II. *Researches on the Structure, Organization, and Classification of the Fossil Reptilia.*—Part IX., Section 5. *On the Skeleton in New Cynodontia from the Karroo Rocks.*

By H. G. Seeley, *F.R.S.*

Received February 13,—Read June 21, 1894.

CYNODONTIA.

This name was originally used, by Sir R. Owen, for the division of the Anomodontia, of which *Galesaurus* is the type. Subsequently, Theriodontia was defined, so as to be co-extensive with the older Cynodontia, both groups being based upon a type of dentition, which approximates to that of Carnivorous Mammalia. The name Theriodontia, hence, has some appearance of being a synonym of Cynodontia. The group Theriodontia, is obviously a larger group than the original Cynodontia, since its type, *Lycosaurus*, has simple pointed molar teeth, and it also includes *Nythosaurus* and *Scaloposaurus*, in which the molar teeth are laterally cuspidate. The Theriodontia include the Cynodontia, because the Cynodont genera were grouped in this way by Sir R. Owen, and, because there is no evidence of ordinal differences in the skull. The Cynodontia is conveniently distinguished from the Lycosauria by dental, and other minor characters of the skull; and I propose to use the name Cynodontia for animals which resemble *Galesaurus* in skull structure, and resemble *Nythosaurus* in the type of molar teeth. The crowns of the cheek teeth not being preserved in *Galesaurus*, I take *Cynognathus*, the genus now to be described, as the type of the group, which will be thus defined and limited. This genus makes known, for the first time, the more important parts of the Theriodont skeleton in association with the skull. The small bones of the limbs were not found in *Cynognathus*. Some account of bones of the extremities in other types of Theriodonts is given in other sections (§ 2, 4, 6) of this paper, but in no case is there similar actual association of those bones and the skull.

This sub-order of Therosuchian Anomodontia is defined as having incisor, canine, and laterally cuspidate molar teeth, of carnivorous type. The mandible fits within the upper jaw so as to give the teeth a dividing action, as in shears. The coronoid process of the lower jaw is formed by the dentary bone, and is strongly developed. There is no descending pedicle to the squamosal bone which, with the malar bone, forms a zygoma, placed as in Lemurs and Carnivora; and as in the extinct Mammal *Elotherium*.

CYNOGNATHUS CRATERONOTUS (SEELEY).

The skeleton of this animal was found near the top of the hill which faces towards the house of the Rural Magistrate of Lady Frere. I was indebted for knowledge of the locality to Dr. JAMES BERRY, of Queenstown, who possessed portions of two small skulls, one of them referable to this genus, which were found upon the surface near the foot of this hill. With the aid of Dr. W. G. ATHERSTONE, F.G.S., Dr. JAMES BERRY, Mr. T. BAIN, and the Rural Magistrate, the whole surface of the hill was searched for indications of a fossil still remaining in the rock. In this examination a few isolated bones of Theriodonts were found enclosed in matrix. And, at last, after many hours' unproductive toil, a small trail of freshly-broken and transported fragments was discovered, which have since been divested of matrix, and have proved to be fragments of the shoulder girdle, and limb bones of the skeleton, which was found by following up the trail in the usual way. The trail led to the skeleton.

It was lying nearly horizontally in the red rocks, in a hard concretionary matrix, in a position which was worked with difficulty with room for one person.

Mr. BAIN did the mechanical work, and extracted the skull, vertebral column, shoulder girdle, pelvis, and part of the femur, under my direction. As the blocks were worked out on the hill side, I marked each with colour, so as to ensure that they should go together again, in the positions in which they were found. By these marks I re-united all the fragments brought home. It is necessary to mention that although the bones are in sequence from the skull to the tail, the vertebral column was divided into two parts in the dorsal region when found, by a slip in the rocks which displaced the anterior part of the animal, throwing it behind the posterior part, as though two skeletons were present. There is no ground for supposing that two animals occurred side by side, first because the severed parts of the column can be re-united so as to show their original continuity; and secondly because both portions of the vertebral column showed corresponding fractures with oblique surfaces. No other bones than those described were obtained in this excavation. The fault in the rocks was discovered because I persisted in the excavation in the belief that the remainder of the skeleton must be present.

Several minor but unfortunate defects of the specimen, such as the loss of the occipital crest and condyle, the atlantal bones, and extremity of the tail, may have resulted from an accident to the box containing the fossil, after I left Queenstown, which scattered its contents, as I was informed, over the road, on its way to the railway station when in charge of a Hottentot, and necessitated its being repacked.

The specimen makes known the essential parts of the largest skeleton of a Cynodont, a group previously known only from small skulls allied to *Galesaurus*. It is slightly distorted by oblique compression, which has made the back of the head unsymmetrical.

The removal of the matrix is the work of Mr. RICHARD HALL, Assistant Mason in the British Museum. It is an example of skill, patience and success which I have not seen equalled, and has been done under my supervision in the Museum.

The Skull (figs. 1–9).

The skull is about 15¾ inches long. The anterior nares are divided, terminal and lateral. The muzzle is long, high, narrow and rounded. The orbits of the eyes are lateral, and behind the middle of the length of the head. The zygomatic arch is deep and strong, with its hinder upper border reflected downward, and its anterior part perforated at the junction of the squamosal and malar bones. The supra-temporal vacuities are large, and divided from each other by a narrow elevated parietal crest. The skull is 8 inches high at the orbits; and higher at the occipital plate, which is expanded, concave, and diverges backward. The skull widens rapidly from three inches at the canines to about nine inches at the back of the head. The lower jaw is deep, with an immense coronoid process formed by the dentary bone, behind which it contracts to the articular region, forming an inferior angle.

The teeth on each side are four incisors, one canine, five premolars, and four molars which have some resemblance to those of the dog, and suggested the generic name. In the lower jaw the teeth are not so completely exposed, but are probably as numerous, except that the incisors appear to number only three on each side; they are overlapped by those of the upper jaw.

The lateral aspect of the skull is mammalian, but the superior aspect is intermediate between *Teleosaurus* and *Belodon*, because the back of the head has the diverging form of occiput of the latter, with the narrow parietal crest of the former. On the palate descending processes of the palatine and transverse bones lie between the rami of the mandible, as in lizards and crocodiles.

The prefrontal and postfrontal bones remain distinct; there is a small quadrate bone, and the lower jaw is composite. These structures are reptilian.

The Teeth.

The Incisors (fig. 1).—The alveolar border of the incisor teeth in the upper jaw is a rounded curve of less than half a circle, undulated by the excavations of the alveoli which are near its margin. The incisors are in the premaxillary bones, which are divided by a median suture, and limited posteriorly by a sagittate suture, which marks the overlap of the maxillary bones, and descends in front of the fourth incisor. The roots of the four incisors in each premaxillary bone appear to be longitudinally ovate, for the bases of the teeth, where exposed, are a little longer than deep. They are close set, but not in contact. The crowns of the incisors are conical, elongated, directed downward parallel to each other, slightly curved backward, and slightly overlapping the external alveolar margin of the lower jaw, as the jaws are preserved in close contact.

These teeth are similar in size and length, but the third on the left side is the largest, and on the right side the corresponding tooth is short and broad, and imperfectly preserved. The first incisor is $\frac{7}{10}$ inch long as preserved above the

Fig. 1.

Anterior aspect of the head of *Cynognathus crateronotus*, showing the anterior nares, eight incisor teeth, and two vertical canines, between which the mandible fits. Natural size.

alveolus; the second is slightly longer; the third measures $\frac{17}{20}$ inch long; and the fourth is $\frac{13}{20}$ inch long. At the alveolus each tooth is about $\frac{7}{20}$ inch wide, but owing to the curvature of the jaw, and the teeth being approximately parallel, the crowns of the hinder incisors are exposed in an aspect which is more lateral than in the anterior teeth.

The crowns of the teeth are enamelled for $\frac{4}{10}$ to $\frac{5}{10}$ of an inch. Their external surfaces are convex, especially in the first and second. All are bordered laterally on both sides by serrated margins, though the preservation of the serrations is better in the flatter outer crowns than on the more convex crowns of the inner incisors. The serrations have a beaded aspect, with the beads just divided from each other, and not nearly so deeply divided as in the Megalosauria. These serrated ridges appear to define the buccal rather than the external aspect of the crown, like the similarly-placed unserrated lateral ridges of the incisor teeth of a dog. There is some appearance of the tooth thickening at the inner side of the base of the crown, as in Carnivora like the dog, and lizards like *Amblyrhynchus;* but this is not quite demonstrated, owing to the way in which the teeth are exposed.

The extremity of the second incisor of the right side shows some amount of wear with use during the animal's life, a condition the more singular since there is no evidence that it could have resulted from contact with an opposing tooth. The incisor teeth of the lion become worn in old individuals.

In the mandible, the incisor teeth are partly overlapped and hidden by the premaxillary teeth. They are placed in the interspaces between them, as in Carnivora; and appear to be more slender. Only six can be counted, so that there are probably only three on each side.

The arrangement of the incisor teeth, and the larger size of the third tooth, are resemblances to Carnivora. The existence of a fourth incisor in the upper jaw and the serrations upon the teeth are distinctions. Among Opossums the incisor teeth are more numerous, five in the upper jaw and four in the mandible. In the *Myrmecobius*, *Phascogale*, *Thylacinus*, *Sarcophilus*, among Marsupial genera, there are four incisor teeth above and three below, as in the fossil, and in those types the fourth tooth is the largest.

Among South African fossils, the only genus with four incisors in the premaxillary bone and three in the mandible, is the skull fragment described by Sir R. OWEN as *Cynochampsa.* In that genus molar teeth are unknown, and the anterior nares appear to be undivided. There is no evidence of close affinity between *Cynochampsa* and *Cynognathus.*

Canine Teeth (fig. 1).—Behind the last premaxillary tooth in *Cynognathus* a lunate excavated interspace, $\frac{13}{20}$ inch long, with sharp alveolar margin, separates that tooth from the canine. Internal to this area, the large canine from the mandible passes upward into the skull, almost vertically, just behind the anterior narine. That tooth appears to be fully $\frac{1}{2}$ inch wide; it is close to the external border of the lower jaw, but only exposed for $\frac{9}{10}$ inch of its length.

Both the canine teeth in the skull have the extremities of their crowns broken, possibly during the life of the animal. The base of the crown is longitudinally ovate in transverse section, and on the left side measures $\frac{8}{10}$ inch from front to back, while that on the right side scarcely exceeds $\frac{7}{10}$ inch in the corresponding measurement, so that the teeth are unequal in size, as is sometimes seen in existing Carnivora.

The crowns of the teeth extend downward and somewhat forward, and are moderately curved backward; $1\frac{1}{2}$ inch remains on the left side, and less than $1\frac{3}{4}$ inch on the right side. The right tooth is broken by an oblique truncation which faces forward; it was certainly produced before fossilization, and its present condition may be due to wear. The tooth is serrated upon its posterior border, and may have been serrated in front, but the border is too imperfect to show that character. The external surface is smooth and well rounded, and the enamel is absent from the lower part of the crown. These teeth are parallel to each other, and, when perfect, they may have extended to near the base of the lower jaw, which expands a little transversely in front of them.

Immediately behind each canine there is a somewhat triangular area upon the alveolar surface, which may indicate a remnant of the root of an absorbed tooth which has been replaced by the tooth now in use. I have no doubt, from other evidence, that these indications may be accepted as proof that there was succession of the canine teeth, and that the successional teeth descend anteriorly in the maxilla, and rise posteriorly in the mandible, as compared with the teeth which they replace.

Behind each canine the alveolar borders of the jaws are constricted or approximate from side to side, so that the maxillary teeth are not in the same straight line with the teeth in front of them, but, seen from the palate, they have the aspect of representing three parallel rows on each side, of which the outermost incisor row is separated from the inner molar row by the canines. An approach to this parallelism is seen in existing Carnivora. It recalls the parallelism of long overlapping rows of serrated teeth which characterizes *Endothiodon bathystoma.*

No existing reptile has canines developed as in this fossil, though the condition may admit of nearer comparison with the lizard *Chlamydosaurus* than is at present obvious, for I have reason for believing that in some of these reptiles the second canine may descend in the maxillary bone without absorbing the first tooth, so as to persist with it, showing two canine teeth behind each other as in *Chlamydosaurus*, thus making a nearer approach to *Endothiodon.* Otherwise, the canine teeth are entirely mammalian.

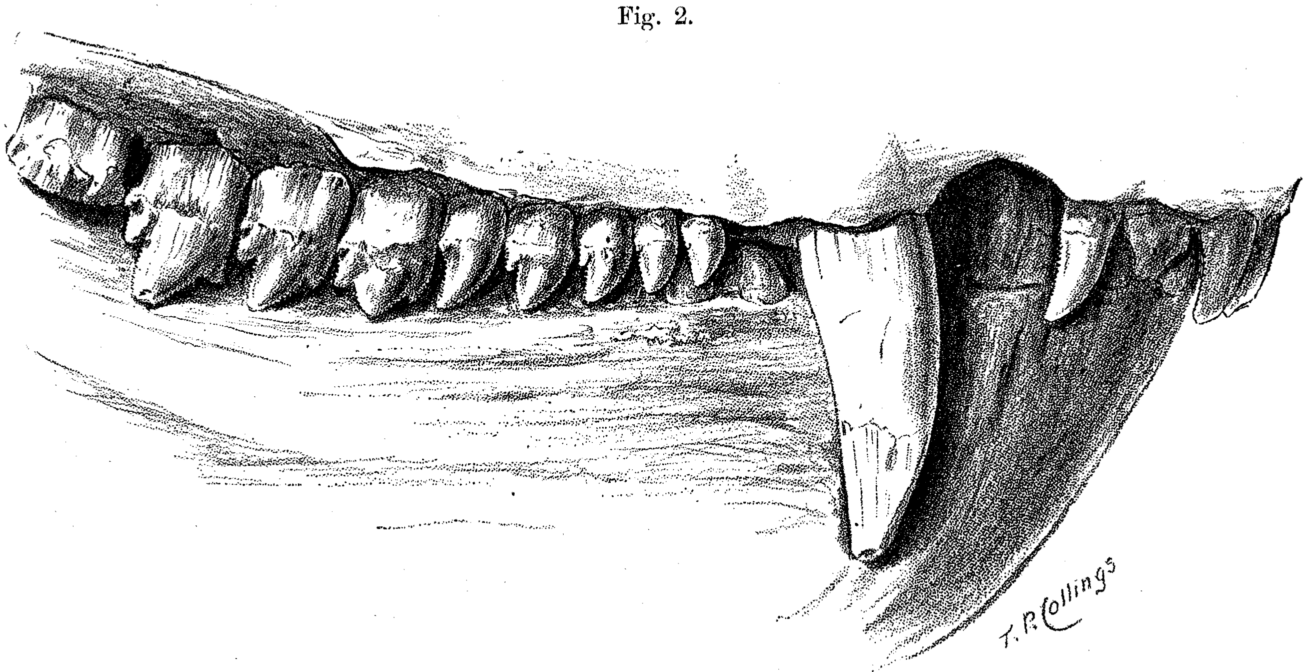
Molar Teeth (figs. 2, 3, 5).—There are nine teeth of the molar series on the right side, in the gently convex alveolar margin of the maxillary bone, where they cover a length of $3\frac{3}{4}$ inches. On the left side (fig. 3), the fifth tooth is absent, otherwise all the teeth are in close contact with each other; except that on the left side, there is an interspace of about $\frac{3}{20}$ inch between the last two teeth, which may result in part from strain due to torsion of the rock, since the alveolar margin on the left side is more convex than that on the right side.

Of the nine teeth (fig. 2) the first five are smaller and simpler in structure than the posterior four; so that the two groups correspond in position and character with premolars and molars.

The first tooth is $\frac{4}{10}$ inch behind the canine. Its crown rises about $\frac{4}{10}$ inch from the alveolar margin; the second is of similar size. These teeth have the external surface of the strong pointed crown inflated, and of conical aspect; bordered back and front by an edge margined by serrations of the beaded type, which do not appear to exceed twelve in number, on the internal edge of the tooth. The anterior edge is the more convex; the posterior edge has a tendency to be concave; so that the crowns have the aspect of curving a little backward and inward.

In the third tooth the width of the base and height of the crown are both slightly increased, though there is no increase in the depth to which the enamel descends upon the crown. The anterior margin of the tooth remains convex; but in the

Fig. 2.



Dentition seen upon the right side of the skull of *Cynognathus crateronotus*. In the interspace between the last incisor tooth and the maxillary canine, a portion of the mandibular canine is seen. Natural size.

third, fourth, and fifth teeth, the posterior margin develops a cusp towards its base, so that the hinder margin of the crown seems to be notched out much upon the pattern of the tooth of a dog. The whole of the cutting margin of the tooth continues to be serrated, though the individual denticulations increase somewhat in size. There is no difference in plan between the third, fourth, and fifth teeth, though the third is conspicuously smaller. The crown of the third has a vertical measurement of $\frac{9}{20}$ inch, and a longitudinal measurement of $\frac{3}{10}$ inch; while the fifth crown is $\frac{6}{10}$ inch high and $\frac{4}{10}$ inch wide. These crowns rise from the alveoli for about $\frac{5}{20}$ inch without enamel; and where the enamel terminates, it ends in a transverse line, with a slight cinguloid character.

The last four teeth are much larger, with the elevated unenamelled parts of the crowns flattened laterally on the external surface. These teeth I regard as representative of the molar teeth of Mammals, without having any theoretical opinion that they were not preceded by other teeth. The antero-posterior measurement over the last four teeth is $2\frac{1}{4}$ inches, and that over the first five $1\frac{1}{2}$ inch, so that those termed molars are more than half as wide again front to back as the premolars.

The crowns are similar in character to the earlier series; but are distinguished by developing one subordinate pointed cusp at the anterior margin of the backwardly-directed principal cusp, and two subordinate cusps upon its posterior margin. The crown is very slightly ribbed vertically, and the cutting margin is serrated as in the earlier teeth. The base of the enamel is slightly thickened, and it terminates in the hindermost teeth in a concave outline, such as often appears in Mammals above the divided root to a molar tooth. Between the enamel and each alveolus the flattened unenamelled part of the crown is vertically channelled by a wide shallow groove, which approximates to the partial division of the root seen in some Edentata and other Mammals. The eighth tooth rises three-quarters of an inch above the alveolar border, and is $\frac{6}{10}$ of an inch wide. The ninth tooth has the crown less elevated. All these teeth are compressed from within outward without internal cusps.

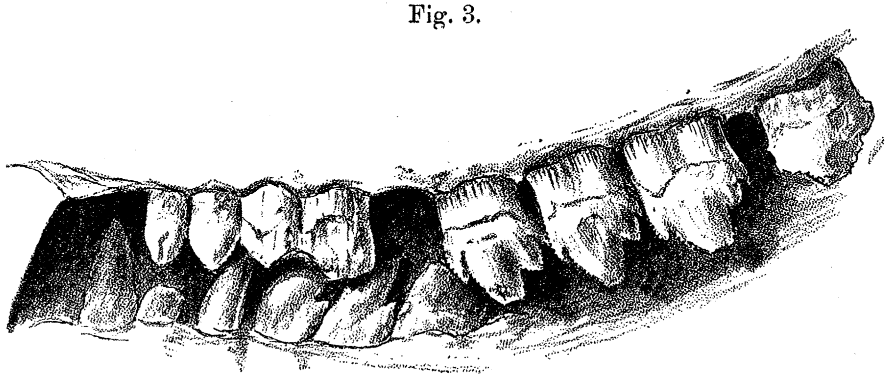
On the right side of the skull the jaws are in such close contact that only the first three teeth of the mandibular molar series are visible. On the left side the teeth may be counted as nine in number, though the second of these is missing. The mandibular molars alternate with the maxillary molars in exactly the same way as do the two sets of incisors. And just as the canine of the lower jaw is in front of the maxillary canine, so the first mandibular pre-molar is in advance of the first maxillary pre-molar, and the last mandibular molar is between the ultimate and penultimate maxillary molars. The teeth, in the lower jaw, do not stand quite so high above the alveolar margin, as in the maxilla. They are completely hidden when the jaws are closed, because they close behind the maxillary teeth so as to form a dividing apparatus cutting like shears.

The only manifest difference in the mandibular teeth from those of the upper jaw, is that the first three teeth behind the canine are simple and without the posterior cusp (fig. 3), though the second tooth is imperfectly preserved. The accessory posterior cusp is developed in the fourth and fifth teeth. The remaining wide flat teeth of molar type, with compressed crowns inclined backward, show no differences from the molars in the maxillary bones.

As compared with existing Mammals, the distinctive character of this fossil is in the number and character of its molars. The existing Cape mole, *Chrysochloris*, has nine molars on each side in the upper jaw, and eight molars on each side in the lower jaw, but the teeth are expanded transversely, and there are no canine teeth. And, although many existing placental Mammals have the molars as numerous, or more numerous, I am not aware that such types ever possess well-developed canine teeth.

In the Dasyurina among Marsupials, there is a closer approximation, for not only are the incisors four above and three below, with strong canine teeth, but in one genus, *Myrmecobius*, the molar teeth number nine above and below. In *Thylacinus* the number is smaller, but, since it varies with the genera, it is unnecessary to pursue the comparison. It is, however, not without interest that the oldest Mammals of the secondary rocks show a large number of teeth. *Dromatherium*, of North Carolina, from the Trias, has, according to Sir R. Owen, seven tricuspid molars, preceded by three simple, slender, cuspidate premolars, in advance of the canine, and three conical incisors in the lower jaw, so that it has one more molar tooth than this fossil; and the twelve molar teeth of *Amphitherium*, from the Stonesfield slate, are evidence that the teeth of *Cynognathus* are less numerous than in some fossil Mammalia which admit of comparison. The distinctive feature of the molar teeth in this fossil is the

Fig. 3.



Maxillary and mandibular teeth on the left side of *Cynognathus crateronotus*, showing the small size of the pre-molar teeth, and the width, denticulation, and serration of the denticles of the molar teeth. Natural size.

absence of internal cusps, such as are found in the hinder molars of carnivorous Marsupials, and most placental Carnivora. They are, however, absent from teeth of *Zeuglodon*, and of seals, some of which offer a certain resemblance in form of the lateral cusps to this fossil, though I have found no seal with a tooth so dog-like, or so specialized in passing from the premolars to the molars. This absence of internal cusps in seals is the more interesting since it is sometimes associated in existing types with undivided roots to the molar teeth, as in *Otaria*, *Cystophora*, &c., making a further parallel to the condition of teeth in this fossil. The two Mammal groups, Edentata and Monotremata, which have shown resemblances to some parts of the skeleton in allied South African fossils, manifest differences in dental functions, and are excluded from comparison in the dentition, owing to the absence of incisors and canines in those existing orders, but they show no molars like those of *Cynognathus*.

The Upper Surface of the Skull. (Fig. 4.)

The Nares.—The anterior nares are terminal, divided by the premaxillary bones in front, which arched convexly forward in advance of the alveolar border, though the contour of this curve is lost with fracture of this median process (fig. 5). The vacuities are lateral in aspect (fig. 4), longitudinally ovate, $1\frac{1}{2}$ inch long and about an inch deep. They converge forward and upward. The premaxillary bones which form their lower borders are convex and rounded from within outward, and extend into the nares forming their floor. From the posterior narial angle, a small narrow bony process extends forward inward and upward towards the median line (fig. 1). I have regarded this curved clavate process as a portion of one of the sub-nasal plates present in well preserved skulls of many Anomodonts, which may be representative of turbinal bones. The ascending process is $\frac{1}{2}$ inch long and $\frac{1}{10}$ inch wide, and the scute from which it rises, lies in the floor of the narine.

The transverse measurement across the nares at their hinder angle is $2\frac{1}{10}$ inches, where the maxillary bones form their hinder borders. Superiorly they are margined by the sharp edges of the nasal bones, which narrow as they extend forward in a wedge, descending a little to the point where the narrow ascending process of the premaxillary bones extends between their extremities, at the front of the nasal septum. It is not improbable that an infra-nasal scute, such as appears to be present in *Pareiasaurus* and *Dicynodon*, descends on each side from the narine to the alveolar border, but the sutures are indefinite, and do not quite demonstrate this structure. The nares are slightly above the middle of the extremity of the snout.

The Snout.—The muzzle, which may be taken to include the tooth-bearing region of the skull, is somewhat long and rather narrow; higher than wide, rounded superiorly, and somewhat convexly inflated at the sides, in advance of the maxillary teeth. The roots of the canine teeth contribute to the prominence of this convexity, which arches forward in a semicircular curve, to the sharp median ascending premaxillary ridge in front, which divides the nares. The contraction of the snout behind the maxillary canines, forms a wide shallow channel on each side of the head, and these concavities are prolonged upward and backward so that they do not meet on the summit, but give the muzzle a pinched aspect, midway between the nares and the orbits. Over this anterior region especially, the bone is rugose, and sculptured with pits and short irregular grooves, which somewhat obscure the sutures.

A very thin pair of bones about $\frac{1}{10}$ inch wide appears upon the median line above the nares. They seem to be distinct from the premaxillary bones in front, and I believe the ossifications which flank them superiorly to be premaxillaries. So that if they form, as they appear to do, a nasal septum, they may be ossified representatives of the cartilaginous nasal septum in the bird's skull described by Professor W. K. PARKER; just as the ossification regarded as turbinal is associated in some Anomodonts like *Dicynodon*, with what appears to be an ossified alinasal element. The width of the superior premaxillary processes at their termination is ½ inch.

The nasal bones are about 6 inches long. They extend from the back of the nares to just above the anterior border of the orbits, from which they are separated

Fig. 4.

Showing the V-shaped bifurcation of the occipital plate; the elongation of the temporal vacuity, which is bounded in front by the postfrontal bone; below that bone is the orbit, placed far behind the middle-length of the skull. Between the orbits and nares are two hemispherical pits at the meeting of the nasal and maxillary bones. ⅓ natural size.

by the prefrontal bones. They are an inch wide at their junction with the frontals, and widen to about 2½ inches. The lateral border is sinuous, and the nasal bones become narrow in the middle length, varying from 1 inch to 1½ inch wide, between the maxillary bones, where they roof the snout.

About 2 inches in advance of the fronto-nasal suture, above the laterally-contracted part of the muzzle, the nasal bones bear upon their surface a thin oblong ossification like a saddle, $2\frac{1}{4}$ inches long and $1\frac{1}{2}$ inch wide, which rises above the surface of the bone for $\frac{1}{10}$ inch or more, and obliterates the median suture between the nasal bones. It has an aspect like the base of a fibrous horn. It is $3\frac{3}{4}$ inches from the extremity of the snout. On each side of the posterior edge of this ossification is a large, smooth, transversely ovate pit, which is cup-shaped and smooth; each is 1 inch wide and $\frac{3}{4}$ inch long. The space dividing them is less than $1\frac{1}{2}$ inch wide. The pits may have lodged glands connected with the supranasal saddle.

The maxillary bone on each side is approximately vertical, with a surface which is irregular with undulating depressions and convexities. It is $3\frac{1}{2}$ inches high in the middle where deepest, at the transverse compression of the skull behind the canines.

In this position is the sub-orbital foramen, $\frac{9}{20}$ inch in diameter, passing forward, inward and downward, so that while in Mammals such a foramen passes outward from above the molar teeth, in this fossil it passes inward above the premolar teeth. It is situate $1\frac{1}{2}$ inch above the alveolar border, about $4\frac{3}{4}$ inches behind the extremity of the snout, and is vertically above the root of the fifth premolar tooth. Between this pit and the pit in front of the orbit, the bone is a long convex boss.

The length of the maxillary bone from the fourth incisor tooth to its termination below the middle of the orbit is about 7 inches. Above the alveolar margin is a row of conspicuous vascular dental foramina, about four or five in number, commencing behind the canine, $\frac{7}{10}$ inch above the teeth. They do not correspond to individual teeth. Smaller foramina extend further forward at a lower level. There is one in each premaxillary bone, $\frac{1}{2}$ inch above the first incisor.

The width of the jaw over the roots of the canines is about $3\frac{1}{10}$ inches, and its width at the first premolar, on the alveolar margin, is nearly an inch less. From this point the widening of the jaw as it extends backward is nearly uniform, to the posterior termination of the zygomatic arch; and the contour is very slightly concave in length. The convex alveolar margin in advance of the maxillary canine, to the median premaxillary suture, measures $2\frac{3}{4}$ inches. The base of the canine is $\frac{8}{10}$ inch from front to back, and the measurement from the canine over the cheek teeth is 4 inches. From the last molar to the extremity of the squamosal bone behind the articulation with the lower jaw, is 8 inches. Seen laterally, the contour of the alveolar margin of the cheek teeth is convex from front to back, but behind the teeth the contour of the arch, chiefly formed by the malar bone, is concave, with the concavity broken into two parts by a small descending process of the malar bone, which may be a diminutive representative of the descending element of the malar seen in *Elotherium*, *Nototherium*, *Diprotodon*, *Macropus*, certain Edentata, such as *Glyptodon*, *Megatherium*, *Mylodon*, *Bradypus*, but unparalleled, so far as I am aware, in fossil Reptilia, although *Dimorphodon* and some Ornithischia have the back of the mandible partly covered by the malar arch. The superior contour of the muzzle is nearly straight behind the nares (fig. 5), and there does not appear to be any increase in the depth of the jaw in the maxillary region, except such as results from the descending transverse-palatine processes on the palate; and these, like the position of the articular condyles, cause the depth of the skull, exclusive of the lower jaw, to steadily increase as it extends backward. At the palatine process, which corresponds in position with the front of the orbit and the end of the maxillary, the height of the skull exceeds $6\frac{1}{4}$ inches; its height at the last incisor, above the hinder border of the nasal vacuity, is $2\frac{4}{10}$ inches.

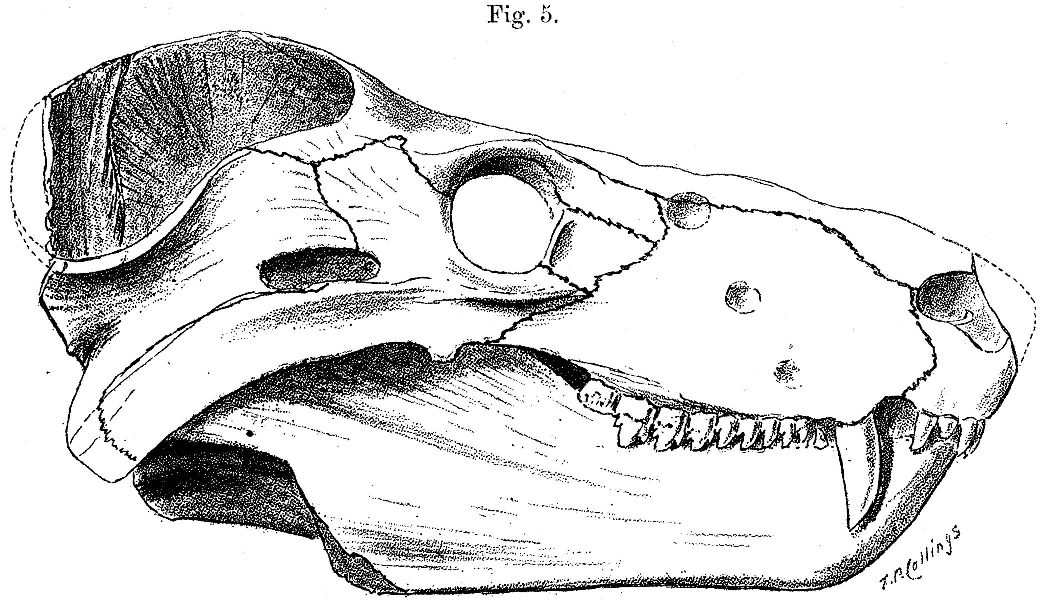
Orbital Region.—The orbit of the eye is complete only on the right side; on the left side it is distorted. It is nearly circular, $1\frac{9}{10}$ inch in diameter, looks outward and very slightly forward and upward. It is nearly 8 inches behind the extremity of the snout, fully an inch behind the last maxillary tooth, and one inch above the base of the malar bar at its least vertical measurement, by which it is separated from the post-alveolar margin of the jaw.

The orbit is margined in front by the lachrymal bone, which is about $1\frac{8}{10}$ inch long and $1\frac{1}{2}$ inch deep, between the prefrontal bone above and the malar below. The orbital edge of this bone is sharp, and there is a deep vertical pit immediately in front of the margin. The vertically ovate lachrymal foramen is seen on the inner border, about $\frac{4}{10}$ inch from the edge of the bone, on a level with the base of the external pit (fig. 5).

Above the lachrymal bone, the superior border of the orbit is thickened and reflected somewhat upward. It is formed in front by the prefrontal bone, which extends forward for less than 2 inches from the middle of the upper margin of the orbit. The bone is half-an-inch deep at the side of the orbit in front, and on its superior concave surface it is somewhat wider.

Behind the prefrontal is the relatively large postfrontal bone, which has a somewhat thicker margin, and combines with it to make the upper contour of the orbit, which is concave from front to back when seen from above. The superior surface of the postfrontal is concave. Its posterior border seen from above is concave, for it bounds the front of the temporal vacuity. The postfrontal bone joins the frontal bone by a slightly sinuous but nearly straight suture. The sutures of the two postfrontal bones converge as they extend backward, enclosing the V-shaped back of the frontal between them for about $2\frac{1}{2}$ inches; and they are then produced backward into the temporal vacuities for about 2 inches further, upon the anterior and upper part of the parietal crest, as slender splints more than half-an-inch deep in front and narrowing behind, so as to slightly widen the crest in front. Seen from above, the postfrontal bone extends outward and backward, joining the squamosal bone behind, to form the zygomatic arch. Externally it joins the malar bone, the post-orbital process of which ascends laterally in front of it, to a level with the top of the orbit. The least median measurement over the bone from the frontal to the malar is 2 inches, which is rather less than the measurement at the anterior border; between the squamosal and frontal on the posterior border the bone measures about $2\frac{8}{10}$ inches. The transverse measurement over the temporal vacuity between the internal and external extremities of the bone is $2\frac{1}{2}$ inches. The postfrontal bones, with the intervening frontal, define a concavity on the top of the head in advance of the median crest. The width of the interspace between the antero-superior margins of the orbits is about $2\frac{1}{2}$ inches. The part of it between the prefrontal and postfrontal bones is occupied by the frontals. They are divided by the longitudinal

Fig. 5.



Right side of the skull of *Cynognathus crateronotus*, showing the dentary bone of the mandible, with its posterior angle, above and behind which the articular elements are indicated by shading. The premaxillary bone contains the incisors; the maxillary contains the canine and molar teeth. Around the orbit are the lachrymal, prefrontal, postfrontal, and malar bones. There is a perforation in the zygoma between the squamosal and malar bones. In the temporal vacuity the squamosal bone ascends vertically behind the parietal, and the postfrontal extends along its superior crest. $\frac{1}{3}$ natural size.

median suture, which makes a ridge, continuous with that at the back of the nasal bones. The frontals are $1\frac{1}{10}$ inch wide in front, and though now narrower from crushing, were about 2 inches wide where the prefrontals meet the postfrontals. Their sides are straight and the length of the lanceolate contour is about $3\frac{1}{4}$ inches.

Finally, the malar bone forms the base and back of the orbit. It measures 8 inches from the lachrymal to its hinder termination, close to the articulation of the lower jaw. Behind the orbit, where it meets the postfrontal, it rises to a height of $3\frac{2}{10}$ inches. This ascending bar, like all the bones behind the front of the orbit, is smooth. It inclines a little backward, is $1\frac{1}{2}$ inch wide superiorly, and a little narrower as it descends vertically. Its base is defined by an elevated horizontal ridge on the bar of the malar which passes backward from in front of the orbit, forming a prominent bony ledge external to the base of the orbit, defined by an inferior excavation. It is nearly 3 inches long, and is continued backward by the angular ridge, which divides the flattened vertical surface of the malar bone below from the concave area of the squamosal bone above it. At the back of the base of this ascending process of the malar bone, between the malar and squamosal, is what appears to be the small post-orbital vacuity $1\frac{6}{10}$ inch long and $\frac{6}{10}$ inch deep. The measurement from the orbit to this foramen is $1\frac{1}{10}$ inch. The greatest depth of the flattened smooth spathulate malar process which extends posteriorly upon the squamosal is $1\frac{3}{10}$ inch, becoming a little narrower towards both the orbit and the mandibular articulation.

There is no inter-orbital septum ossified; and the orbits are in advance of the brain-case. On the under surface the frontal bone is concave and margined internally by ridges, apparently formed by the prefrontal bones, which descend at the back of the lachrymal bones. In the Crocodile, the corresponding ridge unites with the ascending process of the palatine bone. In this fossil there is apparently a similar union between the prefrontal and the palatine, supposing the descending inter-mandibular processes upon the palate, comparable to those of crocodiles and lizards in aspect, to be partly formed by those bones. In Mammals, there is a large union between the frontal bones and the palatines which descend to form the sharp lateral ridges which usually margin the posterior nares. In *Cynognathus*, these immense processes similarily margin the external sides of the posterior nares, so that what looks at first like a typical reptilian character, may be regarded as an intensified form of a character common in Mammalia, and making the condition of the posterior nares in Mammals intelligible. The form and position of the orbit, and the way in which its hinder boundary is made, are suggestive of the condition in Mammals, like Mangusta and Lemurs, in which the malar bone similarly ascends behind the orbit to meet the external bar of the frontal bone, and which have the zygoma formed by the malar and squamosal bones. The posterior development of the malar bone is an important difference of Theriodont skulls from Dicynodonts.

The Post-orbital Region.

Behind the postfrontal divisions of the frontal bones are the temporal vacuities, divided from each other by the narrow median crest of the cerebral region, bounded by the occipital plate behind and defined externally by the zygoma.

The temporal vacuities seen from above are ovate and laterally compressed, about $6\frac{1}{2}$ inches long, 2 inches wide, rounded in front, rounded but narrower behind. Their axes diverge outward as they extend backward, for while there is nothing between the vacuities in front except the fronto-parietal crest, they are separated behind by the width of the occipital plate. Seen laterally, the parietal and occipital border rises high above the superior border of the zygoma (fig. 5), which is made by the squamosal bone, and descends as it extends backward from the postfrontal, before it rises again on the occipital plate. These vacuities descend vertically to the palate. The thin coronoid process of the dentary bone rises in each vacuity near to the zygoma, but does not reach its summit.

There is a close general resemblance in form of this region of the skull to the Teleosauria, especially in the shape of the supra-temporal vacuities, their abutment against a vertical occiput, division by a narrow fronto-parietal crest, separation from similarly placed orbits by the postfrontal bar, and external boundary by zygomatic elements at a lower level than the parietal crest. But the minute post-orbital vacuity in which this species of *Cynognathus* parallels *Procolophon*, becomes in Teleosaurs the large lateral-temporal vacuity, which divides the zygoma into superior and inferior arcades, tending to prove that the Mammalian zygoma results from the obliteration of the post-orbital vacuity of the Reptilia by approximation of its constituent bones, or the two arcades when present may result from enlargement of a foramen, which in *Cynognathus* is not necessarily a generic character.

The zygoma is deeper than is usual in Mammals, being $3\frac{1}{2}$ inches deep at the back of the postfrontal bones, and $2\frac{1}{2}$ inches in the least posterior measurement. Its extreme external length, from the back of the orbit to the convexity of the squamosal behind the articulation with the lower jaw, is $6\frac{1}{2}$ inches. As it extends backward it extends somewhat downward in a curve. Its superior border is sinuous, being slightly convex in front, and more concave behind; and at the back of the skull this concavity rises on to the occipital plate; and though the connecting bone is lost, its position was indicated when I reconstructed the matrix from which the skull was developed. The upper part of the bar for more than half its depth is made by the squamosal bone. The narrower inferior flattened and widest part of the bar is made by the malar externally. The concave posterior part of the superior edge of the squamosal is reflected outward (figs. 4 and 5), and the outward reflection increases in amount posteriorly, till the bone ascends to the occipital plate, when it decreases. It is associated with the formation of a concave longitudinal channel which extends below it, upon the external surface of the squamosal bone, becoming deeper and narrower as it passes backward to the point where the depth of the bar is least, beyond which it widens again; and the convex inferior articulation is prolonged downward, so as to make the convex part of the back of the bone which is seen posteriorly above the articulation of the lower jaw (fig. 7). This condition of the squamosal bone in the zygoma I regard as a generic character of *Cynognathus*. Seen from above this folded plate-like condition of the squamosal bar, gives the bone the aspect of steadily widening from $\frac{2}{10}$ or $\frac{3}{10}$ inch where it leaves the postfrontal bone, to $1\frac{1}{2}$ inch at the back of the temporal fossa. This smooth superior ledge necessarily makes the inner surface of the bar strongly convex, from above downward. The ascending wing of the squamosal forms the anterior-lateral part of the occipital plate. It extends upward and inward on each temporal vacuity converging superiorly to the point where the two halves of the occipital plate diverge outward, so that the squamosal bones at the back of the temporal vacuities are only separated by the thickness of the parietal crest.

The inferior vertical portion of the zygoma, formed by the malar bone, is below the angular ridge, from which the longitudinally concave squamosal bone retreats inwardly along its length. This angle is a slight rounded ridge under the post-orbital foramen. The posterior process of the malar, blade-like in form, curves a little downward, is rounded at its thin posterior extremity, and is longitudinally concave in front, where its superior and inferior ridges are prolonged upon the maxillary bone, as far forward as the last molar tooth, and the front of the orbit. The length of the malar is 8 inches. Its depth from the postfrontal bone at the back of the orbit, to the descending small postalveolar process is $3\frac{3}{4}$ inches. The depth of the thin malar part of the zygomatic bar is from an inch in front, to $1\frac{1}{4}$ inch behind. I infer the width of the head, at the hinder termination of the malar bone, to have been $10\frac{1}{2}$ inches, from the width of the right half of the skull.

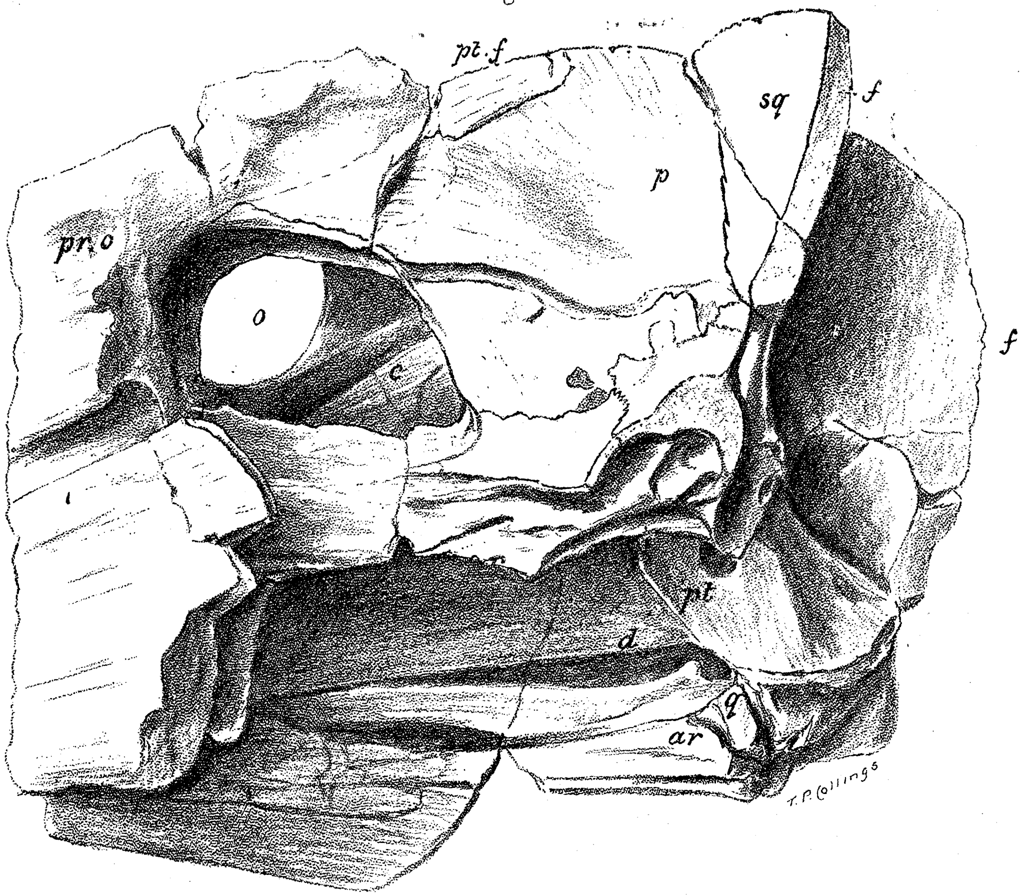
The cerebral region has been entirely freed from matrix. It is as greatly compressed from side to side as in some Dicynodonts. It rests upon a base of sphenoidal and occipital bones, and rises as a vertical mass, less than an inch from side to side, measured through the bony walls of the brain case. The thickening occupied by the brain, ascends as it extends forward to the back of the orbits. Its length, from the foramen magnum, appears to be $3\frac{1}{2}$ inches; and its greatest depth does not appear to have exceeded $2\frac{1}{2}$ inches. This narrow vertical cavity somewhat recalls the cavity in the cerebral region in *Chelone*. Judging from the cast of the cavity in the skull seen in *Nythosaurus larvatus*, there is no reason to suppose that the cranial bones were moulded upon the substance of the brain, so that the brain was probably smaller and shorter than the cavity in which it was contained.

The parietal crest rises above the brain case as a very thin vertical plate; its height, from the base of the sphenoid at the back of the palate, is fully 5 inches. Its longitudinal median extent on the superior surface of the skull between the temporal vacuities, from their anterior limit to the front of the occipital plate where the superior angles of the squamosal bones terminate, is $3\frac{1}{4}$ inches. Its anterior two inches are flanked by the thin posterior extensions of the postfrontal bones, which widen the plate in front to nearly half an inch. This anterior part of the plate is vertically grooved between the postfrontal bones. There is no certain evidence of a parietal foramen, which, if present, must have been small, and may have been at the bifurcation of the occipital plate, though it is not found quite so far back in any South African fossil. In this position the crest widens a little.

The bones of the brain-case are not distinctly defined. A longitudinal sinuous groove extends from the under surface of the frontal, backward and downward to the upper angle of the triangular perforation in the occipital plate (fig. 6), which is above the opisthotic bone and below the squamosal (*sq*), $2\frac{1}{2}$ inches below the superior crest.

The bone above this groove is identified as parietal (fig. 6, *p*). Its greatest depth appears to be $2\frac{3}{4}$ inches; its length is about $3\frac{1}{2}$ inches. It meets the postfrontal (*pt. f*) and frontal in front, and the squamosal behind. It extends above the cerebral region, and its superior edge appears to indicate two bones.

Fig. 6.



Left side of the brain-case of *Cynognathus crateronotus* seen when the post-orbital arch and part of the mandible are removed, showing, *pr.o*, the pre-orbital pit; *pt.f*, the splint of the postfrontal bone extending upon the median parietal crest formed by the parietal bone (*p*), behind which the squamosal (*sq*) diverges outward and backward to define the concave occipital plate, the external margins of which (*f*, *f*) are fractured. A groove runs at the base of the parietal. There is an inter-orbital vacuity, through which is seen (*o*) the right orbit and (*c*) the superior ascending border of the dentary bone (*d*) forming the coronoid process. Below (*c*) is the pterygo-sphenoid keel. The pterygoid bone (*pt*) diverges outward on the right side to unite with the opisthotic bone. In a groove in the inner side of the dentary bone the articular bone is seen (*ar*); it unites with (*q*) the quadrate bone. $\frac{1}{2}$ natural size.

The thickened base of the parietal is supported on each side upon an exceedingly thin vertical bone. These bones converge a little at their anterior borders, where they extend forward as they ascend. The plates are certainly $1\frac{1}{2}$ inch deep, and are overlapped at their bases by the pterygoid bones, which develop laterally, forming thin processes, which diverge transversely outward (*pt*) to the articular region of the lower jaw, separated from the opisthotic by a large foramen. The vertical plates in the side of the brain-case are in front of the exoccipital bones, apparently meet the opisthotic behind, which is shown upon the base of the temporal vacuity, crossed by a groove descending to the foramen between that bone and the transverse process of the pterygoid.

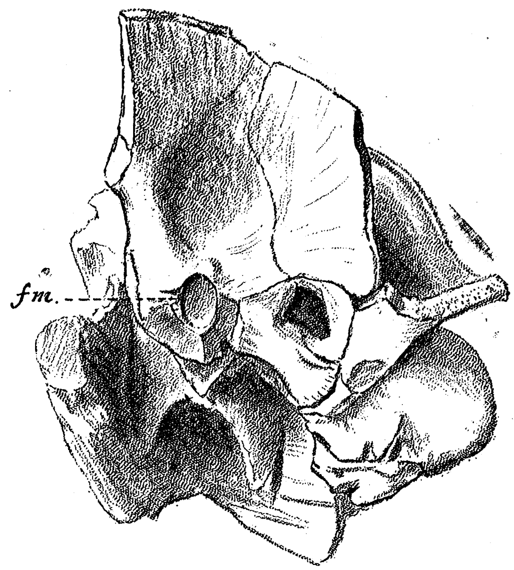
On the anterior border of the opisthotic are two foramina divided by a minute ossification (fig. 6), and as they are placed vertically they correspond to the vertically ovate foramen recorded in this position in the skulls of Dicynodonts. There is every appearance of a distinct ossification being between the opisthotic and parietal, and behind these foramina. And there is some appearance of the ossification in front of the foramina comprising two distinct bones—first, a bone with a wide base an inch long, which becomes narrower as it ascends to meet the frontal, below and in front of the parietal. In front of it is the median ascending plate of the ethmoid, which partially closes the base of the inter-orbital vacuity. The bones are therefore in the position of orbito-sphenoids, if distinct from the hinder part of the ossification, which would then be in the position of the ali-sphenoid. The small ossification between the two nerves is in the position of the pro-otic, supposing the anterior foramen to be the fifth nerve. Then the ossification above and in front of the opisthotic would be the epiotic bone. In this suggested reading of the bones of the brain-case everything depends on the value of the ossification which divides the nerve outlet, which is absent from the right side of the skull, and upon the supposed division of the bone in front of the nerves, but the division is not very distinct. If the interneural ossification is ignored, then the hinder bone becomes the pro-otic, and the anterior would be orbito-sphenoid or ali-sphenoid, and *Cynognathus* would parallel Mammals in having the pro-otic or ali-sphenoid and orbito-sphenoid side by side below the parietal and frontal, though the cerebral conditions do not admit of comparison. The condition seems to me more to resemble the mammalian type than that of reptiles, though the condition is transitional between the two.

The Occipital Region of the Skull (fig. 7).

The occipital plate is imperfectly preserved on the left side, and a portion of the squamosal bone is lost from the superior hindermost angle; and the occipital condyle is lost. These missing portions, however, may be approximately restored from another species. There is a slight twist in this region of the skull by which its left side is a little elevated, and the right side slightly depressed.

The foramen magnum is vertically ovate (fig. 7), placed at the base of the occipital plate, with nothing below it but the occipital condyle; thus making a marked contrast to the Russian genera, *Rhopalodon* and *Deuterosaurus*. The foramen is $\frac{8}{10}$ inch high, and rather less than $\frac{6}{10}$ inch wide in the middle. The depth of the fractured base of the occipital condyle below it, is $\frac{11}{20}$ inch. The fracture appears to indicate for it a semi-circular form, crescentic, owing to the way in which the foramen magnum excavates it above, so that it extends laterally halfway up the foramen, and appears to have been about $1\frac{3}{10}$ inch wide. There is an interspace at the basal angle of the foramen, as though for a nerve outlet, which is about a quarter of an inch deep, margined superiorly by an elevated process or facet, which is common in Theriodont skulls, and may be compared with the lateral facets on the sides of the foramen magnum in Placodonts, which I believe to have given attachment to the neural arch of the short first vertebra.

Fig. 7.



Posterior or occipital aspect of the skull of *Cynognathus crateronotus*.

fm. is the vertically ovate foramen magnum, above which is the vertically concave excavation of the occipital plate. Below *fm.* is the fractured base of the occipital condyles; and lower still, between the rami of the lower jaw, are the descending pedicles of the transverse-palatine arch. On the right side the lower jaw articulates with the squamosal region of the skull. $\frac{1}{3}$ natural size.

The vertical measurement from the basal fracture of the condyle to the summit of the occipital plate was about $4\frac{8}{10}$ inches; and the transverse width of that plate, over the occipital condyle, I infer to have been 10 inches, from its measurement as preserved on the right side. Its superior contour was apparently convex, but for the lateral external notch, caused by the outward reflection of the external edge of the squamosal bone on the hinder part of the zygomatic arch; the inferior border of the occiput is concave, except where the occipital condyle extends convexly down to it in the middle.

The articulation for the lower jaw is about $1\frac{1}{4}$ inch below the occipital condyle, or $1\frac{3}{4}$ inch below the base of the foramen magnum. Owing to this downward position of the lateral expansions of the skull, and the depth of the lower jaw, the height from the angle of the jaw to the summit of the skull is 9 inches.

The most remarkable features of the back of the skull are, first, the convex prominence of the region round the occipital foramen; secondly, the deep cuplike concavity of the lower half of the area above it, which gives the supra-occipital region the aspect of receding forward; third, the outwardly diverging lateral halves of the occipital plate, which as preserved are inclined to each other backward at their superior edges, at about a right angle (fig. 4). The osseous substance of this plate is thin, averaging about $\frac{3}{10}$ inch thick, though a little thinner at its edge, and a little thicker at the base of the posterior cup, where the strong rounded surfaces of the squamosal bones diverge outward and upward from the supra-occipital. The fourth feature of the occiput is a large subtriangular foramen seen on the right side of the foramen magnum, from which it is separated by a bone 1 inch wide. This infralateral foramen is $\frac{9}{10}$ inch wide and $\frac{7}{10}$ inch deep. Its margins are rounded back and front; and its three corners are rounded. Below it is the transverse process, formed by the opisthotic, which extends outward and downward from the exoccipital region, enlarging in its outward course to meet the lower part of the squamosal, with which it unites by a suture which looks outward, backward, and downward. This opisthotic bone is flattened externally. On its posterior surface there is a sharp median ridge. An angular basal ridge on this bone separates the base of the skull from the back of the skull. The bone is defined inferiorly by a second foramen, transversely amygdaloidal, $\frac{8}{10}$ inch wide, and less than $\frac{7}{20}$ inch from back to front externally. Its anterior border is formed by the thin transversely-expanded plate of the pterygoid, which extends in a long triangle from the sphenoid to the suture with the squamosal, but, so far as can be seen, does not reach the quadrate bone.

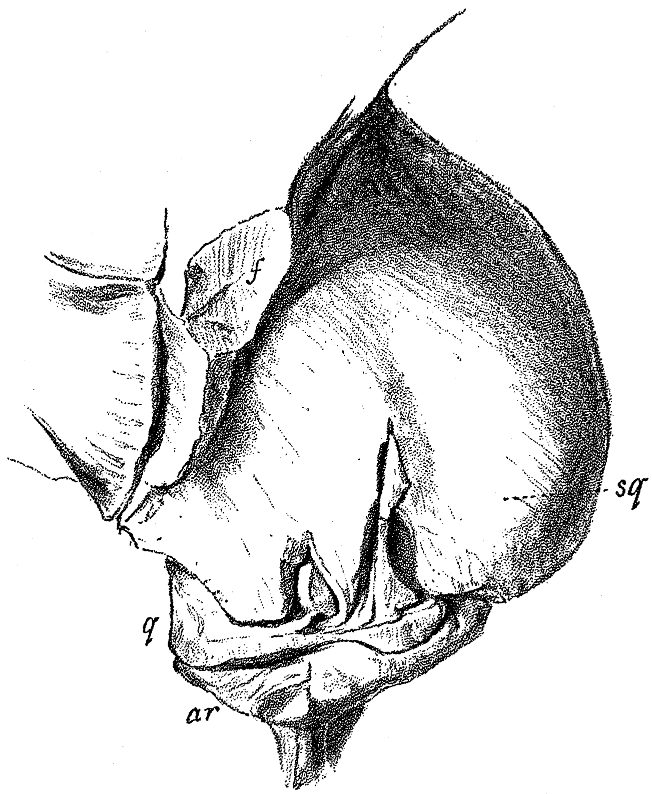
The bones which are exposed on the back of the occipital plate are closely blended by squamous and other sutures, which cannot always be easily traced, so that there is sometimes difficulty in carrying the sutures across both sides of the skull. I believe the basi-occipital to be narrow and defined on the fractured surface by sutures, so that its basal width, as preserved, is $\frac{1}{2}$ inch, and this width is diminished on the foramen magnum to less than $\frac{3}{10}$ inch. The exoccipital bones extend apparently but little above the middle of the foramen magnum, so that its upper portion is formed by the supra-occipital plate; the transverse suture between these bones extends outward and apparently slightly upward. The area of the supra-occipital is not easily defined. There is no trace of a median vertical suture; but the lateral sutures which separate it from the squamosal bone are distinctly traced, so that I regard the supra-occipital as extending about an inch in width and apparently $1\frac{1}{10}$ inch in advance of the superior border of the foramen magnum, which is defined by a hemispherical tubercle. Above the supra-occipital, and uniting with it by a sagittal suture, is the deeply concave bone, $1\frac{9}{10}$ inch high, reaching a width of fully $1\frac{1}{2}$ inch, which I regard as the interparietal. It extends to within $\frac{17}{20}$ inch of the summit of the occipital plate, from which it is separated by what appear to be posterior divarications of the parietal bone, which may, however, be separate ossifications, such as extend behind the median parietal in certain Dicynodonts. That character of a threefold ossification of the parietal I have believed to be of some interest, as possibly showing that the single parietal bone of certain reptilia may represent the median parietal of *Dicynodon*, while the divided parietal bones of other reptiles may represent the posterior ossifications of *Dicynodon*, and the triradiate parietal of lizards may correspond to the entire Anomodont ossification. All are explained by the structure of the vertebral neural arch in Elasmobranch fishes ('Phil. Trans.,' B., 46).

The whole of the occipital plate external to the lateral and nearly vertical suture, with the parietal, inter-parietal, supra-occipital, and other bones, down to the great lateral foramen, is formed by the squamosal bone, which is flattened, vertical, slightly convex from the median line, and convex on the superior margin, outward downward and backward, though its external angle is imperfectly preserved. The surface of the bone is marked with muscular impressions and vascular grooves, which extend from the superior edge inward and downward towards the foramen magnum. There is an appearance of suture on the upper border of the lateral foramen which extends outward and passes through the bone, but on the external surface the sutural appearance is not sustained, and the bone appears to be fractured. The measurement, from the superior angle of the squamosal where it meets the parietal, downward to the inferior angle where it meets the lower jaw, is about $6\frac{1}{2}$ inches. It has already been described as bending forward to contribute to the zygoma. Its posterior surface above the articulation is thick and strong, and measures $2\frac{4}{10}$ inches from within outward. This posterior area of the squamosal is convex obliquely, from above downward and inward, the convexity passing externally into the groove below the reflected superior border of the zygoma (fig. 8, *sq*).

The posterior inferior surface of the squamosal bone gives attachment to some small ossicles. The largest of these I regard as the quadrate bone (fig. 8, *q*) (if they are not all parts of the quadrate). It appears to be a thin wedge, about $1\frac{1}{4}$ inch wide on its posterior margin, which is less than $\frac{3}{20}$ inch thick from front to back. It appears to become thinner superiorly, and articulates with the articular bone (fig. 8, *ar*) of the lower jaw. Its extreme depth from above downward is less than $1\frac{1}{2}$ inch. It is embedded on the antero-internal surface of the inner part of the squamosal bone, almost absolutely hidden by the structures around it. It faces forward, where it appears above the articulation, external to the opisthotic, where it forms a small sub-quadrate surface about $\frac{3}{4}$ inch in each measurement, and slightly concave in front. If the quadrate bone were proportionately reduced in a skull 2 or 3 inches in length, its dimensions would be so small as not greatly to exceed those of the auditory bones of some Mammals. So long as the articulation of the mandible with the skull is made by means of the quadrate bone, no matter how small, and an articular bone, it is obvious that the condition is reptilian. The posterior surface of the squamosal above the quadrate shows two small ossifications, which may possibly be posterior processes from the quadrate, imperfectly covered by the squamosal bone.

First, there is an external groove or pit of some depth on a level with the middle of the external part of the articulation. This pit passes into the squamosal bone where the thin edge of the quadrate ends and the squamosal comes in contact with the articular bone. On the inner side of this pit is a vertical bar of bone about $\frac{17}{20}$ inch long, which appears to be distinct from the quadrate bone below, and from the squamosal bone with which it is in close contact superiorly. It is impossible to affirm that it is distinct from the squamosal, and there is some appearance of a minute ossification at its quadrate extremity. The inner boundary of this bone has more the aspect of a canal than of a suture. The smaller posterior ossification is of a globular

Fig. 8.



Posterior aspect of the right mandibular articulation of *Cynognathus crateronotus*, showing (*ar*) articular region of the mandible; (*q*) quadrate bone with two ascending bars; and (*sq*) the vertically convex descending posterior extremity of the squamosal bone; (*f*) fracture. Natural size.

form just above the quadrate, and internal in position to the slender vertical bar with expanded ends just referred to. A ridge of bone, hardly thicker than a thread on its posterior aspect, appears to connect it with the quadrate from which I am unable to separate it with certainty. Here, possibly, are small bones embedded in the squamosal between it and the quadrate, which have not been previously noticed in reptiles. I am unable to affirm that they represent auditory ossicles. Something similar is seen behind the articulation of the mandible in *Galesaurus* and other Theriodonts.

The Palate (fig. 9).

As the lower jaw is in natural articulation with the skull, the anterior part of the palate has not been completely excavated. It is remarkably narrow, being 2 inches wide at the first molar tooth.

At about 5 inches behind the extremity of the snout are the deep lanceolate palato-nares. The bone of the hard-palate in front of this undivided opening on the palate, is a strong ridge continuous on the right side with the longitudinal stouter ridge on the hard-palate, which is produced obliquely outward and backward to define the front of the opening. The ridge becoming thinner, then bends backward parallel to the lower jaw, and descends to form the intermandibular process, which is convex in front, concave behind, concave internally, convex externally. The posterior contours of these processes ascend and converge inward and backward in a V-shape, upon the presphenoid bar of the base of the skull. The nasal vacuity lies entirely in front of this area, ovate in form anteriorly, and narrow behind, where its vertical sides converge, and are prolonged back as conspicuous rounded ridges divided by a groove, all of which extend between the descending process. On each side of the rounded ridge which borders this groove, is a longitudinal concavity on the palate, about half an inch wide, which is prolonged outward upon the inner surface of each descending process, which is less deeply concave from front to back (fig. 9). There is no certain indication of division in the bones which surround the nares. I identify the palatines on each side of the vacuity. The bones which form the roof of the nares with the two parallel median ridges are probably palatine; and the bone in front of them, which is unseen, may be the maxillary. The palatines may then be defined as a pair of bones, about 4 inches long, consisting of a pair of bars truncated posteriorly between the approximating descending plates of the transverse bones, on which they extend. The palatine bones are somewhat plough-shaped bones, which lie in front of the descending plates of the transverse bones, and diverge as they extend forward to make the lateral walls of the palato-nares before approximating in the anterior median suture. There is a transverse suture $\frac{3}{4}$ inch in advance of the hinder margin of the descending plate of the transverse bone, which defines the back of the palatine bone. This condition of the palato-nares is perhaps more like that in certain Chelonia than in other existing reptiles, except that the descending processes of the palatine and transverse bones are not found. In Dicynodonts, the external anterior wall of the palato-nares is formed by the palatine bones, between which the vomer may extend, dividing the nares; but the posterior palatal wall is made by the pterygoid bones, and there are no descending postpalatine processes formed by the transverse bones.

The palatine bones are chiefly remarkably for developing two ascending processes which meet the prefrontals, as in crocodiles; as well as two descending processes, which give the expanding part of the bone the transverse contour of a capital H. The transverse width is $2\frac{1}{2}$ inches, and the vertical measurement is about $3\frac{1}{2}$ inches. The descending processes are compressed from side to side. They are sub-triangular, concave on the inner surface from front to back, and covered externally and behind by the larger processes of the transverse bones with which they are closely united.

Fig. 9.

Skull of *Cynognathus crateronotus* seen from the palate. The composite structure of the mandible is well seen on the right side. The palato-nares are between the molar teeth. The transverse-palatine arch is behind the orbits. The pterygo-sphenoid keel is longer than the parietal crest, but not wider.

Those processes, which I term transverse-palatine, are thick in the middle. They terminate downward in points about $2\frac{1}{2}$ inches below the palate, and 8 inches behind the anterior extremity of the snout. The ascending processes which meet the prefrontals are more slender than the transverse-palatine processes, and each is rounded on the vertical hinder edge.

Behind these expansions the bones contract both transversely and vertically to form a thin lateral investment upon the front of the slender vertically-compressed bar behind the descending processes, which connects the palate with the basi-cranial region. This bar is $2\frac{1}{4}$ inches long, $\frac{6}{10}$ inch wide in the middle, and about $\frac{8}{10}$ inch deep. Its sides are compressed inferiorly to a narrow median edge, which widens anteriorly between the descending transverse-palatine processes. The sides also converge superiorly to enclose the thin vertical ethmoid plate; which, commencing in front of the base of the brain-case, rises higher as it extends forward, and is $1\frac{1}{10}$ inch deep at the anterior limit of the excavation of the matrix in front of the orbit. This bar, which I regard as the pre-sphenoid, is only paralleled in the genus *Tropidostoma*, of which the jaws are unknown; but the character seems to indicate an ordinal difference between *Tropidostoma* and the Dicynodont with which it has been associated,* which has led me to refer the genus to the Endothiodontia.

The only fossils from South Africa, other than Theriodonts, hitherto described, which show descending processes to the palatine and transverse bones, are *Pareiasaurus*, probably *Gorgonops*, *Endothiodon*, and *Esoterodon;* though they are not fully preserved in either of the latter.

I regard the posterior processes of the transverse bones as extending upon the pre-sphenoid, backward as far as the Ethmoid, and then the bone appears to meet the pterygoid on each side by a sagittate suture.

The pterygoid is in the same position in Mammals as the transverse bone in Theriodonts, so that those bones may be blended in the mammalian pterygoid. The pterygoid bones diverge as they extend backward, so as to expose the long triangle of the basi-sphenoid between them. They ascend upon the base of the brain-case as in Mammals and crocodiles. From the upper part of the sphenoidal bar already described, the thin transverse plates are developed, which extend outward, backward, and a little downward, with a concave margin towards the quadrate. There is an excavation more than half-an-inch deep under this transverse plate which defines vertical sides of the triangular mass of the sphenoid.

The occipital condyle extends downward, and the triangle formed by the basi-occipital and basi-sphenoid is $1\frac{8}{10}$ inch long and $1\frac{1}{2}$ inch wide behind. Its sides are straight with sharp margins. The suture with the sphenoid is nearly an inch in advance of the broken occipital condyle. The inferior surface of the sphenoid is a smooth concavity between the prominent V-shaped lateral ridges. The occipital portion is concave with a slight median ridge bordered by slight lateral furrows, but there is no evidence that vascular perforations open into those depressions. The posterior lateral expansions of the pterygoid bones, and the anterior lateral expansions of the transverse and palatine bones on each side of the median bar give the most distinctive characters of the postnarial region of the palate.

* R. LYDEKKER, 'Cat. Foss. Rept. Brit. Mus.,' Part 4, p. 36.

The structure of the Theriodont skull will be discussed after the whole of the Theriodont types are described.

The Lower Jaw.

The mandible consists of two straight rami which blend in front, so that the suture is completely obliterated, though its position is marked by a very faint elevation in the median line of the anterior aspect of the jaw. The rami are $13\frac{1}{2}$ inches long, compressed from side to side, deep from above downward, with the basal contour nearly straight for $7\frac{1}{2}$ inches behind the inferior divergence of the rami, where the depth from the summit of the coronoid process is $6\frac{1}{2}$ inches. At this point the jaw puts on its most remarkable character. The dentary bone terminates on the inferior border in an oblique truncation (fig. 4), which extends from this inferior angle, backward and upward above the articulation (fig. 6). And from beneath and internal to this truncated dentary element, the articular and angular bones are prolonged horizontally backward, as a narrow process with the articular surface at its posterior extremity, rather below the level of the mandibular teeth. This condition has, at first sight, the aspect of mutilation of the jaw, but the condition is paralleled in another species of this genus, and in other genera of Theriodonts. Hence, the distinctive features of the mandible are (1) union of the rami, (2) composite structure of each ramus, (3) great development of the coronoid process, (4) posterior oblique truncation of the dentary bone, (5) horizontal position of the condylar articulation formed, not by the external dentary element, but by the internal articular bone.

I describe the lower jaw in the following regions: anterior, lateral, coronoid, articular, and internal surfaces.

The anterior region of the mandible is characterized by being obliquely truncated in front, somewhat in the manner of larger Carnivora, like the lion. This anterior surface on its alveolar margin is parallel to the premaxillary contour, and convex from side to side. It recedes backward as it descends to the base of the jaw. Its greatest width superiorly, external to the inferior canine, is 2 inches; and its least width inferiorly, just behind the symphysis, is $1\frac{3}{4}$ inch, at a distance of $2\frac{1}{2}$ inches behind the anterior alveolar extremity.

The convexity becomes less as the anterior area descends and divides, where the rami diverge. The area is bordered on each side by a convexly curved rounded ridge of moderate elevation, which descends backward from the front of the inferior canine, and is parallel to the lateral curvature of the front of the jaw. It descends to its base, and is prolonged as a slightly elevated ridge along the basal contour of the ramus, backward to the posterior truncation of the base of the dentary bone, so as to thicken it, and give its inferior margin a rounded aspect. This anterior area appears to be slightly roughened with vascular perforations, especially in its lower portion.

The lateral aspect of the dentary bone is quite as mammal-like in appearance as the anterior area. The inferior contour is not perfectly straight, being slightly concave in length below the middle part of the alveolar area. The alveolar region is markedly concave in length, owing partly to the manner in which the coronoid process begins to rise at its hinder part. There is hence a slightly constricted appearance in the jaw at the commencement of the maxillary series of teeth, where its depth is diminished to 2 inches. On the whole, the jaw is vertical, and approximately flattened externally. There is, however, a superior longitudinal convexity, which becomes obliquely bevelled away towards the alveolar margin, and forms an inclined superior surface upon which the crowns of the maxillary molar teeth rest, when the jaws are closed. This broad rounded superior convexity defines a longitudinal lateral inferior concavity, of slight amount, which extends from the region of the maxillary canine, where the jaw contracts behind the anterior oblique marginal ridge, and is prolonged backward on the lower half of the ramus. Below the penultimate molar this concavity begins to divide into two concavities. The inferior narrower one is prolonged backward parallel to the rounded basal ridge of the jaw to the termination of the dentary bone. The upper one is prolonged upward and backward, widening as it proceeds, upon the coronoid process, from the superior margin of which it is separated by a flattened area about $\frac{6}{10}$ inch wide. This superior concavity has the effect apparently of reflecting the coronoid process somewhat inward, so that it passes behind the zygomatic arch. These two concavities are divided by a flattened convexity of triangular or wedge-shaped form, with ong, straight, rounded, superior contour, about 6 inches long, which is common to the corresponding wedge-shaped concavity, already described as extending upon the coronoid part of the bone. The inferior border of the wedge is less elevated, and merges in a less defined way in the slight channel above the basal ridge of the jaw. The posterior contour is abruptly and obliquely truncated. This margin appears to be slightly sinuous and about 4 inches in length, commencing at about 10 inches from the anterior extremity of the jaw, and $7\frac{1}{2}$ inches from the divergence of the rami inferiorly, where it forms the angle, from which the jaw recedes upward and backward. Its posterior contour appears to be approximately straight, but may have been slightly sinuous; it terminates in a thin edge, which ascends as it extends backward above the articulation of the jaw and beneath the malar bone. The depth of the mandible in front of the first premolar tooth, measured from the alveolar margin, is $2\frac{3}{10}$ inches; and its depth behind the last maxillary molar is $3\frac{3}{20}$ inches. In the middle depth of this area is a longitudinal series of small vascular foramina below the premolar teeth.

The coronoid region does not show any indication of a separate coronoid bone. The coronoid process of the dentary bone passes obliquely upward behind the orbit, and reaches an elevation of $6\frac{1}{2}$ inches above the angle of the jaw, already described. The process soon loses the superior sub-alveolar convexity, which borders its upper margin at first, and then becomes a long, thin concave plate with a nearly straight rounded superior margin. It is about $\frac{2}{10}$ inch thick in the middle part, thinning away to $\frac{1}{20}$ inch or less at its posterior termination. It is marked by parallel longitudinal grooves of a vascular aspect. The internal surface is convex from above downward and smooth, in harmony with the external concavity. The height of the plate above the elements of the lower jaw, which lie within it, is about $3\frac{3}{4}$ inches. It extends back within about $1\frac{1}{2}$ inch of the posterior border of the excavation of the temporal vacuity in the squamosal bone, and it rises to within about $1\frac{1}{2}$ inch below the superior border of this vacuity, where it is formed by the squamosal and postfrontal bones.

The postdentary external articular part of the lower jaw is obviously formed of two bones, divided by a longitudinal suture. This area is about 3 inches long, $1\frac{2}{10}$ inch deep, with its superior and inferior borders straight, longitudinal, and parallel to each other. There is some reason for thinking that the superior external part of the bone is not in firm contact with these internal elements of the lower jaw. It ascends freely above them, being now only united by matrix; so that the dentary bone has the aspect of being in process of extending back to the squamosal so as to take on itself the work of the internal elements of the jaw, since it extends above them, in front of them, and below them. These elements are carried beneath the external flattened convexity of the dentary bone, which has already been described as characterizing the hinder part of the lower jaw. A fortunate transverse fracture on the left side shows three bones lying severally internal to each other in this position. One of these is obviously the splenial; it lines the whole interior of the front part of the jaw, and in front is blended with its fellow, exactly as the dentary bones are blended. It is a film of no more than paper thickness, which is channelled in front, in the middle line, on a level with the series of small external foramina already referred to. It descends at first quite to the basal margin of the jaw; and then not quite so far, until in the region of the transverse-palatine processes it begins to retreat from the basal border. It forms the inferior of the three elements which are shown in the fracture on the left side; but I do not think it extended backward far beyond the inferior truncation of the dentary bone.

There is another squamose bone of smaller size, which extends external to the descending transverse processes of the pterygoid bones. It also is of paper thickness. It does not descend quite so low as the splenial, or ascend quite so high, so that it appears to be a scale of irregular ovate form, about 3 inches long and 2 inches deep. This scale is in the usual position of the coronoid of a reptile, but it does not enter into the formation of the coronoid process, upon which its hinder margin appears to lie. Between the inferior border of this coronoid, and the splenial, are intercalated the two elements of the lower jaw, which extend backward parallel to each other. The superior of these elements in front is manifestly the articular bone; and below this the angular element, and possibly the sur-angular element, extend above the articular bone, seen on the inner side of the jaw. Externally the longitudinal extension of the articular bone widens from $\frac{2}{10}$ inch to $\frac{4}{10}$ inch, and then it descends obliquely at the expense of the angular bone, so as to articulate with the skull, and form an articulation which is terminal, like that of a turtle. It is about $1\frac{7}{10}$ inch wide, though the transverse thickness of the jaw in front does not exceed half an inch.

On the base of this articular bar of the lower jaw the longitudinal suture extends backward for $5\frac{1}{2}$ inches, which separates the angular bone from the articular bone. The articular is overlapped on the inner side of the jaw, in front, by the splenial. Above the truncated inferior border of the dentary, there is, on the inner side of the jaw, a long ovate vacuity, bordered on the inner side by the splenial and articular bones; and, on the outer side, by what I suppose to be the sur-angular bone; which has a straight superior border, extends back to the articulation, and appears to be separated by a long narrow vacuity from the coronoid process of the dentary bone, which is external to it and above it.

The formation of the first of these vacuities causes the articular bone, which is flattened on the inner side, and flattened superiorly, to form a strong angular ridge below the middle of the inner side of the articular end. The backward extension and extraordinary vertical development of the dentary bone obscures the relation of the constituent elements of the articular region of the mandible. The articular extremity of the jaw is only preserved on the right side. It is inclined so as to look somewhat inward and backward. It articulates externally with the squamosal bone, internally with the quadrate bone. Between these bones are the posterior ossicles, or processes already described, which have the aspect of being embedded between the quadrate bone and the squamosal, though possibly parts of the quadrate bone itself. The quadrate is greatly reduced in size, so that it appears on the posterior aspect of the skull, above the articular bone, as a wedge of bone, $\frac{2}{10}$ inch or $\frac{3}{10}$ inch wide, which is wedged into the squamosal bone, with which the articular element of the lower jaw makes a close-fitting trochlear joint, defined by a median ridge upon the articular bone. The articular surface is wider than deep; deeper on the outer side than on the inner side.

The transverse internal measurement at the angles of the jaw is $3\frac{1}{2}$ inches, and the transverse internal measurement, judging from the preservation of the right side, at the articulation was about 5 inches, while the external transverse measurement did not greatly exceed $8\frac{1}{2}$ inches.

There is no character by which the anterior half of the jaw could be distinguished from that of a Mammal, except in the presence of the thin internal film of the splenial bone, and not the least remarkable of the characters of the posterior region is the evidence that the dentary bone extends to within $\frac{1}{10}$ inch of the superior external surface of the mandibular articulation, so that it only needs to be ossified on its truncated inferior border to present the external aspect of a ramus of the lower jaw in a Mammal. The circumstance that the dentary already extends back external to the articular bone, so as to come between it and the squamosal, although not actually making an articulation with the squamosal, is suggestive of a process by which the articulation may have been eventually transferred from the articular bone to the dentary bone. When this suggestion was first put forward ('Phil. Trans.,' B., vol. 180, pp. 291 and 292) the evidence was much less clear, and, at the present time, instead of accepting the conclusion then put forward, that the angular and sur-angular bones persist in the Mammal in an undifferentiated condition, I urge that the present evidence renders it not improbable that articulation with the skull was established by the dentary bone, and that the mammalian lower jaw came in consequence to be developed out of that bone only, so that all the internal elements of the jaw, which are distinctively reptilian, have disappeared from the lower jaw in consequence of the loose connection between those bones and the dentary, and the transfer of work from them to the dentary, which would result from the rigidity of a ramus formed of one bone only.

When the lower jaw is compared with that of existing animals, there is obviously no reptile which makes an approach to it in any character, other than the composite structure of the jaw. Chelonians have the rami blended, the articulation terminal, and a slight coronoid elevation, into which the dentary bone ascends in several types; but there is no forward prolongation of the articular bone in Chelonians, and in that group, as well as in lizards, the sur-angular bone is considerably developed. The articular bone does extend forward among lizards, though not at all in the way shown in this fossil; but on the other hand the dentary bone does not rise externally over the coronoid bone. In its external aspect there is not much to recall any of the extinct terrestrial reptilia; and only in some minor details of form is there any approximation. Thus, among Ornithosaurs, one of the most remarkable characters of *Ornithostoma*, to which genus Professor WILLISTON refers the American type named *Pteranodon*, is a similar angle on the basal margin of the lower jaw, and the contour of the bone behind it recedes towards the articulation, where the depth of the jaw is greatly diminished, in a way that recalls, though it does not parallel, this fossil. There is a less marked approximation in other Ornithosaurs, though the jaw conspicuously decreases in depth posteriorly in *Dimorphodon*. But in no fossil reptile outside the Anomodontia, is the coronoid process of the dentary bone developed as in this fossil, or is the articular end of the jaw similarly modified in any other type, while no genus except those allied to *Galesaurus*, is known to have the teeth similarly differentiated.

The only other fossil which appears to permit close comparison is the small jaw from the Upper Trias of North Carolina, described in 1887 by Professor H. F. OSBORN as a Mammal, under the name *Microconodon tenuirostris*. This type is known from the enlarged figures given by Professor OSBORN ('Proc. Am. Philos. Soc.,' vol. 29, No. 125, fig. 1, p. 111, and 'Journal of the Academy of Natural Sciences of Philadelphia,' vol. 9, No. 2, p. 223). The jaw as preserved is about $\frac{7}{10}$ inch long. The molar teeth, which have cusps, somewhat on the pattern attributed to *Galesaurus*, are described as characterized by imperfect division of the roots indicated by a depression at the base of the crown, as in the American fossil reptile, *Dimetrodon*.

When the lateral contour of the jaw is compared with the fossil now described, there are seen to be the following points of resemblance. First, a wide diastema behind the mandibular canine, due to the descending maxillary canine. Secondly, a slight median concavity in the region below the cheek teeth. Thirdly, the replacement of this depression behind the teeth by an elevated region which is prolonged backward to the articulation of the lower jaw, which Professor OSBORN has not defined. Fourth, the concave space about this ridge, upon the ascending coronoid, which is margined superiorly by an elevated ridge, and prolonged back almost as far as the articulation. Five, the termination of the inferior border of the dentary region in an angle, behind which the jaw retreats abruptly to the articulation, and above which it is concavely excavated, apparently with the indication of a suture defining the articular bone. Thus, in every point in which the minute size of the fossil admits of comparison, even to the presence of two denticles or cusps on the posterior border, and one on the anterior border of molar teeth, there is absolute identity of plan between the two jaws, which would lead to the conclusion that *Microconodon* is more likely to be a Theriodont reptile, than that it establishes a complete link between *Cynognathus* and the Mammalia. But that an anatomist so familiar with Mammals as Professor OSBORN should have regarded *Microconodon* as a Mammal, only shows the technical difficulties which present themselves in discriminating these types in such fossils.

The position of the angle in the jaw is a character of some importance in Mammals. Professor OSBORN compares *Microconodon* with the Purbeck species of *Perameles,* in which, however, the angle, though marked, is almost as far back as the articular condyle. Some American genera offer an intermediate condition, such as may be seen in the fossils described by Professor MARSH, named *Diplocynodon* and *Docodon,* in both of which the angle is much anterior to the articulation, and is directed slightly downward. Such types could be regarded as derived from such a form as *Cynognathus,* by extension of the dentary bone to the articulation of the jaw. In existing Carnivora the angle of the jaw is well developed, but it has extended further backward, so as to be almost immediately below the condyle. In the Secondary rocks the angle becomes prolonged horizontally backward in such genera as *Stylacodon* and *Dryolestes,* and this condition is more pronounced in some existing Insectivora, like the common shrew, in which the angle extends far beyond the articulation; this condition characterizes the sloths, in which, however, the articulation is above the level of the teeth.

There is, therefore, no very conclusive inference to be drawn from the form of the angle of the jaw in its bearing upon mammalian affinity, but it is not without interest that the nearest approach to the form of the jaw is found among extinct Mammals, and animals which have been regarded as mammalian.

The Shoulder-girdle. (Figs. 10, 11.)

The scapula and associated bones are well preserved on the right side; but the left scapula, having already been separated and washed down the hillside in fragments by the rains, was imperfectly collected, for the fragments showed no certain indication of the nature of the bones which the rock would yield. Nevertheless the fragments have some interest, because they prove that the characters which are most distinctive of this part of the skeleton are the same on both sides of the body. In neither case is the coracoid complete, and the pre-coracoid is also broken; but in both specimens the state of preservation is almost identical, which suggests the inference that very little may be lost from those bones, which would be exceptionally small as compared with the scapula, and apparently smaller than in edentate Mammals in which the coracoid is a separate ossification.

As preserved, the scapula is about 7 inches long, while what remains of the coracoid, including its articular surface, is $1\frac{7}{10}$ inch. It terminates in a thin broken surface, which extends on to the pre-coracoid, which unites with it by a sagittal suture, and enters into the humeral articulation in the usual way.

The coracoid is triangular in section, being flattened posteriorly below the articular surface, which is defined by an elevated condition, and its superior and inferior surfaces are flattened and compressed, and rapidly approximate as they extend forward.

The pre-coracoid shares in the compression. On its visceral surface it is somewhat excavated by the foramen which passes through the bones, in harmony with the excavation in the scapula. The form of the visceral excavation is ovate, without any approach to the lunate form seen in the Russian Deuterosauria, and dissimilar to the perforation which characterizes the Dicynodontia, though the excavation is similarly prolonged by a small perforation on the anterior external surface of the pre-coracoid. The visceral concavity is $1\frac{1}{4}$ inch long, and fully $\frac{7}{10}$ inch wide. But the foramen does not appear to have had a greater diameter than $\frac{4}{10}$ inch. I suppose this excavation to have been nearly in the horizontal line of the body, which would indicate that the scapula extended upward and backward, at an angle of about 45°.

The articulation for the humerus is chiefly formed by the scapula; the two parts formed by the scapula and coracoid meet each other at an angle of about 115°, defined by the groove in the line of suture between them, so that the two articular surfaces do not form a continuous smooth concavity, but an angular notch. In both bones the articular surface is slightly convex transversely. (Figs. 10, 11.)

The coracoid surface is sub-triangular, $1\frac{1}{2}$ inch wide and $1\frac{3}{20}$ inch deep, with a small triangle notched out on its hinder border, so that it does not cover the bone quite up to the posterior margin. The anterior margin of the articulation extends slightly on to the pre-coracoid bone.

The articular surface of the scapula, which is semi-ovate, obliquely truncates the articular end of the bone, in harmony with its presumed backward direction. The transverse width of the bone, as preserved at the suture with the coracoid and pre-coracoid, both imperfect, is $2\frac{3}{20}$ inch, and the transverse width of the same line of the articulation, which is complete, appears to be $1\frac{8}{10}$ inch.

This humeral surface is half an ellipse, $1\frac{6}{10}$ inch deep, with the margin sharp and elevated, and the surface somewhat irregular, being convex in the front part, and concave in the hind part. From this massive articular end the scapula is produced upward and backward, with a curve, which is concave in length on the visceral surface, corresponding to the curvature of the ribs in animals in which they are developed.

The visceral surface of the bone is about $6\frac{1}{2}$ inches long and 3 inches wide at the transversely truncated, free, or dorsal border. The bone on this internal aspect is concave in length, and convex transversely, with the transverse convexity least at the superior dorsal extremity, and greatest in the narrow part of the bone, which is $\frac{9}{10}$ inch wide on the visceral surface above the acromion, at about one-third the length from the articular end. The internal convexity is most complete at the articular extremity, where it extends into the ovate vascular excavation already described.

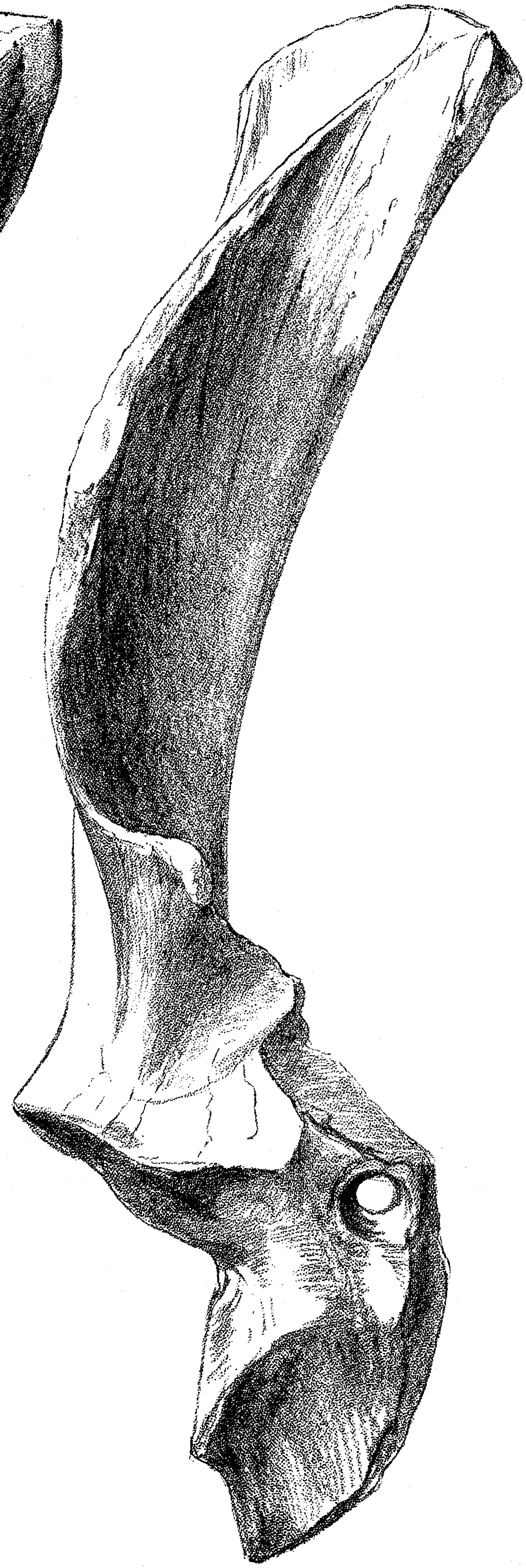
The flattening of the free end of the scapula is due to the development, for the length of about 2 inches, of a narrow anterior expansion, or prolongation of the bone laterally in front of the spine of the scapula (fig. 11), which rises almost at right angles to the blade. It is this vertical development of the spine on the anterior margin of the bone which gives so striking an aspect of convexity to its middle portion, where the spine has a vertical development of $1\frac{1}{2}$ inch. The spine is thus proved to be the anterior edge of the scapula developed upward.

Seen from the external surface, the bone is nearly straight on the posterior border, being slightly concave in length, widening slightly towards the proximal and distal extremities, thus contributing to increase the transverse expansion of the bone. This posterior border is somewhat elevated, rather than reflected, upward in the middle, compressed, and convex in length on its external contour, thus making the greater part of the blade of the bone a deeply concave channel (fig. 10), which widens as it extends dorsally, being bounded in front by the spine of the scapula. This spine (fig. 11) is very thin, nearly straight for three-fourths of its length, when it turns convexly forward, almost to a horizontal position, to become the acromion process, which is necessarily the extremity of the spine of the scapula; and then its margin is still further compressed to a sharp edge, which descends, being reflected downward, to a level with the visceral surface of the bone, so as to make the scapula externally convex transversely, just above the humeral articulation. The spine of the bone varies in thickness from $\frac{2}{10}$ to $\frac{3}{10}$ inch; and just at its dorsal extremity widens to half-an-inch, so there is a slight increase in thickness on the transversely convex crest of the blade, which is rugose with muscular attachments; its contour rises bow-shaped as it extends from the acromion to its dorsal termination. The transverse measurement at the acromion is rather less than 2 inches, and that process is situate at an external

Fig. 10.

External aspect of the left shoulder girdle, showing scapula, the articular surface for the humerus, the pre-coracoid foramen, and parts of the coracoid and pre-coracoid bones.

Fig. 11.



Anterior lateral aspect of the same specimen, showing the reflection outward of the anterior margin of the scapula to form the spine, in front of which a pre-scapular region is developed. The spine terminates in the acromion process, which extended forward.

level above the anterior angle of the humeral articulation, from which it is distant about $1\frac{1}{4}$ inch.

The most remarkable feature of this scapula is the development of the spine of the bone, which hitherto, so far as I am aware, has not been recognized in the scapula of any vertebrate of lower grade than the Mammalia. The spine in the human scapula is chiefly towards the anterior margin, and that may be regarded as its predominant direction among Mammals, though there are many types in which the spine does not reach the anterior border of the bone; and there is no Mammal in which the anterior part of the blade, or pre-scapula of the late W. K. PARKER's nomenclature, is so little developed.

The spine is the distinctive feature of the mammalian type of scapula, which is almost universally present. It is convenient to recognize that Professor KITCHEN PARKER termed the body of the spine of the mammalian scapula, meso-scapula, so that the pre-scapula is necessarily regarded as a structure developed in advance of the meso-scapula of such a Mammal as *Echidna*, or *Ornithorhynchus*, in which there is no trace of the mammalian pre-scapula, and in which the meso-scapula has an extension in the same plane as the blade of the scapula, such as obtains among the Cetacea.

The termination of the spine of the scapula above the humeral articulation is free in Mammals only; the bone which expands above the humeral articulation in Plesiosaurs being probably homologous with the blade of the mammalian scapula. This process which extends above the humeral articulation in most Mammals, is known as the acromion. So that the acromion is theoretically the part of the meso-scapula which is separated from the scapula itself, and gives attachment to the clavicle. I have not seen any embryological evidence of the meso-scapula being at any time a distinct element in the skeleton. It seems possible that it should be so, on account of the structures shown in connection with the scapula of *Pareiasaurus*, where the clavicle terminates upon the acromial process of the scapula, which has the form and appearance attributed to the meso-scapula among the Monotremata. Another ossification runs along the anterior margin of the scapula of *Pareiasaurus* as a distinct though moderate elevation upon the bone. This ossification was termed the epi-clavicle, and regarded as a new element in the reptilian skeleton. It is in very close union with the scapula, though the two ossifications are not blended together, as is shown by a fragment being lost from the superior bar. Whether it be known in future as epi-clavicle, or meso-scapula, it appears to me in every respect to correspond to the spine of the mammalian scapula; in which case it would appear to originate in an element of the skeleton, which, in *Pareiasaurus*, is a separate bone. Hence, what appears in *Cynognathus* to be an upward reflection of the spine, may also be regarded as an upward growth of the epi-clavicle. The scapula agrees with the Mammal in every point in which comparison can be made; in its spine, down to the acromion, or meso-scapula, which is not prolonged over the humeral articulation, but forward and inward, in the same plane with a margin of the coracoid and pre-coracoid, over the anterior borders of which the clavicular bones, if developed, would extend. The direction of the acromion process in Edentata, which retain the coracoid as a distinct ossification, tends to show that the Theriodont type is not so far removed as might at first appear, from some Mammals. But the condition of this process, in the genus now described, is at once so easily compared with the corresponding process of the scapula in *Deuterosaurus*, *Dicynodon*, *Pareiasaurus*, and their allies as to suggest, if it does not prove, that the mammalian type is modified out of a typical reptilian condition of the shoulder girdle.

This shoulder girdle is very unlike that figured by Professor COPE as Pelycosaurian ('Proc. Am. Phil. Soc.,' 1884, Plate 1, fig. 3), for not only is the form of the arch dissimilar in the American type, but it shows no evidence of the spine or of the acromion process.

Indications of a Theriodont Humerus, possibly referable to Cynognathus crateronotus.

Upon the rain channel, at a little distance below the skeleton of *Cynognathus crateronotus*, I gathered some fragments of bones, two of which are portions of the proximal end and distal part of the shaft of a right humerus, which I estimate to have been about $7\frac{1}{2}$ inches long. It may be possibly referred to the skeleton of *Cynognathus*, which was *in situ* above, since I met with no other remains in the vicinity.

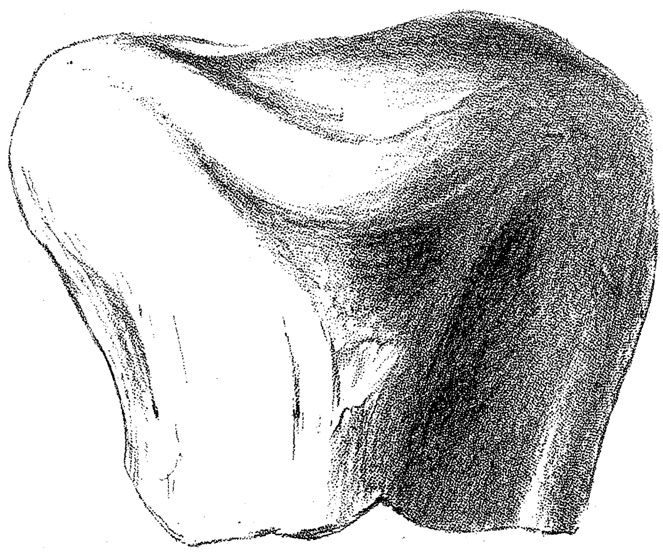
The proximal end (fig. 12) is about $3\frac{3}{10}$ inches in extreme width, and the fragment is $2\frac{1}{2}$ inches in length. The proximal articulation truncates the bone transversely, is sub-triangular in outline, its inferior border, which is $2\frac{9}{10}$ inches wide, is concave, in harmony with the concavity of the inferior surface of the bone, which results first from the downward direction of the radial crest, and secondly from the thickening of the inner side of the articular surface. The superior contours of the articular surface are two nearly straight lines inclined to each other at an angle of about 100 degrees, nearly equal in length, rounded where they meet in the middle of the bone, and they make the articulation $1\frac{13}{20}$ inch deep in the middle. On the inner side the margin of the shaft is somewhat thickened and rounded, an inch deep proximally, while towards the radial side it becomes compressed to the crest, which is less than half-an-inch deep. The articular surface on its inner part is slightly concave from within outward, and slightly convex from below upward. But the outer portion extends a little further proximally, and is convex in both directions. The superior margin is about half-an-inch wide and concave from side to side.

At the transverse inferior fracture the bone is $2\frac{3}{20}$ inches wide, and consists of two portions. First, a transversely ovate shaft $1\frac{4}{10}$ inch wide and $\frac{8}{10}$ inch deep, slightly compressed towards the outer side, from the base of which the radial crest is prolonged outward and downward at an angle of 45°. This crest is of nearly uniform thickness, $\frac{4}{10}$ inch thick, slightly compressed in the middle, and about an inch deep.

There is no indication on the superior surface of separation or distinction between these parts of the bone; and, on the superior surface of the shaft, the crest is only defined by being concave from above downward and transversely, which marks it off from the transverse convexity of the shaft. The bone has a dense external layer, about $\frac{2}{10}$ inch thick, within which its texture is spongy, but there is no trace of a medullary cavity.

The external margin of the crest appears to be flattened, and its curvature is prolonged proximally, so as to be continuous with the articular surface.

Fig. 12.



Nat. size. Proximal end of humerus seen from the antero-inferior aspect.

The thick inner margin is regularly convex from above downward, but shows a slight ridge on the side of the bone $2\frac{1}{10}$ inches below the proximal articulation. This side, on its superior border especially, is rounded convexly, so as to be continuous with the articulation, below which its lateral contour is vertically concave. The thickness of the shaft, as preserved, does not augment proximally till it deepens with the articular surface which is not globose as in most Mammals.

The second fragment is apparently from the distal end of the same humerus, just above the distal articulation. It is imperfect on both the external and internal margins, being broken so as to remove the bridge of the ant-epicondylar foramen. As preserved it is $2\frac{1}{2}$ inches wide and 1 inch long. On the superior surface it is remarkably flat, and shows the upper portion of a deep olecranon pit, which from other evidence is affirmed to have been hemispherical. As indicated, it appears to be about $\frac{7}{10}$ inch wide, and half that depth. External to the pit on the opposite inferior surface, the bone is rounded in a ridge, as it approaches towards the compressed external margin, which is imperfectly preserved, and on the inner side is a stronger convex ridge.

This ridge is about half-an-inch wide, and is inclined downward and inward. Its inner side formed the wall of the ant-epicondylar foramen which is thus shown to have been about $\frac{17}{20}$ inch long. The other convex ridge, less elevated, extends downward and outward, terminating in the distal ridge of the bone, which is imperfectly preserved.

These fragments indicate a bone which closely approximates the humerus referred to *Cynodraco*, in which, however, there is no supra-condylar concavity of the same kind or olecranon pit. The bone is closely comparable in essential characters with the humerus of a Marsupial; only the radial crest in Marsupials is much less developed, and the proximal articulation in Marsupials is never developed transversely.

The Vertebral Column (figs. 13–18).

The vertebræ measure 37 inches from the body of the atlas to the last lumbar vertebra, and their total length as preserved is about 45 inches; but the extremity of the tail is missing. The number of vertebræ in the several regions of the body is not easily determined. There may not be more than six cervicals, for the first five vertebræ which develop transverse processes have those processes directed downward, outward, and backward; while in the sixth and subsequent vertebræ the processes are a little higher in position, directed horizontally outward, and have a different aspect, accompanied by a more elevated lateral position; so that although the seventh vertebra has a transverse process shaped like those which succeed it, it is intermediate in position, and its rib is smaller than in the succeeding vertebræ. Judging by the backward transverse processes there are six cervicals.

The trunk vertebræ may perhaps be divided into three groups. First, those with the dorsal ribs long and slender; secondly, those in which the dorsal ribs are shorter and overlap each other, owing to antero-posterior expansion, and are prolonged outward, beyond the interlocking region; and thirdly, those with short truncated ribs which interlock with each other, but may conveniently be classed as lumbar, having no free rib-like process prolonged outward. The number of presacral vertebræ is twenty-nine, of which I should count six as cervical, eighteen as dorsal, and five as lumbar. Although this number is large, it is paralleled in many Mammals.

The six cervicals, as is well known, are paralleled in one of the sloths, *Cholœpus Hoffmanni*, a group in which the number of cervical vertebræ varies; and this character is also seen in *Manatus*. The trunk vertebræ in the skunk number twenty-two, sixteen dorsal, and six lumbar.

In the Insectivore, *Centetes*, there are twenty-four vertebræ, nineteen dorsal and five lumbar. The exact number of presacral vertebræ in the fossil is found in the modern South African Mammal, *Chrysochloris*, in which the dorsal vertebræ however are nineteen and the lumbar vertebræ three. The Dugong has nineteen dorsal and four lumbar vertebræ, the Cape Ant-eater thirteen dorsal and eight lumbar.

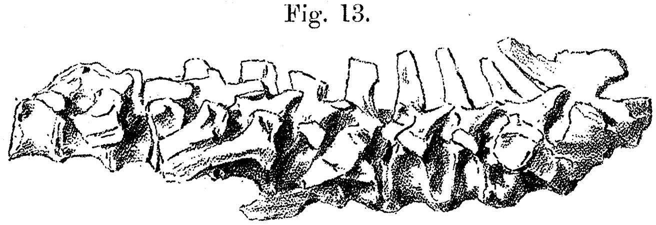
In the *Ornithorhynchus* there are seventeen dorsal vertebræ and two lumbar. There is so much variation in the number of vertebræ in the several regions of the body among Mammals, and the total number of vertebræ is so variable, that the resemblances in this respect to Mammalia are striking. Among Crocodiles, which alone are comparable in vertebral characters, the number of pre-sacral vertebræ is twenty-four, of which the lumbar vary from two to five, so that the dorsal vertebræ vary from ten to thirteen. In *Hatteria*, Dr. GÜNTHER enumerates eight cervical, fourteen dorsal, and three lumbar, so that the greater number of vertebræ in the trunk in this fossil is, as far as it goes, a divergence from Reptiles, which is suggestive of Mammals.

I am not aware that any animal, recent or fossil, has hitherto shown an interlocking of the vertebræ by means of the ribs, such as is found in this fossil. Although, in view of the overlapping of the ribs in *Cyclothurus*, the complicated interlocking of the neural arch in the lumbar region by an arrangement resembling the zygosphene and zygantrum of serpents is of some interest.

Cervical Vertebræ.

The bodies of the neck vertebræ are strong, and somewhat deep, with compressed sides concave from front to back, terminating in elevated margins to the articular faces; and convex from above downward. They terminate inferiorly in the first five in a median hypophysial keel, which decreases in elevation as the vertebræ extend backward, and is lost in the sixth and subsequent vertebræ. The bodies of the cervical vertebræ do not appear to have been in close contact, and as preserved they

Fig. 13.

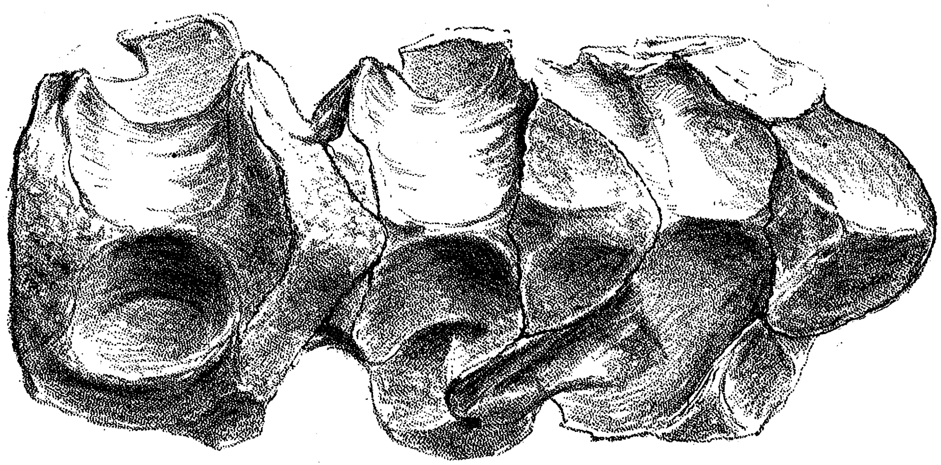


Right side of the anterior portion of the vertebral column, showing the attachment of the head of the rib to the intercentrum in the earliest vertebræ, and afterwards to the intercentral suture.

curve a little upward. They are united together at their inferior edges by a series of wedge bones, comparable to those figured by Sir PHILIP EGERTON in the neck vertebræ of *Ichthyosaurus*. These intercentral ossifications appear to have been seven in number. The first, which is lost, was placed between the first and second centrums. Those at the meeting of the succeeding vertebræ are broadly V-shaped ossifications, with a sharp visceral keel (fig. 14). Their anterior border is pointed and V-shaped, and the posterior border concave. They articulate with the vertebræ, and are at first thick, but at last become thin and narrow. The antero-posterior measurement exceeds half-an-inch, each inclined half of the bone is about $\frac{8}{10}$ inch deep. The transverse measurement over its superior extremities is 1 inch; but is less in the first, sixth, and seventh. The head of the rib is certainly articulated to the intercentrum in the first two; and in many subsequent vertebræ, if the rib does not meet the intercentrum, its head lies upon the suture between the bodies of the vertebræ. This appears to explain the double-headed articulation of ribs as having originated in a primitive division of the centrum transversely.

The length, from the front of the first vertebra to the suture on which the last intercentral plate lies, is $9\frac{1}{2}$ inches; and the antero-posterior measurement of each centrum exceeds $1\frac{1}{8}$ inch, though the first is longer. The depth from the neural canal to the base of the centrum is about $1\frac{6}{10}$ inch, without measuring the wedge bone; but there is a slight decrease in depth, as the vertebræ extend backward in harmony with the less depth in the dorsal region. The transverse width of the margins of the articular faces of the cervical vertebræ is rather less than the depth. The width of the interspace between the vertebræ is about a quarter of an inch. The intervertebral articulations on the centrums are concave, with a somewhat plesiosauroid concavity. There are no articular facets on the bodies of the vertebræ. So that the ribs present the unique condition of articulating, in the cervical region, by the tuberculum with the neural arch only, while the head of the rib is received upon the sutural interspace This may explain the absence of facets on the centrum in allied animals. The neural arch is well developed, though without presenting an exceptional transverse extension. The suture closely unites the arch with the centrum. Its ascending neurapophyses are strong, and they develop transverse diapophyses, which are directed outward, backward, and downward, and have somewhat compressed articular diagonal facets, for the tubercle of the rib, from the second to the sixth vertebra. These processes are strong, $\frac{8}{10}$ inch from front to back, and about $\frac{4}{10}$ inch thick; well excavated on the under surface, which is supported by a posterior-rounded ridge, which descends obliquely to the posterior articular face of the centrum. The transverse measurement across these processes is 2 inches. The upper margin of the process is opposite the neural canal, but its lower margin descends to a lower level than that perforation. Laterally, each process is above its own centrum. The downward direction of the anterior border of the process almost circumscribes a canal like that for the vertebral artery. From this transverse process, and the neurapophysis of which it is an outgrowth, the zygapophyses are developed. They extend obliquely forward and upward as compressed bars, parallel to each other, so that the transverse width over them, which decreases a little posteriorly, exceeds an inch. The facets look inward and a little upward. The posterior zygapophyses are facets at the wide base of the neural spine, received between the pre-zygapophyses. The neural foramen between the arches is large, somewhat vertically ovate or sub-triangular, and placed obliquely, so that its axis passes backward and downward. The neural spines are exceptionally modified by great development in the second vertebra, and a corresponding atrophy in the third, but in the fourth, fifth, and sixth they are vertical, compressed from side to side, form a sharp knife-like edge in front, and are flattened or slightly concave towards the base behind, are moderately high, taper upward, and increase in antero-posterior measurement as they extend backward. They are all imperfect at the summit, but the fourth and fifth are $3\frac{7}{10}$ inches high from the base of the centrum, and the neural spine rises $1\frac{1}{4}$ inch above the pre-zygapophysis which margins its base. The antero-posterior extent of the zygapophyses is $1\frac{6}{10}$ inch. The thickness at the base of the neural spine is $\frac{3}{10}$ of an inch, and its antero-posterior extent leaves a considerable interval between the spines. The massive spine of the second vertebra is altogether different in character from the others. Its antero-posterior extent as preserved is about $3\frac{1}{10}$ inch, and its height

Fig. 14.

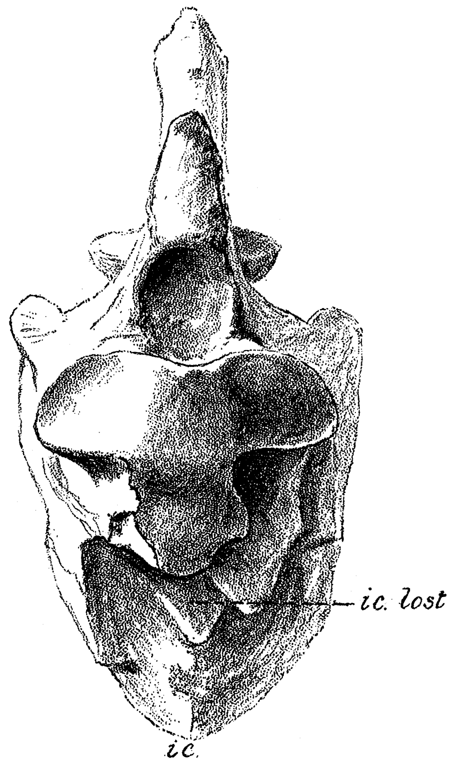


Ventral aspect of three cervical centrums and intercentra, showing the articulation of the cervical rib to the external superior margin of the intercentrum. The ribs are most distinctly shown on the left side. Natural size.

above the zygapophyses is not greater than in the succeeding vertebræ, but its base is much stronger. It is compressed from below upward to a sharp ridge, which is concave from front to back, so that it consists of a triangular posterior portion like an ordinary neural spine, only twice as thick, and extending backward at an angle greater than that of succeeding vertebræ; secondly, there is the anterior portion, about $\frac{6}{10}$ inch deep, and $\frac{4}{10}$ inch thick, which is directed somewhat upward and forward over the neural canal, and terminates anteriorly in a blunt triangle, somewhat rounded, which presumably gave attachments to ligaments of the occipital basin. This process terminates about half-an-inch behind the anterior face of the first vertebra (figs. 15, 16).

The first vertebra appears to be anchylosed to the second; but it is not possible to show whether the neural arch of the second vertebra is articulated to it, as I suppose to be the case from indications upon the left side. This vertebra is remarkable for its form being exactly like the odontoid process of the vertebra in many animals, and suggesting the idea that the atlas is lost.* The wedge-bone between the first and second centrums is lost, and it is not improbable that another wedge-bone may have extended in front of it below the occipital condyles, as in *Pareiasaurus.* The anterior termination of the vertebræ is in a triangle of articular facets which when seen in front have the outline of a capital T. The two superior parts recede backward, making less than a right angle with each other; their surfaces are smooth, convex

Fig. 15.



Anterior aspect of the first vertebra of *Cynognathus crateronotus*, showing a T-shaped articular surface on the centrum, the transverse bar of which is regarded as fitting between the occipital condyles, while the vertical bar may have articulated with the under side of the condyles when the neck was erect. Behind it is a notch from which an (*ic. lost*) intercentrum appears to be lost. Below this at the back of the centrum (*ic.*) an intercentrum is preserved.

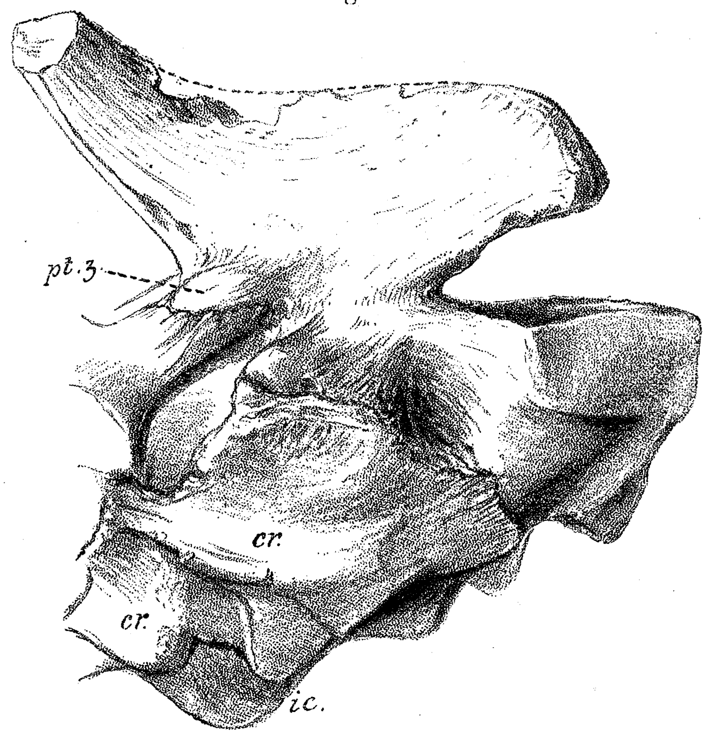
from above downward, limited by sharp parallel margins; and the vertical bar similarly recedes inferiorly. The width of each of these bars is $\frac{6}{10}$ inch, and they are defined by excavation of the intervening area of the side of the odontoid process. The superior neural surface is concave and appears to indicate some expansion of the neural matter. The depth of the odontoid process, to the facet from which the wedge-bone is lost, is less than an inch. The transverse width of the horizontal

* This appears to be confirmed by the subsequently to be described condition in *Tropidostoma Dunni*,

articular faces is $1\frac{7}{10}$ inch. The form of this part of the articulation may be compared with the occipital condyles in allied Theriodonts.

The early cervical ribs are of a remarkable form (fig. 16, *cr.*), intermediate between the rhomb and the cross, being an expanded plate with four angles in the form of a cross, about 2 inches long, and $1\frac{1}{2}$ inch deep. The anterior extremity articulates at the hinder margin of the odontoid process; the superior angle articulates on the transverse process of the second vertebra. The inferior angle appears to have contact with the intercentrum, and the posterior angle has a thickened ridge on its inferior border, which in later ribs becomes more developed. The ribs which

Fig. 16.



Right side of the first and second vertebra of *Cynogathus crateronotus*, showing the large size, and truncated anterior termination of the vertebra. The post-zygapophyses (*pt.z.*) are the only zygapophyses. The rhomboid cervical rib (*cr.*) has a long attachment to the transverse process; its anterior angle extends to the first intercentrum (now lost) and its inferior angle articulates with the second intercentrum (*ic.*) with which the second rib (*cr.*) also articulates.

succeed are similarly expanded plates, but less perfectly preserved; though the inferior articulation with the wedge-bone appears to be evident, and the superior tubercular edge is under the transverse process, as in the preceding vertebra. The ribs are absent or very badly preserved in the two succeeding vertebræ; but in the sixth the inferior angle is lost, the tubercle and head are about of equal size, with a notch between them; and the posterior process which afterwards becomes the substance of the rib, carries a marked ridge on its infero-anterior margin. The depth of its proximal end is $1\frac{1}{2}$ inch, and its length as preserved somewhat exceeds 2 inches, The rib attached on the right side to the seventh vertebra is rather narrower in the head than that on the sixth. Its posterior part is thin and curved imperfectly, and appears to be more slender than the eighth and ninth ribs, but not otherwise different, so far as can be judged from the imperfect preservation.

Dorsal Vertebræ.

If six vertebræ only are counted as cervical, then twenty-three may be counted as trunk vertebræ in advance of the sacrum. All of these bear ribs, and in that sense may be considered as dorsal; but in the later half of the series the ribs are so singularly modified and short that they form a distinct region of the skeleton, which may be regarded as functionally lumbar. In the true dorsal region no rib is complete, or represented by more than its articular end and a few inches of its length.

Six dorsal vertebræ are connected with the first portion of the vertebral column (fig. 13), which was separated from the second portion (fig. 17) by an oblique fracture, which is seen in the neural arch of the anterior part, and in the succeeding centrum of the posterior part of the vertebral column, accompanied by a very slight deformation of the two vertebræ affected by the dislocation. There is very little difference in the characters of the centrum in the dorsal region. On the base it is $1\frac{3}{20}$ inch long. The measurement of the first six is $7\frac{1}{4}$ inches; and of the second six, $7\frac{1}{2}$ inches. The length of the succeeding eleven is $14\frac{1}{2}$ inches; so that there is a slight apparent elongation, which results in part from the later lumbar vertebræ not being in such close contact with each other, on the visceral surface. These vertebræ are well rounded on the under side, so that they present a regularly constricted aspect. The constriction, however, is small, for the transverse measurement of the middle of the centrum is 1 inch, while the transverse measurement at the margin of the intervertebral articulation is $1\frac{3}{10}$ inch. The depth from the neural canal to the base of the articular margin is at first about $1\frac{1}{2}$ inch; but this depth becomes reduced as the vertebræ extend backward, so that at about the tenth it does not exceed $1\frac{1}{10}$ inch. At first the appearance of the centrum is slightly different, owing to the somewhat greater prominence of the margins of the articular faces.

The technical character by which I define the dorsal vertebræ from the cervicals is the direction outward of the transverse processes, which look upward on their superior surface; and these processes are in a somewhat more elevated position than those of the cervical vertebræ, which are inclined backward, so as to have a compressed aspect. The transverse process of the seventh is intermediate in elevation between the sixth and ninth, and is somewhat narrower than in the succeeding vertebræ. These transverse processes are short and strong, rarely preserved on both sides, deep on the anterior margin, and compressed behind; concave on the under side and supported by an anterior ridge which gives depth to the anterior border. Hence the transverse section of the process is triangular. Though the ridge supporting this process descends below the level of the neural canal, it is entirely upon the neural arch. The transverse, curved suture between the arch and centrum is distinctly seen in many vertebræ.

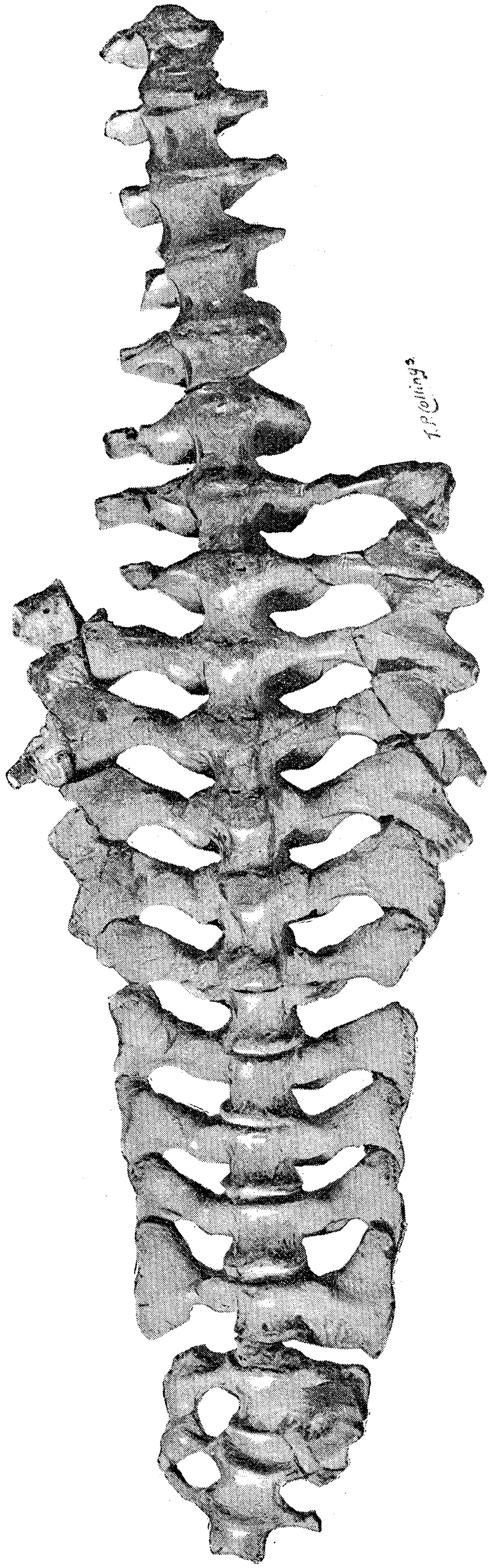
The neural arch appears to extend upon the anterior face of the centrum, but it does not extend upon the posterior face, terminating at the periphery of the articular surface of the centrum, as in some Ornithosaurs. The transverse processes of the first ten or eleven dorsal vertebræ have the superior surface divided by a rounded ridge into two areas; one anterior, which is rounded, and the other posterior, which is impressed or concave; and as the series extends backward the posterior area becomes narrower, till at the twelfth it is lost in the rounded or flattened vertical posterior margin, which replaces the oblique area of the earlier vertebræ.

There is no parapophysial facet for the articulation of the dorsal rib; so that the head of the rib, as in the cervical region, is articulated upon the suture between the two vertebræ. Many of the ribs remain *in situ*, so that their relation to the vertebræ is well seen; and other ribs have been removed or lost, so that the lateral faces of the inter-central sutures are exposed. They show a slight recession of the articular margins, as compared with the ventral margins of the centrums, and in the lower part of the series, the posterior border of the centrum below and behind the neural arch, is appreciably elevated, so as to make the centrum wider posteriorly than anteriorly, and thus show some faint approximation to a facet; which, however, would then be upon the preceding vertebra to that which bears the tubercular articulation with the neural arch. Portions of ribs are preserved upon the eighth, ninth, tenth, and eleventh dorsal elements of the vertebral column, on the right side; and upon the fourteenth, fifteenth, sixteenth of the left side; seventeenth and eighteenth on the right side; and on both sides in subsequent vertebræ. In the anterior portion of the column the ribs lie flat at the sides; and in the posterior part they extend transversely outward as in life. The fragment attached to the eighth vertebra has the head of the rib directed downward, and the tubercle inclined somewhat upward, so that the vertical measurement of its head is about $1\frac{4}{10}$ inch.

The rib is slightlyc u ved in length, so that, as it extended outward, it was directed a little backward. The facet to which it was attached, appears to have been transverse. The rib is compressed from front to back, so that it is $\frac{5}{10}$ inch deep, and about half as thick, with a distinct median ridge, $1\frac{1}{4}$ inch long, on its anterior face, opposite the division between the two articular facets of the head, and more than a quarter of an inch behind them. Subsequently, as the ribs are directed more horizontally outward, the tubercular articulation becomes narrower; the ridge appears to have a more inferior position, though it is very imperfectly preserved, and the capitular articulation becomes much the stouter, and is rounded on its under side. The anterior face of the rib is flattened, and its posterior face is concavely excavated, under the transverse process.

In these dorsal vertebræ, the zygapophysial articulation appears to be somewhat

Fig. 17.



The ventral aspect of the lower dorsal vertebræ and sacrum of *Cynognathus crateronotus*, showing successive modifications of the ribs in mode of articulation with the vertebræ and in form; and the unanchylosed condition of the (three) sacral vertebræ, which have been removed from the pelvis. One-third natural size (from a photograph).

peculiar. There is a small indication in the first vertebra of a slight posterior process, margining the base of the posterior zygapophysis, so that the facets of these vertebræ are nearly vertical, much more vertical than in the neck. There is an inferior wedge of bone above the neural canal, produced backward, so as to extend between the pre-zygapophysis. This is distinctly seen throughout the first twelve dorsal vertebræ, so that it gives a lateral appearance as though the zygapophyses were a zygosphene received into a zygantrum; but the excavation is very shallow, and the zygapophyses are divided by the neural spine, which extends between them.

This structure appears to be developed to the end of the series; and is shown in transverse section as a cylindrical apophysis in the fracture between the last dorso-lumbar and the sacrum.

This condition is distinct from interlocking of the lumbar vertebræ seen in many Mammals. The zygapophyses are only moderately developed. They rise from the transverse processes, extend forward and a little upward, converging with slight but sharp median lateral ridges, and sharp margins. The antero-posterior measurement over them appears to be $1\frac{9}{10}$ inch. The pre-zygapophyses extend in advance of the centrum; but the post-zygapophyses do not appear to extend behind it.

The neural spines are at first directed vertically upward, or only slightly backward. All are broken, but they do not appear to have been elongated, to judge from that of the last vertebra but one, in which the spine is complete, and only rises $\frac{9}{10}$ inch above the posterior zygapophyses. All the spines, as preserved, are of similar length. They are compressed from side to side, and in the first twelve are sharp back and front, and where best preserved and widest, are $\frac{9}{10}$ inch from front to back. After the twelfth they become flattened on the narrow posterior area, and widen from side to side, so as to present a long triangular outline, to the summit of the spine.

The next seven vertebræ I propose to term lower dorsal. They count from the nineteenth to the twenty-fifth. The division may be an artificial one, consequent upon the imperfect preservation of the earlier dorsal ribs; but, as preserved, these vertebræ, while showing very little difference in their general character as compared with the earlier vertebræ, have ribs which are very singularly modified. There are slight differences in the vertebræ, especially in the increased width of the posterior zygapophyses, which rapidly augments from $\frac{4}{10}$ inch in the twelfth to $\frac{6}{10}$ at the thirteenth, and an inch at the nineteenth; this increase of width being accompanied by a change in direction of the facets, which are no longer vertical, but inclined obliquely. There is also an increase in width of the anterior face of the centrum, and to a less degree in the posterior face of the centrum also, which is correlated with the greatly augmented width of the attachment of the head of the rib, which is so wide, that it must inevitably form an anterior capitular facet on the anterior face of the centrum. It is not possible to determine whether this facet is separated from the tubercle on the transverse process, by a notch for the vertebral artery, such as I believe to exist in the earlier part of the dorsal region. The evidence, such as it is, shows that the foramen, if present, is small. Another character, which these vertebræ share with the last six, from which they are divided by no good distinctive character, is the sutural anchylosis of the rib with the vertebra.

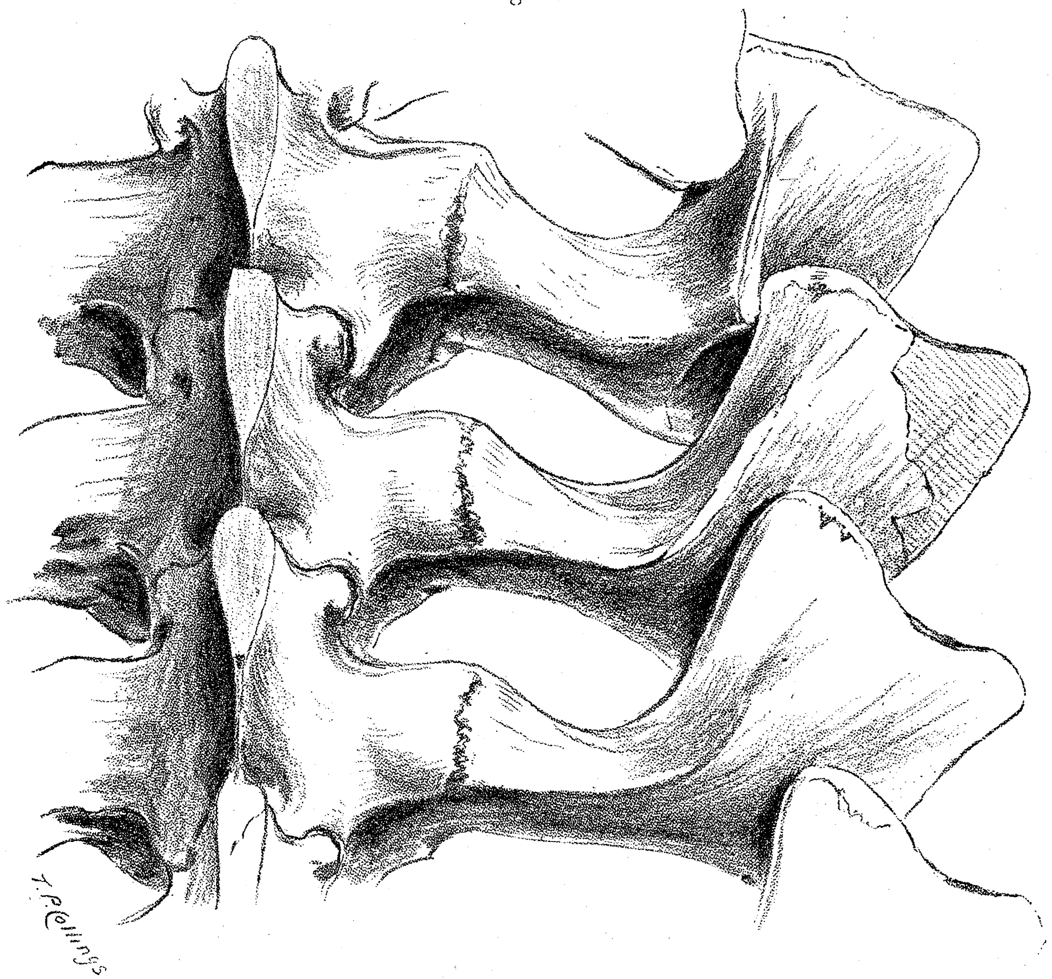
I am unable to determine whether this character is present in the thirteenth and fourteenth dorsals, but it is unmistakable in the seventeenth and subsequent vertebræ.

Finally the ribs are attached somewhat lower down the sides of the centrum; or rather the development of the articular tubercules upon the centrum gives them that appearance.

Beginning to count the lower dorsals at the fourteenth, the remarkable feature of that, and the four succeeding vertebræ, is that the ribs extend horizontally, outward, and very slightly forward, for about an inch beyond the transverse process, and then expand into an oblique oblong form, which, in the three middle vertebræ, is about $2\frac{1}{4}$ inches long by $1\frac{1}{2}$ inch wide. These expanded, oblong plates, give the ribs the aspect of being directed backward, and a little downward. The posterior part of this expanded rib overlaps and rests upon the anterior part of the succeeding rib, which terminates in front in a thin edge. All the four margins of the expansion are concave. The inferior surface is smooth, and concave from within outward, convex from front to back, and its outermost extremity contracts into a slender rib, which is semicircular in section, at the outer fracture, where it is about $\frac{7}{20}$ inch wide and has a singular resemblance to the rib attached to the costal plate of a Chelonian. It is preserved in the fourteenth, fifteenth, and sixteenth dorsal vertebræ of both sides. There is some appearance of the expansion being due to a plate superimposed upon the rib; but the evidence is not quite conclusive. The rib of the preceding thirteenth dorsal vertebra is also expanded, but not to the same extent. I regard the number of ribs which exhibit this modification as a generic character, and count them as six. The expansion resembles that of cervical ribs.

On the inferior surface the posterior side of the expanded plate is compressed, especially in the earlier vertebræ, in relation to being underlapped by the anterior angle of the rib which follows. Seen from above, these ribs have the anterior margin sharp, and the posterior margin rounded; and on the superior surface develop a ridge which extends from the anterior border of the transverse process outwards; as it turns backward it extends on the posterior side of the rib, and becomes greatly elevated as a ledge, forming a groove, into which the posterior angle of the preceding rib fits. All of these ribs, with the exception of the thirteenth or most anterior, which has the proximal part compressed from front to back, have the ribs in the main horizontal, so that they become successively wider, and the least antero-posterior measurement of the nineteenth, which is widest, is nearly $\frac{8}{10}$ inch, but there are slight differences in the width of the bones on the two sides. The least width of the fourteenth is $\frac{11}{20}$ inch. The interlocking and overlapping of the ribs encloses a series of inter-pleural foramina, which have a slight sigmoid curve, inclining forward in front, and backward behind. They are larger on the ventral than on the dorsal surface, because the rib develops dorsally, at its articulation with the transverse process, a tubercular apophysis, which lies mostly behind the stout base of the more or less vertical and capitular articulation; which is $\frac{1}{20}$ inch from front to back in the fourteenth rib, and about $\frac{9}{10}$ inch wide in the eighteenth vertebra. The longest of

Fig. 18.



Dorsal aspect of the neural arch and rib in three lower dorsal vertebræ of *Cynognathus crateronotus*, showing the broken summits of the compressed neural spines; the anchylosis of the ribs to short transverse processes, and the external expansion of the ribs from front to back, so as to overlap each other, the lateral movement of each being restricted by the development of a ridge upon the superior posterior border of the succeeding rib. Natural size.

these expanded ribs measured on the under-surface is $3\frac{1}{2}$ inches in length, and the preservation in atnoher type suggests that very little of the length has been lost.

The last five vertebræ have lost the expansion and all trace of rib prolongation. If there were no evidence to the contrary, they might, from their firm union with each other by means of their short massive ribs, be regarded as sacro-lumbar. They certainly had no connection with the sacrum, and I propose to regard them as lumbar vertebræ.

There is some reason, though inconclusive, for supposing that very thin plates may have underlapped the intercentral sutures of the six lower dorsal vertebræ with the expanded ribs, and it is possible that such ossifications may have been present in the lumbar region, as the basal surface of the centrum is roughened at the articular margins.

The lumbar, or lumbar-dorsal ribs, present a singular example of the modification which a structure may undergo by consecutive degrees of change, for the expanded blade of the rib has now disappeared, and become represented by an inferior longitudinal ridge. The superior longitudinal ridge, already described, persists parallel to it; the two defining a deep external concavity, about $\frac{3}{4}$ inch from above downward. The rib-margins diverge in front, and converge behind forming a wedge, which is received into the succeeding rib, thus locking the vertebral column together in an exceptionally strong way. The transverse processes, in this region, have become shorter. The zygapophyses are directed horizontally forward, and widened laterally, so that the anterior excavation below them is quite as marked as in the lower dorsal vertebræ, with expanded ribs. The ribs themselves have the same general character, as in the preceding series, except that they are shorter by loss of the anterior expansion, and prolongation of the rib, and are stronger, so that the lateral vacuities between them become smaller. The transverse width over the first of the five, on the ventral surface, is about six inches. Over the second it is $5\frac{1}{2}$ inches, and over the fourth $4\frac{1}{2}$ inches. The antero-posterior measurement of these five vertebræ is $6\frac{1}{4}$ inches. The antero-posterior extent of each rib is, at its outer extremity, 2 inches, and, in the last, about $2\frac{1}{4}$ inches. This rib has its posterior angle reflected downward, and receives the anterior process of the succeeding vertebra into a notch on its posterior border. In the last three vertebræ the ribs are entirely supported upon the centrum of the vertebra to which they belong, and, in the preceding vertebræ, the attachment of the rib to the posterior face of an anterior vertebra is small. The height in these vertebræ, from the base of the centrum to the neural arch, is 3 inches.

Sacrum.

The transverse processes undergo a singular contraction in dimensions in the sacral region. The last sacro-lumbar vertebra is only distinguished from the true sacral by the transverse process being slightly larger, though very much smaller than in the preceding part of the series.

It bears its own rib, which is greatly constricted in the middle; and its outward extremity is expanded so as to form an ovate concavity. The transverse measurement superiorly over these processes is $2\frac{8}{10}$ inches, and inferiorly it is $3\frac{1}{2}$ inches.

The vertebra is displaced a little from the next in the series, although its margins were overlapped by the sacral rib of the following vertebra. The displacement shows that the characters of the zygapophysial facets, referred to in the earlier part of the vertebral column, by which the pre-zygapophysis is underlapped by a tongue from the preceding vertebra, still persists. The succeeding vertebræ have the aspect of being anchylosed together. The depth of their bodies has become rapidly reduced; so that, at the posterior fracture of the second, the centrum is only $\frac{11}{20}$ inch deep. The third sacral vertebra is displaced on the left side of the ischium. Its transverse process is somewhat larger, and its posterior articular margin appears to be somewhat deeper. The intercentral margin is rounded. So far as can be inferred from the state of preservation, these four vertebræ may all have contributed to support the ilium. It is remarkable that there is no approximation to the enlargement of the sacral ribs seen in *Pareiasaurus* and *Deuterosaurus*, but, on the contrary, a tendency for the sacral ribs to diminish in size. The middle two being anchylosed, are perhaps the only true sacral vertebræ; they have absolutely the smallest ribs in the vertebral column. The displacement of the last sacral, and the tail, is not dissimilar to the displacement which occurred in the same region of the skeleton of *Pareiasaurus*, and may be attributed to *post-mortem* decomposition.

Caudal Vertebræ.

The tail is unfortunately imperfect, only four vertebræ being preserved. They are in sequence with each other, and in sequence to the last sacral vertebra. The tail, however, appears to have been small, for these vertebræ have the centrum $\frac{9}{10}$ inch long, with the articular margins rounded and inflated, and the base covered with a multitude of vascular perforations. The caudal ribs appear to be anchylosed and sickle-shaped, directed downward and backward. The pre-zygapophyses extend far forward, and the distinct post-zygapophyses have a corresponding extension backward. Between these processes the neural spine rises vertically in the third caudal vertebra. Beneath the suture between the third and fourth caudal, is an ossification which may be inter-central, though, from its size, over an inch wide and $\frac{9}{10}$ inch long, it has rather the aspect of a dermal plate, but no indication of dermal armour is met with, and the ossification is too much in the matrix for its true nature to be determined. The height from the base of the centrum to the summit of the neural spine, as preserved, exceeds 2 inches; and the length of the caudal rib is about $1\frac{1}{4}$ inch.

The vertebral column of *Cynognathus* finds its nearest parallel in the Texas fossil figured by Professor COPE ('Proc. Am. Phil. Soc.,' vol. 19, 1881) as *Dimetrodon incisivus*, though no South African genus approximates to the remarkable development of the neural spines seen in *Clepsydrops*, *Dimetrodon*, *Naosaurus*, *Edaphosaurus*, and possibly in other American types.

There is the same difficulty in defining the limits of the cervical region. The diapophyses in *Dimetrodon* in the neck appear to be inclined backward, while in the dorsal region they are directed transversely outward. In 1880, Professor COPE says of *Dimetrodon*: "All the ribs are two-headed, commencing with the axis. All the cervical and dorsal vertebræ have diapophyses with tubercular facets. The head of the rib is prolonged downward and forward to the prominent border of the anterior articular face against which it abuts, but so far as yet observed without a corresponding facet. On the caudal vertebræ the two facets of the ribs are approximated, and finally they are not distinguished. They are here co-ossified with the centra." In *Clepsydrops* the length of the diapophyses varies. In *C. pedunculatus* the diapophyses are elongated; in other species they are short. Professor COPE figures twenty-five pre-sacral vertebræ in *Dimetrodon incisivus*. The sacrum appears to comprise only two vertebræ. In *Clepsydrops macrospondylus* (1884) intercentra are said to be present throughout the dorsal and caudal series of vertebræ. In the same memoir Professor COPE affirms: "The ribs of the Theromorpha are two-headed While the tubercular articulation has the usual position at the extremity of the diapophysis, the capitular is not distinctly, or is but partially, indicated on the posterior edge of the centrum in *Clepsydrops* and *Dimetrodon*. In *Embolophorus*, as I showed in 1869, the capitular articulation is distinctly on the intercentrum. A second and larger species of that genus, recently come to hand, displays this character in a striking degree, since the intercentrum possesses on each side a short process with a concave articular facet for the head of the ribs. From the slight corresponding contact with the intercentrum, seen in *Dimetrodon* and other genera there can be little doubt that this is the true homology of the ribs in the order Theromorpha." Professor COPE adds: "The ribs in this order are intercentral and not central elements, and that they do not therefore belong to the true vertebræ, thus agreeing with the chevron bones, with which they are homologous. It is also true that this type of rib-articulation approximates closely to that of the Mammalia, where the capitular articulation is in a fossa excavated from two adjacent vertebræ. This is what would result if the intercentrum were removed from a Theromorph reptile, and the head of the rib allowed to rest in the fissure between the centra left by the removal." I know nothing of the data on which these observations rest, other than figures of the vertebræ of *Dimetrodon* and *Clepsysaurus* ('Proc. Am. Phil. Soc.,' vol. 19, plate 6, and 'Trans. Am. Phil. Soc.,' vol. 16, plate 1, fig. 9). But not only is the condition of the vertebral column described in this passage similar to that of *Cynognathus*, so far as the cervical and early dorsal ribs are concerned; but Professor COPE's theoretical explanation is almost exactly such as I was led to by the study of this specimen.* In *Cynognathus* intercentra are unknown in the proper dorsal region, and the vertebral column may so far be regarded as more Mammalian; but the comparison seems to me to show beyond question that the Cynodontia as represented by *Cynognathus*, and the Theromora as represented by *Dimetrodon* and *Clepsydrops*, must both be referred to the same group of animals, for they are distinct in vertebral

* I regard chevron bones as being sometimes the intercentrum; sometimes as ribs of the intercentral parts of the caudal vertebræ; but never as being homologous with cervical dorsal, sacral, or caudal ribs of Anomodontia. If the early ribs of *Cynognathus* have superior articulation with the intercentrum and the intercentral suture, the lower dorsal vertebræ have the rib entirely on the side of the centrum.

characters from other reptiles. The mode of articulation of the ribs is distinct from that seen in any other reptile type, recent or fossil, and only capable of being compared with Mammalia. Not that it is identical with the mammalian condition, but the approximation is so great as to suggest the position of these fossils as a new and closer link with Mammalia, which indicates a possible transition.

The Pelvis (figs. 19–22).

The pelvis consists of three bones: the pubis and ischium placed ventrally, and the ilium in the usual lateral sacral position. The bones are in natural association with the sacral region, except that the ilia, which are free from the sacrum, have been displaced from their inwardly inclined position, so as to lie horizontally outward. The left ilium has lost its thin expanded plate, but on the right side the bone is well preserved, although a little broken at the superior border in front.

The only type of ilium from the South African rocks hitherto described, which it at all resembles is that provisionally named *Phocosaurus* ('Phil. Trans.,' 1888, B., Plate 21). It also resembles the Russian ilium from the Permian rocks, which is associated with *Deuterosaurus,* though differing in having an expanded vertical plate, and in the character of its lateral borders. For, whereas *Deuterosaurus* has the anterior margin with a deep narrow concave excavation, and the posterior border with a shallow excavation, as is proved by the association of the bone with the sacrum, this fossil agrees with *Phocosaurus* in having the converse conditions of a relatively shallow anterior concavity, and a narrow notch on its posterior contour.

Another point of agreement between these types, which distinguishes them from most other examples of the ilium in South African fossils, is an anterior supra-acetabular wedge, for articulation with the head of the femur. That wedge is also seen in the Deuterosauria figured by EICHWALD and VON MEYER. A distinctive feature of the ilium, in *Cynognathus,* is the circumstance that its antero-posterior extent is due to development of the posterior part of the superior blade, thus making some approach to the proportions of the ilium found in *Megalosaurus,* though the antero-posterior constriction above the acetabulum in the middle of the bone is much greater, and the depth of the blade is relatively greater, giving a closer resemblance to *Orycteropus.* The right bone is partly obscured on its external surface by matrix, and by the head of the femur which is attached to it; but on the left side the acetabular region is distinctly seen. The external surface of the bone is smooth, and the visceral surface is marked by some small ridges which radiate upward in front.

The acetabular region of the ilium is greatly thickened, so that the transverse measurement from within outward is $1\frac{8}{10}$ inch, in the middle of the acetabulum. This thickening is due, first to the convexity of the visceral surface, which corresponds with the concavity of the sacral ribs; and secondly to the mode of formation of the acetabulum, by which the bone thickens externally in front, so as to make a wedge-like buttress $1\frac{3}{20}$ inch wide, projecting $\frac{9}{10}$ inch outward from the acetabular surface.

External to this buttress, both the pubic and ischiac sides of the bone are compressed, so that its thickness is reduced to about half-an-inch on each side (fig. 19). On the pubic border the bone is flattened and slightly compressed, so as to terminate anteriorly in a ridge, in a way comparable to the condition shown in *Phocosaurus*. The posterior ischiac process is shorter, smaller, and more distinctly rounded, for the supra-acetabular wedge is slightly nearer to the ischiac border, so that the acetabulum somewhat concavely excavates its inner side. The antero-posterior extent of the ischio-pubic suture of the ilium is $2\frac{9}{10}$ inches. It is transverse to the vertical axis of the bone; it is convex from front to back on the internal aspect. There is no distinct division into pubic and ischiac portions, though these triangular areas appear to have nearly equally divided the border. There are distinct traces of a cartilaginous character in the articular margin. The bone is constricted from front to back as it ascends till the

Fig. 19.

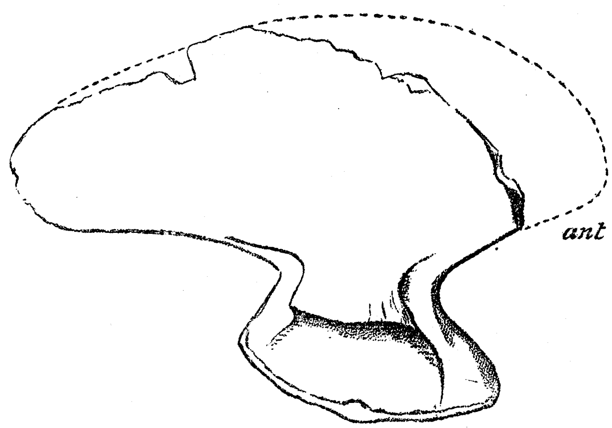


Diagram of the ilium, showing (*ant*) the broken anterior border; there is a prominent wedge above the acetabulum. Half natural size.

measurement is $1\frac{13}{20}$ inch, thus forming the anterior and posterior notches. It is at the same time compressed from within outward; but the compression is rather more marked in front than behind, the thickness at the anterior constriction being $\frac{9}{20}$ inch, and at the posterior constriction it is $\frac{13}{20}$ inch, for the ascending contour advances in front of the descending iliac process. The blade of the bone, as preserved, increases its depth on the internal surface, from above the middle of the acetabular border to the point where the summit margin of the ossification is preserved, where it measures 4 inches, so that the blade may be regarded as rising $2\frac{1}{2}$ inches posteriorly above the antero-posterior constriction, and somewhat less anteriorly as preserved, though being stronger, that part of the bone was probably higher.

The antero-posterior extent of the blade, as preserved, is $5\frac{1}{4}$ inches, and, although something is lost from the superior anterior margin, there is no reason for supposing that the bone was much over 6 inches long. This would depend upon the form of the missing extension of the anterior wing, which I suppose to have been rounded like the posterior termination of the iliac blade. The posterior part of the blade has its inferior border horizontal, and very slightly concave, its posterior extremity rounded, and its superior border convex. The anterior part of the blade is thicker than its posterior part, owing to the development of a vertical ridge, which gives a slight angularity to the inner surface, and reflects the anterior extremity of the bone outward in advance of its pubic descending process, and thus makes the external surface of the bone slightly concave in length, just as the thickening of the acetabular base of the bone makes both back and front somewhat concave in depth. The blades of the two bones manifestly converge towards each other superiorly, and above the neural spines they may have been almost in contact.

The Pubis (figs. 20–22).

The ventral median suture between the pubic bones is obliterated. They meet in a short ventral ridge, which has a slightly cartilaginous aspect, and is continuous with the anterior transverse cartilaginous margin of the pubic bones, so as to form with it the outline of a capital T, as in *Pareiasaurus*, only the anterior transverse border has not the aspect of being reflected so far downward. On the whole, the pubis, in its anterior aspect, otherwise resembles *Pareiasaurus*, except that the pubis of *Pareiasaurus* is developed downward instead of forward. There is no conclusive evidence of a distinct inter-pubic ossification, though this may be present; but, if it exists, the ossificatiom is small, and lies along the anterior margin of the pubic bone.

The pubis, supposing the right and left bones to be distinct from each other, consists of two portions: first, the acetabular part, and, secondly, the ventral symphysial part. The acetabular portion is greatly thickened, and forms a close sutural union with the ischium, each bone contributing to the acetabulum.

The suture between them is distinct on the left side, where there is a distinct notch of unarticular surface, corresponding to the notch which, in Mammals, divides the articular surfaces of the pubis and ischium, though, in this Theriodont, those surfaces do not approximate so closely as among Mammals. At the acetabulum, the pubis is $1\frac{3}{20}$ inch deep, and it measures $2\frac{3}{10}$ inches from front to back, of which the acetabular part is about an inch, so that there is a considerable extension of the bone on each side of its acetabular facet. The anterior part is a sub-triangular area which articulates with the ilium, and the posterior projection is a thinner process, which articulates with the ischium, so as apparently to form a small perforated acetabular interspace, or unossified area, of triangular form, between the pubis, ilium, and ischium, seen upon the left side of the pelvis. Below the acetabular surface the bone is compressed on its under side, and constricted from side to side, so that the antero-posterior measurement is one inch. It then expands anteriorly and posteriorly, though more behind than in front, and its anterior margin becomes greatly thickened, and reflected downward so as to be in a horizontal line. The bone thus has a twisted aspect, which makes its inferior surface concave, its anterior surface truncated, its antero-lateral surface thick, and concave in every contour.

The most interesting point of structure is the posterior constriction of the os pubis, which is due to the excavation of a large triangular obturator foramen, which indents both pubis and ischium, and is $1\frac{8}{10}$ inch long, with the anterior and posterior borders rounded, forming an elongated excavation, dissimilar to anything previously known in these animals, and much more mammalian than any reptilian pelvis. Its

Fig. 20.

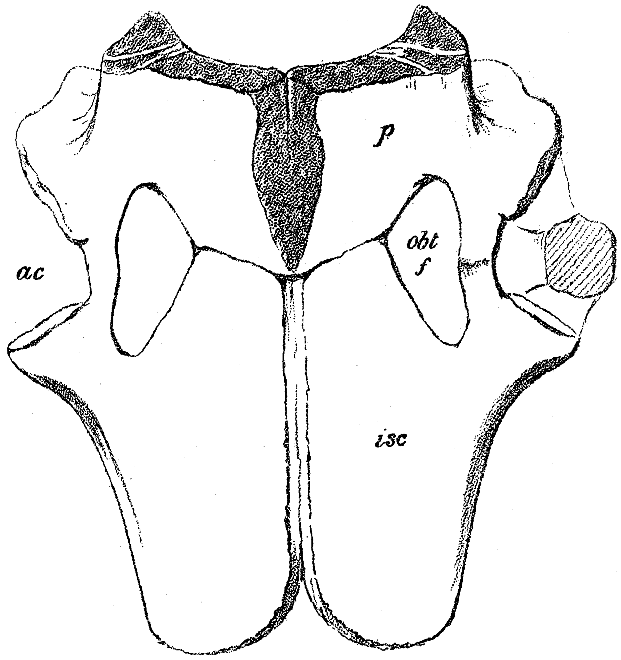


Diagram of the ventral aspect of the pelvis of *Cynognathus crateronotus*. The ischiac bones (*isc*) are highly inclined to each other, the pubic bones (*p*) are much flatter, there is no clear median suture between them, their anterior margin (shaded) is cartilaginous, the cartilage appears to have extended on the line of median suture: (*obt.f*) is the obturator foramen, (*ac*) is the acetabulum formed by three distinct surfaces contributed by the ilium, pubis, and ischium. About half natural size.

inner border is not perfectly preserved, but enough is seen to show that the foramen was narrow in proportion to its length, the width apparently being about an inch. The length of the pubis in the median line is $2\frac{1}{10}$ inches, the transverse measurement of the pubic bone, from the hinder margin of the acetabular surface to the median line, is $2\frac{4}{10}$ inches. The transverse measurement from the anterior tuberosity to the median line is $1\frac{8}{10}$ inch.

The pubes are not quite symmetrical in front, where the descending bones slightly converge inward, before they bend horizontally, forming at the bend an angle which is directed conspicuously downward on the right side, but does not appear to be so much developed on the left side. The thickness of the anterior margin is greatest at this external angle, it is slightly concave towards the middle line, where it becomes thinner. No trace is preserved of ossification in advance of the pubes, though the median anterior pubic surface is cartilaginous; as in Pliosaurs and Plesiosaurs.

Ischium.

The ischium is elongated, relatively large, and somewhat resembles the bone in a Plesiosaur; being much longer than wide. The two bones are inclined to each other at about a right angle, as preserved, and are in close ventral union, though the suture can be traced. The length of the bone is about 4 inches. Its extreme depth, measured obliquely from the suture with the ilium to the median line, is $3\frac{1}{2}$ inches, and its width transversely about $2\frac{6}{10}$ inches. The bones have flattened surfaces, except for a shallow concavity, below the acetabulum and behind the obturator foramen. The posterior contour is convex, from the median suture outward, and here the least width of the bone is about $1\frac{8}{10}$ inch. The thin plate is thickened towards the superior border, upon which there is a strong ridge on the outer side, which extends forward towards the acetabular pedicle, so as to define a lateral area of the bone which looks outward and a little upward, is concave in length and in depth, and increases in depth to the acetabular surface. This area terminates upward in a sharp ridge. Seen from above, the acetabular pedicle has the aspect of being reflected outward. It is massive, with the articular surface looking forward and outward. Its transverse measurement is $1\frac{1}{2}$ inch; its antero-posterior extent to the pubic suture is $1\frac{8}{10}$ inch. The depth of the neck of the acetabular process of the ischium is one inch. The obturator foramen extends for about $\frac{17}{20}$ of an inch behind its articular surface, which has a sharp margin, similar to that of the pubic bone. The width of the median notch between the pubic and ischiac articular surfaces of the acetabulum, is about $\frac{7}{10}$ inch, and the superior straight border of the obturator foramen is about $\frac{3}{10}$ inch below this notch.

The bone extends inferiorly forward below the foramen, and forms the rounded margin of the pubic bone by a straight suture, so that the median posterior angle of the pubes is received between the ischia.

The transverse width of the pelvis, as preserved, measured over the posterior borders of the acetabular margins, is about $5\frac{1}{4}$ inches; and the internal measurement at the hinder margin of the iliac suture is rather under 3 inches. The entire length of the ischium and pubis is about $6\frac{1}{2}$ inches.

As compared with the pelvis of Dicynodonts this specimen differs in the form of every bone, and especially in the antero-posterior extension of both pubis and ischium. It differs in the posterior expansion of the ilium, and in the large size of the obturator foramen, as well as in the mode of formation of the articular parts of the acetabulum. In these respects it offers a nearer approach to *Pareiasaurus;* but the length of the pelvis, as compared with its width, is greater in this fossil, and the ilium does not extend so far forward. The pelvis differs quite as much from the pelvis of the Dicynodontia as does the scapula arch, vertebral column, or skull; and *Pareiasaurus* is the only type in the South African rocks so far known which can be compared with it.

The posterior termination of the ischium wants the tuberosity seen in *Dicynodon leoniceps* and other Dicynodonts which so remarkably parallels the condition of the bone in many Mammals ('Phil. Trans.,' B, 1888, p. 103). In its antero-posterior expansion, general form, and union with the pubis, it rather suggests *Pliosaurus*, though there are edentate and other Mammals in which the posterior contour of the bone is equally convex. The pubis is distinct from that of any placental Mammal. Its anterior contour makes an appreciable approximation to that of a monotreme in the angular division of the anterior border of the bone into a completely ossified proximal part which descends with a concave border to the inferior horizontal part. This is exactly paralleled in *Ornithorhynchus*. I am indebted to Professor G. B. HOWES (August, 1893), for the loan of bones which gave me the greater facility in subsequently closely comparing this fossil with that genus. The anterior border in *Ornithorhynchus*, which supports the prepubic bone, is not less like the horizontal cartilaginous anterior border of the pubis in this fossil, which however is relatively thicker. The pectineal prominence in *Cynognathus* is not isolated from the cartilaginous anterior border, but projects a little forward above its external angle. The preservation of the specimen is insufficient to prove the nature of the bodies which were attached to these anterior margins of the pubes, but they are in the position of pre-pubic elements of the skeleton of monotremes.

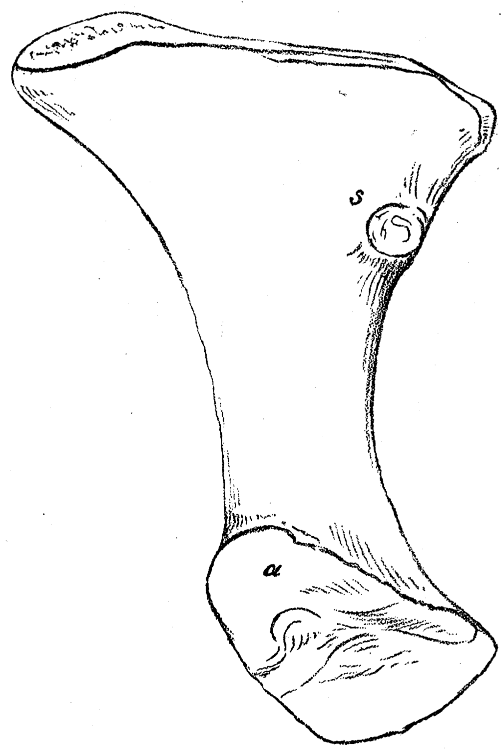
The ilium is not so obviously mammalian, because it does not conform to the Monotreme shape and position, which are essentially the characteristic condition of placental Mammals also; but rather shows an approximation to the form of the bone in the Edentate *Orycteropus*, in which the bone is constricted from front to back above the acetabulum, with vertically concave contours, and the blade of the ilium produced backward, with a form not unlike its anterior extension. There is some appearance of a small acetabular vacuity on the posterior border of the pubis; but there is no indication of a notch in the posterior sutural border of the ilium, such as is seen in some Russian Deuterosauria.

Probably too much importance has been attached to the form, position, and direction of the ilium. But no group of Sauromorpha is more instructive as to the development of its sacral expansion than the Sauropterygia. In most known examples of the ilium in that Order the bone is massive at its acetabular end, and usually gives attachment to the pubis and ischium, though apparently in some types from the Oxford Clay, discovered by Mr. A. N. LEEDS, F.G.S., the attachment is with the ischium only. The bone usually contracts above the acetabular end, so that the sacral end is compressed to a thin blade without anterior or posterior expansion other than suffices to give a very slight concavity to the nearly straight anterior and posterior margins. There is sometimes an obscure facet at some distance below the superior margin which gave attachment to a sacral rib, and since the transverse width over the sacral ribs is usually much less than the transverse width over the pubic or ischiac bones, it is obvious that the iliac bones were more or less inclined towards each other as in Anomodonts. So that the obvious difference between these ordinal types has been in the absence of antero-posterior expansion of the sacral margins of the iliac bone.

Fig. 21.

Anterior aspect of the ilium of *Pliosaurus*, No. 2, from the Oxford Clay. Half natural size.

Fig. 22.



Internal aspect of ilium showing the transverse expansion of the iliac crest; (*s*) articulation for sacral rib; (*a*) acetabular surface below which is the surface for the ischium. Half natural size.

The British Museum acquired, with the Leeds collection, the skeleton of a Pliosaur (No. 2), in which this difference to some extent disappears. The superior margin of the ilium is long and straight, and the anterior and posterior borders of the bone are markedly concave; so that there is no obvious difference in the form of the expanded blade of the ilium in this Pliosaur and the form seen in *Dicynodon leoniceps* ('Phil. Trans.,' 1888, B, p. 103) with which this bone may be compared. The Sauropterygian pelvis, as a whole, is unlike that of this Dicynodont because there is a large foramen between each pubis and ischium in the Pliosaur, which has the ventral pelvic bones much larger and the ischium especially more elongated. In both these respects *Cynognathus* makes a nearer approach to the Pliosaur, sufficient to suggest a relationship, which finds support in other parts of the skeleton, between Anomodonts and Sauropterygia. And it seems to me that, if the affinities of Anomodonts with Mammals are conspicuous, those with Sauropterygia cannot be ignored.

Professor COPE has not figured the pelvis in any of the allied Theromora from Texas. In *Clepsydrops natalis*, the ilium is a flat bone which contracts downward and forward to the pubis ('Proc. Am. Phil. Soc.,' 1878, p. 510). In 1884 ('Proc. Am. Phil. Soc.,' vol. 22, p. 32), it is stated of *Clepsydrops leptocephalus* (COPE), "the ilium has a process, or narrowed continuation with parallel sides, directed backwards and upwards, and bearing a keel on the middle line on the internal side." And in *C. macrospondylus* (COPE, *loc. cit.*), it is remarked that the acetabular surface of the ilium "is remarkable for the prominence of the tuberosity on the superior border, which exceeds that of any species of Pelycosaurian known." Hence, it would appear that the ilium is unlike that of *Cynognathus* in form and direction, but that the acetabular region is of similar type. "The acetabulum is formed" in *Clepsydrops natalis* ('Proc. Am. Phil. Soc.,' 1878, p. 510) "by the uninterrupted junction of the three elements."

The pubis is said to be "something like the ilium in form, widening in the opposite direction, *i.e.*, downwards and forwards. Its form is something like that of the Crocodilia, and it is uncertain whether those of the opposite side unite below." It is not possible to recognize, in this description, any resemblance to *Cynognathus.*

The ischium in *Clepsydrops* is greatly produced anteriorly and posteriorly to the acetabulum. It forms, with the ischium of the opposite side, a keeled boat-shaped ventral surface, the superior middle part of which includes the inferior part of the acetabulum. In other species *C. leptocephalus* ('Proc. Am. Phil. Soc.,' 1884) the ischia are described as much produced posteriorly, where they are separated by a notch in the middle line.

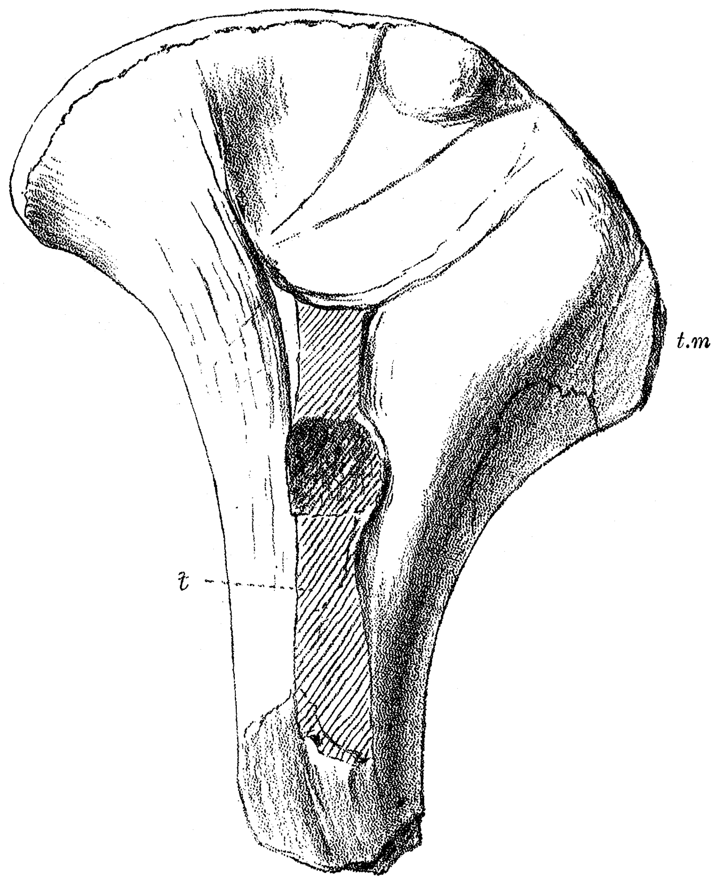
In *Dimetrodon* the pelvis appears to be similar. In *D. incisivus* the ventral pelvic bones are said to form a compressed boat-shaped body with a prominent inferior keel, but the ischiac symphysis only extends behind the acetabulum for one half of the acetabular diameter. The inferior border of the acetabulum is not sharply defined except at its posterior portion. The front of the pubic symphysis presents an obtuse keel (*loc. cit.*, 1878, p. 514). It would hence appear that there is considerable resemblance to *Cynognathus* in the pubis and ischium of these American types, although they do not appear to possess an obturator foramen.

Proximal End of the Femur (fig. 23).

The proximal end of the right femur is preserved *in situ*, on the external surface of the ilium above the acetabulum. The head of the bone is transversely expanded to a width of $3\frac{1}{2}$ inches, and vertically compressed, possibly owing to fossilization, but the shaft retains its original sub-cylindrical condition.

The bone shows no trace of such a lateral minor trochanter as is conspicuous on the inner margin of the femur in Monotremata. In general character the bone approximates to the femur referred to *Titanosuchus ferox* ('Phil. Trans.,' 1889, B, Plate 19), though its shaft is more slender. But it may not depart essentially from the plan of the femur of *Pareiasaurus* ('Phil. Trans.,' 1892, B., Plate 22), since a fractured ridge towards the middle of the shaft, below a slight proximal concavity, may be compared with the internal trochanter of *Propappus* (*loc. cit.*, p. 353), as well as with the internal trochanter in the Deuterosaurian femur, from which a transition

Fig. 23.



Inferior aspect of the proximal end of the right femur of *Cynognathus crateronotus*, showing the reflection upward of (*t.m*) the superior external trochanter major and (*t*) the long strong linear base of the inferior trochanter minor (shaded). Natural size.

may be made to the corresponding structure in *Cryptobranchus* and in *Sphenodon*. So that an essential difference of the femur of *Cynognathus* from that of a Mammal is in the trochanter minor being inferior instead of lateral. It is much larger than in the Saurischian femur, but the plan is the same. The transverse expansion of the head of the femur is greater than in any South African fossil at present known. And I have not seen any other form in which the anterior external margin of the great trochanter is reflected forward as in this fossil, but that character is approximated in Marsupial and other Mammals.

The bone as preserved is extended backward parallel to the ilium. The fragment is $4\frac{1}{2}$ inches long, with the shaft $\frac{17}{20}$ inch in diameter at the distal fracture, widening gradually to $3\frac{1}{2}$ inches at the proximal expansion. The inner anterior margin is the longer, and concave, so as to allow the thickened head of the bone to curve inward. The proximal contour is transversely convex, descending externally with the forwardly-reflected trochanter; and the thickness of the inner articular area, which is less than 2 inches wide, is about half-an-inch on the inner side. As the convex contour is produced outward the bone becomes a thin compressed edge, though there is some thickening externally as in Marsupials, where the outer lateral edge, below the head of the bone, is developed forward and upward to make the great trochanter, which is distal in position to the articular head upon the opposite side of the bone. This external process of the bone is convexly rounded on the posterior surface, with a corresponding concavity in front. Below it the lateral border of the shaft is gently concave.

The inferior surface at the proximal end includes three areas; an interior compressed sub-triangular oblique area limited by the ridge now broken which prolonged the trochanter minor down the shaft.* A middle semi-circular impressed area where the bone appears to have been thinnest, immediately above the minor trochanter, the base of which extends within $1\frac{3}{4}$ inch of the proximal extremity of the bone. The outer area is parted from the inner area by the nearly vertical trochanteric ridge on the under side of the shaft, which inclines a little backward as it descends. This area consists of a wide flattened inner horizontal part, and a narrower oblique external part behind and below the great trochanter. Distally, these surfaces blend in the convex surface of the shaft, though the trochanteric ridge is prominent as far as the shaft is preserved, inclined towards the outer side. I infer the distal end of the bone to have been but little expanded, and the length of the femur to have been about 7 inches. As a whole the bone may be compared with the *Saurodesmus Robertsoni*, from which it is distinguished by the minor trochanter being median instead of internal.

CYNOGNATHUS BERRYI (SEELEY).

I visited Queenstown, in the eastern part of Cape Colony, in September, 1889, and was then shown an imperfect pre-orbital portion of a skull which had been obtained by Dr. JAMES BERRY from Lady Frere. Mr. ALFRED BROWN, of Aliwal North, had previously submitted to me a single tooth of the same genus obtained from the quarry near the Aliwal North railway station; but the fossil, which I now describe, stimulated me to make excavations at Lady Frere, for it made known the dentition

* Evidence is given subsequently that a femur from Lady Frere, referred to *Tribolodon*, has this ridge greatly elevated and prolonged half-way down the shaft (fig. 33, p. 147).

and general form of the front of the head, which, so far as preserved, offered a singular resemblance in type to the dog, though the teeth are more numerous.

The anterior nares have been weathered away, and with them the superior incisor teeth; and of the inferior incisor teeth only one remains, indicated by its root, while the others are only known from impressions left by the roots, the teeth being lost. Posteriorly the fracture through the skull passes through the middle of the frontal bones and orbits, and just behind the transverse expansion of the transverse palatine bones on the palate. The greater and inferior part of the lower jaw has been lost by exposure, so that only a small depth remains, which exhibits transverse sections of the single roots of the teeth.

This fragment is instructive from the cleanness of the surfaces of bone preserved, and the clearness with which the sutures between the bones are shown. I estimate the skull when complete to have been 9 inches long; this specimen, as preserved, has an antero-posterior extent of $4\frac{3}{4}$ inches. The depth of the snout at the first pre-molar is $1\frac{13}{20}$ inch. The width below the pre-orbital foramen, which is over the third pre-molar, is $1\frac{6}{10}$ inch. The jaw widens as it extends backward, partly by the outward development of a post-alveolar ridge, so that the width at the last molar tooth is $2\frac{7}{10}$ inch. The depth from the middle of the frontal bone to the median depression on the palate between the transverse palatine expansions is $1\frac{8}{10}$ inch. The form of the head is dog-like in the side to side compression behind the canines; in the transverse widening of the alveolar border in the molar region; in the position of the pre-orbital foramen; in the approximation of the maxillary bones superiorly, and the convex rounding of the region of the nasal bones, which are relatively higher in front; in the increased elevation and flattening of the hinder parts of the nasal bones (though the elevation is relatively less than in the dog), and the concavity between the frontal bones, with a similar width between the orbits. The superior border of the orbit is close under the flattened frontal, but is formed at its anterior corner by the pre-frontal bone. There is no indication of bony walls between the orbits, but the width between the ridges on the under sides of the frontals is $\frac{7}{10}$ inch. The depth of the orbit at the posterior fracture of its contour, which is semi-circular in front, is $1\frac{2}{10}$ inch. Immediately in front of the concave excavation of the orbit is the ant-orbital pit, which is a semi-circular excavation, deep posteriorly, with a narrow sharp border half an inch in vertical extent, which separates it from the orbit. It impresses the lateral surface of the lachrymal bone. At the bottom of the pit appears to be a vertical circular canal. The lachrymal canal from within the orbit appears to communicate with the pit, indicating a bifid superior termination to the lachrymal duct. The inferior border of the orbit in front is made by the malar, which has a pre-orbital squamous overlap upon the maxillary, as among Carnivora, and appears to exclude that bone from the orbital border.

The Frontal Bones (fig. 24).

The frontal bones show a median suture slightly sagittal, the borders of which form a slightly elevated longitudinal ridge. At the posterior fracture the transverse measurement over the pair of bones is $\frac{9}{10}$ inch; the median suture as preserved is about an inch long. The frontal bones join the pre-frontals by straight sutures, which form slightly elevated ridges, converging somewhat as they extend forward, so that the anterior transverse measurement is less than half-an-inch. The anterior borders are also straight, and converge anteriorly to a point between the nasal bones, which they join by suture.

The Pre-frontal Bones (fig. 24).

The pre-frontal bones are separated from each other by the frontal bones behind and the nasal bones in front. Their surfaces from above are irregular rhombs, rounded from within outward to the horizontal infero-lateral border, which meets the lachrymal. Their anterior points, wedged between the lachrymal and nasal, are $1\frac{9}{20}$ inch apart. The posterior extremity appears to have met the post-frontal, though no trace of that bone is preserved. The length of the bone is $1\frac{1}{2}$ inch; its width is $\frac{6}{10}$ inch. Its posterior lateral surface, which is free, is the smooth bevelled anterior margin of the orbit. The greatest external transverse measurement, at the anterior angle of the orbit, where this border meets the lachrymal, is $1\frac{7}{10}$ inch.

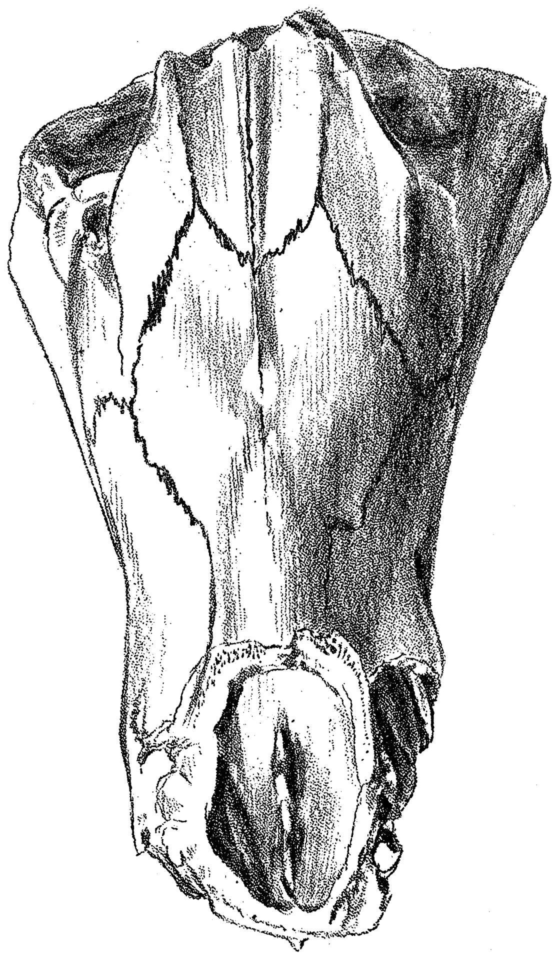
Nasal Bones (fig. 24).

The nasal bones are as long as in existing Carnivora, but widen behind more markedly. Their posterior sutural margin, seen from behind, is shaped like a W, while in existing Carnivora that is commonly the contour of the anterior border of the frontal. One effect of the transverse expansion of the nasal bones is to remove the maxillary bone from near proximity to the frontal, so that the nasal bone borders the lachrymal by its straight postero-lateral suture, which is directed outward forward and downward, and measures $1\frac{3}{10}$ inch from the frontal to the anterior angle of the lachrymal. The transverse measurement, at the latter point, is $1\frac{7}{10}$ inch.

The hinder part of the bones is traversed by a median suture elevated into a slight ridge which prolongs the median ridge of the frontal bones forward. On each side is a wide shallow concavity, then the rounded shoulder of the bone, and finally, on the front of its wide lateral part, where the bone is slightly concave, is a well-defined small concave circular pit of a glandular aspect. The nasal bones become narrow from side to side in advance of these pits, and the bones are convexly rounded from side to side. This part of the roof of the snout appears from the anterior fracture to be thickened, while the median suture is obliterated, and laterally the bone is covered by squamous overlap of the maxillary.

The obliteration of the median suture is accompanied by a thickening and wrinkled modification of the surface of the bone, over a length of $1\frac{1}{2}$ inch as preserved, and a breadth of $\frac{7}{10}$ inch, indicative possibly of the attachment of a covering upon the back

Fig. 24.



Superior aspect of the pre-orbital part of the skull of *Cynognathus* with the extremity of the snout lost; showing the sutures defining the nasal, frontal, maxillary, and pre-frontal bones. Natural size.

of the nose. The aspect may be compared with the corresponding region in such Mammals as Rhinoceros, but whether the superimposed structure was osseous or fibrous, thin or large, I have no evidence, other than the absence of any trace of a scute in the skull described, in which a similar modification of the nasal region is seen.

Lachrymal Bone (fig. 25).

The lachrymal bone is four-sided, oblong, and irregular in front. It appears to meet the frontal on the inner side behind, the pre-frontal above, the nasal in front, by the oblique suture described; and inferiorly are the maxillary bone in front, and the malar bone behind. Its length is about $1\frac{2}{10}$ inch, and its depth is $\frac{7}{10}$ inch. Its surface is concave, descending to the pre-orbital pit already described, which is margined by a vertical bar upon the orbital border.

Maxillary Bone (fig. 25).

The maxillary bone is a large vertical plate at the side of the face, convex from above downward, and concave from front to back. It is imperfect, not extending in advance of the pre-molar teeth, and, as preserved, measures more than 3 inches from front to back. Its vertical depth below the modified supra-nasal area, is $1\frac{6}{10}$ inch. The depth diminishes rapidly posteriorly where the bone is overlapped by the lachrymal and malar, coming at last to form only the alveolar edge. It is convex over the maxillary canine teeth, where the middle of its surface is pitted with a radiated sub-crocodilian ornament. The bone is a little inflated in advance of the lachrymal bone, below which there is a shallow longitudinal concavity. The alveolar border is thin in front, but it thickens over the maxillary teeth, and over the last tooth or two forms a ridge, which is bevelled towards the alveolar border, and helps to define the superior concavity, as it extends backward below the orbit. It is convex from front to back.

The mode of ossification of this bone seems to favour a scaling in thin laminæ, which gives the appearance of a film of bone superimposed on the maxillary in the lower half of its extent, especially on the left side.

Lower Jaw (fig. 25).

The fragment of the lower jaw preserved shows no trace of composite structure. The symphysial suture is obliterated. The transverse measurement behind the mandibular canines is less than one inch. The thickness of the jaw in the region of the pre-molar teeth is $\frac{7}{20}$ inch; in the middle of the molar region it augments to $\frac{4}{10}$ inch. At $3\frac{1}{10}$ inch behind the posterior divarication of the rami from the symphysis, is the transverse development to the palatine arch which meets the lower jaw. At this point, which is just behind the last teeth, the transverse measurement over the jaws is $2\frac{3}{20}$ inches. The superior external alveolar margin is sharply bevelled, for the maxillary teeth to rest against them. The lower jaw teeth are completely hidden behind the maxillary teeth, with the exception of the first left pre-molar, and their number would have been unknown but for the exposure of the fractured roots. Five mandibular molars are indicated by the large size of the roots; but in front of these the sections of the roots are smaller and appear to be four in number, with indications of successional teeth.

Dentition.

The number of incisors in the lower jaw is indicated as three on each side. The first two are directed upward and forward, and the third is also inclined a little outward. There are five impressions of teeth, and the root of the third tooth. These show that the first has a very slender root; and the pair of impressions have a diameter of about $\frac{3}{20}$ inch. The second incisor is relatively large on both sides; its diameter being from $\frac{3}{20}$ to $\frac{4}{20}$ inch. The third incisor is rather larger than the first; it has an ovate root which is deeper than wide. The transverse measurement over the spaces for the six teeth is not more than $\frac{9}{10}$ inch. The teeth formed a flattened arch just in advance of the canines.

The inferior canine teeth are large, directed upward and somewhat outward, with the crowns recurved. They widen the jaw, but the bone, external to their roots, is lost. Their roots are longitudinally ovate in section, about half-an-inch from front to back. The crown is enamelled and rises high into the upper jaw, so that it might be completely hidden behind the maxillary tooth. The external surface of the crown is convex, and the internal surface is flattened; and the two surfaces meet in sharp cutting edges back and front, which are strongly serrated, with well-cut transverse denticulations. The fragments preserved of root and crown are under $1\frac{3}{4}$ inch long. A pulp cavity is seen in the fractured root of each tooth. In front of the anterior surface of the base of the root of each tooth is an incrusting layer of bone, less than three-quarters of an inch long, as exposed, which I regard as the unabsorbed portions of roots of preceding teeth. This condition appears to be characteristic of these animals and is found on the hinder border of the roots of the maxillary canines.

The dental formula for the lower jaw may therefore be

$$\overline{|\,\text{i}\,3\,.\,\text{c}\,1\,.\,\text{pm}\,4\;\text{m}\,5.}$$

The sockets of the mandibular molars are well defined from each other.

Dentition of the Upper Jaw.

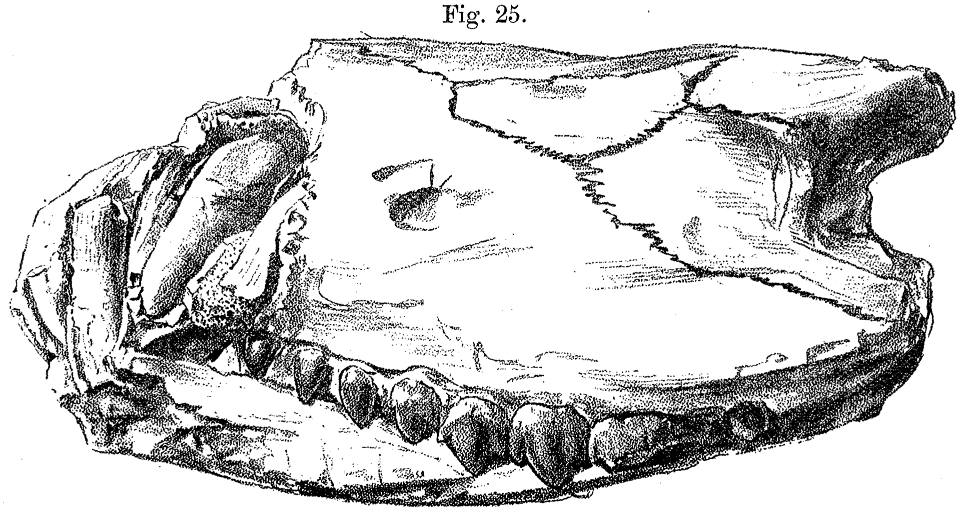
Of incisors there is practically no evidence, though the impression remains of what I take to be the last left incisor, which is between the canine and third incisor of the lower jaw, so that I should anticipate eight incisor teeth in the upper jaw, divided from the canines by the interspaces, which correspond to the breadth of the mandibular canines.

The canines are large and directed downward and forward, crossing behind the crowns of the mandibular canines. Both crowns are lost, but on the right side a transverse section of the base is seen showing the usual ovate section, a thick portion of an absorbed tooth immediately behind it. On the left side the root is exposed, and shows a large pulp cavity about $1\frac{3}{10}$ inch long. On its hinder border is a large portion of a tooth which has been replaced.

The molar teeth are nine in number, of which five or six may be regarded as corresponding to the molars of a Mammal, while three or four smaller teeth in front may be termed pre-molars. The anterior four are relatively small, and the five which succeed are larger, though the ninth tooth is small.

The first pre-molar tooth appears to be quite simple, without accessory cusps. Its base is less than $\frac{3}{20}$ inch wide, and the crown is $\frac{2}{10}$ inch high, strongly convex on the external surface, with the summit of the crown inclined a little backward, and the hinder border somewhat compressed, so as to leave a thickened projection at the base of the crown. As in all the teeth, the margins are serrated. There is an interspace of $\frac{3}{20}$ inch between the first and second teeth, and, as this is exactly the width

Fig. 25.



Left side of the skull of *Cynognathus Berryi*, showing the maxillary dentition and maxillary, lachrymal, pre-frontal, and nasal bones. Natural size.

necessary for a tooth, there may be some ground for supposing that a tooth is missing, for there is no interspace between the crowns of other teeth.

The second tooth preserved is similar in size to the first, though the crown is slightly higher and thicker; and the thickening, at the base of the hinder border of the crown, has now become a distinct posterior cusp.

The third tooth is much wider, and develops a strong posterior cusp.

With the fourth tooth an anterior cusp is developed, and the posterior cusp is large and not well defined. It is $\frac{3}{10}$ inch wide and almost as high. It resembles the preceding teeth in size, and is like the larger succeeding teeth in construction, so that there is some ground for grouping it with them as a molar.

The fifth, sixth, and seventh teeth are larger, exceeding $\frac{7}{20}$ inch from front to back, and in the sixth the crown is $\frac{8}{20}$ inch high. As in the earlier teeth there is an inflation towards the base of the enamel, which does not produce the effect of a cingulum. The main cusp is directed upward and backward, parallel to those of the pre-molars; the anterior cusp is directed upward and forward; the principal posterior cusp is a little lower in position and larger than the anterior cusp. The second posterior lateral cusp is small, sharp, directed backward and a little upward, and placed just above the line where the enamel terminates. The cutting edges of the teeth are exceedingly sharp, owing to compression of both the anterior and posterior margins. The serrations are inclined upward, as well as forward and backward.

The summit of the crown of the seventh tooth is lost, and the whole crown of the eighth. The ninth tooth is small ($\frac{2}{10}$ inch from front to back), and although the summit of the crown is lost the cusps are similar in number to those of the teeth in front. There is an overlap of all the molar teeth, the posterior cusp of one covering the anterior margin of the tooth next behind; so that it is possible that there is a second cusp on the anterior border below that which is seen. The antero-posterior extent of the cheek teeth is $2\frac{7}{10}$ inches.

The anterior fracture indicates a thin post-narial septum, in the vertically ovate cavity between the nasal bones and the palate, which rises vertically from the median line.

This specimen is similar in proportions to the large fossil (*Cynognathus cratero-notus*) which I obtained from Lady Frere, so that there is some reason to refer both to the same species. The chief ground for separating them is the dentition. First, the large fossil shows no indication that the middle mandibular incisor differs in size from the other incisors. Secondly, the cheek teeth may have numbered ten in the small fossil, while only nine are seen in the large specimen; the crowns overlap in the small specimen, but not in the large example; and in the latter the roots stand high above the alveolar border, while in the former the roots are barely shown. In the small fossil the compression of each tooth on its cutting margin is much better defined and in the larger fossil the posterior cusps have a less well-defined aspect. There appears to be a change in the number of cusps, and in size and character of the teeth as they are traced from front to back in the two specimens, such as among Mammals would be ample evidence of distinction between the skulls, but if the teeth of the smaller type were replaced by a successional series (of which the specimen gives no evidence), it might be that both number of teeth and the forms and numbers of cusps would vary. Still identity of species would imply that the last two molars of the smaller skull are lost in the larger skull; and while this is not impossible, it would be desirable to have proof either that the dentition is so variable in different individuals of the same species, or that skulls which closely resemble each other in form, differ as species in details of their dentition. As the question is of interest, I have drawn attention to it by suggesting a specific name which associates the fossil with its discoverer, by whom I was conducted to the locality from which it was obtained.

Occipital Plate of a Theriodont Skull referred to Cynognathus Berryi ?

Low down on the side of the hill at Lady Frere, I found a large concretionary block of stone, containing the occipital plate of a skull which appears to be referable to *Cynognathus.* I have no evidence that it is a part of the same small skull as the specimen originally found by Dr. Berry, but it agrees with it in size, and it appears to differ from the larger type of the genus *C. crateronotus* in a greater transverse breadth of the occipital region. Like all the other specimens it has been developed by Mr. Richard Hall, in the British Museum, and has the great advantage of preserving the occipital condyles, in a specimen which appears to be free, or almost free, from distortion, and on that account the fossil may be regarded as indispensable to a correct appreciation of the characters of the group ; since, although the occipital condyles are shown in *Cynognathus platyceps,* they are less well-preserved, less definite in character, and the back of the skull is distorted.

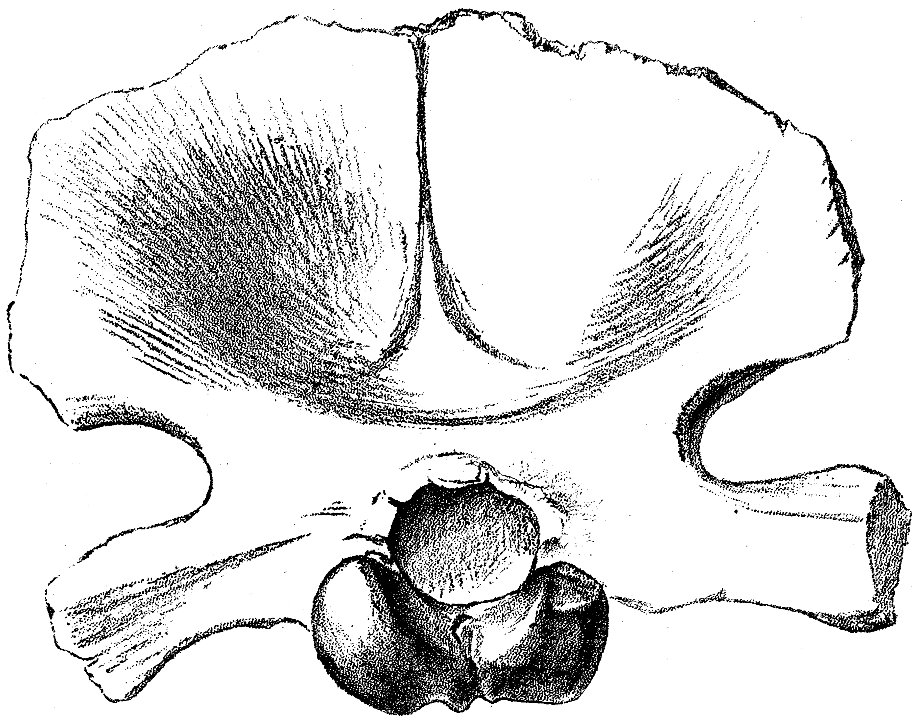
The occipital plate shows the two occipital condyles in rather closer approximation than is usual in Mammalia, but without any indication of the third inferior element, which is seen in all Dicynodonts, and there is no reason to suppose that these condyles are not formed by the ex-occipital bones. They appear to me to have developed posteriorly and inferiorly, so as to extend behind and below the basi-occipital, which I suppose to form the floor of the foramen magnum, but to be excluded from the condylar articulation. These condyles are transversely ovate, inclined to each other at an angle of about 45°, separated from each other by a narrow vertical groove where they meet inferiorly. The transverse width of the two condyles is rather less than $1\frac{1}{2}$ inch, and together they make a somewhat reniform articulation, only they are divided superiorly by a deep V-shaped notch. Each condyle, measured obliquely, is $\frac{9}{10}$ inch long and $\frac{1}{2}$ inch deep ; the superior and inferior surfaces being sub-parallel. The superior half of each condyle is convex, both from above downward and transversely, and the inferior half is flattened.

The vertical groove which divides the condyle into two parts widens superiorly into the basin-shaped excavation behind the foramen magnum, on which the medulla oblongata presumably rested.

There appears to be an anterior surface to the condyles, as though the vertical movement of the skull was greater than is usual among Reptilia ; and this may be supposed to be paralleled among Mammals, though probably in a less degree. The depth of the condyles in the median line, including the smooth crescentic space on their upper surface, is $\frac{1}{2}$ inch, and the depth laterally is about $\frac{8}{10}$ inch. The foramen magnum is $\frac{13}{20}$ inch deep and $\frac{14}{20}$ inch wide, circular in its curve, with the superior margin above the condyles compressed to a sharp edge, which is prominent laterally owing to a slight depression towards the opisthotic region. This margin serves as the base for the basin which excavates the supra-occipital region as it ascends to the inter-parietal, as in *Cynognathus crateronotus.* The depth of the occipital plate is

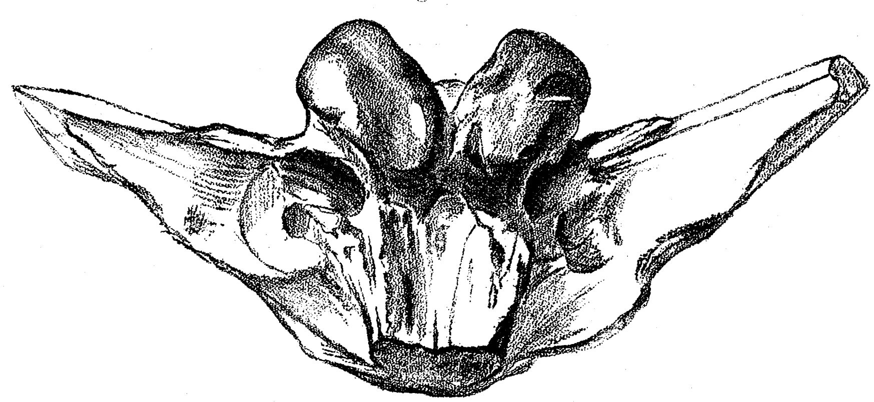
$3\frac{6}{10}$ inches; its transverse width as preserved is about $4\frac{1}{2}$ inches. A thin film of the parietal bone is lost on the lateral margins above, and the opisthotic bones are imperfectly preserved below. The opisthotic bones extend transversely outward, slightly backward, and a little downward. They have an inferior angle which separates the inferior surface of the skull from the posterior surface; and there is a

Fig. 26.



Posterior aspect of the occipital plate of *Cynognathus*, showing the two occipital condyles, the circular foramen magnum, the transverse lateral notch in the plate, and the concavity above the foramen magnum. Natural size.

Fig. 27.



Inferior aspect of the same specimen, showing the vertical convexity of each condyle, and the nature of the division between the two condyles; the basi-sphenoid is in front of the condyles; the auditory region is external to their lateral border.

superior angle which defines a superior surface forming a part of the lateral notch, ovately curved, which divides the opisthotic below from the parietal bone above. The vertical depth of the notch is $\frac{8}{10}$ inch; its transverse indentation into the plate is 1 inch, and the transverse width from the notch to the foramen magnum is $\frac{9}{10}$ inch. The vertical height from the summit of the foramen to the summit of the plate as preserved, is $2\frac{2}{10}$ inch. There is a slight vertical median ridge in the middle of the occipital plate, but it neither ascends to its summit nor descends to the foramen magnum. The bones are so firmly united together that the sutures between them are traced with difficulty.

The ex-occipitals, supposing them to include the condyles, appear to be defined by a transverse suture which runs outward to the middle of the opisthotic notch—the position of this suture being marked by a tubercle on the side of the foramen magnum, which is generally found in Theriodonts, and is present in some Dicynodonts. The opisthotic bone has much the same form as in *Plesiosaurus*, and it appears to be similarly blended with the exoccipital. Above this is the supra-occipital, which is defined by a sagittate suture, and the bone appears to extend forward substantially in the same way as in *Pareiasaurus*, so that it occupies the inclined surface above the foramen magnum for about $1\frac{1}{10}$ inch, and it here appears to be nearly $1\frac{1}{2}$ inch wide; but the transverse suture which divides it from the inter-parietal bone, which ascends vertically, is not easily traced. There is no doubt the parietal is in front of the inter-parietal if that bone has not united with the supra-occipital. But there is another bone in the occipital plate, placed laterally, which meets the opisthotic below the supra-occipital internally and the parietal above, and this bone forms the upper boundary of the opisthotic notch. I regard it as being probably the pro-otic.

The superior border of the parietal diverges backward as a thin superior crest which is not quite perfect. In front it shows the narrow vertical surface of the parietal, which forms the parietal crest when prolonged forward, which is nearly $1\frac{1}{2}$ inch from the brain case and $\frac{3}{10}$ inch wide superiorly, widening as it descends to the pro-otic, which forms a very narrow strip on the anterior aspect of the occipital plate, dividing the parietal wall of the brain from the opisthotic wall.

The superior outer angle of the parietal in front is overlapped in the usual way by the thin film of the squamosal, although the preservation does not show the superior approximation of these bones at the parietal crest, which is evident in some other specimens, for the thin film has scaled off the face of the parietal. Below the parietal, which is about $1\frac{7}{10}$ inch deep, a suture may be traced at the transverse fracture in front, separating the bone which arches over the brain case, from the bone between it and the opisthotic. It is about $\frac{7}{20}$ inch deep and appears to me to be separated by an oblique suture from the pro-otic bone behind, with which it is otherwise continuous. It is not possible to determine whether this ossification below the parietal is a forward extension of the supra-occipital. But, since there is no trace of vertical division in the bone which arches over the brain case, that may, with more probability, be identified as the inter-parietal, which is overlapped externally by the parietal bones, between which a median division appears to be indicated; so that being in contact with the pro-otic and opisthotic, and in front of them, the bone which enters the wall of the brain case below the inter-parietal would appear to be the ali-sphenoid. The bone below the ali-sphenoid, defined from it by a well-marked horizontal groove and suture, I regard as being the opisthotic; and the inferior border of this bone I interpret as meeting the tympanic and basi-sphenoid.

On its anterior aspect, the opisthotic is constricted below what I have termed the opisthotic notch, so that its depth upon the skull wall is about $1\frac{2}{10}$ inch; and its depth below the inner corner of what is here termed the opisthotic notch, is less than $\frac{1}{2}$ inch. The bone is concavely channelled on its under side, where it carried a bone connected with the auditory region, which, as being tubular, may be a representative of the tympanic bone or the cochlea.

The section of the brain case is vertically pear-shaped, $1\frac{4}{10}$ inch deep, and $1\frac{3}{20}$ inch wide, in the lower third between the opisthotic bones. The depth from the base of the brain case to the base of the skull is about $\frac{8}{10}$ inch. A vertical transverse fracture here divides the basi-sphenoid bone, and at the fracture the bone is $\frac{3}{4}$ inch wide, its fractured part about $\frac{6}{10}$ inch deep; its sides are flattened and vertical, and its base concavely channelled. Above the fracture a vertical film of bone borders the front of the brain case.

On the under or palatal aspect, on each side of the occipital condyles and basi-sphenoid, are the triangular areas, $1\frac{7}{10}$ inch wide and $1\frac{3}{10}$ inch from front to back against the sphenoid, of the under side of the opisthotic processes, which are inclined a little backward and slightly downward, and concave from back to front, where the area is bordered by a compressed edge. In the depression between the occipito-sphenoidal axis and this triangle are two foramina; first, a large foramen just in advance of the occipital condyle; and secondly, a smaller foramen in advance of the first, which is surrounded by a flattened border, except on the side towards the first foramen. This foramen I suppose to have been auditory. I have suggested that the bone which I believe to be attached to this surface in well preserved skulls of Anomodonts and Theriodonts, is the malleus. In some Anomodonts it lies between the opisthotic and basi-sphenoid on the one side and the quadrate bone on the other. But the tubular condition and mode of attachment in *Cynognathus* are more suggestive of the tympanic bone or cochlea.

CYNOGNATHUS PLATYCEPS (SEELEY).

This skull was found by Dr. D. K. KANNEMEYR, as he states in a letter to myself, at Wonderboom railway bridge, and by him presented to the Albany Museum, at Grahamstown; to the Trustees of which I am indebted for the opportunity of removing the matrix with which it was originally invested.

It is a skull which in general aspect of the post-orbital region, especially of the temporal vacuities, somewhat recalls the Teleosauria. The extremity of the snout, including the canine teeth and the mandibular symphysis, is lost. It is important in showing the sutures on the roof of the skull, the structure of the palate, the posterior part of the lower jaw, and occipital condyle.

The head is distinguished as a species by its transverse width relatively to its small depth, though this is somewhat further reduced by oblique compression; by the rapidity with which the lateral contours of the jaws converge anteriorly; by the slight development of the occipital crest and the parietal crest; and by the absence of a perforation in the zygoma. I estimate that not less than 1 inch and not more than $1\frac{1}{2}$ inch is lost from the extremity of the snout. The extreme length of the skull, as preserved, is 6 inches; and its width on the occipital plate is 5 inches. Its depth from the summit of the occipital crest to the base of the occipital condyle, is 2 inches, as preserved; and may have been slightly more. The vertical depth at the anterior fracture, to the alveolar margin, is $1\frac{4}{10}$ inch.

The superior surface of the skull comprises the two temporal vacuities, divided from each other by the narrow cerebral region, which forms a sharp thin crest. The antero-posterior measurement of these temporal vacuities is 2 inches, and the transverse measurement is somewhat more posteriorly, though they are narrower in front. The squamosal bone forms the posterior and outer border; the post-frontal bone makes the anterior border and extends a short distance backward upon the inner dividing median ridge.

The parietal foramen appears to have been placed near to the occipital crest, just in front of the median union of the squamosal bones; but is not well preserved.

The post-frontal bones are somewhat hammer-shaped, having a long internal superior union with the frontals, and converging towards each other as they extend backward. They join the pre-frontal bones above the middle of the orbit. They are directed outward, slightly backward, and at first a little upward, and then downward to meet the malar and squamosal bones and divide the orbits from the temporal vacuities. With the frontals they form a slight concavity behind the orbits, on the flattened roof of the skull. The antero-posterior extent of the post-frontal bar, between the orbit and the temporal vacuity, is $\frac{6}{10}$ inch; and the antero-posterior length of the inner margin of the bone, from the pre-frontal to the parietal, is $1\frac{6}{10}$ inch.

The orbits are placed laterally, are longer than deep, though the difference is not appreciable if the measurement is made on the outermost ridge of the orbital border, where depth and length are both about $1\frac{1}{4}$ inch; the transverse width of the inter-space, between the orbits formed by the frontal bones, is the same.

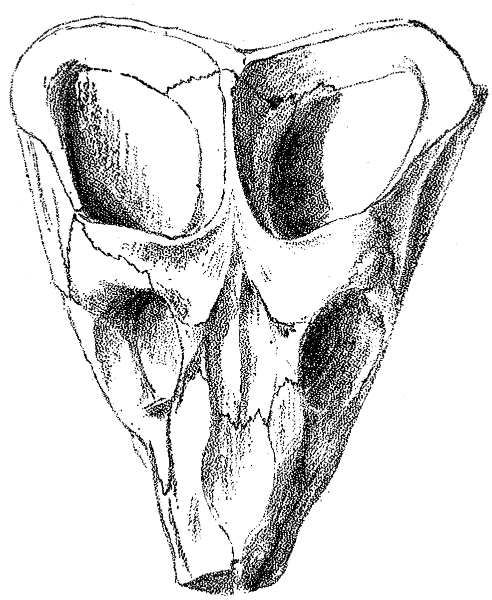
The back of the orbit is $2\frac{6}{10}$ inches in advance of the summit of the occipital plate, in the median line, as preserved. There is a slight descending process of the malar bone below the orbit, and the depth of the malar bar at this point where the maxillary terminates, is $\frac{4}{10}$ inch.

The pre-frontal bone is a narrow bar above the front of the orbit, which forms a slightly elevated supra-orbital ridge.

Below it is the lachrymal, which has a concave surface. It is about $\frac{8}{10}$ inch deep, and somewhat longer, truncated behind by the orbit, and narrower in front. It rests upon the maxillary, meets the malar below, and the nasal and pre-frontal above.

The frontal bones are lanceolate, more than 2 inches long, $\frac{3}{4}$ inch wide at the suture, where the pre-frontal and post-frontal meet. Behind this point their straight outlines converge backward in a V-shape; and in front of that point their outlines contract a little to $\frac{6}{10}$ inch at the anterior transverse truncation, where they join the nasal bones. The two frontal bones are separated by a median suture, which forms

Fig. 28.



Superior aspect of the skull of *Cynognathus platyceps*, showing its wide triangular contour, the forms of the orbits and temporal vacuities, and sutures defining some of the skull bones. Half natural size.

a slightly elevated median ridge, which is not prolonged forward on to the nasal bones. And this ridge makes each frontal bone longitudinally concave.

The small portion of the nasal bones preserved is about $1\frac{1}{2}$ inch in length, $1\frac{3}{10}$ inch wide behind, and limited to the superior surface of the snout, where they are becoming convex from side to side at the anterior fracture. They are divided by a median longitudinal suture. Their width at the anterior fracture was about an inch.

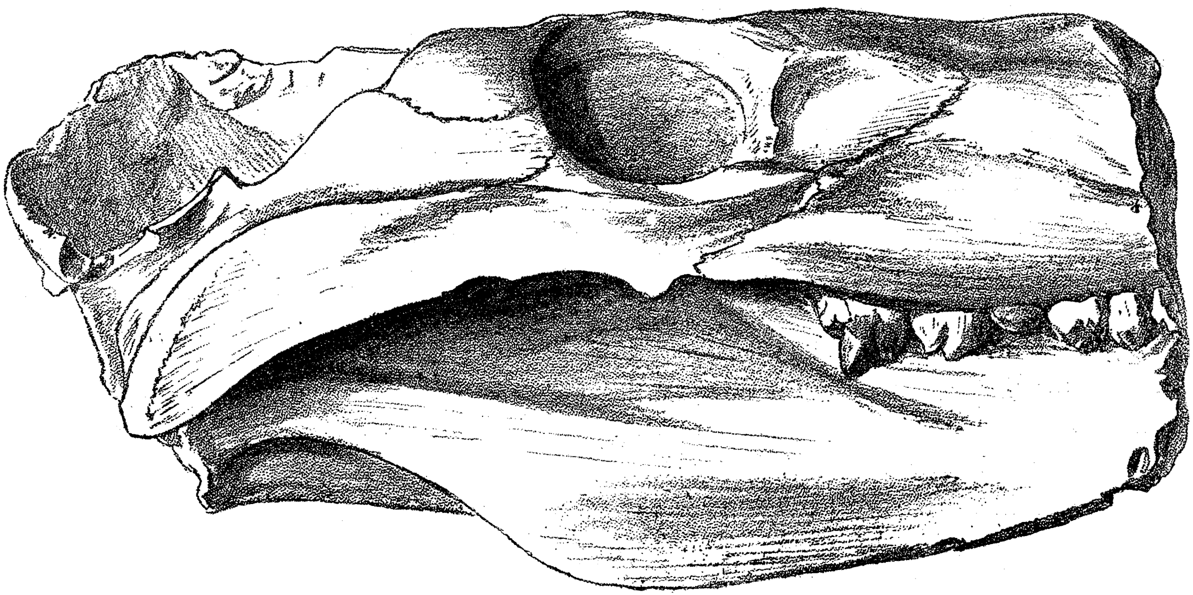
In side view the skull is remarkable for the very slight difference in depth which it shows from front to back. At the anterior fracture it is $\frac{9}{20}$ inch deep, and although a little deeper in front of the orbit, is again reduced to this depth behind the orbit, at the post-frontal bone, although the depth from the orbit to the base of the palatine process is $2\frac{3}{4}$ inches. The extreme vertical depth at the occiput is less than 2 inches.

The maxillary bone is preserved for a length of $2\frac{1}{2}$ inches. It is slightly concave from front to back, and the posterior extremities of these bones, which overlap the malar bones, are $2\frac{9}{10}$ inches apart. The vertical depth of the maxillary, from the nasal to the alveolar border, above the ante-penultimate tooth, is $1\frac{3}{10}$ inch.

The surface of the maxillary bone is slightly convex from above, downward, and slightly rugose, with faint longitudinal ridges. A glandular pit appears to be present on the right side, upon the nasal bone, just above the highest point of the maxillary.

On the right side, which alone is completely preserved, there are indications of

Fig. 29.



Right side of the skull of *Cynognathus platyceps*. Albany Museum. Showing the post-frontal, squamosal, and malar bones at the back of the orbit; the descending sub-orbital malar tubercle; the pre-orbital lachrymal pit, the laterally denticulated molar teeth; the posterior recession of the dentary bone behind its inferior angle, and the internal position of the articular bone.

six teeth, but only the last two have the crowns preserved. Four of the large teeth may, from their size, perhaps, be classed as molars. The teeth have the usual pattern found in *Cynognathus.* The crowns do not, however, project from the alveolar border so as to expose the unenamelled surface. They are compressed from side to side. All their denticles are inclined backward; they are five in number. The middle denticle is the largest and highest, and the others progressively diminish in size. All are strongly marked at the cutting edge with transverse serrations. The external surface of the principal denticle is so convex that its apex appears to incline inward. The antero-posterior extent of the last tooth is $\frac{1}{2}$ inch, and its vertical depth to the alveolar border is $\frac{4}{10}$ inch. It is conspicuously larger and much deeper than the teeth in front of it. In the penultimate tooth the principal denticle is not nearly so strong, and in the earlier teeth the crown is imperfectly preserved.

Behind the teeth the alveolar margin diverges outward, and is compressed to a sharp edge. The malar bone is similar in character to that in the type from Lady Frere. It extends below the orbit and above the maxillary to meet the lachrymal. Its superior surface in the orbit is flattened, but somewhat convex from within outward: and this internal surface is bounded externally by a prominent ridge, which extends from the lachrymal backward along the upper edge of the part of the malar bone behind the orbit. The anterior limit of the malar bone on the inferior post-alveolar border is marked by a slight descending compressed tubercle, behind which its inferior contour is concave and sharp. The external surface of the malar bone is triradiate; first, there is the anterior infra-orbital portion already described; secondly, the post-orbital portion, which ascends to meet the post-frontal above at the shoulder of the orbit, and meets the squamosal bone behind; and, thirdly, the posterior bar defined by the longitudinal superior ridge already mentioned, which extends backward parallel to the squamosal and below it, contributing with that bone to form the zygoma.

The superior border of this bar is convex, and it extends back a little above and beyond the articulation with the lower jaw

The external bar of the squamosal bone, behind the post-frontal and malar, descends as it extends backward; and then, at the superior hinder outer border of the temporal fossa, has its superior edge flattened and reflected a little outward. These anterior plates of the squamosal are thin, and incline inward a little as they extend upward and forward. Posteriorly, a groove descends from the external surface backward and inward below the outwardly reflected superior edge which contributes to form it, so as to define the thin posterior plate of the squamosal bone, which forms the whole of the back of the temporal vacuity and the outer part of the occipital plate, from the thick inferior and posterior mass of the squamosal rounded behind, which contributes largely to the mandibular articulation.

The least depth of the zygomatic bar posteriorly is rather less than 1 inch, measured vertically over the squamosal and the malar. The length of the latter is 4 inches from front to back, while the length of the lateral external bar of the squamosal above it is $2\frac{1}{4}$ inches.

The quadrate bone is not distinctly defined from the squamosal, in which it is presumably included.

The back of the skull is distorted by pressure, which has indented the inter-parietal region. The occipital condyle looks downward and backward; is transversely reniform; convex below, and concave above; $\frac{8}{10}$ inch wide, $\frac{3}{10}$ inch deep; somewhat flattened, but concave from side to side; and is directed a little downward, so as to be below the level of the sphenoid bones on the palate. Its superior border is notched in the median line, and this notch appears to divide the ex-occipital bones, though the preservation does not make their limits clear. I suppose the inferior wedge between these lateral prominences, forming the basal part of the condyle, to be made by the basi-occipital bone.

The foramen magnum as preserved is slightly wider than high, the inside transverse measurement being $\frac{11}{20}$ inch, and the inside vertical measurement $\frac{9}{20}$ inch. The margin of the foramen appears to be sharp.

The opisthotic bones extend transversely outward to the quadrate region. They are defined superiorly by a concavity, which appears to penetrate through the occipital plate, though this is not proved on the left side, and may not exist on the right side. The opisthotic is not distinguished suturally from the ex-occipital. It extends transversely outward, and very slightly backward, is concave above and below, so that its extremity is a little expanded and rounded.

The supra-occipital bone is small, and forms the upper part of the foramen magnum; it is $\frac{17}{20}$ inch wide, inclines obliquely forward and upward, and measures about $\frac{3}{10}$ inch from front to back. It is the beginning of the concave depression at the back of the foramen magnum, which appears to be excavated chiefly in the inter-parietal bone. It is manifest from this specimen that posterior to the inter-parietal is a bone which meets it laterally, and meets the supra-occipital and opisthotic, and rests upon the squamosal on the occipital plate.

This appears to be the parietal bone, but the only evidence is the superior fracture of the left occipital crest, which shows that the parietal bone extends from the temporal vacuity behind the squamosal on to the back of the occipital plate. Hence the inter-parietal is flanked laterally by the parietal.* This bone has always offered some difficulty, and, in the absence of evidence of its relation to the parietal, I have referred to it provisionally in Dicynodonts as epiotic.

This is the bone which Professor COPE has termed the intercalare of CUVIER. This simplifies the structure of the back of the skull, and removes the difficulty in the way of identification of the otic bones. The depth of the back of the skull, from the occipital condyle to the summit of the parietal, as preserved, is less than 2 inches.

The transverse width of the back of the head, at the posterior terminations of the malar bones, inferiorly is $4\frac{1}{2}$ inches; and the greatest width, measured at the summit of the occipital condyle, is rather less than 5 inches. At the base of the opisthotic process is another bone parallel to it extending transversely outward, without apparently any foramen between it and the opisthotic, which it somewhat resembles in form, though rather smaller. I suppose this to be the bone extending transversely from the sphenoid region to the articular and quadrate region of the skull, which I have regarded as the malleus, and which Mr. E. T. NEWTON, in his description of *Scaphognathus*, regarded as basi-pterygoid ('Phil. Trans.,' B, 1888, Plate 77,

* Mr. R. LYDEKKER has figured this bone as parietal in *Ptychognathus declivis* (OWEN), p. 34, 'Cat. Foss. Rept. Brit. Mus.,' Part 4; but I am not aware that the evidence for the identification has been previously described.

fig. 4). In this fossil these bones are perfectly preserved, are compressed from side to side, flattened on the under side, upon which there appears to be a long large foramen opening into the hollow bone, though this may be only a consequence of the mode of removal of the matrix. Each bone is $\frac{17}{20}$ inch in transverse measurement, about $\frac{2}{10}$ inch wide, slightly expanded at the outer extremity. It is placed between the squamosal bone and the pterygoid bone. I now incline to regard it as a rudimentary straight cochlea.

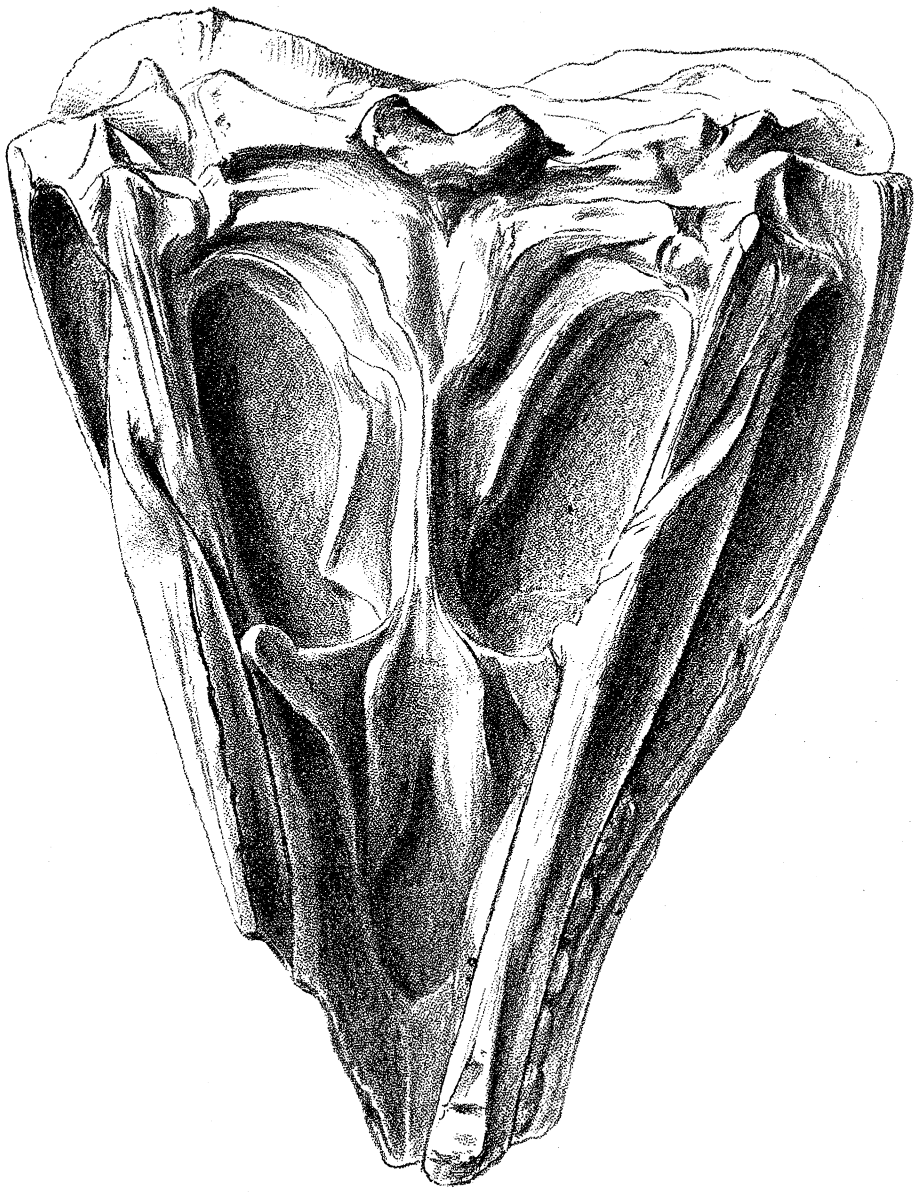
The palate is on the type of all other Theriodonts, though it shows some small distinctive characters. Between the anterior teeth the maxillary bones appear to close the palate in the median line, so that it forms a flat surface between the teeth, with a median suture ; and the posterior transverse border, concave from side to side, truncates the palate in advance of the penultimate molar tooth. Then the large palatonares form a descending channel bordered by what I regard as the palatine bones. This narrow vault to the palate is limited by a lateral thickening, external to which the palatine bones appear to unite with the transverse bones, and therefore, as those bones present a triangular surface, which descends vertically, abutting on the sides against the rami of the mandible, the palatines are distinctly defined from the transverse by this lateral depression. The descending processes of the transverse palatine arch present the usual characters, forming a wide arch transversely compressed from front to back to a sharp transverse edge, and somewhat expanded anteriorly on the flattened triangular surface which abuts against the lower jaw. The palatonares are $4\frac{1}{2}$ inches in advance of the occipital condyle, and these palatine processes are nearly 3 inches in advance of the occipital condyle.

Immediately behind the descending palatine processes is the vertically compressed sharp keel of the sphenoidal region, which is embraced by the pterygoid bones in front ; and expands transversely behind in the long triangle of the basi-sphenoid, which is longitudinally concave. It is from the side of the sphenoid apparently, near its junction with the basi-occipital, that the cochlea is given off. The pterygoid bones appear to extend as a transverse lateral border, from behind the palatines along the whole length of the side of the sphenoid, forming a thin plate, directed horizontally outward and a little downward, at some distance above the median keel of the palate ; and it extends outward parallel to the sphenoid and the malar, towards the quadrate region, but no evidence of pterygoid articulation with the quadrate bone is seen.

These pterygoid plates are about $\frac{4}{10}$ inch wide, and a distinct channel runs between them and the sphenoid. The lateral vacuities, on each side of the pterygoid, correspond with the temporal vacuities. The sutures of the palate are very well shown in this specimen. The key to the structure of the palate in all Theriodonts is the downward direction and lateral position of the palatine and transverse bones. Some approach to the condition is seen in the palate of *Procolophon trigoniceps*.

The lower jaw, as preserved, is perfectly straight, the rami diverge as they extend backward. As preserved they are $5\frac{1}{2}$ inches long, and the anterior symphysis is lost. The jaw is deep and strongly compressed. It increases in depth as it extends backward, owing to the vertical development of the coronoid process of the lower jaw towards its articular end. Beyond the back of the orbit, the depth of the lower jaw decreases, in a way which is characteristic of Cynodont Reptilia, owing

Fig. 30.



Palatal aspect of the skull of *Cynognathus platyceps;* natural size; showing the composite structure of the mandible, the formation of the mandibular articulation by the articular bone; the position of the palato-nares between the maxillary molar teeth; the descending inter-mandibular transverse palatine arch behind the maxillary teeth, the lateral expansion of the pterygoid bones on each side of the narrow pre-sphenoid keel and the transverse reniform concave occipital condyle.

apparently to the retreat of the inferior border of the dentary bone upward behind the angle of the jaw, so as to expose the elements which form the articulation, and partly traverse its inner side. The depth of the jaw at the anterior fracture is $\frac{9}{10}$ inch, and its thickness $\frac{1}{4}$ inch. At the back of the last tooth the depth is $1\frac{4}{10}$ inch. From the angle of the jaw to the summit of the coronoid process is about $2\frac{1}{2}$ inches. The dentary bone extends backward forming the coronoid process, reaching to the articulation, and appearing to be obliquely truncated posteriorly, from above the articulation to the angle of the lower jaw. This oblique surface is about 2 inches long, and shows the interior bones of the lower jaw behind it, descending about $\frac{1}{2}$ inch below the inferior border of the dentary bone, which is rounded from side to side, and straight from front to back. The dentary bone is modified in form by the excavation of a great V-shaped longitudinal depression in the external hinder half of the bone, $3\frac{1}{2}$ inches long, below which the surface is convex from above downwards for the depth of 1 inch at the angle of the jaw, which extends forward in advance of the last molar tooth in the upper jaw. The posterior excavation is defined superiorly by a narrow convex area which ascends the edge of the coronoid process, and diminishes in thickness as it ascends.

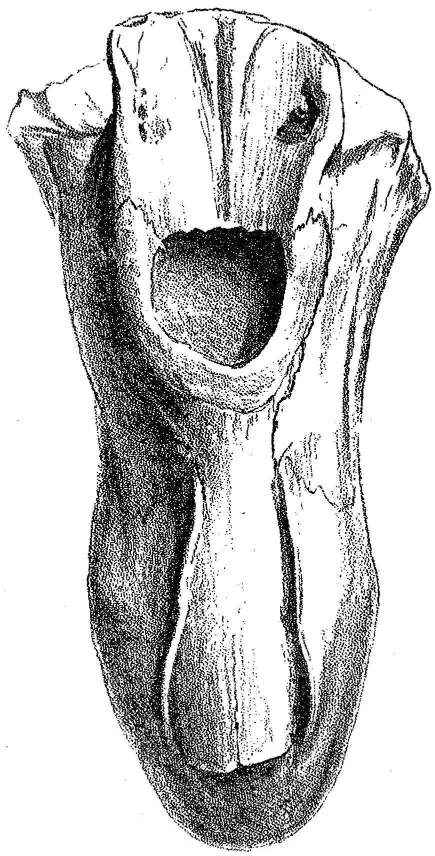
Along the inside of the dentary bone, at between $\frac{3}{10}$ and $\frac{4}{10}$ inch above its base on both sides, so as to be embedded in the upper and most convex part of the inferior area of the dentary, run the bones which contribute to form the transverse articulation of the lower jaw. One of these, the splenial, appears to come from the symphysis, and to extend backward upon the inferior edge of the articular bone, chiefly upon its outer side, though the articular bone emerges apparently from behind it, more than $\frac{1}{2}$ inch in advance of the articulation. The articular bone is seen as a slender splint on the inner side of the splenial bone, behind the palatine. It widens transversely, developing an inner process which appears to be in contact with the bone which I have termed cochlea, and thickening externally in front of the articulation. The depth of the lower jaw at the articulation is only $\frac{7}{10}$ inch. It is impossible to give the number of teeth in the lower jaw.

A point of some interest in this mandible is the limitation of the splenial bone to the inner side of the dentary, so that it neither rises to the alveolar border, nor descends to the base of the jaw as in Crocodiles; and therefore appears to be undergoing a form of atrophy or limitation such as might lead to its eventual disappearance.

? CYNOGNATHUS LEPTORHINUS. (SEELEY).

A remarkable fragment of a skull anterior to the orbit, for the opportunity of studying which I am indebted to the Trustees of the Albany Museum, is about $4\frac{1}{4}$ inches long, and shows the mandible as well as the anterior part of the head. It is possible that the nasal characters indicate a generic difference, but the maxillary teeth are like *Cynognathus*. The jaws are in close contact, so that no part of the mandibular dentition is seen, except portions of two incisors exposed in removing the matrix. The skull is probably slightly compressed, since the nasal bones lie within the elevated longitudinal superior margins of the maxillary bones (fig. 31); but the most remarkable feature of the head is the existence of a nearly circular hole upon its crown, at the back of the nasal bones, slightly approximating in position and aspect to the anterior nares of a Porpoise. The structure has every appearance of being normal, and not due to *post-mortem* changes, or an accident during life; for the foramen has been excavated, and proves to have a flat, smooth floor of bone. Its margin has been

Fig. 31.



Superior aspect of pre-orbital part of the skull of ? *Cynognathus leptorhinus* showing the fronto-nasal pit, behind which are the frontal bones. The nasal bones are in front, the maxillary bones are defined from the nasal bones by elevated borders due to compression. The nasal opening shows no sign of vertical division.

left so as to preserve the original condition of the fossil. Just as a thin bony film has been described upon the narrowest part of the nasal bones in the other species of *Cynognathus*, with two pits having a glandular aspect, at its posterior angles, so I am disposed to regard this large pit behind the nasal bones as indicating a single homologous structure.

There is another point in which this skull differs from all others, and that is in the persistence of two canine teeth, side by side, in the anterior part of the maxillary region. Though this condition is well known in some existing lizards, like *Chlamydosaurus*, it has hitherto been unknown among fossils from South Africa.

It is chiefly on these two characters of the canine teeth and the pit on the nasal bones that I think this fossil may perhaps be distinguished generically from *Cynognathus*, though the teeth show no important generic difference. The entire series of teeth appears to be preserved, and may be counted as four molars, three or four pre-molars, two canines, and four incisors in the skull.

The form of the snout is slender, elongated, and tapers from above downward. The depth of the head at the front of the orbit on the left side is $1\frac{6}{10}$ inch, and on the right side $1\frac{4}{10}$ inch. The transverse width between the orbits, as preserved, is $1\frac{7}{20}$ inch, and the transverse width at the back of the alveolar part of the maxillary bone is $2\frac{1}{4}$ inches. As the jaw tapers forward, there is the usual transverse compression behind the canine teeth, so that the width of the alveolar area, as preserved, diminishes from less than 2 inches behind to about $\frac{17}{20}$ inch in front, opposite the second pre-molar tooth; and then the jaw widens at the canines to nearly $1\frac{1}{2}$ inch, in front of which it tapers forward in a lanceolate contour. The anterior margin of the first canine is $1\frac{7}{20}$ inch behind the extremity of the jaw, as preserved.

The anterior nares are imperfectly preserved, and have the aspect of being crushed vertically. It is possible, however, that instead of forming one terminal aperture they form two small lateral vacuities, the appearance of a terminal aperture resulting from the loss of the anterior extremity of the nasal bone, which I suppose to have rested upon the pre-maxillary, and to have divided the nares. In this view the nares are much smaller than in similar fossils. The sutures of the skull are not very distinct, but the pre-maxillary bones appear to be exceptionally large for a Theriodont, forming the whole of the lateral aspect of the snout from its extremity to behind the canine. These bones converge forward. The incisors are all in the anterior half of the bone, and do not extend behind the anterior nasal vacuity. There is a diastema $\frac{1}{2}$ inch long between them and the canines, and as this is about the antero-posterior extent of the two maxillary canines, which are close together, presumably the unseen canines in the lower jaw had a similar development. The antero-posterior extent of the pre-maxillary on the alveolar border to the hinder margin of the canine teeth is $1\frac{3}{4}$ inch, and its vertical depth at the canine teeth to the suture with the nasal bone is $1\frac{1}{4}$ inch; at the anterior nares its least depth is $\frac{1}{4}$ inch.

The maxillary bone, owing to the contraction of the alveolar border, is more convex from above downward; the bone is also concave from front to back, while the pre-maxillary is convex from front to back. The length of the bone, as preserved, to the commencement of the sub-orbital ridge, below the orbit and behind the last tooth, is $2\frac{3}{10}$ inch. The bone receives the lachrymal on its superior border behind, which bone appears to separate the maxillary from the pre-frontal, which is only exposed on the superior surface, round the supra-nasal glandular pit. This pit is $\frac{13}{20}$ inch wide, and rather shorter from back to front. It is about $\frac{7}{20}$ inch deep in front and $\frac{2}{10}$ inch deep behind, with vertical walls, and the excavation appears to extend forward. The floor of the vacuity is occupied by a horizontal, flat, smooth, bony surface, which has almost the aspect of having been forced down from above, since it resembles the surface bones in texture. On its anterior border, for a distance forward of half-an-inch, I am unable to trace the suture between the nasal bones. It is, therefore, possible that there may have been a blending of the bones in that position similar to the blending seen in the species of *Cynognathus*, and due to a like cause.

The nasal bones are $\frac{9}{10}$ inch wide at the superior angle of the nares, and $\frac{4}{10}$ inch wide behind, as preserved. Their length cannot be given with certainty, but the distance from the front of the supra-nasal pit to the anterior border of the pre-maxillary bone, is from $2\frac{1}{2}$ to $2\frac{3}{4}$ inches.

Between the orbits are the frontal bones, concave from side to side, with a slight elevation in the median suture. They are flanked laterally by the pre-frontals, which are chiefly defined by the different direction of the vessels in the bony tissue. The orbit is margined in front by the supra-orbital ridge, made by the pre-frontal bone. The lachrymal bone in front of the orbit is a large sub-triangular plate. The maxillary bone enters into the orbit below. The depth of the orbit as preserved is about $\frac{9}{10}$ inch. There is no evidence of a complete bony septum between the orbits in front.

The incisor teeth are exceptionally small. The four which are preserved on the right side are contained in a length of $\frac{6}{10}$ inch.

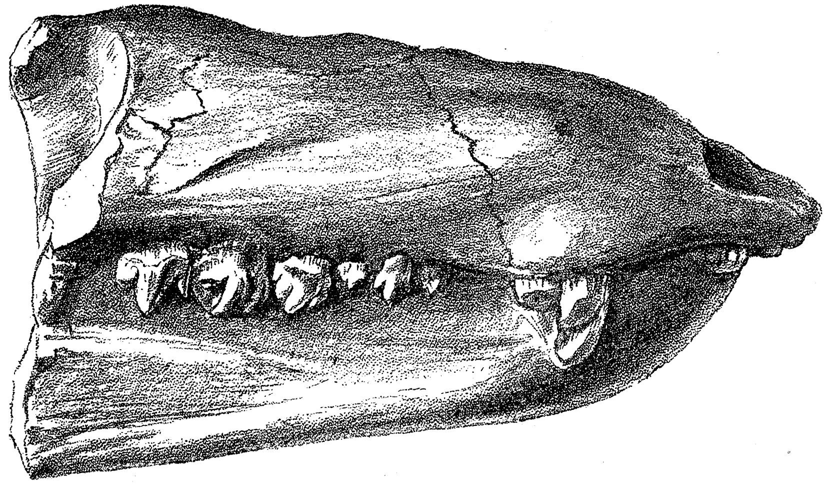
The interspaces between them are wider than the teeth, which have the crowns nearly circular, smooth, directed a little backward, and, as preserved, they show no signs of serration which would be an important difference from *Cynognathus*. The anterior teeth on the left side are lost with a fragment of the bone.

The two canine teeth are very nearly in contact, parallel to each other, compressed so as to have an ovate section, flatter on the inner side than on the outer side. The anterior of the two has both edges strongly serrated; but the second tooth is too imperfectly preserved on both sides, to show its edges.

The first pre-molar tooth is close behind the second canine. Its crown is broken, but it appears to have been smaller than an incisor. Then succeeds a wide inter-space; but no trace of a tooth is exposed in it. Then follows the second pre-molar. This is also a small tooth with the crown imperfectly preserved; but it appears to show a posterior cusp in addition to the principal cusp. The remaining teeth may be classed as molars. They all show enamelled crowns, with a root which does not appear to be enamelled, projecting from the jaw, and flat on its external surface.

The crowns show a principal cusp which is short and strong. It is flanked back and front by a cusp which becomes relatively more developed in the three hindermost teeth; and there is below the hindermost cusp, a small accessory cusp, in the last four teeth, which have the principal cusp inclined a little backward. The cutting edges of the cusps are serrated with coarse bead-like crenulations. The last two teeth, which are the largest, are $\frac{4}{10}$ inch each from front to back, and project nearly this amount from the alveolar border; but they become rapidly smaller in front.

Fig. 32.



Right side of the skull of ? *Cynognathus leptorhinus*, the maxillary dentition and two canine teeth.

The mandible is preserved for a length of 4 inches, of which the symphysial region occupies $1\frac{1}{2}$ inch. It is convexly rounded from side to side, and from above downward, shows no trace of division by suture, and has this rapidly retreating surface roughened with small vascular perforations. It is $1\frac{1}{20}$ inch wide just in front of the maxillary canines, and $\frac{17}{20}$ inch wide at the inferior lateral ridge where the rami bifurcate. Above that ridge, behind the canines, the jaw is slightly compressed. Its depth on the right side, as exposed below the maxillary teeth, is $\frac{8}{10}$ inch. The rami are compressed and slender, and about $1\frac{8}{10}$ inch wide at the posterior fracture, though the left ramus is less perfectly preserved.

The dental characters closely approximate this type to *Cynognathus;* but the lower jaw appears to be relatively less deep; the pre-orbital excavation is almost absent, while the slender snout, median pit on the back of the snout, and the simultaneous development of two canine teeth, have the aspect of being generic characters by which it may be distinguished; but in the absence of the complete skull it may be premature to separate the specimen as a distinct genus.

Portion of the Carpus of a Large Anomodont from Lady Frere.

I picked up a block of rock at Lady Frere which had evidently been transported by the rains from the mountain above. There is no proof that it belongs to *Cynognathus* or that it is Theriodont, though I have no doubt that it is the proximal part of the carpus of an Anomodont. It has been figured in an earlier section of this paper (§ 2), $\frac{1}{2}$ nat. size in illustration of the structure of the carpus. The three bones in the proximal row I regard as scapho-lunar, cuneiform, pisiform, and the inferior fragment appears to be a part of one of the central bones. The width of the carpus is $5\frac{1}{2}$ inches, which is wider than I should expect in any species of *Cynognathus*. The scapho-lunar is a strong transversely ovate bone with rounded edges. The pisiform is equally deep, measuring nearly 2 inches from above downward, but it is widely reniform, being concave on its inner border; and it is greatly compressed from front to back. The rhombic cuneiform is about $1\frac{1}{4}$ inch deep, and as wide.

Tribolodon Frerensis (Seeley).

The teeth of *Nythosaurus larvatus* have the crowns in the molar region with three or five cusps, and closely set. The crowns in *Galesaurus planiceps* are presumably similar. This character in the tooth crown of a central cusp, with a smaller lateral cusp on each side, is also found in the molar teeth of *Thrinaxodon*, and, with the lateral cusps smaller, in *Scaloposaurus;* so that the laterally tri-cuspidate teeth probably characterize many genera. One of the most interesting of these fossils is known from a lower jaw which is imperfect anteriorly, contained in a block of rock from Lady Frere, already figured in a plate to § 1, of this paper, as an example of Cynodont dentition.

The jaw, as preserved, is about $2\frac{1}{4}$ inches long. The symphysis is broken away and lost; the jaw may have been appreciably longer than is indicated by its present state of preservation. Only three molar teeth are preserved. With the two interspaces between them, they extend over $\frac{6}{10}$ inch. Each interspace is wider than the teeth which it separates. The middle crown is the highest, exceeding $\frac{5}{20}$ inch. The one in front is about $\frac{3}{20}$ inch above the alveolar border. The last tooth exceeds $\frac{4}{20}$ inch in height.

The crowns stand high above the alveolar margin, and consist of a flattened cylindrical staff, with an enamelled triradiate crown, which thickens a little at its base, and then from the basal thickening gives off obliquely on each side a sharp cusp, well defined from the sharp pointed vertical median cusp, which is concave from above downward, and terminates inferiorly with a thickening which connects its base with the lateral cusps. There is no trace of serrations on the borders of the cusps, which have sharp cutting edges.

The form of the crowns is such as might be expected on the *internal* rather than on the external aspect of the teeth. But, as the crowns of such teeth are usually directed inwards, the internal aspect is not absolutely established owing to the absence of curvature in the crowns of these teeth. The dentary bone in which the teeth are implanted, is thickened at the alveolar margin; and also thickened and convexly rounded at the inferior margin; so that there is a concave longitudinal depression extending along the jaw to its posterior angle. The depth of the jaw in front of the first tooth is $\frac{7}{20}$ inch, behind the last tooth it is about $\frac{9}{20}$ inch, and from this position the coronoid process begins to ascend. The basal margin is nearly straight, though very slightly convex. The portion of the jaw preserved measures, from the anterior fracture to the angle on its base, $1\frac{11}{20}$ inch. The angle is about $\frac{6}{10}$ inch behind the third tooth. At this point the dentary bone becomes thin. Its posterior inferior margin is perfectly preserved behind the angle, and ascends in a concave curve, which, if there were no coronoid process, might recall the form of the jaw in *Echidna.* The length of this region behind the angle is $\frac{17}{20}$ inch. Above the posterior extremity of this inferior curve of the hinder part of the jaw, which is on a level with the line of the alveolar margin, the coronoid process rises vertically, as an extremely thin plate, with a slightly concave posterior border, $\frac{8}{10}$ inch high. The measurement, from its summit, which is rounded and narrow to the angle of the jaw, is $1\frac{4}{10}$ inch, and the measurement is almost the same to the third tooth, from which the coronoid process begins to ascend, gradually becoming thinner as it extends higher. A slight longitudinal ridge prolongs the alveolar ridge backward to the position where the articulation is usually developed in Theriodont jaws; but there is no trace of a condyle preserved, and there can be no doubt that the articular element is lost. It is probable that it and the associated bones may have been carried upon the dentary bone in the concavity below the alveolar thickening, so that the jaw would be a left ramus, and the surface exposed the internal surface. In favour of this interpretation there is, first, the slightly convex condition of the coronoid process laterally from above downward; secondly, the form of the denticles upon the crowns of the teeth; thirdly, the evidence given by the anterior fracture that the side of the jaw, which is not seen, was convex; fourthly, marks as of squamose attachment in the channel below the coronoid process; and, finally, a very slight development of the angle of the jaw in what would be an inward direction. The anterior fracture does not show any indication of a tooth socket, or of that extension of the jaw which presumably took place towards the symphysis.

The distant position of the teeth; their vertical exposure above the alveolar margin; the longitudinal deflection of the minor cusps of the crown are distinctive features, as are the limitation of the cusps to three in number, and the great vertical development of the coronoid process. In the same block of rock other bones were found which may belong to the same animal.

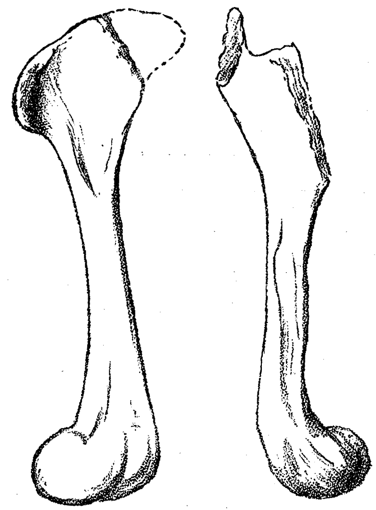
Right Femur of Tribolodon Frerensis (fig. 33).

The right femur is $2\frac{1}{2}$ inches long, and is exposed so as to show the antero-superior and inner surfaces but not the posterior surface of the bone. The femur is remarkable for its slender shaft, moderately expanded proximal and distal ends, and the deep inferior ridge forming a plate which is longitudinally developed towards the proximal end on the inner side of the bone, representing the Mammalian trochanter minor, and the lateral internal trochanter in Saurischia.

In general character this femur may be closely compared with the proximal end of the femur of *Cynognathus,* and it is probable that both conform to the same plan at their distal ends, and in development of the inferior plate-like trochanter at the proximal end (see fig. 23). This trochanter is completely preserved in the genus *Herpetochirus* (§ 6, fig. 4). The distal end of the bone is somewhat flattened above, with a broad slight concavity between the condyles in front. The condyles are well developed backward; and the distal end is not in the same plane with the proximal

Fig. 33.

Trochanter major.



Lateral trochanter minor broken.

Superior. Internal.

Superior and lateral aspects of the right femur, *Tribolodon Frerensis*. Natural size.

end (fig. 33), being rotated inward. The proximal end is inclined upward, and expands transversely; though the inner side of the bone is nearly straight from above downward; and the inner side of the distal end, although marked by a slight angular ridge, is nearly in the same plane with the inferior plate of the trochanter at the proximal end. From this ridge the measurement to the compressed inner margin of the bone is fully $\frac{4}{10}$ inch, though the shaft of the bone is less than $\frac{2}{10}$ inch thick, and scarcely wider in its upper half. The superior part of the proximal end, which has lost the inner articular condyle, is concave, thin as in *Cynognathus*, with the external trochanter rounded and reflected upward; though the preservation does not definitely show whether it includes representatives of both the great trochanter and the third trochanter of Mammals. It is not largely developed, and the bone extends distally for two inches below it.

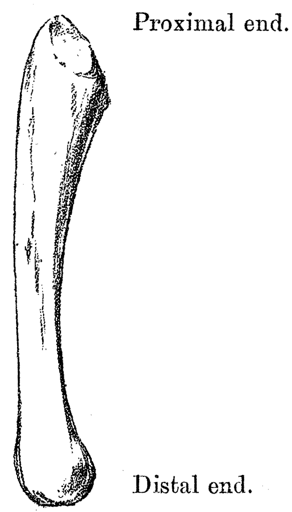
The proximal end begins to contract in width, below the trochanter, so that the least transverse width of the shaft, measured superiorly, is above the middle length. The width of the distal end is $\frac{6}{10}$ inch; the external surface is somewhat oblique at the distal end, and the external contour of the bone is concave in length, so as to be in contrast with the straight inner side. The depth of the distal end at the condyles appears to be about $\frac{1}{2}$ inch, one-half of which at least is to be attributed to the rounded convexity of the inferior distal condyles.

The proximal inferior compressed plate of the trochanter minor commences above the middle length of the bone, and becomes rapidly elevated, though its greatest elevation is broken away. It may be compared with the lateral trochanter in *Ichthyosaurus.* It does not appear to extend to the proximal extremity of the bone, in this respect resembling *Cynognathus* and *Pareiasaurus.* In position, compression, downward direction, it is essentially homologous with the ridge which is seen in the under side of the proximal end of the femur of all Saurischian reptiles such as *Euskelesaurus*, *Palæosaurus* (and *Megalosaurus*), in which, however, there is no such transverse expansion of the proximal end of the bone.

Fibula.

Associated with the femur is a slender curved bone $2\frac{6}{10}$ inches long, with an oblique articulation at the larger end which is presumably proximal and appears to be $\frac{4}{10}$ inch wide. The distal articulation is $\frac{3}{10}$ inch wide and somewhat compressed from side to side. The bone is concave on what I suppose to be the inner tibial side, and slightly convex on what I regard as the outer side. It is probably a left fibula. It has much the form of the ulna in Crocodiles, Tortoises, and some other reptilia. The fibula is curved in *Trionyx* and *Chamæleon.*

Fig. 34.

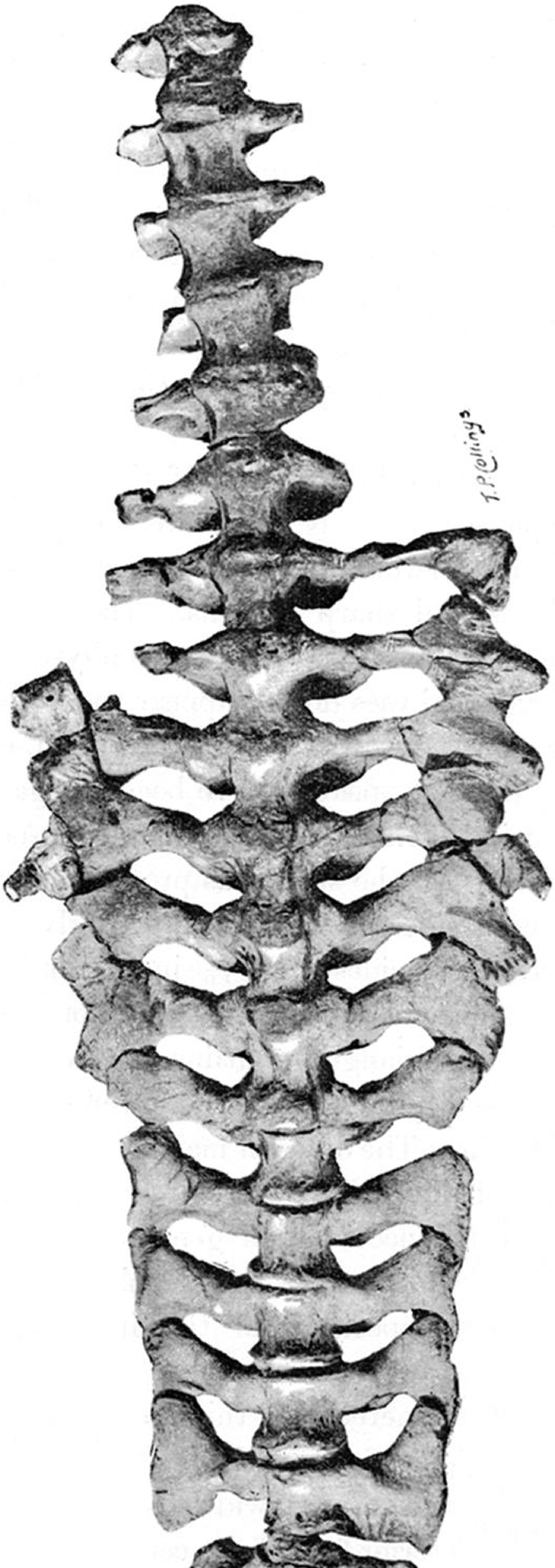


Fibula of *Tribolodon Frerensis.* Lateral. Natural size.

The only point of structure in it which appears to be unusual in Theriodonts is the appearance of an oblique articulation at the proximal end. A similar form is seen in the stout tibia described in the imperfect skeleton of *Microgomphodon* sent to me by Dr. KANNEMEYER.

There is no proof that these bones belong to the animal *Tribolodon,* to which the dentary bone has been referred, but they were all found with some other small fragments in removing the matrix from a skull of *Gomphognathus*, and are hence inferred to be naturally associated.

Fig. 17.



The ventral aspect of the lower dorsal vertebræ and sacrum of *Cynognathus crateronotus*, showing successive modifications of the ribs in mode of articulation with the vertebræ and in form; and the unanchylosed condition of the (three) sacral vertebræ, which have been removed from the pelvis. One-third natural size (from a photograph).