A Survey of the Fossil Vertebrates of Kansas

H. H. LANE
University of Kansas, Lawrence.

PART II: AMPHIBIA*
SUPERCLASS TETRAPODA

In contrast to the fishes with their paired fins, all those vertebrates which have legs to support the body and for locomotion are grouped together in the Superclass Tetrapoda. Typically, there are two pairs of these appendages, the anterior or pectoral pair of limbs, corresponding to man's arms, and the posterior or pelvic pair, corresponding to man's legs. However, in some cases, the anterior pair may be modified into wings for flight, as has happened in three known cases among the tetrapods; or, the two pairs may be reduced to one, usually the anterior. In some snakes vestiges of the hind pair may be found, with no trace of the front pair; in a few other snakes vestiges of the front pair may be present, although the hind pair may have been entirely lost. In most snakes, however, as well as in some lizards and a few amphibians, both living and fossil, both pairs of limbs have been lost. Generally speaking, the normal habitat of the tetrapods is the land; however, some, e.g., the whales among the mammals and certain reptiles, have returned to live in the water and have transformed their pentadactyl limbs into flippers for swimming; and, of course, many amphibians, as well, are wholly aquatic.

The transformation from fish to amphibian was of more fundamental importance than most other changes which the vertebrates have undergone. Compared with it, changes from fresh to salt water, or from terrestrial to arboreal or volant habit, are insignificant. But although the amphibians succeeded in making this momentous change, on the whole they have never been successful in mastering the land. They have never been able to emancipate themselves from the water—and fresh water at that—except in the case of a few exceptional species. In most instances their eggs must be laid in water; their young are larvae ("tadpoles" or "pollywogs") that must have water in which to live, feed and grow. Even the

*For Part I of this Survey (The Fishes) see these Transactions, volume 47, pp. 129-176 (1944). Part I also contains a time chart of rocks exposed in Kansas, the classification of vertebrates, and a glossary of geological and biological terms.

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adults must, in general, keep near the water or at least damp situations in order to keep from drying out and mummifying. In the water, however, the amphibians are at a disadvantage in competition, with most fishes; and on land they are unable to overcome their handicaps in competition with their own offspring, the reptiles. So, crowded out of the water and barely able to maintain themselves on shore, they have never played a conspicuously successful rôle in vertebrate life.

**CLASS AMPHIBIA**

The *Amphibia* constitute a class of tetrapods that is, on the one hand, very closely allied in structure and mode of life with the fishes, and, on the other hand, has such a marked superficial resemblance to the reptiles that few persons not professional zoologists distinguish between them. However, the fact is that in many respects the frog, for example, is far more highly specialized than most living reptiles, other than the snakes. The name “*Amphibia*” is from the Greek “*amphibios*”, signifying “double life”, in allusion to their most distinctive characteristic, namely, a true “metamorphosis”, or change of form, that occurs when the larva becomes like the adult, except in size. Their young are typically wholly aquatic, respiring by means of gills and propelling themselves through the water by means of a large compressed tail. At first, the tadpole has no more resemblance to its parents than a maggot has to a fly, or a caterpillar to a moth. Later, but gradually, the tadpole grows legs, resorbs (not loses) its tail and gills, develops lungs and nostrils, replaces its temporary larval mouth with the “true” mouth of an adult, and becomes a land-living form, such as a toad or frog.

Arising, in so far as now known, in the Upper Devonian of Greenland, the *Amphibia* underwent their greatest changes in form during the Mississippian, Pennsylvanian and Permian times, although one order, the labyrinthodonts, did not reach their zenith until the Triassic. The *Class Amphibia* includes eight orders of which three are wholly extinct, while the others all have living representatives. They are “cold-blooded”, or, more accurately speaking, their body-temperature varies with that of their surroundings since they have no physiological mechanism for its control. In the living amphibians, with the exception of the *Apoda*, the skin is totally devoid of scutes, scales or plates, but many of the extinct forms had dermal scutes or bony plates more or less covering the body. The living *Apoda* have peculiar scales buried in the skin, either on the
ventral side of the body only, or all over, as in the Mexican genus *Siphonops.*

Different amphibians are aquatic or terrestrial, some even fossorial, and breath by means of gills or lungs, or the skin of the general body-surface, depending upon the habits and structure of the species under consideration. The heart consists of three chambers, two auricles and one ventricle. The skull in living amphibians (and in many of the extinct forms as well) articulates with the back-bone by means of two articular surfaces (*condyles*), but in many of the earlier extinct forms this articulation involves a single structure—sometimes, however, with clear indications of a division into three parts—one median and two lateral, the last represented by the condyles in modern amphibians. The pelvic girdle ("hip-bones") is attached to the back-bone by means of a single pair of sacral ribs. The appendages of the amphibians may be adapted to walking, crawling, leaping, climbing, or swimming; more rarely they may be reduced or absent.

**OUTLINE CLASSIFICATION OF THE AMPHIBIA**

**PHYLUM CHORDATA**

**SUBPHYLUM VERTEBRATA (=CRANIATA)**

**SUPERCLASS TETRAPODA**

Class AMPHIBIA

Subclass I. **STEGOCEPHALIA**

Order 1. *Ichthyostegalia*

Order 2. *Lepospondyli*

Order 3. *Labyrinthodontia*

Suborder a. *Embolomeri*

Suborder b. *Rhachitomi*

Suborder c. *Stereospondyli*

Order 4. *Apoda (=Caecelia=Gymnophiona)*

Subclass II. **CAUDATA (=URODELA)**

Order 5. *Proteida*

Order 6. *Mutabilia*

Order 7. *Meantes*

Subclass III. **SALIENTIA**

Order 8. *Anura*

Suborder a. *Amphicoela*

Suborder b. *Opisthocoela*

†Personal communication from Senor Professor Manuel Maldonado-Koerdell, Polytechnic Institute, Mexico.

*Entirely extinct.
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Suborder c. Anomocoela
Suborder d. Procoela
Suborder e. Diplasiocoela.

SUBCLASS I. STEGOCEPHALIA

The Subclass Stegocephalia comprises four orders, of which three are entirely extinct; the fourth living, with no certainly known fossil representatives. In form the members of this subclass generally resemble a modern salamander, or an alligator, with the tail often more or less adapted for swimming, i.e., flattened from side to side (compressed). The skull consists of a solid "roof" of bones, perforated only by the nasal openings, the orbits of the eyes, and the parietal foramen—the last to accommodate a third eye that was located on the top of the skull in the median line slightly back of the paired eyes. This is absent in the living *Apoda*. The skull surface is frequently sculptured and also marked with grooves for the lateral line system of sense-organs. The teeth are usually conical and sharp-pointed, mostly with a large pulp-cavity, and with simple or complex, radially arranged folds of dentine and enamel, which finally are so complex as to deserve the appellation of "labyrinthine". The origin of this type of tooth structure may be seen among the early crossopterygian fishes (see pages 150-152, Part I, of this survey, Dec., 1944); later stages also occur in these fishes, but the climax is reached only in the amphibian order of *Labyrinthodontia*. The bodies (centra) of the stegocephalian vertebrae are varied in form and structure, and constitute the basis for the determination of the several orders and suborders as given in the table of classification (p. 288). On the throat and "chest" (thoracic) region there are generally three externally sculptured bony plates forming the ventral part of the shoulder (pectoral) girdle. In contrast to the other subclasses of amphibians, the *Stegocephalia*, as a rule, possess a well-developed dermal skeleton consisting of ossified scutes, scales, or rods, especially on the ventral side of the body, but sometimes covering the under sides of the legs as well; in a few cases similar structures are also more or less well-developed on the dorsal side of the body. The ventral scales or rods are generally arranged in oblique rows, and vary extremely in form.

ORDER 1. ICHTHYOSTEGALIA

The earliest amphibians at present known are two genera (*Ichthyostega* and *Ichthyostegopsis*) from the Upper Devonian of
Greenland. These genera are so primitive that they must be set off from all known later members of the class in an order to themselves, called the *Ichthyostegelia*. They are surprisingly large for early amphibians, the skulls alone being six inches or more in length—high and narrow after the manner of most fishes, instead of broad and flat as in most later amphibians. Every bone, except one, occurs in these skulls that has been found in the skulls of the higher tetrapods, and in addition there is the noteworthy persistence of the *preopercular*—the last remnant of the gill-cover of the fishes—as well as a *rostral* bone on the front end of the snout. Still another crossopterygian reminiscence is found in the location of the *external nares* (nostrils) on the *under* side of the head and separated from the *internal nares* by a slender bar of bone only. However, the lower jaw has extended forward enough to cover the internal nares, while leaving the external exposed. Any statements concerning the habitat and habits of these, the oldest amphibians, would be purely conjectural, but it is clear that the climate of Greenland in the Upper Devonian was far different from that to be found there now. Certainly, instead of "icy mountains" Greenland then must have been a land of semi-tropical climate and "coral strands"; and as such it continued until a much later date in the history of the earth.

**Order 2. Lepospondylida**

The *Order Lepospondyli* is made up of small amphibians, at first rather like the modern salamanders in form, with a rather long body and tail, moderately developed legs, and a skull of normal amphibian proportions, *i.e.*, broad and very flat. However, divergence in these characters arose at a very early date, and even degenerative changes appeared, such as the loss of limbs and the development of a greatly elongated eel-like body, indicating a completely *aquatic* life. In general, when present, the hind limbs are longer than the front ones; the *pubes* are ossified, a condition rarely found in amphibians elsewhere except among the early labyrinthodonts. Furthermore, many of them have elements of the wrist (*carpus*) and ankle (*tarsus*) also fully ossified—another condition rarely found among the amphibians. The teeth are simple and conical with large pulp cavities, but no infoldings of dentine and enamel are found. The ventral surface of the body is protected by an armor of oval scales.

The *Lepospondyli* are so called because of the shape of their vertebrae, which have the form of constricted cylinders, enclosing the continuous notochord. They are frequently compared to a spool or
an hour-glass in shape. The neural arches rest upon the centra, either sitting loosely, or united by a suture, or sometimes even firmly coössified with them.

This order, chiefly of small-sized creatures, was on this account formerly called the "Microsauria". It reached its peak in numbers and variety in Pennsylvanian time, when its members outnumbered all other amphibians combined. It was a relatively short-lived group, for there were but three known survivors in the earliest Permian, and not one in later time. The oldest known lepospondylids are from the upper Mississippian, yet, because of the high degree of specialization which had even then been attained, it is evident that they must have arisen much earlier. Apparently the only lepospondylid yet found in Kansas is an undetermined species of nectridian—possibly belonging to the genus Sauropleura, or to one closely related to that genus—from the Rock Lake shale of Anderson County.

The second line of nectridians included creatures with small legs, a broad flat body, and a bizarre plowshare-shaped skull with its postero-lateral angles produced into horn-like projections. Diplocaulus (Fig. 1) of the Lower Permian was the culmination of this line of aberrant development. Its body was two feet or more in length and almost as broad as long. Its legs were not only disproportionately small but they were attached well within the lateral borders of the body and probably took small part in locomotion. While Diplocaulus is known only from Texas and Oklahoma, in the latter state it occurs so close to the Kansas state-line, that there can be little doubt that it actually lived in this state. Its head as a whole was so large and massive and had so much heavy bone in it that it could not have been lifted from the ground on land. Only in the water could this misfit creature have moved at all, as is clearly indicated by its broad body and long, flattened tail. Its teeth, small, delicate and conical, suggest a diet of soft animal or plant materials. It was thus a highly specialized animal that had departed widely from its ancestral type and had become degenerate.

ORDER 3. LABYRINTHODONTIA

The Labyrinthodontia are so named on account of their most striking feature—the structure of their teeth, in which the infolding of the enamel and dentine into the pulp cavity follows such an extremely tortuous course that a cross-section of a tooth (Fig. 2) reveals a complicated pattern that is truly labyrinthine. This order of amphibians is made up of heavy, clumsy animals with heads long,
wide and flat; bodies broad and very stout; tails generally short. The thighs and upper arms are attached at right angles to the body so that the latter is suspended as in a sling, resulting in a slow, awkward, waddling gait. All but one of them known have but *four* fingers on the hand, though all have *five* toes on the foot. They include practically all the larger amphibians of the late Mississippian, Pennsylvanian, Permian and Triassic times. Relatively few in the Carboniferous, fairly common in the Permian, they attain their maximum in size, number and variety of form in the Triassic, during which time they spread to all the continents, except possibly South America.

The more generalized of the labyrinthodonts were certainly ancestral to the earliest reptiles, which greatly resemble them, and yet they are structurally not far removed from the earliest tetrapods. On the other hand, they were in part prophetic types, for as Gregory has shown and as Romer points out, “almost every skeletal element of a bird or of a man may be traced back to these primitive types. Later forms have greatly modified the shape and relationships of parts and there have been frequent losses of bones, but the fundamental pattern laid down in the early tetrapods still persists.”

Three suborders of the *Labyrinthodontia* are usually recog-
nized—the distinctions being based upon the structure of their vertebrae and other parts—namely, the Embolomeri, the Rhachitomi, and the Stereospondyli.

"Phyllopondyli"

In paleontological textbooks and journals a supposedly early "order" of amphibians has been widely recognized under the name of the "Phyllopondyli". A recent study of these forms by Romer, however, has demonstrated that as an order the Phyllopondyli do not exist. The Branchiosouria and other forms heretofore assigned to it are simply small and immature (i.e., larval) labyrinthodonts belonging to the suborders Embolomeri and Rhachitomi. The typical branchiosaurs are small, imperfectly ossified, short-headed, and in many cases certainly gill-bearing. These features in themselves indicate larval stages. Even Credner's monograph on the branchiosaurs is replete with evidence that supports Romer's conclusion. We therefore give no place to the "Order Phyllopondyli" in our table of classification.

Suborder A. Embolomeri

The Embolomeri are very primitive amphibians common in the Upper Paleozoic swamps, from two feet in length up to a size comparable to that of a modern alligator. In general proportions they are somewhat like modern salamanders, though the body is proportionally higher and more rounded. Apparently more aquatic than otherwise, they probably fed on the small palaeoniscid fishes (see Part I of this survey, pages 152-153) of their time, as well as on one another. In the many details of structure and mode of life they were still much like the ancestral crossopterygian fishes. The most obvious difference lies in their possession of legs instead of fins. Remnants of the old fish scales were still present, but confined to the ventral side of the body in V-shaped rows. The most ancient Embolomeri occur in the Mississippian, and had their head joined to the anterior end of the backbone by means of a single occipital condyle. The neck was short, with only four or five vertebrae; the trunk was long and cylindrical, supported by a series of vertebrae, whose bodies were composed of two rings of bone, threaded like beads on the persistent notochord (Fig. 3). The ribs were double-headed and were borne on neck, trunk and tail vertebrae. The tail was long and laterally flattened, so that it evidently was an efficient organ of locomotion.
The structure of the vertebrae just described is called "embolomericus", from the Greek, meaning "cut in two parts", the first of which, called the intercentrum, is intercalated between the adjacent pleuracenta. The well-developed neural arches, and, in the tail region, the haemal arches as well, rest upon the intercentra (Fig. 3).

![Image of vertebral structure]

**Fig. 3.** Embolomericus vertebrae of Spondylus, from Moodie in K. U. Science Bulletin, Vol. VI, No. 2, Jan., 1912, plate 9, figure 1. Natural size.

n, neural arch; i, intercentrum; p, pleurocentrum.

The neural arches, in turn, bear special articular processes called zygapophyses. On the anterior end of the vertebra these zygapophyses consist of a pair of rounded articular surfaces which face upwards to meet the posterior pair on the vertebra next anterior, which face downwards. Between the ilia, or dorsal elements of the pelvis, there is a single pair of enlarged sacral ribs with which the ilia articulate. This arrangement permits better support of the body-weight on the hind legs, as well as giving the latter a more substantial part in the forward propulsion of the animal in locomotion.

The dorsal surface of the skull is covered with dermal bones, recalling the condition in the crossopterygian fishes, and still has, in addition to orbits for the usual pair of eyes, an opening on the top of the head for the third eye, which was commonly present in all the early amphibians. In the strictly aquatic embolomeres the old piscine lateral line system of sense organs was still retained, forming grooves over and under the eyes and elsewhere on the lower jaw and rear portion of the skull.

The first embolomere recorded from Kansas belongs to the genus *Cricotus*, an incompletely known form with an elongated body and short, sturdy limbs. The long triangular skull has a reduced
snout; the large, oval eyesockets are located at about the middle of the length of the skull. The dermal bones roofing over the head are weakly sculptured, and carry grooves for the accommodation of the lateral line canals. The embolomeric vertebrae are disk-shaped in the caudal region, but anterior to the sacrum the pleuracentra and intercentra are horseshoe-shaped, the pleuracentra alone bearing the neural arches and the ribs; in the caudal region the neural arches are jointly supported by one each of these two elements, while the haemal arches are borne exclusively by the intercentra. The abdominal plates are rhomboidal in shape, closely packed in V-shaped rows.

*Cricotus* occurs from Illinois southwestward through Kansas and Oklahoma into Texas. It is obviously a fish-eating type with sharp-pointed conical teeth that varied in size in different parts of the jaws. Its skull articulates with the backbone by means of a single condyle only. *Cricotus heteroëlitus*, the largest species, is about ten feet long. It was first described by Cope in 1884 from the Upper Pennsylvanian deposits on Salt Creek, in Illinois. Williston described a specimen from the Upper Pennsylvanian of Cowley County, Kansas, in 1897.

**Suborder B. Rhachitomi**

This suborder of the labyrinthodonts occurs from the Upper Pennsylvanian to the Lower Triassic. Its members are very large forms, especially those in the Permian and the few survivals in the Triassic. The name indicates their most striking characteristic, namely, the “dissected” condition of the vertebral centra, due to the failure of the large ventral wedge-shaped intercentrum to fuse with the paired lateral pleuracentra (Fig. 4). In the skull, the palatal vacuities are medium to large; the occipital condyles, double or triple.

**FIG. 4. Rhachitomous vertebrae: diagrammatic. Original.**

*na,* neural arch; *Ic,* intercentrum; *Pl C,* pleurocentrum.
Of the dozen or more known families of rhachitomes, only one has so far yielded a representative in Kansas. This is the genus *Eryops* of the Permian, which was among the largest forms of its suborder; in fact, it is one of the largest amphibians of any sort that ever lived in America, reaching a length of eight feet or more, while its body and limbs are massive. Its skull in some specimens is more than two feet long and up to eighteen inches broad across its posterior end, and is somewhat depressed. The bones of the skull are both tuberculated and pitted. The sutures and the parietal foramen usually disappear with age. The relatively small eyes lie just back of the middle of the length of the skull. The external nares are large. The teeth in the jaws are conical and rather small; a pair of larger teeth are located on the palatine and prevomer. The parasphenoid bone on the base of the skull is broad and dagger-shaped. The ribs are notable for the presence of uncinate processes. Contrary to the general habit of amphibians, *Eryops* has five toes on both the front and hind feet; although one on the front foot is vestigial. The limbs are short and powerful, such as would be needed by an animal that spent most of its time on land, even though near the water into which it could plunge for an occasional wetting of its skin. Its shoulder girdle does not articulate with the skull; the pelvis, on the other hand, is united with the vertebral column through a single sacral rib on each side.

*Eryops* was collected in "the red-beds of Kansas" (Cowley County) by the late Dr. S. W. Williston in 1899; the species was identified as *Eryops megacephalus*.

**Suborder C. Stereospondyli**

The *Stereospondyli* are the largest, the last and the most specialized labyrinthodonts, sometimes with a head three to four feet
The skull is much flattened and the paired eyes look directly upward, indicating a bottom-dwelling habit. Since the lower jaw articulates with the skull well back of the occipital condyles, as in modern crocodiles, the gape is enormous, and it may be, as some maintain, that they "opened the mouth by lifting the upper part of the head while the jaw rested on the mud". Their many teeth are sharp-pointed and conical, and two at the front of the jaw are so long in some species that they pass through openings in the upper jaws in front of the nostrils, actually protruding from the top of the skull when the mouth is closed. The body and tail are short, though the trunk is broad and flat. The ventral side of the pectoral ("chest") region is protected by a broad breast-plate composed of three bones—a pair of clavicles ("collar-bones") and an interclavicle—upon which is borne the weight of the anterior part of the body while at rest.

Although confined mostly to Triassic time, nevertheless the stereospondylids became common the world around, and some of them apparently even became marine. No other amphibian, ancient or modern, is known to be able to withstand the toxic effects of sea water for any appreciable length of time. Two genera of Stereospondyli have been recorded from Kansas. The first was described in 1897 by Dr. S. W. Williston from the "Coal Measures" (? Manhattan limestone) near Louisville, Pottawatomie County, Kansas. The specimen was collected by Herbert Bailey and consists of a single tooth with some associated bone fragments. Williston compared this tooth with those of Mastodonsaurus from the Triassic of Germany, and was unable to detect any differences between this Upper Pennsylvanian tooth and those of the Old World Triassic form, so he assigned it (KUMVP No. 457) to that genus, but refrained from giving it specific designation. Mastodonsaurus, as might be inferred from the name, was probably the largest of all the labyrinthodonts. Its skull is about four feet long, subtriangular in shape, with very large openings for the eyes lying just back of the middle of the skull length. Two additional openings in the pre-maxillary bones, anterior to the nostrils, accommodate a pair of very long teeth in the lower jaw.

The most extreme development of labyrinthine teeth known distinguishes this genus (Fig. 2). In the smaller paleozoic stegocephalians the teeth are small slender cones with large pulp cavities. In later genera the lower half or two-thirds of the length of the tooth is externally furrowed or ribbed, and the dentine is in folds to
an equal height, radiating inward toward the pulp cavity. In *Mastodonaurus* the radiating folds of dentine and enamel follow tortuous courses, some extending only partially, others completely through the substance of the tooth, and convert it into a literal labyrinth when observed in cross-section.

The second stereospondyloid from Kansas was described by Moodie in 1911 under the name of *Erpetosuchus kansensis*. This species is represented in the United States National Museum by a fragment of a skull, portions of two ribs, and the larger part of the left half of the lower jaw, 305 mm. long (USNMVP, Cat. No's. 6680 and 6699). These fragments are labelled as from the “Coal Measures, Washington County, Kansas”, and very likely came from the eastern edge of that county near the bank of the Little Blue River, or a tributary of the same. Although *Erpetosuchus* was originally referred to the “Coal Measures”, there is yet the possibility that it actually came from the *Lower Permian*, for no actual Pennsylvanian outcrops are known to occur in Washington County, though they seem to be present in adjacent Marshall County, near Marysville.

**Order 4. Apoda**

The systematic position of this order has not been a stable one. It has been regarded as the most highly specialized of all living amphibians. Some authorities have included it among the *Caudata* close to the Amphiumidae (See p. 288). Others have placed it at the bottom of the line of living amphibians as an independent order not closely related to any other. But recently the conclusion has been advanced that the Apoda represent a highly specialized but degenerate group of stegocephalians closely related to the Lepospondyli.

Whatever the final decision may be, it is clear that the Apoda at present constitute an order of legless, burrowing amphibians of tropical or subtropical distribution. The group comprises over fifty species living in South America, Central America, Mexico, Africa, India and Ceylon. They are wormlike in appearance, with short tails or none at all. Superficially their skin is smooth and naked, but buried within it are many peculiar scales, either covering the whole body (*Siphonops mexicana*) or limited to the ventral side. *This is the only occurrence of scales in living amphibians*. Although not exceeding ten inches in length, the backbone may be made up of no less than 250 vertebrae. The whole order is clearly a highly specialized and degenerate one; their eyes are vestigial, but the tactile
sense is evidently keen; a retractile tentacle lies in a groove below, or in front of, each eye and it functions as a special organ of touch.

No apodan is known from Kansas, either living or fossil.

**Subclass II. Caudata (==Urodela)**

The Subclass Caudata comprises a large number of species which have an elongated body and tail, in some instances so long as to be eel-like or snake-like in proportions. They have either two or four legs of nearly equal size, i.e., with the hind pair not enlarged for leaping. They include both primitive and specialized forms. Some are wholly aquatic throughout life; others leave the water after passing through the larval (“tadpole”) stage and become terrestrial. The changes in the tadpole as it becomes adult are, in most instances, not very great, while in others they amount to a real metamorphosis. Some retain their external gills throughout life, even in cases where functional lungs are also developed, as in the mud-puppy (*Necturus maculosus*). The waterdogs and newts have the tail compressed (i.e., flattened from side to side) to function as the chief organ of propulsion in swimming. The terrestrial salamanders have a rounded tail and resorb their gills as they become adults; in others the gills atrophy although the gill-slits may remain open; others dispense with both gills and lungs, and the soft moist skin of the body functions as a respiratory organ.

The *Caudata* have received a variety of popular names, such as salamander, mudpuppy, waterdog, hellbender, newt, evet and eft. By many they are mistakenly called “lizards”, because some of them look a bit like such reptiles, from which they are easily distinguished by the absence of scales. Moreover, the terrestrial caudates live only under stones, rotten logs, and in damp situations generally, never in hot, dry habitats where lizards abound.

The caudate skull is generally notable for the absence of many bones well-developed in the stegocephalians, particularly in the brain-case (*cranium*) which is largely cartilaginous. In fact, as this condition reveals, there is considerable degeneration clearly manifest in the skull and jaws of these amphibians. The caudal vertebrae are of several types, some acentrous, some biconcave (*amphicoelous*) and some convex in front but concave behind (*opisthocoelous*). The trunk vertebrae bear ribs which may be well developed or reduced to mere vestiges. Both the pectoral and pelvic girdles are less completely ossified than in the stegocephalians. The limbs are attached to the girdles so that their proximal elements are usually at right
angles to the body, thus making for a slow, awkward, waddling gait. The pubis is never ossified; the bones of the limbs are less so than in their paleozoic relatives; the wrist (carpus) and ankle (tarsus) are rarely ossified. There are never more than four fingers on the hand although the foot generally has five toes. Claws are absent in all cases.

Fossil representatives of the Caudata are few and give little insight into their origin and the course of their development. Only one skeleton is known from the Mesozoic—Hylaebatrachus croyi from the Lower Cretaceous of Belgium. This was a little fellow about four inches long, apparently with three pairs of gills. Its front legs were shorter than its hind pair, but the number of toes, four in front and five behind, is characteristic. It had extremely short ribs and its tail contained at least fifteen vertebrae. Its relationship to other caudates is uncertain but it seems to belong somewhere near the cryptobranchids (see below, p. 302).

Throughout the Cenozoic Era, the remains of Caudata are likewise very rare and mostly modern in structure and appearance. A newt has been recorded from the upper Eocene or lower Oligocene of France on the basis of a few detached vertebrae and limb-bones, under the generic name of Megalotriton. From the lower Miocene, near Bonn, have come fragmentary remains of Molge (=Triton). Molge is a member of the modern European fauna, but "Tylotriton, living today in southeastern Asia and on one of the Loo-Choo Islands (Iwo Jima), has recently been discovered in the Miocene of Switzerland" (Noble). From the upper Miocene of Oeningen, Switzerland, in 1726, came Andrias, a cryptobranchid genus about the size of the related giant salamander living today in China and Japan. Triturus, the common newt, is a well-known member of the living fauna in both Europe and North America, but it occurs also in the Miocene and more recent formations of Europe. Most finds of fossil caudates have consisted of fragments not sufficiently characteristic to determine with certainty their relationships to living genera. However, they suffice to make sure that salamanders lived in Europe at least as early as the Oligocene. This is the reason why Europe is and long has been the center of variation and dispersal of salamander species.

The Subclass Caudata, for our purpose, may be most conveniently divided into three orders:

1. The Proteida; 2. The Mutabilia; and 3. The Meantes.
Order 1. Proteida

The members of this order never lose their gills, hence are often referred as "perennibranchs". They include the well-known genus *Necturus*, with some seven named species, of which *Necturus maculosus*, the "mudpuppy" living in the streams throughout the eastern United States from the Great Lakes to the Gulf States and westward into eastern Kansas, is the largest and best known species. It is commonly used as an "example" of a *primitive* caudate in courses in comparative anatomy. The second genus is *Proteus*, the blind, usually rosy white newt, or "olm", of the caves of Austria and other nearby parts of Europe. It turns dark, almost black, when exposed to light for a considerable time and is famous among zoologists because it has the largest red blood-corpuscles of any known vertebrate. It is somewhat less than a foot in length, whereas *Necturus* may reach a length of 18 inches.

It is generally agreed that these two genera are *permanent larvae* as indicated by the largely cartilaginous skull; the absence of maxillary bones; the mutual relations of the palatines and pterygoids; the absence of eyelids; and the retention of the plumose external gills. In fact the whole branchial apparatus is larval except the loss of the fourth arch. Another striking larval character is the lack of the *rectus abdominis* muscle. *Proteus* is even more larval than *Necturus*, since it has only three fingers and two toes on its appendages, whereas *Necturus* has four and four. Both genera habitually walk on the bottom, though capable of rapid swimming under the propelling power of the well-developed compressed tail which is provided with large dorsal and ventral median fins. No fossil representatives of this order are known.

Order 2. Mutabilia

This order may be divided into three natural suborders, termed respectively the *Cryptobranchoidea*, the *Ambystomoidea*, and the *Salamandroidea*. Though distinct enough now, they all appear to point back to a common ancestry.

The members of the *Cryptobranchoidea* are probably the most primitive of the *Mutabilia* as shown by the more generalized condition of the skull and skeleton, the persistent gill-slits, and the small eyes without obvious lids. They are permanently aquatic. To this suborder belongs *Cryptobranchus alleganiensis*, the "hell-bender", found in the rivers and smaller streams from western New York state through Pennsylvania to the Ohio River and its tributaries, and
south to Georgia and Louisiana. It is particularly at home in the Alleghany Mountains of Virginia. It reaches a length of 18 to 20 inches, and is looked upon with superstitious fear by fishermen who may catch it on the hook when after catfish. It is really altogether harmless and probably as good to eat as catfish. Its gill-slits are normally reduced to one pair. Its color is brown or dark gray above, and lighter below. It feeds voraciously upon worms, crustaceans and small fish, and is said to destroy great quantities of the valuable whitefish. Its larva is unknown.

Our Cryptobranchus is a smaller relative of the giant Japanese salamander, Megalobatrachus, living in China as well as in Japan, which sometimes reaches a length of five feet or more. It is used for food by the natives of those countries. It differs from our hell-bender also in the total absence of gill-slits and in the associated modifications of the branchial apparatus. It occurs in small mountain streams at elevations varying between 600 and 4500 feet above sea-level. It feeds upon worms, insects, fishes and amphibians. It has been known to live for more than fifty years in captivity.

The Hypnobiidae of eastern Asia, the most primitive of all existing Mutabilia, also belong to the Cryptobranchoidea. Structurally they are very close to known extinct fossil forms. Certainly belonging in this suborder is the famous Andrias scheuchzeri from the upper Miocene of Oeningen, Switzerland, referred to above, discovered in 1726 and described by Scheuchzer himself as “Homo diluvii testis”, i.e., a man who was a witness of the Noachian deluge. If it has not been removed or destroyed in this war, it is in the Teyler Museum in Haarlem, Netherlands. It is about three feet long as preserved, but in life may have been as large as the living giant salamander of Japan. Another smaller species (Andrias tschudii) occurs in a lignite deposit near Bonn, and still another has been taken from the coal beds of Bohemia. Only one fossil cryptobranchid has thus far been found in North America, and this was described by Dr. Harold J. Cook from the lower Pliocene of Nebraska under the generic name of Plicognathus. It may well have lived in Kansas, though as yet not recognized here.

The Suborder Ambystomoidea includes only one family with but six recorded genera: Ambystoma, Dicamptodon, Rhyacotriton, Plioambystoma, Lanebatrachus and Ogallalabatrachus, comprising over a dozen species, living or extinct, and widely distributed from southern Alaska to Mexico, and from Long Island and the Atlantic Coastal Plain, as far south as Florida, westward to Texas and
Mexico; also across southern Canada from Ontario to British Columbia; and throughout all the continental United States, except New England and a few other localities of unfavorable habitat.

All the Ambystomids are very much alike in form but are extremely varied in color pattern. With the exception of *Ambystoma opacum* which lays its eggs on land in the fall, all the ambystomids deposit their eggs in the water, usually in small ponds among brush very early in the spring, often before the ice has melted. All their larvae are very similar, with external gills, laterally compressed head and tail. The most wide-spread species is the common and well-known Tiger Salamander (*Ambystoma tigrinum*), the “water dog” often found in Kansas around ponds and stock-tanks, in cellars or cisterns, and in other damp situations. Its larval form is called the “axolotl” and has a head that is higher than broad, while in the adult it becomes broader than high, and thus takes on the proportions usual to the group. This metamorphosis, which involves changes in color and in the form of other parts of the creature, is so great that the young was long supposed to belong to a different genus (*Siredon*) from that to which the adult is assigned (*Ambystoma*). This conclusion was supported by the fact that neoteny occurs in this salamander and the larva is often larger than the regular adult, and reproduces without undergoing metamorphosis.

Among the fossil ambystomids from Kansas, *Lanebatrachus martini* (type, KUMVP No. 1468) from the Middle Pliocene, Edson quarry, Sherman County, and *Ogallalabatrachus horarium* (type, KUMVP No. 1470), from the Middle Pliocene, Rhino Hill quarry, Wallace County, were both based on fragmentary material by Dr. E. H. Taylor. Very little can be said about these two salamanders except that they are undoubtedly ambystomids.

The sensational find of thousands (probably more than 30,000) of small fossil amphibian bones by the late H. T. Martin in the Edson quarry in Sherman County, Kansas, on a branch of the Smoky Hill River, representing at least 150 individuals, brought to light a new ambystomid genus, described by Dr. L. A. Adams of the University of Illinois and H. T. Martin under the name of *Plioambystoma kansense* (type, KUMVP No. 5250). The deposit is middle Pliocene and lies about twenty feet below the level of the surrounding prairie. The bones are mostly disarticulated, but the fossilization is complete, and the bones are in such excellent condition that they can be articulated and studied as though fresh. The new form agrees with the *Ambystomidae* in all determinable points that are
A Survey of the Fossil Vertebrates of Kansas

characteristic of the family, yet it differs in others so that it is generically distinct. Apparently, as reassembled by Adams, the animal had sixteen body vertebrae (an axis and fifteen vertebrae with ribs), the sacral being the seventeenth, and there were about thirty to thirty-five caudals. Adams was able to reassemble several practically complete skeletons — only a very few unimportant elements being lost. (Fig. 6.) He notes that Plioambystoma is the first member of its family recorded from the Pliocene. “It thus represents a group that was in all probability ancestral to some of the present day Ambystomidae” (Adams). The two genera mentioned above, i.e., Lanebatrachus and Ogallalabatrachus, especially the former, probably were closely related to Plioambystoma.

The Museum of Natural History of the University of Kansas has other, but unidentified, “salamander” material from both the upper Pliocene (Rexroad) and the Pleistocene (Borcher) of Meade County, Kansas. Also, over 1200 specimens of larval Ambystoma tigrinum were studied by J. A. Tihen (1942) from the late Pleistocene, Jones Fauna, Meade County. Hence this form, now common in Kansas

must have been equally common in the Pleistocene here.

FIG. 6. Type of Plioambystoma kansense. From the Edson Quarry, Sherman County. From photograph. Natural size.
The upper Cretaceous Judith River Beds have yielded a few vertebrae of two genera described by Cope as Scapherpeton and Hemitrypus, which may have been ambystomids, but their remains are too fragmentary for definite assignment. Ambystomid remains from the Pleistocene are more numerous. Thus, Barnum Brown, of the American Museum, found in the Conard Fissure, in Arkansas, a number of vertebrae and other bones that may even belong to the genus Ambystoma.

The genera Dicamptodon and Rhyacotriton are western forms confined to the humid coastal region—the first ranging from southern British Columbia to Southern California; while the latter is confined to the Olympic Mountains. "Dicamptodon is the largest land salamander in the world, attaining a length of 271 mm." (Noble), i.e. almost a foot.

The Suborder Salamandroidea is an extremely heterogeneous group that includes all those forms that not only undergo a distinct metamorphosis, but have teeth on the roof of the mouth well back of the internal nares. This suborder includes such typically aquatic forms as the newts (Triturus) and Amphiuma, as well as such thoroughly terrestrial forms as the lungless plethodonts. It is represented by a variety of species on every continent, except Australia, though most of them are found in Eurasia.

The family Salamandridae is confined to Europe and Asia, except for the American newts of the genus Triturus, a genus which is not, however, itself confined to this continent. No fossil newt from North America is known to me.

The family Amphiumidae has but the single genus, Amphiuma, comprising two species, both living in the southeastern part of the United States as far west as Louisiana and Missouri. In both, the limbs are very small and end in two or three very tiny fingers or toes. The body and tail are rounded. A single pair of small gill-slits are persistent. The general color is black above and lighter below. Amphiuma means reaches a length up to three feet; A. tridactyla is measured only in inches. They live in swamps and muddy waters, occasionally burrowing in the muck, feeding upon crayfish, mollusks, small fish, etc. The eggs are laid in August or September, and the female coils about them until they hatch in November or December. The newly hatched young have well developed external gills. The gills are lost before the following February when the young are about three inches long.

The amphiumids are semi-larval types, as indicated by their
Lidless eyes, the parallel arrangement of the teeth on the maxillary and vomerine bones, the presence of four branchial arches, and the bi-concave vertebrae. Because of these larval features, Amphiuma has been mis-grouped with the cryptobranchids, with which in fact it has no near relationship. No fossil members of this family are known.

The family Plethodontidae includes the majority of the species of American salamandrids. They live in small streams or on land, and apparently they arose in North America from a salamandrid stem. Only a few are yet known outside this continent, one genus having spread to southern South America, and another has reached Europe, where it is represented by two species in the Mediterranean region. Undoubtedly this genus spread westward from America through Asia, though it is not yet recorded from the latter continent. The plethodontids are regarded as being more specialized than the salamandrids, since their vomerine teeth "are carried back by processes during ontogeny to lie over the parasphenoid as either one or two dentigerous patches. The pterygoid either fails to ossify, remaining entirely cartilagenous throughout life, or is represented by a small bony nodule" (Noble). The several genera recognized in this family form a very natural series. Despite the fact that so many of them are strictly terrestrial as adults, they are all lungless, and have only the thin moist skin of the general body surface to function as an organ of respiration. They all "possess a nasolabial groove to assist in freeing the nostril from the water" (Noble). This character alone serves to distinguish a plethodontid from any other salamander, "but without a hand-lens the fine groove from nostril to lip is sometimes difficult to see" (Noble). The body musculature of the plethodontids is also specialized, resembling that of Salamandra, which is also strictly terrestrial.

But the most curious of all the plethodontids is Typhlomolge—a veritable "walking skeleton", with its long slender legs too weak to support the weight of its body when out of the water, and wearing a "white shroud". Typhlomolge came to light from an artesian well, 188 feet deep, near San Marcos, Texas. It has four fingers and five toes which are slender and pointed but not webbed. "The legs are used for locomotion and the animals creep along the bottom of the aquarium with a peculiar movement, swinging the legs in irregular circles at each step. They climb easily over rocks piled in the aquarium, and hide in crevices between them. The head is large, the mouth square. All efforts to induce them to eat have been futile."
The eyes are completely hidden beneath the skin and the whole animal is colorless and white. The tail is furnished with a dorsal and a ventral fin. The three pairs of gills are remarkable for their blade-like stalks, while the gill-lamellae proper are short and restricted to the tapering ends. The total length is about 75 mm." (Gadow). No fossil plethodonts are known.

**Subclass III. Salientia**

This subclass is represented in Kansas at the present time by the toads, tree-toads and frogs. It is apparently a natural group of amphibians, all of which have short bodies and long legs, but no tails in the adults. Their hind limbs differ noticeably from those of the **Caudata** in having four segments instead of the three occurring in the latter, and they function as powerful levers in leaping. In the terrestrial toads the hind legs are relatively not so large as they are in the more aquatic frogs. When resting undisturbed at the top of the water, a frog assumes a very ungraceful pose, with his front legs outspread from the sides of the body and his hind legs hanging down limply in the water below. But this apparently careless sprawl is not without effectiveness, for if threatened from above a single movement of the hind-legs upward pulls the frog well below the surface of the water, and his outspread fore-limbs are in exactly the position to effect most expeditiously the down-turn of the head and body necessary to bring the frog as quickly as possible into a place of safety.

From the fossil record few facts have been recorded that give us light upon the evolutionary history of the **Salientia**. The oldest known genera are **Montsechobatrachus**, of uncertain relationship, from the Upper Jurassic of Spain, and **Eobatrachus** from the Upper Jurassic of Wyoming. From their fragmentary remains it can only be determined that they were either frogs or toads, but even this makes it certain that this subclass goes back at least beyond the middle of the Mesozoic Era.

**Order 8. Anura**

The **Order Anura** is the only one that we may recognize in this subclass. Its characteristics are the same as those of the **Salientia** in general. The American representatives of this order include the frogs, toads and tree-toads, all of which are familiar to every child. Five suborders are recognizable on the basis of the form of the vertebrae, as follows:

**Suborder a. Amphicoela**, as the name indicates, has biconcave
vertebrae. Its one family and two genera are of particular interest since they are the most primitive anurans living today. That this is a remnant group, probably long ago widely distributed over the earth, is indicated by the fact that the genus *Liopelma*, only 1½ inches long, is found only in New Zealand where it is the sole amphibian native to these islands, while the other genus, *Asaphus*, occurs in North America. Both genera are primitive in that they possess two muscles for wagging the tail, an organ which neither of them possess. Moreover, *Asaphus* is the only frog in the United States that has a cloacal extension that serves as a copulatory organ when mating. No fossils of this suborder are known.

**Suborder b.** *Opisthocoela* includes two families of toad-like forms which have their vertebrae concave behind but not in front. The tongue in one is not protrusible and has the form of a circular disk attached to the floor of the mouth by nearly its whole base; the other is tongueless. They are both primitive in having short, free ribs borne on the lateral processes of the second to fourth vertebrae. No opisthocoelan is known from Kansas, either living or fossil.

**Suborder c.** *Anomocoela* includes forms that are intermediate in structure between amphicoelids and opisthocoelids, on the one hand, and the bufonids (true toads), on the other hand, without apparently having any close relationship to either side. At no time do they have free ossified ribs; the sacral vertebra is concave in front, and immovably fused behind with the urostyle, or if not so fused, then with only a single condyle for articulation with the urostyle. There are eight vertebrae anterior to the sacrum, all of which are concave in front. The one family, called the *Pelobatidae*, is widely distributed throughout the northern hemisphere. They are usually so toad-like in appearance that no one except a student of the group probably would distinguish the two forms. In Kansas, the living *Pelobatidae* comprise only the genus *Scaphiopus*, or “spade-foot toads”, so-called because on the inner side of the foot they have a large, broad and sharp-edged tubercle, borne on a prehallux—i.e., an additional toe preceding the “big toe” in position—which serves as a spade in digging. The most easily noted distinguishing feature is the vertical pupil of the eye. The skin is only slightly tubercular (“warty”). The true toads have a “warty” skin and a horizontal pupil in the eye. The living species in Kansas is *Scaphiopus bombifrons* Cope, which has its toes distinctly webbed, fingers only partly so. It has been recorded from Barton, Finney, Ford, Greeley, Morton, Reno, Rice and Sherman Counties in this state.
The known fossil spade-foot toads include *Macropelobates* from the Oligocene of Montana; *Pelobates* itself from the lower Miocene of Europe; *Scaphiopus* from the middle and upper Pliocene of Kansas; and *Neoscaphiopus* from the upper Pliocene of Meade County. The genus *Scaphiopus* includes three fossil species, all described by Dr. E. H. Taylor. One of these, *Scaphiopus studeri*, is a medium sized spade-foot more nearly like *S. bombifrons* Cope than any other living form, but is also related to *S. pliobatrachus*, mentioned below. It has a total length from snout to vent of about 58 mm., and the type specimen lies on a split slab of marl, each portion of which comprises both imprints and bones of a single animal. (Fig. 7). This is noteworthy as being probably the most perfect specimen of a fossil anuran yet found anywhere in the world. It was presented in 1936 to Dr. Claude W. Hibbard for the University of Kansas Museum of Vertebrate Paleontology, in which col-
lection it is catalogued as No. 1478. Its finder was Mr. Frank Studer, of Wallace, Kansas, for whom the species was named by Taylor. It came from a bed of diatomaceous marl in Logan County. This bed of marl lies in contact with the “Rhino Hill Quarry” beds, which are of middle Pliocene age.

From the Edson Beds, Ogallala formation, middle Pliocene of Sherman County, came the second species of fossil spade-foot, *Scaphiopus antiquus* (type, KUMVP, No. 1469), and the third species, *S. pliobatrachus* (type, KUMVP, No. 1430), both described by Taylor. A fourth species, *S. diversus* (type, KUMVP, No. 6368) is from the Rexroad formation, Blancan Age, Meade County, Kansas, and likewise was named and described by Taylor. It is about two inches long from tip of snout to vent, and is therefore smaller than *Scaphiopus bombifrons* Cope, living in western Kansas at the present time. From the same spot came a new genus of spadefoot, described by Taylor under the name of *Neoscaphiopus noblei* (type, KUMVP, No. 6367).

*Suborder d. Procoela*, including the “true toads”, tree-toads and a few others less commonly recognized, forms a very natural group all of which have the vertebrae uniformly concave in front and the sacral vertebrae with a double condyle for articulation with the urostyle—a long slender bone formed by the fusion of the caudal vertebrae into one element. The ribless presacral vertebrae are five to eight in number. One family, the *Palaeobatrachidae*, is extinct and includes two genera, *Palaeobatrachus* and *Protopelobates*. They occur from the Jurassic to the Miocene in Europe only. *Palaeobatrachus* seemingly was aquatic since it had very long metacarpals, which equal the radius in length and are only slightly shorter than the humerus.

The second family, the *Bufonidae*, includes the “true toads”, which are familiar to every child because of their “warty” skin and their terrestrial habit. They lack an ossified sternum (“breast bone”) such as is present in the frogs, and the two sides of the *pectoral* (“shoulder”) girdle slide across each other in the mid-ventral line, constituting what is called an “arciferal girdle”. The transverse processes of the sacral vertebra are cylindrical or dilated at the distal end. All the members of this family—and they are many—except the common genus *Bufo*, are confined to Africa and southern Asia. *Bufo*, however, is almost worldwide in its distribution, occurring everywhere on land except in Madagascar, Australia, New Guinea and neighboring regions of the south-west Pacific.
Fossil bufonids come from the Miocene or later deposits of Europe and North America. From Kansas two species have been described by Taylor: *Bufo arenarius* (type, KUMVP, No. 1452) and *Bufo hibbardi* (type, KUMVP, No. 1437), both from the Edson Beds, Ogallala formation, middle Pliocene, Sherman County. Besides the types, much additional material representing each of these species is also in the University of Kansas Museum of Natural History.

The tree-toads (*Hylidae*) usually have their toes provided with claws and in many cases with adhesive pads; they are mostly tree-dwelling. Exceptions are the almost minute aquatic *Acris*, or “cricket frog”, and the terrestrial or fossorial *Pternohyla* (not recorded from Kansas). *Hyla* is the most widespread genus, being absent only from Ethiopia, Madagascar, India, Malaya and the islands of the sea. All the other genera occur only in America. *Hyla* in particular is noted for its chameleon-like ability to change the color of its skin surface to blend with its immediate environment. As the moisture in the air approaches the saturation point just preceding a rain, *Hyla* becomes more and more pleasurably affected and finally breaks into a “song” that is popularly regarded as a prognostication of rain.

*Suborder e. Diplasiocoela* comprises the “true” frogs and their closest allies, including the Old World “tree-frogs” (*Polypedatidae*—not to be confused with the American *Hylidae*), and the narrow-mouthed “toads”, or *Brevicipitidae*. In the members of this suborder the first seven trunk vertebrae are *concave in front*; the eighth is *biconcave*. The sacral vertebra has its centrum *convex* anteriorly, while posteriorly it carries *two condyles* for articulation with the *urostyle*. There are no ribs, and the shoulder girdle articulates with a *sternum* (“breast bone”), the right and left halves of which do not slide the one over the other, as in the toads. Instead of having an “arciferal girdle”, therefore, the frogs are said to be “firmisternal”.

The members of this suborder, culminating in the family *Ranidae*, are the most highly specialized of all the anurans. Some are primarily aquatic, some terrestrial, and some are even fossorial. They occur over most of the land surface of the world, except Australia, New Zealand, and the southern end of South America. Africa seems to have been their original home. Of the many living genera, only two, *Rana* and *Gastrophryne*, now occur in North America.

While the *Ranidae*—true frogs—are the most highly specialized of the *Salientia*, they are nevertheless characterized by a high
degree of structural uniformity. The shoulder girdle displays scarcely any variation in form among the various genera and species and the same is true also of the skull.

The genus *Rana* occurs in the fossil condition from the Miocene and later formations of both Europe and North America. While there are five living species of *Rana* recorded from Kansas and one of the related *Gastrophryne*, it is interesting to note that two genera, *Rana* and *Anchylorana*, the first with seven and the second with three species, have been described by Taylor from the upper Pliocene of Meade County. These are:

*Rana valida* (type, KUMVP, No. 5133) from the Rexroad formation, Blancan Age; *R. rexroadensis* (type, KUMVP, No. 6369); *R. ephippium* (type, KUMVP, No. 6370), a small frog; *R. meadensis* (type, KUMVP, No. 6376), a medium-sized frog; *R. fayae* (type, KUMVP, No. 6378); *R. parvissima* (sic) (type, KUMVP, No. 6451), a very diminutive frog the relationship of which, according to Taylor, is very probably with the “woodfrogs” represented in the eastern United States today by *Rana sylvatica* and *Rana catabrigensis*. Kansas now has no living representative of this group the habitat of which is the heavily wooded regions where deciduous trees abound. The seventh fossil species (KUMVP, No. 6379) has not been named, but is listed by Taylor from the Rexroad fauna.

The second fossil genus, *Anchylorana*, has three species so far recognized, all by Taylor, and all from the same locality as the seven species of *Rana* just referred to. *Anchylorana moorei* (type, KUMVP, No. 6375), a small frog only about 2½ inches long from snout to vent, is known only from Meade County, Kansas. *Anchylorana dubita* (type, KUMVP, No. 6377) is a much smaller species than *A. moorei*, being scarcely more than 2 inches from snout to vent. *Anchylorana robustocondyla* (type, KUMVP, No. 5106) is “a rather large frog” (Taylor).

Taylor has presented in tabular form a comparison of the recent *Salientia* in Kansas with the fossil species in the Rexroad fauna, and this shows:

<table>
<thead>
<tr>
<th>Family</th>
<th>Recent Fauna</th>
<th>Rexroad Fauna</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Genus</td>
<td>Species</td>
</tr>
<tr>
<td>Pelobatidae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bufonidae</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Ranidae</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Microhylidae</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals:</td>
<td>5</td>
<td>11</td>
</tr>
</tbody>
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Recent .......... 5 families, 6 genera, 11 species
Rexroad ........ 3 families, 5 genera, 14 species
The following comments by Taylor are of sufficient interest to be quoted here. He says:

It seems safe to postulate that a very much larger amphibian fauna was present in the Rexroad than is represented by the finds to date. So large a number of ranid frogs warrants the postulation that the climate was such as to supply a much heavier rainfall, in order to provide sufficient moisture for these water-loving frogs. It seems strongly probable that with forests, which would be concomitant of the heavier rainfall, numerous species of the Hylidae, small Leptodactylidae and Microhylidae would be present. It is likewise probable that there was also a population of small salamanders, although not a single species has been so far recovered [from the Rexroad]. . . . The present climate of North Carolina supports an anuran population of 26 species and subspecies, representing 5 families and 8 genera. The Caudata are even richer with 40 species and subspecies, representing 6 families and 16 genera. In the case of the caudate fauna the mountainous character of the country is a factor contributing to its diversity. While the two areas are not entirely comparable, the presence in the Rexroad of so large a number of Rana in the fauna suggests the possibility that the climates were similar in character, and at least the anuran fauna may eventually prove even richer than the present day fauna of North Carolina.

Of the ranid species in the Rexroad fauna, in comparison with those living in Kansas today, none is identical. . . . The present day R. brachycephala apparently approaches closely to Rana valida. They are, however, not identical.

In regard to the Edson Quarry, middle Pliocene, Ogallala formation, of Sherman County, Kansas, Taylor remarks:

One of the surprising facts concerning this fauna is the abundance of toads and the seeming absence of ordinary frogs of the genus Rana, which today are usually the most conspicuous members of any amphibian fauna in the United States. . . . This is not true of the amphibian fauna of the upper Pliocene deposits of Meade County, Kansas, or the Broadwater beds of Nebraska, because in both places frogs of the genus Rana predominate, and toads are rare or absent.

Previous to the publication of the papers by Taylor, referred to above, the fossil remains of frogs and toads of the Western Hemisphere had been little studied, and only 7 species of extinct anurans had been described from this enormous area. The salamanders were scarcely better known. Now, at least 16 species of frogs and toads, and 4 of salamanders are known from western Kansas alone.

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