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SECOND CONTRIBUTION

TO THE

History of the Vertebrata

OF THE

PERMIAN FORMATION OF TEXAS.

BY E. D. COPE.

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*Second Contribution to the History of the Vertebrata of the Permian Formation of Texas. By E. D. Cope.**

(*Read before the American Philosophical Society, May 7*, 1880.)

Since my synopsis of this subject, published in May, 1878, the accession of much new material had enabled me to make a number of important additions to it. Notes which record some of these may be found in the American Naturalist for September and December, 1878, and for April and May, 1880. The substance of these is included in the present essay.

At the meeting of the National Academy of Sciences, held in New York, in November, 1878, I pointed out that the scapular arch in the *Pelycosauria*† consists of scapula, coracoid and epicoracoid, which form a continuum in the adult, in the same way as the three elements of the pelvis in the same group form an os innominatum. The tibiale and centrale of the tarsus unite to form an astragalus which has no movement on the tibia. The fibulare forms a calcaneum. The distal side of the astragalus presents two faces, one of which receives a large part of the proximal extremity of the cuboid.

The structure of the scapular and pelvic arches is identical with that already described by Owen as belonging to the *Anomodontia*. Several important characters distinguish this group from the *Pelycosauria*, but the two together form an order which I have thought must, for the present at least, be retained as distinct from the *Rhynchocephalia*. The characters of this order, with its two sub-orders, are as follows :

THEROMORPHA Cope. Scapular arch consisting at least of scapula, coracoid and epicoracoid, which are closely united. Pelvic arch consisting of the usual three elements, which are united throughout, closing the obturator foramen and acetabulum. Limbs with the phalanges as in the ambulatory types. Quadrate bone proximally united by suture with the adjacent elements. No quadratojugal arch.

Pelycosauria. Two or three sacral vertebræ ; centra notochordal ; intercentra usually present. Dentition full.

Anomodontia. Four or five sacral vetebræ ; centra not notochordal ; no intercentra. Dentition very imperfect or wanting.

The *Rhynchocephalia* have no distal ischio-pubic symphysis, and apparently no epicoracoid bone. They have an obturator foramen, and a quadratojugal arch.

The order *Theromorpha* approximates the *Mammalia* more closely than any other division of *Reptilia*. This approximation is seen in the scapular arch and humerus, which nearly resemble those of the *Monotremata*, especially *Echidna ;* and in the pelvic arch, which Owen has shown in the sub-order *Anomodontia* to resemble that of the Mammals, and as I have

* Abstract read before the National Academy of Sciences, April 20, 1880.

†See Proceed. Amer. Philos. Soc., 1878, p. 511 and 528.

pointed out, especially that of *Echidna*. The tarsus is also more mammalian than in any other division of reptiles. In the genus *Dimetrodon* the coracoid is smaller than the epicoracoid, as in Monotremes. The pubis has the foramen for the internal femoral artery.

A not less remarkable characteristic of the *Pelycosauria*, as represented by *Clepsydrops* and *Dimetrodon*, is their resemblance to the *Batrachia* in some important respects. This is seen in the scapular and pelvic arches, which resemble very much those of the *Urodela*, and of such types as *Eryops*. The small coössified coracoid only differs from that of *Eryops* in having two deep sinuses of its free border. The general form of the pelvis is similar, but the ilium has a special and peculiar articular face for the sacral diapophysis, which is wanting in *Eryops*. In the inferior arches, the absence of obturator foramen, and general boat-like form, are the same in both; but in the *Pelycosauria* the symphysis is not so deep, and the walls less massive. But the resemblance of these arches to those of the *Batrachia* in question is greater than to those of any order of reptiles.

Another point of resemblance to the *Batrachia* is seen in the humerus. In my previous essay on the *Pelycosauria* above cited, I defined six types of humerus as occurring in the Texas Permian. Two of these were described as wanting the foramen,* while the others were stated to possess it; other differences between these types exist, but they were not mentioned. Since then Gaudry has added a third form to the former group, which he has ascribed to a reptile under the name of *Euchirosaurus*. I have detected this form in my Texas collections together with another, which has no condyles at either extremity. Thus eight forms of humerus are found in this formation.

That the type with the supracondylar foramen belongs to the *Pelycosauria* has been satisfactorily shown by its presence in the skeleton of *Clepsydrops natalis* and in *Cynodraco major*, where Owen first identified it. I find the type without this foramen frequently associated with the skeletons of *Eryops*, and other *Stegocephali*. There is no other element that can be regarded as the humerus of this type. It moreover has distinct points of resemblance to the humerus of existing *Batrachia*, parallel with similarity traceable in the femora of the extinct and recent genera. There is then every reason for believing that we have in the humerus of *Eryops* and its allies, an element which approaches closely in its characters to that of the *Pelycosauria*, and hence to that of the *Monotremata*.

There are some other peculiarities which constitute resemblances of the same kind. The tooth bearing elements of the roof of the mouth have batrachian character. Such is the densely packed body of teeth seen in *Dimetrodon*; and so are the teeth on the vomer in *Empedocles*. There is also a possible existence of epiphyses, judging from various specimens of humeri in my possession of both *Pelycosauria* and Stegocephalous forms.

In spite of these approximations, the *Pelycosauria* are distinctively rep-

* This word was misprinted "fossa" l. c. p. 529.

tilian in their single occipital condyle, ossification of the basicranial cartilage, and single vomer.

Thus the reptiles and batrachia of the Permian period resembled each other and the *Mammalia*, more closely than do the corresponding existing forms.

PELYCOSAURIA.

THEROPLEURA Cope.

Paleontological Bulletin No. 29, May, 1878, p. 519, Proceed. Amer. Philos. Soc., 1878, p. 519.

A more complete specimen of the *Theropleura uniformis* than any hitherto obtained gives the following generic characters.

The teeth are generally similar to those of *Clepsydrops* and *Dimetrodon*, having compressed crowns with fore and aft cutting edges. The incisors are distinguished by the presence of a diastema. Posteriorly to this the teeth increase in size, and then diminish; one tooth near the middle of the series is the largest, but does not in this species very much exceed the others. There is at least one large incisor tooth. The bones of the head are smooth, and not sculptured; a character distinguishing the genus from *Ectocynodon*. The symphysis of the mandible is short.

The neural arches of the vertebræ are all distinct from the centra. Intercentra are not present in any of the thirteen vertebræ preserved, but there was probably one below the centrum of the atlas. The ribs are two-headed, the capitular process extending downward to the anterior border of the centrum. The neural spines of some of the vertebræ are greatly elevated as in the species of *Clepsydrops* and *Dimetrodon*. The scapula is long; the ilium is similar to that of the genera named. A character which has not been detected in either of the genera named is the presence of dermal rods, which from their position adherent to the vertebræ, I suspect to be abdominal, and similar to those of the genus *Oëstocephalus*. This is a batrachian character. The neural spine of the axis is extended fore and aft. The odontoid is distinct and is of large size. It has lateral and inferior articular surfaces.

THEROPLEURA UNIFORMIS Cope.

Paleontological Bulletin No. 29, p. 519, 1878.

This species is about the size of one of the larger *Varanidæ*, and about equal to the *Clepsydrops natalis*. It is characterized by a long and acuminate head, with a large lateral nostril on each side, well forwards, and approaching near the border of the diastema. In the specimen the top of the head is crushed and the postorbital portion is wanting. Anterior to the large lateral tooth there are nine teeth; posterior to it there are eighteen. The anterior cutting edge of the crown does not extend so near the base as the posterior, and is best marked on the anterior teeth. In the crowns preserved the edges are not serrate.

Measurements.	M.
Length of alveolar edge of mandible	.120
" from diastema to canine tooth	.030
" of centrum of atlas	.010
" " " " axis	.018
" " centra of following five vertebræ	.071
" " ilium at acetabulum	.040

The lanciform shape of the skull with its consequent peculiarities distinguishes this species from the *Clepsydrops natalis*, and the *Dimetrodon incisivus*. The canine tooth is more posterior, the teeth more numerous, and the alveolar borders less curved than in either of those species. The diastema is less excavated, and the muzzle less obtuse.

THEROPLEURA OBTUSIDENS, sp. nov.

This species is represented by nearly all parts of the skeleton, including jaws of both sides with teeth, numerous vertebræ, and bones of the limbs. Many of these pieces are preserved in continuous masses, thus greatly aiding in the identification of parts.

Although the species is not larger than the *Theropleura retroversa*, the neural arches are coössified with the centrum.

The jaws are long and rather slender, and there is no such inequality in the sizes of the maxillary teeth as in the genera *Dimetrodon* and *Clepsydrops;* the canine being scarcely larger than the others. The crowns are elliptical in section at the base, with straight sides; the sections of the crowns are lenticular, and the apices are not very acute. The superficial coating is striate with fifteen or sixteen rather obtuse ridges The cutting edges are not very acute, nor are they denticulate. The number of teeth in the dentary bone cannot be precisely stated, but is about twenty-one.

The mandibular articular face consists of two open parallel grooves, one shorter than the other, extending obliquely to the long axis of the jaw. The palatal dentigerous bone is quite different from that of *Dimetrodon*. Its inferior face instead of being narrow, is rhombic. The ascending process arises from one of the terminal angles of the rhomb, and the horizontal process continues from the opposite angle in line with the inferior surface. The borders of the rhomb next to the ascending process are dentigerous; the one bears a single series of four large teeth; and the adjacent angle and side bear numerous small teeth.

The vertebræ have the elongated neural spines of the allied genera, and they are simple. The centra have curved articular margins indicating the presence of intercentra, which are, however, not preserved. Traces of sutural articulation with the neural arch remain. Many of the centra are much compressed and have a narrow sharp median keel. In a few vertebræ, apparently from the posterior part of the column, an angular ridge extends posteriorly from the base of the diapophysis; this is apparent also on a caudal centrum. This point is characteristic of the *T. retroversa*, but I do not find the large capitular facet of that species in the *T. obtusidens*. The

lateral ridges of *T. triangulata* are situated low down on the centra. The diapophyses supporting the tubercular articulation are frequently elongate.

The scapular and pelvic bones are of the usual type. The humeri belong to form second of my Pal. Bull. No. 29. They have rather slender shafts, and much expanded extremities. The proximal articular surface is well defined. The supracondylar foramen and other points are as in the *Pelycosauria* generally. There were probably distal condyles, but this is not absolutely certain.

Measurements.	M.
Length of mandibular series of teeth (nearly complete), on block	.110
Length of crown of mandibular tooth	.008
Anteroposterior diameter of mandibular tooth	.004
Diameters of articular extremities of a vertebra on the same block: vertical	.021
Diameters of articular extremities of a vertebra on the same block: transverse	.020
Length of another centrum on same block	.020
Diameters of humerus (separate): of head: larger	.065
Diameters of humerus (separate): of head: smaller	.013
Diameters of humerus (separate): of shaft	.017

The above description represents the parts which belong either certainly or very probably to one individual. Bones of a second and larger animal are mingled with these. The species to which they belong is uncertain, but they resemble very much those of the *Theropleura obtusidens*, and may belong to a larger individual of that species. A femur has the form already described under the head of *Clepsydrops natalis*. (Paleontological Bulletin, No. 29, p. 510.) Some phalanges belonging no doubt to one or the other of the two animals, are like those I have already ascribed to *Clepsydrops*. They are depressed, and are expanded at the articular extremities. The distal extremities expand the most abruptly, and their convex trochlear face is without groove or keel, and is more extended on the inferior than the superior surface.

DIMETRODON Cope.

Proceedings American Philosophical Society, 1878, p. 512.

The accession of a considerable amount of material representing this genus enables me to add important points to our knowledge of its osteology. The most noteworthy additions include the greater part of the skeletons of two individuals of *D. incisivus;* and vertebræ attached to the pelvis and femora of *D. gigas*. There are also vertebræ of several individuals of *D. cruciger*, and various parts of the skull of a species distinct from the *D. incisivus*.

In both specimens of *D. incisivus*, portions of the palatopterygoid arch are attached to the maxillary bone. One of these elements is an oval plate with a thickening of its inferior side, so as to bevel the long border farthest from the maxillary bone. The surface thus produced is thickly studded with small conical teeth irregularly disposed.

A second tooth-bearing element of the palate is adjacent to the last. It

is a massive plate, the ends of which are produced in opposite directions ; the one into a massive shorter prominence ; the other longer and plate-like. Between these prolongations, the inferior edge of the bone bears a single row of well developed teeth. The patch of small teeth first described, commences at the extremity from which the longest process rises on the opposite side of the series of large teeth. This Z-shaped bone is, from its massive character, generally preserved, and I was long familiar with it, before I could refer it to its position. In one specimen, a part of it bearing teeth, adheres to the upper jaw at the diastema.

The posterior part of the skull of one of the specimens above mentioned displays typical reptilian characters. The occipital condyle is not perforated, nor divided by sutures. The exoccipital bones project well backwards. The lateral walls of the brain-case are massive as far forward as the exit of the fifth pair of nerves ; anterior to this point they were thin or wanting. The basisphenoid carries two parallel descending laminæ, which bound a deep median fissure, and then unite anteriorly. Posteriorly they abut on a descending process, which is followed by a lid-like element which is applied to a circular fossa with a raised border near the occipital condyle.

The articular face of the articular bone of the mandible consists of two parallel cotyli, divided by a ridge of articular surface. This part of the jaw is much depressed, as in *Eryops*. The large teeth of the lower jaw are at the anterior extremity.

The neural spine of the axis is flat and elongate antero-posteriorly. From this point the neural spines rise rapidly in elevation until on the dorsal region they are many times as long as the diameters of the centra. The latter are not very unequal in their proportions in different parts of the column. Those from the posterior regions are less compressed than the dorsals and cervicals. The dorsals are separated by intercentra below, which are small in the *D. incisivus*, and larger in the *D. gigas*. All the ribs are two-headed, commencing with the axis. All the crevical and dorsal vertebræ have diapophyses with tubercular facets. The head of the rib is prolonged downwards and forwards 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 are not distinguished. They are here coössified with the centra.

The humerus accompanying one of the specimens of *D. incisivus*, is of the form No. 3, of my description of humeri in the Paleontological Bulletin No. 29, p. 528. The extremities are expanded and the shaft is without diagonal ridge ; the supracondylar foramen is enclosed, and the condyles are robust. The pelvis of the *D. gigas* is in general like that of *Clepsydrops natalis* (l. c., p. 510). The elements are coössified, but the ischiopubic symphysis is not so deep as in the *Batrachia* of the same beds. The ilium is shortened above, and its direction is at right angles to the long axis of the inferior elements The foramen of the internal femoral artery is distinct. The femur of the

same individual of *D. gigas* has no head, but a regular wide crescentic proximal articular surface. Below this on the posterior side is the large trochanteric fossa, which is bounded by lateral ridges, which are at first equal, but one soon exceeds the other in height, forming a trochanteric ridge a little above the middle of the shaft. The condyles are distinct from each other and are flattened below. One of them bears a robust longitudinal crest above, which makes it much larger than the other, and causes the groove that separates them above, to look outward, or to the side which supports the trochanter.

Three of the species may be distinguished as follows:

Vertebral centra much compressed, acute below; neural spines without processes.....*D. incisivus.*

Vertebral centra less compressed, obtuse below; neural spines without processes; larger.....*D. gigas.*

Vertebral centra compressed, not acute below; neural spines with cross projections.....*D. cruciger.*

DIMETRODON CRUCIGER Cope.

American Naturalist, 1878, p. 830.

This species is not uncommon in the Permian Formation of Texas. It is characterized by the enormous length of the neural spines of the lumbar vertebræ, which form the dorsal fin seen in other species of the genus. They are found in masses adhering together like sticks or branches of bushes. In this species the spine sends off, a short distance above the neural canal, a pair of opposite short branches, forming a cross. At various more elevated positions there are given off tuberosities which alternate with each other. They form on several consecutive spines oblique rows. The spines are broadly oval in section, the long axis antero-posterior, and have a shallow groove on both the anterior and posterior aspects. The centra are elongate as compared with their other diameters, and are much compressed between the articular extremities, leaving a strong inferior median obtuse rib. Articular faces of zygapophyses oblique. Diapophyses short and robust, with large costal faces, and standing below the prezygapophyses.

Measurements.	M.
Diameter of centrum, antero-posterior	.043
Diameter of centrum, vertical at end	.028
Diameter of centrum, transverse at end	.030
Elevation of posterior zygapophyses above centrum	.025
" cruciform process " "	.058
Expanse of posterior zygapophyses	.034
" cruciform process	.048
Diameter of spine at base, antero-posterior	.030
Diameter of spine at base, transverse	.020
" " .090 above base, antero-posterior	.016
" " .090 above base, transverse	.016
Length of several pieces of neural spines	.140

DIADECTIDÆ.

I have obtained three skulls of the *Empedocles molaris*, a species of this family, which display the occiput, and two of them the basis of the cranial and facial regions. From them I derive the following characters.*

The relations of the quadrate and zygomatic arches are as in the *Theromorpha* generally. The pterygoids extend to the quadrates, and the vomer bears teeth. The brain-case extends to between the orbits, and its lateral walls are uninterrupted by fissures from this point to near the origin of the *os quadratum*. There is an enormous frontoparietal foramen. The mode of connection with the atlas is peculiar. There is a plane facet on each side of the *foramen magnum*, which then expands largely below them. The bone which bounds it inferiorly, presents on its posterior edge a median concavity. On each side of this, is a transverse cotylus, much like those of an atlas which are applied to the occipital condyles of the *Mammalia*. They occupy precisely the position of the Mammalian condyles. The median point of their upper border, which forms the floor of the foramen magnum, is produced in the position occupied by the median occipital condyle of a reptile. From its position between the cotyli, the section of this process is triangular. The element in which the cotyli are excavated has the form of the mammalian basioccipital, and of the reptilian sphenoid. It is not the batrachian parasphenoid. Its extreme external border on each side where it joins a crest descending from the exoccipital, is excavated by a circular fossa which looks outwards.

The character of this articulation is so distinct from anything yet known among vertebrated animals, that I felt justified in proposing (l. c., p. 304) a new division of the *Theromorpha* to include the *Diadectidæ*, to be called the *Cotylosauria*. The superior facets described, indicate the presence of atlantal zygapophyses as in the *Ganocephala*.

There are three genera of *Diadectidæ*, one of which is now introduced for the first time. They are distinguished as follows :

I. Molar teeth in one series ;
  A distinct canine..... ..... *Diadectes.*
  No canine..... *Empedocles.*
II. Molar teeth in two series ;
  A canine..... *Helodectes.*

I am acquainted with six species of this family, two of each of the genera.

DIADECTES Cope.

Proceeds. Amer. Philos. Society, 1878, p. 505. American Naturalist, April 22, 1878.

The typical species of the genus has compressed teeth, with one end of the crown much more elevated than the other. In the lower jaw the inner extremity is the elevated one, and *vice versa*. There is a large tooth in the position of a canine in the inferior series, but it is not certain whether or not it is an incisor. A new species is now described which is intermediate

*These were first described in the American Naturalist, 1880, p. 304.

between the *D. sideropelicus* and the *Empedocles molaris* in the form of the molar teeth. The species are distinguished as follows :

Much inequality in the elevation of the extremities of the molars; lower tubercle small ..... *D. sideropelicus.*

Extremities of molars not very unequal in height; lower tubercle large..... *D. phaseolinus.*

DIADECTES PHASEOLINUS Cope. sp. nov.

This species is represented in my collection by the maxillary bones of three animals, and a portion of the mandible with most of the tooth line of a fourth. These fragments are of about the size of the *D. sideropelicus* and *Empedocles molaris.*

The molars possess a low cusp which is nearly in the middle of the tooth. Of the lower and external cusps, the internal is the wider and more rounded ; when unworn it is as elevated as the external, but it is soon reduced by attrition. The external part of the tooth is somewhat narrowed, and there is no horizontal surface on either side of the median cusp, as in *Empedocles molaris.* The last maxillary tooth is rather small; preceding it are eight wide transverse ones, and then two less extended transversely before reaching the broken end of my best specimen. The anterior of these is elongate, and may be caniniform, but its apex is lost. External layer smooth; some wrinkles round the base of the median cusp.

The broken base of the molar bone is subround and small, and shows that that element is slender below the orbit.

The portion of mandible preserved is quite deep, and is incurved at the symphysis. But few of its teeth are preserved, and it is not possible to say how long the anterior ones with subround bases may have been. The molar whose crown is preserved does not differ materially from those of the maxillary series. The alveolar line does not retreat inwards from the external border as in *Empedocles latibuccatus*, resembling in this respect the *D. sideropelicus.* The external surface of the lower jaw is roughened by shallower and deeper small or minute pits closely placed.

Measurements.	M.
Length of series of eleven maxillary teeth.....	.075
Length of series of seven widest molars.....	.048
Diameter widest molar { anteroposterior.....	.006
Diameter widest molar { transverse.	.016
Depth of mandible externally.....	.050
Width of mandible at middle.....	.026

It is possible that it may yet be necessary to refer this species to *Empedocles.*

EMPEDOCLES Cope.

Proceedings Amer. Philos. Soc., 1878, p. 516. American Naturalist, April 22, 1878 ; April, 1880.

I am acquainted with two species of this genus, *E molaris** and *E. lati-*

* *Diadectes molaris*, Amer. Naturalist, 1878, p. 565.

buccatus.* The latter is represented by portions of two mandibles in my collection; the former by two or three skulls, with part of the mandible accompanying one of them. The difference in the forms of the mandibles is well marked. In *E. molaris* the dental series is parallel to the external border of the jaw; in *E. latibuccatus* the tooth line is deflected inwards from the border, leaving a wide space.

Empedocles molaris Cope.

Diadectes molaris Cope. American Naturalist, 1878, p. 565.

The molar teeth are wider in this species than in any species of the family yet known. The internal and external extremities of the crown are about equally wide and equally elevated, and there is a low median cusp. A portion of the grinding surface both internal and external to the cusp is horizontal; the surface of this portion is wrinkled. The last molar is smaller than the others. The inner border of the maxillary bones forms a curved ridge on each side of the palate, which is separated by a groove from the vomer. The latter forms a median keel at the anterior portion of the palate, where it supports two rows of small conical teeth. The palatines have their prominent internal edges juxtaposed as far as the transverse line of the last molars. There they diverge a little, and extend as two nearly parallel keels to a prominent angle on each side, opposite the middle of the zygomatic foramen. There the inner borders cease to project, and are directed obliquely outwards to the inner extremities of the quadrate bones. The external borders of the pterygoids are more elevated than the internal. The median keel of the basisphenoid arises between the internal angles of the pterygoids above mentioned, and ceases before reaching the inferior border of the occipital condyle. The external border of the exoccipital is sigmoidally flexed.

It has occurred to me that the peculiar condition of the occiput described under the head of the family *Diadectidæ*, may be due to the loss of the basioccipital bone. It would be a remarkable coincidence if this accident should have befallen the only three crania which have come into my possession.

The anterior border of the orbit is above the anterior part of the fourth molar, counting from behind. The distinct incisive foramina are longitudinal and rather large. The anterior border is opposite to the fourth tooth counting from the first incisor. The nostrils look out laterally and a little forward; the united spines of the premaxillaries form a stout septum. The incisors are not more than three or four on each side (I cannot find the premaxillo-maxillary suture), and they form a regularly convex series. With the maxillaries, the entire dentition of one side forms a gentle sigmoid curve. The median incisors are the largest; the sizes regularly diminish until the smallest are reached on the anterior part of the maxillary bone. Posterior to this point they enlarge again. Their apices are not preserved.

* *Diadectes latibuccatus*, Proceed. Amer. Philos. Soc., 1878, p. 505.

The superior surface of the skull is only partly preserved in one specimen. This renders it probable that there is a crotaphite foramen as in the crocodiles, etc. The surfaces of the external cranial elements are finely pitted, or rather punctured.

Measurements.	M.
Total length of skull	.180
Width of skull at quadrates	.145
" " " origin of zygoma	.115
" " " incisive foramen	.056
Length of dental series to posterior extremity of incisive foramen, on curve	.090
Diameters of third molar from behind { anteroposterior	.010
Diameters of third molar from behind { transverse	.021
Depth of mandible at fifth molar from behind	.048

Maxillary series of seven, and parts of the mandibular series of four, individuals, are in my collection.

HELODECTES Cope. Genus novum.

Maxillary bones of two species, which I refer to this genus, were found associated with many bones of appropriate size, among which are vertebræ of the type of *Empedocles*. The characters observable are generally similar to those of the *Diadectidæ*, where I accordingly place the genus. Its principal characters, the presence of two rows of teeth in the jaws, has already been pointed out. I may add that there is apparently a large tooth in the position of anterior incisor, in the typical species.

The species differ in the arrangement of their teeth, as follows :

Molar teeth of the two rows subequal in size, and equally numerous ..... *H. paridens.*

Molar teeth of one row wider, and more numerous than those of the other ..... *H. isaaci.*

HELODECTES PARIDENS Cope. Sp. nov.

The smallest species of the family, is of about half the linear dimensions of the *Empedocles molaris*. It is represented by a left maxillary and probably premaxillary bone, which are so far covered with the adhesive, hardened ferruginous mud of the formation, as not to expose a clean surface. The apices of all the teeth are broken off, so that the bases alone remain to indicate their number, form and positions.

Of the molar teeth proper I count six in the inner, and eight in the external row. The two series are close together, and are gently convex inwards. The bases of the teeth are wide ovals, transversely placed. In front of the eighth tooth of the external row (from behind), are two teeth without apparent mates of the internal row (possibly the latter lost). Then follows a tooth of each row, and in front of these another pair, the external being the larger. Anterior to these, the jaw is so split as to remove any teeth of the inner row, if there are any, and one large tooth of the external series stands at the extremity of the fragment. This latter exceeds the

other teeth in the length and diameter of its basal portion. From its position it is probably an incisor.

The anterior border of the orbit falls above the third tooth of the external row (counting from behind). The inner border of the maxillary bone is elevated into the ridge convex inwards, as in the other species of this family. The malar base of the zygomatic arch is a moderately stout vertical oval.

Measurements.	M.
Length of dental series	.062
Length of molar 6-8 series	.029
Width of the two molar series	.009
Vertical diameter malar bone	.013

The associated bones of the skeleton may belong to this or to the next species, or even to a small *Empedocles* whose teeth occur in the same lot. In the uncertainty of reference I do not describe them.

HELODECTES ISAACI Cope. Sp. nov.

Founded on a fragment probably of a maxillary bone, lacking both extremities, and considerably obscured by ferruginous deposit.

The characters are well marked, leaving no doubt that this species is distinct from those previously known. The bases of the teeth of one of the rows are much more extended transversely than those of the other, having the form of some of those of *Empedocles*. As in that genus, they shorten anteriorly. In the fragment, I count on this row, bases of nine teeth. In the other row, I can only definitely count three, which are opposite the second, third, and fourth of the other series (counting from behind). They are wide transverse ovals, about half the long diameter of the posterior teeth of the other series.

Measurements.	M.
Length of bases of eight larger molars	.032
Diameter of large molar, anteroposterior	.004
Diameter of large molar, transverse	.008
Length of three smaller molars	.012
Long diameter of a smaller molar	.004

This species is dedicated to J. C. Isaac, the discoverer of the first species of this family.

GANOCEPHALA.

Examination of abundant material shows the correctness of my anticipation (American Naturalist, 1878, 633), that the vertebræ of the large batrachian *Eryops*, would turn out to have the structure found in *Rhachitomus*. This genus then must be referred to the same sub-order as *Trimerorhachis*, and probably *Actinodon* Gaudry, which will be characterized by the segmented vertebral centra. If European authors are correct in stating that the vertebræ of the *Labyrinthodontia* have undivided centra, the sub-order above mentioned must probably retain the name of *Ganocephala*, with additional characters.

The identification of the scapular arch in *Eryops*, and of the pelvic arch

in *Eryops* and *Cricotus*, gives the following result: The glenoid cavity is an excavation in two coössified elements, of which the inferior and posterior is probably coracoid. The latter is then much smaller than in *Reptilia* and *Batrachia anura*, but resembles that of the salamanders. The scapular arch proper resembles that of the *Urodela*. The pelvis is intermediate between that of the anurous and urodelous *Batrachia*. There is no obturator foramen, and the common symphysis is deep. The humerus closely resembles that of the *Pelycosauria*, differing chiefly in the non-enclosure of the supracondylar foramen; and as in that sub-order, some genera possess condyles and some do not.

Prof. Owen proposed the order *Ganocephala* chiefly for *Archegosaurus*, but he included in it also the genera *Denderpeton* and *Pelion* (Paleontology, p. 182–3). This division has not been generally adopted, the genera mentioned being usually placed in the *Labyrinthodontia*. Of the eleven characters given by Prof. Owen in evidence of the existence of this order, one only does not belong also to the *Labyrinthodontia;* this is the absence of occipital condyles. On this account I thought that the group should be retained, but not as an order. Besides this group and the *Labyrinthodontia*, there were the types called *Microsauria* by Dawson, some of which have simple enamel, all agreeing in general characters, and differing from other Batrachia. I therefore combined the three groups into one order, the *Stegocephali*. (Proceedings, Academy, Philada., 1868, p. 209.) This order was most distinctly characterized in the Report of the Geological Survey of Ohio, Paleontology, ii, p. 354, 1875.

Von Meyer has given us enough of the characters of *Archegosaurus* to enable me to refer the forms of the Texan Permian to the same order. Prof. Owen, in his discussion of the affinities of that genus (l. c., p. 170), remarks, that the vertebræ and numerous very short ribs, with the "indications of stunted swimming limbs, impressed me with the conviction of the near alliance of the *Archegosaurus* with the *Proteus* and other perennibranchiate reptiles." As it is now well known that perennibranchiate batrachians belong to three different orders of the class (*Trachystomata*, *Proteida* and *Urodela*), the above expressions lose point, and especially as the characters mentioned as indicative of affinity are of the most subordinate importance, or as in the structure of the vertebræ, are totally distinct from what is found in those orders. When we read later (p. 173), that the fact that the superior "ossifications of the skull have started from centres more numerous than those of the true vertebral system, gives the character of the present extinct order of *Batrachia;*" we find that Prof. Owen has quite failed to perceive either the definitions or affinities of his new order. He commits an error in describing a distinct pubic bone; an element which Von Meyer states (Paleontographica, vi, 179, 1858) that he had not discovered. Von Meyer describes the coössified inferior elements of the pelvis as ischia. My numerous Texan specimens show that each of these bones includes both pubis and ischium.

In now defining the *Ganocephala* anew, I confine myself to characters

which I know to be common to the known genera. Some of them possess two occipital condyles. For the purpose of avoiding the multiplication of synonymes, I employ Prof. Owen's name.

Vertebræ consisting of centra and intercentra, the former not extending to the base of the vertebra, the latter not rising to the neural canal. The centrum consisting of two parts distinct from the superior neural arch; viz., a lateral piece (pleurocentrum), on each side. Atlas consisting of separate segments, the superior of which are not united above the neural canal, and the inferior (intercentrum) divided on the middle line, into two segments.

Genera. *A.* Basioccipital bone without condyles: *Trimerorhachis* Cope; *Archegosaurus* Meyer. *A. A.* Basioccipital condyles two: *Actinodon* Guadry; *Rachithomus* Cope; *Eryops* Cope.

All the above genera have well-developed neural spines except *Trimerorhachis.*

ERYOPS Cope.

Paleontological Bulletin No. 26, p. 188. Nov. 21st, 1877. Proceedings Amer. Philos. Society, 1877 (1878), p. 188.

In the essay above cited, the cranial characters of this genus were pointed out with some of those of the vertebræ. It remains to describe the other parts of the skeleton. Notices of some of these have already appeared in the American Naturalist for September, 1878 and May, 1880.

The largest element of the vertebra is the intercentrum. This, which occupies the entire inferior surface of the vertebra, is a segment, representing the sixth part of a sphere, with a slight central vacuity. The element representative of the centrum is wedged in between the superior external angles of adjacent intercentra, as in *Trimerorhachis.* These, as well as the intercentra, differ from those of that genus in their greater degree of ossification, which is so far complete as to greatly contract the *canalis chordæ dorsalis.* The central elements of opposite sides do not unite on the middle line below, although in contact. The neurapophysis is produced downwards and outwards, terminating in the simple diapophysis, with rib articulation. The inferior articular faces of the arch are two on each side, one for the central element in front, and the other for the one behind it. The whole is surmounted by a continuous neural spine, which is expanded at the summit, in the known species. The vertebræ do not differ much in different parts of the column. The cervicals are not distinguished in any way from the dorsals, but their anterior intercentra have more extensive costal surfaces, which give the inferior posterior border lateral angles. The diapophyses of the second and third cervicals are of reduced size. The neural spine of the axis is a little less elevated, and is longer anteroposteriorly than that of the third and succeeding cervicals. I do not possess an entire atlas free from matrix. Attached to the axis of this specimen are two elements which connected it with the skull, as they are separated from it only by closely fitting fractures. The elements are lateral, and each presents a semi-spherical articular face in front, and a long process with acute apex at right angles to it, posteriorly. These processes lie, one on each

side of the neural spine of the axis, above the position which would be occupied by its prezygapophysis ; they represent the distinct halves of the arch of the atlas. At the superior base of each process near the edge of the articulation is a button-like tubercle, which represents a prezygapophysis ; the inferior articular faces correspond with those of the occipital condyles in form but not in position, which is inverted. The inferior elements of the atlas are lost.

The intercentra are rather longer and more elevated in the sacral region. One only can be properly said to belong to the sacrum, and this is closely united with the one that follows it by a rough surface of contact. In old animals it may become coössified. What the relations to the intercentrum immediately preceding may be I am unable to state, owing to the condition of the specimen. A pair of caudal vertebræ are peculiar. Their intercentra are in contact throughout, excluding the pleurocentra. The latter rest above the intercentra, and between the inferior parts of adjacent neural arches. Each intercentrum supports a coössified chevron bone, and these, in the two vertebræ in question, become coössified with each other, forming a robust rod directed backwards, whose double base is perforated by the hæmal canal. This peculiar structure probably belongs near the extremity of the caudal series, as the anterior caudals observed in other specimens, are much like the dorsals.

The costal articulations are everywhere undivided, and have an obliquely vertical extension. The articular surface extends to the intercentrum in the *E. megacephalus*, forming a short superficial depression which enters from the supero-posterior border. The costal surfaces of the diapophyses become more robust anteriorly, and are more narrowed, especially at the middle and inferior portions, posteriorly. The diapophysis of the sacral vertebra is very robust, and presents a large tubercular face downwards, and a little backwards. The external side of the intercentrum about its superior angle is also covered by a large capitular facet, and the two facets support a sacral rib. This element is much more robust anteriorly than the true ribs, and its capitular and tubercular facets are distinct from each other, although they are separated by but a slight interruption. The body of the rib is plate-like, and is directed downwards and backwards, its union with the ilium being squamosal. The costal elements posterier to the sacrum diminish rapidly in size. From the size of the vertebræ in *E. megacephalus*, the tail is probably of medium length only.

The coracoid is but little incurved; its internal border is convex, and is roughened as though for cartilaginous attachment. Its superior portion forms a convex continuum with the scapula. The direct line or external face of the scapula extends in a nearly plane surface to the glenoid cavity, embracing a perforating foramen above the latter, precisely as in the *Pelycosauria*. Its surface is continuous anteriorly with a wide expansion forwards, whose fine inner border is continuous with that of the coracoid. This plate doubtless includes a third element, but its borders are not preserved, on account of the obliteration of the sutures. It is probably epicoracoid, as in the *Pelycosauria*. In its form it is less produced than in the known scapular arches of the latter.

The coössified pelvic elements resemble, in their compression below, the corresponding parts in the *Anura*. The ilia are, however, shorter and worn as in the *Urodela*. They are flat, and stand at right angles to the line of the ischiopubic symphysis. There is an open concavity of their inferior posterior free border, and a facet-bearing elevation on the inferior border, or that entering into the formation of the acetabulum. The latter is large and half as long again as deep. The anterior and posterior borders of the pelvis descend regularly to the inferior edge, forming with it a triangle. The ischiadic or posterior border is but little thickened; the anterior, or pubic is flat in front and presents a reverted edge outwards. This expands prominently where it is joined by a ridge which bounds the acetabulum below; it there contracts to an inferior apex. Beneath the anterior point of the acetabulum it is pierced by the usual foramen, which issues on the inner edge of the anterior face, just above the symphysis.

The humeral bones of this genus I probably possess; but I have several forms between which I am not able to decide. They are in general like those of the *Pelycosauria*, but differ from them in not having an enclosed supracondylar arterial foramen, but only the buttresses of its enclosing arch. Two such forms I have already described,* and a third has been obtained from the French Permian by Professor Gaudry. One quite similar to the latter I have since obtained from Texas. Not having been able at first to determine the proper reference of these humeri, I suggested to Prof. Gaudry that his humerus belongs to one of the *Pelycosauria*, and he accordingly described it as *Euchirosaurus rochei*.† I now think that there is greater reason for believing that it belongs to a species of the same group as *Eryops* and *Actinodon*.

In all these humeri the extremities are expanded in different planes, and the shaft contracted. The articular surface of the proximal extremity is band like and passes obliquely from one side to the other as in the *Pelycosauria*. The condyles are large, consisting of a globular portion and a depressed trochlea without ridges at one side of it.

The femora are very different from the humeri, but in much the same way as in the corresponding bones of existing *Batrachia*. There are no condyles at either extremity, but outlines of such, enclosing roughened surfaces. These look as though the bases of attachment of cartilaginous caps or epiphyses. The proximal extremity is convex, and is extended in one direction. One border, the anterior, is regularly gently convex; the opposite arc is strongly convex near one end only. The articular face is in two planes, one larger than the other. The trochanteric fossa is at first shallow, and occupies the entire width of the bone, it narrows with the shaft downwards and the borders rise, one more than the other. The two join in a strong protuberance, which looks directly backwards, and may be called for the present the third trochanter. The shaft is keeled below and in continuation of the trochanter, to where it expands for the distal articu-

* Paleontol. Bulletin, 29, 1878, p. 529.

† Bulletin Soc. Geol. France, Dec, 1878.

lar extremity. The latter looks partly downwards, and is divided by a deep groove above into two parts representing the usual condyles. One of these is comparatively depressed, while the other has a massive superior crest, which makes its long axis vertical instead of horizontal, as is that of the other condyle.

There is considerable resemblance between this femur and that of *Dimetrodon gigas*, and in a less degree to that of *Clepsydrops natalis*, but both the latter have well developed condylar surfaces. They are also larger in proportion to the size of the rest of the skeleton, in the *Pelycosaurians* mentioned.

Further characteristics of this genus and of the species it embraces will be given at a future time.

TRIMERORHACHIS Cope.

American Naturalist, 1878, p. 328 (April 22). Proceedings American Philos. Society, 1878, p. 524.

This genus, as has been pointed out, differs from *Eryops* in the superficial character of its vertebral ossifications, and in the absence of ossified neural spines.

A well-preserved cranium, and portions of several others referrible to this genus, furnish characters which have been hitherto inaccessible. They probably belong to the *T. insignis*, but this is not certain.

Generic Characters, etc.—The type of skull is that of the order of *Stegocephali* generally. The superior walls are thin, and are sculptured on the superior surface. The mucous grooves are distinct, but do not form a well-defined lyra. There is a groove which is parallel to the anterior borders of the orbit for a short distance, and which then turns forwards and then inwards. The dermal ossification is distinguished from that of the maxillary bone by a squamosal suture. A mucous groove descends to it obliquely forward from the superior quadrate region, and sends a branch at right angles to its anterior extremity to a point posterior to the orbit. Of superficial ossifications, the boundaries are difficult to determine, owing to the obscurity of the sutures. Enough can be seen to demonstrate the presence of supramaxillary, epiotic, and supraoccipital dermal bones. The nostrils are large and well-separated, and look upwards.

The teeth are acute, and of subequal size; their superficial layer is deeply inflected at the base.

The parasphenoid bone is wide posteriorly, but contracts abruptly, and extends forwards on the middle line. Owing to crushing of a part of the surface, I am unable to ascertain its anterior, or vomerine suture. The basifacial axis bone is quite narrow, and is edentulous. It is connected with the superior cranial walls by a vertical osseous plate on each side, which may represent alisphenoid, orbitosphenoid and ethmoid. The palatopterygoid arch is a longitudinally extended sigmoid, enclosing with the axial elements, an enormous choanoörbital foramen. It extends from the middle line below a short distance posterior to the position of the nostrils

outwards, and follows closely the maxillary bone well posteriorly. It then turns inwards, extending to the parasphenoid bone, with the wide portion of which it has an extensive contact. It then turns outwards as pterygoid bone, and rapidly narrowing, joins the inner distal extremity of the quadrate. It thus encloses a foramen with the quadratojugal bone, which is much smaller than the choanoörbital foramen. The posterior part of the inferior surface of the bones of this arch, not including the slender pterygoid portion, is roughened with hard nodules resembling teeth in material, and serving the purpose of such organs.

Two rod-like bones extend outwards and backwards from the posterior part of the parasphenoid and the basioccipital, which belong to the inferior arches. The anterior is the larger, and is bent backwards at an obtuse angle ; its proximal extremity is a truncate oval. This bone occupies the position of the stapes. The second is extensively in contact with the basioccipital by its proximal extremity. It is curved backwards at its distal third. The occipital condyle is represented by a fish-like cotylus, which has a deep notch at its superior border.

The mandible has a short angular process, vertical by lateral compression. The symphysis is very short and the Meckelian cavity large, and completely enclosed.

The anterior cervical vertebræ consist of the same elements as the dorsals. The intercentra of the second and third vertebræ support capitular costal articulations, somewhat elevated above the surrounding level. The pleurocentra do not support the ribs, but the neural arches terminate below in diapophyses. There is a pleurocentrum in front of the second intercentrum, and above and in front of it a neurapophysis, which has no distinct diapophysis. Its superior portion is a subacute process which is not in contact with that of the other side, but is separated from it by a vertical osseous plate, which is probably the neural spine of the second vertebra or axis. This is similar to the structure already observed in *Eryops*, and the parts being in place, should explain those of that genus. The portion of the atlas which represents the intercentrum is divided into two lateral portions, each of which has the form of an entire intercentrum, i.e., crescentic. The intercentrum of a cervical of a large species of this group, is wider than that of the other vertebræ, and presents two articular facets anteriorly.

Specific Characters.—The skull is flat and rather wide, the length exceeding a little the transverse posterior diameter. The posterior borders of the orbits mark a point half way between the extremity of the muzzle, and the posterior supraoccipital border. The orbits themselves are of medium size, and are separated by a space about equal to their transverse diameter. Their form is a wide oval, with the long axis obliquely anteroposterior. The diameter of the external nostril is nearly half that of the orbit, and the form is similar to that of the latter. The interorbital and ethmoid regions are concave ; the prefrontal regions are convex. The supraoccipital border is strongly concave ; and the notch separating the epiotic angle from the quadrate angle is as deep as the supraoccipital. The

surface of the cranium is thrown into wrinkles which form no regular pattern, and which inosculate to a moderate extent, most so on the preorbital region. The anterior parts of the maxilliary and mandibular bones are marked with small pit-like impressions.

Measurements.	M.
Total length to quadrate angles measured on median line	.170
Length to supraoccipital border	.138
Total width posteriorly	.155
Width at orbits	.095
" between orbits	.021
" at nares	.062
" between nares	.030
Long diameter of orbits	.026
Transverse diameter of occipital cotylus	.012

This cranium is much shorter and wider than that of *Archegosaurus decheni*, and has the orbits more anteriorly placed.

CROSSOPTERYGIA.

ECTOSTEORHACHIS Cope, gen. nov.

Tribe *Crossopterygia;* family *Rhombodipteridæ* Traquair; sub-family *Saurodipterini* Huxley. Pectoral and ventral fins rather acutely lobate, with few or no radii on their external borders. Dorsal and anal fins unknown. Scales imbricate, rhombic, smooth. Ganoine wanting from top of head in specimens examined, but present on sides and inferior surfaces. Coronal suture distinct. End of the muzzle covered with separate scales. Distinct sub- and postorbital bones. Gular bones, an anterior azygus and two laterals on each side, the posterior the shorter. Teeth acutely conic, rather small; a few large ones at the anterior part of each jaw. Vertebral centra represented by osseous rings which enclosed a notochord.

This new genus is apparently nearly related to *Megalichthys*, and in a less degree to *Osteolepis* and *Diplopterax*. Pander, Miller and others represent the ventral fins of the two genera last named as not lobate, but sessile, a state of things entirely different from what is observed in *Ectosteorhachis*. The sub-division of the dermal bones of the muzzle is also rather characteristic of *Megalichthys*. From the latter genus it differs in the form of the vertebral centra. Both Agassiz and Huxley describe those of *Megalichthys* as completely ossified, and as biconcave. In *Ectosteorhachis* they are represented by annular ossifications resembling somewhat those of the stegocephalous genus *Cricotus*, but with a larger *foramen chordæ dorsalis*.

The elongate-lobate axis of the fins of this genus render it probable that those of *Megalichthys* present the same character.

ECTOSTEORHACHIS NITIDUS Cope, sp. nov.

This fish is represented by several specimens, the best preserved of which includes the head and body inclusive of the ventral fins. These form an ichthyolite nearly denuded of matrix, the inferior side being best preserved.

No indications of dorsal fin are to be found in the specimen, and those which exist must originate behind a point above the base of the ventral fins. The pectoral fins originate further behind the head than is usual. The ventrals are well posterior, and close together.

The skull is transversely fractured at the coronal suture, as I suppose it to be, which divides the front, just anterior to the point of attachment of the hyomandibular bone. At the antero-external angles of the parietals, are distinct post-frontal bones of a sub-triangular form, which send a process posteriorly from their external angle. The hyomandibular presents a narrow convex external edge, and is directed backwards and downwards. It leaves a wide space posterior to the postorbital bones. Of the latter there are two, the inferior connected with the front of the orbit by a single wide, suborbital bone. The orbits are as much lateral as vertical, and are in front of a transverse line dividing the skull equally. The muzzle is broadly rounded, and is covered with rounded plates of ganoine. Several of these have median perforations. The opercular apparatus is obscured by matrix in the specimens; a small bone lies on the inferior part of the suspensorium on both sides, and may be the preoperculum. The top of the head behind the muzzle is entirely without ganoine layer in two specimens; its surface is smooth, or weakly finely ridged. On the other hand, the premaxillary, maxillary, mandibular and gular bones are invested with perfectly smooth ganoine.

The pectoral fins are quite wide, and their rays diverge exclusively from the inner border, and are very fine. The axial portion is thick and acuminate, and has no fulcra on the external edge, but is covered with quadrate and rhomboidal scales, of very much smaller size than those of the body. The axial portion of the ventral fins is not quite so large as that of the pectoral.

The scales of the body are quite large and overlap each other by both the free edges. Though their form is rhombic, the apex is rounded. The surface is ganoid, and entirely smooth. There are five rows between the internal bases of the ventral fins, and twelve between the external bases of the pectorals. The gulars of the posterior pair are about as long as those of the anterior. There are anteriorly one and posteriorly two rows of plates between the anterior gulars and the mandible.

This fish was probably three feet in length.

Measurements.	M.
Length of head to base of first distinct lateral body scale (posterior border of skull damaged)	.161
Length to base of pectoral fin	.180
" (axial) to canthus oris	.077
" of skull to coronal suture	.067
" " " anterior border of orbit	.021
Width " at " " "	.065
" of front between " " "	.036
" " at coronal suture	.029

Measurements.	M.
Width of skull at canthus oris	.145
Length of inferior canine tooth	.006
Width between bases of pectorals	.092
Length of basal axis of pectoral	.060
" " " " ventral	.035
Width between bases of ventrals	.033
Diameters of exposed parts of an abdominal scale { fore and aft	.012
Diameters of exposed parts of an abdominal scale { longitudinal	.015

The *Megalichthys hibberti* Ag., which this species resembles in some degree, is represented by authors as having the scales minutely granulated on the surface. The ganoine layer also covers the superior surface of the skull, a peculiarity which is not present in the *Ectosteorhachis nitidus.*

Explanation of Figures.

Figure 1.—*Skull of Eryops megacephalus* from above, one fifth natural size.
Fig. 2.—The same skull, profile.
Fig. 3.—The same from below.
Fig. 4.—Mandibular ramus from above, one-fourth natural size.
Fig. 5.—A large part of the vertebral column of a second specimen from the left side, one-fourth natural size.
Fig. 5.—The same from below.
Fig. 7.—Anterior view of atlas and axis, natural size.
Fig. 8.—Posterior view of a dorsal vertebra, natural size.
Fig. 9.—Inferior part of scapula with coracoid, of same animal, external side.
Fig. 10.—Same, interno-posterior view.
Fig. 11.—Pelvis of the same individual, left side.
Fig. 12.—Same, from front.
Fig. 13.—Same, from behind.
Fig. 14.—Same, from below.
Fig. 15.—Femur of same individual, from above.
Fig. 16.—Same, from below and behind.
Fig. 17.—Proximal end.
Fig. 19.—Distal end.
Fig. 9.—Inferior view of skull of *Empedocles molaris*, one-half natural size.
Fig. 10.—Posterior view of the same skull, half natural size.
Fig. 11.—14 bones of *Dimetrodon incisivus*, one-fourth natural size, from a single individual.
Fig. 11.—End of muzzle, left side.
Fig. 12.—Lateral view of a large part of the vertebral column.
Fig. 13.—Thirteenth vertebra, lacking the summit of the neural spine, from behind.
Fig. 14.—Fourteenth vertebra, lacking apex of neural spine, from front.
Fig. 15.—Nineteenth vertebra of same skeleton, lacking most of neural spine, from behind, two-thirds natural size.
Fig. 16.—Sacrum of same from front, two-thirds natural size.

The above figures will appear in the Proceedings of the American Philosophical Society.

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SECOND CONTRIBUTION

TO THE

History of the Vertebrata

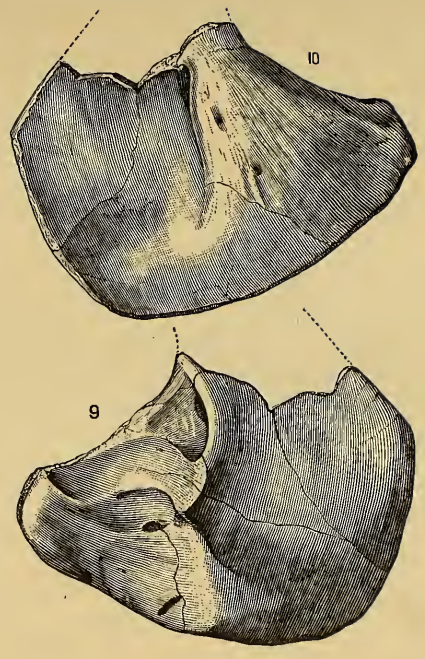
OF THE

PERMIAN FORMATION OF TEXAS.

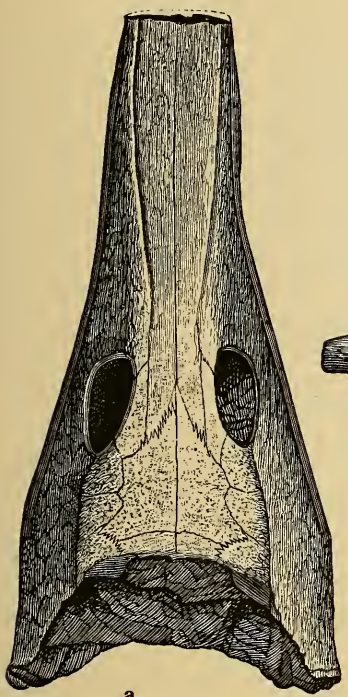
FIGURES.

BY E. D. COPE.

MAY 2, 1881.



ERYOPS MEGACEPHALUS. Fig. 1, $\frac{1}{5}$ nat. size. Figs. 9–10, $\frac{4}{15}$.



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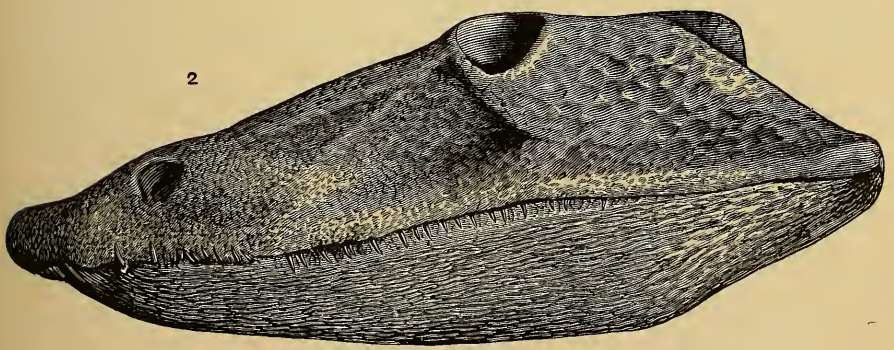

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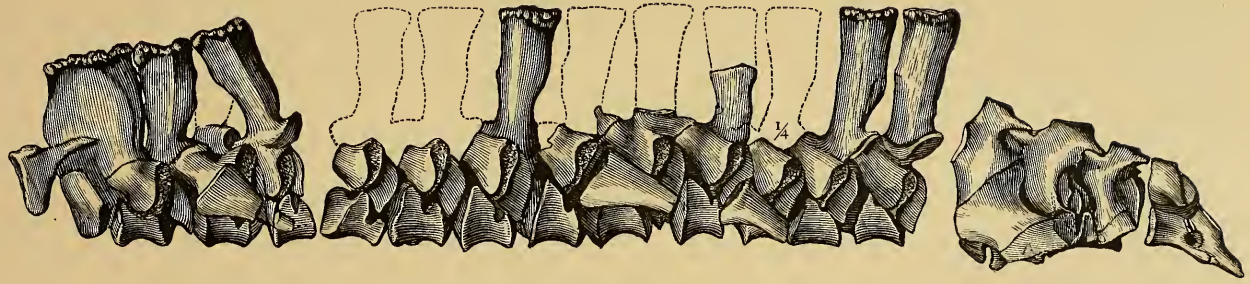
a–b CRICOTUS sp. $\frac{1}{2}$.

2 ERYOPS MEGACEPHALUS. $\frac{1}{5}$.



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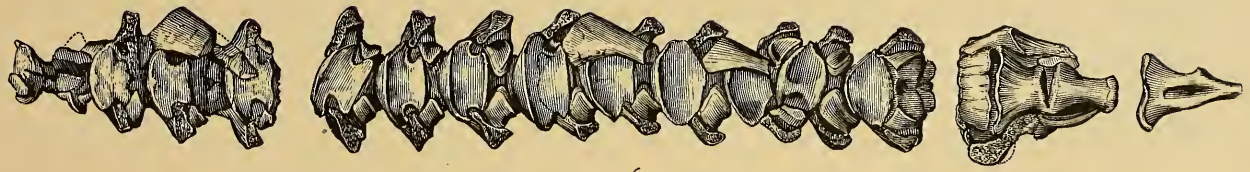

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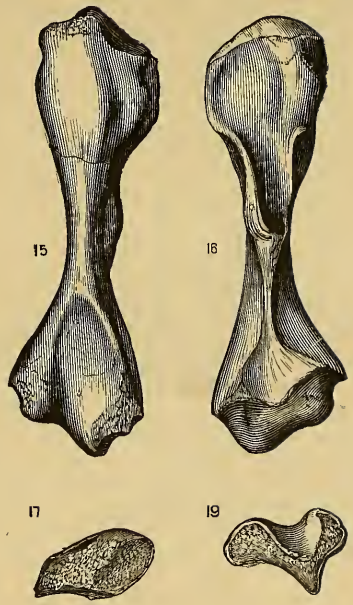
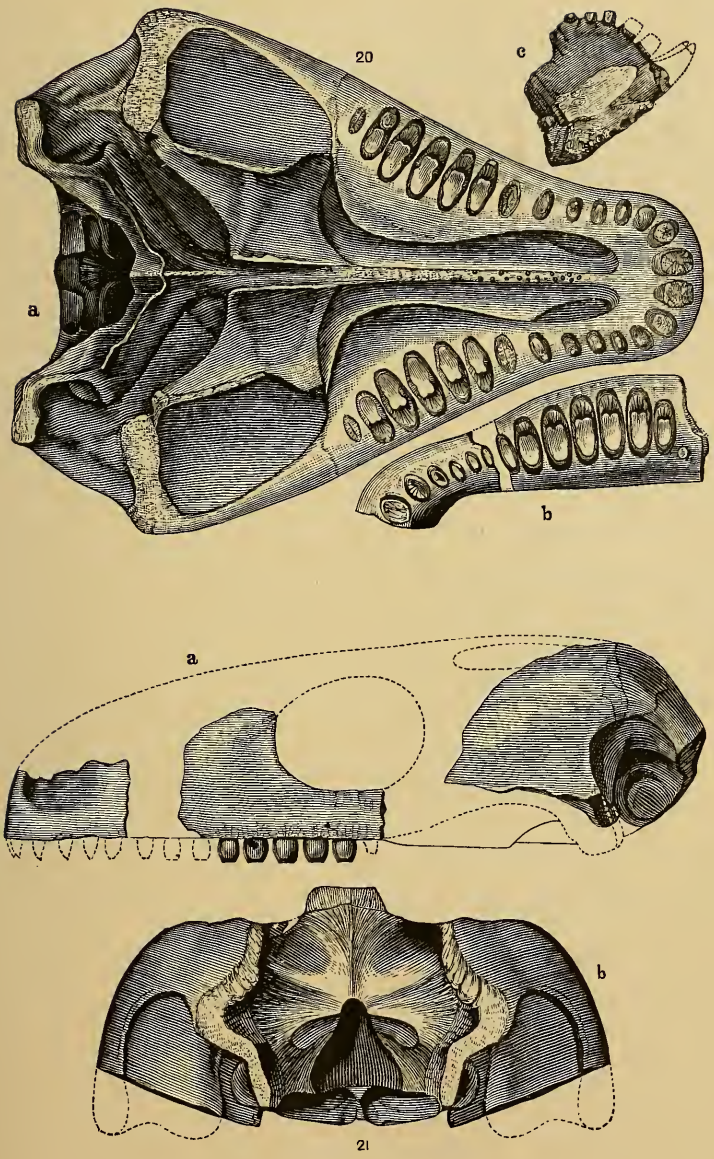
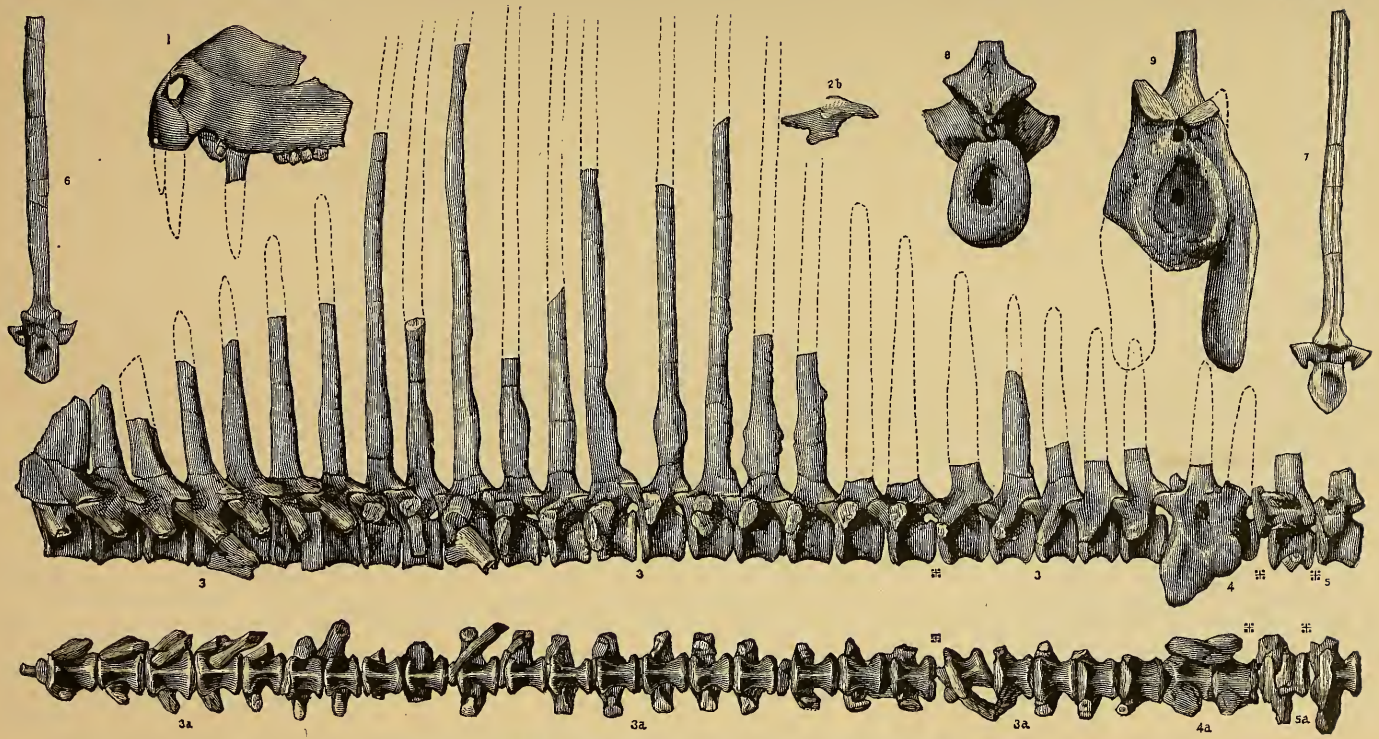
ERYOPS MEGACEPHALUS. $\frac{1}{4}$.



ERYOPS MEGACEPHALUS. $\frac{4}{15}$.



EMPEDIAS MOLARIS. $\frac{1}{2}$.



22–27 DIMETRODON INCISIVUS, $\frac{1}{4}$, except 8 and 9, $= \frac{2}{3}$.