

Appendix: Classification of the vertebrates

The classification given below is a ‘conservative cladistic’ scheme based upon the cladograms described in this book. The hierarchical ranking (indenting) of the group names gives an indication of the ranking of taxa in the cladogram. There have been proposals recently to avoid naming the ranks of taxa (e.g. ‘Placodermi’, ‘Dipnoi’), but rank names are used here (e.g. ‘Class Placodermi’, ‘Order Dipnoi’) in order to provide a broad marker to the relative positions of clades within the hierarchical scheme. Further, there is a debate about the use of traditional group names, such as Archosauria or Mammalia, whether they should be used in an inclusive sense to indicate the clade that is closest to the original definition of the name, or in an exclusive sense to refer to the crown-group clade only, that is, the minimal clade defined by the closest common ancestor of all living forms. The former usage is used here. Fishes, amphibians, reptiles, birds, and mammals are tabulated

separately. All groups named below are monophyletic, except for a very small number of commonly used paraphyletic group names (marked *). All groups have living members, unless they are marked †. Where the sequencing of groups is uncertain, they are indicated as *sedis mutabilis*.

Classifications are based on overviews by Forey and Janvier (1993) and Donoghue *et al.* (2000) for agnathans; Goujet (2001) and Smith and Johanson (2003) for placoderms; de Carvalho (1996) for chondrichthyans; Gardiner *et al.* (1996) and Johnson and Patterson (1996) for actinopterygians; Zhu and Schultze (2001) for sarcopterygians; Ruta *et al.* (2003a) and Yates and Warren (2000) for amphibians; Benton (1993b, 1999a), O’Keefe (2002), Rauhut (2003), and Lee *et al.* (in press) for reptiles; Chiappe (2002b) and Cracraft *et al.* (in press) for birds; and Luo *et al.* (2002a) and McKenna and Bell (1997) for mammals.

1 CLASSIFICATION OF THE FISHES

Phylum Chordata

Subphylum Tunicata (Urochordata)

Subphylum Cephalochordata (Acroniata)

Subphylum Vertebrata (Craniata)

*Class ‘Agnatha’

Subclass Myxinoidea

Subclass Petromyzontida

†Subclass Conodonts

†Subclass Pteraspidomorphi

Order Astraspida

Order Arandaspida

- Order Heterostraci
- †Order Anaspida
- †Order Thelodonti
- Subclass unnamed
 - †Order Osteostraci
 - †Order Galeaspida
 - †Order Pituriaspida
- Infraphylum Gnathostomata
 - †Class Placodermi
 - Order Acanthothoraci
 - Order Rhenanida
 - Order Antiarchi
 - Order Petalichthyida
 - Order Ptyctodontida
 - Order Arthrodira
 - Class Chondrichthyes
 - Subclass Elasmobranchii
 - Infraclass unnamed
 - †Family Cladoselachidae
 - †Order Symmoriida
 - Family Symmoriidae
 - Family Falcidae
 - Family Stethacanthidae
 - †Order Eugeneodontiformes *sedis mutabilis*
 - †Order Petalodontiformes *sedis mutabilis*
 - Infraclass Euselachii
 - †Order Xenacanthiformes
 - †Order Ctenacanthiformes
 - †Order Hybodontiformes
 - Cohort Neoselachii
 - Division Galeomorphii
 - Order Heterodontiformes
 - Order Orectolobiformes
 - Order Lamniformes
 - Order Carcharhiniformes
 - Division Squalea
 - Order Hexanchiformes
 - Order Echinorhiniformes
 - Order Squaliformes
 - Superorder Hypnosqualea
 - Order Squatiniformes
 - Order Pristiophoriformes
 - Superorder Batoidea
 - Subclass Subterbranchialia
 - †Order Iniopterygiformes
 - †Order Chondrenchelyiformes
 - Superorder Holocephali

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- †Class Acanthodii
 - Class Osteichthyes
 - †*Psarolepis*
 - Subclass Actinopterygii
 - †Family Cheirolepididae
 - Infraclass Cladistia
 - †Family Guildayichthyidae
 - Family Polypteridae
 - Infraclass Actinopteri
 - †Family Mimiidae
 - †Family Stegotrachelidae
 - †Family Ptycholepididae
 - †Family Amblypteridae
 - †Superfamily unnamed
 - Family Redfieldiidae
 - Family Amphicentridae
 - Family Dorypteridae
 - Superdivision Chondrostei
 - †Family Birgeriidae
 - †Family Chondrosteidae
 - Order Acipenseriformes
 - Family Acipenseridae
 - Family Polyodontidae
 - †Order Palaeonisciformes
 - †Order Saurichthyiformes
 - †Order Pholidopleuriformes
 - †Order Perleidiformes
 - †Order Peltopleuriformes
 - Superdivision Neopterygii
 - Division Ginglymodi
 - Family Lepisosteidae
 - †Order unnamed
 - Family Semionotidae
 - Family Dapedidae
 - †Family Macrosemiidae
 - †Order Pycnodontiformes
 - Division Halecostomi
 - Subdivision Halecomorphi
 - Family Amiidae
 - †Family Parasemionotidae
 - Subdivision Teleostei
 - †Family Pachycormidae
 - †Family Aspidorhynchidae
 - †Family Pholidophoridae
 - †Family Leptolepididae
 - †Family Ichthyodectidae
 - Infradivision Osteoglossomorpha

- Order Osteoglossiformes
- Infradivision Elopoccephala
- Cohort Elopomorpha
 - Order Anguilliformes
- Cohort Clupeoccephala
 - Subcohort Otocephala
 - Division Clupeomorpha
 - †Order Ellimmichthyiformes
 - Order Clupeiformes
 - Division Ostariophysa
 - Order Gonorhynchiformes
 - Order Cypriniformes
 - Order Characiformes
 - Order Siluriformes
 - Order Gymnotiformes
- Subcohort Euteleostei
 - Order Salmoniformes
- Infracohort Neognathi
 - Order Esociformes
- Division Neoteleostei
 - Order Stomiiformes
- Subdivision Eurypterygii
 - Order Aulopiformes
- Infradivision Ctenosquamata
 - Order Myxophiformes
 - Order Polymixiiformes
- Superorder Paracanthopterygii
 - Order Percopsiformes
 - Order Ophidiiformes
 - Order Lophiiformes
 - Order Gadiformes
- Superorder Acanthopterygii
 - Series Atherinomorpha
 - Order Atheriniformes
 - Order Cyprinodontiformes
 - Order Belontiiformes
 - Series Percomorpha
 - Order Beryciformes
 - Order Lampridiformes
 - Order Zeiformes
 - Order Gasterosteiformes
 - Order Dactylopteriformes
 - Order Scorpaeniformes
 - Order Perciformes
 - Order Pleuronectiformes
 - Order Tetraodontiformes

Subclass Sarcopterygii
 Order Dipnoi
 Infraclass Crossopterygii
 †Order Porolepiformes
 Superorder unnamed
 †Order Onychodontida
 Order Actinistia
 Infraclass Tetrapodomorpha
 †Order Rhizodontida
 Superorder Osteolepidida
 †Order Osteolepiformes
 †Family Tristichopteridae
 †Order Panderichthyida
 Superclass Tetrapoda

2 CLASSIFICATION OF THE AMPHIBIANS

Superclass Tetrapoda

[†Family Elginerpetontidae]

†Family Ichthyostegidae

†Family Acanthostegidae

†Family Tulerpetontidae

†Family Colosteidae

†Family Crassigyrinidae

†Family Whatcheeriidae

†Family Baphetidae

Class Batrachomorpha/ Amphibia

*Order ‘Temnospondyli’

†Family Trimerorhachidae

†Suborder Dvinosauria

†Family Archegosauridae

†Family Rhinesuchidae

†Suborder Capitosauria

 Family Mastodonsauridae

 Family Capitosauridae

†Suborder Trematosauria

 Family Trematosauridae

 Family Metoposauridae

 Family Plagiosauridae

 Family Rhytidosteidae

 Family Brachyopidae

 Family Chigutisauridae

†Family Dendrerpetontidae

†Family Eryopidae

†Family Dissorophidae

- *†Family 'Branchiosauridae'
- †Family Amphibamidae
- Infraclass Lissamphibia
 - †Family Albanerpetontidae
 - Order Gymnophiona
 - Order Urodela
 - Order Anura
- Class Unnamed
 - †Superorder Lepospondyli
 - Order Microsauria
 - Order Nectridea
 - Order Aistopoda
 - Superorder Reptiliomorpha
 - *†Order 'Anthracosauria'
 - †Order Seymouriamorpha
 - †Order Diadectomorpha
 - Series Amniota

3 CLASSIFICATION OF THE REPTILES

- Series Amniota
 - Class Synapsida
 - *Order Pelycosauria
 - Family Eothyrididae
 - Family Caseidae
 - Family Varanopidae
 - Family Ophiacodontidae
 - Family Edaphosauridae
 - Family Sphenacodontidae
 - Order Therapsida
 - †Suborder Biarmosuchia
 - †Suborder Dinocephalia
 - †Suborder Dicynodontia
 - †Suborder Gorgonopsia
 - Suborder Cynodontia
 - †Family Procynosuchidae
 - †Family Galesauridae
 - †Family Cynognathidae
 - †Family Diademodontidae
 - †Family Chiniquodontidae
 - †Family Traversodontidae
 - †Family Tritylodontidae
 - †Family Trithelodontidae
 - Class Mammalia (see below)
 - Class Sauropsida

Subclass Anapsida

†Family Mesosauridae

†Family Millerettidae

†Family Bolosauridae

†Family Procolophonidae

†Family Pareiasauridae

Order Testudines (Chelonia)

†Family Proganochelyidae

†Family Australochelidae

Suborder Pleurodira

Suborder Cryptodira

Superfamily Baenoidea

†Family Meiolaniidae

Superfamily Chelonioidea

Superfamily Trionychoidea

Superfamily Testudinoidea

†Family Captorhinidae

†*Family Protorothyrididae

Subclass Diapsida

†Order Araucoscelidia

†Family Weigeltisauridae

†Order Younginiformes

†Infraclass Ichthyosauria *sedis mutabilis*

Infraclass Lepidosauromorpha

†Superorder Sauropterygia

Order Placodontia

Order Nothosauroidae

Suborder Pachypleurosauria

Suborder Nothosauria

Order Plesiosauria

Suborder Plesiosauroidae

Family Cryptoclididae

Family Cimoliasauridae

Family Polycotylidae

Family Elasmosauridae

Suborder Pliosauroidae

Family Rhomaleosauridae

Family Pliosauridae

Superorder Lepidosauria

Order Sphenodontida

Family Sphenodontidae

†Family Pleurosauridae

Order Squamata

*Suborder Lacertilia (Sauria)

Infraorder Iguania

Infraorder Gekkota

- Infraorder Amphisbaenia
- Infraorder Anguimorpha
- Infraorder Scincomorpha
- Suborder Serpentes (Ophidia)
- Infraclass Archosauromorpha
 - †Family Trilophosauridae
 - †Family Rhynchosauridae
 - †Order Prolacertiformes
- Division Archosauria
 - †Family Proterosuchidae
 - †Family Erythrosuchidae
 - †Family Euparkeriidae
- Subdivision Crurotarsi
 - †Family Phytosauridae
 - †Family Ornithosuchidae *sedis mutabilis*
 - †Family Stagonolepididae *sedis mutabilis*
 - †Family Prestosuchidae *sedis mutabilis*
 - †Family Poposauridae *sedis mutabilis*
- Superorder Crocodylomorpha
 - †Family Saltoposuchidae
 - †Family Sphenosuchidae
- Order Crocodylia
 - †Family Protosuchidae
- Division Mesoeucrocodylia
 - †Family Teleosauridae
 - †Family Metriorhynchidae
- Subdivision Metasuchia
 - †Family Notosuchidae
 - †Family Sebecidae
- Infradivision Neosuchia
 - †Family Goniopholididae
 - †Family Dyrosauridae
- Suborder Eusuchia
 - Family Gavialidae
 - Family Crocodylidae
 - Family Alligatoridae
- Subdivision Avemetatarsalia
 - †*Scleromochlus*
- Infradivision Ornithodira
 - †Order Pterosauria
 - *Suborder Rhamphorhynchoidea
 - Suborder Pterodactyloidea
 - †*Lagerpeton*
 - †*Marasuchus*
- Superorder Dinosauria
 - Order Saurischia
 - †Family Herrerasauridae

Suborder Theropoda

†Infraorder Coelophysoidea

†Infraorder Ceratosauria

Family Ceratosauridae

Family Abelisauridae

Infraorder Tetanurae

†Division Carnosauria

Subdivision Spinosauroidae

Family Megalosauridae

Family Spinosauridae

Subdivision Allosauroidae

Family Allosauridae

Family Carcharodontosauridae

Division Coelurosauria

†Family Coeluridae

Subdivision Maniraptoriformes

†Family Tyrannosauridae

†Family Ornithomimidae

Infradivision Maniraptora

†Family Alvarezsauridae

†Family Therizinosauridae

†Cohort Deinonychosauria

Family Dromaeosauridae

Family Troodontidae

Class Aves (see below)

†Suborder Sauropodomorpha

Thecodontosaurus

Family Plateosauridae

Riojasaurus

Family Massospondylidae

Infraorder Sauropoda

Family Vulcanodontidae

Family Euhelopodidae

Family Omeisauridae

Division Neosauropoda

Family Cetiosauridae

Family Diplodocoidea

Subdivision Macronaria

Family Camarasauridae

Infradivision Titanosauriformes

Family Brachiosauridae

Family Titanosauridae

†Order Ornithischia

Family Pisanosauridae

Family Fabrosauridae

Suborder Thyreophora

Family Scelidosauridae

- Infraorder Stegosauria
- Infraorder Ankylosauria
 - Family Nodosauridae
 - Family Ankylosauridae
- Suborder Cerapoda
 - Infraorder Pachycephalosauria
 - Infraorder Ceratopsia
 - Family Psittacosauridae
 - Family Protoceratopsidae
 - Family Ceratopsidae
 - Infraorder Ornithopoda
 - Family Heterodontosauridae
 - Family Hypsilophodontidae
 - *Family Iguanodontidae
 - Family Hadrosauridae

4 CLASSIFICATION OF THE BIRDS

Class Aves

- †Family Archaeopterygidae

- †*Rahonavis*

- †*Jeholornis*

Subclass Pygostylia

- †Family Confuciusornithidae

- †Order Oviraptorosauria

Infraclass Ornithothoraces

- †Order Enantiornithes

Supercohort Ornithomorpha

- †*Patagopteryx*

- †*Vorona*

Cohort Ornithurae

- †Order Hesperornithiformes

Subcohort Carinatae

- †Order Ichthyornithiformes

Superdivision Neornithes

Division Palaeognathae

- †Order Lithornithiformes

Order Ratites

Division Neognathae

Subdivision Galloanserae

Order Anseriformes

Order Galliformes

Subdivision Neoaves

Superorder unnamed [‘waterbird assemblage’]

Infraorder unnamed

Order Gruiformes
 Order Ralliformes
 Infraorder unnamed
 Order Pelecaniformes
 Order Ciconiiformes
 Infraorder unnamed
 Order Charadriiformes
 Order Phoenicopteriformes
 Order Podicipediformes
 Order Falconiformes
 Order Procellariiformes
 Order Gaviiformes
 Order Sphenisciformes
 Order Strigiformes
 Superorder unnamed
 Order Apodiformes
 Order Caprimulgiformes
 Order Musophagiformes
 Order Columbiformes
 Order Psittaciformes
 Order Cuculiformes
 Superorder unnamed ['higher land birds']
 Order Piciformes
 Order Coliiformes
 Order Trogoniformes
 Order Bucerotiformes
 Order Coraciiformes
 Order Passeriformes

5 CLASSIFICATION OF THE MAMMALS

Class Mammalia

†*Adelobasileus*

†Family Sinoconodontidae

Subclass Mammaliaformes

†Family Morganucodontidae

Infraclass Holotheria

†Family Kuehneotheriidae

†Order Docodonta

Superdivision Australosphenida

†Ausktribosphenidae

Division Monotremata

Superdivision Theriimorpha

†Order Triconodonta

Division Theriiformes

- †Order Multituberculata
- Superlegion Trechnotheria
- †Order Symmetrodonta
- Legion Cladotheria
 - †Superfamily Dryolestoidae
 - †*Vincelestes*
- Sublegion Boreosphenida
- †Order Deltatheroida
- Infralegion Theria
 - Cohort Marsupialia
 - Magnorder Ameridelphia
 - Order Didelphimorphia
 - Family Didelphidae
 - Order Paucituberculata
 - Family Caenolestidae
 - †Family Argyrolagidae
 - †Family Caroloameghinidae
 - Order Sparassodonta
 - †Family Borhyaenidae
 - †Family Thylacosmilidae
 - Magnorder Australidelphia
 - Order Microbiotheria
 - Order Dasyuromorphia
 - Order Peramelemorphia
 - Order Notoryctemorphia
 - Order Diprotodontia
 - Cohort Placentalia (Eutheria)
 - Magnorder Afrotheria
 - Grandorder unnamed
 - Order Tubulidentata
 - Mirorder unnamed
 - Order Afrosoricida
 - Family Tenrecidae
 - Family Chrysochloridae
 - Order Macroscelidea
 - Grandorder Paenungulata
 - Order Hyracoidea
 - Mirorder Tethytheria
 - Order Sirenia
 - Order Proboscidea
 - †Family Moeritheriidae
 - †Family Deinotheriidae
 - Suborder Elephantiformes
 - †Family Mammutidae
 - †Family Gomphotheriidae
 - †Family Stegodontidae
 - Family Elephantidae

- Magnorder Xenarthra
 - Order Cingulata
 - Family Dasypodidae
 - †Family Glyptodontidae
 - Order Pilosa
 - Family Myrmecophagidae
 - Family Bradypodidae
 - Family Megalonychidae
 - †Family Megatheriidae
 - †Family Mylodontidae
- Magnorder Boreoeutheria
 - Incertae sedis*
 - †Order Leptictida
 - †Order Anagalida
 - †Order Apatemyida
 - †Order Taeniodonta
 - †Order Tillodontia
 - †Order Pantodonta
 - †Order Pantolestia
 - †Order Dinocerata
 - Grandorder Laurasiatheria
 - Order Lipotyphla
 - Suborder Erinaceomorpha
 - Suborder Soricomorpha
 - Order Chiroptera
 - Suborder Megachiroptera
 - Suborder Microchiroptera
 - Mirorder Ferungulata
 - †Family Zhelestidae
 - Superorder Cetartiodactyla
 - †Order Arctocyonia
 - †Family Mesonychidae
 - Order Artiodactyla
 - †Family Dichobunidae
 - Suborder Suiformes (Bunodontia)
 - †Family Entelodontidae
 - Family Suidae
 - †Family Anthracotheriidae
 - Family Hippopotamidae
 - Suborder Selenodontia
 - Infraorder Tylopoda
 - †Family Merycoidodontidae
 - Family Camelidae
 - Infraorder Ruminantia
 - †Family Hypertragulidae
 - Family Tragulidae
 - Family Antilocapridae

- Family Giraffidae
- Family Cervidae
- Family Moschidae
- Family Bovidae
- Order Cetacea
 - Suborder Archaeoceti
 - Suborder Odontoceti
 - Suborder Mysticeti
- Order Perissodactyla
 - Superfamily Hippomorpha
 - Family Equidae
 - †Family Brontotheriidae
 - Suborder Tapiromorpha
 - †Family Chalicotheriidae
 - Superfamily Ceratomorpha
 - Superfamily Tapiroidea
 - Superfamily Rhinoceroidea
- ?Superorder Bulbulodonta
 - †Family Hyopsodontidae
 - †Superorder Meridiungulata
- Order Litopterna
- Order Notoungulata
- ?Order Astratheria
- ?Order Pyrotheria
- Superorder unnamed
 - †Order Creodonta
- Order Carnivora
 - †Family Miacidae
 - Suborder Feliformia
 - †Family Nimravidae
 - Infraorder Aeluroidea
 - Family Viverridae
 - Family Herpestidae
 - Family Hyaenidae
 - Family Felidae
 - Suborder Caniformia
 - Family Canidae
 - Family Ursidae
 - †Family Amphicyonidae
 - Family Mustelidae
 - Family Procyonidae
 - Infraorder Pinnipedia
 - †Family Enaliarctidae
 - Family Otariidae
 - Family Odobenidae
 - †Family Desmatophocidae
 - Family Phocidae

- Order Pholidota
- Grandorder Euarchontoglires
- Superorder Archonta
 - †Suborder Plesiadapiformes
- Order Primates
 - Suborder Strepsirrhini
 - †Infraorder Adapiformes
 - Infraorder Lemuriformes
 - Family Lemuridae
 - Family Indriidae
 - Family Daubentoniidae
 - Family Lorisidae
 - Family Galagidae
 - Suborder Haplorhini
 - †Family Omomyidae
 - Family Tarsiidae
 - Suborder Anthroidea
 - Infraorder Platyrrhini
 - Family Cebidae
 - Family Atelidae
 - Infraorder Catarrhini
 - †Family Oligopithecidae
 - †Family Parapithecidae
 - †Family Propithecidae
 - Superfamily Cercopithecoidea
 - Family Cercopithecidae
 - Superfamily Hominoidea
 - †Family Proconsulidae
 - Family Hylobatidae
 - Family Hominidae
- Order Scandentia
- Order Dermoptera
 - †Family Paromomyidae
 - Family Galeopithecidae
- Superorder Glires
 - †Family Zalambdalestidae
- Order Rodentia
 - Suborder Sciurognathi
 - †Superfamily Ischyromyoidea
 - Infraorder Sciuromorpha
 - Infraorder Myomorpha
 - Suborder Hystricognathi
 - Infraorder Hystricomorpha
 - Infraorder Phiomorpha
 - Infraorder Caviomorpha
- Order Lagomorpha