A NEW URODELE FROM THE LOWER PLIOCENE OF KANSAS.

L. A. ADAMS AND H. T. MARTIN.

I. Introduction.

H. T. MARTIN.

The material herein described as the basis for a new genus of the Ambystomidae was discovered by the Paleontological Department of the University of Kansas. As a result of several seasons collecting, material representing about one hundred and fifty individuals was secured and placed in the hands of Dr. Adams for study.

In 1924, a sand quarry was opened in Sherman County, Kansas, on a branch of the Smoky Hill River, where the erosion had made a deep cut in the surrounding prairie. The particular stratum in which the amphibian material was collected is about twenty feet below the level of the prairie and consists of a fine silty deposit, from which we recovered bones representing a rich series of mammals, some birds and reptiles, and two amphibians. When, in the course of the excavating, small bones were discovered in the sand, sieves were procured and used, and about five tons of sand were carefully sifted to make more certain the collecting of this minute material. The only other amphibian bones found were some fragments of a frog.

The deposit in which the material was recovered is north of a quarry of the so-called Loup Fork Miocene, while directly south and bordering the Pliocene exposures is an outcropping of Fort Pierre shale. The sandy Pliocene, apparently, lies unconformably over the Fort Pierre. The general trend of the old stream bed appears to have been closely in line with the present Smoky Hill River drainage, following a course from northwest to southeast along the valley cut into the older Niobrara Cretaceous formation. The eastern edge of the Pliocene deposit terminates very abruptly at the steep, western side of the present gully, the eastern side showing not a trace of any Pliocene material. A mile east, over a high divide, Pliocene material shows again, but of a coarser sand and gravel intermingled with heavy boulders. Further east the high prairie covers all to a depth of from seventy-five to a hundred feet.

The deposit in which the amphibian material was found is

typical of the early Pliocene, and it must be judged by the geological conditions and by the animals associated with this material in the sands. Apparently it is impossible that there could have been much washing or transposing of the material, and one is forced to the conclusion that the skeletons of the amphibia and the other animals were laid down in the sands at about the same time.

The writer has found the following animals, associated with the amphibian material, in the Edson beds of the Early Pliocene, in Sherman County, Kansas:

PERISSODACTYLA
Aphelops, Parahippus, Merychippus, Pliohippus.

ARTIODACTYLA
Prosthenops (serus?), Procamelus, Pliauchenia.
Prosthenops crassigenis, Dromomeryx, Blastomeryx.

RODENTIA
Mylogaulus sp., Sciurus sp.

CARNIVORA
Canidae
Aelurodon, *Hyaenognathus cyonoides.*
Mustelidae
Brachypsalis marshalli.
Felidae
Pseudaelurus, Machaerodus.

CHELONIA, species not determined.
AVES, fragments not determined.
REPTILIA, fragments not determined.
AMPHIBIA, Anura not determined, Urodeles.

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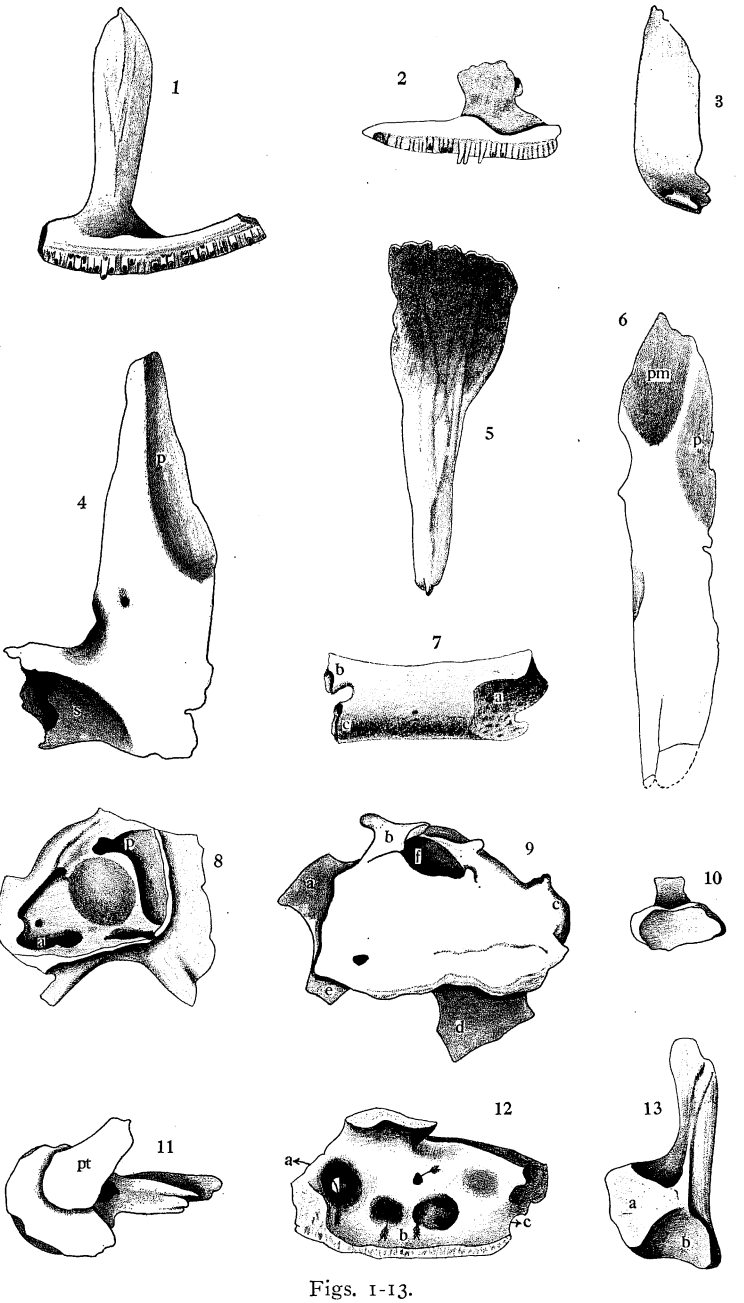
II. PLIOAMBYSTOMA KANSENSIS, gen. et sp. nov.

L. A. ADAMS.*

The small amphibian bones discovered by Mr. Martin represent a new form for the Lower Pliocene. The animal is quite close to the genus Ambystoma, but differs from this genus in several significant respects, so that it has been placed in a new genus in the family Ambystomidae.

* Contributions from the Zoological Laboratory of the University of Illinois, No. 343.



Figs. 1-13.

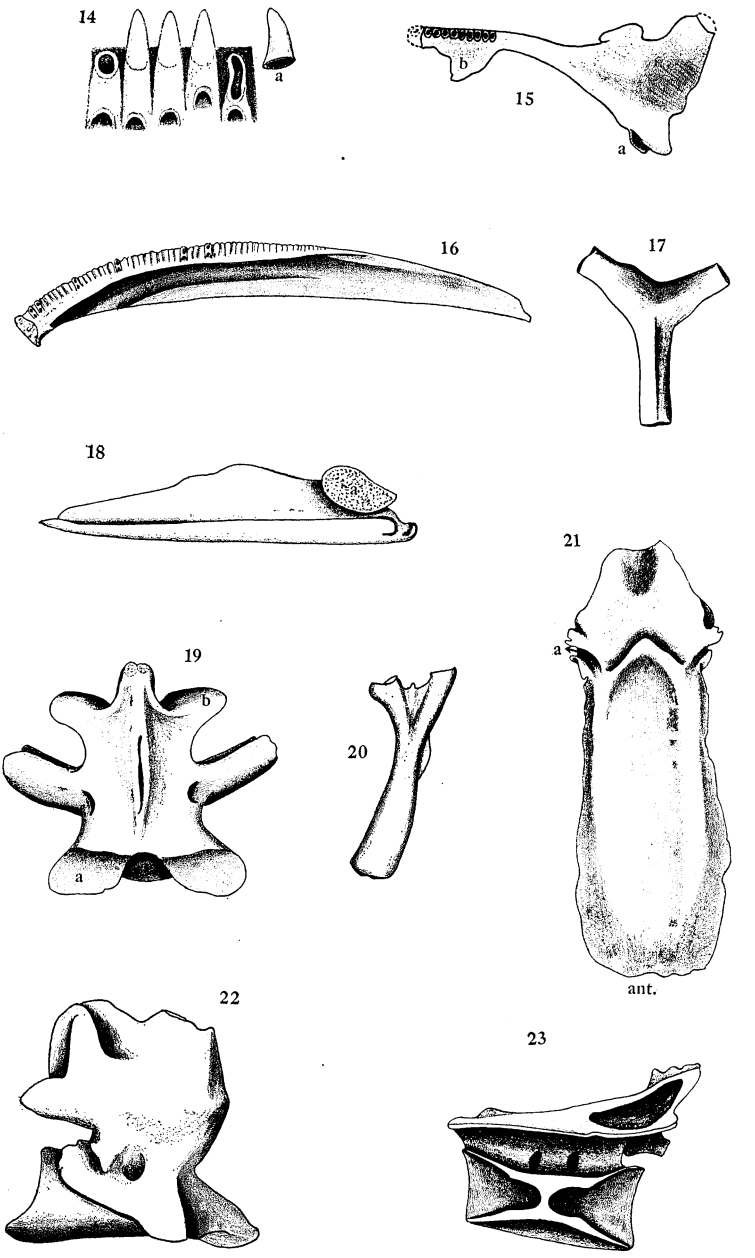
The skeletal material is almost completely disarticulated. The fossilization is complete, and the bones are in such excellent condition that they can be studied and articulated as though they were fresh skeletal elements. Evidently, there has been very little washing or movement in the sands since they were deposited, for such paper-thin bones as the parasphenoids are perfectly preserved. The few articulations found in place were all the result of peculiar abnormal conditions in which an ankylosis had occurred, namely: two otics and parietals; eight otic capsules in which the stapes were ankylosed in position; one quadrate with the natural articulation of the pterygoid; twenty-six angulars with the calcified articulars in position; and three mandibles with all of the elements associated in their natural position.

The only skeletal elements not found were nasals, vomers, carpals, and tarsals, and these are so small and fragile that even the most careful sieving would probably grind them to pieces.

FIGS. 1-13.

1. Premaxilla, right, inner face.
2. Maxilla, left, inner face.
3. Prefrontal, right, dorsal face.
4. Parietal, left, dorsal face.
   - p. articulation with prefrontal.
   - s. " " squamosal.
5. Squamosal, right, ventral face.
6. Frontal, right, dorsal face.
   - p. articulation with prefrontal.
   - pm. " " premaxilla.
7. Orbitosphenoid, right, outer face.
   - a. articulation with chondrocranium.
   - bc. articulation with otic capsule.
8. Otic capsule, showing roof.
   - a. anterior semicircular canal.
   - p. posterior semicircular canal.
9. Otic capsule, left, ventral face.
   - a. process for articulation of pterygoid.
   - b. stapes.
   - c. condyle.
   - d. process for articulation of right capsule.
   - e. process for articulation of orbitosphenoid cartilage.
   - f. foramen ovale.
10. Stapes, right, base of the operculum.
11. Quadrate, right, with part of pterygoid in position.
12. Otic capsule, left, mesial face.
    - a. foramen for cranial nerves IX and X.
    - b. foramina for cranial nerve VIII.
    - c. tunnel for cranial nerve V.
13. Quadrate, left, mesial face.
    - a. articulating face for the pterygoid.
    - b. " " " " articular.

All figures are x4 unless otherwise indicated.



Figs. 14-23.

DIAGNOSIS OF THE FAMILY.

The new Urodele agrees with the Ambystomidae in the following determinable points:—[1]

1. Palatines not prolonged posteriorly over the parasphenoids.
2. Orbitosphenoids separated from the proötic by cartilage.
3. Internal walls of the otic capsule osseous.
4. Pterygoids present.
5. Vertebrae amphicoelous.
6. Prefrontals present.
7. Premaxillaries fully developed.
8. Parasphenoid without dentigerous plates.
9. Second basibranchial, an isolated .

These are well-known characters of the family, and there can be no question as to the inclusion in this group. Some points could not be determined, such as: presence or absence of the ethmoid; ossification of the carpus and tarsus; type of the visceral skeleton; and condition of the nasals and vomers.

DIAGNOSIS OF THE GENUS.

Type of the genus, *Plioambystoma kansensis.*

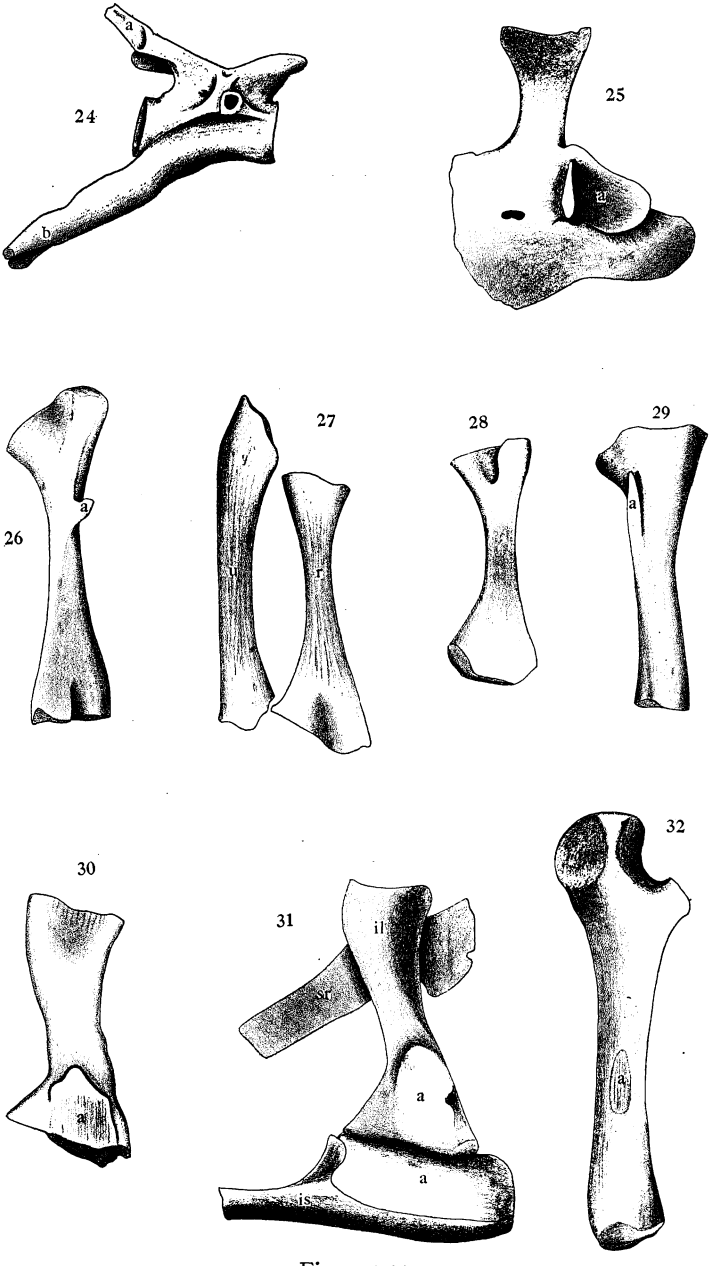
1. Palatine joined to the pterygoid and extending anteriorly, probably to articulate with the vomer—a condition suggesting the larval condition in Ambystoma.

FIGS. 14-23.

14. Teeth from the left maxilla x 25.
    a. tooth tip removed.
15. Pterygoid, left, ventral face (showing position of teeth).
    a. articulating surface for the otic capsule.
    b. palatine region.
16. Dentary, right, dorsal.
17. Second basibranchial.
18. Angular, left, outer face.
    a. articular in position.
19. Sacral vertebra, dorsal face.
    a. prezygapophysis.
    b. postzygapophysis.
20. Rib, left, third on left side.
21. Parasphenoid, dorsal face.
    a. exit of cranial nerve V.
    ant. anterior end.
22. Axis, right lateral face.
23. Body vertebra, sagittal section.

All figures are x4 unless otherwise indicated.

[1] Cope, E. D., Batrachia of North America. Smithsonian Institution. Bull. 34, p. 47. 1889.



Figs. 24-32.

2. Palatine end of the pterygoid element with teeth numbering 6-8.

3. Maxilla relatively short and wide, its width being contained 2 + times in its length, while in *Ambystoma tigrinum* the width of the maxilla is contained in the length 3 + times.

4. Tips of the teeth cone-shaped, as opposed to the peg-like teeth of Ambystoma.

DESCRIPTION OF THE TYPE.

Type No. 5250. University of Kansas.
Paratypes 5251, 5252, 5253.
Horizon and locality. Lower Pliocene, Sherman County, Kansas.

The skeletal system, as worked out from the disarticulated material, was based on the skeleton of *Ambystoma tigrinum*, for details that could not be determined, such as the number of the vertebrae, position of the girdles, and the number of ribs. It is assumed that the animal had sixteen body vertebrae (an axis and fifteen vertebrae with ribs), the sacral being the seventeenth, and thirty to thirty-five caudals.

Skull.

The premaxillae are similar to those of Ambystoma but somewhat smaller, averaging 7 mm. in length and 5 mm. in width. The number of teeth is less than thirty, while in Ambystoma the number is thirty-six or more. Fig. 1.

FIGS. 24-32.

24. Caudal, third, right side.
    a. neural spine.
    b. haemal spine.
25. Scapulo-coracoid, left, outer face.
    a. glenoid cavity.
26. Humerus, right, ventral face.
    a. spine for scapulo-humeral muscle.
27. Radius and ulna, right, dorsal face.
28. Fibula, right, ventral face.
29. Tibia, right, dorsal face.
    a. spine for iliotibialis muscle.
30. Ilium, right, outer face.
    a. part of acetabulum supplied by ilium.
31. Ilium, ischium and sacral rib in position.
    a. acetabulum.
    il. ilium.
    is. ischium.
    sr. sacral rib.
32. Femur, left, mesial face.
    a. surface for the attachment of the puboischiofemoralis muscle.

All figures are x4 unless otherwise indicated.

The maxilla is quite distinctive and differs from that of Ambystoma both in proportion and in the relative size. Proportionally, the bone is much shorter and wider in Plioambystoma, since the width is contained in the length 2 +, while in Ambystoma the width is contained in the length 3 + times. Posteriorly, the maxilla of Plioambystoma tapers abruptly to a sharp point, while in Ambystoma the taper is gradual. The dorsal process which articulates with the prefrontal is much larger in the fossil form. The teeth in the fossil form number 23-28, while those of Ambystoma number about 40. Fig. 2.

The frontal is a long, thin bone, slightly convex on the dorsal face with a very characteristic shape, its sides being parallel and tapering at both ends. The articulation of the pair is along a thin, mesial edge that may be either serrated or smooth. Posteriorly, they overlap the parietals for about half their length, some of the specimens showing distinctly where the prefrontal joins the bone on the lateral, anterior edge. Anteriorly, a well-marked depressed and roughened area shows the articulation of the premaxilla. Fig. 6.

The prefrontal is so thin and fragile that it is very unlikely to be preserved and recovered. Only five were found in perfect condition. The canal on its distal end is short instead of extending the entire width of the bone as in Ambystoma. It narrows abruptly at the proximal end, with the posterior border convex, while in Ambystoma the narrowing is gradual and the posterior border is concave. Fig. 3.

The parietals are slightly larger than in Ambystoma, measuring 12 x 5.5 mm., and the articulating areas are more strongly marked. The articulation of the prefrontal is generally quite evident as a marked surface on the mesial, anterior region of the dorsal face. The region for the articulation of the squamosal is roughened by a conspicuous ridge, making a strong connection, while the same area in Ambystoma is comparatively smooth. Some of the bones are serrate along the mesial edge where the pairs meet. Fig. 4.

The parasphenoid is slightly larger in the fossil form with some minor differences in proportion. It expands anteriorly to a noticeable extent, and in a large series few could be found with parallel sides, while all those studied in the modern form had parallel sides. The ventral face is smooth, with few marks except the groove at the posterior for the exit of cranial nerve V, and the marks of muscle insertions. The dorsal side is slightly concave, showing the outline of the groove for nerve

V and a roughened area for the articulation of the otic capsules. The articulation of the orbitosphenoid is marked by a slight area along the lateral edge of the face. The largest in the fossil form measured 19 x 7 mm., while the largest in Ambystoma was 17 x 6 mm. Fig. 21.

The palatine was found in but five cases, three perfect and attached to the pterygoid, and two that had broken off from this element. It is small and seems to approach the larval condition of the modern form, and evidently this condition is permanent, since all of the pterygoids show a break where the thin bar that connected them with the palatine was broken. It is assumed that this element articulated anteriorly with the vomer. Three specimens had six teeth, one seven and one eight. Fig. 15b.

As no vomers were found, nothing can be said of their condition, but they were probably somewhat like those of larval Ambystoma.

The pterygoid is quite striking in its shape and size and is important because of its bearing on the status of the genus. In the adult Ambystoma the pterygoid does not come in contact with the palatines or with any other bone of this region, while in the young the element has its normal articulation with the toothed palatine. During the metamorphosis the anterior connection is lost, the pterygoid becoming shortened and changed in shape, while the palatine joins with the vomer, as shown by Parker.[2] The pterygoid of the fossil form is a thin plate, well articulated with the otic capsule, and in contact with the squamosal and quadrate. Of the 53 pterygoids studied, but three were unbroken and joined to the palatine, 31 showed clearly where the palatine had been broken off, while the rest were so broken as to offer no evidence either way. While there is variability in the pterygoid, the form is fairly definite, and shows a number of differences separating it from Ambystoma. The articulation with the otic capsule is evidenced by a marked process on the latter. One specimen was found with the broken end of the pterygoid ankylosed to the quadrate, thus showing the size and the type of the process. Fig. 15.

The squamosal is a thin, spatulate bone, curved at the proximal end for the articulation with the parietal and joining the proximal process of the quadrate by a long, contact articulation on the distal, mesial face. As it curves, it widens into

[2] Parker, W. K. On the structure and development of the skull in the Urodelous Amphibia. Phil. Trans. Roy. Soc. Pt. 2, p. 562, 1887.

a spatulate shape and becomes slightly ridged and dentate. This element averaged larger than that of Ambystoma. Fig. 5.

The quadrate is a very characteristic bone with a heavy, angular distal end and a long, thin proximal process for the articulation with the squamosal. In general, the angles marking the articulations are sharper and more distinct than in Ambystoma. A small posterior articulation marks the joining with the ceratohyal. The distal end of the bone is heavy with a roughly rectangular articulation for the articulare. Figs. 11, 13.

The otic capsule is identical with that of Ambystoma except in size. It is entirely ossified with all of the suture lines obliterated, so that the limits of the exoccipitals and the otic bones cannot be determined. The capsules articulate dorsally with each other by a small, flat, mesial wing and ventrally along a thin, mesial flange that forms this part of the capsule. The posterior third of this flange forms the articulating surface. Dorsally the parietals cover most of the capsule, while on the ventral side the parasphenoid covers the median portion of each. The pterygoids fill in between the parasphenoid and the outer ventral face, so that little is exposed on the ventral side except the occipital region. The large foramen ovale marks the lateral face, together with a small foramen posterior to the condyles through which cranial nerves IX and X take their exit. On the anterior superior angle of the lateral face a large and prominent process marks the articulation with the pterygoid. The anterior edge of the inner face has two processes, a dorsal and a ventral, which articulate with the cartilage that lies between the capsule and the orbitosphenoid. The inner face has two foramina for the branches of the auditory nerve and, posteriorly, shows the inner openings of the condylar foramen. The inside of the capsule is quite large with the roof showing the tunnels through which the semicircular canals extend. The arrangement of the foramina is similar to those in the modern form in every case. The inner, or mesial, face shows the arrangement of the foramina in Plioambystoma, with a large posterior foramen for cranial nerves IX and X, two foramina for the entrance of the auditory nerve, and anterior to the auditory foramina, a large tunnel for cranial nerve V, which takes its exit on the ventral face, dorsal to the process for the articulation of the ptery-

goid. The capsule of Plioambystoma is larger than the modern form, measuring 8 x 6.5 mm., while in Ambystoma a large one measured 7 x 6 mm. Figs. 8, 9, 12.

The stapes is of the type found in the Ambystomidae. The opercular region is oval with a short columellar process on the outer face. The opercular face is 2 mm. long and 1 mm. in depth. One stapes was removed from the sand that filled the otic capsule in one specimen, and four others were found ankylosed to the foramen ovale, a condition often observed in modern forms. Fig. 10.

The orbito-sphenoid is placed on the side of the skull resting on the parasphenoid as a base, with the parietal as a roof. The posterior end is notched for the exit of the optic nerve. The notch is quite variable, being sometimes slight and sometimes completely enclosed to make a foramen. All degrees of this notching were observed in the hundred specimens studied. The anterior end is enlarged for the articulation with the cartilage of the chondrocranium, and the posterior end is joined to the otic capsule by means of a small cartilage. The outer face of the bone is convex, while the inner is deeply concave. Fig. 7.

The mandible consists of three elements, the dentary, the angulare, and the articular cartilage. On the whole the mandible resembles that of Ambystoma but differs in some important details.

The dentary differs from that of *Ambystoma tigrinum* in having a shorter tooth-bearing surface (12 mm. as against 16 mm.) and fewer teeth (50-55 as against 60-70), and it tapers gradually from the highest point to the symphysis, instead of dropping abruptly. Fig. 16.

The basal region of the angular is much heavier in Plioambystoma, so that there is a distinct difference in the ventral faces. The measurements are approximately the same. Fig. 18.

The calcified articular cartilage was found in position on twenty-six specimens. It is about twice as large as the same element in Ambystoma. Fig. 18a.

Teeth were found on three premaxillae, two maxillae, and two fragmentary dentaries. From the bases remaining it is possible to count the teeth and compare the number with living forms. They are cone-shaped and taper gradually from their junction with the bases to the tip, while in Ambystoma the teeth are peg-like and usually with a notch at the tip. Fig. 14.

Axial Skeleton.

The axial skeleton is somewhat problematical, since the vertebrae were all disassociated, so that there could be no determination of the number in the different regions. It is assumed that the number is the same as Ambystoma, with an axis and fifteen body vertebrae, one sacral, and thirty or more caudals. The vertebrae are amphicoelous and all of the body vertebrae are ribbed except the axis.

The axis is, in general, similar to that of Ambystoma with about the same proportions. The anterior face is triangular, measuring 6 mm. across the base and with the same altitude. The two articular facets for the condyles are elliptical. The ventral surface of the centrum is rounded on its posterior half, where Ambystoma has a pair of sharp ridges. The foramina are variable but the one through which the spinal nerve I takes its exit is always prominent. There is a tendency for the development of a spine on the side of the centrum anterior and ventral to the post zygapophyses. This is quite variable and is not a stable character. It is in the position of a diapophysis. In eighty-six specimens, seventy have no spines, ten have weak or single spines, and six have strong double spines. The anterior face shows different proportions as the neural spine is slightly larger in Ambystoma. The neural canal is practically circular in this vertebra. Fig. 22.

All of the body vertebrae have dia- and parapophyses for the articulation of the double-headed ribs. These processes are progressively more dorsal on the vertebrae until the eleventh is reached, when they again become progressively lower to the last of the body series. The neuropophyses are not forked in any of the body vertebrae and assume a more nearly horizontal position as the posterior end of the column is approached. Fig. 23.

The sacral vertebra is easily recognized by reason of its relatively large transverse process, the articular face of which is crescent-shaped. The neural canal is elliptical in shape. There is always a large foramen present just posterior to the transverse process, and usually several smaller ones. Fig. 19.

The caudals are very distinctive and can be divided into several groups by different features. The first nine have transverse processes. The first two have no haemal arches. The haemapophyses appear abruptly on the third caudal, where the haemal spine is the largest, and continue through generally to about the twenty-first. The neural spines are distinctive

in that they are all forked, the forking starting on the first or second caudal and continuing to about the twenty-third. The number of caudals was probably 30-35. Fig. 24.

There are fifteen pairs of bicipital ribs, all more or less curved. Their size and curvature increase rapidly from the first to the third and then decrease gradually from the fourth to the fifteenth. There is a gradual reduction in the size of the tubercular head as the ribs approach the posterior end of the series, and the fifteenth may not have the tubercular head articulated with the parapophysis at all. The first four vertebrae have diapophyses of about equal length, but from the fifth to the fifteenth the diapophysis becomes progressively smaller. Fig. 20.

The sacral rib has the appearance of being single-headed because the two heads are so close together. It is slightly thicker than the other ribs and has a more or less pronounced enlargement (muscle attachment?) at about the middle of the superior edge. There is no mark on the outer face to indicate the position of the articulation with the ilium. Fig. 31. sr.

Visceral Skeleton.

No part of the visceral skeleton was found except the Λ-shaped, triradiate, second basibranchial. Twenty-four of these were found. The quadrate shows a distinct surface for the articulation of the ceratohyal so it is certain that this system was present and probably somewhat like that of Ambystoma. Fig. 17.

The scapula and the coracoid are firmly joined, making a single structure for the support of the anterior limb. This element is quite similar to that of Ambystoma. In a large series the coracoid shows much variability in shape. The distal end of the scapula is always slightly forked, while the same part in Ambystoma is straight or slightly curved at the most. Evidently the cartilaginous suprascapula was about the same size as in Ambystoma. The coracoid foramen is always present and is generally smaller than in Ambystoma. It is probable that the procoracoid and the cartilaginous part of the coracoid were similar to those in Ambystoma. The suprascapula was, no doubt, associated with the second body vertebrae. Fig. 25.

The humerus is of slightly smaller proportions than in Ambystoma. Both the proximal and the distal ends are 1 mm. less in width than in the modern form, measuring only 4 mm.

Both show a prominent spine on the posterior side of the shaft for the insertion of the scapulo-humeral muscle, which originates on the base of the inner face of the scapula and attaches to this spine. Fig. 26.

The ulna shows no striking differences or distinctive characters that would separate it from Ambystoma. In size it is slightly shorter. The olecranon face is slightly concave where the radius articulates with it, but in general the olecranon process is convex. A strong ridge marks the palmar process. Fig. 27.

The radius has a well-marked notch at the proximal head, where it articulates with the ulna, and a muscle ridge extending along the same face. The distal end, which is convex on the palmar aspect and concave on the dorsal, broadens rapidly for the articulation of the carpal bones. Fig. 27.

No carpal bones were recovered, but numerous toe bones were collected, so that the foot could be reconstructed on the plan of Ambystoma.

Posterior Limb and Girdle.

The ilium has a characteristic hour-glass shape with a large articulation for the femur. There is no mark on its inner face to show where it articulates with the sacral rib by a contact. The dorsal edge is slightly forked, and the ventral edge articulates with the ischium. The ilium is similar to that of Ambystoma but is slighter. The acetabular region is triangular in shape with the apex placed dorsally. Figs. 30, 31.

The ischium is always completely ossified as in Ambystoma, it joins with the ilium to form the acetabular fossa for the femur. The anterior region is thickened to form the acetabular facet and the articulation for the pubic cartilage. Posteriorly, it becomes much thinner, as does the mesial edge where the two ischia join by a strip of cartilage. An ischiac tuberosity marks the posterior end. Fig. 31.

The pubis, being cartilaginous, was not preserved.

The femur is smaller than that of Ambystoma and is different in several minor respects. The anterior face is marked by the trochanter, which is prominent. Some of the specimens show the insertion of the puboischiofemoralis internus on the ventral side of the shaft. Fig. 32.

The tibia is marked by a spine on the dorsal, mesial face for the insertion of the iliotibialis muscle. The proximal articulation of the tibia and fibula is by a strong notch in the

fibula into which the tip of the tibia fits snugly. The distal face of the tibia is small and rounded for the articulation with tibiale. Fig. 29.

The fibula is a distinctive bone with the anterior face cut in on the external edge to receive the small projecting process from the tibia. The distal end for the articulation of fibulare and centrale is long and oval in shape. Both the tibia and the fibula are smaller than those of Ambystoma. Fig. 28.

Numerous toe bones were found, but no tarsals.

Comparative table of measurements of *Plioambystoma kansensis* and *Ambystoma tigrinum* (in millimeters).

BONE	PLIOAMBYSTOMA		AMBYSTOMA	
	Length	Width	Length	Width
Premaxilla	7	5	8	7
Maxilla	6.5	3	9.5	3
Frontal	11	2.5	13	2.5
Parietal	12	5.5	11	5
Parasphenoid	18	7	17	5
Pterygoid	12	6	6	8
Otic capsule	8	6.5	7	6
Stapes	3	2.5	2.5	1.5
Squamosal	12	3.5	8	3.5
Quadrate	7	3	7	3
Orbitosphenoid	6	2.5	7	2
Dentary (Chord)	20	3	20	3
Angulare	15	4	16	4
Basibranchial	5	4.5	4.5	4.5
Rib No. 5	6	2	6	2
Scapula and Coracoid	10	8	11	8
Humerus	13.5		15	
Ulna	9		10	
Radius	8		8.5	
Ilium	8		8	
Ischium	8	5	9	5
Femur	12		13	
Tibia	7.5		9	
Fibula	7		8.5	

Relationship of *Plioambystoma kansensis.*

The relationship of Plioambystoma to modern forms raises some questions as to changes in the palate in the Ambystomidae, since the condition of the pterygoid and the palatine in the fossil form seems to be indicative of a larval condition existing in an adult form in the Lower Pliocene. The palatine and pterygoid are joined in Plioambystoma, much as they are in Axolotl, and it would seem that this condition was permanent in the fossil form. Fig. 15.

As shown by Parker,[3] there is a gradual retraction of the anterior branch of the pterygoid in the immature Ambystoma, so that in the adult condition, the pterygoid does not come in contact with any of the bones of the anterior palatal region, and the palatine joins with the vomer to form the covering of the palate in the region between the premaxilla and maxilla. It seems, therefore, that the Ambystomidae originally had pterygoids extending anteriorly and articulating with the palatines and retained this connection in the adult form.

As far as the writer knows, this is the only Urodele of the family Ambystomidae that has been found in the Pliocene. It thus represents a group that was in all probability ancestral to some of the present-day Ambystomidae. The Judith River Beds (Upper Cretaceous) contain fossils of two genera, Scapherpeton and Hemitrypus, described by Cope[4] from vertebrae only. These seem to belong to the Ambystomidae, but their exact place in the classification awaits the discovery of material a little more varied than Cope had. Urodele finds in the Pleistocene have been more frequent. In the Conard Fissure, Brown[5] found a number of vertebrae and other bones from Urodeles. His plate XXII shows several bones—femur, ulna, humerus, fibula, scapula-coracoid, and a couple of vertebrae which appear to belong to the Ambystomidae and probably to the genus Ambystoma. Peterson,[6] in the Frankstown Cave, found some Urodele material that he assigned to the family Plethodontidae and a single vertebra that he assigned to Cryptobranchus.

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[3] Op. cit.

[4] Cope, E. D. Synopsis of the Extinct Batrachia of North America. Proc. Acad. Sci. Phila. p. 208, 1868.

[5] Brown, B., The Conard Fissure. Mem. Mus. Nat. Hist. 9, Pt. 4, p. 206, 1909.

[6] Peterson, O. A., The Fossils of the Frankstown Cave, Blair County, Pennsylvania. Annals Carnegie Museum 16, p. 249-297.