VI. *Researches on the Structure, Organization, and Classification of the Fossil Reptilia.—* VI. *On the Anomodont Reptilia and their Allies.*

By H. G. Seeley, *F.R.S., Professor of Geography in King's College, London.*

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[Plates 9–25.]

The Structure of the Skull in Anomodontia.

The chief contributions to a knowledge of the Anomodont skull have been made by Sir Richard Owen, Professor Huxley, and Professor Cope. When Sir R. Owen published his first description of several species of *Dicynodon*, in 1845,* and regarded that genus as indicating a new order of Saurians, an elaborate comparison was made to indicate the nature of its relation to existing orders of Reptiles, with the result that the skull was interpreted as essentially formed on the Lacertilian plan, though upon that plan structures are engrafted which are otherwise characteristic of Chelonians and Crocodiles. The Lizards with which it is chiefly compared are the fossil *Rhynchosaurus* of the Trias, and the existing *Hatteria*. The chief Lacertilian characters enumerated are :—(1) the single pre-maxillary bone and the double external nasal apertures, though the pre-maxillary is single in *Chelys*, and both these conditions are found in many Serpents and some Amphibians, though the great development of the pre-maxillary in Dicynodonts is thought to foreshadow its condition in Birds ; (2) few existing Lizards have the maxillary arch so strong or the maxillary bones so well developed ; (3) the zygomatic bone is continued from the lower border of the orbit to the upper end of the tympanic pedicle ; (4) the tympanic pedicle descends vertically from the junction of the zygomatic and mastoid, and is comparatively free ; (5) the flat anterior part of the parietal bone is perforated by a parietal foramen, and the posterior part of the bone bifurcates ; (6) the orbits are circular and midway in the length of the skull. In some respects the characters are said to show a blending of Chelonian and Lizard structures. Thus, the palate unites features of both those orders ; there is a bony floor to the orbit ; the ex-occipital and basi-occipital bones combine to form the tripartite occipital condyle.

Among the differences of *Dicynodon* from Lizards which were indicated, are:—(1) the

* 'Geol. Soc. Trans.,' vol. 7.

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edentulous Turtle-like mandible and pre-maxillary; (2) the expanded vertical occipital plate, which is compared to that of Crocodiles; (3) the brain-case is only two-thirds the breadth of the inter-orbital space, and in its small size suggests the lowest Amphibians; while (4) the two tusk-like teeth are only paralleled among Mammals. One of the distinctive Dicynodont characteristics is the junction of the par-occipital and sphenoid with the tympanic, near to the broad slightly convex condyle.

The bones which are identified in the skull are:—the basi-occipital, ex-occipital, par-occipital, sur-occipital, basi-sphenoid, mastoid, parietal, post-frontal, mid-frontal, vomer, pre-frontal, nasal, lachrymal, inter-maxillary, maxillary; the malar was thought to be blended with the maxillary; the palatine, dentary, articular, splenial, angular, coronal, zygomatic, tympanic.

In 1859, Professor HUXLEY made an important contribution to knowledge of the Dicynodont skull in his memoir on the *Ptychognathus Murrayi.** By making transverse vertical sections of the skull, the remarkable median vertical longitudinal plate which extends forward from the brain-case was discovered. The pre-sphenoid is said to be united with the basi-sphenoid by an oblique suture. Anteriorly it becomes the inter-orbital septum, and passes into the ethmo-vomerine plate or nasal septum. This expands inferiorly and unites with the maxillary. The palatine bones are found to be attached to the pre-sphenoid below the anterior border of the orbits, and, passing forward into the maxillary, define, with the ethmo-vomerine septum, the two posterior nares. The nasal passages of Birds make a much closer approximation to the condition in *Dicynodon* than is found in the Monitors. And it is observed that the manner in which the palatines and pterygoids are connected with one another and with the pre-sphenoid is extremely Bird-like.

In 1859, Sir RICHARD OWEN made full descriptions† of species which indicated the existence of other genera, named *Ptychognathus* and *Oudenodon*, and elucidated, in a more perfect way, many characters of the skull which were indicated in the original figures and descriptions of *Dicynodon*. In the same memoir the genus *Galesaurus* was defined, which afterwards became the type of a distinct family, and eventually was placed in another order of Reptiles.

In the same year, Sir RICHARD OWEN contributed to the Reports of the British Association for the Advancement of Science, a memoir‡ "On the Orders of Recent and Fossil Reptilia and their Distribution in Time," in which the order Anomodontia is defined for the first time. It then comprised three families: Dicynodontia, founded on *Dicynodon* and *Ptychognathus;* Cryptodontia, founded on *Oudenodon;* and Gnathodontia, founded on *Rhynchosaurus*. The third family does not appear to have been sustained, for, in a later writing,§ *Rhynchosaurus* is grouped under the Cryptodontia.

* 'Geol. Soc. Quart. Journ.,' vol. 15, p. 649, on *Dicynodon Murrayi.*

† *Ibid.*, vol. 16, 1860, p. 49; and 'Ann. Nat. Hist.,' vol. 4, 1859, p. 77.

‡ 'Brit. Assoc. Report,' Aberdeen, 1859, p. 153.

§ 'Palæontology,' 2nd edition, 1861, p. 263.

The same author soon after published his 'Palæontology,' which gives in the second edition, in 1861, a summary of his researches on the Anomodontia,* with some new facts and new views. Thus, it is observed of the Dicynodontia: "The vertebræ, by the hollowness of the co-adapted articular surfaces, indicate these Reptiles to have been good swimmers, and probably to have habitually existed in water; but the construction of the bony passages of the nostrils proves that they must have come to the surface to breathe air. The pelvis consists of a sacrum composed of five confluent vertebræ, with very broad iliac bones, and thick and strong ischial and pubic bones. The bones of the limbs resemble those of the marine Chelonia, but are more expanded at the extremities." The par-occipital in *Ptychognathus* is said to have been connate with the ex-occipital, as in Crocodiles.† A similar observation had been made concerning the skull of *Dicynodon tigriceps*.‡ The bone in *D. lacerticeps* which was named par-occipital in the explanation of the plate was described as wedged between the basi-sphenoid and the quadrate. That bone I propose to interpret as the malleus. In 'Palæontology'§ a new family, named Cynodontia, is founded for the genera *Galesaurus* and *Cynochampsa*.

In 1862 Sir RICHARD OWEN contributed to the 'Philosophical Transactions' of the Royal Society, a memoir "On the Dicynodont Reptilia, with a description of some Fossil Remains brought by H.R.H. Prince Alfred from South Africa, November, 1860."‖ The same volume contains an account of the pelvis of *Dicynodon*,¶ in which the Mammalian character of the pubic symphysis is urged; and the sacrum would have been considered Mammalian, but for its resemblance to Dinosaurs.

Professor COPE in 1870 published in the 'Proceedings of the American Association for the Advancement of Science' a memoir "On the Homologies of some of the Cranial Bones of the Reptilia, and on the Systematic Arrangement of the Class," in which the cranium of the Anomodontia is described from new materials. The new skull is in many respects similar to *Ptychognathus*, but appears not to show the posterior bifurcation of the parietal bone, resembling in this respect types like *Dicynodon tigriceps*. It is referred to a new genus named *Lystrosaurus*. If this specimen justifies all the conclusions which the author draws from it, it should have been more fully figured, for it is a more perfect representative of the order than the materials previously described in this country. Like other writers, Professor COPE uses a nomenclature for the bones which depends upon his theoretical views of the structure of the skull and differs in some points from that already given by OWEN. The order is grouped with the Archosauria, a division of the Reptilia formed to

* *Loc. cit.*, p. 255.

† 'Geol. Soc. Quart. Journ.,' vol. 16, p. 50.

‡ 'Geol. Soc. Trans.,' vol. 7, p. 235.

§ *Loc. cit.*, p. 267.

‖ 'Phil. Trans.,' 1862, p. 455.

¶ *Loc. cit.*, p. 462.

include Anomodontia, Dinosauria, Crocodilia, and Ornithosauria. The immovable articulation of the squamosal throughout the length of the quadrate bone removes the Anomodontia from the Lacertilia. The withdrawal of the pro-otic and opisth-otic from supporting the quadrate bone places it nearest towards the Lacertilia. *Hatteria* has a similar development of the squamosal. In both types the posterior extremity of the pterygoid is much expanded, and supports a columella; there is an osseous inter-orbital septum; distinct (?) epi-otic bones, bi-concave vertebræ, and a parietal foramen. Lizards also agree with Anomodonts in wanting the quadrato-jugal arch, and in having the pre-maxillary bone usually single. The Chelonian characters are limited to the edentulous jaws, and co-ossified mandibular rami. The Crocodilian characters are:—the pre-sphenoid keel, the expansion of the pterygoid to unite with it, the mandibular foramen, and reduced size of the zygomatic bone. Resemblances to the Ichthyopterygia are seen in the parietal and quadrate branches of the squamosal, the sessile suspensorium of the quadrate, and the posterior flat opisth-otic. Resemblances to the Dinosauria are found in the elongate sacrum, the capitular and tubercular attachment for ribs on the neural arch and centrum respectively. This type of rib articulation is also spoken of as Mammalian. The ribs are continued to the sacrum. The author concludes that the Anomodontia are the most generalized order of Reptiles known.

Professor COPE's account of the pterygoid, epi-otic, pro-otic, columella, quadrate, pre-sphenoid, and other structures has hitherto only been supported by the evidence of diagrammatic woodcuts.

In 1876, the Trustees published a descriptive and illustrated 'Catalogue of the Fossil Reptilia of South Africa in the Collection of the British Museum,' by Sir RICHARD OWEN, F.R.S., in which most of the figures published previously are reproduced, with representations of all the more important specimens in the collection.

The family Cynodontia of that author's 'Palæontology' is now raised to the rank of an order, and named Theriodontia, on account of the resemblance of its dentition to that of the Mammalia. In this group are arranged various species of the genera *Lycosaurus, Tigrisuchus, Cynodracon, Cynochampsa, Cynosuchus, Galesaurus, Nythosaurus, Scaloposaurus, Procolophon,* and *Gorgonops.* The last-named genus is the type of a family, Tectinarialia; the other genera are classed as Binarialia or Mononarialia, according as the external nostrils are divided or single.

The Anomodontia are sub-divided into three families. The name Dicynodontia of the 'British Association Report,' is replaced by the term Bidentalia; and in this family are placed species of the genera *Dicynodon* and *Ptychognathus.* The family Cryptodontia now includes the genera *Oudenodon, Theriognathus,* and *Kistecephalus.* A third family, named Endothiodontia, is formed for the genus *Endothiodon,* which has the teeth spread over the palate and absent from the alveolar borders.

In "*Dicynodon lacerticeps*" (*loc. cit.*, Plate XXIII., fig. 3, p. 30), the par-occipital (opisth-otic) was regarded as being confluent with the ex-occipital, as in the Crocodile. Its broad process is said to abut against both the mastoid (squamosal) and tympanic (quadrate). I have been unable to find any certain evidence of the presence of the opisthotic in this position. It is stated that the tympanic pedicle is formed by the mastoid, 8 (squamosal), squamosal, 27 (quadrato-jugal), and tympanic, 28 (quadrate); but neither in the text nor in the figures is the part taken by each bone defined. I recognize no evidence of the quadrato-jugal, and the bone on which the number 28 is placed, Plate XXIII., fig. 1, I regard as the squamosal, and this bone is also numbered 8 and 27. What I regard as the quadrate bone is very imperfectly exposed, and only appears as a slender ossification widening distally, placed in front of the distal end of the squamosal. It is neither described nor figured. Hence, the visible part of the so-called tympanic pedicle is formed by the squamosal bone, though, as will be subsequently proved in other species, the condylar surface is contributed to by the quadrate bone. In the "Description of *Dicynodon leoniceps*" (p. 32, Plates XXIV.–XXVI.), the author regards the occiput as having been crushed into a pair of plates meeting at a right angle. This basin-like occipital depression, also found in *D. pardiceps* and other species, seems to me to be natural; for, if pressure had materially approximated the squamosal bones in the way implied, it would have obliterated the groove between the parietal bones (Plate XXV.), and have otherwise distorted the skull. The form of the condyle of the quadrate bone is compared in this species to the distal end of the humerus of a Ruminant or the tibia of a Bird. Subsequently it may be shown that the form of the condyle varies with the species. The author states that in this species the squamosal descends to near the neck of the outer condyle, and that it extends behind the quadrate. The author states that the composition of the tympanic pedicle is clearly traceable, but the numbers 8 and 27, placed on its upper part, imply distinct elements, which I am unable to find.

The pair of "hypapophyses" below the occipital condyle is said to be formed by the basi-occipital and basi-sphenoid; they are compared to the descending basi-occipital process of Lizards, and are supposed to have given attachment to powerful muscles. In *D. lacerticeps* and many Dicynodonts each process is seen to be formed by the (?) ex-occipital, basi-occipital, and basi-sphenoid, and to give attachment to the malleus, which has not ascended to its position in the skull among Mammals, and extends transversely outward to the quadrate bone. The pterygoid, which rests partly on the basi-sphenoid, is said to send a process backward, which abuts against the quadrate; this character is regarded as Lacertilian. It will subsequently appear that the quadrate may also sometimes send a short pterygoid process inward to meet the pterygoid bone; and that the mode of junction of these bones shows distinctive features. The author then describes the long ovate palato-nasal vacuity, which is single, but apparently without recognizing the vomer at its anterior margin. Evidence will hereafter be given to show that in some other Dicynodonts there are three palatal vacuities—one posterior and median in the pterygoid bones, as Sir R. Owen thinks possible, and two lateral vacuities divided by the vomer. There is reason to doubt whether the ecto-pterygoid (transverse) is found, and the lateral vacuities of the Crocodile's palate are not present. The author compares the inter-palatal vacuity to the condition in many Marsupials. The exposed temporal foss is said to give a Carnivorous Mammalian character to the skull.

On the right side of the type-specimen of *D. leoniceps* (OWEN), British Museum, No. 47,047, the base of the columella is exposed, rising from the posterior part of the pterygoid bone. It has a comparatively long basal attachment, and extends obliquely upward and forward. It is imperfectly indicated in 'Cat. South African Reptiles,' Plate XXIV., above the number 24, but is not described.

The specimen figured in this plate seems to me to give no support to the interpretation of the palate there given. The separation between what are interpreted as the pterygoid and palatine bones, as shown in the figure, has no existence. The bone is divided on one side but not on the other; and the division is probably due to fracture. If the anterior portion were really separate, it would be the transverse bone, and not the palatine; but no such division in the pterygoid is to be detected in any of the numerous specimens which display that bone. Hence, the pterygoids are commonly united below the sphenoid, in the median line (though apparently separate in No. 47,056), and they are constricted from side to side at their confluence. They send a process on each side backward and outward to the quadrate, and forward and slightly outward to the maxillary. The latter union takes place below the orbit, and excludes the palatine bone from the external border of the palatal arch. The palatine bone may be found on each side, in close squamous contact with the anterior bar of the pterygoid, along its inner side. It extends backward to the point where the inner diverging fork or plate of the pterygoid is given off (Brit. Mus., No. 47,047; and 'South African Catalogue,' Plate XXVI., fig. 1). Anteriorly the bone widens, and externally is wedged between the pterygoid and maxillary bones, and internally processes from the two sides converge forward to meet the vomer, which divides them, but is not drawn in Plate XXVI., fig. 1. If the median inter-palatine space had been excavated deeper, it is probable that the internal pterygoid processes between which the number 24 is placed on Plate XXVI. would have converged forward to form a median vertical pterygoid plate, which would have extended forward to meet the vomer, this being the usual relation of the bones in other specimens.

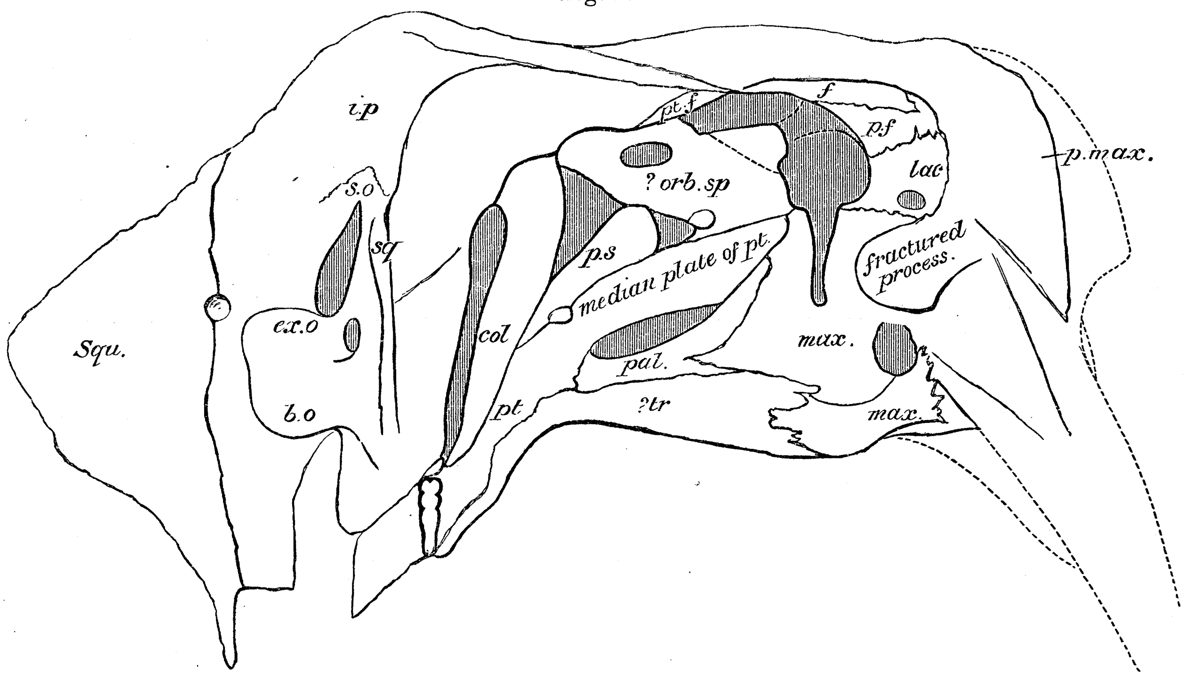
No other specimen which has been described shows so perfectly the form, size, and relations of the quadrate bone, though its individuality has been ignored in Plate XXIV., where only a broken mass of bone is indicated above the condyle, 28. The median descending broken mass, with a black anterior outline in the figure, is part of the squamosal, extending laterally downward over the quadrate bone. The dark oval space in the figure a little behind this bone, and 7 or 8 centims. above the condyle, is part of the proximal surface of the quadrate bone, laid bare by a piece of the squamosal bone being broken away from behind it, so that the bone is received into an arch in the squamosal, and its entire anterior extent is exposed looking obliquely forward and outward. The extreme height of the bone on its external border against the squamosal is 10 centims. from the base of the condyle. At that height there is no indication of its existence in the figure; but in the specimen the bone projects forward a little, and is well defined by a groove above it. Its inner border is convex, and the pterygoid unites with that border, just above the condyle, by an attachment which is 2 centims. deep. The attachment was not firm, for in *D. pardiceps* and other species the quadrate bones are lost from the otherwise perfect skull.

The *Dicynodon pardiceps* (OWEN), South African Cat., No. 70; Brit. Mus., No. 47,045, in many respects the most instructive of all the specimens, has never been adequately described. It shows details of structure, owing to the softness of the matrix, which manifest the union between many of the bones. The remarkably elongated zygomatic arch I find formed chiefly by the squamosal bone, which extends forward to the orbit. The maxillary bone also contributes to form it, extending below and behind the squamosal backward, almost to the descending process. The malar bone forms the lower border of the orbit. It rests externally upon the squamosal, and internally upon the maxillary; its posterior extremity supports the post-frontal bone, and its anterior extremity appears to extend forward to the lachrymal, and inward to meet what I take to be an outwardly directed process of the palatine. The post-frontal is a slender transverse bar, and meets the frontal by a well defined suture. The small parietal lies in front of the parietal foramen; but I do not feel certain that the long oblique posterior processes are rightly referred to that bone, and it would seem as though the analogous structure in Lizards had suggested an explanation which has not been questioned. These bones seem to me to diverge anteriorly to expose the parietal, and they diverge posteriorly to support the squamosals. If they are separate ossifications, they may represent external elements in the Amphibian skull which have remained after a deeper seated ossification was developed, just as in some types basi-temporals remain after the sphenoid is ossified.

In *Dicynodon pardiceps* a groove connects the upper posterior corner of the nasal aperture with the orbit, much as in *Pareiasaurus*, though the depression is but slightly marked. In *D. leoniceps* the region behind the nares is impressed over the depth of the apertures.

In *Dicynodon tigriceps* (OWEN) the configuration of the zygoma and temporal fossa is stated to be most nearly paralleled in *Chelydra*, though the difference is considerable. In another specimen referred to the same species, the inter-orbital space is said to be more completely ossified than in modern Crocodilia, Chelonia, or Lacertilia, and is an approximation to Mammalian structure. The upper anterior angle of the pterygoid is said to join the anterior extension of a cranial bone which may correspond with the pre-sphenoid of Crocodiles, or the orbito-sphenoid of Chelonians. The reference of this specimen to *D. tigriceps* is on several grounds open to question. But the bone which the author regards as pre-sphenoid (5) seems to me to be the median plate of the pterygoid. It is possible that a small ossification above this, which extends obliquely forward and upward, may be the pre-sphenoid, for it is in the position which the pre-sphenoid should occupy. The bone above it, at the back of the orbit, is pierced by a large foramen; a similar foramen appears to be present at the back of the corresponding inter-orbital bone in the specimen termed *Dicynodon Murrayi* (HUXLEY). This perforation I can only regard as the foramen for the olfactory nerve, and the bone as the orbito-sphenoid. A little further back, parallel to the cranial wall, but well separated from it, is a thin flat bone, which extends from the parietal region to the pterygoid; and I therefore identify it as the columella. There appears to be a distinct suture towards the quadrate process between an outer and an inner element of the pterygoid, and a line which might be fracture or suture extends forward to the angle where the posterior end of the palatine is wedged into the bone. This furnishes some evidence, though no proof, that the long external bone may be the transverse bone. In other specimens it appears to be blended with the median element, for no suture has been detected on its palatal aspect. The following figure shows the relations of the median bones of the skull according to the interpretation now given.

Fig. 1.



Skull regarded by OWEN as *Dicynodon tigriceps*.

Obliquely crushed Dicynodont skull, which has lost its external arches and shows the bones between the orbit and squamosal region. The shaded parts are vacuities or spaces occupied with matrix. The fractures produced by the crushing make the recognition of the sutures difficult. The figure now given may be compared with Plate xxxiv., fig. 1, 'South African Catalogue.'

i.p. Inter-parietal.
col. Columella.
p.s. Pre-sphenoid.
orb.sp. Orbito-sphenoid.
pt. Pterygoid.
?tr. Apparently distinct from pterygoid, and, possibly, the transverse bone.
pal. Palatine.
max. Maxillary.
lac. Lachrymal.
p.f. Pre-frontal.
f. Frontal.
pt.f. Post-frontal.

A large number of South African Reptiles were separated by Sir RICHARD OWEN from the Anomodontia, in 1876, to form the order Theriodontia. In several genera the dentition is of the Carnivorous type, and the teeth were regarded as making approximations towards those of Mammals. The order comprised *Procolophon*, which makes a striking resemblance to *Hatteria* in internal structure of the skull;* and in simple unvarying conical form of the teeth approximates to *Pareiasaurus*, though the teeth are never serrated, and never worn down. In most of the Theriodont genera little is preserved of the skull beyond the characters of the snout and the dentition, which are well seen in *Lycosaurus*, *Cynosuchus*, *Tigrisuchus*, *Cynodraco*, *Cynochampsa*, and *Galesaurus*. The chief character in the majority of these genera, which necessarily distinguishes them from *Procolophon*, is the development of a pair of tusks in the position of canine teeth. But this attribute has already been found to characterize the Dicynodontia, in which, however, there are no other teeth developed. The value of the character in classification is unknown, and Sir R. OWEN has suggested that the toothless animals named *Oudenodon* may possibly be the females of *Dicynodon*. The only difference of character in these teeth in Theriodonts is that their margins are serrate, and that the serration extended, in some degree, to all the teeth. But in *Pareiasaurus* and *Anthodon* the serration is well developed, without any indication of canine teeth; while in *Galesaurus* it is reduced to a lateral notch or two, dividing the crown in the molar region into denticles. In some genera the incisor teeth are large and the molar teeth very small. Other characters of the order have been defined by Sir R. OWEN in communications to the Geological Society. In a memoir on *Cynodraco*,† the canine teeth are compared to those of *Machairodus*, while the toothless interval which separates the canines from the lower incisors is found in the Marsupial genus *Didelphis*. In the humerus of *Cynodraco* there is a canal crossed by a bridge of bone at some distance above the distal condyle, on the internal and inferior aspect of the bone. This character is regarded as a characteristic of the Feline family of Carnivora. A similar canal is found in the humerus of Seals, of Insectivora, of Edentates, and Marsupials. This humerus (Brit. Mus., No. 47,910) is about 27 centims. long, and on its external border, at about 10 centims. from the distal end, I find evidence of a second foramen, much smaller than that upon the opposite side, which might be easily overlooked, since it has not been excavated by the Museum "masons." It is about 6 millims. in diameter, and appears to pass obliquely downward through the bone. I have no doubt that this second foramen is homologous with the similarly placed foramen in the humerus of *Hatteria;* but, while its occurrence parallels the humerus with the Rhynchocephalian type, the correspondence is not less close, in this respect, with the Edentate *Cyclothurus*. Humeral bones of Dicynodonts are often broken in the slender part of the shaft in which the foramina are present; and a fragment may

* "On new species of *Procolophon*, &c.," 'Geol. Soc. Quart. Journ.,' vol. 34.

† 'Geol. Soc. Quart. Journ.,' vol. 32, 1876.

show one foramen without indicating the other. There is no reason to suppose that all Anomodonts have a radial as well as an ulnar foramen, for the external foramen is certainly absent in *Galesaurus*; but, when only one foramen is seen, its direction appears to be transverse, and it passes obliquely from the ulnar to the radial side. On referring to drawings which I made in the Senckenberg Museum, at Frankfort-on-the-Main, in 1878, of some fragments of humeri which were described by VON MEYER, and have since been regarded as European Theriodonts by Sir R. OWEN, I find both foramina present, though the radial foramen is relatively small in *Brithopus*.

The ecto-pterygoid bone is stated by Sir R. OWEN to cease to exist in both Theriodonts and Dicynodonts; and this bone never reappears in the Mammalian series. But two specimens in the British Museum suggest doubt whether the bone is absent, or hidden by the pterygoid. Sir R. OWEN also finds in *Iguanodon*, *Scelidosaurus*, and *Pareiasaurus* dental characters which reappear in certain Mammalia, such as the Sloth and Kangaroo. He finds the number of incisors in these fossil Reptiles to be closely comparable with Marsupials. Thus, *Didelphis* and *Cynodraco* have the formula $i\,\frac{5\,.\,5}{4\,.\,4}$; and in *Thylacinus*, *Sarcophilus*, and *Cynochampsa* it is $i\,\frac{4\,.\,4}{3\,.\,3}$.

This memoir was succeeded by two papers* upon *Platypodosaurus robustus*. The vertebræ are said to differ from those of *Kistecephalus* and *Anthodon* in the less depth of the terminal concavities, in which character they approach *Dicynodon* and *Oudenodon*; but among the Plesiosauria this character is very variable, and seems to me a specific rather than a generic difference. The author compares this vertebral condition to that found in *Echidna*, but I do not find the resemblance close enough for comparison. An element of the sternum is recognized as the foremost sterneber, and identified with the first sternal element in *Ornithorhynchus* and the sternum of modern Lizards; and this bone is inferred to have been one of a series such as is present in Chameleons and Skinks. Its upper border is thought to have joined the coracoid, as in Monotremes, while its lower border may have given attachment to sternal ribs. The scapula is intermediate between that attributed to *Dicynodon* and the scapula of *Kistecephalus*. The nearest resemblance to the humerus is found in *Ornithorhynchus* and *Echidna*. On the digits it is remarked that the ungual phalanges, though relatively shorter, have more the proportions of those of *Echidna* than of *Ornithorhynchus*. What remains of the femur is compared with the proximal part of the bone in *Echidna*. The sacrum is said to be more Mammalian than that of *Dicynodon*, and to come nearer in shape to the Megatherioid Mammals. The Mammalian character is considered to be marked by the breadth of the iliac bones, and the extent of the confluence of the similarly expanded ischia and pubes, and by their confluence at the ischio-pubic symphysis.

* 'Geol. Soc. Quart. Journ.,' vol. 36, p. 414, 1880; and vol. 37, p. 266, 1881.

Subsequently,* Sir R. OWEN urged that the Theriodont dentition was monophyodont, and he proposed to include in the order the European genera *Brithopus, Orthopus, Rhopalodon, Deuterosaurus,* &c., which, so far as the dental characters are known, have very strong incisor teeth. But no evidence has yet been adduced, either in the skull or in the skeleton, that Theriodonts differ from Anomodonts as an ordinal group. For the value of the teeth as an ordinal character is small when so little specialized; and the skull shows few differences in plan.

The Structure of the Skull. (Plate 9, fig. 1.)

The only region of the skull which is at present undescribed is the brain-case. There are four specimens in the British Museum which contribute evidence as to its form and structure. There is also some reason to believe that in certain Dicynodonts the brain-case was very imperfectly ossified. A small skull divided vertically, which is partly figured by Sir R. OWEN ('South African Catalogue,' Plate XXVIII., fig. 4), gives no indication of a defined cerebral cavity. A similar skull, selected for its symmetry, and divided in the same way at my request, is equally free from evidence of a roof to the brain-case, though part of its floor is preserved. I am indebted to Dr. HENRY WOODWARD, F.R.S., for having these preparations made, and to Mr. HALL, the mason, for the skill with which the section was kept to the median line. The only bones shown in section (Plate 9, fig. 1) are the anchylosed basi-occipital and basi-sphenoid at the back of the head, and the pre-maxillary and dentary in front. The basi-occipital (*b.o.*) is much less deep in section than the basi-sphenoid (*b.s.*), which is perforated by a somewhat large carotid canal, extending downward and backward. Anterior to this, the posterior part of the bone sends a short process downward; and the middle part sends a short wide process upward. From its anterior corner a short curve of faint narrow marking, which is not bone, extends forward and upward. A faint oblong marking below this occupies most of the interval between the basi-sphenoid and pre-maxillary, and might correspond to the vomer. From the upper border of the foramen magnum a line extends inward parallel to the basi-occipital. It is succeeded by a large oval mass defined in the same way by a sharp line. Upon this, and partly in front of it, is another oval mass, from which a thickish band is prolonged towards the nasal aperture. These outlines are in the position which the brain should occupy; but other evidence of the form of the brain does not lead me to suppose that the brain substance has been preserved. There is no reason for believing that the brain had this form or extended so far forward in a Dicynodont, though it certainly extended obliquely upward in the same way as do these markings. In the other half of the specimen the united basi-occipital and basi-sphenoid are cut slightly on one side of the median line, and here the superior surface is nearly straight and the basi-sphenoid is rounded in front (Plate 9, fig. 2). There is no trace of the pterygoid, which in all other

* "On the Order Theriodontia," 'Geol. Soc. Quart. Journ.,' vol. 37, p. 261.

specimens is in contact with the basi-sphenoid. I am not aware of any circumstance which would account for the absence of the missing bones, except an original delicacy of texture or absence of ossification, which favoured their removal; but such conditions are not found in any larger skulls. It might, however, be characteristic of young individuals, and indicate this skull to belong to a young animal, but the form of the head is that of a new species.

The Occipital Plate. (Plate 10, figs. 1, 2.)

There exists in the British Museum a detached occipital plate from a Dicynodont skull, which is registered as $\frac{R}{1021}$, and appears to belong to an undescribed species. It is about 8 centims. wide by 6·5 centims. high, thin and rounded on the contour of the upper half, and thicker and notched on the lower half. The plate is flattened on the posterior aspect (fig. 1), but more convex on the anterior face (fig. 2). The greatest antero-posterior measurement through the occipital condyle is 3 centims. The condyle is remarkable for its large size, subquadrate form, slight posterior extension beyond the surrounding bone, and subcentral position upon the occipital plate. It measures 2·5 centims. wide, over the ex-occipital elements, which are subtriangular or subovate convexities, and make the wide upper part of the condyle, the lower part being made by the basi-occipital, which has an unusually large condylar surface, 2 centims. wide, and transversely ovate. The vertical depth of the condyle is 1·6 centim. Its contour is concave superiorly at the foramen magnum, with a parallel convex inferior margin, and small lateral concavities between the ex-occipital and basi-occipital elements. Its ex-occipital extension posteriorly does not exceed 6 millims., while that of the basi-occipital is only half as much. There is a saddle-shaped concavity on the inferior margin of the plate below the basi-occipital; it is concave from side to side, convex from behind forward and downward, and partly divides the two hyp-apophyses below the occipital region, which are here shorter than usual. These processes are convex from side to side, and 1·5 centim. wide. A delicate line descends down the middle of each process, coming from the outer side of the basi-occipital portion of the condyle, and this line I regard as the suture between the basi-occipital and ex-occipital bones. The width of the basi-occipital at the inferior termination of these diverging sutures is 2·7 centims. External to the ex-occipital element in the condyle, and hidden beneath its transverse expansion, is the usual perforation for the vagus nerve, which extends obliquely inward and upward.

The middle part of the occipital plate appears to be formed by the ex-occipital bones. The foramen magnum is 1·7 centim. high, and 1·1 centim. wide at the base, with the sides converging slightly upward, and arching together above. At 6 millims. above the floor of the foramen on each side, a delicate suture diverges outward and upward. I regard it as separating the supra-occipital and ex-occipital. The outward extremities of the sutures are 8 centims. apart, so that this is the width of the supra-occipital.

That bone forms the upper two-thirds of the foramen magnum, and its height above the foramen is 3 centims. At the middle of the superior border there is a median depression of the usual V-shape, but shallow and wide. On the anterior aspect (fig. 2) there are sutural lines somewhat undulating but nearly horizontal, and about 2 centims. below the superior margin of the plate, showing that the ex-occipital bones are overlapped externally by the supra-occipital; and this circumstance may account for the larger dimensions of the ex-occipital bones in the external surfaces figured by Sir R. OWEN.

A transverse suture appears to extend outward from the hyp-apophysis over the lateral notch external to it, separating an anterior plate of bone which rests upon the ex-occipital, and would meet the basi-occipital internally, forming the posterior wall of a canal which descends obliquely outward and downward from the sphenoidal region. This ossification enters into the transverse ex-occipital process termed by OWEN paroccipital, but I cannot trace it superiorly. In *Dicynodon lacerticeps* the left hyp-apophysis shows a tripartite structure, and the outer anterior element I regard as the same as the imperfectly indicated ossification just described. It is obviously in the position of the opisth-otic bone. It must meet the basi-sphenoid if it is not an extension of that bone; and its relations posteriorly with the ex-occipital, and internally with the basi-occipital, its combining with those bones in several other specimens to form an articular cup for the malleus, which bone extends transversely outward to the quadrate, favour its identification as an otic bone. It is possible that the thickened smooth convex surface which extends upward in this specimen from the sphenoidal region on each side, anteriorly to the foramen magnum, may be the squamous extension of the pro-otic bone. The body of the sphenoid is broken away, leaving a rough triangular surface with concave sides, which is less than 1 centim. wide superiorly, 3·3 centims. wide at the base, and 3 centims. in vertical depth.

Above this fracture the anterior aspect of the specimen shows a portion of the posterior walls of the brain-case, which has a high subtriangular outline. The foramen magnum is filled with matrix. In front of it the cerebral cavity expands vertically to a height of 3 centims.; and the transverse width increases, towards the base of the foramen, to about 2 centims.; but its lateral border is undefined in the middle for 1·5 centim., because the internal wall of the cerebral chamber rounds convexly into the lateral external surface of the ex-occipital boundary of the temporal vacuity in a way which indicates the absence of bone and the existence of a vertical vacuity in the cranial wall, which I regard as that of the fifth and optic nerves. The lateral walls of the cerebral chamber here exposed are flattened and oblique, so as to converge backward toward the foramen magnum, and upward. Superiorly the sides round into a slightly flattened convex surface, which is inclined downward and backward to the foramen magnum. At the base, the brain-case appears to sink into a depression in the line of the basi-occipital bone, but this may be the result of development with the chisel. Superiorly two diverging processes, like the forks of an inverted V, descend over the summit of the chamber and give attachment to a bone which, if the constituents of the occipital plate are correctly determined, should theoretically be the inter-parietal. At the inferior outer angle of the chamber there is a bony prominence on each side, which defines a notch like the outlet for a nerve which should give attachment to the ali-sphenoid bone.

A Specimen showing the Relative Height of the Cerebral Chamber. (Plate 10, fig. 3.)

Similar evidence as to the form of the back part of the cerebral chamber is seen in the British Museum specimen 47,056, described in the South African Catalogue, No. 80, as *Dicynodon leoniceps.* It may, perhaps, be another species, for, though it resembles that type in the form of the face, the head is relatively shorter, and the palatal characters, in so far as exposed, are more like those of *Dicynodon pardiceps.* In this skull, which is 32 centims. long as preserved, the bones of the occipital plate have been broken away, exposing a natural cast of a portion of the posterior aspect of the brain cavity, which is 8 centims. high. The mould is inclined obliquely forward, and its straight posterior contour makes an angle of 60° with the horizontal plane of the frontal region produced. The base of the foramen magnum is 2 centims. wide, and at about this height from its floor the mould of the cerebral chamber expands a little transversely, giving a convexity to the lower part of the side, and it contracts superiorly to less than half its width at the summit. The inclined sides diverge outward as they extend forward, and, as far as exposed, they are flattened. The straight posterior contour is rounded convexly from side to side, like the surface of a segment of a cone. In every respect the cerebral characters of this specimen are absolutely the same as in the occipital plate just described, only differing as do a seal and an impression from it.

Another Specimen, showing part of the Brain-case, and some characters of the Back of the Skull. (Plate 11.)

A specimen in the British Museum, numbered R. 868, apparently indicates a new species, distinguished by having the back of the head more than twice as wide as high, with the hyp-apophyses close together. The occipital condyle is hemispherical. The foramen magnum is less high than the condyle is deep. The so-called par-occipital process of the ex-occipital is wider than the rest of the bone. The sides of the narrow bones which form the temporal region are inclined to each other and parallel, and arch high above the descending plate of the squamosal. The back of the head is as wide as in *Ptychognathus latirostris,* but the form of the temporal region is that of *Dicynodon leoniceps.* It may be termed *Dicynodon microtrema.*

The brain-case is crushed a little obliquely downwards. Its base is formed by the anchylosed basi-occipital and basi-sphenoid, and the basi-sphenoid is broken trans versely, with the fracture passing through the internal carotid canal (fig. 2). This canal opens on the cerebral surface by a circular foramen, descends vertically, and forks in an inverted Y-shape, so as to have lateral external openings in front of the middle of the inferior descending hypapophyses. So much of the base of the brain-case as is seen is smooth and flat. It is contracted at the anterior corners by lateral tubercles, which may mark the limit of the cerebellum. Behind them the bones enclose a sub-hemispherical cavity, which is 1·9 centim. wide and about as high, though the height is probably reduced by crushing. The anterior border of this cerebral chamber is smooth, and indicates a vertical lateral vacuity in the skull. The ex-occipital bones appear to extend upward and forward in front of the vacuity, forming a concave roof to the back of the brain, but giving off on each side a lateral process which extends forward beneath the so-called supra-occipital bone. This bone (fig. 1) is small on the occipital surface, is narrow, divided by a vertical suture, and situate high above the foramen magnum, has only a linear longitudinal exposure on the median line of the roof of the skull (fig. 2), and extends forward beneath the spatulate bones, which have commonly been regarded as the parietals. The height of the brain-case where the ex-occipital bones terminate in front is 2·7 centims. And then the (?) supra-occipital bone comes into the roof of the cerebral chamber anteriorly, without increasing its width, so that the transverse measurement of the bones, with the median longitudinal interspace which divides them, remains 1·6 centim. The bone forms two distinct parallel plates, which are subtriangular, compressed laterally, and at the anterior fracture are 1·7 centim. high, with the internal surfaces vertical and parallel, and divided by a space 7 millims. wide, which is narrower at the superior border, where a strip of the supra-occipital, 2 millims. wide anteriorly, and 5 millims. wide posteriorly, is exposed. The width of the bones posteriorly at the summit of the occipital plate is about 1·5 centim., increasing suddenly below the median posterior groove to 2·5 centims. Their height above the occipital condyle, posteriorly, exceeds 3 centims. It is impossible not to recall the description of *Loxomma* given by Dr. EMBLETON and Mr ATTHEY* in relation to these bones. They remark, "The upper border of the occipital surface is also the posterior border of the middle part of the skull." "It is formed externally by the mastoids, and between them by a pair of bones corresponding to those which, in *Archegosaurus*, are called by VON MEYER . . . supra-occipitals. Immediately below this border runs a transverse line of suture connecting the bones forming the border with those beneath it, namely, next the median line with the single, and, as we deem it, the true supra-occipital, and laterally with the ex-occipitals. The supra-occipital is of a subtriangular form, wider from side to side than from above downwards, and situated on the median line. It is doubtful whether or not the median suture passes through it. Below, it articulates with the ex-occipitals."

When the external surface of the specimen R. 1021 is compared with the corresponding portion of R. 868 there is a close resemblance, though the latter shows the

* 'Ann. Mag. Nat. Hist.,' July, 1874, p. 50.

squamosal bone on its external border, and two pairs of bones on its superior border. And since the sutures in this occipital plate are obliterated between the basi-occipital and ex-occipital bones, there is an *a priori* probability that they would be obliterated between the ex-occipitals and the supra-occipital, and, therefore, that the composition of the occipital plate in R. 868 may have originally been the same as in R. 1021, so that the supra-occipital would enter into its foramen magnum. Hence, there is some ground for supposing that the pair of distinct bones which surmounts the occipital plate is a pair of inter-parietal bones, with an immense antero-posterior extension. A pair of bones behind the parietals has been figured by Professor FRITSCH* in many genera of Labyrinthodontia, so that they would seem to characterize that order; but the small size of his specimens and their flattened condition would be unfavourable for the identification of a supra-occipital bone below them, if it exists, and these bones, if distinct from the supra-occipital, would also be inter-parietal.

The bone which flanks the inter-parietal in *Loxomma* is termed by Dr. EMBLETON, mastoid; and is the epi-otic of Dr. FRITSCH, though this determination has been questioned.

It is well seen at the side of the skull of R. 868 as a broad plate of bone, which extends between the inter-parietal and the squamosal, and rests upon the supra-occipital part of the occipital plate, so that in plan of construction of this region of the skull there is a close approximation to the Labyrinthodont type, which, in so far as I can judge from Mr. MAW's specimen of *Loxomma* in the British Museum, has a vertical occipital region.

The transverse extent of this (?) epi-otic bone is 4 centims. in R. 868; its position is oblique, and its breadth about 1·5 centim. In other species the position of this bone is different; in *Dicynodon leoniceps* it appears to descend obliquely downward, outward, and backward. In *Dicynodon tigriceps* its development appears to be greater upon the roof of the skull, where it seems to me to overlap the parietal bone, and to be defined by difference of colour of the bone, and a convex sutural border which allows the undivided parietal to extend back between the epi-otic bones.

The epi-otic bones are in contact with the pair of remarkable bones which form the roof of the temporal region of the skull. These bones are each about 1·8 centim. wide, somewhat inclined towards each other so as to look upward and outward, with the surface slightly convex from within outward, and the external margin, which projects well beyond the inter-parietal, is well rounded. The anterior fracture shows the thin blade-like substance of the bone. Its sides are sub-parallel, except that posteriorly it diverges outward and downward, so as to rest on each side upon the margin of the epi-otic. These bones have usually been regarded as the parietals. But they appear probably to be distinct plates, which are developed in the position where the muscles which work the lower jaw are attached. In *Dicynodon leoniceps* these bones, which have a similar smooth oblique surface, are 20 centims. long and 3 centims.

* 'Fauna der Gaskohle und der Kalksteine der Permformation Böhmens.'

wide. They diverge but little posteriorly, and on the inner side appear to show well defined sutures separating them from the bone beneath, which would necessarily be the inter-parietal. The bones diverge anteriorly to disclose the parietal foramen, and appear to show the parietal in front of them, as they open in a V shape. I regard the lateral suture as following the divarication anteriorly round the impressed muscular area to the post-frontal bone. In the genus indicated by *Dicynodon tigriceps* their development is different, because the roof of the skull is flat. They are narrow concave strips of bone which extend round the margins of the temporal vacuities, so as to display the parietal bones between them.

These bones seem to me to be called into existence by the muscular attachment, and they may correspond to the parietals of higher Vertebrates, where the single Reptilian parietal probably becomes absorbed.

Turning to the base of the specimen R. 868, the basi-occipital and basi-sphenoid are seen to be anchylosed together. The union is marked by a transverse ridge, behind which the basi-occipital extends for 1·7 centim. The combined bones are produced downward and outward into two strong processes, divided by a longitudinal median channel. The extremity of each process forms a large concave articular facet, which looks outward and downward, and is somewhat heart-shaped, and about 1·6 centim. wide. I regard this surface as having given attachment to a bone, the mastoid, which extended transversely outward to the squamosal and quadrate, as in *D. lacerticeps* and other specimens. A large hemispherical cavity which is opposite to it in the squamosal bone, is 2 centims. wide, and looks forward and downward, may have given partial attachment to its other end. The distance between these surfaces for the malleus is about 4·5 centims.

The squamosal bone is a large vertical plate, which forms the whole of the lateral expansion of the back of the head, external to the occipital plate (fig. 1). It is 6 centims. wide on the anterior aspect, and 5 centims. wide in the middle, posteriorly. It is 8 centims. high. The bone becomes compressed as it extends downward and outward, so as to form a support for the quadrate bone, which was placed in front of its distal end, as in *D. leoniceps* and other species, though the bone is lost from this example, as in *D. pardiceps*, *D. tigriceps*, and other species. An impressed surface which received it is but slightly indented, so that the attachment was loose and squamous. The main portion of the squamosal bone extends the plane of the ex-occipital outward, and its external border descends in a curve which is at first concave and then convex, so that the bone widens as it extends distally. Superiorly it sends a few sutural processes inward over the ex-occipital, and it extends in front of that bone anteriorly. Its transverse superior contour is concave. From the outer upper angle a greatly compressed and oblique bar is given off, which extends forward to form the external border of the temporal foss, though it is fractured (fig. 2), and the foss is not defined in this specimen.

It may be worth recording that the thickness of the occipital plate suddenly increases from 8 millims. to 2 centims. in passing inward to form the thickened wall of the cerebral chamber. There is some indication that this thickening may be due to another bone, the pro-otic, resting in front of the ex-occipital, with which it is now closely blended, for a transverse fracture on the right side appears to show a nearly obliterated suture, which extends upward from the articular cup in the hypapophysis over the lateral plate by an oblique channel which coincides with the thickening of the plate.

The Back of a Skull which shows the whole of Brain-case and the Relation of the Quadrate Bone to the Pterygoid and Squamosal. (Plate 12.)

The British Museum specimen (R. 866) comprises much of the back of a skull posterior to the parietal foramen, and indicates a new species. The squamosal bones are directed backward, so that the part of the squamosal and occipital plate which is anterior in the last specimen is lateral in this. The squamosal bone has its vertical contour convex posteriorly, and concave distally. The transverse extension of the bone extends vertically above the level of the post-parietal region of the brain-case, which is convex in length as well as transversely. The quadrate bone passes under an arch in the squamosal, so that its posterior and articular part is hidden under that bone. The pterygoid bone is vertically compressed posteriorly, so as to form a sharp ridge on the palate. The bones above the brain-case form a narrow vertical plate which expands transversely. In this species the atlas and axis are anchylosed. Every character separates it from the other described species. It may be named *Dicynodon* (*Tropidostoma*) *Dunnii.*

The squamosal plates, which diverge backward and outward, are remarkably convex from above downward. They approximate superiorly, so that the transverse width over the middle of the concavities in which they terminate is a little over 5 centims. Posteriorly their mutually inclined surfaces are separated by a wedge-shaped vacuity, which is $2\frac{1}{2}$ centims. wide superiorly, and extends forward between the roof bones of the skull for more than 5 centims. (fig. 4), becoming a mere groove in front (fig. 1) which can be traced along the median suture. The transverse width posteriorly in the middle height of the squamosals is over 11 centims., while the measurement over the articulation for the lower jaw is 7 centims. Hence the squamosal bones enclose an oval basin-shaped excavation at the back of the head, where the atlas and axis and succeeding cervical vertebræ are attached. The specimen gives no indication of *post-mortem* compression. The condition of the quadrate bone is unusual. It commonly lies in front of the distal end of the squamosal bone, and forms a flattened wedge, convex on its superior border, concave posteriorly; here it contracts distally to form the long narrow ovate convex condyle, which is directed obliquely forward, and crossed by a slight longitudinal groove. Each condyle is about 3 centims. long (though the left appears to be slightly shorter), and anteriorly measures 1·3 centim. transversely. The condyles are entirely hidden from side view by the squamosal bones. A deep groove separates these two bones; and, on the inner side of the condyle, a second concavity separates the articulation from the small malleus. The external lateral aspect of the quadrate is defined from the squamosal by a deep horse-shoe-shaped groove, which marks posteriorly the limit at which the squamosal overlaps it (fig. 2). The extreme height of this anterior part of the bone is 5 centims.; its extreme antero-posterior extent in front of the squamosal and above its short pterygoid process is 2·5 centims. The squamosal descends in front of it as a slender process, which does not reach down to the pterygoid process. The lateral aspect of the quadrate bone is divided into two areas by an oblique ridge, which extends forward and upward from the anterior termination of the condyle articulation. The superior posterior area is higher than wide, flattened, but slightly concave vertically. The inferior wedge-shaped area looks obliquely downward, outward, and forward. The pterygoid process is about 1·2 centim. deep, and 8 millims. long, and about 6 millims. thick, compressed towards the inferior and superior margins. It is continuous with the quadrate process of the pterygoid, from which it is divided by a vertical suture. Posteriorly the quadrate bone passes obliquely through the squamosal so as to occupy a large area on the posterior face of that bone. In this species the quadrate bone has a general resemblance to the quadrate of *Ichthyosaurus*, though that genus does not develop a pterygoid process, which I have seen in no other Dicynodont. In *Dicynodon leoniceps* the quadrate bone is of different form, and has no extension in front of its condyles, but above the trochlear end it rises in a quarter of a circle, vertical externally, and convex on the inner border, 5½ centims. high, and as wide as high, just above the articulation. It is strong, very slightly convex, and makes an angle of nearly 45° with the longitudinal articulation. Its antero-posterior thickness above the condyle is 4½ centims., and superiorly the posterior surface, which was contained within the squamosal bone, is convex from behind, upward and forward toward the sharp superior margin, which, as preserved, projects forward 1½ centim. in advance of the squamosal bone. Its external margin appears to have been overlapped and hidden, as in all the other species, by a descending squamosal process.

On the palatal aspect (fig. 3) there is a deep saddle-shaped channel over the two downwardly directed processes, which appear to be formed by the basi-occipital and basi-sphenoid bones, which is very convex from behind forward, because the processes converge in front. Each process is 2½ centims. long, and has a long ovate form. The transverse measurement over them is less than 3 centims. On the outer posterior side, wedged in between the basi-occipital part of the process and the quadrate bone, is a relatively small ossification, identical with that which I have recognized in other species and regard as the malleus. It extends obliquely outward and backward. Its surface is less than a centimetre square, and is obliquely convex from behind forward. External to the convex sphenoido-occipital processes the posterior quadrate bars of the pterygoid, which are 2·5 centims. long and about 1·5 deep, converge forward and inward. They do not extend further forward than the processes with which they are in contact, but merge in the median mass of the pterygoid, which is 3 centims. deep and 1·7 centim. wide, with convex sides, but vertically compressed to a sharp palatal ridge and a similar median ridge on its upper surface. The mass is fractured vertically in front, but shows no trace of a median suture (fig. 1). The median blunt longitudinal pterygoid keel distinguishes this species from all others, and nothing could be less like the expanded horizontal plates which the pterygoid bones form in other Anomodonts.

The squamosal bones appear to have a considerable lateral extension forward in the upper part of the wall of the temporal region in advance of the origin of the zygomatic process. The antero-posterior measurement, as preserved, from the middle of the convex posterior border is 10 centims. The zygomatic process, which is directed at first obliquely outward, and then parallel to the temporal region of the skull, is given off in the middle of the width of the bone by a vertical attachment 5 centims. high and fully a centimetre wide, which becomes narrower superiorly as the zygomatic process thins. Beneath this branch the lateral contour of the bone is convex vertically for 3½ centims. down to the quadrate bone (fig. 2); and this convexity with the superior process defines the posterior vertical concavity in the bone, which increases in depth superiorly as this part of the bone becomes narrower. Inferiorly the concavity is lost. At the articulation for the lower jaw the squamosal bone appears to form the entire height of the back of the skull, which is about 12 centims.; but distally, where it rests upon the quadrate, it contracts to a width of 1·7 centim., and both the anterior and posterior borders of the descending process are concave for a length of about 3 centims. At 1 centim. from the distal end there is a transverse suture, and an ossification is displaced, which is 1 centim. deep, 2·5 centims. from back to front, and over a centimetre from within outward. Its distal surface appears to have been articular, and is convex from within outward and gently convex from front to back, as though it formed the outer half of the condylar articulation for the lower jaw. There is a similar transverse division on the left side, where the ossification is *in situ*, but the outer part of both bones is there broken away. In its relations to the quadrate and squamosal this ossification, if its distinctness is established, would correspond to the quadrato-jugal bone, which is not otherwise seen in Anomodonts.

The part of the squamosal bone which is anterior to the zygomatic process is about 4 centims. deep posteriorly, is sub-triangular, contracts in depth anteriorly. The post-parietal bones rest upon it superiorly, and it is in contact with other bones in front which converge forward and form the vertical median post-orbital plate. In front of the delicate process which extends above the superior border of the quadrate is a foramen from which a concave channel extends obliquely upward, over a sub-quadrate bone 3 centims. high and as wide, which lies in the wall of the brain case, widening it transversely above the quadrate process of the pterygoid, which is itself in close contact with the basi-sphenoid bone; so that its position is that of the ali-sphenoid bone, or pro-otic, and it may be compared with the thickened plate which flanks the brain-case in the previously-described specimen (Plate 10, fig. 2). The transverse width between the vertical anterior borders of these bones exceeds 2 centims. Anterior to them, and above them, the median vertical plate extends forward. It is 1·5 centim. wide at its base, which is concave from side to side, straight, and ascends forward and upward. At the anterior fracture the plate is over 3 centims. deep, and is formed of a pair of lamellar bones, in contact in the median line, with concave external sides, so that the transverse measurement in the middle is only 6 millims., but they widen again superiorly to 1·5 centim. before forming the transverse lateral expansions like the cross-piece of a capital T (fig. 1).

These bones, regarded as parietals, are in contact, inferiorly, with a median bone behind, which may be the inter-parietal, while the post-parietals, which appear to cover them superiorly and posteriorly, seem to terminate at about the anterior fracture; but fractures are numerous, and sutures so nearly obliterated, that it is difficult to determine the structure with certainty. This interpretation would bring the parietal bones into the roof of the cerebral chamber in advance of the inter-parietal, with a narrow concave surface, from the lateral borders of which bone appears to have extended downward, so as to define a vertical vacuity in the median plate, though the descending processes are broken away.

The superior surface of the temporal region is divided by a well-marked median suture, which becomes wider posteriorly, and its lateral margins are prolonged backward in a V form to the posterior extremity of the squamosal, though the level of this groove is much below that of the external zygomatic bar, from which it is separated by a deep narrow depression which extends downward and outward over the convexity of the anterior part of the squamosal bone. The postero-anterior convexity of the temporal region ascends in vertical position as it extends forward and diminishes in transverse breadth, till, at about 4 centims. behind the anterior fracture, it merges in the transverse ledge, which extends outward on each side of the median vertical plate, and as it curves forward it comes nearer to the superior surface of the skull. Seen from above, this temporal region has the sides sub-parallel; the transverse section posteriorly is half a circle, about $3\frac{1}{2}$ centims. wide. The width is scarcely diminished anteriorly, but the convexity diminishes, until at the anterior fracture it is replaced by a slight median concavity, and nothing remains of the convexity but the rounded margins of the transverse plate, which is less than half a centim. thick at the fracture, and has a transverse extension outward of 1 centim. beyond the vertical plate. From back to front this superior area is regularly convex, and the contour probably resembled that of *Dicynodon pardiceps*, but behind the convexity there is a slight concavity along the outwardly diverging surfaces. It is possible that the anterior extension of the inferior part of this brain-case was no greater than in the specimen previously described (Plate 10, fig. 2).

Within the post-occipital basin the remains are exposed of what I regard as an extremely thin plate of bone. Its vertical extent, from the side of the axis upward, is $5\frac{1}{2}$ centims. It is over 2 centims. wide, of a ribbon-like thickness, and curves convexly outward, like the squamosal bone, with which its anterior margin may be in contact. Its position is suggestive of part of the hyoid.

The cervical vertebræ of this specimen are described under the vertebral column.

On a New Skull of Dicynodon tigriceps (OWEN) *showing the Sutures of the Pre-parietal Surface.* (Plate 13.)

In the larger skulls of Anomodonts, it is rare to find the sutures between the bones distinctly shown, and I therefore give some notice of a specimen in the BAIN Collection, hitherto undetermined, which I regard as the anterior part of the skull of *Dicynodon tigriceps.* It is slightly distorted, and shows some differences of character in the greater depth of the maxillary bone, in the more anterior direction of the great tusk, and, apparently, in the greater prolongation forward of the pre-maxillary bones to form the cutting edge of the jaw. These characters are such as might be expected to characterize a species, but they are, I conceive, such as might vary with age; and Mr. BOULENGER has shown me such extraordinary examples of augmentation of size and variation of proportion in the skulls of some young and adult Frogs that, in view of the close correspondence of form and size in the bones of the pre-parietal region of the upper surface of the head, I do not feel justified, with only a distorted fragment to work upon, in separating the specimen from the type to which it is obviously closely allied.

The specimen shows the relations of the maxillary, pre-maxillary, sub-narial, nasal, pre-frontal, lachrymal, frontal, and post-frontal bones; while the nares are exceptionally well seen (fig. 2).

The length of the fragment is only about 30 centims. The pre-maxillary bone is shown by a transverse polished section to be single. It is inclined obliquely forward and downward, and is constricted posteriorly where it forms the anterior and superior borders of the nares. Here its transverse width is 8·5 centims., almost exactly the same as in the type skull of *D. tigriceps.* It extends backward in a rectangular wedge, and penetrates in the median line for some distance between the nasal bones. The length of the straight suture by which it joins each nasal bone is 6 centims. The length of the bone in the median line to the transverse polished section is 11 centims., and may have been several centimetres more: these measurements correspond with *D. tigriceps.* In front of the nares the lateral parts of the bone bend somewhat abruptly downward and outward for 4·5 centims. to the straight suture with the maxillary bone, which is parallel to the superior contour when seen from the side, and about 8 centims. long: its direction is also parallel to the median line of the skull when seen from above. The posterior lateral border of the bone is concavely notched out superiorly to form the front border of the narine, and inferiorly it slopes to form the floor on which the sub-narial bone rests.

The maxillary bone is flattened, oblong, and oblique in position, being inclined forward and downward. It contributes the inferior border to the narine, and supports the larger part of the sub-narial bone; but may be excluded from the external margin of the orbit by the malar reaching back to meet the lachrymal. It is 10 centims. deep and nearly 20 centims. long. A shallow depression or groove runs over the bone, parallel to the pre-maxillary suture and 3 or 4 centimetres below it, so as to define a superior convex ridge. The inferior border of the bone extends for 24 centims. in front of the lachrymal corner of the orbit; it is rounded, and contains the base of the tooth, which is sheathed in bone to its fractured extremity, where it measures 3 centims. in diameter.

A fracture shows the root of the tooth of the same size extending for 10 centims. through the surrounding sheath, and it probably extends nearly to the orbit. Its position is parallel to the suture between the pre-maxillary and maxillary, but 6·5 centims. behind it. It is, therefore, not in the place of the canine tooth of a Carnivorous Mammal, and cannot be so determined; but, being entirely in the middle of the maxillary bone, presents a character only found in the lower Mammalia.

The nasal bones are flattened above, and they extend transversely over the hinder part of the nares in a pair of thickened bulbous processes, like horns. The transverse width over the bones is about 19 centims. They meet by a well defined median suture, which is 5 or 6 centims. long; and the anterior margins of the frontal bones rise above them in a slight ridge. These straight sutures, 8 centims. long, converge backward, so that the nasal bones penetrate a little between the frontal bones, but to a less extent than the pre-maxillary bone penetrates them. The superior surface of each bone is convex from front to back, and concave from the median line outward towards the external horn. The external antero-posterior extent of the bone is about 7 centims., and this surface is chiefly occupied with the transverse convexity of the nasal horn, which is 4 centims. thick, though the thickness of the bone greatly diminishes towards its junction with the pre-maxillary. Inferiorly the nasal rests upon the lachrymal bone, which extends as a narrow strip into the narine, on the plan of *Ichthyosaurus*, so as to separate the nasal bone from the maxillary. A deep groove behind the nasal horn separates the nasal bone from the pre-frontal.

The sub-narial bone lies within the floor of the narine. This cavity is transversely ovate, 5 centims. long by 2 centims. deep internally, but 4·5 centims. deep to the outer limit of the sub-narial bone; and a centimetre below that there is a sharp ridge on the maxillary, which marks the lower border of the nasal aperture. The sub-narial bone is 5 centims. wide and 3·5 centims. deep, slightly concave from front to back, and inclined obliquely downward and outward. It is seen on both sides of the skull. When compared with the sub-narial bone in *Pareiasaurus*, this condition is interesting, as the bone is entirely withdrawn from the external suture on the face. And its position is such as to suggest that it may be the germ of the turbinal bones of the Mammalia.

The internal border of the orbit is flattened, and is limited externally by a somewhat thickened rounded edge, in the anterior corner of which lies the lachrymal bone. It is 4 centims. deep within the orbit, 2 centims. wide on the lateral border in front of the perforation for the canal, while the width to the extremity of the narrow tongue, which is prolonged superiorly into the narine, is 5 centims. The lachrymal perforation is 1·4 centim. long and half as wide, with a depressed rounded border.

Above the lachrymal bone, and behind the nasal bone, is the pre-frontal bone. It is a small ossification above the anterior corner of the orbit, where it projects outward in a second sharp but small pyramidal process, similar to the process of the nasal bone. The width over these processes is about the same as that across the nasal horns. But the pre-frontal bone is no larger than the lachrymal. It measures about 4 centims. in the vertical direction, and the transverse and antero-posterior measurements are about the same; so that its small size would suggest that the absence of this bone in the skulls of higher Vertebrates is probably a consequence of the frontal bone continuing to ossify at its expense. Its largest surface is within the orbital border; and the contour of the orbit causes it to narrow inferiorly in the lateral view to its junction with the lachrymal bone, above which the transverse spine or horn extends.

The frontal bones are a pair of large flattened horizontal ossifications which extend between the orbits, and meet in the median line in a slight ridge, which is only a little more elevated than the anterior margin which marks their union with the nasal bones, but there is a conspicuous though small depression where these bones meet in the median line of the skull. Their lateral margins are compressed and convex on the under side; but the lateral contours are concave from back to front, where they form the superior borders of the orbits. Posteriorly, the parietal bones are broken away, apparently at the suture, and on the right side the post-frontal bone is broken away in the line of suture. And these fractures show that the frontal bones extend backward in the median line in a broad Λ shape, which is rather more pronounced than the corresponding contour of the nasal bones; so that each frontal approximates to a rhombic form, with the sharp angles outward and forward, and made by the pre-frontal bones. The least transverse width between the orbits is about 14 centims. The antero-posterior length in the median suture, between the frontals, is fully 10 centims.; the length in the middle of each frontal, from the nasal to the post-frontal suture, is 8·5 centims., and on the orbital margin, between the post-frontal and pre-frontal, the measurement is about 5 centims., or 9 centims. to the deep notch between the pre-frontal and nasal. The length of the post-frontal suture on the posterior border is 5·5 centims., where it appears to be separated from the anterior end of the parietal by a ridge. The flattened superior surfaces of the frontal bones are somewhat concave, owing to the median ridge developed between them anteriorly, but where the ridge dies away posteriorly there is a slight transverse concavity in the middle parts of the bones. The similar depression in the suture at the posterior extremity of the united frontals, when compared to that seen in the type skull, makes it highly probable that the parietal foramen in this skull was similarly situate and conditioned.*

The palatal aspect shows the union of the palatine bone with the maxillary, the extension of the palatine on the internal border of the pterygoid, the median approximation of the pterygoids posteriorly against a compressed median plate, 2 centims. high, 1·4 centim. wide on the palate, and 9 millims. wide superiorly, which appears to be the pre-sphenoid; and a flattened bone descends on to the outer surface of the pterygoid, diverging outward and forward, which is in the position of the columella, but is only seen on the right side.

The Quadrate Bone. (Plate 10, figs. 4–6).

Though several Anomodont skulls in the British Museum have lost their quadrate bones, the collection contains but one specimen separated from the skull, and that bone, hitherto undetermined, is without record of the locality where found, beyond being kept with specimens presented by Mr. BAIN.

It is in a pale grey matrix, which has been completely removed, so that the external form of the bone is fully shown. It agrees substantially with the bones which are attached to the skulls in every character but one, and that is in the presence of a very large foramen or notch, which runs through the bone above the distal articulation. The bone indicates a larger skull than any which has been described, and may eventually be referred to a new genus.

The bone consists of a trochlear articulation, from which a strong wide wedge-shaped process ascends obliquely, and shows, on the middle of what I regard as the inner margin, a large vertical pit for the pterygoid bone (fig. 4).

The trochlear articulation (fig. 6) consists of two well defined condyles, which are convex from behind forward, and separated by a deep wide median channel. The inner condyle, as preserved, is the narrower, but this is probably due in part to a fracture, which has removed its inner margin. The transverse measurement from within outward is 7·5 centims.; and the antero-posterior measurement of the outer condyle is less than 6 centims., and of the inner condyle more than 6·5 centims. Both condyles project forward, and are well defined by the less development anteriorly of the bone which rises from the articulation; but the inner condyle appears to have worked in a well defined excavation, and is defined posteriorly by a transverse emargination or groove above the articular surface. The external condyle has the external margin convex from front to back; while the margins of the other condyle appear to be straight and parallel.

* In the fossil No. 36,235, the parietal foramen is an ovate perforation 1·3 centim. long and 9 millims. wide, with an elevated rounded rim, the transverse measurement over which is 2·3 centims., and the length about 2·8 centims. This border is less than half a centim. wide in front, but widens laterally and posteriorly; and all round it the bone is depressed.

The channel between the condyles is about 3 centims. wide, and fully 1·5 centim. deep, highly inclined towards the inner condyle, and less inclined on the surface which contributes to the outer condyle. This channel makes the anterior margin concave between the condyles, and causes a corresponding concave contour on the hinder border.

The greater length of the inner condyle appears to be correlated with the greater antero-posterior extent of the bone which rises above it. Above the outer condyle this is a small and comparatively slender vertical process, which is fractured, so that its height is not seen. It measures 3·3 centims. from front to back, and less than a centimetre and a half transversely where thickest. The convex external surface is somewhat irregular, as though it were impressed above the condyle by giving attachment to a bone, which may have been the quadrato-jugal or possibly the squamosal, since there is at present no conclusive evidence of the quadrato-jugal as a normal element in an Anomodont skull. The height from the base of the articulation to the fracture of this process is 5·7 centims. The process is separated from the strong bony wedge which rises above the inner condyle by the large notch or channel which is situate above the channel between the condyles, from which it is separated by a thickness of bone of about 2·2 centims. in front and 1·5 centim. behind. The base of the channel is concave from back to front, as well as from side to side; its external border was most produced anteriorly, and its inner border most produced posteriorly. The sides appear to have converged upward without meeting. The greatest width of the perforation in front is about 2·5 centims.

The plate or wedge of bone which rises above the inner condyle terminates superiorly in a thin compressed edge, convex from front to back, which is inclined towards the outer side in front, and towards the inner side behind, so as to obliquely cross the direction of the condyle. The height to this edge from the condylar surface is 10 centims.; its greatest antero-posterior extent is 9 centims. The wedge is somewhat cut into at the base, in front, by the median supra-condylar perforation, while the inner posterior side is excavated for a bony attachment. Otherwise the lateral surfaces are convex from front to back and converge from below upward, so as to meet in a sharp edge which extends from the back of the condyle to the front. On the posterior side the base of this wedge expands to the summit of the outer condyle. I have no doubt, from the evidence of the specimens described, that the larger part of this wedge was received into the squamosal bone. The large vacuity on the inner hinder border of the wedge, which is 4 centims. high and 1·5 centim. wide, is in the position in which the pterygoid bone commonly meets the quadrate; though in *Ichthyosaurus* a similar pit appears to be formed by the malleus.

On the whole, the bone approaches closely to the quadrate of *Ichthyosaurus*, notwithstanding the difference of the supra-condylar perforation; for, if the external ascending process of this South African quadrate were removed, its external surface would have the same concavity as the quadrate of *Ichthyosaurus* where it faces towards the quadrato-jugal bone. Moreover, it would correspond in plan to the quadrate of *Hatteria*, except that it rather resembles *Ichthyosaurus* in the absence of a pterygoid process, in the wedge-like supra-condylar mass, and its superior termination in a sharp margin. The divergence of character, in which it varies from the quadrate of other Anomodonts, and approximates to *Ichthyosaurus*, would warrant its reference to a new genus.

On a somewhat crushed and imperfect Skull of Dicynodon Copei, SEELEY. (See Plate 14.)

The skull numbered 47,074 is distorted, but indicates a new species of *Dicynodon*, which appears to resemble the type named by Professor COPE *Lystrosaurus*,* in which the face is vertical to the superior surface of the head. The nares approximate as closely as possible without being confluent, are circular, and inferior in position to the large circular orbits, which are posterior to the nares. The large teeth descend vertically.

The palate has been very fully excavated (fig. 3), and shows the wide smooth surface of the basi-sphenoid, slightly concave from side to side, and less convex from back to front. At each side, stretching between it and the quadrate bone, is the pair of bones with saddle-shaped surfaces, originally figured† in *Dicynodon lacerticeps* (OWEN), and already recognized in other Dicynodonts. In a line with their anterior margin the irregular transverse suture is seen, which marks the overlap of the pterygoid upon the basi-sphenoid. The lateral surfaces of this mass converge forward to make deep notches, external to which the quadrate processes of the pterygoid are prolonged outward and backward as thin oblique plates, which reach the external borders of the sub-quadrate saddle-shaped bones already referred to, which are regarded as the malleus. In front of these, the quadrate processes of the pterygoid bone are considerably constricted; and then an anterior pair of processes diverge forward and outward, so as to terminate behind the maxillary teeth, where a thin plate of the maxillary overlaps the pterygoid externally, but only on the upper part of the anterior process. In the constricted middle plate of the pterygoid is a long median vacuity, lanceolate behind, and tapering in front to a slender point. It is defined laterally by very slender plates, which converge inward and forward to form a single median plate, reaching forward to the maxillary region; and this plate may probably be identified as the vomer.

Stretching along the inner side of each anterior bar of the pterygoid is the palatine bone, which widens as it extends forward, so as to enclose with the slender V-shaped vomerine plate a pair of long oval vacuities in the palate, which I regard as the

* 'Amer. Phil. Soc. Proc.,' vol. 11, 1870, p. 419.

† 'Geol. Soc. Trans.,' 2nd Series, vol. 7.

palato-nares. The lateral excavation shows the palatine plate to extend upward and inward as in other specimens.

The distorted condition of the specimen makes detailed measurement of little value. The head is about 13 centims. long, and the height of the vertical face is about 8·5 centims. from the cutting margin of the jaw to the flattened frontal region. The circular nares are rather above the middle of this height; each is 2 centims. in diameter, and the bar which divides them, formed by the nasal bones above and the pre-maxillary bone below, is half a centim. wide. The pre-maxillary bone is extremely narrow (about 2 centims.), and may be divided by a median suture, though the state of preservation does not demonstrate this point, and the appearance may be delusive. The circular orbit is 4 centims. in diameter; the malar bone extends internally to the post-frontal at its hinder border, and both bones are overlapped externally by the squamosal, which at once rises to a level with the crown of the head as it extends backward. At the back of the head is a slender sigmoid bone, expanded at both ends, about 9·5 centims. long, which may be the clavicle.

These characters amply establish the distinctness of this species, and make its reference to a distinct genus not improbable; but I do not regard the vertical opposition of the pre-maxillary and mandible on which *Lystrosaurus* was founded as a sufficient definition of the genus.

The Skull of Hyorhynchus platyceps, SEELEY. (Plate 15, figs. 1–3.)

A skull, which is imperfect both in front and behind, registered in the British Museum as R. 872, received from Mr. THOMAS BAIN, is so remarkable in its form that I regard it as probably indicating a new genus. It is characterized by a slender angular Pig-like snout, relatively large orbits, and a narrow parietal region.

The upper surface of the head is flattened, slightly convex from front to back in the median line, with the superior borders of the orbits somewhat elevated, so as to make the frontal bones between them longitudinally concave. The post-orbital region has a length of 3 centims. as preserved, and is about 12 millims. wide at the posterior fracture, where a transverse section shows that it is the summit of a vertically ovate region of the brain-case. As in so many other allied forms, its lateral walls diverge outward as they extend forward to the posterior angle of the orbit, where the post-frontal bone extends transversely outward. The post-frontal is very slender. It is directed at first outward and downward, and then downward and forward, making the posterior boundary of the orbit. This aperture on each side of the head looks outward and a little upward, is 4 centims. long, by 3·3 centims. deep. The width of each frontal bone from the median suture to the orbital border is 1·6 centim. in the middle of the orbit. The sutures are badly defined. The parietal appears to be overlapped by the post-parietal bone, which extends forward to the post-frontal, and has the side flattened and obliquely inclined. At about 1·5 centim. behind the orbits is the long ovate parietal foramen, which appears to be 1 centim. long. At the anterior corners of the orbits are narrow pre-frontal bones, crossed by angular ridges which extend forward and separate the flat roof to the snout from the slightly inclined ant-orbital wall. The transverse width at the corners of the orbits is 3·5 centims. at 7 centims. in advance of the posterior fracture. The roof bones extend for 4 centims. forward in advance of this, converging to about 12 millims. wide at the anterior fracture, so that the angular ridge which borders the area laterally is slightly concave in length. The vertical height of the back of the skull in the post-frontal region is about 5·7 millims.; anteriorly the vertical depth to the maxillary plate of the palate is a little over 4 centims. The transverse width at the base of the hinder border of the orbit is 8 centims., while anteriorly at the maxillary plate it is 4 centims.

The maxillary bone is very imperfectly preserved, and is best seen on the right side, where a part of its inferior palatal border extends backward horizontally towards the orbit, but extends below it. Its rounded lateral border makes a considerable angle with the palatal surface of the bone, which is reflected inward and downward. In the part of the alveolar border which is preserved I can detect no indication of dentition. The form of the head would have suggested teeth of the Gennetotherioid type, in which the incissors are large and the molars small, but so much of the hinder margin of the maxillary bone as is preserved only demonstrates imperfectly a cutting margin, with doubtful indications of immature teeth buried in the substance of the bone.

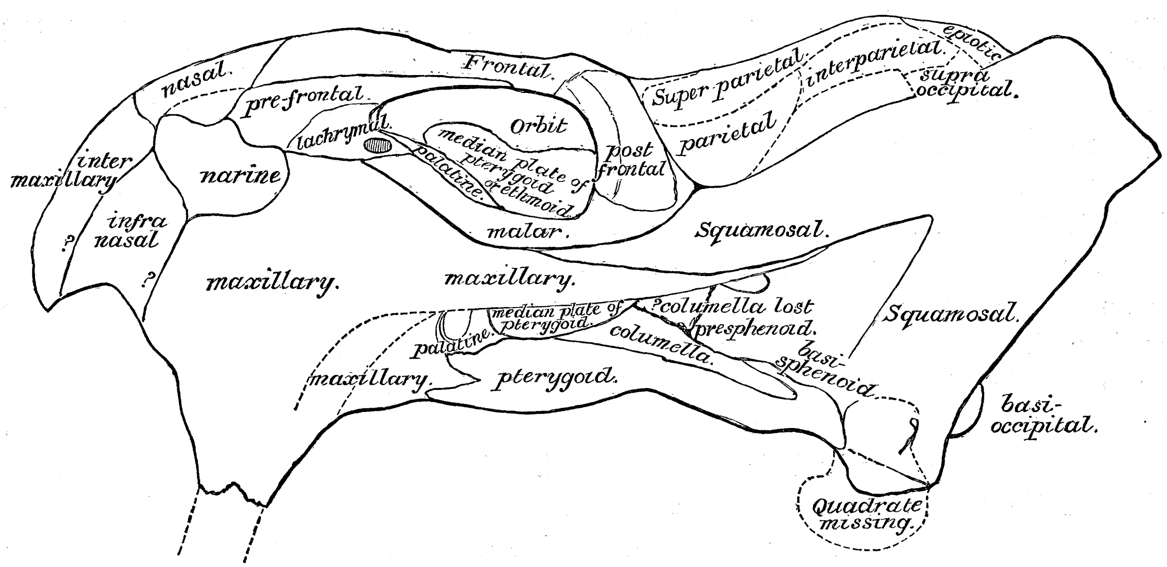
The palate in front is formed by two bones which meet in the median line by a close median suture at the bottom of a slight median concavity. These bones curve convexly upward in front, are in contact with the maxillary bones at the sides, and at their hinder outer corners meet the pterygoid bones, so that they appear to demonstrate the palatine as a transversely ovate plate consisting of two lateral portions. The palatine processes of the pterygoid bones are slender plates of almost rod-like form, which converge inward as they extend backward, but they descend to a lower level, apparently, than the maxillary bones. The exact mode of their union with the mass of the pterygoid bones is not evident. But the pterygoid bones unite in the median line, where they are unusually elongated, and inclined towards each other so as to meet inferiorly in a median keel. On the right side a process is given off which extends transversely outward and upward to the malar region of the base of the orbit, though the malar bone itself is clearly defined. This pterygoid process is therefore in the position of the transverse bone. The sphenoidal region of the palate ascends, and at the fracture is concave from side to side and shows the rounded form of the base of the brain-cavity. The inter-parietal bone is seen to extend obliquely over the cerebellar region in the usual way.

There is a general resemblance between this type of skull and *Ælurosaurus*, which shows that this genus belongs to the Gennetotherioid division of the Anomodont order; but Pig-like ridges on the snout and other features sufficiently distinguish it from Theriodont genera, and the palate is distinctive.

Summary of the Structure of the Dicynodont Skull.

The same plan of structure is found in all the skulls of Dicynodonts which I have been able to compare, although the proportions of the different parts of the head vary in the genera. The post-orbital region may be greatly elongated, as in *Dicynodon leoniceps*, when the parietal area is usually an angular crest, or the transverse expansion may be considerable, and the parietal region flattened and tabular, as in *Dicynodon tigriceps*. The nares may approach near to the extremity of the snout, as in some species of *Oudenodon*, or the pre-maxillaries may have a great anterior development, giving the nares a backward position, as in *Ptychognathus*. But, although the relative size and shape of every bone become modified in harmony with these modes of growth, the plan on which they are arranged never varies, so far as I have been able to ascertain. This plan consists in a solid jaw, from which a vertical longitudinal median plate is prolonged backward, where it divaricates to contain the small brain. This wedge is terminated posteriorly by a more or less vertical occipital plate. Inferiorly the back of the squamosal region is connected with the jaws by longitudinally extended slender bars, which form the palate. Laterally the squamosal extends towards the maxillary, forming a single lateral arch behind the orbit. Superiorly the anterior part of the head is more or less flat, and horizontally extended parallel to the palate.

Fig. 2.



Lateral plan: Skull of *Dicynodon*.

The occipital plate may either be transversely extended and vertical, or may have its lateral halves directed outward and backward. It includes a rounded occipital condyle, which is formed by the basi-occipital and the two ex-occipitals, which are usually developed backward somewhat further. The condyle is less prominent than in Chelonians. Above it is the foramen magnum, more or less extended vertically, with sub-parallel sides. The occipital plate consists of the usual four occipital elements, though the sutures between them may become obliterated. They are at first well defined, but much closer than the sutures which connect the occipital plate with the bones which occur above it and at its sides. The supra-occipital forms the upper part of the foramen magnum, the ex-occipitals make the lower parts of its sides, and the basi-occipital is below. The sutures between this bone and the ex-occipitals run down the descending processes which have been termed hypapophyses.

A large bone is situate above the supra-occipital, and extends the occipital plate vertically. It has an immense anterior extension, may apparently be single or double, enters into the brain-case, and I identify it as the inter-parietal, and regard it as homologous with the bone so named in Mammals and Lizards.

At the sides of the occipital plate are the large squamosals, elongated vertically and expanded laterally. Their connection is mainly with the ex-occipital bones. It is their reflection backward which forms the basin-shaped occipital surface found in *Dicynodon pardiceps* and other types. It is this bone which furnishes the Mammal-like zygomatic process from its anterior border, and it supports the quadrate bone on its base.

Two other bones are found at the back of the head, which form a pair, and lie between the inter-parietal, supra-occipital, and squamosal. They are, apparently, thin plates, which correspond with the similarly placed bones in Labyrinthodonts, which have been termed epi-otic bones.

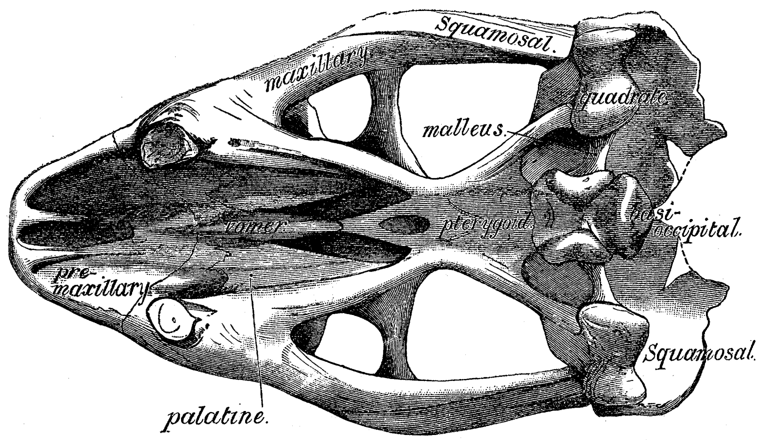
Between the ex-occipital and the squamosal is a large foramen, which may be auditory ; and at the sides of the ex-occipital elements of the condyle are foramina, which may be outlets for the vagus nerve.

There is no certain evidence of the basi-occipital being divisible by suture from the basi-sphenoid, but such a separation is probable (although a vertical section fails to show it), because the hypapophyses which are prolonged downward from the region of these bones sometimes show at their termination a tri-radiate groove, and it has been seen that the basi-occipital and ex-occipital contribute the posterior two of these three elements.

These sphenoido-occipital processes form, at their outer lateral termination on each side of the head, a remarkable crescentic concave articulation. A small bone articulates with it and extends to the squamosal, near to the quadrate or to the quadrate bone. The bone may be very small and sub-quadrate in form, or sub-cylindrical and constricted a little in the middle, with convex articular ends. These bones are much smaller than the pear-shaped bones in *Ichthyosaurus*, which have a large lateral attachment at the junction of the basi-occipital and basi-sphenoid, and which extend transversely outward, so that the small end is received into a pit in the quadrate bone, and they are much less slender than the bones which in some Liassic

Ornithosaurs extend from the sphenoid to the distal end of the quadrate, and less slender than the relatively long bones in the Bird's skull, which extend from the anterior inner angle of the quadrate articulation, and converge forward and inward to the sphenoid, which have been regarded as pterygoid bones. Nothing like these bones of Anomodonts has been recognized in existing Reptiles; and they are regarded as homologues of the malleus of the Mammalia on account of their relation to the surrounding bones.

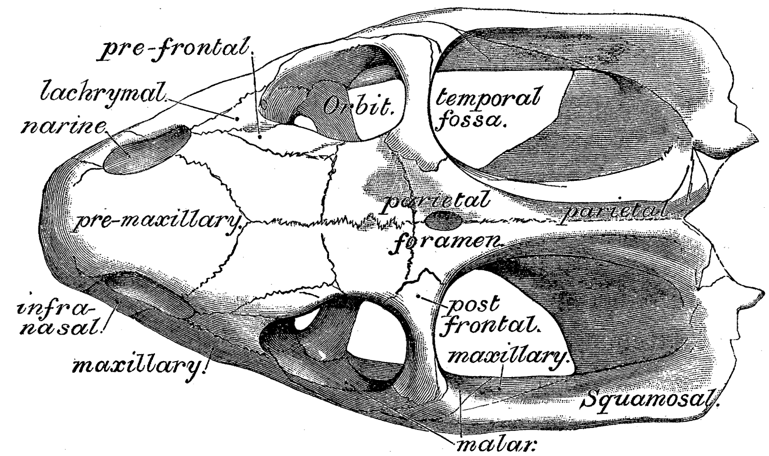
Fig. 3.



Plan of palate of *Dicynodon.*

The cavity which contained the brain is small, narrow, and high. It appears to have the basi-occipital and basi-sphenoid for its floor. The pre-sphenoid ascends obliquely in front, and is very narrow, and there is no certain evidence whether the olfactory nerve was prolonged above it. The superior covering of the brain was formed by the supra-occipital, inter-parietal, and parietal bones; there is no evidence that the brain extended forward to the region of the frontal. It has been seen that the ex-occipital bones enter into the foramen magnum, but on the anterior side the occipital plate thickens, and the thickening appears to be due to a bone, which loses its individuality at an early period, being super-imposed. I regard this bone as the opisth-otic. Its anterior margin is smooth, and formed the hinder wall of a vertical aperture in the brain-case through which a large nerve passed. It corresponds to the outlet for the fifth nerve, but other nerves also, probably, passed out in the same channel. Anterior to this aperture is a large vertical plate, which rises from the basi-sphenoid; and this I regard as the ali-sphenoid bone. It is very thin, and may not always have been ossified, but is well seen in *Ptychognathus.* Much further forward, above the pre-sphenoid, are the bones which appear to correspond to the orbito-sphenoid, placed at the back of the orbit, and perforated. Thus, the sides of the brain-case converge as they extend forward, till they merge in the vertical median septum which may be formed at its base by a flat median process of the pterygoid, on which is placed the pre-sphenoid, similarly compressed from side to side and elongated; above this bone succeed vertical plates of the parietal and frontal bones; and anteriorly these elements are prolonged by the ethmo-vomerine plates described by Professor HUXLEY.

Fig. 4.



Plan of the Upper Surface of the Skull of *Dicynodon.*

The palate in Dicynodonts is characterized by being formed mainly by the pterygoid bones. They are large horizontally extended plates, which meet in the median line and rest upon the basi-sphenoid, much as in Chelonians, but three processes appear to be given off, of which Chelonians show no evidence. First, a process is directed outward and backward to the quadrate bone, and is separated from the mass of the bone behind it by a notch. Secondly, from the anterior corner a long bar of bone is produced forward and outward to meet the maxillary bone behind the great tooth; and so as to make the external margin of the pterygoid concave. Between these anterior bars a pair of smaller processes is given off, which soon converge as they extend forward, and are developed into a vertical median plate which underlaps the pterygoid, and extends forward to meet the vomer, but soon rises so as to disappear from the horizontal plane of the palate. The palatine bones extend along the whole length of the anterior bars of the pterygoids. They are narrow, splint-like bones at first, on the inner sides of the maxillary bars of the pterygoid, and widen as they extend forward into the maxillary, where they converge toward the median line, but are commonly separated from each other by the vomer. A process from the palatine is directed upward and outward, and abuts against the lower border of the orbit, internal to the malar and the lachrymal.

The anterior part of the jaw is formed in Dicynodonts by the maxillary and pre-maxillary bones. The pre-maxillary elements appear to be always comparatively large, and apparently single, though they may be as small in Theriodonts as in any Mammal and divided in the usual way. In some types the suture between the pre-maxillary and maxillary bones appears to be overlapped throughout its length by the sub-narial bone, but in other species this bone is only seen on the floor of the external narine.

The apertures of the skull present nothing remarkable in the ways in which they are defined. The temporal vacuities may be extended transversely, or much extended longitudinally, and are always limited externally by a single zygomatic bar, into which the squamosal always enters, which may be underlapped by the maxillary in Dicynodonts, and is underlapped by the malar in Theriodonts. The orbit is circular or ovate, surrounded by the post-frontal, frontal, pre-frontal, lachrymal, and malar bones. The nares are usually anterior and divided, but their relative position in the head is influenced by the development anteriorly of the pre-maxillary bone. The nasal and frontal bones are double. The pre-frontal is distinct from the lachrymal. The latter bone is below the pre-frontal and above the maxillary; it is always perforated by the lachrymal canal, and extends from the orbit to the narine, as in *Ichthyosaurus.* The post-frontal forms a transverse bar at the back of the orbit, extending from the frontal to the malar, which rests upon the squamosal, and makes the lower border of the orbit. At the hinder margin of the frontal bones is the parietal, which shows no sign of median division, and contains the parietal foramen in its anterior part. External to it are plate-like bones, which margin the superior borders of the temporal fossæ. They appear to be distinct from the parietal, and to overlap that bone anteriorly and the inter-parietal posteriorly, for the inter-parietal succeeds the parietal as a single median roof-bone, which may sometimes be double. But, while it is probable that the post-parietal plates are anteriorly separate from the parietal, there is no specimen which establishes the separation beyond question.

The squamosal bone, by its varied development, greatly modifies the form of the skull. It always gives off a strong laterally compressed zygomatic process, and in Dicynodonts is more or less extended inferiorly and vertically below that process, where it forms an arch into which the vertical part of the comparatively small quadrate bone is received. This inferior process of the squamosal may become small, and in the Theriodont *Galesaurus* has no existence. The squamosal bone always forms the external lateral limit of the occipital area along its extent.

The Vertebral Column.

The only part of the vertebral column in which the number of vertebræ is imperfectly known is the dorsal region. A specimen in the British Museum, of which a portion has been figured by Sir R. Owen ('Cat. South African Reptilia,' Plate 52), indicates not fewer than fifteen vertebræ contained between the head of the humerus and the head of the femur, and in *Deuterosaurus* the number of dorsal vertebræ preserved is eleven, so that the vertebræ in the several regions of the body may be stated with some probability at seven or eight cervical, twelve or thirteen dorsal, one to six sacral, and about twenty caudal.

The forms of the vertebræ appear to differ a little in the several types, but they all show a remarkable approximation to Sauropterygian genera. There are the same biconcave articular surfaces to the centrum, only the mode of ossification of the intervertebral or proto-vertebral substance appears to be different, for the unossified part has a tendency in Anomodonts to contract to a tubular-conical form, while in Plesiosaurs and Nothosaurs the tendency is for the base of the cone to disappear, so that the conical excavation becomes shallower, till the articular surface is perfectly flat, and the cavity becomes obliterated.

The positions of the articulating surfaces for the ribs are more like that in Plesiosaurs than in other animals, since there is a double attachment in the cervical region, a single attachment in the dorsal region, which is entirely on the neural arch (except in the Pareiasauria), and a single caudal attachment, which descends again to the centrum. But, since the cervical diapophysis in Anomodonts is formed by the neural arch, the affinity is obviously closer with the Crocodilia, especially the Teleosauria, and in that group chevron bones are equally well developed ; so that, notwithstanding the general resemblance of these vertebræ to those of Plesiosaurs, the divergence in the cervical region is as absolute as in the sacral region. Yet the sacral vertebræ are quite unlike those of Crocodiles ; and the affinities indicated by these resemblances may be no more important than the affinities with *Hatteria*.

The Vertebræ of Dicynodonts. (Plate 12, figs. 2, 4.)

No specimen has hitherto been described which shows the actual association of the vertebræ attributed to *Dicynodon* with a skull; for, although there is a strong probability that the vertebræ and limb-bones from the Gonzia River, attributed to *Dicynodon tigriceps*,* are parts of the same animal as the skull from the same locality, the specimens are separated. It is, therefore, interesting that the skull fragment already described in this memoir (Brit. Mus., R. 866) has the earlier cervical

* 'Catalogue South African Reptilia,' No. 66, p. 40, Plate 35.

vertebræ preserved in natural articulation in the basin formed by the expanded squamosal bones.

There is no reason to doubt that in this species the occipital condyle was small, and as short as in allied types, though it is not exposed. Attached to it, apparently, is a bony mass projecting backward, which is embedded in matrix, except at the base, and on part of the right side; and this I regard as being probably the anchylosed atlas and axis; not that there is any visible evidence of union between the bones, but the antero-posterior extent of the ossification is 2·3 centims., while the succeeding cervical centrums have an average length of 1·7 centim., and I know of no animal in which the atlas is longer than the succeeding vertebræ, while a similar increased length is found when atlas and axis are anchylosed. Its posterior articular face is less than 2 centims. deep. At its base is a large tubercle, which may be lateral, and is probably one of a pair; though the other, if present, is hidden by matrix. The height from this tubercle to the summit of the neural arch is 4 centims. The neural arch, which is imperfectly exposed, extends backward for a centimetre behind the articular face of the centrum. The succeeding vertebræ are dislocated, and turned round at a right angle. The matrix has been removed so as to expose both the left side and the base.

The first of the free vertebræ has many of the characters of an inter-centrum, for it has no neural arch, but the centrum has been partly chiselled away on the under side. Its antero-posterior extent, as preserved, is 1·7 centim., and, therefore, as long as the vertebræ which follow it. On its left upper anterior angle is a large ovate articular facet, slightly elevated, with a sharp border; it looks forward and outward; and I can only suppose that the neural arch of the axis may have rested upon it. The surface beneath it is deeply excavated. The neural arch of the following vertebra is in close contact with the superior part of its posterior border, and the neural spine of that vertebra extends forward, so that it must have been in contact with the neural spine of the axis. This affords, so far as I am aware, the first evidence of an inter-centrum among true Reptilia developed to the size of an ordinary centrum, as in *Diplovertebron*. There are no interspaces between the vertebræ; their neural arches interlock slightly, and the centrums are in close contact.

The next vertebra has the centrum 1·7 or 1·8 centim. long, flattened on the under side in front, but forming a median ridge behind. At the sides of this flattened part of the base is a pair of tubercles, moderately elevated, placed obliquely so as to look backward and upward; that on the right side is 6 millims. long. The side of the centrum is flattened, but slightly concave, inclined a little outward. It has no elevated anterior border, as though it were the vertebra to which the inter-centrum belongs. The vertical depth of the side of the centrum below the neuro-central suture is about 1·5 centim. The neural arch is large. It extends transversely beyond the centrum, and develops a strong diapophysis directed backward and outward. This process is fractured, and only its base is seen, convex above and flattened below; but it was probably as long as in succeeding vertebræ, where the measurement from the pre-zygapophysis to the articular diapophysial facet is 2·5 centims., and the process projects freely for more than a centimetre. The surface of the neural arch is flattened and inclined concavely. Anteriorly, at a height of 2·5 centims., there is a slight, horizontal, zygapophysial facet, which probably had no function in the skeleton. The posterior zygapophysis is strong, and is developed backward in the usual way. The front to back measurement over these facets is 2·5 centims.

The neural spine expands above into a hatchet shape, which is defined by a small concave notch above the pre-zygapophysis, and a larger concavity above the post-zygapophysis. Its superior border is concave from front to back, and 3 centims. long. It is fractured posteriorly, but is seen to have been a thick wedge of bone terminating in a point. Anteriorly it forms a blunt convexity more than a centimetre in transverse measurement. It makes some approximation in form to the neural arch of the fourth cervical of *Protorosaurus Speneri*,* though it differs in having the posterior process superior in position to the post-zygapophysis. From the base of the centrum to the summit of the neural spine is 4 centims., of which the neural arch measures 2·7 centims.

In the three succeeding vertebræ the characters are modified. The centrum is slightly shorter. The base of the fifth centrum shows a longitudinal median ridge, which is less elevated on the sixth and absent on the seventh, which is convex from side to side. The parapophysial tubercles are more anterior in position, being just behind the anterior articulation, but quite as low on the side of the centrum. The transverse measurement over them is 2·2 centims. Behind these eminences the centrum is concavely compressed. The pre-zygapophyses are strong, directed forward and upward, convex externally, with the facet directed inward and forward. Behind its rounded anterior margin, which is about 1 centim. wide, the process contracts a little. A blunt rounded ridge, which is concave in length, connects the zygapophyses. The neural spines incline a little forward as they extend upward; they are about 1 centim. wide.

The posterior face of the last centrum shows a conical excavation, like the vertebra of an osseous Fish. The articular face is 2·1 centims. high and about 2·5 centims. wide.

The ribs remain in close contact with the vertebræ. Their articular ends fork, so that with the processes from the vertebra they each enclose a sub-rhomboid space. The forks are of equal length, and diverge like the forks of a Y, but the tubercular process is the wider and the more compressed. The ribs are sub-cylindrical, curved, and half a centimetre wide; that attached to the fifth vertebra is preserved for the length of three centrums.

Dorsal Vertebræ. (Plate 16, fig. 1.)

A small slab from South Africa in the British Museum shows on the right side evidence of seven dorsal vertebræ, and on the left side portions of seven dorsal ribs.

* 'Phil. Trans.', Vol. 178, p. 208.

The locality from which the specimen was obtained is unknown, but the bones correspond in size with the cervical vertebræ already described. Three vertebræ in the middle of the series are fairly well preserved.

The centrum is 1·7 centim. long, very slightly concave from back to front, with the articular margins moderately elevated. From side to side the external surface is well rounded, and the transverse diameter is 2 centims.; towards the neuro-central suture the diameter contracts to about half as much in the middle. The vertical depth of the articular face exceeds 1·5 centim.; it is conically excavated.

The neural arch is defined from the centrum by a transverse suture. It is high, rises along the whole length of the centrum, extends obliquely outward, so that this concavity forms a continued depression with the upper part of the centrum. Both anterior and posterior surfaces rise steeply, so as to form at the interlocking of two neural arches a circular foramen for the inter-vertebral nerve, which is given off high above the centrum, on a level with the transverse processes, so that its summit is fully 1·6 centim. above the neuro-central suture, and its diameter about 6 millims. The anterior border is concave between the base and the middle of the pre-zygapophysis, which does not extend in advance of the centrum, and has its facet looking inward. The superior, inferior, anterior, and posterior sides of the lateral part of the neural arch converge outward in a pyramid, and the angularities between them are lost in the rounded transverse process, which extends outward and a little backward for 1·5 centim. beyond the pre-zygapophysis, and terminates in a flattened facet for the single-headed rib.

The neural spine is inclined backward in position, so as to extend above the inter-vertebral foramen. It is prolonged upward and a little backward; is 1 centim. wide from front to back, though the measurement may be slightly more towards the free end, where it is imperfect; but its height from the inter-vertebral foramen exceeds 3 centims. The spine is compressed from side to side, and convex from front to back, so that the anterior and posterior margins are sharp. The post-zygapophyses apparently have an articular facet posteriorly, as well as laterally; the former is immediately above the middle of the transverse process.

The fragments of ribs on the other side of the slab are about 12 centims. long, curved, more than half a centimetre in diameter, and cylindrical.

In the large slab already referred to, as indicating the extent of the dorsal region, there are only seven dorsal ribs exposed; and I infer, from the absence of ribs in the lumbar region, that three or four vertebræ anterior to the sacrum may in some specimens have been without ribs, though other larger fossils appear to have the ribs extending to the sacrum.

Caudal Vertebræ of Platypodosaurus. (Plate 17.)

The only known example of the tail of an Anomodont is the specimen described by Sir RICHARD OWEN* as a mass of matrix, including part of the sacrum and pelvis, with ten anterior caudal vertebræ, probably a species of *Dicynodon.* It is from Fort Beaufort, a locality which yielded the skulls of *Dicynodon Bainii*, *D. pardiceps*, and *D. feliceps*, and it may not improbably be referred to one of these species. Unfortunately, the vertebræ have been separated from the sacrum and pelvic bones. The original description of the vertebræ is brief, and the figure unsatisfactory. The following notes contribute to a knowledge of this region of the vertebral column.

The specimen includes eleven vertebræ, and measures 31 centims. in length. The vertebræ progressively become smaller and shorter. All the earlier caudals have strong transverse processes, which are directed outward and very slightly downward, but the processes, which are separate ossifications, disappear from the later vertebræ. Where the transverse processes begin to decline, strong short chevron bones begin to be developed. These bones are massive, as though they supported the weight of the tail, and are in close contact with each other, but rapidly diminish in size, as though the tail only included about five more vertebræ; though the total number may have amounted to twenty.

In the first four vertebræ, each centrum is 3 centims. long. In the next three, each centrum is 2·6 centims. long, the eighth and ninth are each 2 centims., the tenth 1·9 centim., and the eleventh about 1·7 centim. long.

With this shortening in length, the whole aspect of the vertebræ gradually changes. At first the centrum is evenly convex from side to side below the transverse processes, and somewhat markedly concave from front to back. The margins of the centrum are sharp. Its depth is 6·3 centims., and its transverse width about 5·7 centims., and the transverse measurement below the bases of the transverse processes is 4 centims.

At the base of the fifth centrum, on the posterior border are two strong tubercles with a transverse measurement of nearly 3 centims., and a strong groove between them. On the sixth centrum the tubercle on the right side is elongated into a process directed downward and inward; on the left side the process is lost, being separated by suture from a large rounded boss. This is the beginning of the chevron bones. The chevron bones in the seventh and succeeding vertebræ are similar to each other. Each is a V-shaped bone which appears to articulate by two facets on the posterior face of the centrum. The transverse width over these processes is at first about 3·8 centims., and in the last vertebra preserved it is reduced to about 2·6 centims. In lateral view the processes are directed downward and backward; below the attachment their sides converge downward with a slight lateral concavity, and the anterior and posterior borders are strongly concave, so that the extremities of the bones are expanded from front to back. The length of the chevron bones is

* 'Cat. Foss. Rept. of South Africa,' 1876, p. 73.

in the first four about 3·5 centims.; the fifth is imperfectly preserved, but probably shorter. The antero-posterior extent of the basal expansion of each bone is about 2·4 centims., convex from front to back. It is also convex transversely, and wider behind than in front; the posterior transverse measurement in the second bone is 1·5 centim., the corresponding anterior measurement is about 1 centim., but in the later bones the surface appears to be becoming a rounded boss.

The neural arch is comparatively small, and is rapidly reduced in size in the later vertebræ. The strong pre-zygapophysial processes extend upward and forward as far as the middle of the centrum of the preceding vertebra; they are convex externally, with the articular facet vertical, and looking inward, so as to receive the post-zygapophysial wedge between them. This wedge in the earlier caudals is about 1·8 centim. wide; the bone above it rises into a neural spine, which is broken away, except for an indication that its moderately convex sides converged forward into a sharp anterior ridge which inclines backward as it ascends. The transverse width over the pre-zygapophyses in the earlier caudals was about 4 centims.

As the rounded pre-zygapophysial ridge descends it becomes constricted a little from side to side, and deeply concave on its anterior margin, to form the inter-vertebral foramen, and less concave on its posterior border, and then is directed outward, to form the base for the transverse process. This process is here a separate ossification or caudal rib which is attached high upon the side of the vertebra, partly on the neural arch and partly on the centrum; the depth of this attachment appears to increase to the fourth and fifth caudal vertebræ, where it exceeds 3 centims. The third and fourth processes are between 5 and 6 centims. long. The superior surface of the process is convex from front to back, and narrows as it extends downward and outward to the compressed free end, which is 1·5 centim. wide, and less than half a centimetre thick. Its anterior and posterior margins are sharp, with these ridges placed superiorly, so that the inferior surface is the more convex. In the later vertebræ the transverse processes appear to be inclined a little backward; they obviously have small basal attachments, but appear to have been lost from the last five vertebræ. The centrum was deeply concave in the early vertebræ, but there is an appearance like that seen in the vertebræ referred by OWEN to *D. tigriceps* (Plate 16, fig. 2), only less marked, as though the substance of the notochord were in process of ossification, a condition which I regard as showing that relative depth or flatness of the articular face of the centrum can have no value as a generic character (Plate 16, fig. 3). The articular face of the last centrum preserved is only slightly concave, with a moderate central depression.

The neural canal is small, but it does not appear to decrease in size as it extends backward.

All record of the sacrum with which the specimen was associated had been lost. But, at my request, Mr. A. SMITH WOODWARD, F.G.S., made inquiries from which it results that Mr. BARLOW, the "mason" who developed the specimens, indentifies the sacrum and pelvis referred by Sir RICHARD OWEN to *Platypodosaurus robustus* as the missing fossil. I have attempted to fit the specimens together; but the caudal vertebræ are larger than might have been expected from the size of the sacrum, and a vertebra or two must be missing if the specimens are parts of one animal. On this point there appears to be no doubt, since Mr. WILLIAM DAVIES, F.G.S., who superintended the development, states that he remembers the association of this tail with the remains which were subsequently referred to *Platypodosaurus*. The generic difference of this pelvis from the forms which have been attributed to *Dicynodon* is obvious; but it is not improbable that a skull already referred to *Dicynodon* may be associated with the remains.

The Scapular Arch.

In all Anomodonts the scapular arch probably includes the same elements, which are:—an inter-clavicle, clavicle, scapula, pre-coracoid, and coracoid. In some types there is a sternum also, but there is no reason for supposing that this bone is always ossified. In mode of grouping and arrangement of the bones there is a close resemblance to the Monotremata, the only group in which the pre-coracoid is similarly distinct. But in *Procolophon* it will be shown that there is a sutural union between pre-coracoid and coracoid; not unlike that which has been demonstrated in other Anomodonts, and this leads me to believe that the ordinary Reptilian type of coracoid, which is perforated in many types exactly as is the pre-coracoid, is probably the result of the obliteration of that suture, so that the coracoid in Reptiles may be held, especially when perforated, to comprise both bones; and, therefore, the persistence of the pre-coracoid suture in Anomodonts may rather indicate a line of descent than a direct affinity; and, judging from absence of the suture in some Amphibians, like *Cryptobranchus*, in which this part of the skeleton may be unossified, I am not disposed to regard division of this element into pre-coracoid and coracoid as conclusive against Reptilian affinity, or as showing affinity with Monotremes, which might at first have been surmised. The difference from both Reptile and Mammal is, however, of an ordinal kind; and, so far, the Anomodont characters help to show that only one more ordinal type is required to complete the gradation between these classes. The united pre-coracoid and coracoid in *Procolophon* make a bone elongated in the antero-posterior direction, which may be compared in length and form with the coracoid of Plesiosaurs and certain Ichthyosaurs, and among existing Reptiles with *Hatteria*.

On the Anomodont Scapula.

The scapula appears to be more variable than any other bone in the Anomodont skeleton. In *Keirognathus cordylus* I have described an elongated slender type, like the bone in *Kistecephalus*. The specimen No. 36,272 is imperfect at its junction with the coracoid (Plate 15, fig. 4), but shows a distinct constriction or neck, external to the articulation, because a moderate acromion process is developed on the anterior margin;

and the bone widens in a wedge-shape as it curves backward and inward. The external surface is concave from side to side, and the internal surface is convex in the same direction. The posterior margin is thickened, and the anterior margin compressed, and both these margins are concave in length. The free end of the bone appears to be convex from side to side.

The bone figured by Sir R. OWEN as the scapula of *Dicynodon leoniceps* ('South African Catalogue,' Plate 70, fig. 1) is essentially of the same type, but with the wedge-like blade relatively more expanded towards its extremity. The posterior border appears to be thickened, and the anterior margin is compressed and thin ; but the acromion is not seen, probably because only the internal aspect of the bone is exposed, and the proximal part of the anterior border is invested in matrix. The internal or visceral aspect is bow-shaped in length, and the strong concavity may be supposed to correspond with the external curvature of the ribs. The bone is 28 centims. long. Its proximal end is thickened, and 11 centims. wide. It is divided by a short deep notch or groove into two articular parts, a posterior portion about 7 centims. wide, which gave attachment to the coracoid bone, which is not preserved, and an anterior part over 4 centims. wide, which articulated with the pre-coracoid, a bone represented in Sir R. OWEN's figure, but described as coracoid. It is stated that the coracoid exemplifies the broad and short type with the large "axillary" perforation (p. 35). But, although this specimen is described as the articular end of the right scapula with "the coracoid," it seems to me that the entire length of the scapula is preserved, though the proximal anterior corner of the bone is broken away. The pre-coracoid is imperfect, and too imperfectly preserved to give any idea of its shape. The anterior margin is very thin. Opposite the perforating notch in the scapula is a corresponding large U-shaped notch in the pre-coracoid, which appears to be what is commonly termed the coracoid foramen. It is about 2·5 centims. deep and 2 centims. wide.

Another specimen, No. 36,272, I regard as the left scapula and pre-coracoid, both very imperfect and exposing the external surface of both bones. The scapula is only preserved as far as the acromion process, which curves forward and downward, so making a flattened transverse surface for the clavicle to rest upon. It encloses a space between the clavicle and pre-coracoid. The scapular articulation is greatly thickened, semi-circular, transverse to the external surface ; and the internal surface for the coracoid widens the bone into a large sub-triangular mass. There is no external indication of division between the pre-coracoid and coracoid surfaces of the bone, except that the pre-coracoid plate is obviously compressed and thin. The clavicle is sigmoid, expanded at the ends, which are at right angles to each other.

Coracoid Bones of an Anomodont. (Plate 15, figs. 5, 6.)

A specimen numbered 36,286 consists of a pair of coracoids. On the ventral surface, stretching in a line at right angles to the anterior margin of the left bone, are four dorsal vertebræ, a good deal flattened and distorted, which extend, as preserved, over a space of about 8 centims., but they lie about half a centimetre apart, each centrum being 1·5 centim. long.

I presume that the pre-coracoid joined the straight suture on the anterior margin; that the inter-clavicle joined the internal margin, which is exceedingly thin; and the thicker posterior margin joined the sternum. The bone has a thickened ovate external articular area, 3 centims. deep and 2 centims. wide, which gave attachment to the scapula by a large surface, and contributed with it to form the glenoid articulation for the humerus. In form it may be regarded as a segment of a circle, with the convex border facing toward the inter-clavicle, and the humeral articulation forming the narrow border toward the centre of the circle. The greatest transverse width of the bone is about 6·3 centims. The greatest antero-posterior extent is 7 centims. The internal border is regularly convex from front to back; it is thin, not more than 4 millims. thick in the middle, but becomes about a centimetre thick at the posterior extremity. This thickening is seen on both sides of the bone, and it helps to define the concave visceral surface of the internal aspect, as well as a slight concavity on the posterior part of the external aspect, besides giving rise to a flattened oblique posterior area a centimetre wide, which looks backward, outward, and upward. The extreme measurement from the posterior extremity of the bone to the humeral surface (in a straight line) is 5·5 centims., but the posterior outline of the bone is concave, forming a wide arch behind the articular surface for the humerus, with the contour straightening as it extends backward, and ultimately rounding convexly on to the internal margin of the bone.

The nearly straight anterior margin of the bone is less than 4 centims. long.

Immediately behind the articular surface is the pre-coracoid notch, about half a centimetre wide and nearly as deep, which contributed the posterior border to a foramen, part of the contour of which was formed by the pre-coracoid, and part by the scapula. The straight anterior sutural border is narrow, transverse to the axis of the bone, concave on the visceral surface, convex externally, 7 millims. thick. At this notch the extent of the bone from front to back is about 3 centims., and at the articular surface it measures a few millimetres more. The anterior and superior part of the surface gave attachment to the scapula, while the ovate postero-inferior surface was for the humerus.

The Left Pubic Bone of Titanosuchus ferox. (Plate 16, fig. 4.)

The forms of pubis among Anomodonts vary chiefly in the position and direction of the perforating foramen and extent of union with the ischium. Sir R. OWEN has catalogued one type* as "the coalesced humeral ends of the right scapula and coracoid of *Pareiasaurus bombidens*" from Vers Fontein; and has given the same osteological interpretation to a similar specimen referred to *Dicynodon leoniceps,* from Graaff-Reinet. In these specimens the obturator foramen is narrow and extended transversely; its direction is inward and upward.

Another type is seen in the specimen described in the same catalogue as the left os innominatum of *Dicynodon leoniceps,* Plate XXVIII. Here the obturator foramen of the pubis has a more anterior position, and is directed obliquely forward so as to emerge on the inner side of the anterior margin of the pubic bone (Plate XXVIII., fig. 2).

The bone now to be described (Brit. Mus. 49,367) approaches in general character to the latter type, but is larger, is pierced by the foramen for a greater antero-posterior distance, while the anterior opening of the foramen is hidden by a sharp anterior border to the bone. The narrow transverse median articular surface, about 2·5 centims. thick, by which the pubes met in the median line, would indicate that the position of the bone was ventral and horizontal, and nearly at right angles to the ilium.

The bone is greatly thickened at the acetabular end, where it unites with the ilium; but it is otherwise a moderately thin plate, slightly concave between the acetabulum and the median suture, measures 20 centims. wide, and is convex from front to back anterior to the obturator foramen. The anterior margin is strongly concave, but the concavity, which is 7 centims. deep proximally, becomes narrower distally, and twisted inward so as to merge in the visceral surface, which is saddle-shaped at the anterior end, and otherwise flattened, so that the two opposite sides converged downward in a broad V-shape.

The articular end, which is sub-triangular, with the short side in front, is about 20 centims. long, by 12 centims. deep. It is divided by a longitudinal angle into an inferior acetabular part, about 7 centims. deep, and a superior iliac surface of similar depth, which was longer.

The posterior or ischiac border of the bone is fractured, so that it is not possible to judge of the exact size of this transversely sub-ovate bone; but the anterior extent of the ischio-pubic symphysis is a distinction from the Dicynodont types, while the relatively small size of the pre-pubic tuberosity is a distinction from *Phocosaurus.* That tuberosity may be indicative of affinity; for, if it covered the whole anterior border of the bone, the Anomodont pubis would be more easily compared with that

* 'South African Catalogue,' p. 11, p. 35.

of a Plesiosaur, though I have as yet seen no Sauropterygian in which the obturator foramen passes through the pubis, or in which there is an extended sutural union between the pubis and ischium.

The Limbs of Eurycarpus Oweni (SEELEY). (Plate 18.)

The only evidence of the relative size of the limbs as compared with the vertebræ, in addition to the specimen of *Keirognathus cordylus,** is afforded by a sandstone slab 47 centims. long, which is a natural mould including the neural arches of the anterior part of a vertebral column with a number of dorsal ribs. It appears to show the femur, and the whole of the fore-limb. Isolated parts of this slab, showing the fore-limb and those vertebræ which have ribs attached, have already been figured by Sir R. OWEN in the 'South African Catalogue,' Plate 52, pp. 53, 54, regarded as Dicynodont. When the digits from this specimen were reproduced in 1880, the figure was described as (?) *Dicynodon* ('Geol. Soc. Quart. Journ.,' vol. 36, Plate 17, fig. 5, p. 424). I am unable to detect evidence which would prove the animal to be Dicynodont, for the only data for comparison are the imperfectly displayed humerus and dorsal vertebræ; and in neither are the characters such as have been found in *Dicynodon* or its known allies. The humerus appears to have much in common with that of *Euchirosaurus*, but is of a different generic type, and may conform to the Anomodont plan. The vertebræ are too imperfectly exposed to show the relation of the centrum to the neural arch; and, although the neural spines are very short, and the transverse process short and stout, there is no vertebral character to show that the animal was not an Anomodont. An impression from the slab gives a deceptive appearance of lozenge-shaped dermal armour, which results from fracture of the stone. Although armour is characteristic of Labyrinthodonts, there can be no reason why it might not be present in an Anomodont. Some of the bones of the skeleton were incrusted with a concretionary film, and this has adhered to the ulna and radius, and part of the femur, and to a large sub-triangular bone anterior to the humerus and parallel to the cervical vertebræ, so that the casts of those bones are not sharp. The latter sub-triangular bone appears to resemble the inter-clavicle of *Pareiasaurus* in form, though its position is that of a scapula; and it is too imperfectly exposed to be determined with certainty. It is about 10 centims. long, and 4 centims. wide in the middle, with each of the three sides concave. Taken in association with the other characters, the bone may well be an inter-clavicle, and the fossil would probably be a Pareiasaurian. Partly overlapping the humerus are fragments of bones of the shoulder girdle, but too imperfect for determination.

The neural arches of six dorsal vertebræ extend over 10 centims. The neural spines, which are very imperfectly preserved, appear to have been short in the dorsal region, and longer and more compressed from side to side in the neck. In a few vertebræ,

* 'Phil. Trans.,' B, 1888.

between the neck and the back, metapophyses appear to be developed. The zygapophyses are strong, prominent, directed upward and outward; they are separated by a deep notch. Below this notch is a strong, short, massive transverse process which is rounded superiorly, and to these processes I suppose the ribs to have been attached, though they are now displaced to a lower level. There is no indication of the base of the centrum, but, as the vertebral column is nearly straight, and the vertebræ vertical, they may be presumed to have the base flattened. The seven dorsal ribs are each about 14 centims. long, rather slender, curved, contracting at the abdominal end to about half the diameter, rounded on the under side, flattened above with a slight ridge on the posterior margin, which makes the side of the rib slightly concave. The last rib but one shows, apparently, the expanded articular end. It is concave from above downward so as to overlap the rounded transverse process, and the superior process of the rib appears to be perforated by a foramen. The depth of the articular end is 7 mm.

The distal end of the femur apparently, with its (?) proximal end seen at one extremity of the slab, would show the bone to be 11 centims. long. The shaft expands towards the distal end, where it is about 3·5 centims. wide, convex transversely on the superior side, with the articulation moderately rounded downward and backward, though the distal end is imperfectly exposed. The left humerus is short, about 5·5 centims. long, and broadly expanded at both proximal and distal ends, which are nearly at right angles to each other. The proximal end is about 4·5 centims. wide, with the articular surface extended transversely as in most Anomodonts, and a small but prominent rounded tuberosity in the middle of the superior margin. The radial margin of the proximal end is produced outward as a thin process more proximal in position than is usual. At 2 centims. below the proximal articulation, and well above the middle of the bone, is a large foramen on the radial side in the cast, about 7 mm. in diameter, but it is caused by a boss of phosphatic matter which adheres to the slab. The distal expansion of the humerus begins at a little more than 1 centim. below the proximal articulation, and it evidently developed a strong process on the external side, which is broken away, for the fractured surface is nearly 3 centims. long and about half as wide. The distal end was evidently compressed laterally on the Anomodont plan, but the articular surface is imperfectly exposed.

The radius and ulna cross each other, so that the proximal end of the ulna is thrown behind the radius, which thus becomes partly exposed at its proximal end. The radius is the stronger bone, 2·3 centims. wide at the articulation, which is transversely truncated. Its dimensions become smaller as it extends distally.

The ulna is 8·2 centims. long. It appears to have a slight sigmoid flexure, inclining a little forward at the larger proximal end, which is fully 2 centims. wide, and slightly backward at the distal end, which is about 12 millims. wide. The external surface is somewhat flattened. There is a doubtful indication of an olecranon ossification. The distal end is rounded. The bone is much more slender than the large Dicynodont bones already described, and there is no evidence whether its proximal end received the radius in the same way in a groove as in the bones presently to be described.

The hand is folded back so as to expose the inferior aspect of part of the carpus, the meta-carpus, and the five digits. The width at the carpus is fully 4 centims. and the length of the meta-carpus and phalanges is 5 centims. The entire length of the fore-limb is about 18 centims.

The distal row of the carpus appears to include four bones.

The meta-carpal bones become more elongated from the first to the fourth, and the fifth is only a little shorter. At the same time the middle of the shaft, which at first is scarcely defined, gradually becomes slender, though the terminal ends, and especially the distal ends, do not become narrower. The first meta-carpal is 9 millims. long, and nearly quadrate; the fourth is 3 centims. long. In the first digit there are two phalanges, in the others three phalanges. These bones are short and broad, well ossified, with well defined articular ends and lateral constrictions, but the terminal conical claw phalange is relatively large, and in the middle digit, in which it is longest, measures 1·6 centim., and in every digit it is longer than any other phalange. The claws curve a little downward, are rather flattened on the under side in front, and compressed behind.

The specimen may be named *Eurycarpus Oweni*.

Femur of Titanosuchus ferox (OWEN). (Plate 19.)

The limb bones which are marked in the British Museum Register as associated with the skull fragments named by Sir R. OWEN *Titanosuchus ferox*, comprise, besides smaller pieces, a femur and a humerus. The remains of the femur have been put together by the British Museum masons with great skill, and I have no doubt their restoration exhibits accurately the complete form of an Anomodont femur more perfect than that attributed to *Dicynodon leoniceps*. The specimen is numbered 49,368. It is a straight stout bone, flattened in the vertical or antero-posterior direction, and only moderately expanded at the extremities, as compared with the humeri of *Dicynodon*. Its extreme length from the articular head to the outer condyle is 61·5 centims. The shaft is most constricted in its lower third, and the proximal end is more expanded transversely than the distal end, and twisted a little inward so as to be inclined to it at a slight angle.

The inferior aspect of the bone is flattened, but for the development of the condyles at the distal end. The transverse width over the condyles exceeds 20 centims. The rounded convexities of the inferior surface are worn away. The inner or tibial condyle had a vertical extent of 14 centims., and a transverse width in the middle of about 8 centims. The fibular condyle is developed so as to extend 2·5 centims. distally beyond the other condyle. The posterior surface of this condyle has a vertical measurement at 11 centims., and a transverse measurement of about 9 centims. The inter-condylar space is 3·5 centims. wide, and extends as a shallow concave channel between the distal parts of the condyles; it rounds convexly on to the broad shallow saddle of the middle of the distal articular surface. The posterior surface of bone between the upper parts of the condyles is a shallow concavity, and the surface, which becomes flatter as it extends proximally, is slightly concave in length, but gives to the eye the aspect of being flattened. It is about 30 centims. long, and 9 centims. wide in the middle, and widens a little proximally and distally. Its external border is the external margin of the bone, which is concave in length, and forms a sharp ridge proximally, and is more rounded distally towards the condyle. Its internal border is a slight ridge which descends from the inner margin of the obturator pit concavely towards the outer border of the tibial condyle, without quite reaching it; so that it appears to divide the proximal half of the hinder surface of the bone into an external area, which is slightly concave, and an internal area, which is strongly convex, rounding on to the superior or anterior surface. The thickness of the bone through the condyles is about 12·5 centims.; while the thickness between the condyles is 10 centims. On the anterior aspect the inner condyle has a sub-globate form, well rounded; while the external condyle is laterally compressed so as to rise into a blunt ridge, which is prolonged for a third of the length of the shaft, and then subsides into a slight ridge which extends outward towards the proximal trochanteric extremity of the bone. This ridge defines the external surface of the shaft, which looks outward and a little upward, widens distally, is concave in length, and somewhat convex in the direction of thickness of the shaft. The narrowness of the proximal part of the lateral area is coincident with vertical compression of the proximal part of the shaft.

On the internal side of the distal end of the shaft there is a blunt longitudinal ridge, which makes the superior front part of the area concave, and the inferior posterior part longitudinally convex. This ridge, as it descends, is inclined backward at an angle to the axis of the shaft. The proximal part of the shaft widens on both the inner and outer borders; but the articular head is inclined, as usual, upward and inward, forming a large sub-hemispherical convexity, which inflates the superior anterior aspect of the bone, making it convex in the transverse direction, and concave in length, but flattened, or even a little concave, on the outer side. Seen from the proximal extremity, the articular head is sub-reniform, being rather concave behind. It is worn, but appears to be 20 centims. wide, and 10 centims. from front to back, so that it is somewhat compressed from front to back, and flattened posteriorly. It becomes narrower as it extends outward, and retreats in a convex curve. The region of the external angle or great trochanter is broken away, but the compression of the bone does not suggest the presence of any strong trochanteroid process.

The obturator pit is a shallow depression which is imperfectly excavated, which lies external to the median longitudinal ridge already described on the posterior aspect of the bone, and which dies away at about 14 centims. from the proximal extremity of the bone. The pit is limited inferiorly by a slightly elevated ridge with a concave border, 17 centims. from the proximal extremity, and not less than 6 centims. wide. There are some indications of a second, but slightly impressed, muscular attachment extending distally below this ridge.

The differences of this femur from the corresponding bone in the giant Salamanders of Japan are that in the living type the proximal half of the bone is rotated upward at right angles to the distal end and that the condyles are not ossified; but the result is that the trochanteroid processes on the under side of the proximal end similarly define a shallow pit, comparable to that of the obturator pit in the fossil. The ridge which ascends from the internal condyle to the trochanter may be identical in both types, so that, allowing for the difference in ossification, there is more similarity than might have been expected between the two types. In *Hatteria* the bone is less compressed in the shaft, and has a much greater development of the infero-anterior proximal trochanter. Sir R. OWEN has already drawn attention to the Monotreme characters in the Anomodont femur.

Humerus of Titanosuchus ferox (OWEN). (Plate 20.)

The humerus is a strong bone approximating to the ordinary Dicynodont type, with both proximal and distal ends greatly expanded, but more nearly in the same plane than in smaller animals. It is 53 centims. long, nearly 30 centims. wide over the distal condyles, and slightly wider over the proximal end. The lateral outlines are concave, so that the transverse measurement over the middle of the shaft is reduced to 13 centims. The specimen exhibits a remarkable development of the distal condyles on the inferior aspect of the bone, which is unparalleled among other Reptilia, the vertical extension of the condyles in the middle of the shaft measuring about 18 centims., or fully a third of the length of the bone. On this postero-inferior aspect the outline of the condyles is sub-triangular, with the angles rounded and the superior border convex from side to side, and rising sharply from the shaft. The convexity of the condyle in this region is absent, and the proximal part of the surface, on which a film of matrix remains, appears to be flat. The thickness through the shaft in this region is about 14 centims.; and the measurement is scarcely less through the globate radial condyle. The ulnar condyle is comparatively compressed, and not more than 7 centims. thick, but well rounded on the distal surface; in the transverse direction a moderately wide and shallow concavity divides the smaller ulnar region from the large radial region. On the superior aspect of the bone this concavity is developed as a shallow triangular area, about 15 centims. broad and as high, which is defined towards the radial side by a blunt ridge. The area is gently concave; the surface external to the ridge is about 10 centims. wide and flattened; the corresponding surface of the distal part of the shaft on the ulnar side is rounded convexly towards the lateral margin. Both lateral margins are sharp for some 10 centims. above the condyles, but the ridge is narrower, sharper, and more convex in its lateral outline on the radial side. Above the radial condyle on the inferior aspect the shaft is oblique, concave from above downward, and becomes somewhat concave transversely, distally, as it approaches the condyle. On this area, at 18 centims. from the distal extremity of the bone, 5 or 6 centims. above the sharp proximal termination of the condyle, and 3·5 centims. from the radial margin, is the supra-condylar foramen. It is about 1·3 centim. wide, and descends obliquely downward. A wide notch on the margin of the condyle towards the lateral ridge may have carried the vessel which issued from this foramen. The foramen is situate substantially as in *Cynodraco*, *Brithopus*, and *Hatteria*.

On the ulnar side, the distal part of the shaft is similarly flattened, concave from within outward, with a deep oblique groove facing laterally, defined by a ridge of bone extending over the depression. At 22 centims. from the distal end, and about 3·5 centims. from the lateral margin, is a foramen which appears to be of the same size as the supra-condylar foramen on the radial side. Distally, by the side of the sharp lateral margin, above the condyle, is a moderate longitudinal groove, which may have carried the vessel issuing from the foramen. This foramen is present in Dicynodonts and is found in *Hatteria*.

The proximal end of the bone is only preserved on the inferior surface. It shows the articular head to be well rounded and directed inward, and defined from the radial side of the bone by a deep concavity which extends to the middle of the shaft. The extreme measurement from the head of the bone to the ulnar condyle is 45 centims. The radial crest is prolonged proximally far beyond the head, so that the measurement from the proximal border to the extremity of the radial condyle is 54 centims. In the transverse direction, the space between the head of the bone and the radial crest is concave. The proximal extremity of the radial crest is about 14 centims. in transverse width, convex from within outward, and well rounded on the posterior border. It is about 6·5 centims. thick, and is reflected downward and forward, widening the bone, down which it extends for more than half its length, measuring about 33 centims. in length. It appears to become narrower as it extends distally, but the distal development is imperfectly preserved. Its external or anterior surface is gently convex in the vertical direction, smooth, and has an unbroken concave contour from the rounded summit of the crest to the condyle at the distal end, where the concavity is more marked, and also developed transversely.

The humerus shows some general approximation of plan to that of the giant Salamanders in the expansion of the extremities, the thickening of the distal end of the shaft, the superior concavity between the condyles, and the development of the radial crest.

In *Hatteria* the resemblance of the contour of the humerus to that of an Anomodont is so close as to amount almost to identity of plan, the chief differences being that in *Hatteria* the radial crest is much less developed and that the extremities of the bone are less massive.

Fibula of Titanosuchus ferox. (Plate 21.)

Right fibula.—A bone which was broken in two and has been restored exhibits a flattened hour-glass-like form, with oblique articular ends, a concave internal contour which shows a flattened ovate surface proximally, presumably for contact with the tibia, though a similar surface exists on the proximal end of the radius in No. 36,259, named *Dicynodon tigriceps* (OWEN.) The external contour is so much less concave as to be almost straight. The extreme length of the bone is about 29 centims., so that it was less than half as long as the femur. This is exactly the proportion in the giant Salamanders of Japan, and establishes the Amphibian proportions of the limbs in *Titanosuchus ferox.*

The proximal end is 12·5 centims. broad, and may have been as thick as the distal end, but the external surface of the proximal end is broken away. It appears to have been transversely ovate and convexly rounded. The inferior surface of the shaft is flattened transversely, but still is a little convex, while it is markedly concave in length. The transverse measurement in the middle of the shaft is less than 9 centims., and the thickness is there reduced to 5·5 centims.; but, distally, the bone expands in both dimensions. Its transverse width at the distal surface, which is imperfect towards the tibia, does not appear to have exceeded 12 centims., while its thickness may have been 11 centims. Its outline is sub-ovate. The articular surface is flattened in the antero-posterior direction, and oblique and convex from the tibial margin downward and outward. There is some appearance of the surface towards the tibia being inclined more obliquely inward, as though it had helped to support a tarsal bone which was lodged between the tibia and fibula. The distal end is greatly thickened on the inner side of the shaft. All the surfaces of the shaft are well rounded in the transverse direction, and moderately concave in the vertical direction.

The Ulna. (Plates 22 and 23.)

Besides the ulna, No. 43,525, catalogued by Sir R. OWEN as the right ulna of *Pareiasaurus bombidens,* there are two smaller specimens in the British Museum, registered respectively as No. 36,249 and No. 49,389. Taken in connection with the other specimens, these isolated examples demonstrate the nature and development of the epiphyses, and prove these elements of the bone to have been quite as large and as well developed in Anomodonts as in Urodeles, as far as external contour is concerned, for there is no trace of the epiphysial element having penetrated the shaft. Proximally, the fully ossified ulna is prolonged in a massive olecranon process, and this ossification included the whole of the concave articular surface. In the specimen 49,389, which was forwarded by Mr. BAIN with many bones which were referred to *Dicynodon tigriceps,* the surface is seen from which the epiphysis has come away; and it proves to be convex, and so even that the extent of the epiphysis it carried could not have been suspected without the evidence from the specimen 43,525. The distal epiphysis was quite as singular, for it comes away, leaving a concave surface on the shaft (Plate 23, figs. 2, 3), which has a sharp margin on the superior surface, and allows the epiphysis to extend for some distance proximally on what may be termed the inferior aspect of the shaft. In their well ossified character and large size, transverse separation from the shaft, and union with it in the adult, these epiphyses are unparalleled among Reptilia, and in all these respects are comparable to the similar ossifications in the long bones of Mammals. From the differences of proportion and form, the specimens 36,249 and 49,389 may be regarded as different species of the same genus, and provisionally referred to *Dicynodon*; but No. 43,525 differs in ways which may well be generic.

The specimen is 32 centims. long, and is a massive bone which terminates proximally in an olecranon process (Plate 22, fig. 1), which is larger than the expanded distal end, and helps to form the large obliquely concave articular surface for the humerus, which extends forward so as to widen the proximal end of the bone to about 22 centims., while the width of the distal end is 13 centims., and the least width of the shaft, at 10 centims. from the distal end, is 9·5 centims.

The internal aspect of the bone is comparatively flat, being slightly concave in length and slightly convex transversely, with the proximal and distal borders slightly elevated. The impression on the upper part of the bone is the result of crushing.

The anterior border between the proximal and distal articulations is 17 centims. long, straight in the middle, and becomes curved forward at each end towards the proximal and distal articular surface.

The posterior contour of the shaft is concave at the distal end, but diverges backward as it extends proximally, and becomes a convex curve, which is continued on to the proximal surface of the olecranon.

The bone is compressed from side to side, but a rounded ridge extends longitudinally down the middle of the external aspect of the bone, commencing at the anterior external corner of the proximal articular surface, and running distally and a little inward, widening as it goes, so that distally it only makes the bone transversely convex, while proximally it divides the bone into two lateral portions, which meet each other at an angle. The posterior of these surfaces is about 26 centims. long, 11 centims. wide proximally, and 7 centims. wide distally; flattened, but slightly concave in length, and at the proximal end slightly concave transversely. A narrow posterior area separates this lateral surface from the internal surface, towards which it approximates as it extends outward; it is 5·5 centims. wide proximally, where it passes on to the proximal cartilaginous surface of the olecranon, but becomes narrower distally, and in the middle of the length the limiting angles of this surface, which looks obliquely outward, have disappeared, and the bone is transversely rounded. Distally, it is a groove margined by sharp short tubercles or ridges, defining a channel about 3 centims. wide. In *Dicynodon* this posterior area does not appear to exist.

The antero-external lateral area is much shorter, since it is limited proximally by the tranverse articulation. It is about 10 centims. wide, and deeply concave proximally, forming an excavation for the head of the radius ; but distally its width is reduced to one-half, and the bone, which is flattened transversely in the middle of the shaft, becomes convex transversely above the distal articulation. This surface meets the internal border of the bone in a sharp ridge.

The distal articulation (Plate 22, fig. 3) has a pear-shaped contour, narrow behind, and wide in front. It is oblique, extending distally several centimetres further on the inferior than on the superior border. Its extreme width is 13 centims., and extreme thickness 9 centims. It is convex from back to front, the convexity increasing anteriorly and inferiorly ; but the outer part of the bone is somewhat concave in the transverse direction.

The proximal extremity of the olecranon (Plate 22, fig. 2) is sub-quadrate, being 11 centims. wide by 9 centims. thick at the articulation, and 6 centims. thick at the posterior border. It is defined by four straight borders, is convex superiorly in both dimensions, and its rugose surface gives every appearance of being cartilaginous.

The proximal articulation is imperfectly freed from the matrix, but it consists of an internal part 14 centims. long, and an external part about 10 centims. long, so that internally the bone extends forward as an angular process 6 centims. wide, where it merges in the mass of the articulation. The inner part of the articulation extends further proximally than its external part, and on the middle of the posterior half of this surface is a strong sharp-rounded ridge, which was received into a corresponding groove on the distal end of the humerus.

There is something very Mammalian in the character of this proximal articular surface ; but it is perhaps the character of all others in which the Anomodont type approximates to a Dinosaur.

Small Bones of the Extremities of Titanosuchus ferox. (Plate 24, figs. 1, 2.)

Two small bones, numbered 49,367, were collected with the other remains of *Titanosuchus ferox* (OWEN). Their forms are such that they may be phalanges, or carpal or tarsal bones, for in contour they resemble carpal bones of some Plesiosaurians, but are much thinner than might have been expected from the massive character of the larger limb bones. I regard the larger of the two bones as probably an external phalange, and the smaller as a middle phalange.

The larger bone is compressed, sub-quadrate, but broader than long, with concave lateral margins, long and narrow proximal and distal articular surfaces, which somewhat approximate towards one side of the bone. The external or superior surface is concave transversely, and gently concave in the vertical direction ; the inferior surface is flat.

What I suppose to be the proximal surface is 6·5 centims. long, transverse to the axis of the bone, and inclined obliquely in the transverse direction, so that the length of the bone towards what may be the external side is 6·7 centims., and towards the other side about 5 centims. This articular surface is smooth, flattened, slightly convex in transverse width, and about 2·5 centims. thick in the middle, becoming narrower towards each side.

The distal articular surface is 7·3 centims. wide, and more than 3 centims. thick. It is convexly rounded in the vertical direction as well as at its external corners, but so that the larger part of the articular surface lies towards what I regard as the inferior aspect. An impressed groove appears to margin the superior limit of the articulation, but the extremities of the bone are slightly worn or weathered. The external lateral border of the bone is a sharp ridge formed by the superior surface curving down concavely, so as to depress the inferior surface. The internal lateral border is relatively thick, and traversed by a longitudinal groove. This groove, like a small notch on the external side, I suppose to be for ligaments connecting the phalange, which moved on the sub-cylindrical convexity of the distal surface.

The second phalange is smaller. It also is compressed and sub-quadrate, with concave sides, and the proximal and distal surfaces expanded. The proximal surface is oblong, 5·8 centims. long, 2·6 centims. thick, with the ends rounded. It is transverse to the length, but irregular, so that it is convex transversely towards one side, and inclines to be concave in the same direction towards the other side. The extreme length of the bone is 5·7 centims. The superior surface is still covered with matrix, but was concave vertically, and slightly convex transversely. The inferior surface was similar, but flatter transversely. The distal end is thickened, having a depth of at least 3·5 centims., with the superior and inferior margins straight, and nearly parallel. It is 5 centims. wide. It is strongly convex transversely, with lateral impressed grooves towards the upper part of the articulation for ligamentous union with the adjacent phalange. The inferior surface of the articulation is oblique and flattened and extends proximally, so as to give the sub-trochlear facet a length of 2·5 centims. The superior border of the articulation is broken away. The sides of the bone are thickened, and appear to be vertically rounded.

The Tibia. (Plate 25.)

A specimen from JAN WILLEM'S farm, registered as No. 43,525, determined by Sir R. OWEN as the right tibia, was referred to *Pareiasaurus bombidens.* The only other specimens from this locality are certain vertebræ, determined as dorsal and caudal ('South African Catalogue,' pp. 10, 11); unless the fossils described as *Tapinocephalus Atherstoni* (OWEN) from a locality "four miles from JAN WILLEM'S Fontein," should be part of the same series. But, from the care with which localities are recorded, it is doubtful if there is any warrant for associating this bone with the remains of the skull of *Tapinocephalus.*

The right tibia is a short, massive bone, which shows a small lateral surface at the proximal end for contact with the fibula. Its extreme length from the anterior proximal process to the end of the internal distal talon is about 30 centims.; the least measurement between the proximal and distal articular surfaces at the posterior external angle is 15 or 16 centims.

The proximal surface is sub-triangular, with the posterior and external borders straight, each about 13 centims. long, and meeting at a right angle; with the external anterior border convex and rounding on to the adjacent sides. The transverse oblique measurement over this part of the proximal surface is nearly 20 centims. The articular surface is flattened, but crossed from front to back by a blunt ridge, at about 7 or 8 centims. from the outer border, which corresponds to the groove between the condyles of the femur, and makes a division of the proximal articular surface, which inclines the lateral surfaces to each other in a way seen in Mammals, with a slight anterior eminence extending between them.

The smaller external condylar surface may have been supplemented by the fibula. There is some indication of the large convexity which extends anterior to the articular surfaces being formed by a separate ossification, in which case it might correspond to the patella, but the indication is so obscure that no weight can be attached to it. The anterior proximal border is rounded, and the posterior border is sharp and prominent.

The shaft contracts so that its least measurements are below the middle, where the transverse width is 8 to 8·5 centims. The sides preserve their individuality fairly well; and they expand distally to form the remarkable distal articulation, which has a transverse sub-ovate contour, but develops an anterior process on the middle of the anterior margin. The inner half of the surface is an oblong convexity which is prolonged distally for 3 or 4 centims. below the flattened external half of the articulation. The transverse measurement of the distal articulation is about 15 centims., and the antero-posterior measurement about 13 centims. On the anterior border, a distinct notch in the middle reduces the antero-posterior measurement of the flattened part of the articulation to about 10 centims. Thus, a large process, comparable to the talon of the Mammalian tibia is well defined, and, taken in connection with the character of the proximal end, gives a Mammalian character to the tibia which is unparalleled among Reptiles, and is more remarkable than the Mammalian character of the femur.

There is no evidence of the genus to which this bone should be referred. It may be new or it may be *Pareiasaurus* or *Tapinocephalus*.

Procolophon trigoniceps (OWEN). (Plate 9, figs. 7, 8, 9.)

No specimen has hitherto given an adequate idea of the structure of the skull in *Procolophon* or evidence of its systematic position; and, if I am able to improve upon previous knowledge, it is because the skill of Mr. RICHARD HALL, Mason in the

British Museum, in relieving Dr. EXTON'S specimen from the matrix, has shown the characters of the fossil in a way which leaves nothing to be desired.

Procolophon differs widely from Dicynodontia, Gennetotheria, and Theriodontia in the structure of the skull, for it possesses no proper temporal fossæ. It approximates towards the Pareiasauria in features such as the expansion of the parietals roofing in the back of the skull and the elongation of the roof bones of the head; and is remarkable for the large size of the epi-otic and quadrato-jugal bones. But, on the other hand, the shoulder girdle is dissimilar. There is a large parietal foramen. The palate is very dissimilar in construction to that of a Dicynodont, and, apparently, unlike *Pareiasaurus* in details; so that the genus becomes the type of a new group, which is, in some respects, intermediate between the Pareiasauria and Dicynodontia, and cannot be placed in either sub-order. It is the type of the Procolophonia.

The skull is sub-triangular, 4·7 centims. long, with the transverse posterior outline straight, and measuring 3·5 centims. from one epi-otic horn to another. Anterior to these small posterior angles, the postero-lateral contour is a concave notch, owing to the extension outward of the squamosal and quadrato-jugal bone. This post-quadrate concavity is about half a circle, and its curve extends forward to a line with the back of the orbit, or the middle of the parietal foramen. The great lateral expansion anterior to this notch is made by the quadrato-jugal bone; and these bones widen the back of the skull to upwards of 5 centims., for the median measurement to the one side on which the preservation is perfect is 2·7 centims. Then the lateral contours converge forward, with a moderate constriction towards the front of the orbit, terminating in a blunt snout about 1·1 centim. wide below, but the anterior extremity containing the nares is lost.

Superiorly there is a slight bevelling toward the occipital surface, a horizontal flattening of the parietal and frontal region, a rounding of the nasal and pre-frontal area, and an oblique extension outward and downward of the bones below the orbit.

The circular parietal foramen is 0·4 millim. in diameter, and 9 millims. in advance of the back of the skull. The orbits are longitudinally ovate vacuities, 2 centims. long; 1·4 centim. wide in front, between the frontal and malar, but narrower behind. The least width of the inter-orbital space is rather less than 1 centim. The bones which surround the orbit are the malar, post-frontal, parietal, (?) supra-orbital, pre-frontal, and lachrymal.

The bones on the two sides of the head are not absolutely identical, partly owing to slight differences of form, and partly from differences of preservation.

The parietal bones are large and irregularly subquadrate, with a transverse angular bend separating the somewhat narrow, posterior inclined, occipital area from the flat, transversely extended, parietal area, which includes the parietal foramen, by narrow processes which extend convexly forward between the frontals to enclose it. The median suture between the part of the parietals behind the foramen is a zigzag of one angular bend to the right, followed by a similar angular bend to the left. The transverse width of each bone posteriorly is 1 centim. to the position where it is overlapped on the posterior corner by the epi-otic bone, but it becomes wider anteriorly, since it extends into the posterior corner of the orbital vacuity, where the width is half as much again. The extreme antero-posterior measurement in the median line is 1·4 centim.

There appears to be a small ossification between the posterior angle of these bones on the inclined occipital surface which may be the inter-parietal. Laterally, the parietal meets three bones, of which the most posterior is (1) the epi-otic, which rests upon the parietal; and (2) the squamosal, which is in contact with (3) the post-orbital. Anteriorly, the parietal is in contact with the frontal and post-frontal bones, and there is no evidence of division in the part of the parietal in front of the foramen.

The occipital surface of the skull is not seen.

The frontal bones are a pair of flat oblong bones, almost as long as the orbito-temporal vacuity, divaricating a little posteriorly, and narrower in front. The median suture between them is undulating, 1·7 centim. long. The lateral branches of the bones extend outward and backward above the orbits, about as far as the middle of the parietal foramen; their posterior contour is concave, and the transverse width over the posterior angles is 1·4 centim. The extreme length of the frontal is 2·1 centims. The width of the bones diminishes anteriorly, by the wavy external borders converging to half a centimetre. The width in the narrow space where their borders enter into the orbits is 9 millims.

External to the posterior border of the frontal and partly overlapping the parietal, is a long narrow bone, 1·1 centim. long, pointed in front, and widening to 2 millims. posteriorly, which I regard as the post-frontal. There is no indication that it has any other relations than with those two bones.

Extending along the anterior border of the frontal is a sub-triangular bone, which widens as it extends forward, which is the pre-frontal. It is 1 centim. long, extends as far forward as the frontal, and is 7 or 8 millims. wide, wedged between the frontal and lachrymal, and meeting the nasal. In front of the frontal and pre-frontal are the nasal bones, which, owing to the state of preservation, are imperfectly defined. The suture is seen, by which they unite laterally with the maxillary bones, and there are indications of the median suture, so that they cover the superior convex pre-orbital area. Each is more than 1 centim. wide posteriorly and (as the extremity of the snout is lost) fully 1·5 centim. long.

The post-orbital arch commences with the large sub-triangular bone whose extremity forms on each side the lateral posterior angle of the skull. The surface of the bone is convex from front to back, and its angular extremity is inclined downward, outward, and backward. It rests by squamous overlap upon the posterior border of the squamosal and the external surface of the parietal. Its relative size is comparable with the same bone in Labyrinthodonts, and is much greater than in *Pareiasaurus*, and altogether more conspicuous than in Dicynodonts, which usually have the bone chiefly on the occipital plate. It is about 8 millims. in length and width, with the external margin slightly concave, and the inner border slightly convex.

The bone which is anterior to the epi-otic is in contact with the external process of the parietal, and is hence named the squamosal. It is oblong, and inclined obliquely, downward, forward, and outward. Its inferior margin helps to define the posterior post-quadrate concavity of the skull. It is 1 centim. long and less than half as wide. Its superior anterior border helps to give attachment to a slender bone which extends from the external angle of the parietal to the malar, and forms the postero-inferior border of the orbit. That bone is about 1·2 centim. long and 2 millims. wide. Its inferior border is concave and helps to enclose a small oblong vacuity between it and the squamosal behind and the malar below. This vacuity might correspond with the position of the bone which I term supra-quadrate—the supra-temporal of OWEN and some authors. Below the squamosal is the quadrate, which has already been shown in other species to be compressed from front to back. It descends as a vertical pedicle, which lies below the hinder part of the orbit, and has its chief extension below and behind the malar. It is well seen on the inner side of the jaw, where it sends a strong process inward and upward to the pterygoid bone, and its rounded distal articular end is exposed externally by fracture on the left side; but it is otherwise completely hidden from view by the enormous quadrato-jugal bone, which is imperfect on the left side from being broken away. It is perfectly preserved on the right side, where it extends downward, outward, and backward, terminating posteriorly in a tuberosity which terminates the semi-circular contour of the post-orbital excavation. The form of the bone is obliquely sub-quadrate, 1·4 centim. high, and about 1 centim. wide, with the posterior border concave, and the anterior border convex. It is convex from above downward, where the lower extremity is reflected inward, but does not descend to the articulation so as completely to hide the quadrate. It is remarkable that the quadrato-jugal has a considerable extension behind the quadrate bone.

The malar bone, which forms the inferior border of the orbit, is an irregular crescentic bone, which is concavely constricted in the middle, and is in contact with the maxillary bone below in front, where it tapers away to meet the lachrymal at the anterior corner of the orbit. On the corresponding posterior surfaces it meets the quadrato-jugal below and the post-orbital behind. It contributes with the maxillary in front and the quadrato-jugal behind to define a concave and somewhat angular excavation of the contour of the head below the orbit. The malar extends behind the maxillary; its length is 1·7 centim.; its depth at the middle constriction is 1 or 2 millims.

The maxillary bone, as preserved, measures 2·1 centims. on the right side, but appears to be shorter on the left. The surface of the bone is concave from front to back, and convex from above downward, where it is 8 millims. deep, with a superior convex contour. It extends back somewhat beyond the alveolar border; and above the alveolar border it contains one or two comparatively large vascular foramina. There are six teeth in each maxillary bone. They differ in no way from similar teeth already described. Anteriorly they are 3 millims. long, posteriorly are a little shorter, are cylindrical, terminate in conical points, and have slightly expanded bases, which are in close union with the jaw. The interspaces between them are about a third the diameter of the teeth. They contain sub-cylindrical cavities. The summits, or crowns, of the lower jaw fit into the interspaces between the conical summits of the crowns of the maxillary region, and their form is not defined. The pre-maxillary bones are imperfectly preserved. They were short, as in other specimens, presumably divided the nares, were divided medially, and each contained three teeth, which were rather longer than those in the maxillary bone, and extend in front of the corresponding teeth of the lower jaw. The shortness of the pre-maxillaries gives a truncated appearance to the snout, since their teeth extend transversely.

The lower jaw is in natural articulation with the skull. The rami are loosely connected, 4·1 centims. long, and diverge backward, so that the transverse measurement at the quadrate region is equal to the length of a ramus. Each ramus is slightly curved, consequent on a slight convergence inward, to make the rounded narrow symphysial union; there is a slight inflection in the articular region, and a slight bulging outward below the malar region.

The lower jaw is comparatively stout, being half a centimetre thick, and it has a convex appearance on the external surface, and a flattened appearance on the internal surface. It is deepest (1 centim.) below the hinder end of the maxillary, where the dentary terminates in a slight coronoid elevation, in the middle of the length of the jaw, which divides it into an anterior slightly concave tooth-bearing border, and a posterior slightly convex area. From below this point the jaw decreases in depth, both anteriorly and posteriorly, to less than half its depth in the middle.

The jaw has lost some of the external bone substance, but appears to include five bones. First, on the external surface is the dentary, which forms the whole of the anterior tooth-bearing half. Posterior to this there is a long superior bone, extending back almost to the articulation, which I regard as the coronoid. It is divided by a longitudinal suture from an inferior bone, which extends much farther forward than the coronoid, and forms the sharp inferior ridge on the base of the hinder part of the jaw, which I regard as the angular. On the inner side of the jaw two other bones are seen. First, the articular, which is inflected inward to form a process like that seen in Birds and some of the lower Mammals. This bone extends forward so as to cover the hinder half of the jaw, barely reaching its base, for the angular is seen below it; and at its superior termination in front a small bone is seen above it, which I regard as the internal extension of the coronoid. The whole depth of the dentary appears to be covered internally by another bone, which I regard as the opercular. It meets the articular by an oblique suture, which extends downward and backward; and at its inferior termination there is a conspicuous ovate vascular foramen.

There is a better preserved example of a dentary bone of a new species of *Procolophon* in the British Museum, R. 514, from Kl. Vogelstruisfontein, in the district of

Bethulie, presented by Heer H. S. VILJOEN, which is deeper and relatively shorter than other known jaws, and has the anterior tooth or teeth remarkably long.

The Palate.—The base of the skull is occupied by a large oblong median ossification in the position of the basi-sphenoid, which is 13 millims. in length, is traversed by a deep wide median longitudinal channel, is slightly concave from front to back and concave at the sides, so that the width in the anterior part of the bone is half a centimetre and it terminates in a pair of strong prominent tubercles, directed outward and forward, which give attachment to the pterygoid bones. The transverse measurement over them is 9 millims., and there is a saddle-shaped anterior concavity between these tubercles.

The posterior end of the basi-sphenoid is not perfectly exposed, and there is a possibility that it includes in its posterior part a basi-occipital element, but, if so, the suture is obliterated by ossification, as in the skull section figured (Plate 9, fig. 2), and it terminates in a pair of articular processes. At the posterior extremity of the median groove there is a small ossification extending convexly backward, but this is probably a sub-vertebral wedge bone of the atlas, such as is common in Ichthyosaurs, Plesiosaurs, and other Reptiles. From this angle a bone, partly destroyed, which I do not identify, extends outward and upward.

In front of the basi-sphenoid is an indication of a slight pre-sphenoid ossification, extending upward and forward, seen in an almond-shaped vacuity, 7 millims. long and 4 millims. wide, pointed in front and rounded behind, the sides of which are formed by the pterygoid bones.

The pterygoid bones are large ossifications of tri-radiate form. Each sends a flattened process backward and outward to unite with the pterygoid process of the quadrate; this is 3 millims. wide and about 1 centim. long. There is a wide angular vacuity between it and the basi-sphenoid, which opens backward. Another angular vacuity opens laterally between it and the massive transversely extended part of the bone which descends so as to be almost in contact with the coronoid element of the lower jaw. The transverse width posteriorly over each of the processes is about 1 centim., and the antero-posterior extent may be as much. The external part of this process is crossed by a line which may indicate an external ossification which would be the transverse bone. Anteriorly to these processes the bones converge forward, and unite by suture in the median line for a length of about 3 millims. The extreme antero-posterior extent of the bone is about 2·2 centims. The transverse processes are directed strongly downward at their outer and posterior margins. On the rounded border of the almond-shaped pterygo-sphenoid vacuity there is a row of pterygoid teeth, so placed that they diverge backward in a V-shape. The teeth have all been broken away, but I count the basal attachments of seven on each side.

In front of the anterior parts of the pterygoids are a narrow pair of bones which are not completely exposed anteriorly and only seen for a length of 9 millims. The transverse width over both does not exceed 5 millims. They are in contact throughout their length, and extend forward and downward. I have no doubt that they are the vomera. On each of these bones there were two rows of teeth. In each outer row there were about six ; their bases are folded like the teeth of Labyrinthodonts.

At the back of the lateral palatal vacuities between the vomera and pterygoids is a pair of small oblong, obliquely placed ossifications, which I regard as the palatines. They have been injured in excavation, but are 7 millims. long ; their width is not shown.

At the back of the palate there is a pair of rod-shaped bones, constricted in the shaft, truncated at the ends, which are 2 millims. wide, and with the longer 1·2 centim. long, which I have previously regarded as the hyoid. Their anterior ends converge forward, and are 1·5 centim. apart. They are shifted from the median line towards the left side in harmony with the shoulder girdle.

The Shoulder Girdle of Procolophon. (Plate 9, fig. 9.)

The bones of the shoulder girdle are very little disturbed, though the scapula is not exposed and the clavicle is only imperfectly preserved. But the inter-clavicle, pre-coracoid, and coracoid are exceptionally well seen, and situate immediately behind the back of the skull.

The inter-clavicle is the key to the arch. Owing to its anterior convexity, the bone has the form of a pick-axe. It is shaped as in some Labyrinthodonts, as in *Ichthyosaurus*, and many Lizards, but it has the form of a more elongated and slender capital T than has the bone in Monotremes. The transverse bar is about 14 millims. long, and the median bar is nearly 4 centims. long. The anterior margin of the median bar is convex, and reflected a little downward, so as to make the posterior half of the bar appear impressed. The limbs narrow as they extend outward, being one-half as wide at the termination as at their origin. The transverse measurements are 4, 3, and 5 millims. The median staff has sub-parallel sides, being a little contracted in the middle, so that there is a tendency for the distal end to widen, though the widening is much less marked than in Monotremes.

An elevated median ridge runs down the length of the median bar, which is otherwise flat. It unites with the transverse bar at a right angle, though the junction is not notched out, but rounded.

The pre-coracoid and coracoid are in close sutural union with each other, and their antero-posterior length is about 2·6 centims. They are flattened, somewhat oblong, moderately thin plates ; but there is no evidence whether their straight inner margin rested upon the impressed lateral areas of the inter-clavicle, or whether that bone extended in front of them, as seems probable, after the manner of Monotremes and Ichthyosaurs. These bones appear both to contribute to the articulation for the humerus.

The pre-coracoid is not completely exposed on either side, but as shown it appears to be a longitudinally oblong bone 12 millims. long, with the anterior border probably straight and transverse, probably parallel to the transverse straight suture by which it unites with the coracoid. The internal margin was probably straight, as it appears to be in the specimen as exposed, but it is not quite free from matrix. Thus, there would be three straight sides of the oblong meeting each other at right angles. The width of the bone in the middle is not less than the length ; but the external border is notched, not unlike the external border of the coracoid in many Lizards. In the middle of the side there is a strong short process directed outward and backward towards the articulation, into which it may possibly enter. Anterior to this process the bone is concavely excavated on the margin by a notch which extends to its anterior angle. Posterior to this process is an oval foramen or notch obliquely placed, which extends towards the posterior angle near the suture with the coracoid, and appears to be homologous with the coracoid foramen in Dinosaurs and other Reptiles, which may thus become a pre-acetabular notch.

The coracoid is about 1·4 centim. long, and as wide as the pre-coracoid. Its inner side is straight, and its posterior end convexly rounded from within outward. The external border consists of two nearly equal parts : a thickened anterior articular surface which forms part of the glenoid cavity for the humerus, which looks outward and a little forward; and, secondly, a posterior concave area which contracts the width of the bone, but sends a small process outward and upward like that seen at the posterior margin of the bone in some Plesiosaurs. The length of the articulation as formed by the pre-coracoid and coracoid is about 1·4 centim.

No evidence of a scapula is seen ; and the clavicle is imperfect and only seen on the left side, where it extends, if correctly determined, backward and upward from the outer angle of the transverse bar of the inter-clavicle as a thin flat plate of bone 1·6 centim. long, and narrowing from 4 to 2 millims.

Posterior to the shoulder-girdle are some indications of ribs on the right side. They were sub-cylindrical and hollow. There are much smaller sternal ribs, but their relation to the ribs is not clear.

The Fore-limb.—Both humeri remain in natural contact with the bones of the shoulder girdle. The distal ends are missing on both sides. The bone may have been 3·5 centims. long. The proximal end was expanded, with a rounded condyle. The inferior surface was concave transversely, and slightly convex in length. The radial crest did not reach to the proximal end; it was of moderate length, and reflected downward. The ulnar tuberosity was extended backward; it appears to have been quite as large as the radial crest. The transverse width over these proximal processes, as preserved, is 1·6 centim. The diameter of the middle of the shaft hardly exceeds 3 millims.

The radius is a slender bone, 2·3 centims. in length. Its shaft is slightly twisted, a little convexly bent outward, with the ends moderately enlarged, and their articular surfaces convex.

The ulna is a much stouter bone, with its proximal articular surface obliquely truncated. Its extreme length is 2·5 centims. It is 7 millims. wide proximally and narrower distally, but most constricted in the middle of the shaft.

The carpus, as preserved, is somewhat displaced, but shows two sub-quadrate bones below the ulna—one between the ulna and radius, one below the radius. There appear to be one bone of the central series and four bones in the distal row.

I infer that there are five meta-carpals in contact with this carpus. Indications of three strong short bones are seen attached to the radial side. They are constricted in the middle, and each attached to a carpal. The fourth carpal gives attachment to two bones which appear to be more slender, and the fifth is shorter. In the first digit there is certainly one phalange besides the claw phalange, and I believe there is a second, but the state of preservation justifies some doubt on this point.

On Galesaurus. (Plate 9, figs. 3, 4, 5, 6.)

In 1859, Sir Richard Owen described the South African genus *Galesaurus,* which became the type of a division of the Anomodontia, termed Cynodontia. Three skulls and some fragments referable to this genus are preserved in the British Museum, but no other parts of the skeleton have been recorded, so that its position in classification depends entirely upon evidence from the skull, which hitherto has neither been figured with accuracy nor described in detail.

In 1876, the same author instituted the Theriodontia, characterized as having dentition of the Carnivorous type, with incisors, defined and divided from the molars by a large laniariform canine. It was apparently suggested by the resemblances in number of incisors and molars to certain Mammals, rather than by any distinctive Mammalian attribute in the form of the molar teeth; but many genera were comprised in the group which are still imperfectly known. As there is no skull so perfect as that of *Galesaurus,* I believe that, both as the earliest known type and the only type available for comparison, *Galesaurus,* rather than *Lycosaurus,* which the author places first on his list, should be regarded as the representative genus of the group. I make this suggestion because the order was made to include animals which seem to me to have no near alliance with each other, and have a better claim to distinction from the other Anomodontia than either *Lycosaurus* or *Galesaurus.* Thus, *Procolophon* has been shown to be a type as distinct as any South African Reptile that is known. I am led to believe that *Lycosaurus, Aleurosaurus,* and the allied genera which have small pointed molar teeth, large canines, and large laterally compressed incisors form a division intermediate between the Dicynodontia and the Theriodontia, supposing that group to be accepted with *Galesaurus* for its type. The data for comparison between *Galesaurus* and *Lycosaurus* are of a slender kind. There can, however, be no doubt that *Galesaurus* is conveniently described as Theriodont, and that in form, proportion, and structure of the skull, it is the most Mammal-like of known Reptiles.

It approaches so nearly to Mammals like the Opossums and some of the larger Bats in form of the skull, that demonstration of the presence of typical Reptilian characters was needed to justify the placing of *Galesaurus* among Reptiles. I regard it as differing from the Dicynodontia, as represented by *Dicynodon*, in sub-ordinal characters; for, although the skull seems at first sight so dissimilar, yet in essential characters there is no structural difference which would constitute an ordinal group. Among the more striking characters by which *Galesaurus* differs from the Dicynodonts are:—

First, the possession of incisor teeth, and, secondly, by the development of cuspidate molar teeth. No Dicynodont is known in which teeth of either kind occur, and, therefore, the character is so far a good one; but, as it only extends to the dentition which was represented in *Dicynodon* by canines, I am unable to regard it as more than a sub-ordinal difference. Yet no existing group of Reptiles shows a sub-ordinal character of the same kind; but among Mammals a total absence of teeth in Ant-eaters only separates them as a sub-order from Armadilloes.

Secondly, the lower jaw has the coronoid process rising above the middle of the orbit, and is entirely Mammalian in form. The dentary bone appears to form the coronoid process, though it does not reach back to the articulation, and the lower jaw is certainly composite. As in Carnivorous Mammals, there is no heel prolonged beyond the articulation, and the articular process is only slightly inflected inward.

Thirdly, there is no descending tympanic process of the skull like that seen in Dicynodonts; and on this character depends the backward extension of the jugal arch by its squamosal element to the articulation for the lower jaw, which it contributes to form, though the quadrate bone still remains, though of small size, seen on the posterior aspect of the skull.

Fourthly, there is a manifest difference from Dicynodonts in the occipital articulation, though it is imperfectly exposed, for there appears to be no trace of a basi-occipital condyle.

Nythosaurus larvatus (OWEN) is a *Galesaurus*. It agrees with the type skull in size and form of the cerebral region. Its molar teeth show three or four denticles, and appear to be about eight in number. The dentary bone similarly extends far back, and forms the coronoid process. A perfect mould is preserved of the auditory region, and shows the vertical semicircular canal and the horizontal semicircular canal of the auditory region (Plate 9, figs. 5, 6). The former passes outward, backward, and downward, and from its base the latter extends horizontally forward. On the right side there is indication of a third canal, directed forward at right angles to the posterior vertical.

Relation of the European to the South African Anomodonts.

KUTORGA, FISCHER, EICHWALD, and VON MEYER have described and variously interpreted Reptiles from the Permian rocks of Orenburg, some of which have been classed by Sir R. OWEN as Theriodonts. KUTORGA, with only fragments of the humerus, recognized Mammalian characters, and regarded the animal to which they belonged as a Mammal. For this type, which FISCHER named *Eurosaurus* in 1841, KUTORGA adopted the name *Brithopus;* and I concur with GAUDRY in preferring the older name. EICHWALD'S conception was, however, a remarkable one. He states ('Lethæa Rossica,' p. 1630) that *Eurosaurus* has the skull of a Labyrinthodont, with vertebræ and phalanges like those of *Mastodonsaurus,* and the femur, tibia, coracoid, and scapula like *Pelorosaurus* and *Hylæosaurus*; and he associated KUTORGA'S genera *Brithopus* and *Orthopus* as the humerus of that animal. The foundation for this interpretation is partly in the skull which VON MEYER named *Melosaurus,* and regarded as Labyrinthodont; and, reviewing EICHWALD'S work, that writer considered the association of bones so dissimilar in size and character in one animal to be improbable. It is impossible to form an independent opinion without studying the original materials at Moscow and St. Petersburgh; but the Labyrinthodont character of the skull of *Pareiasaurus*, and many other Labyrinthodont features in the vertebral column, in combination with Dicynodont characters in the pelvis, may justify a suspension of judgment on the conclusions adopted by EICHWALD. But whether the Orenburg fossils should prove to be allied to *Pareiasaurus,* or to some other Anomodont type, they are associated with remains named *Rhopalodon,* which VON MEYER compares in its teeth to *Galesaurus,* though the palate carries a row of small conical teeth on the hinder outer margin of the pterygoid; and the same beds yield *Deuterosaurus,* which VON MEYER compared with the *Bathygnathus* of LEIDY.

In this type there are eleven dorsal vertebræ at least, and, according to EICHWALD and OWEN, two sacral vertebræ, though VON MEYER inclines to think there may have been three, and that the strong transverse process of the eleventh dorsal contributed to support the ilium, although that vertebra was not united with the sacrum. Every dorsal rib unites with two transverse processes, in this respect probably rather approximating to the type of *Pareiasaurus* than to Dicynodonts. There can be no doubt that the pelvis was also substantially formed on the Dicynodont plan, though the antero-posterior processes of the ilium appear to have been much less developed even than in *Phocosaurus.* In 1866, VON MEYER described some additional remains from Orenburg, which he referred to *Eurosaurus verus,* and which may be accepted as making better known the skeleton of *Brithopus priscus* of KUTORGA. I have examined the figured bones preserved in the Senckenberg Museum. They comprise a fragment of a large tooth with a finely serrated border, comparable to canine teeth in many South African genera, described by Sir R. OWEN as Theriodont. VON MEYER remarks on the close resemblance of the posterior part of the skull to the corresponding region of *Dicynodon.* It is obviously formed on the same general plan, but the foramen magnum is triangular, and broader than high. The occipital condyle, which is also very wide, appears to be tripartite, as in Dicynodonts. There is a median excavation below the basi-occipital part of the condyle, though this is much narrower than in Dicynodonts, and rather suggests Placodonts. There is a vertical median ridge above the summit of the foramen magnum. On the other side of the specimen there is an impression of that ex-occipital process which extends transversely outward, and gives attachment to the lower part of the squamosal. The impression was evidently due to a squamous bone being lost from it, and I can only surmise that the missing element may have been the quadrate; but such a relation of the quadrate is never found in any Dicynodont. The impression of the lateral border of the cerebral cavity is seen, and appears to have been relatively wider than in South African Reptiles. The large foramen for the fifth and other nerves is partly defined, and the ali-sphenoid, which bounds it in front, ascends as a slender process. Between the ali-sphenoids the brain cavity contracts. There is a median excavation for its floor in the basi-sphenoid. Anteriorly the basi-sphenoid terminates in a large transverse sutural facet. There are thus conspicuous resemblances of this occipital plate to the bone figured in this memoir, R. 1021, and differences which show it to have belonged to another generic type of the same order. A single vertebra is figured by VON MEYER. Its neural arch rather suggests Nothosaurs, while the cupped form of the body is Plesiosaurian. The vertebra appears to be dorsal, and the rib articulates by two heads, but narrowly separated from each other, rather suggesting the Plesiosaurian than the Ichthyosaurian type, but making a transition from the double-headed anterior dorsal rib type of *Pareiasaurus* to the single-headed dorsal type of *Plesiosaurus*. The scapular arch is instructive, although the bones are imperfect. It was formed by the scapula and coracoid and pre-coracoid. The pre-coracoid is a comparatively large bone, which extends to the margin of the articular surface for the humerus. It is perforated by the usual foramen, which passes obliquely forward, so that on the internal surface it excavates the margin of the scapula, in the way seen in *Dicynodon*. Other specimens show the scapula as a strong compressed plate of somewhat Dinosaurian form, but not dissimilar to types of scapulæ from South Africa. The humerus has the radial crest moderately developed, and has a rather more slender shaft than is usual in the Dicynodont family, though more slender bones are known. The pelvis is remarkable for the way in which the ilium contracts above the acetabulum, and for the narrow superior facet in the acetabulum for articulation with the femur. It more suggests *Phocosaurus* than any Dicynodont; and the obturator foramen has a similar oblique passage through the bone, extending forward towards the pubic border. The narrowing of the superior mass of the ilium may be profitably compared with the spatulate condition of the attached end of the ilium in *Plesiosaurus* (as well as with the reduced dimensions of the bone in *Nothosaurus*). The expanded forms of the pubis and ischium are intermediate in character, as in mode of union, between the conditions of those bones in Plesiosaurs, Nothosaurs, and Ichthyosaurs. A proximal end of an ulna is figured by VON MEYER, which is interesting as showing not only similar form to that seen in South African Dicynodonts, but it also gives evidence that the bone developed an epiphysis or olecranon ossification, which has been lost. Other fragments of long bones appear to be referable to the fibula, but they are too imperfect for determination without re-examination of the specimens. There is, therefore, no doubt that *Brithopus*, if all these bones are correctly referred to it, belongs to the Anomodont order, and that its place is substantially that assigned to it by Sir R. OWEN. There is also good reason for accepting the conclusion that *Deuterosaurus* and *Rhopalodon* must be closely associated with it, and they contribute materially to a knowledge of the vertebral column and limb bones of the group. But I should place them in the sub-order Gennetotheria.

I have seen no evidence which establishes generic identity between the Anomodonts from the Triassic rocks of India and the Dicynodonts from South Africa.

Comparison with Placodus. (See Plate 24, figs. 5, 6.)

In *Placodus* the malar succeeds the maxillary, and behind the orbit overlaps the squamosal, which is equally deep and is prolonged backward, forming the outer bar of the temporal foss. The relation of the squamosal to the expanded plate of the back of the skull is that of an Anomodont, for the back of the skull in *Placodus* is a basin-shaped space. The quadrate bones descend below the squamosals at the outer limits of the basin, but, except at the margin of the condyle, which articulates with the lower jaw, the bone is not exposed in lateral view. Below the squamosal is a bone which is in the position of the supra-quadrate and quadrato-jugal, and it appears to be divided by an oblique suture which would separate the transverse supra-quadrate part from the vertical quadrate part or quadrato-jugal. There is a sub-circular excavation at the anterior angle where these parts meet, and this concavity, which is probably auditory, forms the posterior and inferior limit of the compressed vertical temporal arch.

The mode of union of the head with the vertebræ was remarkable. *Placodus* shows no sign of a basi-occipital condylar articulation, for the inferior margin of the foramen magnum is a thin film of bone. But, laterally, on each side of the middle of the foramen magnum, the ex-occipital bones are prolonged outward and backward, exactly like the posterior zygapophyses of a vertebra; and on the left side, which alone is disengaged from the matrix, this process shows on its inferior surface a transversely oblong flat facet, which looks downward. This is the occipital condyle; and thus *Placodus* has two occipital condyles, which closely approach to the Mammalian type, and the neural arch of the atlas, and not the centrum, articulates with the skull so far as the evidence goes. Therefore I am led to compare the Placodontia and Cotylosauria, and to infer that they are probably members of the same group of animals. Since the Mammalian atlas unites with the skull, by elements of the neural arch, and the centrum takes no part in the articulation, we seem to find in *Placodus* a Reptile in which the mode of union of the vertebral column and skull usual in Reptiles is lost, and that which characterizes Mammals is assumed.

On the Relation to the Anomodontia of the Fossil Animals termed Pelycosauria and Cotylosauria.

In his catalogue of the Permian Reptiles of North America, Professor COPE enumerates 15 genera and 39 species described by himself since 1877, which are referred to a group named Pelycosauria. This group is combined with the Anomodontia into an order named Theromorpha. Few of the American fossils have been figured, so that their exact relation to the Anomodontia is not easily determined; but, in so far as I can judge from the description, few of the characters relied upon to differentiate them sustain the author's estimate of their importance in classification, while their affinity to the Anomodontia is so close that I can realize no obstacle to grouping the Pelycosauria as a sub-order of Anomodonts. I base this conclusion on the following facts:—

(1) Professor COPE defines the Pelycosaurian scapular arch as consisting of scapula, coracoid, and epi-coracoid, blended like an os innominatum. But Sir R. OWEN, in 1876, in his 'South African Catalogue,' Plate 69, figs. 5, 6, figured a South African specimen which shows this condition, and he regarded the fossil as Dicynodont. Professor COPE remarks on the Mammalian character of the scapular arch, and states that in *Dimetrodon* the coracoid is smaller than the epi-coracoid, as in Monotremes.

(2) The author also affirms that the pelvic arch is identical in structure with that of the Anomodontia, and is considered to resemble *Echidna.*

(3) In the limb bones reference is made to the possible presence of epiphyses in Pelycosauria. I have found epiphyses to be well developed in the limb bones of Anomodonts. The humerus is said to resemble that of *Echidna,* but the nature of the resemblance is not stated.

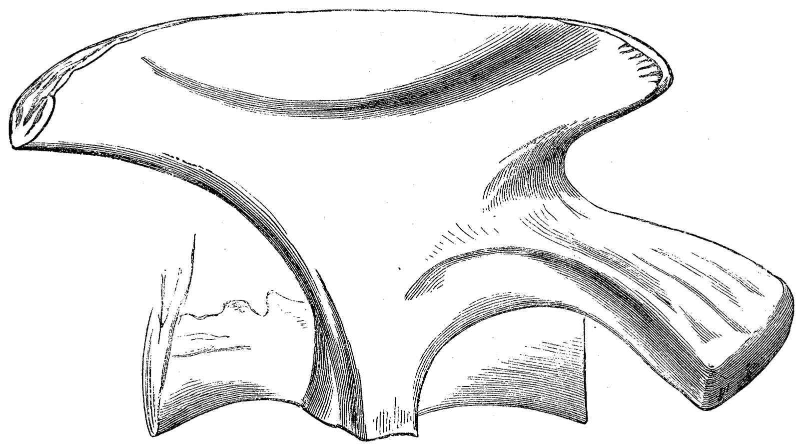
The Pelycosauria.

There are few data for judging of the systematic value of the Pelycosauria. But in view of the fact that the Anomodontia was originally made to include animals which are allied to the Pelycosauria, supposing that group to be well founded, it seems more in accordance with usage to class those animals among the Anomodonts than to adopt a new name like *Theromorpha* for a well-known ordinal type.

There is need, however, that the distinctness of the Pelycosauria should be established. The tibiale and centrale are said to unite to form an astragalus which has no movement on the tibia. One face of the astragalus receives the cuboid. Subsequently an entire tarsus was figured which has a very Mammalian aspect. It is regarded as referable to *Clepsydrops natalis* (COPE)*, and is classed as Pelycosaurian. A similar tarsus was subsequently referred with doubt to the genus *Theropleura*.† It is difficult to judge of its importance. Its characters appear to be more Mammalian than those of the Crocodilian tarsus, for the bones of the distal row are completely ossified. The tarsus is absolutely unknown in any Anomodont from Africa, Europe, or Asia; and, therefore, there is no means of comparison with this American fossil.

The Pelycosauria are said to have two or three sacral vertebræ, a notochordal column, and inter-centra usually present. With the evidence that Dinosaurs may have as few as two sacral vertebræ, as well as a larger number than has been found

Fig. 5.



Ilium and Sacrum of *Zanclodon*.

in any Anomodont, this ground of ordinal distinction fails. Similarly, the mode of ossification of the inter-vertebral substance presents many types among Anomodonts, one of which already figured by Sir R. OWEN might be regarded as notochordal. What the value of the inter-centra may be I am unable to say, as they have not been figured; but, inter-centra, as I understand them, are not unknown among Anomodonts.

The remarkable vertebral column with vertically elongated neural spines referred to *Dimetrodon* is apparently unlike any known Anomodont, but the elongation of the neural spines in certain Wealden Reptiles, like (?) *Hylæosaurus*, is not considered to militate against their position in the group to which they belong. And it may be doubted if the more extraordinary neural spine of *Naosaurus* (*loc. cit.*, Plate III.), with its transverse branches, has any greater classificational value, since the transverse branches are the only character by which the author separates *Naosaurus* from *Dimetrodon*. In *Theropleura*, which is also described as having elevated neural spines, abdominal dermal rods are found. These appear to be of the same nature as

* 'Amer. Phil. Soc. Proc.,' August, 1884.

† 'Amer. Phil. Soc. Trans.,' vol. 16, Plate III.

the abdominal rods of *Protorosaurus*, and *Mesosaurus*, from South Africa; but I shall, when dealing with the latter type be able to show that those rods are composite ribs comparable with the abdominal armature of Plesiosaurians. Professor COPE has also noticed abdominal rods in *Stereosternum*, and in a Batrachian genus *Ichthyacanthus*. No such structure is known in any Anomodont, but there is no evidence of its absence; and *a priori* considerations suggest that it will be found.

Professor COPE'S contributions to a knowledge of the skull are of great interest. The only genera which have been figured are *Empedias* and *Naosaurus*. The former is referred to the Diadectidæ, defined as Pelycosauria with transverse molar teeth. A cast of the brain cavity in this type has also been figured. The author describes the brain case as extending between the orbits, and in that family it is said to be completely closed in front, after the manner of Ophidians. Sir R. OWEN has described a Theriodont *Nythosaurus* (*Galesaurus*) ('S.A. Cat.,' Plate XXXIV., fig. 2) in which a similar condition appears to exist; only there is no such enlargement of the cerebral epiphysis in the South African fossil, and the American fossil, although widening anterior to the epiphysis, expands in a much less marked manner. It may be remarked in passing that the vertical foramen for the fifth nerve, figured by Professor COPE in the cast of the brain case, is quite in harmony with the vertical foramen similarly placed in Anomodonts. In another genus, *Edaphosaurus*, Professor COPE describes a distinct element as connecting the basi-occipital on each side with the quadrate. This is not figured, but the description is suggestively indicative of the bone figured by Sir R. OWEN in 1845 in *Dicynodon lacerticeps*, which was then regarded as the par-occipital. This bone is found to be characteristic of the Dicynodontia. Professor COPE regards the skull in the Diadectidæ as possibly forming the type of a sub-order, for which the name Cotylosauria was suggested. There is a plain facet on each side of the foramen magnum, which expands largely below these facets. The bone which bounds the foramen inferiorly presents a vertical median posteriorly projecting process, on each side of which there is a transverse cotylus, much like those of an atlas which are applied to the occipital condyles of the Mammalian skull. These concavities are further said to occupy precisely the position of the Mammalian condyles. The bone in which they are excavated is said to have the form of the Mammalian basi-occipital and of the Reptilian sphenoid. The author afterwards expressed doubt as to whether this form of articulation might not be due to the loss of a loosely articulated basi-occipital bone. This is the most distinctive feature of the Pelycosauria, but it does not appear to extend beyond the family Diadectidæ. The occipital condyle is described as undivided in *Edaphosaurus*, and, therefore, the argument tends towards the conclusion that the Cotylosauria may be distinguished from the Dicynodontia, but not to sustain the Pelycosauria without further evidence. The nearest approximation to this condition of the occipital articulation with which I am acquainted is that seen in the Placodontia; and, in so far as I can judge from the evidences given in the figures of the skull of *Empedias* ('Amer. Phil. Soc. Proc,' vol. 19, Plate V.), there are no ordinal characters to separate the Cotylosauria from that group. The pterygoid bones are similarly expanded; the vacuities of the skull which can be compared are similarly placed; the quadrate bone appears to be similarly excavated in the auditory region.

The description of the palate in *Empedias* is unintelligible when compared with the figures, for, although the pterygoid bones may be identified by their posterior position and by meeting the quadrate, as well as by the downward direction of their external borders, they are described as the palatines. The median bone in front of them is termed the vomer, and said to carry two rows of small conical teeth. This bone is stated to be separated from the maxillary by a groove, which is represented in the figure. Hence, the pterygoid bones and vomer are the only elements of the palate described, excepting the greatly expanded palatine plates of the maxillary; and I therefore infer that the palatine bones must have occupied the posterior part of the groove between the pterygoid, vomer, and maxillary bones. If the palatines are thus lost and absent, the skull would still have points in common with the Anomodont group, though the absence of a median vacuity, defined by the pterygoids and palatines, is a remarkable difference; but it is a character shared by the Placodontia, and by the Endothiodontia—supposing the latter group to be distinct from the former, which has yet to be established. The figure which Professor COPE has given of the skull of *Naosaurus* establishes a well developed maxillary dentition, but differs in remarkable characters from the Dicynodontia in the conditions and relations which are attributed to the quadrate and squamosal bones; but they do not differ from the Dicynodontia more than do the Pareiasauria, or the Placodontia, hardly more than the Theriodontia. On the evidence of the skull I am led to regard the Cotylosauria as intermediate between the Placodontia and the Theriodontia, and the Pelycosauria, in so far as it is possible to judge from the fragment of skull of *Naosaurus* representing it, is intermediate between the Gennetotheria and the Placodontia.

Comparison of Anomodontia and Protorosauria.

There is no evidence of close affinity between these groups which would at present justify their association under one ordinal type, yet their relation to each other appears to be closer than has hitherto been supposed. The pelvis of *Protorosaurus* is essentially intermediate between that of Ornithosaurs and Anomodonts. The limb bones are more slender than in any known Anomodont, but the somewhat Mammalian character of the tarsus, if unknown in the Anomodontia, appears to be paralleled in the American animals which Professor COPE names Pelycosauria. Although the evidence is very imperfect and inconclusive, I am disposed, from a cast of the Freiberg specimen of *Protorosaurus* which Dr. WOODWARD has obtained for the British Museum, to think that the scapular arch in that specimen probably includes pre-coracoid elements, and may be constructed upon the Anomodont plan. The circumstance that teeth occur upon the bones of the palate in *Procolophon*, and that the vomera meet the pterygoid bones with the palatines external to them in the same relative positions as in my restoration of *Protorosaurus* ('Phil. Trans.,' B., vol. 178 (1887), p. 205), would prepare me to find other points of correspondence in the skulls of those types, while the fact that the Anomodonts occur in the Permian rocks of France and Russia makes an affinity with that type less improbable in the Thüringerwald Saurians.

Comparison of the Anomodontia with the Saurischia.

The skeleton is imperfectly known in the Saurischia in details of structure; but the following resemblances may have value as showing affinity.

The ilium in both types may be extended behind the acetabulum as well as in front of it; but in several genera there is a tendency for the anterior extension to be the more conspicuous. The pubis and ischium meet by a median vertical suture; but while these bones are thus united in known Anomodonts down to the median symphysis, there is in the Saurischia a more or less large ventral vacuity by which the median symphysis of the two pubic bones is separated from the corresponding union of the ischia.

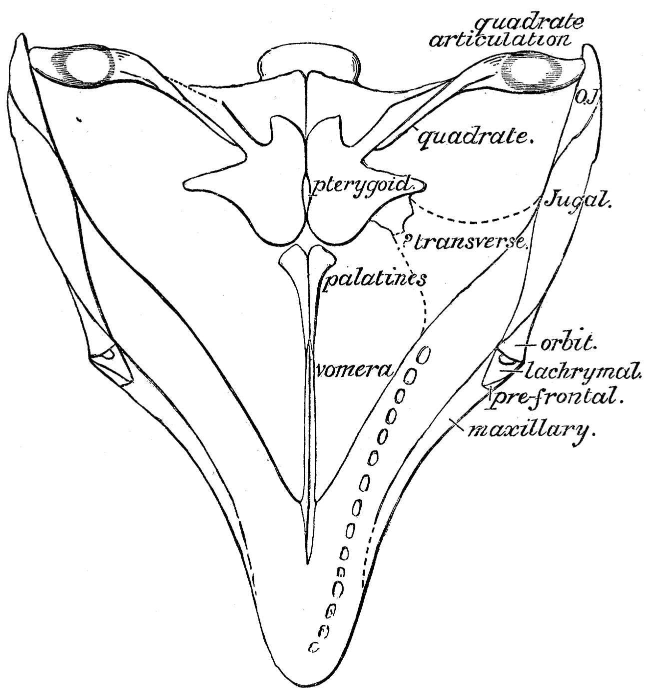
The larger limb bones may have much in common, and I am aware of no satisfactory characters by which the femur, tibia, fibula, ulna, and radius could be always differentiated, and the humerus has enough in common to make the distinction of type dependent upon the absence from the Saurischia of the foramen or foramina in the shaft. The divergence is conspicuous in the carpus and tarsus and the smaller bones of the foot; and the scapular arch appears to be formed on a totally different plan. In the vertebral column there is enough in common to have led Sir R. OWEN to group *Pareiasaurus* and *Tapinocephalus* with the Dinosauria. The cervical vertebræ have the ribs articulated by two heads; but I am aware of no evidence that any Anomodonts, except Pareiasaurians, have this kind of articulation in the dorsal region, and therefore the vertebral characters will prove to be essentially Sauropterygian, with only such divergence as may be correlated with difference in the condition of existence. The resemblance which is found in the sacrum of some genera seems to me to be an induced resemblance, and not an inherited character. The tail is but imperfectly known in Anomodonts, but it is always short, and no examples of long chevron bones are at present known. The skull appears to be constructed upon a different plan, but it is only known among the Saurischia in *Compsognathus* and *Ceratosaurus*, and in neither type is the structure of the palate available for comparison.

Relation between Dicynodon *and* Scelidosaurus.

Scelidosaurus makes a certain approximation in some respects to the Dicynodont skull, but the resemblances are less important than might appear. Thus, though the quadrate bone is concealed, as in Dicynodonts, it is a long, comparatively slender bone, which is not in front of the squamosal, and not wedged into it, while the quadrato-jugal, which covers its distal end, is itself covered by the malar. Internally the quadrate of *Scelidosaurus* sends a long process inward, which laps in front of the quadrate process of the pterygoid. Hence the forms and relations of the quadrate bone in the two types are altogether dissimilar.

There is a certain resemblance in palatal structures, as may be seen from the accompanying restoration of the palate in *Scelidosaurus*. But the pterygoid bones of

Fig. 6.



Restoration of the palate of *Scelidosaurus*, from the specimen in the British Museum.

the Ornithischian are not anchylosed ; and, although the bone has a similar posterior expansion in *Dicynodon*, and a similar pterygoid process, it possesses an external process which *Dicynodon* has not, and in front of that process there is a fragment which may be part of a transverse bone. If so, it was probably prolonged laterally to the malar, and not anteriorly, like the pterygoid of *Dicynodon*. Anterior to the pterygoid *Scelidosaurus* has a small ossification which appears to be a delicate palatine bone placed in the median line, and therefore unlike the lateral palatine of *Dicynodon*, while at the anterior fracture the double vomera make a difference from the vomer of *Dicynodon;* so that I regard the palate in the two groups as formed on different types.

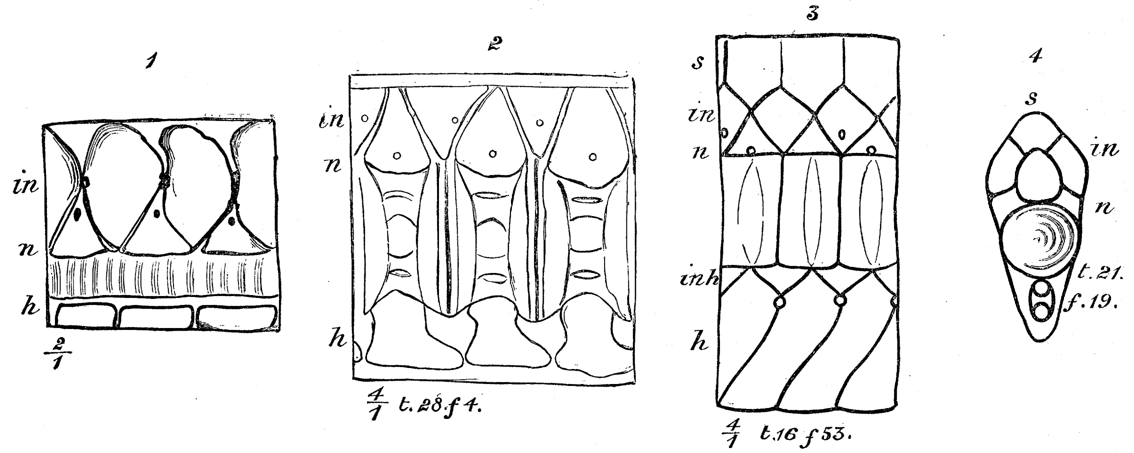
The Theory of the Anomodont Skull.

Only when it is established that the Dicynodontia, and therefore the allied Anomodonts, differ as sub-orders from the Pareiasauria, does it become possible to realize the magnitude of the changes which a skull may undergo in the same natural group of animals, and also how considerable is the gap which remains to be filled in before the most Mammalian type of Anomodont could be transformed, in so far as its skull is concerned, into a Mammal. We are at present ignorant of the modes of elaboration of such change, beyond knowing that certain bones have to be obliterated from the Reptilian skull to make it Mammalian. But whether that loss was brought about by the peculiarly Reptilian elements dwindling in size until they disappeared, while the peculiarly Mammalian elements augmented their growth in a corresponding way to take their places, or whether the Mammalian type implies such an osteological retrogression as the loss of some fundamental segmentations which divide bones from each other in ancestral types, cannot be determined, even with probability, without the aid of theory. I have already regarded the skull as a more primitive part of the skeleton than the vertebral column, less specialized; so that it preserves structures, which originally existed in the vertebral column, long after the vertebræ have lost them.* I have compared the roof bones of the skull to the roof bones of the vertebral column which exist in those plagiostomous Fishes in which there is a superior intercalary segment introduced between two adjacent neural arches. This seems to me to explain the presence in the skulls of lower Vertebrates of those bones which have been termed inter-parietal, post-frontal, and pre-frontal. The inter-parietal persists in some Mammals, and in some orders is absent. When it is absent it is manifestly blended with the supra-occipital. I see no reason for thinking that the inter-parietal gradually disappeared, and that the supra-occipital grew at its expense; but, just as the inter-centrum may become blended with the centrum, so these bones have blended with some associated elements in the skull. The argument in favour of this interpretation rests upon the fact that in those Fishes in which the intercalary neural elements are present the neural arches form an unbroken continuous tube, whereas in those animals in which they are not found there are more or less appreciable gaps between contiguous neural arches; and, if any element in the covering of the skull were absent, it seems more probable that a fontanelle would result than that the other bones would take its place. Similarly, in certain Chelonians, like *Podocnemis* and *Rhinochelys,* the pre-frontal bones retain the distinct individuality which characterizes them in other Reptilia; whereas in the majority of Chelonians this individuality is lost, and the pre-frontal bones are not differentiated

* "The History of the Skull," King's College Science Society, October, 1882.

from the nasal bones. Thus the suture becomes lost, not by the growth of the nasal at the expense of the pre-frontal, but by an absence of segmentation which causes the nasal region of such Chelonians to become Mammalian. In the same way I would interpret the loss of the post-frontal bone in Mammals. The common position of this bone is at the back of the orbital vacuity. It is manifest that in many Mammals there is no bone between the posterior border of the orbit and the jugal bone below, and in all such cases the bone may be lost through not being ossified. But in other types the post-orbital bar is present, and mainly formed by the frontal bone. It therefore would seem probable that the post-frontal had lost its individuality, because in the vertebral plan it was a portion of the arch formed by the frontal bones, just as the pre-frontals were portions of the arch formed by the nasal bones. The parietal bones in Lizards appear to show the accomplishment of a union of a similar kind. Theoretically there should be a pair of bones between the parietal and inter-parietal elements. These bones are not found, but the parietal is seen to bifurcate posteriorly, and the bifurcations have no obvious relation to the plan of the median element of the bone. There is some evidence, though very inconclusive, that these posterior arms of the parietals are separate ossifications in the Dicynodontia. They extend along the parietal crest, parallel to each other, overlapping the end of the parietal, and they appear to diverge forward, whereas the parietal bone of Dicynodonts is undivided. If this distinction should hereafter be established, it would contribute an element of symmetry in the theory of the skull, and would help to fortify the theoretical principles on which, in the matter of the bones referred to, a transition might be made from the Reptilian to the Mammalian type.

A more important difference between Reptiles and Mammals is found in the mode of union of the lower jaw with the skull. Theory has for a long time concerned itself with the fate of the quadrate bone. Sir RICHARD OWEN, following the school of CUVIER, termed the quadrate bone the tympanic, and taught that it becomes in Mammals the ring which supports the drum of the ear. This is a view which follows naturally enough from the study of the Chelonian skull; but I should never have seen my way to accept it without the evidence which Anomodont skulls give of the history of the quadrate bone, and its relation to the squamosal. Hitherto those bones have been imperfectly understood. The squamosal is of large size and sends a zygomatic process forward, which combines with the malar bone to form the zygomatic arch, and it sends a process downward, in which the quadrate bone is embedded. I have here figured several examples of this relation of the quadrate. The squamosal extends in front of it and hides it, and extends internal to it, so that the lower jaw comes to articulate with the squamosal bone apparently, as well as with the quadrate. In one example the quadrate bone is perforated by a large excavation; and I regard this excavation as auditory and comparable to the auditory notch or excavation in the Chelonian quadrate. In the Theriodont *Galesaurus* the form of the skull has become Mammalian; the inferior process of the squamosal is lost, and the zygomatic process forms the larger part of the bone, and it is only on the posterior aspect of the skull that what appears to be the small quadrate is seen, taking part with the squamosal in forming the articulation. Another step in the evidence of transition is needed, but I cannot doubt that when once a direct articulation is established between the lower jaw and the squamosal, with the articulation moved a little forward, and the small quadrate seen only behind, that the loss of work would lead to a diminished growth of that bone; and that no function is eventually left to the quadrate but to support the tympanic membrane and surround the auditory aperture. ALBRECHT, finding that occasionally a suture separates the articular part of the squamosal bone from the squamous portion in mammals, concludes that the zygomatic portion of that bone represents the quadrate bone, but, as we have seen that the squamosal in Anomodonts has the same relation to the skull, and to the lower jaw, as in Mammals, this interpretation has no support in the Anomodontia.



Lamna. *Pristis.* *Aëtobates.* *Chimæra.*

Showing the relation of the centrum to elements of the neural arch in Elasmobranch Fishes, after HASSE.

Professor COPE has described the quadrate bone of *Clepsydrops natalis* as having a horizontal ramus, which he affirms to be "nothing more than the zygomatic process of the squamosal bone of the Mammalia forming with the malar bone the zygomatic arch." But, from the fact that in the Dicynodontia and Theriodontia the squamosal bone always takes the development and function here attributed by COPE to the quadrate, there is an *a priori* improbability that a type so nearly allied to the Anomodontia should present a fundamentally different structure, when the external characters are described as similar. It is difficult to suppose there has been any error in the interpretation of the facts, since Professor COPE, in 1870, recognized the quadrate bone in a South African Anomodont skull; but in the absence of figures it is impossible to judge of the evidence on which the interpretation rests.

A feature which specially distinguishes the Dicynodont skull from the skulls of allied animals is the enormous development of the squamosal bone, and, although it is difficult to speak with confidence on a matter that is necessarily hypothetical, it seems to me probable that this development is the cause for the scattered positions of the otic bones, and that when the squamosal becomes smaller those bones come into closer relation.

The skull structure is especially suggestive in relation to elements in the Mammalian auditory region which are not found in Reptiles. In *Echidna* two elements are seen, one an imperfect circle, and another external and anterior to it. The former of these is in contact with the pterygoid, just as is the quadrate bone in Reptiles and Birds. The latter is extended between the squamosal and the pterygoid, and meets the tympanic ring. It is regarded as the malleus. This bone almost exactly corresponds in position with the bone in the Dicynodont skull which has been often referred to in my descriptions of the palate. The tympanic ring similarly corresponds to the quadrate bone; and the relations of malleus and tympanic in *Echidna* to each other, and to the surrounding skull bones, are almost exactly those of the quadrate and malleus in Anomodonts, though both bones are relatively much larger in the Reptile than in Mammals. Hence it seems to follow that when the squamosal came to extend outside the quadrate and in front of it, taking on itself part of the function of forming the articulation for the lower jaw, that the quadrate and malleus would be thrown inward and backward, and diminish in size at the same time. Some steps in this process of degeneration are seen in Anomodonts, and they are all approximations towards the Mammalian type.

The difficulty in harmonizing the composite structure of the Reptilian lower jaw with the simple Mammalian jaw is similar to the difficulty with the composite roof bones of the Reptilian skull. In the most Mammal-like of Reptiles, *Galesaurus*, the lower jaw remains as Reptilian as in a Chelonian or Crocodile. The Mammalian might be derived from the Reptilian mandible, in one of two ways. It may be supposed that the elements forming the lower jaw ceased to be segmented, as we have assumed in explanation of the roof bones of the skull, and, therefore, that the Mammalian jaw includes the same elements as the Reptilian jaw, but in an undifferentiated condition. In favour of this view it might be urged that a yet more improbable development of a like kind is seen in existing Chelonians, where the dentary elements of the opposite sides lose their individuality, and form a single dentary element which unites the rami. But, perhaps, it may be as well to remember, before following this speculation further, that the articular element of the lower jaw would necessarily undergo a certain change of function akin to those of the quadrate bone, by which it shares the articulation with the sur-angular element in the same way as the quadrate shares the articulation with the squamosal. And, if the articular bone ceases to make the joint with the quadrate, owing to the abstraction of the quadrate from such work in the skull, it should result that the articular bone ceases to be ossified, because the mechanical conditions which determined its ossification have disappeared. The lower jaw is distinctly formed about MECKEL'S cartilage; and, whereas the articular bone is an ossification at the terminal end of that cartilage, and the only part of it which is ossified, it is instructive to note that, in the Mammalian jaw, the foramen by which the cartilage leaves it is some distance in advance of the region in which the articulation is placed. This condition has always seemed to me conclusive against the articular element persisting in the Mammalian jaw. Secondly, the dentary bone attains a varying development. In *Galesaurus* it is very large, and apparently rises into a coronoid process as well developed as in any Mammal. But it seems inconceivable that it could ever come to form the articulation with the squamosal if that articulation was previously established with the sur-angular bone. There appears, therefore, to be a necessity for the preservation of parts which correspond to the dentary and sur-angular and angular elements. But I see no such necessity for the preservation of the splenial bone, which in Crocodiles is little more than a long scale on the inner side of the dentary, or of the coronoid bone which is internal in position to the coronoid process; so that I suppose the three successive bones on the inner side of the Reptilian lower jaws to become lost in the Mammal, and the three external bones to become united and preserved as one continuous ossification. It may be within the limits of possibility that, after the articular bone was lost, the angular bone on which it rests also disappeared from the changed mechanical conditions which affected its ossification, and that the dentary bone, extending backward at its expense, may have eventually invested the outlet for MECKEL'S cartilage before its union with the sur-angular bone was obliterated. Therefore there are facts which seem to point to a loss of some elements from the Reptilian jaw by absence of ossification, and other facts which render the union of the remaining bones by a loss of segmentation highly probable.

Classification.

It would be premature at present to do more than recognize the larger groups into which the Anomodontia may be divided. Among such sub-ordinal divisions are the following:—

	Sub-order.	Example.
Basi-occipital articulation. No temporal vacuities. No median bar to inter-clavicle	PAREIASAURIA	*Pareiasaurus.*
Median bar to inter-clavicle. No temporal vacuities. Teeth on pterygoid and vomer	PROCOLOPHONIA	*Procolophon.*
Tripartite occipital condyle. Descending process of squamosal	DICYNODONTIA	*Dicynodon.*
Not more than one tooth in each maxillary	GENNETOTHERIA	*Lycosaurus.*
Large, laterally compressed incisors, separated by canines from small pointed molars	PELYCOSAURIA (?)	*Clepsydrops.*
[Ex-occipital condyles.] No descending process to squamosal which articulates with lower jaw. Molar teeth with pointed cusps	THERIODONTIA	*Galesaurus.*
Ex-occipital condyles. Molar teeth transversely developed, with cusps	COTYLOSAURIA	*Empedias.*
Ex-occipital condyles. Crushing teeth on vomer, pterygoid, and maxillary	PLACODONTIA	*Placodus.*

This list does not exhaust the modifications which the Anomodont type assumes. It is rather a grade of organization than an order. Its affinities are of the widest kind. Its lowest group connects Reptiles with Labyrinthodonts and Amphibians; its intermediate groups have affinities with all the extinct orders of Reptiles; and its highest groups make approximations to Mammals which go some way towards demonstrating their Reptilian origin.

I would express my grateful thanks to Dr. HENRY WOODWARD, F.R.S., for the many facilities afforded me in making this examination of the Anomodont Reptilia in the Geological Department of the British Museum.

EXPLANATION OF PLATES 9–25.

PLATE 9.

Galesaurus *and* Procolophon.

Fig. 1. Median vertical section of an undescribed Dicynodont skull, showing bones of the median axis of the base of the brain case, the pre-maxillary and dentary bone. A dotted line indicates faint markings in the matrix which extend between the foramen magnum and the narial region. (See p. 225.)

Fig. 2. Anchylosed basi-occipital and basi-sphenoid from the opposite half of the same skull. (See p. 225.)

Fig. 3. Right side of skull of *Galesaurus*, showing the zygomatic arch formed by the malar and squamosal bones, with coronoid process of the lower jaw rising above the squamosal. (See p. 277.)

Fig. 4. Palate of the same skull, showing occipital articulation, position of malleus, and composite structure of lower jaw. (See p. 278.)

Fig. 5. Superior aspect of the posterior portion of internal mould of the brain cavity of *Galesaurus* enlarged, showing vertical and horizontal semicircular canals on the left side. (See p. 278.)

Fig. 6. Posterior aspect of the same specimen, showing the foramen magnum, lateral contour of brain case, and semicircular canals. (See p. 278.)

Fig. 7. Skull of *Procolophon trigoniceps* (OWEN), seen from above. (See p. 269.)

Fig. 8. Right side of the same skull. (See p. 272.)

Fig. 9. Palatal aspect of the same skull, with the shoulder girdle and right fore-limb. (See p. 274.)

PLATE 10.

South African Anomodontia.

Fig. 1. Occipital plate of a small Dicynodont skull, showing its constituent elements. (See p. 226.)

Fig. 2. Anterior aspect of the same specimen, showing the back of the brain-case. (See p. 227.)

Fig. 3. Posterior aspect of brain-case in *Dicynodon leoniceps* (OWEN). (See p. 228.)

Fig. 4. Quadrate bone of a new Anomodont. (See p. 239.)

Fig. 5. Palatal aspect of the same specimen, showing the condyles. (See p. 239.)

Fig. 6. Quadrate bone from the skull of *Dicynodon leoniceps* (OWEN). (See p. 220.)

PLATE 11.

Dicynodon microtrema.

Fig. 1. Occipital aspect of the skull of *Dicynodon microtrema*. (See p. 228.)

Fig. 2. Anterior aspect of the same specimen, showing portion of cerebral cavity. (See p. 228.)

PLATE 12.

Tropidostoma Dunnii.

Skull of a new Anomodont genus allied to *Dicynodon*, comprising the brain case, with the cervical vertebræ.

Fig. 1. Anterior aspect. (See p. 232.)

Fig. 2. Right side, with ventral aspect of cervical vertebræ. (See p. 249.)

Fig. 3. Palate, with atlas and axis. (See p. 249.)

Fig. 4. Occipital aspect of skull, with lateral aspect of cervical vertebræ. (See p. 249.)

PLATE 13.

Skull of Dicynodon tigriceps (OWEN).

Fig. 1. Superior aspect. (See p. 236.)

Fig. 2. Lateral aspect. (See p. 237.)

PLATE 14.

Skull of Dicynodon Copei.

Fig. 1. Anterior aspect. (See p. 241.)

Fig. 2. Left lateral aspect. (See p. 241.)

Fig. 3. Palate, with lower jaw. (See p. 241.)

PLATE 15.

Hyorhynchus platyceps.

Fig. 1. Right side of skull of *Hyorhynchus platyceps*. (See p. 242.)

Fig. 2. Palate of the same specimen. (See p. 242.)

Fig. 3. Superior aspect of the same specimen. (See p. 242.)
Fig. 4. Proximal part of right scapula. (See p. 255.)
Figs. 5, 6. Right and left coracoids of a small Anomodont. (See p. 257.)
Fig. 7. Dorsal vertebra associated with the coracoids. (See p. 257.)

PLATE 16.

Titanosuchus ferox, *&c.*

Fig. 1. Dorsal vertebræ of (?) *Ptychognathus.* (See p. 251.)
Fig. 2. Section of dorsal vertebræ, showing ossification of inter-vertebral substance (See p. 254.)
Fig. 3. Section of caudal vertebræ, showing a similar change of tissue. (See p. 254.)
Fig. 4. Pubic bone, *Titanosuchus ferox.* (See p. 258.)

PLATE 17.

Caudal Vertebræ of Platypodosaurus robustus.

Fig. 1. Lateral aspect, showing zygapophyses, transverse processes, and chevron bones. (See p. 253.)
Fig. 2. Superior aspect, showing neural spines. (See p. 253.)

PLATE 18.

Part of the Skeleton of Eurycarpus Oweni.

Fig. 1. Mould from slab showing vertebræ, ribs, and limbs greatly reduced in size. (See p. 259.)
Fig. 2. Left fore limb of the same specimen. (See p. 259.)
Fig. 3. Fragment of femur from the same slab. (See p. 259.)

PLATE 19.

Right Femur of Titanosuchus ferox.

Fig. 1. Anterior aspect. (See p. 261.)
Fig. 2. Posterior aspect. (See p. 261.)

PLATE 20.

Humerus of Titanosuchus ferox.

Fig. 1. Inferior aspect. (See p. 263.)
Fig. 2. Inner lateral aspect. (See p. 263.)

PLATE 21.

Fibula of Titanosuchus ferox.

Fig. 1. Lateral aspect. (See p. 265.)
Fig. 2. Proximal aspect. (See p. 265.)
Fig. 3. Inner or tibial aspect. (See p. 265.)
Fig. 4. Distal extremity. (See p. 265.)

PLATE 22.

Ulna.

Fig. 1. Ulna, with epiphyses preserved. (See p. 265.)
Fig. 2. Proximal aspect of the same bone. (See p. 265.)
Fig. 3. Distal articular end of the same bone. (See p. 265.)
Fig. 4. Proximal end of another ulna which has lost its proximal epiphysis. (See p. 265.)

PLATE 23.

Ulna which has lost its Epiphyses.

Fig. 1. Inner aspect. (See p. 266.)
Fig. 2. Outer aspect. (See p. 266.)
Fig. 3. Distal extremity. (See p. 266.)

PLATE 24.

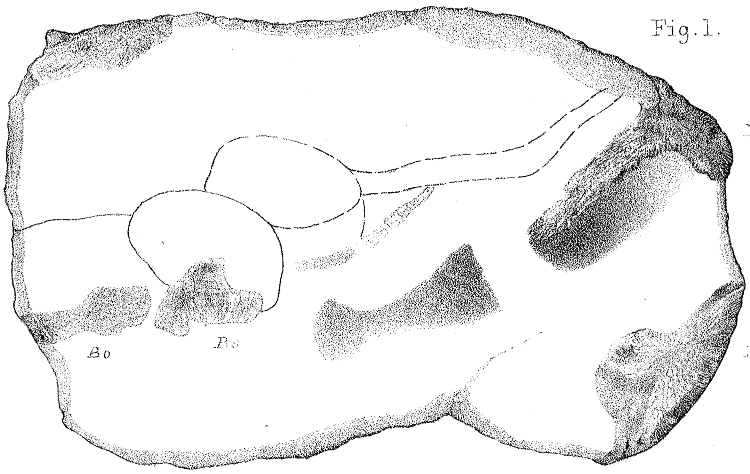
Bones of Titanosuchus *and* Placodus.

Fig. 1. Phalange of an external digit, *Titanosuchus.* (See p. 267.)
Fig. 2. Middle phalange, *Titanosuchus.* (See p. 267.)
Fig. 3. Vertebra of *Titanosuchus ferox.*
Fig. 4. Neural aspect of the same dorsal vertebra.
Fig. 5. Posterior aspect of skull of *Placodus.* (See p. 281.)
Fig. 6. Left occipital condyle of the same skull seen from the palatal aspect. (See p. 281.)

PLATE 25.

Tibia.

Fig. 1. Tibia. (See p. 269.)
Fig. 2. Proximal end of the same bone. (See p. 269.)
Fig. 3. Distal extremity of the same bone, showing the outline of the proximal end extending beyond it. (See p. 269.)



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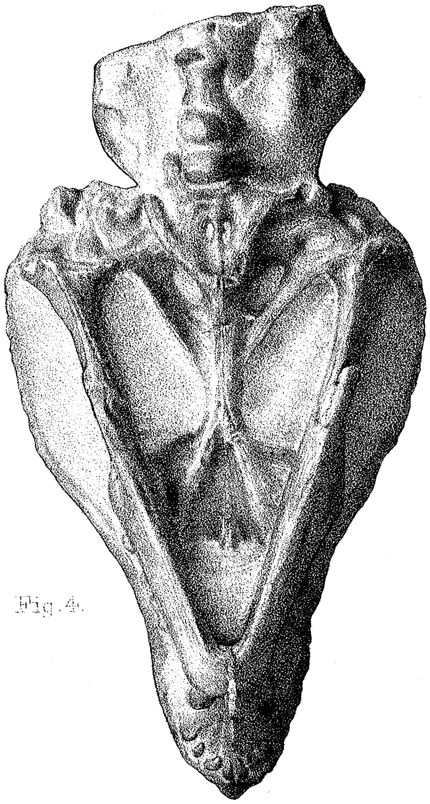
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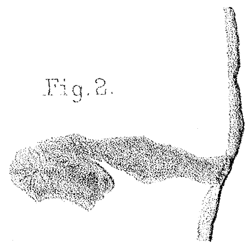
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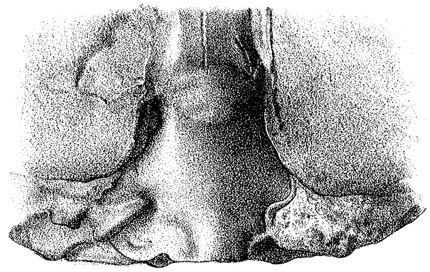

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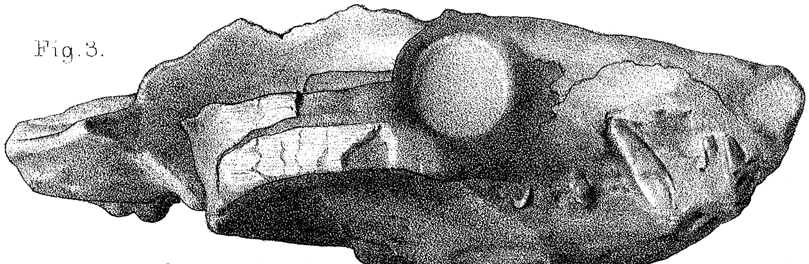
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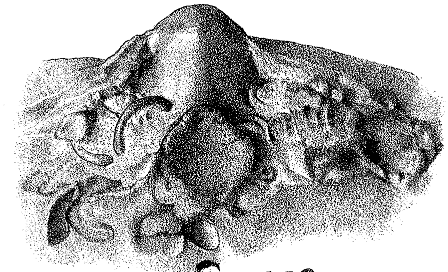
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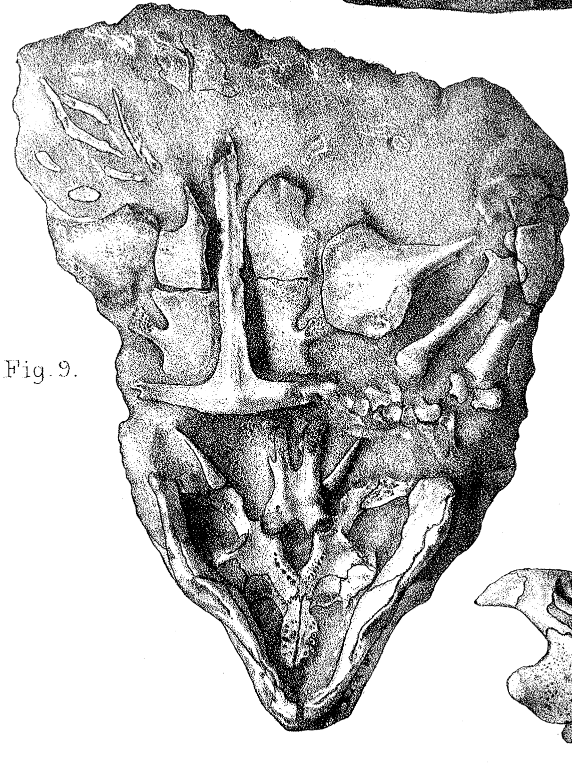
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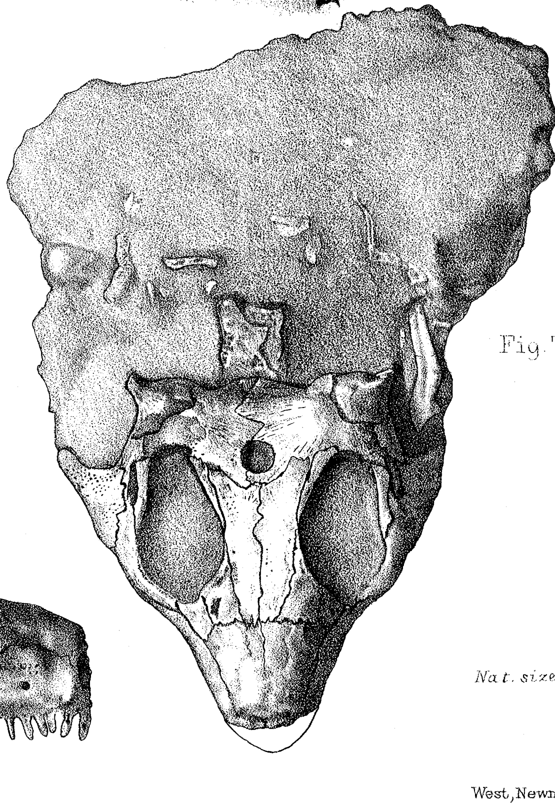
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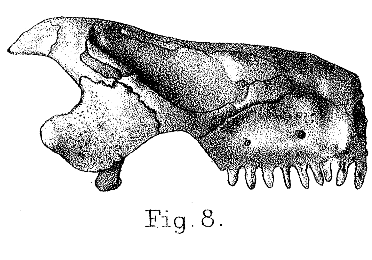
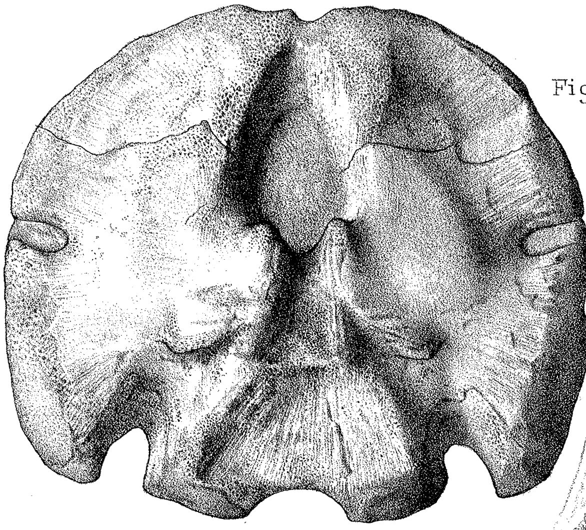


Fig. 8.

G. M. Woodward ad nat. lith.

West, Newman imp.

Galesaurus & Procolophon.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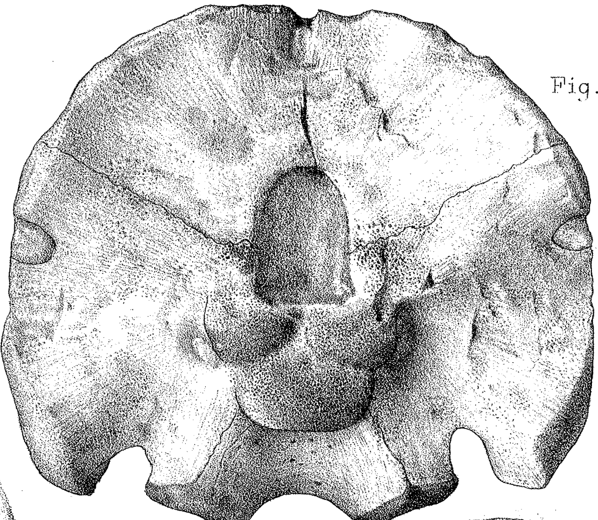
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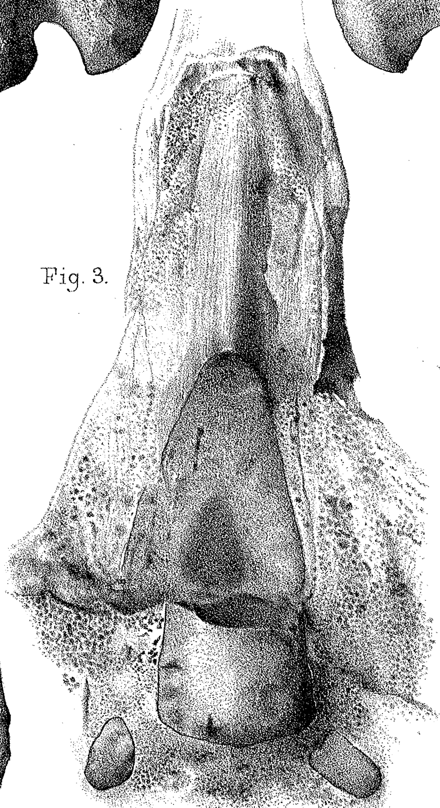
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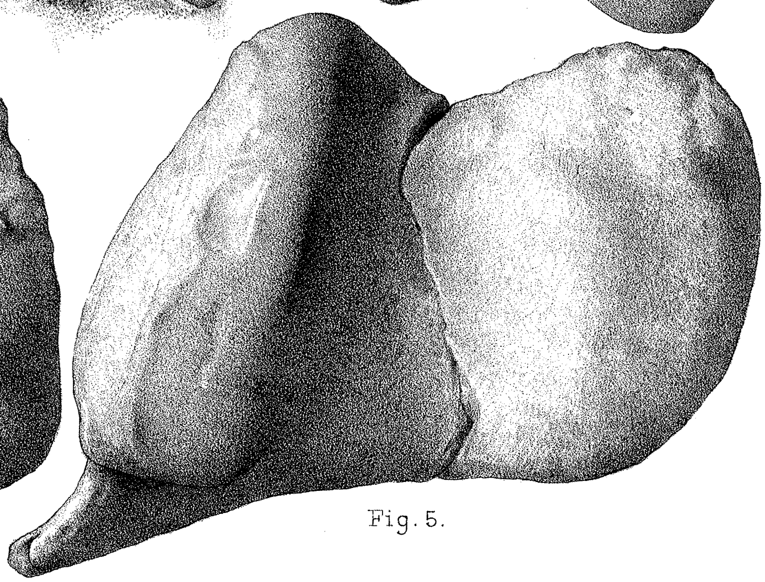
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G. M. Woodward, ad nat. lith. West, Newman & Co. imp.

South African Anomodontia.

Fig. 1.

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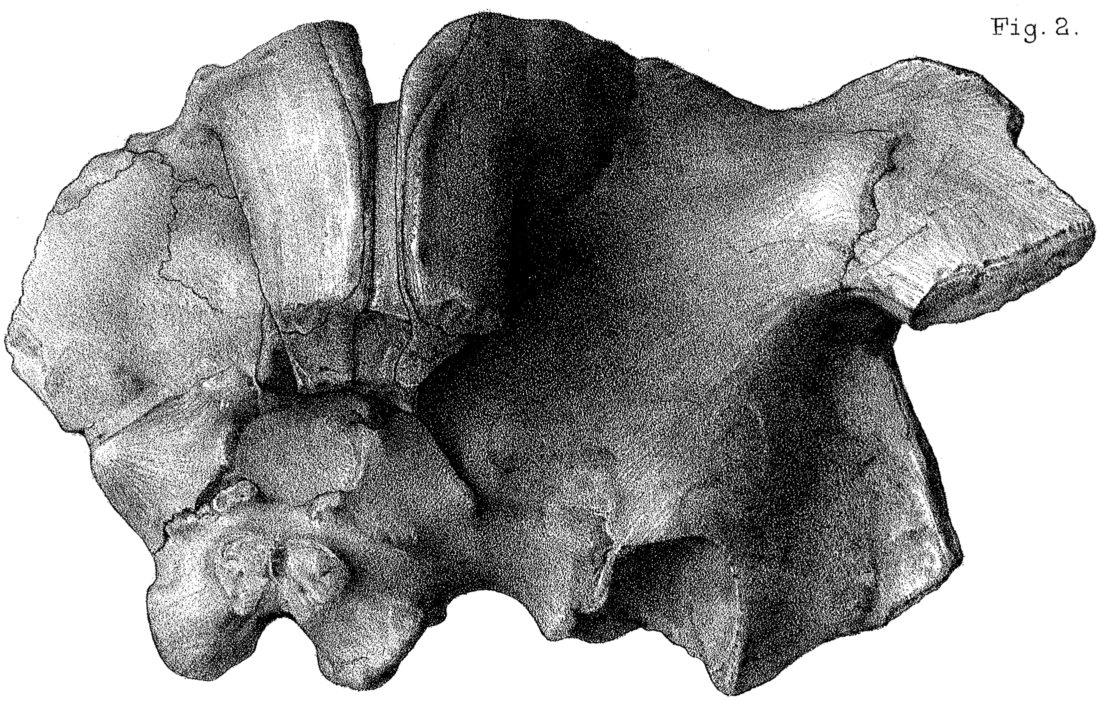

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Dicynodon microtrema.

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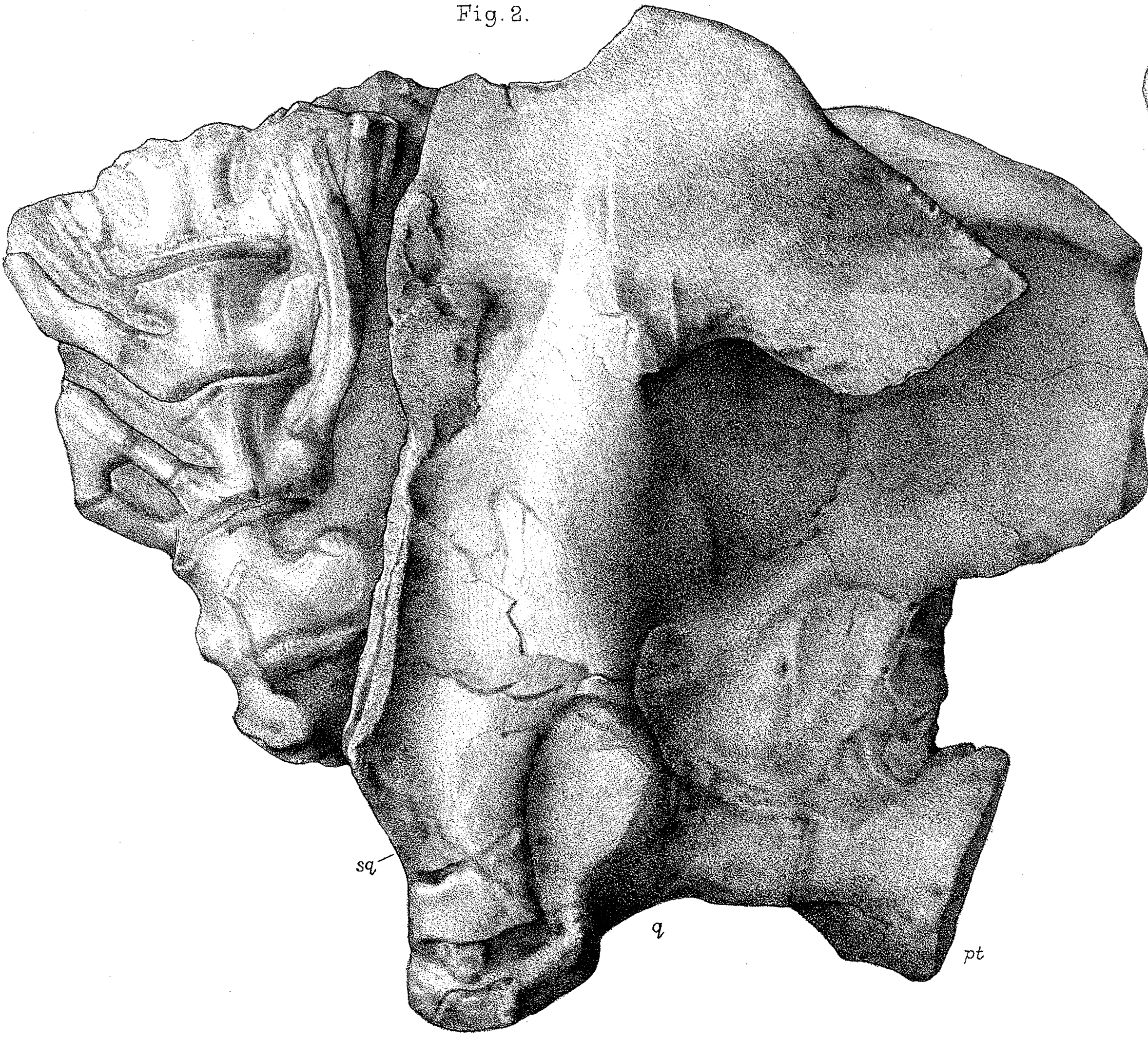
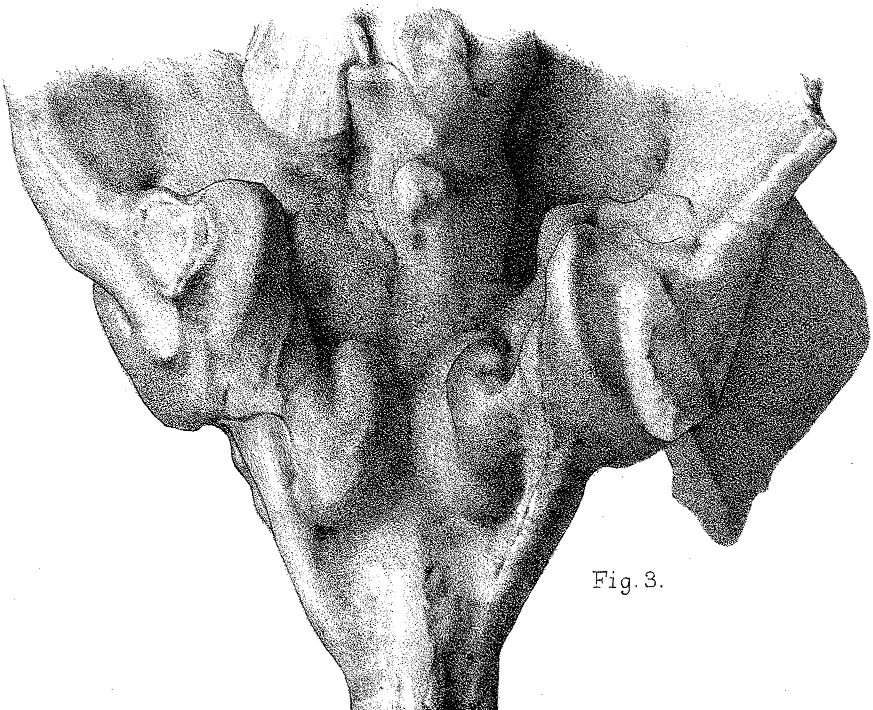
Fig. 2.





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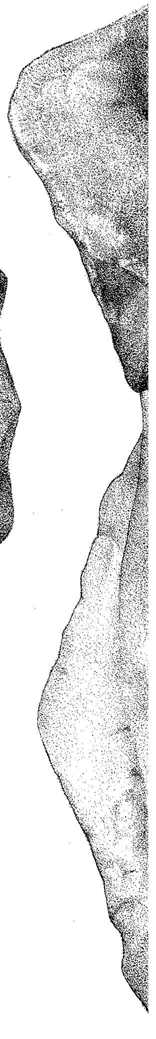

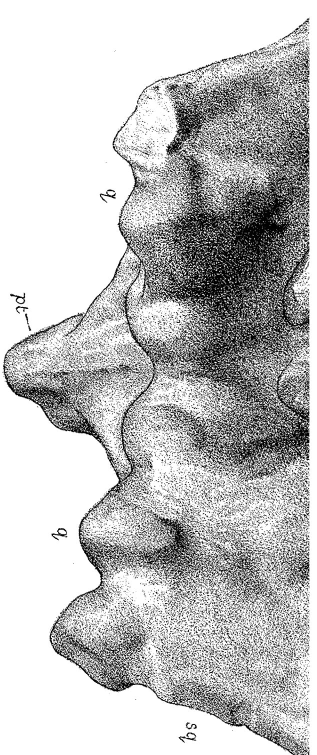

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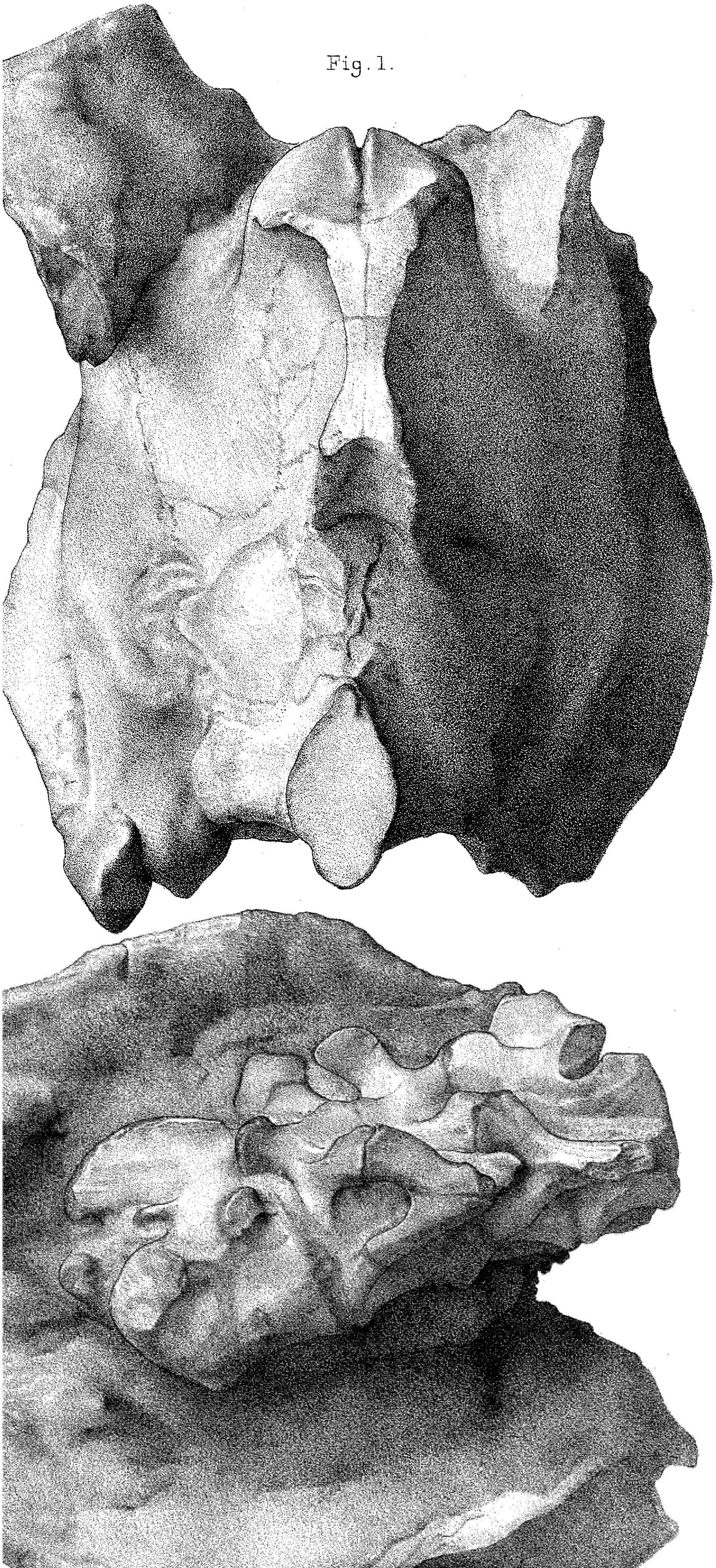

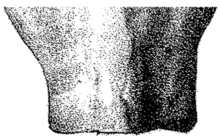

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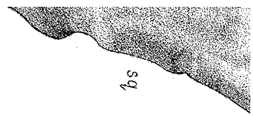

G. M. Woodward ad nat. lith.

Tropidostoma Dunnii.

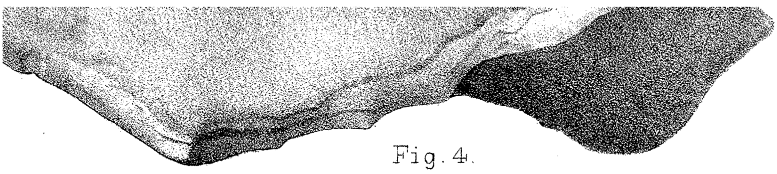

Fig. 4.

West, Newman imp.

Fig. 1. Fig. 2.

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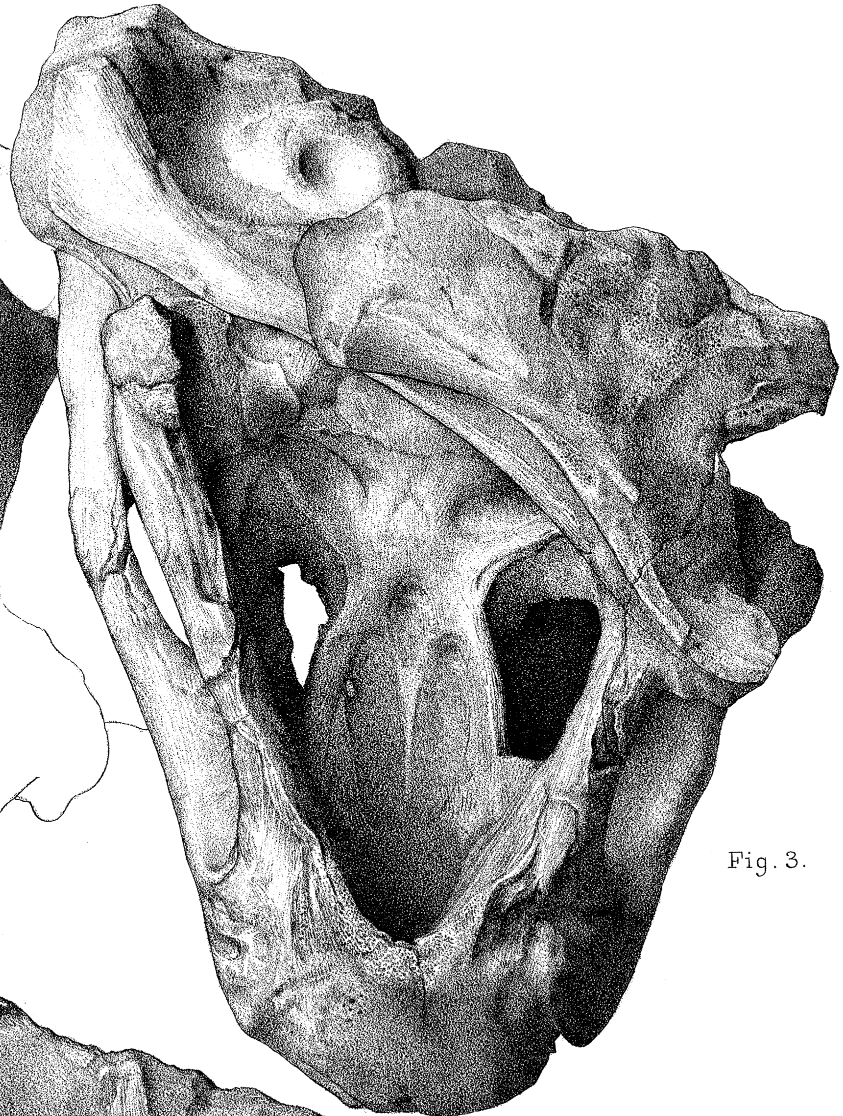
W. H. Wesley, ad nat. lith.

West, Newman imp.

Dicynodon tigriceps.

Fig. 1.



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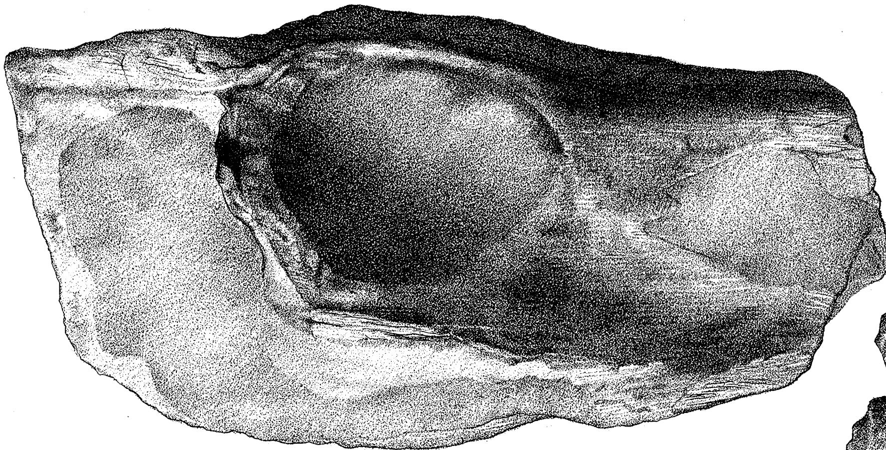
G.M.Woodward, ad. nat. lith.

Dicynodon Copei.

West, Newman & Co. imp.

Fig. 1.



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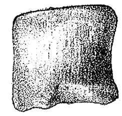

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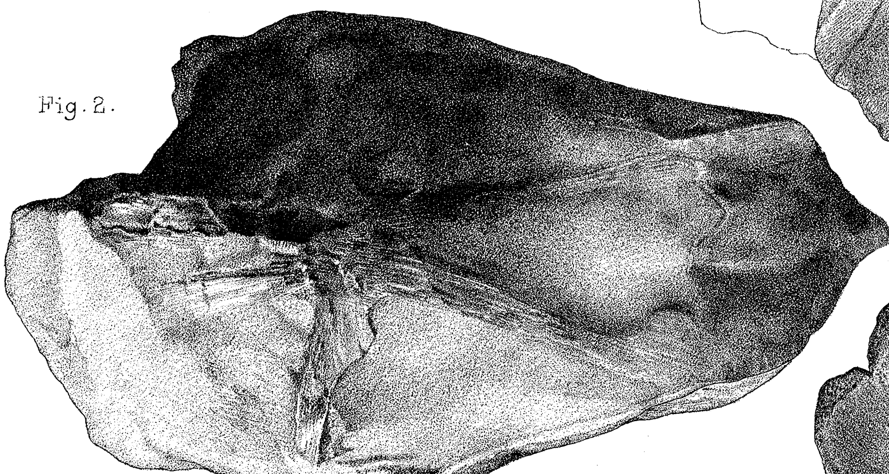

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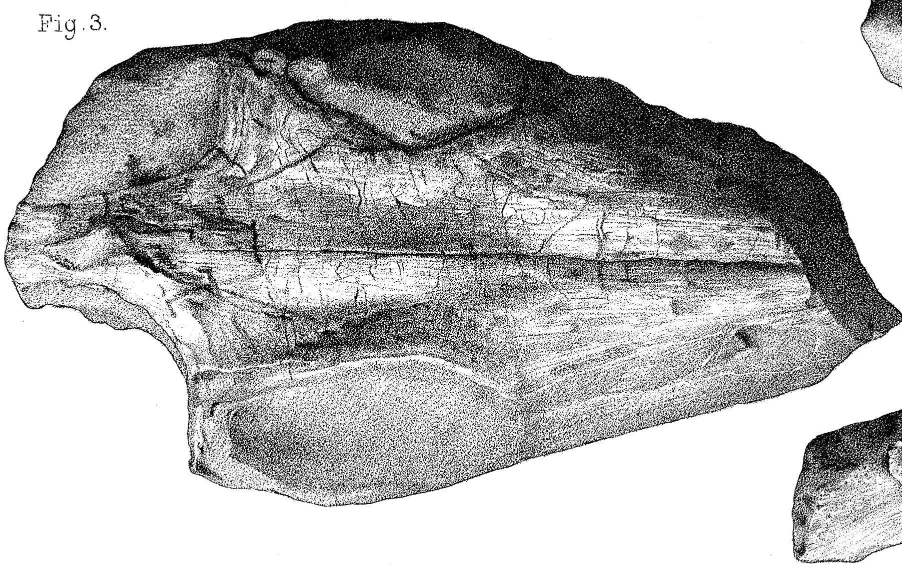

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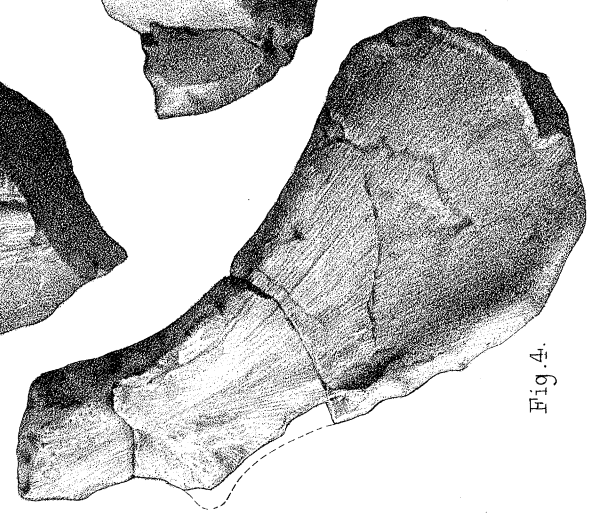
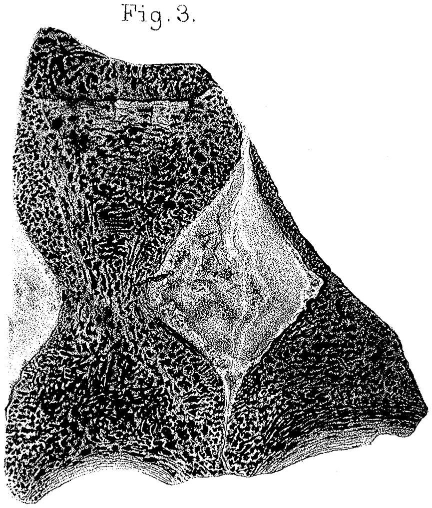


G.M. Woodward ad nat. lith. West, Newman imp.

Hyorhynchus platyceps.

Fig. 3.



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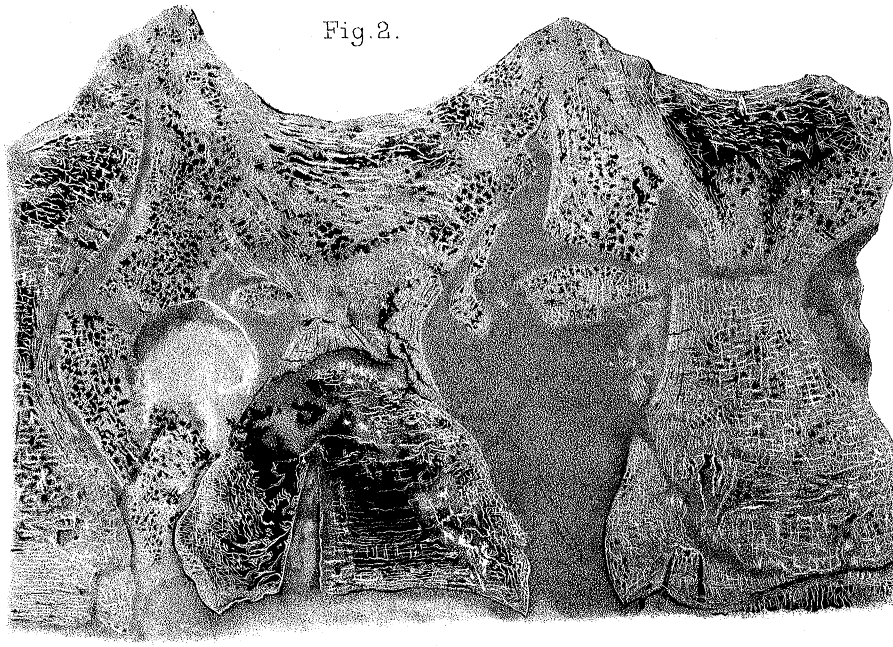

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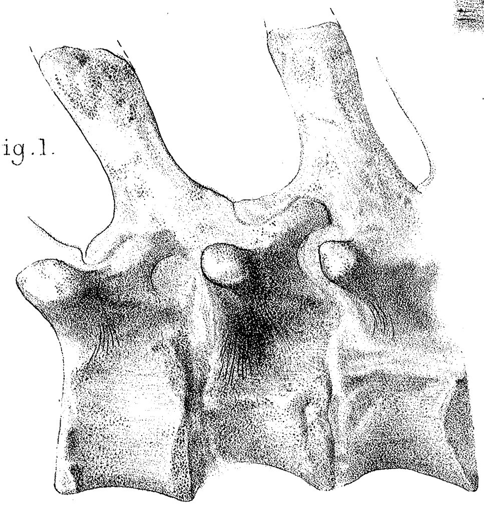

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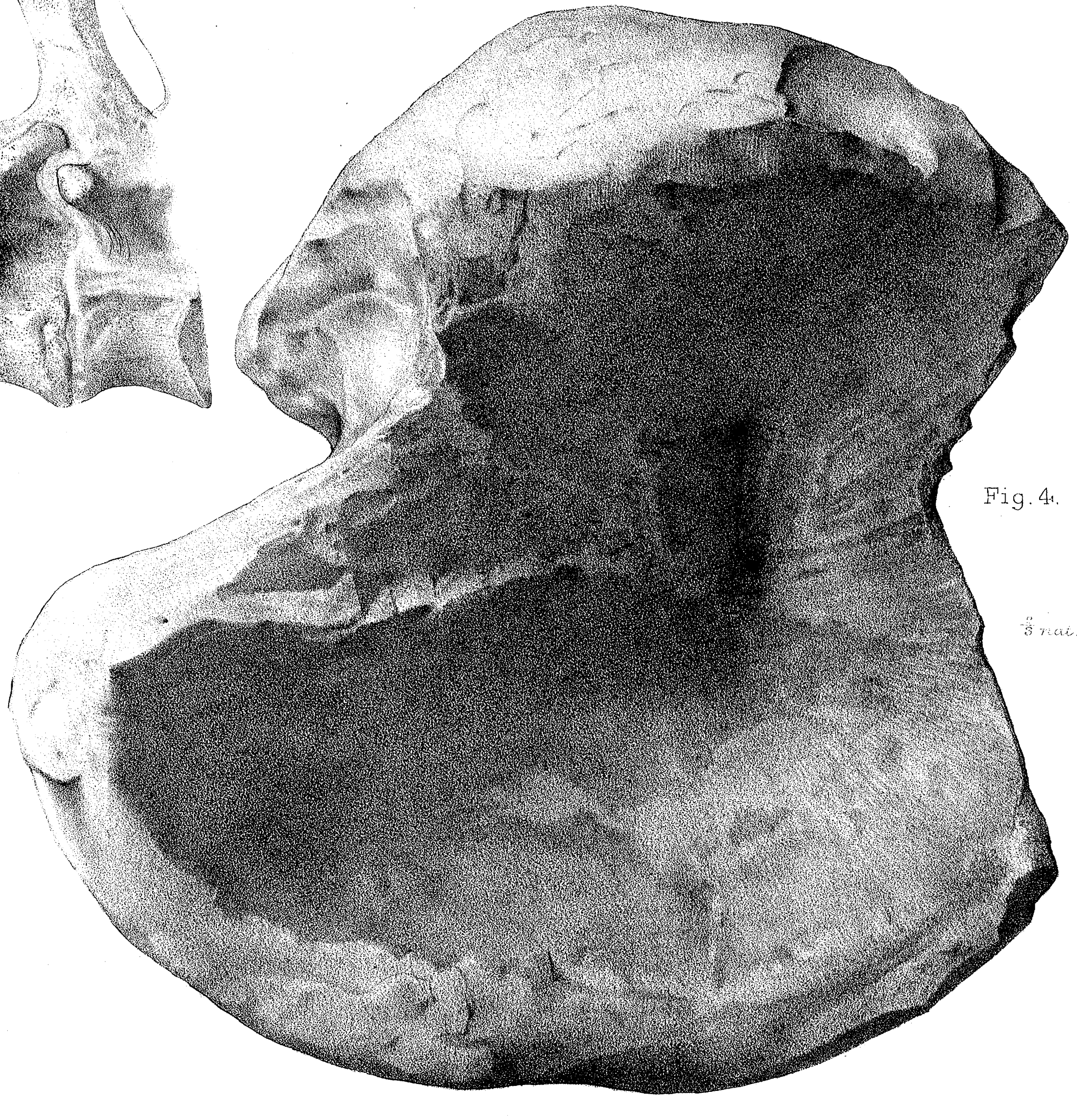

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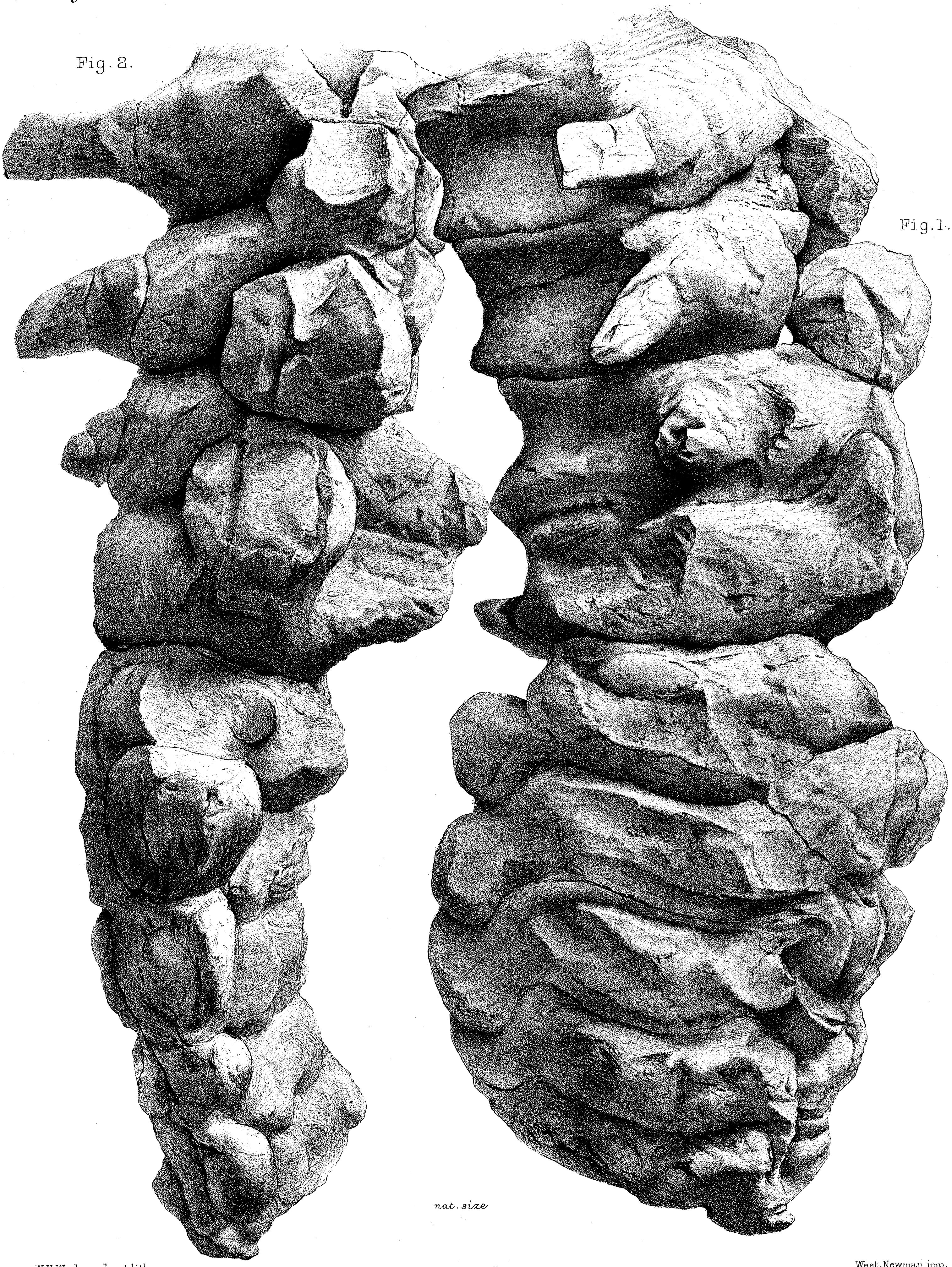
G. M. Woodward, ad nat. lith.

West, Newman imp.

Titanosuchus ferox &c.

Fig. 2.

Fig. 1.



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Platypodosaurus.

West, Newman imp.

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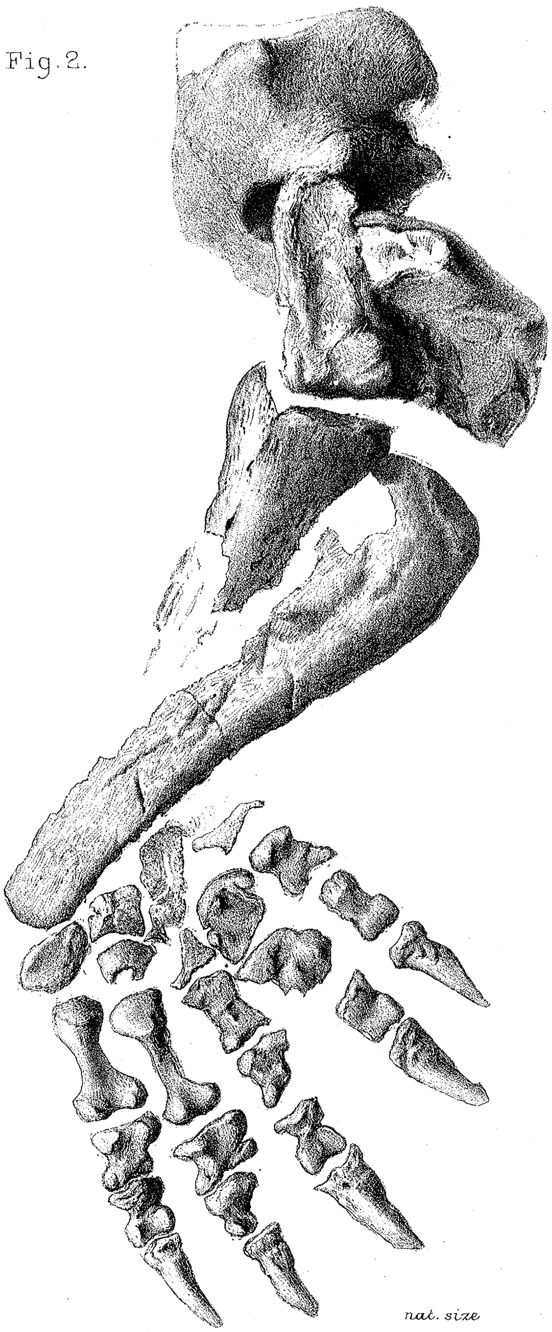

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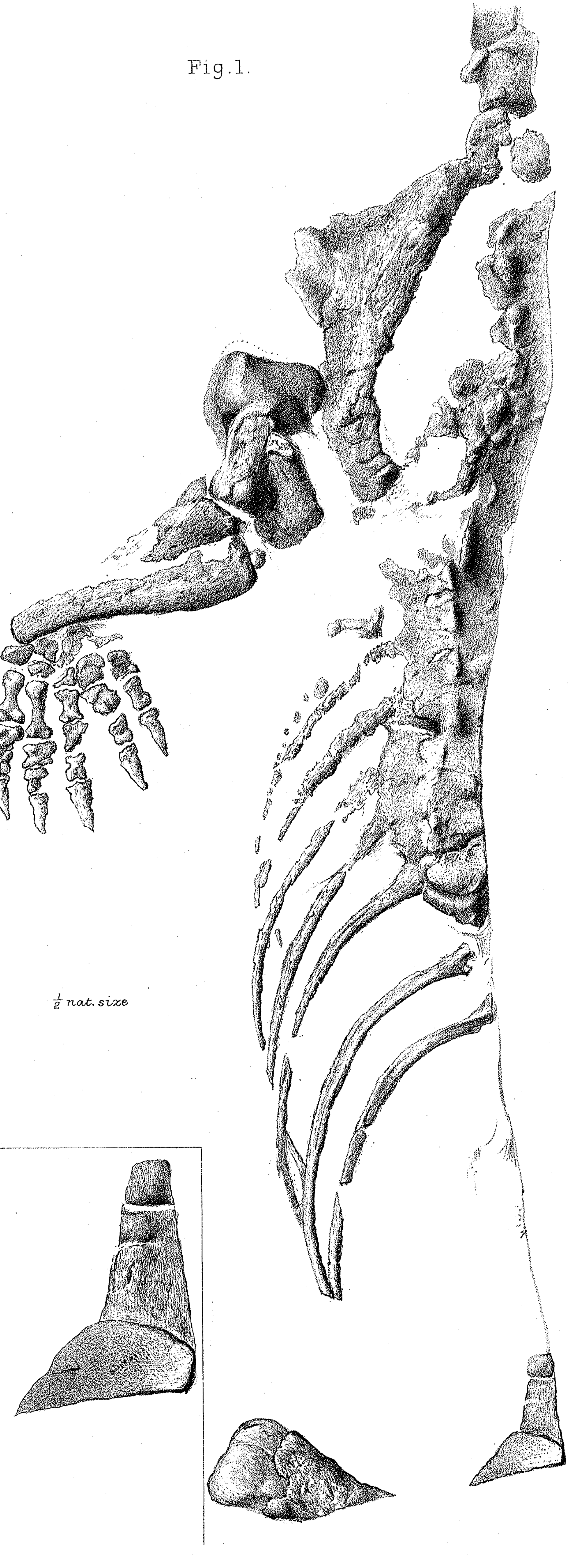

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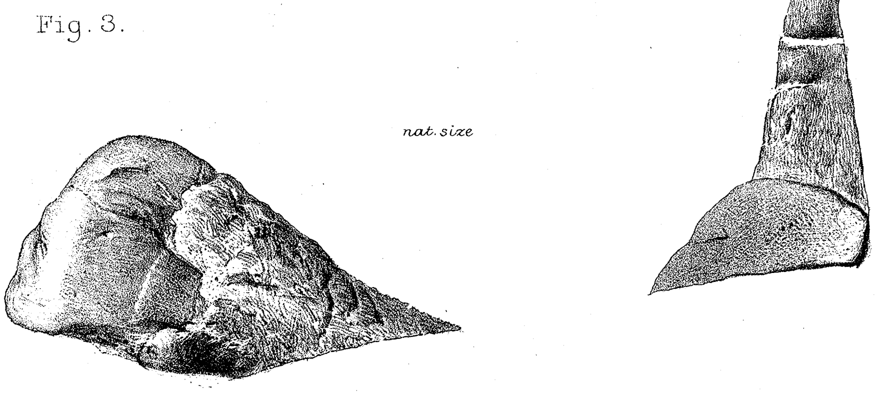


nat. size

W.H.Wesley, ad nat. lith.

West, Newman imp.

Eurycarpus Oweni.

Fig. 1.

Fig. 2.

$\frac{2}{5}$ *nat. size*

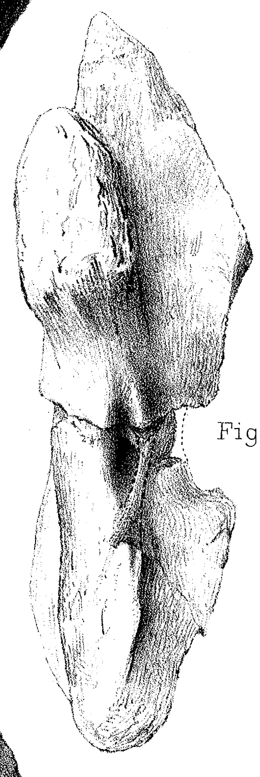
W.H.Wesley, ad nat. lith.

Femur — Titanosuchus ferox.

West, Newman imp.

Fig. 1.

Fig. 2.



$\frac{5}{11}$ nat. size

W.H. Wesley, ad nat. lith.

West, Newman imp.

Humerus—Titanosuchus ferox.

Fig. 1.

$\frac{3}{5}$ *nat. size*

Fig. 2.

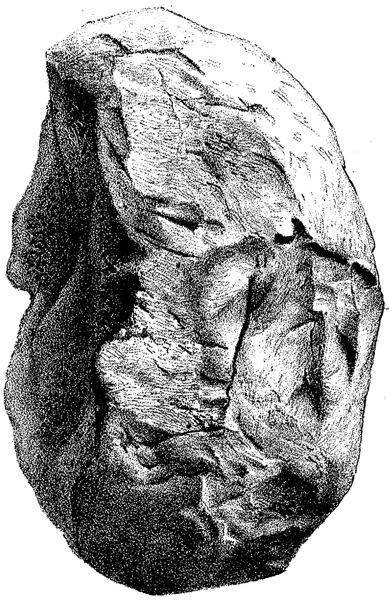
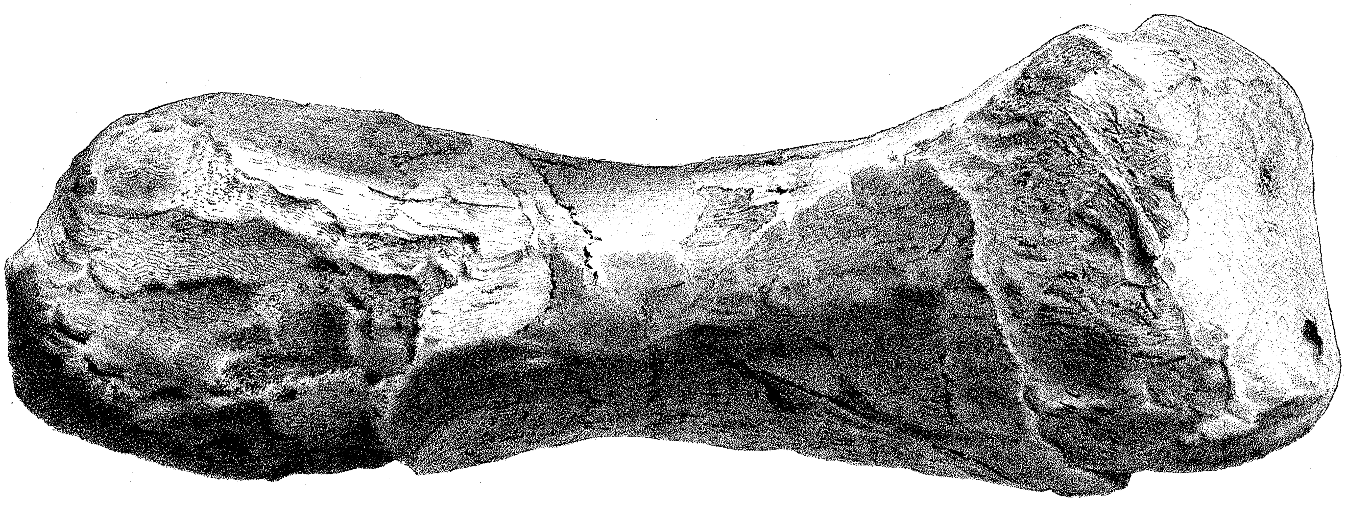


Fig. 4.

Fig. 3.



W. H. Wesley, ad nat. lith.

West, Newman imp.

Fibula —— Titanosuchus ferox.

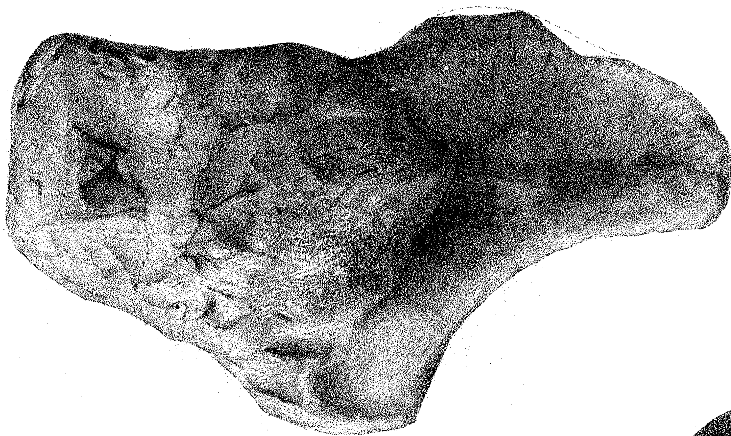


Fig. 2.

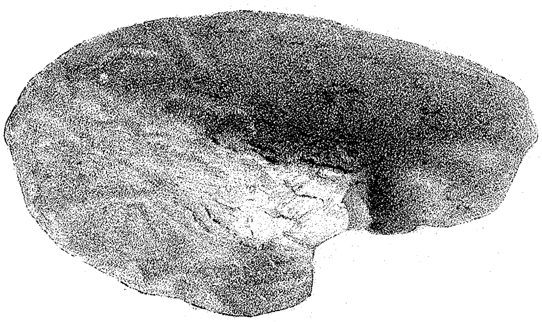


Fig. 4.

Fig. 3

½ *nat. size*

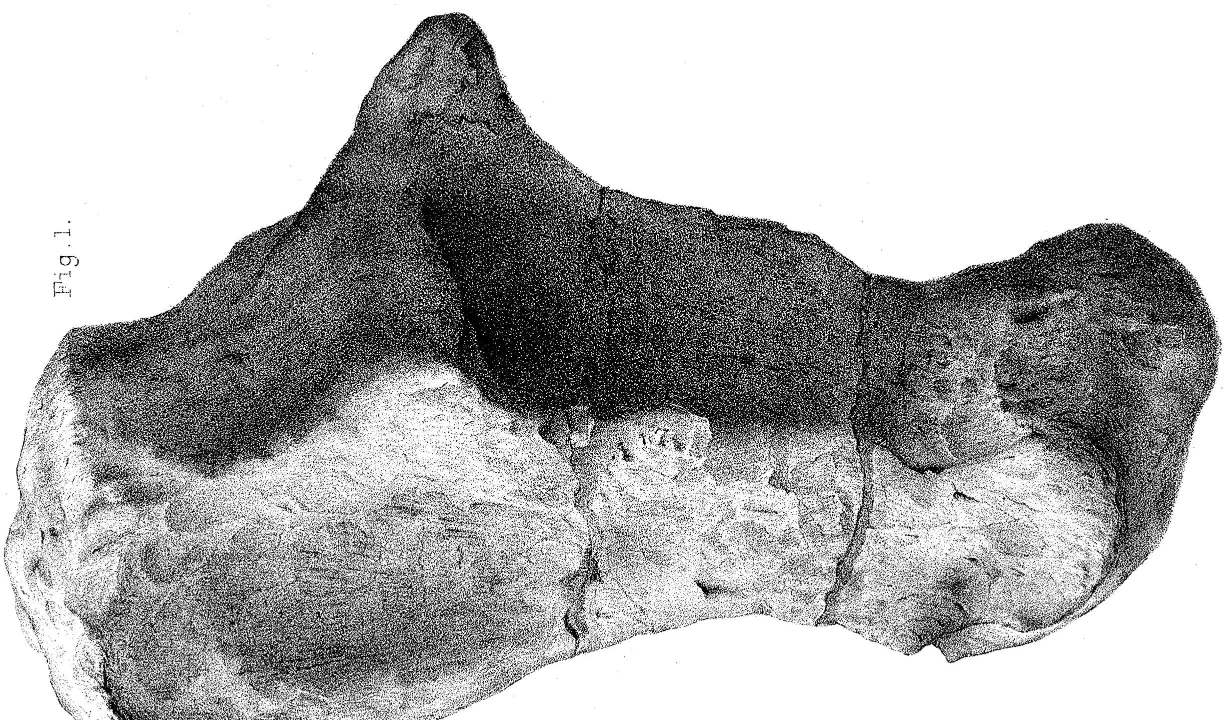


Fig. 1.

W. H. Wesley, ad nat. lith. West, Newman & Co. imp.

Ulna.

Fig. 2.

Fig. 3.

⅔ nat. size

Fig. 1.

W. H. Wesley, ad. nat. lith.

West, Newman & Co. imp.

Ulna.

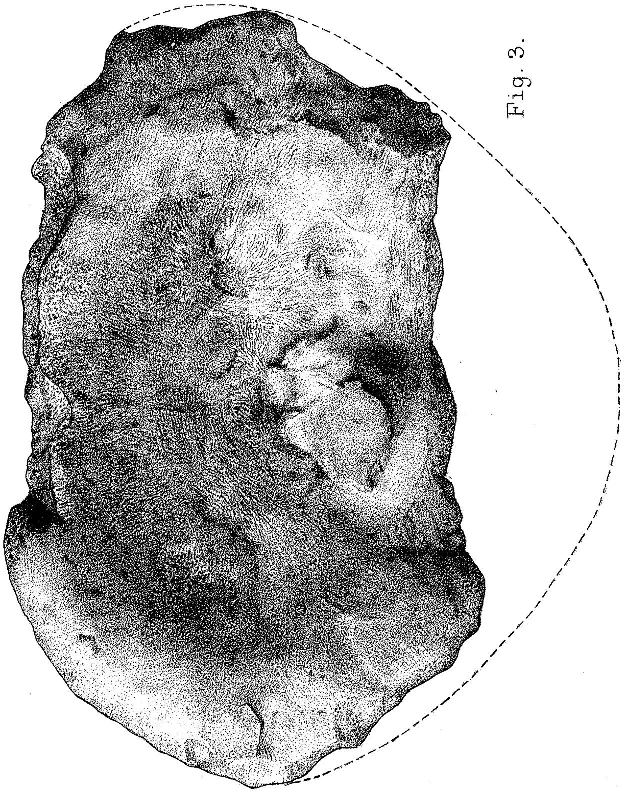


Fig. 3.

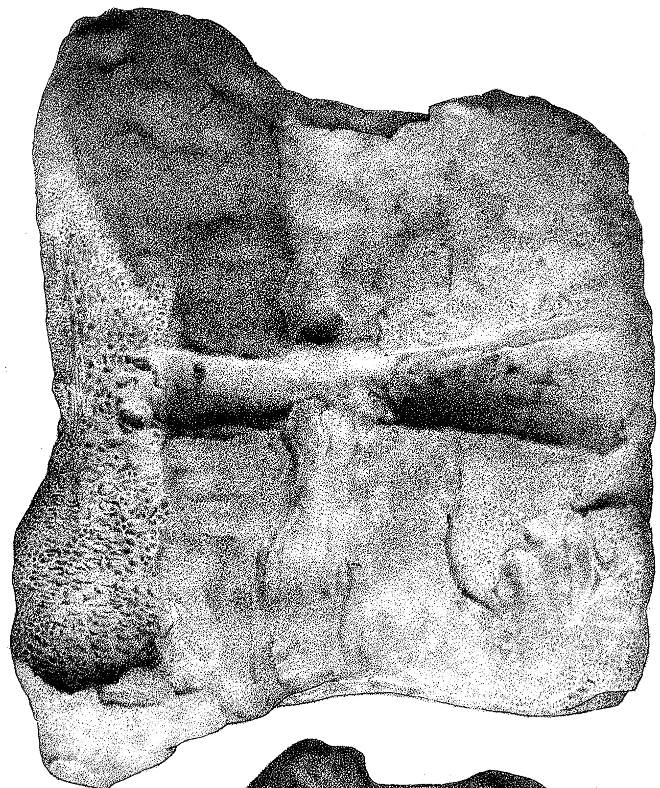


Fig. 4.

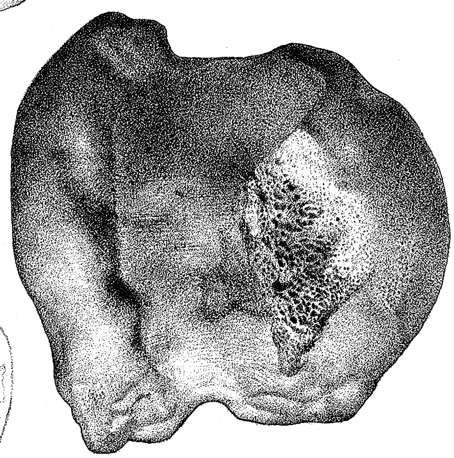


Fig. 2.

Titanosuchus & Placodus.

Nat. size

Fig. 6.

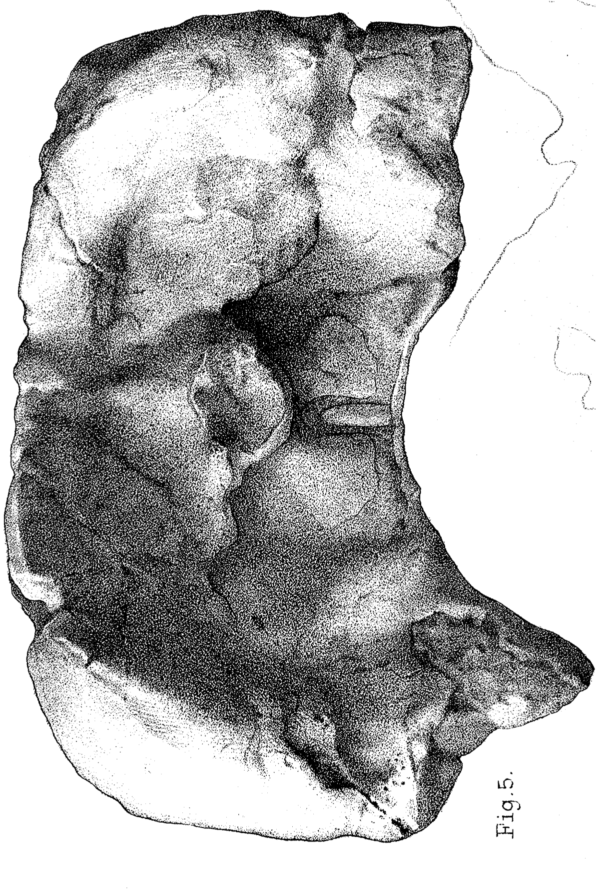


Fig. 5.

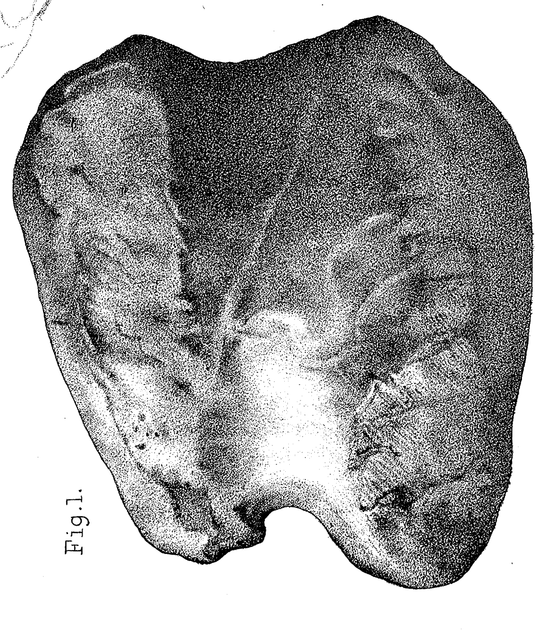


Fig. 1.

G. M. Woodward ad nat. lith.

West, Newman imp.

Fig. 2.

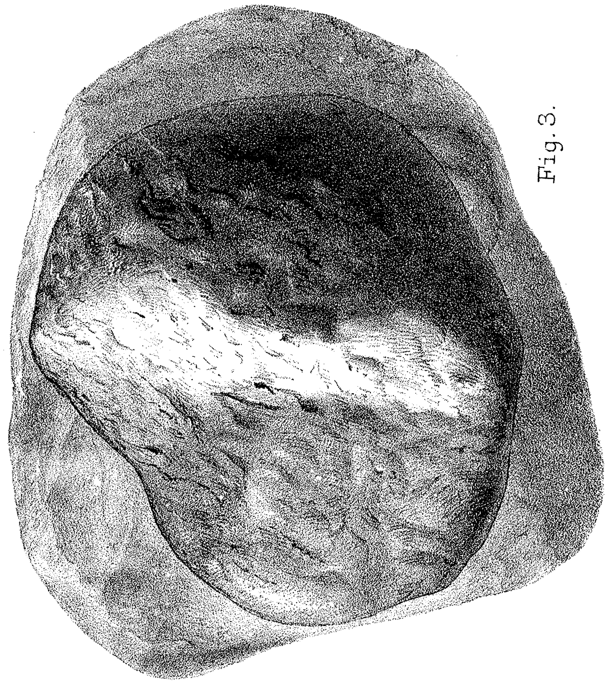


Fig. 3.

Fig. 1.

½ nat. size

W.H. Wesley, ad nat. lith. West, Newman imp.

Tibia.

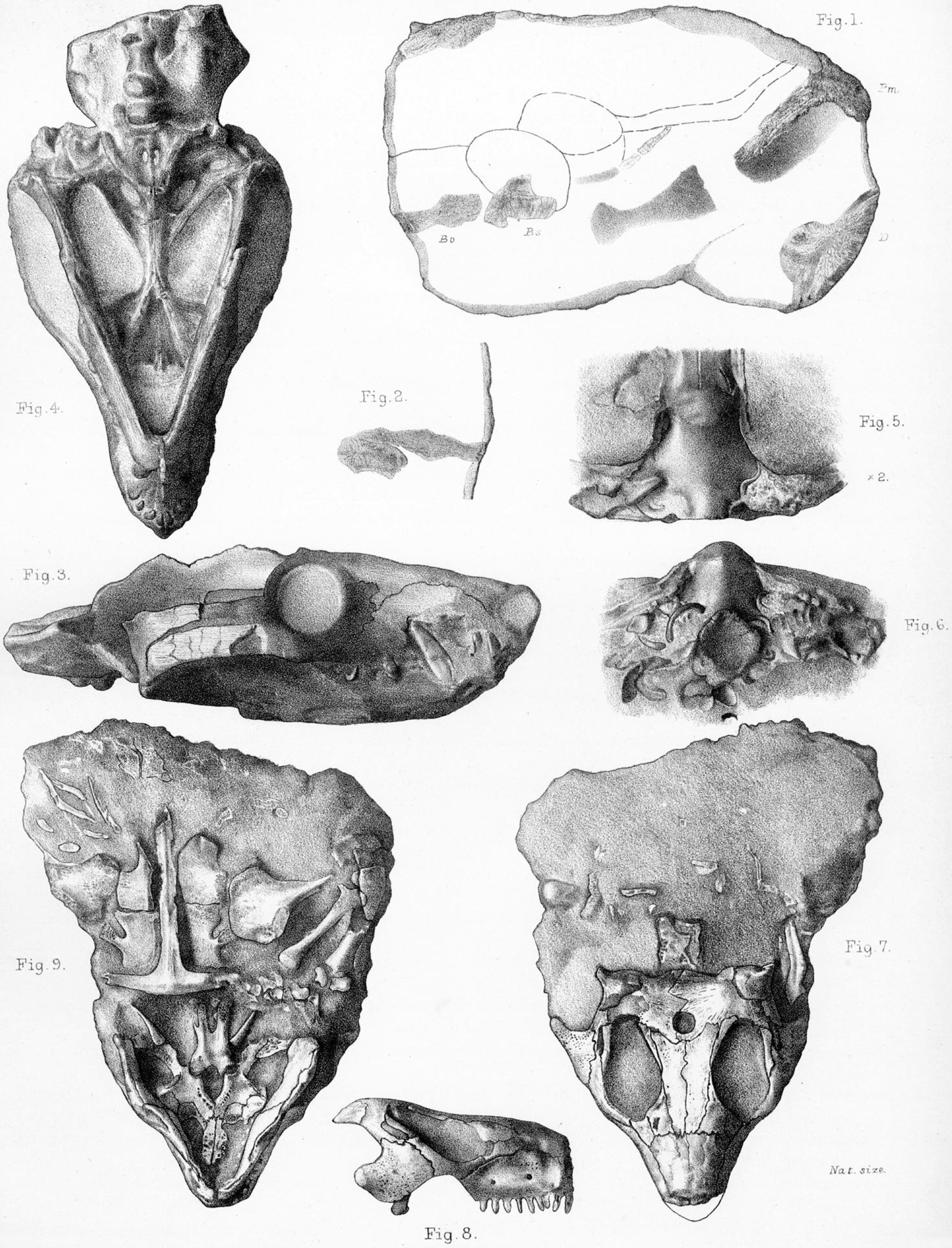


PLATE 9.

Galesaurus *and* Procolophon.

Fig. 1. Median vertical section of an undescribed Dicynodont skull, showing bones of the median axis of the base of the brain case, the pre-maxillary and dentary bone. A dotted line indicates faint markings in the matrix which extend between the foramen magnum and the narial region. (See p. 225.)

Fig. 2. Anchylosed basi-occipital and basi-sphenoid from the opposite half of the same skull. (See p. 225.)

Fig. 3. Right side of skull of *Galesaurus*, showing the zygomatic arch formed by the malar and squamosal bones, with coronoid process of the lower jaw rising above the squamosal. (See p. 277.)

Fig. 4. Palate of the same skull, showing occipital articulation, position of malleus, and composite structure of lower jaw. (See p. 278.)

Fig. 5. Superior aspect of the posterior portion of internal mould of the brain cavity of *Galesaurus* enlarged, showing vertical and horizontal semicircular canals on the left side. (See p. 278.)

Fig. 6. Posterior aspect of the same specimen, showing the foramen magnum, lateral contour of brain case, and semicircular canals. (See p. 278.)

Fig. 7. Skull of *Procolophon trigoniceps* (Owen), seen from above. (See p. 269.)

Fig. 8. Right side of the same skull. (See p. 272.)

Fig. 9. Palatal aspect of the same skull, with the shoulder girdle and right fore-limb. (See p. 274.)

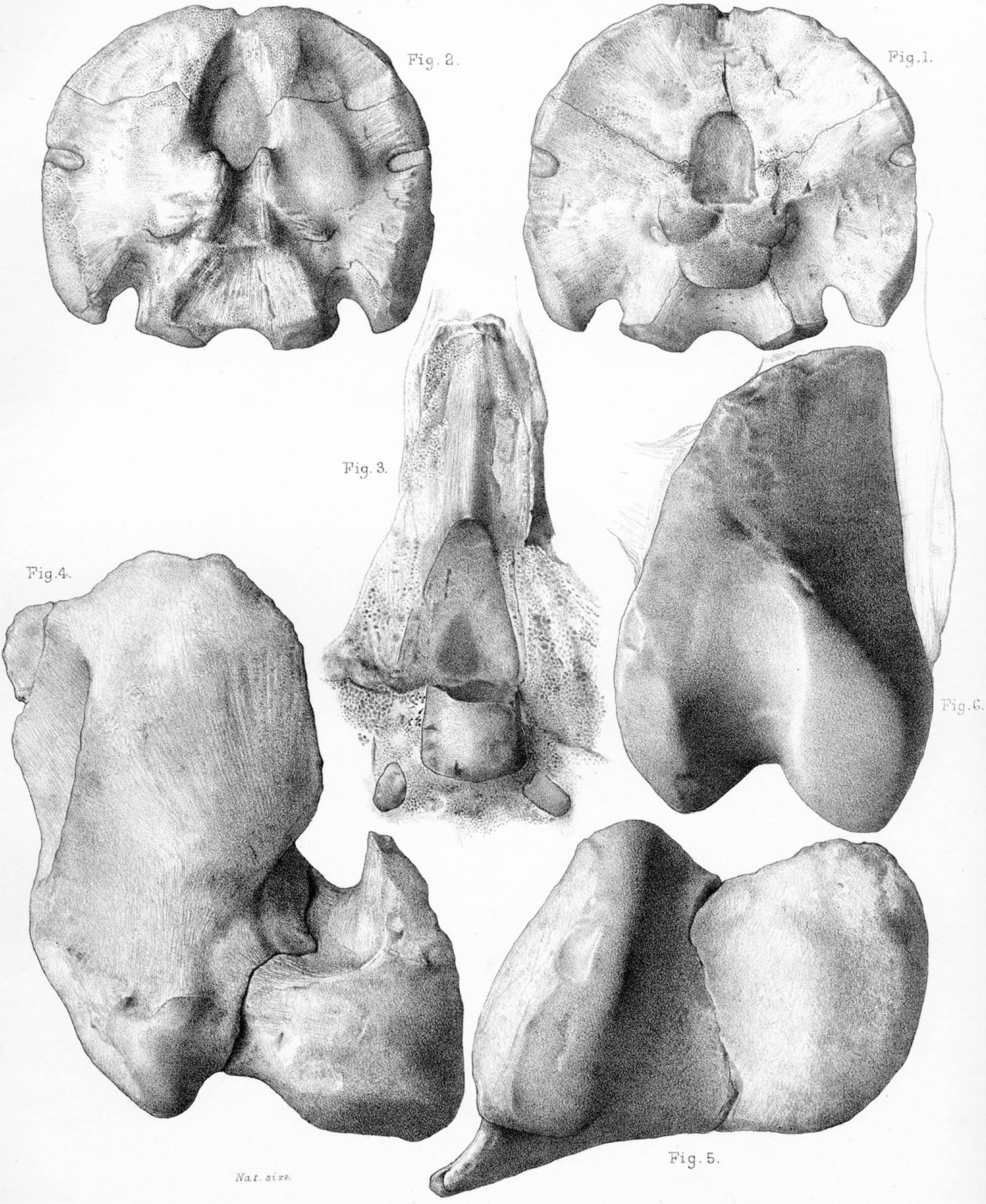


PLATE 10.

South African Anomodontia.

Fig. 1. Occipital plate of a small Dicynodont skull, showing its constituent elements. (See p. 226.)

Fig. 2. Anterior aspect of the same specimen, showing the back of the brain-case. (See p. 227.)

Fig. 3. Posterior aspect of brain-case in *Dicynodon leoniceps* (Owen). (See p. 228.)

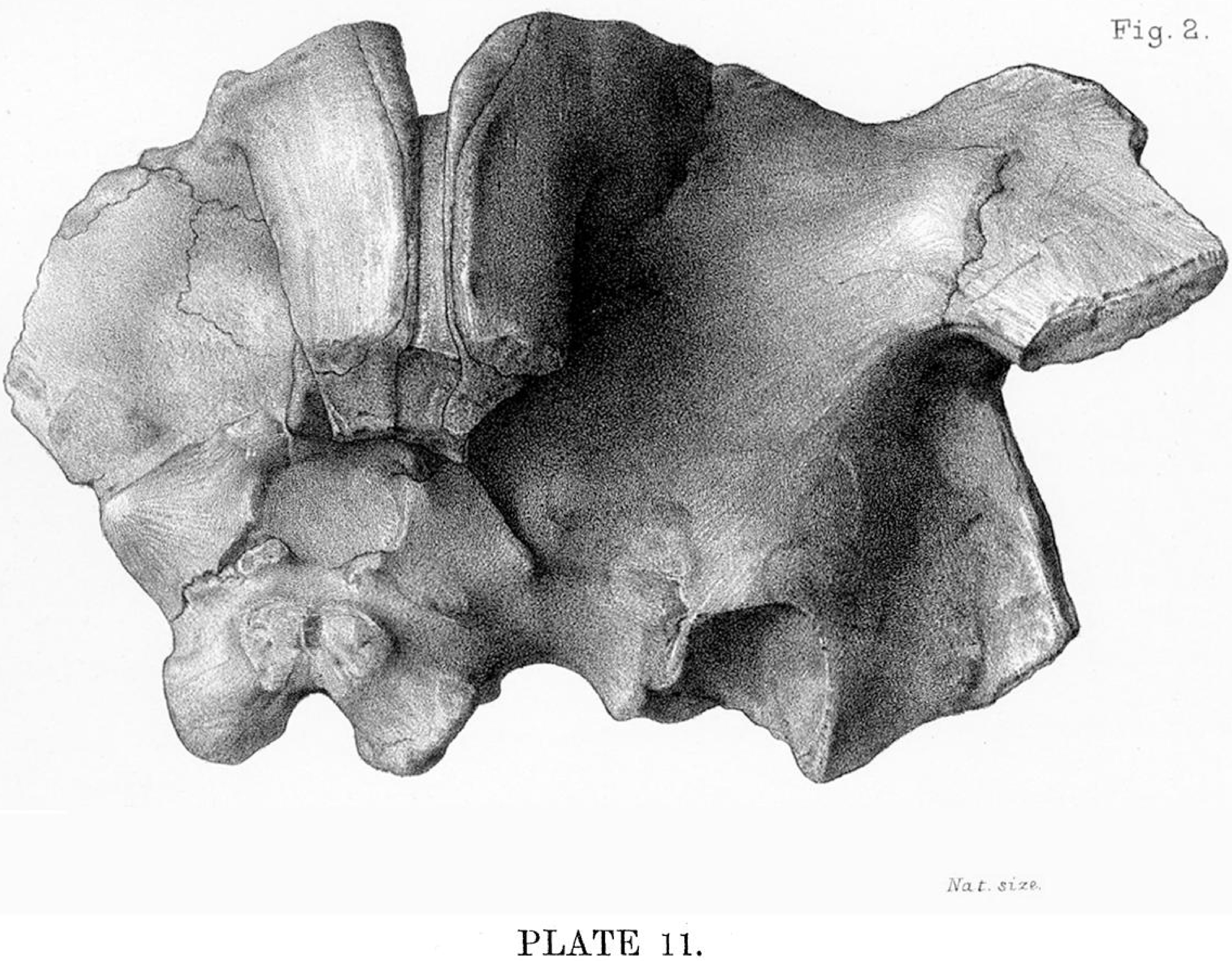
Fig. 4. Quadrate bone of a new Anomodont. (See p. 239.)

Fig. 5. Palatal aspect of the same specimen, showing the condyles. (See p. 239.)

Fig. 6. Quadrate bone from the skull of *Dicynodon leoniceps* (Owen). (See p. 220.)

Fig. 1.

Fig. 2.



Nat. size.

PLATE 11.

Dicynodon microtrema.

Fig. 1. Occipital aspect of the skull of *Dicynodon microtrema.* (See p. 228.)

Fig. 2. Anterior aspect of the same specimen, showing portion of cerebral cavity. (See p. 228.)

Fig. 2.

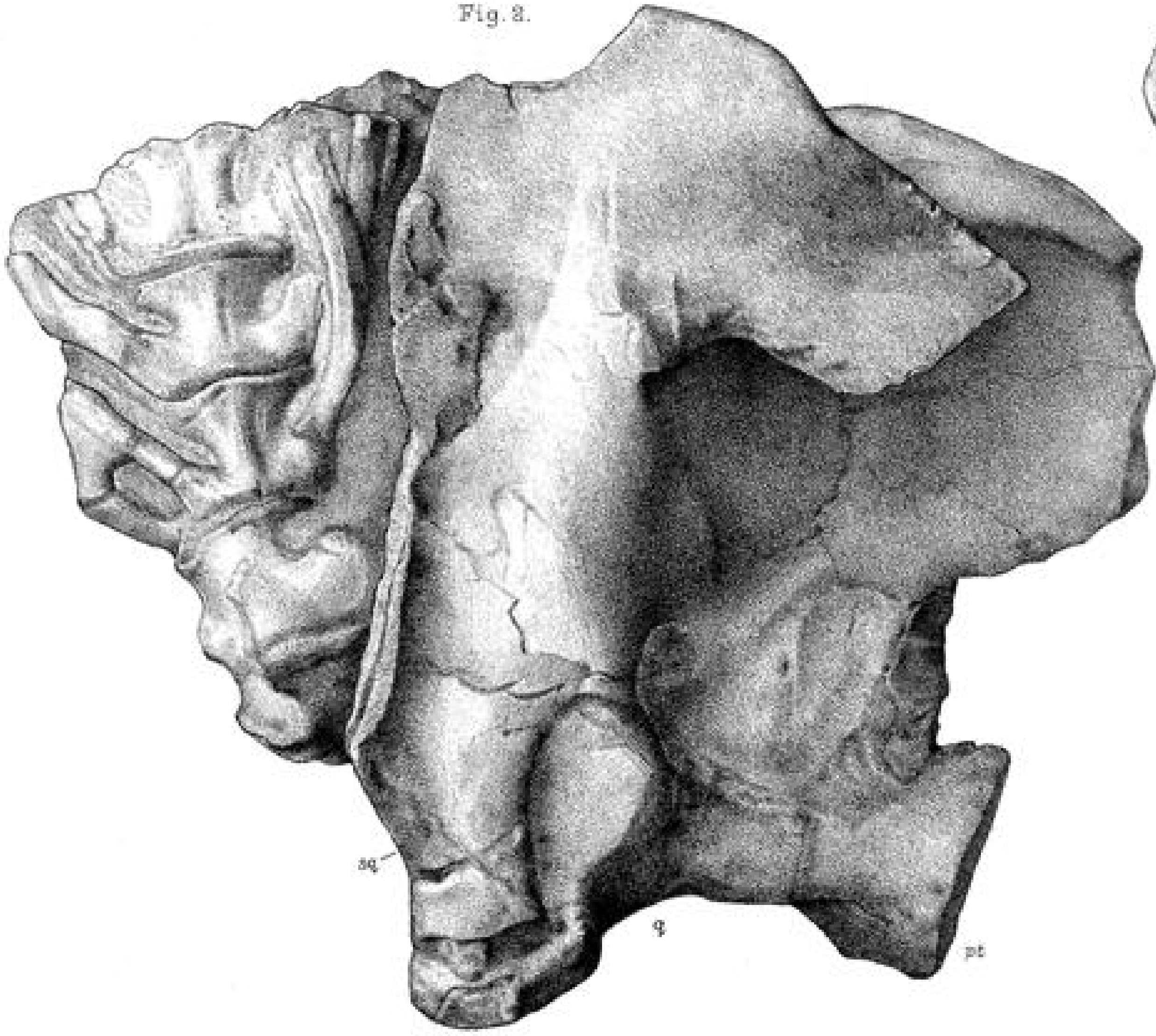
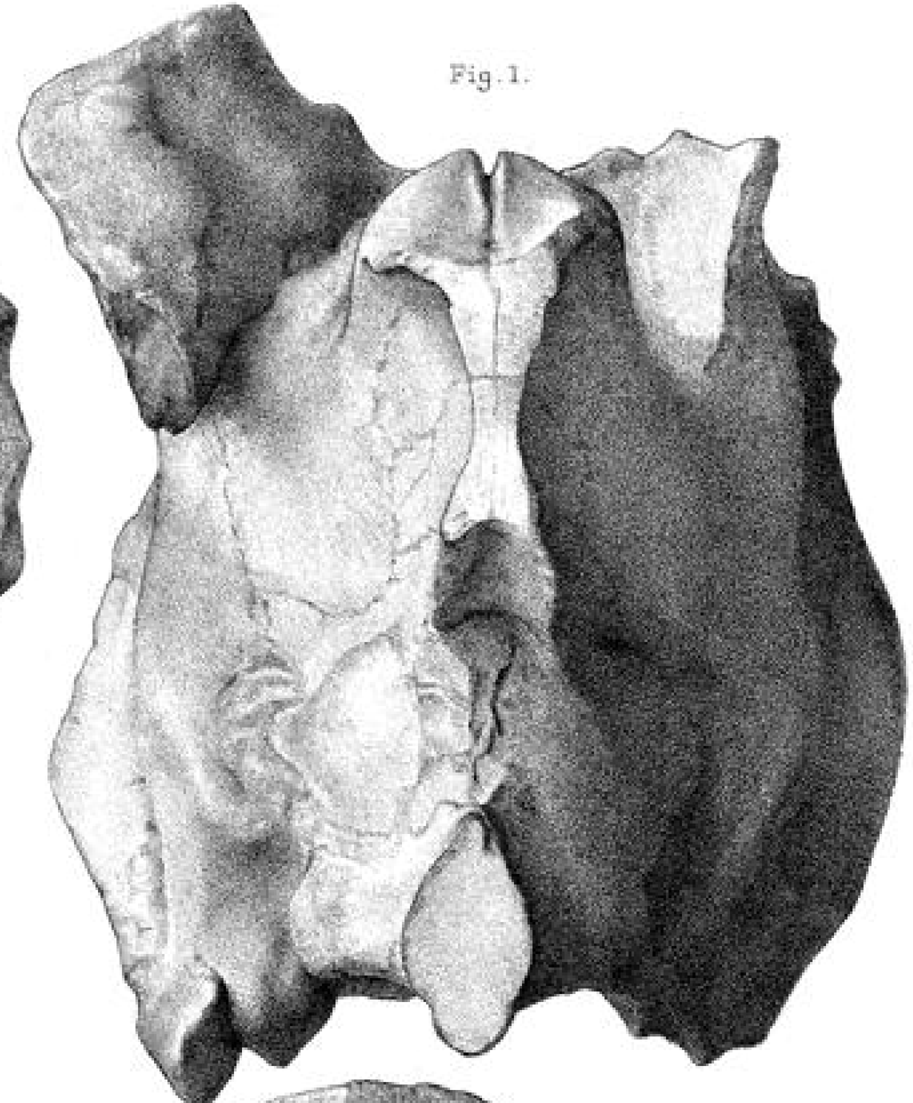


Fig. 1.



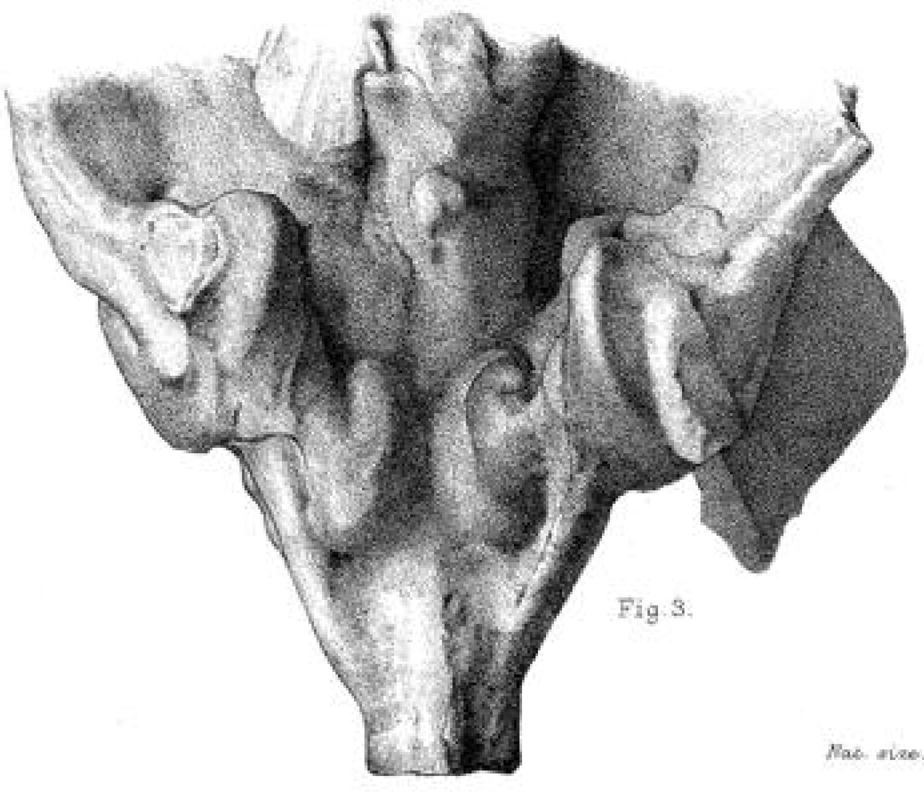


Fig. 3.

Fig. 4.

Nat. size.

G. M. Woodward ad nat. lith.

West, Newman imp.

Tropidostoma Dunnii.

Seeley.

Fig. 2.

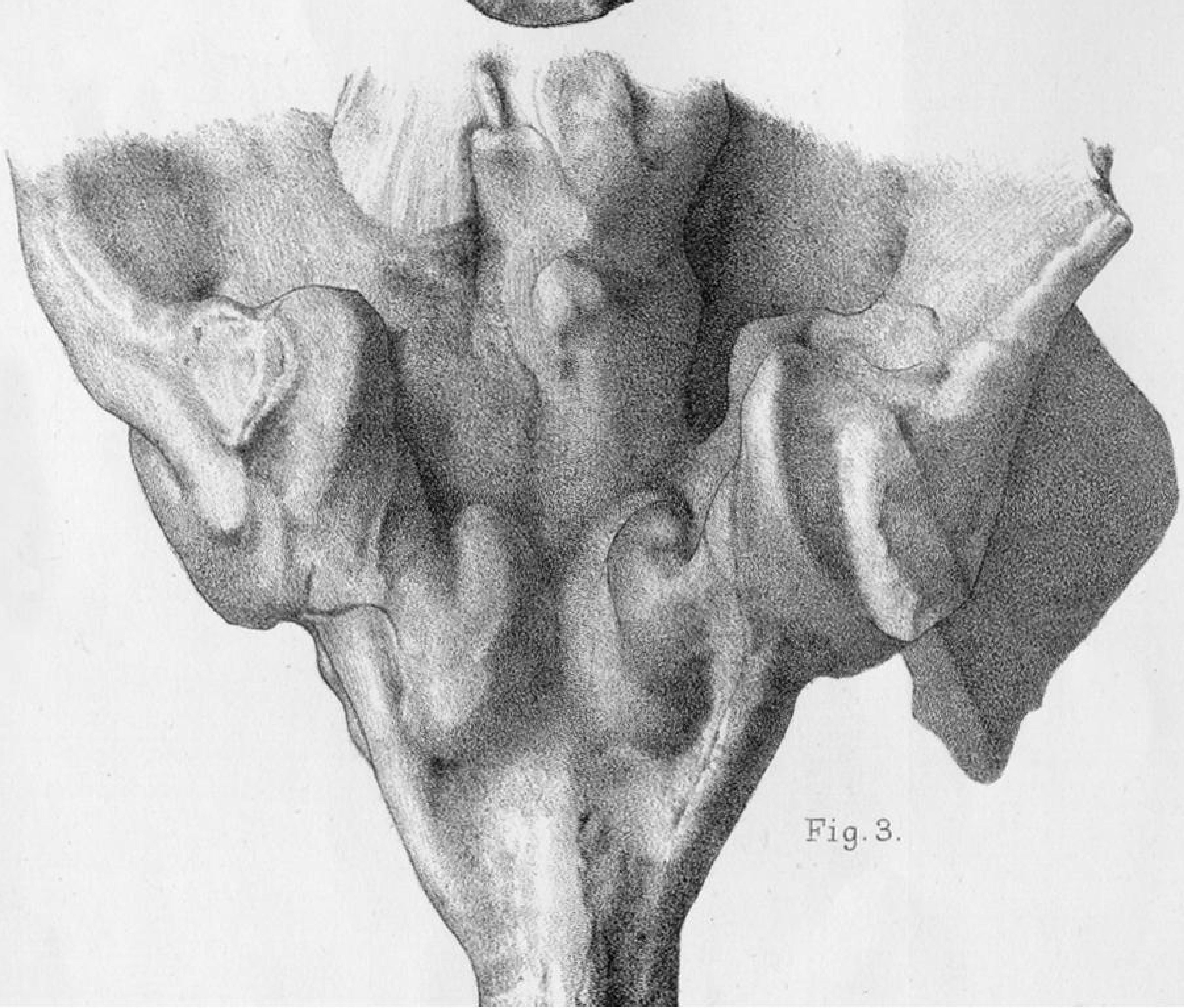
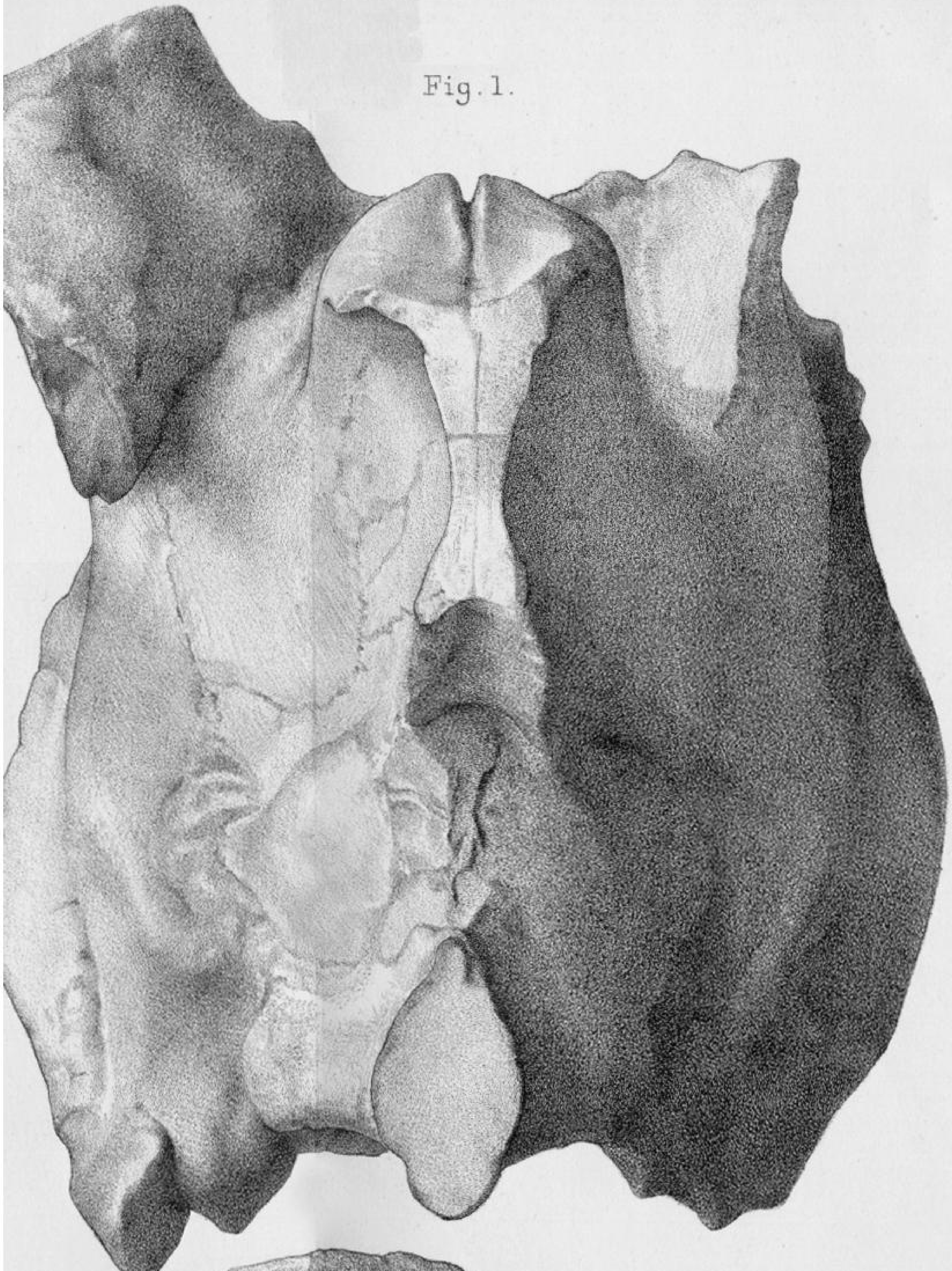
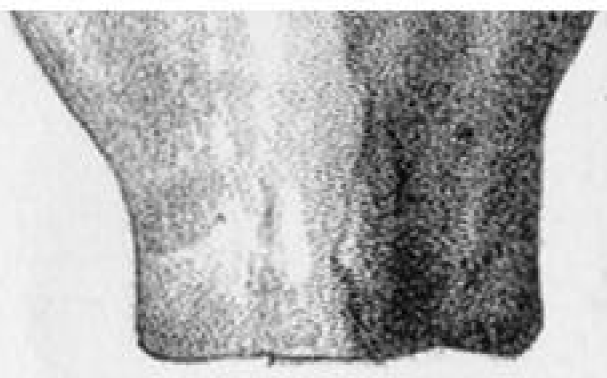
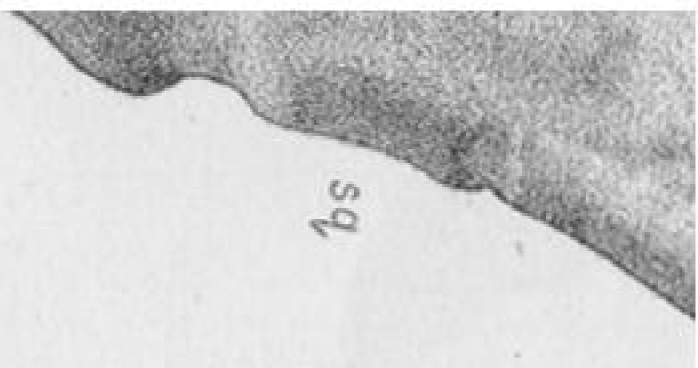


Fig. 3.

Fig. 1.







Nat. size.

G. M. Woodward ad nat. lith.

Tropidostoma Dunnii.

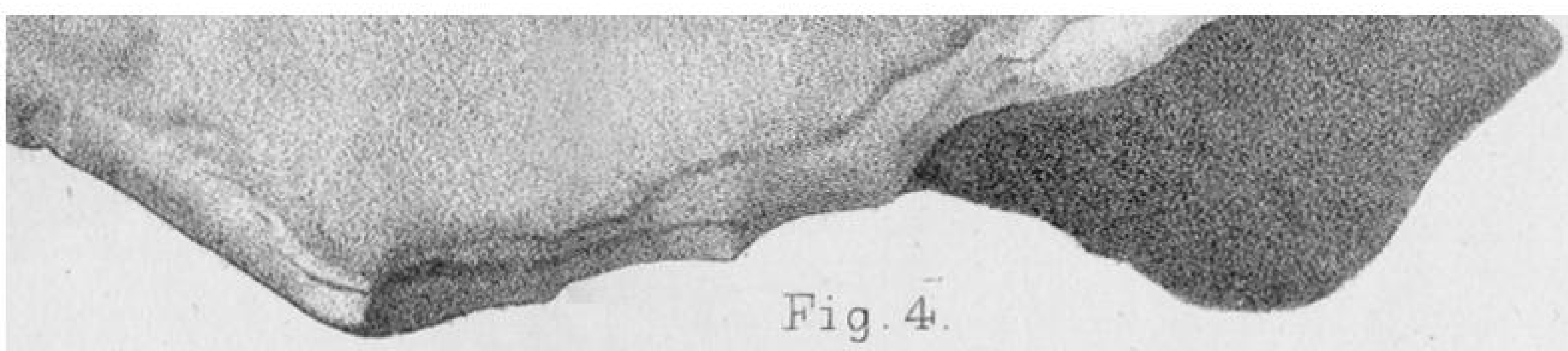


Fig. 4.

West, Newman imp.

Fig. 1.

Fig. 2.

⅓ nat. size

PLATE 13.

Skull of Dicynodon tigriceps (Owen).

Fig. 1. Superior aspect. (See p. 236.)

Fig. 2. Lateral aspect. (See p. 237.)

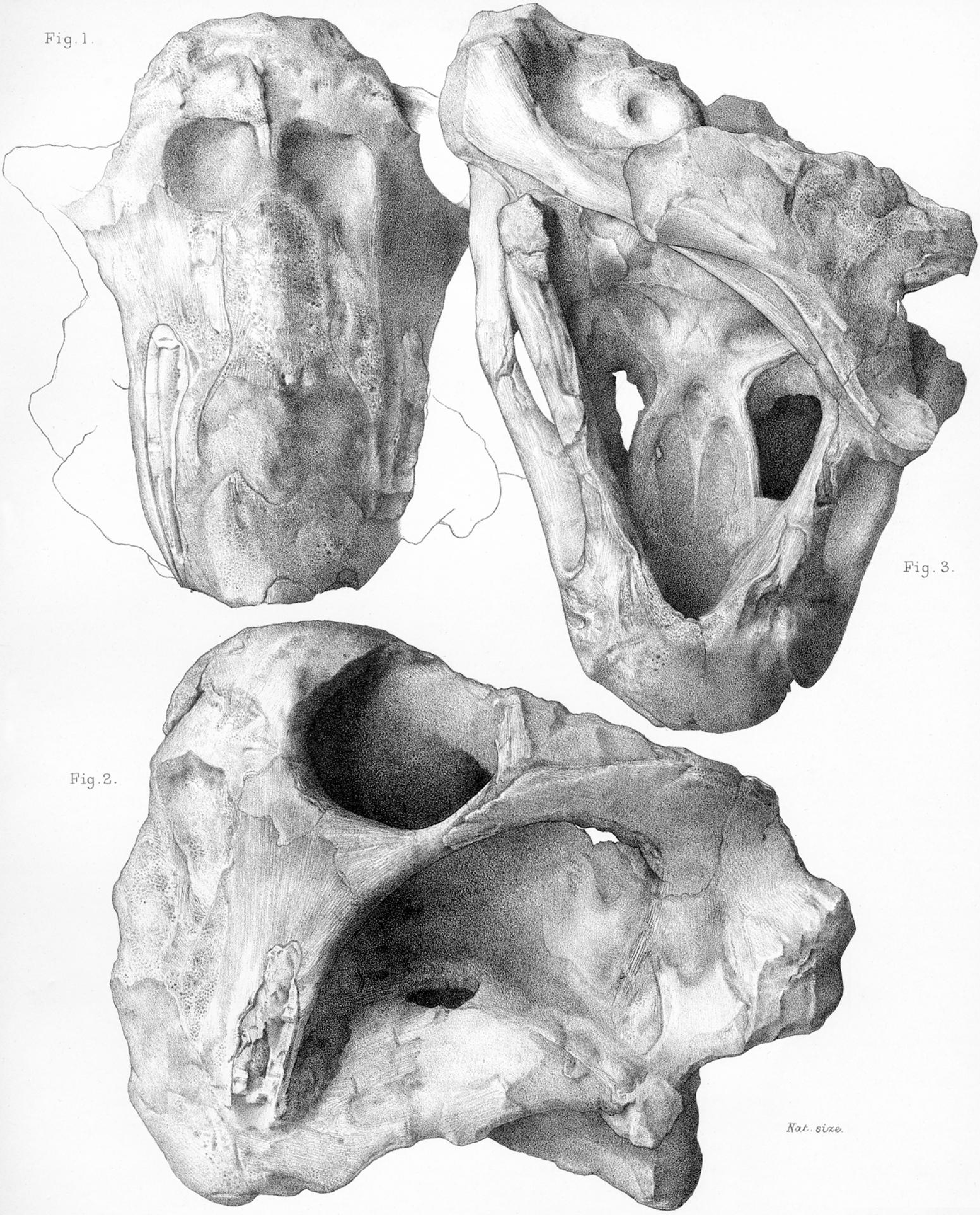


PLATE 14.

Skull of Dicynodon Copei.

Fig. 1. Anterior aspect. (See p. 241.)
Fig. 2. Left lateral aspect. (See p. 241.)
Fig. 3. Palate, with lower jaw. (See p. 241.)

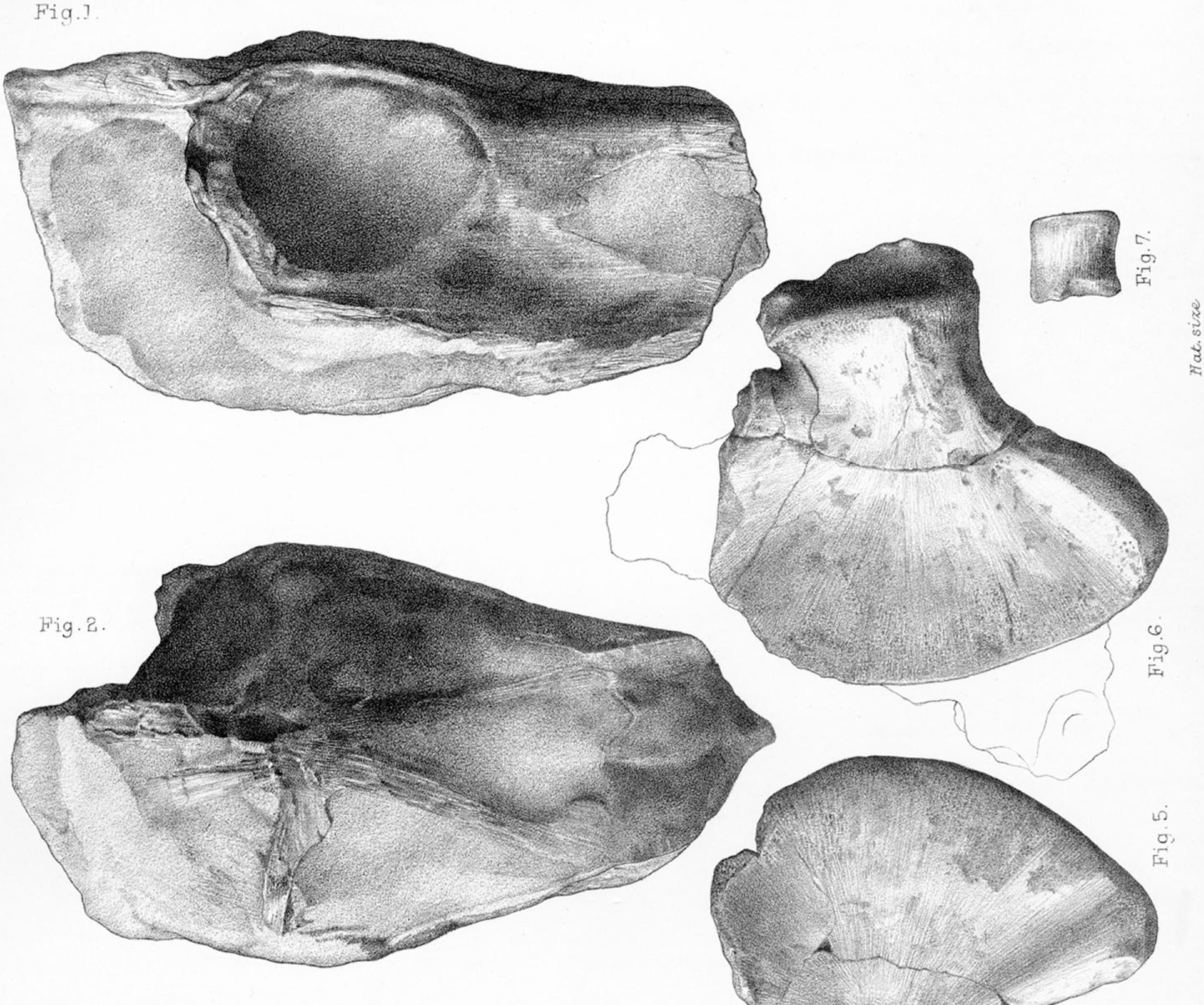


PLATE 15.

Hyorhynchus platyceps.

Fig. 1. Right side of skull of *Hyorhynchus platyceps*. (See p. 242.)
Fig. 2. Palate of the same specimen. (See p. 242.)
Fig. 3. Superior aspect of the same specimen. (See p. 242.)
Fig. 4. Proximal part of right scapula. (See p. 255.)
Figs. 5, 6. Right and left coracoids of a small Anomodont. (See p. 257.)
Fig. 7. Dorsal vertebra associated with the coracoids. (See p. 257.)

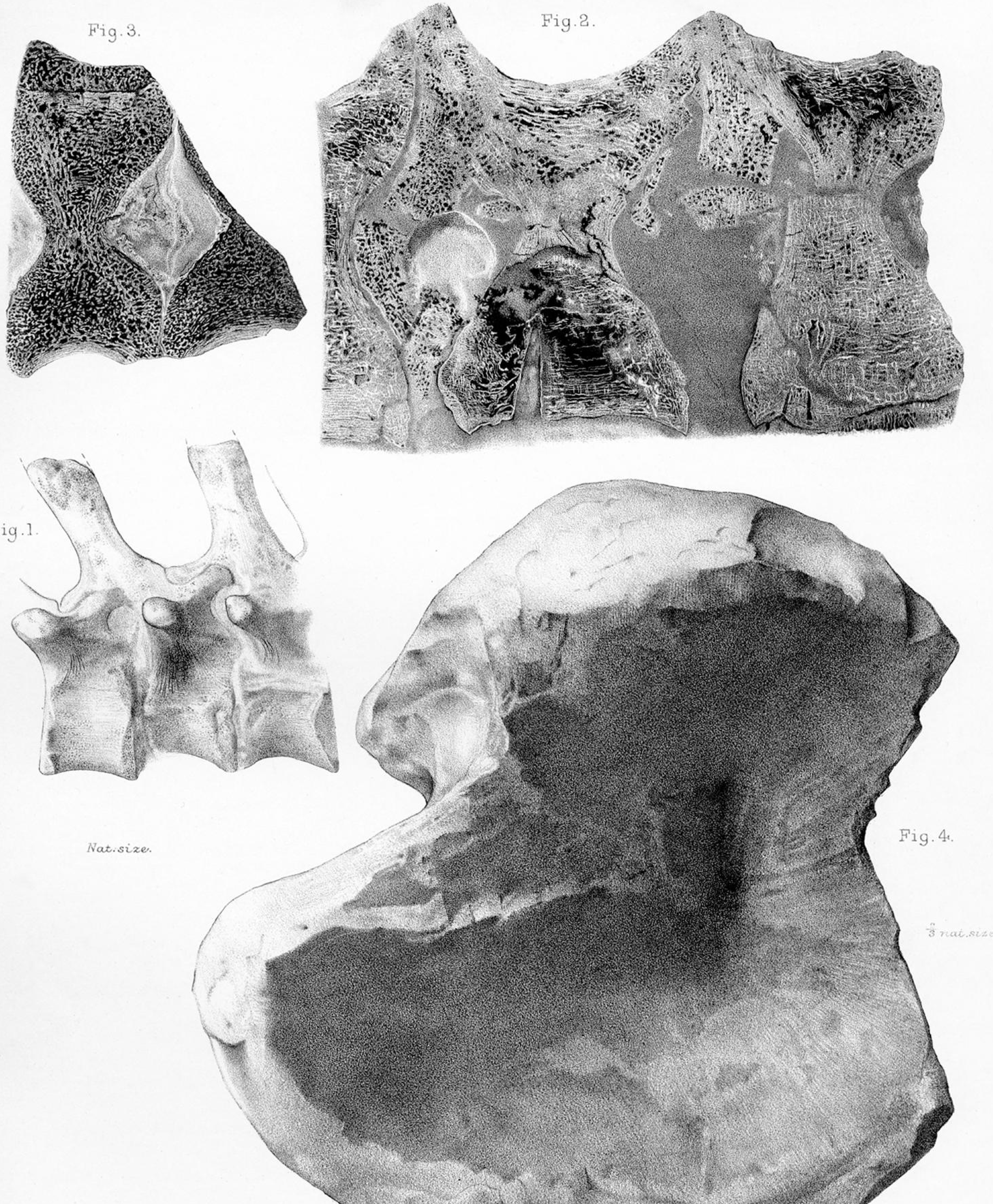


PLATE 16.

Titanosuchus ferox, *&c.*

Fig. 1. Dorsal vertebræ of (?) *Ptychognathus.* (See p. 251.)

Fig. 2. Section of dorsal vertebræ, showing ossification of inter-vertebral substance (See p. 254.)

Fig. 3. Section of caudal vertebræ, showing a similar change of tissue. (See p. 254.)

Fig. 4. Pubic bone, *Titanosuchus ferox.* (See p. 258.)

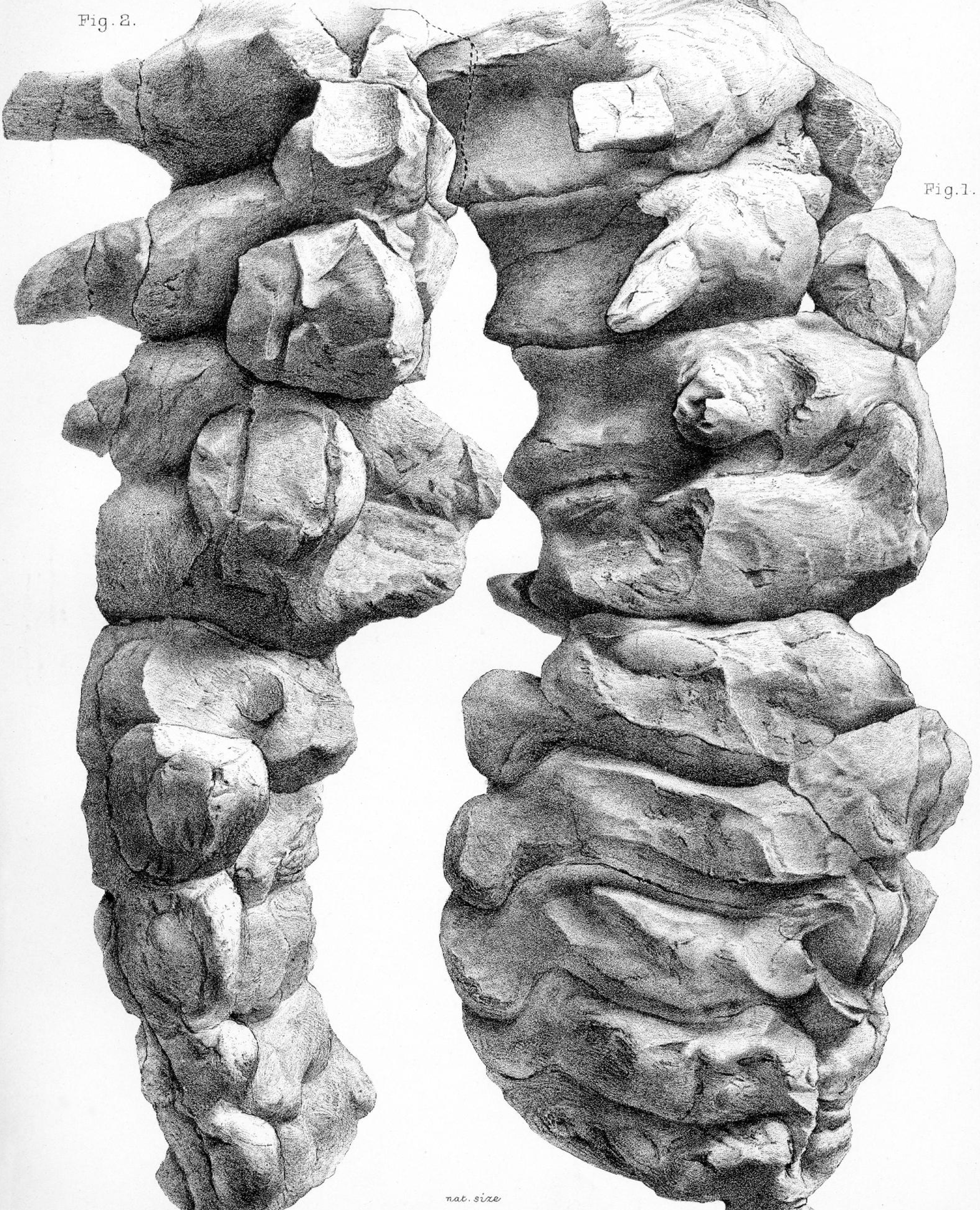


PLATE 17.

Caudal Vertebræ of Platypodosaurus robustus.

Fig. 1. Lateral aspect, showing zygapophyses, transverse processes, and chevron bones. (See p. 253.)

Fig. 2. Superior aspect, showing neural spines. (See p. 253.)

PLATE 18.

Part of the Skeleton of Eurycarpus Oweni.

Fig. 1. Mould from slab showing vertebræ, ribs, and limbs greatly reduced in size. (See p. 259.)

Fig. 2. Left fore limb of the same specimen. (See p. 259.)

Fig. 3. Fragment of femur from the same slab. (See p. 259.)

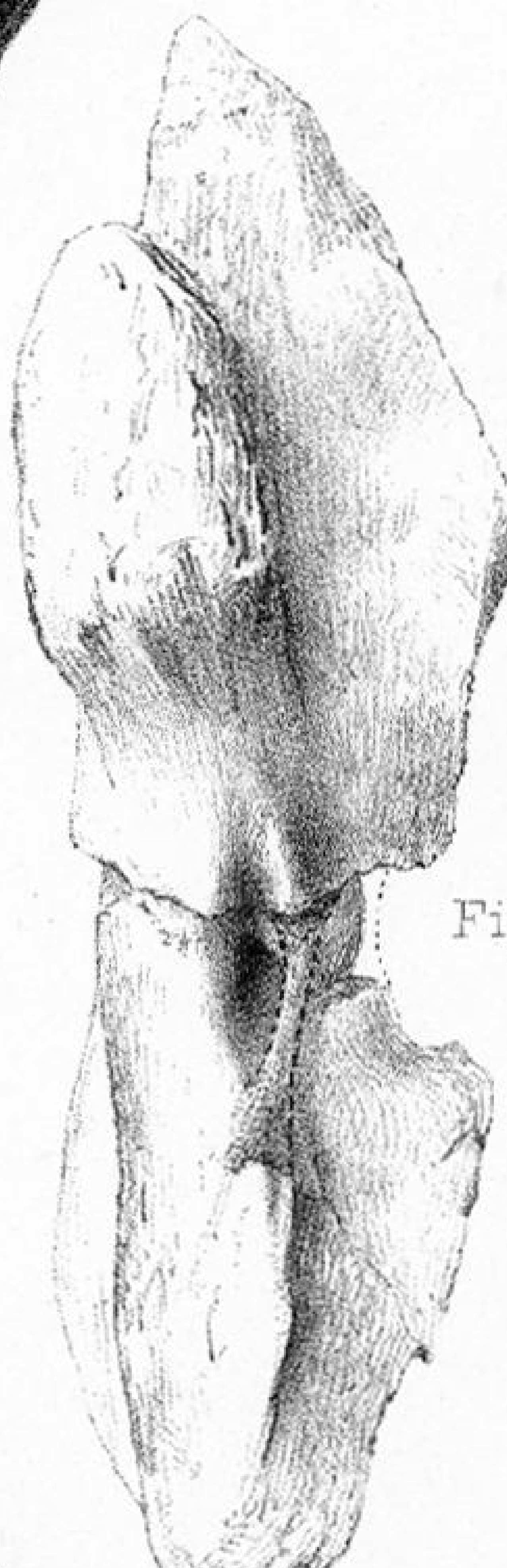
PLATE 19.

Right Femur of Titanosuchus ferox.

Fig. 1. Anterior aspect. (See p. 261.)
Fig. 2. Posterior aspect. (See p. 261.)

Fig. 1.

Fig. 2.



$\frac{5}{11}$ nat. size

PLATE 20.

Humerus of Titanosuchus ferox.

Fig. 1. Inferior aspect. (See p. 263.)

Fig. 2. Inner lateral aspect. (See p. 263.)

PLATE 21.

Fibula of Titanosuchus ferox.

Fig. 1. Lateral aspect. (See p. 265.)
Fig. 2. Proximal aspect. (See p. 265.)
Fig. 3. Inner or tibial aspect. (See p. 265.)
Fig. 4. Distal extremity. (See p. 265.)

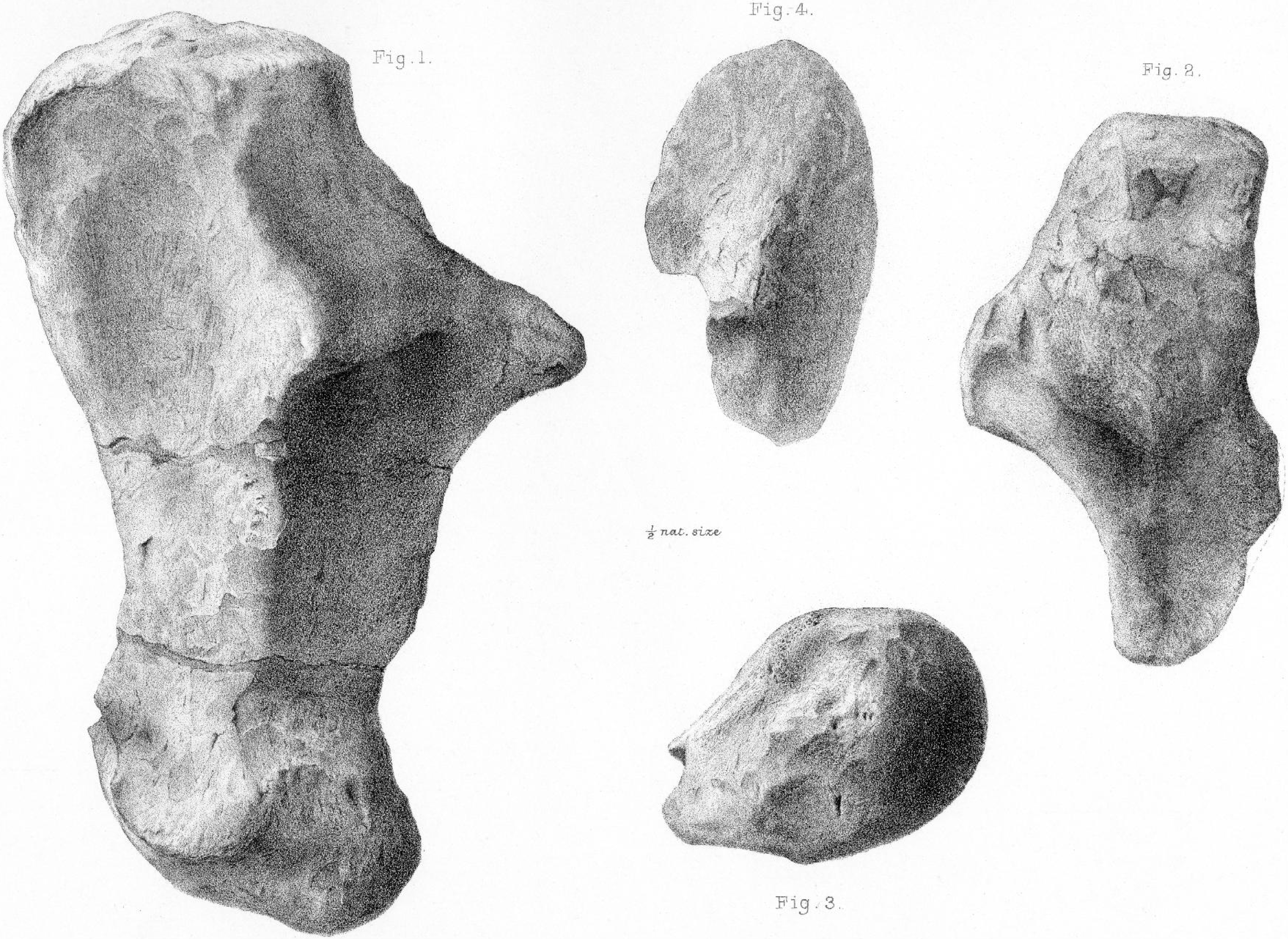


PLATE 22.

Ulna.

Fig. 1. Ulna, with epiphyses preserved. (See p. 265.)

Fig. 2. Proximal aspect of the same bone. (See p. 265.)

Fig. 3. Distal articular end of the same bone. (See p. 265.)

Fig. 4. Proximal end of another ulna which has lost its proximal epiphysis. (See p. 265.)

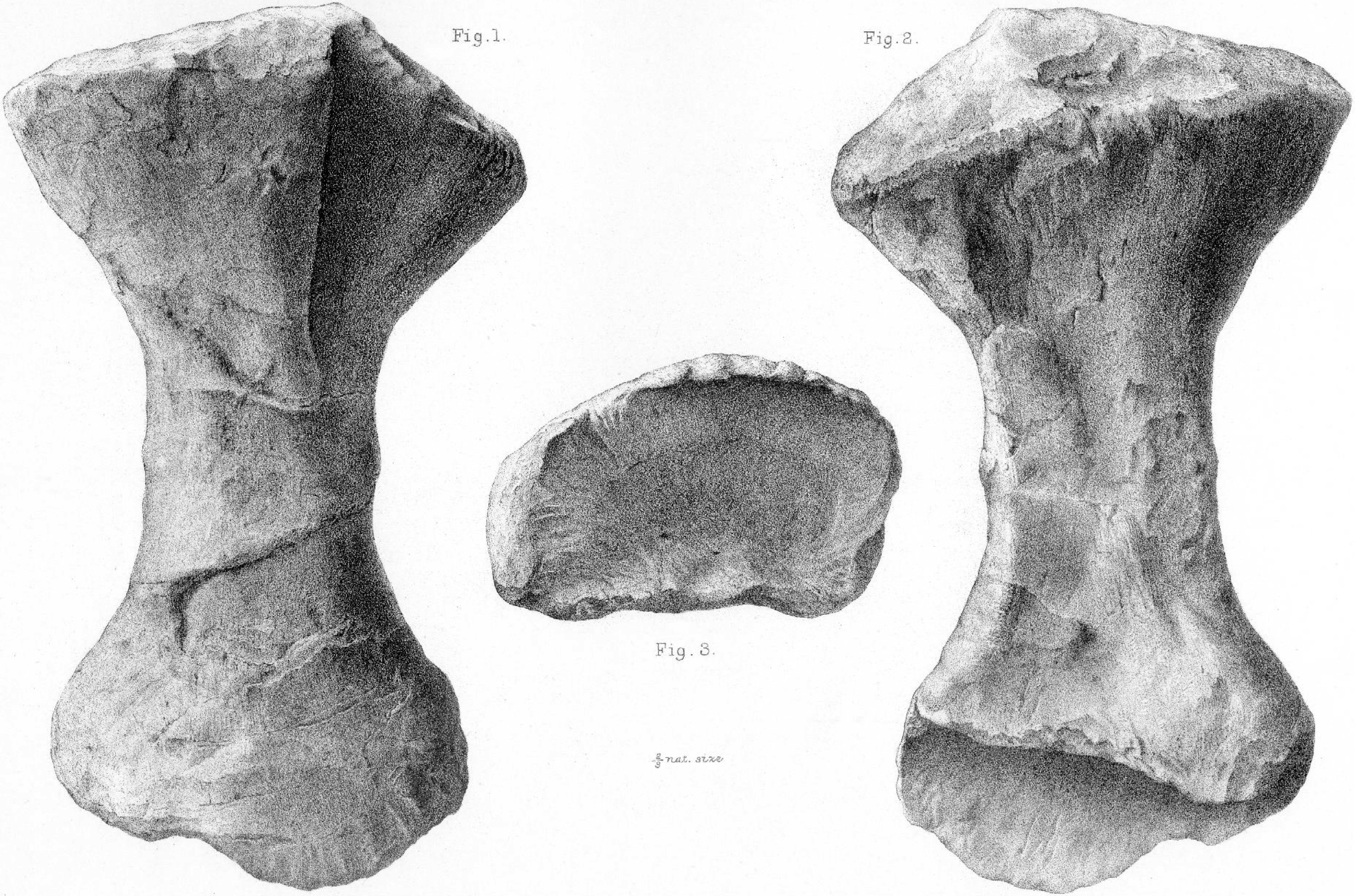


PLATE 23.

Ulna which has lost its Epiphyses.

Fig. 1. Inner aspect. (See p. 266.)
Fig. 2. Outer aspect. (See p. 266.)
Fig. 3. Distal extremity. (See p. 266.)


Fig.5.

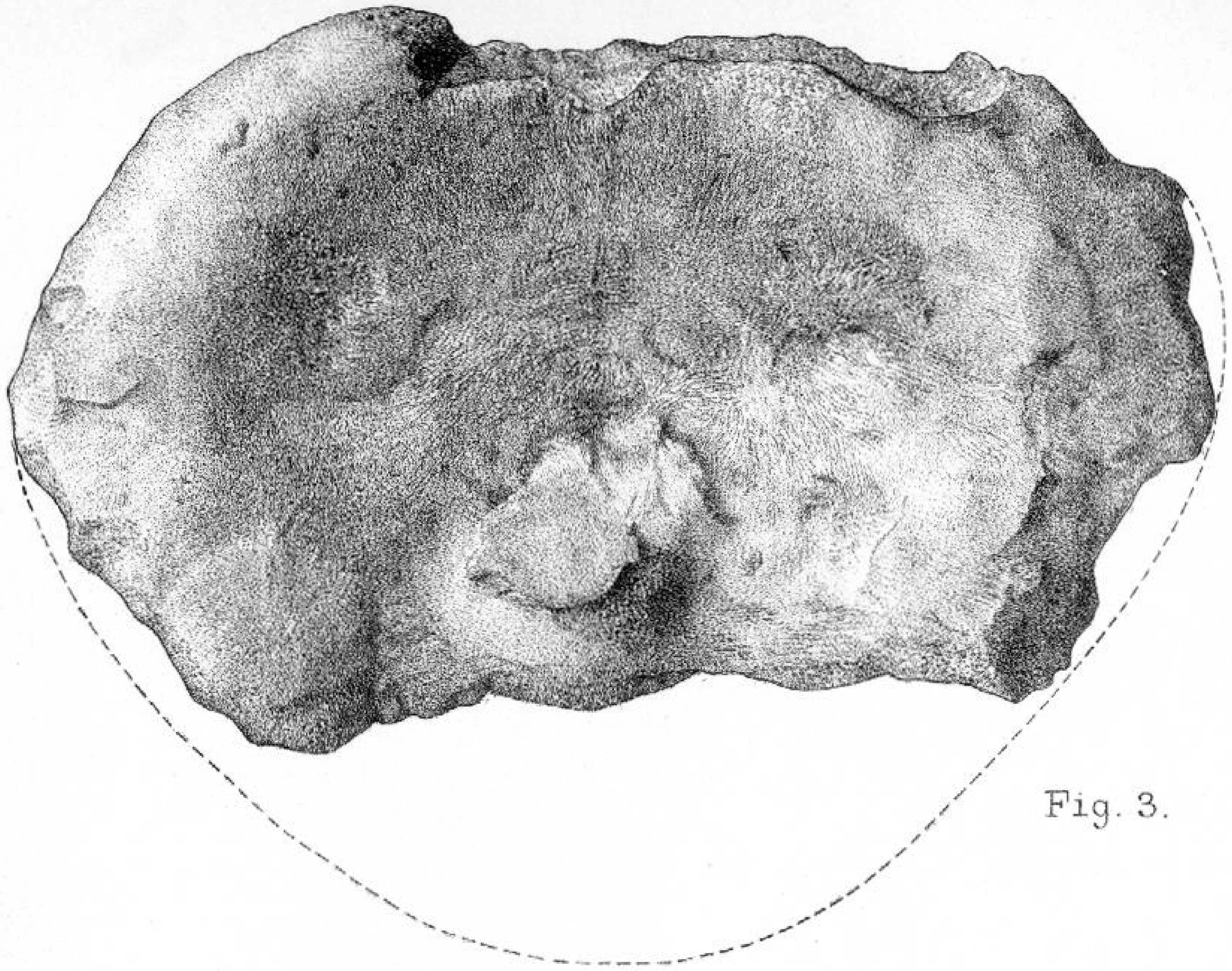


Fig. 3.

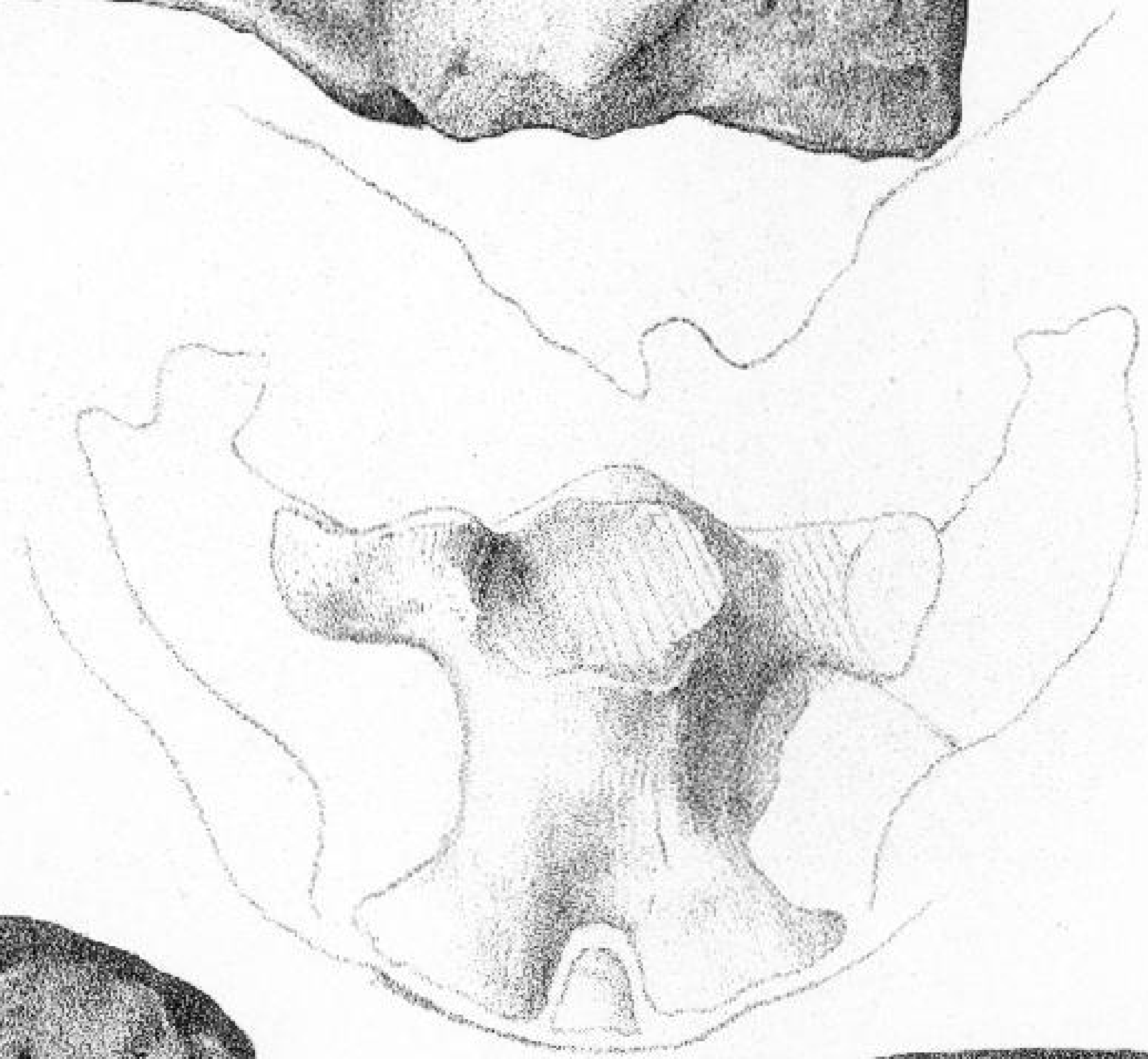


Fig.6.

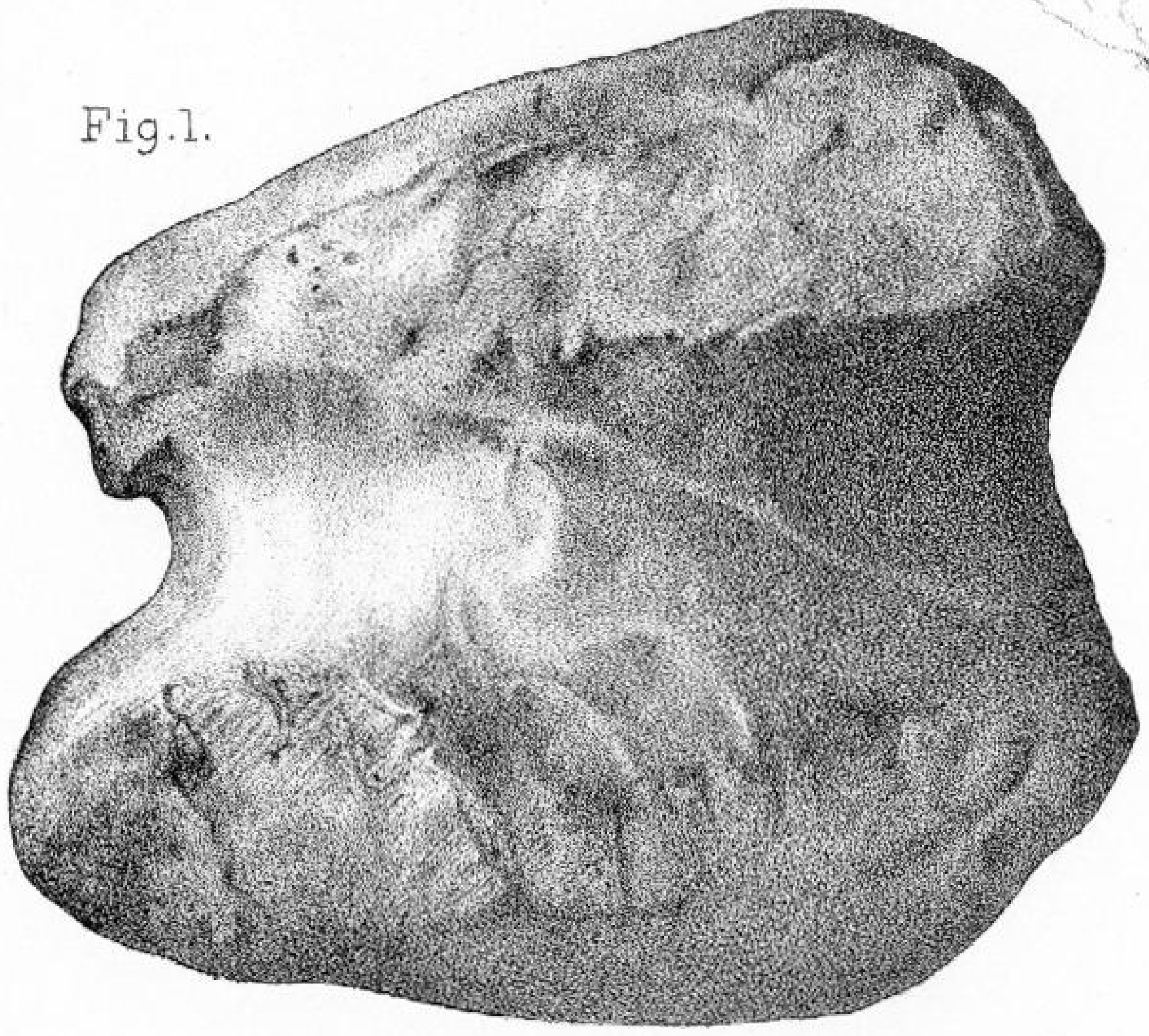


Fig.1.

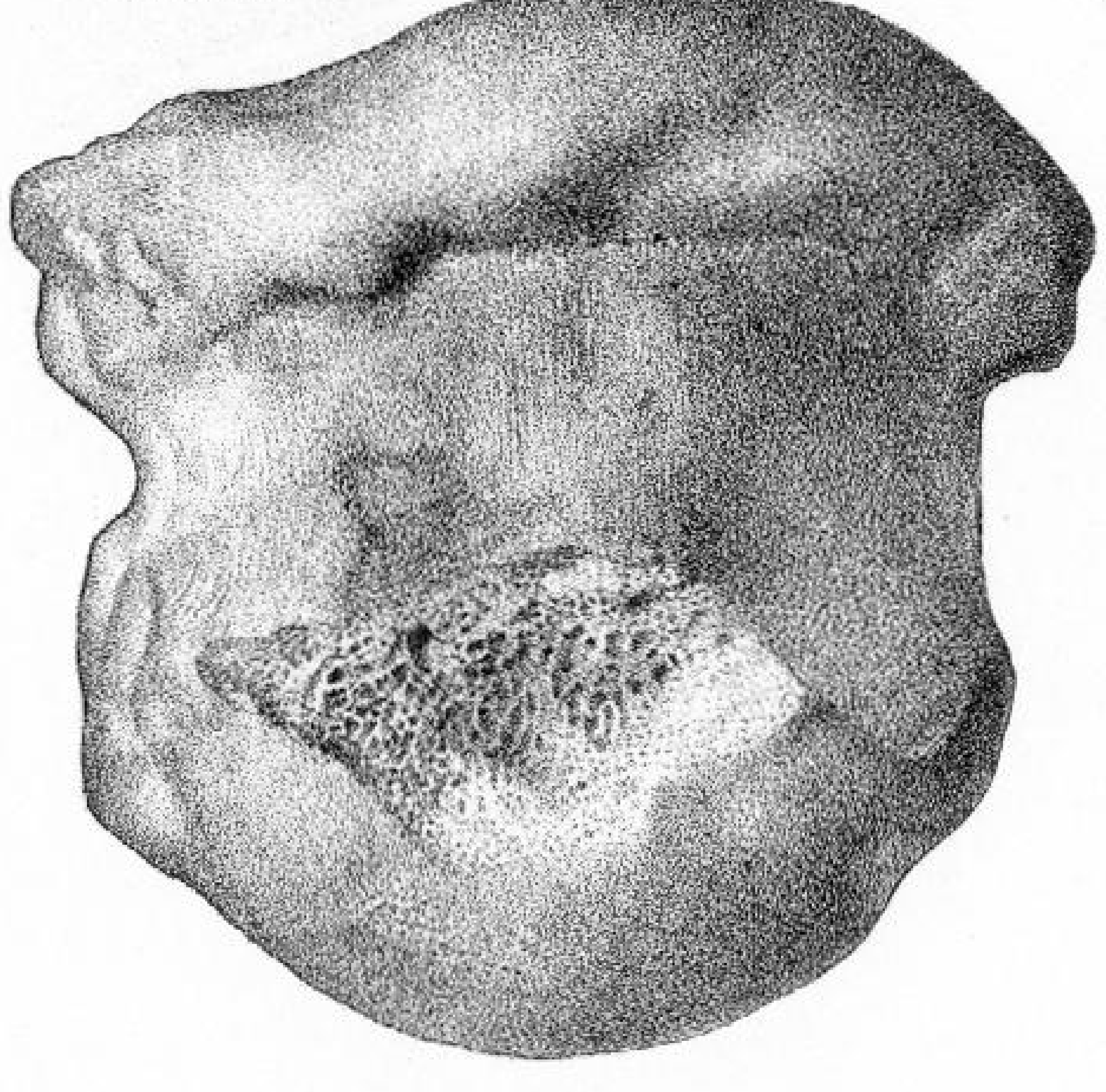


Fig.2.

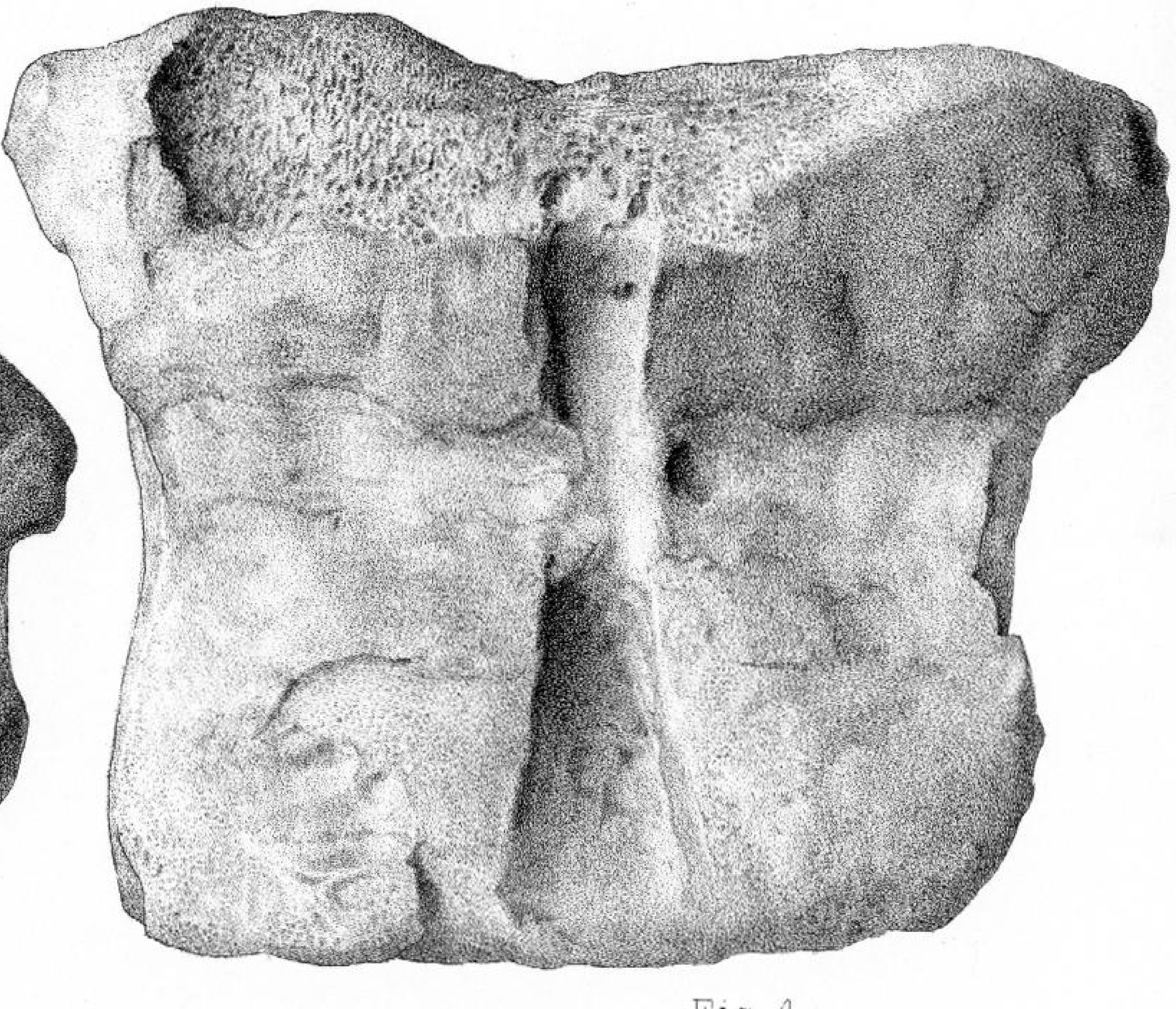


Fig.4.

Nat. size

PLATE 24.

Bones of Titanosuchus *and* Placodus.

Fig. 1. Phalange of an external digit, *Titanosuchus*. (See p. 267.)
Fig. 2. Middle phalange, *Titanosuchus*. (See p. 267.)
Fig. 3. Vertebra of *Titanosuchus ferox*.
Fig. 4. Neural aspect of the same dorsal vertebra.
Fig. 5. Posterior aspect of skull of *Placodus*. (See p. 281.)
Fig. 6. Left occipital condyle of the same skull seen from the palatal aspect. (See p. 281.)

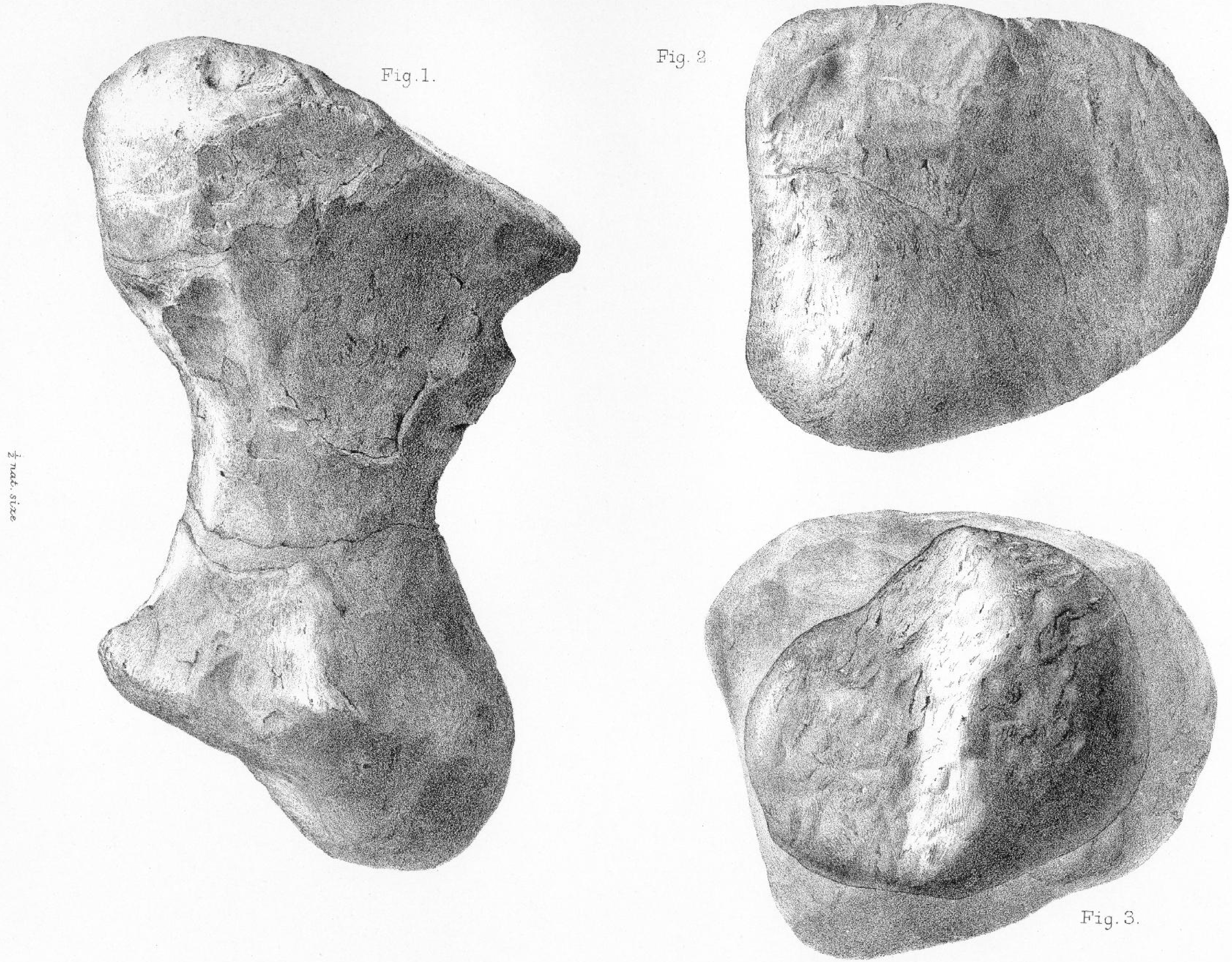


PLATE 25.

Tibia.

Fig. 1. Tibia. (See p. 269.)

Fig. 2. Proximal end of the same bone. (See p. 269.)

Fig. 3. Distal extremity of the same bone, showing the outline of the proximal end extending beyond it. (See p. 269.)