10. A Sketch Classification of the Pre-Jurassic Tetrapod Vertebrates.

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(Text-figures 1 & 2.)

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The enormous expansion of our knowledge of early Tetrapods during the last twenty years, which we owe especially to the work of Broili, Broom, Case, v. Huene, Moodie, and Williston, has led to the general realisation of the inadequacy of our existing scheme of classification.

It is the purpose of this paper to produce a classification of these animals which, whilst including all existing information and paying attention to the taxonomic views of other students, shall be so far as possible a consistent whole expressing my own view of the relationships of the forms which fall within its scope.

The difficulties of classification of early Tetrapods are identical with those which lead to divergence between those classifications of the early Eocene placental mammals characteristic of the American and European schools.

Most American authors, for example, follow Osborn in dividing the Lower Eocene Perissodactyls, which are all very much alike in structure, between the families of Horses, Tapirs, Rhinoceroses, Lophiodonts, Calicotheres, and Titanotheres, whilst European authorities include them all in the one family Lophiodontidæ, ancestral to all other families of Perissodactyls.

Both methods are quite legitimate, expressing as they do different aspects of the subject.

Prof. Osborn's method has the great merit of forcing attention to the consideration of the small details which persist throughout families, and of bringing out clearly our knowledge of actual lines of descent. Its drawbacks are that, without a very considerable knowledge not only of one animal, but of its descendants, it is impossible to be certain of its position in the system, and that the families are with difficulty, if at all, definable.

The other method, of having large primitive families ancestral to all later lines of an order, has the advantage of emphasising the great resemblances between all members of an order in its early youth and of giving readily definable families into which any relatively well-known type can be securely placed. It

suffers from the disadvantage that whilst emphasising resemblances it is liable to obliterate remembrance or recognition of differences.

As in my opinion the study of early Tetrapods is at present suffering from an insufficient appreciation of the differences that do exist, the following scheme will follow Prof. Osborn's method, although I fully realise that this course leads to a multiplication of Orders and to the placing of many types as incerta sedis.

BATRACHIA. Macartney, 1802.

Tetrapods which, either in a larval stage or persistently, breathe by gills.

Super-Order LABYRINTHODONTIA (Owen).

Amphibia with a roofed skull, a lower jaw consisting of at least eight bones on each side, and vertebræ consisting of neural arches and intracentra in all forms, with pleurocentra in addition in most.

Grade **EMBOLOMERI** Cope.

Labyrinthodonts with large well-ossified basioccipital and basisphenoid. Occipital condyle single or triple. Pterygoids with a large palatal part, articulating by movable facets with definite basipterygoid processes of the basisphenoid. Interpterygoid vacuities very small. Tabulars and dermo-supraoccipitals without occipital extensions.

Family Anthracosauridæ Cope, 1875.

Embolomeri with a single occipital condyle. No specialised sacral vertebræ. Clavicles flat plates with parallel anterior and posterior margins. A ventral armour of scutes. Primitively aquatic.

Anthracosaurus Hux. Lower Carboniferous, Scotland.

Pteroplax Hancock & Atthey. L.? Coal Measures, Northumberland.

Pholiderpeton Hux. M. Coal Measures, Yorkshire.

? *Erpetosuchus* * Moodie. U. Coal Measures, Kansas.

Family Loxommidæ, nov.

Embolomeri with triple occipital condyles and enlarged orbits. Post-cranial skeleton not known. ? No ventral armour.

Loxomma Hux. L. Carboniferous, Scotland.

"*Loxomma allmani.*" Lower and Middle Coal Measures, Lanarkshire, Fifeshire, Northumberland, Staffordshire.

Baphetes Owen. Coal Measures, Nova Scotia.

"*Loxomma bohemicum.*" L. Permian, Nŷran, Bohemia.

* Name preoccupied. E. T. Newton, 1893.

Family Pholidogasteridæ, nov.

Embolomeri showing a passage to Rachitomi? With clavicles expanded on the ventral surface. Ventral armour of scutes. (Secondarily aquatic?)

Pholidogaster Huxley. Lower Carboniferous, Scotland.

Family Cricotidæ Cope.

Embolomeri with elongated skulls. Clavicles expanded on the ventral surface. Ventral armour of small scutes. (Secondarily aquatic?)

Cricotus Cope. Artinskian, Texas, and ? U. Coal Measures, Illinois.

Embolomeri incerta sedis.

Diplovertebron Fritsch. L. Permian, Bohemia.
Nummulosaurus ,, ,, ,,
Macromerium ,, ,, ,,
Spondylerpeton Moodie. U. Carboniferous, Illinois.

Grade **RACHITOMI** Cope.

Labyrinthodonts with ossified basioccipital and basisphenoid. Occipital condyle triple or double. Pterygoids usually with a medium-sized palatal part, interpterygoid vacuities of medium to large size. Pterygoids articulating with both parasphenoid and basisphenoid. Tabulars and dermo-supraoccipitals with occipital flanges. Paroccipital always visible from behind.

Vertebræ rachitomous, *i. e.*, with small paired pleurocentra and half-moon shaped intercentra.

Grade **STEREOSPONDYLI** Cope.

Labyrinthodonts with reduced basioccipital and basisphenoid. Occipital condyle double. Pterygoids with a reduced palatal ramus, interpterygoid vacuities large to very large. Pterygoids supported by the parasphenoid. Exoccipital meeting the occipital flange of the tabular so as to hide the paroccipital in an occipital view.

Vertebræ stereospondylous, *i. e.*, with very reduced or absent pleurocentra and enlarged intercentra.

I have discussed the classification of the grades Rachitomi and Stereospondyli in very great detail in a paper which will, I hope, soon be published; it is therefore unnecessary to reproduce the division into families on the present occasion.

Super-Order PHYLLOSPONDYLIA Credner.

Small, very highly specialised Batrachia with a roofed skull, palate with very widely open interpterygoid vacuities, palatines and lower jaw very reduced. Coracoid and pubis not ossified. Four-fingered hand. Ventral armour of small round scutes.

Family Branchiosauridæ Fritsch.

With the characters of the super-order.

Branchiosaurus Fritsch. Upper Coal Measures and Lower Permian, Bohemia, Germany, and France.

Micrerpeton Moodie. Coal Measures, Illinois.
Melanerpeton Fritsch. L. Permian, Bohemia and Saxony.
Pelosaurus Credner. ,, Saxony and France.
? *Dawsonia* Fritsch. ,, Bohemia.

Super-Order LEPOSPONDYLIA Zittel.

Small Batrachia with a roofed skull and lepospondylous vertebræ.

Very few members of the super-order are at all completely known, and these differ in many respects. In the structure of the skull and lower jaw *Batrachiderpeton* and *Diplocaulus* show clear resemblances to the Labyrinthodontia, perhaps only owing to a common descent from Crossopterygian fish.

Family Nectridia Miall.

Lepospondyli with the posterior corners of the skull produced. Two occipital condyles. Palate with a small parasphenoid and small vacuities. Tail with long neural and hæmal spines, expanded and fluted at the ends. Accessory articulating facettes between the vertebræ.

Keraterpeton Hux. Coal Measures, Ireland and England.
Urocordylus Hux. ,, ,, ,,
Batrachiderpeton Hancock & Atthey. Coal Measures, England.
? *Scincosaurus* Fritsch. L. Permian, Bohemia.
? *Oestocephalus* Cope. Coal Measures, Ohio.
? *Ptyonius* Cope. ,, ,,
? *Sauravus* Thevenin. U. Coal Measures, France.
? *Diceratosaurus* Jaekel. Coal Measures, Ohio.
? *Crossotelos* Case. L. Permian, Oklahoma.

Family Diplocaulidæ

Lepospondyli with enormously produced corners of the skull. Palate with a large parasphenoid and moderate-sized vacuities. Tail long, with well interlocked vertebræ.

Diplocaulus Cope. L. Permian, Texas; U. Carboniferous, Illinois.

Family Aistopodidæ.

Legless Lepospondyls.

Dolichosoma Hux. U. Carboniferous, Ireland; and other forms not necessarily closely connected.

Batrachia incerta sedis.

Lysorophus (primitive Urodele?); *Cardiocephalus*, *Gymnarthrus*, etc.

Class REPTILIA.

It is now impossible to give any definition of the class Reptilia which, whilst including all members of the group, will exclude all other Tetrapods. The essential feature of a reptile is that it can carry out the whole of its life-history on dry land, not producing a gill-breathing larva, and that it is not a mammal or a bird. Reptiles lay a shelled egg except in viviparous forms, in which the egg is hatched before it is laid.

Super-Order COTYLOSAURIA (Cope).

Reptiles with a roofed skull and plate-like pelvis. The members of this super-order are merely held together by these primitive characters, the typical forms also by many other common primitive reptilian characters lost by the advanced members of this group.

Order **Seymouriamorpha**, nov.

Cotylosaurs with a skull resembling in nearly all known details that of the Anthracosauridæ. Otic notches small, quadrate inclined backward. Tabulars and dermo-supraoccipitals on the skull roof, but with occipital flanges. Pro-otic reaching the skull roof. Inner ear widely open to the cranial cavity in the lateral wall of the cranium. Vertebræ with very heavy and expanded arches and very large intercentra.

Limbs very primitive, like those of the Rhachitomous amphibian *Eryops* in many features.

Seymouria Broili. Artinskian, Texas.

Order **Diadectomorpha**, nov.

Cotylosaurs with exaggerated laterally placed otic notches and a vertically placed quadrate.

Super-Family Diadectidæ Cope.

Diadectomorphs with a long low brain-cavity. Tabulars and interparietal turned down onto the occipital surface, closed post-temporal vacuities. Inner ear widely open to cranial cavity. Vertebræ with heavy neural arches. Limbs primitive.

Diadectes Cope. Artinskian, Texas.
Diadectoides Case. ,, ,,
Nothodon Marsh. ? U. Coal Measures, New Mexico.
Animasaurus Williston. ,, ,, ,,
? Desmatodon Case. ,, ,, Pennsylvania.
Diasparactus Case. ,, ,, New Mexico.
Chilonyx Cope. Artinskian, Texas.
? Stephanospondylus Geinitz & Deich. M. Rothliegende, Saxony.

Super-Family Pariasauridæ Seeley.

Diadectomorphs with a long low brain-case. Tabulars and dermo-supraoccipitals on the dorsal surface. Large post-temporal vacuities. Otic notch secondarily obliterated. Inner ear separated from cranial cavity by bone.

Vertebræ with heavy neural arches. Pectoral limb advanced in the nearly vertical position of the fore arm in life. Pelvic girdle advanced in the expanded backwardly sloping ilium.

Pariasaurus Owen.	U. Permian,	S. Africa.
Propappus Seeley.	,,	,,
Anthodon Owen.	,,	,,
Bradysaurus Watson.	M. Permian,	,,
Embrithosaurus Watson	,,	,,
Elginia E. T. Newton.	U. Permian,	Scotland.
Pariasuchus Broom.	,,	S. Africa.
? *Sclerosaurus* H. v. Meyer.	L. Trias,	Switzerland.

Super-Family Procolophonidæ Seeley.

Diadectomorphs with a short high Sphenodon-like brain-case. Tabulars partly on the occipital surface.

Vertebræ with heavy neural arches.

Fore limb specialised in the loss of the screw-shaped glenoid cavity.

Procolophon Owen.	L. Trias,	S. Africa.
Telerpeton Mantell.	M. Trias,	Scotland.
Koiloskiosaurus v. Huene.	L. Trias,	Germany.

Order **Capitorhinomorpha**, nov.

Cotylosaurs with an obliterated otic notch and vertically placed quadrates.

Super-Family Captorhinidæ.

Captorhinomorphs with short high brain-cavity, widened supraoccipital (inner ear placed low down ?). Dermo-supraoccipitals on the occipital surface. Stapes perforate, with a very large foot-plate articulating with pro-otic, paroccipital, basisphenoid, and basioccipital, and distally reaching the quadrate.

Limbs primitive.

Fam. Captorhininæ.

Captorhinus Cope.	Artinskian,	Texas.
Labidosaurus ,,	,,	,,

? Fam. Pariotichidæ.

Pariotichus Cope.	Artinskian,	Texas.
Isodectes ,,	,,	,,
Puercosaurus Williston.	Artinskian,	New Mexico.

Super-Family LIMNOSCELIDÆ, nov.

Captorhinomorphs. Brain-case unknown. With primitive limbs, carpus and tarsus only partially ossified.

Limnoscelis Williston. U. Coal Measures, New Mexico.

Super-Family PANTYLIDÆ, nov.

Brain-case unknown.

With light neural arches and limbs.

Pantylus Cope. Artinskian, Texas.

Super-Order ANOMODONTIA Owen.

Reptiles with a single temporal vacuity. A short high brain-case with the inner ear placed low down. Supraoccipital very broad. "Stapes" articulating with the quadrate. Tabulars and dermo-supraoccipital on occipital surface. In typical forms the lower jaw laterally compressed and with a notched angular.

Derived from a common ancestor with Captorhinidæ.

Order **Caseasauria**, nov.

Doubtfully belonging to super-order.

Skull short, with a single laterally placed temporal fossa, surrounded by the postorbital, squamosal, ? quadratojugal and jugal.

Brain-case not well known but apparently considerably different from the normal type of the super-order. Stapes extending nearly to quadrate. Lower jaw showing a projection of the articular on the inner side and perhaps a lateral compression of the angular which may lead on to the typical superordinal arrangement.

Casea Williston. Artinskian, Texas.

? *Trispondylus* Williston. Artinskian, Texas.

Order **Pelycosauria.**

Anomodonts with the postorbital and squamosal meeting over the temporal fossa, with a screw-shaped glenoid cavity carried by scapula, coracoid, and precoracoid, and primitive limbs.

Super-Family POLIOSAURIDÆ Case.

Pelycosaurs with a straight tooth-row and undifferentiated dentition. A small supratemporal; stapes articulating with the pro-otic, paroccipital, basioccipital, and basisphenoid round the fenestra ovale only. Cervical neural arches usually heavy and with nearly horizontal zygapophysial facets.

Varanosaurus Broili. Artinskian, Texas.
Varanoops Williston. ,, ,,
? *Poliosaurus* Case. ,, ,,
Pœcilospondylus Case. ,, ,,
? *Mycterosaurus* Williston. ,, ,,

Super-Family Ophiacodontidæ.

Pelycosaurs with a curved tooth-row and slightly differentiated dentition. A small supratemporal. Stapes articulating with the edges of the fenestra ovale and by a special head with the under surface of the paroccipital process. Cervical neural arches not heavy.

Deiopeus Cope. Artinskian, Texas.
Theropleura Cope. ,, ,,
Ophiacodon Marsh. U. Coal Measures, New Mexico.
? *Stereorachis* Gaudry. L. Permian, France.

Super-Family Sphenacodontidæ.

Pelycosaurs with a curved tooth-row and well-differentiated dentition.

Stapes of two parts, a small element articulating with the fenestra ovale and distally with a large element which articulates with the paroccipital process, the pterygoid and quadrate. A typical compressed and notched angular.

Family Clepsydropidæ Cope.

Sphenacodontidæ with a carnivorous dentition and a pronounced step between the dentigerous edges of the premaxilla and maxilla.

Clepsydrops Cope. Artinskian, Texas.
Upper Coal Measures, Illinois.
Dimetrodon Cope. Artinskian, Texas.
Sphenacodon Marsh. ,, New Mexico.
Tetraceratops Matthew. ,, Texas.
? "*Geosaurus cynodus*" Gervais. L. Permian, France.

Family Edaphosauridæ Cope.

Sphenacodontidæ with a powerful palatal dentition of small teeth.

Edaphosaurus Cope. U. Coal Measures and L. Permian, Texas, New Mexico, Bohemia, Saxony, Urals.
Naosaurus Cope. L. Permian, Texas.

Super-Family Bolosauridæ.

Systematic position very doubtful, but as the occiput seems to be of Anomodont type and the lower jaw is undoubtedly compressed and the angular apparently notched, they may be placed here.

Skull with large orbits and very short pre-orbital and temporal region, upper surface passing smoothly into the occiput. Temporal vacuity entirely on the side of skull and placed low down.

Bolosaurus Cope. Artinskian, Texas.
? *Glaucosaurus* Williston. Artinskian, Texas.
? *Palæohatteria* Credner. L. Permian, Saxony.

Pelycosaurs of undetermined position.

Arribasaurus Williston. U. Coal Measures, New Mexico.
Bathygnathus Leidy. Permian, Canada. (? Clepsydropid.)

Order **Deinocephalia** Seeley.

Anomodont reptiles, with unreduced quadrates. No supra-temporal element. Postorbital and squamosal meeting above temporal fossa. The basicranium forming a deep wall below the condyle. Glenoid cavity supported solely by the scapula and coracoid in typical forms. Limbs modernised.

Super-Family Tapinocephalidæ.

Deinocephalia with a short skull and short mouth.

Tapinocephalus Owen. M. Permian, S. Africa.
Mormosaurus Watson. ,, ,,
Pnigalion Watson. ,, ,,
Lamiasaurus Watson. ,, ,,
Struthiocephalus Haughton. ,, ,,
Moschosaurus ,, ,, ,, ,,
Moschops Broom. ,, ,,
Moschognathus Broom. ,, ,,
Taurops ,, ,, ,, ,,
Eccasaurus ,, ,, ,, ,,
Delphinognathus Seeley. ,, ,,
Deuterosaurus Eichwald. Permian, Russia.
etc.

Super-Family Titanosuchidæ.

Deinocephalia with an elongated mouth.

Titanosuchus Owen. M. Permian, S. Africa.
? *Rhopalodon* Fischer. ,, ,, Russia.
? *Cliorhizodon* Twelvetrees. ,, ,, ,,
? *Dinosaurus* Fischer. ,, ,, ,,

Order **Dromasauria**.

Anomodonts with very long slender limbs. Large orbits, short pre-orbital and temporal region, rounded dorsal contour of skull, and a T-shaped squamosal.

? descended from Bolosauridæ.

Galechirus Broom. M. Permian, S. Africa.
Galepus ,, ,, ,,
Galeops ,, ,, ,,
? *Palæohatteria* Credner. L. Permian, Germany.

Order **Dicynodontia**.

Anomodonts with a reduced quadrate and quadratojugal. T-shaped squamosal without otic groove. Fenestra ovale carried down by a long process composed of basioccipital, basisphenoid, prootic, and paroccipital.

Scapula with acromion.

Glenoid cavity borne only on scapula and coracoid. Pelvis with a pubo-ischiac vacuity.

Dicynodon Owen. M. and U. Permian, S. Africa and Russia.
Tropidostoma Seeley. U. ,, ,,
Endothiodon Owen. M. Permian, S. Africa.
Cryptocynodon Seeley. U. Permian, ,,
Prodicynodon Broom. ,, ,,
Pristerodon Huxley. ,, ,,
Gordonia Newton. ,, Scotland.
Geikia ,, ,, ,,
Kisticephalus Owen. ,, S. Africa.
Diælurodon Broom. ,, ,,
Taognathus ,, ,, ,,
Kannemeyeria Seeley. M. Trias, ,,
Lystrosaurus Cope. L. Trias, ,,
Eubrachiosaurus Williston. M. Trias, Wyoming.
Placerias Lucas. M. Trias, Arizona.

Order **Theriodontia** Owen.

Anomodonts with carnivorous specialisation and reduced quadrate and quadrato-jugal. Glenoid cavity on scapula and coracoid.

Sub-Order *Gorgonopsia* Lydd.

Theriodonts with the parietal excluded from the temporal fossa. Palate with no suborbital vacuities.

Gorgonops Owen. M. Permian, S. Africa.
Scymnognathus Broom. U. ,, ,,
Arctops Watson. M. ,, ,,
Galesuchus Haughton. M. ,, ,,
Scymnosaurus Broom. M. ,, ,,
? *Cynodraco* Owen. M. ? ,, ,,
? *Tigrisuchus* Owen. U. ? ,, ,,
Ælurosaurus Owen. M. ,, ,,
Arctognathus Broom. U. ,, ,,
Inostransevia Amalitzki. U. ,, Russia.

Sub-Order *Cynodontia* Owen.

Theriodonts with a narrow intertemporal bar formed by the parietals. Secondary palate with no suborbital vacuities.

Fam. Cynognathidæ.

Cynognathus Seeley. M. Trias, S. Africa.
Diademodon „ „ „
Trirachodon „ „ „
Cynochampsa Owen. „ „

Fam. Nythosauridæ.

Galesaurus Owen. M. Trias, S. Africa.
Nythosaurus „ „ „

Sub-Order *Therocephalia* Broom.

Theriodonts with a narrow intertemporal bar formed mainly by the parietals. No secondary palate. Large suborbital vacuities.

Scylacosaurus Broom. M. Permian, S. Africa.
Lycosaurus „ „ „
Alopecodon „ „ „
Hyænosuchus „ „ „
Pardosuchus „ „ „
etc.

Sub-Order *Bauriamorpha*.

Theriodonts with short temporal vacuities separated by the parietals. A secondary palate and large suborbital vacuities.

Bauria Broom. M. Trias, S. Africa.
Microgomphodon Seeley. M. „ „
Sesamodon Broom. ? L. „ „
Melinodon Broom. M. „ „

Super-Order CHELONIA.

Reptiles with a roofed skull and the middle eight of the ten dorsal vertebræ provided with widened ribs, supporting a dermal armour.

Order **Eunotosauria.**

? if rightly referred.

Chelonia with costal plates not fused with the ribs and the pectoral and pelvic girdles not within the ribs.

Eunotosaurus Seeley. M. Permian, S. Africa.

Order **Testudinata.**

Chelonia with the pectoral and pelvic girdles within the dorsal ribs.

Family Pleurodeira.

Testudinates which withdraw the head sideways.

Family Amphichelydidæ.

Proganochelys Baur. U. Trias, Württemberg.
Proterocherys E. Fraas. „ „

Super-Order SAUROPTERYGIA.

Aquatic or semi-aquatic reptiles with a single temporal vacuity. Neck long, the cervical ribs articulating solely with the centrum, dorsal ribs single-headed.

A single coracoidal element.

Pelvis with an obturator foramen.

Sub-Order *Nothosauria*.

Semi-aquatic Sauropterygia. Paroccipital expanded and reaching the squamosal, pterygoid, and quadrate so as to close the middle ear behind.

Radius and ulna, tibia and fibula long bones.

Nothosaurus Münster. L. & M. Trias, Germany.
Cymatosaurus Fritsch. M. Trias, Germany.
etc.

Sub-Order *Placodonta*.

Sauropterygia with paroccipital not articulating with pterygoid and quadrate. Massive crushing teeth on the palatines. (Body with a heavy armour of bony scutes.) Limb-bones long.

Placodus Agassiz. M. Trias, Germany.
Cyamodus „ „ „
Placochelys Jaekel. „ Hungary.

Order **Thalattosauria** Merriam.

Aquatic reptiles with a single lateral temporal vacuity. A supratemporal present. A single coracoidal element. Occipital region of skull unknown. Humerus twisted with expanded ends.

Thalattosaurus, *Nectosaurus* } Merriam. M. Trias, California and Nevada.

Order **Ichthyosauria.**

Aquatic reptiles with a single temporal vacuity, very large orbits, and much elongated premaxillæ.

Basisphenoid without definite basipterygoid processes, pterygoids underlying much of its lower surface and that of the basioccipital. Neck short.

Family Mixosauridæ.

Ichthyosauria with relatively small orbits and short rostrum. Upper end of the scapula expanded. Pubis and ischium broad.

Epipodials long and separated. Caudal region not much deflected.

Fam. Mixosaurinæ. With five digits.

Mixosaurus. M. Trias, Italy, Germany, Spitzbergen, W. N. America.

Fam. Shastasaurinæ. Narrow paddles with three or four digits.

Cymbospondylus.
Toretocnemus.
Merriamia.
Shastasaurus.
Delphinosaurus.
} M. Trias, Nevada.

Super-Order ARCHOSAURIA.

Reptiles with a skull with two temporal openings. Brain-case much narrowed between the ears, usually surrounded by bone in advance of the prootic. Paroccipital process antero-posteriorly compressed and long, with the fenestra ovale opening on its lower edge.

A single coracoidal element.

Order **Thecodontia.**

Primitive Archosaurians with clavicles and an interclavicle. Pelvis "plate-like."

Family "Eosuchidæ."

Thecodonts with intercentra throughout the column.

"*Eosuchus*" Watson. U. Permian, S. Africa.
Youngina Broom. ,, ,,

Family Erythrosuchidæ, nov.

Very large semiaquatic Thecodonts with a twisted humerus with much expanded ends. Anterior margin of pubis suddenly deflected. Feeble dorsal armour.

Erythrosuchus Broom. M. Trias, S. Africa.

Family Phytosauridæ McGregor.

Large Thecodonts, with an elongated rostrum formed mainly by the premaxilla. Dorsal and ventral scutes.

Mesorhinus Jaekel. L. Trias, Germany.
Palæorhinus Williston. M. ? Trias, Wyoming.
Phytosaurus Jaeger. U. Trias, Württemberg and U.S.A.
Mystriosuchus Fraas. ,, ,,
Rhytidodon Emmons. ,, U.S.A.
?*Stagonolepis* Agassiz. M. Trias, Scotland.

Family Ornithosuchidæ v. Huene.

Small, slightly built Thecodonts. Pointed skull without produced rostrum. Pubis and ischium much produced.

Hinder limbs longer than the fore.

? Directly ancestral to Theropodous Deinosaurs.

Ornithosuchus E. T. Newton. M. Trias, Scotland.
Euparkeria Broom. ,, S. Africa.
Scleromochlus A. S. Woodward. ,, Scotland.
Sphenosuchus Haughton. U. Trias, S. Africa.

Family Aetosauridæ Baur.

Small Thecodonts with a pointed skull without rostrum, pubis and ischium short. Hind limbs not greatly larger than the fore. A very heavy dorsal and ventral armour.

Aetosaurus Fraas. U. Trias, Württemberg.
?*Dyoplax* ,, ,, ,,
?*Stegomus* Marsh. ,, U.S.A.
?*Notochampsa* Broom. ,, S. Africa.

Family Howesiidæ, nov.

? Thecodonts with several rows of teeth in the maxilla.

Howesia Broom. M. Trias, S. Africa.
?*Mesosuchus* Watson. ,, ,,
??*Proterosuchus* Broom. ,, ,,

Family Erpetosuchidæ, nov.

Small Thecodonts with a pear-shaped skull, not very elongated rostrum. Palate incipiently secondary, with the posterior nares in a deep groove.

? Ancestral to the Crocodilia.

Erpetosuchus E. T. Newton. M. Trias, Scotland.

Order **Saurischia** Seeley.

Archosauria with the astragalus very closely and immovably articulated with the tibia. Pelvis with the pubis and ischia long and projecting downward, usually with an ischio-pubic vacuity.

Thecodontosaurus Riley & Stutchbury. U. Trias, Somersetshire, Swabia, S. Africa, Queensland;

and very many forms representing numerous families, defined especially by v. Huene.

Order **Rhynchocephalia** Günth.

Reptiles with a two-arched skull, a short, high brain-case not ossified in advance of the prootic, and large fenestra ovale. Teeth on the dentary biting into a groove between the maxillary and palatine teeth.

Family Rhynchosauridæ.

With plate-like pelvis.

Rhynchosaurus Owen. U. Trias, England.
Hyperodapedon Hux. M. & U. Trias, England, Scotland, India.
Stenometopon Boulenger. M. Trias, Scotland.
?*Palacrodon* Broom. M. Trias, S. Africa.

Order **Proganosauria** Baur.

Aquatic reptiles with long tails. Skulls elongated. Vertebræ with small notochordal centra and very heavy arches and no intercentra. A single coracoidal element, five distal carpals and tarsals. Pelvis plate-like.

Mesosaurus Gervais. L. ? Permian, S. Africa, Brazil.
Noteosaurus Broom. ,, S. Africa.
Stereosternum Cope. ,, Brazil.

Order **Protorosauria** Seeley.

Lightly built reptiles with pointed skulls and a single temporal vacuity. A single coracoidal element and a plate-like pubis.

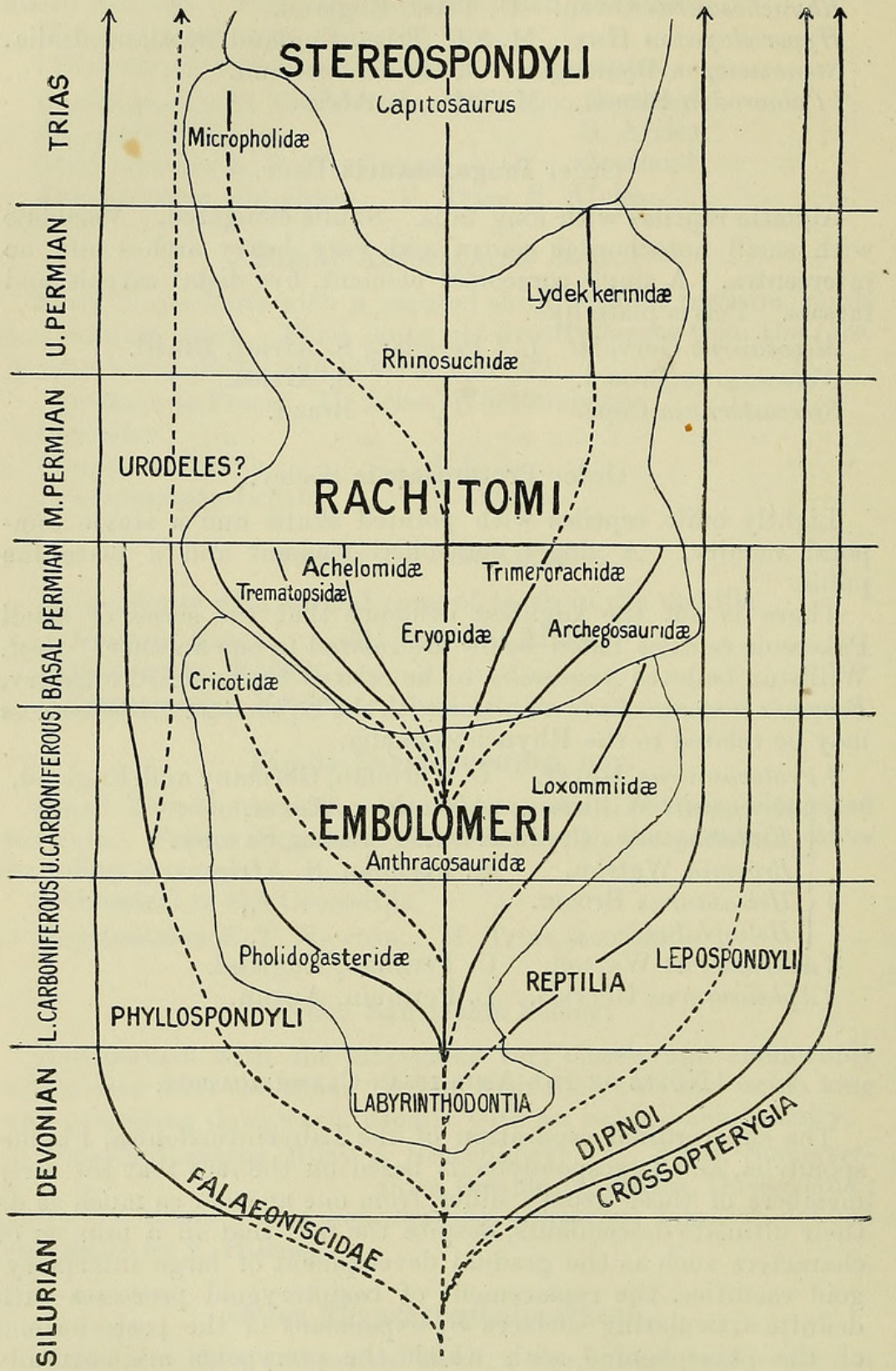
There is not the slightest evidence that the series of small Palæozoic reptiles listed below are related to one another. Prof. Williston believes *Araeoscelis* to be related to the lizard ancestry. *Broomia* may also have affinities with the Squamata. *Adelosaurus* may be related to the Rhynchocephalia.

?*Protorosaurus* Meyer. U. Permian, Germany and England.
? { *Araeoscelis* Williston. Artinskian, Texas.
  { *Kadaliosaurus* Credner. L. Permian, Saxony.
? { *Broomia* Watson. M. Permian, S. Africa.
  { *Heleosaurus* Broom. ,, ,,
  { *Heliophilus* ,, ,, ,,
?*Adelosaurus* Watson. U. Permian, England.
?*Aphelosaurus* Gervais. L. Permian, Autun.

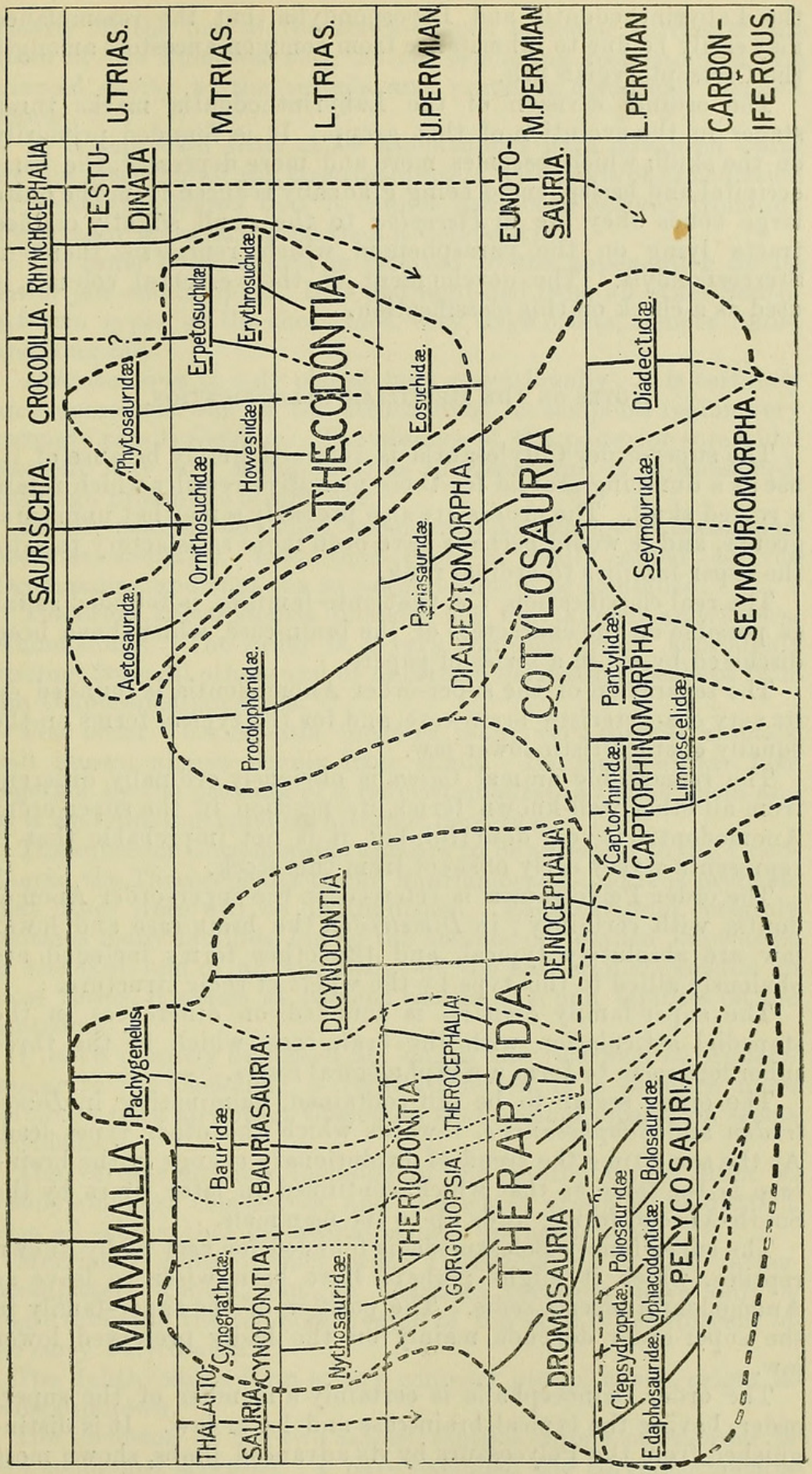
Notes on the Amphibian Classification.

The superordinal separation of the Labyrinthodontia, Phyllospondylia, and Lepospondylia is based on the fact that the early members of these groups differ from one another as much as do their ultimate descendants, despite the fact that in a number of characters such as the gradual development of large interpterygoid vacuities, the replacement of basipterygoid processes with definite articulating surfaces by expansions of the posterior end of the parasphenoid with which the pterygoids are suturally united, and the loss of a finger in the hand, the course of evolutionary change is the same in the first and last group. The structure of the skull and lower jaw is known to be similar in

Text-figure 1.



Phylogenetic tree illustrating the relations of the early Amphibia, each group being placed in its correct time.



Text-figure 2.

Tree illustrating the Phylogeny of the early Reptilia.

the Labyrinthodontia and Lepospondylia, but the resemblance may easily be due to inheritance from common ancestors amongst the Crossopterygian fish.

The ordinal division of the Labyrinthodontia marks three stages in the evolution of that group. It is founded primarily on the skull, which becomes more and more depressed, the basi-occipital and basisphenoid being gradually reduced from the quite large bones they are in *Pteroplax* to the small slightly ossified tracts lying on the parasphenoid which represent them in Stereospondyls. The development of the vertebral column is used as a check on this classification.

Notes on the Reptilian Classification.

The super-order Cotylosauria is retained simply because of its use as a dumping-ground for those primitive reptiles which retain a roofed skull. The orders are also probably somewhat unnatural groups, and it would perhaps have been more satisfactory to raise the super-families to ordinal rank.

The real classification, *i. e.* that into families, is founded as far as possible on the characters of the brain-case, which have been discussed by me in a series of papers.

The separation of the super-order Anomodontia is founded on its very characteristic brain-case, and for the typical forms on the equally characteristic lower jaw.

The remarkable animal *Casea* is obviously ordinally different from all other well-known forms, its position in the super-order Anomodontia is very doubtful, but it is not improbable that it represents a very early offshoot from this stock.

The order Pelycosauria is referred to the super-order Anomodontia with certainty; in *Dimetrodon* the brain-case and lower jaw are absolutely typical, and the other forms included are obviously allied to this type by the whole of their structure.

The super-family division is founded on differences in the stapedial articulation with the brain-case, which in the three suborders seem to form a morphological series.

The order seems to be self-contained, culminating in *Dimetrodon* and *Edaphosaurus*, towards which the other types lead. At the same time the trend of evolutionary change in the brain-case is the same as that which, continued in later times by the South-African forms, leads up to the mammals.

The super-family Bolosauridæ is founded for very badly known reptiles, which it might perhaps have been wiser to leave as Anomodontia incerta sedis. The position of the super-family in the super-order depends mainly on the badly preserved lower jaw.

The order Deinocephalia is certainly a member of the super-order, having the typical brain-case and lower jaw. It is distinguished from the Pelycosaurs by its advanced limbs, shown most

clearly in the loss of the screw-shaped articular surface of the head of the humerus, and the corresponding restriction of the glenoid cavity to the scapula and posterior coracoidal element alone.

It is separated from other Anomodonts with advanced limbs by the retention of the large quadrate. The mode of articulation of the stapes shows that it cannot have been derived from any Pelycosaur more advanced than a Poliosaurid.

The order Dromosauria is referred to the super-order by its lower jaw and occiput. It is distinguished from all other South-African types by the short face, very large orbits, slender limbs, and long tail.

Palæohatteria is only placed here provisionally; it is certainly an Anomodont, and in the structure of its temporal region very strongly recalls *Galepus*. The absence of the posterior coracoidal element may only mean that, as in *Varanoops*, it is unossified, although present as a cartilage.

It will possibly be found, when fuller knowledge of *Bolosaurus* becomes available, that that type is really allied to the Dromosaurs, and that the two orders should be combined.

The order Dicynodontia includes the first known and typical Anomodonts. The order is a very compact group, thoroughly distinct from all others and of uncertain derivation, perhaps from the Deinocephalian stock.

The order Theriodontia includes many very diverse animals, still known almost wholly from skulls. Its members are held together by the presence of a reduced quadrate in all of them and by a well differentiated carnivorous dentition.

The suborder Gorgonopsida appears to be ancestral to the Cynodontia, the Therocephalia to the Bauriamorpha, and it is probable that other lines will be distinguished. Each suborder certainly contains many families, but in the absence of detailed knowledge of the skull and of all knowledge of the post-cranial skeleton in most forms, it seems at present useless to found families on the dentition.

I have recently discussed at length the relations of *Eunotosaurus* to the Chelonia; if rightly referred, it is so much more primitive than any other Chelonian that ordinal separation seems justified.

The various animals included in the Sauropterygia differ so widely amongst themselves, and the whole group is so distinct from all others, that its ordinal rank is unquestionable.

Merriam's quite distinct order Thalattosauria is still rather incompletely known, but its members certainly have only a single arch and the temporal region of the skull is reminiscent of the early Pelycosaurs.

The Ichthyosaurs form a very compact group, whose origin is quite unknown.

The inclusion of the two arched reptiles in one super-order is now commonly accepted. I have excluded the Rhynchocephalia

from the super-order because of certain differences in the brain-case, which may, however, be due to the small size of *Sphenodon*, in which alone is the region known. The exclusion is really for the purpose of drawing attention to the extreme smallness of our knowledge of early two-arched reptiles.

The small aquatic *Mesosaurus* and *Stereosternum* are still unrepresented by well-preserved skulls. They seem to be definitely ordinally distinct, but their affinities are quite obscure.

Finally, the order Protorosauria is retained merely because it is already in existence. Included in it is a series of small Permian reptiles which resemble one another in having slender limbs and a single coracoidal element. There is no evidence that these animals are in reality in any way related.

In this classification I have refrained from throwing weight on the peculiarly modified 5th metatarsal which occurs in Chelonia, Rhynchocephalia, Thecodonts, Crocodiles, Deinosaurs, and Squamates, because it is difficult to believe that all these forms can have been derived from the same advanced Cotylosaurian ancestor. It is perhaps an arboreal adaptation, which may have originated separately. Possibly the broadened ribs of *Eunotosaurus*, which recall those of sloths, are also to some extent an arboreal adaptation.

This classification is on the whole consciously conservative, but contains many new features, chiefly in the definitions and the super-ordinal grouping. An attempt has been made to make the structural differences separating orders approximate, having regard to the total variation, to those used in separating the orders of mammals, but in many cases suborders should perhaps be raised to ordinal rank. Super-orders are used to group together orders which seem to have had a common origin.