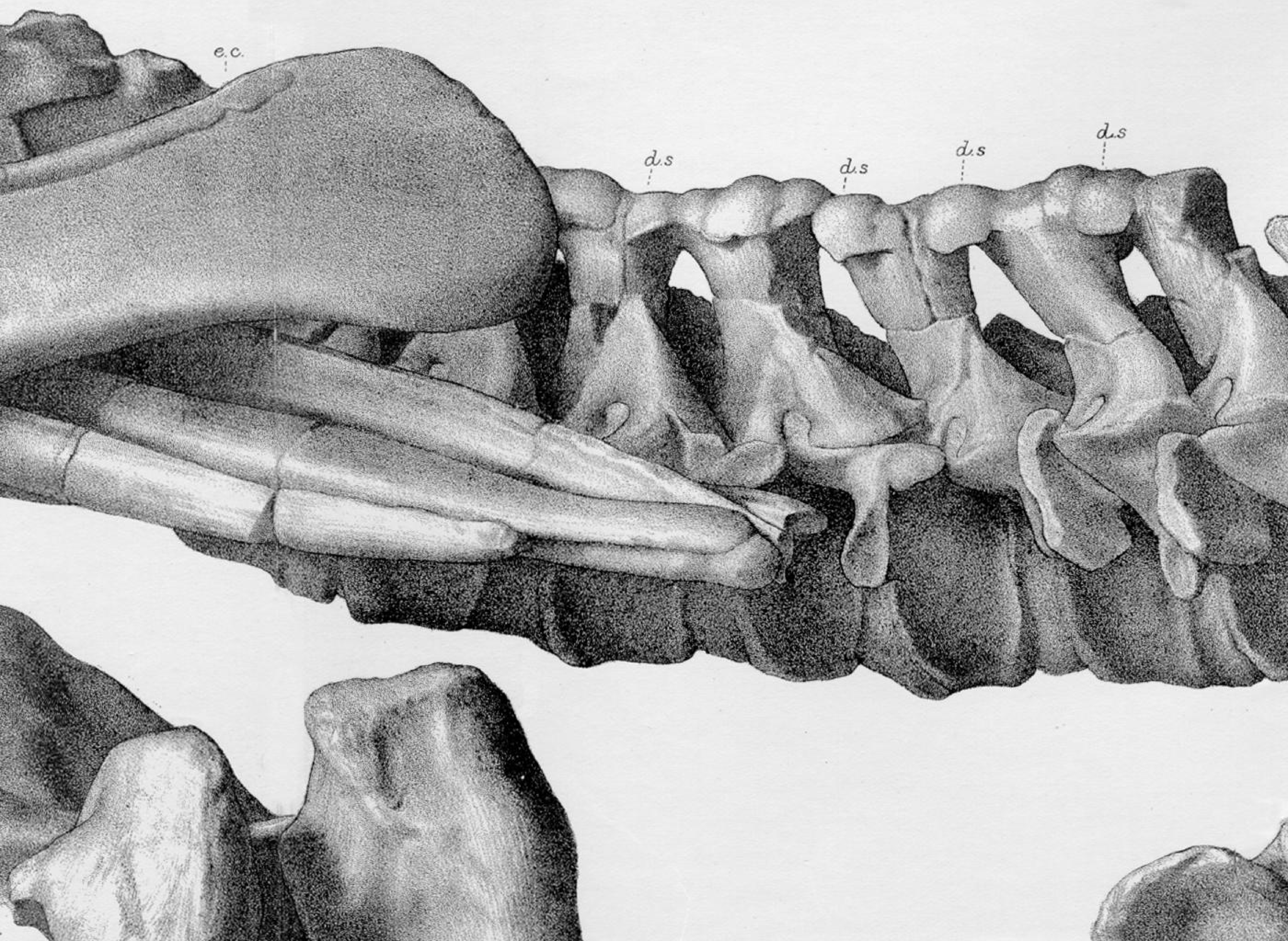
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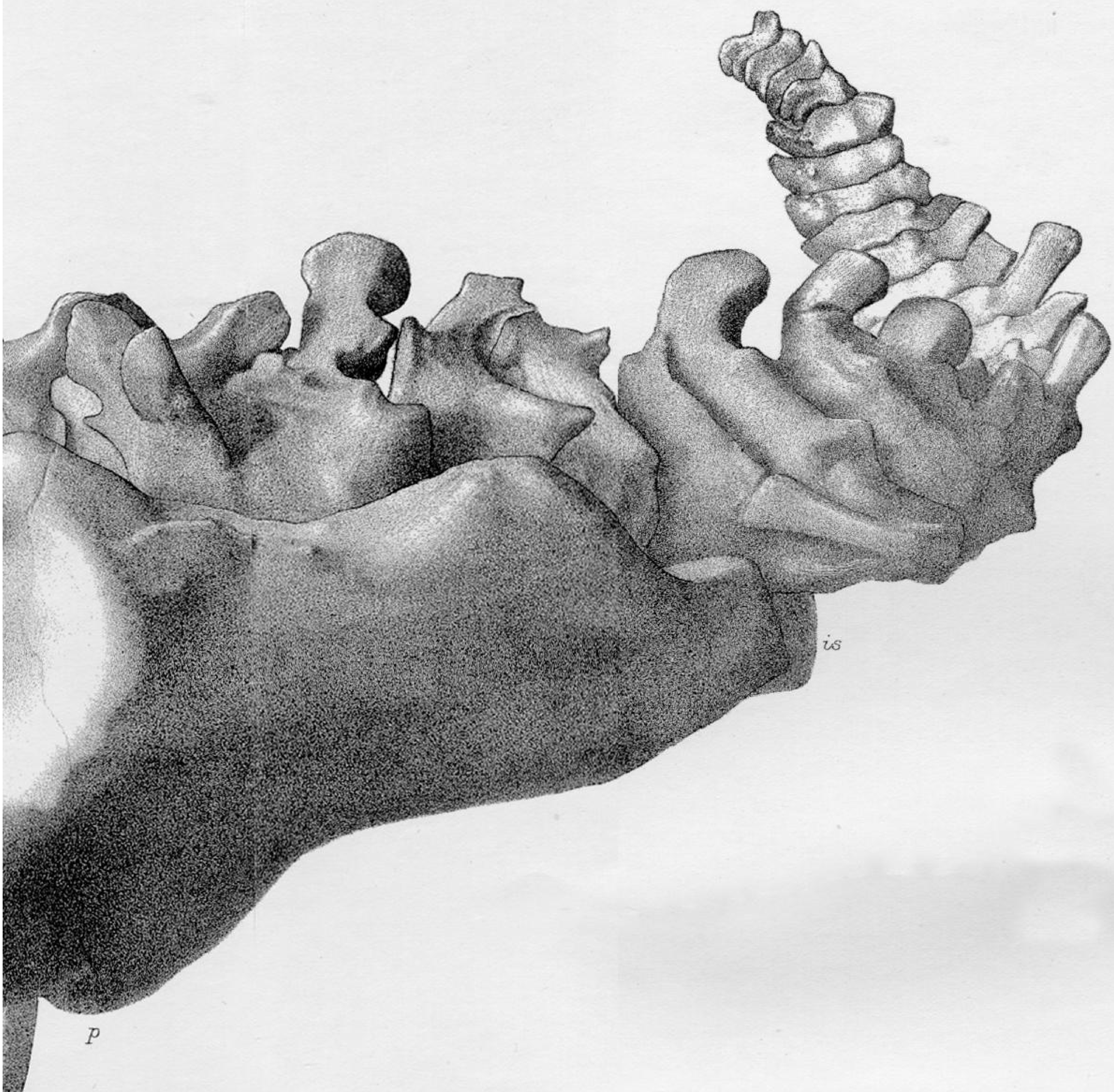
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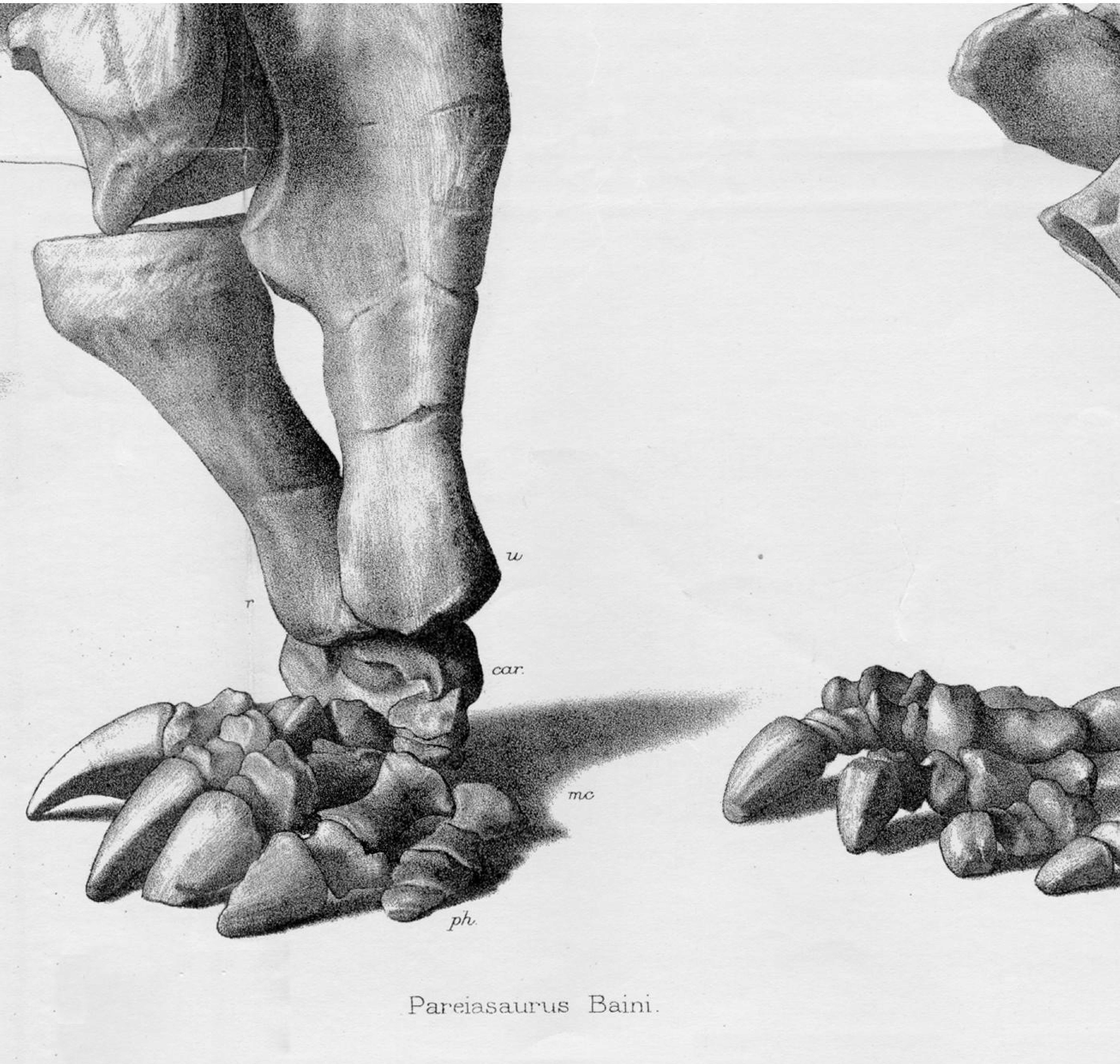
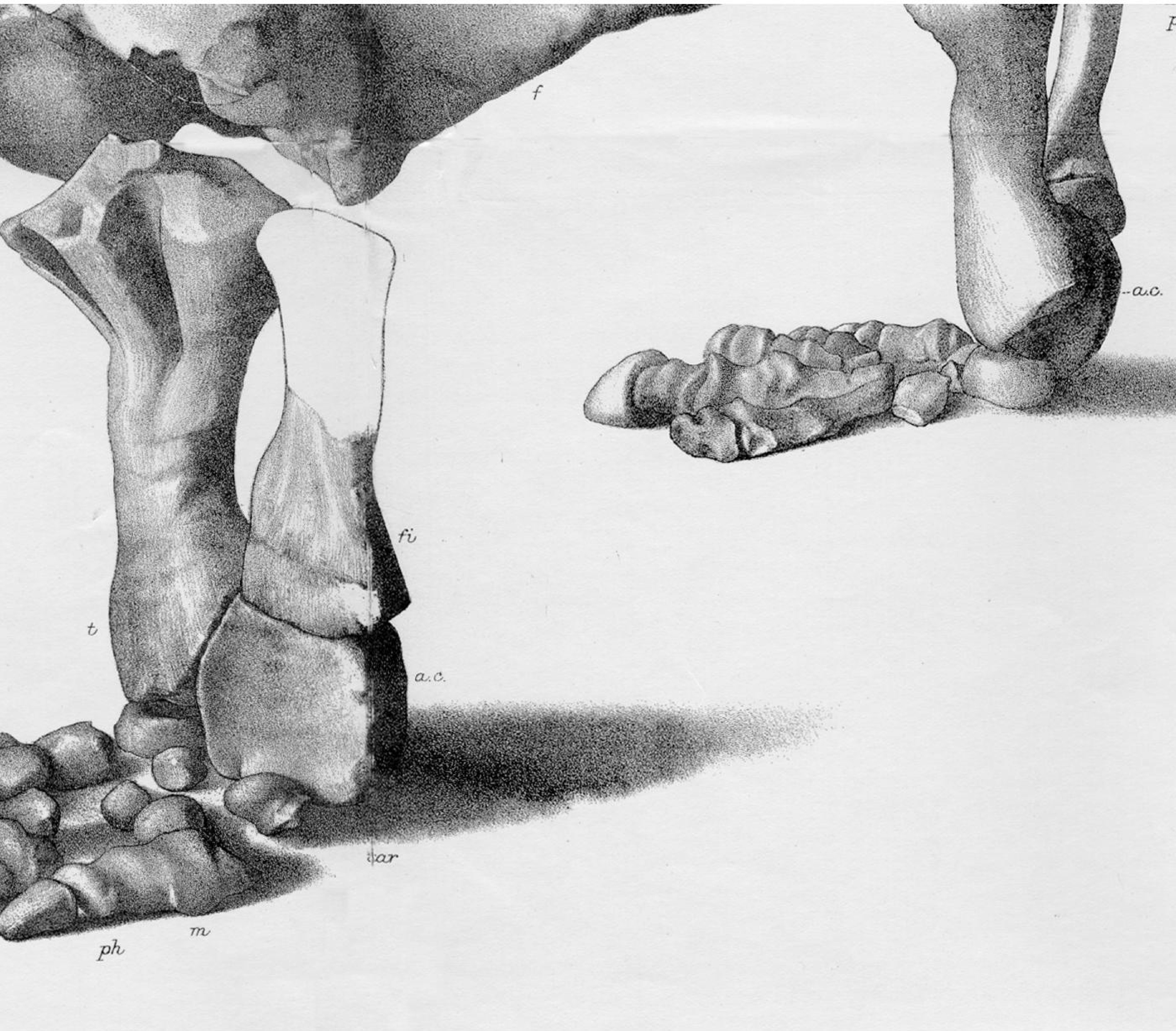


Pareiasaurus Baini.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West, Newman, imp.

Fig. 1.

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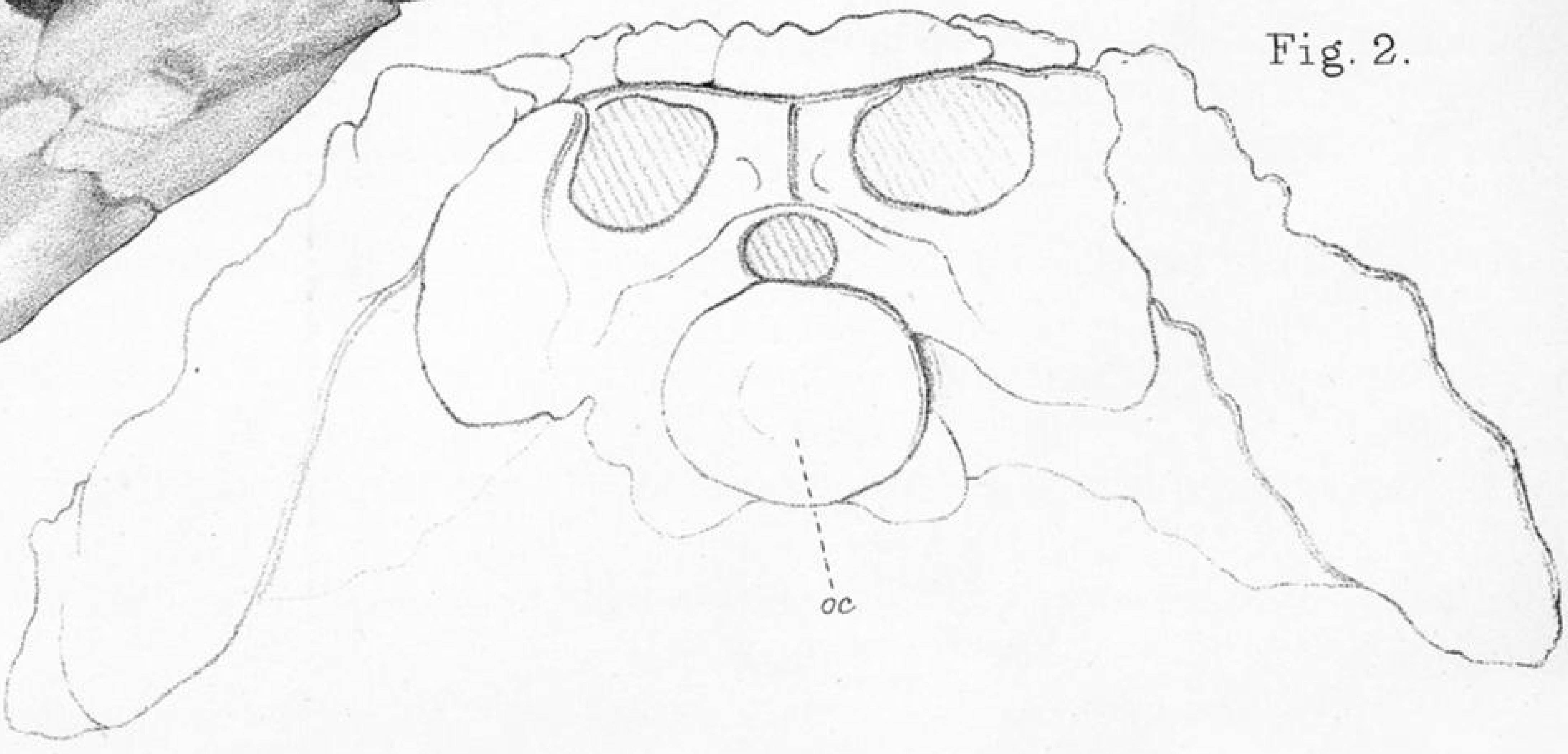

Cranial Armature, Pareiasaurus Baini.

PLATE 18.

Fig. 1. The skull of *Pareiasaurus Baini*, seen from above, showing the wedge-like form of the head with a flattened crown and oblique cheeks; the sculpture of the bones, the parietal foramen, the position of the orbits in the middle length of the side of the head, and the anterior nares divided by the internasal septum of the nasal and premaxillary bones, which bulges forward between them; one-third natural size.

Fig. 2. Outline of the posterior occipital aspect of the skull, showing the occipital condyle *oc.*, with the foramen magnum, and lateral vacuities at the sides of the brain case. The position of the cheeks diverging and descending is seen to give an appearance of depth to the side of the head.

Palate and Dentition, Pareiasaurus Baini.

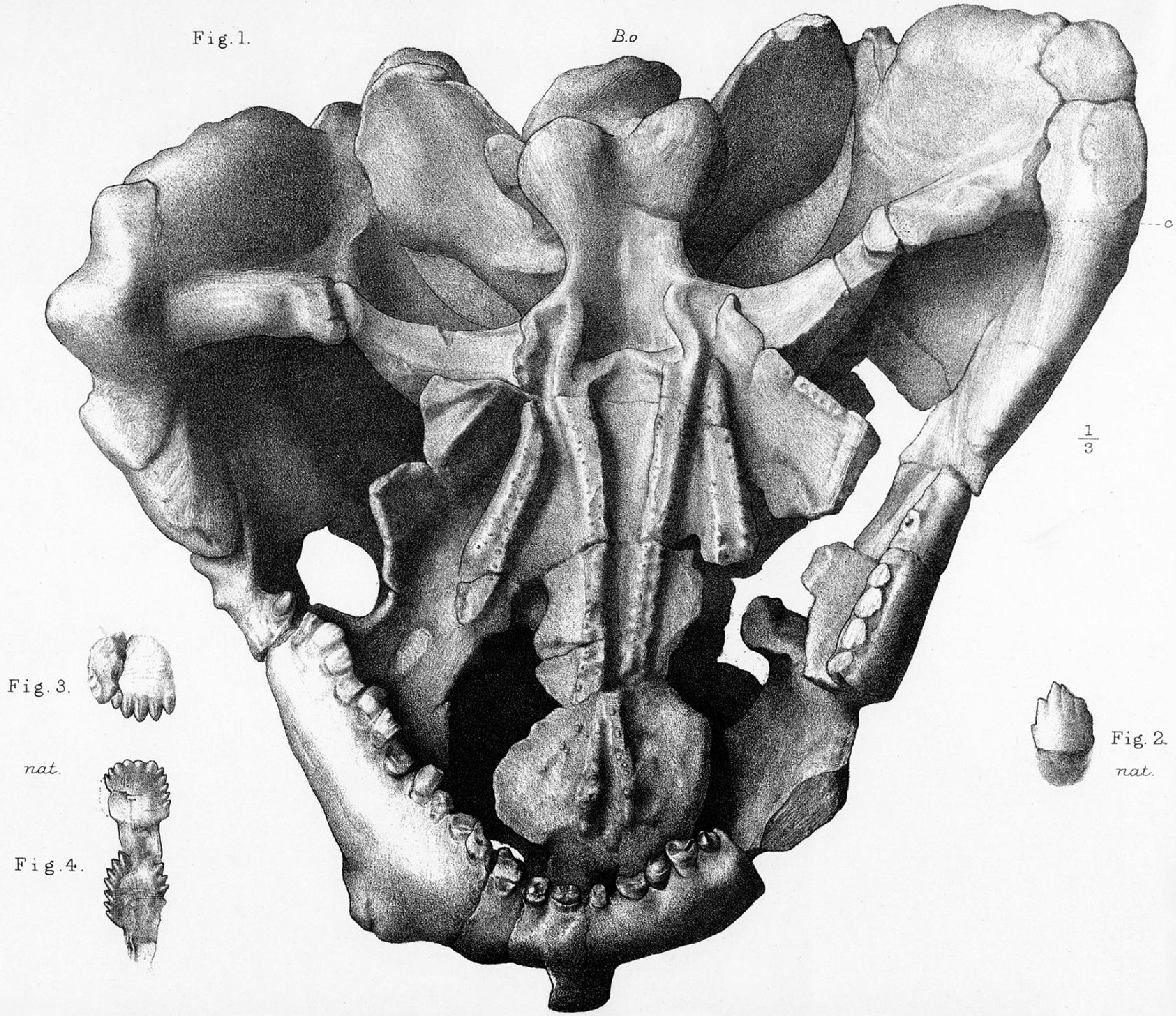

PLATE 19.

Fig. 1. Palatal aspect of the skull of *Pareiasaurus Baini*, showing the positions of the teeth in the premaxillary and maxillary bones. The vomerine, palatine, and pterygoid bones are covered with double parallel rows of teeth, which converge backwards towards the vacuity of the palato-nares. *B.o.* is the base of the occipital condyle; *c.* the condyle of the quadrate bone; one-third natural size.

Fig. 2. External aspect of a maxillary tooth from the Tamboer specimen; natural size.

Fig. 3 and fig. 4 are from the jaws of *Pareiasaurus Russouwi* from the top of the Nieuwveldt range, midway between Klip-fontein and Fraserberg; natural size.

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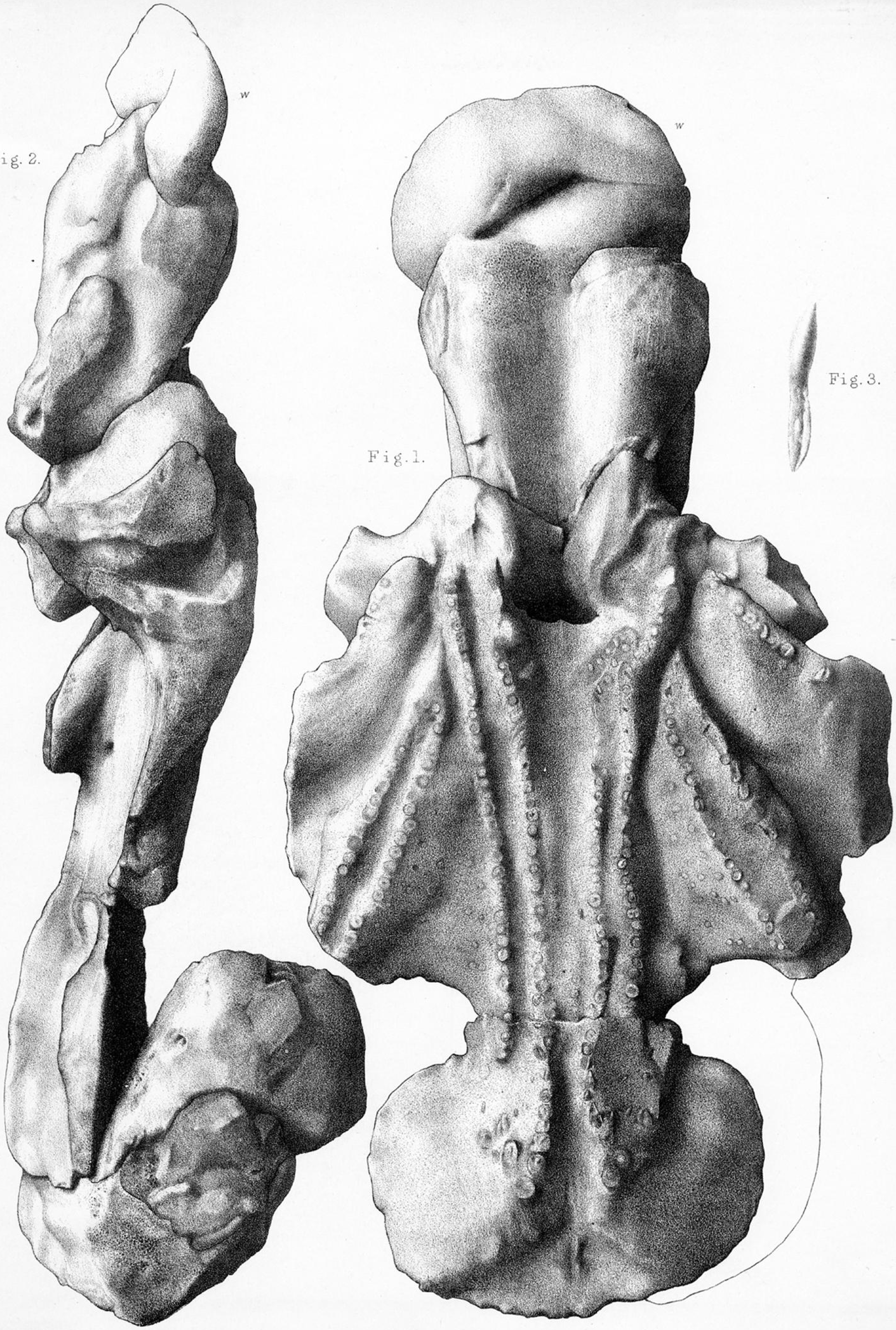
Fig. 4 is a mandibular tooth from the same specimen seen from the inner side of the jaw, showing the radiating denticles. A successional tooth of similar character is seen below; natural size.



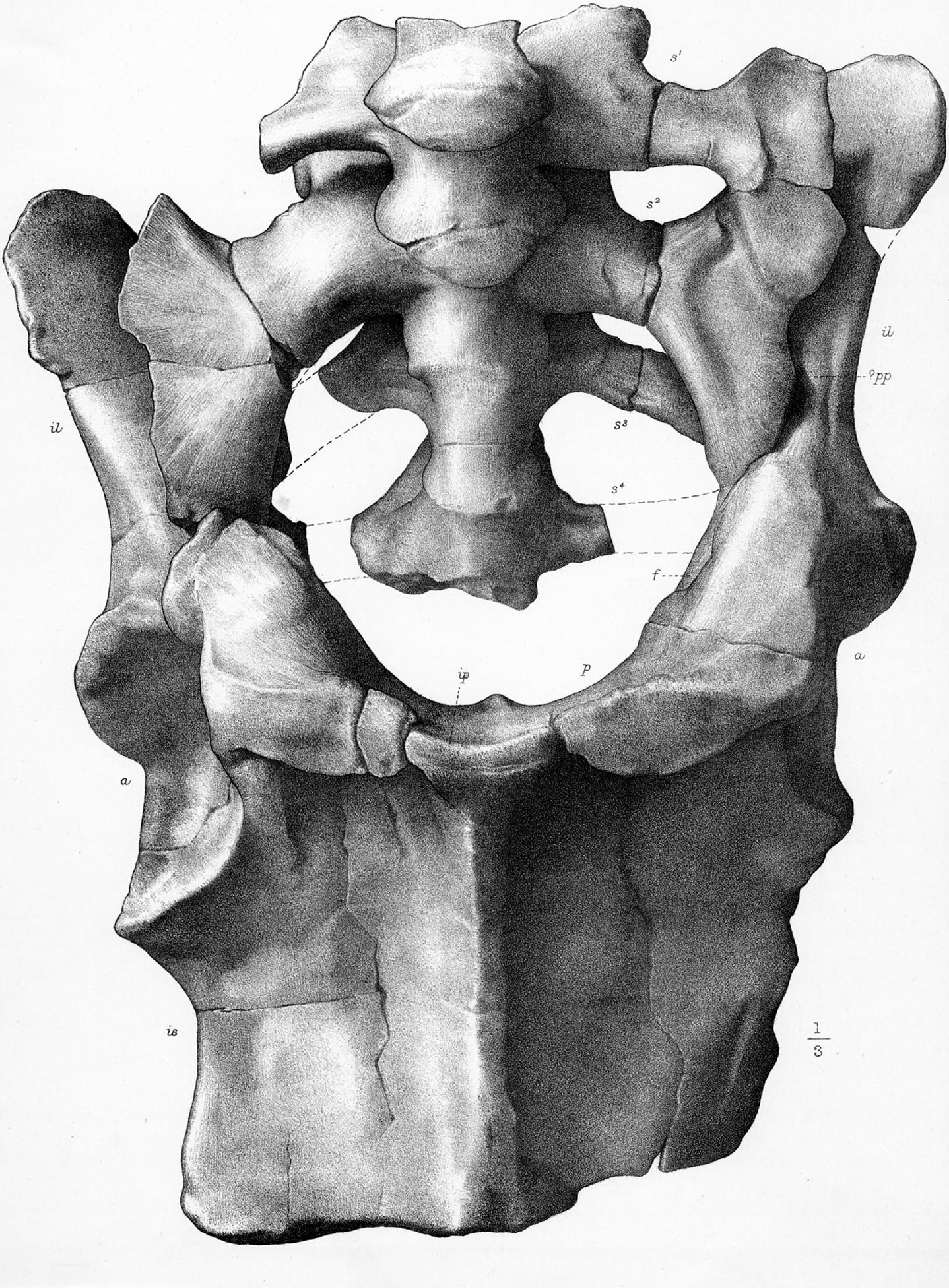
Palate of Pareiasaurus Bombidens.

PLATE 20.

Fig. 1. Palate of the Tamboer specimen referred to *Pareiasaurus bombidens,* showing teeth scattered in the interspaces between the rows. This palate is continuous with the maxillary bones; *w.* is an intercentrum below the basioccipital.

Fig. 2. The same palate seen from the side, so as to show the superior and inferior surfaces of the bones, and position of the maxillary and mandibular bones.

Fig. 3. A single tooth from the palate, showing its cylindrical curved character.



Sacrum and Pelvis, Pareiasaurus Baini.

PLATE 21.

Sacrum and pelvis of *Pareiasaurus Baini*, seen from the ventral aspect. *s.*[1], *s.*[2], *s.*[3], *s.*[4], sacral ribs; *il.*, ilium; ?*pp.*, ossification only seen on the left side, which appears to be an anterior prolongation of the pubis on the inner side of the ilium (also seen in *P. bombidens*, 'Phil. Trans.,' 1888, B, Plate 19, figs. 1 and 2); *f.* is the foramen, which passes longitudinally through the pubic bone; *p.*, the pubis, reflected downwards and forming inferior callosities; *ip.*, a median inter-pubic ossification, which is only defined on the ventral surface; *a.*, acetabulum; *is.*, ischium; one-third natural size.

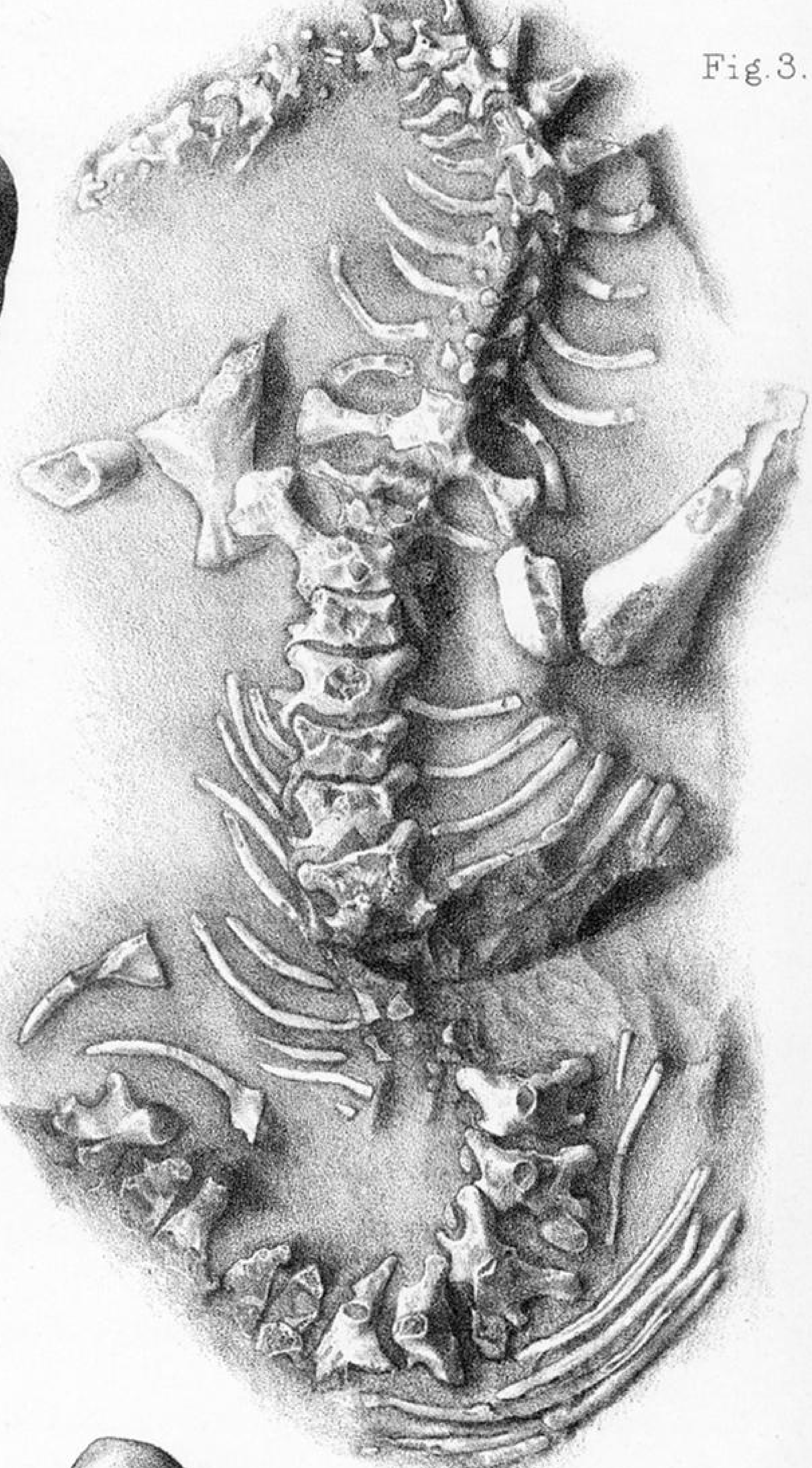
Pelvis and Femur, Pareiasaurus Baini.

PLATE 22.

Fig. 1. Anterior aspect of sacrum and pelvis of *Pareiasaurus Baini*, showing the large size of the neural spine and second pair (*s.*) of sacral ribs and the depth given to the pelvis by the downward reflection of the pubis (*p.*) and interpubic ossification (*ip.*). The pubic foramen (*f.*) is well seen on the left side. The anterior angles on the iliac bones (*il.*) are seen to extend outward.

Fig. 2. Infero-posterior aspect of right femur: *art.*, proximal articulation; *t.*, internal trochanter; *c.*^{1}, *c.*^{2}, flattened distal condyles.

Fig. 3.



$\frac{1}{3}$ Fig. 1.

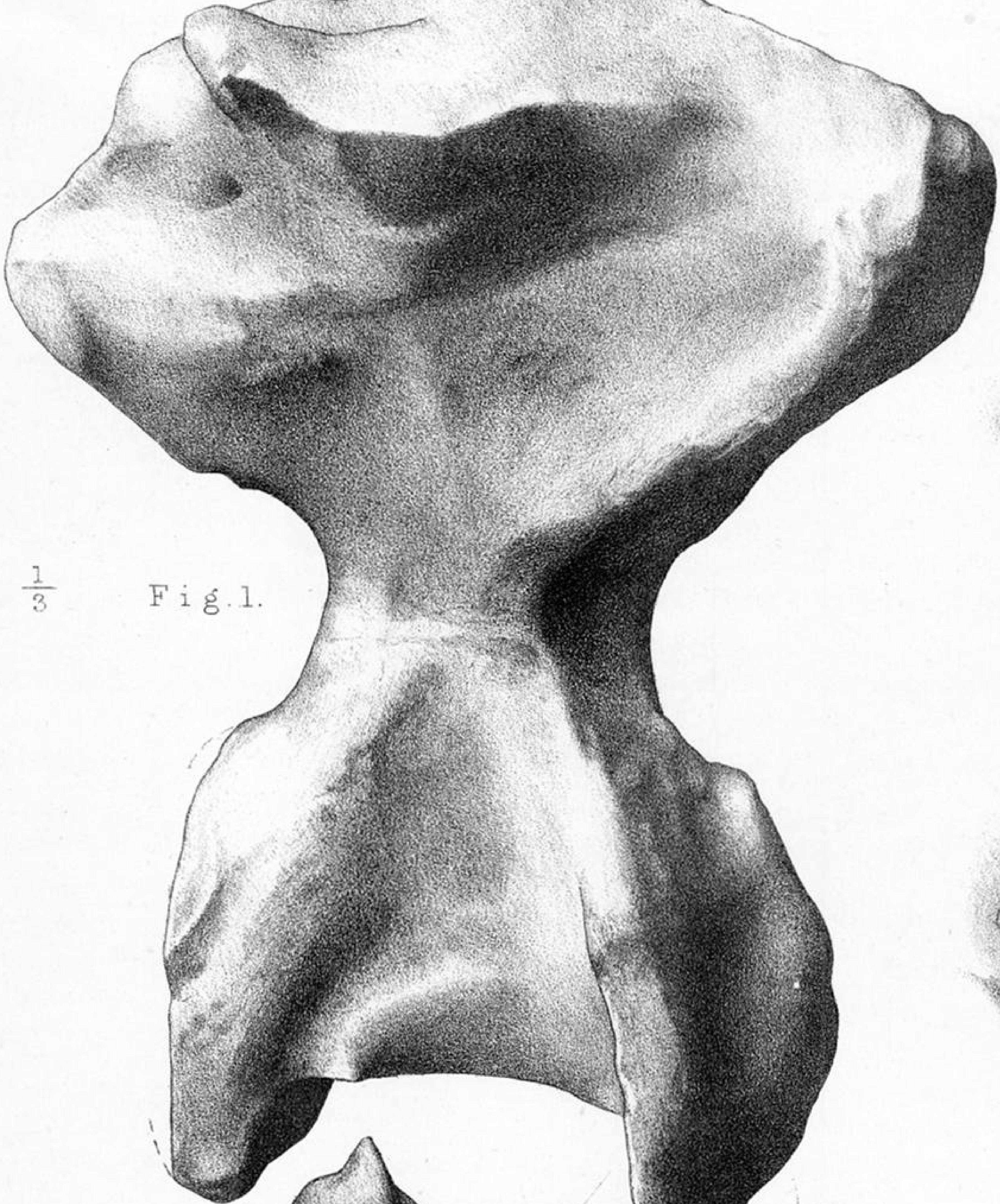
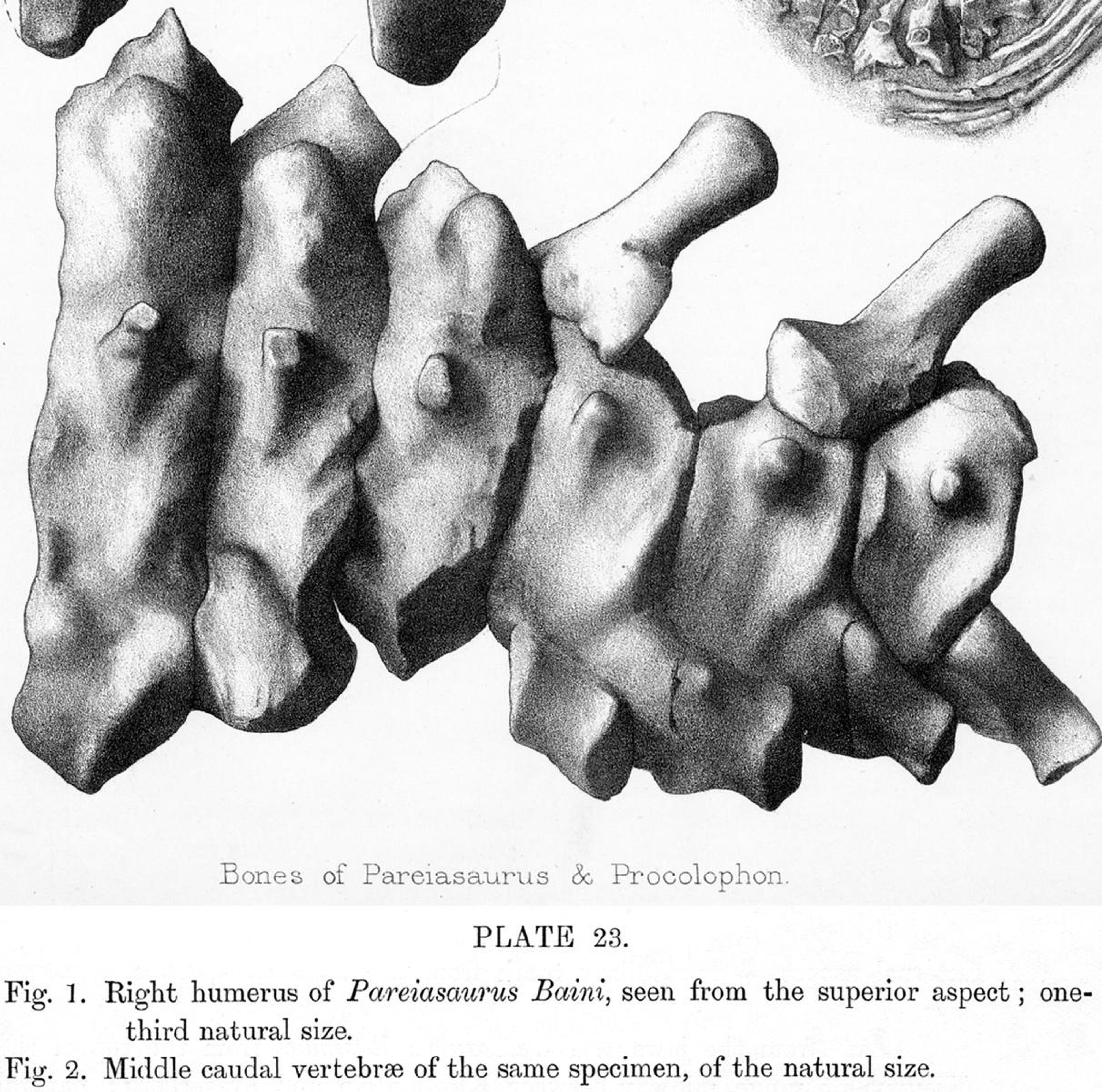


Fig. 2.



Bones of Pareiasaurus & Procolophon.

PLATE 23.

Fig. 1. Right humerus of *Pareiasaurus Baini*, seen from the superior aspect; one-third natural size.

Fig. 2. Middle caudal vertebræ of the same specimen, of the natural size.

Fig. 3. Dorsal aspect of the vertebral skeleton of *Procolophon*, of the natural size, for comparison with *Pareiasaurus bombidens* ('Phil. Trans.,' 1888, B, Plate 12, fig. 2).

The cervical region is at the lower part of the figure.

The caudal region is the upper part of the figure.

The displaced ilium is on the right side, and the femur on the left side.

The anterior extremity and skull are figured 'Phil. Trans.,' 1889, B, Plate 9.