Tarbosaurus at the Naturkundemuseum (Natural History Museum), Münster, Germany. Wikimedia Commons, photo by Thomas Ihle, 2004

Vertebrates: Contents

Part 1: Alphabetical Listings

A. Glossary of terms and abbreviations.

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Part 2: Phylogenetic Listings

A. Dendrograms ("Cladograms")

B. Descriptions

Units marked with an asterisk are placeholders and contain little material. These units will be expanded in de course.

The numbers at the left refer to the numeration used in the old Palaeos com. Some of the previous units have been subdivided, while several have been merged, and some new units for small eccentric taxa added, reflecting the phylogenetic uncertianty regarding the group in question. Note that the old numbering doesn't necessarily follow the current phylogenetic sequence. MAK111021

10: Chordata: tunicates, amphioxus, *Haikouella*
20: Vertebrata: the ancestors of vertebrates, the first vertebrates, primitive survivors like hagfish and and lampreys (Craniata in the old Palaeos)
30: Conodonta: the conodonts
20: Anaspida: not to be confused with *anapsida*, these were early jawless vertebrates
40: Pteraspidomorphi: the other vertebrate lineage
50: Thelodonti: theolodonts
50: Cephalaspidomorphi: galeaspids and osteostracans, the "ostracoderms" with their elaborate headshields
60: Gnathostomata: vertebrates with jaws and paired fins (or limbs in the case of land animals)
60: Placodermi*: placoderms, a diverse group of early armoured fish
90: Acanthodii: "spiny sharks", the common ancestors of all recent fish
70: Chondrichthyes: early sharks and living holocephalians
80: Neoselachii: living sharks,skates & rays
90: Osteichthyes: bony fish
90: Actinopterygii: ancestral "ray-finned" fish; *Cheirolepis*, bichirs, sturgeons
100: Neopterygii: gars, *Amia*
110: Teleostei*: the first "advanced" fishes
120: Euteleostei*: carp,catfish, salmon, pike, deep benthic fish
130: Acanthomorpha*: tuna, bass, flounder, cod, and cichlids, among many others
140: Sarcopterygii: lobe-finned fish
150: Tetrapoda: the transition to land, the first amphibians
160: Temnospondyli: the temnospondyls, an important group of Paleozoic and early Mesozoic amphibains
170: Lepospondyli*: small Paleozoic amphibians
180: Lissamphibia*: living amphibians
190: Reptiliomorpha: anthracosauroids, embolomeres, seymouriamorphs, amphibians on the way to reptiles
190: Amniota: evolution invents the amniote egg; the first reptiles.

210: Eureptilia: previously known as Captorhinomorphs, these are the earliest and most primitive reptiles
200: Anapsida: bolosaurs, mesosaurs, pareiasaurs, and other exotic early types
200: Chelonii: turtles and their relatives, who may be anapsids or, according to recent theories, lepidosauromorphs or archosaurs (we've got them with the anapsids for now).
210: Diapsida: Early diapsids, previously known as Eosuchians, an important stem group, also various oddball groups who have been placed here because we don't know where else to put them
210: Ichthyosauria: the ichthyosaurs or "fish lizards", a successful group of mesozoic marine reptiles
220: Lepidosauromorpha: the archosaurs' unassuming cousins
220: Sauropterygia: plesiosaurs and related marine reptiles
230: Sphenodontia (Rhynchocephalia): *Sphenodon* and relatives
240: Squamata: iguanas, agamids and chameleons (previously separate units 250 Scleroglossa (skinks, gekkos,varanids and other derived lizards) and 260 Pythonomorpha (mosasaurs and snakes) are now included here)
270: Choristodera: a specialised lizard and crocodile like group, previously included under the "Eosuchias"
270: Archosauromorpha: rhynchosaurs, trilophosaurs, and other early types
270: Archosauria: poposurs, rauisuchids, phytosaurs, and friends, the "thecodonts"
290: Crocodilia (Crocodylomorpha): crocodiles and their ancestors
300: Pterosauria*: pterodactyls
310: Dinosauromorpha/Dinosauria*: the ancestors of the dinosaurs, and dinosauria overview (for other dinosaurs see the following units)
340: Theropoda: carnivorous dinosaurs, from little *Coelophysis* to the mighty Carcharodontosaurs
340: Coelurosauria: agile, mostly small, but a few very large, advanced carnivorous and herbivorous dinosaurs with feathers and grasping forelimbs, ground dwellers, tree-climbers, gliders and fliers, intermediate between dinosaurs and the first birds
330: Sauropodomorpha/Sauropoda: sauropods, diplodocii, brachiosauri, and co, the giants among giants
320: Ornithischia: stegosaurs, ankylosaurs, hadrosaurs and *Triceratops*, a diverse and very specialised group of herbivorous dinosaurs.
350: Aves: early birds (this will probably eventually be divided into a number of separate units)
360: Galloanserae: chickens, ducks (possible parent of charadriomorphs)
365: Charadriomorpha: cranes, vultures, flamingos and shore birds (this and the following two units needs revising in the light of molecular phylogeny and the Neoaves hypothesis)
370 Gruimorpha: grebes, hawks, owls & coockoos
380: Passeriformes*: song birds
390: Synapsida: the pelycosaurs, e.g. *Dimetrodon*
400: Therapsida: the mamal-like reptiles: Biarmosuchids, Dinocephalians, Dicynodonts, Gorgonopsians & Therocephalians
410: Cynodontia: cynognaths, tritylodonts, tritylodonts and other furry things that weren't mammals but were on the road to them
420: Mammaliformes: *Morganucodon*, *Hadrocodium*, and kuehneotheriids, also multituberculates (which are like rodents but much more primitive)
430: Mammalia: Monotremes and Mesozoic mammals
440: Metatheria*: marsupials
450: Eutheria: primitive Mesozoic non-placental mammals, and some early Cenozoic placental mammals
450: Xenarthra: sloths, anteaters, armadillos, and glyptodonts
510: Laurasiatheria: a major mammal group revealed through molecular phylogeny
500: Ferae*: cats, bears, dogs, seals
510: Meridiungulata: the South American ungulates, who may or may not constitute a natural group
530: Perissodactyla*: horses, tapirs, rhinos, titanotheres and chalicotheres; the "odd-toes" ungulates
520: Cetartiodactyla: camels, pigs, deer, and other "even-toed" ungulates. And whales, who just happen to be related.
470: Anagalida*: unit retained pending revision; includes a group of obscure extinct forms of uncertain relationships which may or may not belong here, along with rabbits and their ancestors
475: Rodentia*: rodents, the most speciose and succesful group of mammals
480: Archonta: cousins of the primates: tree shrews, plesiadapiformes, colugos, etc
480: Primates: lemurs, tarsiers, monkeys, apes and hominids (or hominans, depending on your preferred terminology)
490: Chiroptera*: bats, previously included with the archonta but in the light of molecular phylogeny now considered a separate group
460: Insectivora: shrews, hedgehogs, etc.
530: Afrotheria*: a diverse group that originated in Africa, includes some taxa previously cobnsidered insectivores
530: Proboscidea:*: elephants and their prehistoric relatives the mastodons and mammoths

Part 3: Bones

Bones

The Braincase (***Neurocranium***)
- **The Ethmoid Region**
  - **Ethmoid**
- **The Occiput**
  - for paroccipital process, see **Opisthotic**
- **The Otic Region**
  - **Dermosphenotic**
  - **Mastoid**
  - **Opisthotic**
  - **Prootic**
- **The Sphenoid Region**
  - **Basisphenoid**
  - **Pleurosphenoid**
  - **Sphenethmoid**

The Dermal Bones (***Dermatocranium***)
- **Facial Series**
  - **Internasal**
  - **Premaxilla**
  - **Septomaxilla**
- **Mandibular Series**
  - **Dentary**
  - **Gular**
  - **Infradentaries** (see Surangular)
  - **Surangular**
- **Opercular Series**
  - **Opercular**
- **Orbital Series**
  - **Jugals**
- **Palatal Series**
  - **Palatines**

The Ear
- **Incus**

Gill Arch Derivatives (***Splanchnocranium***)
- **Epibranchials**
- **Incus** (see **Ear: Incus**)
- **Hypohyal**
- **Meckel's Cartilage**

Teeth
- **Canines**
- **Molars**
- **Tooth Implantation**

Quick Links to Key Taxa

Amniota	**Diapsida**	**Mammalia**	**Reptilia**	**Testudines**
Aves	**Dinosauria**	**Mammaliformes**	**Saurischia**	**Tetrapoda**
Archosauria	**Gnathostomata**	**Osteichthyes**	**Synapsida**	**Theropoda**
Chordata	**Lepidosauria**	**Primates**	**Teleostei**	**Vertebrata**

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Taxon Index: A-C

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-A-

1. Acanthodiformes X: a long-lived group of very Osteichthyan-like acanthodians
2. Acanthodii X: the other teleostomes, sister of Osteichthyes, with the skull based on large cartilaginous plates and with many fin spines
3. Acanthomorpha: a big fish clade, including tunas, basses, flounders, cods, and billfishes among many others.
4. *Acanthostega* X: the most basal well-known tetrapod
5. *Achoania* X: the sister of crown group Sarcopterygii?
6. Acipenseriformes: sturgeons, paddlefish & extinct relatives
7. *Acrocanthosaurus* X: an Albian-Aptian theropod -- and contender for largest land predator of all time
8. Acrochordoidea: wart snakes or file snakes
9. Acrodonta: acrodont lizards, *i.e.* agamids, chamaeleons and that lot.
10. Actinistia: the coelacanth group, odd lobe-finned fish with poorly known relationships
11. Actinolepida X: a cosmopolitan placoderm group closely related to the phylolepidids
12. Actinolepidoidei X: actinolepids + phylolepidids
13. Actinopteri: all actinopterygians (ray-finned fish) except the very primitive Cladistia
14. Actinopterygii: the ray-finned fish
15. Adapiformes X: the extinct (Paleocene to Miocene) sister group of the lorises and lemurs
16. Adelogyrinidae X: another strange and poorly-known Carboniferous lepospondyl group with a long trunk, but with limb girdles, orbits very far forward.
17. *Aegyptosaurus* X: an Early Cretaceous African sauropod just basal to the Titanosauria
18. Aepyornithiformes X: the elephant birds of Pleistocene Madagascar
19. *Aerosaurus* X: a Permo-Carboniferous varanodont "pelycosaur," more robust than most in the family
20. Aetosauridae X: also known as Stagnolepidae -- armored suchian vegetarians of the Triassic
21. *Aetosaurus* X: a smallish aetosaur with square armor plates
22. Agamidae: Old World iguanas; a diverse group of evil-looking lizards with names like *Draco* and *Moloch*
23. Aigialosauridae X: late Mesozoic aquatic reptiles from Europe, sister group of the mosasaurs
24. Aïstopoda X: snake-like Permo-Carboniferous lepospondyls
25. *Alamosaurus* X: a Late Cretaceous titanosaurid immigrant to North America
26. *Albertosaurus* X: a Late Cretaceous, more northerly cousin of *Tyrannosaurus*

27. *Alectrosaurus* X: an Asian relative of *Tyrannosaurus*
28. *Allenypterus* X:a weird Bear Gulch actinistian
29. Alethinophidia: all snakes except the "blind snakes"
30. Alligatoridae: alligators, caimans, and a few others
31. Allosauridae X: *Allosaurus* and *Acrocanthosaurus* -- Late Mesozoic carnosaurs
32. Allosauroidea X: all the carnosaurs except some early odd-balls
33. Allotheria X: haramyids and multituberculates. This clade may or may not exist.
34. *Altirhinus* X: Cretaceous hadrosauroid, sister of the Hadrosauridae.
35. Altungulata: horses > cows
36. Alvarezsauridae X: Late Cretaceous flightless birds with very wide distribution -- and very peculiar arms.
37. *Alvarezsaurus* X: a large and poorly known basal Alvarezsaurid from South America
38. *Alxasaurus* X: a primitive therizinosaur from the Albian of China
39. Ambulocetidae X: "walking whales" -- early amphibious cetaceans from the Middle Eocene
40. Ameridelphia: South American marsupials
41. Amiidae: probably *Amiopsis* + *Amia* -- the Late Mesozoic, Tethys-based branch of the Amiiformes
42. Amiiformes: probably the original (Triassic) worldwide radiation of medium-sized freshwater neopterygians
43. Amiinae: the bowfin, *Amia* and its closest relatives
44. *Amiopsis* X: a Late Mesozoic European member of the Amiidae -- perhaps a staple of *Archaeopteryx*
45. Amniota: fully land-adapted tetrapods
46. *Ampelosaurus* X: a primitive, but very late, armored titanosaur, from the Maastrichtian of Europe
47. Amphiaspidida X: really strange, highly armored, jawless fishes from the Devonian of Russia
48. Amphiaspidoidei X: the most extreme of the amphiaspids
49. Amphibolurinae: Australian agamid lizards
50. *Amphilestes* X: a Middle Jurassic triconodont mammal with interlocking molars
51. Amphisbaena: secretive legless lizards
52. Anagalida: rabbits, rodents and elephant shrews
53. Anagalidae X: poorly known and rarely studied rabbit/rodent cousins from the Paleogene
54. Anagaloidea X: more of the same
55. Anapsida: one of the four great amniote clades, this group includes pareiasaurs, turtles, and bolosaurs
56. *Anarosaurus* X: a small Middle Triassic pachypleurosaur with disproportionately long hind legs
57. Anaspida X: odd, very basal and early jawless fishes without shields (hence the name) and with numerous gill openings in a slanting line
58. *Anatalavis* X: Cretaceous to Eocene goose/duck, sister of the magpie goose of Australia.
59. Anatidae: the crown group of living ducks, geese & swans
60. Anatinae: ducks
61. Anatini: dabbling ducks
62. Anatoidea: ducks, swans, most geese & close relatives
63. *Anatolepis* X: *very* early jawless fish from the Ordovician of North America
64. *Anchisaurus* X: a rather basal prosauropod from the Late Triassic and Early Jurassic of North America and perhaps elsewhere
65. *Andesaurus* X: big, relatively basal titanosaur from South America
66. *Angistorhinus* X: a Carnian phytosaur with a tall skull and down-turned rostrum
67. Anguimorpha: the clade uniting anguimorph and varanoid lizards
68. Anguoidea: *Xenosaurus*, anguid lizards, shinisaurs, etc.
69. *Angusaurus* X: a long-snouted trematosaurid temnospondyl from the Early Triassic of Russia.
70. Anhimidae: screamers
71. Aniliidae: the false coral snake of South America
72. Aniloidea: an almost extinct snake group, sister of the macrostomates
73. Ankylosauria X: ankylosaurs and nodosaurs
74. Ankylosauridae X: *Ankylosaurus* > *Nodosaurus*
75. Ankylosauromorpha X: probably *Ankylosaurus* > *Stegosaurus*
76. Anchipteraspididae X: small pteraspidid Siluro-Devonian jawless fishes which resemble cyathaspidiforms in having a single, fused branchio- cornual plate
77. Anomalepididae: a small family of larger, South American scolecophidians ("blind snakes")
78. Anomochilidae: *Anomochilus*, a very strange and derived aniloid snake
79. Anomodontia X: dicynodonts and other toothless Permo-Triassic therapsids
80. *Anoplosuchus* X: an early (Permian) and basal dicynodont therapsid

81. Anoplotheroidea X: an early Neogene ungulate group, convergent on camels
82. Anotophysi: milkfishes and other freshwater teleosts without Weberian ossicles
83. *Anseranas*: the magpie goose of Australia & New Guinea
84. Anseres: ducks, geese & swans
85. Anseriformes: ducks > chickens. Of extant birds, ducks, geese, swans, & screamers.
86. Anserinae: geese & swans
87. Anteosauria X: the first really succesful therapsids, from the later Permian of Africa, Asia & China
88. Anteosauridae X: rather dog-like carniverous Permian therapsids
89. Anteosaurinae X: large, Late Permian anteosaurs with oddly short legs.
90. *Anteosaurus* X: well-known standard bearer of the family Anteosauridae
91. Anthracosauroidea X: embolomeres, gephyrostegids and a few other Late Paleozoic tetrapod odds and ends
92. Anthracotheroidea X: Eocene artiodactyl group of uncertain composition, probably close to hippos.
93. Anthropoidea: Texans > tarsiers, including apes, monkeys and people
94. Antiarcha X: one of the two big placoderm clades, this is the *Bothriolepis*, bug-like group
95. Anura: crown group frogs
96. Apalolepididae X: a scale family of Early Devonian theolodontid thelodonts
97. Apatosaurinae X: *Apatosaurus*, the former *Brontosaurus*.
98. Apodiformes: hummingbirds and swifts
99. Apternodontidae X: Eocene to Oligocene proto-shrews from North America.
100. Apterygiformes: kiwis
101. Archaeornithes X: *Archaeopteryx*
102. Araeoscelidans X: Permo-Carboniferous lizard-like critters who form one of the anchors for the crown group Diapsida.
103. *Aragosaurus* X: a primitive macronarian sauropod, from the Early Cretaceous of Europe
104. Arandaspida X:a very early (Ordovician) line of pteraspidomorph fishes
105. *Archaeonectrus X:* : a basal pliosauroid from the Early Jurassic of Europe
106. *Archaeosyodon*X: a basal ?anteosaurian dinocephalian from the Middle Permian of Russia with a deep and massive skull
107. *Archaeothyris* X: a Late Carboniferous "pelycosaur" from Canada, the oldest synapsid known from reasonably good remains.
108. Archegosauroidea X: big, rather slim and croc-like temnospondyls from the Permian
109. Archonta: a big, important, but still uncertain clade including primates, tree shrews and bats.
110. Archosauria: rocs + crocs, a big crown group also including dinosaurs and (probably) pterosaurs
111. Archosauriformes: an arbitrary rest stop between Archosauromorpha and Archosauria, defined as *Proterosuchus* + birds.
112. Archosauromorpha: drakes > snakes. One of the two complementary reptile clades making up the Sauria.
113. Arctostylopida X: the most primitive paraxonic (cows > horses) ungulates, mostly from the Paleocene of Laurasia
114. *Argentinasaurus* X: perhaps the largest land animal ever, and perhaps the most frequently misspelled dinosaur, a huge sauropod from the Early Cretaceous of you-know-where
115. Argentiniformes: herring, smelt, etc.
116. Arthrodira X: placoderms with a movable joint between the head and body, including the famous *Dunkleosteus*.
117. Artiodactyla: cows > whales, perhaps, or sows + cows.
118. Ascidiacea: Classic urochordates with "tadpole" larvae and sessile adult.
119. Asioryctitheria X: Epitherians, but no one knows what sort....
120. Asterolepidoidei X: some late and deviant antiarch placoderms with simplified pectoral limbs/fins and very long armor
121. Astraspidae X: Ordovician fishes with tessellated armor and large, mushroom-shaped dentine tubercles
122. *Ateleaspis* X: our favorite osteostracan, which has always reminded us of an "Ironclad" from the American Civil War.
123. *Atlasaurus* X: an early brachiosaur from the Middle Jurassic of Africa
124. Atractaspididae: very basal colubrid snakes
125. *Attenborosaurus* X: an early plesiosaur
126. Ausktribosphenidae X: An extinct group of Cretaceous Australian tribosphenic mammals which are, or have a striking dental similarity to, placental mammals.
127. Australidelphia: the Australian radiation of marsupials
128. Australosphenida: Gondwanan mammaliaforms with convergently derived tribosphenic molars.

129. Autoceta: crown group cetaceans (whales and dolphins)
130. Aves: *Archaeopteryx* + living birds
131. Avetheropoda: *Allosaurus* + birds
132. Aythyini: diving or bay ducks, scaups, and pochards
133. Azemiopinae: The poorly known Fea's Viper of Tibet
134. Azhdarchoidea X: *Quetzalcoatlus* and related pterosaurs

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-B-

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135. Balognathidae X: a group of prionodontidan conodonts
136. Bandringidae X: small ctenacanthiform sharks with hugely elongated rostra from the Late Carboniferous of North America
137. *Baphetes* X: a well-known baphetid (proto-temnospondyl) from the Late Carboniferous of Europe and North America
138. Baphetidae X: a strange group of Late Carboniferous amphibians with "keyhole" orbits
139. *Barapasaurus* X: an early, perhaps the earliest, really big sauropod (14-18 m), sister of the Eusauropoda, from the Early Jurassic of India
140. Barbereniidae X: a probably non-existent group of Late Cretaceous South American symmetrodonts.
141. *Barosaurus* X: a big, Late Jurassic African diplodocine sauropod.
142. Basilosauridae: in essence all whales in which the pelvis has lost contact with the spine.
143. *Basilosaurus* X: a big serpentine whale from the Middle Eocene
144. Batomorphii: modern rays and skates
145. Batrachosauria: *Seymouria* + Jane Seymour -- amniotes and their close relatives
146. *Batrachotomus* X: the dominant predator of the Lower Keuper
147. Baurusuchidae X: terrestrial crocs who looked like therapsids, from the Late Cretaceous of South America
148. *Beipiaosaurus* X: a feathered therizinosaur from the Early Cretaceous of China
149. Benneviaspidida X: Early Devonian cornuate osteostracans with particularly elaborate head shields
150. Biarmosuchia X: the most basal therapsids known from well-preserved fossils
151. Biarmosuchidae X: *Biarmosuchus*, a biarmosuchian of rather light and open construction
152. *Bienotherium* X: an Early Jurassic cynodont from China
153. Birgeriidae X: Triassic fish closely related to the sturgeon
154. *Bishanopliosaurus* **X**: a poorly known pliosaur from the Early Jurassic of China
155. *Bocatherium* X: a cynognathian cynodont from the Middle Jurassic of Mexico
156. Boidea: boas and pythons
157. Bolosauridae X: an odd group of lizard-like anapsids from the Late Permian
158. *Bolotridon* X: an Early Triassic galesaurid cynodont from South Africa
159. Archipelepididae X: a scale taxon of thelodonts, quite similar to *Turinia*, but earlier and with different ornament and very large scale bases, from the Silurian of Canada.
160. Bothremydidae X: an extinct, mostly Cenozoic, group of mostly Laurasian pleurodire turtles
161. Bothriolepidoidei X: *Bothriolepis* and closely related antiarch placoderms of the later Devonian
162. *Bothriospondylus* X: a large European brachiosaurid sauropod of the Late Jurassic
163. Bovoidea: cattle, sheep goats, etc.
164. *Brachauchenius* X: a Late Cretaceous pliosaur from North America
165. Brachiosauridae X: sister group to the titanosaurs
166. *Brachiosaurus* X possibly the largest tetrapod ever
167. Brachyopidae X: late, long-lived family of temnospondyls with short, broad flat skulls with large eyes situated far forward
168. Brachyopoidea X: the last temnospondyls
169. *Brachypterygius* X: Jurassic ichthyosaur distiguished by very broad fore-paddles.
170. *Brachysuchus* X a very large Late Triassic phytosaur
171. Bradysaurs X : large primitive pareiasaurs from the Middle Permian of South Africa
172. Brithopodidae X: a minor family of anteosaurs from the Late Permian of Russia, probably synonymous with Anteosauridae
173. *Brithopus* X: the standard-bearer of the previous family
174. *Broomistega* X: a rhinesuchid temnospondyl from the Early Triassic of South Africa

175. Bulbulodentata X: a non-South American stem group of the endemic South African ungulates

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176. *Cabonnichthys* X: an odd Australian tristichopterid (osteolepiform) fish from the Famennian
177. Caenophidia: all derived poisonous snakes and close relatives
178. Caeciliidae: a large group of caecilians, probably paraphyletic
179. *Californosaurus* X: a medium-large ichthyosaur from the Late Triassic of North America
180. Camarasauridae X: a small family of basal macronarian sauropods
181. *Camarasaurus* X: a very well known *Apatosaur*-like sauropod from the Late Jurassic of North America.
182. Camelidae: camels
183. Campylognathoidea X: an early group of pterosaurs, including *Eudimorphodon.*
184. Canowindridae X: Late Devoinian Australian osteolepiforms
185. Capitosauria X: large to huge Triassic temnospondyls
186. Capitosauridae X: Late Triassic capitosauroids
187. Caprimulgiformes: nightjars, night hawks, potoos, oilbirds, etc.
188. Captorhinidae X: one of two succesful groups of early (eu)reptiles
189. Carcharhiniformes: typical nasty-looking galeomorph sharks
190. Carcharodontosauridae X: large late *Allosaur* cousins
191. *Caridosuctor* X: an actinistian from Bear Gulch
192. Carinatae: *Ichthyornis* plus living birds.
193. Carnosauria X: *Allosaurus* and close relatives
194. Caseasauria X: the earliest branch from the synapsid tree
195. Caseidae X: the first herbivorous synapsids
196. Casuariformes: emus and cassowaries
197. Caturoidea X: Jurassic cousins of *Amia*
198. *Cedarosaurus* X: Early Cretaceous brachiosaur from North America
199. Centrosaurinae X: *Styracosaurus* and close relatives
200. Cephalaspidida X: a group of cornuate osteostracans (jawless fish) from the Early Devonian of Europe
201. Cephalaspidomorphi X: a term we've recycled to mean Osteostraci + Galeaspida (big group of jawless fishes)
202. Cephalochordata: amphioxus -- the sister group to Chordata
203. Cerapoda X: hadrosaurs + ceratopsians
204. Ceratopsia X: all Marginocephalia except the pachycephalosaurs
205. Ceratopsinae X: the immediate family of *Triceratops*
206. Ceratosauria X: coelophysids, abelisaurs and other non-tetanuran theropod dinosaurs
207. *Ceresiosaurus* X: a nothosaur from the Middle Triassic seas of Europe
208. Cervoidea: deer, elk, moose and similar ruminants
209. Cetacea: dolphins > deer -- the whales, dolphins and their older cousins
210. Cetartiodactyla: deer + dolphins
211. Cetiosauridae X: a rather early, unspecialized sauropod from the Middle & Late Jurassic.
212. *Chaliminia* X: a very early (Late Triassic) trithelodont
213. Chamaeleonidae: chameleons
214. Champsosauridae X: a long-lived & well-known family of the odd Choristodera, crocodile analogues
215. Charadriiformes: gulls, auks & relatives.
216. Charadriomorphae: most modern shore birds, pigeons and parrots
217. *Cheirolepis* X: a Devonian fish, about the most basal form we know of with approximately "standard" dermal skull bones
218. Chelidae: Small to medium-sized "snake-neck" aquatic turtles of Australia & South America.
219. *Chialingosaurus* X: an early Chinese stegosaurid -- more gracile than *Stegosaurus*
220. Chigutisauridae X: the last temnospondyls (unless frogs are temnospondyls), from as late as the Jurassic
221. Chimaeriformes: probably *Myriacanthus* + *Chimaera*, living chimaeras and close relatives
222. Chimaeroidei: the crown group of living chimaeras
223. Chiroptera: bats
224. Chondrichthyes: the shark leg of the eugnathostome crown group, hence sharks > lawyers.

225. Chondrichthyes (Crown): chimaeras + living sharks, the crown group of living chondrichthyans
226. Chondrostei: the sturgeon stem group, caviar > lox.
227. Chordata: everything in Palaeos Vertebrates: urochordates + vertebrates, or tunicates + tuna.
228. Chrysochloroidea: the "golden moles" of southern Africa.
229. *Chthomaloporus* X: a poorly known Russian (mid to Late Permian) anteosaur
230. *Chubutisaurus* X: a South American sauropod from the middle Cretaceous, possibly sister to the Titanosauria
231. Chuchinolepidae X: basal antiarch placoderms from the Early Devonian of China
232. *Chunkingosaurus* X: Late Jurassic Chinese stegosaur
233. Cichlidae: cichlids
234. Ciconiidae: storks
235. Ciconiiformes: storks, herons, egrets, ibis, etc.
236. Ciconiimorphae: most modern shorebirds
237. Cimoliasauridae X: a poorly known family of mostly Cretaceous plesiosaurs
238. *Cimoliasaurus* X: a plesiosaur from the middle to Late Cretaceous of Australia
239. Cimolodonta X: late-surviving Cretaceous and Paleocene multituberculates with long snouts and a huge, medial incisor
240. Cladistia: an ancient order of actinopterygian fishes with heavy enameled scales, of which only the bichirs and reedfish survive
241. Cladoselachida X: a very successful group of Late Devonian sharks with large pectoral fins, but otherwise rather modern-looking
242. Cladotheria: the clade uniting dryolestoids with therian mammals
243. *Claudiosaurus* X: a very primitive marine, neodiapsid reptile, from the Late Permian of Madagascar.
244. Clevosaurs X: the sister group of *Sphenodon*, mostly Jurassic
245. Climatiiformes X: the most basal group of acanthodians, from the Late Silurian to Early Carboniferous.
246. Clupeocephala: the clade uniting the herring - anchovy group with the euteleosts
247. Clupeomorpha: fish in tin cans -- anchovy, herring and sardines.
248. *Cnemiornis* X: an extinct goose from the Pleistocene & Holocene of New Zealand
249. *Coahomasuchus* X: Late Triassic aetosaur, sister to *Stagnolepis*.
250. Cochleosauridae X: primitive temnospondyls from the Late Carboniferous of Eastern Europe
251. Cochliodontidae X: a surprisingly modern-looking group of mostly Permian holocephalians
252. Coelurosauravidae X: very basal Permo-Triassic gliding diapsids of Europe, also known as Weigeltisauridae
253. Coelurosauria: all theropods closer to birds than to *Allosaurus*.
254. *Coelurus* X: a poorly-known basal coelurosaur from the Late Jurassic of North America
255. Coliiformes: "mouse birds," good climbers with fluffy feathers
256. Colosteidae X: Carboniferous amphibians, perhaps the sister group to the temnospondyls
257. Colubridae: rat snakes, corn snakes, king snakes, garter snakes, indigo snakes, boomslangs, etc.
258. Colubroidea: advanced, venomous snakes
259. Columbiformes: doves, pigeons (e.g. *Columba*), *Raphus* (dodo), sand grouse.
260. *Colymbosaurus* X: latest and largest of the Plesiosauroidea known from Jurassic England
261. Compsognathidae X: small, light-bodies predators of the Late Jurassic and Early Cretaceous.
262. *Concordia*: X a small, basal captorhinid from the Pennsylvanian of Kansas
263. Confuciusornithidae X: Primitive birds with extraordinarily long wing feathers and long caudal display plumage
264. Conodonta X: very, very early jaws and teeth of poorly understood design and relationships.
265. Cornuata X: a large & long-lived group of osteostracan fishes with pointed lateral processes (cornua) of the head shield
266. *Corosaurus* X: perhaps the most basal known sauropterygian, from the Triassic of North America
267. Corvaspididae X: Late Silurian & Early Devonian jawless fishes -- possibly stem cyathaspids
268. *Corvaspis* X: the best known corvaspid
269. *Corveolepis* X: a genus carved out of *Corvaspis* material
270. Cotylosauria: diadectomorphs + crown group amniotes
271. Cracidae: the colorful curassows, guans, and chachalacids
272. Craniata: hags + hagfish
273. Crassigyrinus X: an odd and evil-looking basal tetrapod (or near-tetrapod) with diminutive arms
274. Crocidurinae: southern shrews
275. Crocodylia: living crocs > dryosaurs

276. Crocodylidae: crocodiles > alligators
277. Crocodyliformes: crocodiles > Sphenosuchia
278. Crocodylinae: the 12 living species of true crocodiles
279. Crocodylomorpha: roughly speaking, the level at which crocs stopped trying to compete with dinosaurs
280. Crotalinae: pit vipers
281. Crurotarsi: crocs > dinosaurs
282. *Cryolophosaurus* X: an Early Jurassic carnosaur from Antarctica (= "Elvisaurus")
283. Cryptocleidoidea X: late Mesozoic short-necked plesiosaurs
284. Cryptocleididae X: *Cryptocleidus* and immediate family
285. *Cryptocleidus* X: an early (Jurassic), successful member of the short-neck plesiosaur tribe.
286. Cryptodira: today, the predominant turtle breed except in some Gondwanan lands
287. Ctenacanthidae X: the dominant elasmobranch sharks of the Permian and Carboniferous
288. Ctenacanthiformes: all elasmobranch sharks except the xenacanthids
289. *Ctenaspis* X: a very peculiar-looking heterosracan jawless fish from the Early Devonian, probably the sister of all other amphiaspids
290. Ctenochasmatoidea X: pterodactyloids with shallow keels and plantigrade feet, from the Late Jurassic and Early Cretaceous
291. Ctenosquamata: most Cenozoic teleosts
292. Cuculidae: all cuculiforms except the roadrunner
293. Cuculiformes: cuckoos, the roadrunner, and possibly a few others
294. Cyathaspidida X: streamlined heterostracans with fusiform or cigar-shaped head-shields made up of two main components, dorsal and ventral epitega
295. Cyathaspidiformes X: the amphiaspid-cyathaspid leg of crown group Heterostraci, Siluro-Devonian jawless fishes with big, unitary armors
296. Cyclosquamata: deep sea teleosts with non-protrusible, toothed maxillae
297. Cylindrophiidae: pipe snakes
298. *Cymbospondylus* X: the most primitive of the Ichthyosauria
299. Cynodontia: cynodonts
300. Cynognathia X: *Cynognathus* > *Sinocodon*, by our reckoning, the eucynodont branch that *didn't* lead to mammals
301. Cynognathidae X: a paraphyletic cluster of basal cynognaths
302. *Cynosaurus* X: a rather obscure Permian cynodont which is, despite the name, a galesaurid.
303. Cypriniformes: carp, minnows, loaches and others

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Taxon Index: D-K

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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303. *Dacentrurus* X : a basal Late Jurassic European stegosaurid, the first stegosaur ever described (1875).
304. *Dactylosaurus* X : a strange and poorly known pachypleurosaur.
305. *Dallia*: the Alaskan blackfish
306. *Damocles* X: a stethacanthid-type shark with a particularly elaborate head-dress.
307. Dasyuromorphia: the infamous Tasmanian Devil and other carnivorous marsupials.
308. *Dendrerpeton* **X**: a basal temnospondyl from the Carboniferous.
309. Dermoptera: colugos or "flying lemurs." A small order of Southeast Asian mammals.
310. *Desmatosuchus* X : a Late Triassic aetosaur
311. *Deuterosaurus* X : a Late Permian anteosaur from Russia.
312. *Diabolepis* X : a rather famous Early Devonian sarcopterygian fish, related to lungfishes.
313. Diadectomorpha X : possibly the sister group to amniotes.
314. Diapsida: roughly, everything with two temporal fenestrae.
315. *Dianzhongia* X : an Early Jurassic cynodont
316. Dichobunidae X: *Diacodexis* and the most basal artiodactyls
317. Dicraeosauridae X: small Gondwanan diplodocines with elongated spines
318. Dicynodontia X: : a large group of advanced, mostly Triassic therapsids with weird jaws.
319. Didelphimorphia: possums and related South American marsupials.
320. Didolodontidae X: litopterns and more basal South American ungulates
321. *Didolodus* X: the sister? aunt? of the litopterns, from the Late Eocene of Argentina.
322. Diictodontia X: a group of Permo-Triassic dicynodonts including the well-known *Cistecephalus*
323. *Dimetrodon* X: the old sail-back himself
324. Dimorphodontidae X: a group of pterosaurs including the controversial *Sordes*
325. *Dinilysia* X: an impotant transitional Late Cretaceous snake from South America
326. Dinocephalia X: medium to large, big-bodied, short-legged "dog-faced" Permian therapsids
327. Dinocerata X: the famous rhino-like uintatheres and cousins
328. Dinornithiformes X: the moas of New Zealand
329. Dinosauria: dinosaurs and birds
330. Dinosauriformes: protodinosaurs from the Middle Triassic of South America
331. Dinosauromorpha: same as Dinosauriformes, with the addition of *Lagerpeton*.

332. Diplocercides X: atypical actinistians from the Late Devonian of Europe
333. Diplodocidae X: *Apatosaurus* + *Diplodocus*
334. Diplodocinae X: extremely long-necked saropods from the Jurassic of Africa and North America
335. Diplodocomorpha X: *Diplodocus* > *Saltasaurus*, *i.e.*, the diplodocid side of the neosauropods.
336. Diplodocoidea X: *Diplodocus* + *Dicraeosaurus*
337. *Diplodocus* X: ask any 6-year-old what this one is
338. *Diplovertebron* X: an embolomere "amphibian" from the Late Carboniferous of Europe and North America
339. Dipnoi: lungfishes and relatives
340. Dipnomorpha: lungfishes > tetrapods.
341. Diprotodontia: kangaroos, potoos, wombats, koalas, etc.
342. *Discosauriscus* X: seymouriamorph anamniote tetrapods from the Late Permian of Europe & China
343. Dissorophoidea X: basal temnospondyls -- possibly the parent of some or all living amphibians
344. Docodonta X: mouse-sized protomammals with long muzzles from the Late Mesozoic of Europe and the Americas.
345. Docodontidae X
346. *Doliosauriscus* X
347. *Dorudon* X
348. *Doswellia* X
349. Draconinae
350. *Drepanaspis* X
351. Dromaeosauridae X
352. Dromasauria X:
353. Dromornithiformes X
354. Dryolestoidea X
355. Dryosauridae X:
356. Dsungaripteroidea X
357. *Dvinia* X
358. Dvinosauria X:
359. Dyrosauridae X

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360. *Echinodon* X
361. Edaphosauridae X: Permo-Carboniferous sail-back vegetarian synapsids
362. *Edaphosaurus* X: an edaphosaurid with particularly elaborate spines
363. Edopoidea X: basal temnospondyls with a rather terrestrial look
364. *Edops* X: a well-known member of the preceding family
365. *Efraasia* X
366. Elapidae: venomous, often marine snakes with hollow, relatively immobile maxillary fangs
367. Elasmobranchii: the Mesozoic sharks -- fusiform shape, cladodont teeth with three enameloid layers
368. Elasmosauridae X: longest, largest and last of the plesiosaurs
369. *Elginerpeton* X: a Frasnian near-tetrapod from Scotland
370. Elginerpetonidae X: near-tetrapods from the Frasnian of Europe
371. *Elliotsmithia* X: perhaps the last of the "pelycosaurs"
372. Elopocephala: all teleosts except the osteoglossomorphs
373. Elopomorpha: all fishes with a leptocephalus larva.
374. Elpistostegalia: a group of Middle and Late Devonian Osteolepiforms, including the famous *Panderichthys*.
375. *Elpistostege* X: a close relative of *Panderichthys*
376. *Emausaurus* X: either an early stegosaur, a " miniature version of *Huayangosaurus*" or a stem thyreophoran from the Early Jurassic of Europe
377. Embolomeri X: Specialized, long-bodied, piscivorous anthracosaurs from the Carboniferous of Europe and North America
378. Enantiornithes X: the "opposite birds" of the Cretaceous.
379. *Endeiolepis* X: a Late Devonian anaspid? or lamprey?

380. Entelodontoidea: X: everyone's favorite terror-pig
381. *Eocecilia* X: the earliest known caecilian, from the Jurassic of Arizona.
382. Eogyrinidae X: a small family of Permo-Carboniferous embolomeres
383. *Eoherpeton* X: an early Carboniferous Scottish anthracosauroid (probably).
384. Eothyrididae X: small, rather primitive group of "pelycosaurs" from the Early Permian of North America
385. Eotitanosuchia X: very big, basal therapsids from the Middle and Late Permian of Russia.
386. *Eotyrannus* X: the most primitive known tyrannosauroid, from the Early Cretaceous of Europe (Isle of Wight)
387. *Epachtosaurus* X: one of very late-surviving South American titanosaurs
388. Eparctocyona: cows > horses. Probably includes ruminants, whales and South American ungulates.
389. Epicynodontia: *Galesaurus* + Galileo? All mammals and all cynodonts except the most primitive.
390. Epitheria: all but the most primitive therian mammals.
391. *Eretmosaurus* X: a very basal plesiosauroid from the Late Triassic
392. Erinaceinae: hedgehogs
393. Erinaceomorpha: hedgehogs > shrews
394. *Erpetosuchus* X:
395. Eryopoidea X: the famous Permian temnospondyl *Eryops*
396. Erythrosuchidae X: early archosauromorphs, the largest terrestrial vertebrates of the Early Triassic
397. Esocidae: the pikes and extinct relatives
398. Esociformes: pikes and mudminnows
399. *Esox*: pikes, pickerel & muskellunge
400. Estemmenosuchidae X:
401. *Estemmenosuchus* X
402. *Estesesox* X
403. Euantiarcha X
404. Euconodonta X
405. *Eucritta* X
406. Eucynodontia
407. Eugaleaspidiformes X
408. Eugeneodontida X
409. Eugnathostomata
410. Euhelopodidae X
411. Euichthyosauria X:
412. Euparkeriidae X
413. Eupelycosauria
414. Euphytosauria **X**
415. Eupleurodira
416. *Euporosteus* **X**
417. Eureptilia
418. Eurhinosauria X:
419. *Eurycleidus* X: an interesting Early Jurassic pliosaur from Europe
420. Eurypoda X: *Stegosaurus* + *Ankylosaurus*, the crown group of armored dinosaurs
421. Eurypterygii: the main group of neoteleost fishes
422. Eusauropoda X: essentially all of the sauropods from the Middle Jurassic and later
423. Eusauropterygia X: all nothosaurs, plesiosaurs and *Simosaurus*
424. *Euscolosuchus* X:
425. Euselachii: a vague group, probably Hybodontiformes + living sharks
426. Euskelia X: a large group of mostly big, terrestrial-looking basal temnospondyls
427. *Eusthenopteron* X
428. Euteleostei: a big, somewhat indefinite group of teleost fishes: Ostariophysi + Neoteleostei?
429. Eutherapsida: dinocephalians + anomodonts + theriodonts
430. Eutheria: people > possums
431. Eutheriodontia: the theriodonts and cynodonts

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432. Fabrosauridae X: a probably paraphyletic group of basal ornithischian dinosaurs
433. Falcatidae X: one of the paleoshark groups with a fancy head-dress, probably ancestral to the holocephalians (chimeras etc.)
434. Falconiformes: hawks, eagles & Old World Vultures
435. Ferae: cats, dogs & seals
436. Fritillaridae: a very basic family of tunicates
437. Furcacaudiformes X: jawless fishes who looked like goldfish

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438. Galeaspida X: a large & long-lived group of armored jawless fishes with a large dorsal opening in the headshield
439. Galeomorphii: most modern sharks
440. Galesauridae X:
441. *Galesaurus* X
442. Galliformes: *Gallus* (chicken), geese, turkey.
443. Gallinuloididae X: an Eocene to Miocene family of basal chickens
444. Galloanserae: chickens + ducks
445. Gavialidae: modern crocs with a very slender snout and very small nasal bones
446. Gaviiformes: loons
447. Gekkota: gekkos
448. Genasauria X: *Stegosaurus* + *Triceratops*.
449. *Georgiacetus* X: a well known Middle Eocene protocetid (early whale) from Georgia
450. Gephyrostegidae X: a family of rather lizard-like anthracosaurs from the Late Carboniferous.
451. Ginglymodi: gars and their cousins
452. *Giraffatitan* X: a close relative of *Brachiosaurus* from the Jurassic of Africa
453. Giraffoidea: giraffes, of course.
454. *Glaucosaurus* X: a Texas edaphosaur known from a single specimen
455. Glires: the clade uniting rabbits and rodents
456. Gnathostomata: vertabrates with jaws
457. *Gobiconodon* X: a stocky, well-known triconodont mammal from the middle Cretaceous of Asia and North America
458. Gobiosuchidae X: a Triassic crocodyliform, sister of the Mesoeucrocodylia (the main line of Mesozoic croc evolution)
459. Gondwanatheria X: the Gondwanan multituberculates
460. Gorgonopsia X: dog-sized, dog-like therapsids -- the dominant carnivores of Late Permian
461. *Gorgosaurus* X: a tyrannosaur, quite similar (and perhaps identical) to *Albertosaurus*
462. *Gracilisuchus* X: a suchian, probably closely related to the Crocodylomorpha, from the Middle Triasic of Argentina
463. *Greererpeton* X: a coleostid -- a sort of armored aquatic slamander from the Carboniferous of North America.
464. Grippidia X: another Triassic aquatic diapsid, the sister of the Ichthyosauria
465. *Grossius* X: a basal sarcopterygian with some porolepiform features
466. Gruiformes: cranes and rails
467. Gruimorpha: tentatively used as *Passer*> *Anser*
468. Guerichosteidae X an important family of earlier psammosteids (big, pancake-shaped jawless fishes)
469. Guildayichthyiformes X: a recently discovered early order of deep-bodied marine fishes with strong medial bones and unique cheek area
470. Gymnophiona: living and extinct caecilians

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471. *Hadrocodium* X: an Early Jurassic almost-mammal from China
472. *Hadronector* X:a Bear Gulch actinistian
473. Hadrosauridae X: *Hadrosaurus* + *Parasaurolophus*
474. Hadrosaurinae X: the hadrosaurids without the fancy crests
475. Hadrosauroidea X: as we use it, *Hadrosaurus* > *Iguanodon*
476. *Haikouella* X: the sister of Craniata, from the Early Cambrian of South China
477. Halecomorphi: as we use it, *Amia* > teleosts
478. Halecostomi: *Amia* + teleosts .
479. Hallucicrania X: an aptly-named group uniting lanthanosuchids and pareiasaurs
480. *Hanosaurus* X: a Chinese pachypleurosaur.
481. *Haplocanthosaurus* X: a relatively small, basal sauropod from the Late Jurassic of North America
482. Haplorhini: tarsirs, apes and monkeys
483. *Haptodus* X: a well-known "pelycosaur" at the base of the sphenacodonts
484. Haramiyida X: weird & poorly-known multituberculate-like proto-mammals from the Late Triassic and Early Jurassic
485. Helohyidae X: The earliest members of the Suoidea, from the Eocene of South & Southeast Asia, China and North America.
486. *Hemicyclaspis* X: a surprisingly derived osteostracan jawless fish from the Late Silurian of North America and Europe
487. Henricosborniidae X: a family of basal notoungulates (endemic South American ungulates)
488. Herrerasauridae X: either very basal theropods or very derived dinosauromorphs from the Late Triassic of the Americas.
489. Hesperornithiformes X: loon-like birds from the Cretaceous, sister of the Carinatae
490. Heterodontiformes: the Port Jackson shark, a unique, basal galeomorph
491. Heterodontosauridae X: very small, basal ornithopod dinosaurs with tusks from the Early Jurassic
492. Heterostraci X: the main group of the "other" vertebrates (Pteraspidomorphi)
493. Heterostracomorphi X: Heterostraci and the astraspids
494. Hibernaspidoidei X: amphiaspids with serrated headshields, frequently with mouth tubes
495. *Hilalia* **X: a rather primitive ungulate from the Middle Eocene of Turkey.**
496. **Hippomorpha: horses > tapirs.**
497. **Hippopotamidae: hippos**
498. ***Hirella* X: an osteostracan jawless fish with plates on the ventral side as well, from the Silurian**
499. **Holocephali: chimaeras and their ancestors with holostylic jaw suspensions**
500. ***Holopterygius* X: a strange, scrappy, Frasnian fish most recently described as an actinistian**
501. **Homalocephalidae X: sister group of the "bone-head" pachycephalosaurids**
502. **Hominoidea: apes**
503. **Huananaspidiformes X: really odd Early Devonian galeaspids from China**
504. **Huayangosauridae X: the most basal family of stegosaurs**
505. ***Huayangosaurus* X: the most basal of all known stegosaurs, from the Middle Jurassic of China**
506. **Hybodontiformes X: the sister group of modern sharks**
507. ***Hylochoerus*: the giant river hog**
508. **Hylomyinae: gymnures or moonrats**
509. **Hyopsodontidae X: insectivore-like animals with arboreal capabilities from the Paleocene through Eocene**
510. **Hyotheriinae X: a group of mostly Miocene pigs**
511. **Hyperoartia: Lampreys and their ancestors**
512. **Hypnosqualea: *Squatina* + *Raja*, generally angel sharks, skates, rays, etc.**
513. **Hypsilophodontidae X: small ornithischian dinosaurs**
514. **Hypsilophodontinae X: advanced small to medium-sized lightly-built fast-running bipedal herbivorous hypsilophodont dinosaurs**
515. **Hyracoidea: hyraxes**

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516. ***Ianthasaurus*** **X: a basal, Pennsylvanian genus of edaphosaur**
517. **Ichthyopterygia X: the stem group of ichthyosaurs**
518. **Ichthyornithiformes X: *Chthyornis*, stout, gull-like Late Cretaceous shore birds with large heads and strong wings**
519. **Ichthyosauria X: ichthyosaurs**
520. ***Ichthyosaurus*** **X: the classic ichthyosaur, from the Early Jurassic of Europe & North America**
521. ***Ichthyostega*** **X: an early, well-known, but probably atypical tetrapod, from the Late Devonian of Greenland**
522. **Ictidorhinidae X: a poorly-known Late Permian biarmosuchian therapsid**
523. **Iguania: iguanid lizards and allies**
524. **Iguanidae: iguanas**
525. **Iguanodontia X: *Iguanadon* > *Hypsilophodon*, the hadrosaur stem lineage**
526. **Iguanodontidae X: supposed to be the monophyletic iguanodonts -- possibly restricted to *Iguanodon*.**
527. **Indrioidea: wooly lemurs, indri, sifakas**
528. ***Inflectosaurus*** **X: large metoposauroid temnospondyls from the Early Triassic of Russia**
529. **Iniopterygii X: a very odd Pennsylvanian group -- looking like a cross between a bat and a shark**
530. **Insectivora: shrews, moles, hedgehogs, tenrecs. etc.**
531. **Ionoscopiformes X**
532. ***Ischigualastia*** **X**
533. **Ischnacanthiformes X**

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534. ***Jachaleria*** **X**
535. ***Jainosaurus*** **X**
536. ***Janenschia*** **X**
537. ***Jeholodens*** **X**
538. ***Jobaria*** **X**
539. ***Jonkeria*** **X**

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540. ***Kannemeyeria*** **X**
541. **Kannemeyeriidae X:**
542. ***Karaurus*** **X**
543. **Katoporida X**
544. **Katoporidae X**
545. ***Kayentachelys*** **X**
546. ***Kayentatherium*** **X**
547. ***Keicousaurus*** **X**
548. **Kentrosaurinae X: basal stegosaurids, small to large in size, with generally small spiked plates and numerous spikes along the tail.**
549. ***Kentrosaurus*** **X: a kentrosaurine with six small pairs of plates**
550. ***Keratocephalus*** **X: a tapinocephalid with the naso-frontal boss raised into a sort of horn**
551. **Kiaeraspidida X: tiny cornuate osteostracans, with reduced "horns" and sensory fields**
552. ***Kimmerosaurus*** **X: a cimoliasaurid plesiosaur with a broad skull from the Late Jurassic of England**
553. **Kotlassiidae X: a seymouriamorph reptilomorph similar to *Seymouria*, but perhaps less terrestrial, from the Late Permian of Russia**
554. **Kowalevskiidae: radically simplified larvacean urochordates without endostyle, heart or spiracles**
555. ***Kronosaurus*** **X: possibly the largest known pliosaur, from the middle Cretaceous of Gondwana**
556. **Kuehneosauridae X: flying or gliding lepidosauriforms of the Late Triassic**
557. **Kuehneotheriidae X: "obtuse-angle symmetrodonts"**

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Taxon Index: L-O

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557. Labridae: wrasses
558. Labroidei: cichlids, wrasses, damselfish, parrotfishes
559. *Laccocephalus* X: a rhinesuchid temnospondyl from just before or just after the end-Permian extinction
560. *Lagerpeton* X: an ornithodiran archosaur from the Middle Triassic of South America, the sister of all other dinosauromorphs
561. Lagomorpha: rabbits & pikas
562. Lagosuchidae X : important protodinosaurs from Triassic South America
563. *Laidleria* X: a notably flat and triangular-headed temnospondyl from the Early Triassic of South Africa
564. Lambeosaurinae X: advanced Late Cretaceous hadrosaurs with expansive hollow crests.
565. Lamniformes: mackerel and Basking sharks
566. Lampridiformes: opahs, crestfish, ribbonfish, oarfish
567. *Lanarkia* X: a thelodontid thelodont -- the only thelodont with two distinct, but mixed, types of body scales.
568. Lanthanosuchidae X: they look like temnospondyls but are actually anapsids
569. Lanthanotidae: earless monitor lizards
570. Lapillopsidae X: a small group of small temnospondyls from the Early Triassic of Australia
571. *Lapparentosaurus* X: a close relative of *Brachiosaurus*, from the Middle Jurassic of Madagascar.
572. *Lariosaurus* X: a Middle Triassic nothosaur from Europe with peculiarly expanded forearms
573. Larvacea : tiny, planktonic urochordates which build gelatinous "houses"
574. *Leaellynasaurua* X: a small hypsilophodont dinosaur from the middle Cretaceous of Australia
575. Lemuriformes: indri and lemurs
576. Lemuroidea: lemurs
577. Lepidosauria: sphenodonts, lizards, mosasaurs & snakes
578. Lepidosauriformes: probably mosasaurs > plesiosaurs
579. Lepidosauromorpha: lizards > buzzards
580. Lepisosteiformes: gars
581. Lepospondyli: toads > Texans
582. Leptictida X: possibly the stem group of Pholidota (pangolins)
583. *Leptocleidus* X: a smallish rhomaleosaurid pliosaur from the Early Cretaceous.

584. Leptotyphlopidae: small (10-25 cm) fossorial snakes, near the base of the snake radiation
585. *Lexovisaurus* X: a European cousine of *Stegosaurus*.
586. Libycosuchidae X: short-snouted, hyena-like crocs from the Cretaceous of Africa
587. Limnarchia X: all temnospondyls except edopoids and Euskelia
588. *Liopleurodon* X: the classic big, mean, Jurassic pliosaur
589. Lissamphibia: living amphibians
590. Lithornithiformes X: early paleognathous birds from the Paleocene and Eocene
591. *Livoniana* X
592. *Lochmocercus*: **X** another Bear Gulch actinistian
593. *Loganellia* X: a rather gnathostome-like jawless fish of the thelodont persuasion
594. Loganiidae X: Silurian theolodonts, possible sister group of the gnathostomes
595. *Longosuchus* X
596. Lorisiformes: pottos, lorises & galagos (lemur-like primates)
597. *Lourinhasaurus* X: an early camarasaur from Portugal
598. *Loxomma* X: a baphetid tetrapod from the Early Carboniferous
599. *Lupeosaurus* X: a poorly-known edaphosaurid from Texas
600. Luzocephalidae X: some of the first temnospondyls to appear after the end-Permian extinction
601. Lydekkerinidae X: Triassic capitosaur temnospondyls
602. Lysorophia X: Permo-Carboniferous microsaurs, possible sister group of living amphibians
603. *Lystrosaurus* X: the well-known South African dicynodont almost synonymous with the Permo-Triassic transition.

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604. Macronaria X: *Brachiosaurus* > *Diplodocus*.
605. *Macroplata* X: an Early Jurassic pliosaur
606. Macroscelidea: elephant shrews
607. Macrosemiiformes X Mesozoic neopterygians with 7 odd, scroll-shaped infraorbitals
608. Macrostomata: advanced snakes with large gapes (*Crotalus* > *Anilius*)
609. Madtsoiidae X: basal macrostomate snakes from Gondwana which persisted in Australia through the Pleistocene
610. *Magyarosaurus* X: a "dwarf" titanosaur from the Late Cretaceous of Eastern Europe
611. Mamenchisauridae X: perhaps the world's longest neck on some Chinese sauropods of uncertain relationships
612. Mammalia: mammals, used here as the crown group monotremes + mastodons
613. Mammaliaformes: mammals and not quite mammals -- defined as a crown group for some reason – *Sinocodon* + snow leopards
614. *Mandageria* X: a derived tristichopterid sarcopterygian fish from the Late Devonian of Australia
615. Maniraptora: birds and specialized, bird-like theropods
616. Maniraptoriformes: *Ornithomimus* + birds, although we think this is a pretty useless definition.
617. *Maresaurus* X: a Middle Jurassic South American pliosaur with a large flat snout.
618. Marginocephalia X: pachycephalosaurs and ceratopsians
619. Massospondylidae X: a widely-distributed family of moderately large prosauropods closely related to plateosaurs.
620. *Mastodonsaurus* X: a huge, stout temnospondyl from the Middle Triassic.
621. Megalichthyidae X: actually not-so-"mega" osteolepiforms which survived into the Permian
622. *Megalocephalus* X: a well-known baphetid of the Early Pennsylvanian
623. Megapodidae: brush turkeys of Australia
624. Megazostrodontidae X: docodont pammamiforms from the Triassic and Jurassic of Africa
625. *Meiolania* X: huge, "horned" turtles
626. Melanorosauridae X: very large prosauropods from the Late Triassic of South America
627. Menaspidae X: odd and early holocephalians of the PermoCarboniferous
628. Mergini: sea ducks
629. Meridiungulata X: originally, all endemic South American ungulates. This may not be a clade, so we're not sure what's in this box.

630. Merriamosauria X: ichthyosaurs characterized by having their teeth set in a groove, without ankylosis to the jaw
631. Mesoeucrocodylia: a clade containing most marine & amphibious crocs from the Mesozoic and Cenozoic
632. Mesonychia X: Medium to large-sized, possibly dominant predators or scavengers of the mid-Paleocene to Early Oligocene.
633. Mesosauridae X: a small group of secondarily aquatic forms with elongated snout & neck, sister group of the reptiles.
634. Metasuchia: *Notosuchus* + *Crocodylus*, including all Cenezoic crocs and some Cretaceous forms
635. Metatheria: marsupials
636. *Metaxygnathus*: X this jaw taxon and *Ventastega* may be the sister of Tetrapoda
637. Metoposauroidea X: A group of large flat-headed aquatic temnospondyls, rather similar to the capitosaurids in size and body proportions.
638. Metornithes: alvarezsaurs + living birds, birds with fused carpometacarpus and reduced fibula
639. Metriorhynchidae X: highly aquatic Jurassic thalattosuchian crocs
640. Microbiotheria: very small, mouse-like marsupials from South America
641. Microbrachiidae X: Tiny (<2 cm) Middle or Late Devonian antiarch placoderms transitional between Yunnanolepidoids and Bothriolepidoids
642. *Microcleidus* X: an early Jurassic elasmosaur of uncertain affinities.
643. Micropternodontidae X: widespread, but poorly known, basal Insectivores of the Paleocene through Miocene.
644. Microsauria: diverse, small, long-bodied lepospondyls best known from the Permo-Carboniferous - probable ancestors of at least some living amphibians
645. *Miguashaia* X: the earliest known actinistian (coelacanth lineage)
646. Millerettidae X: lizard-like things from the Late Permian -- quite likely the sister of all other anapsids
647. *Minicrania* X: Tiny antiarch placoderms (<2cm) intermediate between yunnanolepidoids & euantiarchs, from the Early Devonian of China.
648. *Minmi* X: the only Gondwanan ankylosaur
649. Miolabinae X:
650. *Mixosaurus* X: a small, very basal, early ichthyosaur from the Middle Triassic of nearly everywhere
651. *Molybdopygus* X: a poorly-known dinocephalian from the Late Permian of Russia.
652. *Monolophosaurus* X: a carnosaur with a unique, single ridge-like head crest running from its nose to the rear of the skull, from the Middle Jurassic of China
653. Mononykinae X: the Asian Alvarezsaurids, flightless birds with small, weird arms.
654. *Mononykus* X: perhaps the best known of the alvarezsaurs, from the Late Cretaceous of Mongolia
655. Monotremata: the egg-laying mammals (platypi & echidnas) and their ancestors
656. Monstersauria: venemous varanoid lizards, such as the gila monster
657. Morganucodontidae X: the best-known Mesozoic mammaliaforms
658. Mosasauroidea X: mosasaurs
659. *Moschops* X: perhaps the largest and most bone-headed of the tapinocephalids
660. *Mucrovenator* X: a rather advanced little Middle Triassic North American shark (tooth genus)
661. Multituberculata X: the "rodents of the Mesozoic," a prolific and long lived group of "maybe-mammals"
662. *Muraenosaurus* X: a classic medium-sized plesiosauroid from the Late Jurassic
663. Musophagidae: mouse birds
664. *Muttaburrasaurus* X: the National Iguanodont of Australia (mid-Cretaceous)
665. Mycterosaurinae X: a widespread clade of varanopsid "pelycosaurs" from the Middle and Late Permian
666. *Mycterosaurus* X: the best-known member of the previous group, from the Middle Permian of North America
667. Myriacanthoidei X: a weird & enigmatic family of chimaeriforms, mostly from the Jurassic of Europe.
668. Mysticeti: the baleen whales
669. *Mystriosuchus* X: a late and specialized fish-eating phytosaur from the Late Triassic of Europe
670. Myxinoidea: the hagfishes

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671. *Nanictosaurus* X: a Late Permian galesaurid cynodont

672. *Nanocynodon* X: another Late Permian cynodont, this one from Russia -- very small but very carnivorous
673. *Nanyangosaurus* X: an early hadrosauroid from the middle Cretaceous of China -- hard to distinguish from *Iguanodon*.
674. Narcinidae: a family of electric rays
675. Nectridia X: Permo-Carboniferous newt-like lepospondyls, including the boomerang-head forms like *Diplocaulus*.
676. Necrosauridae X: an ill-defined Cretaceous to Eocene taxon of extinct varanoid lizards
677. Nemegtosauridae X: a titanosaurid group, perhaps *Nemegtosaurus* > *Saltasaurus*, with an odd distribution in Asia, India & Africa
678. *Nemegtosaurus* X: a controversial titanosaur from the Late Cretaceous of China
679. *Neoaetosauroides* X: a late, but primitive aetosaur from the end-Triassic of South America
680. Neochoristodera X: champsosaurs, an odd, late-surviving archosauromorph line
681. Neodiapsida: younginiforms + living reptiles
682. Neognathi: the clade uniting pikes Neoteleosts -- teleosts with acellular bone and depressible teeth
683. Neomorphidae: roadrunners
684. Neopterygii: gars + teleosts -- actinopterygians with symmetrical tails
685. Neornithes: the crown group of all living birds
686. Neosauropoda X: diplodocids + titanosaurs, digitigrade sauropods
687. Neoselachii: the crown group of living sharks and rays
688. Neosuchia: extant crocs + dryosaurs
689. Neoteleostei: most living teleosts
690. Neotherapsida: anomodonts + theriodonts
691. *Neuquensaurus* X: a medium-sized advanced titanosaur from the Late Cretaceous of South America
692. *Neusticosaurus* X
693. *Nicrosaurus* X
694. *Nigersaurus* X
695. Nikoliviidae X
696. Nodosauridae **X**
697. Nothosauria X: plesiosaurs > placodonts.
698. Nothosauridae X
699. *Nothosaurus* X: a large, well-known nothosaur from the Triassic of Europe.
700. Notoryctemorphia: *Notoryctes*, the strange marsupial mole
701. Notostylopidae X: an early (mostly Paleocene) group of notoungulates
702. Notosuchidae X: very terrestrial, solid-looking crocs from the Late Cretaceous of South America
703. *Notosyodon* X: a medium sized anteosaur (carnivorous therapsid) with a massive skull from the Late Permian of Russia
704. Notoungulata X: one of the two main groups of South American endemic ungulates, Paleocene to Pleistocene
705. *Novumbra*: the infamous Olympic mudminnow
706. Numididae: guinea fowl, first cousins to the chicken
707. Nyctitheriidae X: the most basal group on the line to shrews, Paleocene to Early Oligocene of North America & Europe.

-O-

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708. *Obruchevichthys*: X a near-tetrapod and close relative of *Elginerpeton*
709. Odontoceti: dolphins, porpoises & toothed whales
710. Odontophoridae
711. Oikopleuridae
712. *Oligokyphus* X: Jurassic tritylodont, a rodent-like cynodont
713. Oligoryctidae X
714. Onychodontiformes X a very primitive, perhaps paraphyletic, group of sarcopterygians with symphysial tooth whorls
715. *Onychodus* X: A large onychodontiform
716. *Ophiacodon* X: a large Permian pelycosaur from North America

717. Ophiacodontidae X: early synapsids with tall, thin snouts
718. Ophthalmosauria X: : Jurassic ichthyosaurs with huge eyes
719. *Ophthalmosaurus* X the eponymous representative of the above group, sometimes divided into a number of (sub)genera
720. Orectolobiformes: carpet sharks, wobbegons, and nurse sharks
721. Oreodontoidea X: early members of the pig lineage, from the Eocene and Miocene of North America
722. Ornithischia X: *Triceratops* > birds
723. Ornithocheiroidea X: *Pteranodon* and related Cretaceous pterosaurs
724. Ornithodira: the clade uniting pterosaurs and dinosaurs
725. *Ornitholestes* X: a small, Late Jurassic coelurosaur from the Late Jurassic of North America
726. Ornithomimosauria X: very bird-like Cretaceous theropods, sister of the Tyrannosouroidea
727. Ornithopoda X: heterodontosaurs, hypsilophodonts, iguanodonts, and hadrosaurs
728. Ornithosuchidae X: a strange family near the base of the split between croc and dinosaur lineages
729. *Ornithosuchus* X: very large and theropod-like, but actually a member of the Crurotarsi (croc lineage)
730. Ornithothoraces: the clade uniting Enantiornithes with living birds
731. Ornithurae: hesperornithiforms and living birds
732. Orodontida X: big eel-like primitive sharks from the Late Devonian and Carboniferous
733. Ostariophysi: the dominant group of fresh water teleosts
734. Osteichthyes: bony fish -- acanthodians, actinopterygians and sarcopterygians (us)
735. Osteoglossomorpha: the aruana, elephant-nose fish and extincr relatives
736. Osteolepididae X
737. Osteolepiformes X: the group of sarcopterygian fishes which includes the tetrapods
738. Osteostraci X: armored jawless fishes with massive cartilaginous skulls and paired pectoral fins, from the Silurian & Devonian of the Northern hemisphere
739. Othnieliinae X: small Jurassic hypsilophodont dinosaurs with small, enamel-covered teeth
740. Otophysi: the clade uniting catfishes and carp
741. *Ouranosaurus* X: a hump-backed hadrosauroid, from the middle Cretaceous of Africa
742. Oviraptorosauria X: oviraptors, bizarre dinosaurs from the Late Cretaceous of China & North America
743. Owenettidae X: early anapsid insectivores from the Permian of Africa
744. Oxyurini: Gondwanan ducks
745. Ozarkodinida X: : possibly the best known large taxon of conodonts

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Taxon Index: P-Z

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-P-

744. Pachycephalosauria X: *Pachycephalosaurus* > *Triceratops*
745. Pachycephalosauridae X: the classic bone-dome dinosaurs
746. Pachycormiformes X: possibly the sister group of the teleosts, and probably the largest actinopterygians ever
747. *Pachygenelius* X: a trithelodont cynodont from the Early Jurassic of South Africa and perhaps elsewhere
748. Pachyophiidae X: a controversial family of Late Cretaceous aquatic snakes
749. Pachypleurosauridae X: small, Middle to Late Triassic aquatic lepidosauromorphs, cousins of the notosaurs
750. Paenungulata: the part of Afrotheria that is morphologically sound -- elephants, sea cows, & hyraxes
751. Pakicetidae X: the first cetaceans, from the Early Eocene of South Asia
752. Palaeoryctidae X: very early (Cretaceous?) members of the shrew lineage ... maybe
753. Palaeospinacidae X: *Synechodus* and others probably just outside the crown group of living sharks (Neoselachii)
754. Paleognathae: ratites and their ancestors
755. *Paleorhinus* X: a large, somewhat confused, genus of phytosaurs
756. *Panderichthys* X: a well-known almost-tetrapod from the Late Devonian of the Baltics
757. Paraconodontida X: very basal Cambrian conodonts
758. *Paralititan* X: Josh Smith's giant Egyptian sauropod
759. Parapternodontidae X: probably the sister group of living shrews, from the Eocene of North America
760. *Paraorthacodus* X: a tooth genus of palaeospinacid sharks
761. Parasemionotidae X: earliest (Triassic) and most basal family of halecomorph neopterygian fishes
762. *Parasuchus* X: a phytosaur -- probably a synonym of *Paleorhinus*
763. *Parathrinaxodon* X: a basal cynodont, possibly synonymous with *Procynosuchus*
764. *Paratypothorax* X: a late surviving phytosaur
765. Pareiasauria X: very large anapsid herbivores of the Permian -- possible turtle ancestors.
766. *Parvicursor* X: a tiny, poorly known alvarezsaurid bird from the Late Cretaceous of Mongolia
767. Parvipelvia X: Jurassic ichthyosaurs and their Cretaceous descendants
768. Passeriformes: perching songbirds
769. *Patagonykus* X: an alvarezsaurid ?bird from the Late Cretaceous of South America
770. Patagopterygiformes X: a family of rather modern-looking ornithurine birds from the Early Cretaceous of

South America and ?China
771. Paucituberculata: rat opossums, South American marsupials
772. Paulchoffatiidae X: the most basal multituberculates -- from the Late Jurassic of Europe.
773. Pelecaniformes: pelicans, frigate birds, and tropic birds.
774. Pelomedusidae: medium to large size freshwater aquatic turtles from Africa and South America
775. Pelomedusoidea: all derived pleurodire (side-necked) turtles, *i.e.* pelomedusids + podcnemoids
776. *Peloneustes* X: a relatively small, squid-eating pliosaur from the Late Jurassic of Europe
777. *Pelorosaurus* X: a poorly known, possibly non-existent, brachiosaurid dinosaur from the Early Cretaceous of Europe
778. Peramelina: bilbeys and bandicoots
779. Perissodactyla: horses, rhinos & tapirs
780. Petalichthyida X: a peculiar, hard-to-place group of placoderms from the Early Devonian
781. Petalodontiformes X: indescribably weird-looking early chondrichthyans, *e.g.*, *Balantsea*
782. Petromyzontiformes: lampreys
783. Phacochoerini: wart hogs
784. *Phacochoerus*: the extant African warthog
785. *Pharyngolepis* X: a very basal anaspid from the Silurian of Europe
786. Phasianidae: chickens, pheasants, peacocks, turkeys, etc
787. *Phlebolepis* X: a relatively well-known and widely distributed Silurian katoporid thelodont
788. Phlyctaenioidei X: a group of arthrodire placoderms
789. Phoebodontidae X: broad-headed, blunt-snouted ctenacanthiform sharks from the Devonian to the Triassic
790. Phoenicopteriformes: flamingos
791. *Pholiderpeton* X: an odd, long-bodied Bashkirian embolomere from Scotland
792. *Pholidogaster* X: an earlier embolomere, also Scottish, with reduced limbs
793. Pholidota: pangolins (armored eutherian mammals)
794. Phthinosuchidae X: very poorly known, very basal therapsids from the Late Permian of Russia
795. Phyllolepida X: large, late placoderms with terassed armor
796. Physeteroidea: sperm whales and relatives
797. PhytosauridaeX: big, gavial-like (but more terrestrial) proto-crocs from the Late Triassic
798. Piciformes: woodpeckers & toucans
799. *Pistosaurus* X: the sister of Plesiosauria -- and more than half-way between nothosaurs and plesiosaurs
800. Pituriaspida X: a unique, but poorly known group of cephalaspid fishes from the Early Devonian of Australia
801. *Placerias* X: a huge, well-known Kannemeyerid dicynodont from the Triassic of North America
802. Placodermi X: placoderms
803. Placodontia X: big, walrus-like sauropterygians from the Triassic of Europe.
804. Plagiosauridae X: bizarre, crescent-headed temnospondyls (like *Gerrothorax*) from the Triassic of Europe and Greenland
805. Plagiosauroidea X: Triassic temnospondyls with short, wide skulls and pustular ornamentation
806. Plataleidae: ibis and spoonbills
807. Plateosauridae X: European prosauropods of the Late Triassic and Early Jurassic
808. *Platycraniellus* X: a poorly known Early Triassic galesaurid cynodont from South Africa
809. *Platypterygius* X widely occuring large Cretaceous ichthyosaur, distinguished by longer body and paddles than its Jurassic ophthalmosaur ancestors. Divided into a number of subgenera
810. Platyrrhini: New World monkeys
811. Plesiadapiformes X: Paleocene and Eocene mammals, the sister group of Primates
812. *Plesiopleurodon* X: a pliosaurid from the Late Cretaceous of North America.
813. Plesiosauria X: all plesiosaurs and pliosaurs
814. Plesiosauroidea X: the plesiosaurs -- small-headed, long-necked aquatic reptiles
815. *Plesiosaurus* X: the best known plesiosaur, from the Early Jurassic of Europe
816. Pleurodira: one of the two great turtle lineages, now restricted to Gondwanan lands
817. Pleurosauridae X: Jurassic and Cretaceous marine rhynchocephalians, sister to the sphenodonts
818. Pliosauridae X: Jurassic and Cretaceous pliosaurs with very large skulls
819. Pliosauroidea X: all pliosaurs, medium to very large marine reptiles of the Mesozoic.
820. *Pliosaurus* X: a large pliosaurid from the Jurassic of Europe.
821. Podicipediformes: grebes
822. Podocnemidae: Fresh water turtles from South America.
823. Podcnemoidae: podcnemid turtles and their extinct bothremyid sister group.

824. *Poebrotherium* X: : the earliest of the Camelidae
825. Polybranchiaspidida X: Devonian galeaspid fishes with many (10-45) gill openings
826. Polybranchiaspidiformes X: a paraphyletic group of late (Devonian) galeaspid jawless fishes
827. Polycotylidae X: a family of Cretaceous plesiosaurs, sister of the elasmosaurs
828. Polycryptodira: living cryptodire (Gondwanan) turtles
829. *Polyosteorhynchus* X: a Bear Gulch actinistian
830. Polypteriformes: a strange living order of very basal actinopterygian fishes, including bichirs and reedfish
831. Poposauridae X: a family of archosaurs wedged between the rauisuchids and the crocodylomorphs
832. Porolepiformes X: Devonian sarcopterygian fishes, sister to either the lungfishes or the osteolepiforms
833. Potamochoerini: the bush pig & giant forest hog of Africa
834. *Potamochoerus*: bush pig
835. *Powichthys* X: probably a very early lungfish (dipnomorph)
836. *Presbyornis* X: a very important and succesful early duck/goose, known from the Cretaceous to the Late Eocene
837. Presbyornithidae X: the family of *Presbyornis*
838. Prestosuchidae X: the most basal family on the croc side of the croc-dinosaur split.
839. *Priacodon* X: a triconodont spanning the Jurassic-Cretaceous divide
840. Primates: Anglican archbishops, monkeys, etc.
841. Primatomorpha: monkeys > tree shrews? Originally defined as Dermoptera + Primates.
842. Prioniodinida X: : conodont group including the soft tissue fossil *Promissum*
843. Prioniodontida X: conodonts with hairpin S-elements and more gracile P-elements
844. Priscagamidae X: Late Cretaceous lizards on the agamid-chameleonid stem lineage
845. Pristerodontia X:
846. Pristidae
847. Pristiophoridae
848. Probainognathia
849. Proboscidea
850. Procellariiformes
851. Procolophonia - herbivorous reptiles of the Permian and Triassic; may be ancestral to turtles.
852. Procolophonidae X - stocky, Triassic lizard-like herbivores
853. Procolophonoidea X: Procolophonids and their immediate ancestors and relatives
854. Proconodontidae X:
855. Procynosuchidae X:
856. ProcynosuchusX: Late Permian amphibious cynodont
857. Progalesaurus X:
858. Proganochelys X
859. Prolacertiformes X:
860. Prosauropoda X:
861. Protaspididae X: Early Devonian heterostracan fishes, morphologically intermediate between pteraspids and psammosteids
862. Protaspidoidea X: Devonian heterostracan fishes, sister group of the pteraspids and including protaspidids and psammosteids
863. Proterochampsidae X: poorly known croc-like archisauriforms from the Middle and Late Triassic of West Gondwana
864. Proterochersis X: the oldest known pleurodire turtle, from the Late Triassic of Europe
865. Proterogyrinus X: an Early Carboniferous embolomere -- looks like a lizard, put together like an amphibian
866. Proterosuchidae X: a short branch from the archosauriform tree that never went anywhere, with very odd rostra.
867. Prothoosuchus X: might be the same as Thoosuchus, a trematosauroid temnospondyl from the Early Triassic of Russia
868. Protoceratopsidae X: the most basal ceratopsian dinosaurs
869. Protocetidae: the first real radiation of whales
870. Protopanderodontida X: a euconodont group, sister of the Prioniodontida, with a pair of incisor-like elements and a connected set of four pairs of relatively gracile (S?) elements
871. Protopteraspididae X:
872. Protorothyrididae X:
873. Protospinax X

874. *Protosuchia X:*
875. *Psammolepis X*
876. *Psammosteida* ***X***
877. ***Psammosteidae X:***
878. ***Psarolepis X: the most primitive sarcopterygian, from the Early Devonian of China***
879. ***Pseudictopidae X: poorly known fox-sized mammals, with trigonid much taller than talonid, from the Eocene of Central Asia***
880. ***Pseudopalatinae X: large, Late Triassic phytosaurs with a sagittal crest and orbits directed obliquely outwards and upwards***
881. ***Pseudopalatus X: a pseudopalatinine phytosaur closely related to Redondasaurus***
882. ***Psittaciformes: parrots***
883. ***Psittacosauridae X: a very basal family of ceratopsid dinosaurs from the Early Cretaceous of Asia***
884. ***Pteraspidida X: pteraspidiforms (jawless fish group) with separate cornual plates and unfused dorsal shield***
885. ***Pteraspididae X: typical pteraspids with the long rostrum, lateral & dorsal spines and small scales***
886. ***Pteraspidiformes X: the dominant group of Siluro-Devonian heterostracan jawless fishes***
887. ***Pteraspidina X: a rather primitive group of pteraspidiforms***
888. ***Pteraspidomorphi X: "alternate vertebrates" from the Ordovician through Devonian, with little internal skeleton and no paired appendages***
889. ***Pterodactyloidea X: advanced pterosaurs from the Late Jurassic and Cretaceous with short tails and long necks, often with head crests and with teeth reduced or absent.***
890. ***Pterosauria X: the pterosaurs***
891. *Pterygolepis* ***X: a Late Silurian anaspid (very primitive jawless fish)***
892. ***Ptyctodontida X: I once described ptyctodonts as looking like an upper class Englishman dressed for dinner. I stand by that description.***
893. ***Pycnodontiformes X: deep-bodied, durophagous halecostome fishes from the Triassic to Eocene***
894. ***Pycnosteidae X: deeply-keeled psammosteids from the Middle and Late Devonian of Europe***
895. ***Pythonomorpha: mosasaurs + snakes***

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896. ***Quaesitosaurus X: a Mongolian sauropod and close relative of Nemegtosaurus.***

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897. ***Rajiformes: extant rays***
898. ***Raoellidae X: an Eocene group of basal suines***
899. ***Rapetosaurus X: "the most complete titanosaur yet discovered" from the Late Cretaceous of Madagascar***
900. ***Ratites: ostrich, emu, cassowary, kiwis, moas and various others***
901. ***Rauisuchia: Rauisuchus > Aetosaurus -- easy to define, but very uncertain what it incudes***
902. ***Rauisuchidae X: serious competitors of the early theropod dinosaurs***
903. ***Rauisuchiformes: probably includes all but the most basal crurotarsans***
904. *Rebbachisauridae* ***X: a poorly known, but perhaps widely-spread group of Cretaceous diplodocomorphs***
905. ***Rebbachisaurus X: yet another poorly-known basal Gondwanan diplodocomorph***
906. ***Redondasuchus X: a rather non-descript North American aetosaur***
907. ***Remingtonocetidae X: the first clearly aquatic members of the whale lineage***
908. ***Reptilia***
909. ***Reptiliomorpha***

910. *Rhabdoderma X:a Carboniferous actinistian from Britain*
911. *Rhabdodon X*
912. *Rhabdosteidae X:*
913. *Rhamphorhynchoidea X: a group of long-tailed Jurassic pterosaurs with long, pointed jaws*
914. *Rhenanida X: a strange group of ray-like placoderms*
915. *Rhinatrematidae: a family of caecilians with more open skulls than most*
916. *Rhinesuchidae X: a key group of large, Permo-Triassic temnospondyls from South Africa*
917. *Rhinesuchus X: an early member of the family*
918. *Rhipidistia: a big group of more derived sarcopterygians, with membership changing over the years.*
919. *Rhizodontiformes X:*
920. *Rhomaleosauridae X: a group of big-headed Jurassic pliosaurs with spatulate skulls*
921. *Rhomaleosaurus X: a speciose genus of this family*
922. *Rhynchocephalia: Sphenodon > snakes*
923. *Rhyncholepidida X: a group of Silurian jawless fishes, part of the anaspid radiation*
924. *Rhynchosauria X:*
925. *Rhytidosteidae X:*
926. *Riebeeckosaurus X*
927. *Riojasaurus X*
928. *Riojasuchus X*
929. *Rodentia: rodents, of course*
930. *Ruminantia: giraffes, deer & bovines*
931. *Rutiodon X a typical Carnian phytosaur*
932. *Rutiodontinae X: large phytosaurs with rounded skulls and laterally-facing eyes*

-S-

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933. *Salmoniformes: salmon and osmeroid fishes*
934. *Saltasaurinae X: advanced, armored titanosaurs of the Late Cretaceous*
935. *Saltasaurus X: a small member of the above family*
936. *Sanitheriidae X: a small family of suoids from the first half of the Miocene.*
937. *Sarcopterygii: fishes with paired fins with a single basal and muscular lobes, cosmine scales, and enamelled on teeth -- including us.*
938. *Sarcosuchus X: Paul Sereno's big croc, from the middle Cretaceous of Africa*
939. *Sauria: archosaurs + lepidosaurs*
940. *Saurichthyidae X: sort of proto-pike -- long, skinny fishes of the Early Mesozoic*
941. *Saurischia: birds > Triceratops*
942. *Sauropoda X: giant herbivorous dinosaurs*
943. *Sauropodomorpha X: the stem group of sauropods: titanosaur > titmouse*
944. *Sauroposeidon X: Brachiosaurus on steroids; possibly the largest terrestrial vertebrate of all time*
945. *Sauropsida: snakes > St. Patrick*
946. *Sauropterygia X: placodonts + plesiosaurs*
947. *Saurosuchus X: a huge prestosuchid*
948. *Scandentia: tree shrews*
949. *Scelidosauridae X: a family of Jurassic ankylosauromorphs*
950. *Scincomorpha: skinks*
951. *Scleroglossa: all lizards and snakes except the Iguania*
952. *Scleromochlus X:*
953. *Sclerorhynchidae X: Mostly Late Cretaceous chondrichthyans intermediate between sawfish & rays.*
954. *Scolecophidia: "blind snakes," tiny, very basal snakes.*
955. *Scopelomorpha: blackchins and lanternfishes*
956. *Scutellosaurus X: a small, Tithonian dinosaur, sister of the Thyreophoran group.*
957. *Sebecosuchidae X: an interesting, poorly known group of early Cenozoic South American crocodiles.*
958. *Selenodontia: all artiodactyls who aren't pigs.*

959. *Selmacryptodira: all cryptodire turtles except Kayentachelys.*
960. *Semionotiformes X: an important group of helecostome fishes through the entire Mesozoic.*
961. **Serpentes: all snakes**
962. **Serpianosaurus X: a rather nothosaur-like pachypleurosaur from the Middle Triassic of Europe**
963. **Seymouriamorpha X: Permian competitors of the amniotes.**
964. **Shastasauria X: the latest and greatest of the Triassic ichthyosaurs**
965. **Shielia X: perhaps the most gnathostome-like of all thelodonts, from the Wenlock of Europe**
966. **Shuvuuia X : a flightless alvarezsaurid protobird from the Late Cretaceous of Mongolia, with a well-preserved skull**
967. **Siberiaspidoidei X: jawless amphiaspid fishes from the Early Devonian of Siberia, perhaps with two lateral line systems**
968. **Siluriphysi: cat fishes, electric eels, and close relatives**
969. **Simoedosauridae X: an obscure group of champsosaurs**
970. **Simolestes X: a poorly known rhomaleosaurid pliosaur from the Early Jurassic**
971. **Simosaurus X: somewhat intermediate between pachypleurosaurs and nothosaurs**
972. **Sinamiidae X: Early Cretaceous neopterygian fishes, sister of the Amiidae**
973. **Sinolepidae X: early antiarch placoderms with big, squarish heads**
974. **Sinraptoridae X: a well known basal allosauroid group from the Late Jurassic of China.**
975. **Sirenia: manatees & dugongs.**
976. **Sirenidae: the crown group of living salamanders**
977. **Smilosuchus X**
978. **Solenodontidae: a tiny group of Carribean shrew-like insectivores**
979. **Solnhofenamia X: Late Jurassic amiid fishes from Germany & France**
980. **Somphospondylii X: Titanosaurs and their older cousins**
981. **Sonorasaurus X: a middle Cretaceous brachiosaurid from North America.**
982. **Soricidae: shrews**
983. **Soricinae: Northern Hemisphere shrews with pigmented teeth and very high metabolic rates**
984. **Soricoidea: shrews > moles**
985. **Soricomorpha: shrews > hedgehogs**
986. **Spalacotheriidae X: a small group of late "acute angle symmetrodonts." from China and North America.**
987. **Spalacotheroidea X: possible mammals, including essentially all of the later "symmetrodonts"**
988. **Spathicephalus X: a shovel-headed Carboniferous proto-baphetid known from both sides of the Atlantic.**
989. **Sphenacodon X: an Early Permian "pelycosaur" -- close relative of Dimetrodon, but without the sailback fin.**
990. **Sphenacodontia: Dimetrodon + Marilyn Monroe**
991. **Sphenacodontidae X: Big sail-back carnivorous pelycosaurs and relatives. The dominant carnivores of the Early Permian.**
992. **Sphenisciformes: penguins**
993. **Sphenodontidae: clevosaurs and tuataras (Sphenodon).**
994. **Sphenodontinae: Sphenodon + Eilenodon?**
995. **Sphenosuchia X: paraphyletic group of all basal crocodylomorphs**
996. **Sphenosuchidae X: erect, bipedal, terrestrial sphenosuchids of the Triassic and Jurassic**
997. **Squalea: modern rays, skates, and non-galeomorph sharks**
998. **Squalodontidae X: a family of dolphin-like whales from the Oligocene and Miocene**
999. **Squalodontoidea X: rather small, early modern whales with long rostra and shark-like teeth.**
1000. **Squalomorpha**
1001. **Squamata: lizards and snakes**
1002. **Squatinactida X: a skate-like group of Carboniferous sharks**
1003. **Squatinidae: angel sharks**
1004. **Stagonolepis X: an aetosaur from the Late Triassic of Europe and North America**
1005. **Stegosauria X: Stegosaurus > Ankylosaurus**
1006. **Stegosauridae X: all stegosaurs except the basal Chinese forms**
1007. **Stegosaurinae X: the most specialized stegosaurs**
1008. **Stegosaurus X: the famous plate-backed dinosaur of North America**
1009. **Stenomylinae: X**

1010. **Stenopterygii**: Mostly weird, deep-sea fishes, often with photophores and huge mouths
1011. **Stenopterygius** X: a Jurassic ichthyosaur similar to Ichthyosaurus
1012. **Stereognathus** X: one of the last basal cynodonts, from the Middle Jurassic of Europe
1013. **Stereospondyli** X: all stereosponylomorphs except the Permian archegosauroids
1014. **Stereospondylomorpha** X: a large group including most Mesozoic temnospondyls and some close relatives
1015. **Stethacanthidae** X: best-known of the paleozic sharks (Symmoriida) with an elaborate head-dress
1016. **Sthenarosaurus** X: an Early Juassic elasmosaur of uncertain affinities
1017. **Strepsirhini**: lemurs, lorises, indri, and related forms
1018. **Strigiformes**: owls
1019. **Strunius** X: a basal sarcopterygian fish which looks a lot like an actinopterygian
1020. **Struthiocephalus** X a Guadalupian tapinocephalid -- not as hideous as most
1021. **Struthioniformes**: ostriches
1022. **Styloichthys**: X: the sister of Rhipidistia (tetrapods + lungfish)
1023. **Styracocephalus** X: a basal dinocephalian therapsid, from the Guadalupian of South Africa
1024. **Suchia**: aetosaurs + alligators
1025. **Suidae**: pigs > peccaries
1026. **Suina**: pigs, hippos & extenct relatives
1027. **Suinae**: crown group of living suids
1028. **Suini**: Sus scrofa, the domestic pig, and very close relatives
1029. **Suoidea**: same as Suina, but without the oreodonts
1030. **Sus**: the domestic pig and its congenerics
1031. **Symmetrodonta**: by our reckoning, Kuehneotheriids + mammals
1032. **Symmoriida** X: symmoriid and stethacanthid sharks
1033. **Symmoriidae** X: symmoriid sharks with a single dorsal fin and well-developed claspers
1034. **Synapsida**: Darwin > Darwin's finches, from pelycosaurs to people.
1035. **Synechodontiformes** X: the Mesozoic sister group of the Neoselachii (living sharks)
1036. **Synechodus** X: the former Palaeospinax, about halfway from hybodonts to galeomorphs, from the Triassic to Eocene.
1037. **Syodon** X: a small anteosaur with a large pineal foramen, from the Permian of Russia.
1038. **Syodontidae** X: a family od smallish Late Permian anteosaurs known from both Russia and South Africa

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1039. **Talpoidea**: moles
1040. **Tapinocaninus** X: a very large tapinocephalid therapsid from the Middle Permian of South Africa
1041. **Tapinocephalia** X: the herbivorous half of the dinocephalian lineage of Permian therapsids
1042. **Tapinocephalidae** X: specialized tapinocephalians with swollen cranial bones and interdigitating teeth.
1043. **Tapinocephalus** X: a big, robust therapsid which gave its name to the famous Tapinocephalus Zone of the Middle Permian Karoo.
1044. **Tarsiiformes**: tarsirs
1045. **Tarjadia**: X
1046. **Tayassuidae**: peccaries
1047. **Teleosauridae** X: Jurassic and Cretaceous crocs, marine but only minimally adapted for aquatic life
1048. **Teleostei**: the teleost fishes
1049. **Teleostomi**: the huge group uniting bony fish and acanthodians
1050. **Telmabates** X: an Eocene presbyornithid duck from **South America**
1051. **Temnodontosaurus** X: a 9m ichthyosaur with the largest eye of any vertebrate and a key transitional genus between Triassic and Jurassic ichthyosaurs
1052. **Temnospondyls** X: a large and succesful group of primitive amphibians from the Early Carboniferous to the Cretaceous.
1053. **Tenontosauridae** X: some rather late hypsilophodont-like iguanodonts

1054. *Tenontosaurus* X: a basal iguanodont from the middle Cretaceous of North America
1055. *Tenrecoidea*: tenrecs (endemic African shrew relatives)
1056. *Terminonaris* X: a very big croc from the Cretaceous of North America
1057. *Testudines*: turtles
1058. *Tetanurae*: all theropods except the ceratosaurs
1059. *Tetraceratops* X: either a very primitive therapsid or an aberrant pelycosaur
1060. *Tetraconodontinae* X: Miocene-Pliocene pigs often used in dating hominid localities
1061. *Tetrapoda*: see explanation at *"What is a Tetrapod?"*
1062. *Tetrapoda**: see explanation at *"What is a Tetrapod?"*
1063. *Tetrapodomorpha*: lizards > lungfish
1064. *Teviornis* X: a Late Cretaceous duck from Mongolia
1065. *Thalassiodracon* X: a rather plesiosaur-like pliosaur from the Triassic and Jurassic of England
1066. *Thaliacea*: Salps. Free-living urochordates morphologically like Ascidiacean adults
1067. *Thalattosuchia* X: highly marine-adapted late Mesozoic & early Cenozoic crocs.
1068. *Thecodontosaurus* X: a small, very early prosauropod dinosaur.
1069. *Thelodonti*: paraphyletic, very diverse group of small Paleozoic jawless fishes with small scales
1070. *Thelodontida* X:
1071. *Thelodontidae* X:
1072. *Therapsida*
1073. *Thereudontidae* X:
1074. *Theria*
1075. *Theriodontia*
1076. *Therizinosauridae* X:
1077. *Therizinosauroidea* X
1078. *Therocephalia* X:
1079. *Theropoda*: carnivorous dinosaurs and birds
1080. *Thescelosaurus* X: a small hypsilophodont dinosaur from the Late Cretaceous
1081. *Thoosuchinae* X: trematosauroid temnospondyls, in fact possibly sysnonymous with Trematosaurus, from the Early Triassic of Russia
1082. *Thoosuchus* X: differs from Trematosaurus only in details of the squamosal
1083. *Thrinaxodon* X: a famous mammal-like cynodont from the Early Triassic of South Africa
1084. *Thunnosauria* X: aptly named "tuna lizards" -- strongly fish-like ichthyosaurs from the late Mesozoic.
1085. *Thyestiida* X: almost finless, tadpole-like osteostracans from the Late Silurian and Early Devonian of Europe
1086. *Thyreophora* X: stegosaurs, ankylosaurs and their stem group
1087. *Ticinosuchus* X: a very terrestrial prestosuchid from the *Middle Triassic* of Europe
1088. *Tinamiformes*: tinamous, living quail-like paleognathous flyers
1089. *Tinodontidae* X: a common tooth taxon of mainly Jurassic spalacotheroid symmetrodont mammals
1090. *Titanophoneus* X: the largest of the anteosaurs, a top predator of Late Permian Russia
1091. *Titanosauria* X: the last and probably largest and longest-living group of sauropods
1092. *Titanosauridae* X: a big family containing all the "traditional" titanosaurs
1093. *Titanosauriformes* X: Titanosaurus + Brachiosaurus
1094. *Titanosaurus* X: a remarkably scrappy sauropod, considering its fame, from the Late Cretaceous of India.
1095. *Titanosuchidae* X: a rather messy group of tapinocephalian therapsids from the Middle Permian of South Africa
1096. *Titanosuchus* X: the standard-bearer of the titanosuchidae.
1097. *Tomistominae* X: the "false gharial" of SE Asia
1098. *Torpedinidae*: the electric rays
1099. *Torpediniformes*: the two main families of electric rays
1100. *Torvosauroidea* X: spinosaurs and bunch of other basal theropods
1101. *Toxodontia* X: pig, hippo, and perhaps elephant analogs of the South American Paleogene ungulate radiation.
1102. *Trematosauria* X: Trematosaurus > Parotosuchus
1103. *Trematosauridae* X: specialized long-snouted fish-eaters of the Early Triassic, the only temnospondyls to adopt a marine existence
1104. *Trematosauroidea* X: Large, gharial-like forms with elongated rostrums, probably specialized for catching fish.

1105. *Trematosaurus* X: the name-sake of these clades.
1106. *Trialestidae* X: small, lightly built crodylomorphs with elongate limbs and digitigrade feet, from the Late Triassic of South America
1107. *Tricleidia* X: the last and most derived of the plesiosaurs
1108. *Tricleidus* X: a Late Jurassic plesiosaur of the above group
1109. *Triconodonta* X: carnivorous, cat-sized Mesozoic mammals who branched off after the marsupials, but well before placentals and marsupials
1110. *Triconodontidae* X: Jurassic European and Cretaceous North American triconodonts
1111. *Triisodontidae* X: the largest mammals of the Paleocene
1112. *Trilophosauridae* X: a very strange, herbivorous archosauromorph from the Triassic of Texas (one of personal favorites)
1113. *Trioracodon* X: a triconodont which appears to bridge the gap between Jurassic European and Cretaceous North American groups.
1114. *Tristichopteridae* X: a family of very large Middle and Late Devonian osteolepiforms
1115. *Trithelodontidae* X: sister of the mammaliaforms ... perhaps.
1116. *Tritylodon* X: a Late Triassic or Early Triassic cynognathian cynodont from South Africa
1117. *Tritylodontidae* X: the other possible candidate for mammaliaform sister group
1118. *Troodontidae* X: a family of weird Cretaceous dinosaurs quite close to the birds
1119. *Tropiduridae*: a family of iguanuan lizards with big tails and coarse scales
1120. *Tubulidentata*: aardvarks and their aancestors.
1121. *Turiniidae* X: a family of thelodont fishes that did very well in Devonian Gondwana
1122. *Typhlopidae*: a family of small to medium-sized, primitive, fossorial snakes
1123. *Typotheria* X: South American analogue of the rodents, Paleocene to Pleistocene
1124. *Typothorax* X: Advanced large broad-bodied aetosaur from the Late Triassic of North America.
1125. *Tyrannosauridae* X: Tyrannosaurus + Aublysodon
1126. *Tyrannosaurinae* X: Tyrannosaurus + Albertosaurus + Gorgosaurus
1127. *Tyrannosaurini* X: Tyrannosaurus > (Albertosaurus and Gorgosaurus), including Daspletosaurus and Tarbosaurus as well as the infamous Tyrannosaurus.
1128. *Tyrannosauroidea* X: Tyrannosaurus > tiny birds (or any bird, for that matter), including the whole Cretaceous clade from Eotyrannus to Tyrannosaurus.

-U-

1129. *Ulemosaurus* X: a grotesque and primitive tapinocephalid therapsid from the Late Permian of Russia
1130. *Umbra*: the mudminnows
1131. *Ungulata*: the whole modern ungulate clan, used here as horses + cows.
1132. *Ungulatomorpha*: the ungulate stem group, cows > cats.
1133. *Uranocentradon* X: a fairly large and flatheaded rhinesuchid temnospondyl from the Permo-Triassic boundary in South Africa.
1134. *Urochordata*: an ancient group of marine suspension feeders with chordate characters in the larval stage.
1135. *Urodela*: salamanders
1136. *Uropeltidae*: "shield-tail snakes"
1137. *Utatsusaurus* X: the most primitive known ichthyosaurian, from the Early Triassic of Japan & Canada

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-V-

1138. *Varanidae*: varanid lizards, including the Komodo dragon, the monitor lizards, etc.
1139. *Varanodontinae* X: an interesting family of very early, very primitive synapsid "pelycosaurs" from the Permo-Carboniferous
1140. *Varanoidea*
1141. *Varanops* X:
1142. *Varanopseidae* X

1143. Velosauria X
1144. Venaticosuchus X: a long-legged ornithosuchid archosaur from the Late Triassic of South America
1145. Venenosaurus X: a middle Cretaceous sauropod from Utah, one possible sister of the Titanosauria
1146. Venyukovioidea X: small-headed anomodont therapsids, basal to the dromasaurs and dicynodonts
1147. Vertebrata: lampreys + gnathostomes: forms with at least some restriction of the notochord.
1148. Vidalamiinae X: big, nasty-looking amiid fishes from the Cretaceous to Eocene of Africa and South America
1149. Viperidae: adders, vipers, & copperheads
1150. Viperinae: "pitless" viperids
1151. Vulcanodontidae X: likely a poly- and/or paraphyletic group of very primitive sauropods
1152. Vulturides: teratorns & New World vultures, condors.

-W-

1153. Wuerhosaurus X: the sister genus of Stegosaurus, from the Early Cretaceous of China

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-X-

1154. Xenacanthida X: Permo-Carboniferous fresh water sharks
1155. Xenarthra: armadillos, anteaters & sloths
1156. Xenocretosuchus X: a late tritylodont cynodont with moderately-well-developed molar-like cusps

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-Y-

1157. Yarengia X: an obsucure Early Triassic trematosaurian temnospondyl
1158. Younginiformes X: Medium-sized lizard-like Permo-Triassic diaspids, some forms very aquatic, closely related to the Sauria and to ichthyosaurs.
1159. Youngolepis X: a very early member of the lungfish lineage, from the Early Devonian of China
1160. Yunnanodon X: an Early Jurassic cynodont
1161. Yunnanolepidae X: Small, very primitive South China antiarch placoderms from the Early Devonian
1162. Yunnanolepidoidei X: Early Devonian Chinese antiarch placoderms with short, wide heads
1163. Yunnanosaurus X: a remarkably late (Pliensbachian) prosauropod from China
1164. Yuzhoupliosaurus X: a Middle Jurassic rhomaleosaurid from China, known only from a mandible.

-Z-

1165. Zalambdalestidae X: well-known, but poorly understood, early Eutherian mammals from the Asian Cretaceous
1166. Zenaspidida X: a family of cornuate cephalaspids with particularly massive headshield, from the Devonian.
1167. Zephyrosaurinae X: a small group of small dinosaurs -- North American

hypsilophodonts

1168. *Zhelestidae X: a (paraphyletic?) group of earliest ungulatomorphs.*
1169. *Zopherosuchus X: a small dinocephalian therapsid with thickened skull from the Middle & Late Permian of Russia.*

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Cladistics: An Introduction

Cladograms are the heart of paleontology in these opening years of the Third Millennium. The theory and practice of these diagrams is a subject which would fill many pages. In fact it *does* fill many pages on this site; and the questions get very technical indeed. Here, we present only a basic introduction.

Cladograms are simply diagrams which show how species, or groups of species, are interrelated. They look like this:

```
Vertebrates
|--sharks
`--Tetrapoda
   |--dinosaurs
   `--+--monkeys
      `--you
```

Notice that we don't have to put in every group. Presumably there are other tetrapods besides dinosaurs, monkeys and you. Nor do we have to name every group. For example, there is some taxon that unites you and monkeys to the exclusion of dinosaurs (*e.g.*, Primates or Mammalia), but it is represented simply by the '+' in the diagram. It's the *relative* position that is important.

This cladogram can be written several ways. The most inclusive group always goes at the top, by convention. However, we could describe precisely the same set of relationships like this:

```
Vertebrates
|--Tetrapoda
|  |--+--you
|  |  `--monkeys
|  `--dinosaurs
`--sharks
```

In both diagrams, to go from the first vertebtrate to you, we have to split off sharks, go through Tetrapoda, split off dinosaurs and split off monkeys -- *in exactly that order*. So, we are presenting the same evolutionary sequence, however it is displayed. The path between taxa counts, not where they fall on the page.

For reasons we will not get into here, each group is normally expected to diverge into precisely two others. However, we are often unsure (and unwilling to guess) exactly what the sequence was. Thus, you will frequently encounter:

```
Vertebrates
|--sharks
`--tetrapods
   |--dinosaurs
   `--+--monkeys
      |--Chopin
      |--Mozart
      |--Tansen
      `--you
```

Absent some unexpected miracle of genetics, you do not represent an evolutionary advance over Tansen or Mozart. (As to Chopin -- perhaps the less said the better.) The diagram simply indicates that, for phylogenetic purposes, you, Mozart, Chopin and Tansen are all the same distance from monkeys, dinosaurs, etc. and that all of you are more closely related to each other than to any of the other animals on the list (...with the possible exception of Chopin).

So why do we use cladograms? Cladograms do not necessarily require a "cladistic" view of the world. On the other hand, the cladogram does focus on phylogeny -- how different groups relate to one another. In that sense, cladograms differ a good deal from the usual Linnaean block diagrams. Let's look at a very simple example, a high-level description of the ornithischian dinosaurs in a Linnaean format:

```
Order Ornithischia
    Suborder Fabrosauria
    Suborder Thyreophora
        Superfamily Stegosauria
        Superfamily Ankylosauria
    Suborder Ornithopoda
            Family Hypsiliphodontidae
            Family Heterodontosauridae
        Superfamily Iguanodontia
        Superfamily Hadrosauria
    Suborder Marginocephalia
        Superfamily Pachycephalosauria
        Superfamily Ceratopsia
```

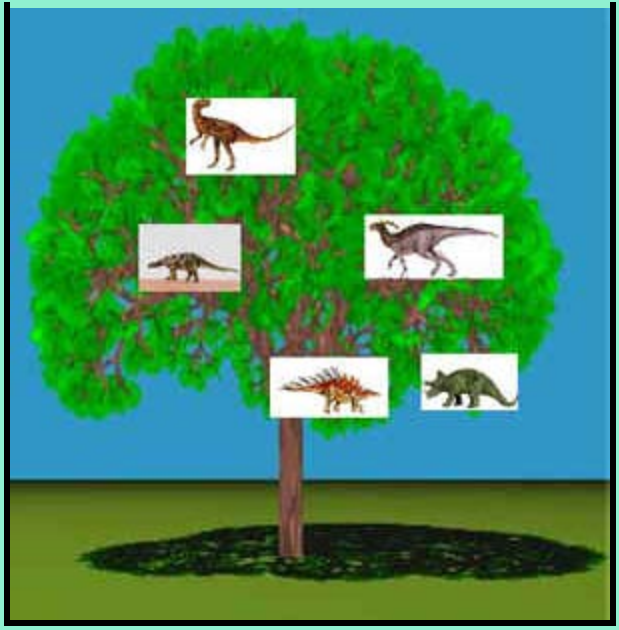
Note that every group has a "rank:" order, family, genus, species, and innumerable gradations in between. Much breath and paper has been wasted arguing the appropriate rank of a group. What does a rank indicate? It cannot be a measure of internal similarity. There is no possible scientific answer to questions such as: "are hypsilophodonts more like each other than ceratopsians are like other ceratopsians?" Even if the question had an answer, it would tell us nothing. All sauropods, for example, are very much alike. Yet no one would argue that they are a mere family. Nor is rank a measure of diversity. Many families have only one member. Others have a hundred or more.

Perhaps a more significant problem is that the scheme doesn't tell us about the evolution or relationships of these groups. The current best guess, for example, is that all ornithischians are descended from "fabrosaurs" (the reason for the quotation marks will be explained later). The hypsilophodonts and heterodontosaurs are independently derived from the ornithopod stem. The iguanodonts may or may not be specialized hypsilophodonts, but the hadrosaurs are definitely of the Iguanodontia. The Linnaean diagram may be good *systematics*, that is, a reasonable classification scheme. But it tells us nothing about phylogeny. It would be equally valid, and less misleading, to sort them in alphabetical order or by the zodiacal sign of the date of first publication.

Another way of stating this problem is that the Linnaean formalism doesn't tell us whether these taxa are natural groups or just a man-made assortment of similar organisms. Linnaean taxa are defined, if at all, by a list of characteristics. This is sometimes referred to as an "*apomorphy*-based definition" **[1]**. What if another, unrelated, organism were found with the same characteristics, or (as is more usually the case) it turns out that a Linnaean taxon contains organisms that have arrived at the same condition by convergent evolution? Conversely, if, for example, hadrosaurs are descended from iguanodonts, where do we draw the line? *Ouranosaurus* has characteristics which are somewhat intermediate between *Iguanodon* and "advanced" hadrosaurs. In the Linnaean scheme, we can call it an iguanodont or a hadrosaur, depending on exactly what characteristics we use to define these mutually exclusive terms. But, in doing so, we are arbitrarily putting things in boxes we ourselves have built and labeled. We are not discussing natural groups, but human constructs. Nor are we making testable scientific statements.

The cladistic view of the same group (with some additions) may be

represented by the cladogram:



```
Dinosauria
|--Saurischia
|   |--Carnosauria
|   `--birds
`--Ornithischia
    |--"Fabrosaurs"
    `--+--Thyreophora
       |  |--Stegosauria
       |  `--Ankylosauria
       `--+--Ornithopoda
          |  |--Heterodontosauridae
          |  `--+--Hypsilophodontidae
          |     `--Iguanodontia
          |        |--Iguanodon
          |        `--+--Ouranosaurus
          |           `--Hadrosauridae
          `--Marginocephalia
             |--Pachycephalosauria
             `--Ceratopsia
                |--Monoclonius
                `--Triceratops
```

Here, there are no ranks. The phylogenetic relationships are open and obvious. They may not be *correct*. But we can see what they are posited to be and can challenge the cladogram with evidence. It is testable, unlike a Linnaean scheme. The reason it is testable is that each taxon should (although even scientists are sometimes sloppy about this) have an explicit *phylogenetic* definition. The Ornithischia are "all dinosaurs more closely related to *Triceratops* than to birds." The phrase "more closely related to" is used in the following special sense: a dinosaur is more "closely related to" *Triceratops* than to birds if its last common ancestor with *Triceratops* is more recent than its last common ancestor with birds. For example, consider *Ouranosaurus*. Its last common ancestor with *Triceratops* was some primitive cerapod (Cerapoda being the name of the "intersection" just to the left of "Ornithopoda" in the cladogram). The last common ancestor with birds would be much further up on the diagram.

There are four important things to note about this definition:

1) We didn't make up this group. We applied a man-made name, but it is a group which was produced by nature and defined by the actual course of evolution -- even though we may not have full knowledge of what that course was.

2) We don't know *a priori* who belongs in each category, or what characteristics the members of each group might have. Instead we use the tools of science to determine the answers to those questions. Taxa may be characterized by having particular physical attributes, but they are never *defined* by reference to these attributes. The attributes ("characters") are things we *discover* about the taxon.

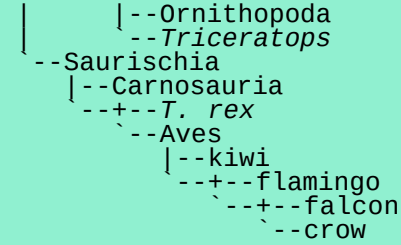
3) There are no boxes. The Ornithischia are *all* dinosaurs closer to *Triceratops* then to birds. Not just some dinosaurs who look more like our mental preconception of what an ornithischian "ought" to be like.

4) Ornithischia is an example of a *stem* group: "**all organisms closer to x than to y**." A second kind of group used in cladistics is the "*crown group*." Usage has made this term a bit ambiguous. In its most general sense, a crown group is any group defined in the form: "**the last common ancestor of x and y and all the descendants of that ancestor**." For example, Dinosauria is defined as the last common ancestor of *Triceratops* and birds and all of its descendants. Cladistics, at its most elegant, describes phylogeny as a series of triads consisting of a crown group and two complementary stem groups:

```
Dinosauria (= birds + Triceratops)
|--Ornithischia (= Triceratops > birds)
`--Saurischia (= birds > Triceratops)
```

As in the diagram above, stem groups are usually described by the shorthand form "x > y". So, Ornithischia = "*Triceratops* > birds." Crown groups are indicated "x + y." Dinosauria = "*Triceratops* + birds." Note that the anchor taxa (*Triceratops* and birds) can be changed without necessarily changing the definition. It doesn't matter what species of bird we might select, for example, if we are correct in believing that all birds have a single common ancestor.

```
Dinosauria
|--Ornithischia
|  |--Thyreophora
|  `--Cerapoda
```



In some cases, of course, those assumptions may be wrong. We should be careful in picking anchor taxa. However, it is much easier to remember Craniata as "hags + hagfish," rather than "*Myxine* + *Ausktribosphenos*." Unless something is very wrong with our picture of vertebrate evolution, the two are logically equivalent definitions.

However, it is critical to remember the "all" part of the definitions. Birds *are* dinosaurs because Dinosauria includes *all* of the descendants of the last common ancestor of birds and *Triceratops* -- including all birds. Birds are not "descended from" dinosaurs. Many people, scientists included, are frustrated by this rule. However, it is only by rigorous application of this (and other) cladistic rules that we can be sure that we are doing science and not just making arbitrary boxes. A natural group is called a *clade*, and only clades are valid taxa for purposes of cladistic analysis. The ultimate reasons for this are well beyond the scope of this essay. For the moment, it will be enough to remember that the use of taxa other than clades invites confusion and ambiguity when we are generally using cladistic principles.

That is the reason that "fabrosaurs" are found only in quotation marks on this page. "Fabrosauridae" is not a clade. It is simply a collection of primitive ornithischians. The best data available today suggest that their last common ancestor was also the ancestor of some (and perhaps all) other ornithischians. Since "Fabrosauridae" does not contain *all* of the descendants of the ancestral "fabrosaur" it is a *paraphyletic group*, rather than a clade. Conversely, a group which does not contain its own last common ancestor is referred to as *polyphyletic*.

But how do we go about making these determinations? That is a much longer and more difficult story. In fact, it is the whole subject of the science, theory, practice and art of cladistics. Aspects of this topic are discussed at many different points in **Palaeos**. A more systematic introduction to the subject may be added here in due course.

For the moment, this section contains a master cladogram of the Vertebrata -- a very high level cladogram containing only about 60 of the larger taxa. This is followed by a series of intermediate-level cladograms (incomplete as of this date) which cover the vertebrates in large chunks. For the most detailed level, see the individual units. ATW020430, last modified ATW041013.

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[1] That's not quite right. An apomorphy is a characteristic unique to a *natural* group -- a group descended from a single ancestor who had this character. The characters listed in a Linnaean definition need not, and often do not, meet this rigorous requirement. By the way, remember that, taken by itself, an apomorphy is inherently useless when it comes to inferring relationships to organisms lacking the apomorphy. The group which shares a derived character has a *synapomorphy*, and we may infer that they are more closely related to each other than to others. So, for example, Mozart, Tansen, and (presumably) you enjoy good music and form a sort of musical clade. That doesn't mean that Chopin was more closely related to musical monkey than to Mozart. That's *possible*, of course, and perhaps even likely, but we would need to identify other specific characteristics which Chopin shared with monkeys to the exclusion of Mozart and other tetrapods -- probably a long Liszt. ATW041013, revised ATW070828.

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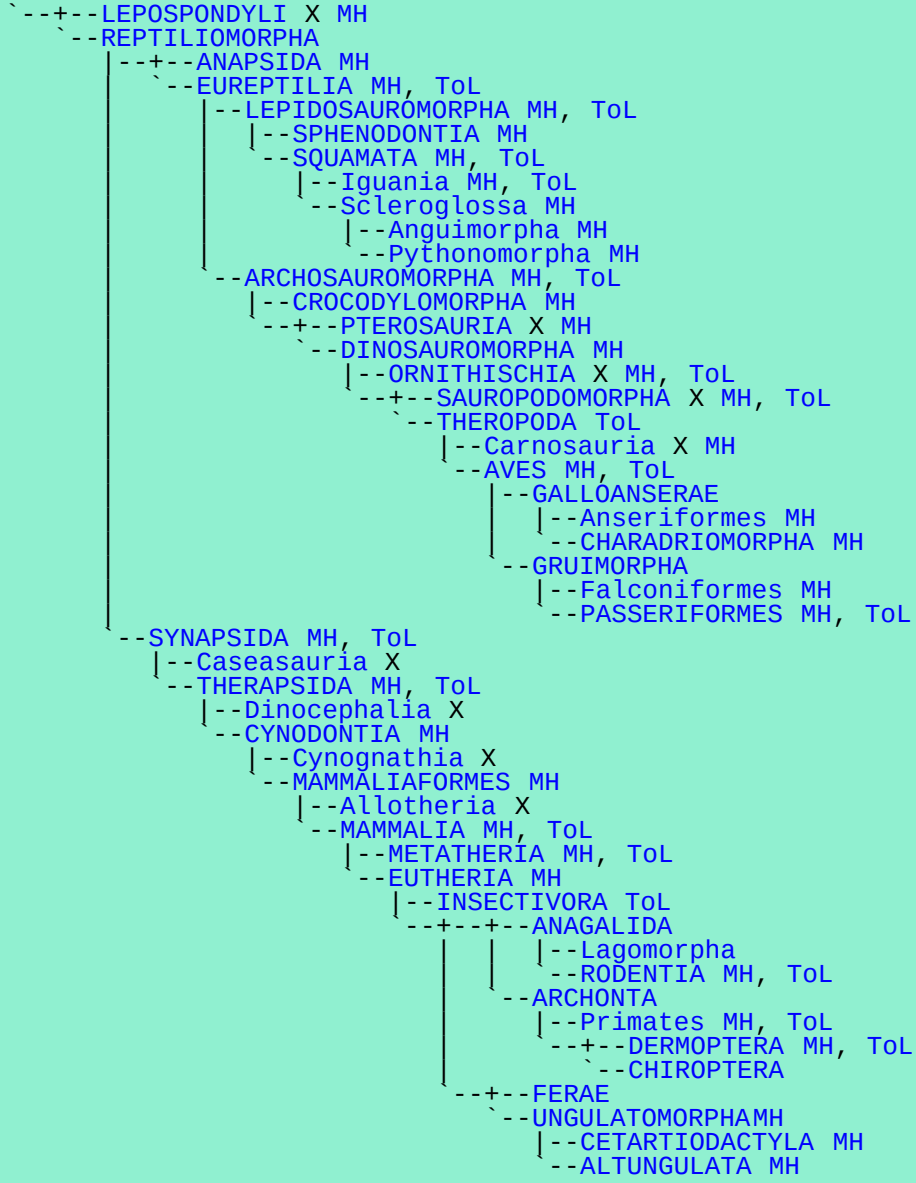
Summary Dendrograms (Dendrogram)

This is the highest level dendrogram. It shows only taxa corresponding to "units" in the **Palaeos**: Vertebrates index, plus a few others necessary to avoid showing spurious relationships. The cladograms on the following pages are on a somewhat lower level, corresponding to the "abbreviated dendrograms" shown on each page in the individual units. For the a higher level of detail, see the individual unit dendrograms, if any.

Taxa in **BOLD CAPITAL LETTERS** correspond to units in the main section. **MH** is a link to the equivalent page of Mikko Haaramo's phylogeny archive.
ToL is a link to the equivalent page of the Tree of Life.
X indicates an extinct taxon.
Quotation marks indicate either a paraphyletic group or an unpublished name.

```
CHORDATA MH, ToL
|--Cephalochordata MH
`--CRANIATA ToL
   |--Hyperoartia MH, ToL
   `--+--CONODONTA X MH, ToL
      `--+--PTERASPIDOMORPHI X MH, ToL
         `--THELODONTI
            |--PLACODERMI X MH
            `--+--CHONDRICHTHYES MH
               |  |--Holocephali MH
               |  `--NEOSELACHII MH
               `==ACANTHODII
                  |--NEOPTERYGII MH
                  |  |--Lepisosteiformes MH
                  |  `--TELEOSTEI MH, ToL
                  |     |--Clupeomorpha
                  |     `--EUTELEOSTEI MH
                  |        |--Elopomorpha
                  |        `--ACANTHOMORPHA MH
                  `--SARCOPTERYGII MH, ToL
                     |--Dipnomorpha MH
                     `--TETRAPODA MH, ToL
                        |--TEMNOSPONDYLI MH, ToL
                        |  `--LISSAMPHIBIA MH, ToL
```



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Chordate Dendrogram (Dendrogram)

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

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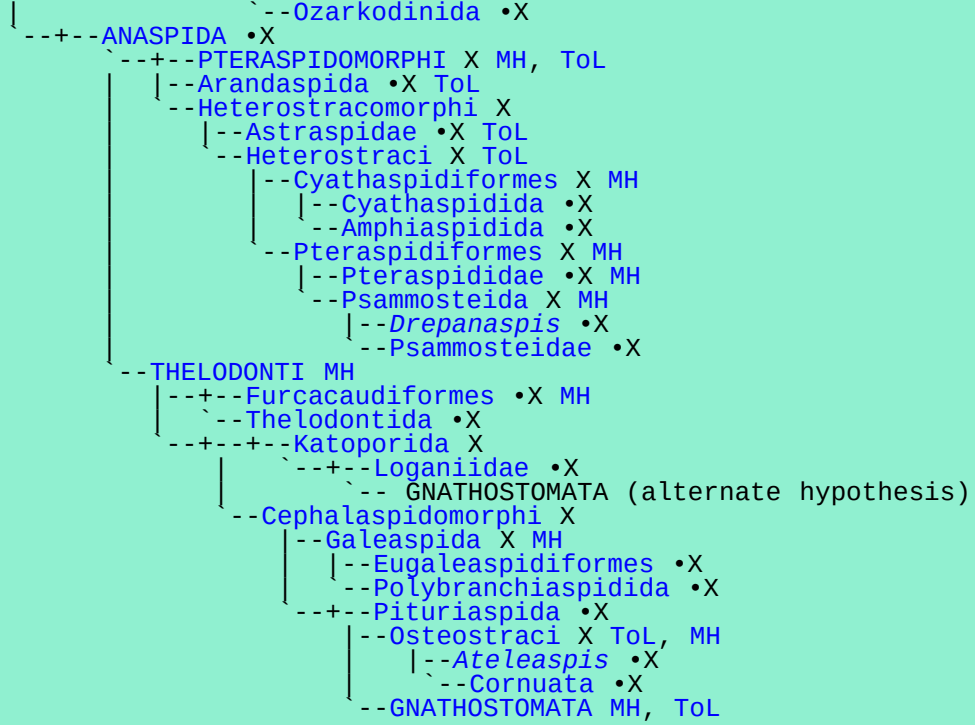
Note also that the dendrogram given here may not match revisions in the Palaeos unit pages. As always, Palaeos is a work in progress - MAK)

```
CHORDATA MH
|--Urochordata MH
|   |--Larvacea MH
|   |   |--Oikopleuridae •
|   |   `-+--Kowalevskiidae •
|   |     `--Fritillaridae •
|   `--+--Ascidiacea •
|      `--Thaliacea • MH
`--+--Cephalochordata • MH
   `--+--Haikouella •X
      `--Craniata  = VERTEBRATA ToL
         |--Myllokunmingia
         |--Haikouichthys
         `--+--Zhongjianichthys
            |--Myxinoidea • MH
            `--Vertebrata MH
               |--Jamoytiiformes •X
               `--+--Hyperoartia MH
                  |  `--Petromyzontiformes • MH
                  |--CONODONTA X MH, ToL
                  |  |--Paraconodontida •X
                  |  `--Euconodonta X
                  |     |--Proconodontidae •X
                  |     `--+--Protopanderodontida •X
                  |        `--Prioniodontida X
                  |           |--Balognathidae •X
                  |           `--+--Prioniodinida •X
```



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Gnathostome Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

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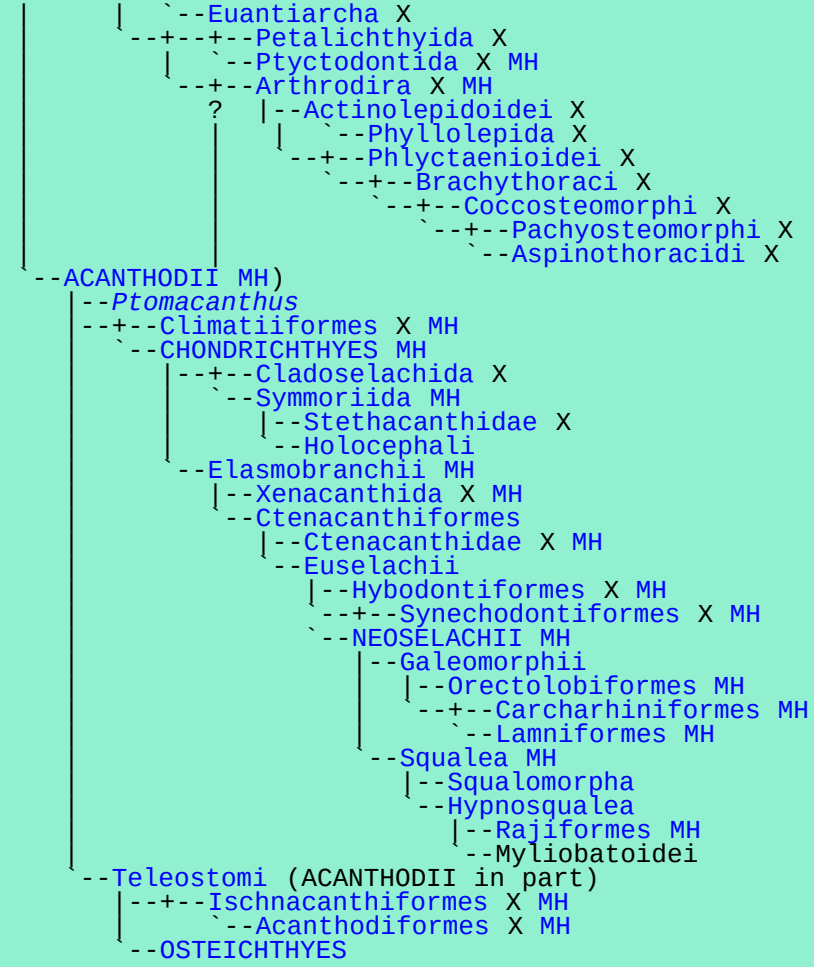
```
GNATHOSTOMATA
|--+--Stensioella
|   `--Ramirosuarezia
|--Pseudopetalichthyida
|--PLACODERMI X MH
|  |==Acanthothoraci X
|  |--Rhenanida X MH
|  `--+--Antiarchi X MH
|     |  |--Yunnanolepidoidei X
```



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Actinopterygian Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

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```
OSTEICHTHYES
   |--ACTINOPTERYGII MH
   |  |--Cladistia MH
   |  `--Actinopteri
   |     |--Chondrostei
   |     `--NEOPTERYGII MH
   |        |--Ginglymodi
   |        |  |--Macrosemiiformes X MH
   |        |  `--Lepisosteiformes
   |        `--Halecostomi
```

---

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Sarcopterygian Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to the abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

Taxa in **BOLD CAPITAL LETTERS** correspond to units in the main section. **MH** is a link to the equivalent page of Mikko Haaramo's phylogeny archive .
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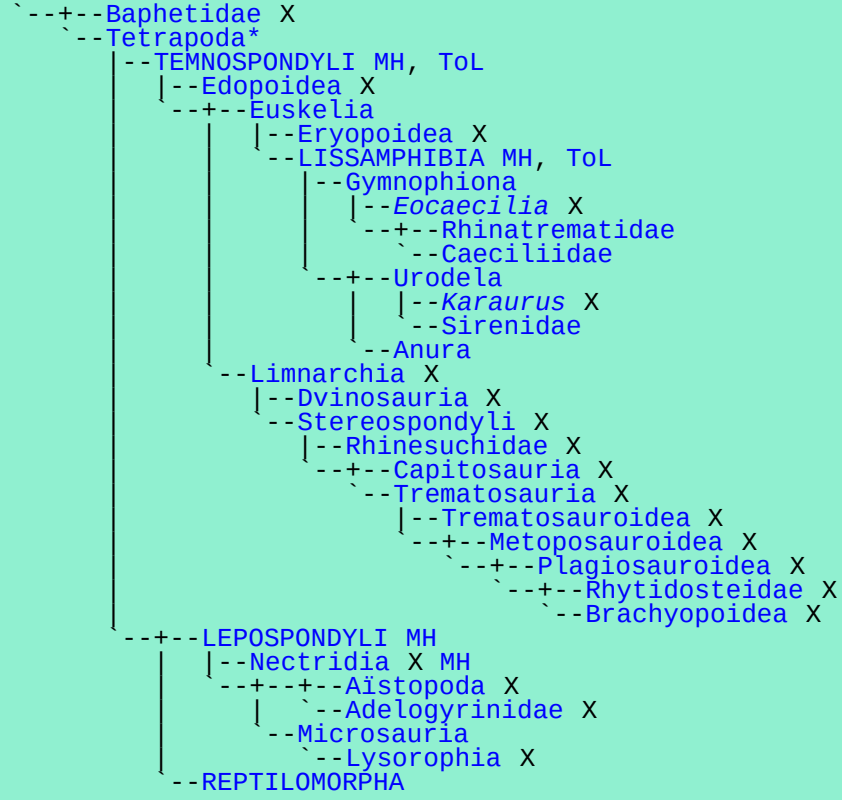
```
SARCOPTERYGII MH, ToL
|--+--Onychodontiformes X
|  `--Actinistia
`--Rhipidistia
   |--Dipnomorpha
   `--Tetrapodomorpha
      |--Rhizodontiformes X
      `--Osteolepiformes X
         |--Tristichopteridae X
         `--Elpistostegalia
            |--Panderichthys X
            `--TETRAPODA MH, ToL
               |--Acanthostega X
               `--+--Ichthyostega X
                  `--+--Crassigyrinus X
                     `--+-Colosteidae X
```



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Reptiliomorph Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the basic overview, see the summary dendrogram. For the highest level of detail, see the individual unit dendrograms, if any.

Taxa in **BOLD CAPITAL LETTERS**correspond to units in the main section. **MH** is a link to the equivalent page of Mikko Haaramo's phylogeny archive
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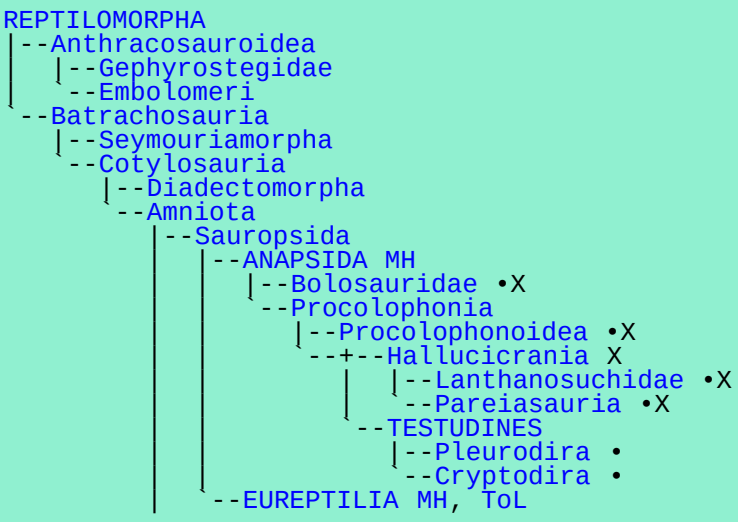

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Synapsid Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

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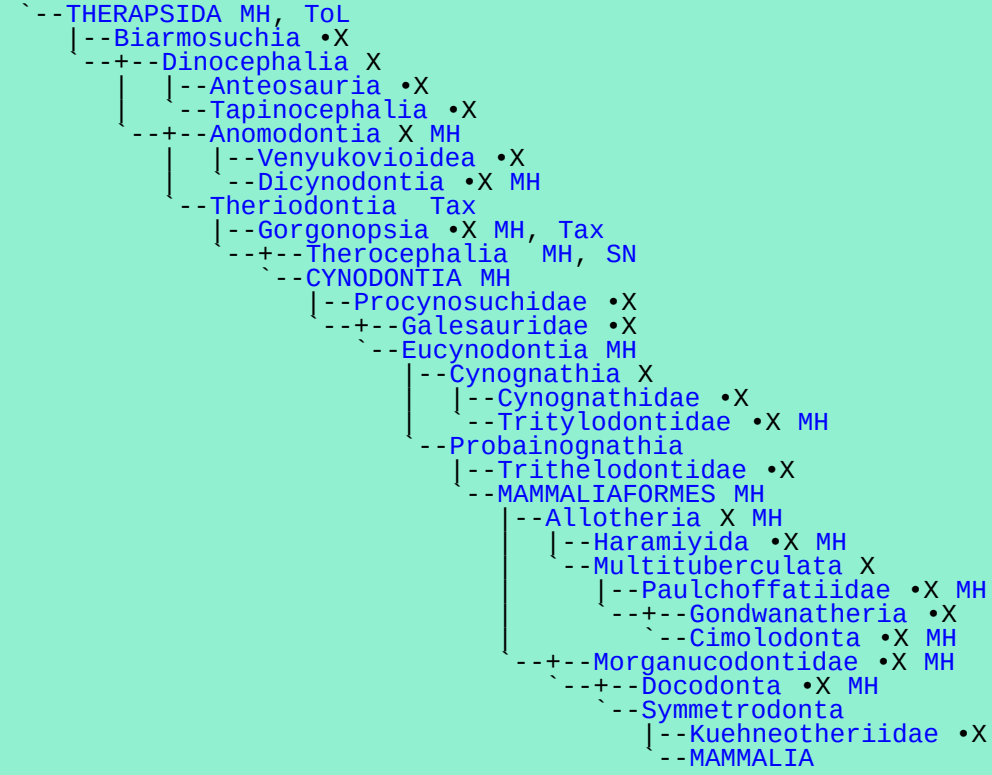
```
SYNAPSIDA MH, ToL
|--Caseasauria X
|   |--Eothyrididae •X
|   `--Caseidae •X
`--Eupelycosauria
   |--Varanopseidae •X
   `--+--Ophiacodontidae •X
      `--+--Edaphosauridae •X
         `--Sphenacodontia
            |--Sphenacodontidae •X
```



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Mammal Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

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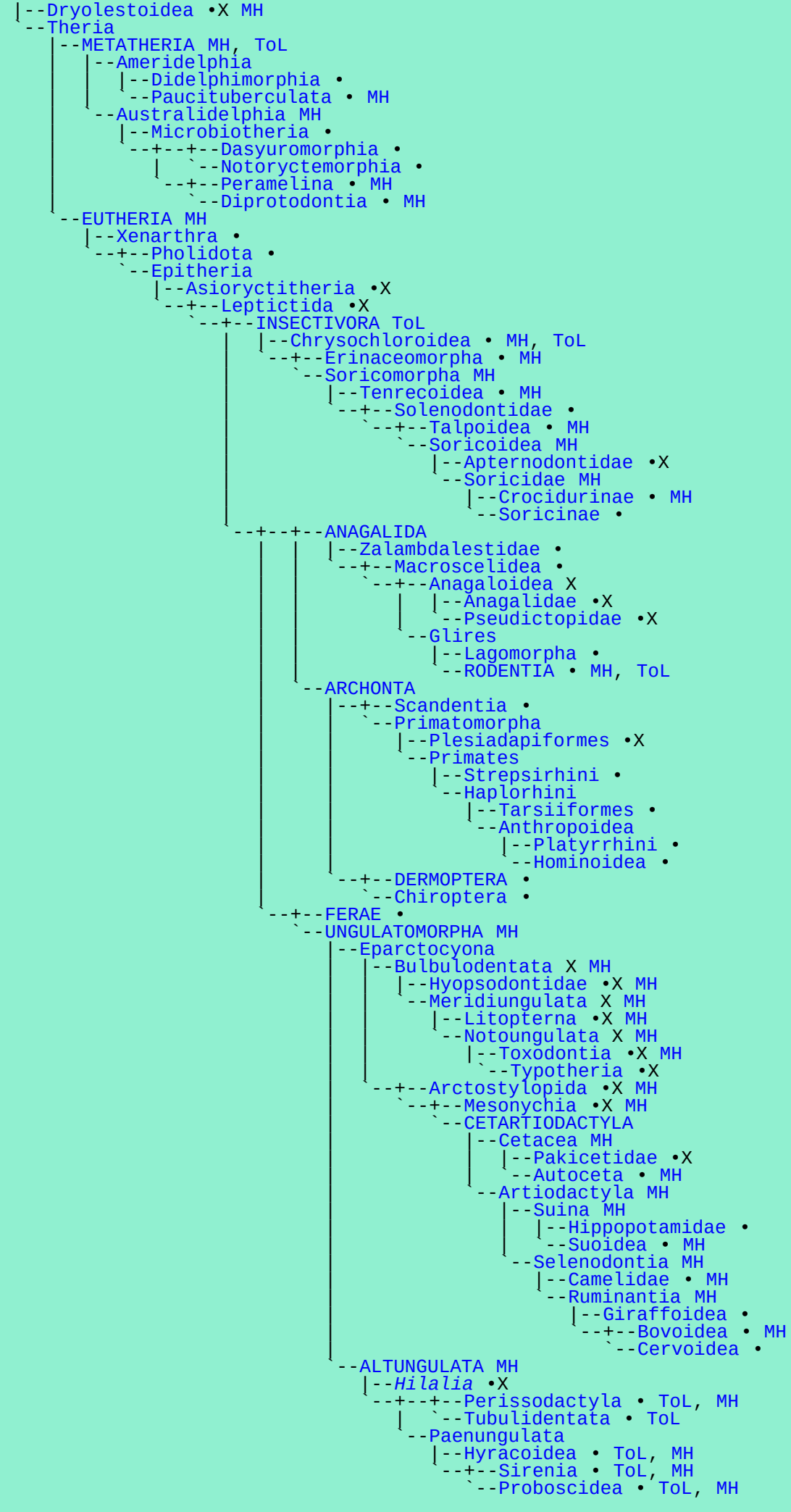
```
MAMMALIA MH, ToL
|--Australosphenida MH
|   |--Ausktribosphenidae •X
|   `--Monotremata •
`--+--Triconodonta •X
   `--+--Spalacotheroidea X MH
      |  |--Tinodontidae •X
      |  `--Spalacotheriidae •X
      `--Cladotheria MH
```


Dryolestoidea •X MH
Theria
METATHERIA MH, ToL
Ameridelphia
Didelphimorphia •
Paucituberculata • MH
Australidelphia MH
Microbiotheria •
Dasyuromorphia •
Notoryctemorphia •
Peramelina • MH
Diprotodontia • MH
EUTHERIA MH
Xenarthra •
Pholidota •
Epitheria
Asioryctitheria •X
Leptictida •X
INSECTIVORA ToL
Chrysochloroidea • MH, ToL
Erinaceomorpha • MH
Soricomorpha MH
Tenrecoidea • MH
Solenodontidae •
Talpoidea • MH
Soricoidea MH
Apternodontidae •X
Soricidae MH
Crocidurinae • MH
Soricinae •
ANAGALIDA
Zalambdalestidae •
Macroscelidea •
Anagaloidea X
Anagalidae •X
Pseudictopidae •X
Glires
Lagomorpha •
RODENTIA • MH, ToL
ARCHONTA
Scandentia •
Primatomorpha
Plesiadapiformes •X
Primates
Strepsirhini •
Haplorhini
Tarsiiformes •
Anthropoidea
Platyrrhini •
Hominoidea •
DERMOPTERA •
Chiroptera •
FERAE •
UNGULATOMORPHA MH
Eparctocyona
Bulbulodentata X MH
Hyopsodontidae •X MH
Meridiungulata X MH
Litopterna •X MH
Notoungulata X MH
Toxodontia •X MH
Typotheria •X
Arctostylopida •X MH
Mesonychia •X MH
CETARTIODACTYLA
Cetacea MH
Pakicetidae •X
Autoceta • MH
Artiodactyla MH
Suina MH
Hippopotamidae •
Suoidea • MH
Selenodontia MH
Camelidae • MH
Ruminantia MH
Giraffoidea •
Bovoidea • MH
Cervoidea •
ALTUNGULATA MH
Hilalia •X
Perissodactyla • ToL, MH
Tubulidentata • ToL
Paenungulata
Hyracoidea • ToL, MH
Sirenia • ToL, MH
Proboscidea • ToL, MH

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Archosauromorph Dendrogram

This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

Taxa in **BOLD CAPITAL LETTERS** correspond to units in the main section. **MH** is a link to the equivalent page of Mikko Haaramo's phylogeny archive (*note*: these links *no longer work*, but have not been updated as yet. When they are updated, this message will be removed. - MAK).
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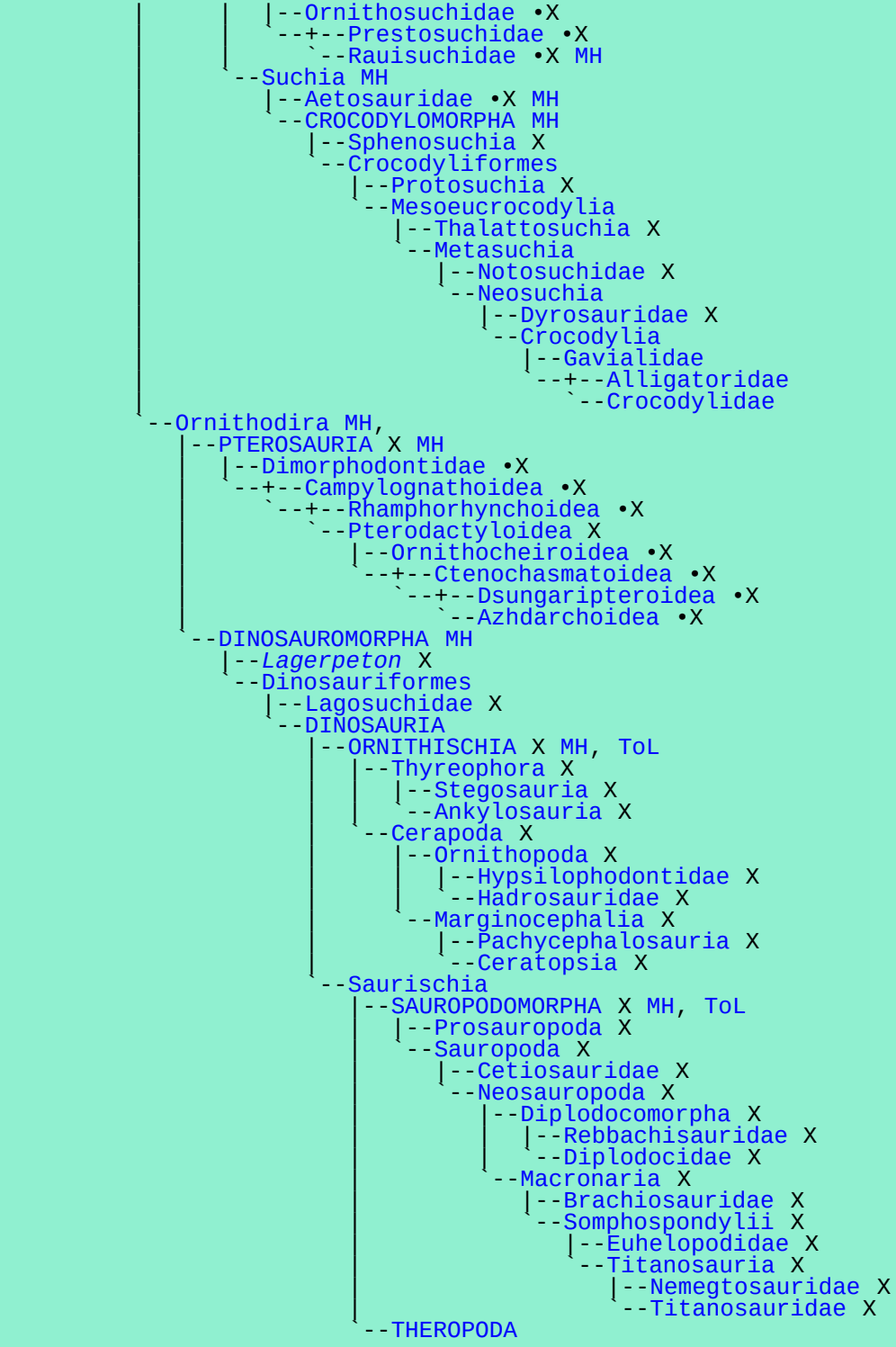
```
ARCHOSAUROMORPHA MH, ToL
|--Rhynchosauria X MH
 --+--Prolacertiformes •X MH
   `--Archosauriformes MH
      |--Euparkeriidae •X
       --Archosauria MH, ToL
         |--Crurotarsi MH
         |  |--Phytosauridae •X MH
         |   --Rauisuchiformes
         |      |--Rauisuchia X
```



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Theropod Dendrogram

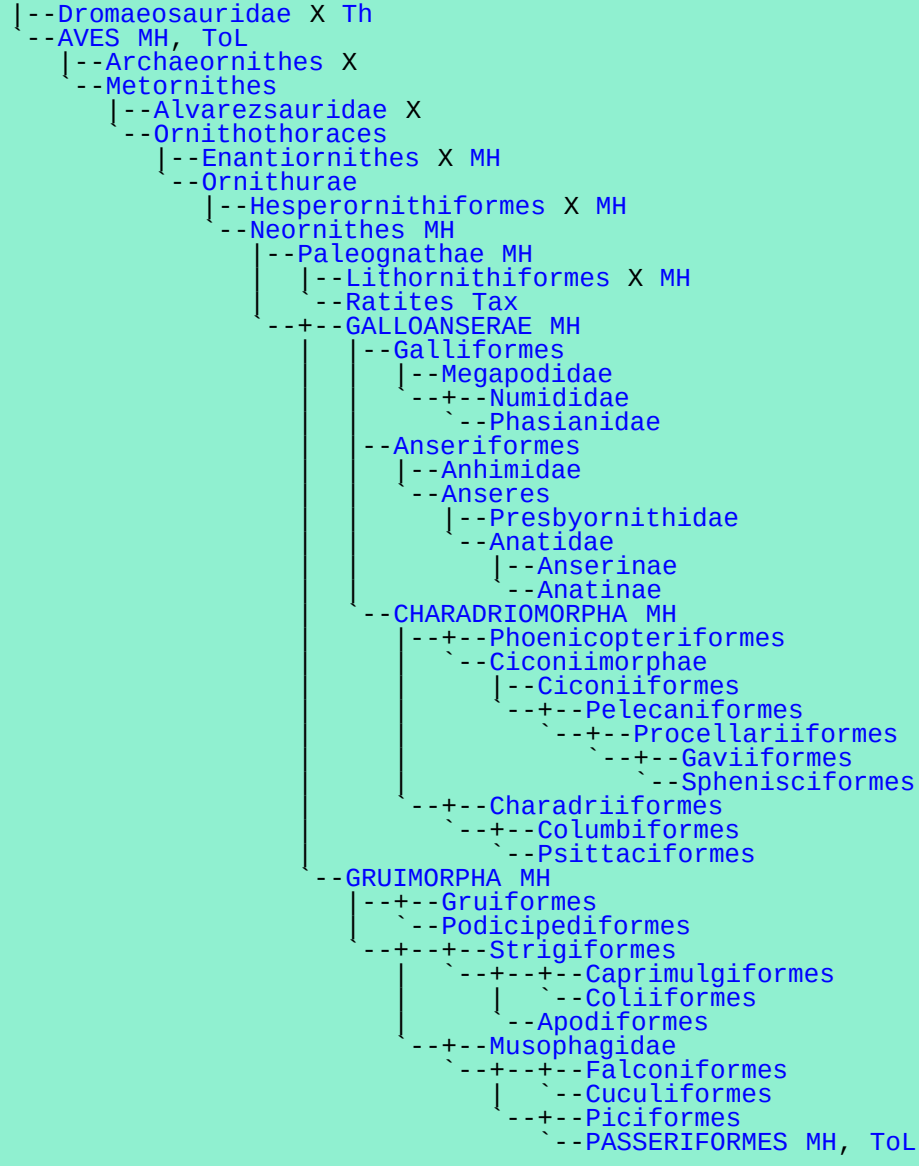
This is an intermediate level dendrogram ("cladogram"). It shows taxa corresponding to abbreviated dendrograms in each unit of **Palaeos**: Vertebrates, plus a few others necessary to avoid showing spurious relationships. For the highest level of detail, see the individual unit dendrograms, if any.

Taxa in **BOLD CAPITAL LETTERS** correspond to units in the main section. **MH** is a link to the equivalent page of Mikko Haaramo's phylogeny archive (*note*: these links *no longer work*, but have not been updated as yet. When they are updated, this message will be removed. - MAK). **Th** goes to the *Thescelosaurus!* dinosaur listing, and **ToL** is a link to the equivalent page of the Tree of Life.
X indicates an extinct taxon.
Quotation marks indicate either a paraphyletic group or an unpublished name. ATW

Note also that the dendrogram given here may not match revisions in the Palaeos unit pages. As always, Palaeos is a work in progress - MAK)

Important note - page (and site) still under construction, many of these links don't work, either because the pages they point to have notr yet been uploaded, or because the links themselves need to be updated to reflect the changes in the new site)

```
THEROPODA MH, ToL
|--Herrerasauridae X MH
 --+--Ceratosauria X Th, MH
   `--Tetanurae Th, MH
      |--Torvosauroidea X
       --Avetheropoda
         |--Carnosauria X  Th, MH
          --Coelurosauria MH
            |--Tyrannosauroidea X Th, ToL, MH
             --Maniraptora Th
```



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Note: The present page is just a holding page. At some point we may add more material here. Follow the links above for the glossary pages. For a much more cursory and generic review, see also the general Palaeos glossary.

MAK111028

Glossary: A

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

Other Web Glossaries and Related Lists

Anatomical Dictionary (One of several useful pronunciation and definitional guides from Jeff Poling's site)
Laboratories
GLOSSARY (general anatomy)
Greek and Latin Roots and Terms (what it says)

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- A -

A/paracone: in symmetrodont upper molars, the central (lingual) cusp of the trigon. This is homemade terminology used to reflect the fact that cusp homologies are unclear in symmetrodonts so that some workers use only a letter designation. However, many others traditionally refer to this cusp as the paracone.

Abducens nerve: cranial nerve VI. The abducens enervates the lateral rectus muscle of the eye, which rotates the eyeball laterally. See figure at rectus muscles; *see also* discussion and figures of the gnathostome orbit.

Abduction: in tetrapod locomotion, rotation of a limb upward, in a vertical plane. Opposite of adduction; and in contrast to *protraction* or *retraction* (movement in a horizontal plane) or to rotation about the long axis of a limb. *C.f.* **Humerus**.

Abductor L. *ab* = away from, and *ducere* = to lead. These muscles (and nerves) are named for their function. For example, the abducens nerve is named because it turns the eyeball outward.

Abo-Cutler Formation: Late Carboniferous to Early Permian of New Mexico. The Abo Reef underlies the Early Permian Cutler fm of West Texas. One can only speculate that this is the same.

Abomasum: the fourth chamber of the ruminant digestive tract, the second of two chambers used for bacterial fermentation of cellulose. See Artiodactyla for figure.

Aboral: in a direction away from the mouth cavity. This slightly ambiguous term is used to mean the opposite of occlusal in some cases where the side of the tooth opposite the biting surface is *not* a root, as in the tooth plates of chimaeriforms, or other "bradydont" dentitions in which spent teeth are retained in the dentition as, *e.g.*, part of a pavement dentition.

Abrahamskraal Formation: Late Permian of South Africa. Part of the *Tapinocephalus* Assemblage Zone of the Beaufort Group. *Elliotsmithia*, therapsids.

Acellular: without cells; *e.g.* "acellular bone" is bone that is not supported by or contain living cells.

Acetabulum: the socket in the pelvis for the head of the femur, normally at the junction of the pubis, ischium and ilium. See figure at *antitrochanter*.

Acicular: Needle-shaped; slender like a needle or bristle, or having a needle-like point.

Acinaciform: shaped like a scimitar (or cutlass, or even saber).

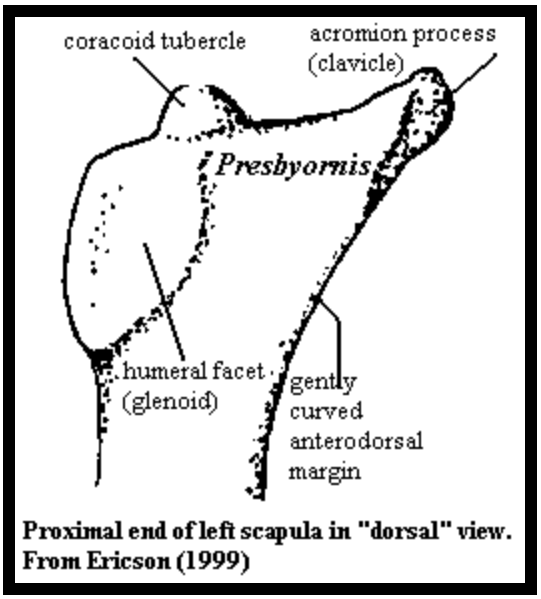
Acoelous: or "amphiplatynate" vertebral centra flat on both ends -- neither *procoelous* (anteriorly concave & posteriorly convex) or *opisthocoelous* (vice-versa). Same as platycoelous.

Acoustic meatus, internal: on posterior surface of petrosal (or petrous portion of temporal); transmits facial nerve, auditory nerve (vestibulocochlear or VIIIth nerve), & labyrinthine artery from brain to inner ear.

Acrocoracoid process: in neornithine birds, the distinctive hook-shaped process at the proximal end of the coracoid that forms a part of the triosseal canal. Actually, the process is not restricted to birds and isn't hook-shaped in, for example, ducks. But such details are tedious ...

Acrodont: Having teeth attached to the edge of the jawbone without sockets. See **Tooth Implantation**.

Acromioclavicular joint: The acromioclavicular joint is located between the acromion (a projection of the scapula that forms the point of the shoulder) and the clavicle (the collar bone). This is a gliding type of joint.



Proximal end of left scapula in "dorsal" view. From Ericson (1999)

Acromion (or Acromial) (Process): the outer end of the spine of the scapula that forms the outer angle of the shoulder, and articulates with the clavicle. Etymology: Gr. ακρον (*akron*) = tip or summit, and ομος (*omos*) = shoulder. The word ακρον gives the combing forms *acra-* or *acro-*. The Acropolis in Athens was built on a summit. See figure at *supraspinous fossa*.

Acuminate: tapering (usually gradually) to a sharp point.

Adduction: in tetrapod locomotion, rotation of a limb downward, in a vertical plane. Opposite of abduction; and in contrast to *protraction* or *retraction* (movement in a horizontal plane) or to rotation about the long axis of a limb. *C.f.* **Humerus**.

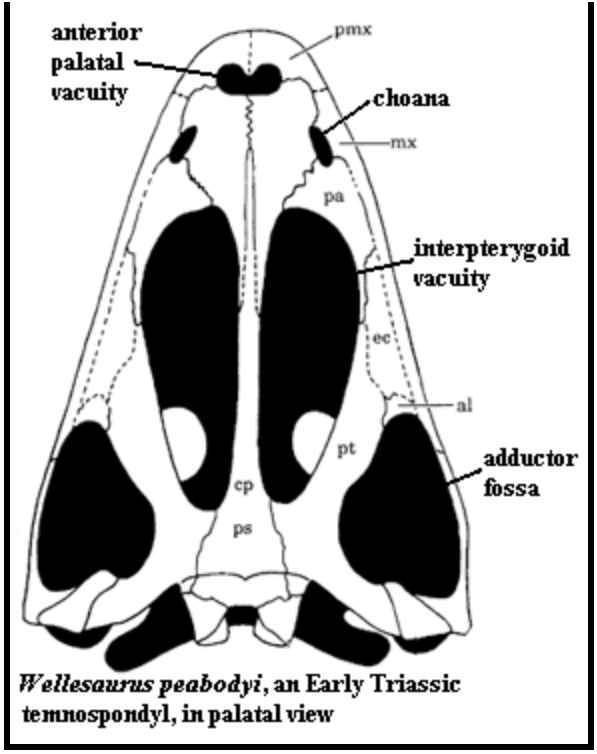
Adductor: L. *ad* = to, toward, and *ducere* = to lead. These muscles (and nerves) are named for their function. For example, the all important jaw adductors are muscles that move the jaws together.

Adductor blade: longitudinal ridge on the femur of Elpistostegalia and basal Tetrapoda. "The term 'adductor blade' ... is used ... to distinguish the prominent ridge bearing fourth and internal trochanters, from the more acute, and what appears to be primitively short, adductor crest." Coates (1996). The **adductor crest** is continuous with the distal end of the blade. *See* image of *Acanthostega* hindlimb.

Adductor fossa: The opening in the palate which in life contained the adductor (jaw closing) muscles. Not to be confused with the interpterygoid vacuities, choanae or other holes in the palate. The image at right, from Damiani (2001), shows a temnospondyl palate with the various fossae labeled.

Adipose: fat.

Admiral Formation: *See* Stanton Formation.



Wellesaurus peabodyi, an Early Triassic temnospondyl, in palatal view

Adsymphysial: same as parasymphysial, *i.e.* flanking the symphysis (the point at which the two halves of the jaw meet).

Aegithognathous: type of avian palate with vomer broad and truncate anteriorly. Maxillopalatines do not join but do touch basisphenoidal rostrum. e.g., Passeriformes.

Aeolian: of sediments, deposited by wind, as in desert sand dunes.

Aina Dal Formation: Famennian of East Greenland, Celsius Bjerg Group, above Elsa Dal and below Wimans Bjerg Fms. *Ichthyostega* (*Acanthostega* also present, but rare). "The Aina Dal Formation reaches a maximum thickness of 90 m at its type section on Stensiö Bjerg and towards Paralleldal (Olsen and Larsen 1993). The formation consists of dark red to grey or black fine-grained sandstones and siltstones, representing a variably active meandering river and flood basin environment. The Wimans Bjerg Formation conformably overlies the Aina Dal Formation, and is, apart from trace fossils, almost unfossiliferous." Blom (2005).

Alar process: generic term for a wing- or fan-like projection.

Albedo: a surface property of a material which measures the proportion of incident light is reflected, rather than absorbed or transmitted. Albedo varies with wavelength and angle of incidence. Unless these are specified, the term refers to an average reflectivity across the visible light spectrum and assumes normal incidence (*i.e.* that the incident light strikes at an angle of 90° with the surface). The effective albedo of a surface also depends on its texture and contour, since some incident light may be reflected onto other portions of the surface.

Albian: the last age of the Early *Cretaceous* (Early Cretaceous II), about 112-99 Mya.

Alisphenoid: epipterygoid bone in mammals.

Alisphenoid Canal: see dog_orbit.jpg. I'm a bit vague on whether this is really the "maxillary." In any case, it appears to be just below the middle ear. In somewhat more rational animal like insectivores, the alisphenoid canal consists of a foramen in the alisphenoid exposure on the basicranium, near the *foramen ovale* which communicates with the *cavum epiptericum* just behind its opening into the orbitotemporal region. Asher *et al.* (2002).

Allantois: one of the membranes of the *amniotic egg*, it provides a surface for gas exchange and waste removal.

Allotype: A term, not regulated by the ICZN Code, for a designated specimen of opposite sex to the holotype.

Alternating diplospondyly: see diplospondyly.

Alula: the small digit 1 (thumb) which emerges from the proximal base of the carpometacarpus in birds.

Alveolar shelf: the tooth-bearing palatal shelf of the marginal bones of the jaws.

Allometry: roughly speaking, proportionality at different sizes, but sometimes used with respect to age, temperature, or any other variable. A structure is said to exhibit "positive" or "negative" allometry if it becomes larger more or less than in direct proportion to size. For example the human head grows with age, but becomes a smaller proportion of overall body size with age and development. Therefore we might say (assuming that we wished to be unusually difficult to understand) that the "cranium exhibits negative allometry with ontogeny."

Ameloblast: a specialized epithelial cell type responsible for enamel deposition. *See* **Teeth**.

Amelogenin: the protein which appears to be largely responsible for forming the matrix in which enamel is formed.

Aminadav Formation: Late Cretaceous (*Cenomanian*) of Israel, Judea Group. Includes the 'Ein Yabrud limestone quarry, type locality of *Haasiophis*.

Amnion: the innermost layer of the *amniotic egg*, it retains a fluid which surrounds the embryo.

Amniotic egg: see Introduction to the Amniota.

Amphiarthrodial: slightly moveable joints, such as between vertebrae, as opposed to freely moveable (*diarthrodial*) or immoveable (*synarthrodial*), such as the knee and sutural joints, respectively.

Amphicoelous: vertebral centra concave at both ends. lab7 photos

Amphistylic: a form of jaw suspension (*e.g.* in basal gnathostomes, other than placoderms) in which jaw is suspended both by the hyomandibula and by a direct connection between the jaw and the **braincase**. Introduction to the skeletal system

Amphiplatinate: see *acoelous*.

Ampulla L. *ampulla* = a jug. Perhaps an onomatopoetic word whose sound suggests the object; in this case, fluid flowing from the jug. Applied in anatomy to a number or structures supposedly resembling a jug, such as the ampullae of the *labyrinth* in the inner ear. See **The Ear**.

Anacanthous: of fishes, lacking dorsal fin spines. Opposite of *phalacanthous*.

Anacleto Formation: Early Campanian of Argentina. Overlies the Bajo de la Carpa Fm. and underlies the Allen Fm. Part of the Río Colorado Subgroup, Neuquén Group, Neuquén Basin. Braided stream and floodplain deposits with soils. Fossiliferous with dinosaurs, fishes, crocs, birds, lizards & turtles. Apparently east, or forming part, of the Andes foreland Basin but also just west of the South Atlantic.

Analogy: see *homology*.

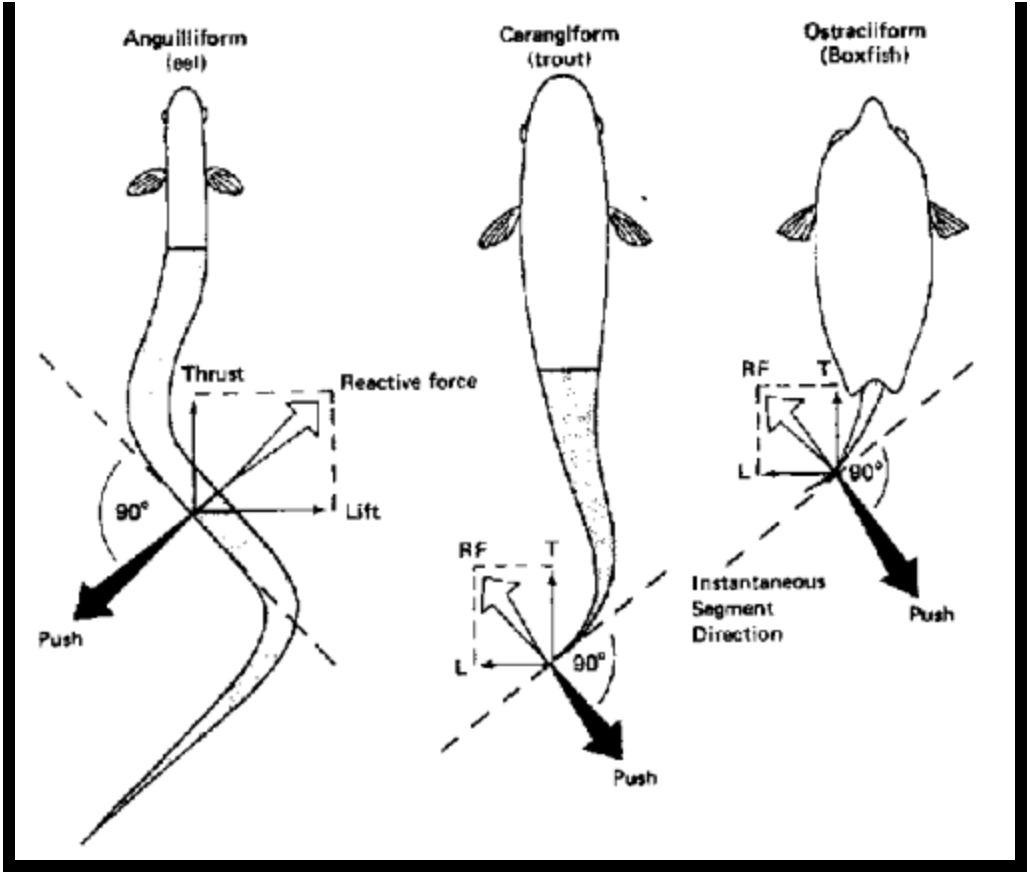
Anamestic: of fish bones, a dermal bone which forms from ossification of embryonic membranes without nucleating around a sensory canal. Anamestic bones tend to be small, irregularly shaped and show considerable variability between individuals.

Anapophysis: in some mammals, the articular surfaces of the vertebrae are on the neural arches, rather than on the centra. The anapophyses are the posterior articulations, analogous to the postzygapophyses. Frequently both structures are present and in close proximity. The corresponding anterior articulations are the metapophyses.

Anastomosis Gr. *ana* = up, and *stoma* = mouth; hence an opening up. (Don't take this etymology too seriously ...)

Anconal: [1] in medical terminology, relating to the elbow. **[2]** as a directional indication, looking towards the elbow. As far as we can make out, this is another antonym for palmar, and so synonymous with "dorsal" in the special sense of that word as it applies to limbs.

Anguilliform: [1] eel-like in shape. [2] eel-like in locomotion, in which the body subscribes more than 1 sine wave at any given time and the there is a perceptible "traveling wave" down the body during locomotion. As opposed to, *e.g.* thunniform or carangiform locomotion in which a limited posterior segment moves back & forth (or up & down in



mammals). Some useful detail at DESIGNING AN UNDERWATER EEL-LIKE ROBOT AND DEVELOPING ....

Angular process: in mammals, the most ventral of the three proximal processes of the jaw. *See* image at coronoid process.

Angulated: bent, V-shaped. This useful term isn't used much. It generally refers to the shape of an otherwise plate-like bone with a relatively sharp bend in the middle, like the covers of a partly open book, or an open laptop computer.

Anisian Age: The first Age of the **Middle Triassic** (242-234 Mya).

Anisodactyl: In birds, the basic digital configuration in which digit 1 (the toe or *hallux*) points posteriorly.

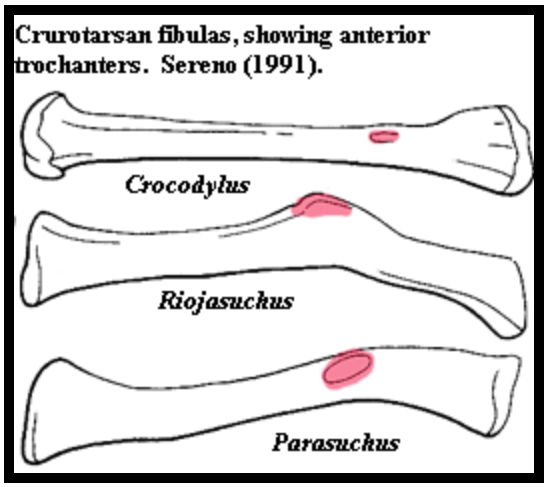
Ankylosed thecodont: See **Tooth Implantation**.

Ankylosis: ontogenetic fusion of bones. That is, a bone fusion that occurs after birth. Often used of pathologically fused bones in medicine, but a normal biological process in many organisms including humans.

Annulus (pl. annuli). L. *anus* = ring + diminutive *ulus*. Hence a little asshole. Applied to any ring or ring-shaped structure, not merely to junior siblings.

Anocleithrum: a relict member of the supracleithral series (bones dorsal to the cleithrum in fishes), found in some early tetrapods. The anocleithrum is a small, oval bone, normally dorsal and medial to the cleithrum and articulating with it.

Ant: (abbr.) anterior



Anterior trochanter: [1] (of the femur) probably the same as the lesser trochanter. **[2]** (of the fibula) probably the same as the illiofibularis tubercle.

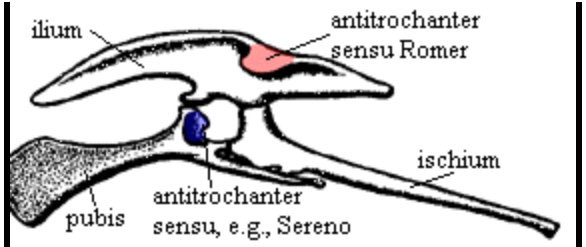
Anticlinal: in geology, sloping away from a common center or peak. More generally, having elements which bend away from a common center. Opposite of *synclinal*.

Antimere: the opposite member of a paired structure, *e.g.* flapping flight requires the coordinated exertion of each wing with its antimere.

Antimeric: relating to an antimere.

Antitrochanter: a tuberosity or ridge

contained in the acetabulum. MUSEE. DINOSAURES - LES COLLECTIONS. See **Figure.** This definition is quite different from the usage of Romer, who states: "Above the acetabulum the upper margin of the ilium was thickened ... . In hadrosaurs and ceratopsians there develops a downward projection from this thickened area, the *antitrochanter*, from which the iliofemoralis muscle probably took origin." Romer (1956: 326). Romer's definition is probably the only correct usage.



Anatotitan ("Anatosaurus") left pelvis in lateral view from Romer (1956: 327), fig. 157B.

Antorbital fenestra: a hole in the skull just in front of the orbit. See figure at *maxillary fenestra*.

Antorbital fossa: a depression in the skull anterior to the orbit. The fossa is frequently excavated all the way through the bone, at least in part, to form an antorbital fenestra (*q.v.*) as well as other fenestrations.

Antotic process: of the ethmoid or sphenethmoid. In sarcopterygians (and perhaps other fishes), a process of the braincase located posterodorsal to the orbit which articulates with the ascending process of the palatoquadrate (= epiptyerygoid) as part of the dorsal jaw articulation. *See Diplocercides* for gigantic image.

Antrum: Gr. *antron* = a cave. A cavity.

Apatite: A class of minerals including several incorporated in the teeth and/or scales of vertebrates. The basic unit of apatite has peculiar chemical formula sometimes given as: $Ca_5(PO_4)_3(OH, Cl, F)$. To understand what's going on, its best to start with a simple block of calcium phosphate: $CaHPO_4$. This has a very simple structure in which the two positive charges of the calcium ion, Ca^{++} are balanced by the two negative charges of the phosphate ion, in the form at which it exists at physiologically relevant pH levels: $HPO_4^{\cdot\cdot\cdot\cdot}$. In apatite, some of the phosphate groups are replaced by another ion, one with only a single negative charge. This typically results from the inclusion of hydroxyl ($OH^{\cdot}$), chloride ($Cl^{\cdot}$), or fluoride ($F^{\cdot}$) ions. If the inclusion is a hydroxyl ion, the resulting material is hydroxyapatite (except in Europe, where it becomes hydroxylapatite), the mineral constituent of bone, including dentine and enamel. In order to maintain charge neutrality, two things happen. First, some of the charges are "shared" between adjacent cells of the crystal. Second, the phosphate is forced to behave as a *tri*valent ion (an ion with three negative charges), equivalent to phosphate at a much higher pH, *i.e.*, $PO_4^{\cdot\cdot\cdot\cdot\cdot}$. The physical properties of the resulting material make it uniquely useful for living organisms. The cross-linking of crystal cells through charge-sharing make apatite extremely strong. The actual alignment of the ions in the crystal is partially planar, but adjacent planes are rotated at 60° angles to each other, which means that the bulk material is highly resistant to shearing -- a very important attribute for teeth. The substitution of a small, monovalent ion for phosphate also leaves a regular series of physical "holes" in the crystal structure, which contributes to three additional important properties. (1) It provides room for organic components of the matrix to approach the ions and bind closely to the mineral by polar interactions. (2) For the same reason, enzymes can "reach inside" the crystal to dismantle it, allowing bone to be reworked and reshaped. It also helps that the phosphate ions in the crystal are held in a trivalent state. All it takes to dismantle the structure is the introduction of hydrogen ions from water in exactly the right places to unlock the crystal structure. (3) Finally, the presence of "holes" in the crystal gives the bulk material some compressibility, so that it can adapt flexibly to compression rather than shattering. In short, apatite exhibits a remarkable combination of strength, hardness, flexibility, and biochemical reactivity.

Aphetohyoidean: a condition involving "the presence of a non-suspensory hyoid arch behind a full post-mandibular gill slit." Stahl (1988: 858). This is one presumed primitive condition for the jaw suspension of gnathostomes.

Apical: in mammalian dentition, toward the crown.

Aplesodic: of a fin, the condition in which the basals and radials do not reach to the distal margin of the fin. This may refer to very primitive fish which have no support for the distal fin, or to highly derived fish which may have ceratotrichia or other non-bony support for the distal fin. Opposite of *plesodic*.

Apocrine glands: sweat glands associated with hair cells which secrete sweat containing complex organic compounds often having a characteristic odor. In humans, these glands become active at puberty and the odors may

reflect emotion, state of health, sexual identity and maturity, and diet. Compare *eccrine glands*.

Apomorphy: a character state which is unique to a single, terminal taxon. Example: among primates, complex grammar is an apomorphy of human beings. It is quite diagnostic of humans, but useless in determining phylogenetic relationships because it is not a *shared, derived* characteristic, or synapomorphy, of any larger group.

Aponeurosis: a sheet- or ribbon-like tendinous expansion, serving mainly to connect a muscle with the parts that it moves. The best example is perhaps "palmar aponeurosis," the dense sheet of tendons underlying the palm in humans and many other tetrapods.

Appress: to be in contact with.

Apteria: areas on the skin of the embryonic bird which do not develop feather primordia.

Aptian: an age of the Early Cretaceous (mid-Cretaceous) about 121-112 Mya.

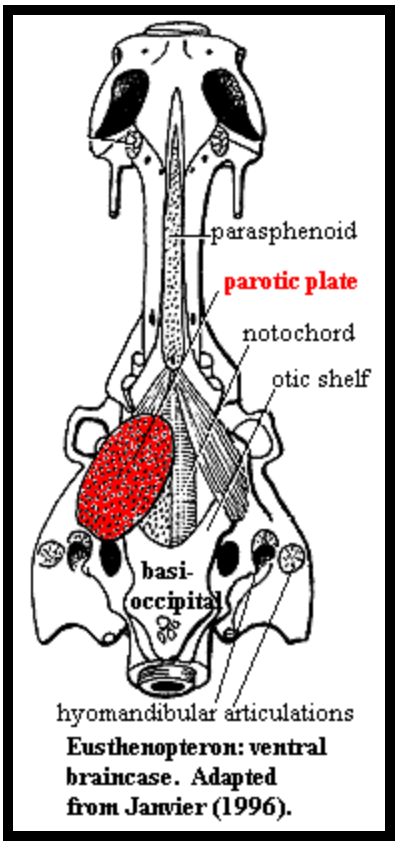
Archenteron: the internal body cavity formed by *gastrulation*. The cells lining the archenteron develop into *endoderm*. See **Early Development Terms.**

Arcocentrum: in elasmobranchs, the cartilaginous arch and its base in the vertebrae. Dictionary of Ichthyology. I have also seen this used of actinopterygians. Poyato-Ariza & Wenz (2002).

Arctometatarsalian: condition in which proximal half of metatarsal III is thin, splint-like, or even absent and closely appressed by metatarsals II and IV. The distal portion of metatarsal III is hollow (as are II and IV) and typically longer than II and IV. The functional significance of this arrangement is not completely clear. Likely, the entire metatarsus was bound tightly and the condition served to transmit force evenly over the metatarsals and aid in running. Holtz (1995).

Arcual plate: oblong, denticulated palatal bones which covered the anterior end of the notochord in some sarcopterygian groups. Also referred to as *parotic plates.*

Arcualia: "There are primitively two pairs of [*metamerically* arranged *endoskeletal*] elements in each metamere and on each side [of the *notochord*]: the interdorsals and basidorsals. In the gnathostomes, there are two additional pairs ventrally to the notochord: the interventrals and basiventrals. These elements are called **arcualia** and can fuse to a notochordal calcification, the *centrum*. The ensemble of the arcualia + centrum is the vertebra, and the ensemble of the vertebrae is the vertebral column." See Vertebrata (Phillipe Janvier).



Eusthenopteron: ventral braincase. Adapted from Janvier (1996).

Arcuate: in the shape of a smooth arc; not straight or broken line.

Arenig Age: Formerly, the second age of the Early Ordovician Epoch. Includes the current Floian Age of the Early Ordovician, as well as the Dapingian and early Darriwilian Ages of the Middle Ordovician. Approximately 488 to 465 Mya.

Argillaceous: Describing rocks or sediments containing particles that are silt- or clay-sized, less than 0.625 mm in size; any sediment containing large amounts of clay.

Articulated: of a fossil, a condition in which the bones are still contacting the each other more or less as they would in life.

Arundel Clay: according to Cifelli *et al*. (1999), a member of the *Patuxent Formation*. According to the Maryland Geological Survey, it conformably overlies the Patuxent Formation in the Potomac Group. Early Cretaceous II (Albian) of Maryland, USA. Dark gray and maroon lignitic clays; abundant *siderite* concretions; present only in Baltimore-Washington area. Oxbow swamps. *Deinonychus, Tenontosaurus, Acrocanthosaurus,* and triconodonts.

Ascending process of the palatoquadrate: the epipterygoid -- termed *ascending process* when enough of the palatoquadrate is present to think of it as a process. Under either name, it forms an articulation between the upper jaw

and the braincase (and/or the skull table). *See* pterygoid for more context and figure.

Aspect ratio: in wings, the ratio of length to mean width for wings of regular shape. For irregular wings, other formulae apply. Wings with high aspect ratio indicate high-speed, long distance fliers. Such wings are less useful for low-speed flying or high maneuverability because they generate relatively little lift. To back off from jargon for a moment, a wing keeps the critter in the air because it pushes down on the air. At high speed, even a narrow wing passes over (and so pushes down on) a lot of air during the power stroke. At low speed, it takes a lot more area to push on the same amount of air. Length of wing helps, since a long wing pushes down *further* for each degree of downstroke. However, a long wing creates other problems: (a) it takes a lot of muscle to move a wing-tip out at the end of a long lever arm; (b) a tiny change in attitude at the end of a long lever arm can make a big difference in exactly how the airstream is directed. The bottom line is that high aspect ratio wings are for strong animals flying fast and high who don't need to be troubled too much about precision maneuvers or the sudden changes in wind speed and direction found near the ground.

The same general principles apply to the caudal fins of fish and the expanded tails of aquatic tetrapods. However, these principles are less easy to correlate with design and function in water. As an empirical matter, caudal fins of low aspect ratio are usually found in "unsteady swimmers" -- such as ambush predators using very high acceleration lunges with no sustained swimming.

Aspidine (= **aspidin**)**:** When all is said and done, *aspidine* is probably a generic term for acellular bone, as it occurs in early vertebrates. Janvier (1996: 84-85, 95). When fully elaborated, it is typically three layered. The outer layer is the dentine cap. The large middle layer is cancellous, with straight vertical walls enclosing large spaces. The thin inner layer is dense and lamellar with no included spaces. Janvier also states that aspidine is characterized by "incremental growth zones, as well as some peculiar fibre-like lineaments." As with most terms for bone-like substances, the word (in this sense) refers to a structural type, rather than a distinct chemical entity. Unfortunately, there is considerable structural variation in the materials referred to as "aspidine," making the foregoing definition -- or any definition -- somewhat suspect. Either the middle or outer layer may be missing or replaced by other material, as shown for psammosteidans in the figure. In psammosteidans, the cancellous middle layer is replaced by a thick layer of amorphous "trabecular aspidine" as shown in the figure.

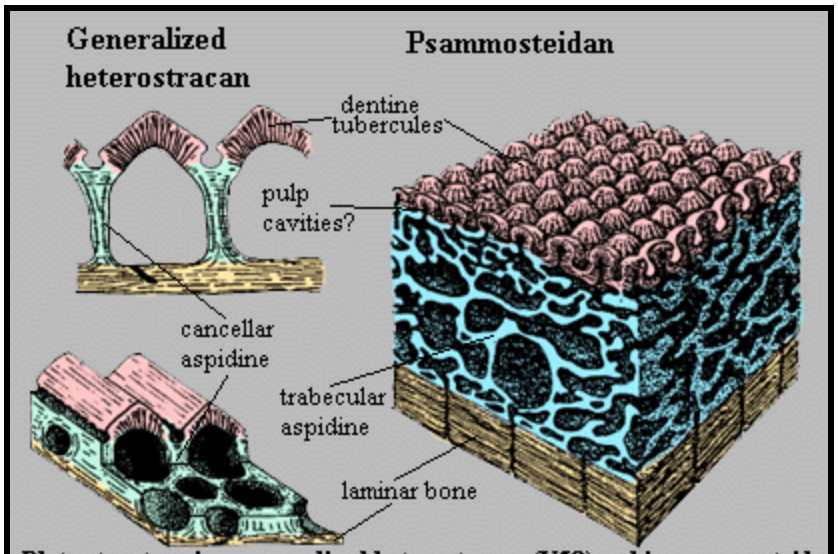


Plate structure in a generalized heterostracan (X50) and in psammosteids (about X30). From Janvier (1996: 89) and Halstead (1973: 306).

Aspidospondyly: a condition in which all vertebral elements (centra, arches) remain as separate units. Opposite of *holospondyly*.

Aspondyly: the condition of having no vertebral *centra*.

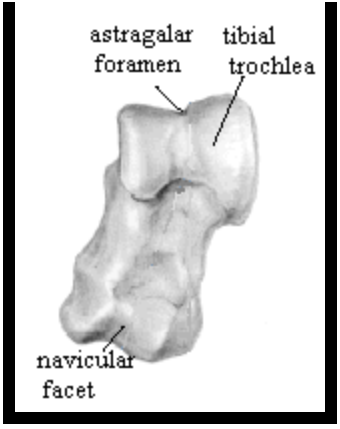
Astragalus: One of the two proximal tarsals or upper ankle bones. It is the more medial of the two and usually articulates with the tibia. Compare calcaneum. See Figure at *Tarsus*.

Astragalus, ascending process: the ascending process of the astragalus is just like it sounds. The inner (medial) ankle bone (the astragalus) sends a process up the shaft of the tibia. The ascending process is normally fused to the tibia.

Astragalar foramen: the opening of a canal on the proximal surface of the astragalus through which a nerve and vessels pass in primitive mammals.

Atlantal: relating to the *atlas*.

Atlas: Gr. *Atlas* was the mythological Titan who supported the world on his shoulders.



Vesalius, in the sixteenth century, gave this name to the first cervical vertebra of tetrapods, which articulates with the skull, normally via *condyles* which permit the skull to move dorsoventrally.

Auditory bulla: the "inflated"-looking osseous covering of the middle ear and the floor of the skull in that region.

Auditory meatus, external: the "ear" of conventional speech; the outer ear; a passage leading from the environment to the tympanic membrane, often shaped so as to gather and concentrate sound from a particular direction. See **Ear**

Auditory meatus, internal: in mammals, the common foramen for the VIIIth (auditory) and VIIth (facial) cranial nerves. Kermack *et al*. (1981: 97). "an opening on the posterior surface of the petrous portion of the temporal bone through which the auditory and facial nerves pass." EPIC Glossary

Auditory ossicle: a small bone used to conduct sound energy. The term is normally used to refer to the mammalian complement of malleus (articular), incus (quadrate) and stapes. It applies equally well to the columella (hyomandibula) of many other tetrapods and the weird assortment of bones in the Weberian organs of various teleost groups.

Aulacodont: See **Tooth Implantation**.

Autapomorphy: a character which is unique to a particular taxon.

Autodiastyly: a form of jaw suspension in which the palatoquadrate is suspended from two articulations with the braincase. This may be the original form of jaw suspension. See discussion at Holocephali.

Autogenous: of bones, separate, not fused.

Autopalatine: an endochondral bone consisting of the anterior portion of the palatoquadrate (primitive upper jaw). *See* image and additional information at *pterygoid*.

Autopodium (autopod)**:** the manus or pes, including digits (*phalanges*), metacarpals or metatarsals (*metapodium*). May or may not include the carpals or tarsals (*mesopodium*).

Autostylic: a form of jaw suspension (*e.g.* in lungfishes and in stem tetrapods) in which the upper jaw (palatoquadrate) articulates or is fused with the chondrocranium, lower jaw forms from the mandibular cartilage, and the jaw remains unsupported by the hyomandibula.

Autotomy: in Lepidosaurs and related forms, an animal can frequently escape predators by allowing part of its tail to break off. This is referred to as autotomy.

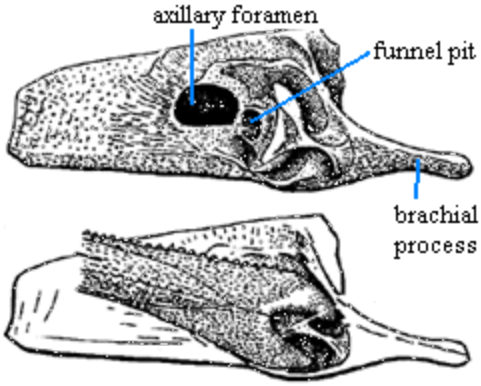
Axial: toward an imaginary axis running antero-posteriorly through the middle of the organism or structure; central. Opposite of *radial*. In almost all cases, **axially** means the same as *anteroposteriorly* or *longitudinally*.

Axilla: arm pit.

Axillary foramen: in some antiarch placoderms, an opening in the anterior ventrolateral plate which presumably allowed nerves and blood vessels to communicate with the pectoral appendages ("arms"). See figure.

Axis: the second cervical vertebra of terrestrial vertebrates; rotary movements of the head occur between the atlas and axis. Fr L. *axis* = axle or pivot.

Axonost: pterygiophore (the cartilage or bone on the outer end of which sit the median fin rays or spines), sometimes the proximal pterygiophore



Bothriolepis: right anterior ventrolateral plate in lateral view, with and without right pectoral limb

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Glossary: B

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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- B -

B / stylocone: see *stylocone*. This is home-made terminology used to reflect the fact that cusp homologies are unclear in symmetrodonts so that some workers use only a letter designation. However, many others traditionally refer to this cusp as the stylocone.

Baer's Law. General features common to all members of a group appear earlier in development than do the special features that distinguish the various subdivisions of the group. The use of phylogenetic systematics (cladistics) renders this synonymous with *Haeckel's Law*.

Baleen: in mysticete whales, a keratinous substance probably derived from mucous membrane which forms sheets, plates, or curtains used to trap small & micro- organisms for filter feeding. Water is filtered either by pressing the enlarged tongue against the baleen plates, or by swallowing large quantities of water and squeezing the mouth shut, thus forcing the water out through the baleen sieve.

Balfour Formation: of the Beaufort Group, Early Triassic of South Africa. A classic very Early Triassic exposure in the lowest part of the *Lystrosaurus* Assemblage Zone. Apparently siltstone and mudstone derived from the floodplains of ephemeral, low-sinuosity rivers flowing through a generally arid region. Sidor & Smith (2004).

Barbs: the "branches" of a feather which emerge from the central shaft (*rachis*).

Barremian: an age of the Early Cretaceous (Early Cretaceous), about 127-121 Mya.

Baruun Goyot Formation: Late Cretaceous of Mongolia, probably Late *Campanian*, ~75 Mya. Inland arid & semi-arid environments with wind-borne deposits.

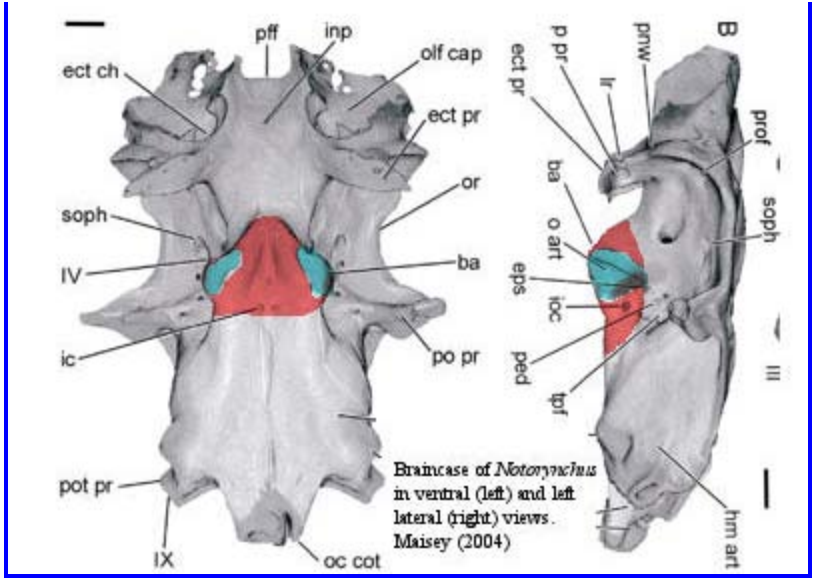
Basal: (a) viewed toward the base or root of the tooth (b) opposite of derived, i.e. "primitive" or plesiomorphic.

Basal Angle: In squaloid and certain other sharks, a thickened area of the basicranium between the orbits. The basal angle bears a strong ventral process containing the foramina for the internal carotids. It may also bear the articulation for the

orbital process of the palatoquadrate.

Basal tuber: (pl. tubera) posteroventral projections below the occipital condyle. These may occur on the basioccipital, the basisphenoid, or both. *See also* basioccipital tubera.

Basement membrane: The basal (inner) layer of an epithelial wall. Usually composed of an epithelial basal lamina (= layer) and a connective tissue reticular lamina. *See also*, figure at integument



Basibranchial: the most ventral of the gill arch elements. See **Gill Arches**. In sharks, the basibranchial elements are fused in a somewhat triangular structure referred to as the **basibranchial copula**.

Basicranial articulation: See *basipterygoid process* for anatomical details. This articulation staples the braincase to the palate. In basal tetrapodomorphs, there may be mobility at this articulation, the nature and function of which is unclear and likely variable from one species to another.

Basicranial fenestra: a large vacuity in the oticoccipital region below the notochord in many sarcopterygians and some very basal tetrapods. See *vestibular fontanelle*.

Basicranium: the base of the braincase, commonly involving the basioccipital, basisphenoid and elements of the otic capsule.

Basidorsal: "There are primitively two pairs of [*metamerically* arranged *endoskeletal*] elements in each metamere and on each side [of the *notochord*]: the interdorsals and ***basidorsals***. In the gnathostomes, there are two additional pairs ventrally to the notochord: the interventrals and basiventrals. These elements are called arcualia and can fuse to a notochordal calcification, the *centrum*. The ensemble of the arcualia + centrum is the vertebra, and the ensemble of the vertebrae is the vertebral column." See Vertebrata (Phillipe Janvier).

Basihyal: the basibranchial of the hyoid arch (generally beloved to be the 2nd primitive gill arch).

Basilar membrane: the outer membrane of the cochlea (= lagena) facing the *scala tympani*. It vibrates in response to compression waves caused by the middle ear ossicles. In mammals, the basilar membrane supports the Organ of Corti which sorts the vibrations according to frequency. See the **Ear**.

Basioccipital: One of the bones of the occiput, the part of the skull which articulates with the spine. The basioccipital is located (if present) ventral to the foramen magnum. It often rests on or articulates with the basisphenoid, as well as meeting the exoccipitals. The basioccipital usually forms most (sometimes all) of the occipital condyle(s) and the ventral margin of the foramen magnum. See **The Occiput** for details.

Basioccipital recess: a large median recess on the ventral surface of the basioccipital, near or between the basal tubera of the basioccipital. This structure is found in various Crurotarsi. It may be found as a blind-ended structure. However, it is also believed to be homologous

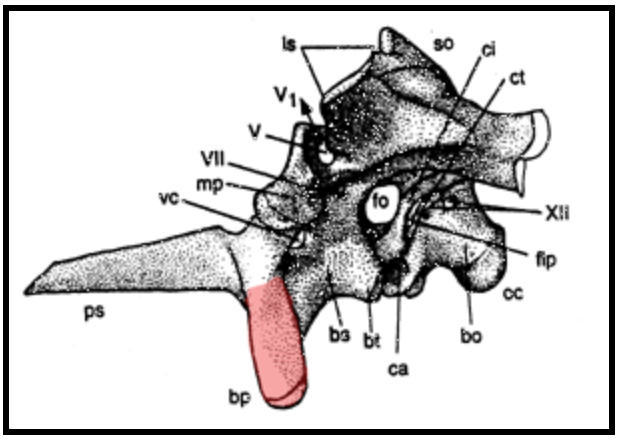
with the crocodylian median eustachian foramen which communicates with the pharynx. Gower (2002).

Basioccipital tubera are a pair of ventrolaterally directed blobs descending from the basioccipital. They are sometimes simply referred to as "basal tubera." However, the basisphenoid may also bear tubera. Presumably the basioccipital tubera act as attachment sites for ligaments stabilizing the head on the neck.

Basipterygium: in fishes, the pelvic bone or cartilage to which the pelvic fin is attached. FISHBASE

Basipterygoid articulation: of the palatoquadrate. Same as palatobasal articulation (?). A ventral articulation of the palatoquadrate in which the palatoquadrate articulates with the basipterygoid process. See image at paratemporal articulation.

Basipterygoid process: The basipterygoid processes are (despite the name) processes of the basisphenoid. They act to join the braincase to the palate. In many basal tetrapods and their ancestors, this was a moveable articulation. In most derived tetrapods, they simply staple the braincase to the palatal bones. That is, this is the *basicranial articulation*, the main link between the braincase and palate in reptiles. The image shows the reconstructed braincase of the basal prosauropod *Thecodontosaurus* in left lateral view. The basipterygoid process is in red. From Benton *et al.* (2000). The basipterygoid process may pass through a notch in the pterygoid, at the origin of the quadrate ramus. In some texts, the resulting cavity is referred to as the *conical recess*.



Basisphenoid: The **basisphenoid** forms the floor of the braincase anterior to the basioccipital. Ventrally it is covered by a dermal bone, the parasphenoid. The fusion between these two is so close that some workers refer to the complex as the "parabasisphenoid." The basisphenoid gives rise to the basipterygoid process and other structures of the braincase.

Basisphenoid pillar: a dorsal or anterodorsal process of the basisphenoid from near the base of the basipterygoid process into the orbit. This process helps support the eyestalk, if present, and anchor the extrinsic eye muscles of the rectus series. Also called the *postorbital pila*. See figure at rectus muscles; *see also* discussion and figures of the gnathostome orbit.

Basitrabecular process: an embryonic skull cartilage derived from the polar cartilages at the junction of the

trabecular and parachordal cartilages. See *diagram*.

Bathonian Age: The third Age of the Middle *Jurassic*, 169-164 Mya.

Baudelot's ligament: in fishes, a ligament, sometimes ossified, which joins the 1st centrum with the supracleithrum. This ligament has been interpreted as homologous with a first rib. Wilson & Veilleux (1982).

Bayn Shire Formation: Late Cretaceous (but very uncertainly dated) of Mongolia. Holtz (2001a).

Bear Gulch: Lund Land or Flat Shark City. Bear Gulch is an Early Carboniferous lägerstat in Montana featuring a high-diversity fish fauna, of which over half are chondrichthyans. Details are provided at The Bear Gulch by Prof. Richard Lund, who is believed to have been digging there since at least the Late Permian.

Beaufort Group: Permian and Triassic of South Africa, including the famous Karoo Basin Permian exposures.

Belly River Formation: of the Montana Group. Late Cretaceous (Campanian to ?Maastrichtian) of southern Canada (Alberta, Saskatchewan & points East). Probably continuous with the Judith River Fm. "The Belly River Formation comprises an eastward-thinning wedge of sandstones, siltstones, shales and minor coals, up to 900 m thick, which extends from the southern foothills to Saskatchewan, where correlative strata are assigned to the Judith River Formation. In the outer foothills, the Belly River Formation extends from the United States border north to the Bow River, where correlative strata are assigned to the Brazeau Formation of the Saunders Group." from DinoData Fossilsites Belly River Fm. The Belly River Fm. is overlain by the Bearpaw and itself overlies the Pakowki. "Belly River Formation" is a name rarely used these days, with most of the territory previously ascribed to it now designated as the Dinosaur Park Formation.

Ben Nevis Formation: from the Red Bay Group of Spitsbergen. Early Devonian (middle to late Lochkovian). Many jawless fishes including thelodonts, psammosteids, and heterostracans. Overlies the Fraenkelryggen Formation. Blom & Goujet (2002).

Berriasian: The first age of the Cretaceous (Early Cretaceous), approximately 144-137 Mya. *See* Berriasian.

***Bi-*: [1]** Latin prefix meaning *two*; **[2]** Chinese combining form meaning *wall*.

Biogenic: having a biological origin.

Biramous: having two rami, *i.e.* two shafts or projections.

Biserial: of fish fins, bearing both preaxial and postaxial radials (long bones projecting from both the leading and trailing sides of the main fin axis, as in lungfishes).

Bissekty Formation: middle Cretaceous (Turonian) to Late Cretaceous (Santonian, perhaps Campanian) of Uzbekistan. Coastal and lowland environment. Mammals. Archibald *et al*. (2001).

Bituminous: composed of partially decayed organic matter which has solidified with time/heat/pressure to form substance which crumbles or smears and will liquefy on heating under appropriate conditions. Soft coal is the best-known bituminous deposit.

Blastocoel: See *blastula*.

Blastoderm: See *blastula*.

Blastopore: the entrance to the *archenteron* where *gastrulation* begins. Among *Deuterostomes*, in contrast to *Protostomes*, the blastopore develops into the anus and, consequently, into a time-hallowed tradition of undergraduate humor.

Blastula: the hollow sphere of cells initially formed by repeated division of the fertilized egg in *microlecithal* development. Alternatively, the stage of embryonic development characterized by formation of a blastula or its equivalent. The cells themselves, initially in a monolayer, are referred to as the **blastoderm**. The cavity is the **blastocoel**. In *mesolecithal* development, the process much is the same (i.e., *holoblastic*), except that the early cleavage pattern of the fertilized egg is unequal, leaving the blastocoel at the *animal pole* of the embryo. The opposite

pole, the *vegetal pole*, is composed of a smaller number of large, yolk-filled cells. In *macrolecithal* development, cleavage is *meroblastic*, and the blastula stage embryo is not hollow, but generally consists of a sheet of blastoderm on the surface of the egg (exclusive, of course, of any shell, jelly coat, etc) at the animal pole. The blastula stage is followed by *gastrulation*.

Bob (the Basal Amniote): Bob is the proud possessor of the Standard Condition. Bob is a (hypothetical) basal amniote. He is our main point of reference for anatomical comparison among tetrapods.

Bodenaponeurosis: a tendinous mass that serves to attach the mandibular adductor to the coronoid process.

Bone: a rigid structural tissue primarily composed of *apatite* with varying amounts of structural protein. See Introduction to the skeletal system for discussion of some of the issues relating to formation, growth and morphology of bone.

Boss: a raised, thickened, normally round area of a dermal bone.

***Bothrio-*:** Greek root = "pitted".

Brachiopatagium: The main flight membrane of pterosaurs (and bats?) .

Brachydont: cheek teeth having low crowns. Opposite of *hypsodont*.

Bradydont: having slow tooth replacement. This is inferred from retention of spent teeth in the dentition.

Braincase: See **Bones: Braincase**

Branchial Arch: Vertebrates are unique in having the gills develop internally, as evaginations of the anterior gut. It is supposed that these internal gills were, primitively, filter-feeding structures which secondarily developed as respiratory organs. The branchial arches support the gills and have also been exapted for various other functions.

Branchiopercular: in fish anatomy, the last branchiostegal ray, conceived as a continuation of the opercular series (which it probably is).

Branchiosaur: generic term for an aquatic, larval tetrapod, typically a temnospondyl. Presumably the reference is to external gills.

Breccia: rock containing pieces of angular gravel.

Brevis: L. *brevis* = short.

Brevis shelf: a ridge running along the inside surface of the ilium behind (i.e. posterior to) the acetabulum.

Britta Dal Formation: Famennian of East Greenland, *Remigolepis* or Celsius Bjerg Group, above Wimans Bjerg and below Obrutschew Bjerg Fms (both Late Famennian). "The thick Britta Dal Formation [is made up of] 550 m of red and gray siltstones and some red sandstones containing both *Ichthyostega* and *Acanthostega*. This unit has been interpreted as dominantly fluviatile and floodplain sediments. The taphonomy of these sites strongly suggests that *Ichthyostega* and *Acanthostega* inhabited the sedimentary basins in which they were buried and dwelled within large freshwater river systems." Long & Gordon (2004) (citations omitted). Also "*Eusthenodon*, plus the porolepiform *Holoptychius*, the dipnoan *Soederberghia*, the placoderm *Remigolepis*, and isolated ctenacanth fin spines." Coates (1996). *Compare* Blom (2005): "Recent stratigraphical and sedimentological studies may, however, challenge previous interpretations [*i.e.* river and flood plain deposits] against a new hypothesis of sheet flood origin for most of the main sandstone bodies (T. R. Astin and J. E. A. Marshall, pers. comm. 2002). The alternation of sandstone bodies and siltstones, nevertheless, characterizes the whole stratigraphical extension of the formation, which can reach about 500 m in thickness."

Bronchus (adj. **bronchial**) Gr. *bronchos* = windpipe; originally from Gr. *brechein* = to moisten. Plato believed that swallowed liquids went down the trachea into the bronchi. Remember that the next time someone mentions the old ...

Buccal L. *bucca* = the cheek. Of dentition, the "outside" of the teeth, toward the cheeks. Same as *labial* and opposite of *lingual*.

Buccinator L. *buccinator* = a trumpeter. Hence the muscles of the cheek.

Bucco-hypophyseal canal: perhaps a persistent remnant of Rathke's pouch. This is a short canal which links the *sella turcica* with the mouth. In other words, it provides a direct connection between the pituitary and the digestive tract.

Bulla L. *bulla* = a bubble. The adjective is bullous; both are used of a lesion or structure which resembles a bubble. See *Auditory bulla*.

Bullion Creek Formation: Late Paleocene of North Dakota, USA. Subtropical swamp, lake & river, & delta sediments. Formerly known as "Tongue River" Formation. *Presbyornis*. Benson (1999).

Bunodont: dentition of, for example, pigs (see Ungulate teeth, More on Artiodactyla) follows the basic tribosphenic pattern and consisting of low, rounded cusps. It is characteristic of fairly unspecialized omnivores. See **Molars**. See also, your own molars, which are essentially bunodont.

Burnt Bluff Group: Early Silurian of North America (Michigan Basin). Carbonates. Turner *et al*. (1999).

Bursa ML. *bursa* = a purse, hence any closed sac.

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Glossary: C-Cg

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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- C -

©: *Cambrian Period* or copyright

C: the *Carboniferous Period*.

C/c: in mammalian dentition, an upper (C) or lower (c) canine tooth.

C-terminal: The region of a protein near the end with a free carboxyl group. *See* N-terminal for explanation and figure.

Calamus: the unbranched base of a feather.

Calcaneal tuber: the "heel." The proximal or proximo-plantar portion of the calcaneum may project outward from the ankle (as in humans) and serve as an attachment for the *m gastrocnemius* via the Achilles tendon.

Calcaneum: One of the two proximal tarsals or upper ankle bones. It is the more lateral of the two and often articulates with the fibula. Compare *astragalus*. See Figure at *Tarsus*.

Calcaneus: the human calcaneum.

Calcareous: made up of biogenic calcium carbonate (shells and related materials). Thus, for example, "calcareous limestone" is limestone of biogenic origin, made up of crushed fragments of shells that have solidified into rock over time and under pressure.

Calcified cartilage: cartilage containing deposited calcium salts; found in the vertebrae of cartilaginous fish. Introduction to the skeletal system (comment: this is probably a weak, even incorrect, definition.)

Camber: curvature of a wing.

Cambrian: Abbreviated '©'. The period from 543 - 490 Mya. As used here, the Early Cambrian comprises the Cambrian A epoch (543-520 Mya), Middle Cambrian comprises the Cambrian B & C epochs (in North America, the Montezuman, Dyerian, Delmaran and Marjuman ages, 520-500 Mya), and the Furongian the Cambrian D epoch (the North American Steptoean and Sunwaptan ages, 500-490 Mya).

Campanian: An age of the Late Cretaceous, about 83.5-71.3 Mya.

***Campyl-*:** Greek root meaning curved or bent.

Cancellate: (or **cancellous** or **cancellar**) having cavities. ***Note*** for non-native English speakers or linguistic pedants of all nationalities: the suffix *-ate* is usually derived from the Latin passive perfect participle, thus here would carry the sense of "having had holes cut out of it." The suffix *-ous* is derived from a simple Latin adjectival ending and carries a purely descriptive sense ("having holes" or "characterized by having holes"), without the implication of past action to *create* the holes. The suffix *-ar* may be Greek. In any case, it should be used to mean "of, or pertaining to, holes." Obviously, the word *cancellar* should not be used to mean something that merely has a lot of holes, and *cancellate* should be reserved for describing objects that were solid, but have been hollowed out in some way. Fortunately, no one has the time or patience for this sort of nonsense, so all three words are used interchangeably.

Canine: (a) of dentition, typically a single pair of elongate, pointed, recurved teeth in the anterior jaw. The term, properly speaking, applies only to therapsids. In mammals, the canines are located between the incisors and premolars. Canines are most frequently found in carnivores, many omnivores, and in particularly bellicose herbivores. *See* **Canines**. (b) of or relating to dogs.

Canine buttress: same as *canine flange*, but typically used in reference to non-mammals.

Canine flange: an expanded and/or reinforced section of the maxilla (and, rarely, the dentary) in which the canines are rooted.

Caniniform: of dentition, a tooth shaped like a canine, *i.e.*, long, pointed & recurved.

Cannon bone: bone created by fusion of two adjacent metapodials.

Capitate: in mammal osteology, one of the distal carpals, essentially a proximal extension of Mc III. Also referred to as the magnum.

Capitellum: of the humerus, the rounded structure on which the radius rotates. See **Humerus**.

***Capitis lateralis, vena*:** a superficial vein that drains the side of the head in mammaliforms. The VCL drains into the internal jugular after the latter leaves the braincase.

Capitulum: [1] of the humerus, same as *capitellum*. Medical terminology used primarily for humans and other mammals. See **Humerus. [2]** of ribs, the more ventral of the articulations with the vertebrae.

Caput*:** L. = *head*. Usually refers to a large, convex articular surface such as the head of the humerus (=caput humeri***). More generally, any enlarged, rounded terminal structure to which we might apply the English term "head."

Carangiform: type of undulatory locomotion in which the body inscribes less than < ½ wavelength at any one time.

Carboniferous Period: (C) The penultimate period of the *Paleozoic Era*, 354-290 Mya. The Early Carboniferous (354-323 Mya) is known as the Mississippian in North America. Elsewhere, it is divided into the Tournasian, Viséan and Serpukhovian Ages. The North American Late Carboniferous (323- 290 Mya) is the Pennsylvanian. Elsewhere it includes the Bashkirian, Moscovian, Kasimovian and Gzhelian Ages.

Cardioid: heart-shaped.

Carina: L. *carina* = keel of a boat. (1) The medial keel of the sternum which, in birds, supports the *supracoracoideus* muscle and, in part, the *pectoralis* muscle. (2) used of several anatomical structures having a central ridge, normally a ventral ridge.

Carinate: **[1]** of birds, having a massively enlarged sternum to support flight muscles;**[2]** more generally any structure bearing a "keel" or sharp, longitudinal median ridge.

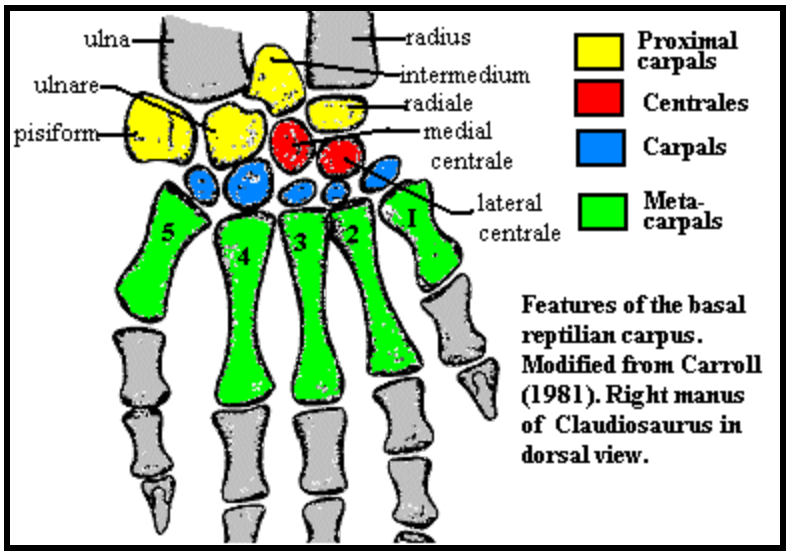
Carnassial: In some carnivores, one or two of the cheek teeth may be **carnassials**, specialized blade-like cutting teeth. La Brea Tar Pits. See **Molars**.

Carotid artery: the major artery supplying the brain. The **internal (cerebral) branch of the carotid** is of special significance in anatomy because it enters the braincase through phylogenetically interesting foramina. In mammals, the internal carotid supplies the anterior part of the brain, the eye and its appendages, and sends branches to the forehead and nose. The **external carotid** rapidly splits into numerous branches which supply mostly external structures.

Carpal: relating to the carpus (= wrist). Sometimes used to refer to all of the bones of the wrist and hand.

Carpometacarpus: the fused wrist+hand unit in birds.

Carpus: the wrist. The basic features of the reptilian carpus are shown in the figure. Modified from Carroll (1981)'s figure of *Claudiosaurus*. Mammalian terminology is quite different. See image at unciform.



Features of the basal reptilian carpus. Modified from Carroll (1981). Right manus of Claudiosaurus in dorsal view.

Carrier's Constraint: essentially, that it is not possible to walk and chew gum. Primitively, locomotion involves lateral bending of the body so that air is pressed out of one lung at each step. Thus breathing and locomotion aren't possible at the same time. The term was coined in 1990 by Richard Cowen in his **History of Life**, accompanied by this limerick:

The reptilian idea of fun
Is to bask all day in the sun
A physiological barrier,
Discovered by Carrier,
Says they can't breathe if they run.

--R. Cowen, *The History of Life*

Several lines of organisms have engineered around this constraint. Many archosaurs did so by developing bipedal locomotion, thus decoupling walking from breathing. Mammals developed a diaphragm and undulation in the *vertical* plane with the same effect. The original cite is Carrier, DR (1987), *The evolution of locomotor stamina in tetrapods: circumventing a mechanical constraint*. **Paleobiology** 13: 326-341. More information can be found here.

Cartilage: firm but elastic skeletal tissue whose matrix contains chondroitin sulfate and collagen or elastic protein (fibers) and is generally not vascularized. Cartilage typically contains considerable tightly-bound water. The cellular elements of cartilage are called chondrocytes which lie in spaces called lacunae surrounded by the perichondrium, fibrous connective tissue that lies on the outside of cartilaginous tissue. Structurally, cartilage is incompressible, highly flexible, but not ductile (that is, it returns to its original form). May be found in several forms (ranked from least dense to most dense): Hyaline, elastic, fibrocartilage and calcified cartilage (*q.v.*). Introduction to the skeletal system.

Casamayoran Age: South American Land Mammal Age traditionally thought to correspond to the Early Eocene. Recent work suggests a significantly later age -- Middle or Late Eocene.

Caudad: a really effete and obnoxious adverb of direction, meaning towards the tail, or (almost always) posteriorly. Opposite of "cephalad," "rostrally," or "anteriorly." In the late 1990's and early 2000's, the caudad-cephalad terminology was considered trendy. However, it met considerable resistance from sensible people and is hopefully on on its way out (or *cloacad*).

Caudal: (1) as a direction, towards the tail, *i.e.*, posterior; (2) of, or relating to, the tail; (3) as a noun, a tail vertebra.

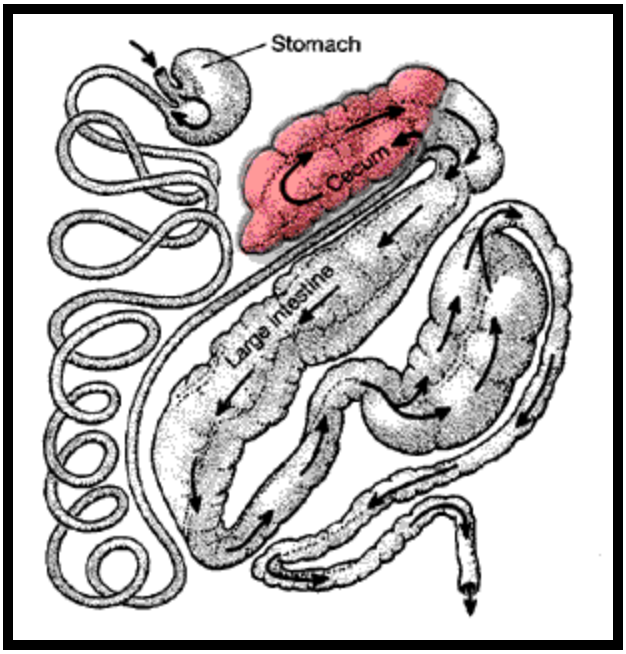
Caudofemoralis: a muscle which originates on the tail and inserts on the fourth trochanter of archosaurs and is active in retraction of the limb during stance phase.

Cava L. *cavus* = hollow, as in the word cave

Cavum conchae: See *concha* and **Ethmoid**.

Cavum epiptericum: "a large primitively extracranial space situated lateral to the sidewall of the orbitotemporal region of the skull. The space contains the post-trigeminal ganglion, primary head vein and several nerves (ophthalmic, oculomotor, trochlear, maxillary, mandibular and abducent)" Reconstruction of the petrosal in Late Cretaceous multituberculates (Mammalia). In therian mammals, the medial wall of the cavum, formed by the pila antotica (*q.v.*) is lost and the cavum is bounded laterally by the alisphenoid. It is thus incorporated into the braincase. Curiously mutations in certain retinoic acid receptors can recreate something rather similar to the primitive condition. Lohnes *et al.* (1994).

Cecum: a blind pouch or pocket, such as an alveolus in the lung. In particular, the cecum refers to a blind pocket in the gut used by non-ruminants to cultivate bacteria which digest cellulose. This is so-called "hind-gut" fermentation. Image from Prothero & Schoch (2002).



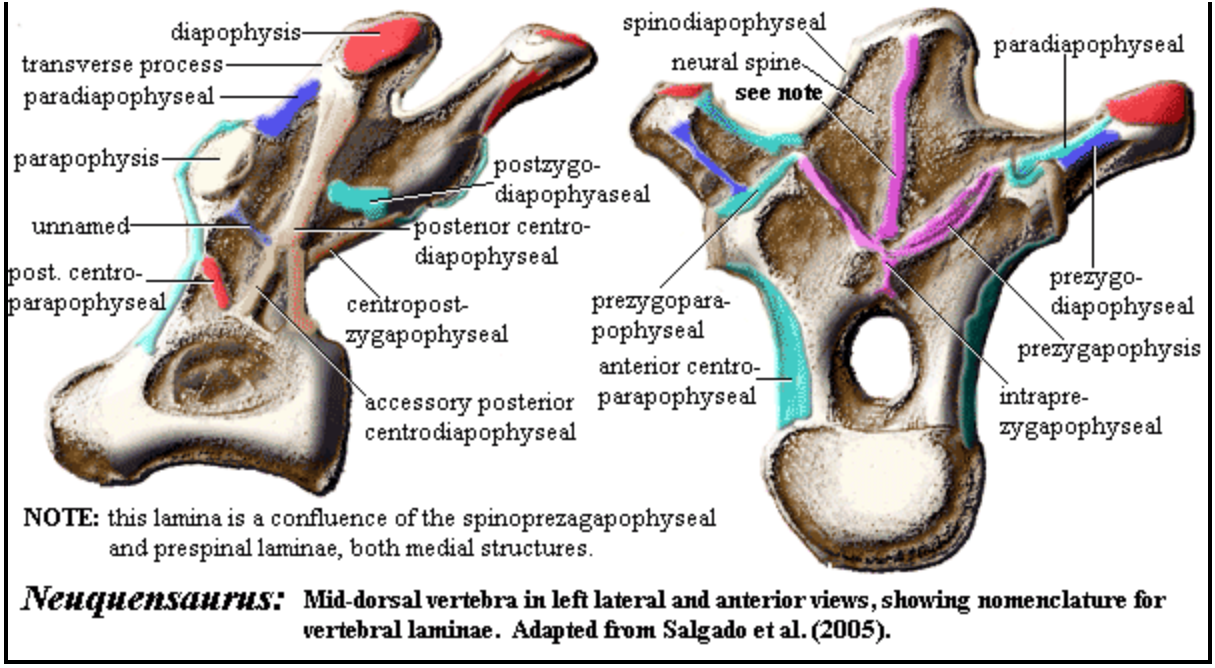
Cedar Mountain Formation: Cretaceous (Early Cretaceous to Late Cretaceous), of western Colorado & eastern Utah. According to Head (2001), late Albian & early Cenomanian. According to Cifelli & Madsden (1998), Barremian to Cenomanian. Various iguanodontians & hadrosaurids, multituberculates, triconodontids & *Kokopellia* (an early tribosphenid). The Cedar Mountain Formation has two principal members: the Buckhorn Conglomerate (lower) and an unnamed shale member (upper). Both are terrestrial in origin. The Cedar Mountain unconformably overlies the Morrison Formation and underlies the Late Cretaceous Dakota Formation.

Cenomanian: The first age of the Late Cretaceous, about 99.0-93.5 Mya.

Cenozoic Era: the present era (65-0 Mya). The Cenozoic is carved up in an irritating number of different ways. Instead of Periods, it has Epochs: the Paleocene, *Eocene*, Oligocene, Miocene, Pliocene, Pleistocene and Holocene Epochs. Each of the epochs has one or more Ages attached to it. However, these Ages don't get as much exercise as Mesozoic Ages because they often refer to a single subdivision. That is, for example, the Ypresian (54.8-49.0 Mya) is the same as the Early Eocene. The Paleocene, Eocene and Oligocene are collectively referred to as the Paleogene, while the Miocene, Pliocene, Pleistocene and Holocene are known as the Neogene. The Tertiary means everything except the Pleistocene and Holocene, which are collectively the Quaternary. Finally, the Recent refers to approximately the last thousand years.

Center of mass: For purposes of analyzing momentum, torque, and balance, a body can often be treated as dimensionless point of identical mass located at a position referred to as the center of mass or, more colloquially, the center of gravity. Imagine that the body is divided into a very large number of tiny pieces. Assign each piece a position on a coordinate grid. Multiply the mass of each piece by its x, y, and z coordinates (*i.e.*, mx + my + mz). Add everything up. If the origin of the grid (the point 0, 0, 0) is the center of mass, and the pieces are infinitely small, the result is zero. (This is calculus. Don't try it on your hamster). In a gravity field, this point is the **center of gravity** and can be compactly defined as the point at which net torque is zero. Operationally, although less accurately, the center of gravity is the point (there's only one) at which the body would balance, no matter how you chose to orient the body.

Centrale: One of the distal carpals or tarsals. See Figures at tarsus, carpus and unciform.



Neuquensaurus: **Mid-dorsal vertebra in left lateral and anterior views, showing nomenclature for vertebral laminae. Adapted from Salgado et al. (2005).**

Centrodiapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the centrum and the *diapophyses*. Anterior, posterior, and/or accessory lamina may be present, as in the image.

Centroparapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the centrum and the *parapophyses*. Anterior, posterior, and/or accessory lamina may be present, as in the image.

Centropostzygapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the centrum with one of the *postzygapophyses*.

Centroprezygapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the centrum with one of the *prezygapophyses*.

Centrum(-a): the central portion of the vertebra, which in early vertebrates, was taken up by the notochord. In derived forms, the centrum becomes ossified. See diagram at *diapophysis*.

Ceratal: referring to the more ventral of the two main elements of a gill arch, *i.e.* the ceratobranchials, the ceratohyal, and/or Meckel's Cartilage. See **Gill Arches**.

Cerato-: prefix referring to a ceratal element. See **Gill Arches**.

Ceratobranchial: the more ventral of the two main elements of a gill arch. Serial homologues of Meckel's Cartilage and the ceratohyal. See **Gill Arches**.

Ceratohyal: in fishes, the ventral or ceratal main element of the hyoid arch. See **Gill Arches**.

Ceratotrichia: fin support structures which are primarily made of keratin, rather than bone. Ceratotrichia may replace fin radials, or simply act as a third level of support (*i.e.* basals -> radials -> ceratotrichia).

Cervical: **[1]** relating to the neck. As a noun, the cervical vertebrae. **[2]** of mammalian dentition, towards the root.

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Glossary: Ch-Co

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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Chandler Bridge Formation: Late Oligocene of North & South Carolina. Marine. Squalodont whales. Luo & Eastman (1995).

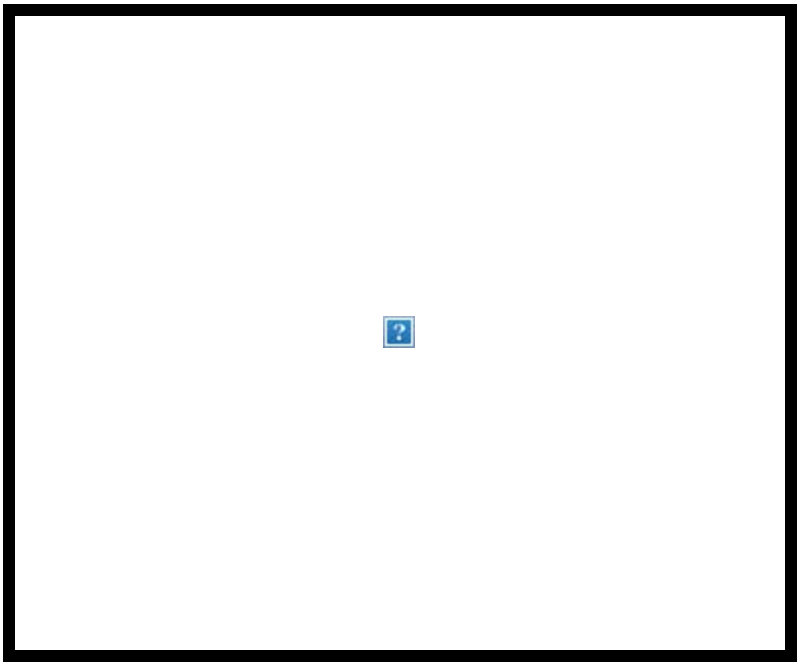
Chapadmalalan Age: South American Land Mammal Age corresponding to the Middle Pliocene (Piacenzian).

Chasicoan Age: South American Land Mammal Age corresponding to the Early Miocene.

Cheek teeth: molars. Actually, this term is used to avoid saying "molars," since that word refers to specialized, occluding, grinding teeth. Cheek teeth is more generic and simply refers to post-canine teeth, particularly in therapsids.

Chemosensory: relating to taste, smell, and other senses that operate directly on chemicals dissolved in the medium (air, water).

Chevron: [1] the Y-shaped bones on the underside of caudal vertebrae in many archosaurs. The image shows chevrons from the tail of the tyrannosaurine *Gorgosaurus*. Another example may be found at Earth History Research Center; **[2]** Generally, the hemal arches -- ventral projections of the vertebrae.



Chiasm (var: "chiasma") Gr. *chiasma* = two crossing lines. Derived from the Greek letter *chi* which in Greek script was written 'X'.

Chiro-: Gr = hand

Chiropatagium: a flight membrane running between the fingers.

Chitarwata Formation: Early Oligocene of Pakistan. Terrestrial. Small mammals.

Choanae: **choana** Gr. *choane* = a funnel. Applied to the internal nares, i.e. nostrils that open into the oral cavity.

Choanae are a character of derived sarcopterygians, including tetrapods.

Chondral Gr. *chondros* = cartilage.

Chondrocranium: The chondrocranium is sometimes called the neurocranium or endocranium and covers the ventral, lateral and posterior parts of the brain as well as closely related sensory structures. *Development*: the chondrocranium is formed by a combination of mesodermal sclerotome and neural crest cells. During development, cartilage forms around the brain beginning at the notochord. Sense organs are then surrounded by cartilage to form the optic capsules (for the eyes), nasal capsules (for the olfactory organs) and auditory capsules (for the ear, if present). In the posterior region of the chondrocranium the occipital arch develops, which is perforated by the foramen magnum to allow for passage of the spinal cord to the developing brain. *Parts of the chondrocranium:* the chondrocranium is most visible in more primitive species, such as the cartilaginous fishes. Specific regions, such as the rostrum, denotes the anterior portion of the cranium. The occipital condyle is in the posterior region of the chondrocranium and articulates with the notochord/vertebral column. In more advanced vertebrates, the chondrocranium is later ossified and becomes a more minor part of the skull. Introduction to the skeletal system.

***Chorda Tympani*:** branch of the facial nerve that passes through the middle ear and conveys taste sensation from the anterior two-thirds of the tongue and carries fibers to the submandibular and sublingual salivary glands.

Chorion: the outer membrane of the *amniotic egg*.

Choroid Gr. *chorion* = skin, and *eidos* = resemblance; thus, skin-like.

Chucal Formation: Middle Miocene of northern Chile. River and lake deposits. Mammals (endemics and a very early chinchillid rodent). Flynn *et al*. (2002).

Cingulum: a ridge surrounding a tooth. pl. = **cingula**.

***Circum-*:** L. *circum* = around, surrounding.

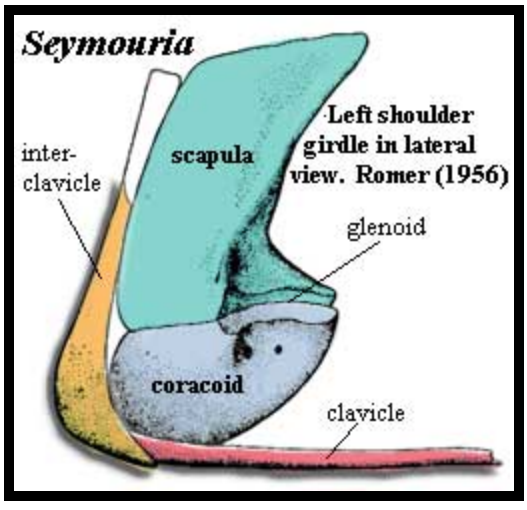
***Cis*-acting elements**: DNA sequences in the vicinity of the structural portion of a gene that are required for gene expression, presumably by regulating the binding of regulatory proteins and RNA polymerases (*trans-acting factors*).

Clade: an organism and all of its descendants, i.e. a *monophyletic* group.

Cladodont: These teeth are characterized by a wide tooth base, a large central cusp and a variable number of lateral cusps. In cross-section the cusps are circular to somewhat D-shaped. *See* example and a bit more discussion at Crown Group. The **OOK site** also has a number of well-illustrated examples.

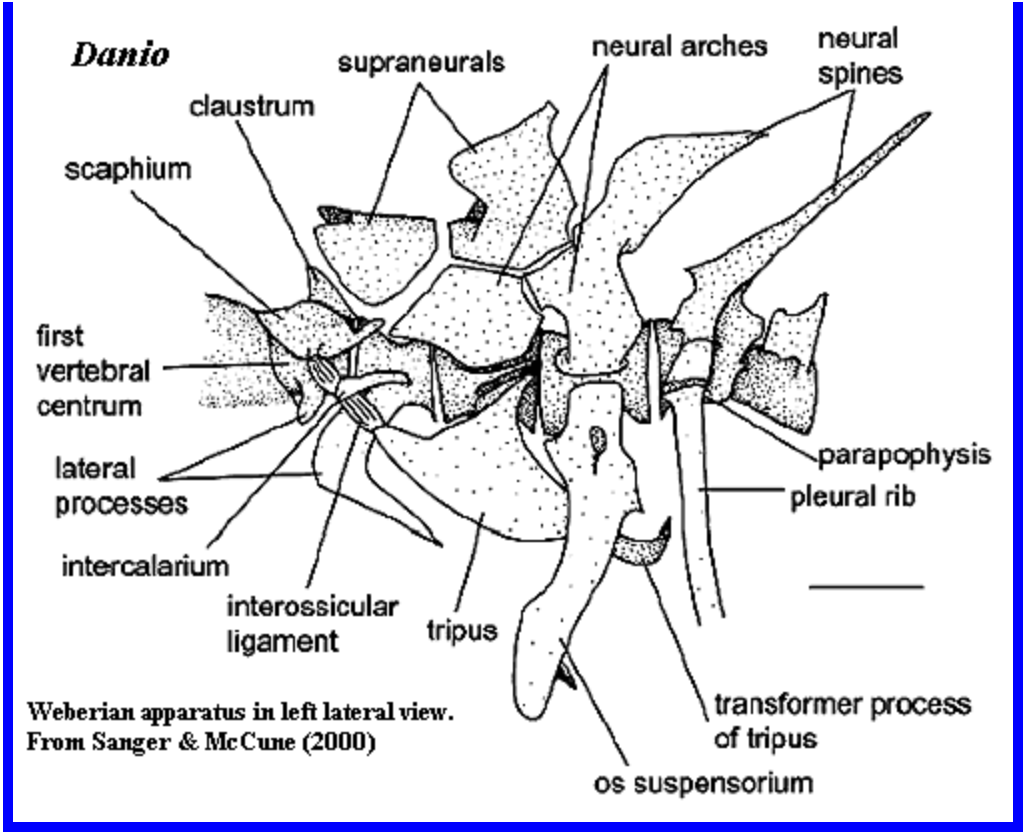
Clastic: Sediment consisting of broken fragments derived from preexisting rocks and transported elsewhere and redeposited before forming another rock. Examples of common clastic sedimentary rocks include siliciclastic rocks such as conglomerate, sandstone, siltstone and shale. Carbonate rocks can also be broken and reworked to form clastic sedimentary rocks.

Clavicle: in humans, the collar bone. The clavicle is part of the dermal shoulder girdle. Typically in tetrapods, it braces the coracoid (or lower part of the scapulocoracoid) laterally and/or ventrally and extends posteriorly as a long rod. Anteriorly, it bends inward and articulates with the interclavicle, if present, binding the two shoulder girdles together in a flexible way. In most derived tetrapod lineages, the clavicle is reduced and frequently disappears. However, it may become very large in flying and swimming tetrapods. In these forms, the clavicle anchors part of the *pectoralis* musculature, or its equivalent, which performs the power stroke in locomotion.



Claustrum: the last of the Weberian ossicles in Otophysi. The claustrum receives vibrations from the scaphium and, in turn, transmits vibration to the perilymph of the *sinus impar*.

Clay: sediment particles less than



Weberian apparatus in left lateral view. From Sanger & McCune (2000)

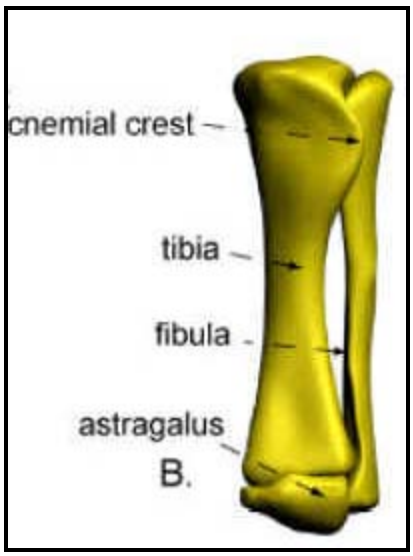
1/256th mm in diameter. See silt, sand, gravel.

Clear Fork Group: Lower(?) *Permian* of west & central Texas and Oklahoma, consists mostly of mudstone and shale with thin beds of limestone and dolomite. Deposits include flood plains and point bars deposited by small, variable-discharge, perennial streams with high sinuosity. untitled. "...the interval was deposited under hot and humid conditions in a complex array of specific environments ranging from nearshore marine, shoal, reef, and island complexes to lagoonal, tidal flat, and supratidal settings. Vegetal covering of island and supratidal areas was intermittently widespread. In the upper part of the Clear Fork, where peritidal and lagoonal facies dominate, solution collapse breccias testify to fresh water invasion during periods of sea level lowstand." [dead link]. Best known for remains of lepospondyls and synapsids (*Tetraceratops*, *Varanops*, sphenacodonts).

Clinoid process, posterior: a bony process of the sphenoid which projects dorsally and/or anteriorly from either side of the *dorsum sellae*.

Cloverly Formation: Early Cretaceous of Montana & Wyoming.

Cnemial: relating to the tibia; tibial. The **cnemial crest** is a longitudinal crest on the proximal part of the tibia, sometimes extending above the proximal end of the shaft of the tibia.



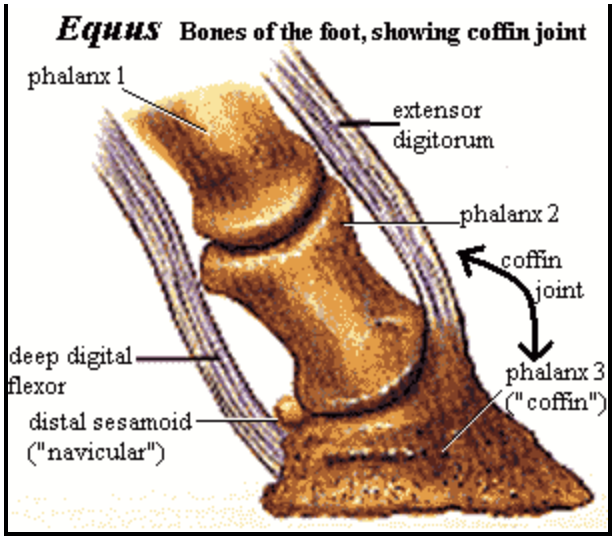
Coal Measures: Coal measures, generically, are the typical coal-bearing formation in which seams of coal, derived from the vegetation of lowland swamps, are separated by sediment resulting from periodic marine incursions. In British paleontology, the Lower, Middle and Upper Coal Measures refer to a periods corresponding to Westphalian stages A, B and C of the Late Carboniferous. The Lower and Middle Coal Measures map to the second half of the Bashkirian (~316- 311 Mya) and the Upper Coal Measures map to the first half of the Moscovian (311- ~306 Mya).

Coccyx Gr. *kokkyx* = cuckoo. A tube in the inner ear supporting the hair cells which transmit vibrations in the fluid of the ear to the brain. Adopted for anatomy from a supposed resemblance of this bone to the beak of a cuckoo. Actually, it looks more like a corkscrew. Unfortunately, the classicists who named this stuff drank wine right out of their *ampullae*, which would have been really confusing.

Cochlea: an elongated process of the lagena in the inner ear, associated with normal hearing in mammals. See **The Ear**.

Coelom: See **Early Development Terms.**

Coeval: of the same age; originating or existing during the same period of time.



Coffin Joint: in ungulates, the joint which rotates the distal phalanx ("**coffin bone**") with respect to the middle phalanx.

Colhuehuapian Age: South American Land Mammal Age corresponding to the Late Oligocene.

Columella: [1] same as the hyomandibula, stapes or epihyal. Used in reference to a slender derivative of the hyomandibula which extends from the tympanic membrane to the inner ear in tetrapods* other than mammaliforms. See **Gill Arches** and **The Ear**. **[2]** Any long, very thin portion of a bone, *e.g.* the columella of the epipterygoid which rises dorsally from the palate to the skull table.

Columnar: (of a cell layer) made up of elongated cells, as opposed to squamous or cuboidal.

Compound bone: a single postdentary bone created by fusion of the surangular, prearticular and articular. Characteristic of snakes.

Concha: (L. *concha* = seashell) a structure of the ethmoid also referred to as a turbinal or turbinate. The concha may or may not be ossified. It is typically made up of multiple layers of very thin, delicate bone or cartilage. The conchae may serve as an olfactory structure, or as a surface for the exchange of respiratory heat and water, depending on its location and the type of epithelium with which it is covered. In archosaurs and squamates, the concha tends to form a capsule surrounding olfactory tissue, the cavum conchae. In mammals, it tends to be a more open, layered structure. Thus the term *concha* is perhaps more appropriate for archosaurs, while *turbinal* or *turbinate* is more appropriate for mammals. See **Ethmoid**.

Condylar foramen, anterior: exit of the XIIth cranial (hypoglossal) nerve. Located just anterior to the occipital condyles, between the petrosal and exoccipitals, in mammaliforms.

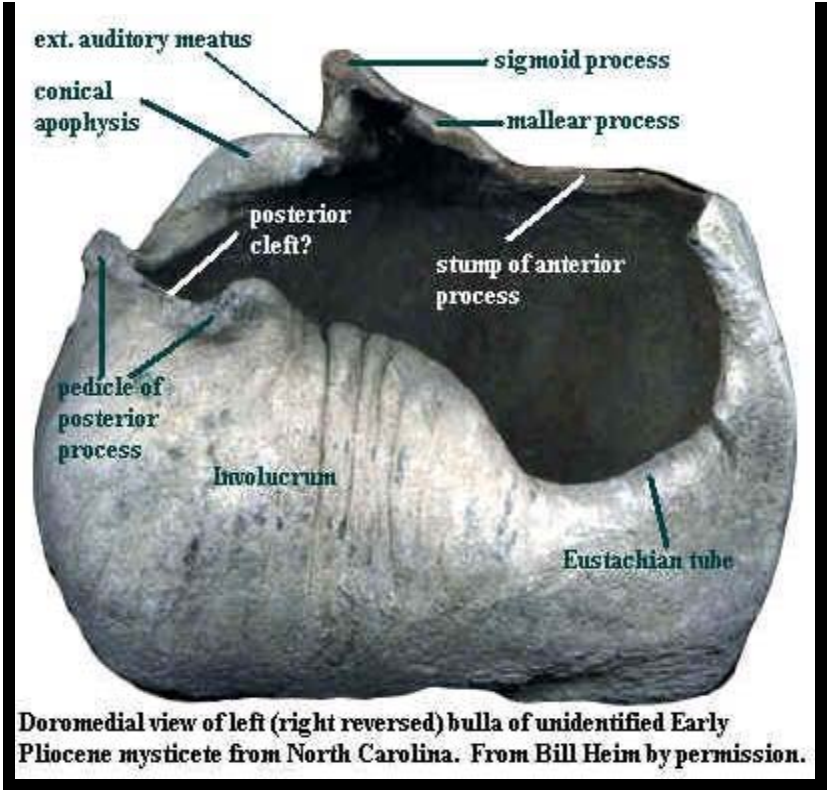
Condyle: Gr. *kondylos* = a knuckle. The protruding element of a hinge, as the ball of a ball-and-socket joint or the pin of a hinge joint.

Condyloid process: of the dentary. The posterior process of the dentary which bears the dentary condyle in mammaliforms. *See* image at coronoid process.

Coniacian: an age of the Late Cretaceous, about 89.0-85.8 Mya.

Conical apophysis: a dorsal process of the bulla in whales which arises by a folding of a medial process of the ectotympanic ring. The apophysis develops above the external auditory meatus and tends to compress the meatus between the apophysis and the sigmoid process.

Conical recess: in the braincase and palate of basal tetrapods, particularly baphetids and temnospondyls, the pterygoid is notched near its articulation with the basipterygoid process of the braincase, at the base of the quadrate ramus. In part, this simple serves as an edge around which the basipterygoid process hooks to latch the palate to the braincase. It also leaves a small hole in the palate leading straight up into the braincase. This cavity is bordered by the pterygoid, the parasphenoid, and the braincase, and is located close to the basicranial articulation. It thus represents an unusually



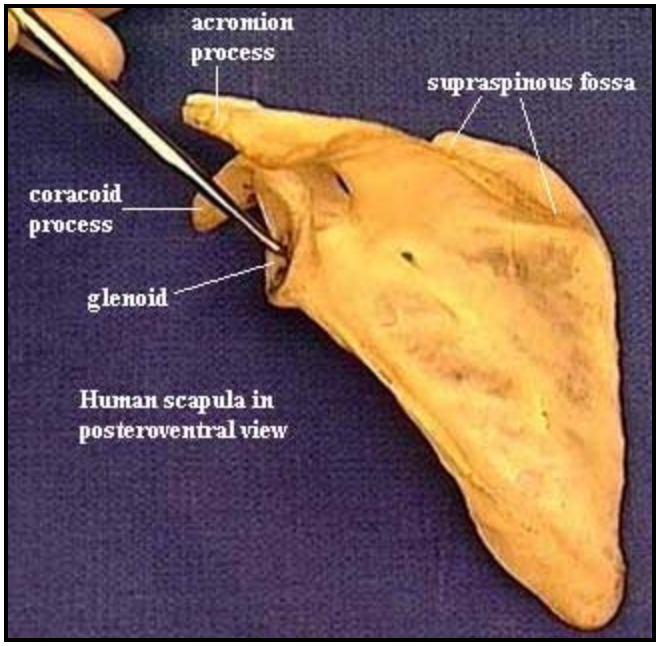
Doromedial view of left (right reversed) bulla of unidentified Early Pliocene mysticete from North Carolina. From Bill Heim by permission.

stable, strongly protected, and centrally-located cavity which may have housed a cartilaginous extension of the epipterygoid.

Contour feathers: the basic body feathers of a bird. Contour feathers often have a distal *pennaceous* region and a proximal *plumaceous* region.

Coprolite: fossilized shit.

Copula, basibranchial: *see basibranchial*.



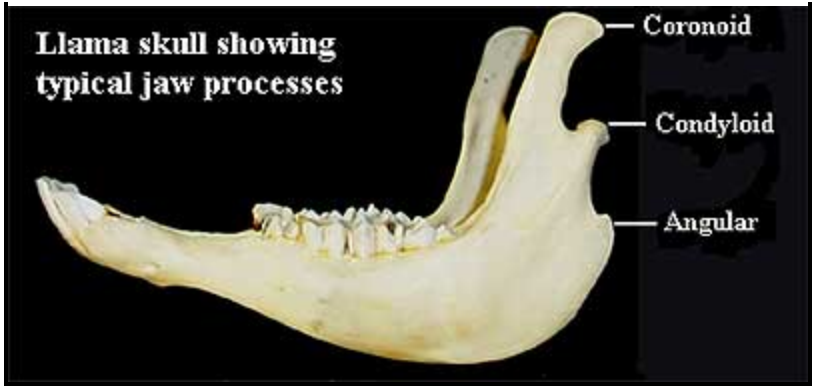
Coracoid process: in mammals, the scapula and coracoid are fused. The coracoid is therefore found as a process of the scapulocoracoid, generally ventral to the glenoid. It anchors a number of muscles mostly relating to movement of the humerus.

Cornus, cornua: lit. "horn"; any horn-like projection from the head area.

Coronoid (emminence or process): a dorsal process on the lower jaw associated with muscle attachment. It may be formed by a separate coronoid bone or as a process of the dentary. In most living (and many extinct) mammals, the most dorsal of the three proximal processes of the jaw.

Cortical bone: generic term for the dense outer layer of bone found, particularly, on the outer surface of mammalian long bones. However, the term is far more general than this. It applies not only to periostial, lamellar, acellular bone, but to a variety of other bone types which may be cellular. Probably the common denominators are (a) lack of large internal spaces (cellular or otherwise) and (b) a network of parallel collagen (always?) fibers. More than one type of cortical bone may be present on any one "bone."

Cosmine: characteristic surface histology of many sarcopterygians and a few other groups.



Continuous layer of dentine, covered by layer of enamel. Often pierced by numerous pores which open into (Ehrlenmeyer) flask-shaped cavities. The cavities are connected by canals (the "pore-canal system"). Enamel may or may not penetrate and cover all or a part of the inner surface of the pore cavity. The pore-canal system may have housed an electrosensory organ because the cavities and connecting canals resemble the ampullary canals of Lorenzini of sharks and the ampullary and tuberous organs of teleosts. This type of organ is especially useful in turbid water, where it can locate prey better than the eyes. It is also a system that still seems to be in use in the only living actinistian, the deep water marine *Latimeria*.

Cotyle: an articulation shaped as a round-bottom pit. Example: the blunt pit in the posterior braincase of lower vertebrates for articulation with the anterior notochord.

Cotyloid: cup-shaped.

Cotylus: same as a *cotyle*.

Cotype: A term not recognized by the ICZN, formerly used for either syntype or paratype, but that should not now be used in zoological nomenclature.

Covert: a feather or group of feathers which covers another structure, typically the rachis of a large flight or tail feather.

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Glossary: Cr-Cz

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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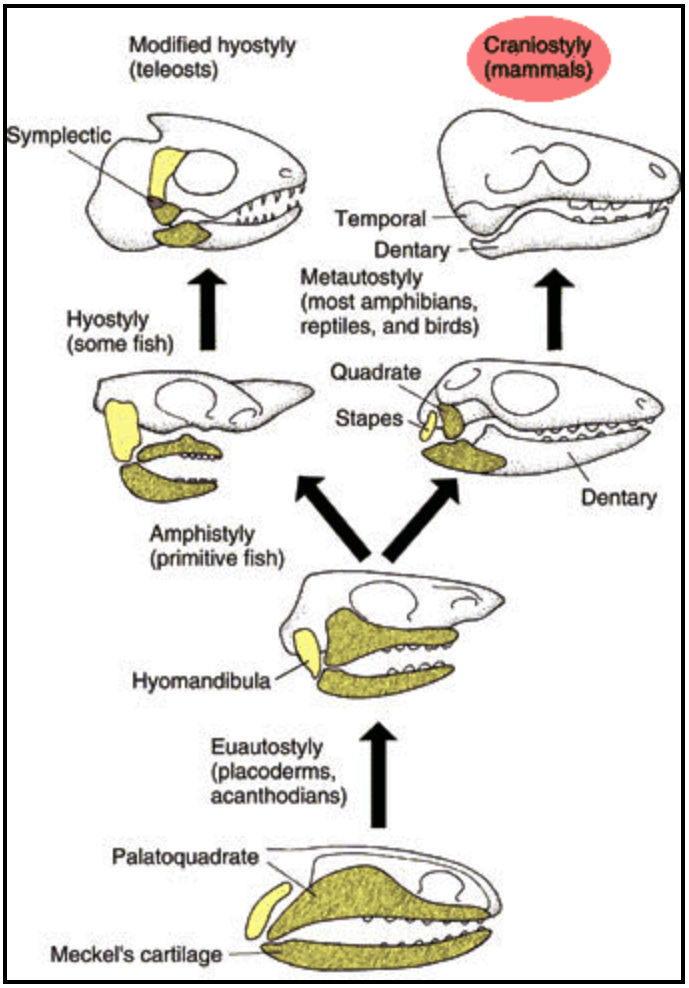
Craniostyly: a type of jaw suspension characteristic of mammals in which the lower jaw is supported by the squamosal or by the squamosal region of the fused skull.



Crato Formation: Early Cretaceous II (Aptian) of northeastern Brazil. Freshwater?

Crenulate (or **crenulated**)**:** having a margin which is finely notched, scalloped, embayed, or incised in a regular pattern (not just randomly eroded). Examples might include the stellate ornamentation of the gold paper seal on a high school diploma or the wavy lateral margins of a store-bought cupcake -- both designed to impart a sense of importance and refinement to an otherwise and unfulfilling product.

Crepescular: active during "half-light" hours, dawn or sunset.

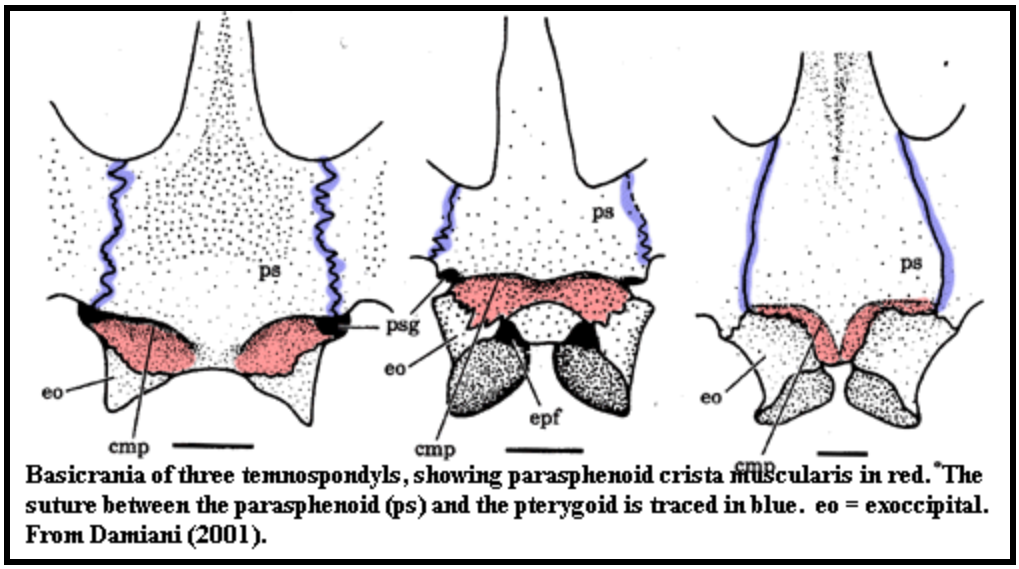
Cretaceous: (K) the last period of the Mesozoic Era, from 144-65 Mya. The Early Cretaceous I includes the Berriasian, Valanginian, Hauterivian, and Barremian, Ages. The Early Cretaceous II covers the Aptian and Albian Ages (144-99 Mya). The Late Cretaceous is made up of the *Cenomanian*, Turonian, Coniacian, Santonian, *Campanian*, and *Maastrichtian* Ages (99-65 Mya).

Cribriform L *cribrum* = a sieve, and *forma* = form. Applied to the sieve-like plate of the ethmoid bone.

Crista: L. *crista* = a crest, as on a cock or helmet; a ridge. For one specialized use, see **Molars**.

Crista galli: the dorsal continuation of the perpendicular plate of the ethmoid. The crista galli can be envisioned as a thin sheet of bone oriented straight up and down. It splits the ethmoid in two lengthwise and rises into the brain where it may partially separate the hemispheres of the mammalian brain.

Crista interfenestralis: a ridge of bone that divides the inner ear of many reptiles into two parts. The anterior part contains the *fenestra ovalis* and seems to be analogous to the *scala vestibuli* recess and is referred to by that name. The posterior part is analogous to the recess for the *scala tympani* and is sometimes called by that name.



Basicrania of three temnospondyls, showing parasphenoid crista muscularis in red. The suture between the parasphenoid (ps) and the pterygoid is traced in blue. eo = exoccipital. From Damiani (2001).

Crista muscularis: of the parasphenoid, a shelf, or pair of shelves on the posterior end of the parasphenoid. This crista is associated with the *m. rectus capitis*, apparently involved in moving the head on the occiput. The crista muscularis is shown in red in the image at right.

Crista obliqua: see *oblique ridge*.

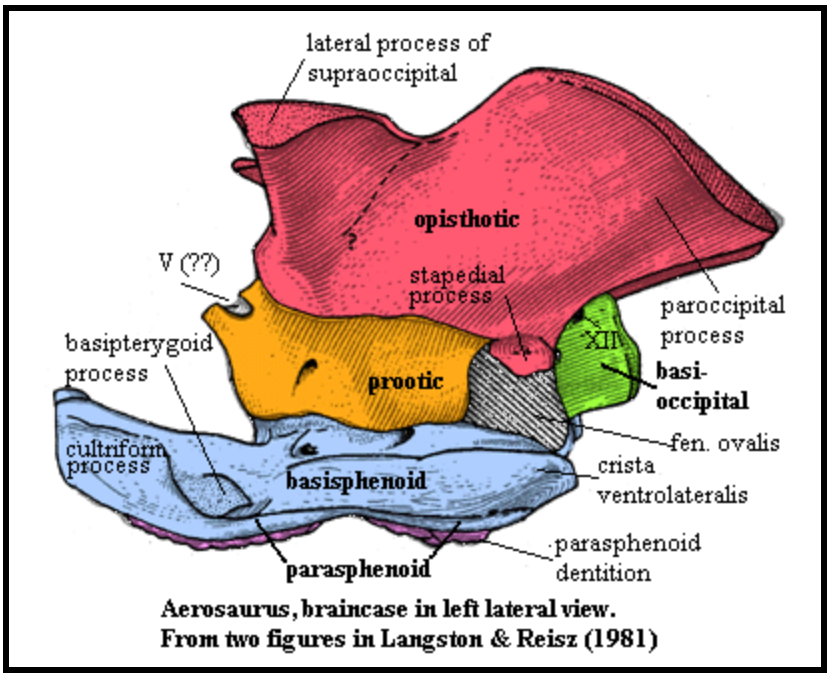
***Crista parotica*:** seems to be the same as the *crista prootica*. However, since this lateral ridge of the otic capsule is frequently formed by the opisthotic, rather than the prootic, this may be a better name.

***Crista prootica*:** a ledge or ridge which elaborates the dorsal surface of the prootic or, more generally, the roof of the otic capsule, laterally. The crista may extend posteriorly & laterally, continuous with the paroccipital process, and/or anteriorly or anteroventrally to protect cranial nerve foramina and form part of the fenestra ovalis/vestibuli. In basal tetrapodomorphs and tetrapods, the crista prootica forms the floor of the posttemporal fenestra. See **The Prootic**. In many tetrapods, the *crista prootica* is not ossified, or incompletely ossified. However, in frogs, the *crista* is the main strut joining the skull roofing bones (frontoparietals) with the squamosals. The *crista prootica* has a similarly expanded role in mammals where it forms an important part of the epitympanic recess and anchors the tympanohyal.

Crista ventrolateralis: The spelling is suspicious, but follows Langston & Reisz (1981). Apparently, ventrolateral ridges on the braincase formed by the lateral edges of the parasphenoid and basisphenoid.

***Crista vestibuli*:** a bone ridge which partially walls off the lagena (or cochlea) from the rest of the vestibular apparatus. Similar structures by this name have evolved at least twice (crocs and mammals) presumably to improve the efficiency of the lagenar hearing apparatus.

Crochet: in mammalian dentition, a hook-like branch from a molar loph. See image at lophodont.



Aerosaurus, braincase in left lateral view. From two figures in Langston & Reisz (1981)

Crocodile normal tarsus: a phrase usually ascribed to Chatterjee (1982). It refers to the type of archosaur ankle in which the joint passes between the astragalus and calcaneum. In the croc-normal joint, the ball is on the astragalus, and the socket is on the calcaneum, which acts mechanically as a part of the foot.

Crop: a bilobed *cecum* (blind diverticulum) of the esophagus, characteristic of certain birds.

Crown Group: **[1]** a clade defined in terms of living organisms. (Example: crown group archosaurs are the last common ancestor of living birds and crocodiles and all of its descendants); **[2]** any clade defined in terms of "the last common ancestor of species X and species Y and all of its descendants."

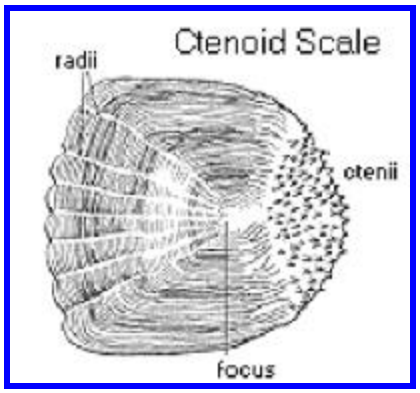
Cruropatagium: a wing membrane stretched between the legs.

Crurotarsal joint: an ankle joint that passes between the astragalus and calcaneum, as in crocodiles. Compare mesotarsal.

Crus: L. *crista* = leg. **[1]** Any structure in anatomy resembling a leg or, in the plural *crura*, of a pair of dividing structures; more often **[2]** the shin, *i.e.*, the tibia & fibula.

***Crus communis*:** the point in the vestibular apparatus where the semicircular canals meet. The corresponding bony compartment is the *sinus superior utriculi*.

Ctenoid: a type of fish scale. Thin, flexible, and overlapping. The posterior edge has comb-like teeth which are believed to reduce drag during swimming. See Cycloid and Ctenoid Scales.



Cuboid: one of the distal tarsals, also referred to as the "fourth tarsal" in non-mammals. The cuboid normally articulates with the calcaneum and the proximal ends of metatarsals IV & V. See figure at **Protocetidae**.

Cuboidal: (of a cell layer) made up of round or cube-shaped cells, as opposed to *squamous* or columnar.

Cuifengshan formation: Early Devonian exposure in Yunnan, China (South China Province). Young & Zhang (1996).

Culmen: in birds, the upper bill between the distal nares and the tip of the bill. More generically, a ridge or summit; often the upper ridge of the maxilla.

Cultriform: knife-shaped, blade-like.

Cultriform process: the extended process at the anterior end of the braincase. Normally, a process of the parasphenoid.

Cuneiform: [1] L. *cuneus* = a wedge, and *forma* = form. Anything wedge-shaped. Used in anatomy for wedge-shaped distal tarsals or carpals. **[2]** in mammalian osteology, one of the carpal bones, normally articulating distally with the unciform and proximally with the ulna & pisiform. See image at unciform.

Cupula: The gelatinous covering of a neuromast organ. See also, **The Ear** .

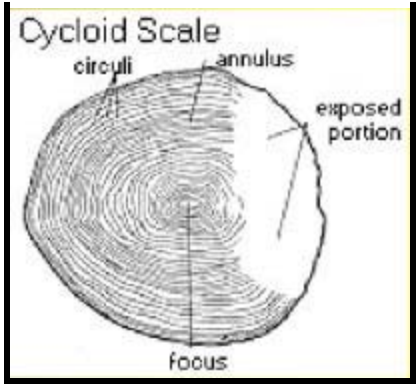
Cursorial: related to, or adapted for, running.

Cusp: of a tooth, a point.

Cutler Formation: Early Permian and possibly Late Carboniferous of Colorado, New Mexico, and Utah. "Polymict, poorly-sorted conglomerates and arkosic sandstones, usually trough-crossbedded, representing channel fills of a braided to anastomosed fluvial system, and overbank deposits of fine-grained sandstones, siltstones and claystones, and intercalated crevasse channel and splay deposits. Conglomerates contain abundant reworked caliche carbonate clasts." CUTLER FORMATION. "The Cutler Formation and stratigraphically equivalent parts of the Cedar Mesa Sandstone constitute deposits of an extensive alluvial-braidplain and aeolian sand-sea system which was active in the Colorado Plateau region of the western United States in the Early Permian. The region was situated on the western margin of the North American craton, between the equator and latitude 10 degrees north." Aeolian Module [former site]. Overlies Abo Reef. See *Abo-Cutler Formation*.

Cycloid: a type of scale found in fish. The cycloid scale is thin and essentially

round. Cycloid scales grow by concentric additions. In some species scales show growth rings, with spring and summer rings well-separated, and little growth in winter. If present, this allows age and growth rate to be estimated. See Cycloid and Ctenoid Scales.



Cyclomorial: a form of scale in which large, stout *lepidomorial* units are added anteriorly and light thin, elongated units are added posteriorly. The bases of the large lepidomorial units grow concentrically around the previously added bases and are partially fused. Zangerl (1981).

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Glossary: D

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- D -

D: *Devonian*

Dacriform: shaped like a tear drop.

Dactylo-: Gr. root = "finger."

Dapingian Age: The first age of the Middle Ordovician Epoch, 472-468 Mya. *See* Dapingian.

Darbasa Formation: Late Cretaceous (*Campanian*) of southern Kazakh.

Darriwilian: Second Age of the Middle Ordovician Epoch, 468-461 Mya. *See* Darriwilian.

Deccan Intertrappean: various deposits preserved between layers of the **Deccan Traps**, the enormous volcanic outpouring in North and Central India during the latest Late Cretaceous (Late *Maastrichtian*), ~65 Mya. For various reasons, the preservation is usually not very good, but the Traps are full of fascinating and suggestive bits and pieces.

Deciduous: of mammalian dentition, relating to "baby" teeth.

Delorme Group: Early and Middle Silurian of Arctic Canada. Thelodonts. Soehn *et al.* (2001).

***Delphy-*:** Greek root for "womb."

Deltopectoral crest: a longitudinal ridge or crest on the (proximal) humerus. See figure. Cursorial forms typically do *not* have a large crest. It is typically an important attachment point for adductors, rather than retractors. See **Humerus**.

Dendrodont: dentition marked by dentine with primary and secondary folds; secondary folds filled in with attachment bone.

Dens: L. dens, dentis = "tooth". Can refer to any number of tooth-shaped structures. Most commonly, the peg on the axis which

articulates with a pit on the atlas. See *fovea dentis*.

Dental formula: a formula, which may be written in a variety of ways, showing the number of upper and lower incisors, canines, premolars and molars, in that order. In these Notes, the formula is typically written: 2/1, 0/0, 4/3-4, 3/3. This would indicate that the animal has, on each side, 2 upper incisors, 1 lower incisor, no canines, 4 upper premolars, 3 or 4 lower premolars, and 3 upper and 3 lower molars. Partial formulas may be written, e.g. I2/2: two upper and two lower incisors.

Dentary peduncle: in mammaliforms, the stem which bears the dentary's articulation with the squamosal. That is, the process on which the dentary's contribution to the temporomandibular (jaw) joint is built.

Denti-: L. root = "tooth" (*dens, dentis*).

Denticle: a "tooth-let," i.e. a small protuberance having the characteristic histology of teeth (typically enamel + dentine + pulp cavity), but small and without roots.

Denticulate, Denticulated: characterized by having denticles.

Dentigerous: same as *denticulate*

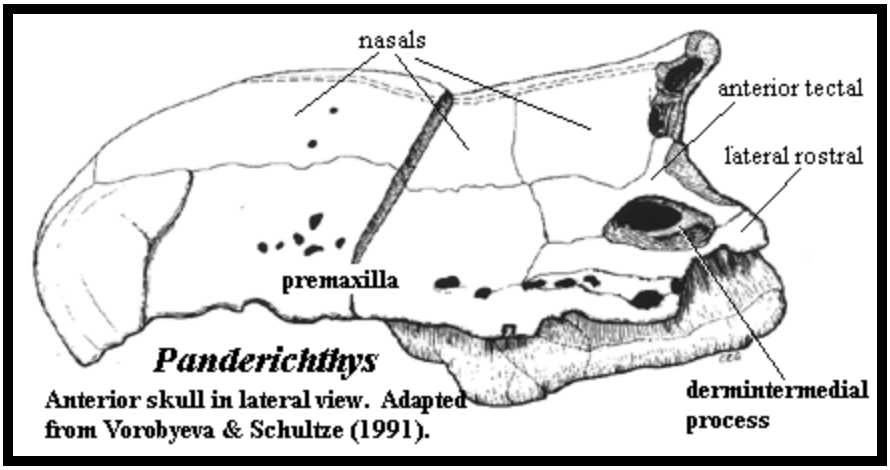
Dentine: dense, highly mineralized bone formed by mineralization of a collagen matrix by odontoblasts, mesenchyme-derived cells which form tubules in the dentine as they travel through it. The pattern of tubules is often used to subdivide dentine into various types, *e.g.* orthodentine, mesodentine.

Dermal bone: bone which is formed directly, rather than pre-formed in cartilage.

Dermatocranium is composed of plates of dermal bone that cover the head and protect the brain and gills. Six basic groups of dermal bones make up the dermatocranium: the facial, orbital, temporal, vault, palatal and mandibular series.

Dermatome: See **Early Development Terms.**

Dermintermedial Process: A large or small bump on the floor or wall of the naris in some sarcopterygians, generally cosmine covered in cosmine-covered fishes. This bump has led to endless arguments about whether one or the other species has a true choana (nasal opining inside the mouth), because the derimintermedial process may represent the fusion of two *external* nasal openings. In recent years, the presence or absence of the choana has not been given as much phylogenetic importance as it once had. It is simply one more character among many. Thus, the debates involving this structure have generally subsided.



Anterior skull in lateral view. Adapted from Vorobyeva & Schultze (1991).

Dermopalatine: same as palatine. The prefix is used by fish people because the palatine is a dermal replacement bone for a section of the autopalatine section of the palatoquadrate. In that context, *palatine* is potentially ambiguous.

Deseaden: South American Land Mammal Age corresponding to the Late (possibly Early) Oligocene.

Desmognathous: of birds, a condition of the palate characterized by vomers small or absent, maxillopalatines in contact in midline, pterygoids and palatines articulate with basisphenoidal rostrum.

Deuterostomes: All *triploblasts* closer to the early bird than to the worm. Deuterostomes (as opposed to protostomes) are characterized by development of the *blastopore* into the anus, rather than the mouth. The major deuterostome taxa are the Echinodermata and Chordata. Actually, in our treatment of the group, we use an alternate, crown group definition: "sea stars + movie stars." See Deuterostomia.

Devonian: The fourth period of the *Paleozoic* Era. The Devonian Period includes the time from 417 to 354 Mya. The Early Devonian comprises the Lochkovian, Praghian and Emsian Ages (417-391 Mya). The Middle Devonian includes the Eifellian and Givetian Ages (391-370 Mya); and the Late Devonian is divided into the *Frasnian* and *Famennian* Ages (370-354 Mya). The Devonian is the "Age of Fishes" between the *Silurian* and Carboniferous Periods.

Dexter, Dextral: Latin for right, toward the right, etc.

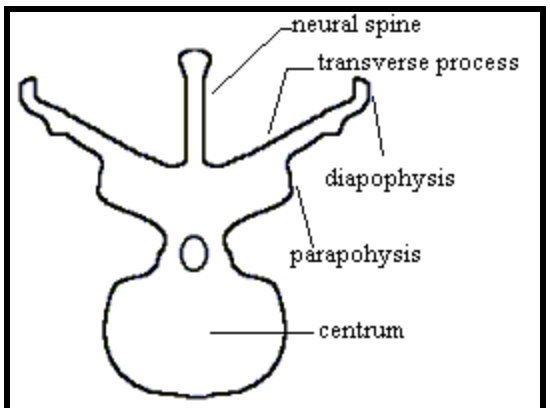
Di-: Gr. root = "two".

Diamictite: *see Tillite*.

Diaphragm: generally, a muscular partition. In mammaliforms, the diaphragm is analogous to pulmonary fold (see *pleural cavity*), but is formed from a dorsal process of the coelom itself which is invaded by migrating cervical mesenchymal cells. The mesenchyme differentiates into neuromuscular tissue which creates a muscular diaphragm bringing ventilation under direct muscular control. Reptiles possess a similar (analogous? homologous?) diaphragm, but posterior to the liver, which is also involved in hepatic pump ventilation in, for example, crocodylians and probably some dinosaurs.

Diaphysis: the middle, shaft region of long bones which is usually fully ossified and contains the medullar cavity ("marrow"). As opposed to the *metaphysis* and *epiphysis*.

Diapophysis: upper, articulating process of transverse process of the neural arch; typically bears the secondary (tubercular) articulation of the ribs. For a better picture, see Untitled Document.



Vertebra in anterior view showing articulating surfaces for ribs

Diarthrodial: freely moveable joints, such as the knee, as opposed to slightly moveable (*amphiarthrodial*) or immoveable (*synarthrodial*), such as the back and sutural joints, respectively.

Diastataxy (= Diastaxis): having a wing lacking a secondary feather associated with the fifth secondary covert. Adj: **diastaxic**. Opposite of *eutaxic*.

Diastema: a gap in the tooth row or (rarely) a gap in some other series of structures.

Dichocephalous: of ribs, having two heads.

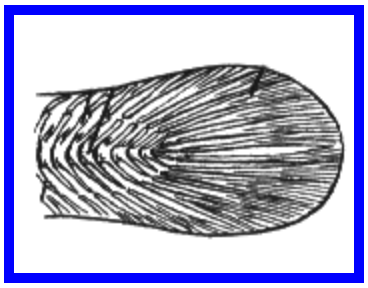
Diencephalon Gr. *dia* (di-) = through, and *encephalon* = brain. Hence the "between" brain.

Digitigrade: a style of locomotion in which the main weight-bearing surfaces are the digits (fingers and toes).

Dilambdodont: having upper molars similar to *zalambdodont* teeth except that the *ectoloph* is W-shaped. There is no 'W' in Greek or Latin, hence di-lambda = 2 (upper case) lambdas, *i.e.* "ΛΛ". The *metacone* and *paracone* are at the (lingual) base of the 'W.' Crests run from these cones to buccal stylar cusps and form the arms of the 'W.' In addition, the molar has a low shelf, lingual to the rest of the tooth, with a small *protocone*. See images at **Molars;** The

Diversity of Cheek Teeth.

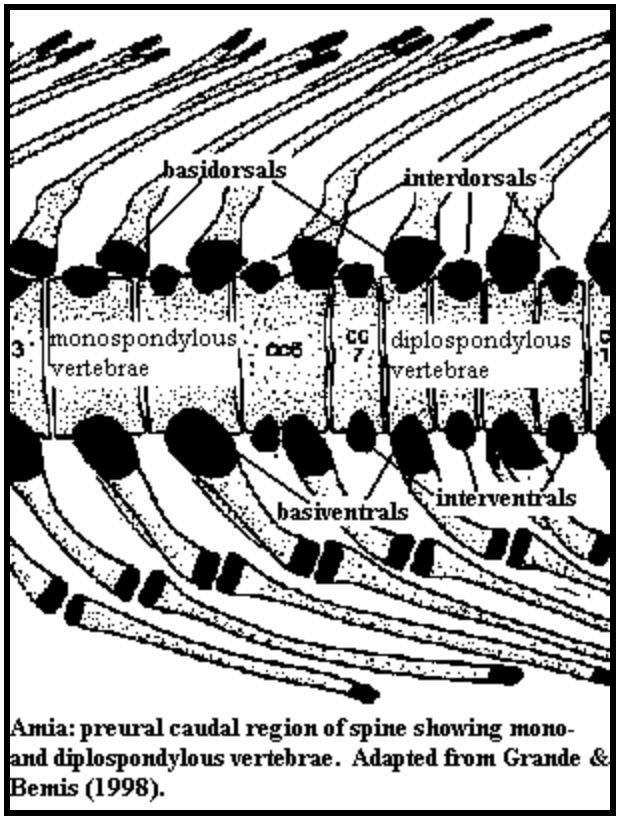
Dinosaur Park Formation: Late Cretaceous (Late Campanian) of North America (Alberta). Holtz (2001a). Previously referred to as part (?all) of the Belly River Formation. *Gorgosaurus*.



Diphycercal: of fish tails, a form of tail which is symmetrical top and bottom and usually comes to a point. The best example is probably the coelacanth, *Latimeria*, although the figure at left is from a dipnoan.

Diphyodont: having only two sets of teeth during a lifetime, as in humans, as opposed to *polyphyodont*.

Diplospondyly: the condition in which the vertebrae have two *centra*. In the tetrapod version of this condition, the centra are morphologically distinct intercentra and pleurocentra. However, in the neopterygian edition, the centra are all identical, and only the neural and hemal arches (*arcualia*) are distinct. Neopterygian diplospondyly may be of two kinds. In "normal" diplospondyly, the centra (more accurately, the *hemicentra*) each bear a basidorsal plus basiventral OR an interdorsal plus intervententral. In alternating diplospondyly, the basidorsals are paired with interventrals, and basiventrals with interdorsals. The figure, shows part of the preural caudal region of *Amia*, which is monospondylous on the left (anteriorly) and exhibits "normal" diplospondyly on the right (posteriorly). As a point of information, all amiids have some degree of both normal and alternating diplospondyly.



Amia: preural caudal region of spine showing mono- and diplospondylous vertebrae. Adapted from Grande & Bemis (1998).

Disarticulated: of a fossil, a condition in which the bones are found separated or not contacting each other as they would in life.

Diverticulum: a small passage diverging from a larger channel; most commonly used to refer to various by-ways off the digestive tract.

Distal: further away. "But from what?", you ask. A good question with variable answers. When all else fails, from the center of the organism. Thus, the distal femur is the part that participates in the knee. The distal phalanges of the third manual digit are used to express contempt. An exception is in dental terminology, when "distal" means further from the axis of symmetry which passes through the mandibular *symphysis* or its equivalent on the upper jaw. Thus, a distal tooth is one further back along the jaw (upper or lower), as opposed to *mesial*. In these Notes, "posterior" is often used instead for dental work -- sloppy, but easier to understand.

Distal carpals: the small wrist bones between the carpals and metacarpals. See Figure at *carpus*.

Distal tarsals: the ankle bones between the proximal tarsals (astragalus and calcaneum) and the metatarsals. See Figure at *Tarsus*.

Djadokhta Formation: Late Cretaceous of Mongolia, probably Early(?) *Campanian*, ~80 Mya. Sites include Bayan Zag. Inland arid & semi-arid environments with wind-borne deposits. *Shuvuuia*.

Dolomite: $CaMg(CO_3)_2$. A mineral, or sediment consisting of particles, made up of calcium and magnesium carbonates, with the calcium and magnesium in nearly equal proportions. The crystal structure of dolomite is planar, with calcium and magnesium occupying alternate planes.

Domanda Formation: Middle Eocene (Lutetian) of Pakistan. Gingerich *et al.* (1994). *Rodhocetus*.

Dorsal: (1) as a direction, towards the back; (2) noun, a dorsal vertebra, one of the vertebrae between the neck and the sacrum.

Dorsum sellae: If the *sella turcica* is a Turkish saddle (*i.e.* like a medieval knight's saddle), the dorsum sellae is the back, which braced the lancer against the shock of impact. That is, the dorsum sellae forms the posterior bone margin of the pituitary fossa, and is also the most dorsal point of the sphenoid bone. It is composed of square plates of the sphenoid bone that end in two tubercles as the (to use mammalian terminology) posterior clinoid processes. For additional discussion, see **Basisphenoid**.

Doswell Formation: Late Triassic (Carnian) of North America, (Virginia, USA). Overlain by poorly consolidated Pleistocene sand & gravel. River or lake sediments, with very high seasonality (wet/dry) periods, becoming deltaic. *Doswellia*, Crurotarsi (phytosaurs and Rauisuchia) , fish, clams, plant & wood fragments. Weems (1980).

Double Pump: in fish respiration, "the mechanics of water movement across the gills involve the combined pumping action of both the oral and opercular cavities – a "double pump" system. The volume of the oral pump (mouth cavity) can be arranged by raising and lowering the jaw and lowering the mouth. The volume of the opercular pump (opercular cavity) can be enlarged and decreased by muscles that swing the operculum in and out. Valves guard the opercular clefts, preventing the backflow of water. The action of the two pumps creates a pressure differential that maintains a smooth flow of water across the gills throughout nearly the entire breathing cycle." From Background.

Down: *plumaceous* feathers with a *rachis* shorter than the longest *barb*. Common on neonatal and below contour feathers. It makes excellent insulation but does not repel water.

Downtonian: a former name for the Pridoli.

Drag: the sum of all forces opposing movement in a medium. Normally the most important elements of drag, like sex, are friction and back-pressure.

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Glossary: E-En

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- E -

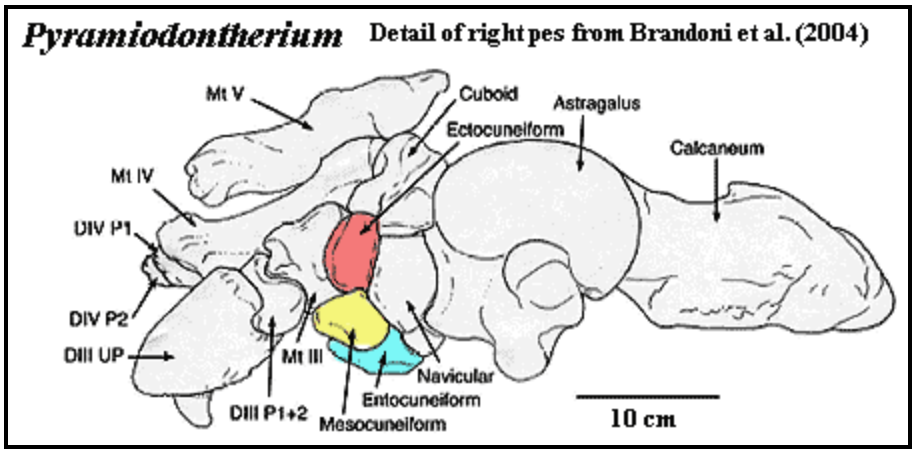
Ec: abbreviation for the Eocene.

Eccrine glands: L. *ex* + *crinis* (hair). Sweat glands under sympathetic nervous system control, primarily involved in thermoregulation. As the name suggests, eccrine glands are not associated with hair follicles. Compare *apocrine gland*.

Ectal: outer or exterior. In particular the outer (more peripheral) contact between the calcaneum and astragalus in mammals. See figure at **Protocetidae**.

Ectepicondylar foramen: see **Humerus**.

Ectepicondyle: a process on the distal humerus (upper arm bone) on the outer or ulnar side. It is associated with attachment of the extensor muscles of the lower forelimb. See **Humerus**.



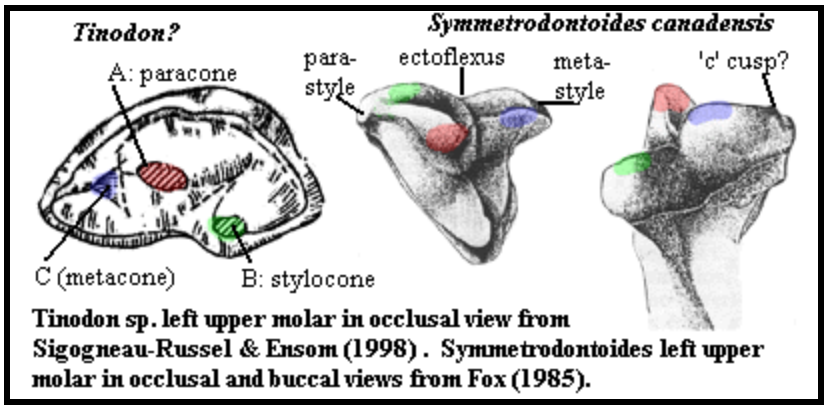
Ectocuneiform: the cuneiform is one of the bones of the ankle (a distal tarsal). It articulates proximally with the navicular and distally with metatrsals III and/or IV (the latter particularly in ungulates and some marsupials). In some types, the cuneiform is found as two or three bones, in which case the more anterior ("dorsal" in dorsal/plantar terminology) is the ectocuneiform, while the more posterior or plantar bones are the *mesocuneiform* and *entocuneiform*. Image: Brandoni *et al.* (2004).

Ectoderm: One of the three primordial germ layers of all *triploblast* animals. Ectoderm may be the "original" tissue of all animals. Generally, ectoderm is composed of the cells that are left on the outside after the *blastula* undergoes

gastrulation. This basic ectodermal material, somatic ectoderm, goes on to form the skin, other epidermal structures, and various more-or-less external sensory structures. Other ectoderm, apparently under the influence of mesoderm, differentiates into neural and skeletal structures. See *neural crest* and *neural tube*.

Ectodermal placodes: See **Early Development Terms**.

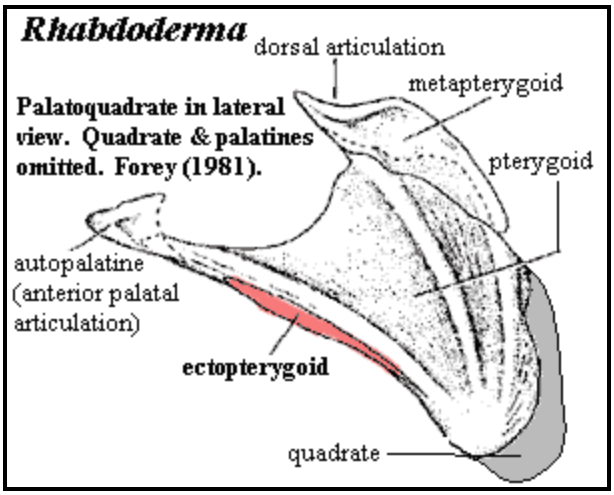
Ectoflexus: in mammalian dentition: the indentation on the buccal (labial or outer) face of an upper molar between the two principal buccal cusps (paracone & metacone). This term seems to be used more by symmetrodont workers, in which case the definition cannot be the same, since the paracone ('A' cusp) is normally a lingual (inner) cusp in symmetrodonts. Perhaps, it would be best to think of the ectoflexus simply as a medial indentation on the buccal face of the upper molar, without worrying too much about the names of cusps. See image at right for example of symmetrodont usage.



Tinodon sp. left upper molar in occlusal view from Sigogneau-Russel & Ensom (1998). Symmetrodontoides left upper molar in occlusal and buccal views from Fox (1985).

Ectoloph: a loph (enamel ridge) running along the buccal margin of an upper molar. See image at lophodont.

Ectomesenchyme: See **Early Development Terms.**



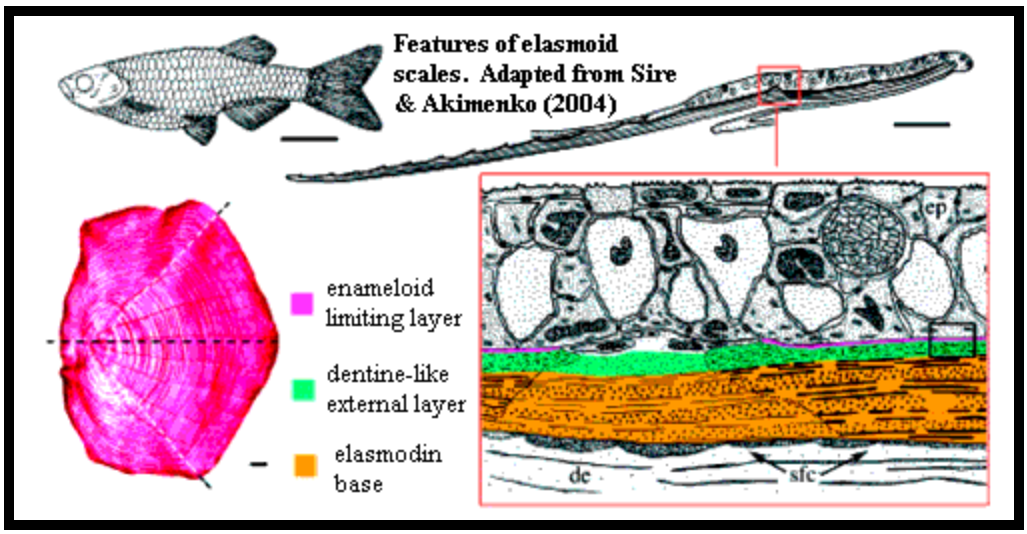
Ectopterygoid: a palatal bone which -- like many palatal bones -- may originally have developed as a dermal bone replacing part of the palatoquadrate, the primitive upper jaw. Like the palatine (also called dermopalatine), the ectopterygoid replaces the middle part of the autopalatine. It may be serially homologous with the palatine(s), but is somewhat specialized, being the last (most posterior in palatal view) of the series and bordering the fossa for the jaw muscles. In a typical tetrapod it abuts the palatine anteriorly, the maxilla laterally, the pterygoid or the fossa mandubuaris medially, and the fossa posteriorly.

Edentulous: without teeth.

Eifelian Age: The first age of the Middle Devonian, 391-380 Mya.

El Rhaz Formation: middle Cretaceous of Niger. Fluvial lowland(?). Dinosaurs, crocs. Sereno *et al.* (2001).

Elasmoid scale: the general scale type of most extant fishes, known from both actinopterygian and sarcopterygian forms. It is believed by many to be derived from teeth or oral denticles, rather than directly from placoid scales.



Elastic cartilage: cartilage containing elastin fibers that appears yellowish; found primarily on external ear and epiglottis. Introduction to the skeletal system.

Emarginated: embayed, cut away, concave.

Embolomerous: a vertebral condition in which the *intercentra* and *pleurocentra* are of roughly the same size. A

type of *aspidospondyly*. See also figure and note under Anthracosauroidea.

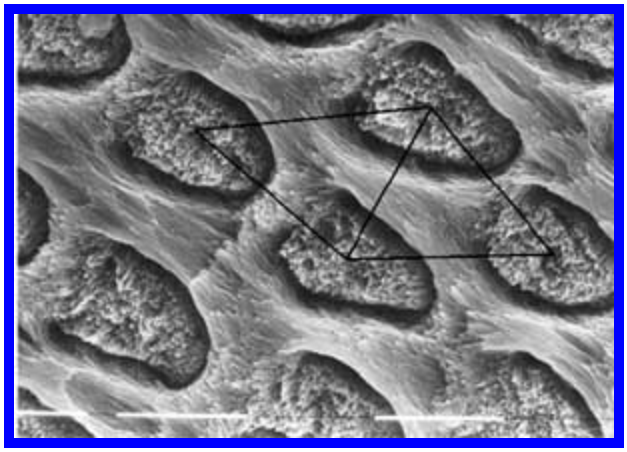
Embrasure: the space between two adjacent teeth.

Emminence: a raised section of a surface, such as a low ridge or tubercle. Typically, the word is used for structures which are low and not sharply defined, or which have a shape which doesn't fit one of the standard descriptive terms.

Emsian Age: Third and last age of the Early Devonian, 400-391 Mya.

Enamel: Hardest mineralized tissue in tetrapods and various other vertebrates; formed by ectoderm, always acellular, <3% organics. *See* apatite for more information.

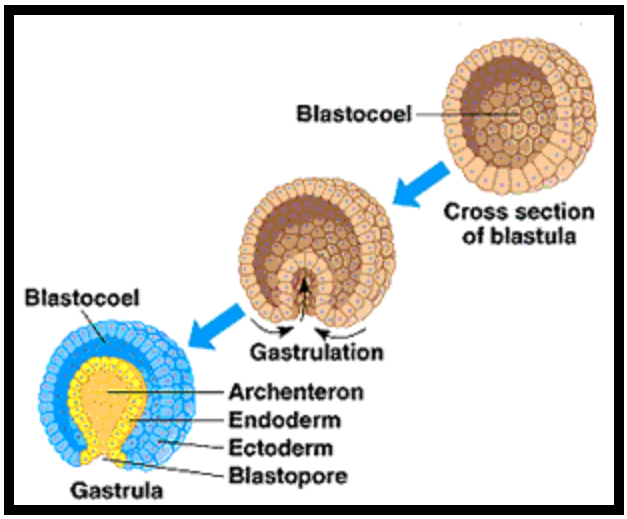
Enamel prism: a structure characteristic of mammalian teeth, consisting of parallel bundles of enamel crystallites bounded by a cylindrical or hemicylindrical sheath of other crystallites which are likewise parallel, but oriented at a sharp angle to the bundle. The image shows fossilized enamel prisms from a multituberculate, *Meniscoessus*.



Enameloid: a form of bone with even greater density and mineralization than dentine, usually found as a superficial layer over a dentine structure (e.g. scales of Paleozoic fish); mesodermal derivative laid down at outer surface of mesodermal papillae; may be up to 25% organic material.

Endochondral bone: bone which is pre-formed as cartilage, as opposed to dermal bone.

Endocranium: more or less same as neurocranium, *chondrocranium*.



Endoderm: The inner layer of tissue formed in the gastrula stage of development. At the end of *blastula*, the cells are arranged in the form of a hollow ball. Cell movement during *gastrulation* results in an invagination so that the embryo comes to resemble a double-walled cup. The inner layer of the cup is the endoderm. Endodermal cells usually end up forming the gut, pharynx, liver, lungs, and similar structures.

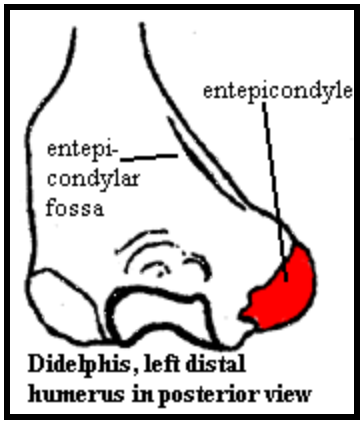
Endolymphatic duct: in chondrichthyes and some other fishes, the inner ear has an external opening (or at least an opening outside the braincase) via an endolymphatic duct.

Endothelium: the tissue lining circulatory or lymphatic vessels.

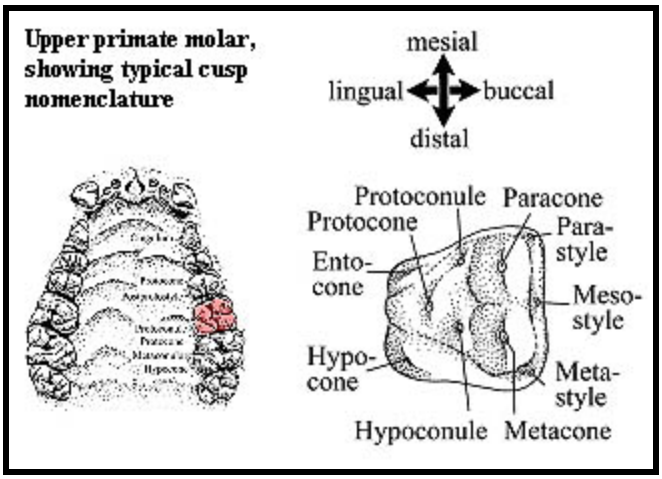
Ensenadan Age: South American Land Mammal Age corresponding to the middle Pleistocene.

Entepicondylar foramen (or fossa): a hole (foramen) or groove (fossa) in the distal humerus, proximal to or on the entepicondyle which accommodates blood vessels and nerves associated with the humeral (ulnar) flexor muscles. See image under *entepicondyle*. See also **Humerus**.

Entepicondyle: on the distal humerus, the condyle which faces posteriorly (for sprawling tetrapods) or medially (for erect tetrapods). See figure. This structure serves as the origin for the flexor muscles of the manus. See **Humerus**. With fine disregard for the hard facts of geometry, note that the entepicondyle faces outward in most illustrations, while the *ect*epicondyle protrudes between the two distal articulations of the humerus.



Enterocoely: See **Early Development Terms**.



Entocone: in mammalian upper molars. The nomenclature for small cusps in the mesiolingual (toward the tongue and anterior) region of upper molars is difficult. If the cusp is on the main body of the tooth, it is a *protoconule*. If it is a stylar cusp (derived from the cingulum) it is a *protostyle*. If it takes the form of a ridge, it is an *entocone*. The figure shows an upper right molar with both an entocone *and* a protoconule. Note that the protoconule, if present, will lie along the crista (ridge) connecting the protocone and the paracone, if such a crista is present. In any case it will be somewhere along a theoretical line between the two and probably mesiobuccal to the protocone. An entocone or protostyle is likely to be further out on the margin and mesio*lingual* to the protocone.

Entoconid: in mammalian dentition, a major cusp on the lingual side of the talonid (*i.e.* the linguodistal quadrant of the molar) in lower molars. See **Molars**.

Entocuneiform: one of the distal tarsals. *See* ectocuneiform for image and explanation.

Entoplastron: one of the dermal bones in the plastron of turtles.

Entopterygoid: This is a frustrating term, as it seems to refer to 3 different and probably non-homologous bones: (a) a key hinge bone in the suspensorium of certain actinopterygian fishes (cichlids?), (b) tooth-bearing plates flanking the parasphenoid in dipnomorph sarcopterygians, and (c) synonymous with the pterygoid in temnospondyls. However, such ambiguity is not without its uses. The next time you are confronted with some random fragment of vaguely palatal bone you may stroke your beard (or some more acceptably gender-neutral pilosity) and confidently pronounce, "Ah, yes. Of course. Undoubtedly a fragment of the entopterygoid." Then move on with your reputation for osteological omniscience untarnished. *See also* pterygoid.

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Glossary: Early Development

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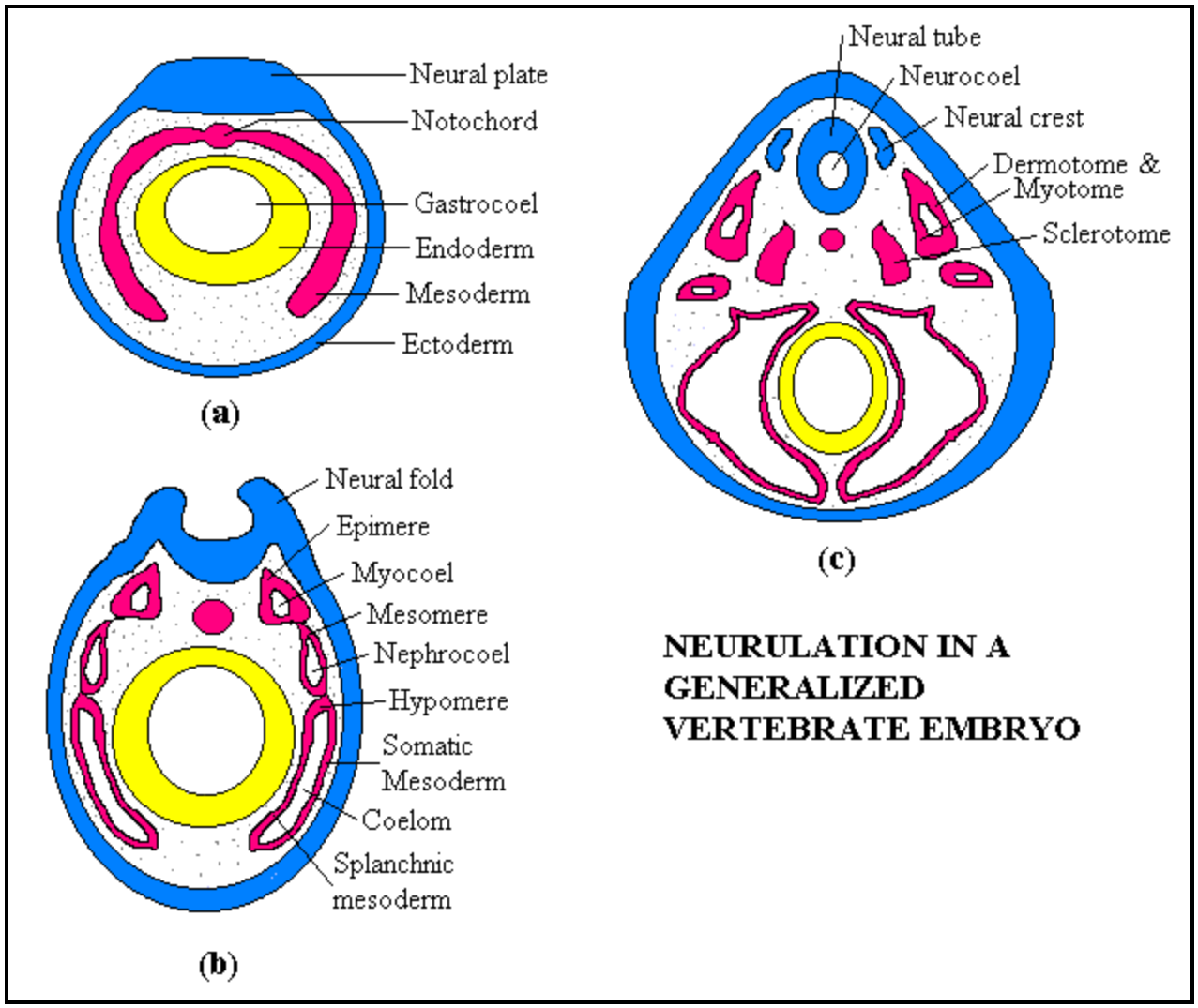
Archenteron: same as *gastrocoel*.

Coelum: the cavity surrounding the endodermal gut, formed by the *hypomere*. The coelom comes to be lined with *splanchnic mesoderm* axially and *somatic mesoderm* radially. The coelum is later divided into at least two cavities. The *pericardial cavity* contains the heart, and the *pleuroperitoneal cavity* contains the other internal organs. They are separated by the *transverse septum*.



Dermotome: The *somites* split into three segments, the most axial of which is the dermotome. This mesoderm is fated to become dermis.

Ectodermal placodes: ectodermal analogue of neural crest mesoderm and may be developmentally related. These are special populations of ectodermal cells that segregate during neurulation and sink into the body to form sensory receptors (visual, chemosensory etc. organs and related nerves) and (as mesenchyme) cranial nerves.

Ectomesenchyme: same as *mesenchyme*, according to some sources. More strictly, mesenchyme derived solely from ectodermal cells of the neural crest.

Enterocoely: the (presumably primitive, but less common) mode of coelom formation illustrated in the figure in which the mesoderm enfolds the endoderm from the inception. The alternative mode is *schizocoely*.

Epimere: The original mesoderm differentiates into three sections. The epimeric mesoderm is the most dorsal region. It separates longitudinally into discrete clumps of mesoderm termed **somites**. Each somite is further split into *dermotome*, *myotome*, and *sclerotome* segments. The dermotome and myotome frequently remain connected for some time (as in **(c)**) and are referred to as a **dermomyotome**. Epimeric mesoderm is ultimately fated to further differentiate into dermis, body muscles and vertebrae.

Gastrocoel: the space enclosed by the endodermal tube created by *gastrulation.*

Hypomere: The original mesoderm differentiates into three sections. The hypomeric mesoderm is the most ventral region. It is fated to further differentiate into limbs, peritoneum, gonads, heart, blood vessels and mesenteries.

Intermediate mesoderm: same as *mesomere*.

Lateral plate mesoderm: same as *hypomere*.

Mesenchyme: a sort of fourth germ layer formed by mixture of *neural crest* ectoderm and *epimeric* mesodermal cells. It is fated to differentiate into bone and dermis, among other structures.

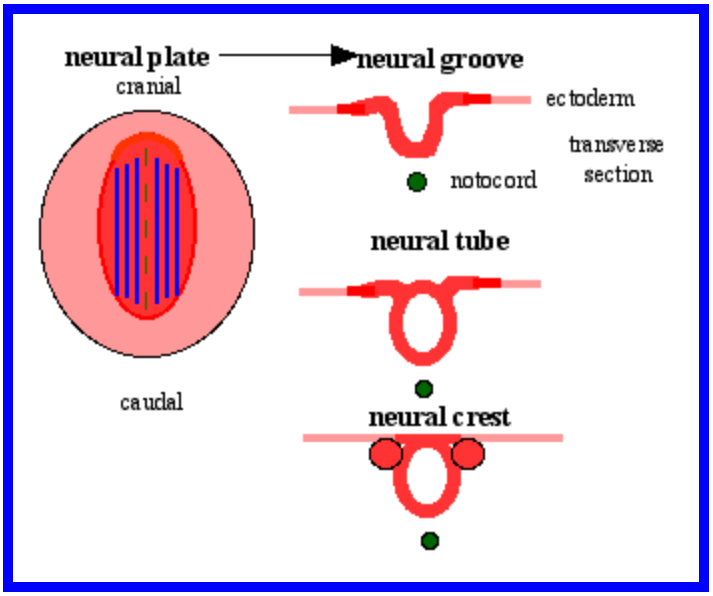
Mesomere: The original mesoderm differentiates into three sections. The mesomere is the middle section. It is fated to further differentiate into the kidney and urogenital structures.

Myotome: The *somites* split, roughly axially, into three segments, the middle one of which is the myotome. This mesoderm is fated to become body musculature.

Neural crest: populations of mesodermal cells that separate from the neural tube as the neural tube pinches off from the surface ectoderm. It is fated to differentiate into visceral skeletal elements, nerve ganglia and, in combination with mesodermal cells, a variety of mesenchymal derivatives.

Neural folds: see figure **(b)**

Neural Plate: dorsal thickening of ectoderm along the anterior-posterior axis. This invaginates and thickens to form the neural tube. Image from **UNSW Embryology**.



Neurocoel: the space enclosed by the neural tube.

Neurulation: the process of forming a dorsal ectodermal tube -- the neural tube.

Paraxial mesoderm: same as *epimere*.

Schizocoely: the (presumably derived, but more common) mode of coelom formation. It differs from the mode illustrated in the figure in that the mesoderm is originally the dorsal half of the invagination formed by *gastrulation*, rather than a separate layer which enfolds the endoderm. In schizocoel development, the presumptive mesoderm folds down over the endodermal tube and ultimately pinches off, so that, by the stage labeled **(c)**, the two modes appear quite similar. The alternative mode is *enterocoely*.

Sclerotome: The *somites* split into three segments, the most medial of which is the sclerotome. This mesoderm is fated to become vertebral structures.

Somatic mesoderm: the outer wall of the hypomere. In association with ectoderm, it is fated to form limbs, gonads, and the peritoneum.

Somite: see *epimere*.

Splanchnic mesoderm: the inner wall of the hypomere. In association with endoderm, it differentiates into the heart and blood vessels, mesenteries, and (in mammals), extra-embryonic membranes.

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Glossary: Eo-Ez

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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- E -

Eocene: The second Epoch of the ***Cenozoic***, 54.8-33.7 Mya. The Early Eocene (34.8-49 Mya) is the Ypressian Age. The Middle Eocene (49.0-37.0 Mya) includes the Lutetian and Bartonian Ages. The Late Eocene (37.0-33.7 Mya) is the Priabonian Age.

Epal: in fishes, relating to the upper main gill arch segment (***i.e.***, the epibranchials, hyomandibula or palatoquadrate). See **Gill Arches**.

Epaxial: the region dorsal to the lateral septum in fishes. Although tetrapods lack a lateral septum, this region remains developmentally distinct and gives rise to a special set of muscles, the epaxial musculature, which includes elements ultimately traceable to the dorsal fin musculature of fishes. The lateral septum in fishes extends laterally from the spinal cord. The spine tends to be somewhat centrally located, and the epaxial region is thus quite large. In tetrapods the epaxial region is more limited.

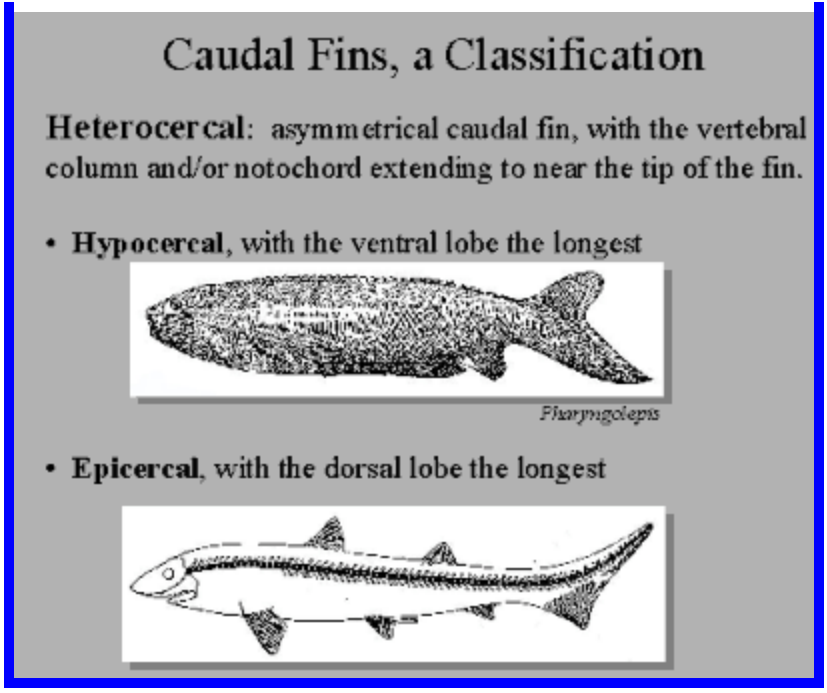
Epiblast: see ***gastrulation***.

Epibranchial: the more dorsal of the two main gill arch elements. Serial homologues of the palatoquadrate and the hyomandibula. ***See*** the **Epibranchials**.

Epicaudal lobe: the part of the tail fin above the notochord.

Epicercal: of the tail (caudal) fin of certain fishes, upwardly tapering. Generally, this signifies that the notochord or spine forms the upper margin of the tail fin. Same as ***heterocercal***, according to some. But see the image at right, which makes more sense to us.

Epihyal: this ***should*** be the same as the



hyomandibular. That is, the hyomandibula is (very probably) the epal element of the hyoid arch. However, in many actinopterygian fishes, the ceratohyal (ceratal element of the hyoid arch) has two separate ossifications. The more proximal (or posterior or dorsal, depending on the fish and frame of reference) is frequently referred to as the epihyal.

Epidermis: the outermost layer of the ***integument*** (see figure at that entry) During development, the inner layer (***stratum basale*** or ***stratum germinativum***) is in contact with the ***basement membrane***.

Epiglottis: A small thin flap of cartilage behind the tongue that covers the larynx during swallowing.

Epimere: See **Early Development Terms.**

Epineural: in fishes, a slender bone which lies in the myoseptum and projects backwards and upwards from the neural arch and spine. Epineurals may be forked. Compare supraneural.

Epiotic: a ?median dorsal ossification of the otic capsule, somewhat like a second, more anterior, supraoccipital. This bone, if present, normally has no external exposure. Presumably, like the supraoccipital, it arises by ossification of dorsal soft tissues joining the otic capsules dorsally.

Epiphysis: **[1]** the terminal, usually ossified sections of long bones, including the articulating surfaces. As opposed to the ***diaphysis*** and ***metaphyses***. **[2]** a small, light-sensitive endocrine gland in the brain; situated beneath the back part of the ***corpus callosum*** which secretes elation.

Epipodial: same as ***epipodiale***. See figure at ***metapodial***

Epipodiale: (pl. ***epipodialia***) one of the distal limb bones, ***i.e.*** ulna, radius tibia or fibula. See figure at ***metapodial***.

Epipterygoid: The epipterygoid is a misnomer. Like the quadrates, the epipterygoids are ossified portions of the palatoquadrate (the original upper jaw which, like the hyomandibular, is homologous with an upper gill arch segment). The epipterygoids often appear to arise from the pterygoid, but do not. The epipterygoids are the

true, old stuff of the palatoquadrate, while the pterygoid is but common dermal bone with pretensions. In fact, the epipterygoids are the original braincase articulations of the palatoquadrate. They demonstrate this ancient nobility by rising up in a graceful curve to reach the bones of the skull roof, like the last remaining columns of an abandoned temple.

Epitegum: a shield element of jawless fishes, considered as arising from separate growth centers. The ventral shield is considered as a single epitegum.

Epithelium: a tissue forming the boundary of an organ; a characteristic tissue type forming such boundaries.

Epitympanic recess: the distal or upper end of the middle ear, opposite the Eustachian tube. The middle ear ossicles of mammals are lodged in this part of the middle ear.

Epoccipital: one of the small bones along the margin of the parietal frill of many Ceratopsia.

Epural: in fish tail anatomy, an elongate detached bone above the urostyle and behind the last neural spine supporting caudal fin rays. Apparently derived from neural spines or the urostylic centra; dorsal homologues of the hypurals. Vary in number between one in advanced fishes to three in primitive actinopterygians. From Dictionary of Ichthyology (site no longer available). See image at urodermal.

Eretmo-*:** Greek root for ***oar.

Erythro-*:** Greek root for ***red.

Escuminac Formation: Frasnian? (Late Devonian) of Canada. This is the formation containing the famous Miguasha fauna including many incomparable specimens of ***Eusthenopteron***, possibly the best known Middle Paleozoic vertebrate. The sediments are probably coastal marine or possibly deltaic, although they are frequently reported as fresh water in the older literature. Schultze & Arsenault (1985).

Ethmoid: Gr. ***ethmos*** = a sieve, and ***eidos*** = resemblance. A term describing the structure of the ethmoid bone of the skull, the most anterior of the four principal braincase regions. It is associated with the nasal capsules and chemosensation. Frequently it fuses with the sphenoid region and is referred to as the sphenethmoid. In mammals, the ethmoid is reduced to a series of turbinals: very thin bones in the nasal passage that help recover respiratory water vapor.

Ethmoid articulation: of the palatoquadrate. An anterior articulation of the palatoquadrate in which the palatoquadrate articulates with a an anterior portion of the sphenethmoid portion of the braincase. See image at paratemporal articulation.

Ethmosphenoid: same as sphenethmoid. The combined sphenoid and ethmoid regions of the braincase. The anterior half of the braincase, physically separate from the posterior, otoccipital unit in Sarcopterygii. See **Bones: The Braincase**.

Euautostylic: jaw suspension in which the jaw is attached directly to the braincase as in placoderms.

Eurybasal: having a wide fin base (as sarcopterygian fin); opposite of ***stenobasal***.

Euryhaline: tolerating a wide range of salinity; opposite of ***stenohaline***.

Eustachian tube: a passage joining the middle ear and pharynx.

Eutaxy (= Eutaxis): of bird wings, having the 5th secondary present. Adj. **Eutaxic**. Opposite of ***diastaxy***.

Euxinic: relating to a water layer or water column which is anoxic (little or no oxygen) and sulfidic (contains reduced sulfur species, ***e.g***. H_2S, FeS, etc., as opposed to sulfate). In Phanerozoic environments, euxinic waters are generally deep, stagnant, and cool, since any significant current or convection would tend to introduce oxygen. The best modern example is the bottom of the Black Sea. In fact, the term is derived from the Greek name for the Black Sea, ***Εὔξεινος Πόντος***.

Evaporite: a deposit created by the evaporation of sea water.

Exaenodont: in mammalian dentition, a condition of the cheek teeth in which the base of the crown is significantly lower on the buccal than on the lingual side of the tooth. Rich ***et al***. (2001).

Exapt: to adapt, by selection, to a different purpose. Examples: (1) the muscles homologous to the usual vertebrate eye muscles have become exapted to move the tentacles in caecilians; (2) the swim bladder, originally adapted for control of buoyancy, was exapted as a respiratory organ in various groups of fish.

Exoccipital: The exoccipitals are paired bones of the occiput. They derive from the neural arch elements of embryonic vertebrae which have been incorporated into the braincase. Dorsally, the exoccipitals contact the supraoccipital and the ***foramen magnum***. Ventrally, they contact the basioccipital. The exoccipitals often form part of the ***occipital condyle***. See **The Occiput** for details.

Extensor muscles: the muscles which extend the digits of a limb.

Extrinsic eye muscles: the muscles which rotate the eyeball, as opposed to the intrinsic eye muscles which dilate the retina, etc. These are the various oblique and rectus muscles. See figure at ***rectus muscles***; ***see also*** discussion and figures of the gnathostome orbit.

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Glossary: F-G

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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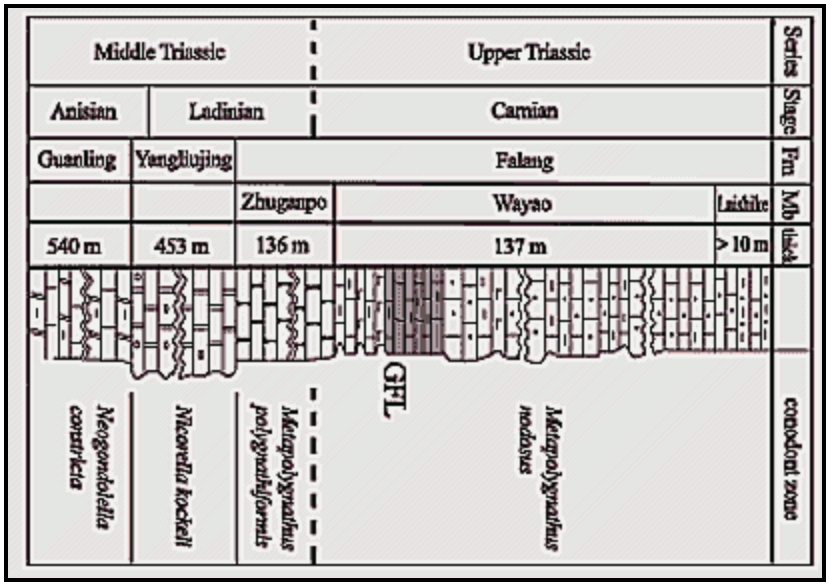
-F-

Facet: any small articular surface, usually relatively flat.

Facial nerve: Cranial nerve VII. In fishes, this is the motor nerve associated with the hyoid gill arch. In tetrapods, it became associated with neck musculature. In mammaliforms it becomes the principal motor nerve controlling the facial muscles. Like the trigeminal (Vth) nerve, with which it closely associated, the facial nerve has several branches which *may* exit the brain separately. The principal branches are the superficial opthalmic, buccal, palatine & hyomandibular. However, all of these rami are present even in the hagfish, which has none of the structures these nerves normally innervate in mammals. Clearly, there has been quite a bit of re-engineering over the course of vertebrate evolution; and it is not possible to give a taxon-independent characterization of what the various branches accomplish.

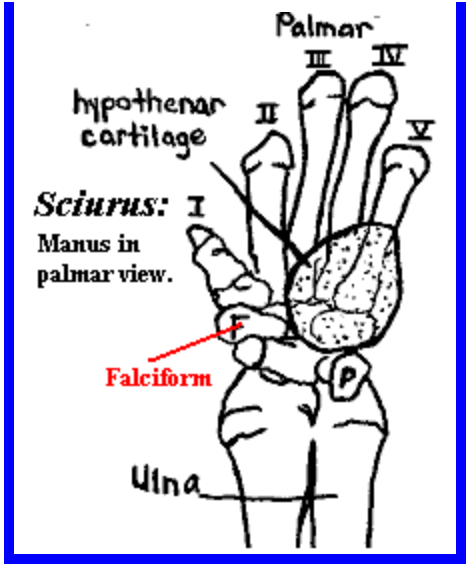
Falang Fm.: Late Ladinian (Middle Triassic) to Carnian (Late Triassic) of **Guizhou Province**, South China. The Falang Formation includes the Zhuganpo, Wayao (= Xiaowa) and Laishike Members, which are often (usually?) treated as separate formations. The Zhuganpo member includes extraordinary preservation of various sauropterygian fossils (e.g. *Keichousaurus*), as well as invertebrates (e.g. crinoids, brachiopods) from the latest Ladinian (**Post-Congress Excursion** and Holmes et al., 2008) or early Carnian (Lehrmann et al., 2004).



Falcate: same as *falciform*.

Falcate process: of the basioccipital. A sort of *faux* paroccipital process derived from the basioccipital and apparent mostly on the basicranium. Occurs in *Remingtonocetus* and other early whales.

Falciform L. *falx* = sickle, and *forma* = form. The falciform ligament has this



shape. The **falciform bone** is an ossification of the falciform ligament at the base of the thumb (manus I).

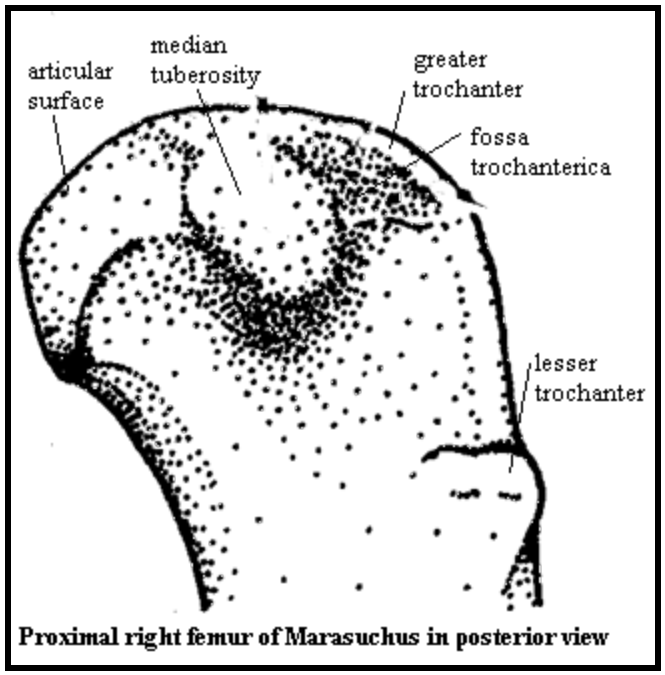
Famennian Age: Late Devonian. The last age of the *Devonian* Period, 364-354 Mya.

Fang pair: basal tetrapods frequently bore pairs of fangs on the inner row of bones in both the upper and lower jaw. In fact, these are not pairs of fangs, but rather a single fang and its replacement pit.

Fascia L. *fascia* = a ribbon or fillet.

Femoral: relating to the femur.

Femur: the upper leg bone. The femur articulates with the pelvis proximally and with the *tibia* (and, usually, the *fibula*) distally.



Proximal right femur of Marasuchus in posterior view

Fenestra: L. = window. Generally opening in a structure, especially bone.

Fenestra cochleae: same as the *fenestra rotunda*.

***Fenestra exonaria*:** the external nares, the "nostril." Thus, the anterior nares in non-choanates is the *fenestra exonaria anterior*.

***Fenestra ovalis*:** the oval window in the inner ear which communicates with the *stapes* or columella, and with the operculum if present. See **The Ear**.

***Fenestra pseudorotunda*:** a structure in reptiles functionally analogous to the fenestra rotunda of mammals, *i.e.* the distal end of the perilymphatic duct and lateral opening of the *recessus scala tympani*, where the remaining energy of a compression wave in the inner ear is dissipated. Fortunately -- for just such questions – we also have a small essay on the **inner ear in reptiles**. The *fenestra pseudorotunda* is created by walling off part of the metotic foramen into a specialized vagus foramen for the exit of various cranial nerves.

***Fenestra rotunda*:** the round window in the inner ear which relieves pressure in the inner ear. See **The Ear**.

***Fenestra vestibulae*:** same as *fenestra ovalis*.

Fermentation: digestion; the oxidation of carbohydrates to water, carbon dioxide and simple organics with the net production of ATP (adenosine-5'-triphosphate).

Fibrocartilage: cartilage containing collagen fibers; found in the intervertebral disks and pubic symphysis. Introduction to the skeletal system.

Fibula: the smaller and more lateral of the two lower leg bones.

Fibulare: the calcaneum of mammals.

Fish's Law: a "law" of evolution we have taken the liberty of naming for the work of Prof. Frank Fish (1998). We have devised the following useful mnemonic to assist in remembering the rule:

The style of locomotion lags the locus of the motion
So the motor muscle sequence is the same on land or ocean.

In other words, locomotion is conservative. Lifestyle, and even body form, tend to evolve faster than the basic hard-

wired locomotor patterns.

***Fissura Glaseri*:** same as petrotympanic fissure

fl. (abbrev.) *floriat.* Indicates the period of greatest success and diversity for a taxon.

Fleming Fjord formation: Late Triassic of Greenland. Dinosaurs, early mammaliforms. Sites: Tait Berg Beds (*Rhaetian*).

Flexor bone: an ossified flexor tendon serving as a third element of the distal limb (zeugopodium). See image at Chrysochloroidea.

Flexor muscles: the muscles which flex the digits of the fore- or hindlimb in tetrapods.

Floian Age: second age of the Early Ordovician, 479-472 Mya. *See* Floian.

Fluorapatite: a mineral found, *inter alia*, in the highly mineralized cap of shark's teeth. *See* apatite for an explanation of this remarkable class of minerals. Fluorapatite is slightly harder than hydroxyapatite, the more usual mineral component of bone, and less easily attacked by biochemical agents. In fact, the whole point of fluoridating public water supplies is to substitute fluoride ions for hydroxyl ions on the surface layer of human teeth in order to improve resistance to bacterial tooth decay.

Follicle L. *folliculus*, diminutive of *follis* = a bag.

Fontanel (fontanelle): an opening (usually medial) in the skull. As far as I can tell, there is no formal difference between fenestra, foramen and fontanels. "Foramen" is usually used when something (e.g. nerve, vessel, notochord) normally passes through the opening in life. "Fenestra" is usually used for paired openings. "Fontanel" is infrequently used and generally refers to an unpaired, mid-line opening.

Foramen L. *foramen* = an opening; from *forare* = to bore.

***Foramen magnum*:** the "big hole" in the occiput through which the spinal nerves enter the brain. See **The Braincase** and **The Occiput** for details.

Foramen ovale: see fenestra ovalis.

Foramen pseudorotundum*:** in spite of the name, it has nothing really to do with the ear. This is a foramen in the anterior lamina of the petrosal by which the maxillary branch of the trigeminal nerve (V) exits the braincase. ***But see *fenestra pseudorotunda, supra*.

***Foramen pseudovale*:** as with the *f. pseudorotundum*, this is unrelated to hearing. It is a foramen in the anterior lamina of the petrosal by which the mandibular branch of the trigeminal nerve (V) exits the braincase.

Fort Union Formation: Paleocene terrestrial? of Wyoming. Sites include the Gidley Quarry. Mammals.

Fossa L. *fossa* = a ditch. Used in anatomy for depressed areas.

***Fossa antorbitalis maxillaris*:** same as antorbital fossa.

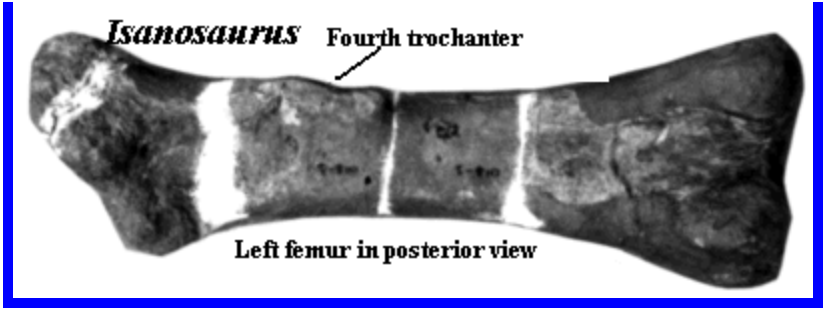
***Fossa incudis*:** a region of the petrosal which is recessed to hold the incus.

***Fossa trochanterica*:** a gap on the femoral head between the median tuberosity and the greater trochanter. See figure at *femur*.

Fossorial: burrowing habit, like moles, early snakes, etc.

Fourth tarsal: same as the cuboid for non-mammals.

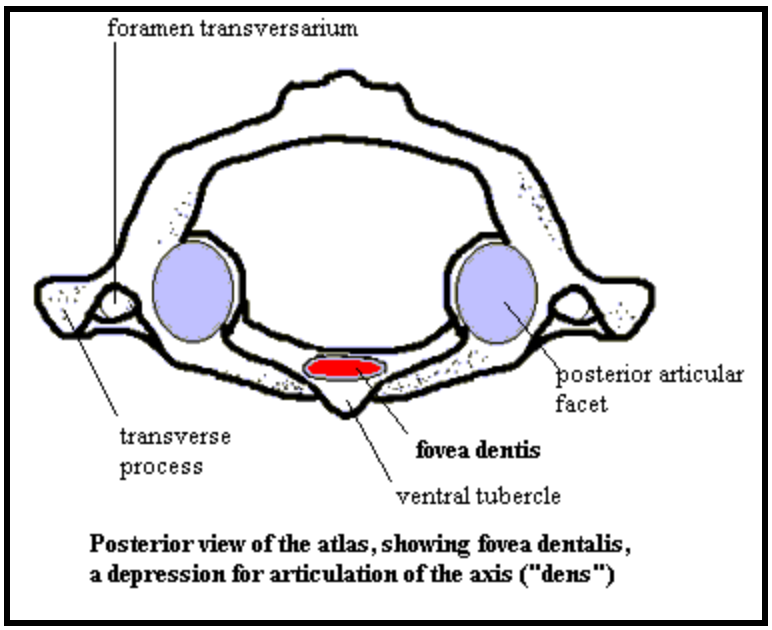
Fourth trochanter: a muscle attachment point, which lies on the inside surface of the femur in archosaurs. This is typically the attachment point



of the *m. caudofemoralis* which retracts the hind limb during the stance phase of locomotion.

Fovea L. *fovea* = a pit. In ophthalmology it applies to the central depression in the retina (**fovea centralis**) associated with particularly acute vision.

Fovea dentis: a depression on the inner, ventral surface of the atlas for the articulation of the axis ("dens"). See Image.



Posterior view of the atlas, showing fovea dentalis, a depression for articulation of the axis ("dens")

Fraenkelryggen Formation: from the Red Bay Group of Spitsbergen. Early Devonian (early to middle Lochkovian). Many jawless fishes including thelodonts, psammosteids, and heterostracans. Underlies the Ben Nevis Formation. Blom & Goujet (2002).

Francis Creek Shale: Late Carboniferous of Illinois, USA. Includes the famous *Mazon Creek* locations.

Frasnian Age: Late Devonian. The penultimate age of the *Devonian* Period, 377-367 Mya.

Friasian Age: South American Land Mammal Age corresponding to the Middle Miocene.

Frontal: One of the principal paired midline bones of the vertebrate skull. The frontals lie posterior to the nasals and anterior to the parietals, typically at the level of the orbits. In older (and some recent) papers on actinopterygian fishes, the term "frontal" refers to the parietal, due to a Nineteenth Century error in determining the homology of this bone. Although the error was pointed out by Westoll in 1943, many fish specialists have continued using the old terminology for the sake of consistency with the previous literature.

Frontate: of orbits, facing dorsally. Presumably so said because the line of vision then runs in the direction of the frontals. Many theropods, who are normally illustrated as looking down their snouts, might be better regarded as frontated so that their normal attitude would be with head down, looking over the bridge of the nose, so to speak.

Fulcral scales: or "Fringing fulcra." " ... special arrow-shaped scales ... on the leading edge of ... fins. Fringing fulcra are formed by fusion, side-by-side, of two adjacent elongated, diamond-shaped scales." Janvier (1996: 70).

Funnel pit: in most antiarch placoderms, a pit in dermal plate at the pectoral appendage ("arm") articulation containing the remaining scapulocoracoid structure. See image at *axillary foramen*.

Fusain: fossilized charcoal.

- G -

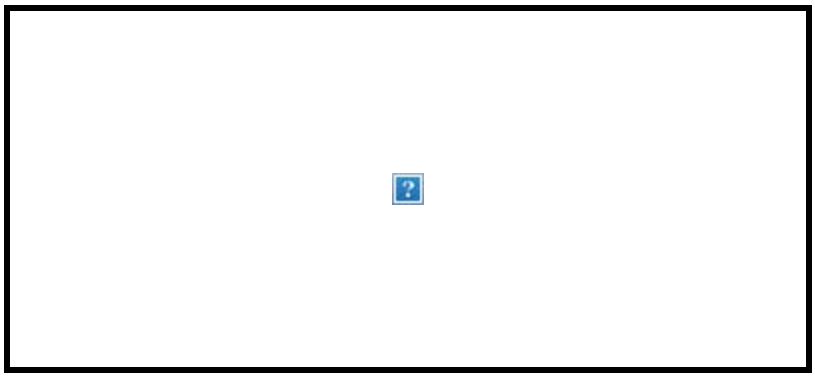
Galli, crista: see *Crista galli*.

Ganoid: a heavy form of enamel characteristic of the scales of various early fish and extant Polypteriformes.

Gashato Formation: Late Paleocene of Mongolia. Same as Khashaat Formation.

Gastric: relating to the stomach. **Gastric fermentation** is fermentation which occurs in the esophagus and stomach, as opposed to intestinal fermentation.

Gastrocentrous: a vertebral structure in which the neural spine rests on the pleurocentrum and the intercentra are reduced to spacer elements appearing as arches over the dorsal surface of the notochord between pleurocentra. See figure and note under Anthracosauroidea.



Gastrocnemius: a large superficial muscle of the leg which originates on the femur and inserts on the heel (calcaneum) via the Achilles tendon and acts to extend the foot.

Gastrocoel: See **Early Development Terms.**

Gastrolith: a stone deliberately swallowed by an organism (usually a herbivore, or an herbivore if east of the Azores) and retained in the gut to cut and crush bulk food items. Many organisms exercise great selectivity in selecting gastroliths of the right size, shape and composition. When gastroliths are worn smooth, they are sometimes regurgitated. Presumably long-necked forms, like sauropods, got their rocks off in some other manner.

Gastrosteges: A single row of wide ventral scales in snakes which are erected during locomotion to increase friction.

Gastrulation: the process by which the blastula is invaginated to form a double-walled hollow sphere of cells in *microlecithal* development. Alternatively, the stage of embryonic development characterized by formation of a gastrula or its equivalent. The process is illustrated graphically in computer simulation. Conceptually, the blastula is a weakly inflated ball. Gastrulation is analogous to poking a finger into the ball at one point until the ball folds down around the finger. The cells surrounding the invaginated "finger" become the inner layer of a new double-walled sphere. The internal cavity thus formed is the *archenteron*. The entrance to the cavity, i.e. the base of the "finger," is the *blastopore*. The cell layer forming the outer wall is the **epiblast** and is generally fated to become *ectoderm*. The cell layer forming the inner wall is the **hypoblast** and is generally fated to become endoderm. Mesoderm forms in the former blastocoel, between the endodermal and ectodermal cell layers, particularly at the tip of the invaginating archenteron. In mesolecithal embryos, the case is similar. See Gastrulation II. See Atlas of *Xenopus* embryogenesis and subsequent figures. Mammalian gastrulation is similar to *macrolecithal* development. However, on this topic, I defer to Embryo Images Online - Unit 1 - Body Form. See also, **Early Development Terms**.

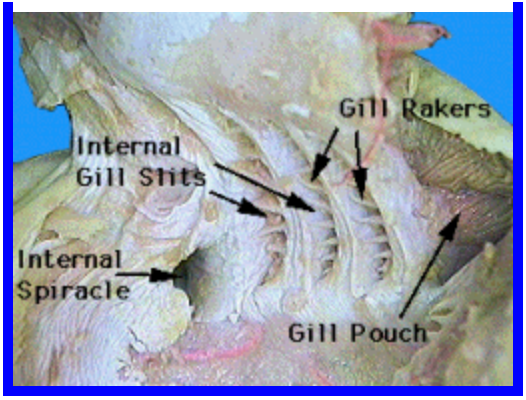
Gauja Formation: variously dated as Givetian or Frasnian of Latvia (probably Givetian). Reddish brown or -yellow sandstone and siltstone. Low energy fresh water environment. Various sarcopterygians and antiarch placoderms. Comparable fauna to Escuminac Formation, but with the addition of psammosteids. Vorobyeva (1980), Ahlberg *et al*. (2000); Forey *et al*. (2000).

Gedinnian: same as Lochkovian.

Geniculate: bent abruptly at an angle, normally a right angle. The reference is to *L. genu* = knee (closely related to Gr. κνηη [*cneme*] = knee), as the bending of the leg at the knee (hence *genuflect* and similar words).

Ghost lineage: a phylogenetic lineage that is inferred to exist but has no fossil record. This sort of thing is one of the results -- and success stories -- of phylogenetic taxonomy, i.e. cladistics. For example, cladistic analysis demonstrated that birds must have derived from advanced theropods. Yet, the only advanced theropods were known from the Late Cretaceous, while *Archaeopteryx* -- clearly a bird -- was known from the Latest Jurassic. The necessary implication was that advanced theropods had been around for almost 70 My before the first known fossil evidence of their existence! This was far too much ectoplasmic ancestry for most of us to swallow even in the mid-1990's. But, with the products of the Great Chinese Feather Factory now before us, the gap is much smaller and there are few doubters left.

Gill rakers: "one of a series of variously shaped bony or cartilaginous projections on the inner side of the branchial arch. The rakers have



epithelial denticles and both their gross and fine structure serves to retain food particles in the mouth. The gill raker count normally includes all rakers, even the rudiments, and is made on the front half of the first arch. Upper and lower gill raker counts may be presented as the upper and the lower (including the central raker), e.g. 9 + 17; or as upper rakers, central raker, and lower rakers, e.g. 9 + 1 + 16. The most anterior and posterior rakers are often small and delicate, easily torn or lost if the arch is removed. Plankton feeders have numerous, crowded, elongate and fine rakers while predators have few, separated, short and stubby rakers." Dictionary of Ichthyology (former site). Fishes which eat large prey such as other fishes and mollusks have short, widely spaced gill rakers. This type of gill raker prevents the prey item from escaping between the gills. The gill rakers of the Blue Mackerel are like this. Fishes which eat smaller prey have longer, thinner and more numerous gill rakers. Species which feed on plankton and other tiny suspended matter have the longest, thinnest and most numerous gill rakers, with some species having over 150 on the lower arch alone. Fish Dissection - Gill rakers

Ginglymoid: of a joint, hinge-like.

Glauconite: A monoclinic mineral, $4[(K,Na)(Fe^{3+}, Al, Mg)_2 (Si, Al)_4 O_{10} (OH)_2]$; mica group; basal cleavage; dull, light to dark green; soft; a common authigenic mineral in marine sediments, useful for radiometric ages for host rocks. Sometimes called greensand. Cetacean remains are often associated with glauconitic sediments.

Glaserian fissure: same as petrotympanic fissure.

Glenoid (cavity): [1] the shallow cavity of the upper part of the scapula by which the humerus articulates with the pectoral girdle. **[2]** Also used to refer to the similar cavity in the squamosal (in mammals) or quadrate (in most other vertebrates) forming the jaw joint.

Glenoid fossa: same as *glenoid*, but almost always referring to the jaw joint.

Glove finger: in mysticete whales, a membrane which forms the inner part of the fibrous plug occluding the external auditory meatus. The glove finger is attached to the ectotympanic ring and the squamosal. Luo (1998).

Gluteal Gr. *gloutos* = buttocks

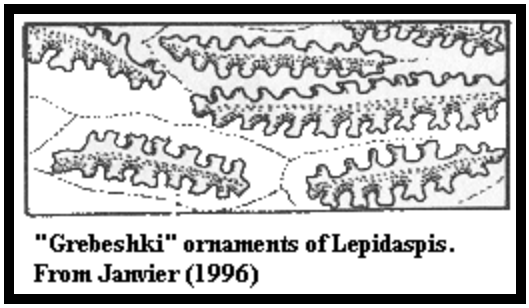
Gnathal: relating to the jaw.

Gracile: slight, slender, small, light-weight, thin etc. Opposite of robust or massive. Gracile is best used to describe something which may be thinner and less massive than the object to which it may be compared, but retains a similar overall form and dimensions. Thus, a cheetah is more gracile than a tiger, but a house cat is just smaller.

Gravel: particles of rock or sediment more than 2 mm in diameter. See *sand, silt, clay*.

Greater trochanter: a trochanter located on the dorsolateral "corner" of the femoral head. See figures at *femur* and *trochanter*.

Grebeshki: a peculiar type of ornamentation found on the armor of heterostracans, sometimes referred to as "oak-leaf shaped," for which no good English word applies. Clearly, they don't look much like oak leaves -- perhaps more like priapulid worms. For lack of reasonable alternatives, we adopt the Russian term "гребешки" used by Novitskaya (1986). Literally, this means "crista" or "ridge". However, it is almost the same as the Russian word for "scallop." Since these are, for a fact, scalloped ridges, the term is doubly appropriate.


"Grebeshki" ornaments of Lepidaspis. From Janvier (1996)

Grès de Luxembourg: Jurassic of Luxembourg and Belgium. Marine bay.

Guettioua Formation: late Middle Jurassic (Bathonian - Callovian) of Morocco. Part of the Couches Rouge (Red

Beds) of the Atlas Mountains. These are terrestrial exposures which overlie and interbed with marine carbonate facies. Monbaron *et al*. (1999). These authors state: "The environment suggested by the Guettioua formation is that of a vast plain close to sea level traversed by powerful rivers with anastomosing channels. The clastic load (principally pelites [lithified mudstone] and sand, with occasional stringers of pebbles) accumulated in the form of cross-bedded channel deposits."

Guild: Like a good many ecological terms, "guild" is intellectually interesting and productive, but almost impossible to define with any precision. If the ecological term "niche" can be compared to a species, the guild is a family. It consists of a group of similar niches which can be filled by organisms with the same general way of life, *e.g.*, "large-bodied ambush hunters," "fossorial selective herbivores." There is a vague and much-contested correlation between adaptive radiations of organisms and ecological guilds, so the family-guild connection is not entirely specious (but *speciose!)*. Thus, for example, in a moment of incautious speculation, these Notes speak of early dinosaurs moving into certain guilds. This makes a certain amount of theoretical sense, since the distance between niches in a guild is presumably large enough to maintain species stability, but small enough to permit adaptive radiation over reasonably short periods of geologic time. The word also carries the implication that there is substantial gap between guilds – much larger than the gap between niches. If so, we ought perhaps to avoid describing guilds by reference to things like body size, which are continuous attributes of the organisms occupying the guild, rather than fairly sharp discontinuities in ecospace. However, this tradition is rather strong.

Guimarota: a coal mine in Portugal with a well-known Late Jurassic (*Kimmeridgian*) fauna, ~152 Mya.

Gulars: Bones lying between the two halves of the lower jaw in certain fishes. See **The Gulars** for a brief discussion and diagrams.

Gull River Formation: Middle Ordovician of Canada. Astraspidae, Thelodontida. Sansom & Elliott (2002).

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Glossary: H-I

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-H-

Habib Rahi Formation: Middle Eocene (Lutetian) of Pakistan. Marine. Gingerich *et al*. (2001).

Haeckel's Law: ontogeny recapitulates phylogeny. Neither true nor false, Haeckel's Law remains an important tool in understanding and analyzing phylogenetic problems.

Hair cell: a mechanosensory cell characterized by the presence of microvilli. When the microvilli are deformed by mechanical pressure or vibration, the cell increases or decreases the rate at which it sends an electrical signal to the nerve cell with which it is coupled. Hair cells frequently are highly directional. If the villi are bent on one direction, the rate of discharge increases. In the opposite direction, the rate decreases. If the villi are deformed at right angles to this axis, there may be no change in the signal. Hair cells are the basic cellular unit involved in hearing, in the labyrinth (balance organ), and in the lateral line system of fish.

Halite: a mineral composed mainly of table salt. NaCl.

Hallux: digit 1 of the foot in birds, normally reversed to point posteriorly, presumably as an adaptation for perching, rather than out of sheer perversity. Digits are counted from medial to lateral, so this is the big toe.

Hamular: hook-shaped.

Harding Sandstone: Late Ordovician (Sandbian) of North America (Colorado). Vertebrate microfossils, including Astraspidae, *Eriptychius*, and possibly thelodonts and sharks. Sansom *et al*. (1996).

Harudi Formation: Middle Eocene (Lutetian) of far western India (Gujarat). Bajpai & Thewissen (1998). *Remingtonocetus*

Hauterivian: an age of the Early Cretaceous about 132-127 Mya.

Haversian Canal: the central canal in an osteon. The *Haversian system* refers to the organization of advanced vertebrate bones characterized by osteon units.

Haymana Basin: Late Cretaceous to Pliocene of Turkey (Central Anatolia). Forearc accretionary basin sediments

accumulated during closure of Tethys Sea along its Northern margin. Mammals.

Heath Formation: Early Carboniferous of Montana, part of the Big Snowy Group. Mostly near-shore marine, near a very arid terrestrial environment (about 10° S paleolatitude) with little or no fresh water contribution. Includes the Bear Gulch Limestone. May extend geographically south into the Dakotas and temporally into the Late Carboniferous.

Hell Creek Formation: Late Cretaceous (Maastrichtian) of Montana. Dinosaurs, birds, multituberculates, crocs, turtles & champsosaurs.

Hemapophysis: The second element in each half of a hemal arch, corresponding to the sternal part of a rib. In Paleozoic chondrichthyans, hemapophyses are frequently present in the tail and for an important part of the attachments for basals and radial elements forming the ventral tail lobe. See Orodontida.

Hemochorial placenta: type of a chorioallantoic placenta in which the villi are in direct contact with maternal blood supply.

Hendricks Formation: Early Silurian (Llandovery) of North America (Wisconsin), Burnt Bluff Group. Coral-stromatoporoid intertidal environment found as wackestone. Thelodont scales. Turner *et al*. (1999).

Hepatic: relating to the liver.

Hepatic diverticulum: an evagination of the embryonic gut (i.e. the endoderm) which invades the surrounding *coelom* and, specifically, the *transverse septum*. The diverticulum develops into the liver and tastes revolting, although it is quite good for you and may remain fairly diverting with spinach and crisp bacon, accompanied by a reasonably mature Merlot.

Heterocercal: same as *epicercal*, according to some sources, or (perhaps better) referring to the condition in which the caudal fin is asymmetric as either epicercal or hypocercal. See PPT Slide.

Heterodactyl: a specialized digital configuration in birds in which both digits 1 and 2 are reversed.

Heterodont: bearing teeth of more than one sort. The shapes may change progressively or abruptly. The term is usually used to imply more than a change in size. Humans have heterodont dentitions, consisting of incisors, a canine, premolars, and molars.

Heterothermy: metabolic temperature regulation, but regulation is imprecise or variable.

Hirnantian Age: third and last age of the Late Ordovician, 446-444 Mya. *See* Hirnantian.

Histo-: Greek root meaning tissue. Supposedly derived from a word meaning *web* or *loom*.

Histogenesis: development of tissues; differentiation of tissue types in development.

Histology: study of the structure of biological tissues.

Holocephalic: (or **holocephalous**) of ribs, having one head. That is, having a single articulation with the vertebrae, as opposed to *dichocephalic* or *dichocephalous*, having two articulations.

Holospondyly: a condition in which all of the vertebral elements are fused. Opposite of *aspidospondyly*. Sometime used in a more restricted sense to mean the condition in which there is only one centrum per vertebra, rather than separate pleurocentra and intercentra.

Holostylic: a type of jaw suspension in which the palatoquadrate is fused to the braincase.

Holotype: A single specimen designated as the name-bearing type of a species or subspecies when it was established, or the single specimen on which such a taxon was based when no type was specified.

Homeobox: The DNA sequence that codes the homeodomain. See *homeodomain*.

Homeodomain: "the homeobox [sic] is a 60-amino acid helix-turn-helix motif that acts as a DNA-binding domain.

Homeobox-containing genes are usually involved in developmental processes, such as embryonic patterning, organogenesis, and/or cell differentiation." Lanctôt, *et al.* (1999: 1416). This is succinct and (with one glaring exception) technically correct, but a horrible definition for beginners. To add at least a little background, note the following: (1) this is actually the definition of the homeo*domain* -- one of many known protein structures that bind DNA. The "homeo*box*" is the DNA sequence which codes for this protein fragment. The current generation of molecular biologists is incredibly sloppy in failing to distinguish between (a) the gene (including all regulatory sequences), (b) the DNA coding sequence, (c) the RNA transcript (including exons, introns, etc.), (d) the ultimate mRNA, (d) the translated polypeptide, and (e) the final functional protein (with subunits, modified side-chains, etc.). These are *critical* differences, and it is important that one knows exactly which one is meant. Actually, the homeodomain is none of the above. It is a "motif," a sequence of amino acids found, with minor variations, in many proteins. (2) The "helix" referred to is the well-known alpha helix formed in any number of protein sequences. A simplified explanation can be found at PPS 96' - Alpha-Helix Geometry Part. 2. (3) The homeodomain seems to bind DNA without much specificity except that it requires a TAAT sequence [interestingly, and not coincidentally, RNA polymerases use the sequence TAATAA to locate the transcription initiation site]. (4) Homeodomain- containing proteins also contain a *third* alpha- helical segment which supplies the detailed sequence specificity. The homeodomain segment simply aligns the protein in the groove of the DNA double helix so that the protein's "recognition helix" is brought into contact with the base pairs of the DNA. The recognition helix is structured so that it binds only to specific sequences of DNA bases.

Homocercal: of caudal fins, having the lower and upper fin lobes of approximately the same size and shape.

Homodont: All teeth in the jaws are of the same shape, although they may be of slightly different proportions and quite different sizes.

Homology: the relationship between structures in different organisms which are united by modification of the same structure, gene or set of genes of a common ancestor. Examples: whale caudal fins, lizard tails, bird pygostyles and the human coccyx are homologues. As contrasted with **analogy**, the relationship of two structures, genes or gene sets that are related by present structural or functional similarity without regard to phylogeny. Dolphins and ichthyosaurs share many analogous functional units, although their last common ancestor was likely a terrestrial proto-lizard. Both factors may be acting at once. Thus, prosauropods and sauropods had a sauropodomorph last common ancestor in the mid-Triassic. They diverged, but both developed quadrupedal gigantism of a similar type *convergently*, presumably in response to similar ecological pressures.

The strict Patterson formalism for homology requires that possible homologues satisfy the tests of similarity, congruence and conjunction. These tests can be summarized as follows: *Similarity*: Each homologue must have the same 1:1 topographical relationship with other structures. In practice, we may add "or a really good developmental explanation of why it differs." *Congruence*: The presence of the homologous character must be congruent with the cladogram. That is, the homology must be a synapomorphy of some clade. *Conjunction*: If two structures are homologous, then both can never appear in the same organism. See, e.g., Wittmer (1995).

Homoplasy: a character which is shared by two taxa, but not by their common ancestor. That is, it arose independently in the two lineages and represents a convergence.

Honda Group: Middle Miocene of Columbia. Cifelli & Villarroel (1997).

Hornerstown Formation: Late Cretaceous (Maastrichtian) or Early Paleocene of New Jersey, USA. The "Main Fossiliferous Layer" is apparently terminal Maastrichtian. Glauconite greensands. Livezey (1997); Olson & Parris (1987). *Anatalavis*

Horseshoe Canyon Formation: Late Cretaceous (early Maastrichtian) of Alberta, Canada. Holtz (2001a).

Huayquerian Age: South American Land Mammal Age corresponding to the Late Miocene.

Humerus: Nature's way of connecting the forearm to the shoulder. Sadly, this is an incredibly complicated bone and has been given its own page. See **Humerus**.

Hunter-Schreger bands: in mammalian dentition, the enamel layer is acellular, being made up of closely packed, hydroxyapatite crystallites (? how does this differ from a crystal?) laid down by ameloblast cells in the form of enamel "prisms" or rods, which are arranged more or less at 90° to the surface of the tooth. It's the "more or less" that

leads to the formation of bands. Alternating layers of enamel rods make roughly equal and opposite departures from this angle. The crystallites are literally "prisms" in their effect on light. As a result, the different layers show up as alternating light and dark bands under polarized light. These are the Hunter-Schreger bands. One might speculate that this is also why clean, healthy teeth literally "gleam" under appropriate circumstances (such as under the powerfully suggestive influence of low lighting and pheromones). See An Atlas and Practical Guide to Histology.

Hyaline cartilage: cartilage with a clear translucent matrix; found primarily on the ends of ribs and on the trachea. Introduction to the skeletal system; lab7 photos

Hydroxyapatite: the form of apatite in which the monovalent ion is the hydroxyl (OH ¨) ion. See long-winded explanation at apatite.

Hyoid Arch: the second hypothetical ancestral gill arch, from which derives the *hyomandibula* and other elements of the splanchnocranium. See **Gill Arches**.

Hyodont: of teeth, not ankylosed to the jaw.

Hyomandibula (= *hyomandibular*)**:** the upper (epal) main element of the hyoid arch. The same bone as the stapes, columella, and epihyal. See **Gill Arches**.

Hyostylic: a form of jaw suspension (*e.g.* in elasmobranchs and teleostomes) in which the upper jaw loses any major direct connection with the braincase and the upper and lower jaws are supported solely by the hyomandibula. Introduction to the skeletal system.

Hypantrum: see *hyposphene-hypantrum*

Hypapophysis: a ventral "spine" or keel on a vertebra. See Axial Skeleton.

Hyperphalangy: the condition of having numerous additional phalanges (toe or finger bones).

Hypoblast: see *Gastrulation*.

Hypobranchial: in fishes, small gill arch elements which forms joints between the main ventral elements, the ceratobranchials, and the basibranchials, which are usually fused or tightly bound to the ventral aspect of the pharynx (throat).

Hypocaudal lobe: the part of the caudal fin below the notochord.

Hypocercal: caudal fin structure in which the notochord or vertebral centra extend only into the lower fin lobe.

Hypochordal: [1] of a fin, same as *hypocercal*, but refers expressly to the notochord. **[2]** of a fin lobe, the caudal fin lobe below the notochord.

Hypocleidium: an enlarged, flattened ventral area of the furcula at the distal end, formed by the fused clavicles. The *pectoralis* muscle attaches, in part, to the hypocleidium (if present).

Hypocone: The main cone on the talon (distolingual extension) of a mammalian (tribosphenic) upper molar. See **Molars**, or figure at *mesostyle*.

Hypoconid: in mammalian dentition, on the lower molars, the buccal main cusp of the talonid. In a quadrate-type molar, this would be the buccodistal main cusp. I understand there is an alternate system of nomenclature in which the terms *hypoconid* and *entoconid* are reversed and the hypoconid is the lingual main cusp of the talonid, i.e. what is referred to in these Notes as the entoconid. See Teeth, diastema lengths.

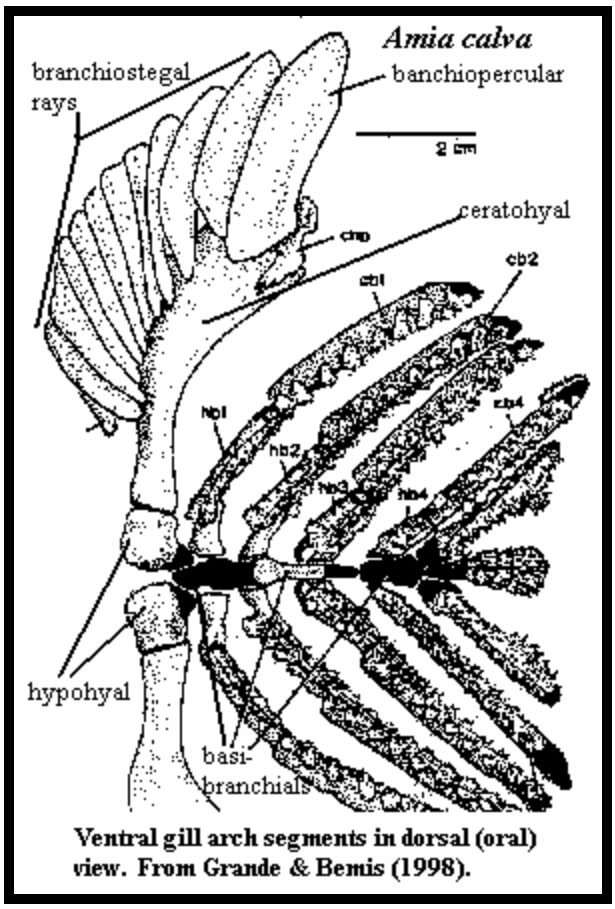
Hypoconule: in mammalian dentition. Apparently, this is the same as the *metaconule*, that is, a small cusp on an upper molar lying near the line between the *protocone* (the lingual main cusp) and the *metacone* (the distal main cusp). If the line is marked by a ridge, the ridge is the *postprotocrista*. By "main cusp," I mean one of the large cusps defining the vertices of the trigon. See figure at *mesostyle*.

Hypoconulid: in mammalian dentition, a cuspule (accessory cusp) usually located near the distal (posterior) edge of a

lower molar. See **Molars**.

Hypoglossal foramen: the foramen for the exit of the *hypoglossal nerve*, usually located near the base of the occipital condyle. The hypoglossal nerve may also exit as part of the jugular or vagus foramen, or (from the *scala tympani*) in or near the metotic foramen.

Hypoglossal nerve: The XIIth cranial nerve, with both sensory & motor fibers. Enervates , *e.g.*, base of tongue.



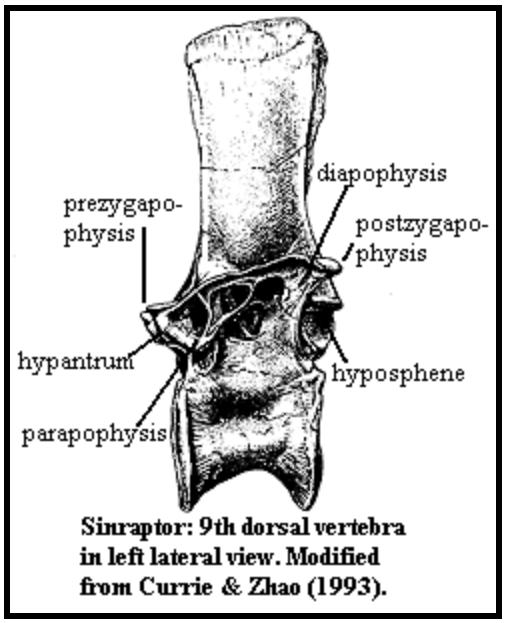
Ventral gill arch segments in dorsal (oral) view. From Grande & Bemis (1998).

Hypohyal: in fishes, the hypohyal is a ventral element of the hyoid arch which links the ceratohyal and the basihyal. The gill arches have two basic parts, dorsal and ventral. Each part is associated with a main gill arch segment, the (dorsal) *epal* and (ventral) *ceratal* segments, respectively. Thus, each of the *branchial arches*, the arches which actually function as respiratory arches in fishes, has an epibranchial and a *ceratobranchial*. The *hyoid arch* is a an additional arch anterior to the first branchial arch. The hyoid is often involved in respiration, but its primary functions are related to jaw support and extension. The ceratal and epal segments of this arch are called the *ceratohyal* and the *hyomandibula*, respectively. Most gnathostomes also have some kind of ventral extension of the gill arches, a basal component, and these usually lie flat along the ventral "throat" of the fish. The basal elements of adjacent arches are often closely interlocked, or even fused. The basal element of the hyoid arch, the *basihyal*, is no exception. The ceratal segment is typically long and relatively rigid and partially vertical, while the basal elements are typically fused and/or tightly bound to the base of the gullet in a horizontal orientation. Keeping these elements in articulation as they move in different planes requires a complex joint. This joint is normally supplied by a small element of complex shape. This element is the *hypobranchial* or, in the case of the hyoid arch, the *hypohyal*. *See* **Hypohyal**.

Hypolophid: in mammalian dentition, a cutting edge running generally along the buccal side of the talonid of a lower lophodont molar. See image at lophodont and **Molars**.

Hypomere: See **Early Development Terms**.

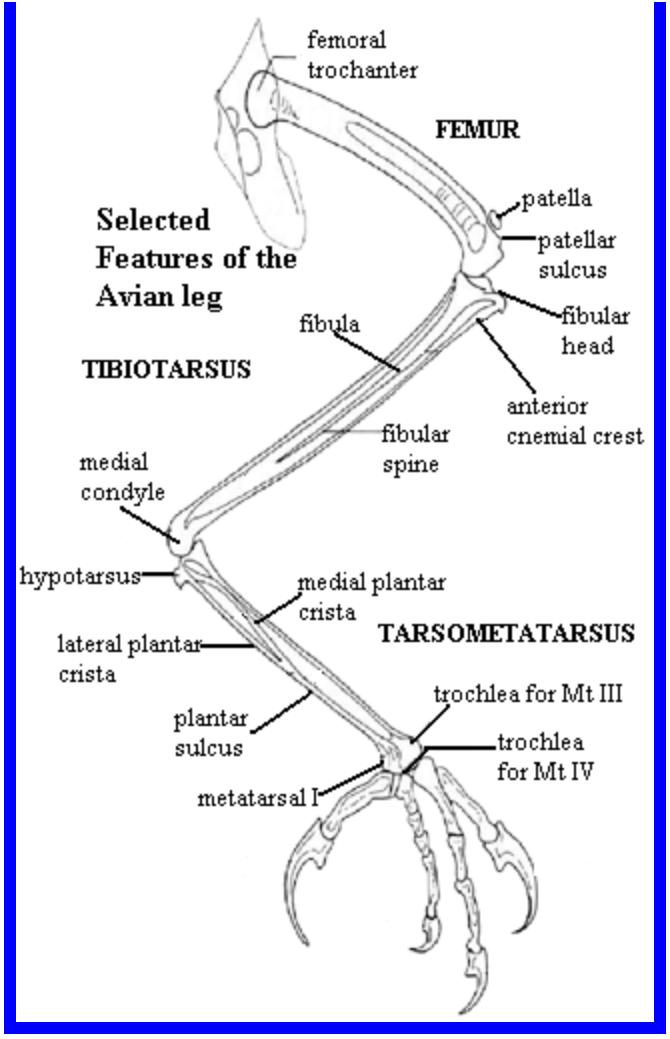
Hyposphene-hypantrum articulation: "In many primitive theropods (the Triassic *Coelophysis*, for example) and allosaurs the pre-zygapophyses surfaces have two distinct articular planes: 1) the primary zygapophysis, a surface facing mostly upward and inward; and 2) a hypantrum, a surface facing mostly inward and downward. The right and left hypantra enclose a narrow triangular space below and between the primary joint surface of the zygapophyses. Into this space fits the hyposphene on the posterior of the preceding vertebra. Hyposphene-hypantra joints increase the backbone rigidity - the vertebra can flex side-to-side and up-and-down but cannot twist at all...." Megalosaurid Dinosaurs from the Late Jurassic [site defunct] [Siegwarth, JD, RA Lindbeck, PD Redman, EH Southwell, & RT Bakker (1999?)] See figure at right and also figure at *zygapohysis*.



Sinraptor: 9th dorsal vertebra in left lateral view. Modified from Currie & Zhao (1993).

Hypostyle: A stylar cusp near the buccomesial corner of an upper tribosphenic molar. See figure at *mesostyle*.

Hypotarsus: in birds, a ridge or process located on the posterior side of the tarsometatarsus, near the proximal end. It may be derived from the calcaneum. The hypotarsus is the attachment point for the



posterior cruciate ligament, which originates on the posterodorsal part of the intercondylar groove of the femur (just about opposite the patellar sulcus). See Ch 1-5. Image adapted from Topographische Anatomie der Hintergliedmaße beim Habicht (....

Hypsodont: having teeth with high crowns (cusps). Hypsodont dentition is associated with a diet of abrasive foods. Hypsodont teeth are frequently ever-growing. See The Diversity of Cheek Teeth. Opposite of brachydont.

Hypural: in fish anatomy, one of the flattened, fused bony hemal spines fanning out at the base of the caudal fin and bearing caudal rays. *Amia* has 10 hypurals, *Salmo* 7 but in most teleosts the number is reduced or fused into a single structure, the urostyle. (from the Dictionary of Ichthyology). See image at urodermal.

Hypurapophysis: see *parhypural*.

- I -

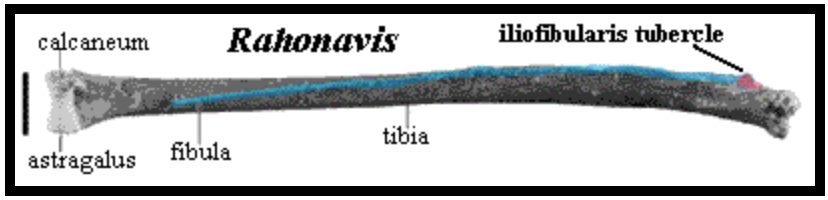
I/i: in mammalian dentition either an upper (I) or lower (i) incisor. In English grammar, the nominative case of the first person singular pronoun (I) or, in the case of the poet e.e. cummings or one of his many imitators, (i).

Iliac: pertaining to the ilium

Iliac peduncle: the ilium often has two peduncles (ventral processes) which come down on either side of the acetabulum to form the sides of the acetabulum and meet the pubis and ischium. These are referred to as the pubic peduncle and the ischiac peduncle (or, sometimes, *pedicle*). By analogy, if the pubis or ischium have dorsal process which come up to meet the ilium, this structure is referred to as an *iliac peduncle*.

Iliofemoralis: The *m. iliofemoralis* is a muscle of variable importance which, as the name implies, originates on the ilium and inserts on the lateral femur. Hutchinson & Gatesy (2000). In turtles, the muscle is rather massive and inserts on an almost unique structure, the trochanter major. A similar, conceivably homologous, structure is found in some pachypleurosaurs. Carroll & Gaskill (1985). In birds, the anatomy is complicated by terminology. The reptile iliofemoralis is the *m. iliotrochantericus caudalis* and the *iliofemoralis externus* of birds, while the muscle called the "iliofemoralis internus" is the homologue of one of the several reptile *mm. puboischiofemoralis*. Carrano & Hutchinson (2002). Primitively, the origin is above the acetabulum, but it is moved far forward in most archosaurs, where it starts on and under the anterior iliac blade (*id*.; Currie & Zhao, 1993) and inserts on the internal trochanter (Hutchinson, 2001a). It generally acts to raise or abduct the femur. However, in cynodonts, due to the different geometry of the femur, it came to act as a retractor (Carroll, 1988), with a tendon running through a notch in the *supraacetabular buttress* (Surkov *et al*. 2005). Eventually (in mammals) it was absorbed into the gluteal musculature. Carroll (1988).

Iliofibularis tubercle: the ***m. iliofibularis*** is a muscle originating high on the ilium, posterior to the acetabulum, often involved in flexing the lower leg. It inserts on the fibula, near the proximal end. The point of insertion may be marked only by a rugose (roughened) patch.



However, it may also insertion a more or less prominent tubercle, the iliofibularis tubercle, or even an **iliofibularis trochanter**. This seems to be the same thing as the *anterior trochanter of the fibula*.

Iliotrochantericus: a deep, relatively small muscle of the pelvis, normally (in birds) with separate cranial & caudal origins on the lateral face of the ilium. Both heads insert on the femoral trochanter and presumably act as protractors and/or to stabilize the femur.

Ilium L. *ilium* = the flank and the iliac bone. The dorsal bone of the three bones forming the pelvis. The ilium supports the sacrum. Originally so called because the small intestines are largely supported by this bone, and the old term for the small intestines was ilia (plural of *ilium*). See figure at *antitrochanter*.

Imbricating: overlapping. Sometimes used simply to indicate a complex pattern made up of small parts.

Impedance: acoustic impedance is the resistance of a medium to the propagation of sound, and is largely a function of density and the speed of sound in the medium. In a slightly different sense, it is a measure of the resistance of an interface to the propagation of sound from one medium to the next. See **The Ear**.

Incisive foramen: a foramen in the palatal process of the premaxilla just posterior to the incisors.

Incisor L. *incidere* = to cut into; from *in* = in, and *caedere* = to cut. Applied to the cutting teeth of the anterior jaw.

Incisure (= **incisura**): [L *incidere* to cut into] a cut, notch, or incision; a general term for an indentation or depression.

Incrassate: of teeth, labiolingually expanded.

Incudomalleal joint: the joint between the malleus and incus in the middle ear of mammals. See The Incus.

Incus L. *incus (incudis)* = anvil. The quadrate, when it is exapted as an auditory ossicle in mammals. See The Incus.

Incumbent: Lying, leaning, or resting on something else: *incumbent rock strata.*

Induan Age: The first Age of the Early Triassic, about 248-245 Mya. Probable age of the *Lystrosaurus* Zone of the Karoo and elsewhere. See Induan

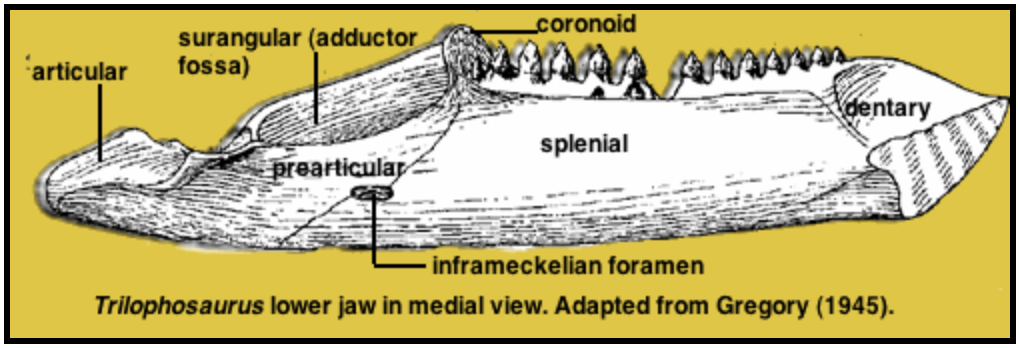
Induced drag: no, this has nothing to do with cross-dressing. Induced drag is drag created incident to the production of lift. See Induced Drag.

Inferognathal: (adj) relating to the lower jaw; (n) bone "tooth" plate(s) on the lower jaw of placoderms.

Infradentary: a serially homologous group of bones ventral to the dentary. Basally, they are long bones running generally anterior to posterior, but at an angle to the line of the dentary. InOsteolepiformes and, progressively, in tetrapods they obey Williston's Law very nicely. That is the originally serially homologous group becomes fewer in number and more specialized. The most dorsal member (sometimes not considered an infradentary) is the surangular. This is followed by the angular and the splenials (if any). *See* image at **Surangular**.

Infrahemal: autogenous spines distal to the hemal arches.

Inframeckelian Foramen: a small foramen on the inner surface of the lower jaw, normally located on the suture between the splenial and prearticular and (as you may have guessed) below the level of the Meckelian cartilage.



Trilophosaurus lower jaw in medial view. Adapted from Gregory (1945).

Infundibulum: Any of various funnel-shaped bodily passages, openings, structures, or parts, especially: **a.** The stalk of the pituitary gland. **b.** The calyx of a kidney. **c.** The ovarian opening of a fallopian tube.

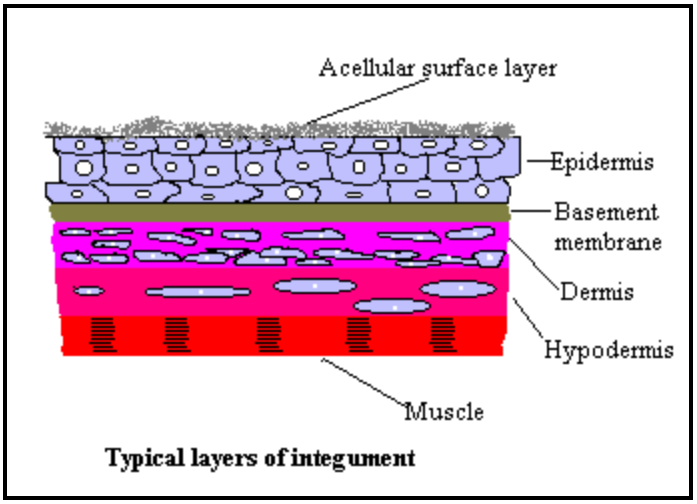
With respect to dentition, it refers to an infolded area on the occlusal surface.

Inguinal L. *inguen* = groin.

Innominate: In mammals, the hip bone, consisting of three consolidated bones, the ilium, ischium, and pubis.

Insertion L. *in* = in, and *serere* = to put. Hence, the point of attachment of a muscle in the more movable of the two structures which it joins.

Integument: skin. A typical arrangement of dermis is shown in the figure. The outer, usually acellular, layer may be composed of scales, cuticular material, mucous, etc. The columnar epithelial layer may contain invaginations forming numerous structures including hair or feather roots, endocrine or exocrine glands, sensory structures, tattoos, and so on. The epithelium is an ectodermal structure, and its inner boundary is almost always marked by a fibrous basement layer (which has additional microstructure not discussed here). The dermis is formed from mesenchyme and/or mesoderm. The dermis produces and supported the production of dermal bones and osteoderms. The hypoderm is a transitional layer of loosely linked connective tissue and subcutaneous (adipose) fat. Finally, the integument is generally bound, as a unit, to the body wall musculature. For development, see *epidermis* and *dermis* entries.



Typical layers of integument

Intercalarium: an occipital bone of actinopterygian fishes and one of the Weberian ossicles in Otophysi. *See also* image at claustrum.

Intercentrum: the vertebral *centrum* associated with the *interneural arches*, if present. The intercentrum is formed in the center of each *myomere* and is thus formed by a single myomere, as opposed to the *pleurocentrum*, which is formed between two adjacent myomeres.

Interdorsal: "There are primitively two pairs of [*metamerically* arranged *endoskeletal*] elements in each metamere and on each side [of the *notochord*]: the **interdorsals** and basidorsals. In the gnathostomes, there are two additional pairs ventrally to the notochord: the interventrals and basiventrals. These elements are called arcualia and can fuse to a notochordal calcification, the *centrum*. The ensemble of the arcualia + centrum is the vertebra, and the ensemble of the vertebrae is the vertebral column." See Vertebrata (Phillipe Janvier).

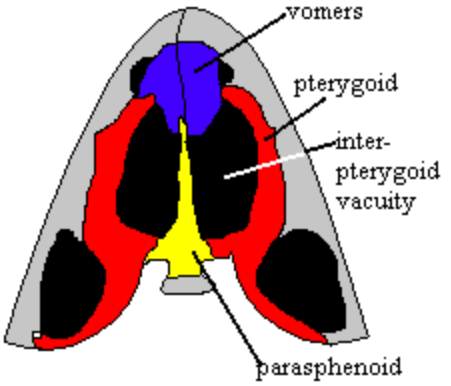
Intermediate mesoderm: See **Early Development Terms**.

Intermedium: one of the proximal carpal bones of the wrist. See figure at *carpus*.

***Internal* ____ :** for most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

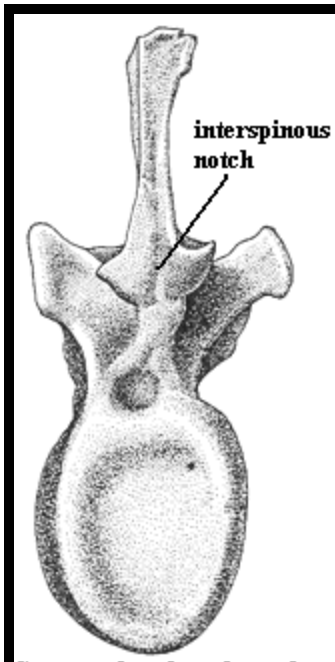
Interneural arch: In the earliest vertebrates, it is supposed that each embryonic segment (*myomere*) of the spine contained two dorsal arches -- or actually one arch and two half-arches. One arch developed in the middle of the segment. At **each** end of the segment another arch was formed which fused with the arch forming at the end of the adjoining segment. With breathtaking illogic, the arches in the middle of each segment are referred to as interneural arches. The arches formed between two segments are then, by default, the *neural arches*.

Interpterygoid vacuity: an open palate. See image. That is, a palate with open space between the pterygoids and the anterior ("cultriform") process of the parasphenoid. Not to be confused with the choanae, which are the posterior nasal openings normally located between the anterior marginal bones and the vomers (as in the image), or the suborbital fenestra (not shown), a second pair of marginal fenestrae found in lepidosauromorphs and related forms.



Palatal view of a generalized tetrapod (loosely modelled on a temnospondyl), showing interpterygoid vacuities

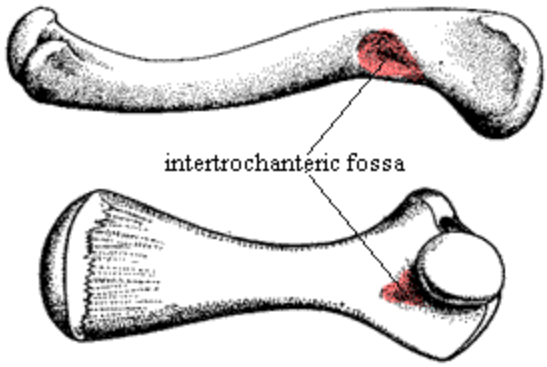
Interspinous notch: a notch formed by anterior (or posterior) processes from the bases of the two halves of the neural spine where they meet at the midline. See image from Sill (1974).



Saurosuchus dorsal vertebra in anterior view. From Sill (1974).

Intertemporal bar: a bar of bone separating the upper and lower temporal fenestrae in reptiles.

Intertrochanteric fossa: a fossa or depression usually located directly under the head of the femur, for insertion of an important portion of the *PIFE* adductor musculature or its homologue.



Top: left femur of Caiman in posterior view. Bottom: left femur of Lepidochelys in ventral or medial view. Both adapted from Romer (1956).

Intracranial joint: in Sarcopterygii, a complete transverse division of the braincase into anterior and posterior halves. The division runs between the basisphenoid & basioccipital ventrally and immediately anterior to the otic capsule dorsally. See image at otic shelf.

Intraprezygapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the *prezygapophyses*. *See* image at *centrodiapophyseal lamina*.

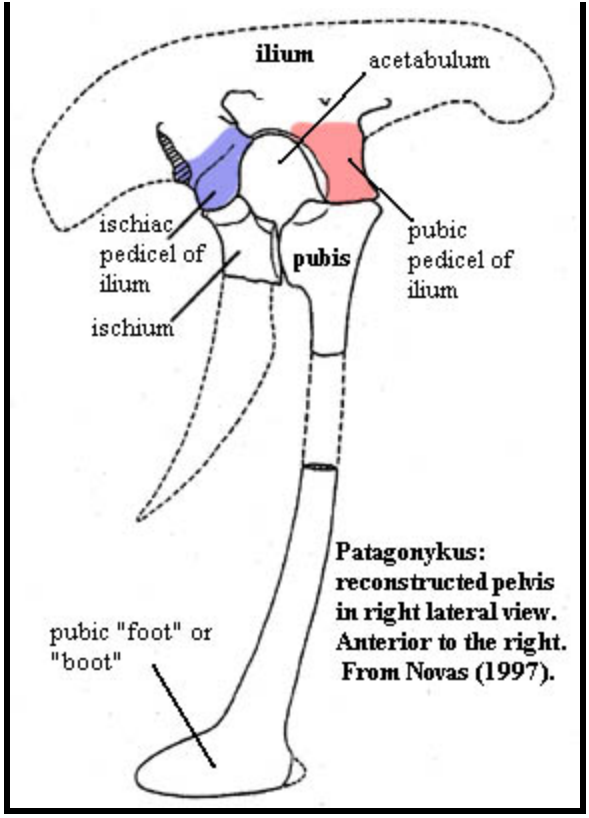
Involucrum: usually used in medical jargon to mean a sheath of replacement bone grown over dead or diseased bone, as in osteomyelitis. Used more generally to mean any bone sheath and, in particular, a sheath formed as an extension of the tympanic into the middle ear. The term is most frequently used by whale people who are specifically referring to a pachyostosis of the medial rim of the bulla which is enormously expanded, even in quite early whales. Luo (1998).

Iren Dabasu Formation: Late Cretaceous, but very uncertainly dated, of North China (Inner Mongolia). Holtz (2001a) The formation directly overlies a slate floor of Cambrian age and is overlain by Eocene lake deposits of the Arshanto Formation. The Iren Dabasu sediments are clay with a few carbonate lenses. Vertebrates are found in the upper third of the formation, probably from a lowland lake depositional environment. Recovered vertebrate fauna include advanced theropods, an ankylosaur, turtles, fish and crocodiles. Mader & Bradley (1989).

Ischiac pedicle: of the ilium, the posteroventral extension of the ilium below the iliac blades which forms the posterior margin of the acetabulum and contacts the ischium. See blue area in figure at right. See also *pubic peduncle*.

Ischial peduncle: (of ilium) same as *ischiac pedicle* or *ischial pedicle*.

Ischigualasto Formation: Late Triassic (Carnian) of South America (Argentina). One of the great vertebrate fossil beds of the world and the source of countless important archosaur specimens of



all flavors.

Ischium: the posteroventral member of the three bones forming the pelvis. See figure at *antitrochanter*.

Isopedin: the material forming a basal layer of laminal, dermal bone in paleozoic fish scales -- ossified, or largely ossified, layers of connective tissue. Also apparently used to describe any laminar dermal bone.

Itaboraí Formation: Late Cretaceous or Early Paleocene of Brazil. Mainly limestone with sandy marl fissure and channel fills of Late Paleocene (Riochican) age. Didolodonts and litopterns in fissure fills. Cifelli (1983).

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Glossary: The Humerus

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

"Let us go then, you and I
When the evening is spread out against the sky
Like a patient etherized upon a table"

T.S. Elliot, *The Love Song of J. Alfred Prufrock*

Introduction

At the most simplistic level, the humerus is the bone which connects the shoulder to the elbow; and at the most refined level, it is the forelimb propodial. Somewhere in between, there is undoubtedly some level of jargon which is appropriate to the reader's own inclination and purposes. At a higher level of detail, the humerus has a remarkably complex topology -- one that has also changed dramatically over the course of tetrapod evolution. We cannot do it justice in the cramped format of a glossary entry. Accordingly, although this is still a far from adequate treatment, we will use this somewhat expanded space to provide a few schematics and landmarks. For a fuller treatment, see Romer (1956).

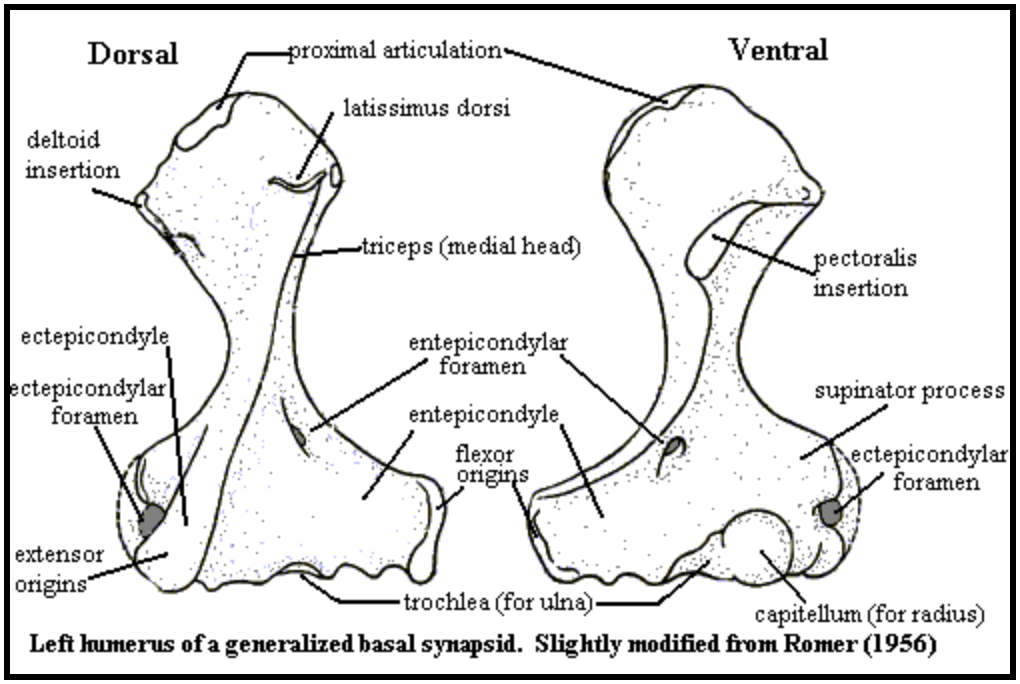
Orientation

Initially, there is the matter of orientation. We will concentrate on the dorsal and ventral views. But what does "dorsal" mean with respect to a limb? By their nature, limbs do not have a fixed orientation with respect to the force of gravity. This problem is solved by adopting roadkill as a reference posture. To achieve this posture, one mentally splays the organism out on the center lane of Interstate 10, limbs straight out to the sides, and allows imaginary rush-hour traffic to do its worst. While this does little for the specimen quality of real animals, it quickly renders complex three-dimensional concepts as easily digested (perhaps a poor choice of words) two-dimensional shapes in dorsal view. Needless to say, quick application of a conceptual spatula generates the corresponding ventral view. Dorsal roadkill view is actually quite different from the orientation of tetrapods which do not sprawl. However, for purposes of comparability, we will use the same directional indications throughout. In tetrapods with an erect stance, the conventional directional indications are usually shown in parentheses.

Romer analyzes the humerus as the four triangular faces of a tetrahedron. This is excellent for basal tetrapods, and for those with samples and laboratory facilities. It is less easily applied to the flatter humeri of most Mesozoic forms, or by those without access to labs or to a teaching assistant (the T.A. is the pale, hungry-looking person with straggly, unkempt hair and a slightly frightening laugh who apparently lives under the lab bench). Nevertheless, it is well to remember that the humerus, primitively, *is* a four-sided object, and that we are collapsing it for pedagogical reasons.

Basic Features of an Early Humerus

The figure at right illustrates some of the fundamental features of the left humerus of *Bob* in dorsal and ventral roadkill view. Fortunately, this is almost as bad as it gets. More derived tetrapods usually have much simpler humeri. However, Bob is our customary starting point. He is also Romer's starting point on the topic. So, 'though our choice be dubious, yet it is made on impeccable authority.



Left humerus of a generalized basal synapsid. Slightly modified from Romer (1956)

Proximal Humerus

The most proximal point on most humeri is the **proximal articulation** which fits into the glenoid articulation formed by the scapula and coracoid. Primitively, this is an elongate curved surface which permitted the humerus to rotate anteriorly or posteriorly, allowed for a limited degree of motion up or down, but supported very little rotation around the long axis of the humerus. **[1]**

In some cases, we will find an even more proximal structure in the form of a **lateral tubercle** (sometimes referred to as the **internal tuberosity**), as in the aberrant bird (?) *Mononykus* or the turtle *Platypeltis.* This arises from the posterior margin of the humerus and sticks out at an angle, sometimes rising above the main proximal articular surface. However, it is infrequently encountered. The more typical homologous structures is the small, unmarked tubercle shown on the posterior margin of Bob's humerus, and the horizontal ridge on the posterodorsal surface, both just above the triceps attachment. These serve as attachments for muscles originating on or near the coracoid, or from the body wall. One relatively common example of the latter is the *m. latissimus dorsi*. In early tetrapods, such as Bob, the **latissimus dorsi process** is an easily recognizable feature of the dorsal humerus.

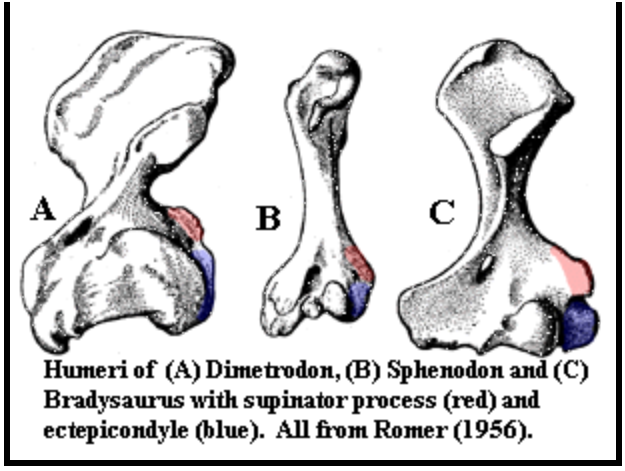
Another common structure in later tetrapods is the **deltopectoral crest**, which most typically occurs as a long ridge near the anterior edge of the proximal humerus, oriented generally with the long axis of the humerus. However, it may take other forms. Bob has no deltopectoral crest, as such, since he has a large, separate pectoral insertion on the ventral face of the upper humerus. However, one can already note the beginnings of a characteristic deltoid "tab" on the anterior margin in dorsal view.

Distal Humerus

The distal portion of the humeral shaft may be thought of as being divided into two epicondylar areas. The posterior moiety (or lateral moiety in graviportal and other non-sprawling forms) is the **entepicondyle**. In roadkill view, the large distal flange of the entepicondyle is usually a good landmark for early tetrapods and serves as an arrow pointing posteriorly. The entepicondyle is associated with the origin of the **flexor muscles** of the manus, the muscles which flex the wrist and close the fist. The entepicondyle is minimally scored by a groove to accommodate the passage of major blood vessels and nerves. Very frequently, this groove is roofed over and becomes a foramen, the **entepicondylar foramen**. Sadly these road signs are generally lost in more derived tetrapods.

The anterior, or (primitively) the anterodorsal portion of the

humerus is likewise expanded as the **ectepicondyle**. In reality, i.e., in a three-dimensional basal tetrapod, the ectepicondyle is actually oriented more dorsally than anteriorly. The ectepicondyle is associated with the origin of the **extensor musculature** of the wrist and manus. Proximal to this region, the ectepicondyle may merge with a more anteriorly-oriented **supinator process** from which originate the muscles which rotate the wrist. The ectepicondyle may also bear a groove or foramen, the **ectepicondylar foramen**.



Humeri of (A) Dimetrodon, (B) Sphenodon and (C) Bradysaurus with supinator process (red) and ectepicondyle (blue). All from Romer (1956).

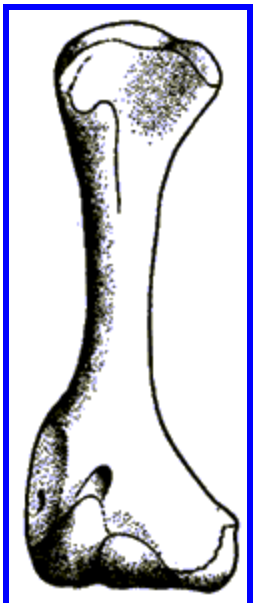
The distal surface of the humerus bears the articulations for the ulna and radius. The ulnar articulation is called a trochlea, although it frankly looks very little like the usual trochlea in the case of basal tetrapods. The ulnar trochlea allows the ulna to rotate principally only in one plane. Theradial articulation is located more anteriorly and ventrally. It consistes of a rounded surface, the **capitellum**, which accommodates the broad range of motion necessary for rotation.

Some Examples

Rather than pretending that we took all this in at first intention, let us work through some examples. The reader is sternly warned that we have no answer book. Possible error lurks at every turn. Even in the professional literature, limb bones are frequently mislabeled or reversed. You have now been cautioned, and fore-warned is forearmed ...

Example #1

In the first example, the entepicondyle is easily identified as a prominent tab of bone sticking out to the right of the distal end. **Do not** leap to the conclusion that this is therefore a humerus in dorsal view. It might be, for example, a *right* humerus. Look at the left side of the distal end. There are two rounded structures, one of which *must* be a capitellum. Therefore, our darkest fears are confirmed. This is a right humerus in ventral view. The entepicondylar foramen is unaccountably displaced anteriorly, compared to Bob's humerus. Another feature which suggests that the view is ventral is the overall concave shape of the proximal portion. This clue is not infallible, but frequently works, particularly for lepidosauromorphs. Yet another clue is the relative invisibility of the ectepicondyle, which is seen almost edge-on. If this is a ventral view, then the hook-shaped process on the anterior half of the proximal humerus is a *pectoralis* insertion, and not a latissimus dorsi process or triceps tubercle. Note that the posterior portion of the proximal end bears a small lateral tubercle. Click on the image to reveal the completely labeled figure.


Humerus: example 1

Example #2

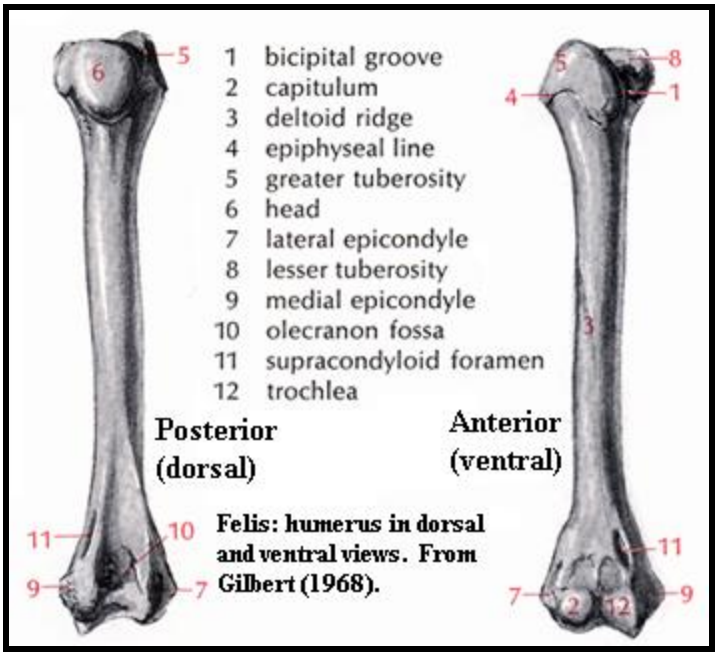
The second example is considerably harder. The proximal articulation is round. Therefore we are dealing with a derived form in which the forelimbs are carried under the body. In these, later tetrapods, our **conventional *roadkill dorsal* face is now *posterior***. The epicondyles and their foramina are no longer useful indicators. The epicondyles are reduced, flattened and roughly symmetrical. The epicondylar foramina are lost. Instead, we take our cue from the enormous deltopectoral crest The deltopectoral crest is roadkill anterior (lateral) and generally dorsal (posterior). Thus, this must be a left humerus in dorsal (posterior) view. The angle of the proximal articulation confirms this. The proximal articulation leans toward the right (medially) into the glenoid (articulation with the pectoral girdle), which confirms our fond expectations. Accordingly, the odd looking protuberance on the posterior (medial) side is probably a latissimus dorsi process.

Humerus: Example #2

An important point to note is that, with the transition to a more erect stance, everything rotates *except* the relative position of the radius and ulna (epipodials). In a sprawling stance, the epipodials are arranged along the line of the distal humerus with the radius anterior, and the ulna posterior. When the humerus rotates under the body, the radius is *still* anterior, not lateral. The ulna is still posterior, not medial. Now, however a line between them is transverse to the line of the distal humerus, rather than parallel.

Example #3

The final example is not provided in self-test format because it cannot readily be analyzed in terms of the landmarks provided above. Instead, we have simply reproduced an illustration of a cat humerus from Gilbert (1968), virtually without change. Note that a few of the basic boundary stones remain. The capitellum (transformed by medical terminology into the ***capitulum*** **[2]**) remains an easily-identified feature of the distal end of the ventral humerus. On the dorsal side, the distal humerus develops a long *olecranon* fossa to accommodate the olecranon process, a proximal extension of the ulna. However, the ulnar trochlea is changed into something resembling much more closely a conventional pulley-like *trochlea*. The deltopectoral crest is now found on the ventral face, and in a far more distal position than we might expect. The proximal humerus is almost unrecognizable with reference to Bob.



Felis: humerus in dorsal and ventral views. From Gilbert (1968).

Arma virumque cano ...

Anterior (lateral)	**Posterior (medial)**
Deltopectoral crest	*Latissimus dorsi* process
Ectepicondyle and/or supinator process	Entepicondyle
Extensor & supinator muscles	Flexor muscles

To put the matter in context, and continuing in a highly over-simplified way, we may think of the arm in a slightly different way. Imagine the entire arm as having two tracks: anterior (lateral) and posterior (medial). (The directional indications in parentheses refer, as before, to the orientation in non-sprawling forms.) On the two tracks we have parallel landmarks, as shown in the table.

Because the epipodials do not rotate from their original basal positions, the radius can continue to articulate with

Capitellum	Trochlea
Radius (always anterior, never lateral)	**Ulna (always posterior, never medial)**
Ulnare and pisiform (if present)	**Radiale and centralia (if any)**
Digit V	Digit I

the medial carpals, primarily the radiale; and the ulna continues to articulate with the lateral wrist bones, the ulnare and pisiform. However, this arrangement is devilishly hard to draw in an accurate and informative manner. Many sketches of the lower forelimb are, as a result, rather mysterious and vague.

It may be that this topic is simply too difficult for presentation without real bones and real troglodyte T.A.s. However, we hope it will serve as a useful introduction to an exceedingly difficult point of osteology. ATW020927.

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[1] As an aside, the general trend in tetrapod locomotion has been to further develop those abilities in more or less that order, *i.e.* horizontal movement, vertical movement, and rotation about the long axis. For those with a biomechanical bent, you may try the following non-laboratory demonstration. Lie flat on the ground with arms straight out in roadkill position. (1) Move your arms forward and backward horizontally. These movements are, respectively, **protraction** and **retraction**. The angle of protraction or retraction is conventionally noted (presumably with a protractor or retractor) by the Greek letter theta, which looks like a zero in italics with a *horizontal* line through the middle. (2) If you are athletic enough, move your arms in, as in a push-up, and back out flat. These vertical movements are **abduction** and **adduction**. The abduction angle is conventionally noted by the Greek letter phi, which looks like zero with a *vertical* line through the middle. (3) Finally, rotate your arms about their long axes. This is, oddly enough, referred to as rotation, and is sometimes denoted by the Greek letter omega, a script 'w,' which may be imagined as a zero with the top half rotated down to the right.

[2] For once, the physicians have the right of it. *Capitulum* means "little head" in classical Latin. In later texts it also came to mean "chapter" or "heading" as in a book. *Capitellum*, by contrast, has a suspiciously Italianate sound to it, and may come from Renaissance anatomy texts. We owe an enormous debt to these anatomists, the first scientists in the modern sense. But, although their science was often excellent, their Latin was often not.

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Glossary: J-L

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- J -

J: The *Jurassic Period.*

Jacobson's Organ: The vomeronasal organ; a chemosensory organ located in the roof of the mouth.

Javelina Formation: Late Cretaceous (Campanian-Maastrichtian) of W. Texas. Pterosaurs.

Jobu Formation: Early Cretaceous I or early Early Cretaceous II (Aptian) of Japan. Manabe (1999).

Jugal bar: In birds, the bony process which supports the upper beak on the moveable quadrate.

Jugular canal: in many sarcopterygians, on the side of the otoccipital (posterior) portion of the braincase, there is a sort of dorsoventrally oriented bone bridge bearing the articulations for the hyomandibula. This is the lateral commisure. Under this bridge is a tunnel that passes from the otic capsule, posteriorly, and opens onto the otic shelf, anteriorly. The jugular vein passes through this tunnel, and it is consequently known as the jugular canal. Note that this is *not* the same as the jugular foramen.

Jugular foramen: An important landmark on the occiput. It is a small hole where the jugular vein exits the braincase. It generally marks the exit of the Xth and XIth nerves, as well. This jugular foramen is normally located along the articulation between the opisthotic (or petrosal) and the exoccipitals. In human and sometimes other mammals, the jugular foramen is referred to as the *posterior lacerate foramen*.

Jugular vein, internal: the IJV drains the brain and internal structures of the head. At least in mammaliforms, it originates at the sigmoid sinus. The IJV exits the skull through the jugular (or posterior lacerate) foramen between whatever passes for the opisthotics and exoccipitals in the organism of interest.

Jurassic Period: The middle period of the *Mesozoic*, 206-144 Mya. The Early Jurassic (206-180 Mya) includes the Hettangian, Sinemurian, Pliensbachian and Toarcian Ages. The Middle Jurassic (180-159 Mya) takes in the Aalenian, Bajocian, *Bathonian*, and Callovian Ages. The Late Jurassic (159-144 Mya) is made up of the Oxfordian, *Kimmeridgian* and *Tithonian* Ages.

- K -

K: the *Cretaceous*. Also the element Potassium. If you are likely to be confused and think that the dinosaurs expired at the end of the potassium, or that neuronal potentials are maintained by an ATP-dependent sodium-Cretaceous pump, then you may require more assistance than these Notes can provide.

Karaginskaya Formation: Late Oligocene of western Kazakhstan. Squalodontids. Dubrovo & Sanders (2000).

Katian Age: second age of the Late Ordovician, 456-446 Mya. *See* Katian.

Kayenta Formation: Early Jurassic of Colorado.

Khashaat Formation: Late Paleocene of Mongolia. Same as Gashato Formation.

Keratin, Keratinous: keratin is a protein which comes in a variety of forms, all of which are waterproof and durable. It is the principle component of horn, skin, hair, feathers, hooves, and the rasping "teeth" of lampreys, among others.

Kimmeridgian Age: The second age of the Late *Jurassic Period* (see also Late Jurassic), 154-151 Mya.

Kinesis: ability of parts (*e.g.*, of skull or jaw) to move or flex relative to each other. One of the critical design issues of the vertebrate skull and a frequent source of lineage-splitting, the degree of skull kinesis involves numerous trade-offs.

Kinetic line: a feature of some sarcopterygian skulls in which there is a sharp angle between the skull table and the cheek region. The sutures along this line are typically not interdigitating and thought to be at least somewhat kinetic.

Kinocilium: No different from any other cilium, it seems, but given a special name in mechanoreceptors for historical reasons. See **The Ear**.

Kota Formation: Early Jurassic of India. *Kotatherium*.

Kuldana Formation: Early to Middle Eocene of Pakistan. Shale, marl & bleached dolomite. Pakicetidae.

- L -

La Colonia Formation: Late Cretaceous (Campanian - Maastrichtian) of Chubut State in South Central Argentina (Patagonia region). Known for snakes, turtles, fish, dinosaurs, plesiosaurs and some mammals.

La Victoria Formation: Middle Miocene of Venezuela Cifelli & Villarroel (1997).

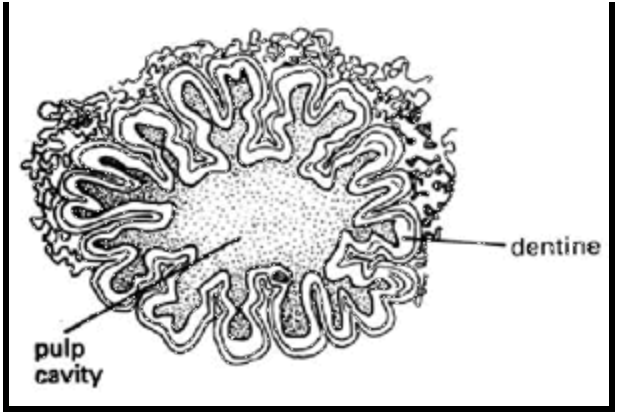
Labial: (a) relating to the lips; (b) viewed from the "lip" or outside of the mouth; opposite of *lingual* & same as *buccal* (c) of dentition, the "outside" surface.

Labial pleurodont: See **Tooth Implantation**.

Labyrinth: see "*Semicircular Canal*." See also, **The Ear**.

Labyrinthodont: teeth (or having teeth) characterized by folded sheets of dentine. Such teeth are common in sarcopterygians and basal tetrapods. A pulp cavity is not always present, and the entire tooth may be filled with folded dentine. An outer enamel layer may also be present. See image: cross section of labyrinthodont tooth from *Eusthenepteron*.

Lacerate foramen, posterior: same as the *jugular foramen*. Used in mammalian anatomy, where it is formed by the suture of



the petrosal and basisphenoid..

Lachrymal: an alternate spelling of *lacrimal*, a dermal bone of the facial series. Although, spelled this way, it may refer to a style of lute song invented by John Dowland -- a Seventeenth Century equivalent of the Blues, much emulated by later composers.

Lacrimal foramen: Opening of the tear duct.

Ladinian Age: The second and last age of the Middle *Triassic* (234-227 Mya).

Lafayette Bugt Formation: Early Silurian (Llandovery) of Hall Land, north Greenland. Thelodonts. Blom (1999).

Lag deposit: a layer of gravel or larger particles left behind when smaller particles have been removed by wind or water.

Lagena: the region of the inner ear related to "normal" hearing. See **The Ear**.

Lagenar crest: a crista in crocodylomorphs, birds, and lizards which walls off the lagena from the vestibular elements of the *recessus scala vestibuli*. Gower (2002).

Lambdoid: relating to the articulation between the parietals and occipitals. The **lambdoid crest** is a transverse crest, typically formed by the parietal(s), that may serve as the attachment for neck muscles supporting the head. The squamosals, intertabular, tabulars, etc. may also get into the act.

Lamellar: same as *laminar*.

Laminar: layered.

Laminate: in layers.

Lappet: a projecting, flap-like structure. In osteology, "lappet" often, but not always, refers to a projection of one bone that overlaps another.

Lateral centrale: One of the carpals. See Figure at *carpus*.

Lateral commisure: in the braincase of sarcopterygians and basal tetrapods, a flange of bone on the lateral surface of the otoccipital region that folds over the jugular vein. See image at *vestibular fontanelle*.

Lateral condyle (of the tibia): the condyle at the proximal end of the tibia which is further from from the midline of the body. It contacts the lateral condyle of the femur and generally also has some contact (often soft tissue) with the proximal head of the fibula.

Lateral line: a conspicuous sensory structure in aquatic vertebrates which usually appears as a system of lines on the surface of the animal made up of pores lines with mechanoreceptive and/or electroreceptive cells. Lines contain *neuromast organs* consisting of pairs of oppositely oriented *hair cells* embedded in gelatinous cupula. The electrosensitive elements of the lateral line system sense weak electric currents created by other fish (prey, school etc.). The mechanoreceptors detect current. Since electrosensory systems cannot function on land, and air currents are more effectively detected by other means, the presence of a lateral line system is an indicator of aquatic habits in a doubtful case.

Lateral otic fissure: *see* metotic fissure.

Lateral plate mesoderm: ***See*** **Early Development Terms**.

Lateral septum: In fishes, this is an important structural entity, a sheet of tough, fibrous tissue extending straight laterally from the spine and dividing the body into dorsal (epaxial) and ventral (hypaxial) halves. The structure is easily visible, if you are ever the recipient of a well-presented salmon steak. In other vertebrates, the lateral septum *per se* is often lost, but the epaxial/hypaxial boundary still has enormous developmental significance, particularly in tracing the development of musculature. **Caution:** the brain and limbs also have structures referred to as "lateral septa." Obviously, these aren't the same thing at all.

Lateral tubercle: of the humerus, see **Humerus**.

Laterale Grenzfelte: a possible homologue of the turbinals found in turtles. See **Ethmoid**.

Latissimus dorsi: a group of (normally adductor or retractor) muscles which originate on the laterodorsal body wall and insert on the humerus.

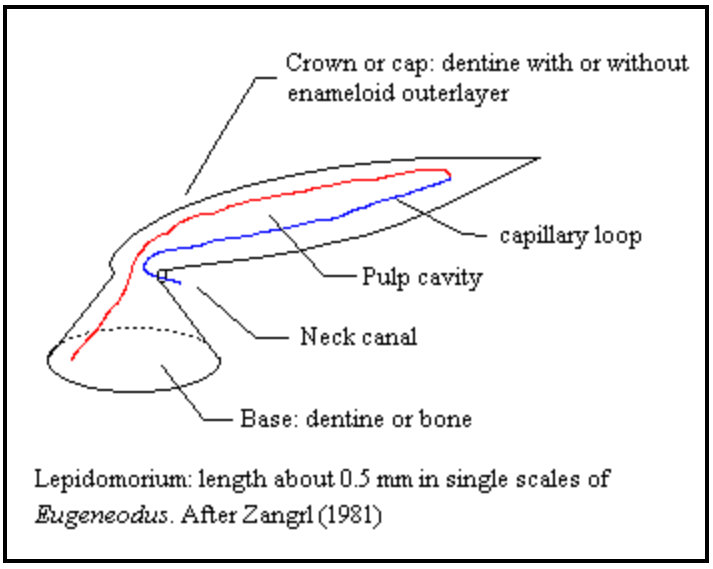
Latissimus dorsi process: see **Humerus**.

LCA: (abbr.) last common ancestor (and all descendants of that ancestor).

Lectotype: A syntype designated as the single name-bearing type specimen subsequent to the establishment of a nominal species or subspecies

Lenticular process (of incus): the long ventral process of the incus which articulates with the stapes. See **The Incus**.

Lepidomorium: the basic unit of squamation and dentition, according to theories of Erik Stensiö (1891-1984) and other members of the Scandanavian School. However Stensiö's overall theory may stand, it is beyond dispute that (a) he accurately predicted the structure of the lepidomorial unit (since scales of this type are now known from early eugeneodontids and (b) teeth and scales have a great deal in common, both structurally and developmentally. Scales and teeth both form at the level of the basement membrane (see *Intgument*) at the mesoderm - ectoderm boundary. In scale formation, the epidermal (ectoderm) cells form the base, which is invaded by mesenchyme recruited from the dermis.



Lepidomorium: length about 0.5 mm in single scales of *Eugeneodus*. After Zangrl (1981)

Lepidotrichia: Fin rays. "Scale-like structures that form the segments of soft rays in bony fishes." Fishbase. They are usually described by anatomists as "modified scales," but the details are more complicated:

> Teleost fins are composed of a species-specific number of branched rays. These are sustained by a segmented dermal bone called lepidotrichia, which is, in turn, composed of two concave, facing bones, named hemi-lepidotrichia. Lepidotrichia are immersed in a loose, vascularized, and innervated connective tissue, and are surrounded by a multilayered epidermis. At their distal tip, two palisades of actinotrichia parallel hemi-lepidotrichia inner faces. Actinotrichia are rigid, but non-mineralized, collagenic rods that not only support the ray tip, but are also though to have some morphogenetic role. Rays are connected to each other by the soft interray region, which lacks skeletal elements.

Santos-Ruiz *et al.* (2001).

Lepospondyly: a condition in which the elements of the vertebra are fused into a single piece (*i.e.* *holospondyly*) and the centra have hollow core allowing for a continuous notochord to pass through the centra. Characteristic, not

surprisingly, of the lepospondyls.

Lesser trochanter: a trochanter located below the greater trochanter on the lateral or anterior face of the femoral shaft. See figures at *femur* and *trochanter*.

***Levator arcus palatini, m.*:** in fishes, a muscle involved in feeding. The origin and attachment(s) of this muscle are quite variable, but it always functions to expand the buchal cavity laterally. It may originate on the anterior neurocranium, the dermosphenotic, the parasphenoid, or any other similar location, usually at an antero-posterior position just behind the orbit. In fishes other than derived teleost groups, it runs posterolaterally (and somewhat ventrally) to insert on the hyomandibular. By retracting the hyomandibular, which is closely integrated with the dorsal rim of the palatoquadrate, it causes the ventral half of the palatoquadrate to rotate outward (laterally), expanding the mouth cavity. In advanced teleosts -- about which we disclaim any reliable knowledge -- it apparantly acts on the palatines directly, or even on the lower jaw.

***Levator bulbi, m.*:** this is a thin muscle in the floor of the orbit innervated by the 5th cranial nerve, that causes the eye to bulge outward and to enlarge the buccal cavity. This muscle is present in anurans and urodeles and in a modified form in caecilians.

***Levator hyoidei, m.*:** non-mammalian homologue of the stapedius muscle.

Lift: The force opposing gravity in flight. For those who can envision air as moving in a laminar fashion, lift is generated by well-behaved laminar airflows. When air meets a well-designed airfoil, it splits into two streams. The lower surface of the airfoil is straight. By contrast, air flowing over the top is moving faster because it is magically attracted to the lamina it was previously associated with. This is a marvelous mathematical model but frankly makes very little physical sense. For those of us who insist on thinking of air as made up of molecules, rather than bed sheets, the math is difficult. However, one may intuit the proper result with some effort. Think of a moving airfoil as 3 surfaces. The bottom is flat. Molecules of air will hit this surface (and impart upward momentum) about as often as if it were sitting in a garage. The anterior surface is approximately parabolic. It will collide frequently with molecules, but will impart and absorb vertical momentum symmetrically, with no resultant force. The top is concave and in the air "shadow" of the moving anterior surface. As a result, fewer molecules will strike it (imparting downward momentum). The net result is that air molecules impart a net upward momentum on the moving airfoil. However, if the combination of speed and geometry is not optimal, the airfoil's anterior surface may absorb enough horizontal momentum per unit time to overcome the motive force (recall that F=dp/dt) of the bird, plane or superman, with unfortunate results. As a general rule, the more asymmetric the surface, the more lift, but also the more horizontal drag, since the front-to-back asymmetry also increases. In the laminar model, this drag is explained in terms of "*turbulence*," which is also treated by engineers as a magical property retarding progress. The turbulence is quite real, but is only mathematical proxy for the resultant of random collisions between air molecules and a moving surface of given shape and velocity.

Limb: the following table summarizes tetrapod limb nomenclature.

General name	Forelimb	Hind limb
Propodium	humerus	femur
Epipodium	radius + ulna	tibia + fibula
Mesopodium	carpals	tarsals
proximal series	radiale intermedium ulnare	tibiale intermedium fibulare
medial series	centralia (4)	centralia (4)
distal series	carpalia (5)	tarsalia (5)
Autopodium	manus	pes
Metapodium	metacarpals (5)	metatarsals (5)

Limestone: A carbonate sedimentary rock composed of calcite ($CaCO_3$), which may or may not be biogenic. It is generally light colored. The composition of sediment in intermontane areas or alluvial plains may be classified as a limestone. This is not to imply the landform is rock but that it is primarily composed of sediments of that composition and may have rock fragments of other compositions and/or have windblown sediments from undetermined origins as well

Lingual: (a) relating to the tongue; (b) viewed from the inside of the mouth, looking out (opposite of *labial* or *buccal*).

Lisbon Formation: Middle Eocene (late Lutetian or early Bartonian) of Georgia, South Carolina and the

Gulf Coast of the United States. Marine. *Georgiacetus*. Hulbert *et al.* (1998).

Digits	fingers (5)	toes (5)
Phalanges (sing. = *phalanx*)	phalanges	phalanges

Lochkovian: the first age of the *Devonian* Period, 417-412 Mya.

Lockhovian: misspelling or alternate spelling of *Lochkovian*.

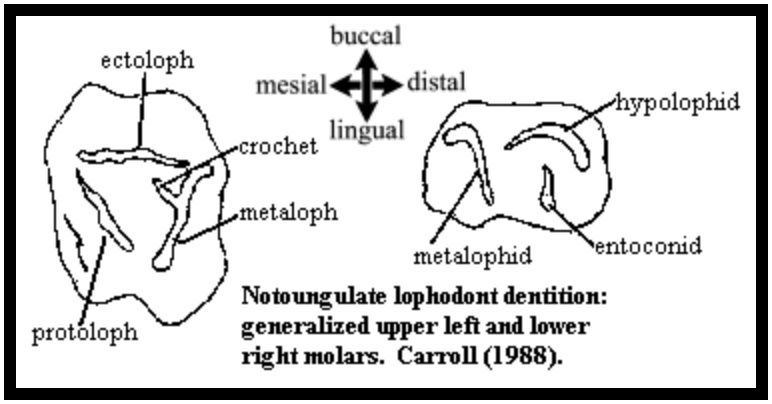
Lode Formation: variously dated as Givetian or Frasnian of Latvia (probably Givetian). Overlies Sietini Fm unconformably and is probably contemporaneous with upper part of Gauja Fm. Light grey quartzitic sandstone. Low energy fresh water or deltaic environment. Various sarcopterygians and antiarch placoderms. Comparable fauna to Escuminac Formation, but with the addition of psammosteids. Vorobyeva (1980), Ahlberg *et al*. (2000); Forey *et al*. (2000).

London Clay: Early Eocene (Ypresian) of England. Famous for any number of avian fossils, e.g. *Anatalavis*.

Longirostrine: a suite of adaptations in crocs and others related to fish-eating. These include a long, thin rostrum and procumbent teeth.

Loph: a ridge of enamel in a dentine surface (as opposed to a crista on an enameled surface). See **Molars**.

Lophodont: (also called *selenodont*). Dentition characterized by lophs, as in ruminants. See **Molars**. The figure at right shows the nomenclature of lophs in the special case of notoungulate dentition.



Notoungulate lophodont dentition: generalized upper left and lower right molars. Carroll (1988).

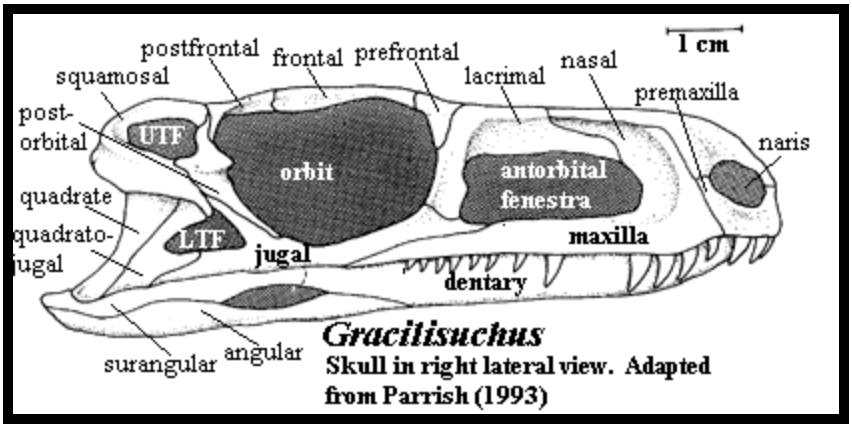
Los Alamitos Formation: Late Cretaceous of Argentina.

Los Chañares Formation: Middle Triassic of Argentina, Agua de la Peña Group. Medium energy flood plain with seasonal drought. *Tarjadia*. Arcucci & Marsicano (1998).

Lossiemouth Sandstone Formation: Late Triassic (Late Carnian) of Scotland.

Loxodont: an extreme form of lophodont or selenodont dentition. See **Molars**.

LTF: abbreviation for lower temporal fenestra. *See* image.



Skull in right lateral view. Adapted from Parrish (1993)

Lujanian Age: South American Land Mammal Age corresponding to the Late Pleistocene.

Lulworth Formation: Late Jurassic to Early Cretaceous (mostly Early Cretaceous) of southern England. Purbeck Limestone Group. Symmetrodonts (*Spalacotherium*, *Thereudon*), unidentified dinosaur footprints. The fossiliferous Cherty Freshwater Member may have been a very large, anaerobic mud flat or marsh adjacent to a lake.

Lumachelle: Fire marble - a brown limestone or marble ("marble"?) with some areas that exhibit internal fire-like reflections from included fossil shells.

Lumbar: The ribless region of the mammaliform body between the *thorax* and *sacrum*. Related to *lumbus*, Latin for loins, as in the often-used Biblical phrase *succingere lumbos* (to gird up [one's] loins). Somehow, between classical and medieval days, the meaning of the word seems to have shifted from front to back, so to speak.

Lumbos: the lumbar region, *esp.* the lumbar region of the back.

Lumbricales: intrinsic muscles of the hand and foot originating in the palm and inserting on the radial side of the metacarpals. They are responsible for flexing the digits at the metacarpo-phalangeal joint and extending the digits at the interphalangeal joints for digits II-V.

Lunate: [1] (L *luna* = moon) shaped like a (quarter) moon. **[2]** in mammalian osteology, one of the carpal bones, normally articulating distally with the magnum and proximally with the radius. See image at unciform.

Lutetian Age: the first age of the Middle Eocene (mEc), 49.0-41.3 Ma.

***Lystro-*:** Greek root for *spoon* or *shovel*.

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Glossary: M

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- M -

M/m: in mammaliform dentition, an upper (M) or lower (m) molar.

Maastrichtian: the last age of the *Cretaceous* and of the *Mesozoic* Era, about 71.3-65.0 Mya.

Macrolecithal: (of an egg) having a large amount of yolk. **Macrolecithal development** is the pattern of embryonic development characteristic of eggs with considerable yolk.

Macula: (pl. maculae) L. *macula* = stain, spot, blemish. This root has no obvious relationship to the maculae, which are vaguely sac-like areas of the vestibular apparatus in the inner ear involved in the perception of linear acceleration, orientation in a gravity field, and low-frequency or high-volume sounds. See **The Ear**. Presumably the name comes from some histological property.

Maevarano Formation: upK (*Campanian*?- Maastrichtian) of Madagascar.

Magnum: in mammal osteology, one of the distal carpals, essentially a proximal extension of Mc III. Also referred to as the capitate. See image at unciform.

Malleolus: rounded projections on either side of the distal end of the tibia which stabilize the tibia on the tibial trochlea of the astragalus. In other words, a couple of bone tabs at the end of the lower leg that help keep the leg properly oriented on the ankle joint.

Malleus: the articular, when it is exapted as an auditory ossicle in mammals.

Mammalian jaw: a jaw with a dentary-squamosal articulation, as opposed to the articular-quadrate articulation which was good enough for everyone else.

Mandagary Sandstone: Late Devonian of New South Wales, Australia. The Mandagary Sandstone is the home of the Famennian Canowindra fauna, dominated by *Bothriolepis*, but with various other placoderms and sarcopterygians.

Mandible: L. *mandibula* = jaw; from *mandere* = to chew. The lower jaw as a functional unit, regardless of which

bones or cartilage make up the lower jaw in a particular organism.

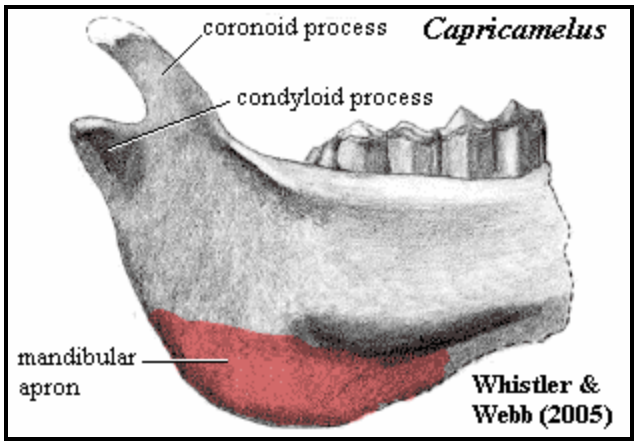
Mandibular apron: a laterally thin expansion of the posteroventral section of the jaw in certain mammals.

Mandibular arch: a hypothetical first gill arch which became the basis for the jaw. See **Gill Arches.**

Mandibular fenestra: a fenestra or hole in the dentary -- a synapomorphy of crown group archosaurs.

Mandibular groove, internal: same as Meckelian groove

Mandibular symphysis: the area where the two halves of the lower jaw articulate.



Manse Burn Formation: lwC of Scotland. Sequentially marine & nonmarine. *Akmonistion, Deltoptychius, Denaea, Tristychius*, actinopterygians, rhizodonts & osteolepids, coelacanth.

***Manu-*:** L. = hand

Manubrium: [1] (from the slight resemblance of the partially fused ribs to the fingers of a hand) anterior 3 segments of the sternum; more generally, the anterior portion of the sternum. See sternum. **[2]** the retroarticular process of the articular, when it becomes an auditory element of the middle ear in mammaliforms. A process of the malleus (articular) which attaches to the tympanic membrane and provides the insertion for the tendon of the tensor tympani.

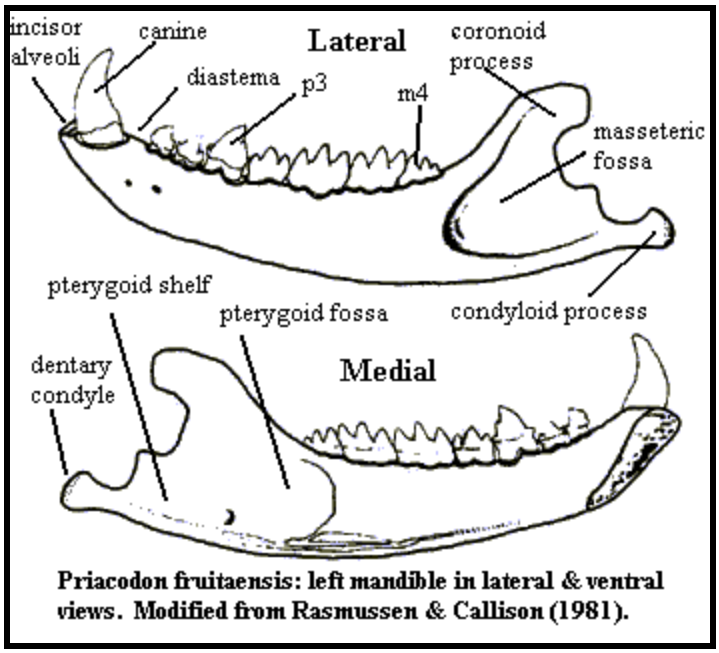
Marble: Most marble is made up of 90 percent or more of either calcite or dolomite; typically saccharoidal to relatively coarsely crystalline -- *i.e.*, made up largely of grains a millimeter or more in greatest dimension.

Marl: sediment composed of clay mixed with calcium carbonate (calcite). *Shell marl* is marl in which the lime is in the form of invertebrate shells, i.e. biogenic (or calcareous) limestone.

Masseter Gr. *maseter* = chewer. One of the few muscles named in the writings of Galen. The characteristic jaw muscle of therapsids which permits the longitudinal, grinding, motions of the jaw. The masseter is derived from the *m. adductor mandibulae externus*, which originates in the adductor chamber (in the temporal fenestra) and inserts on the coronoid process and internal surface of the lower jaw. *See* figure from Carroll (1988). In cynodonts, the adductor chamber is opened up as the dermal bones form a laterally bowed zygomatic arch. As a result, the origin of the external adductor mandibulae is split between the braincase and the medial surface of the zygomatic arch. The portion which remains on the braincase is referred to as the temporalis. The portion originating on the zygomatic arch now inserts in a fossa on the lateral surface of the dentary, the masseteric fossa, and is referred to as the *m. masseter*. In the later cynodonts, the masseter splits into deep and superficial elements. The superficial masseter is a new element which originates on the anterior portion of the zygomatic arch, below the orbit, and inserts on the posteroventral portion of the masseteric fossa. This combination of the temporalis with the deep and superficial masseters allows precise control of the jaws and, most significantly, control of mediolateral and anteroposterior movements, *i.e.*

masseter development in cynodonts

grinding. With this system in place, it became both possible and advantageous for cynodonts to evolve complex molar teeth designed for precise occlusion -- the hallmark of the mammalian condition.

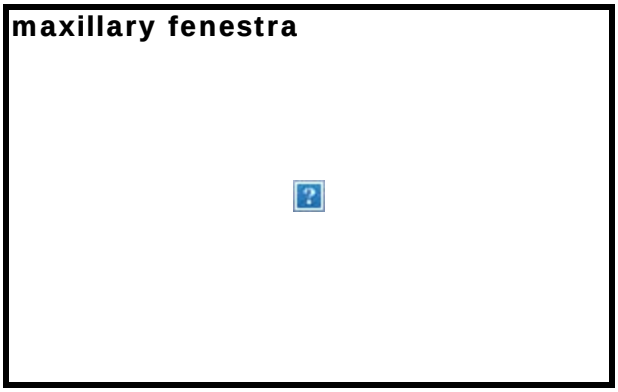


Priacodon fruitaensis: left mandible in lateral & ventral views. Modified from Rasmussen & Callison (1981).

Masseteric fossa: The fossa for the masseter. In some therapsids, the coronoid process of the dentary bears a large external depression which accommodates the masseter -- an important muscle in closing and in grinding motions of the jaw.

Mastoid Gr. *mastos* = breast or nipple, and *eidos* = resemblance.

Maxilla: the bone which normally forms the lateral upper jaw in osteichthyans, including tetrapods.



Maxillary fenestra: a fenestra or hole which pierces the maxilla anterior to the antorbital fenestra. See figure. The maxillary fenestra is frequently inside the antorbital fossa, the large depression in the skull which includes the antorbital fenestra. For the terminally curious, no. There is no such dinosaur, and the head bearing integument is that of the noted German philosopher, Immanuel Kant.

Maxillary nerve: the maxillary branch of the trigeminal nerve, or CN V2. The maxillary is a sensory branch which communicates sensations from the teeth, nasal sinuses, and (in mammals) parts of the face lateral to the nose. The nerve is closely associated with the premaxilla.

Mazon Creek: Pennsylvanian of Illinois, part of the *Francis Creek Shale*. Swamp, bayou & estuarine. Especially well known for chondrichthyan fossils.

Mc: abbreviation for metacarpal.

Mecca Quarry Shale: upC of the Mid-Western U.S. Part of the Cleveland Shale? The **Mecca Fauna** are a characteristic community of inshore marine or brackish water organisms which flourished during marine transgressions over swampland.

Meatus L. *meatus* = a channel or way. Thus the "external auditory meatus" is the channel for sound through the outer ear.

Mechanical Advantage: the ratio of output force to input force.

Mechanoreceptor: sensory cell or (less often) organ responsive to mechanical forces, such as water currents, touch, sound, or some moron with a really loud stereo in his car.

Meckelian bone: the Meckelian cartilage is normally ossified (if at all) only at its ends, *i.e.* at the jaw symphysis and as the articular (in, *e.g.*, reptiles). However, in sarcopterygians (other than crown tetrapods), and in a few other taxa, it may ossify completely -- in which case it would be rather lame to continue referring to it as the "Meckelian *cartilage*," as if we hadn't noticed the difference. When the Meckelian is ossified anteriorly, it is also referred to as the "mental bone."

Meckelian cartilage: The cartilage formed in the mandibular process of branchial arch I; the primitive lower jaw, derived from the ceratal element of the hypothetical mandibular arch. See **Gill Arches**, **Meckel's Cartilage**, Gnathostomata.

Meckelian foramen: in some sarcopterygians, (including many temnospondyls and lizards), the Meckelian cartilage is not completely surrounded by dermal bone, but lies in an open fossa visible on the medial face of the lower jaw.

Meckelian groove: same as Meckelian **fossa**, **foramen**, or **canal**, but usually refers to tetrapods.

Medial: referring to the midline of the body (or, occasionally, the midline of some other reference point). For example, the heart is medial to the ribs; and a biped must place its limbs medially when walking. Note, however, that a **medial view** is a view from the midline, looking outward. Opposite of *lateral*. The terms *axial* and *radial* are usually (not always) equivalent to medial and lateral, respectively. See *medial* for a discussion of related terms.

Medial centrale: One of the distal carpals. See Figure at *carpus*.

Median: in the middle. When used correctly, this is a more general term than *medial*, which refers to a specific axis. A classic example of confusion in these terms (possibly my confusion) is briefly discussed at Hadrosauroidea. The problem there is is the meaning of the phrase "medial carina" on a tooth. A *median* carina would be a keel up the middle of the tooth (on the inside face, the outside face, or both). A *medial* carina would be a keel on the inside, or lingual, face of the tooth. A *mesial* carina would be a keel on the anterior face of the tooth. So, it really does make a difference.

Median eustachian foramen: in crurotarsans, a foramen on the ventral surface of the basioccipital and/or basisphenoid which communicates with the pharynx via the eustachian tubes. It is also referred to as the *medial pharyngeal recess*.

Medial pharyngeal recess: same as *median eustachian foramen*. Alcober (2000), citing a paper by Witmer (1997) which we have not reviewed.

Median tuberosity: a bulge on the proximal femur which is an attachment site for ligaments (*ligamentum capitis femoris*) binding the femoral head in the acetabulum. See figure at *femur*.

Medulla L. *medulla* = marrow. Used for the non-cortical (peripheral) part of some organs, such as the kidney and adrenal.

Melon organ: in odontocete whales, a complex pocket of connective tissue and unusual, frequently toxic, fats located on the concave "forehead" formed by the maxilla between and anterior to the orbits. The melon organ is believed to focus ultrsound clicks used for echolocation. See discussion at Cetacea.

Mental: [1] relating to the mind, from L. *mens* (pl. *mentes*) = mind; **[2]** relating to the chin, from L. *mentum* (pl. *menti*) = chin. I understand that many 3rd declension Latin nouns, such as *mens*, were taken over from the Romans' early mentors, the Etruscans. Presumably this is why there are two, very similar Latin words here with unrelated roots and meanings. This hypothetically Etruscan root is quite possibly related to Greek terms such as *mania*. Whoever the Etruscans were -- a mystery at least as deep as the origin of vertebrates -- they seem to have had Greek and Semitic influences. **[3]** relating to Meckel's cartilage. Thus the *mental bone* is an anterior ossification of Meckel's cartilage.

Mental foramen: a pit, hole, or channel in the mandible (usually in the dentary) leading to the Meckelian cartilage or bone.

Mental groove: in snakes, on the underside of the head, an anterior mental scale generally is followed by large, paired chin shields and smaller gular scales. Most snakes have a longitudinal mental groove between rows of chin scales.

Mentomeckellian: the mental bone, a bone developed by ossification of Meckel's cartilage in the region where the two halves of the lower jaw meet (the mandibular symphysis).

Meristic: of a character, having a number of parts, or divided into serially repeated, countable features (e.g. the rays in a fin, the myomeres of an eel larva, the rakers on a gill arch, etc.). From FishBase.

Mesaxonic: middle toe is largest, and the plane of symmetry of the foot passes through it.

Mesenchyme: See **Early Development Terms**.

Mesial: [1] relating to dentition, closer to the axis of symmetry passing (vertically) through the front (symphyses) of the jaw, as opposed to "*distal*." In these Notes, "anterior" may be used instead of "mesial." Since we are usually discussing molars, the difference is immaterial. See *medial* for a discussion of confusingly similar terms. **[2]** In British, the word seems to be synonymous with *medial*, as in the opposite of *lateral*. This is unbelievably confusing when English-educated writers are discussing jaws and dental matters.

Mesocuneiform: one of the distal tarsals. *See* ectocuneiform for image and explanation.

Mesodactyl: same as mesaxonic.

Mesokinetic joint: joint along articulation between frontals and parietals. SQUAMATES.

Mesolecithal: (of an egg) having a moderate amount of yolk. **Mesolecithal development** is the pattern of embryonic development characteristic of eggs with moderate yolk.

Mesomere: (a) a mesodermal component; see **Early Development Terms.** (b) the median series of bones supporting the pectoral fin of sarcopterygian fish. See Dipnomorpha. In the pectoral fin, the first mesomere is the humerus, the second the ulna, and the third probably the intermedium. The radius is the first preaxial radial. All other homologies are suspect.

Mesoplastron: one of the dermal bones in the plastron of turtles.

Mesopodium: the bones of the ankle and wrist, that is the tarsals and carpals (both proximal & distal), variously known as astragalus, calcaneum, fibulare, intermedium, tibiale, ulnare, intermedium, and radiale, and all centralia. See figure at *metapodial*

Mesopterygium: fins are often attached to the torso by relatively large, columnar cartilages known as basals. Radials attach to the basals and extend towards the margin of the fin. Typically, there are three basals. In some cases, one of the basals becomes elongated, typically by adding segments bearing radials, and becomes a primary axis of the fin. When the middle basal becomes extended in this fashion, it is referred to as the mesopterygium.

Mesostyle: in mammalian dentition, one of the stylar cusps along the buccal margin of an upper molar. The mesostyle is, appropriately enough, the one in the middle. See figure.

Upper molar cusps

Mesotarsal joint: an ankle joint that passes between the proximal and distal tarsals, as in dinosaurs. Compare crurotarsal.

Mesothelial: relating to the tissue lining body cavities.

Mesozoic Era: the *Triassic*, *Jurassic* and *Cretaceous* Periods (248-65.0 Mya).

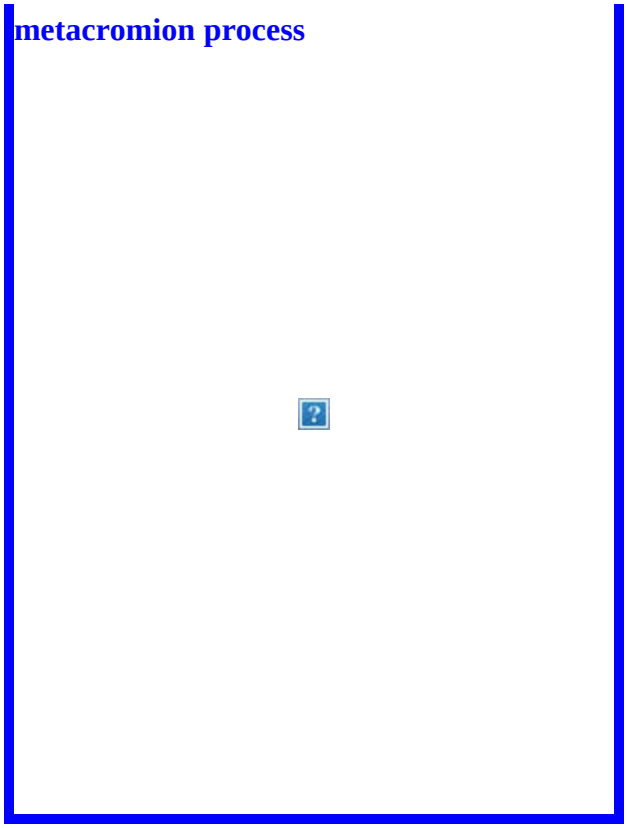
Metacarpus Gr. *meta* = after or beyond, and *karpos* = wrist. The wrist bones between the distal carpals and the finger bones (phalanges). See Figure at *carpus*.

Metacone: the most posterior (& buccal) cusp of the trigon on an upper tribosphenic molar. See **Molars.**

Metaconid: the most linguodistal cusp of the trigonid on a lower (tribosphenic) molar. See **Molars** or Teeth, diastema lengths.

Metaconule: in mammalian dentition. Apparantly, this is the same as the *hypoconule*, that is, a small cusp on an upper molar lying near the line between the *protocone* (the lingual main cusp) and the *metacone* (the distal main cusp). If the line is marked by a ridge, the ridge is the *postprotocrista*. By "main cusp," I mean one of the large cusps defining the vertices of the trigon. See figure at *mesostyle*.

Metaconulid: the most distal cusp of the trigonid. See **Molars**.



Metacromion process: in mammals, a lateral, posterolateral or dorsolateral process of the coracoid portion of the scapulocoracoid, appearing as a outwardly-produced extension of the spinous process near its ventral (humeral) end. It frequently bears a further, angled projection at its highest point. In the cat, the metacromion serves as an attachment for the middle slips of the *m. trapezius* (*i.e.* the *m. acromiotrapezius*), as well as the insertion point of the *m. levator scapulae ventralis*, which originates on the atlas. A particularly emphatic (and very French) shrug might be summarize the motions involved.

Metakinetic joint: "Joint occurs where parietal and supraoccipitals meet (metakinetic articulation)" PPT Slide. A joint "between the braincase and skull roof." Lee *et al*. (1999: 656). "In squamates other than snakes, the metakinetic axis passes through the tips of the paroccipital processes and their suspension from the supratemporal and, in some taxa but not *Varanus*, the squamosal." Rieppel & Zaher (2000: 492). At any rate, a joint at the intersection of the skull table and occipital region. An animal with a metakinetic joint is said to exhibit **metakinesis**.

Metaloph: in mammalian dentition, a cutting edge running generally along the distal side of an upper lophodont molar. See image at lophodont and **Molars**.

Metalophid: in mammalian dentition, a cutting edge running generally along the distal side of the trigonid on a lower lophodont molar. See image at lophodont and **Molars**.

Metamere: a body segment

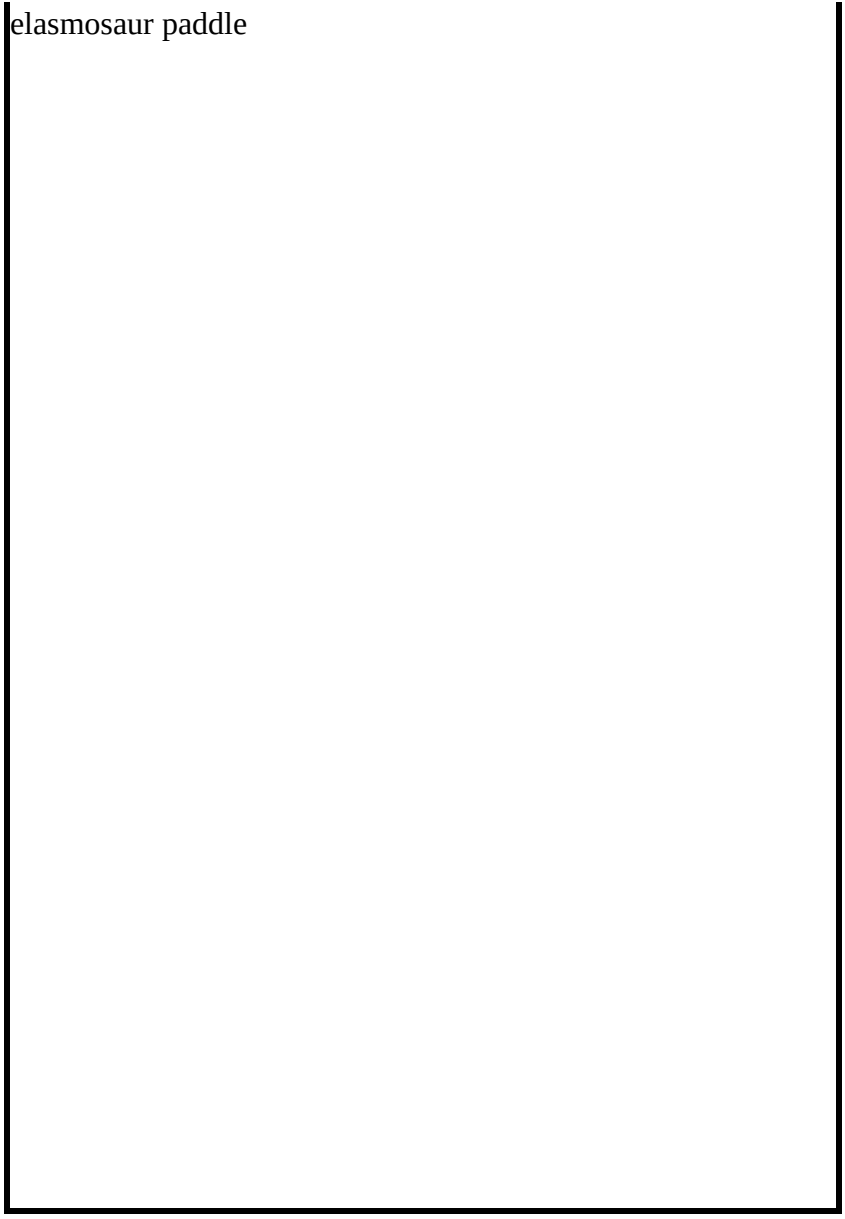
Metameric: characterized by serial repetition of segments.

Metaphysis: the sub-terminal, actively growing section of long bones. As opposed to the *diaphysis* and *epiphysis* (*q.v.*).

Metapodials: the metatarsals and/or metacarpals. Legs, Feet, and Locomotion. The term sometimes includes the phalanges as well.

Metapophysis: in some mammals, the articular surfaces of the vertebrae are on the neural arches, rather than on the centra. The metapophyses are the anterior articulations, analogous to the prezygapophyses. Frequently both structures are present and in close proximity. The corresponding posterior articulations are the anapophyses.

Metapterygium: fins are often attached to the torso by relatively large, columnar cartilages known as basals. Radials attach to the basals and extend towards the margin of the fin. Typically, there are three basals. In some cases, one of the basals becomes elongated, typically by adding segments bearing radials, and becomes a primary axis of the fin. When the posterior basal becomes extended in this fashion, it is referred to as the metapterygium. Shubin (1995). Sometimes this results in an elongated, thin, extension of the fin, which is referred to as a **metapterygial whip**. The


elasmosaur paddle

individual segments along the metapterygial axis are referred to as *mesomeres*, and the side-branches (on one side or both are referred to as *radials*. A distinction is often made beween radials (or other features) which occur on the leading and trailing sides of the axis, and these structures are referred to as being *preaxial* and *postaxial*, respectively. **Test yourself:** it should now be possible for you to translate such classic ichthyo-babble as "the third mesomere bears two elongate preaxial radials."

Metapterygoid: the portion of the palatoquadrate (primitive upper jaw) which actually articulates with the braincase to form the dorsal and/or basal articulation(s). Long explanation: the upper jaw in basal fishes consisted of a large, at least partially ossified, cartilage called the palatoquadrate. The upper jaw can be attached to the skull in a number of ways, but the most common attachments involve dorsal and/or ventral articulations (which may or may not be moveable joints), usually located just behind the orbit. This is accomplished by means of some postorbital process of the ethmoid region of the braincase (dorsal) and/or a basipterygoid process (ventral). The metapterygoid is the part of the palatoquadrate which holds on to these processes. In tetrapods, this arrangement is largely replaced by dermal bone (the pterygoid) except for the dorsal articulation itself, which is formed by a small remnant of the metapterygoid called the epipterygoid. **Warning:** in actinopterygians, *metapterygoid* has another meaning, for which we have been unable to pin down a reasonable definition.

Metastyle: a stylar cusp near the buccodistal corner of an upper tribosphenic molar. See figure at *mesostyle*.

Metastylid: a small, presumably stylar, cusp on the lingual edge of a lower tribosphenic molar, typically located just distal to the metaconid and more or less in the break between the trigonid and talonid. Appears to be the same as the *tuberculum intermedium*. See Teeth, diastema lengths.

Metatarsus Gr. *meta* = after or beyond, and *tarsos* = instep (actually, the ankle). The **Metatarsals** are the long bones inside the foot (in humans), between the ankle bones (distal tarsals) and the toes (phalanges).

Metataxon: In cladistics, a group of species or specimens which is assumed in advance to constitute a clade for purposes of establishing relationships among other groups (not sure about this one). This is frequently necessary in two situations. (a) If the existing material is scrappy, and it may make better sense to combine odds and ends of

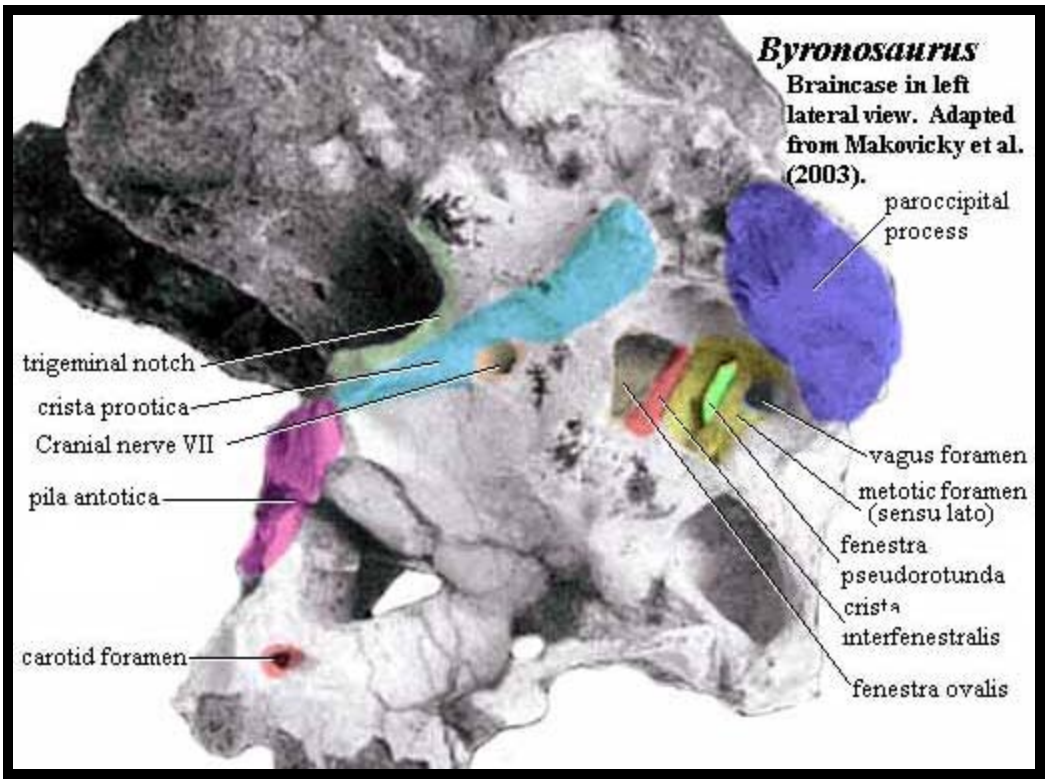
material which is very likely related as one metataxon, rather than use numerous taxa with missing data. (b) If the taxon contains one or more derived groups which exhibit reversals of character states which were originally synapomorphic.

Metautostylic: a type of jaw suspension characteristic of tetrapods (other than mammals) in which the lower jaw is supported by the quadrate; that is, the basic quadrate-articular jaw articulation.

Methyostyly: "Hyostilic jaw suspension is found in elasmobranchs. The jaw is formed by the palatoquadrate and Meckel's cartilage, and they are suspended from the hyomandibular element that attaches to the cranium. Methyostylic jaw suspension is a derivation of hyostilic suspension in that the hyomandibular still plays a role in jaw suspension, but in this case the original elements have been replaced by dermal bone, and the hyomandibular is a reduced element at the jaw joint. Methyostilic suspension is found in Osteichthyes." Midterm_key_2001.pdf

Metotic Fissure: an embryonic fissure between the otic capsule and the arches which develop into the occipital bones. The fissure may persist into adulthood. It is also referred to as the "lateral otic fissure." The metotic fissure opens into the *vestibular fontanelle*, if the fontanelle is present. Johanson *et al.* (2003). Otherwise it opens to the metotic foramen. See the **inner ear of reptiles**.

Metotic foramen: a foramen by which the *metotic fissure* may open to the outside. See the **inner ear of reptiles**. Strictly speaking, the metotic foramen refers to an undivided opening which serves both as the lateral opening of the *recessus scala tympani* (*i.e.* it is the *fenestra pseudorotunda*) and as the exit for various cranial nerves (*i.e.* the vagus foramen). More broadly, it refers to the region in which both (if separate) are found.



Microlecithal: (of an egg) having little or no yolk. **Microlecithal development** is the pattern of embryonic development characteristic of eggs with little or no yolk.

Microsquamose: having very small scales.

Microvillus: (pl. microvilli). See *villus*.

Milk River Formation: middle Cretaceous to Late Cretaceous (Campanian?) of Alberta, Canada. Multituberculates. Esociformes.

Mixopterygium: the pelvic copulatory "clasper" of male chondrichthyans. Sometimes spelled **mixipterygium**.

Modesto Formation: Late Carboniferous of Illinois

Molar L. *mola* = a millstone. Hence, a grinding tooth.

Moment Arm: In a rigid system, the distance between a reference point and the point at which a force is exerted on the system. See *torque*.

Monoecious: having one sexual form. Not asexual, but every individual produces both gametes.

Monophyletic: descended from a single common ancestor within the group being studied. The term is also used in a

slightly different sense. A "monophyletic group" usually refers to a *clade*, i.e. an organism and *all* of its descendants. Thus *Sinraptor* and *Allosaurus* are (very likely) monophyletic within Allosauroidea. However they are not, by themselves, a clade, because they do not include all descendants of their last common ancestor.

Monospondyly: the condition of a spine having one vertebral *centrum* per segment.

Monte San Giorgio: Middle Triassic locality in northern Italy and southern Switzerland, south of Lake Lugano. The locality is particularly well-known for pachypleurosaurs. Expeditions from the University of Zurich began excavating exposures here in the 1930's. Since this was Switzerland, and since no one ever told them to *stop* excavating, they continued to dig with ceaseless diligence *for 40 years*. Sander (1989). Mercifully, someone seems to have realized what was going on and put a stop to the madness before the entire southern Alpine Massif was carved into tidy slabs, carefully labeled, and deposited in the cavernous drawers of the Zurich University Museum. Note that the valley now filled by Lake Lugano follows the line of the Monte San Giorgio locality exactly and lies just a little to the north. This raises a truly disturbing question: is Lake Lugano really a natural phenomenon -- or might it represent the scars of other extended fieldwork by these implacable Swiss paleontologists?

Montehermosan Age: South American Land Mammal Age corresponding to the Early Pliocene.

Moraine: *see Tillite*

Moran Formation: Wichita Group, Asselian or Early Sakmarian (Cisuralian: Permian: Paleozoic) of Texas. *Lupeosaurus*, an edaphosaur (Eupelycosauria: Synapsida) (Romer & Price, 1940) and *Romeria*, a captorhinid (Benton & Donoghue, 2007). Marginal marine sediments of thin limestone beds, massive shales, and lenticular channel fill sandstone. Includes shellbanks of the mollusk *Myalina*.

Morphotype: a theoretical construct of the primitive form of a taxon. A hypothetical generalized form, having all the synapomorphies of a group and no specializations.

Morrison Formation: an enormous upJ (*Tithonian*?) formation with various exposures. The formation stretches from northern New Mexico up to southern Canada and takes in the entire states of Colorado and Wyoming (although it is naturally overlaid in most places). The Morrison has two principal members, the Salt Wash (lower) and Brushy Basin (upper).

Mosaic: (a) having a mixture of features characteristic of more than one lineage -- which usually means that some of the features are plesiomorphic after all (b) made up of small pieces, as a mosaic tile.

***Mosch-*:** Greek root for *calf*.

Mt: abbreviation for metatarsal.

Mustersan: South American Land Mammal Age roughly corresponding to the Middle or Late Miocene.

Mylohyoid groove: obsolete term for Meckelian groove

Myodome: a dome-like space in bone or cartilage which is presumed to be occupied by muscle in life.

Myomere: A unit of segmented muscle separated from contiguous units by a connective tissue, particularly the embryonic muscles blocks formed by the mesodermal *myotome* derived from each *somite* in early development. Thus the myomeres mark the embryonic segmental pattern originally established by the somites. See, generally, **Early Development Terms.**

Myotome: a *myomere* enervated by one spinal nerve; a voluntary muscle segment. In embryology, see **Early**

Development Terms.

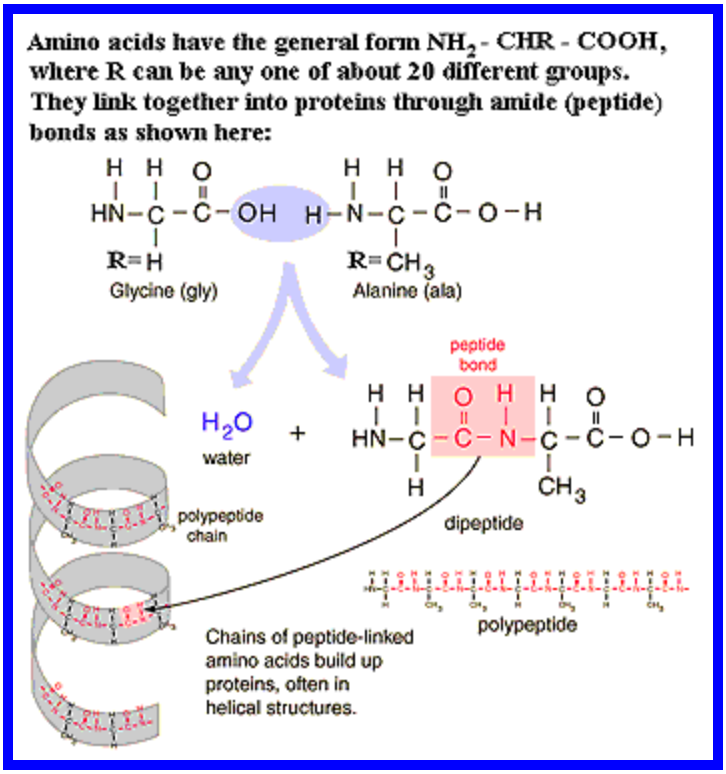
Glossary: N

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-N-

N-terminal: when amino acids are linked to form proteins, the amino group ($-NH_2$) of one amino acid combines with the carboxyl group (-COOH) of the next to form an amide or peptide linkage (-CONH-) as shown in the image. This leaves a free amino group at one end of the protein and a carboxyl group at the other. The end of the protein with the free amino group is called the N-terminal or amino-terminal region. The end with the free carboxyl group is called the C-terminal or carboxy-terminal region.



Namurian: European Carboniferous epoch, normally subdivided into three stages, A - C. Namurian A is roughly equivalent to The Serpukhovian Epoch of the Early Carboniferous. Namurian B & C together correspond to the first half of the Bashkirian Epoch of the Late Carboniferous. The Namurian thus relates to the period from about 333 to 316 Mya.

Nares L. *naris* = nostril.

Narial: relating to the nose.

Naso-frontal hinge: the medial articulation of a bird's upper beak with the skull. The articulation permits the upper jaw to swing upward relative to the skull and increases the possible gape. In some neornithine species with long beaks, the upper beak can be moved significantly without opening the jaws at all.

Navicular: [1] One of the distal tarsals. It normally articulates proximally with the astragalus and distally with one or more of the cuneiforms. See figure at **Protocetidae**. **[2]** shaped like a boat. **[3]** the distal sesamoid in ungulates.

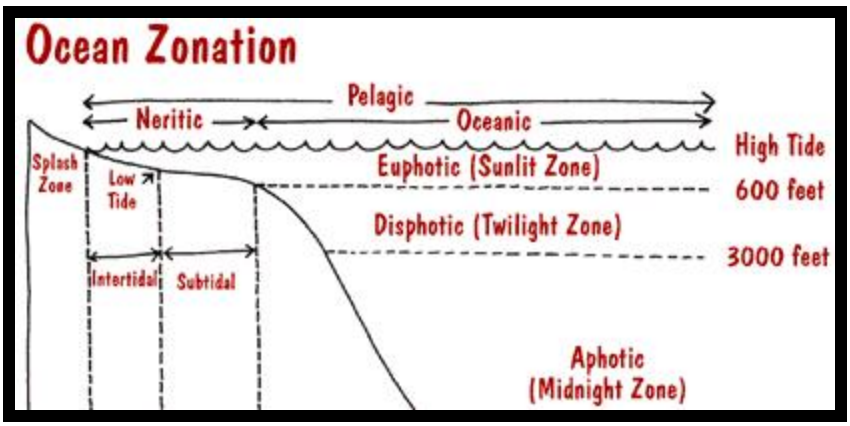
Nektonic: habitually swimming

Neochoanate: palatal foramen for Jacobson's organ separate from choana.

Neotype: The single specimen designated as the name-bearing type of a nominal species or subspecies for which no holotype, or lectotype, or syntype(s), or prior neotype, is believed to exist.

Nemegt Formation: Late Cretaceous of Mongolia, probably Early *Maastrichtian*, ~70 Mya, with the base in the late Campanian. *Teviornis* Kurochkin *et al*. (2002).

Neritic: the neritic zone includes all marine waters out to the point at which the continental shelf begins to drop off rapidly, or, by convention, to a depth of 300 m.



Neuquén Basin: Northwestern Argentina. A large, presently arid region of Late Triassic to Paleocene sediments. The Neuquen sediments are divided into three supercycles: Jurassic (Late Triassic and Early Jurassic), Ándico (Early Jurassic to Early Cretaceous), and Riográndico (Late Cretaceous to Paleocene). Salgado *et al*. (2005). The Riograndico is divided into two cycles. The Neuqueniano or Neuquen Group consists of river sediments in a continental setting from the High Cretaceous and earlier Campanian. The Malalhueyano or Malargüe Group consists of marine sediments from the advancing South Atlantic (End Cretaceous and Paleocene), during which time the eastern part of the Basin became a foreland basin, filling with molasse from the mountains in the West. *Id*.

Neuquén Formation: See *Río Neuquén Formation*.

Neural arch: any of the dorsal arches of the spine. The neural arches may have been the first bone elements to evolve on the spine. They probably acted to enclose and protect he dorsal nerve which rested on the notochord. Originally, there were two arches per embryonic segment, a neural and an *interneural arch*, *q.v.* for details.

Neural crest: see **Early Development Terms.**

Neural fold: see **Early Development Terms.**

Neural plate: see **Early Development Terms.**

Neurapophysis: the structure forming either side of the neural arch; but may also be used to refer to the dorsal process of the neural arch, *i.e.* a neural spine or spinous process.

Neurocentral suture: term used in developmental biology and anatomy, with somewhat different connotations. The term refers simply to a suture between the vertebral body (centrum) and the neural arch above it. Usually, the implication is that the organism is young or pedomorphic, with the (usually unstated) assumption that the normal state is fusion of centrum and neural arch. In the anatomy of non-tetrapod vertebrates, the "normal" state is not necessarily fusion, so the presence of a suture merely represents one position in a continuum of relationships between centrum and arch, without any developmental baggage. Just to confuse matters, Huxley (1859), who ought to know since he invented the term, argues that the neurocentral suture doesn't necessarily represent the developmental boundary between centrum and arch.

Neurocoel: see **Early Development Terms.**

Neurocranium: see "Chondrocranium."

Neuromast organ: The basic unit of mechanoreception (current, balance and hearing) consisting of *hair cells* and support cells embedded in a gelatinous cupula. Mechanical deformation of the *villi* on the hair cells alters the signal

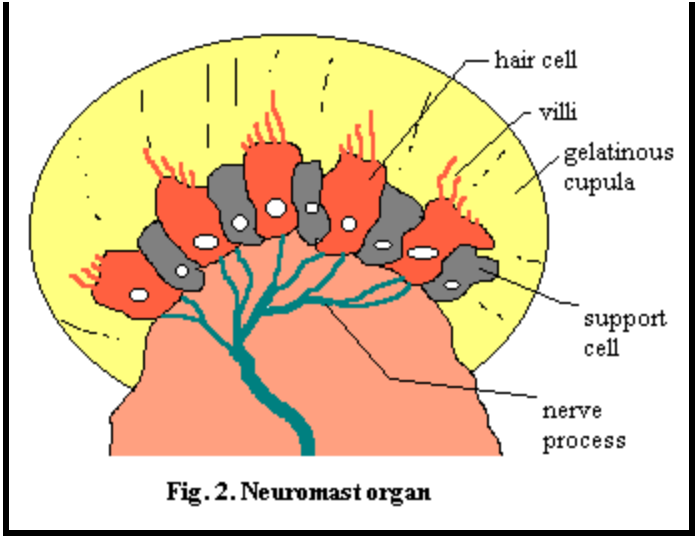


Fig. 2. Neuromast organ

transmitted to the brain by the nerve processes which synapse with the hair cells. See entry on hair cells for (slightly) fuller explanation.

Neurulation: see **Early Development Terms.**

New Haven Formation: Late Triassic (Carnian & Norian) of North America (Connecticut, USA), Newark Supergroup. Several different Crurotarsi. Olsen *et al.* (2000).

Newark Supergroup: "The early Mesozoic Newark Supergroup comprises the remnants of the sedimentary and igneous fill of a long series of fault-bounded basins that formed in continental crust along the eastern margin of North America in response to extensional forces during the initial phase of the breakup of Laurasia." Sues (1992: 142).

Nocona Formation: formerly, the Admiral Formation; Wichita Group. Possibly Asselian but more likely late Sakmarian of Texas. Overlies Archer City Formation and underlies the Petrolia Formation. Plants rare. Mudstone, sandstone, siltstone, and conglomerates. Sandstone in broad channel-fillbodies, tan to dark-reddish-brown, fine-grained to very coarse grained. See Sherman Sheet. Probably a floodplain drainage system. Labandeira & Allen (2007).

Notarium: In birds and pterosaurs, a series of fused dorsal vertebrae separate from, and anterior to, the sacrum (or *synsacrum*) which stiffens the body, improving energy efficiency in flight. Strictly speaking, the term is Latin for a secretary of indeterminate gender. However, it seems unlikely that pterosaurs, for example, needed much clerical help.

Notochord: a continuous dorsal rod of cartilaginous material running from the head to the tail. This is perhaps the "defining" characteristic of the chordates. In more derived forms, the notochord is excluded from the head and may become discontinuous, its structural function assumed by serial ossifications, i.e. the vertebrae.

Notochordal pit: used somewhat inconsistently, but usually refers to the cavity which receives the convex anterior end of the notochord in the braincase.

Nuchal: relating to the neck. *nucha* = the back of the neck. This word, originally Arabic (*nuq*?), was adopted into Latin and changed in French to *nuque*.

Nuchal crest: a transversely oriented crest at the back of the skull table.

Nuchal gap: the gap between the cranial and thoracic armor of placoderms.

Nutritive foramina: peculiar foramina in the vertebral centra found only in the Plesiosauria.

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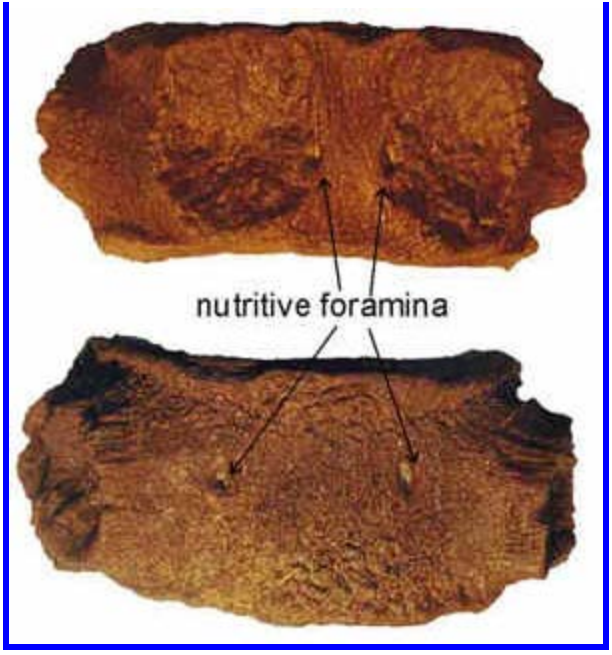

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Glossary: O

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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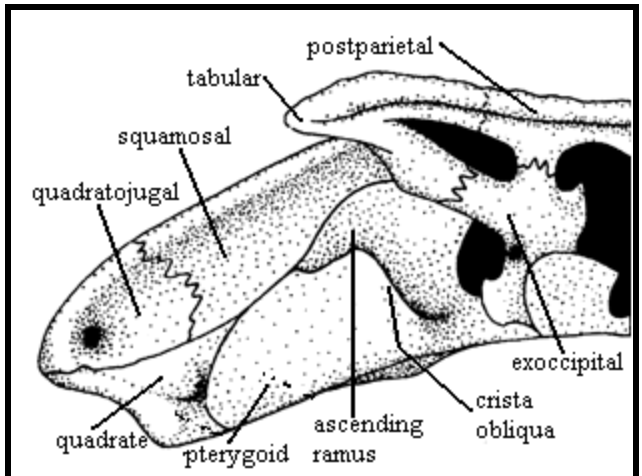
-O-

Oblique muscles: the anterior pair of extrinsic eye muscles. See figure at *rectus muscles*; *see also* discussion and figures of the gnathostome orbit.

Oblique ridge: (= *crista obliqua*) **[1]** in mammalian lower molars, (at a guess) a ridge that proceeds from the hypoconid, generally in the direction of the metaconid or the middle of the trigonid, *i.e.* diagonally across the tooth in a linguomesial direction. **[2]** of the pterygoid in basal tetrapods, a marked flange on the occipital exposure of the pterygoid presumably providing muscle attachments related to lateral movements of the head. See figure at right.

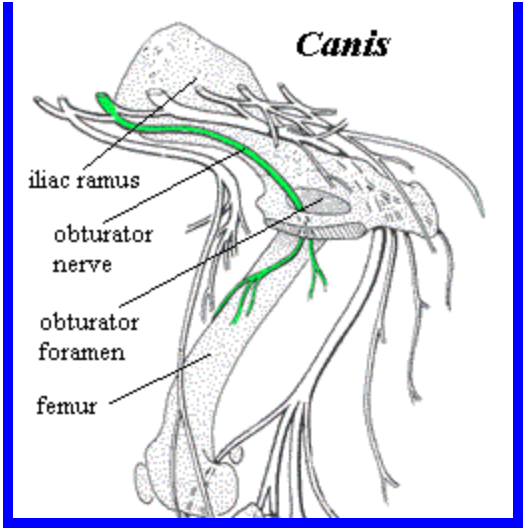


***Wetlugasaurus angustifrons*: left occiput, showing oblique ridge and ascending ramus of pterygoid. From Damiani (2001).**

Obturator Foramen: a depression or hole formed by the pubis and ischium. See figure at *antitrochanter*. Discovery of the ichthyosaur Ophthalmosaurus (Reptilia) in the Late Jurassic of the Boulonnais (ichthyosaur).

Obturator nerve: The obturator nerve supplies the adductors of the thigh and contributes to the nerve supply to the skin of the medial side of the thigh. The obturator nerve follows the medial surface iliac shaft, before leaving the muscle dorsomedially, crossing over the ventrally lying common iliac vein into the obturator foramen. The nerve then branches into the adductor muscles of the thigh. In mammals, these include the *gracillus*, *pectineus* and *adductor externus*. All of these muscles are primarily adductors of the pelvic limb, and their motion is innovated by the obturator nerve. Source: image & most text from 4. The Obturator Nerve.

Obturator process: a blade-like process extending from the ventral



shaft of the ischium. See figure at *antitrochanter*.

Occipital condyle: a rounded projection(s) from the back of the skull which meets the first cervical (neck) vertebra and allows the head to flex and/or rotate on the end of the spine. It is usually formed by some combination of the basioccipital and the exoccipitals. See **The Occiput** for details.

Occipital region: (a) the most posterior region of the braincase. See **The Braincase**. (b) the bone surrounding the foramen magnum and bearing the occipital condyles. Formed from 4 embryonic elements, the basioccipital below, 2 exoccipitals, and the supraoccipital above. See **The Occiput**.

Occipital view: looking towards the back of the skull.

Occlusal: viewed toward the biting or contact surface of the tooth. See **Molars.**

Ocher Locality: *Tartarian* (Late Permian) of Russia, in the southern Urals. Known for basal therapsids and temnospondyls.

Oculomotor nerve: Cranial nerve III, which controls the extrinsic eye muscles except for the superior oblique and lateral rectus. See figure at *rectus muscles*; *see also* discussion and figures of the gnathostome orbit.

Odontoblast: a dentine-forming cell

Odontode: the basic unit of teeth and scales, sometimes lengthened and thickened to form spines. Odontodes have an inner cavity of soft tissue, often containing blood vessels, covered by a cone of dentine and capped by hypermineralized tissue (*e.g.*, enamel). According to some sources, spongy bone may also be involved. However, the attachment to underlying bone seems to be rather variable. This may be an anatomical term with slightly different meanings in different taxa.

Odontoid process: [1] Apparently, same as the dens, *i.e.*, a process of the axis (2nd cervical vertebra) which projects anteriorly into the atlas (1st cervical). Embryologically, this process results from fusion of the axis intercentrum and the atlas centrum in mammals, creating a rotary joint about which rotary movement occurs. In other tetrapods a variety of arrangements are possible, including the mammal-like arrangement. However, since the condyle is not doubled in these forms, the odontoid process does not have the same significance or necessarily have the same function. **[2]** a small process on the anterior surface of the atlantal (first cervical) centrum that fits into a cavity on the occipital condyle (in the back of the skull). Used in this sense at Phylogeny of Stegocephalians.

Oldman Formation: may be part of Judith River Fm. Mid-Campanian of Alberta, Canada. Wilson *et al*. (1992). Esociformes. *Id.*

Olecranal fossa: same as *olecranon fossa*.

Olecranon Gr. *olenokranon*, from *olene* = elbow, and *kranos* = helmet. In other words, the protector of the elbow. The pectoral limb analog of the knee cap (patella). Occurs as a proximal extension of the ulna, important as attachment for extensor muscles of the forelimb.

Olecranon fossa: on the distal humerus, posterior (dorsal or anconal) face, in mammals and birds. A long groove

beginning between the epicondyles and extending proximally up the humeral shaft. This groove accommodates the olecranon process of the ulna. See **Humerus**.

***Oligo-*:** Gr. root for *few, several, somewhat*

Omasum: the third chamber of the ruminant digestive tract, the first of two chambers used for bacterial fermentation of cellulose. See Artiodactyla for figure.

Ontongeny: development. Normally used of post-larval or post-fetal development to the final adult form.

Open-rooted: of mammaliform dentition, ever-growing. This condition is marked by tooth roots which are "open," being very thin-walled with large pulp cavities. Such roots are typically quite long, since they would otherwise be too weak to fix the very active teeth of the herbivores which typically have this type of dentition.

Operculum: L. *operculum* = lid, cover. Used of the dermal bone covering the gill slit in actinopterygian fish, the plate-like bone found on the *fenestra ovalis* of amphibians (See **The Ear**.), etc.

***Opistho-*:** Greek root meaning either "behind" or "reversed," "opposite." In the latter sense it is synonymous with the prefix "*enantio-*."

Opisthocoelous: a pattern of vertebral articulation in which the individual vertebrae are convex anteriorly and concave posteriorly. Opposite of *procoelous*. lab7 photos.

Opisthopubic: "retroverted" pubes, *i.e.*, a pelvic girdle with the pubic bones pointing back toward the tail.

Opisthotic: The **opisthotic** is the posterior of the two bones making up the otic capsule and is usually fused to the prootic, the anterior otic bone. The opisthotic is an endochondral bone. It is usually the largest contributor to the paroccipital process and to the structures of the middle and inner ear. It normally contacts all of the occipital bones and the prootic, and may contact the basisphenoid. It often forms part of the edge of the foramen ovale, the door to the inner ear.

***ops*:** Greek root (normally suffix) for *face* or (less often) *eye*.

Optic nerve: Cranial nerve II, which enervates the intrinsic eye muscles and the retina of the eye. See figure at *rectus muscles*; *see also* discussion and figures of the gnathostome orbit.

Oralobranchial: relating to the normally medial duct or cavity which serves both for respiration and ingestion; the mouth or throat.

Orbitosphenoid: Portion of the sphenoid that is visible in the wall of the orbit.

Orbito-occipital region: see **The Braincase**

Orbitostylic: a type of jaw suspension in which the upper jaw is attached to the braincase near the orbits, generally by a strong, but somewhat flexible soft tissue connection.

Ordovician: The second period of the Paleozoic, c. 490-442 Mya.

***Orecto-*:** Gr. root (*ορεκτο-*) stretched out, thrust forward, or placed erect (to which it is closely related through the L. *erigo, erectus*). It has a secondary meaning as want, desire -- for reasons too obvious to discuss.

Organ of Corti: The system of hair cells in the mammalian cochlea of the inner ear which sorts sound by frequency and transduces it into nerve impulses. See the **Ear**.

Orthal: of jaw motion, up and down. This kind of motion is primitive for synapsids and is usually associated with simple carnivory. However, it can be adapted to shearing, as the cusps slide past each other, or even to grinding. As opposed to *propalinal*, using back & forth anteroposterior motion.

Os basale: fused ossification in Gymnophiona, consisting of exoccipitals, parasphenoid & otic capsules.

Osawa Formation: Early Triassic (Spathian) of Japan. *Utatsusaurus*.

Ossification: the process of becoming bone

Osteoderm: scute; dermal bone lying over the epidermis as armor or ornamentation.

Osteon: structural unit of bone in advanced vertebrates, consisting of concentric rings of osteocytes in an apatite matrix around a central canal, through which pass nerves, blood and lymphatic vessels. Osteons are cross connected at intervals by lateral Volkmann's canals which allow lateral connections of circulatory vessels or nerves.

Osteosclerosis: increased density of bone due to replacement of trabecular bone by compact bone.

Ostium L. *ostium* = door or opening.

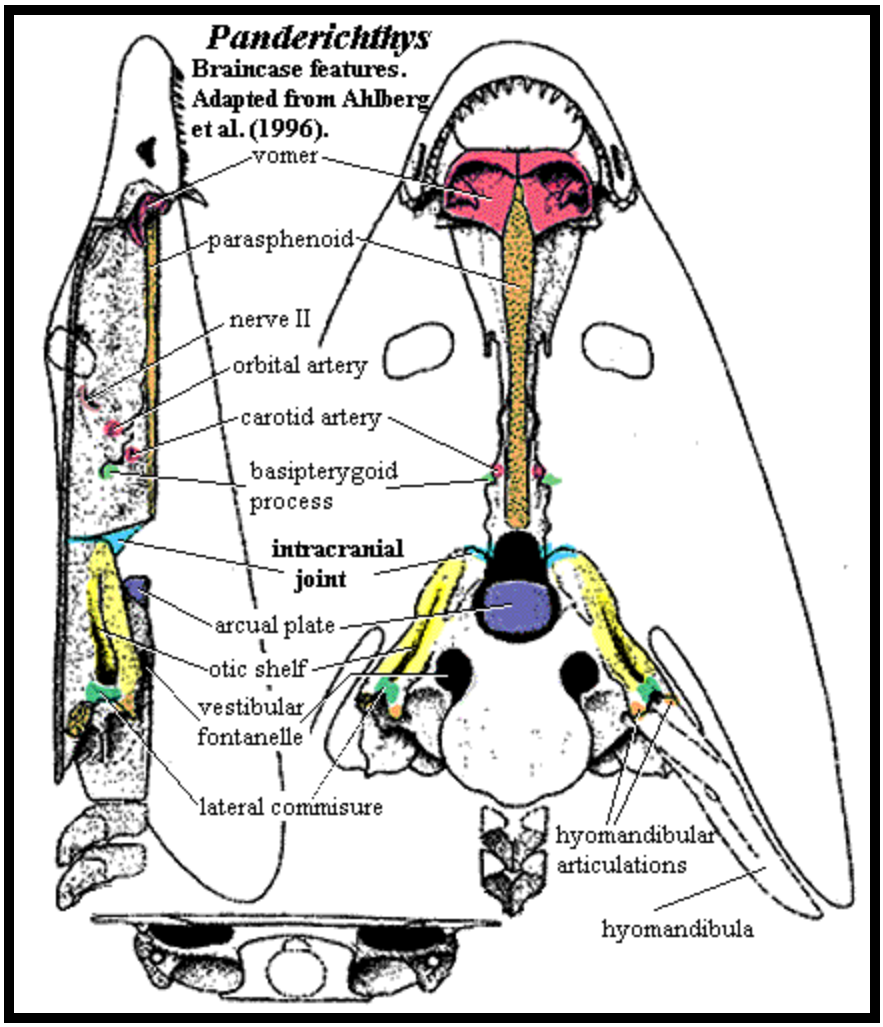
Ostraciform: a type of undulatory locomotion in which the body is inflexible and only the tail undulates.

Otic: (a) of or pertaining to the ear. (b) the region of the braincase associated with the otic capsules. See, **The Braincase**. The otic region is dominated by the prootic. Other "bones" may include the epiotic, sphenotic, opisthotic and (in mammals) the petrosal. The otic capsule is typically setoff anterolaterally from the occiput by a fissure or gap, and may be bordered anteriorly by a ventral fissure separating it from the sphenoid region.

Otic articulation: of the palatoquadrate. One of the possible dorsal articulations of the palatoquadrate in which the palatoquadrate articulates with a process on the otic capsule. See image at paratemporal articulation.

Otic capsule: The bone structures containing the organs of the inner ear, principally the labyrinth and the maculae.

Otic shelf: in sarcopterygians, the basioccipital divides on either side of the basicranial fenestra to form two shelves. The jugular vein runs along the top of these shelves toward the intracranial joint.



Otoccipital: in sarcopterygians and basal tetrapods, relating to the posterior half of the divided braincase, containing the otic and occipital regions. The anterior half is referred to as the ethmosphenoid or sphenethmoid.

Otico-occipital: same as *otoccipital*.

Otoconium: same as *otolith*. See **The Ear**.

Otolith: Gr. "ear-stone" (?). Minute calcium carbonate "stones" associated with neuromast organs in the labyrinth. The "stones" deform the villi of the hair cells in response to changes in orientation in the gravity field. See **The Ear**.

Otosphenoidal crest: appears to be synonymous with the *crista prootica*. See Makovicky *et al*. (2003).

Outgroup: In cladistics, a taxon, not a member of the group under study, which is used to fix the polarity of character states. Cladistics without an outgroup yields a shortest path between species, but does not say where the path begins – where the root of the phylogenetic tree is. The outgroup comparison roots the tree. Typically, the outgroup is a taxon just basal to the group under study and is assumed to have all characters in the primitive state. In essence, the outgroup is used as a proxy for the last common ancestor of the group (assuming the group turns out to be monophyletic within the limits of the study). This assumption need not be completely accurate. However, the degree

to which the outgroup differs from the hypothetical ancestor obviously introduces an error of essentially unknown size and requires some assumptions about the phylogeny of the outgroup itself. Example: *Panderichthys* in a study of early tetrapods.

Oval window: see *fenestra ovalis*.

Ovate: egg-shaped, *i.e.* an ellipse with one end larger than the other.

Ovoviviparous: young are born from eggs, but the eggs are incubated internally.

Oxbow: Low-energy rivers, as on coastal plains, will frequently change course, leaving long, arc-shaped lakes in the former riverbed. These lakes may persist for considerable periods. They are referred to as oxbows, based on the resemblance to the shape of the yoke traditionally used to harness oxen.

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Glossary: Pa-Pl

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-P-

P: Permian. *q.v.*

P/p: in mammaliform dentition, an upper (P) or lower (p) premolar.

Pace: in locomotion, "The pace resembles the trot, in which pairs of fore and hind legs are moved together, with a period of suspension between the movement of each fore-/hindlimb pair during which all four feet are off the ground. However, in the trot, contralateral pairs of fore and hind legs are moved simultaneously (e.g., left fore with right hind), whereas the pace involves ipsilateral pairs of legs (e.g., left fore with left hind). The pace prevents the fore and hind leg on the same side from interfering with each other during fast locomotion, allowing a longer stride length, and hence a faster and more efficient mode of locomotion than the trot. Three distinct types of pace gait can be distinguished in extant *Camelus*: a slow pace, where the animal may be supported for four legs during some part of the locomotory cycle; a medium pace, where the animal is only ever supported by two legs;and a fast pace, where there are times during the cycle when no legs are on the ground. The fast pace is the one that would be termed a 'running pace' by Hildebrand (1976)." Janis *et al*. (2002).

Pachyosteosclerosis: pachyostosis (bone thickening), combined with replacement of trabecular bone with compact bone. Madar (1998).

Pachyostosis: increase in thickness of bone. Sometimes used as a synonym of *pachyosteosclerosis*. "Pachyostosis functions to increase an aquatic animal's density so that it approaches that of water, and the degree of pachyostosis usually increases with size and age [citations omitted]. It appears that lung volume (and thus buoyancy) increases allometrically with weight, such that older, larger animals have proportionately more positive buoyancy [citations omitted]. The corresponding increase in the degree of pachyostosis with age appears to compensate for this [citations omitted]." Lee *et al*. (1999: 516).

Pacinian corpuscle: a weird neurosensory structure which looks like an onion on a string. This is a characteristic pressure receptor of therian mammals.

Paedomorphosis: the retention of juvenile characters into adult life. Opposite of *peramorphosis*.

Palatal Arch: palatines + pterygoids. Lee *et al.* (1999a).

Palate: the bones of the roof of the mouth, esp.: vomer, palatine, pterygoid, ectopterygoid, parasphenoid. Depending on context and author, may include maxilla and premaxilla, as well as any braincase elements which are exposed on the roof of the mouth.

Palatine (transverse) torus: the *torus palatinus*, palatine torus: a bony protuberance sometimes found on the hard palate at the junction of the intermaxillary suture and the transverse palatine suture.

Palatobasal articulation: of the palatoquadrate. Same as basipterygoid articulation (?). A ventral articulation of the palatoquadrate in which the palatoquadrate articulates with a process on the basisphenoid. See image at paratemporal articulation.

Palatobasal ridge: in sharks, a ridge formed by the ventral part of the ethmoid articulation of the palatoquadrate. In essence, this is a lateral ridge anteroventral to the orbit. See *Synechodus* for an example.

Palatoquadrate: The primitive upper jaw formed from the hypothetical mandibular arch. See **Gill Arches**, Gnathostomata, *Synechodus*, and (especially) the glossary entry at *pterygoid*.

Paleocene Epoch: The first epoch of the Cenozoic (65.0-54.8 Mya). The Early Paleocene is the Danian Age (65.0-61.0 Mya). The Middle Paleocene is not formally recognized. In these Notes, it refers to the Selandian Age (61-57.9 Mya). The Late Paleocene includes both the Selandian and Thanetian and thus the entire period from 61-54.8 Mya. However, in these Notes, and where there is enough information to make a distinction, it refers only to the Thanetian (57.9-54.8 Mya).

Paleognathous palate: see Paleognathae

Paleomagnetism: When igneous rock is first extruded from the mantle, it usually cools slowly enough that small crystals of magnetic iron in the rock orient toward the magnetic poles as they exist at the time. When the rock cools, the positions of the crystals are frozen -- barring remelting, folding, secondary magnetization, etc. By making a great many, very finicky, measurements it is sometimes possible to reconstruct the original orientation *and* the original dip (variation from the horizontal). The direction can often be used to determine whether the Earth's magnetic poles were normal or reversed. Since the sequence of these magnetic reversals is well known for some periods of Earth's history, a series of reversals over an exposure can sometimes date its levels quite precisely. When information on dip is available, it may be possible to reconstruct the approximate latitude of the landmass where the rock was found. The Earth's magnetic field is horizontal at the (magnetic) equator and vertical at the (magnetic) poles. The relationship between dip and latitude is straightforward and allows a reasonable approximation of magnetic latitude. With a large number of measurements, and with sample ages spread over about 100,000 years, the effect of random magnetic pole "wander" can be averaged out, so that true geographic latitude can be computed as well. Surprisingly, this type of calculation has been corroborated often enough that high quality paleomagnetic data, when and if available, has now become the gold standard for reconstructing the latitude of the continents during the Paleozoic and Proterozoic. Paleomagnetic studies do not yield direct information about longitude. However, samples of the same age, taken from different locations on the same continent, can be used to establish rotation of the continent.

Paleostylic: jaw suspension in which the jaw and braincase are not connected. Apparently, a common condition in children and politicians.

Paleozoic Era: Traditionally, the first era associated with the presence of abundant multicellular life, 543-248 Mya. The Paleozoic Era includes the Cambrian (543-490), Ordovician (490-443), *Silurian* (443-417), *Devonian* (417-354), *Carboniferous* (354-290) and Permian (290-248 Mya) Eras. The Era began with recovery from a period of intense glaciation, and ended with the Permo-Triassic mass extinction.

Palmar: see *plantar* for confusing "explanation."

Palpebral: odd bones of uncertain function that often originate on the anterior margin of the orbit and arch over the orbit -- seemingly blocking vision in part. Palpebrals are common in, for example, the ornithischian dinosaurs. However, in Stegosaurians, the palpebrals are modified to form an extra series of supraorbitals. One might speculate that the eyes of most other ornithischians (and other dinosaurs) were frontated and that vision was commonly directed over the bridge of the nose, rather than down the snout. This would have a number of advantages.

Pamprodactyl: of bird feet, having all four toes in front, as in swifts.

Panniculus L. diminutive of *pannus* = cloth or covering. Hence a little covering.

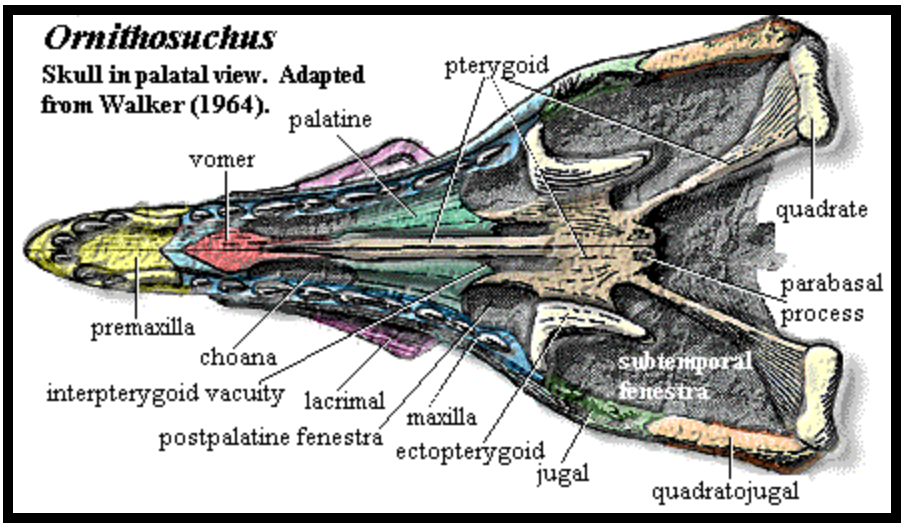
Panniculus carnosus, m.: fine, flat muscles within the hypodermis. Their origin is in the deep fascia of bone and they insert into superficial skin. They act to raise hair, quills, feathers, etc. It is also used in "twitch" reflexes to shake off insects, etc. *See* Untitled (lecture notes).

Papilla amphibiorum: in Lissamphibia, at least, a sensory area in the wall of the sacculus of the inner ear, sensitive to sound frequencies below 1000 Hz (the *papilla basilaris* is sensitive to frequencies above 1000 Hz).

Parabasal process: (of the pterygoid) a posteriorly directed process of the pterygoid near the midline for articulation with the basipterygoid processes of the basisphenoid. Walker (1964).

Parabasisphenoid: a term for the conjoined basisphenoid and parasphenoid, used mainly by Gower and Clack.

Parachordal: In early development, two pairs of cartilaginous rods form parallel to the notochord in the cranium: the anterior trabeculae and the posterior parachordals. These form the foundation for the development of the braincase.



Parachucla Formation: Late Oligocene of Florida. Nearshore environment with sirenians and occasional land mammals. MacFadden & Morgan (2003).

Paracone: one of the major cusps of a tribosphenic upper molar, typically in the antero-buccal corner, q.v. and **Molars**.

Paradiapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the *parapophysis* with the *diapophysis* on the same side. *See* image at *centrodiapophyseal lamina*.

Parafibula: an unusual third bone of the lower leg, normally restricted to the area of the knee, in multuberculates, monotremes and some therians.

Paraglossale: in the avian hyoid apparatus, the arrowhead-shaped bone which forms the base of the tongue.

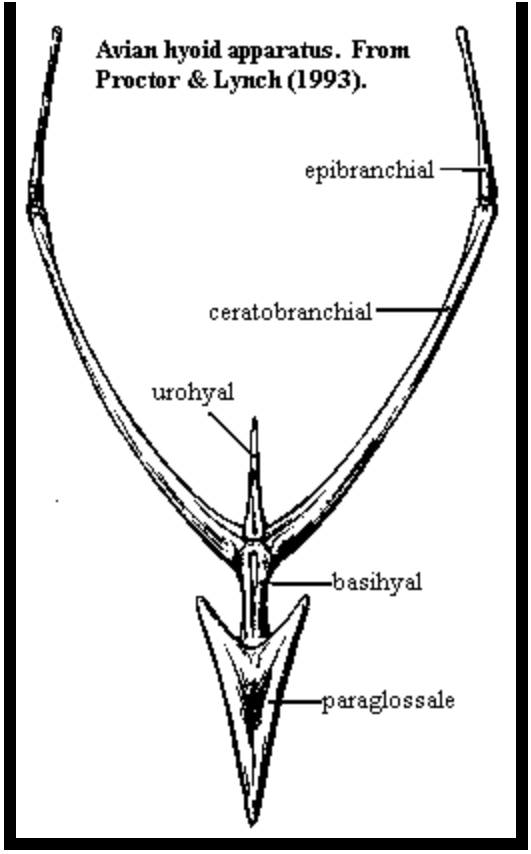
Paralectotype: Each specimen of a former syntype series remaining after the designation of a lectotype.

Paramedian: on each side of a line down the middle. Used mostly by archosaur folk to describe the placement of osteoderm (armor) plates with respect to the vertebral column. Thus *imbricating pairs of paramedial osteoderms* (Sues, 1992: 143) means "with pairs of overlapping armor plates flanking the backbone."

Parampular process: in Actinistia, a posterior process from region of semicircular canals which bridges to occipital region. *See* image at Actinistia.

Paraphyletic: (of a group) a group which does not contain all of the descendants of its last common ancestor.

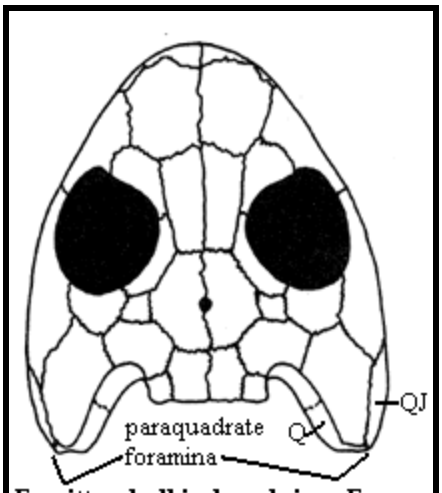
Parapophysis: (pl. *parapophyses*) the articulating surface for the lower, capitular branch of the rib. See diagrams at *diapophysis* and *zygapophyses*. For a much better diagram, see Untitled Document. In



Avian hyoid apparatus. From Proctor & Lynch (1993).

those vertebrae which bear well-developed ribs, a tubercle near the end of the rib articulates at a tubercular facet on the transverse process (diapophysis), while the end, or head, of the rib articulates at a more ventral capitular facet which is sometimes developed into a second, or ventral, transverse process, the parapophysis. The parapophysis is often spoken of as if it were always a process of the neural arch. However, it may extend from the centrum as well. In some papers, the diapophysis and parapophysis are referred to as the *upper* and *lower parapophyses*, respectively. *See, e.g.* Sander (1989).

Paraquadratic foramen: [1] either a foramen *in* the quadratojugal or, more likely, a foramen *for* the quadratojugal located on the quadrate. This feature – whatever it is -- appears to be of considerable importance in the systematics of ornithischians. Dinosaurian ungulates (Ornithopods) (November 12). **[2] paraquadrate foramen:** a small, round hole located along the suture between quadratojugal and quadrate in basal tetrapods, e.g. *Eucritta*. Clack (2001). We have no information on the relationship, if any, between **[1]** and **[2]**.



Eucritta: skull in dorsal view. From Clack (2001).

Parasagital: parallel to the long axis (but not on the midline); parallel to the midline. A parasagittal section is a vertical slice made other than on the midline.

Parasagittal gait: style of locomotion in which the limb moves more or less parallel to the midline of the body.

Parasphenoid: a dermal bone of the palate. Despite the name, it is not part of the braincase. One might speculate that the name is derived from the fact that the parasphenoid runs along the midline of the posterior palate, parallel to (and often functionally replacing) the usual path of the basisphenoid. Then again, one might – very easily – have better things to do.

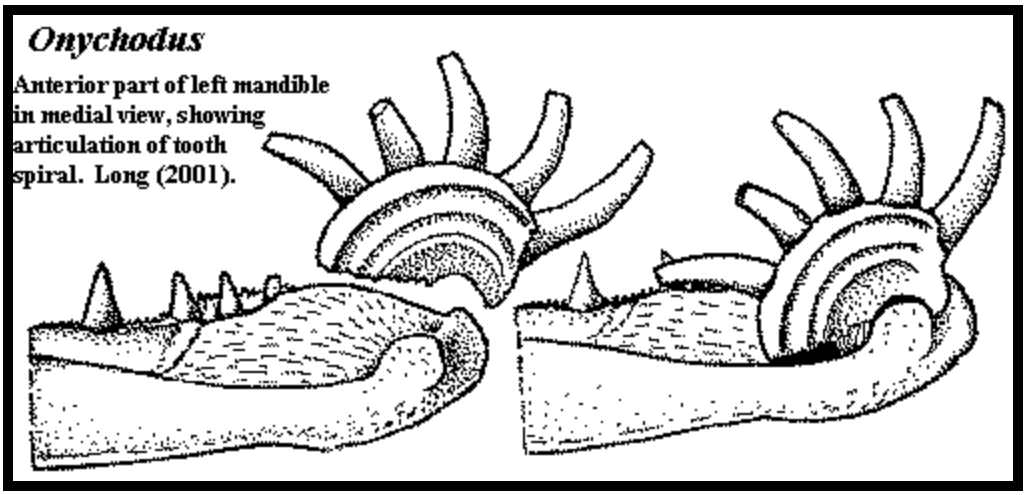
Parasternal process: in basal tetrapods, the posterior "stem" of the interclavicle. This may be a developmental artifact. See Note under *Eucritta*.

Parasymphysial: on either side of the a symphysis, normally referring to the point at which the two halves of the lower jaw are joined.

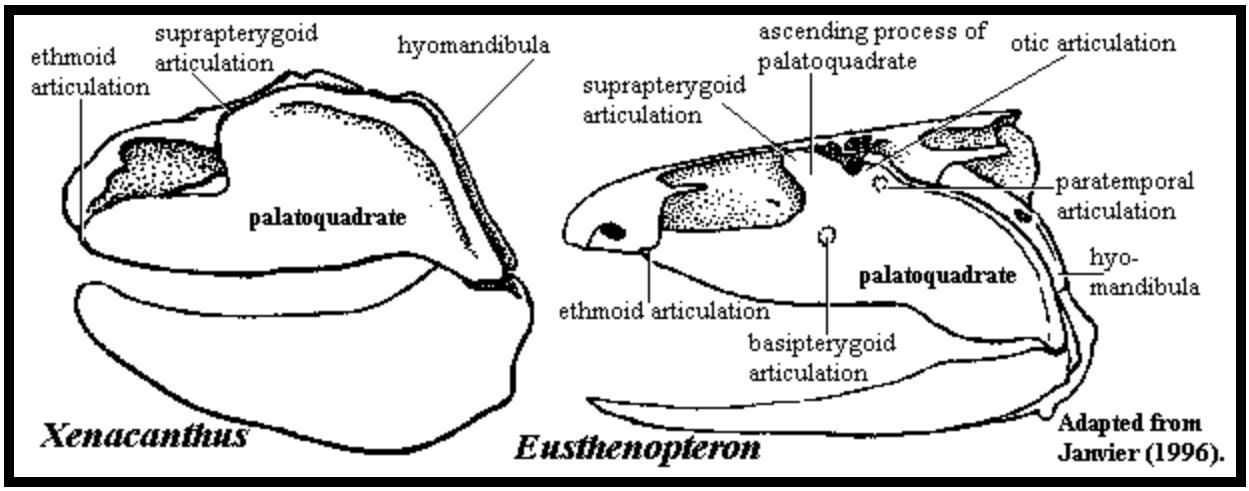
Parasymphysial plate: a plate of dermal bone, normally denticulated or bearing a fang pair, which lies across, or just behind, the point where the two halves of the lower jaw meet, *i.e.* the dentary (or mandibular) symphysis.

Parasymphysial tooth whorl: or spiral. A possible gnathostome synapomorphy. This structure is more easily

illustrated than explained:



Paratemporal articulation: of the palatoquadrate. One of the possible dorsal articulations of the palatoquadrate in which the palatoquadrate articulates with a process on the epihyal.



Paratype: Each specimen of a type series other than the holotype.

Paravertebrae: bony projections lying along side neural spines -- probably same as ossified tendons common in ornithopod dinosaurs. See Dann's Dinosaur Info: MINMI.

Paraxial locomotion: locomotion in which the propulsive force is applied by limbs, flippers or otherwise away from the axis of motion.

Paraxial mesoderm: see **Early Development Terms.**

Paraxonic: foot type in which the plane of symmetry passes between two digits of roughly equal size.

Parhypural: in fish tail anatomy, the last hemal spine that forms part of the hypural plate. It is considered a typical hemal spine or a hypural by some authors, but is recognized as distinct because it bears a **hypurapophysis** (*i.e.*, a process for the origin of the anterolateral portion of the hypochordal longitudinal muscle which inserts on the upper principal caudal fin rays) and is notched to allow the caudal artery to exit the hemal canal. It also supports the lowermost principal caudal fin ray, *e.g.* in Siluriformes. *See* image at urodermal.

Paroccipital process: A usually long cross-bar across the back of the skull formed by the exoccipitals and/or opisthotic. See **The Prootic**. The paroccipital process apparently (a word which signals my gross ignorance) may have contributions from the exoccipitals, opisthotic, and even the crista prootica of the prootic.

Parsimony: In phylogenetic systematics, "parsimony" is the principle that the phylogeny which requires the least number of character changes is the most likely to be correct. In this form, parsimony is neither a logical assumption nor a necessary condition for cladistics. It is simply the working or null hypothesis. That is, parsimony is assumed only when there is no reason to believe that another path was followed. In this form, parsimony is not really different from the classical understanding that a phylogeny which requires convergences and/or reversals is less likely than one which does not. A stronger version of the parsimony principle is less often expressly stated, but is often applied. The

strong version states that the use of numerous character traits increases the strength of the parsimony assumption. The argument is that, because reversals and convergences are statistically rare events, it is only necessary to use a large enough number of characters to swamp any such aberrations. With enough data, so the thought goes, parsimony graduates from being a null hypothesis to being an independent argument for phylogeny, the strength of which is limited only by the statistics of large numbers. This strong form of parsimony is valid statistical reasoning. However, if parsimony is used as more than a null hypothesis, it becomes sensitive to the truth of various assumptions. The most significant of these is the statistical independence of the measured character traits. We are just beginning to understand how groups of characters are governed genetically. We know very little about how selective pressures affect groups of characters; and, much of the time, we have no idea what the functional significance of a character is (i.e., what does it do for/to the organism), much less how it relates to the functional units of selection or genetic regulation (whatever they may be). Thus, the strong form of parsimony is attractive as an idea, but it is generally untestable at present because its assumptions cannot be verified.

Parastylar lobe: in symmetrodont dentition, the (mesiobuccal) lobe of the upper molar containing the parastyle and B/stylocone. The image at *stylocone* shows several upper molars with relatively large parastylar lobes.

Parastyle: in mammalian cheek teeth, a (usually small) cusp on the anterior stylar shelf near the paracone.

Paroccipital process: may be considered a process of the opisthotic, but the process may be formed by bones in addition to, or even instead of, the opisthotic. The paroccipital process runs horizontally (and sometimes dorsally) across the back of the skull. It joins the occiput and braincase to the quadrate, squamosal and the other dermal bones of the "cheek." See **Braincase** or **Opisthotic**.

Parotic plate: oblong, denticulated palatal bones which covered the anterior end of the notochord in some sarcopterygian groups. Also referred to as *arcual plates*. *See* image at arcual plate.

Parietal foramen: unpaired midline foramen located on the parietals for the tetrapod median "eye." *See*, *e.g.* image of *Eucritta* above under *paraquadratic foramen*. This term is used as a neutral alternative to "pineal foramen" since the light sensitive organ within the foramen may not be the pineal in all cases -- it may be the *epiphysis*.

Patagium: a flight membrane as in bats, pterosaurs, and gliding animals.

Patuxent Formation: Early Cretaceous to middle Cretaceous of Maryland, USA. White or light gray to orange-brown, moderately sorted, cross-bedded, argillaceous, angular sands and subrounded quartz gravels; silts and clays subordinate, predominately pale gray. See Geologic Maps of Maryland: Coastal Plain Rocks and Sediments. Arundel Clay facies believed to be Middle Aptian.

Pavement dentition: teeth formed as a broad, crushing surface.

Paw Paw Formation: Early Cretaceous II (Albian) of Texas.

Pectinate: L. *pecten* = a comb. Adjective form of *pecten*, applied to anatomical structures with projections like the teeth of a comb.

Pectiniform: same as pectinate.

Pectoral: relating to the forelimb, esp. the attachment of the forelimb to the trunk.

Pectoral girdle: the bones or cartilaginous structures in the trunk which articulate with the forelimb, including any parts which articulate with the spinal column or skull. These may include the scapula, coracoid(s) (if separate), cleithrum and associated elements, clavicle, interclavicle and sternum. The exact composition will depend on the type of organism.

Pectoralis: The muscle which is largely responsible for the flight stroke in birds, or the digging stroke in moles. The *pectoralis* originates on the sternum and on the furcula (if present) and attaches on the anteroventral face of the humerus. In fishes, it originates on the medial face of the cleithrum.

Pedicel: same as *pedicle*. Probably an incorrect spelling

Pedicle: L. *pes (pedis)* = foot, and the diminutive suffix *-culus*. Hence a little foot; but the word also meant a stalk of

fruit. From this latter comes the anatomical use, for the pedicle of an organ suggests the stalk of an apple or other fruit. The most common use of this word is in connection with the two ventral "stalks" of the ilium which contact the pubis and ischium and forms the posterior and anterior sides of the acetabulum. These are the *pubic pedicle* and *ischial* (or *ischiac*) *pedicle*, respectively.

Pedomorphosis: the retention of juvenile characters into adult life. Opposite of *peramorphosis*.

Peduncle: a pedunculate process. The most common use of this word is in connection with the two ventral "stalks" of the ilium which contact the pubis and ischium and forms the posterior and anterior sides of the acetabulum. These are the *pubic pedicel* or peduncle and the *ischial* (or *ischiac*) *pedicel* or peduncle, respectively.

Pedunculate: hanging from or supported by a stalk.

Peel Sound Formation: Late Silurian (Pridoli) to Early Devonian (Pragian) of the Canadian Arctic. This unit is a red bed located on Prince of Wales and Somerset Islands and the Boothis Peninsula, surrounded (both geographically and temporally) by carbonates. CHAPTER 5 -CANADIAN ARCTIC ISLANDS BANKS BASIN. Marginal marine and estuarine environment of very low energy. Dineley (1976).

Pelage: hair, fur, spines, or other keratinous dermal projections (not skin, scales, hooves, etc.). The term is usually only applied to mammals.

Pelite: any lithified mudstone or other very fine-grained (i.e. clay) material.

***Pelte-*:** Gr. root = shield

Pelvic: relating to the hind limb, esp. the attachment of the hind limb to the trunk.

Pelvic girdle: the bones or cartilaginous structures in the trunk which articulate with the hind limb, including any parts which articulate with the spinal column. These may include the ilium, ischium and pubis.

Pelycosaur: a paraphyletic group comprising all Synapsida except therapsids. The archetypal pelycosaur is *Dimetrodon*.

Pennaceous: flat, sheet-like feathers or regions of feathers with ordered barbs. Not *plumaceous.*

Penultimate: next to last.

Peramorphosis: "a process by which the juvenile condition is modified from the ancestral, juvenile condition, and juvenile traits are completely or substantially modified." Jaime Headden.

Pericardial cavity: one of the two primitive partitions of the *coelom*. The *pericardial cavity* contains the heart, and the *pleuroperitoneal cavity* contains the other internal organs. They are separated by the *transverse septum*.

Perichondral: a type of bone which grows as a layer over the surface of a bone or cartilaginous structure from the fibrous perichondral (or periosteal) covering. Perichondral bone is formed directly, not preformed in cartilage.

Perilymphatic duct: the duct in the inner ear that directs the perilymph (and the compression waves caused by sound) along the lagena (= cochlea) and into the metotic cavity. See figure at **The Ear**.

Periosteal: around the outside of the bone. Typically applied to lamellar, acellular bone which coats the surface of endochondral bones. The shiny, white surface layer of many bones. Same as perichondral (*q.v.*) except that it surrounds other bone, rather than cartilage.

Periotic: same as the petrosal, *q.v.*

***Perisso-*:** Gr. = "odd" in both senses of the English word, i.e. (a) strange and (b) integers not evenly divisible by 2.

Peritoneum: see *pleuroperitoneal cavity.*

Permian: The last period of the Paleozoic Era, between the Carboniferous and Triassic, approximately 290 to 248 Mya. As used here, the Lower Permian ("lwP") refers to the Asselian, Sakmarian, Artinskian and Kungurian Ages

(290 - 256Mya), Middle Permian ("mP" -- rarely used, as this is not a recognized epoch) refers to the Artinskian and Kungurian Ages (269 - 256Mya), and the Upper Permian ("upP") refers to the Urmian-Kazanian and *Tatarian* Ages (256 - 248Mya).

Peroneal: relating to the fibula.

Perpendicular plate: the ventral continuation of crista galli of the ethmoid. It descends from the ethmoid through the nasal cavity, forming part of the nasal septum and articulating with the ascending processes of the vomers and palatines in the palate. See large figure at figure3.

Peskapoo Formation: Paleocene (Tiffanian) of Alberta. Freshwater lacustrine deposits. Wilson (1980).

Petrosal: the fused otic capsule of mammals. It is homologous to at least the prootic and opisthotic, and may contain elements of the amniote supraoccipital as well. Sometimes referred to as the "periotic." The petrosal of mammaliforms and early mammals is described in considerable detail at Morganucodontidae and Triconodontidae.

Petrotympanic fissure: the space between the ?medial rim of the bulla and the basicranium. Luo (1998).

Phalacanthous: having dorsal fin spines, as in ctenacanthiforms. Opposite of *anacanthous*.

Phalanges: Gr. *phalanx* = a packed triangular formation of infantry. Finger (or toe) bones.

Pharyngo-: prefix referring to (a) the pharynx or nasal passage, or (b) the most ventral element of a gill arch. See **Gill Arches**.

Pharyngobranchial: the most ventral element of a branchial arch.

Pharynx: anterior portion of gut from which internal gills develop as a series of paired pouches.

Phylogenetic bracket: A technique for inferring the unknown characters of an organism from the known characters of related organisms. Given the phylogeny:

```
A
|--B
`--+--C (extinct)
   `--D
```

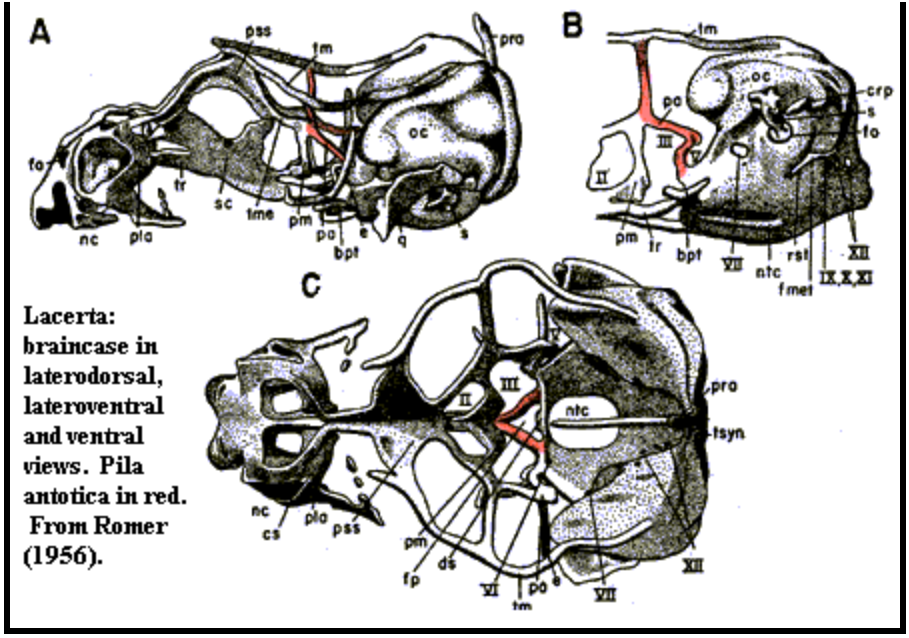
If B and D are known to have a character, then, absent evidence to the contrary, we may infer that this character is common to all members of taxon A. Thus our working assumption should be that the extinct organism C also possessed that character. Crocodiles (B) and birds (D) generally demonstrate some level of parental care of hatchlings. Our default assumption is that this is common to all archosaurs (**A**), and was thus present in ornithischian dinosaurs, such as *Stegosaurus* (C). Note that parental care is not a synapomorphy of archosaurs. The bracket is a method for making educated guesses. It is not a matter of strict logic, and applies only in the absence of evidence to the contrary. It could well be that stegosaurs hung around in bars all night and never paid their child support.

Phylospace: a portmanteau word used to describe the placement of organisms in space, time and phylogeny. It is an evolving concept, so to speak.

Physostomous: of swim bladders, having a connection (pneumatic duct) between the gas bladder and the esophagus, e.g. many freshwater fishes; fishes in which the air bladder is connected at some point to the digestive tract by an open duct. Some physostomous fishes use the gas bladder as temporary or supplementary organ of respiration (e.g. arapaima, gars, bowfin). FISHBASE

PIFE: the *m. pubo-ischio-femoralis externus* an important leg adductor which runs from the ventral or lateral face of the pelvic girdle (the puboischiadic plate) to the femur. Its attachment on the femur is associated with the *intertrochanteric fossa* on the medial face of the femur, below the femoral head.

Pila antotica: The sphenethmoid does not simply disappear over the course of tetrapod evolution. Rather, like a decrepit dwelling, it gradually sheds superstructure



Lacerta: braincase in laterodorsal, lateroventral and ventral views. Pila antotica in red. From Romer (1956).

until only a few main beams remain. In development, the embryo still dutifully constructs these beams as a latticework of cartilage, although the frame will never be built out or ossified. One of these beams is the *pila antotica.* These *pilae* (since there are actually a pair) arise from either side of the *dorsum sellae*, the sturdy process which guards the pituitary fossa just in front of the hind-brain. The *pilae* rise anteriorly and medially from the *dorsum sellae* until the two processes meet in the middle. It then rises to the *taenia marginalis* which runs sagittal along the midline of the skull table, just under the dermal bones. In therapsids (at least), the pila forms the internal wall of the cavum epiptericum, and is lost in therian mammals.

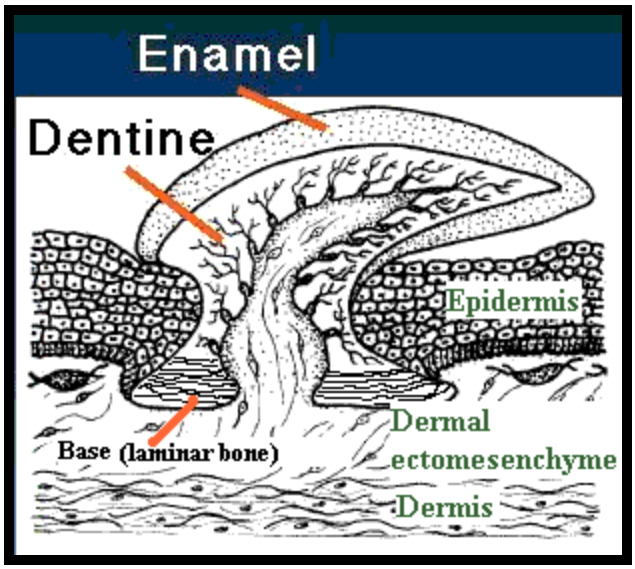
Pilaster: in architecture, a false or half-column built into a wall, usually as a decorative element. Hence, in anatomy, a long bone which overlies another so that it appears to be a cylinder partially enveloped by the bone it overlies. Common examples include the ascending ramus of the quadrate, as it merges with the quadrate ramus of the pterygoid, or the fibula, when reduced to a splint, as it appears to merge into the column of the tibia.

Pineal L. *pinea* = a pine cone. Presumably so named from the shape of this body. A light-sensitive body associated with the brain.

Pinna L. *pinna* = a wing. Applied to the external ear.

Piriform: pear-shaped. Often spelled *pyriform* (*q.v.*).

Pisiform L. *pisum* = a pea, and *forma* = form. one of the proximal carpal bones of the wrist. See figure at *carpus*.



Placoid: form of scale frequently found as microsquamation in chondrichthyans. With reference to the *lepidomorial* unit (if it has any continuing meaning), the crown grows at right angles to the base and the pulp cavity is filled with dentine or bone, leaving only narrow circulatory canals. It consists of one basic odontode unit. That is, it includes a pulp cavity covered with dentine. This is usually covered with a layer of enamel or enameloid, and is attached to the integument by a bony base.

Plagio-: Gr. for slanted, inclined, or "to the side"

Plagiopatagium: a flight membrane running between the body and the limb or digits.

Plantar: This is a peculiar term which has become ambiguous because of the bizarre structure of bipedal primates. In human medical terminology, it generally means of, relating to, or occurring on the sole of the foot -- *i.e.*, same as palmar or ventral and opposite of dorsal. See PALMAR, PLANTAR and DORSAL. This is fine for plantigrade organisms. However, in veterinary and more general use, *plantar* is used to describe the *caudal* facing aspect of the hind limb from the tarsus distally because this is the primitive ventral surface in embryonic development. In this sense it is still (somehow) regarded as being the opposite of dorsal. However, for digitigrade (or unguiligrade) organisms, it is actually a posterior, caudal, or posterodorsal surface. We may summarize as follows for a generalized quadruped:

- For structures *proximal* to the tarsus or carpus, the relationship of the front and back sides of the legs can be

described by using *cranial* and *caudal*:

- *Cranial* means the structure is closer to the *front* side of the leg.
- *Caudal* indicates the structure is closer to the *back* side of the leg.

- For structures *distal* to the carpus or tarsus, *dorsal* is used to describe the *cranial* surface.

  - *Palmar* is used to describe the caudal surface of the forelimb
  - **Plantar** the similar area on the hindlimb.

  The problem is when the proximal tarsals themselves are illustrated. In this case,*dorsal* could mean *proximal* (i.e. the surface in contact with the epipodials - tibia, ulna, fibula, radius, or whatever) or the opposite of *plantar* (i.*e.* the front of the ankle). See Protocetidae for more information, illustrations, and perhaps a better rule of thumb (or toe as the case may be).

Plantigrade: Feet in which parts enclosing the phalanges and metatarsals all touch the ground and bear significant weight in ambulatory (walking) locomotion.

Plate, perpendicular: See *Perpendicular plate.*

Platycoelous: of vertebral centra, flat ends -- neither *procoelous* (anteriorly concave & posteriorly convex) or *opisthocoelous* (vice-versa). Same as acoelous.

Pleromic: used to describe a material that fills in interstices, spaces or gaps. **Pleromic dentine** is a relatively amorphous form of dentine, having fewer and less branched tubules, which fills in spaces in bone or in tubulate dentine.

Plesiomorphy: (retention of a) primitive character. One of the important contributions of cladistics is its insistence that plesiomorphies carry no phylogenetic signal, *i.e.*, they cannot be used to classify organisms.

Plesion: in taxonomy, a word used and misused in various senses. Here it is used to mean a group consisting of a series of successive branches from a stem lineage which are united by plesiomorphic characters or homoplasies. This is ***not*** a clade. It is a paraphyletic grouping equivalent to a grade. Perhaps the best example of taxa arranged in a plesion are the early tetrapods between *Acanthostega* and the temnospondyls. These forms seem to have stubbornly resisted all temptations to diversify, with each genus remaining as a separate, short-lived branch from the tetrapod stem lineage.

Plesodic: of a fin, the condition in which the basals and radials reach to the distal margin of the fin. Opposite of *aplesodic*.

Pleural cavity: In many amniotes, the lungs are separately partitioned off from the rest of the *coelom*, and particularly the *pleuroperitoneal* cavity, by a pulmonary fold (of the transverse septum?). The mechanism in mammals is somewhat different. See *diaphragm*.

Pleural ribs: see **ribs**

Pleuroacrodont: See **Tooth Implantation**.

Pleurocentrum: the vertebral *centrum* associated with the *neural arches*. The pleurocentrum is formed between adjacent *myomeres* and is thus formed by two myomeres, as opposed to the *intercentrum*, which is formed in the center of a single myomere.

Pleurocoel: an internal cavity in bone, usually presumed to be an air-filled space, presumably a weight-saving adaptation.

Pleurodont: See **Tooth Implantation**.

Pleuroperitoneal cavity: one of the two primitive partitions of the *coelom*. The *pericardial cavity* contains the heart, and the *pleuroperitoneal cavity* contains the other internal organs. They are separated by the *transverse septum*.

Pleurosphenoid: See **The Pleurosphenoid**.

Pleurothecodont: See **Tooth Implantation**.

Plicidentine: "infoldings of dentine at the base of teeth, forming striations" Lee (1997a). "Infolding of the dentine into the pulp cavity (plicidentine) that results in faint grooves on the enamel surface close to the base of the tooth crown." [former site]

Plumaceous: "fluffy" feathers or regions of feathers in which the barbs are not ordered. Not *pennaceous*.

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Glossary: Po - Ps

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Pod''emnaya Formation: that's not a typographical error. Its a Lochkovian exposure in Severnaya Zemlya. Sometimes spelled "Pod'emnaya."

Polar cartilage: Two or more small cartilage bodies that form at the posterior end of the sphenoid region during development of the braincase. See **The Braincase** and figure, *infra*, at *prechordal bars*.

Polarity: (of a character) Determination of polarity is the determination of which character state is primitive for a group, i.e. the character state of the ancestor of a monophyletic group.

Pollex: pes digit 1; the big toe; 15 & 16 (if you count on your digits); this little piggy went to market; etc...

Polyphalangy: the condition of having many phalanges. For example, aquatic reptiles have repeatedly evolved flippers from limbs by elongating their limbs with additional finger and toe bones.

Polyphyletic: (of a group) a group which does not contain its own last common ancestor.

Polyphyodont: having more than two sets of teeth in a lifetime, as opposed to *diphyodont*.

Polyprotodont: having more than two lower incisors.

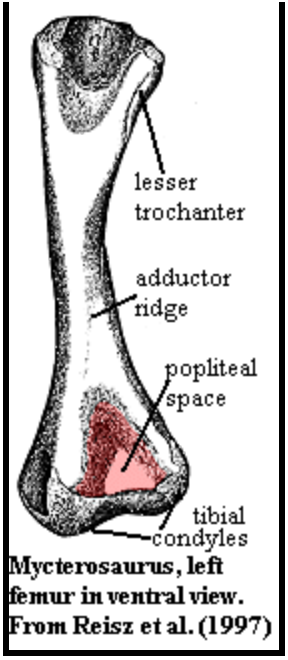
Polyspondyly: [1] the condition in which the vertebrae have more than two *centra*. This condition is found in some *dipnoans* and *holocephalians*. It is also one of the few English words having 3 'y's, although it would not be difficult to construct others. For example: *polycryoichthyodactyly* -- the very common parental condition of having many frozen fish-sticks. **[2]** Also used in the special case of certain chondrychthyans which have calcified "rings" around the notochord at intervals which do not seem to correspond in a regular way to the placement of body segments.

POMC: *Proopiomelanocortin*.

Pondaung Formation: Middle and Late Eocene of Myanmar. Terrestrial. Primates.

Popliteal area (or space or fossa): a depression on the ventral side of the femur, between the condyles, presumably related in some fashion to the popliteal nerve and/or artery.

Pore-canal system: see *cosmine*.



Mycterosaurus, left femur in ventral view. From Reisz et al. (1997)

Posongchong Formation: Early Devonian (Pragian) of China (Yunnan). Onychodonts & galeaspids. Zhu & Janvier (1994).

Post: (abbr.) posterior.

Post-dentary bones: same as *postdentary* bones.

Postaxial radial: see figure at Dipnomorpha

Postbranchial lamina: of the cleithrum. See section on the elpistostegalian pectoral girdle.

Postcingulum: a transverse *cingulum* running across the distal (posterior) face of an upper molar. If a lower molar, then **postcingulid**.

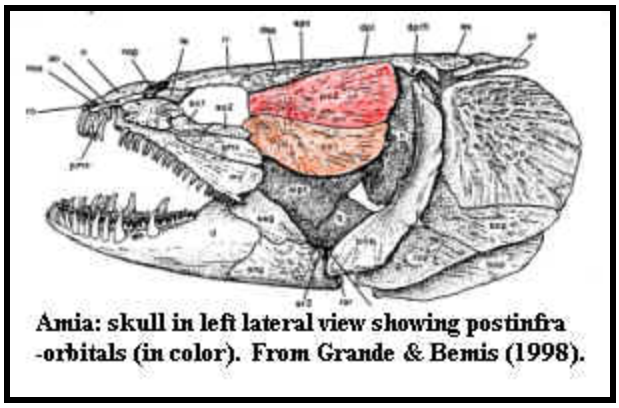
Postcristid: in mammalian dentition, the ridge running around the distal end of a lower molar (the talonid side) from entoconid to hypoconid (i.e. with the hypoconulid more or less in the middle).

Postdentary bones: collectively, the angular, surangular and articular bones. This term is used almost exclusively to refer to these bones in mammaliforms, in which they are *not* posterior to the dentary. It seems never to be used with reference to reptiles, in which the postdentaries *are* posterior to the dentary.

Postinfraorbital: in fishes, dermal bones of the circumorbital series which are located posterior to the orbit and often elongated anteroposteriorly.

Postorbital articulation: of the palatoquadrate. One of the possible dorsal articulations of the palatoquadrate in which the palatoquadrate articulates with a process on the posterodorsal part of the ethmoid.. See image at paratemporal articulation.

Postorbital bar: A bony bar separating the orbit and *temporal fenestra* ("temple").

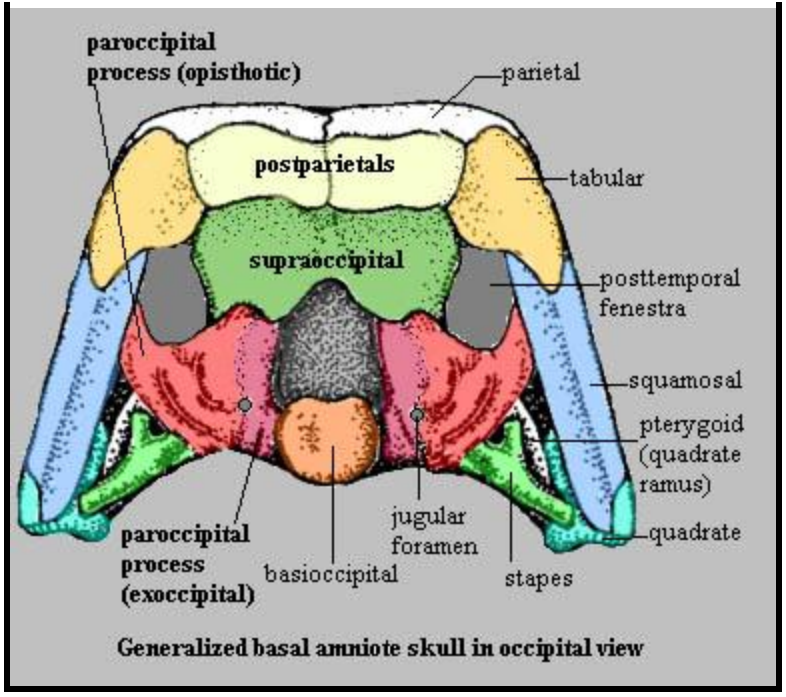

Amia: skull in left lateral view showing postinfra -orbitals (in color). From Grande & Bemis (1998).

Postorbital pila: a dorsal or anterodorsal process of the basisphenoid from near the base of the basipterygoid process into the orbit. This process helps support the eyestalk, if present, and anchor the extrinsic eye muscles of the rectus series. Also called the *basisphenoid pillar*. See figure at rectus muscles; *see also* discussion and figures of the gnathostome orbit.

Postorbital Process: A projection from either the jugal bone on the zygomatic arch, or the frontal bone, partially separating the orbit and the temporal fossa.

Posttemporal: a paired bone of the sarcopterygian skull and shoulder girdle. The posttemporal attached to the skull anteriorly and also bridged the lateral extrascapular (dorsomedially) to the supracleithrum (ventrolaterally). See *Eusthenopteron* for an image of the whole series. The posttemporals are lost in all tetrapods.

Posttemporal fenestra: in stem and basal tetrapods, the paroccipital process does not completely seal off the braincase. A space is left, generally bordered ventrally by the paroccipital process and dorsally by the tabular. The squamosal, the exoccipitals (if distinct from the paroccipital process), and the supraoccipital (if present) may also be involved. The fenestra defined by these elements leads to a shelf on the dorsal surface of the otic capsule.



Generalized basal amniote skull in occipital view

Posttemporal foramen: in some forms, notably basal archosaurs, the posttemporal fenestra is reduced to a small foramen. Normally, the foramen is bordered by the paroccipital process ventrally, and by some combinationof the parietal, squamosal and perhaps supraoccipital dorsally and laterally.

Postzygapophysis: see *zygapophyses*.

Postzygodiapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the postzygapophysis with the *diapophysis* on the same side. *See* image at *centrodiapophyseal lamina*.

Praespiraculum: in jawless fishes, an anterior head opening supposedly representing the gill slit of the mandibular arch, assuming that the mandibular arch was a functional gill arch at some point. The openings just medial or just lateral to the orbits in some very basal vertebrates are identified by some as praespiracula. Today, the more conventional interpretation is probably that these are nasal or nasohypophyseal openings.

Pragian Age: Early Devonian. The second and middle age of the Lower Devonian, 412-400 Mya.

Preacetabular tubercle: an anteriorly or laterally directed short process of the pubis located, as the name suggests, on the body of the pubis, anterior to the acetabulum. Known from, *inter alia*, various birds and lizards.

Preaxial radial: see figure at Dipnomorpha

Prechordal bars: same as *trabeculae*. See also figure at right.

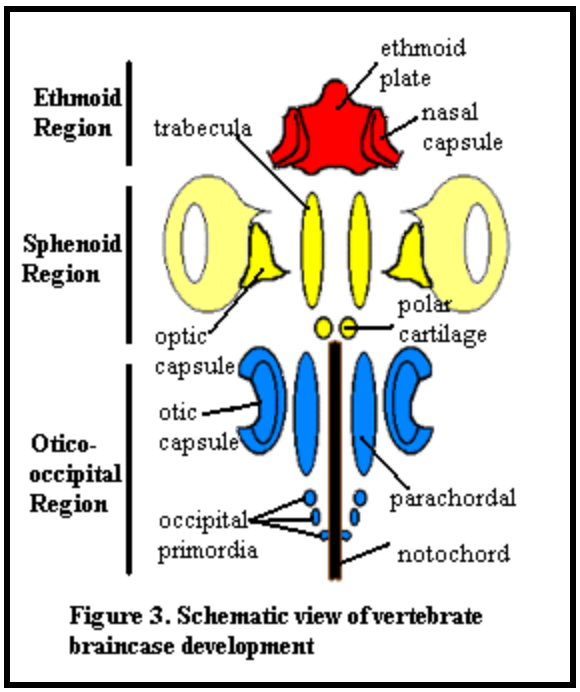


Figure 3. Schematic view of vertebrate braincase development

Precingulum: a transverse *cingulum* running across the mesial (anterior) face of an upper molar. If a lower molar, then **precingulid**.

Precurrent: preceding or, more specifically, the members of series (e.g. vertebrae) which are more anterior to the subject member. "The prezygapophyses articulate with corresponding structures on the precurrent vertebra."

Prehensile: Structures adapted for grasping or seizing by curling or wrapping around such as the tail of some American monkeys and opossums.

Prehension: the act of seizing or grasping. For an interesting essay on tongue prehension vs. jaw prehension of food in lizards, see Foraging and Trophic Ecology.

Premaxilla: a dermal bone of the facial series, including the anterior portions of the upper jaw and rostrum. See **Bones: The Premaxilla** for the gory details.

Premolar: molariform replacement teeth mesial (anterior) to the molars. "The fundamental distinction between premolars and molars is developmental: premolars developed from a secondary dental lamina and replace deciduous

precursors (which may or may not erupt), whereas molars originate from the primary dental lamina and, by definition, neither replace precursors nor are replaced by successor teeth." Kielan-Jaworowska *et al*. (2002: 481).

Prepatagium: a roughly triangular flap of skin on the wing of a bird or pterosaur which fills the space bounded by the humerus and ulna.

Presacral: of vertebrae, the vertebrae other than the sacral (pelvic) and caudal (tail) vertebrae, *i.e.* the cervical (neck) vertebrae and the dorsal (back) vertebrae, the latter including the thoracic (upper spine) and lumbar (lower back) vertebrae, if these regions are specialized (as in mammals).

Prespinal lamina: reinforcing medial bone ridge in the vertebrae (normally, of sauropods) running down the anterior face of the neural spine. *See* image at *centrodiapophyseal lamina*.

Prespiracle: *see* praespiraculum.

Pressure: force per unit area.

Preural caudal: in fish anatomy, the more anterior of the two "tail" regions, in which the hemal arches are joined distally to encircle the caudal artery & vein. More posteriorly, the caudal artery splits in two and runs along both sides of the spine. Preural vertebrae also lack hypurals. The two anatomical definitions (distally joined hemal arches & absence of hypurals) are used cumulatively or interchangeably.

Prezygapophysis: see *zygapophyses*.

Prezygodiapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting a prezygapophysis with the *diapophysis* on the same side. *See* image at *centrodiapophyseal lamina*.

Prezygoparapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting a prezygapophysis with the *parapophysis* on the same side. *See* image at *centrodiapophyseal lamina*.

Pridoli: the Silurian is split into 4 epochs, rather than the usual three (*i.e.*, Early, Middle & Late). The Pridoli is the latest Silurian. The Pridoli is not split into ages, so that it is often spoken of as the Pridolian Age as well as Epoch. It is sometimes (and probably correctly) spelled "Pridoli." The "Late Silurian" usually refers to the Ludlow plus the Pridoli.

Primary calcification: a process apparently unique to neoselachian sharks in which calcification of the notochord occurs by secondary invasion of chondrocytes into the notochord itself. These cells deposit cartilage between the external and internal elastic membranes of the notochord. The cartilage is then secondarily mineralized. Prismatic? endochondral? perichondral? ossification -- dunno... And with all this secondary activity, why is it called "primary calcification"?

Primary feathers: the flight feathers on the wrist, hand and fingers (*carpometacarpus* and *phalanges*) of a bird.

***Processus alaris*:** generic term for a wing- or fan-like process.

***Processus connectens*:** in Sarcopterygii, the posteriorly directed processes of the sphenethmoid section of the braincase which articulate with the otoccipital section. *See* image at *Diplocercides*.

Processus tubarius: in whales, by analogy with a structure on the human sphenoid, the anterior process of the bulla which supports -- actually forms -- the Eustachian tube. Generally, = anterior process of the bulla. Luo (1998). See also, *image*.

Procoelous: a pattern of vertebral articulation in which the individual vertebrae are concave anteriorly and convex posteriorly. Opposite of *opisthocoelous*. lab7 photos

Procumbent: slanted forward.

Procurrent: inclined forward.

Procurrent ray: one of a series of small, unsegmented rays on the dorsal and ventral edges of the caudal fin.

Profundus nerve: This nerve is known by a ridiculous number of names, most of which are variations on: ***V1*** (*i.e.* branch #1 of the trigeminal or Vth cranial nreve), ***n. ophthalmicus profundus***, or ***deep ophthalmic nerve***. Note that the profundus is sometimes simply called the "ophthalmic nerve" because the term "superficial ophthalmic nerve" often refers to a branch of the facial (VII) nerve. However, the two often run together, making the term "ophthalmic nerve" ambiguous. Use of the English "deep ophthalmic" is also problematic. In some cases, the profundus splits into internal and superficial rami well forward of its exit from the braincase, in which case, the internal ramus of the nerve may be called the "deep ophthalmic," although both rami are part of the profundus. Finally, recent evidence suggests that the profundus is the same as the *ciliary nerve* in mammals.

The profundus exits the braincase with, or close to, cranial nerve V, the trigeminal nerve. In many sarcopterygians and actinopterygian fishes, the profundus exits together with the trigeminal and also enters into the semilunate ganglion with the trigeminal immediately outside the braincase. That is why the profundus was historically regarded as a branch of the trigeminal. That may or may not actually be the case. A good deal of theoretical wrangling depends on the answer, assuming that the question is meaningful (and it probably is). Somesegmentalists associate the profundus with sensory inervation of the hypothetical pre-mandibular arch. Thus, they tend to argue that the profundus is a separate structure which is related to this hypothetical arch in the same way that the trigeminal (V) is related to the mandibular arch or the facial (VII) to the hyoid arch.

Whether or not a premandibular arch ever existed, the profundus has certainly always been associated with sensory inervation of the most anterior parts of the head, and with the area around (but not in) the nasal capsule. This applies even in hagfishes, osteostracans, and other jawless forms.

In many osteostracans and gnathostomes, the profundus exits with, or just anterior to, the trigeminal and slightly posterior to the orbit. The profindus exit is located near the posterodorsal corner of the orbit in organisms with more or less laterally-placed orbits. The exit is frequently sheltered by a process of the ethmoid portion of the skull, such as a dorsal process for articulation with the upper jaw. From there, the profundus runs anteriorly across the interorbital septum, then dorsomedially over the orbitonasal wall, before plunging down into the area around the nasal capsules. In following this course, the profundus may enter and exit the bone/cartilage of the anterior braincase several times

Prognathous: having the jaws projected anteriorly. Sometimes used to mean having only the *lower* jaw projected anteriorly.

Promaxillary fenestra: a third anterior skull fenestra, in front of the antorbital and *maxillary fenestra*e.

Promontorium: A bulge in the petrosal (otic capsule) of mammals marking the location of the cochlea in the inner ear.

Pronate L. *pronare* = to turn palm or face downward. Compare supinator.

Proopiomelanocorticotropin: same as *proopiomelanocortin*.

Proopiomelanocortin: ("POMC") an unusual hormone complex manufactured by the anterior lobe of the hypophysis. This complex is metabolized into four separate hormones: adrenocorticotropic hormone (ACTH), melanocyte stimulating hormone (MSH), encephalin and beta-endorphin.

Propalinal: of jaw motions, using a back & forth front-to-back motion, as opposed to *orthal*, straight up and down.

Propatagium: In bats and pterosaurs, thin web of skin that extends from the shoulder to the wrist *anterior* to the upper arm and forearm, and is fixed on the neck or skull.

Propodium: the upper unit of the tetrapod limb, *i.e.*, the humerus and/or femur. Same as *stylopodium*, in contrast to the lower unit, which is the *zeugopodium* or *epipodium*.

Propterygium: fins are often attached to the torso by relatively large, columnar cartilages known as basals. Radials attach to the basals and extend towards the margin of the fin. Typically, there are three basals. In some cases, one of the basals becomes elongated, typically by adding segments bearing radials, and becomes the primary axis of the fin. When the anterior basal becomes extended in this fashion, it is referred to as the propterygium.

Protandrous: sperm and eggs produced by same organ.

Prothecodont: See **Tooth Implantation**.

Protocone: the most lingual of the major cusps of the trigon on an upper tribosphenic molar; the mortar of the mortar & pestle formed by the protocone and talonid of a molar. See figure and **Molars**. See also figure at *Mesostyle*.

Protoconid: the most buccal of the major cusps of the trigonid on a lower tribosphenic molar See figure and **Molars**. See also figure at *Mesostyle*.

Protoconule: in mammalian upper molars. The nomenclature for small cusps in the mesiolingual (toward the tongue and anterior) region of upper molars is difficult. If the cusp is on the main body of the tooth, it is a *protoconule*. If it is a stylar cusp (derived from the cingulum) its a *protostyle*. If it takes the form of a ridge, it is an *entoconule*. The figure at *entocone* shows an upper right molar with both an entocone and a protoconule. Note that the protoconule, if present, will lie along the crista (ridge) connecting the protocone and the paracone, if such a crista is present. In any case it will be somewhere along a theoretical line between the two and probably mesiobuccal to the protocone. An entocone or protostyle is likely to be further out on the margin and mesio*lingual* to the protocone.

Protocristid: in mammalian lower molars, the ridge joining the protoconid with the metaconid. This cristid probably has considerable physiological importance since this ridge forms a barrier which limits the motion of the opposing trigon to the talonid and thus prevents the opposing trigon "pestle" from slipping off the trigonid "mortar" -- the area where it is designed to occlude. This is particularly important to an animal which eats seeds, for example, which could easily cause the trigon cusps to slip out of occlusion before they could enter the talonid basin.

Protoloph: in mammalian dentition, a cutting edge running generally along the mesial side of an upper lophodont molar. See image at lophodont and **Molars**.

Protostyle: See *protoconule* or *entocone*.

Protraction: in tetrapod locomotion, rotation of a limb anteriorly, in a horizontal plane. Opposite of retraction; and in contrast with *adduction* or *abduction* (movement in a vertical plane) or rotation about the long axis of a limb. *C.f.* **Humerus**.

Proventriculus: anterior stomach chamber.

Proximal: closer to a reference point. If no reference point is indicated, then (usually) the center of gravity of an organism. Thus, the femur is proximal to the foot. "Proximal caudals" are the tail vertebrae close to the base of the tail. The "proximal tarsals" are the astragalus and calcaneum, because they are closer to the body than the distal tarsals (the navicular, cuboid, etc.). The opposite of *proximal* is usually distal.

Proximal articulation: of the humerus, the articular surface of the proximal end of the humerus which articulates with the glenoid, and on which the humerus rotates.

Proximal carpals: the upper wrist bones: radiale, intermedium, ulnare and (if present) pisiform. See figure at *carpus*.

Proximal tarsals: the upper ankle bones, the astragalus and calcaneum. In mammals, these may be referred to as the tibiale and fibulare. The tarsal intermedium, if present, is also a proximal tarsal. See Figure at *Tarsus*.

Pseudohyal: In batomorphs (rays and relatives), the ventral elements of the hyoid arch are reduced or absent. The hyoid rays coalesce into novel elements, termed pseudohyals, which functionally replace these elements. Compagno (1999a).

Pseudohypocone: type of cusp that develops through cleavage of the protocone, unlike the true hypocone, which arises from the cingulum.

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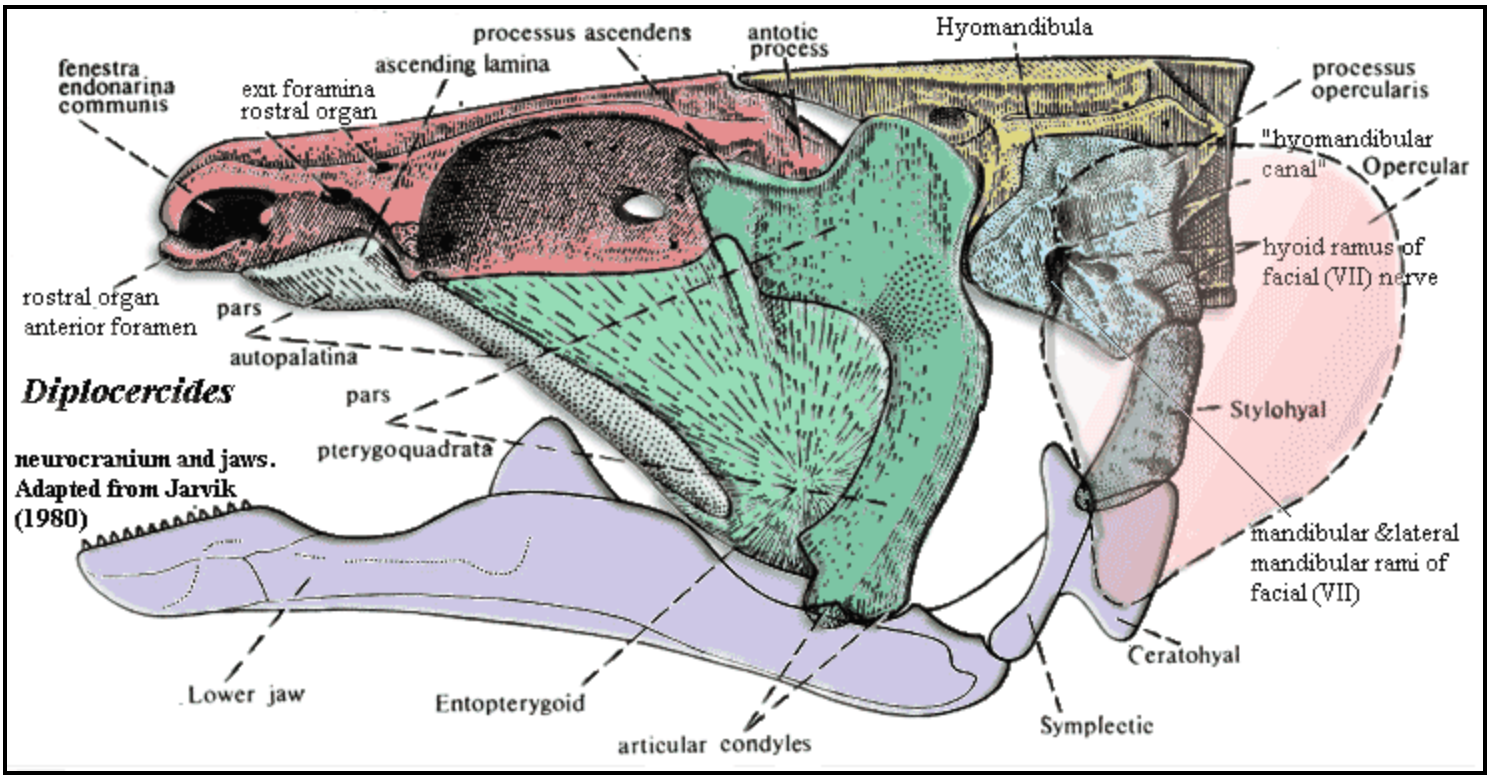
Glossary: Pt-Pz

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Pterygiophore: the cartilage or bone on the outer end of which sit the median fin rays or spines and to which are attached erector and depressor fin muscles. There may be three cartilages that ossify into proximal, median and distal pterygiophores (or axonost, mesonost and baseost or epibaseost). The distal pterygiophore is the one next to the fin. When there are only two pterygiophores these are termed proximal and distal. In some fishes the proximal pterygiophore is very elongate and is known as a basal. Basals may be elongate enough to reach and fuse with the vertebrae, e.g. in *Hippocampus*. Proximal pterygiophores of the dorsal fin are also called interneurals and of the anal fin interhaemals. The last dorsal fin pterygiophore is named a stay. Vestigial pterygiophores anterior to the dorsal fin are called predorsals (or supraneurals although these are derived from neural spines). Same as fin basals.

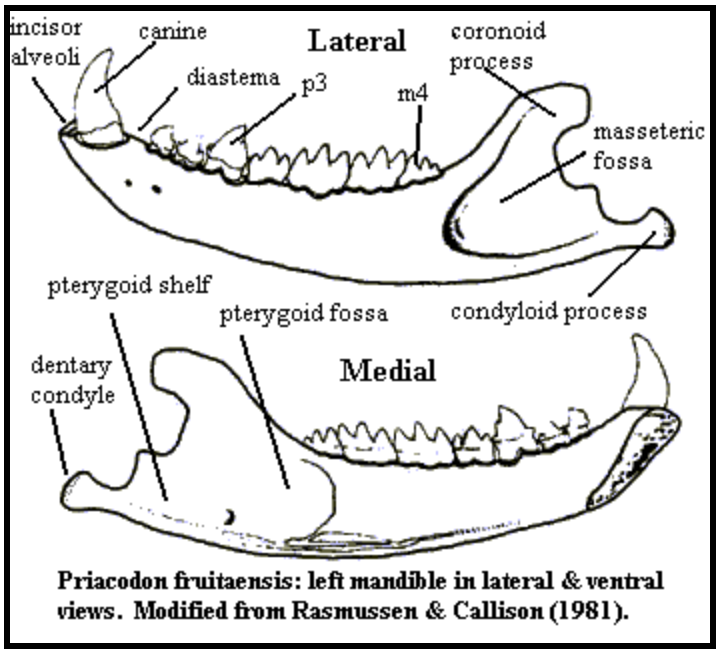


Pterygoid: In tetrapods, the pterygoid is a complex, but relatively stable, paired palatal bone with a number of parts. For the following discussion, it may be best to refer to the images of tetrapod palates at, for example *Ornithosuchus*, Therapsida, or Palatines. In many tetrapods, it is the largest palatal bone and serves as the main structural support.

Most typically, the pterygoids meet extensively on the mid-line of the palate and jointly send a process, the **palatal ramus**, anteriorly, which may cover the parasphenoid more or less completely. Sometimes this term is used to include the main body of the pterygoid as well. More variably, there are one or two anterolateral processes which go by various names, such as **ectopterygoid ramus**. In many amniotes, the pterygoid develops a strong **transverse process** or **transverse flange** which forms a bar running laterally across the palate. The pterygoid also articulates with (where present) the dorsoventral supports for the palate: the epipterygoid (dorsal) and the basipterygoid process of the braincase. Finally, the pterygoid sends a long, robust **quadrate ramus** with complex curvature down (posteroventrally) to grasp the quadrate and support the jaw articulation.

Basally, in fishes, the terminology tends to be a little different. Refer to the image of the Frasnian actinistian *Diplocercides*. The pterygoid bone of tetrapods is, roughly speaking, derived from the middle, **entopterygoid** (*see also* entry at *entopterygoid* for alternative definitions) portion of the palatoquadrate complex. The entopterygoid is not actually a part of the palatoquadrate. It is a dermal bone which has replaced the middle section of the primitively continuous endochondral bone of the palatoquadrate, the original upper jaw. In tetrapods, the pterygoid advances further, and also replaces the central part of the posterior, **pterygoquadrate** unit. This becomes the quadrate ramus. The upper part of this unit, the portion involved in the dorsal and basipterygoid articulations between jaw and braincase, is referred to as the **metapterygoid**. In tetrapods, most of this region is incorporated into the pterygoid as well, with the exception of the *ascending process of the palatoquadrate*, which becomes the **epipterygoid**.

Since the anterior braincase articulation is lost in tetrapods, the only remaining sections of the palatoquadrate are the epipterygoid and the quadrate (or, in mammals, the incus). Everything else is either lost or is replaced by the pterygoid.



Priacodon fruitaensis: left mandible in lateral & ventral views. Modified from Rasmussen & Callison (1981).

Pterygoid fossa: apparently an ambiguous term. In mammals, the medial pterygoideus muscle originates between the pterygoid plates of the palate and attaches on the medial face of the jaw near the angle of the dentary. *Both* ends are sometimes referred to as the "pterygoid fossa". For our purposes, it is generally the fossa on the mandible that counts.

Pterygoid shelf: See *Pterygoid fossa*. The pterygoid shelf is the lip on the bottom of the fossa. This runs along the bottom of the jaw and may extend onto the condyloid process, reaching the dentary condyle in some cases.

Pterygoid transverse flange: see transverse flange

Pterygoquadrate: the posterior portion of the palatoquadrate, containing the epipterygoid, articular, and everything in between (usually replaced by the quadrate ramus of the pterygoid). *See* pterygoid for better explanation..

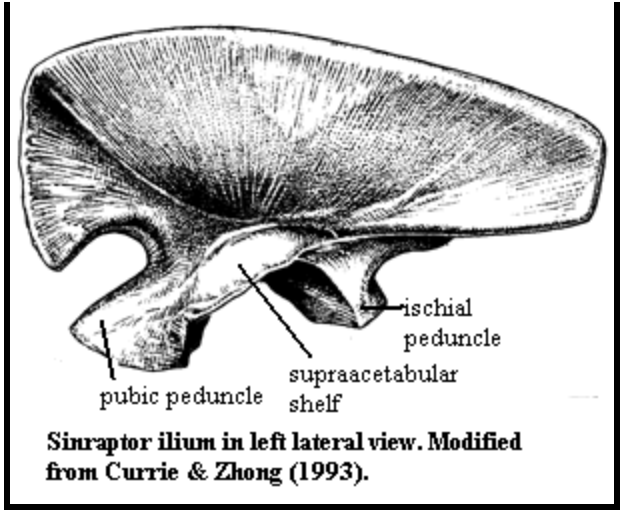
Pterylae: the tracts along the skin of a bird embryo along which feather primordia develop.

Pubic apron: the plate-like surface formed by the pubic symphysis.

Pubic pedicle: same as *pubic peduncle*.

Pubic peduncle: (of ilium) in lateral or medial view, the ilium of tetrapods often appears to have two "legs" which form, on their interior surfaces, two sides of the acetabulum. The anterior leg, which joins with the pubis, is the *pubic peduncle*. The posterior leg, which joins with the ischium, is the *ischial peduncle*. See **Figure**.

Pubic symphysis: Midventral plane of contact between the two halves of the pelvic girdle.



Sinraptor ilium in left lateral view. Modified from Currie & Zhong (1993).

Pubis: the anteroventral member of the three bones forming the pelvis. See figure at *antitrochanter*.

***Pubo-ischio-femoralis externus*:** see PIFE.

***Puboischiofemoralis externus*:** see PIFE.

Pygostyle: the fused caudal vertebrae of a bird that support the tail feathers.

Pyriform: [1] generally, pear-shaped. **[2]** In brain anatomy, a particular lobe in the brain ("pyriform lobe") which includes the lateral olfactory gyrus, and areas of the anterior parahippocampal gyrus. These correspond to the primary and secondary olfactory areas of cortex. **[3]** In Insectivora, the piriform fenestra is a gap between the squamosal and alisphenoid, on one side, and the petrosal on the other. *See*, *e.g.*, image at Apternodontidae. Sometimes spelled "piriform," *q.v.*

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Glossary: Q-R

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A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-Q-

Quadrate: [1] In tetrapod osteology, the quadrate lies at the posteroventral corners of the skull and forms the jaw joint (except in mammaliforms). In the Sauria, it is often the main "pillar" supporting the skull table and the occiput, and its anterolateral border provides the surface for attachment of the tympanum. **[2]** In mammalian dentition, quadrate means **[2a]** four-sided and having sharp corners or, **[2b]** in describing one or more corners of a tooth, sharp corners of about 90°. In addition, **[2c]** when a molar is described as "quadrate" the author usually means that the four main cusps are of roughly equal height, and the trigonid is not markedly elevated with respect to the talonid. The primate molar is perhaps the morphotype one should have in mind.

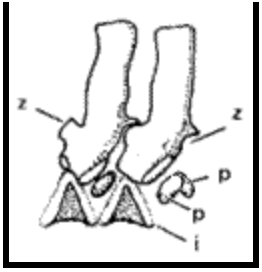
Quadrate ramus: of the pterygoid. This is the part of the pterygoid (often the largest and most central bone of the palate) which emerges from the body of the pterygoid, where it participates in the articulation with the braincase (the basicranial articulation), if present, and the epipterygoid articulation (if present). The quadrate ramus then runs posteriorly, laterally and often ventrally to reach the quadrate. Thus, it parallels the course of the original palatoquadrate unit and may have been derived from a dermal bone sheathing the posteromedial surface of the palatoquadrate -- much as the maxilla began as dermal bone sheathing the anterolateral portion of the palatoquadrate. The geometry of the quadrate ramus is extraordinarily complex and usually involves tortion *and* bending. That is, the quadrate ramus begins as a horizontal strip of bone running back from the center of the palate. It bends downward and twists as it approaches the quadrate so that, by the time it articulates with the quadrate, it is a *vertical* strip of bone with its formerly dorsal surface now facing laterally (outwards).

-R-

Rachis: (pl. raches) the central stem of a feather.

Rachitomous: a condition in which the various elements of the vertebrae are divided into a large, wedge-shaped intercentrum plus two pleurocentra (smaller, intersegmental pieces). A type of *aspidospondyly*. See also figure and note under Anthracosauroidea.

Radial: (a) direction away from imaginary axis running antero-posteriorly through the



middle of the organism or structure; peripheral. Opposite of *axial*. (b) one of a series of bones (preaxial or postaxial) branching from the mesomeres of sarcopterygian pectoral fins. See figure at Dipnomorpha.

Radiale: one of the proximal carpal bones of the wrist. See figure at *carpus*.

Ramiform: branch-like; alternatively, branching or having branches. This is a slippery word and tends to get used improperly as a synonym for *straight* or *rod-like*.

Ramus (pl. **rami**)**:** branch. The word is typically used in a sense synonymous with *process*. Perhaps the word might better be confined to cases in which a bone or other structure actually appears to splits into two or more parts, as this is the sense in Latin.

Rastrate: rake-like.

Rathke's Pouch: an embryonic invagination of the stomodeal ectoderm (*i.e.* the roof of the embryonic mouth) which migrates dorsally to come into contact with the diencephalon (the posterior section of the forebrain). This differentiates into the anterior pituitary gland or adenohypophysis. The tube thus formed between the mouth and pituitary is pinched off in most higher vertebrates. However in at least some non-gnathostomes, it develops into a blind naso-hypophyseal canal or may develop a secondary opening to the environment, with or without a connection to the oralopharyngeal cavity (mouth). See **The Basisphenoid.** Note that this is not the same developmental process which forms the nasal cavity. Other than an initial depression at the nasal placodes, the nasal cavity, at least in mammals, is apparently formed by partition of the stomodeum.

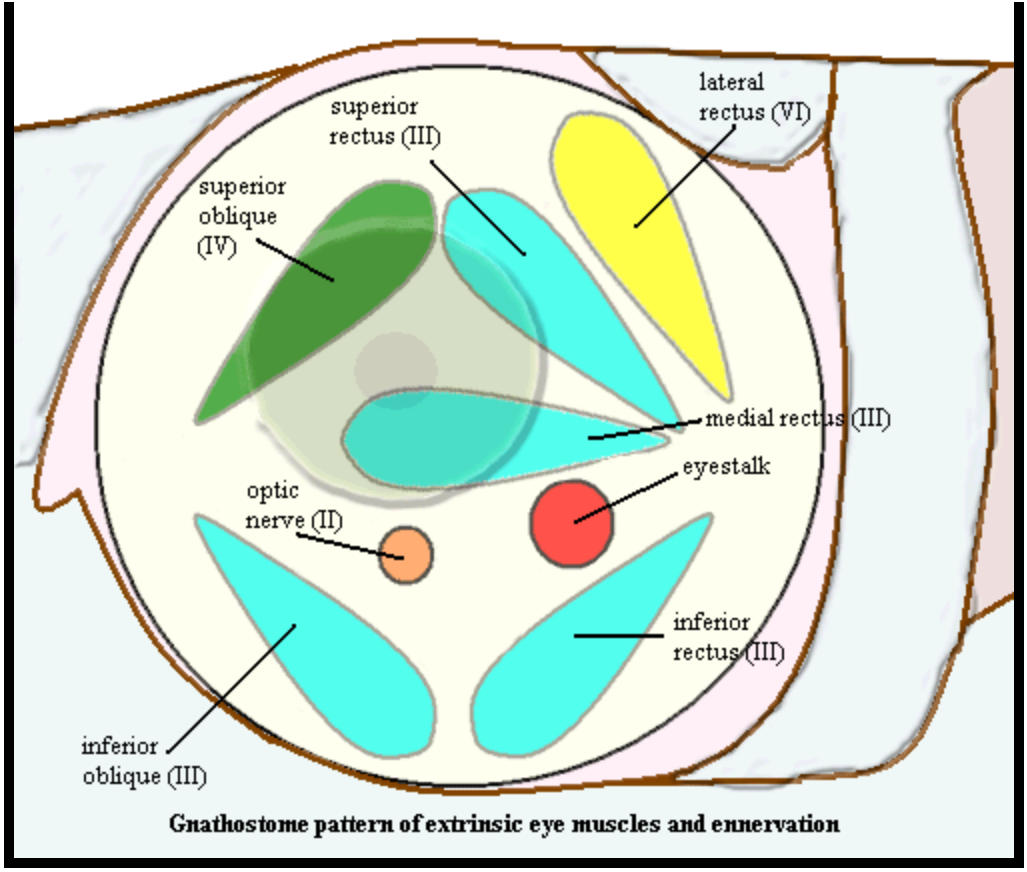
***Recessus conicalis*:** any conical recess. In certain anseriforms, "a deep conical hollow extending on the medial side from the retroarticular process [of the articular] anteriorly under the articulation." Olson (1999).

Recessus scala tympani*:** the *recessus scala tympani* and ***recessus scala vestibuli are created by the subdivision of the inner ear. The two *recessi* are the osteological correlates in reptiles of the *scala tympani* and *scala vestibuli*, respectively. See the **inner ear in reptiles** for an explanation in English.

Rectus muscles: the posterior extrinsic eye muscles. See discussion and additional figures of the gnathostome orbit.

Red Bay Group: Silurian-Devonian of Spitzbergen. Blom & Goujet (2002).

Red Bed: a term applied to sedimentary sequences which are predominantly red in color but usually associated with variable proportions of interdigitated drab strata, typically grey, grey-green, brown or black. They comprise a wide range of facies representing the whole spectrum of non-marine depositional environments from alluvial fans, river floodplains, deserts, lakes and deltas and range in age from Early Proterozoic to Cenozoic. STRATIGRAPHY AND SEDIMENTOLOGY OF



Gnathostome pattern of extrinsic eye muscles and ennervation

CONTINENTAL RED BEDS

Peter ....

Reflected lamina: used of several bone processes where the bone appears to split into two "mirror image" processes. Most commonly refers to the synapsid reflected lamina of the angular. See figure with reflected lamina of angular.

Regression: period of low sea level when previously marine sediments are exposed. Opposite of transgression.

Reichert's cartilage: in mammals, the embryonic precursor of the tympanohyal.

Reissner's membrane: the membrane of the cochlea separating the *scala media* from the *scala vestibuli*. See the **Ear**

Remix: (pl. remiges) the principle flight feathers, including primaries and secondaries.

Reniform: shaped like a kidney.

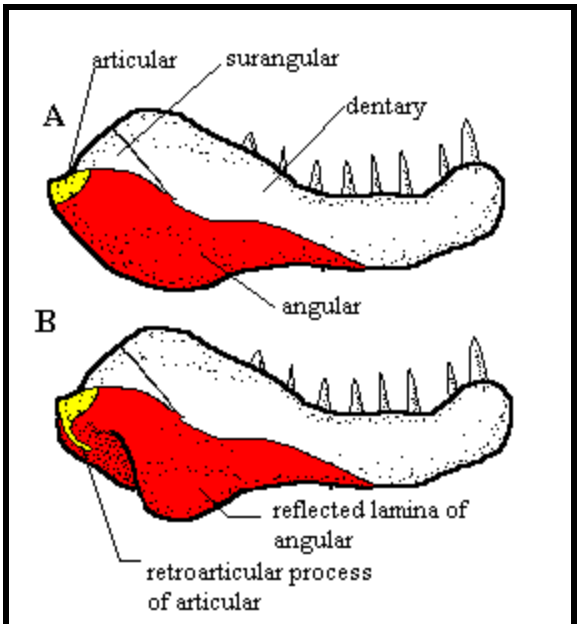


Fig. 1. Synapsid right mandible in right lateral view, with and without reflected lamina of angular and retroarticular process of articular

Replacement pit: a pit paired with a tooth alveolus and joined to it by a channel. The replacement tooth grows in the pit and migrates to the alveolus as it matures. See image at left from Nosotti & Pinna (1999)

Reptilian jaw: a jaw with an articular-quadrate articulation, as opposed to the mammalian dentary-squamosal articulation.

Reticulate: as an adjective, net-like. A *reticulate* pattern may be used to describe a network of raised lines creating a web-like pattern. Sometimes used generally as meaning complex & interdependent.

Reticulum: the second chamber of the ruminant digestive tract, used for sorting out fine plant particles for further fermentation. See Artiodactyla for figure.

Retraction: in tetrapod locomotion, rotation of a limb posteriorly, in a horizontal plane. Opposite of protraction; and in contrast to *adduction* or *abduction* (movement in a vertical plane) or rotation about the long axis of a limb. *C.f.* **Humerus**.

Retrix: (pl. *retrices*) a tail feather.

Retroarticular (bone): in Actinistia, Meckel's cartilage ossifies posteriorly in *two* places. The more anterior of these is the usual articular bone. However, a second ossification occurs posterior to this, creating a separate retroarticular bone which receives the symplectic (which, in turn, is ultimately connected to the hyomandibular). In adults, the retroarticular and articular may fuse, but development is probably always from two separate centers of ossification.

Retroarticular process: a posterior process which despite the name, may be composed of any combination of the articular, angular, and surangular, projecting behind the glenoid. See image at *reflected lamina* for one example. Perhaps a more typical retroarticular process is the usual archosaur process. This type of retroarticular process is more blunt, fairly massive, and projects posteromedially (and often somewhat dorsally). The retroarticular process initially evolved in the elpistostegalian lineage (tetrapod stem group) as an attachment point for the *depressor mandibulae*. The evolution of this muscle is correlated with the loss of the opercular complex, since the jaw depressor originates on the hyoid arch. The thought seems to be that the hyoid would not have been available to anchor the depressor if it were still coupled to the opercular apparatus. Ahlberg *et al*. (2005).

Revolute: permitting only rotation in one plane. Thus a **revolute joint** is a joint which permits rotational motion (but not translation) only in one plane.

Rhaetian Age: the last Age of the *Triassic Period*, 210-206 Mya.

Rhachitomous: having vertebrae with a large, dorsal, crescentic intercentrum and a small, dorsal, paired pleurocentrum.

Rhamphotheca: The hardened keratinous beak of a turtle, bird, anomodont, trilophosaur, etc.

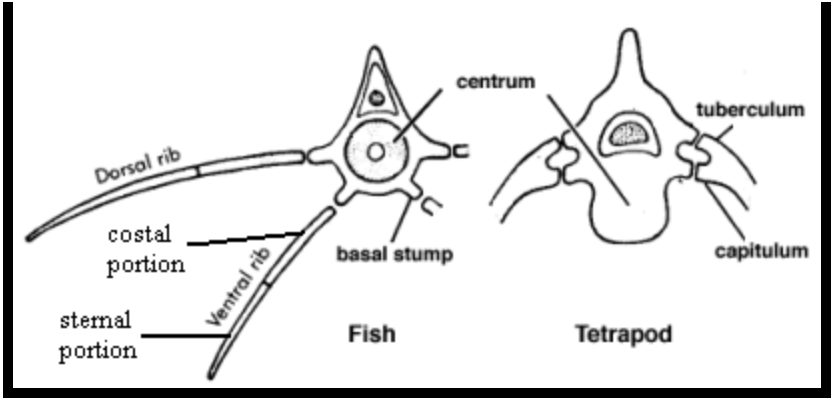
Rhinarium: an area of moist, hairless skin surrounding the nostrils of primates.

***Rhino-*:** Greek root = "nose".

Rhomboid: diamond-shaped, *i.e.*, trapezoidal with sides of roughly equal length.

Rhynchokinetic: having the ability to flex the upper jaw independently. Usually applied to birds which raise the upper jaw by moving the quadrate forward. This motion is translated and amplified into an upward movement of the upper jaw through the jugal + quadratojugal and the pterygoid + palatine. Think of it as a sneer involving the whole upper jaw.

Ribs: Ribs are endochondral bone. They are



preformed in cartilage which develops from the membranes separating muscle blocks (myosepta). There are two kinds: **Dorsal ribs** (**intermuscular ribs**) ribs occur at the junction of myosepta and the horizontal septum, separating the epaxial from hypaxial muscles. **Ventral ribs** (subperitoneal or **pleural ribs**) ribs are found in the junction of myosepta and the peritoneum, next to the body cavity. Ventral ribs appear to be serially homologous with the hemal arches of the caudal vertebrae. Lampreys and hagfish have no ribs; elasmobranchs have short, ventral ribs, and holocephalians have none. *Polypterus* and some teleosts have dorsal and ventral ribs. Other fishes have only ventral ribs. The ribs of tetrapods are thought to be dorsal ribs. The earliest fossil tetrapods had bicipital (two-headed) ribs, with a tuberculum that articulates with the diapophysis, and a capitulum articulating with the intercentrum. Many living tetrapods have unicapitate (one-headed) ribs. The ribs of the thorax region in amniotes have a dorsal, ossified costal portion, and a usually cartilaginous sternal part. True ribs articulate with the sternum; false ribs articulate with each other, but not the sternum. Modified from Axial Skeleton. Image from BIO 342.

Riochican Age: South American Land Mammal Age corresponding to the Late Paleocene.

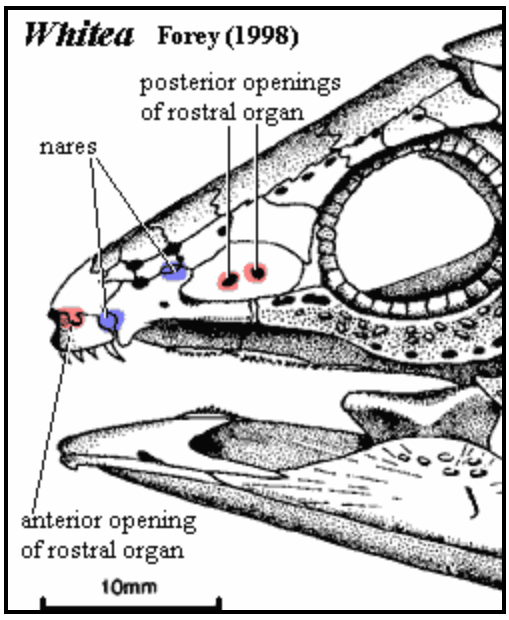
Ricochetal: jumping locomotion in the time-honored zigzag pattern of rabbits and some kangaroos.

Río Neuquén Formation: Late Cretaceous (Turonian) of Argentina. *Patagonykus*.

Riochican: South American Land Mammal Age (q.v.) roughly equivalent to the Late Paleocene.

Roadkill view: an orientation in which the torso is shown dorsally, with the limbs sticking straight out to the sides. The fine points are discussed in connection with the **Humerus**.

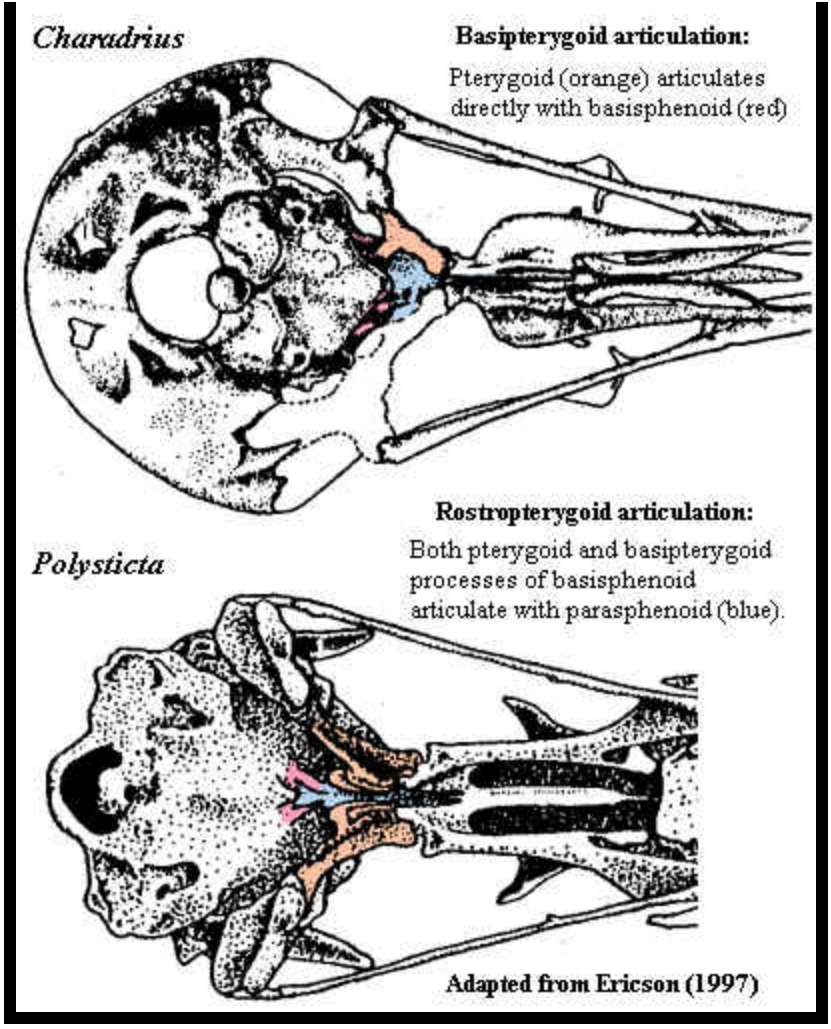
Rostral: (1) Relating to the rostrum. (2) Towards the rostrum. Normally synonymous with "anterior," but not always. In discussing features of the human head, for example, "anterior" is ambiguous and "cephalad" (towards the head) is meaningless, so "rostral" is used instead. I am unsure what the opposite direction is. I've seen "caudal" used, but that's senseless as well as ambiguous. "Rostral" is reserved for head structures, and there is no tail (L. *cauda* = tail) on the head. "Occipital" or "nuchal" might be better, but I have not seen them used in that fashion.



Rostral organ: in Actinistia, a presumably sensory structure located in the rostrum, dorsomedial to the nasal capsules. The rostral organ has paired anterior openings anterior to the anterior nares, and two pairs of posterior foramina posterior to the posterior nares. In *Latimeria*, the organ is filled with a gel of unknown composition. The rostral organ may have an electrosensory function.

Rostral tubules: in dipnomorph sarcopterygians, "a network of branching canals ... which are interpreted as transmitting either nerve fibers to sensory organs on the surface ... or capillary blood vessels." Janvier (1996: 200)

Rostropterygoid articulation: in some birds, a state in which the pterygoids, rather than articulating with the *basipterygoid processes* of the basisphenoid, articulate with the parasphenoid only. There is some doubt whether this state



actually exists as a separate phenotype. Apparently, the pterygoids normally articulate with the parasphenoid to some degree. Thus the "rostropterygoid articulation" may be no more than the absence of a basipterygoid articulation. See Ericson (1997) (expressing doubt).

Rostrum (pl.: rostra): (1) in early vertebrates, an anterior medial projection of hard tissue from the head, normally containing the mouth (2) an anterior medial bone of the skull which forms part of the muzzle or rostrum.

Round window: same as fenestra rotunda or fenestra cochleae.

Rugose: roughened. The implication of a rugose bone is normally that it served as a surface for muscle or tendon attachment. Another possibility is that the bone was extended in cartilage.

Rumen: the first chamber of the ruminant digestive tract, used for storage of ingested food and initial digestion of proteins and simple carbohydrates. See Artiodactyla for figure.

Ruminant: an herbivore which uses gastric, as opposed to intestinal, fermentation to digest cellulose. See Artiodactyla for figure and further explanation.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

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Glossary: Sa-Sp

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-s-

$: abbreviation indicating a *synapomorphy*.

S: abbreviation for the *Silurian* Period.

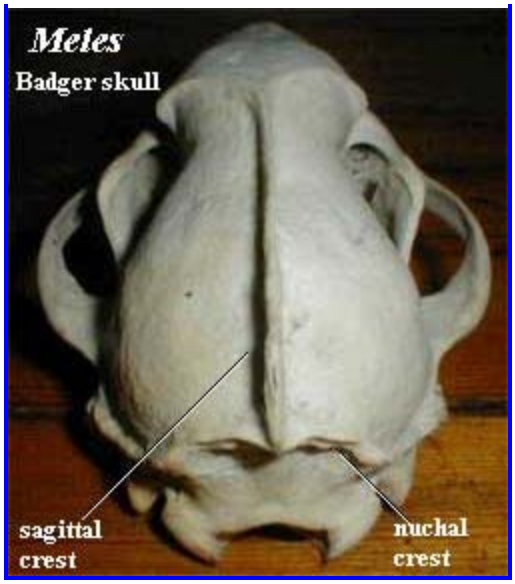
Sabkha: "Sabkha is an Arabic name for a salt-flat that has come into general use in sedimentology following classic research in the United Arab Emirates of the Arabian Gulf in the 1960s and later. They are flat and very saline areas of sand or silt lying just above the water-table and often containing soft nodules and enterolithic veins of gypsum or anhydrite. A thin crust of halite and gypsum may be present in some parts. Many ancient evaporites show sedimentary feature of sabkhas, such as gypsum nodules." Sabkha and Desert Features - Introduction

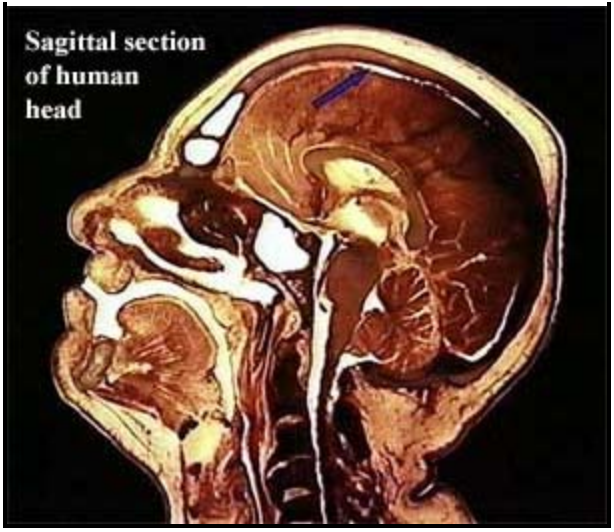
Sacculus: one of the maculae, vaguely sac-like areas of the vestibular apparatus in the inner ear involved in the perception of linear acceleration, orientation in a gravity field, and low-frequency or high-volume sounds. See **The Ear**.

Sacral: Of or pertaining to the **sacrum** - the region of the vertebral column involved with the pelvic girdle, between the dorsal (or, in mammals, the lumbar) and the caudal vertebrae. The **sacrals** or **sacral vertebrae** are the vertebrae associated with the pelvic girdle. They are usually fused to each other and to the ilium.

Sagittal: Dorsoventral. Usually used to refer strictly to a dorsoventral structure or section at the midline, where *parasagittal* refers to a dorsoventral structure or section parallel to the midline.

Sagittal Crest: A longitudinal median bony ridge dorsal to the braincase. Often formed by a coalescence of temporal ridges. *Compare*: *nuchal*





ridge -- same, but transverse

Sakarya Continent: "southern part of northwest Turkey, was a Jurassic-Early Cretaceous [through Eocene -- see Maas *et al*. (2001)] carbonate platform micro-continent distant from terrestrial sediment influx." Mekik et al.. The geological history of this area seems quite complex.

SALMA: South American Land Mammal Age.

Saltatorial: Adapted for leaping locomotion.

Sand: sedimentary particles in the size range 0.0825 (i.e. 1/16) to 2.0 mm. See *clay, silt, gravel*.

Sandbian Age: first age of the Late Ordovician, 461-456 Mya. *See* Sandbian.

Sanping Formation: middle Cretaceous of China.

Santa Lucía Formation: Early Paleocene of Bolivia. Most famous for its Tiumpampan exposure with numerous mammal fossils.

Santana Formation: middle or Late Cretaceous (Cenomanian) of northeastern Brazil. Pterosaurs. Noted for soft tissue preservation.

Santonian: an age of the Late Cretaceous (, about 85.8-83.5 Mya. See Santonian.

Sau Khua Formation: Late Cretaceous (Barremian) of northeastern Thailand.

***Scala media*:** the inside of the lagena or cochlea, conceived as a fluid compartment of the inner ear. It contains the Organ of Corti. See the **Ear**.

***Scala tympani*:** The compartment of the inner ear adjacent to the *fenestra rotunda* (or equivalent). See the **Ear**.

***Scala vestibuli*:** The compartment of the inner ear adjacent to the *fenestra ovalis*. It contains the vestibular apparatus. The scala tympani is immediately impacted by vibration of the middle ear ossicles. See the **Ear**.

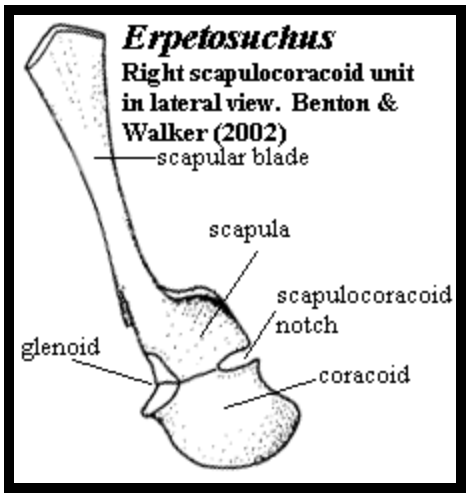
Scansorial: Pertaining to arboreal mammals that climb by means of sharp recurved claws. e.g. tree squirrels.

Scaphium: one of the Weberian ossicles in Otophysi, derived from the first neural arch. *See also* image at claustrum.

Scaphoid: in mammalian osteology, one of the carpal bones. Normally articulating distally with the trapezium and trapezoid and proximally with the radius. See image at unciform.

Scapula: One of the two main bones of the *pectoral girdle*. In many forms the scapula is the principal link between the forelimb and the axial skeleton. Proximally, it normally participates in the glenoid (articulation of the humerus) and articulates with the clavicle (by way of an *acromion process*) and the coracoid. Axially, it articulates with the ribs and/or spine. The scapula may be fused with the *coracoid*, the second main bone of the pectoral girdle, to form a scapulocoracoid. See example of mammalian scapula at supraspinous fossa.

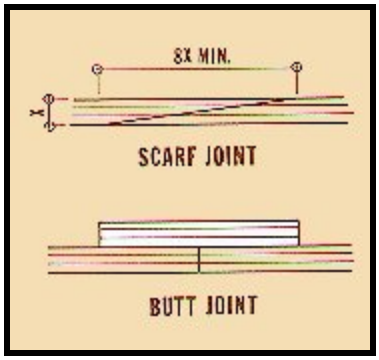
Scapular spine: a distinct ridge running along the external length of the scapula, characteristic of therian mammals. See image at supraspinous fossa.



Scapulocoracoid: either a fusion of the scapula and coracoid (the two main bones of the shoulder girdle), or the scapula & coracoid considered as a single structural unit.

Scapulocoracoid notch: a notch on the anterior of the shoulder girdle, where the scapula & coracoid meet -- opposite the glenoid (articulation for the humerus).

Scarf Joint: a joint formed by a long overlap between two bones.



Scat Craig: late Frasnian locality near Elgin, Scotland. Lag deposits of reworked material transported from an unknown upstream location. Ahlberg (1998).

SCC: see *semi-circular canal*.

Schizocoely: see **Early Development Terms**.

Schizognathal: palatines do not meet at the midline.

Schizorhinal: in osteology, having separated nasals; in general anatomy, having slit-like nostrils.

Schreckstoff: "An alarm response in these fishes is the result of an alarm substance (*Schreckstoff*) being introduced into the water via rupture of specialized dermal club cells. Presumably fish are traveling in some kind of school or shoal when one or more of them are damaged (attacked). Release of Schreckstoff into the water (*Schreckreaktion*) results in the remaining conspecifics making a variety of coordinated escape actions. It is also believed that a predator that has recently consumed an Ostariophysian will secrete Schreckstoff in its feces, also warning other Ostariophysians of the predator's presence." Lab 5 [former page].

***Sclero-*:** a Greek combining form meaning "hard." The Latin equivalent would be *dura-*.

Sclerotome: see **Early Development Terms**.

Sclera: (1)a recess holding the eye; (2) the circle of bone(s) supporting the orbit; (3) any recess or compartment.

Sclerotic ring: a ring of bone or small bones inside the sclera, presumably acting to support the eye.

Scrofic: after *Sus scrofa*, one of two morphotypes of the canine found in suoids. In scrofic canines, the tooth is approximates an equilateral triangle in cross-section. The lingual face is broadest, and the posterolateral face is second broadest. As opposed to verrucosic.

Sebaceous gland: (a) generic name for any oil-producing gland, not a particular structure. (b) in mammals, sebaceous glands refer to a particular structure which looks a bit like a bunch of grapes and which produce skin oils and zits. Homologues of the mammalian sebaceous glands probably include the mammary glands and scent glands.

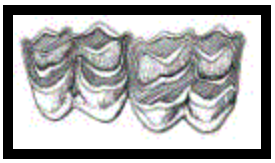
Secodont: in mammals, cheek teeth with a cutting or shearing action adapted for a carnivorous diet. Sameas *sectorial*.

Secondary feathers: the flight feathers originating on the ulna.

Secondary Palate: structural separation of the mouth and upper throat from the nasal passages). Functionally, a separation of respiration and feeding -- an important adaptation permitting the organism to eat and breathe at the same time, or to breathe without opening the mouth. Normally requires secure attachment of upper jaw to braincase and is thus inconsistent with extreme jaw kinesis.

Sectorial: of teeth, having an occlusal surface with shearing or cutting edges formed by the fusion of cusps. Think of it as the carnivore's answer to lophodonty.

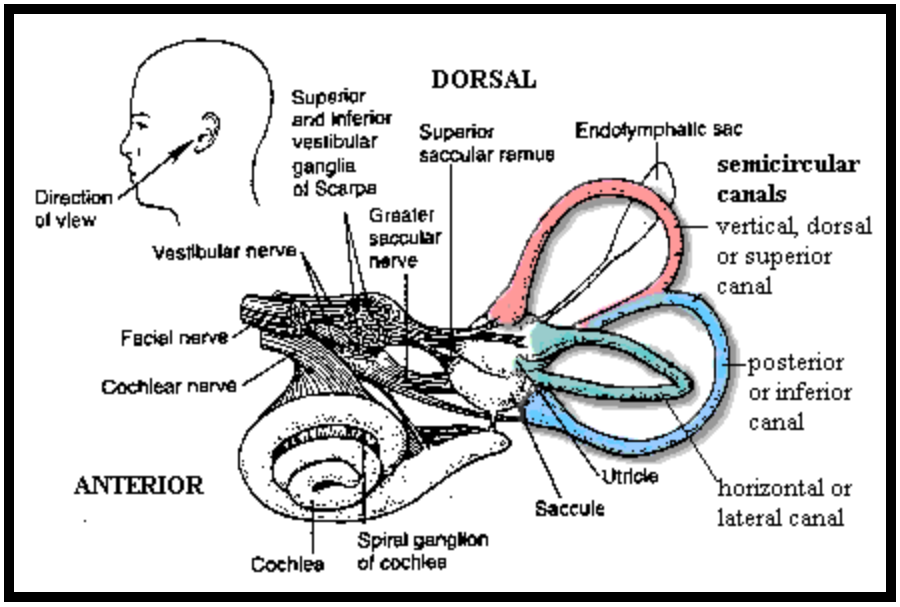
Segmentalism: a school of vertebrate anatomy which tends to analyze anatomical structures, particularly cranial structures, as evolutionary derivatives of one or more sets of repeated segments. This school is far from homogeneous in its conclusions. It is characterized only by a mode of analysis which assumes an underlying ancestry of repeating units, rather than any specific set of conclusions from that premise.



Selenodont: Similar to *lophodont* teeth, except that the enamel ridges form characteristic crescent-shaped cusps. *See* **Molars**.

Sella Turcica: A cavity in the basisphenoid, site of the adenohypophysis (= anterior pituitary). See **The Basisphenoid.**

Semicircular Canal ("SCC") Organs closely associated with the brain which contain minute otoliths and hair cells. Their function is to sense angular acceleration. Except in the most primitive vertebrates, there are 3 pairs of SCCs, each of which probably senses motion or orientation in one spatial dimension. The *labyrinth* is composed of the semicircular canals and associated *ampullae*. See **The Ear**.



Semilunar ganglion: the large ganglion from which the nerves of the trigeminal nerve (cranial nerve V) arise.

Semilunate: in mammalian osteology, one of the carpal bones, normally articulating distally with the magnum and proximally with the radius. See image at unciform. Also called the lunate.

Septum: a dividing wall separating two cavities, or dividing a single cavity into two parts.

Serosa: the membranes covering the liver. These are derived from the *transverse septum*. The *hepatic diverticulum* of the embryonic gut invades the *transverse septum.* The growing liver almost pinches off, carrying the posterior layer of the septum with it. This layer forms the serosa, and the remaining attachment to the septum becomes the coronary ligament.

Serratus anterior: a muscle originating on the ventral (internal) face of the (proximal) scapula and inserting on the ribs. It may either aid in stabilizing the scapula during forelimb excursion (as in humans) or move the ribs to aid in respiration (as in birds).

Serratus, superficial: apparently the same as the *m. serratus anterior*.

Sesamoid bone: bone formed directly within tendons, sometimes epigenetically, as in response to repetitive mechanical stress.

Sesamoid, distal: sometimes called the "navicular." a sesamoid partially separating the distal and middle phalanges in ungulates. *See* coffin joint for image.

Severnaya Zemlya Formation: Early Devonian (Lochkovian) of, appropriately enough, Severnaya Zemlya, an island group north of Siberian Russia. It represents a minor transgression during a historic marine lowstand. Blieck *et al*. (2002).

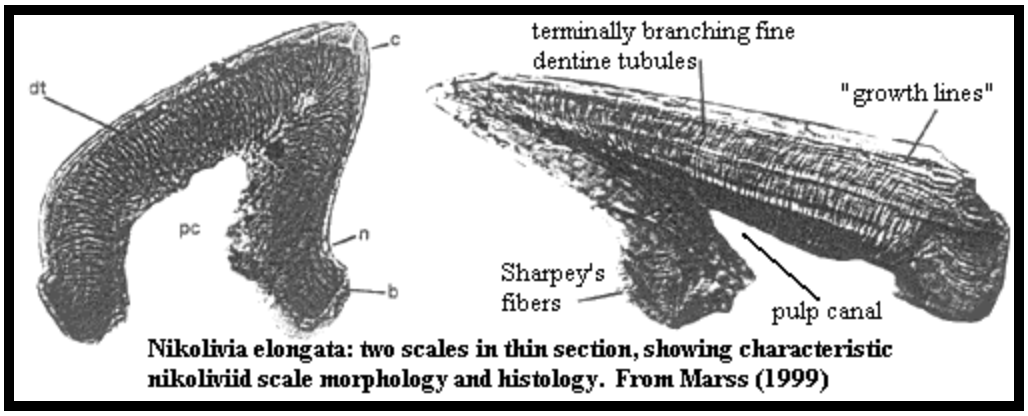
Shagreen: bearing many small round protuberances. Usually said of denticles on palatal bones when they are not arranged in regular rows.

Shale: a fissile sedimentary rock primarily composed of *clay*.

***Shan*:** Chinese combining form meaning *mountain*.

***Shang-*:** Chinese (Mandarin?) prefix indicating upper? newer? when attached to the name of a geological formation.

Sharpey's fibers: "Periosteal connective tissue collagen becomes incorporated into the matrix that is being laid down by the surface osteoblasts and serves to anchor the periosteum to the bony surface. These attachments, as well as the attachments of tendon and ligament collagen to the bony surface are called Sharpey's fibres." Slide # 32 - Sharpey's Fibres (former site). Sharpey's fibers are often easily observed because they are anchored in the spongy, cellular bone and extend into the lamellar periosteum. Shearing forces between the periosteum and the spongy bone can cause inflammation at the base of the Sharpey's fibers, *i.e.* shin splints. Another form of Sharpey's fiber is found in the teeth. The periodontal ligaments and gums have collagen processes which are anchored in the cementum around the roots. These are also referred to as Sharpey's fibers.



Nikolivia elongata: two scales in thin section, showing characteristic nikoliviid scale morphology and histology. From Marss (1999)

Shaximiao Formation: Middle to Late Jurassic of the Sichuan Basin of China. River or lake sediments with *Shunosaurus* fauna from the Middle Jurassic Lower Shaximiao Formation, and *Mamenschisaurus* fauna from the Late Jurassic Upper Shaximiao Formation.

Siderite: iron carbonate, $FeCO_3$.

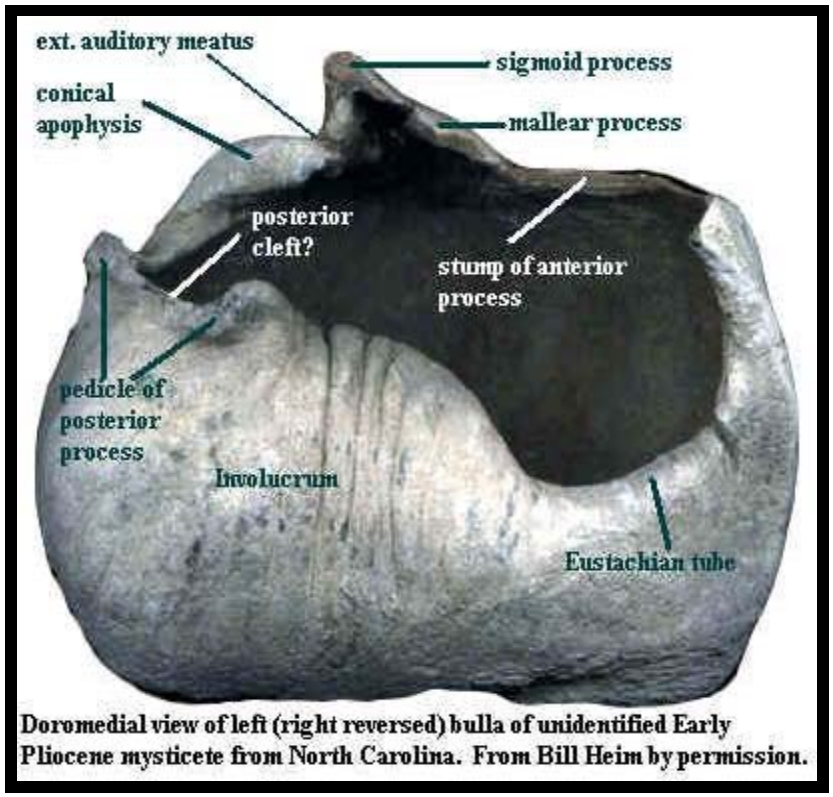
Siegenian Age: same as Pragian Age

Sigmoid: S-shaped.

Sigmoid Process: a wavy crest externally on the tympanic bone of cetaceans. A "laterally projecting crest of the anterior crus of the tympanic that is formed by an undulation of the lateral wall." Thewissen (1998: 454-55). The sigmoid process is homologous to the anterior crus of the ectotympanic ring and the anterior wall of the external auditory meatus. Luo (1998).

Sigmoid Sinus: "a portion of the lateral venous sinus, bulging prominently into the mastoid cavity, that serves as a principal conduit by which blood leaves the cranium" EPIC Glossary [former site]. The sigmoid is drained by the *internal jugular vein*.

Silt: sedimentary particles between 1/256th & 1/16th mm in diameter. See *clay, sand, gravel*.



Doromedial view of left (right reversed) bulla of unidentified Early Pliocene mysticete from North Carolina. From Bill Heim by permission.

Silurian Period: The third period of the *Paleozoic* Era, 443-417 Mya, between the Ordovician and Devonian Periods. The Early Silurian (443-423 Mya) is usually referred to as the Llandovery (443-428 Mya). The Middle Silurian is the Wenlock (428-423 Mya). The Late Silurian (423-417 Mya) includes both the Ludlow (423-419 Mya) and Pridoli (419-417 Mya) epochs. Another scheme of nomenclature

uses "Early Silurian" for both the Llandovery and Wenlock epochs. Most of the major groups of fishes are thought to have originated by the Llandovery, with a major radiation already under way by the beginning of the Devonian.

Sinister: not evil -- just the Latin word for left, as in left-handed. Hence **sinistral**, meaning *relating to the left hand member of a pair* or *towards the left side*.

***Sinus superior utriculi*:** The bony compartment which contains the *crus communis*, the portion of the inner ear where the three semicircular canals meet.

Sister group: A clade that is believed to be the closest genealogical relative of a given taxon exclusive of the ancestral species of both taxa.

Skin: see *integument*

Skolop-*:** Gr. root σκολοψ = thorn, spiked object, a sharpened post for, *e.g.*, a palisade. Sometimes σκωλος (*skoolos* or *skoulos*), which may be restricted to the literal meaning, *thorn*. ***Not, however, σκολος (*skolos*).

Skull table: the top of the head; the raised, dorsal portion of the skull in amniotes, usually extending from the orbits to the occiput, normally dominated by the parietals and, frequently, the frontals. May also include nasals, postparietals if present, and premaxillae in forms (*e.g.* Diplodocomorpha, Hadrosauridae) with external nares or air chambers above the orbits. Like *rostrum*, this is a topological, rather than an osteological term. That is, it includes whatever bones form the top of the head, rather than a specific set of bones.

Solnhofen Limestone: Late Jurassic (*Tithonian*) of S. Germany. Lägerstat with remarkable preservation. Fossils include fishes, turtles, pterosaurs, crocodilians, and *Archaeopteryx*.

Solum nasi: used generally to refer to the floor of the nasal passage, particularly when this region is ossified. The solum is an early embryonic structure and develops as a lateral outgrowth of the trabeculae. It gives rise (at least in actinopterygians) to an orbitonasal lamina which articulates with the palatine. The whole business is actually quite a bit more interesting than it sounds. *See* The ontogeny of the chondrocranium in Clarias gariepinus: trends in siluroids. Adriaens & Verraes (1997).

Somatic mesoderm: see **Early Development Terms**.

Somerset Island Formation: Late Silurian (Ludlow) or possibly Early Devonian (Lochkovian) of Arctic Canada. Thelodonts, cyathaspids and osteostracans. Marss (1999).

Somite: see **Early Development Terms**.

South American Land Mammal Ages: A chronology of the South American Cenozoic based on characteristic terrestrial mammal assemblages. *See also* **Cenozoic -- timescale** on this site.

Spathiform: shaped like a machete or some primitive wakizashi, *i.e.* an elongate, flat quadrangle (or slightly curved), broader distally than proximally, and having a distal end with relatively sharp corners, although not necessarily square angles.

Spatium interossium: the space between the epipodials (radius & ulna or tibia & fibula).

Spatulate: having a parabolic or U-shaped outline.

Spermaceti organ: in physeteroid whales, a cephalic structure structurally analogous, and probably functionally equivalent, to the melon organ of other odontocetes.

***Sphen-*:** Gr. root meaning "wedge" or "wedge-shaped."

Sphenoid: Alternate name for the basisphenoid, especially when fused with the alisphenoid and pterygoids.

Sphenethmoid: Same as ethmosphenoid. The combined sphenoid and ethmoid regions of the braincase. The anterior half of the braincase, physically separate from the posterior, otoccipital unit in Sarcopterygii. See **Bones: The Braincase**.

Sphenoid: The region of the braincase associated with the orbit. It lies between the ethmoid and otic regions. See **Vertebrate Notes: The Braincase**. The sphenoid is typically made up of the orbitosphenoid, basisphenoid and, in various groups, the alisphenoid, and mesethmoid. It is frequently fused into a sphenethmoid unit and/or bordered posteriorly by a transverse ventral fissure.

Spinodiapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the neural spine with one of the *diapophyses*. *See* image at *centrodiapophyseal lamina*.

Spinoprezygapophyseal lamina: reinforcing ridge bone ridge in the vertebrae (normally, of sauropods) connecting the neural spine with one of the *prezygapophyses*. *See* image at *centrodiapophyseal lamina*.

Spinose: bearing spines.

Spiracle: A respiratory aperture, especially a small respiratory opening behind the eye of certain fishes, such as sharks, rays, and skates or the blowhole of a cetacean. Any aperture or opening through which respiratory air or water is admitted and/or expelled. Supposedly this is a remnant of the gill slit from the hyoid arch.

Splanchnic mesoderm: see **Early Development Terms**.

Splanchnocranium: consists of the visceral arches composed of cartilage or cartilage replacement bone. Each visceral arch is a V-shaped structure composed of two parts, the epibranchial cartilage and a ceratobranchial cartilage. In more derived vertebrates, parts of the splanchnocranium are modified to form derived structures such as jaws, ears and parts of the hyoid apparatus and pharyngeal cartilage. Introduction to the skeletal system.

Splenial: a dermal bone on the inner surface of the lower jaw.

S Continued at Sq

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Glossary: Sq

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

-Sq-

Squamation: the type or degree of scales on the surface of an organism or structure.

Squamosal: a dermal skull bone located on the posterior "corners" of the skull. The squamosal may be primarily associated with the occiput or the skull table, or both. It often appears as a sort of transition bone which links these two major skull elements. It is closely associated with the quadrate and, in amniotes, with the temporal fenestra(e).

Squamose: covered with, or made up of, scales. Sometimes mistakenly used instead of "squamous" (*i.e.* flat).

Squamous: **[1]** (of a cell layer) flat, i.e. scale-like, as opposed to cuboidal or columnar. **[2]** (of a suture) a scalelike suture, one whose opposing margins are scalelike and overlapping. Used of sutures where one bone overlies the other with a thin, usually irregular lamina. **[3]** (medical, sometimes used by mammal workers) relating to the squamosal portion of the skull. Hence *the* **squamous suture** is the suture between the temporal and parietal bones. It has nothing to do with the *type* of suture as in definition #2.

Square Cube Law: For any given shape, surface area increases in proportion to the square of any linear dimension, while volume increases as the cube. The surface area of a cube of side x is $6x^2$, while the volume is x^3. Thus, for any given shape, doubling linear dimension will increase surface area by a factor of four and volume by a factor of eight. Biological interactions may depend on linear dimension, surface area or mass. Other things being equal (although they never are), a taller organism will be able to access vegetation in proportion to its height. The surface area over which it will lose heat from metabolizing all that fodder increases as the square of its height. The mass it has to support to get the additional height increases as the cube of the height. Thus, increasing or decreasing size requires morphological adaptations. Simply scaling up or down won't work beyond a fairly small range. As a practical matter, biological organisms are sufficiently complex that they can compensate by a series of small adaptations, including morphologically invisible behavioral adaptations, to a surprising degree. The square-cube law is therefore not quite the limitation it appears to be. Nevertheless it is an important constraint on evolution. As a point of reference, there are actually few biologically important parameters that depend on dimension. However, one of these is the force per unit cross-sectional area of muscles. "Square" interactions, those which depend on surface area, include respiratory efficiency, bone strength (i.e. cross-sectional area), aerodynamic lift, and rate of heat gain or loss to the environment, frictional resistance to motion in water, and pressure exerted on a surface. "Cube" interactions are often metabolic.

Again, other things being equal, an animal twice as tall will need eight times as much energy to run at the same rate. An important, but very consistent, oddity in this respect is that larger organisms almost invariably have lower basal metabolic rates. It takes much less energy per kilogram to run a 100 kg kangaroo than a 50 g kangaroo rat.

Stance phase: the phase of the locomotion cycle during which the limb is in contact with the ground (opposite of swing phase).

Standard Condition: A shorthand term used in these Notes to reference a set of osteological relationships which is used as a baseline for comparative purposes. Usually the Standard Condition is established by reference to a conjectural basal amniote ("Bob"), a creature of simple osteological tastes. Occasionally, another type is used.

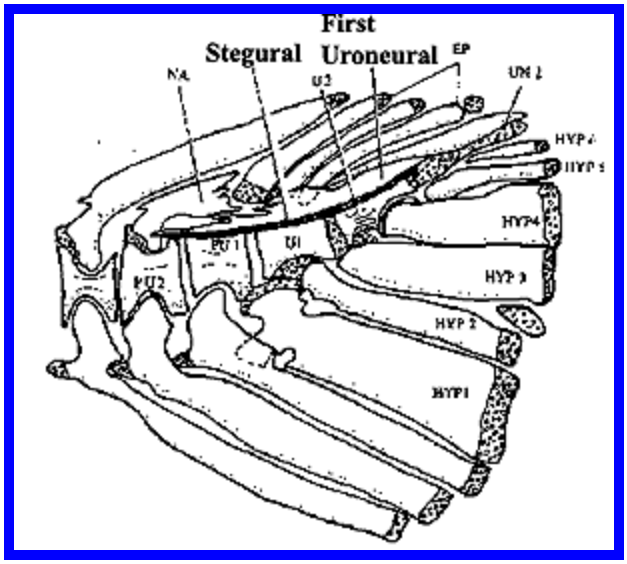
Stanton Formation: formerly Admiral Formation or Stanton Limestone. Pennsylvanian and/or earliest Permian of Central US (Kansas). Largely marine and deltaic, but with conifer-dominated terrestrial or lacustrine component. Notably Permian-like biota, including insects and the edaphosaurid *Ianthasaurus*. Marine component notable for crinoids.

Stapedius muscle: a small muscle of the middle ear which acts to damp excessively loud sounds by restricting the movement of the stapes

Stapes: The **stapes** is an incarnation of the hyomandibular. It may have originally (jawless vertebrates) been the main upper element of a gill arch. It later appears as the hyomandibular, an accessory jaw element. In early tetrapods, it becomes a stout bone bracing the braincase against the quadrate. As the paroccipital process took over this function, the stapes was reduced, eventually becoming specialized for hearing as the *columella*, in sensible amniotes, or the stapes, in mammaliforms. The stapes bears a footplate which fits over the foramen ovale.

Stegokrotaphic: "When a skull is completely roofed (containing only openings for sense organs) it is called stegokrotaphic. A well-ossified skull with little kinesis is definitely an adaptation for a fossorial existence. In some rhinatrematids, scolecomorphids, and some caeciliids, the temporal region is partial open, is slightly kinetic, and is known as zygokrotaphic." Untitled Document

Stegural: a membranous outgrowth of the first uroneural in the caudal fin of various fishes.



Stellate: star-shaped, having points or rays like a star.

Stem group (or taxon): a clade defined as "all organisms closer to species Y than to species Z." "Stem group" or simply "stem" as an adjective, is often used more loosely to refer to the usual diverse odds and ends near the base of a radiation. In this sense, it does *not* describe a clade. Thus "stem tetrapods" to indicate the *paraphyletic* group of Baphetidae, Colosteidae, and other difficult to classify "amphibian" taxa outside the probable crown group Tetrapoda*. Other examples include the Paleoniscoids (Actinopterygian radiation), and probably Thelodonts (Vertebrate radiation).

Stenobasal: having a narrow base (e.g. actinopterygian fins); opposite of *eurybasal*.

Stenohaline: tolerating only a narrow range of salinities; opposite of *euryhaline*.

Stereospondylous: vertebrae without an ossified *pleurocentrum*, although this element may be retained in a cartilaginous state. That is, the centrum is derived almost entirely from the *intercentrum*.

Sternal ribs: In birds, the ossified gastralia which articulate dorsally on the ends of the dorsal ribs and ventrally on the sternum.

Sternebra: one of the individual bones of the sternum in mammals.

***Sthenaros-*:** Greek root for *strong*.

stomodeum: the embryonic precursor of the mouth and anterior pharynx. All vertebrates are deuterostomes. That is, the gut is formed butt-first. The mouth and pharynx are derived by a secondary invagination of superficial ectoderm -- the stomodeum. See Gilbert (2000: 490-492). Eventually, the stomodeum meets the gut endoderm and the two coalesce into a continuous tube from mouth to anus.

Stratigraphic: (1) relating to vertical position in a rock column. (2) More generally, relating to relative geological age, since -- all things being equal -- older is lower in any given sequence of sedimentary rock.

***Strepto-*:** Greek root meaning *reversed, backwards*.

Streptostyly: a special moveable hinge between the quadrate and squamosal bones in the skull... This hinge gives greater flexibility and allows the pterygoideus (jaw) muscle to exert more force. "A flexible connection at the articulation of the quadrate bone with the squamosal. This articulation allowed for mobility in the quadrate, a condition known as streptostyly." Untitled Document.

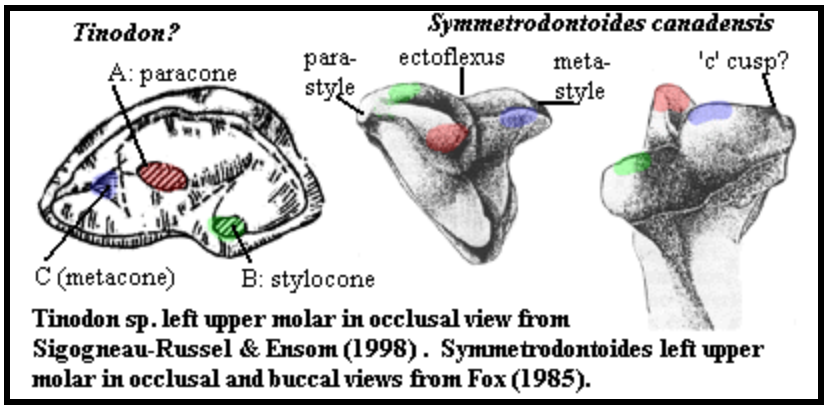
Stria (-ae): *see striated*. However, when used as a noun, it usually carries some of the original sense -- not merely an object with parallel lines, but with parallel lines defining or bordering a groove running between them. Differs from a *sulcus* in that striae are presumed to be striaght, as well as in the emphasis on the borders of the groove, rather than the furrow itself.

Striated: marked with **striations**, i.e. thin parallel lines. From L. *stria*, a groove. Sometimes used in the original sense.

Stylar cusps: subsidiary molar cusps developed from the cingulum. See **Molars**.

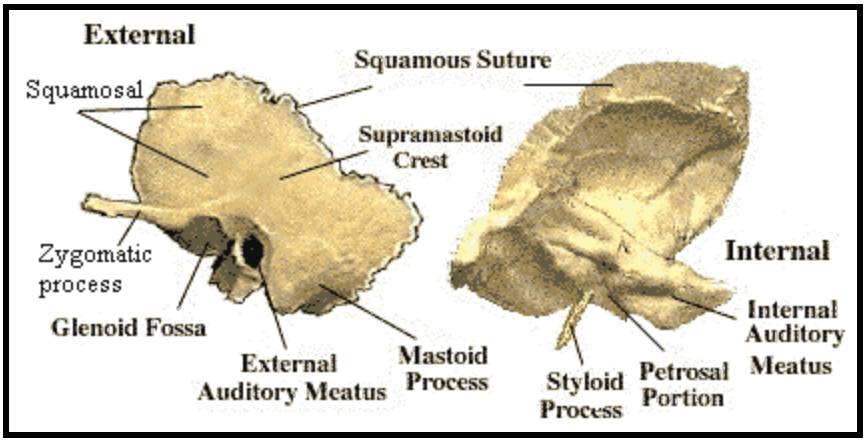
Styliform: slender and pointed.

Stylocone: generally a stylar cusp. In symmetrodonts, it refers to a particular cusp of the trigon, the B cusp at the mesiobuccal position on upper molars. See image.



Tinodon sp. left upper molar in occlusal view from Sigogneau-Russel & Ensom (1998). Symmetrodontoides left upper molar in occlusal and buccal views from Fox (1985).

Styloid process: (a) a sharp spine that projects rostroventrally from ventral surface of the temporal bone (or petrosal) just in front of the stylomastoid foramen and serves as an attachment point for various small muscles of the mouth & tongue (b) a distal process of the ulna projecting from the dorsomedial surface and attaches to a ligament of the wrist (c) a conical extension of the lateral surface of the distal radius that attaches to several tendons and ligaments. All definitions modified from STYLOID PROCESS (Search FastHealth.com) STYLOID PROCESS. Image of human left temporal bone with styloid process (a) from Dept of Anth: Temp .



Stylopodium: the upper unit of the tetrapod limb, *i.e.*, the humerus and/or femur. Same as *propodium*, in contrast to the lower unit, which is the *zeugopodium* or *epipodium*, and the hand or foot (*autopodium*).

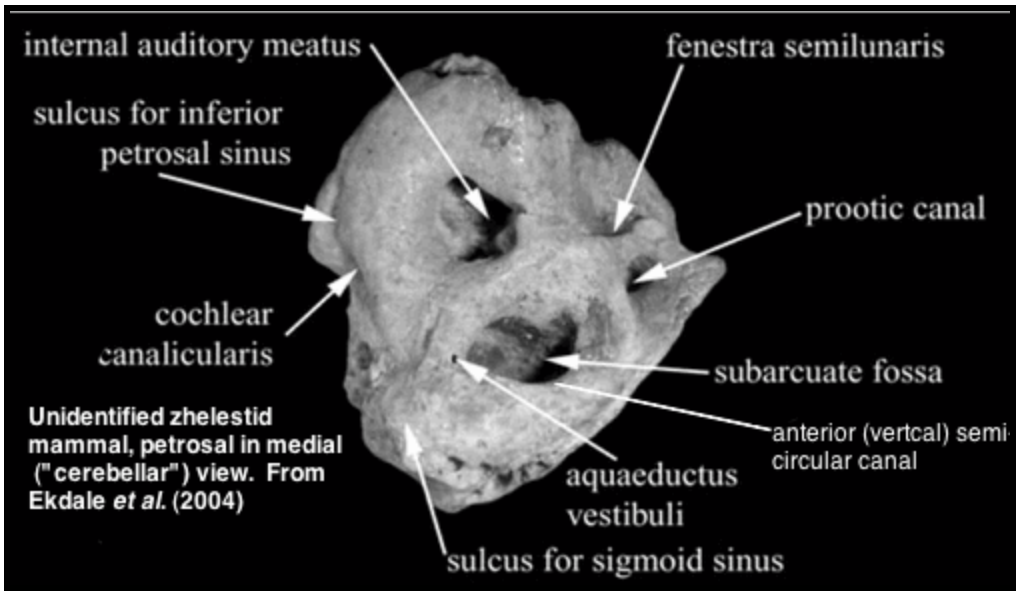
***Styrac-*:** Greek root for spiked, spiky

Sub-: prefix which used to mean "under." Now it means "more or less," "approximately," or "sort of." In other words, the writer is too gutless to commit to a description, wants to hide uncertainty or ignorance with a pseudoscientific polysyllable, or has had some nit-picking reviewer go over his manuscript with a micron caliper.

Thus: "subrectangular" = square-ish, "subequal" = similar, "subparallel" = oriented kind of the same way.

Subacrodont: See **Tooth Implantation**.

Subaponevrotic: immediately under ectodermal tissue, or between ecto- and endoskeletal tissue.



Subarcuate fossa: (sometimes known as the "floccular fossa") in mammaliforms, a large oval window in the petrosal which is formed by one of the semicircular canals. The literature is curiously contradictory on which one. Either the anatomy or the nomenclature is variable. See Kermack *et al*. (1981) (posterior); Luo (2001) (anterior). We believe the latter is correct. Kermack asserts that, in mammaliforms and early mammals, the foramen for the chorda tympani on the lateral face of the anterior lamina emerges inside the subarcuate fossa, and, in life, the fossa was probably filled with sensory nerves from the chorda tymapni, carrying taste information from the mouth. See Morganucodontidae for images and more information. More recently -- and for more recent mammals -- the subarcuate fossa has been associated with the paraflocculus, a region of the cerebellum "involved with coordination, balance, and vestibular sensory acquisition." Macrini *et al*. (2007).

Subashi Formation: Late Cretaceous (Maastrichtian?) of China.

Subathu Formation: Late Paleocene to Latest Eocene or Early Oligocene of northern India. Bajpai & Gingerich (1998). Marine. Indeterminate cetaceans.

Subinfraorbital: one of the long postorbital bones in amiiform fishes. See images and explanation at Neopterygii: Overview.

Subjacent: in stratigraphy, underlain by. Used to describe a stratigraphic unit which lies just below the unit being described. Opposite of *superjacent*.

Submandibular: in Sarcopterygii, essentially the continuation of the opercular series onto the ventral face of the jaw. Sometimes referred to as "lateral gulars."

Suborbital fenestra: see image at *transverse flange*. A fenestra in the palate located along the marginal bones at the level of the orbit. Typical of lepidosauromorphs and allies.

Subpleurodont: See **Tooth Implantation.**

Subtemporal bar: same as *temporal bar*.

Subtemporal fossa: the (usually large) opening on the lateral margin of the palate through which the jaw adductor passes to attach to the lower jaw in tetrapods, sometimes called the *adductor chamber*. Teleosts have a somewhat analogous structure, with the same name, which is not homologous. Poyato-Ariza & Wenz (2002).

Subthecodont: See **Tooth Implantation**.

Sulcate: bearing grooves, grooved, groovy?.

Sulcus: furrow, groove, or fissure. In Latin, 'sulcus' carries the sense of a track left by a moving body, originally a plow, but including the wake of a boat, the trail of a snake, etc.

Summerville Formation: Late Jurassic of Arizona, Utah and Colorado. Part of the San Rafael Group. Unfossiliferous except for ichnofossils. Red to chocolate, sandy mudstone. Tidal flats? Deposited in shallow, quiet marine waters.

Sundance Formation: mJ (*Bathonian*?) of Wyoming and Utah ~167 Mya.. Shallow marine and nearshore. Pterosaur and dinosaur tracks.

Superior vestibular nerve: a branch of the auditory (VIIIth) nerve which communicates information from the lateral semicircular canal.

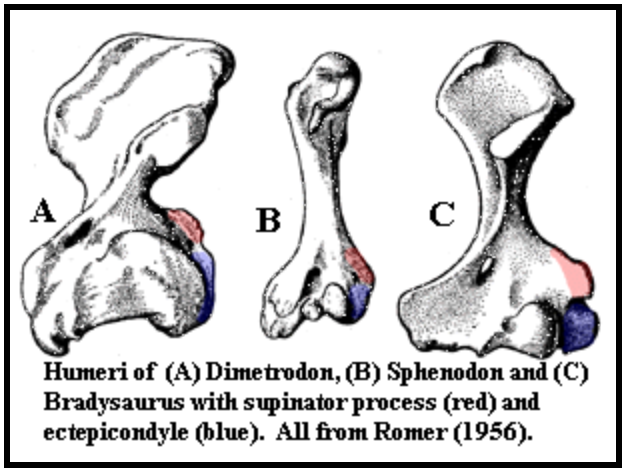
Superjacent: in stratigraphy, overlain by. Used to describe a stratigraphic unit which lies just above the unit being described. Opposite of *subjacent*.

Superognathal: (adj) relating to the upper jaw; (n) the bone "tooth" plate(s) on the upper jaw of placoderms.

Supinate: rotation of hands or feet so that the palmar or plantar surface faces more inward. This word is used by different people in slightly variant ways peculiar to their interests. In medicine, it typically refers to turning the palms upward or forward. In sports medicine or physical therapy it usually refers to the angle of the feet with respect to the substrate. The latter is a bit closer to the typical use in paleontology. Most tetrapods have a sprawling or semi-sprawling stance, so that *static* supination is required to exert force on the outside of the hands or feet and avoid a belly flop with each step. As the stance approaches a more erect carriage, supination can also be substituted for limb retraction as part of the power stroke. If this sounds complicated, it is. But stand on one leg and then rotate onto the outside of the foot, and you'll see the significance.

Supinator (muscle): a muscle which originates on the distal humerus, inserts on the radius and accomplishes supination (rotation of the wrist).

Supinator process: a ridge or tuburcule on the anterodistal part of the humerus, usually just proximal to the ectepicondyle, from which it may be separated by a groove or fenestra, the ectepicondylar foramen. supinator muscle originates on the supinator process. See also **Humerus**.

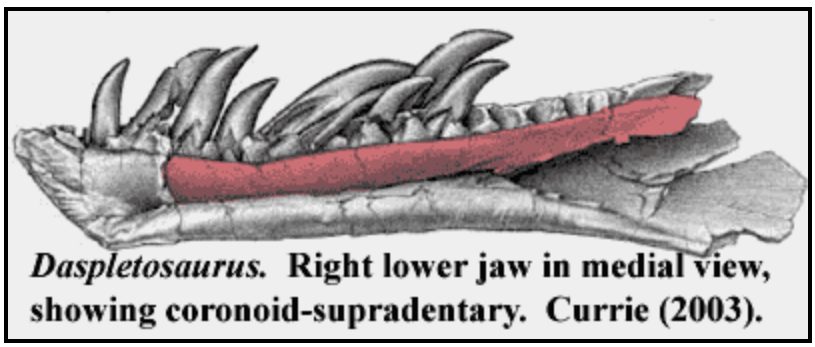


Humeri of (A) Dimetrodon, (B) Sphenodon and (C) Bradysaurus with supinator process (red) and ectepicondyle (blue). All from Romer (1956).

Supraacetabular shelf: a shelf or ridge on the ilium, along the dorsal edge of the acetabulum.

Supracleithrum: a paired bone of the sarcopterygian skull and shoulder girdle. The supracleithra bridged the posttemporals (dorsomedially) to the cleithrum (ventrolaterally). See *Eusthenopteron* for an image of the whole series. The supracleithra are lost in all tetrapods.

***Supracoracoideus*:** A muscle which, in birds, is primarily involved in the recovery stroke. The supracoracoideus attaches on the sternum and acts on a tendon which passes over the top of the glenoid through the triosseal canal and insert dorsally on the humerus. It thus exerts a pulley-like force which raises and rotates the humerus. The contractile properties of the M. supracoracoideus in the pigeon and starling: a case for long-axis rotation of the humerus.


Daspletosaurus. Right lower jaw in medial view, showing coronoid-supradentary. Currie (2003).

Supradentary: some theropod dinosaurs re-invented the row of coronoids that reinforced the edges of the lower jaw in sarcopterygian fishes and early tetrapods. In theropods, this took the form of a neomorphic supradentary which was formed as an extension of the one remaining coronoid.

Supraglenoid buttress: "At the back of the lower portion of the scapular blade, above the anterior portion of the glenoid cavity, is a thickened triangular region which we may term the *supraglenoid buttress*. This is perforated by the *supraglenoid foramen*, presumably carrying blood vessels and possibly nerves of the brachial plexus." Romer (1956: 307).

Supraglenoid foramen: *see Supraglenoid buttress*. Unfortunately, there is a structure with the same name associated with the glenoid involved in jaw attachment.

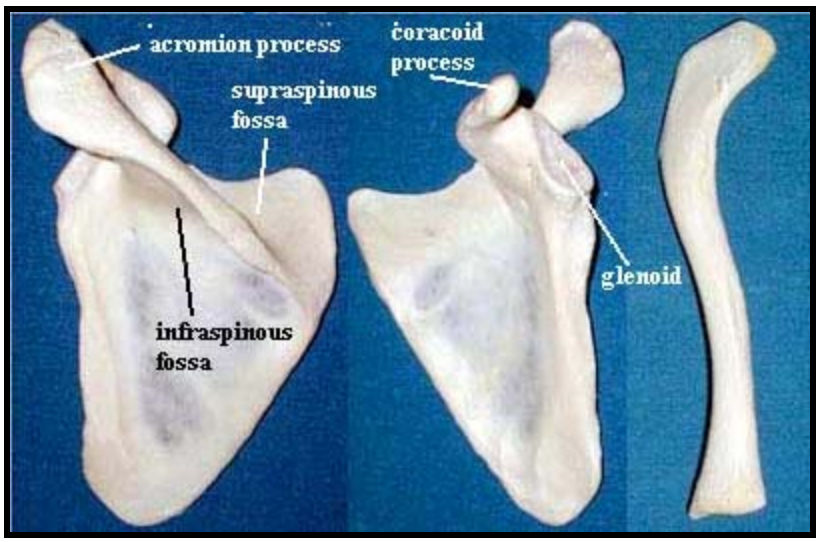
Supraneural spines: "Large blade-like supraneural spines are present above neural arches 1, 3, and 5, but not 2 or 4. The supraneural spines supported a muscular complex involved in feeding not only through raising the snout, but also by depression of the lower jaws induced by the forward swing of the quadrate. Flexion of the intracranial joint is likely responsible for the initiation of jaw closure during feeding." See Hitchcock. Also present in the tail to support the tail fin. Acanthostega gunnari. Generally, supraneurals are dermal bones which extend the line of the neural arch spines. Unlike epineurals, they are thought to be autogenous neural spine elements, not separate endochondral elements formed from myoseptal cartilages.

Supraoccipital: One of the bones of the occiput, the part of the skull which articulates with the spine. The supraoccipital is located (if present) dorsal to the foramen magnum. It is frequently fused with the opisthotic bone to form a large horizontal bar across the back of the skull, separating the rest of the occiput from the dermal bones on the roof of the skull -- typically the parietals or postparietals. It sometimes participates in the foramen magnum. The supraoccipital seems to have developed from a dorsal ligament joining the otic capsules, early in tetrapod evolution. See **The Occiput** for details.

Suprapterygoid articulation: of the palatoquadrate. One of the possible dorsal articulations of the palatoquadrate in which the palatoquadrate articulates with a suprapterygoid process of the ethmoid, more or less directly dorsal to the basipterygoid process near the dorsal margin of the ethmoid. See image at paratemporal articulation.

Suprapterygoid process: *see* suprapterygoid articulation, *supra*.

Supraspinous fossa: In mammals, the scapula is divided by a prominent ridge, the scapular spine. The dorsal (upper in bipeds) division is concave and is referred to as the supraspinous fossa. See image.

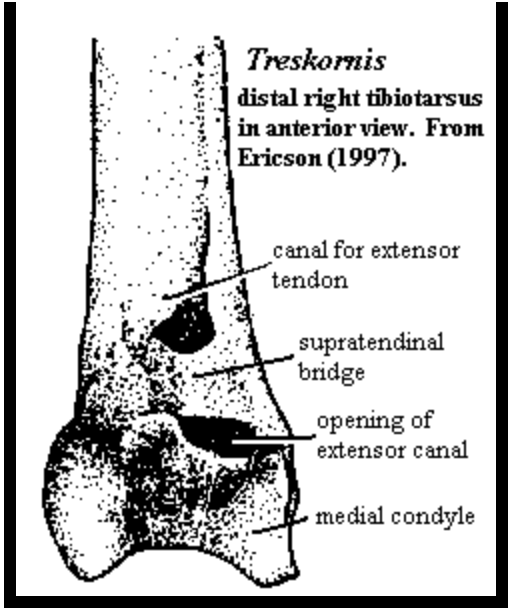


Supratemporal: The skull table of basal osteichthyans had not only the usual series of paired mid-line bones (frontals, parietals, and postparietals), but a series of bones lateral to them. These, from anterior to posterior, were the infratemporal, supratemporal, and tabular. These accessory skull table bones persisted into the early amniotes, but were convergently lost in all lineages. In actinopterygians, the pterotic or dermopterotic is probably homologous to the supratemporal bone, but we wouldn't swear to it. The supratemporal in fishes can often be recognized by its close relationship with the spiracle and the presence of a commissure (i.e. junction) of the lateral line system. For an example, see *Grossius*.

Supratendinal bridge: could refer to any bony bridge over a tendon. Particularly, the bridge over the extensor canal at the distal end of the tibiotarsus of certain birds. The presence of the bridge and the position of the canal opening relative to the condyles may have phylogenetic significance. Ericson (1997).

Surangular: See **Bones: The Surangular**

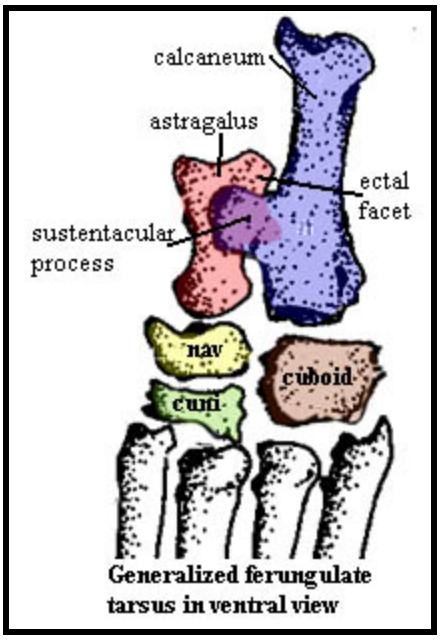
Suspensorium: (1) the arrangement of bones which supports the jaw from the braincase; (2) in teleost fish, a large, usually triangular, bone which supports the jaw. The teleost suspensorium is formed by fusion of various elements which vary among different taxa. See **Gill Arch Derivatives**.



Treskornis **distal right tibiotarsus in anterior view. From Ericson (1997).**

Sustentacular facet: the convex articular surface of the astragalus which inserts on a concavity of the sustentaculum, a medial process of the calcaneum.

Sustentaculum: (= **sustentaculum tali = sustentacular process**) a medial process of the calcaneum which articulates with the astragalus.



Generalized ferungulate tarsus in ventral view

Swing phase: [1] the phase of the locomotor cycle during which the limb is not in contact with the ground (opposite of stance phase). [2] A particularly unfortunate episode in the general decline of orchestral music.

Symphysis: area where two paired bones meet and articulate, particularly the bones of the lower jaw (*i.e.*, the "mandibular symphysis", "jaw symphysis").

Synapophysis: fusion of the articular heads of a rib into a single elongate articulating surface.

Synapomorphy: a character which is shared by all basal members of a clade and is derived from their common ancestor. A synapomorphy may be secondarily lost in later descendants. Only a synapomorphy may be used to infer phylogeny.

Synapophysis: of ribs, an intermediate between single (holocephalous) and double-headed (dichocephalous) ribs, in which the rib articulates with the vertebral column by a single, broad head, or two heads not distinctly separated.

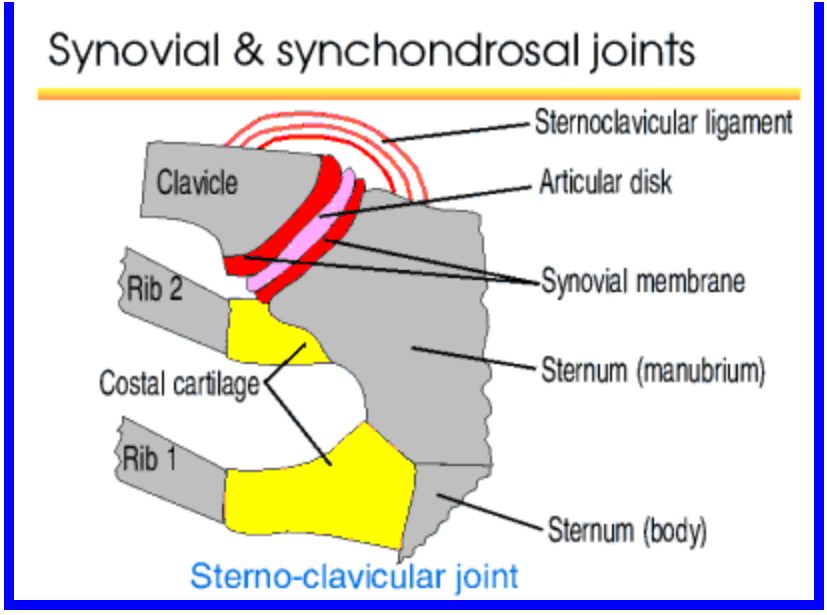
Synarcual: a group of fused anterior vertebrae. The synarcual is normally at the anterior end of the vertebral column and is involved in the articulation of the head.

Synarthrodial: immoveable joints, such as sutural connections, as opposed to slightly moveable (*amphiarthrodial*) or fully moveable (*diarthrodial*), such as the back and knee joints, respectively.

Synarthrosis: A form of articulation in which the bones are rigidly joined by fibrous tissue. More generally, any "immovable joint." More generally yet, any immovable articulation between bones. Most likely, it originally referred to a condition in which one bone grew to match exactly the complex articulating surface of another. That is, it was a reference to a developmental event, rather than an anatomical structure. As matters stand, it has become a rather useless word suited best for taking up space in glossaries.

Synchondral: same as *synchondrosal*.

Synchondrosal "joint": where two bones are flexibly joined by a length of cartilage, the resulting structure has a variable amount of mobility, and the join is referred to as a synchondrosal joint.



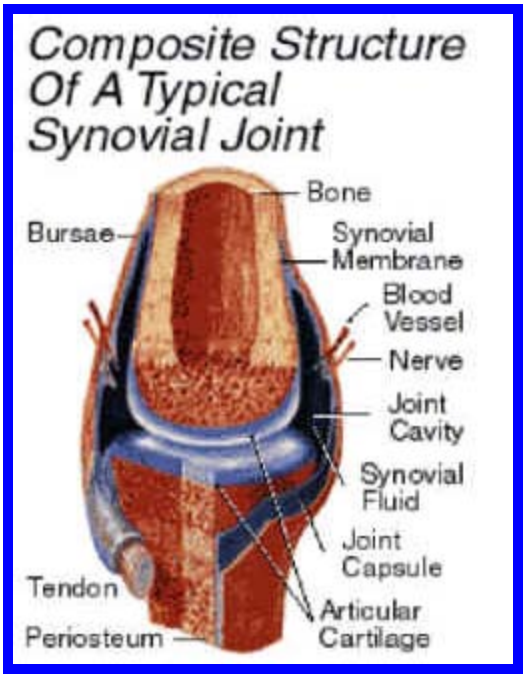
Syndactylous: Pertaining to two or more digits that are fused together or, in mammals, are encased in the same fleshy covering.

Syndesmotic: relating to an articulation in which the bones are joined by ligaments.

Synostosis: in paleontology, more or less identical to fusion of bones. It differs, if at all, in referring specifically to the case in which two bones are fused in such a way that there is no intervening periosteal layer -- which is normally what one means by "fusion" anyway. In human medicine, *synostosis* refers to the premature or pathological fusion of bones during development and is the cause of genuinely sad and painful facial deformities.

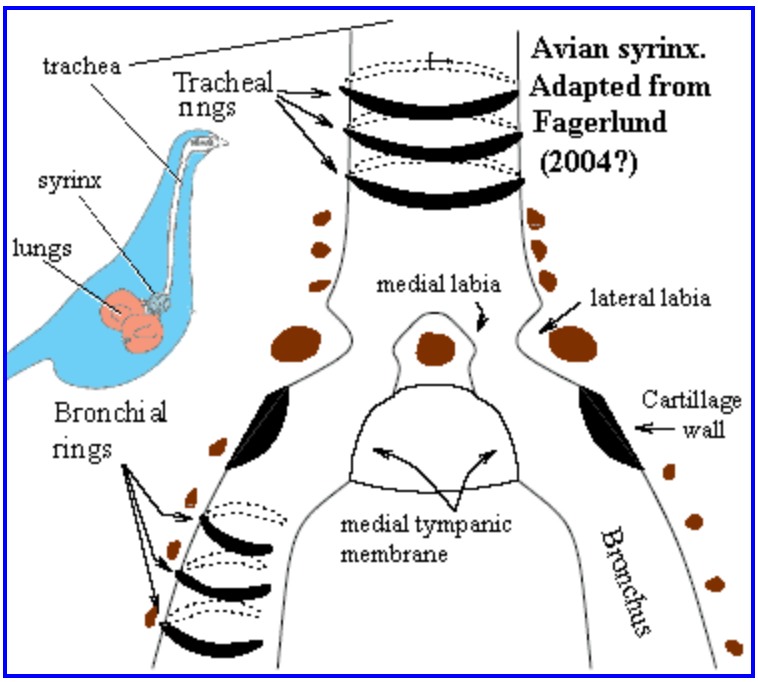
Synotic tectum: in tetrapods, the otic capsules are joined dorsally by an embryonic membrane which may ossify in whole or in part. In at least some forms, this seems to be the origin of the unpaired median supraoccipital. See Berman (2000).

Synovial joint: a joint with the following characteristics: (a) the articulating bones are separate, (b) the bones are held together by a cuff of fibrous tissue, (c) the capsule is lined by synovial membrane, (d) the articulating surfaces are covered by cartilage, usually hyaline (but can be fibrocartilage, as in the temporomandibular joint), and (e) there is synovial fluid between the articulating bones.



Synsacrum: A sacrum enhanced by incorporation of additional (fused?) caudal or dorsal (lumbar) vertebrae.

Syntype: Each specimen of a type series from which neither a holotype nor a lectotype has been designated.



Syrinx (pl. syringes): in birds, a structure analogous to voice box of humans, located low on the trachea and/or on the bronchi. Sound is produced either through vibration of the labia or the medial tympanum, or some combination of the two. It is modulated by cartilaginous rings in the tracheae, by C-shaped cartilages in the bronchi, or by both. The location of the modulating cartilages is used to classify the syrinx as, *e.g.*, a *tracheobronchial syrinx*. Fagerlund (2004?).

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Glossary: Ta - Th

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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-T-

Tabular horn: a posterior or posterolateral projection of the skull table formed by the tabular and/or squamosal in basal tetrapods, particularly embolomeres.

Taenia clino-orbitalis: an ossified *pila antotica*.

Taenia marginalis: a cartilage which runs sagitally along the midline of the skull table, just under the dermal bones.

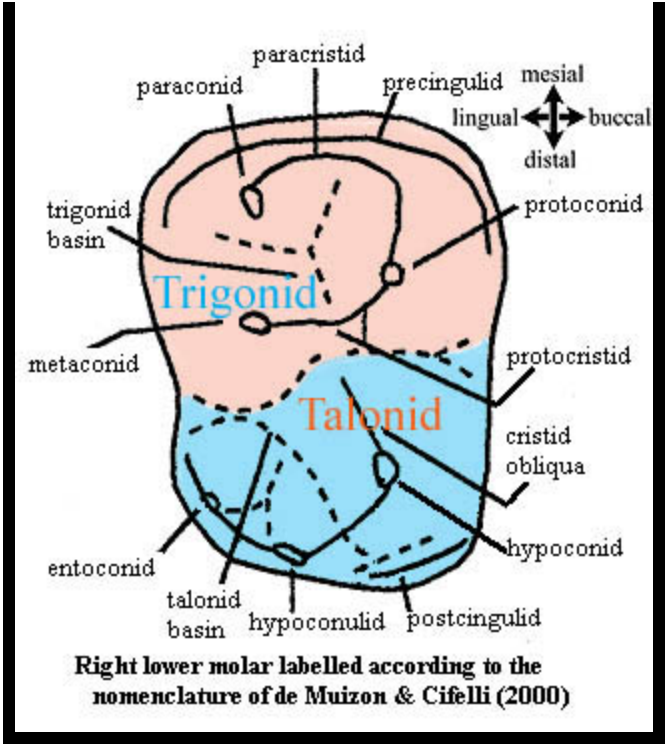
Talon: in mammalian dentition, the distolingual (toward the tongue & back of the mouth) extension of an upper molar, as opposed to the main, triangular part which is the *trigon*. The main cusp on the talon is the *hypocone*.

Talonid: the crushing surface of a tribosphenic molar. See figure and **Molars**.

Talus: the astragalus, one of the proximal tarsals (ankle bones). Primitively, it links the tibia with the distal tarsals, particularly the navicular. The term *talus* is primarily found in medical sources. Another synonym, *tibiale*, is used for Paleozoic tetrapods and sometimes elsewhere. The great English composer, Thomas Tallis (1505 - 1585), spelled his name quite differently. If you are a Tallis Scholar (or one of their fans) who has happened on this web site, your musical tastes are excellent, but you need to improve your spelling skills.

Tapetum lucidum: the reflective layer of the retina that causes the eyes of, *e.g.*, cats to appear to shine in darkness. An adaptation for nocturnal vision.

Taphonomic: relating to burial, decay and fossilization. A **taphonomic artifact** is an artifact caused by these



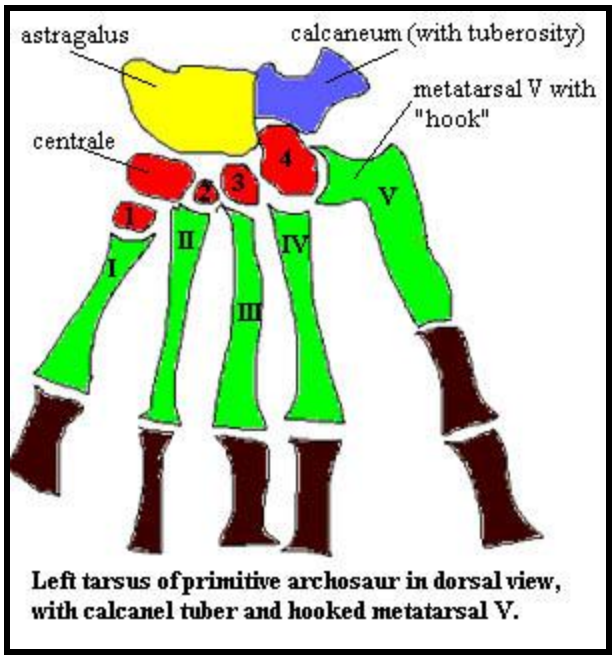
Right lower molar labelled according to the nomenclature of de Muizon & Cifelli (2000)

processes. A classic example is the sharply arched neck of some long-necked dinosaur fossils. After death, the tendons of the back and neck dry out. In life these tendons are formed by collagen, elastin, and other fibers which are held in a springy, elongated conformation through hydrogen bonds and other polar interactions with water. When the tendons dry, the fibers assume a more compact conformation and the neck is retracted back over the body slowly, but with great force.

Taphonomy study of the processes of decay, burial and fossilization.

Tarsal (bones): Series of bones in the ankle. The astragalus, calcaneum, and distal tarsals. They are distal to the fibula and tibia and proximal to the metatarsals

Tarsus: the ankle, including proximal and distal tarsal and the metatarsals.



Left tarsus of primitive archosaur in dorsal view, with calcanel tuber and hooked metatarsal V.

Tarsometatarsus: in birds, the fused unit comprising the tarsus and metatarsus (ankle and foot).

Tartarian: the last age of the *Permian*, 252-248 Mya.

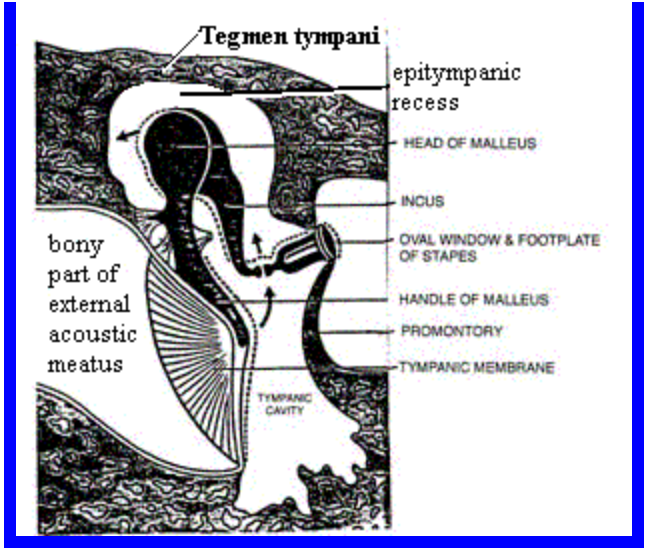
Tecopa Lake: A Plio-Pleistocene lake located in the present Death Valley, California important for good preservation of upland species and well-constrained chronology. Whistler & Webb (2005).

Tectal: one or more anterolateral dermal skull bones in fishes. The posterior tectal is homologous to the tetrapod prefrontal. Vorobyeva & Schultze (1991). The anterior tectal lies just above the nares and *may* be homologous to the tetrapod septomaxilla. A pretty, but crowded, image may be seen *here*.

Tectorial membrane: a membrane in the mammalian cochlea. Part of the Organ of Corti. See the **Ear**.

Tectum: a roof-like structure, particularly the dorsal part of the midbrain.

Tegmen tympani: thin plate of bone forming the roof of the epitympanic recess in the middle ear. Also referred to as the *anterior process of the petrosal*. Luo (1998).



Telychian: the third and last stage of the Llandovery (Early Silurian). The beginning of the Telychian has not been determined. It ended 428 Mya.

***Temno-*:** Greek root for *cutting*.

Temporal bar: Not to be confused with **Callahan's Crosstime Saloon**. Most amniotes have at least one hole in the skull behind the eyes which probably evolved to allow more room for the jaw adductor muscles, i.e. the temporal fenestra(e). The lower margin of these holes is formed by a bar of bone, the temporal bar. The term is most often used in reference to synapsids (e.g., mammals). Synapsids have only one temporal fenestra, so that the term is unambiguous. The temporal bar is formed by some combination of the maxilla, jugal, squamosal and quadratojugal. The exact makeup of the temporal bar is important because it is frequently diagnostic of the group.

Temporal condyle: a medical misnomer for the *temporomandibular joint*. Its a misnomer because a condyle is a rounded projection with an articular surface. With respect to mammals, the condyle is on the dentary and is properly referred to as the dentary condyle. This condyle articulates with the glenoid fossa on the squamosal or, to use medical terminology, on the squamous portion of the temporal bone.

Temporal fenestra: Most amniotes have at least one hole in the skull behind the eyes which probably evolved to allow more room for the jaw muscles. Generally, mammals have one temporal fenestra, while sensible animals have two. See examples and full explanation at Temporal Fenestration and the Classification of Amniotes.

***Temporalis* muscle:** of mammals, a muscle which originates broadly in the temporal fenestra and normally attaches on the medial or anterior face of the coronoid process. It elevates and may retract the lower jaw. The *m. temporalis* is innervated by the Vth cranial nerve. Extensive discussion and diagrams at The Mammalian Masticatory Apparatus. On the evolution of the temporalis, see the discussion at masseter.

Temporomandibular joint: the dentary-squamosal jaw joint of mammaliforms; in particular the condition of living mammals in which (a) it is the only jaw joint and (b) only the squamosal (temporal) and dentary participate.

Tenaculum: a structure rather similar to a mixypterygial clasper, but developing *anteriorly* from the pelvis, found in certain Holocephali.

Tensor tympani: a small muscle which inserts on the manubrium of the ear. Contraction of the tensor tightens the tympanic membrane and attenuates sound.

Tergal: relating to the back, from. L. *tergum* = back.

Tergal angle: the peak on the dorsal thoracic armor of some antiarch placoderms formed by the intersection of the median dorsal ridge with the ridges running from the outside corners of the anterior median dorsal plate.

Terrigenous: having a terrestrial, as opposed to marine, origin.

Tessellate: tiled; shapes which fit together in a repeating pattern. MC Escher is famous for his tessellations. In paleontology, the "repeating pattern" part is frequently ignored and any surface made up of small, congruent polygonal pieces is said to be tessellate.

Thagomizer: this started out as a Far Side joke, but has now more or less become a part of the serious anatomical literature. The thagomizer is the, otherwise difficult to describe, collection of spikes at the end of a stegosaurid's tail. It is named after the *late* Thag ...

Thanatocoenosis: death assemblage, more or less. A true death assemblage represents a collection of organisms

which all died in a "common accident" as they say in the insurance business. A thanatocoenosis is a dodgier sort of word -- the sort of word where one really wants a bunch of Greek roots to disguise a squishy lack of precision. It refers to a bunch of different organisms which all lived and died at *about* the same time and in *about* the same place, give or take a few miles and a hundred thousand years. The implication is not that these particular individuals were next-door neighbors, but that their actual next-door neighbors included members of those species found together as fossils.

Thecodont: See **Tooth Implantation**. Having teeth set in sockets, without ankylosis to the jaw (as a noun, *thecodonty*). Archosauria: More on Morphology.

Thoracic: Relating to the **thorax**, i.e. the chest or upper (anterior) body.

Thyroid fenestra: fenestrated pelvic girdle, a broad opening between the pubis and ischium (characteristic of Lepidosauria).

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Glossary: Ti - Tz

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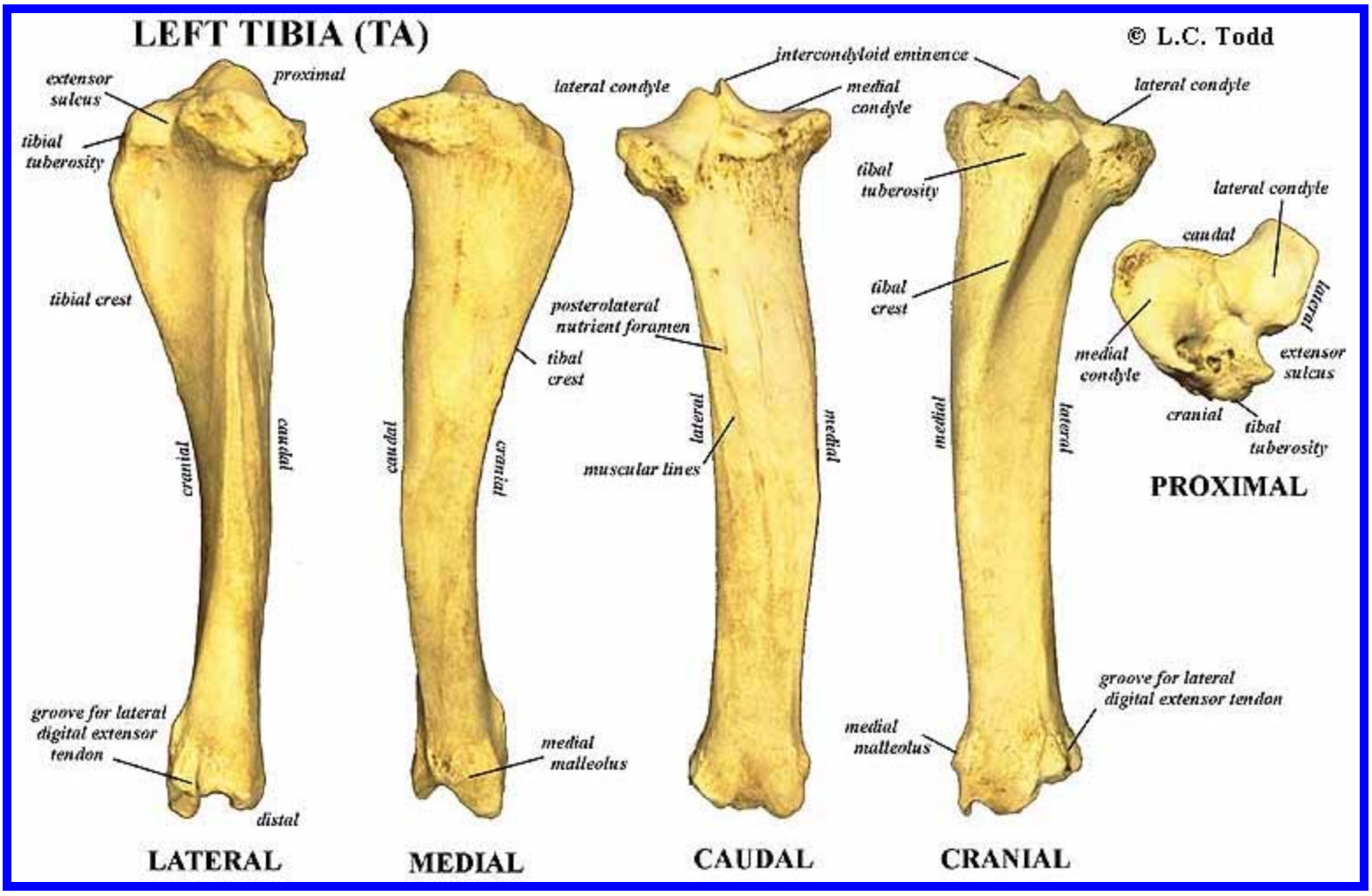
Tibia: the larger and more medial of the two lower leg bones. See image of *Bison* tibia below. Image © Prof. Larry Todd, of Colorado State Univ. Used by permission.



Tibial trochlea: as the name implies, a trochlea on the proximal end of the astragalus which allows the ankle to rotate anteroposteriorly on the end of the tibia.

Tibiale: the astragalus, one of the proximal tarsals (ankle bones). Primitively, it links the tibia with the distal tarsals, particularly the navicular. The term *tibiale* is not often used except for Paleozoic tetrapods and in some veterinary literature. There may or may not be a distinction between the tibiale and the astragalus, as some workers hold that the astragalus derives from a fusion of the tibiale, proximal centrale and intermedium. Another synonym is *talus*, is used in medical work.

Tibiotarsus: In birds, the fused unit comprising the tibia, fibula and (perhaps) some tarsal elements.

Tiffanian: One of the North American Land Mammal Ages (NALMA) corresponding roughly to the Late Paleocene and dated at roughly 58-62 My. The Tiffanian is often subdivided into Tiffanian substages I through IV.

Tillite: usually, of glacial origin. A mass of unconsolidated, poorly sorted rock debris left by glacial action or mass wasting (landslide, flood, avalanche, etc.) of some other kind. Image from Physical Geology Slides, Steven Dutch, U. Wisconsin – Green Bay. The original pile of rock is *till*, usually part of a hedgerow of rock left by a glacier, *i.e.* a *moraine*. It may be left at the terminus of a glacier, in which case it's called a *terminal moraine*. Alternatively, it may be loose material pushed out of the way as the glacier advances, a *lateral moraine*. Considered as a type of rock, this is called tillite. When the tillite has fully consolidated and (typically) is gummed together with clay-sized particles, it may be referred to as *diamictite*.

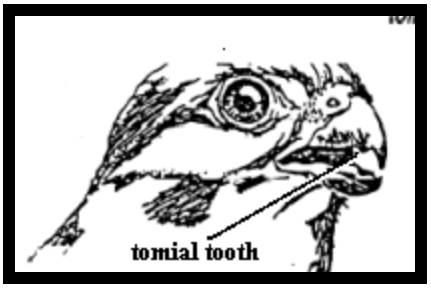
Tithonian: the last age of the *Jurassic* (Late Jurassic), 151-144 Mya.

Tiumpampa: a town in Bolivia. See *Santa Lucia Formation*.

TMJ: the *temporomandibular joint*.

Tomes process: a terminal process of ameloblasts which orients and controls the growth of enamel prisms in the developing teeth of mammals. See image at **Teeth**.

Tomium: the cutting edge of the beak in birds. Raptorial birds often have a **tomial tooth**, a pointed area of the tomium which works a bit like a canine, or even a carnassial.



Tongue River Formation: *See Bullion Creek Formation*.

Torque: A shorthand definition might be "force times distance." In a rigid system, the torque exerted by a force with respect to any reference point is the distance between the reference point and the point where the force is applied multiplied by the component of the force normal to the line between them. More precisely, it is a vector quantity with magnitude equal to this product and direction equal to the direction of the force normal to the line between the reference point and the point at which the force is applied. In English, imagine Hamlet holds the skull of Yorik straight out from his body. The torque exerted by Yorik's skull on Hamlet's shoulder is the length of Hamlet's arm multiplied by the weight of Yorik's skull. Note that if the skull is raised or lowered, the torque decreases. The distance remains the same, but the forces directed normal (i.e. 90 degrees) to the line between skull and shoulder are decreased (specifically, by a factor equal to the cosine of the angle from the horizontal). When Salome holds the head of John the Baptist straight over her head, the torque on her shoulder is near zero because the force is directed along the line of her arm, rather then at 90 degrees to it (cos(90) = 0), permitting her to perform the sinuous and erotic Dance of the Seven Veils, which Hamlet couldn't manage.

Torrejonian Stage: A North American land mammal stage (62-59 Mya), corresponding to the Middle *Paleocene Epoch* or Selandian Age.

Torso: in aquatic tetrapods, the section of the body providing undulatory motion. In aquatic mammals, the lumbar

vertebrae and lumbarized vertebrae of the thorax, sacrum and tail. See Buchholtz (1998).

Torus: [1] a donut shape **[2]** A bony elevation or protuberance of normal bone. For example, the swelling seen on the upper palate behind the front teeth or under the tongue inside the lower jaw. CIGNA.com - News & Learning: Glossaries.

Totipalmate: of bird feet, having all 4 toes, including hallux, contained in a single web.

Trabeculae: In early development, two pairs of cartilaginous rods form parallel to the notochord in the cranium: the anterior trabeculae and the posterior parachordals. These form the foundation for the development of the braincase. See diagram at **The Braincase.**

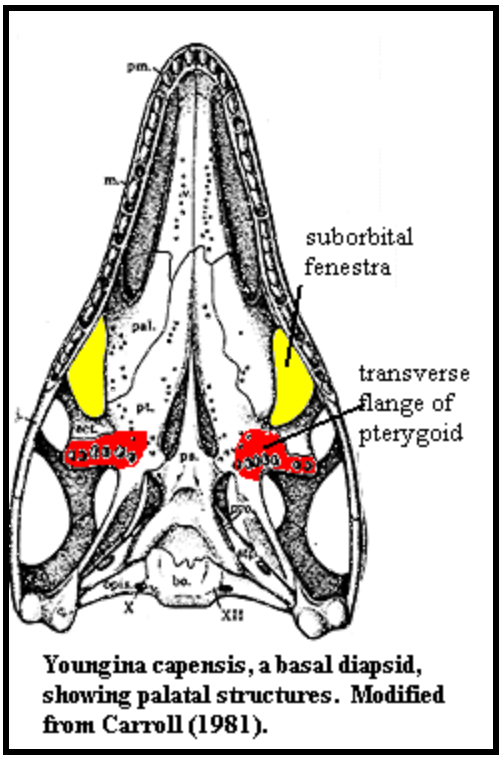
Trabecular: as applied to bone and related materials: spongy bone, as opposed to either lamellar, acellular periostial bone or, more generally, *cortical bone*. Trabecular bone is generally characterized as a cellular solid, or foam.

***Trans*-acting factors:** factors, usually considered to be proteins, that bind to the *cis-acting sequences* to control gene expression. See Cis-acting Elements and Trans-acting Factors.

Transduction: signal transduction is very hot with our molecular brethren right now. It refers to the biochemical or biophysical translation of information from one type of signal to another. For a more physiological example, see **The Ear**.

Transgression: periods of high sea level, when sea water flooded previously terrestrial regions. Opposite of regression.

Transverse: a somewhat confusing directional term indicating extension at right angles to some other axis. When used without a clear referent, it usually describes a structure extending at right angles to the long axis of the body mediolaterally (not dorsoventrally). In mammalian dentition, where all terminology is more difficult, "transverse" generally refers to linguobuccal extension. Thus "transversely compressed" teeth means thin, blade-like teeth, even if we are referring to incisors, in which this would indicate antero-posterior compression because they are at the front of the mouth.



Youngina capensis, a basal diapsid, showing palatal structures. Modified from Carroll (1981).

Transverse flange(or process): of the pterygoid. A lateral process of the pterygoid, a palatal bone. See image.

Transverse process: of the vertebrae, a lateral process of the neural arch which bears the articulations for the ribs. See diagram at diapophysis. Perhaps, anyway. It has also been said that this term has been used for so many non-homologous vertebral structures that it has no fixed meaning at all.

Transverse septum: The fibrous partition that separates the *pericardial* and *pleuroperitoneal* cavities of the *coelom*. The transverse septum is invaded by the *hepatic diverticulum* which differentiates into the liver. The posterior (or ventral, depending on the organism) wall of the septum them becomes the *serosa* covering the *hepatic* tissues.

Transverse ventral fissure: in the braincase of basal tetrapods, a transverse ventral fissure is the last remnant of the deep sarcopterygian division of the brain into separate otoccipital and sphenethmoid (posterior and anterior) halves.

Trapezium: in mammalian osteology, one of distal carpals, normally associated with Mc I and the scaphoid. See image at unciform.

Trapezoid: in mammalian osteology, one of distal carpals, normally associated with Mc II, the scaphoid and the (medial) centrale. See image at unciform.

Tremadoc Age: The first age of the Ordovician Period, 488-479 Mya. See Tremadoc.

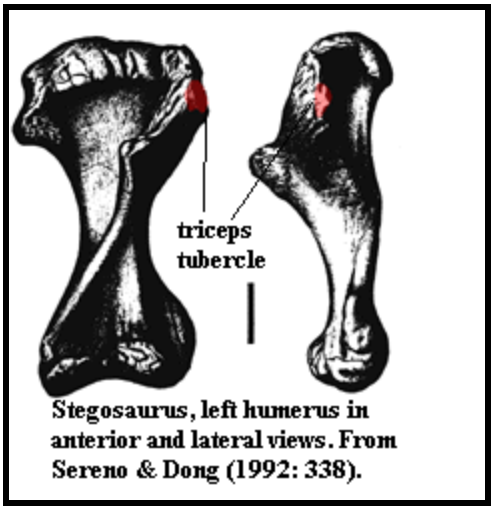
Trenchant: of dentition, sharp, cutting. Sometimes, more figuratively, sharply defined.

Triassic Period: The first period of the Mesozoic, 248-206 Mya. The Early Tertiary (248-242 Mya) includes the Induan and Olenekian Ages. The Middle Tertiary (242-227 Mya) refers to the *Anisian* and *Ladinian* Ages. The Late Tertiary (227-206 Mya) is comprised of the Carnian, Norian and *Rhaetian* Ages.

Tribosphenic molar: See **Molars.**

Triceps: a muscle of the forelimb. The triceps originates on the proximal humerus, the scapula and the coracoid. It inserts on the olecranon process of the ulna and acts to extend the lower part of the limb.

Triceps tubercle: a tubercle which projects laterally from the lateral side of the humerus, just below the proximal head and serves as a sort of gathering point for combining muscle fibers contributing to the triceps muscle.



Stegosaurus, left humerus in anterior and lateral views. From Sereno & Dong (1992: 338).

Trigeminal nerve: Cranial nerve V. Called "trigeminal" because it typically has three branches which may exit the braincase separately: the maxillary, mandibular and ophthalmic branches. The maxillary branch provides sensory nerves to the palate and teeth. The mandibular branch carries both motor and sensory nerves of the lower jaw, as well as the tensor tympani. The ophthalmic branch, in mammals, carries sensory information from the face, particularly the area around the eyes and nose. See Brain Stem and Cranial Nerves.

Trigeminal notch: a notch on the anterior face of the prootic (that is, at the front of the otic capsule) where the trigeminal (Vth) nerve exits the braincase. See **Braincase Overview**.

Trigon: The basic 3-cusped tooth of early mammals; the main, triangular unit of the upper tribosphenic molar. The trigon is defined by its main cusps at the vertices: the *protocone* (lingual), *metacone* (distal or posterior) and the *paracone* (mesial or anterior). See **Molars.**

Trigonid: The main, triangular unit of the lower tribosphenic molar. The trigonid is defined by its main cusps at the vertices: the *protoconid* (buccal), *metaconid* (distolingual) and the *paraconid* (mesiolingual). See figure at talonid. See also, **Molars.**

Trilobate: having three lobes.

Triosseal canal: passage through the pectoral girdle formed by the coracoid, scapula and furcula. In birds, this is the route through which the supracoracoideus tendon inserts on the dorsal surface of the humerus. The canal thus acts as the block through which the tendon passes and which converts the ventral pull of the muscle contraction into a dorsally directed force on the humerus.

Triploblasts: Animals possessing three basic germ layers: *ectoderm*, *mesoderm* and *endoderm*. As a practical matter, this includes all known except sponges, Cnidarians, Ctenophores, acoelomate worms (probably), and Ediacaran forms.

Tripus: one of the ossicles of the Weberian apparatus. The tripus is in contact with the swim bladder and moves in response to volume changes in the swim bladder as it responds to external sound. In turn, it articulates with the intercalarium (= interclary?) Lecture 6. *See also* image at claustrum.

Triramous: having three branches.

Tritor: (adjective, **tritoral**) in Holocephali, the hypermineralized (enameloid) areas of the dental plates corresponding to (but not necessarily homologous with) individual tooth crowns.

Trochanter: a prominent tuberosity (especially? only?) on the femur which provides an attachment site for muscles.

Trochanter, anterior: [1] (of the femur) probably the same as the *lesser trochanter*. **[2]** (of the fibula) probably the same as the illiofibularis tubercle.

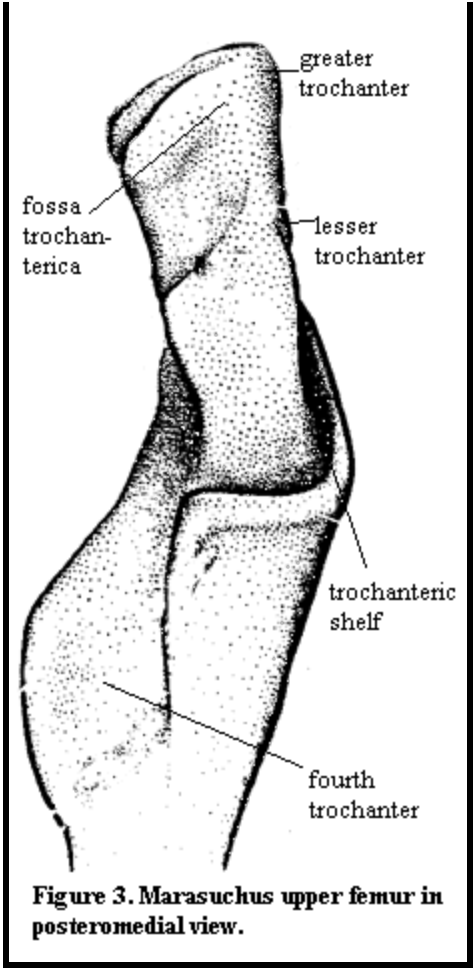


Figure 3. Marasuchus upper femur in posteromedial view.

Trochanteric shelf: see figure.

Trochlea: a spool-shaped area of bone which provides a smooth articular area for rotation on another bone. For example, the trochlea on the distal humerus articulates with the proximal ulna. Particularly good pictures of a trochlea (the *tibial trochlea*) may be found at Protocetidae.

Trochlear nerve: Cranial nerve IV, which supplies the superior oblique muscle of the eye. See figure at *rectus muscles*; *see also* discussion and figures of the gnathostome orbit.

Trujillo Formation: Early Eocene and possibly Late Paleocene of northwestern Venezuela, East of Lake Maracaibo. Patterson (1977).

Trunk: the main part of the body, exclusive of the limbs, tail and head.

Tuberculum: the dorsal process of a rib which articulates with the *diapophysis* on the neural arches. The shaft of the rib normally originates at or near the tuberculum.

Tuberculum intermedium: see *metastylid*.

Tuberosity: a large projection with a rough surface to which muscles, ligaments, or tendons are attached.

Tuff: a sediment composed of volcanic particles.

Turbinal: see concha and **Ethmoid**.

Turbinate: [1] same as *turbinal*. See concha and **Ethmoid**. **[2]** shaped like a top.

Turbulence: see *Lift*.

Turkey Branch Formation: Late Triassic (Carnian?) of Virginia. Traversodonts (*Boreogomphodon*), archosaurs (*Euscolosuchus*) and others, disarticulated in mudstone with plant debris. Sues (1992)

Turonian: an age of the Late *Cretaceous* (Late Cretaceous), about 93.5-89.0 Mya.

Tusk pair: in basal tetrapods, the palatal bones often bore a pair of relatively large, sharp, frequently recurved teeth. This "pair" actually consists of a single tusk and a replacement pit.

Two Medicine Formation: Late Cretaceous (*Campanian*) of Montana, ~75 Mya. Dinosaurs (including eggs), pterosaurs, *Daspletosaurus*. Floodplain with lacustrine and overbank river deposits. Varricchio (2001)

Tympanic: in mammals, the bone that forms the *auditory bulla*.

Type: A term used alone, or forming part of a compound term, to denote a particular kind of specimen or taxon.

Type locality: The geographical place of capture or collection of the name-bearing type of a nominal species or subspecies. If the name-bearing type was captured or collected after being transported by boat, vehicle, aircraft, or other human or mechanical means, the type locality is the place from which it, or its wild progenitor, began its unnatural journey.

Type specimen: the specimen in systematic biology to which the name of the species is attached. The concept of a given species, however, is based, when available, on additional specimens besides the type.

Type species a single species on which the concept of a genus is based; generitype. Although many species may be included in a genus, a generic taxon is based on a single type species.

Glossary: U-V

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

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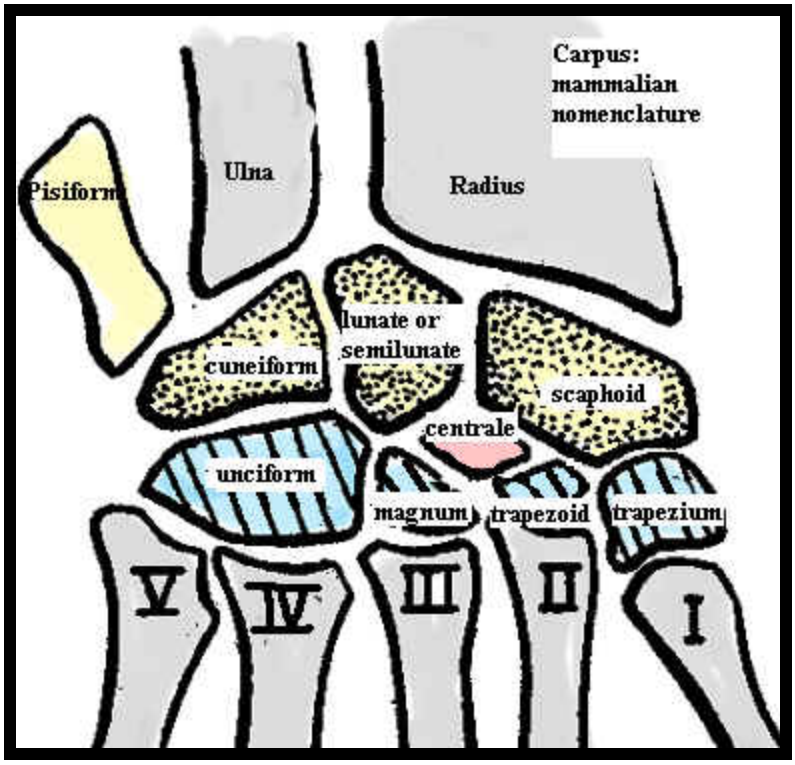
- U -

Ulan Gochu Formation: Early Oligocene of China (Inner Mongolia).

Ulnare: one of the proximal carpal bones of the wrist. See figure at *carpus*.

Unciform: [1] in mammalian osteology, one of the distal tarsals, normally articulating with metacarpals IV & V and with the cuneiform. **[2]** anything hook-like (same as *hamate*).



Uncinate: bearing a tab-like process at right angles to the main shaft; particularly of ribs, bearing a posteriorly-directed uncinate process which overlaps with the next more posterior rib (common in early tetrapods, birds and some other groups) to assist in respiration, in bracing the scapula, or to stiffen the body wall against lateral pressures for protection of the gut or in locomotion.

Uncinate process: A roughly triangular posterior process on the dorsal ribs of birds which overlaps the shaft of the next most posterior rib. In birds, uncinate processes are thought to be involved (a) stiffening the body to improve flight efficiency and (b) providing muscle attachment sites which move the ribs as a part of the avian respiratory cycle. Uncinate processes were also developed in Colosteids and other basal tetrapods.

Unfinished bone: bone lacking a smooth periosteal surface. The usual implication is that the bone was still growing, was covered in cartilage, or both.

Ungual: the terminal phalanx of a digit which bears a claw, hoof or other keratinous terminal extension of the phalanges.

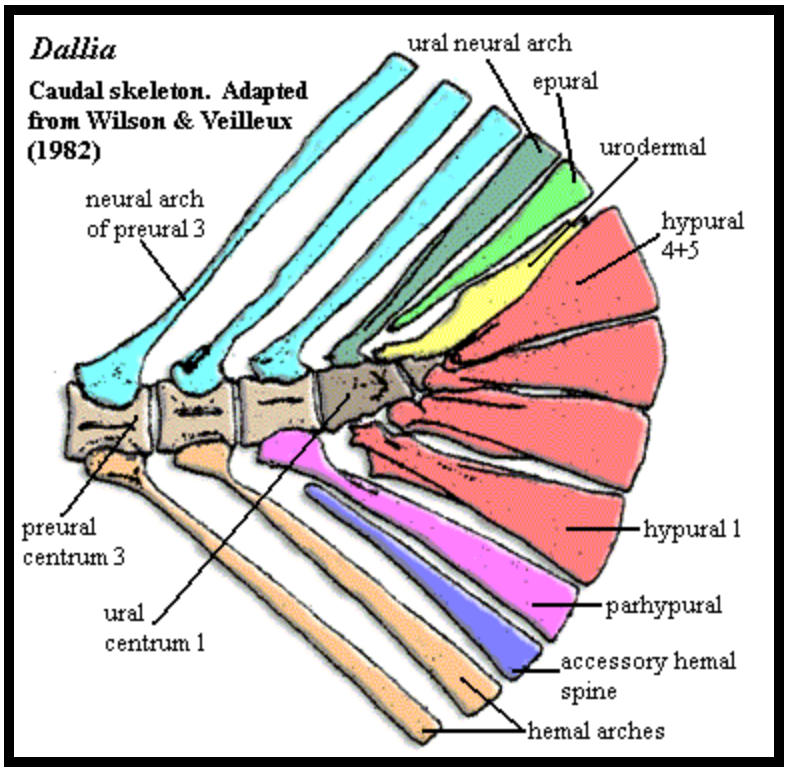
Unguiligrade: locomotion in which the main weight-bearing surface is the unguals -- typical of (surprise!) ungulates.

Uniserial: "In one row or series; arranged in a single row" FishBase Glossary Searched Term. As applied to fins, having the bone elements extended along a single axis.

Uquian Age: South American Land Mammal Age corresponding to the Late Pliocene and Early Pleistocene.

***Uro-, Ura-*:** Gr. = tail.

Ural: [1] in geography, relating to the Ural Mountains in western Russia; **[2]** in anatomy, relating to the tail; **[3]** in fish anatomy, the more posterior tail region, in which the hemal arches bear flat hypurals, rather than hemal arches enclosing the caudal artery.



Urodermal: in fishes, paired, thin dermal bones at the rear of the caudal fin skeleton, derived from scales.

Uroneural: in fish tail anatomy, obsolete term for urodermal? But Johnson & Patterson (1997) treat them as two different bones. In their view, the esociform bone, illustrated here, is a uroneural.

Uropatagium: Skin membrane extending between the hind legs and frequently enclosing the tail - especially in bats or pterosaurs.

Urostyle: [1] the small upturned posterior tip of the vertebral column, generally formed of fused vertebrae and associated elements (in homocercal caudal fins of Teleostomi), **[2]** the fan-like series of bones articulating with the last true vertebra, including preural centra, ural centra, epurals and hypurals. Counted as one vertebra in some vertebral counts, not counted in others.

Usu: (abbr.) usually; used here as a signal that the described character is not a synapomorphy, although it may be common within the clade.

UTF: abbreviation for upper temporal fenestra, *see* image at LTF.

Utriculus: One of the *maculae*, vaguely sac-like areas of the vestibular apparatus in the inner ear involved in the perception of linear acceleration, orientation in a gravity field, and low-frequency or high-volume sounds. See **The Ear**.

Uzunçarsidere Formation: Late Cretaceous (Early Paleocene?) to Middle Eocene (Lutetian) of Central Anatolia, Turkey -- very close to Ankara. Part of the Haymana Basin. Red clastics. Mammals. Sometimes referred to as part of the Kartal Formation.

-V-

Vacuity: opening or perforation in a bony plate

Vagus nerve: the Xth (tenth) cranial nerve. Both motor and sensory functions. Innervates (among other organs) the

heart and anterior digestive tract, as well as gill arches 4-7 and the lateral line system.

Vagus foramen: the reptile analogue of the jugular foramen. It is located near the base of the paroccipital process, between the exoccipitals and the opisthotic, and contains one or more foramina for cranial nerves IX, X and/or XI, and who knows what else. The vagus foramen is created by walling off part of the metotic foramen into a specialized exit for various cranial nerves. The remaining part of the metotic fissure is may then be referred to as the *fenestra pseudorotunda* since it can specialize to perform the same function as the *fenestra rotunda*.

Valanginian: an age of the Early Cretaceous, about 137-132 Mya. *See* **Valanginian**

Vasodentine: dentine penetrated by blood vessels.

Velum: a respiratory pump found in basal craniates.

Ventral Fissure: a transverse gap, fissure, crack, fossa, or what-have-you in ventral surface of the **braincase** separating the sphenoid and otic regions.

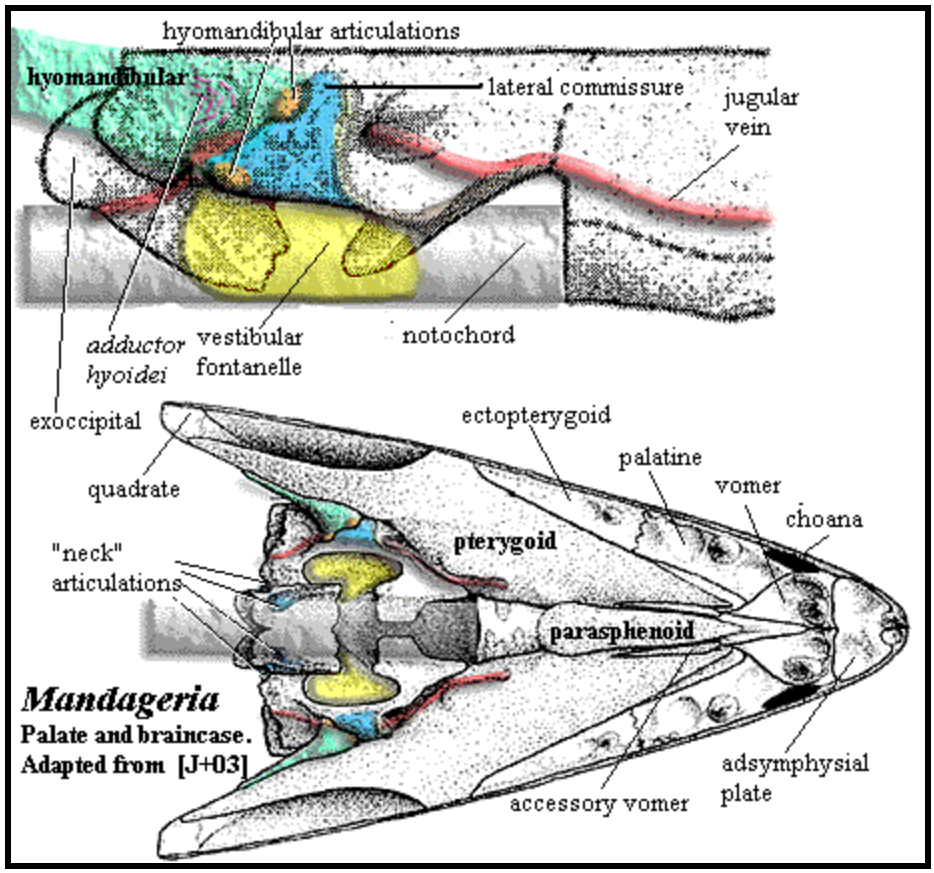
Verrucosic: after *Sus verrrucosus*, one of two morphotypes of the canine found in suoids. In verrucosic canines, the tooth is approximates a scalene triangle in cross-section. The lingual face is broadest, and the labial (inner) face is second broadest. As opposed to scrofic.

Vert: (abbr.) vertebra.

Vestibula: an enclosed space

Vestibular apparatus: The functional apparatus of the inner ear. See **The Ear**.

Vestibular fontanelle: a large basicranial fenestra below the notochord in some sarcopterygians and very basal tetrapods. The vestibular fontanelle opens into the saccular region of the inner ear.



Vestibulocochlear nerve: same as auditory or VIIIth cranial nerve.

Vibrissa: in mammals, a "whisker," *i.e.*, a stout, stiff and generally very long, tactile bristle growing singly or in small clusters, mostly in a few constant sites on the body

Vidian Canal: a/k/a Pterygoid canal. Palatine ramus of the VIIth (facial) nerve (humans) and/or internal carotid artery (mosasaurs). In mammals it also carries elements of the petrosal nerve. PPT Slide; Discussion. Structurally, I'm not sure what it is or how to define it ... Sorry.

Viliform: thin, elongate, needle-like.

Villus: (pl. "villi") Latin for (shaggy) hair (hence O. Fr. villein, at a guess?). A hair-like projection, normally used in describing microvilli, hair-like projections from a cell wall which are not motile. They normally function as sensory organelles or to increase surface area for absorption.

Vinculum: In birds, a tendon which emerges from the distal end of the humerus and follows the posterior margin of the wing, attaching at the distal end of digit 2. The *raches* of the *remiges* (i.e., the stems of the flight feathers) are stabilized by passing through the vinculum.

Visceral: medial or axial. Normally used of surface anatomical structures to describe the side toward the center or axis of the body.

Volant: flying, capable of flight.

Volar: imagine a man standing with arms at the sides, palms facing toward you - that is the volar surface of the arm. directions on the body. Apparently synonymous with palmar or plantar.

Volkmann's Canals: see *Osteon*.

Vomer: A median paired or unpaired bone lying in the floor of the nasal cavity (above the hard palate in mammals).

Vomeronasal Organ: Jacobson's Organ; a chemosensory organ located in the roof of the mouth.

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Glossary: W-Z

For most phrases beginning with directional words, *e.g.* "posterior," "dorsal," "external," etc., or some generic anatomical terms, *e.g.*, "vena," look under the next word in the phrase. However, note that this convention is not used with complete consistency in this Glossary.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

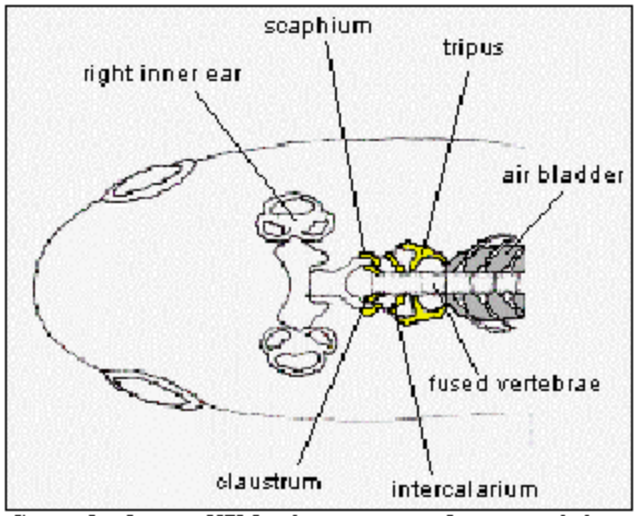
-W-

Wackestone: carbonate rock which is matrix-supported; i.e., there are more than 10% grains, but the fine grain clay size matrix essentially surrounds the grains.

Wadi Esh-Shallala Formation: Early Eocene to Early Oligocene of Eastern Jordan. Marine marls and limestones. *Basilosaurus*. Zalmout *et al.* (2000).

Waihao Greensand: Middle? Eocene of New Zealand. Glauconitic sandstone, very fine-grained sediment from a low-energy marine environment. Köhler & Fordyce (1997). *Zygorhiza* (protocetid whale similar to *Dorudon*).

Weberian apparatus: "Series of four or five modified vertebrae which connect the swim bladder to the inner ear of ostariphysian fishes; a set of structures, including a series of small bones, connecting the dorsal wall of the air bladder to the region of the ear; in carp, minnows, suckers, catfishes, and other ostariophysan fishes" See FishBase Glossary Searched Term. The apparatus is a chain of bony ossicles (derived from vertebral processes) linking the swim bladder with the inner ear. A change in swim bladder volume as sound waves pass through the fish rocks the tripus. This movement is transferred through the intercalium and schaphium to the claustrum which abuts onto the perilymphatic sinus impar. The sinus, in turn, is linked to an endolymphatic transverse duct joining the saculi of either side. The system allows reception of an unusually wide range of frequencies and also seems capable of directional hearing. *See also* image at claustrum.



General scheme of Weberian apparatus for transmitting vibrations from air bladder to ear. Weberian ossicles shown in yellow.

Weberian ossicles: a chain of small bones which convey sound from the swim bladder to the inner ear in various teleost groups.

Wessex Formation: Early Cretaceous (Hauterivian & Barremian) of England (Isle of Wight). Clayey sand

containing considerable plant debris & wood fragments. Believed to be flood-born deposits. Hutt *et al.* (2001).

Westoll lines: in some sarcopterygians (Dipnoi and some others), "the cosmine of lungfishes shows more or less concentric lines of discontinuity, the Westoll lines ... which are interpreted as being due to cyclic resorption and redeposition during growth ... ." Janvier (1996: 209). Apparently, these occur both on the bases of individual scales and also as large structures between head shield plates.

Westphalian Epoch: Normally subdivided into four stages, A through D. European Late Carboniferous epoch corresponding to the second half of the Bashkirian (A&B) and the Moscovian (C&D) epochs. That is, roughly 316 to 303 Mya.

Williston's Law: another one of those paleontological "laws" which describe frequently -- but not invariably -- encountered trends. The "Law" is that, in any given lineage, the number of serially homologous elements tends to decrease while the individual elements tend to become divergently specialized. See **Epibranchials** for an interesting example and counter-example.

Wing loading: ratio of weight to wing area. Lower wing loading permits slower flight without stalling.

Witpoort Formation: Late Devonian. *Famennian* fm in eastern South Africa near Grahamstown. Arthrodire and antiarch placoderms. Long *et al.* (1997).

-X-

***Xia-*:** Chinese (Mandarin?) prefix indicating lower? older? when attached to the name of a geological formation.

Xiphoid Process: the most posterior bone of the sternum. See sternum.

Xishancun Formation: Early Devonian (early Lochkovian) of China (Yunnan). *Psarolepis*, petalichthyids & galeaspids. Zhu *et al*. (1999).

Xitun Formation: Early Devonian (late Lochkovian) of China (Yunnan). Zhu *et al*. (1999). Also referred to as the Xitun Member of the Cuifengshan Formation. Yu (1998). *Psarolepis*.

-Y-

Yarenskian Gorizont: Early Triassic of Russia (Arkhangel'sk). Temnospondyls.

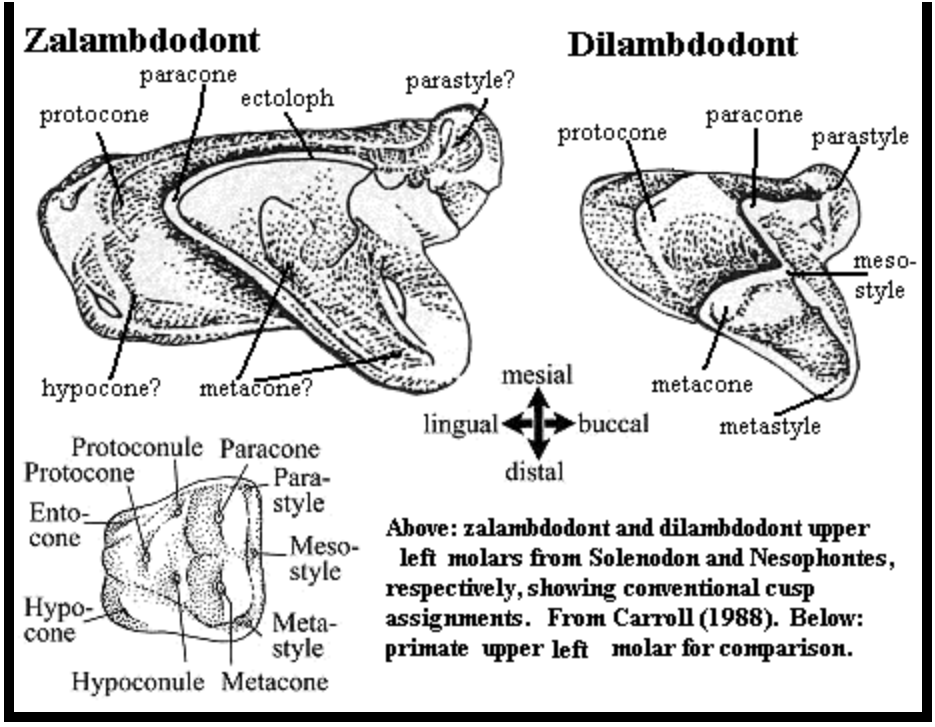
Yixian Formation: Early Cretaceous (& perhaps uppermost Jurassic) of Liaoning Province, China. Fish, birds, theropods, iguanodonts, mammals. Famous for feathers on everything. Localities include the Jianshangou Beds (*Zhangheotherium*). See, generally, Luo (1999) for a non-technical discussion of age and biota.

Yolk sac: a membrane-bound compartment in the *amniotic egg* which contains stored food for the developing embryo.

Yulongsi Formation: Late Silurian (Pridoli) of China (Yunnan). *Psarolepis*. Zhu *et al*. (1999).

-Z-

Zalambdodont: molar characterized by a V-shaped crest along the margin (ectoloph). At the apex of the V (on the



Above: zalambdodont and dilambdodont upper left molars from Solenodon and Nesophontes, respectively, showing conventional cusp assignments. From Carroll (1988). Below: primate upper left molar for comparison.

lingual side of the tooth) is usually the paracone (fused with the metacone, with metacone lost). This looks odd, since the paracone is typically at the buccomesial corner of the molar. However, animals with zalambdodont molars have offset jaws, so that the ectoloph is occluding with the hypoflexid on the lower molar, just as the paracone typically does. In mammals with the usual cusp pattern, this occlusion is secondary to the protocone-talonid occlusion. In zalambdodont animals, the ectoloph- hypoflexid relationship is dominant. In fact, Asher *et al*. (2002) have defined zalambdodonty as incorporating three elements: (a) primary occlusion between paracone & hypoflexid, (b) primary shear between preparacrista and protocristid, and (c) reduction or elimination of the metacone & talonid basin. The crests of the ectoloph run to stylar cusps on the labial side of the tooth. The protocone is typically absent. *See* **Molars** and The Diversity of Cheek Teeth.

Zap: (abbr.) zygapophysis

Zeugopodium: the lower part of the limb, *i.e.* radius + ulna or tibia + fibula. *Compare stylopodium* (upper limb) and *autopodium* (hand/foot).

Zygantrum: *see zygosphene*

Zygapophyses: articular processes that extend forward and backward of neural arches and help to strengthen union between vertebrae. The prezygapophyses of one vertebra articulate with the postzygapophyses of the next vertebra anterior to it. The angle of the zygapophyses commonly controls the degree to which the spinal column can bend laterally.

Patagonykus dorsal vertebra

Zygodactyl: a specialized digital configuration in birds in which both digits 1 and 4 are reversed. Some birds (*e.g.* musophagids, cuculiforms) are facultatively zygodactyl, i.e., digit 4 may be held in either an anterior (anisodactyl) or reversed (zygodactyl) position.

Zygokrotaphic: "When a skull is completely roofed (containing only openings for sense organs) it is called stegokrotaphic. A well-ossified skull with little kinesis is definitely an adaptation for a fossorial existence. In some rhinatrematids, scolecomorphids, and some caeciliids, the temporal region is partial open, is slightly kinetic, and is known as zygokrotaphic."

Zygoma: the zygomatic arch.

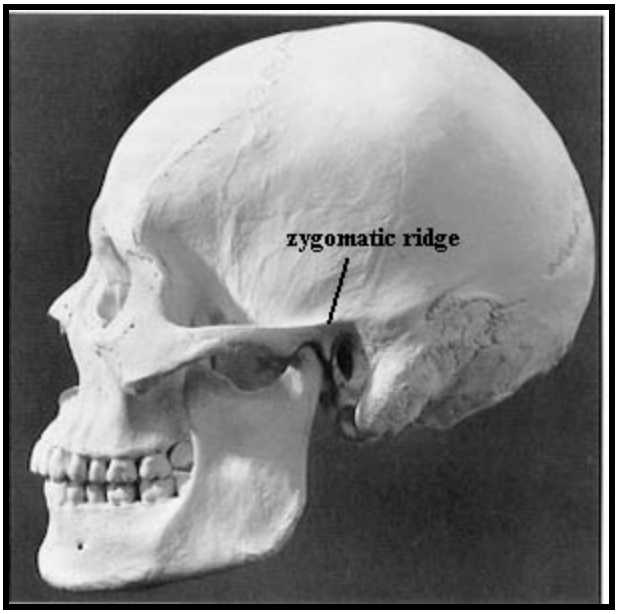
Zygomatic arch: the arch running under the orbit and temporal fenestra in synapsids. Same as subtemporal arch, and roughly equivalent to the jugal arch in diapsids. Normally formed from jugal and squamosal (maxilla &

squamosal in multituberculates). The presence of a zygomatic arch, at least when bowed outward, implies the presence of the masseter muscle which permits chewing of food.

Zygomatic plate: The zygomatic process of the maxillary bone when this process is in the form of a thin plate.

Zygomatic process -A process of either the maxillary or squamosal bone that contributes to the formation of the zygomatic arch.

Zygomatic ridge: a ridge which continues the zygomatic arch posteriorly. See image. Interesting trivia: the continuation of the ridge over the external auditory meatus, as in the figure suggests that the skeleton is male in anthropoids.



Zygosphene: "A median process on the front part of the neural arch of the vertebrae of most snakes and some lizards [also mosasaurs -- ed.], which fits into a fossa, called the **zygantrum**, on the back part of the arch in front." OPTED v0.03 Letter Z.

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References

-A-

Abbott, EA (1884), **Flatland: A Romance of Many Dimensions**. Republished at http://www.geom.umn.edu/~banchoff/Flatland/ as of 4/20/02. Neoselachii Overview.

Adriaens, D & W Verraes (1997), *The ontogeny of the chondrocranium in* ***Clarias gariepinus****: trends in siluroids*. **J. Fish Biol.**50: 1221-1257. WWW. Cladoselachida.

Adriaens, D & W Verraes (1998), *Osteology of the osteocranium in the African Catfish,* ***Clarias gariepinus*** *Burchell (1822) (Siluriformes: Clariidae): ossification sequence as a response to functional demands*. **J. Morphol.** 235: 183-237. WWW. Dermosphenotic, Siluriphysi.

Ahlberg , PE (1995), ***Elginerpeton pancheni*** *and the earliest tetrapod clade*. **Nature**, 373: 420-425. Elginerpetonidae, *Elginerpeton*, *Obruchevichthys*, Tetrapoda, *Ventastega*.

Ahlberg, PE (1998), *Postcranial stem tetrapod remains from the Devonian of Scat Craig, Morayshire, Scotland* **Zool. J. Linn. Soc.**122: 99-141. *Acanthostega*, *Elginerpeton*, *Ichthyostega*, Tetrapoda

Ahlberg, PE (1999), *Something fishy in the family tree*. **Nature** 397: 564-565. Osteichthyes.

Ahlberg, PE (2004), Comment on "The early evolution of the tetrapod humerus." **Science**305: 1715c. *Elginerpeton*.

Ahlberg, PE & JA Clack (1998), *Lower jaws, lower tetrapods -- a review based on the Devonian genus* ***Acanthostega***. **Trans. Roy. Soc. (Edinburgh), Earth Sci.**, 89: 11-46. *Acanthostega*, *Baphetes*; Baphetidae, Crocodyliformes, *Ichthyostega*, *Loxomma*, *Megalocephalus*, *Metaxygnathus*, *Obruchevichthys*, *Panderichthys*, Tetrapoda, *Ventastega*.

Ahlberg, PE & Z Johanson (1997), *Second tristichopterid (Sarcopterygii, Osteolepiformes) from the Upper Devonian of Canowindra, New South Wales, Australia, and phylogeny of the Tristichopteridae*. **J. Vert. Paleontol.** 17: 653-673. ***Cabonnichthys***, Osteolepiformes, Tristichopteridae.

Ahlberg, PE & Z Johanson (1998) *Osteolepiforms and the ancestry of tetrapods*. **Nature**395: 792-794. Osteolepiformes.

Ahlberg, PE & E Luksevics (2004) *New light on the Devonian tetrapod* ***Ventastega curonica***. **10th Intl. Symp. Early Vert. Lower Vert.**, p. 10 (abstr). *Elginerpeton*, Tetrapoda, *Ventastega*.

Ahlberg, PE & AR Milner (1994), *The origin and early diversification of tetrapods*. **Nature**368: 507-514. Elpistostegalia, Osteolepiformes.

Ahlberg, PE, JA Clack & E Lukševics (1996), *Rapid braincase evolution between* ***Panderichthyes*** *and the earliest tetrapods*. **Nature**381: 61-64. *Panderichthys*, Tetrapoda

Ahlberg, PE, M Friedman & H Blom (2005), *New light on the earliest known tetrapod jaw.* **J. Vert. Paleontol.**25: 720-724. *Elginerpeton*.

Ahlberg, PE, E Lukševics & E Mark-Kurik (2000), *A near-tetrapod from the Baltic Middle Devonian*. **Palaeontology**43: 533-548. Elpistostegalia, ***Livoniana***, Osteolepiformes.

Albanesi, GL & CP Barnes (2000), *Subspeciation within a punctuated equilibrium evolutionary event: phylogenetic history of the Lower-Middle Ordovician* ***Paroistodus originalis*** *-* ***P. horridus*** *complex (Conodonta).* **J. Paleontol.**74: 492-502. Conodonta

Albino, AM (2000), *New record of snakes from the Cretaceous of Patagonia (Argentina)*. **Geodiversitas** 22: 247-253. Madtsoiidae

Alcober, O (2000), *Redescription of the skull of* ***Saurosuchus galilei*** *(Archosauria: Rauisuchidae)* **J. Vert. Paleontol.**20: 302-316. Poposauridae, Rauisuchidae, *Saurosuchus*.

Anderson, HM & JM Anderson (1970), *A preliminary review of the biostratigraphy of the Uppemost Permian, Triassic, and Lowermost Jurassic of Gondwanaland*. **Paleontol. Afr.**13(suppl.): 1-22. *Uranocentradon*.

Anderson, LC & PD Roopnarine (2005) *Role of constraint and selection in the morphologic evolution of* ***Caryocorbula*** *(Mollusca: Corbulidae) from the Caribbean Neogene*. **Palaeont. Elec.**8: 32A, 18pp. WWW. *Holopterygius*.

Anderson, JM & ARI Cruikshank (1978), *The Biostratigraphy of the Permian and Triassic, Part 5, a review of the classification and distribution of Permo-Triassic Tetrapods*, **Paleontol. Afr.**21: 15-44. *Laccocephalus*.

Andrews, SM (1973), *Interrelationships of crossopterygians* **in**PH Greenwood, RS Miles & C Patterson [eds.], **Interrelationships of Fishes**. **Zool. J. Linn. Soc.**53(supp.1): 137-177. Onychodontiformes, *Onychodus*, *Strunius*.

Andrews, SM & TS Westoll (1970), *The postcranial skeleton of* ***Eusthenopteron foordi*** *Whiteaves*. **Trans. Roy. Soc. Edin.**68: 207–329. *Acanthostega*, *Eusthenopteron*.

Andrews, SM & TS Westoll (1970a), *The postcranial skeleton of rhipidistian fishes excluding* ***Eusthenopteron***. **Trans. Roy. Soc. Edin.**68: 391–489 (1970). *Eusthenopteron*, Megalichthyidae, Osteolepididae, Osteolepiformes, Rhizodontiformes, Tristichopteridae.

Archibald, JD, AO Averianov & EG Ekdale, (2001), *Late Cretaceous relatives of rabbits, rodents, and other extant eutherian mammals*. **Nature**414: 62-65. Eutheria, Glires, Zalambdalestidae.

Arcucci, AB (1997), *Dinosauromorpha* in Currie, PJ and K Padian (eds.), **Encyclopedia of Dinosaurs.**Academic Press, pp. 179-183. Dinosauromorpha, *Lagerpeton*, Lagosuchidae.

Arcucci, AB & CA Marsicano (1998), *A distictive new archosaur from the Middle Triassic (Los Chañares Formation) of Argentina*. **J. Vert. Paleontol.**18: 228-232. *Tarjadia*

Arnason, U & A Janke (2002), *Mitogenomic analyses of eutherian relationships*, **Cytogenet. Genome Res.**96: 20-32. Insectivora.

Arnason, U, JA Adegoke, K Bodin, EW Born, YB Esa, A Gullberg, M Nilsson, RV Short, X-F Xu, & A Janke (2002), *Mammalian mitogenomic relationships and the root of the eutherian tree*, **Proc. Natl. Acad. Sci. USA** 99: 8151-8156. Insectivora.

Arnason, U, A Gulberg & A Janke (1998), *Molecular timing of primate divergences as estimated by two nonprimate calibration points*. **J. Mol. Evol.**47:718–727 Hippomorpha.

Asher, RJ, MC McKenna, RJ Emry, AR Tabrum & DG Kron (2002), *Morphology and relationships of* ***Apternodus*** *and other extinct, zalambdodont placental mammals*, **Bul. Amer. Mus. Nat. Hist**. #273: 117 pp. Apternodontidae, Chrysochloroidea, Insectivora, Micropternodontidae, Oligoryctidae, Palaeoryctidae, Parapternodontidae, Solenodontidae, Soricidae, Soricinae, Soricomorpha, Tenrecoidea.

Averianov, AO (2000), *Mammals from the Mesozoic of Kirgizstan, Uzbekistan, Kazakhstan and Tadzhikistan*in MJ Benton, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**, Cambridge Univ. Press, pp. 627-652. Zhelestidae

Averianov, AO (2002), *Early Cretaceous "symmetrodont" mammal* ***Gobiotheriodon*** *from Mongolia and the classification of "Symmetrodonta"*. **Acta Palaeontol. Pol.**47: 705-716. Tinodontidae.

-B-

Bailey, JB (1997), *Neural spine elongation in dinosaurs: sailbacks or buffalo-backs?* **J. Paleontol.** 71: 1124-1146. *Ianthasaurus*, *Ouranosaurus*

Bailon, S (1988), *Un aniliidé (Reptilia, Serpentes) dans le Pliocène Supérieur Européen*. **C.R. Acad. Sci. Paris (Ser. II)** 306: 1255-1258. Aniliidae.

Bajpai, S & PD Gingerich (1998), *A new Eocene archaeocete (Mammalia, Cetacea) from India and the time of origin of whales*. **Proc. Nat. Acad. Sci. (USA)**95:15464-15468. Cetacea, Cetartiodactyla.

Bajpai, S & JGM Thewissen (1998), *Middle Eocene cetaceans from the Harudi and Subathu Formations of India*, **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 213-233. Protocetidae, Remingtonocetidae.

Bakker, RT (1975), *Dinosaur Renaissance*, **Scientific American**232: 5878. Tapinocephalidae.

Bakker, RT, (1986), **The Dinosaur Heresies : New Theories Unlocking the Mystery of the Dinosaurs and Their Extinction**. Kensington Pub Corp.: 481 pp. *Diplodocus*, Tapinocephalidae, Titanosauria, Tyrannosauroidea.

Barghusen, HR (1968), *The lower jaw of cynodonts (Reptilia, Therapsida) and the evolutionary origin of mammal-like adductor jaw musculature*. **Postilla**116: 1-49. Cynodontia.

Barghusen, HR (1975), *A review of fighting adaptions in dinocephalians (Reptilia, Therapsida)*, **Paleobiology**1: 295-311. *Struthiocephalus*, Tapinocephalidae.

Barlow, AJ & PH Francis-West (1997), *Ectopic application of recombinant BMP-2 and BMP-4 can change patterning of developing chick facial primordia.* **Development** 124: 391-398. Meckel's Cartilage.

Barlow, GW (2000), **The Cichlid Fishes: Nature's Grand Experiment in Evolution**. Perseus Publishing: 335 pp. Cichlidae, Epibranchials, Labridae, Labroidei.

Barsbold, R & T Maryanska (1990), *Segnosauria* in DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press, pp. 408-415. Therizinosauridae.

Basden, AM & GC Young (2001), *A primitive actinopterygian neurocranium from the Early Devonian of southeastern Australia*. **J. Vert. Paleontol.** 21: 754-766. Sarcopterygii

Battail, B & MV Surkov (2000), *Mammal-like reptiles from Russia* in MJ Benton, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**, Cambridge Univ. Press, pp 86-119. *Anoplosuchus*, Anteosauria, *Archaeosyodon*, Biarmosuchia, *Brithopus*, *Chthomaloporus*, *Deuterosaurus*, *Dolisauriscus*, *Dvinia*, Eotitanosuchia, Estemmenosuchidae, *Estemmenosuchus*, Jugals, *Lystrosaurus*, *Molybdopygus*, *Nanocynodon*, *Notosyodon*, Phthinosuchidae, Procynosuchidae, Sphenacodontia, *Syodon*, Tapinocephalidae, Therapsida, *Ulemosaurus*.

Beaumont, EH (1977), *Cranial morphology of the Loxommatidae (Amphibia: Labyrinthodontia).* **Trans. Roy. Soc. Lond. B**280: 29-101. *Baphetes*, Baphetidae, *Loxomma*, *Megalocephalus*, Septomaxilla, *Spathicephalus*.

Beaumont, EH & TR Smithson (1998), *The cranial morphology and relationships of the aberrant Carboniferous amphibian* ***Spathicephalus mirus*** *Watson*. **Zool. J. Linn. Soc.**122: 187-209. *Spathicephalus*

Behrensmeyer, AK, JD Damuth, WA DiMichele, R Potts, H-D Sues & SL Wing (1992), **Terrestrial Ecosystems Through Time: Evolutionary Paleoecology of Terrestrial Plants and Animals** Univ. Chicago Press, 568 pp. Heterodontosauridae.

Bemis, WE, EK Findeis & L Grande (1997), *An overview of Acipenseriformes.* **Env. Biol. Fishes**, 48: 25-71. Acipenseriformes, Birgeriidae, Chondrostei, Saurichthyidae.

Bendix-Almgreen, SE (1971), *The anatomy of* ***Menaspis armata*** *and the phyletic affinities of the menaspid bradydonts*. **Lethaia**4: 21-49. Menaspidae.

Bennett, SC (1996), *Aerodynamics and thermoregulatory function of the dorsal sail of* ***Edaphosaurus***. **Paleobiology** 22: 496-506. *Ianthasaurus*.

Bennett, SC (1996), *Year-classes of pterosaurs from the Solnhofen Limestone of Germany: taxonomic and systematic implications*. **J. Vert. Paleontol.** 16: 432-444. *Dactylosaurus*, Pterodactyloidea.

Bennett, SC (1997), *Terrestrial locomotion of pterosaurs: a reconstruction based on* ***Pteraichnus*** *trackways*. **J. Vert. Paleontol.** 17: 104-113. Pterodactyloidea, Pterosauria.

Bensch, S & A Härlid (2000), *Mitochondrial genomic rearrangements in songbirds*. **Mol. Biol. Evol.** 17: 107-113. Cuculiformes.

Benson, RD (1999), ***Presbyornis isoni*** *and other Late Paleocene birds from North Dakota.* **Smithsonian Contribs. Paleobiol.**89: 253-259. *Presbyornis*, *Telmabates*.

Benton, MJ (1984), *Rauisuchians and the success of dinosaurs*. **Nature**310: 101. Poposauridae, Prestosuchidae, Rauisuchia, Rauisuchidae, *Saurosuchus*.

Benton, MJ (1997), *Origin and early evolution of Dinosaurs*, **in**JO Farlow & MK Brett-Surman (eds.), **The Complete Dinosaur**. Indiana Univ. Press, pp. 204-215. Dinosauria

Benton MJ (1999), ***Scleromochlus taylori*** *and the origin of dinosaurs and pterosaurs*, **Phil. Trans. Roy. Soc. Lond.**B354: 1423-1446. Ornithodira, Ornithosuchidae, *Scleromochlus*.

Benton, MJ & JM Clark (1988), *Archosaur phylogeny and the relationships of the Crocodilia* **in**MJ Benton (ed.), **The Phylogeny and Classification of the Tetrapods** 1: 295-338. Oxford, The Systematics Assoc. Archosauria, *Gracilisuchus*, Ornithosuchidae, Prestosuchidae.

Benton MJ & PCJ Donoghue (2007), *Paleontological Evidence to Date the Tree of Life*. **Mol. Bio. Evol.** 24: 26-53. Glossary.

Benton, MJ & DJ Gower (2002), *Alick D. Walker 1925–1999: an appreciation*. **Zool. J. Linn. Soc.**136: 1-5. Euparkeriidae.

Benton, MJ & AD Walker (2002), ***Erpetosuchus***, *a crocodile-like basal archosaur from the Late Triassic of Elgin, Scotland*, **Zool. J. Linn. Soc.**136: 25-47. Aetosauridae, *Batrachotomus*, *Erpetosuchus*, *Gracilisuchus*, Ornithosuchidae, Prestosuchidae.

Benton, MJ, L Juul, GW Storrs, & PM Galton (2000), *Anatomy and systematics of the prosauropod dinosaur* ***Thecodontosaurus antiquus*** *from the Upper Triassic of Southwest England*. **J. Vert. Paleontol.** 20: 77-108. *Dactylosaurus*, Sauropodomorpha.

Beresford, P, FK Barker, PG Ryan & TM Crowe (2005), *African endemics span the tree of songbirds (Passeri): molecular systematics of several evolutionary 'enigmas.'* **Proc. Roy. Soc. London B** 272: 849-858. Ratites.

Berger, AJ (1960), *Some anatomical characters of the Cuculidae and the Musophagidae*. **Wilson Bull.** 72: 60-103. Cuculidae.

Berman, DS (2000), *Origin and early evolution of the amniote occiput.* **J. Paleontol.** 74: 938-956. *Acanthostega*, *Baphetes*, Baphetidae, The Occiput, The Opisthotic

Berman, DS, RR Reisz, D Scott, AC Henrici, SS Sumida & T Martens (2000),*Early Permian bipedal reptile*. **Science** 290: 969-972. Bolosauridae, The Opisthotic.

Berner, RA & Z Kothavala (2001), *GEOCARB III: a revised model of atmospheric CO_2over Phanerozoic time*. **Amer. J. Sci.** 301: 182-204. Tetrapoda.

Berner, RA, DJ Beerling, R Dudley, JM Robinson & RAWildman, Jr (2003), Phanerozoic atmospheric oxygen. **Ann. Rev. Earth Planet. Sci.**31: 105–34. Tetrapoda.

Bertelli, S & LM Chiappe (2005), *Earliest tinamous (Aves: Palaeognathae) from the Miocene of Argentina and their phylogenetic position*. **Contrib. Sci.**#502, 20 pp. Ratites.

Bertelli, S & AL Porzecanski (2004), *Tinamou (Tinamidae) systematics: A preliminary combined analysis of morphology and molecules*. **Ornit. Neotrop.**15 (supp.), 8pp. Ratites.

Birstein, VJ, R Hanner & R DeSalle (1997), *Phylogeny of the Acipenseriformes: cytogenetic and molecular approaches*. **Env. Biol. Fishes**, 48: 127-155. Acipenseriformes, Chondrostei.

Blieck ARM & P Janvier (1999), *Silurian-Devonian vertebrate-dominated communities, with particular reference to agnathans*, **in**AJ Boucot & J Lawson [eds.], **Paleocommunities: a Case Study from the Silurian and Lower Devonian**. Cambridge Univ. Press, pp. 79-105. Amphiaspidida, Corviaspididae, *Ctenaspis*.

Blieck, A & VN Karatajute-Talimaa (2001) *New corvaspids from the Lochkovian (Lower Devonian) of Severnaya Zemlya, Russia (Vertebrata: Pteraspidomorphi: Heterostraci)*, **in**DK Elliott & MD Gottfried [eds.], 9th International Meeting on Early Vertebrates/Lower Vertebrates. **J. Vert. Paleontol.**21: 639-650. *Corveolepis*, Corviaspididae.

Blieck, ARM, VN Karatajütë-Talimaa & E Mark-Kurik (2002), *Upper Silurian and Devonian pteraspidomorphs (Vertebrata) from Severnaya Zemlya (Russia): a preliminary report with biogeographical and biostratigraphical implications*. **Geodiversitas**24: 805-820. WWW Amphiaspidida, Corviaspididae, *Corveolepis*, Hibernaspidoidei.

Blom, H (1999), ***Loganellia*** *(Thelodonti, Agnatha) from the Lower Silurian of North Greenland*, **Acta Geol. Polonica**49: 97-104. *Loganellia*.

Blom, H (2005), *Taxonomic revision of the Late Devonian tetrapod* ***Ichthyostega****from East Greenland*. **Palaeontology**48: 111-134. *Ichthyostega*, Tetrapoda.

Blom, H & D Goujet (2002), *Thelodont scales from the Lower Devonian Red Bay Group, Spitsbergen*, **Palaeontology**45: 795-820. Apalolepididae, Katoporida, Nikoliviidae, Turiniidae, Thelodontida.

Bolt, JR & S Chatterjee (2000), *A new temnospondyl amphibian from the Late Triassic of Texas*. **J. Paleontol.**74: 670-683.

Bonaparte, JF (1971), *Annotated list of the South American Triassic tetrapods*, **in** SH Haughton (ed.), **Second Gondwana Symposium, Proceedings and Papers**[1970]. Council of Scientific and Inustrial Research [Praetoria] 2: 665-682. Ornithosuchidae, *Neoaetosauroides*, *Saurosuchus*, *Stagonolepis*, *Venaticosaurus*.

Bonaparte, J (1986), *The early radiation and phylogenetic relationships of the Jurassic sauropod dinosaurs, based on*

vertebral anatomy, **in** K Padian (ed.), **The Beginning of the Age of Dinosaurs**. *Barapasaurus*, *Haplocanthosaurus*

Boonstra, LD (1956), *The skull of **Tapinocephalus** and its near relatives*. **Ann. S. Afr. Mus.** 43: 137-169. Tapinocephalidae.

Boonstra, LD (1963), *Diversity within the South African Dinocephalia*. **S. Afr. J. Sci.**59: 196-206. Tapinocephalidae, *Ulemosaurus*.

Boonstra, LD (1965), *The skull of **Struthiocephalus kitchingi***. **Ann. S. Afr. Mus.**48: 251-265. *Struthiocephalus*, Tapinocephalidae.

Boonstra, LD (1969), *The fauna of the Tapinocephalus Zone (Beaufort Beds of the Karoo)*. **Ann S. Afr. Mus.**56: 1-73. *Anteosaurus*, *Jonkeria*, *Struthiocephalus*, Tapinocephalia.

Brandoni, D, AA Carlini, F Pujos & GJ Scillato-Yané (2004) *The pes of **Pyramiodontherium bergi** (Moreno & Mercerat, 1891) (Mammalia, Xenarthra, Phyllophaga): the most complete pes of a Tertiary Megatheriinae*. **Geodiversitas**26: 643-659.

Brant, SV & G Ortí (2002), *Molecular phylogeny of short-tailed shrews, **Blarina** (Insectivora, Soricidae)*, **Mol. Phylogen. & Evol.**22: 163-173. Insectivora.

Brett-Surman, MK (1997), *Ornithopods*, in Farlow, JO & MK Brett-Surman (eds.), **The Complete Dinosaur**, pp. 330-346. Hadrosauridae.

Brink, AS (1956), ***Struthiocephalus kirchingi** sp. nov.* **Palaeont. Afr.**5: 39-56. *Struthiocephalus*.

Brochu, CA (2001), *Progress and future directions in archosaur phylogenetics*. **J. Paleontol.**75: 1185–1201. Archosauria

Brown, DS (1981), *The Upper Jurassic Plesiosauroidea (Reptilia) and a review of the phylogeny and classification of the Plesiosauria*. **Bull. Brit. Mus. Nat. Hist., Geol.**35: 253-347. *Colymbosaurus*, Cryptocleididae, Elasmosauridae, *Microcleidus*, *Muraenosaurus*, Plesiosauroidea, Pliosauroidea

Bry, C (1996), *Role of vegetation in the life cycle of pike* **in**JF Craig [ed.], **Pike Biology and Exploitation.**Chapman & Hall, pp 45-67. Esociformes.

Buchholtz, EA (1997), *Paleopathology* **in**PJ Currie & K Padian (eds.), **Encyclopedia of Dinosaurs**. Academic Press, pp. 522-534. Tyrannosauridae, Tyrannosauroidea.

Buchholtz, EA (1998), *Implications of vertebral morphology for locomotor evolution in early Cetacea* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 325-351. Ambulocetidae, Autoceta, Basilosauridae, *Basilosaurus*, *Georgiacetus*, Remingtonocetidae.

Buffetaut, E (1982), *Radiation évolutive, paléoécologie et biogéographie des crocodiliens Mésosuchiens*, **Mém. Soc. Géol. de France**, N.S. 60 (dated 1981) No. 142, 88 pp. Lybicosuchidae.

Burmeister, KC, JJ Flynn, JM Parrish, RL Whatley & AR Wyss (2000), *Biostratigraphic and biogeographic implications of new middle to Late Triassic fossil vertebrates; Morondava Basin, Madagascar*, **Abstracts of the 2000 Meeting of the Western Association of Vertebrate Paleontologists, Museum of Northern Arizona, Flagstaff**- pdf. - Aetosauridae

Busbey, AB (1986), *New material of **Sebecus cf. huilensis** (Crocodilia: Sebecosuchidae) from the Miocene La Venta formation of Colombia*, **J. Vert. Paleontol.** 6: 20-27. Sebecosuchidae

Butler, PM (2000), *Review of the early allotherian mammals*. **Acta Palaeontol. Pol.** 45: 317-342. Allotheria, Haramiyida, Multituberculata.

-C-

Caldwell, MW (1994), *Developmental constraints and limb evoluiton in Permian and extant lepidosauromorph diapsids*. **J. Vert. Paleontol.** 14: 459-471. Neodiapsida

Caldwell, MW (1996), *Ichthyosauria: a preliminary phylogenetic analysis of diapsid affinities*. **N. Jb. Geol. Paläont. Abh.** 361-386. Neodiapsida

Caldwell, MW (1999), *Squamate phylogeny and the relationships of snakes and mosasauroids*. **Zool. J. Linnean Soc.** 125: 115-147. Agamidae, Anguoidea, Lanthanotidae, Monstersauria, Pythonomorpha, Serpentes, Varanoidea.

Caldwell, MW (2000), *On the phylogenetic relationships of* ***Pachyrachis*** *within snakes: a response to Zaher (1998)*. **J. Vert. Paleontol.** 20: 187-190. Serpentes

Caldwell, MW & AM Albino (2001), *Paleoenvironment and paleoecology of three Cretaceous snakes:* ***Pachyophis***, ***Pachyrachis***, *and* ***Dinilysia***. **Acta Palaeontol. Pol.** 46: 203-218. *Dinilysia*; Madtsoiidae; Pachyophiidae.

Caldwell, MW, RL Carroll, & H Kaisar (1995), *The pectoral girdle and forelimb of* ***Carsosaurus marchesetti*** *(Aigialosauridae), with preliminary phylogenetic analysis of mosasauroids and varanoids* **J. Vert. Paleontol.** 15: 516-531. Pythonomorpha.

Caldwell, MW & MSY Lee (1997), *A snake with legs from the marine Cretaceous of the Middle East.* **Nature** 386: 705-709. Jugals, Pachyophiidae, Serpentes, Squamata.

Callaway, JM (1997), *A new look at* ***Mixosaurus***, **in**JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles**. Academic Press. pp. 45-59. Grippidia, Ichthyosauria, *Mixosaurus*.

Callaway, JM (1997a), *Ichthyosauria: Introduction*, **in**JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles**. Academic Press, pp. 3-16. Ichthyosauria, *Ichthyosaurus*, *Mixosaurus*, Neodiapsida, Sauria, *Temnodontosaurus*.

Callison, G. & HM Quimby (1984), *Tiny dinosaurs: are they fully grown?* **J. Vert. Paleontol.** 3:200-209. Genasauria.

Cameron, CB, JR Garey & BJ Swalla (2000), *Evolution of the chordate body plan: new insights from phylogenetic analyses of deuterostome phyla*. **Proc. Nat'l. Acad. Sci.** 97: 4469-4474. Vertebrata

Camp, CL (1980), *Large ichthyosaurs from the Upper Triassic of Nevada*. **Palaeontographica Ser. A.**170: 139-200. *Californosaurus*, Shastasauria.

Campbell, KSW & RE Barwick (1995), *The primitive dipnoan dental plate*. **J. Vert. Paleontol.** 15: 13-27. *Diabolepis*; Dipnoi; *Youngolepis*.

Caputi L, N Andreakis, F Mastrototaro, P Cirino, M Vassillo & P Sordino (2007), *Cryptic speciation in a model invertebrate chordate*. **Proc. Nat. Acad. Sci. (USA)**104: 9364-9369. Ascideacea.

Carpenter, K (1997), *Comparative cranial anatomy of two North American Cretaceous plesiosaurs*, in JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles** Academic Press, pp. 191-216. *Liopleurodon*, *Peloneustes*.

Carpenter, K (1997a), *Thyreophora* in Currie, PJ and K Padian (eds.), **Encyclopedia of Dinosaurs** Academic Press, pp. 737-738. Thyreophora.

Carpenter, K (1997b), *Ankylosaurs* in JO Farlow & MK Brett-Surman, **The Complete Dinosaur**. Indiana Univ. Press, pp. 307-316. Ankylosauria.

Carpenter, K (1997c), *Tyrannosauridae* **in**PJ Currie & K Padian (eds.), **Encyclopedia of Dinosaurs**. Academic Press, pp. 766-768. Tyrannosauridae.

Carpenter, K & M Smith (2001), *Forelimb osteology and biomechanics of* ***Tyrannosaurus rex***, K Carpenter & D Tanke [eds.], **Mesozoic Vertebrate Life**. Indiana Univ. Press, pp. 90-116. *Albertosaurus*, *Gorgosaurus*,

Tyrannosauroidea.

Carr, TD (1999), *Craniofacial ontogeny in Tyrannosauridae (Dinosauria, Coelurosauria)*. **J. Vert. Paleontol.**19: 497-520. Tyrannosauroidea.

Carr TD, TE Williamson & DR Schwimmer (2005), *A new genus and species of tyrannosauroid from the Late Cretaceous (Middle Campanian) Demopolis Formation of Alabama*. **J. Vert Paleontol.**25: 119-143. *Alectrosaurus*.

Carrano, MT & JR Hutchinson (2002), *Pelvic and hindlimb musculature of **Tyrannosaurus rex**(Dinosauria: Theropoda)*. **J. Morphol.**253: 207-228 (2002).

Carrano, MT, CM Janis & JJ Sepkoski, Jr. (1999), *Hadrosaurs as ungulate parallels: lost lifestyles and deficient data*. **Acta Pal. Pol.** 44: 237-261. Hadrosaurinae, Lambeosaurinae, *Ouranosaurus*.

Carroll, RL (1981), *Plesiosaur ancestors from the Upper Permian of Madagascar.* **Phil Trans. R. Soc. Lond. B** 293: 315-383. *Claudiosaurus*, Neodiapsida, The Opisthotic, Septomaxilla.

Carroll, RL (1988), **Vertebrate Paleontology and Evolution**, WH Freeman & Co., 698 pp. Actinistia, Anagalidae; Anomodontia, Anthracotheroidea, Antiarcha, *Basilosaurus*, Cetacea, Champsosauridae, Chimaeroidei, Cochleodontidae, Chondrichthyes, Chrysochloroidea, Colosteidae, Crocodyliformes, *Diabolepis*, Dicynodontia, Didolodontidae, Dromasauria, The Ear, Entelodontoidea, Epicynodontia, *Eusthenopteron*, Gulars, Halecomorphi, Hybodontiformes, Hypohyal, Insectivora, Jugals, *Laccocephalus*, Lepidosauriformes, Lissamphibia, Litopterna, Macrosemiiformes, Menaspidae, Metoposauroidea, Molars, Notostylopidae, Notoungulata, Nyctitheriidae, Occiput, Osteolepididae, Osteolepiformes, Pachycormiformes, Pakicetidae, Phthinosuchidae, Procynosuchidae, Pseudictopidae, Pycnodontiformes, Rhinesuchidae, Rhipidistia, Sphenodontia Overview, Sauropterygia, Semionotiformes, Septomaxilla, Solenodontidae, Soricoidea, Synapsida, Synechodontiformes, Talpoidea, Temnospondyl Overview, Therapsida Overview, *Thrinaxodon*, Trematosauroidea, Trilophosauridae, Venyukovioidea; Zalambdalestidae.

Carroll, RL (1988a), *Late Paleozoic and early Mesozoic lepidosauromorphs and their relation to lizard ancestry*, in R Estes & G Pregill (eds.), **Phylogenetic Relationships of the Lizard Families**, Stanford Univ. Press, pp. 99-118. Lepidosauriformes

Carroll, RL & Gaskill, P (1985), *The nothosaur **Pachypleurosaurus**and the origin of plesiosaurs*. **Phil. Trans. Roy. Soc. Lond.**309: 343-393. *Anarosaurus*, *Neusticosaurus*, Nothosauria, Nothosauridae, *Nothosaurus*, Plesiosauria, Sauropterygia, *Simosaurus*.

Carroll, RL, J Irwin & DM Green (2005), *Thermal physiology and the origin of terrestriality in vertebrates*. **Zool. J. Linn. Soc.**143: 345–358. *Acanthostega*, *Ichthyostega*.

Carroll, SB (2005), Evolution at two levels: On genes and form. **PLOS Biology**3: 1159-1166 (WWW). Books.

Cerdeño, E & M Bond (1998), *Taxonomic revision and phylogeny of **Paedotherium**and **Tremacyllus**(Pachyrukhinae, Hegetotheriidae, Notoungulata) from the Late Miocene to the Pleistocene of Argentina.* **J. Vert Paleontol.**18: 799-811. Typotheria.

Cerny, R, P Lwigale, R Ericsson, D Meulemans, H-H Epperlein & M Bonner-Fraser (2004), *Developmental origins and evolution of jaws: new interpretation of "maxillary" and "mandibular."* **Devel. Biol.**276: 225–236. Cladoselachida.

Chang, M-M & MM Smith (1992), *Is **Youngolepis** a porolepiform?* **J. Vert. Paleontol.** 12: 294-312. *Diabolepis*; *Powichthys*; *Youngolepis*.

Chatterjee, S (1978), *A primitive parasuchid (phytosaur) reptile from the Upper Triassic Maleri Formation of India*, **Palaeontology**21: 83-127. *Angistorhinus*, Euphytosauridae, *Mystriosuchus*, *Nicrosaurus*, *Paleorhinus*, *Parasuchus*, Phytosauridae, *Rutiodon*, *Smilosuchus*.

Chatterjee, S (1982), *Phylogeny and classification of thecodontian reptiles*. **Nature**295: 317-320. Archosauriformes.

Chatterjee, S (1985) ***Postosuchus**, a new thecodontian reptile from the Triassic of Texas and the origin of Tyrannosaurs*. **Phil. Trans. R. Soc. Lond. B**309: 395-460. Poposauridae.

Chatterjee, S (1986), *Late Triassic Dockum vertebrates: their stratigraphc and paleobiolographic significance*, **in**K Padian (ed.), **The Beginning of the Age of Dinosaurs**. Cambridge Univ. Press. Phytosauridae.

Chen, J-Y, D-Y Huang & C-W Li (1999), *An early Cambrian craniate-like chordate*, **Nature** 402: 518-522. WWW. Craniata, Gill Arches, *Haikouella*, Meckel's Cartilage, Vertebrata.

Chen, Y-P, M Bei, I Woo, I Satokata & R Maas (1996), ***Msx1****controls inductive signaling in mammalian tooth morphogenesis*. **Development**122: 3035-3044. Teeth.

Chiappe, LM (1995), *The first 85 million years of avian evolution*. **Nature**378: 349-355. Aves, Carinatae, Metornithes, *Mononykus*, Ornithothoraces, Ornithurae

Chiappe, LM & CA Walker (2002), *Skeletal morphology and systematics of the Cretaceous Euenantiornithes (Ornithothoraces: Enantiornithes)*, **in**LM Chiappe & LM Witmer [eds.], **Mesozoic Birds: Above the Heads of the Dinosaurs**. Univ. Calif. Press. pp. 240-267. Neornithes.

Chiappe, LM, MA Norell & JM Clark (1998), *The skull of a relative of the stem-group bird* ***Mononykus***. **Nature**392: 275-278. *Parvicursor*, *Shuvuuia*.

Chiappe, LM, J Shu'an, J Qiang, & MA Norell (1999), *Anatomy and systematics of the Confuciusornithidae (Theropoda: Aves) from the Late Mesozoic of northeastern China*. **Bul. Amer. Mus. Nat. Hist.** 242: 1-89. Confuciusornithidae, Ornithurae.

Chilton, G, KA Martin & JH Gee (1984), *Winter feeding: an adaptive strategy broadening the niche of the central mudminnow,* ***Umbra limi***. **Environ. Biol. Fish.**10: 215-219. Esociformes, *Umbra*.

Cifelli, RL (1983), *The origin and affinities of the South American Condylarthra and early Tertiary Litopterna (Mammalia)*. **Am. Mus. Nov.**772:1-49. Didolodontidae, *Didolodus*, Litopterna.

Cifelli, RL (1985), *South American ungulate evolution and extinction*, **in**SD Webb & FG Stehli [eds.], **The Great American Biotic Interchange**. Plenum Publ. Co., pp. 249-266. Didolodontidae, Henricosborniidae, Litopterna, Notoungulata, Notostylopidae, Typotheria.

Cifelli, RL (1993), *The phylogeny of the native South American ungulates* **in**FS Szalay, MJ Novacek & MC McKenna [eds.], **Mammal Phylogeny.** Springer-Verlag 2: 195-216. Didolodontidae, Litopterna, Notoungulata, Notostylopidae, Typotheria.

Cifelli, RL & SK Madsen (1998), *Triconodont mammals from the medial Cretaceous of Utah.***J. Vert. Paleontol.** 18: 403-411. *Amphilestes*; *Priacodon*, Triconodontidae, *Trioracodon*.

Cifelli, RL & C Villarroel (1997), *Paleobiology and affinities of* ***Megadolodus***, **in** RF Kay *et al*. [eds.], **Vertebrate Paleontology in the Neotropics: the Miocene Fauna of La Venta, Colombia**. Smithsonian Inst. Press: pp. 265-288. Notoungulata.

Cifelli, RL, TR Lipka, CR Schaff & TB Rowe (1999) *First early Cretaceous mammal from the eastern seaboard of the United States*. **J. Vert. Paleontol.**19: 199-203. *Amphilestes*, *Priacodon*, *Trioracodon*.

Cifelli, RL, JR Wible & FA Jenkins, Jr. (1998), *Triconodont mammals from the Cloverly Formation (Lower Cretaceous), Montana and Wyoming*. **J. Vert. Paleontol.**. 18: 237-241. Triconodontidae.

Clack, JA (1989), *Discovery of the earliest-known tetrapod stapes*. **Nature**342: 425-427. Tetrapoda.

Clack, JA (1994), *Earliest known tetrapod braincase and the evolution of the stapes and fenestra ovalis*. **Nature**369: 392-394. *Acanthostega*, Tetrapoda.

Clack, JA (1997), *Devonian tetrapod trackways and trackmakers; a review of the fossils and footprints.* **Palaeogeog. Palaeoclimatol. Palaeoecol.**, 130: 227-250. Elpistostegalia, *Obruchevichthys*, Tetrapoda, Tetrapoda.

Clack, JA (1998), *A new Early Carboniferous tetrapod with a mélange of crown-group characters*. **Nature**394: 66-69. *Baphetes*, *Eucritta*.

Clack, JA (1998a), *The neurocranium of **Acanthostega gunnari** Jarvik and the evolution of the otic region in tetrapods*. **Zool. J. Linn. Soc.**122: 61-97. *Acanthostega*, *Ichthyostega*, Tetrapoda.

Clack, JA (2001), ***Eucritta melanolimnetes**from the Early Carboniferous of Scotland, a stem tetrapod showing a mosaic of characteristics*. **Trans. Roy. Soc. Edin.: Earth Sci.**92: 72-95. *Eucritta*, *Spathicephalus*.

Clack, JA (2002), **Gaining Ground: the Origin and Evolution of Tetrapods** Indiana Univ. Press, 369 pp. *Acanthostega*, Anthracosauroidea, *Baphetes*, Baphetidae, Elpistostegalia, *Elpistostege*, Embolomeri, *Eoherpeton*, Epibranchials, *Ichthyostega*, Jugals, Lepospondyli, *Loxomma*, *Megalocephalus*, Osteolepiformes, *Panderichthys*, *Pholiderpeton*, *Proterogyrinus*, Rhizodontiformes, Septomaxilla, Seymouriamorpha, *Spathicephalus*, Tetrapoda, *Ventastega*

Clack, JA (2002a), *The dermal skull roof of **Acanthostega gunnari**, an early tetrapod from the Late Devonian*. **Trans. R. Soc. Edin., Earth Sci.**93: 17-33. *Acanthostega*, *Ichthyostega*, Tetrapoda, *Ventastega*.

Clack, JA (2003), *A revised reconstruction of the dermal skull roof of **Acanthostega**, an early tetrapod from the Late Devonian*. **Trans. R. Soc. Edin., Earth Sci.**93: 163-165. *Acanthostega*, *Ventastega*.

Clack, JA, PE Ahlberg, SM Finney, P Dominguez Alonso, J Robinson & RA Ketcham (2003), *A uniquely specialized ear in a very early tetrapod*. **Nature**425: 65-69. *Acanthostega*, *Ichthyostega*, Tetrapoda.

Clark, JM (1994), *Patterns of evolution in Mesozoic Crocodyliformes*, in NC Fraser & H-D Sues (eds.), **In the Shadow of the Dinosaurs** Cambridge Univ. Press pp. 84-97. Crocodyliformes.

Clark, JM & RR Hernandez (1994), *A new burrowing diapsid from the Jurassic La Boca formation of Tamaulipas, Mexico*, **J. Vert. Paleontol.**, 14: 180-195. Lepidosauriformes.

Clark, JM, H-D Sues & DS Berman (2000), *A new specimen of **Hesperosuchus agilis**from the Upper Triassic of New Mexico and the interrelationships of basal crocodylomorph archosaurs*, **J. Vert. Paleontol.**20: 683-704. Trialestidae.

Clarke, JA & LM Chiappe (2001), *A new carinate bird from the Late Cretaceous of Patagonia (Argentina)*. **Amer. Mus. Nov.**3323, 23 pp. WWW. Carinatae

Clarke, JA, CP Tambussi, JI Noriega, GM Erickson & RA Ketcham (2005), *Definitive fossil evidence for the extant avian radiation in the Cretaceous*. **Nature**433: 305-308. Neornithes.

Clement, G (2005), *A new coelacanth (Actinistia, Sarcopterygii) frm the Jurassic of France, and the question of the closest relative fossil to **Latimeria***. **J. Vert. Paleontol.**25: 481-491. Sarcopterygii: Dendrogram.

Clement, G, PE Ahlberg, A Blieck, H Blom, JA Clack, E Poty, J Thorez, & P Janvier (2004), *Devonian tetrapod from western Europe*. **Nature**427: 412-413. *Ichthyostega*, *Ventastega*.

Cloutier, R & PE Ahlberg (1996), *Morphology, characters, and the interrelationships of basal sarcopterygians*, **in**LJ Stiassny LR Parent & GD Johnson (eds.), **Interrelationships of Fishes**. Academic Press, pp. 445-479. Canowindridae, Cladoselachida, *Grossius*, Onychodontiformes, Osteolepididae, Osteolepiformes, *Panderichthys*, Rhizodontiformes, Rhipidistia, Sarcopterygii, *Strunius*, Tetrapodomorpha.

Coates, MI (1996), *The Devonian tetrapod **Acanthostega gunnari**Jarvik: postcranial anatomy, basal tetrapod interrelationships and patterns of skeletal evolution*. **Trans. R. Soc. Edin, Earth Sci.**87: 363-421. *Acanthostega*, *Elginerpeton*, Elpistostegalia, *Elpistostege*, *Eusthenopteron*, *Ichthyostega*, *Panderichthys*, Tetrapoda, Tetrapoda.

Coates, MI & JA Clack (1991), *Fish-like gills and breathing in the earliest known tetrapod*. **Nature**352: 234-236. *Acanthostega*, *Elginerpeton*, Tetrapoda.

Coates, MI & SEK Sequeira (1998), *The braincase of a primitive shark*. **Trans. R. S. Edinburgh (Earth Sci.)** 89: 63-85. The Occiput, The Prootic, The Sphenethmoid, Symmoriida, Synechodontiformes.

Coates, MI & SEK Sequeira (2001), *A new stethacanthid chondrichthyan from the Lower Carboniferous of Bearsden, Scotland*. **J. Vert. Paleontol**. 21: 438-459. *Damocles*, Falcatidae, Stethacanthidae, Symmoriida, Symmoriidae.

Coates, MI, JE Jeffery & M Ruta (2002), *Fins to limbs: what the fossils say*. **Evol. & Devel.**4: 390-401. *Acanthostega*, *Elginerpeton*, Elpistostegalia, *Eusthenopteron*, *Ichthyostega*, *Panderichthys*, Rhipidistia, Rhizodontiformes, Tetrapoda, Tetrapoda.

Coates, MI, NH Shubin & EB Daeschler (2004), *Response to comment on "The early evolution of the tetrapod humerus*." **Science**305: 1715d. *Ichthyostega*.

Colbert, EH (1969), ***Evolution of the Vertebrates***. John Wiley & Sons. Synapsida Overview.

Colgan, P & B Silburt (1984), *Feeding behavior of the central mudminnow,* ***Umbra limi****, in the field and laboratory*. **Environ. Biol. Fish.**10: 209-214. Esociformes, *Umbra*.

Compagno, LJV (1999), *Systematics and body form*, **in**WC Hamlett [ed.], **Sharks, Skates, and Rays: the Biology of Elasmobranch Fishes**. Johns Hopkins Univ. Press, pp. 1-42. Batomorphii, Hypnosqualea, Squatinidae.

Compagno, LJV (1999a), *Endoskeleton*, **in**WC Hamlett [ed.], **Sharks, Skates, and Rays: the Biology of Elasmobranch Fishes**. Johns Hopkins Univ. Press, pp. 69-92. Batomorphii, Epibranchials, Hypnosqualea, Squatinidae.

Conrad, J & C Sidor (2001), *Re-evaluation of* ***Tetraceratops insignis*** *(Synapsida: Sphenacodontia)*. **J. Vert. Paleontol**. 21: 42A (abstract). *Tetraceratops*, Therapsida Overview.

Coombs, WP, Jr. & T Maryanska (1990), *Ankylosauria* in DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press, pp. 456-483. Ankylosauria, Jugals.

Coombs, WP, Jr., DB Weishampel, & LM Witmer (1990), *Basal Thyreophora*, in DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press, pp. 427-434. Genasauria, Scelidosauridae.

Cooper, A, C Lalueza-Fox, S Anderson, A Rambaut, J Austin & R Ward (2001), *Complete mitochondrial genome sequences of two extinct moas clarify ratite evolution*. **Nature**409: 704-707. Ratites.

Cope, ED (1887), *The dinosaurian genus* ***Coelurus***. **Amer. Naturalist** 21: 367-369. *Coelurus*.

Cote, S, R Carroll, R Coutier & L Bar-Sagi (2002), *Vertebral development in the Devonian sarcopterygian fish* ***Eusthenopteron foordi****and the polarity of vertebral evolution in non-amniote tetrapods*. **J. Vert. Paleontol.**22: 487-502. Septomaxilla.

Couly, GF, PM Coltey & NM Le Douarin (1993), *The triple origin of skull in higher vertebrates: a study in quail-chick chimeras*. **Development** 117: 409-429. The Basisphenoid.

Couly, G, S Creuzet, S Bennaceur, C Vincent & NM Le Douarin (2002), *Interactions between* ***Hox****-negative cephalic neural crest cells and the foregut endoderm in patterning the facial skeleton in the vertebrate head*. **Development**129: 1061-1073. Teeth.

Cox, B, RJG Savage, B Gardiner & D Dixon (1988), **Collins Illustrated Encyclopedia of Dinosaurs and Prehistoric Animals**. Collins Publishers Aus. 312 pp. Eureptilia, Pliosauridae, Tapinocephalidae, Therapsida Overview.

Cracraft, J (1970), *A new species of Telmabates (Phoenicopteriformes) from the lower Eocene of Patagonia*. **Condor**, 72: 479-480. *Telmabates*.

Cracraft, J (1974), *Phylogeny and evolution of the ratite birds*. **Ibis**116: 494-521. Ratites.

Cracraft, J (2001), *Avian evolution, Gondwana biogeography and the Cretaceous-Tertiary mass extinction event*. **Proc. Roy. Soc. London B** 268: 459-469. Ratites.

Craig, JF, (1996), *Population dynamics, predation and role in the community*, **in**JF Craig [ed.], **Pike Biology and Exploitation.**Chapman & Hall, pp 201-217. Esociformes.

Crawford, RH (1974), *Structure of an air-breathing organ and the swim bladder in the Alaska blackfish,* ***Dallia***

pectoralis*Bean*. **Can. J. Zool.**52: 1221-5. *Dallia*, Esociformes, *Esox Umbra*.

Crompton, AW & P Parker (1978), *Evolution of the mammalian masticatory apparatus*. **Amer. Sci.**66: 192-201. Procynosuchidae.

Crossman, EJ, (1996), *Taxonomy and distribution* **in**JF Craig [ed.], **Pike Biology and Exploitation.**Chapman & Hall, pp 1-11. Esociformes, *Esox*.

Cruickshank, ARI (1994), *A juvenile plesiosaur (Reptilia: Plesiosauria) from the Lower Lias (Hettangian: Lower Jurassic) of Lyme Regis, England: a pliosaurid-plesiosaurid intermediate?* **Zool. J. Linn. Soc.**112: 151-178. *Eurycleidus*.

Cruickshank, ARI & JA Long (1997), *A new species of pliosaurid reptile from the Early Cretaceous Birdsong sandstone of Western Australia*. **Recs. W. Aus. Mus.**18. *Eurycleidus*.

Cruickshank, ARI, P Small & M Taylor (1991), *Dorsal nostrils and hydrodynamically driven underwater olfaction in plesiosaurs*. **Nature**352: 62-64. *Rhomaleosaurus*.

Cundall, D & DA Rossman (1993), *Cephalic anatomy of the rare Indonesian snake* ***Anomochilus weberi***. **Zool. J. Linnean Soc.** 109: 235-273. Anomochilidae, Cylindrophiidae, The Occiput, Palatines, Scolecophidia, Uropeltidae.

Cundall, D, V Wallach & DA Rossman (1993), *The systematic relationships of the snake genus* ***Anomochilus***. **Zool. J. Linnean Soc.** 109: 275-299. Aniliidae; Anomochilidae; Cylindrophiidae; Scolecophidia; Serpentes, Uropeltidae.

Cuny, G, O Rieppel & PM Sander (2001), *The shark fauna from the Middle Triassic (Anisian) of North-Western Nevada*. **Zool. J. Linn. Soc.**133:285-301. *Mucrovenator* , Palaeospinacidae, Synechodontiformes, *Synechodus*, Teeth.

Currie, PJ (1997), *Braincase anatomy* in Currie, PJ and K Padian (eds.), **Encyclopedia of Dinosaurs** Academic Press, pp. 81-85. The Sphenethmoid.

Currie, PJ (1997a), *Theropoda* **in**PJ Currie & K Padian (eds.), **Encyclopedia of Dinosaurs**. Academic Press, pp. 731-737. Tyrannosaurinae.

Currie, PJ (2000), *Theropods from the Cretaceous of Mongolia*, in MJ Benton, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**, Cambridge Univ. Press, pp 434-455. *Alectrosaurus*, *Alxasaurus*, Therizinosauridae, Therizinosauroidea, Tyrannosauridae, Tyrannosaurinae.

Currie, PJ (2003), *Cranial anatomy of tyrannosaurid dinosaurs from the Late Cretaceous of Alberta, Canada*. **Acta Pal. Pol.**48: 191–226.

Currie, PJ & K Carpenter (2000), *A new specimen of* ***Acrocanthosaurus atokensis*** *(Theropoda, Dinosauria) from the Lower Cretaceous Antlers Formation (Lower Cretaceous, Aptian) of Oklahoma, USA*. **Geodiversitas** 22: 207-246. *Acrocanthosaurus*, Allosauridae; Carcharodontosauridae, Carnosauria, *Monolophosaurus*, Sinraptoridae; Theropoda, Tyrannosauridae.

Currie, PJ & X-J Zhao (1993), *A new carnosaur (Dinosauria, Theropoda) from the Jurassic of Xinjiang, People's Republic of China*. **Can J. Earth Sci.** 30: 2037-2081. Allosauridae; Allosauroidea; Carnosauria; Jugals, *Monolophosaurus*; The Occiput; The Opisthotic, Sinraptoridae; Theropoda.

Czerkas, SA (1997), *Skin*, **in**Currie, PJ and K Padian (eds.), **Encyclopedia of Dinosaurs** Academic Press, pp. 669-675. Titanosauridae.

-D-

Daeschler, EB (2000), *Early tetrapod jaws from the Late Devonian of Pennsylvania, USA*. **J. Paleont.**74: 301-308. Tetrapoda, Tetrapoda, *Ventastega*.

Daeschler, EB, NH Shubin, KS Thomson & WW Amaral (1994), *A Devonian tetrapod from North America*. **Science**265: 639-642. *Elginerpeton*, Tetrapoda, Tetrapoda.

Damiani, RJ (2001), *A systematic revision and phylogenetic analysis of Triassic mastodonsauroids (Temnospondyli: Stereospondyli)*. **Zool. J. Linn. Soc.**133: 379-482. *Angusaurus*, *Dactylosaurus*, Thoosuchinae, Trematosauridae, Trematosauroidea, *Trematosaurus*, *Yarengia*.

Dean, B (1906), *Chimæroid fishes and their development*. **Carnegie Inst. Publs.**#32. Chimaeroidei, Myriacanthoidei

deBraga, M & O Rieppel (1997) *Reptile phylogeny and the interrelationships of turtles*, **Zool. J. Linnean Soc.** 120: 281-354. Champsosauridae, Neodiapsida, Pareiasuria, Pythonomorpha, Squamata, Velosauria.

deCarvalho, MR (1996), *Higher-level elasmobranch phylogeny, basal squaleans, and paraphyly*, in Stiassny, MLJ, LR Parenti & GD Johnson (eds.), **Interrelationships of Fishes**, pp. 35-62. Academic Press. Batomorphii, Carcharhiniformes; Galeomorphii; Heterodontiformes, Hypnosqualea, Lamniformes; Neoselachii; Neoselachii Overview, Orectolobiformes, Pristiophoridae, Squalea, Squatinidae, Synechodontiformes, *Synechodus*.

Delgado, S, D Casane, L Bonnaud, M Laurin, J-Y Sire & M Girondot (2001), *Molecular evidence for Precanbrian origin of amelogenin, the major protein of vertebrate enamel*. **Mol. Biol. Evol.**18: 2146-2153. Teeth.

deMuizon, C & RL Cifelli (2000), *The "condylarths" (archaic Ungulata, Mammalia) from the Early Palaeocene of Tiupampa (Bolivia): implications on the origin of South American ungulates*. **Geodiversitas** 22: 47-150. WWW. Didolodontidae, *Didolodus*, Litopterna, Molars, Ungulata, Ungulatomorpha, Zhelestidae.

deMuizon C, RL Cifelli & LP Bergqvist (1998), *Eutherian tarsals from the early Paleocene of Bolivia*. **J. Vert. Paleontol.** 18: 655-663. Didolodontidae

deRicqlès, A (1989), *Les mécanismes hétérochroniques dans le retour des tétrapodes au milieu aquatique*, in **Colloque International du CNRS : Ontogénèse et Evolution, Dijon, septembre 1986**, pp. 171-178. Pachypleurosauridae.

Deufel, A & D Cundall (2003), *Feeding in **Atractaspis**(Serpentes: Atractaspididae): a study in conflicting functional constraints*. **Zoology**106: 43-61. Septomaxilla.

Deufel, A & D Cundall (2003a), *Prey transport in "palatine-erecting" elapid snakes*. **J. Morphol.**258: 358–375. Septomaxilla.

Didier, DA, BJ Stahl & R Zangerl (1994), *Development and growth of compound tooth plates in **Callorhinchus milii**(Chondrichthyes, Holocephali)*. **J. Morphol.**222: 73-89. Chimaeroidei, Cochliodontidae, Holocephali.

Dilkes, DW (1998), *The Early Triassic rhynchosaur **Mesosuchus browni**and the interrelationships of basal archosauromorph reptiles*. **Phil. Trans. R. Soc. Lond. B**353: 501-541. Rhynchosauria.

Dilkes, DW & RR Reisz (1996), *First record of a basal syanapsid ("mammal-like reptile") in Gondwana*. **Proc. Royal. Soc. Lond. B** 263: 1165-1170. *Aerosaurus*, *Elliotsmithia*, Synapsida, *Varanops*, Varanopseidae.

Dinely (1976), *New species of **Ctenaspis**(Ostracodermi) from the Devonian of Arctic Canada*, **in**CS Churcher [ed.], **Essays in Palaeontology in Honor of Loris Shano Russell**. Royal Ont. Mus., pp. 73-89. *Ctenaspis*.

Dineley, DL & EJ Loeffler (1976), *Ostracoderm faunas of the Delorme and associated Siluro-Devonian formations, North West Territories, Canada*. **Palaeontol. Spec. Papers**, 18: 214 pp. Corviaspididae.

Dodson, P (1996). **The Horned Dinosaurs**, Princeton, 346 pp. The Occiput.

Donoghue, PCJ (2002), *Evolution of development of vertebrate teeth and scales: unravelling concepts, regulatory theories and homologies*. **Paleobiology**, 28: 474-507. Teeth.

Donoghue, PCJ & MA Purnell (1999), *Growth, function, and the conodont fossil record*. **Geology**27: 251-254. Teeth.

Donoghue, PCJ & IJ Sansom (2002), *Origin and early evolution of vertebrate skeletonization*. **Microscopy Res. & Tech.**59: 352 - 372. Teeth.

Donoghue, PCJ & MP Smith (2001), *The anatomy of **Turinia pagei**(Powrie), and the phylogenetic status of Thelodonti*, **Trans. Roy. Soc. Edinburgh, Earth Sci.**92: 15-37. Katoporida, Teeth, Thelodonti, Thelodontidae, Turiniidae.

Donoghue, PCJ, PL Forey & RJ Aldridge (2000), *Conodont affinity and chordate phylogeny*. **Biol. Rev.** 75: 191-251. Conodonta, Craniate Overview, Euconodonta, Ozarkodinida, Paraconodontida, Thelodonti, Vertebrata.

Douadya, CJ, PI Chatelierb, O Madsenc, WW de Jong, F Catzeflise, MS Springer, & MJ Stanhope (2002), *Molecular phylogenetic evidence confirming the Eulipotyphla concept and in support of hedgehogs as the sister group to shrews*, **Mol. Phylo. Evol.**25: 200-209. Insectivora

Doyle, KD & H-D Sues (1995) *Phytosaurs (Reptilia: Archosauria) from the Upper Triassic New Oxford Formation of York County, Pennsylvania*, **J. Vert. Paleontol.**15: 545-553. Phytosauridae.

Dozo, MT (1996), *Endocranial casts of Hegetotheriidae Notoungulates: a case of neuromorphological convergence between extinct south american ungulates and living rodents*. **J. Vert. Paleontol.**16: 31A. Meridiungulata, Typotheria.

Dubrovo, IA & AE Sanders (2000), *A new species of **Patriocetus**(Mammalia, Cetacea) from the Late Oligocene of Kazakhstan*. **J. Vert. Paleontol.**20: 577-590. *Dactylosaurus*, Squalodontidae.

Dubuisson, J-Y, P Rachebouf, & P Janvier (2003), *Du Silurien au Devonien: les sorties des eaux* **in** P. Janvier & V. Dupres [eds.] (2003-2005), **Evolution: De l'Origine de la Vie aux Origines de l'Homme**. WWW. Tetrapoda.

Dudley, R (1998), *Atmospheric oxygen, giant Paleozoic insects and the evolution of aerial locomotor performance*. **J. Exper. Biol.**201, 1043–1050. Tetrapoda.

Duffin, CJ & D Delsate (1993), *A new myriacanthid holocephalan (Chondrichthyes) from the Early Jurassic of Luxembourg*. **N. Jb. Geol. Paläont. Mh.**1993: 669-680. Chimaeriformes, Chimaeroidei, Holocephali, Myriacanthoidei.

Düttmann, H, H-H Bergmann, & W Engländer (1998), *Development and behavior*, **in**JM Starck & RE Ricklefs (eds.), **Avian Growth and Development**. Oxford Univ. Press., pp. 223-246. Ciconiiformes

Dyke, GJ (1998), *Does archosaur phylogeny hinge on the ankle joint?* **J. Vert. Paleontol.**18: 558-562. Archosauria.

Dyke, G (2000), *The fossil waterfowl (Aves: Anseriformes) from the Tertiary of England.* **J. Vert. Paleontol.**20: 39A. Anseres, *Anatalavis*.

Dyke, GJ (2001), *The fossil waterfowl (Aves: Anseriformes) from the Eocene of England*. **Amer. Mus. Nov.**No. 3354, 15 pp. WWW. *Anatalavis*.

Dzik, J (2000), *The Origin of the Mineral Skeleton in Chordates*. **Evol. Bio.**31: 105-154. Teeth.

-E-

Edwards, SV, B Fertil, A Giron & PJ Deschavanne (2002), *A genomic schism in birds revealed by phylogenetic analysis of DNA strings*. **Syst. Biol.**51: 599-613. Ratites.

Ekdale EG, JD Archibald & AO Averianov (2004), *Petrosal bones of placental mammals from the Late Cretaceous of*

Uzbekistan. **Acta Pal. Pol.** 49: 161–176. Glossary.

Ensom, P & D Sigogneau-Russell (2000), *New symmetrodonts (Mammalia, Theria) from the Purbeck Limestone Group, Lower Cretaceous, southern England*. **Cretaceous Res.** 21: 767-779. Symmetrodonta, Tinodontidae

Ericson, PGP (1997), *Systematic relationships of the paleogene family Presbyornithidae (Aves: Anseriformes)*. **Zool. J. Linn. Soc.** 121: 429-483. Anatidae, Anhimidae, Anseriformes, Presbyornithidae, *Telmabates*.

Ericson, PGP (1999), *New material of **Juncitarsus**(Phoenicopteriformes), with a guide for differentiating that genus from the Presbyornithidae (Anseriformes)*, **Smithsonian Contribs. Paleobiol.**89: 245-251. *Presbyornis*, Presbyornithidae.

Estes, RD, TH Frazzetta, & EE Williams (1970), *Studies on the fossil snake **Dinilysia patagonica** Woodward: part I. Cranial morphology*. **Bul. Mus. Comp. Zool.** 140: 25-73. Scolecophidia.

Estes, RD & FdeBSyG deAvalle (1982), *Early Cretaceous lower vertebrates from Galva (Teruel), Spain*. **J. Vert. Paleontol.** 2: 21-39. Genasauria

Evans, SE & D Sigogneau-Russell (1997), *New sphenodontians (Diapsida: Rhynchocephalis) from the Early Cretaceous of North Africa*. **J. Vert. Paleontol.** 17: 45-51. Sphenodontidae.

-F-

Fagerlund, S (2004?), *Acoustics and physical models of bird sounds*. WWW.

Fairman, JE (1999), **Prosauropod and Iguanodont Jaw Musculature: A Study on the Evolution of Form and Function**. Unpub. M.A. thesis, Johns Hopkins Univ., 95 pp. *Hadrocodium*

Farlow, JO & TR Holtz, Jr. (2002), *The fossil record of predation in dinosaurs* **in**M Kowalewski & PH Kelley [eds.], **The Fossil Record of Predation**. The Paleontological Society Papers 8: 251-266. WWW. Tyrannosauroidea.

Farlow, JO, MB Smith & JM Robinson (1995), *Body mass, bone "strength indication," and cursorial potential of **Tyrannosaurus rex***. **J. Vert. Paleontol.**15: 713-725. Tyrannosauroidea.

Feduccia, A (1999), **The Origin and Evolution of Birds** (2nd ed.). Yale Univ. Press, 466 pp. Anhimidae, Aves, Charadriomorpha Overview, Gallinuloididae, Genasauria, Lepidosauriformes, Ornithurae, Presbyornithidae.

Fish, FE (1998), *Biomechanical perspective on the origin of cetacean flukes* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 303-323. Basilosauridae.

Flynn, JJ, DA Croft, R Charrier, G Hérail & AR Wyss (2002), *The first Cenozoic mammal fauna from the Chilean Altiplano*. **J. Vert Paleontol.**22: 200-206.

Flynn, JJ, JM Parrish, B Rakotosamimanana, WF Simpson, RL Whatley & AR Wyss (1999), *A Triassic fauna from Madagascar, including early dinosaurs*. **Science** 286: 763-765. Sauropodomorpha.

Fordyce, RE & LG Barnes (1994), *The evolutionary history of whales and dolphins*. **An. Rev. Earth & Planet. Sci.**22: 419-455. Autoceta, Basilosauridae, *Basilosaurus*, Mysticeti, Odontoceti, Physeteroidea, Remingtonocetidae, Rhabdosteidae.

Forey, PL (1981), *The coelacanth **Rhabdoderma**in the British Isles*. **Palaeontology**24: 203-229. Actinistia, *Diplocercides*, *Rhabdoderma*.

Forey, PL (1998), **History of the Coelacanth Fishes**. Chapman & Hall, 419 pp. Actinistia, *Allenypterus*, *Caridosuctor*, *Diplocercides*, *Euporosteus*, *Hadronector*, *Lochmocercus*, *Miguashaia*, *Polyosteorhynchus*, *Rhabdoderma*.

Forey, PL, PE Ahlberg , E Lukševics & I Zupinš (2000), *A new coelacanth from the Middle Devonian of Latvia*. **J. Vert Paleontol.** 20: 243-252. Actinistia, *Diplocercides*, *Miguashaia*, Sarcopterygii.

Forster, CA, SD Sampson, LM Chiappe & DW Krause (1998), *The theropod ancestry of birds: new evidence from the Late Cretaceous of Madagascar*. **Science** 279: 1915-1919 Metornithes, *Patagonykus*.

Fostowicz-Frelik, L & Z Kielan-Jaworowska (2002), *Lower incisor in zalambdalestid mammals (Eutheria) and its phylogenetic implications*. **Acta Pal. Pol.**47: 177-180. Glires, Zalambdalestidae.

Fox, RC (1985), *Upper molar structure in the Late Cretaceous symmetrodont* ***Symmetrodontoides*** *Fox, and a classification of the Symmetrodonta (Mammalia)*. **J. Paleontol.** 59:21-26. Kuehneotheriidae, Spalacotheriidae, Symmetrodonta, Tinodontidae.

Franzosa, J & T Rowe (2005), *Cranial endocast of the Cretaceous theropod dinosaur* ***Acrocanthosaurus atokensis***. **J. Vert. Paleontol.**25: 859-864. *Acrocanthosaurus*.

Freeman, EF (1979), *A Middle Jurassic mammals bed from Oxfordshire*. **Palaeontology**22: 135-166. *Amphilestes*.

Frey, E & Reiss, J (1982), *Considerations concerning plesiosaur locomotion*. **N. Jb. Geol. Palaont. Abh.** 164: 188-192. Plesiosauria.

Frieß, M [Friess] (2003), *An application of the relative warps analysis to problems in human paleontology - with notes on raw data quality*. **Image Anal. Stereol.**22: 63-72. *Holopterygius*.

Friedman, M & MI Coates (2005), *A newly recognized fossil coelacanth highlights the early morphological diversification of the clade*. **Proc. Roy. Soc. Bio.** 273: 245-250. *Holopterygius*, Sarcopterygii: Dendrogram.

Frost, DR, WC Wozencraft & RS Hoffman (1991) *Phylogenetic relationships of hedgehogs and gymnures (Mammalia: Insectivora: Erinaceidae)*, **Smithsonian Contrib. Zool.**#518, 69 pp. Erinaceinae, Erinaceomorpha, Hylomyinae.

-G-

Gabbert, SL (2004), *The basicranial and posterior cranial anatomy of the families of the Toxodontia* **in**GC Gould & SK Bell [eds.], **Tributes to Malcolm C. McKenna : His Students, His Legacy**. Amer. Mus. Nat. Hist., pp. 177-190 (**Bull. Amer. Mus. Nat. Hist.** #285: 177-190). WWW.

Gabbott, SE, RJ Aldridge & JN Theron (1995), *A giant conodont with preserved muscle tissue from the Upper Ordovician of South Africa*. **Nature** 374: 800-803. Euconodonta.

Gaffney, ES & PA Meylan (1988), *A phylogeny of turtles*, in MJ Benton (ed.), **The Phylogeny and Classification of the Tetrapods**, 1: 157-219. Jugals, Podcnemoidae

Galton, PM (1978), *Fabrosauridae, the basal family of ornithischian dinosaurs (Reptilia: Ornithopoda)*. **Paläontol. Zeit.** 52: 138-159. Genasauria

Galton, PM (1986), *Herbivorous adaptations of Late Triassic and Early Jurassic dinosaurs*, **in**K Padian (ed.), **The Beginning of the Age of Dinosaurs**. Cambridge Univ. Press, pp. 203-221. Heterodontosauridae, Prosauropoda, Vulcanodontidae.

Galton, PM (1990), *Stegosauria*, **in**DB Weishampel, P Dodson, & H Osmólska (eds.), **The Dinosauria**. Univ. Calif. Press, pp. 435-455. Eurypoda; Huayangosauridae; Stegosauria, Stegosauridae.

Galton, PM (1990a), *Basal Sauropodomorpha* **in**DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press. Massospondylidae, Prosauropoda.

Galton, PM (1997), *Stegosaurs*, in Farlow, JO & MK Brett-Surman (eds.), **The Complete Dinosaur**, pp. 291-306. Huayangosauridae, Stegosauria, Stegosauridae

Gao, K & RC Fox (1998), *New choristoderes (Reptilia: Diapsida) from the Upper Cretaceous and Palaeocene, Alberta and Saskatchewan, Canada, and phylogenetic relationships of Choristodera*. **Zool. J. Linnean Soc.** 124: 303-353. Champsosauridae; Neochoristodera.

Garner, JP, GK Taylor & ALR Thomas (1999), *On the origin of birds: the sequence of character acquisition in the evolution of avian flight*. **Proc. Roy. Soc. London B** 266: 1259-1266. Aves

Gasparini, Z (1984), *New Tertiary Sebecosuchia (Crocodylia: Mesosuchia) from Argentina*. **J. Vert. Paleontol.** 4: 85-95. Sebecosuchidae

Gaudant, J & FJ Meunier (1996), *Observation d'un cas de pachyostose chez un Clupeidae fossile du Miocène terminal de l'ouest Algérien, **Sardina ? crassa**(Sauvage, 1873)*. **Cybium**20: 169-83. Pachypleurosauridae

Gaudin, TJ (1991), *A re-examination of elasmobranch monophyly and chondrichthyan phylogeny*. **N. Jahrb. Geol. Paläont. Abh.**182: 133-160. *Synechodus*

Gauthier J.A. 1986. Saurischian monophyly and the origin of birds. **Memoirs of the California Academy of Sciences**8: 1-55. Ornithosuchidae, Prestosuchidae

Gauthier, J, K deQuieroz, & R Estes (1988), *A phylogenetic analysis of Lepidosauromorpha*, in R Estes & G Pregill (eds.), **Phylogenetic Relationships of the Lizard Families**, Stanford U. Press, pp. 15-98. Lepidosauriformes

Gauthier, J, AG Kluge & T Rowe (1988), *The early evolution of the Amniota*, **in**MJ Benton (ed.) **The Phylogeny and Classification of the Tetrapods, Volume 1: Amphibians, Reptiles, Birds**. Clarendon Press, pp. 103-155. Testudines

Gee, H. (1999), **In Search of Deep Time**, Free Press. Aves

Geisler, JH (2001), *New morphological evidence for the phylogeny of Artiodactyla, Cetacea, and Mesonychidae*. **Amer. Mus. Nov.**No. 3344, 53 pp. Anoplotheroidea.

Gendron-Maguire, M, M Mallo, M Zhang & T Gridley (1993), ***Hoxa-2** mutant mice exhibit homeotic transformation of skeletal elements derived from cranial neural crest*. **Cell** 75: 1317-1331 (abstract only). Meckel's Cartilage

Gheerbrant, E, J Sudre, M Iarochene & A Moumni (2001), *First ascertained African "condylarth" mammals (primitive ungulates: **c.f.**Bulbulodentata and **c.f.**Phenacodonta) from the Earliest Ypresian of the Ouled Abdoun Basin, Morocco*. **J. Vert. Paleontol.**21: 107-118. Meridiungulata.

Gilbert, SF (2000), **Developmental Biology**, 6th ed. Sinauer Associates: 749 pp. The Basisphenoid, Teeth

Gilbert, SG (1968), **Pictoral Anatomy of the Cat**. U. Washington Press, 120 pp.

Gillis JA & PCJ Donoghue (2007), *The homology and phylogeny of chondrichthyan tooth enameloid*. **J. Morph.** 268: 33-49. Teeth.

Gingerich, PD (1998), *Paleobiological perspectives on Mesonychia, Archaeoceti, and the origin of whales* **in**JGM Thewissen [ed.] **The Emergence of Whales**, Plenum Press pp 423-449. Ambulocetidae, Autoceta, Cetacea, Basilosauridae, *Basilosaurus*, *Dorudon*, Mysticeti, Protocetidae, Remingtonocetidae.

Gingerich, PD & MD Uhen (1998), *Likelihood estimation of the time of origin of Cetacea and the time of divergence of Cetacea and Artiodactyla*. Palaeontologia Electronica. WWW. Autoceta, Basilosauridae, *Basilosaurus*, Pakicetidae, Protocetidae.

Gingerich, PD, SM Raza, M Arif, M Anwar & X-Y Zhou (1994), *New whale from the Eocene of Pakistan and the origin of cetacean swimming*. **Nature**368: 844-847. Protocetidae.

Gingerich, PD, M ulHaq, IS Zalmout, IH Khan, & MS Malkani (2001), *Origin of whales from early artiodactyls: hands and feet of Eocene Protocetidae from Pakistan*. **Science** 293: 2239-2242. Protocetidae.

Ginter, M. (2002), *Chondrichthyan fauna of the Frasnian–Famennian boundary beds in Poland*. **Acta Pal. Pol.**47: 329–338. WWW. *Strunius*

Gleiberman, AS, NG Fedtsova & MG Rosenfeld (1999), *Tissue interactions in the induction of anterior pituitary: role of the ventral diencephalon, mesenchyme, and notochord*. **Devel. Biol.** 213: 340-353. The Basisphenoid

Godfrey, SJ (1984), *Plesiosaur sub-aqueous locomotion: a reappraisal*. **N. Jb. Geol. Palaont. Abh.**11: 661-672. Plesiosauria

Godfrey, SJ (1989) *The postcranial skeletal anatomy of the Carboniferous tetrapod* ***Greererpeton burkemorani*** *Romer, 1969*. **Phil. Trans. R. Soc (Lond.)**, B323: 75-133. Colosteidae.

Gower, DJ (2002), *Braincase evolution in suchian archosaurs (Reptilia: Diapsida): evidence from the rauisuchian* ***Batrachotomus kupferzellensis***, **Zool. J. Linn. Soc.**136: 49-76. Aetosauridae, *Batrachotomus*, Crocodylomorpha, The Ear, Euparkeriidae, Phytosauridae; Prestosuchidae, *Saurosuchus*, Suchia.

Gower, DJ & AG Sennikov (2000), *Early Archosaurs from Russia* **in**MJ Benton, EN Kurochkin, MA Shishkin & DM Unwin [eds.], **The Age of Dinosaurs in Russia and Mongolia**. Cambridge Univ. Press, pp. 140-159. Euparkeriidae, Rauisuchidae.

Gower, DJ & AD Walker (2002), *New data on the braincase of the aetosaurian archosaur (Reptilia: Diapsida)* ***Stagonolepis robertsoni****Agassiz*, **Zool. J. Linn. Soc.**136: 1-7. **Archosaurian Anatomy and Palaeontology: Essays in Memory of Alick D. Walker**, DB Norman & DJ Gower [eds.] abstract. Aetosauridae, *Stagonolepis*, Suchia.

Gower, DJ & E Weber (1998), *The braincase of* ***Euparkeria****, and the evolutionary relationships of birds and crocodilians*. **Biol. Rev.**73: 367-411. Euparkeriidae.

Grande, L & WE Bemis (1996), *Interrelationships of Acipenseriformes, with comments on "Chondrostei"*, in Stiassny, MLJ, LR Parenti & GD Johnson, **Interrelationships of Fishes**, pp. 85-115. Academic Press. Acipenseriformes, Amiiformes, Birgeriidae, Chondrostei.

Grande, L & WE Bemis (1998), *A comprehensive phylogenetic study of amiid fishes (Amiidae) based on comparative skeletal anatomy. An empirical search for interconnected patterns of natural history*. Soc. Vert. Paleontol. Mem. #4. **J. Vert Paleontol.** 18 (supp.): 1-681. Amiidae, Amiiformes, Amiinae, *Amiopsis*, Caturoidea, Epibranchials, *Dactylosaurus*, Ginglymodi, Halecomorphi, Hypohyal, Ionoscopiformes, Lepisosteiformes, Neopterygia (Overview), Parasemionotidae, Sinamiidae, *Solnhofenamia*, Vidalamiinae.

Greene, HW (1997), **Snakes: the Evolution of Mystery in Nature.** U. Calif. Press, 351 pp. Scolecophidia.

Gregory JT (1945), *Osteology and relationships of* ***Trilophosaurus***. **Univ. Tex. Publ.** No. 4401: 273-359.

Gregory JT (1969), *Evolution und interkontinentale beziehungen der Phytosauria (Reptilia)*. **Paläontol. Zeit.**43: 37-51. Phytosauria

Gregory, WK (1951), **Evolution Emerging: a Survey of Changing Patterns from Primeval Life to Man** New York, Macmillan, 2 vol. *Aetosaurus*

Gregory, WT (1926), *The skeleton of* ***Moschops capensis****Broom, a dinocephalian reptile from the Permian of South Africa*. **Bull. Amer. Mus. Nat. Hist.**56: 179-251. Tapinocephalidae.

Gritli-Linde, A, M Bei, R Maas, X-YM Zhang, A Linde & AP McMahon (2002), ***Shh****signaling within the dental epithelium is necessary for cell proliferation, growth and polarization*. **Development**129: 5323-5337. Teeth

Grogan, ED, R Lund & D Didier (1999), *Description of the chimaerid jaw and its phylogenetic origins*. **J. Morphol.**239: 45-59. Holocephali.

-H-

Haddrath, O & AJ Baker (2004), *Complete mitochondrial DNA genome sequences of extinct birds: ratite phylogenetics and the vicariance biogeography hypothesis*. **Proc. R. Soc. Lond. B** 268: 939-945. Ratites.

Halstead, LB (1973), *The heterostracan fishes*. **Biol. Rev.** 48: 279-332. Amphiaspidida, *Corvaspis*, *Drepanaspis*, Guerichosteidae, Protaspididae, *Psammolepis*, Psammosteida, Psammosteidae, Pteraspidomorphi, Pycnosteidae.

Hampe, O (1992), *Ein grosswuechsiger pliosauride (Reptilia: Plesiosauria) aus der Unterkreide (oberes Aptium) von Kolumbien*. **Courier Forsch. Senckenberg**. 145: 1-32. *Kronosaurus*.

Hanke, GF & MVH Wilson (2006), *Anatomy of the Early Devonian acanthodian* ***Brochoadmones milesi*** *based on nearly complete body fossils, with comments on the evolution and development of paired fins.* **J. Vert. Paleontol.**26: 526-537. Acanthodii.

Hancox, PJ & BA Rubidge (1997), *The role of fossils in interpreting the development of the Karoo basin*. **Palaeontol. Afr.**33: 41-54. Therapsida Overview

Harris, SR, DJ Gower & M Wilkinson (2003), *Intraorganismal homology, character construction, and the phylogeny of aetosaurian archosaurs (Reptilia, Diapsida)*. **Syst. Biol.**52: 239-252. [review/synopsis by Stephan Pickering Willis O'Brien's aetosaur in the spider pit at Paleo-Boy's Dinosaur Discussion List] *Aetosaurus*, *Stagonolepis*, *Neoaetosauroides*

Harrison, GL, PA McLenachan, MJ Phillips, KE Slack, A Cooper & D Penny (2004), *Four new avian mitochondrial genomes help get to basic evolutionary questions in the Late Cretaceous*. **Mol. Biol. Evol.**21: 974–983. Ratites.

Head, JJ (1998), *A new species of basal hadrosaurid (Dinosauria, Ornithischia) from the Cenomanian of Texas*. **J. Vert. Paleontol.** 18: 718-738. Hadrosauridae, Hadrosauroidea, Iguanodontidae, Jugals, Lambeosaurinae; *Ouranosaurus*.

Head, JJ (2001), *A reanalysis of the phylogenetic position of* ***Eolambia caroljonesa*** *(Dinosauria, Iguanodontia)*. **J. Vert. Paleontol.** 21: 392-396. *Ouranosaurus*.

Heads, M (2005), *Dating nodes on molecular phylogenies: a critique of molecular biogeography*. **Cladistics**. 21: 62-78. Ratites.

Hecht, MK (1959), *Amphibians and reptiles*, in PO McGrew (ed.), *The geology and paleontology of the Elk Mountain and Tabernacle Butte area, Wyoming*. **Bull. Amer. Mus. Nat. Hist.** 117: 130-146. Aniliidae; Cylindrophiidae; Serpentes.

Heckert, AB & SG Lucas (1999), *A new aetosaur (Reptilia: Archosauria) from the Upper Triassic of Texas and the phylogeny of aetosaurs*, **J. Vert. Paleontol.**, 19: 50-68. Aetosauridae, *Aetosaurus*, *Coahomasuchus*, *Desmatosuchus*, *Longosuchus*, *Paratypothorax*.

Heckert, AB & SG Lucas (2002) *South American occurences of the Adamanian (Late Triassic: Latest Carnian) index taxon* ***Stagonolepis*** *(Archosauria: Aetosauria) and their biochronological significance*, **J. Paleontol.**, 76: 852-863. *Stagonolepis*.

Heckert, AB & SG Lucas (2003), *Clarifying aetosaur phylogeny requires more fossils, not more trees -- Reply to Intraorganismal homology, character construction, and the phylogeny of aetosaurian archosaurs (Reptilia, Diapsida)*. **Syst. Biol.**52: 253-255. Aetosauridae.

Heckert, AB, SG Lucas & JD Harris (1999),*An aetosaur (Reptilia: Archosauria) from the Upper Triassic Chinle Group, Canyonlands National Park, Utah*, **in**VL Santucci & L McClelland [eds.], **Paleontology of the National Parks, Geologic Resources Division Technical Report**NPS/NRGRD/GRDTR-99/03. Washington, D.C.: National Park Service.pp. 23-26 Aetosauridae, *Coahomasuchus*, *Stagnolepis*.

Hedges, SB & LL Poling (1999), *A molecular phylogeny of reptiles*. **Science**283: 998-1001. Archosauria.

Hedges, SB, MD Simmons, MAM vanDijk, G-J Caspers, WW deJong & CG Sibley (1995), *Phylogenetic relationships of the hoatzin, an enigmatic South American bird*. **Proc. Natl. Acad. Sci.** 92: 11662-11665. Cuculiformes.

Hetzer-Egger, C, M Schorpp & T Boehm (2000), *Evolutionary conservation of gene structures of the **Pax1/9** gene family*. **Biochim. Biophys. Acta**1492: 517-521. Teeth

Hildebrand, M (1974), **Analysis of Vertebrate Structure**. John Wiley & Sons, 710 pp. Ear

Hill, RV, LM Witmer & MA Norell (2003), *A new specimen of **Pinacosaurus grangeri** (Dinosauria: Ornithischia) from the Late Cretaceous of Mongolia: ontogeny and phylogeny of ankylosaurs*. **Am. Mus. Nov.** No. 3395, 29 pp. WWW. Septomaxilla.

Hillenius, WJ (1994), *Turbinates in therapsids: evidence for Late Permian origins of mammalian endothermy*. **Evolution**48: 207-229. *Thrinaxodon*.

Hillenius, WJ (2000), *The Septomaxilla of non-mammalian synapsids: soft-tissue correlates and a new functional interpretation*. **J. Morphol.**245: 29-50. Septomaxilla.

Hoang, AM, RJ Klebe, B Steffensen, OH Ryu, JP Simmer & DL Cochran (2002),*Amelogenin is a cell adhesion protein*. **J. Dent. Res.**81: 497-500. Teeth

Holman, JA (2000), **Fossil Snakes of North America: Origin, Evolution, Distribution, Paleoecology**. Indiana Univ. Press, 359 pp. Alethinophidia; Aniliidae

Holmes, R (1984), *The Carboniferous amphibian **Proterogyrinus scheeleri** Romer and the early evolution of tetrapods*, **Phil. Trans. Roy. Soc. Lond. B**, 306: 431-527. Embolomeri.

Holmes R, Y-N Cheng & X-C Wu (2008), *New information on the skull of **Keichousaurus hui** (Reptilia: Sauropterygia) with comments on sauropterygian interrelationships*. **J. Vert. Paleont.** 28: 76-84.

Holtz, TR, Jr.(1995), *The arctometatarsalian pes, an unusual structure of the metatarsus of Cretaceous Theropoda (Dinosauria: Saurischia)*, **J. Vert. Paleontol.** 14: 480-519. Multituberculata.

Holtz, TR, Jr. (1996a), *Phylogenetic taxonomy of the Coelurosauria (Dinosauria: Theropoda)*. **J. Paleontol.** 70: 536-538. Maniraptora, Maniraptoriformes, Multituberculata.

Holtz, TR, Jr. (2000), *A new phylogeny of the carnivorous dinosaurs*. **Gaia**15: 5-61. WWW. Tyrannosauroidea.

Holtz, TR, Jr. (2001), *Pedigree of the tyrant kings: new information on the origin and evolution of the Tyrannosauridae*. **J. Vert Paleontol.** 21: 62A-63A. **Note:** this is the abstract of a paper which included a new, unpublished phylogenetic analysis of the Theropoda. Further details of the paper, including much of the cladogram, were reported by Micky Mortimer at *Details on SVP 2001 Friday talks*. *Coelurus*, Tyrannosauridae.

Holtz, TR, Jr. (2001a), *The phylogeny and taxonomy of the Tyrannosauridae* **in**K Carpenter & D Tanke [eds.], **Mesozoic Vertebrate Life**. Indiana Univ. Press, pp. 64-83. *Albertosaurus*, *Alectrosaurus*, *Gorgosaurus*, Tyrannosauridae, Tyrannosaurinae, Tyrannosauroidea.

Hope, S (2002), *The Mesozoic radiation of Neornithes*, **in**LM Chiappe & LM Witmer [eds.], **Mesozoic Birds: Above the Heads of the Dinosaurs**. Univ. Calif. Press, pp. 339-388. Anatidae, Anatoidea, Anseres, Neornithes, Presbyornithidae.

Hopson, JA (1969), *The Origin and Adaptive Radiation of Mammal-Like Reptiles and Non-Therian Mammals*. **Ann. N.Y. Acad. Sci.**167: 199-216. Therapsida Overview, Theriodonta

Hopson, JA (1991), *Systematics of the nonmammalian Synapsida and implications for patterns of evolution in synapsids*, **in**H-P Schultze & L Trueb [eds], **Origins of the Higher Groups of Tetrapods: Controversy and Consensus**. Comstock, pp. 635-693. Cynodontia, *Dvinia*, Edaphosauridae, Epicynodontia, *Ianthasaurus*, *Parathrinaxodon*, *Procynosuchus*.

Hopson, JA & HR Barghusen (1986), *An analysis of therapsid relationships* in N Hotton, III, PD MacLean, JJ Roth & EC Roth, **The Ecology and Biology of Mammal-like Reptiles**, Smithsonian Inst. Press, pp. 83-106. Cynodontia, *Dvinia*, Eotitanosuchia, Epicynodontia, Galesauridae, Procynosuchidae, Sphenacodontia, Therapsida.

Hopson, JA & JW Kitching (1972), *A Revised Classification of the Cynodonts (Reptilia; Therapsida)*, **Paleontol. Afr.**, 14: 17-85. Cynognathidae, *Oligokyphus*, Trithelodontidae, *Tritylodon*.

Hopson, JA & JW Kitching (2001), *A probainognathian cynodont from South Africa and the phylogeny of non-mammalian cynodonts*. **Bull. Mus. Comp. Zool.**156: 5-35. Cynodontia, Epicynodontia.

Horn, PL, JA Rafalski & PJ Whitehead (1990), *Molecular genetic (RAPD) analysis of breeding magpie geese*. **Auk**113: 552-557. *Anseranas*.

Hu, Y, Y Wang, Z-X Luo, & C Li (1997),*A new symmetrodont mammal from China and its implications for mammalian evolution*. **Nature** 390:137-142. *Gobiconodon*, *Hadrocodium*, Monotremata, Spalacotheriidae, Spalacotheroidea, Symmetrodonta.

Hua, S & E Buffetaut (1997), *Introduction*, in JM Callaway & EL Nichols (eds.), **Ancient Marine Reptiles**, Academic Press pp. 357-374. Crocodyliformes, Dyrosauridae.

Hughes, JM (1996), *Phylogenetic analysis of the Cuculidae (Aves, Cuculiformes) using behavioral and ecological characters*. **Auk**113: 10-22. Cuculidae.

Hughes, JM & AJ Baker (1999), *Phylogenetic relationships of the enigmatic hoatzin (**Opisthocomus hoazin**) resolved using mitochondrial and nuclear gene sequences*. **Mol. Biol. Evol.** 16: 1300-1307 (reviewed abstract only). Cuculiformes.

Hulbert RC Jr, RM Petkewich, GA Bishop, D Bukry & DP Aleshire (1998), *A new Middle Eocene protocetid whale (Mammalia: Cetacea: Archaeoceti) and associated biota from Georgia* **J. Paleont.**72: 907-927. *Georgiacetus*, Protocetidae.

Hurlburt G (1999), *Comparison of body mass estimation techniques, using Recent reptiles and the pelycosaur **Edaphosaurus boanerges***. **J. Vert Paleontol.** 19: 338– 350. *Edaphosaurus*, *Ianthasaurus*.

Hurum, JH & PJ Currie (2000), *The crushing bite of tyrannosaurids*. **J. Vert. Paleontol.**20: 619-621. Tyrannosauroidea, Tyrannosaurini.

Hutchinson, JR (2001), *The evolution of pelvic osteology and soft tissues on the line to extant birds (Neornithes)*. **Zool. J. Linn. Soc.**131: 123-168. Cetacea, Dipnomorpha, Tyrannosauroidea.

Hutchinson, JR (2001a), *The evolution of femoral osteology and soft tissues on the line to extant birds (Neornithes)*. **Zool. J. Linn. Soc.** 131: 169-197. Cetacea, Tyrannosauroidea.

Hutchinson, JR (2004), *Biomechanical modeling and sensitivity analysis of bipedal running ability. I. Extant taxa*. **J. Morphol.**262: 421-440. Neornithes, Ratites.

Hutchinson, JR & LR Chiappe (1998), *The first known alvarezsaurid (Theropoda: Aves) from North America*. **J. Vert. Paleontol.**18: 447-450. Mononykinae, *Mononykus*, *Suvuuia*.

Hutchinson, JR & M Garcia (2002) ***Tyrannosaurus** was not a fast runner*. **Nature**415: 1018-1021. Tyrannosauroidea.

Hutchinson, JR & SM Gatesy (2000), *Adductors, abductors, and the evolution of archosaur locomotion*. **Paleobiology** 26: 734-751. Pterodactyloidea, Tyrannosauroidea.

Hutt, S, D Naish, DM Martill, MJ Barker & P Newbery (2001), *A preliminary account of a new tyrannosaurid theropod from the Wessex Formation (Early Cretaceous) of southern England*. **Cretaceous Res.**22: 227-242. *Alectrosaurus*, Coelurosauria, *Eotyrannus*, Ornithomimosauria, Tetanurae.

Huttenlocker A, E Rega & SS Sumida (2007), *New histological investigations of hyperelongate neural spines in*

eupelycosaurs (Amniota: Synapsida) and the affinities of ***Lupeosaurus kayi***. **J. Vert. Paleont.** 27: 93A (abstr.). Edaphosauridae, *Ianthasaurus*.

Huxley, TH (1859), *On the theory of the vertebrate skull*. **Proc. Zool. Soc. Lond.**9: 381-457, **reprinted WWW. (frequently cited 1858, the date of the underlying Croonian Lecture, but apparently not published until the following year. Also sometimes cited to Proc. Roy. Soc. Lond. We're not sure which is correct.)**

Huysentruyt, F & D Adriaens (2005), *Descriptive osteology of Corydoras aeneus (Siluriformes: Callichthyidae)*. Cybium, 29: 261-273. *Diplocercides*.

-I-

Ivakhnenko, MF (1999), *Biarmosuches from the Ocher faunal assemblage of Eastern Europe.* Paleontol. J. 33: 289-296. Biarmosuchia, Eotitanosuchia, Therapsida Overview

-J-

Jalil, N-E (1997), *A new prolacertiform diapsid from the Triassic of North Africa and the interrelationships of the Prolacertiformes*. J. Vert. Paleontol. 17: 506-525. Trilophosaridae

Janis, CM & J Damuth (1990), *Mammals*, in K McNamara (ed.) Evolutionary Trends. Belhaven Press. Synapsida Overview

Janis, CM, JM Theodor & B Boisvert (2002), *Locomotor evolution in camels revisited: a quantitative analysis of pedal anatomy and the evolution of the pacing gait.* J. Vert. Paleontol.22: 110-121. *Poebrotherium*, Stenomylinae.

Janvier, P (1980), *Osteolepid remains from the Middle East with particular reference to the endoskeletal shoulder girdle*, in AL Panchen [ed.], The Terrestrial Environment and the Origin of Land Vertebrates. Systematics Assoc. Spec. Pub.15: 223-254. Megalichthyidae, Osteolepididae, Osteolepiformes.

Janvier, P (1981), *The phylogeny of the Craniata, with particular reference to the significance of fossil 'agnathans'*. J. Vert Paleontol.1: 121-159. Amphiaspidida, *Ctenaspis*.

Janvier, P (1995), *Conodonts join the club*. Nature 374: 761-762. Euconodonta.

Janvier, P (1996), Early Vertebrates, Oxford, 393 pp. Actinistia, Actinolepida, Actinolepidoidei, Actinopteri, Actinopterygii, Amphiaspidida, Anaspida, Antiarcha, Apalolepididae, Arandaspida, Astraspidae, Asterolepidoidei, *Ateleaspis*, Benneviaspidida, Birgeriidae, Bothriolepidoidei, Canowindridae, Cephalaspidida, Chimaeroidei, Cochliodontidae, Chondrostei, Chuchinolepidae, Cornuata, Corviaspididae, Craniate Overview, *Ctenaspis*, Dipnomorpha, *Drepanaspis*, Elpistostegalia, Epibranchials, Euantiarcha, Eugaleaspidiformes, Galeaspida, Gulars, *Hemicyclaspis*, Heterostraci, Heterostracomorphi, Huananaspidiformes, Hypohyal, *Ichthyostega*, Iniopterygii, Jugals, Kiaeraspidida, *Lanarkia*, *Loganellia*, Loganiidae, Meckel's Cartilage, Megalichthyidae, Microbrachiidae, Osteichthyes, Osteolepididae, Osteolepiformes, *Phlebolepis*, Polybranchiaspidida, Polybranchiaspidiformes, Porolepiformes, Psammosteida; Pteraspidida, Rhenanida, Rhizodontiformes, Sarcopterygii Overview, Saurichthyidae, Sinolepidae, Symmoriida, Teeth, Thelodonti, Thyestiida, *Youngolepis*, Yunnanolepidae, Yunnanolepidoidei Zenaspidida.

Janvier, P (1999), *Catching the first fish*. Nature 402: 21-22. Craniata.

Janvier, P & A Blieck (1993), *The Silurian-Devonian Agnathan Biostratigraphy of the Old Red Continent* in JA Long (ed.), Palaeozoic Vertebrate Biostratigraphy and Biogeography. Johns Hopkins Univ. Press, pp.70-73.

Craniate Overview, **Heterostraci**, **Psammosteida**, **Thelodonti**.

Jared, C, CA Navas & RC Toledo (1999) ***An appreciation of the physiology and morphology of the caecilians (Amphibia: Gymnophiona).*** **Comp. Biochem & Physiol. A 123: 313-328. Gymnophiona.**

Jarvik, E (1980), Basic Structure and Evolution of Vertebrates, Academic Press, 1: 575 pp. Actinistia, *Diplocercides*.

Jarvik, E (1996), *The Devonian tetrapod* ***Ichthyostega***. **Fossils & Strata**40: 1–213. *Elginerpeton*, *Ichthyostega*, Tetrapoda.

Jenkins, FA, SM Gatesy, NH Shubin & WW Amaral (1997), *Haramiyids and Triassic mammalian evolution.* **Nature** 385: 715-718. Haramiyida, Multituberculata.

Jenkins Jr., FA & CR Schaff (1988), *The Early Cretaceous mammal* ***Gobiconodon****(Mammalia, Triconodonta) from the Cloverly Formation in Montana*. **J. Vert. Paleontol.**8: 1-24. *Gobiconodon*.

Jenkins, FA & DM Walsh (1993), *An Early Jurassic caecilian with limbs.* **Nature** 365: 246-250. *Eocaecilia*, Jugals.

Jernvall, J, SVE Keränen & I Thesleff (2000), *Evolutionary modification of development in mammalian teeth: quantifying gene expression patterns and topography*. **Proc. Nat. Acad. Sci. (USA)**97: 14444-14448. Teeth.

Jessen, H (1973), *Weitere fischreste aus dem Oberen Plattenkalk der Bergisch-Gladbach Paffrather Mulde (Oberdevon Rheinisches Schiefergebirge)*. **Palaeontographica A**143: 159-187. *Diplocercides*, *Holopterygius*.

Ji,Q, Z-X Luo & S-A Ji (1999), *A Chinese triconodont mammal and mosaic evolution of the mammalian skeleton.* **Nature** 398: 326-330. *Gobiconodon*, *Hadrocodium*.

Ji, Q, Z-X Luo, C-X Yuan, JR Wible , J-P Zhang & JA Georgi (2002), *The earliest eutherian mammal*. **Nature**416: 816-822. *Gobiconodon*, *Priacodon*, Triconodonta.

Johanson, Z (1997), *New antiarchs (Placodermi) from the Hunter Siltstone (Famennian) near Grenfell, N.S.W.* **Alcheringa**, 21: 191-217. Antiarcha

Johanson, Z (1997a), *New* ***Remigolepis*** *(Placodermi; Antiarcha) from Canowindra, New South Wales, Australia.* **Geol. Mag.** 134: 813-846. Antiarcha

Johanson, Z (1998), *The Upper Devonian fish* ***Bothriolepis*** *(Placodermi; Antiarchi) from near Canowindra, New South Wales, Australia*. **Rec. Aus. Mus.** 50: 315-348. Antiarcha; Bothriolepidoidei.

Johanson, Z & PE Ahlberg (1997), *New tristichopterid (Osteolepiformes; Sarcopterygii) from the Mandagery Sandstone (Famennian) near Canowindra, N.S.W., Australia*. **Trans. Roy. Soc. Edin.**88: 39-53. *Cabonnichthys*, *Eusthenopteron*, *Mandageria*, Megalichthyidae, Osteolepididae, Osteolepiformes, *Panderichthys*, Rhizodontiformes, Tristichopteridae.

Johanson, Z & MM Smith (2003), *Placoderm fishes, pharyngeal denticles, and the vertebrate dentition*. **J. Morphol.**257: 289 - 307. Teeth

Johanson, Z & GC Young (1999), *New* ***Bothriolepis*** *(Antiarcha: Placodermi) from the Braidwood region, New South Wales, Australia (Middle-Late Devonian).* **Rec. Aus Mus. Supp.** 57: 55-75. Antiarcha

Johanson, Z, PE Ahlberg & A Ritchie (2003), *The braincase and palate of the tetrapodomorph sarcopterygian* ***Mandageria fairfaxi****: morphological variability near the fishtetrapod transition*. **Palaeontology**46: 271–293. *Ichthyostega*, *Mandageria*, *Panderichthys*, Rhipidistia, Sarcopterygii.

Johnson, GD & C Patterson (1997), *Relationships of lower euteleostean fishes* **in**MLJ Stiassny, LR Parenti & GD Johnson [eds.], **Interrelationships of Fishes**. Academic Press, pp. 251-332. Argentiniformes, *Dallia*, Epibranchials, Esocidae, Esociformes, *Esox*, Neognathi, Neoteleostei, *Novumbra*, Salmoniformes, *Umbra*.

Jollie, M (1975), *Development of the head skeleton and pectoral girdle in* ***Esox***. **J. Morphol.**147: 61-88.

Esociformes, *Esox*.

Jones, TD, JA Ruben, LD Martin, EN Kurochkin, A Feduccia, PFA Maderson, WJ Hillenius, NR Geist, & V Alifanov (2000), *Nonavian feathers in a late Triassic archosaur*. **Science** 288: 2202-2205. Archosauriformes, Pterodactyloidea.

Jung, H-S, Y Hitoshi & H-J Kim (2003), *Study on Tooth Development, Past, Present, and Future*. **Microsc. Res. & Tech.**60: 480–482. Teeth

Juul, L (1994), *The phylogeny of basal archosaurs*. **Palaeont. Afr.**, 1994: 1-38. Archosauria, *Gracilisuchus*, Ornithosuchidae, Paracrocodylomorpha.

-K-

Karatajute-Talimaa, VN (2002), *Lower Devonian (Lochkovian) Thelodonts from October Revolution Island (Severnaya Zemlya Archipelago, Russia)*, **Geodiversitas**24: 791-804. Furcacaudiformes, Thelodontida, Thelodontidae, Turiniidae.

Karatajute-Talimaa, VN & T Marss (2002), *Upper Silurian thelodonts from Severnaya Zemlya Archipelago (Russia)*, **Geodiversitas**24: 405-443. Loganiidae, *Phlebolepis*, Thelodontidae.

Kardong, KV (1998), **Vertebrates: Comparative Anatomy, Function, Evolution**, McGraw-Hill, 747 pp. Incus.

Kardong, KV & EJ Zalisko (1998), **Comparative Vertebrate Anatomy: a Laboratory Dissection Guide**, WCB McGraw-Hill, 214 pp. Protocetidae.

Karhu, AA & AS Rautian (1996), *A new family of Maniraptora (Dinosauria: Saurischia) from the Late Cretaceous of Mongolia*. **Paleontol. J.**30: 583-592. *Parvicursor*.

Kellner, AWA (1997), *Reinterpretation of a remarkably well preserved pterosaur soft tissue from the Early Cretaceous of Brazil*. **J. Vert. Paleontol.** 16: 718-722. Pterodactyloidea.

Kellner, AWA & W Langston, Jr. (1996), *Cranial remains of **Quetzalcoatlus** (Pterosauria, Azhdarchidae) from Late Cretaceous sediments of Big Bend National Park, Texas*. **J. Vert. Paleontol.** 16: 222-231. Azhdarchoidea; Ornithocheiroidea; Pterodactyloidea.

Kellogg, EA & ND Juliano (1997), *The Structure and function of RuBisCo and their implications for systematic studies*. **Amer. J. Bot.**84: 413–428. *Acanthostega*.

Kemp, NE (1999), *Integumentary system and teeth*, **in**WC Hamlett [ed.], **Sharks, Skates, and Rays: the Biology of Elasmobranch Fishes**. Johns Hopkins Univ. Press, pp. 43-68. Batomorphii, Hypnosqualea.

Kemp, TS (1982), **Mammal-like Reptiles and the Origin of Mammals**. Academic Press. Bolotridon, Cynodontia, *Cynosaurus*, *Dvinia*, Epicynodontia, Galesauridae, *Galesaurus*, Procynosuchidae, *Procynosuchus*, *Thrinaxodon*.

Kermack, KA (1963), *The cranial structure of the triconodonts*. **Phil. Trans. R. Soc. Lond.**243: 83-103. Cynodontia, Triconodontidae, *Trioracodon*.

Kermack, KA, F Mussett & HW Rigney (1981), *The skull of **Morganucodon***. **Zool. J. Linn. Soc.** 71: 1-158. Jugals, Morganucodontidae.

Kettler, MK & GS Whitt (1986), *An apparent progressive and recurrent evolutionary restriction in tissue expression of a gene, the lactate dehydrogenase-C gene, within a family of bony fish (Salmoniformes: Umbridae)*. **J. Mol. Evol.**23: 95-107. Esociformes.

Kettler, MK, AW Ghent & GS Whitt (1986), *A comparison of phylogenics based on structural and tissue-expression differences of enzymes in a family of teleost fishes (Salmoniformes: Umbridae)*. **Mol. Biol. & Evol.**3: 485-498. WWW. *Dallia*, *Novumbra*, *Umbra*.

Kielan-Jaworowska, Z & JH Hurum (1997), *Djadochtatheria -- a new suborder of multituberculate mammals*. **Acta Palaeontol. Pol.** 42: 201-242. Cimolodonta; Gondwanatheria.

Kielan-Jaworowska, Z, RL Cifelli & Z-X Luo (2002), *Dentition and relationships of the Jurassic mammal* ***Shuotherium***. **Acta Palaeontol. Pol.**47: 479–486. WWW. Australosphenida.

Kielan-Jaworowska, Z, MJ Novacek, BA Trofimov & D Dashzeveg (2000), *Mammals from the Mesozoic of Mongolia*, in MJ Benton, MA Shshkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**. Cambridge Univ. Press. pp. 573-626. Cimolodonta; *Gobiconodon*, Multituberculata, Triconodonta, Zalambdalestidae, Zhelestidae.

King, GM (1988), *Anomodontia*, **in Encyclopedia of Paleoherpetology**. Gutsav Fischer Verlag. Part 17 C. Anteosauria, *Brithopus*, *Chthomaloporus*, *Struthiocephalus*, Tapinocephalia.

King, GM (1990), **The Dicynodonts: A Study in Palaeobiology**, Chapman & Hall. Dicynodontia

Kioussi, C, S O'Connell, L Saint-Onge, M Trier, AS Gleiberman, P Gruss & MG Rosenfeld (1999), ***Pax6*** *is essential for establishing ventral-dorsal cell boundaries in pituitary gland development*. **Proc. Nat. Acad. Sci. (USA)** 96: 14378-14382. The Basisphenoid.

Kirkland, JI & MC Aguillón-Martínez (2002), ***Schizorhina****: a unique sawfish paradigm from the Difunta Group, Coahuila, Mexico*. **Rev. Mex. de Cienc. Geol.**19: 16-24. Sclerorhynchidae.

Kley, NJ (1998), *Kinematics and mechanics of prey transport in scolecophidian snakes*. **Amer. Zoologist** 38: 202A (abstract). Scolecophidia.

Kley, NJ (2001), *Prey transport mechanisms in blindsnakes and the evolution of unilateral feeding systems in snakes*. **Am. Zool**. 41: 1321–1337. WWW. Septomaxilla.

Kley, NJ & EL Brainerd (1999), *Feeding by mandibular raking in a snake*. **Nature** 402: 369-70. Scolecophidia.

Kluge, AG (1989), A concern for evidence and a phylogenetic hypothesis of relationships among Epicrates (Boidae, Serpentes). **Syst. Zool.**38: 7-25. Dipnomorpha.

Köhler, R & RE Fordyce, (1997), *An archaeocete whate (Cetacea: Archaeoceti) from the Eocene Waihao Greensand, New Zealand*. **J. Vert. Paleontol.**17: 574-583. Basilosauridae, *Dorudon*.

Kondoh, H, M Uchikawa, H Yoda, H Takeda, M Furutani-Seiki & RO Karlstrom (2000), *Zebrafish mutations in* ***Gli****-mediated* ***hedgehog*** *signaling lead to lens transdifferentiation from the adenohypophysis anlage*. **Mech. Devel.** 96: 165-174. The Basisphenoid.

Krause, DW, GVR Prasad, W von Koenigswald, A Sahni & FE Grine (1997), *Cosmopolitanism among Gondwanan Late Cretaceous mammals*. **Nature** 390: 504-507. Gondwanatheria.

Krebs, B. (1976). Pseudosuchia. In Handbuch der Palaeoherpetologie, Teil 13: Thecondontia (O. Kuhn, Ed.), pp. 40-98. Fisher-Verlag, Stuttgart. *Aetosaurus*.

Krettek, A, A Gullberg, & U Arnason, (1995), *Sequence analysis of the complete mitochondrial DNA molecule of the hedgehog,* ***Erinaceus europaeus****, and the phylogenetic position of the Lipotyphla*. **J. Mol. Evol.**41: 952-957. Insectivora

Kriwet, J (2003), *Neoselachian remains (Chondrichthyes, Elasmobranchii) from the Middle Jurassic of SW Germany and NW Poland*. **Acta Pal. Pol.**48: 583–594. *Protospinax*, *Synechodus*.

Kriwet J & S Klug (2004), *Late Jurassic selachians (Chondrichthyes, Elasmobranchii) from southern Germany: Re-evaluation on taxonomy and diversity*. **Zitteliana**A44: 67-95. *Synechodus*.

Kurochkin, EN, GJ Dyke & AA Karhu (2002), *A New Presbyornithid Bird (Aves, Anseriformes) from the Late Cretaceous of Southern Mongolia*. **Amer. Mus. Nov.**3386: 11 pp. Anseres, *Presbyornis*, Presbyornithidae, *Telmabates*, *Teviornis*.

-L-

Labandeira CC & EG Allen (2007), *Minimal insect herbivory for the Lower Permian Coprolite Bone Bed site of north-central Texas, USA, and comparison to other Late Paleozoic floras.* **Paleogeog. Paleoclimatol. Paleoecol.**247: 197-219.

Lambe, LM (1917), *The Cretaceous theropodous dinosaur* ***Gorgosaurus***. **Mem. Geol. Surv. Can.** #100, 84+ pp. ("No. 83, Geological Series"). *Gorgosaurus*, Tyrannosauridae, Tyrannosauroidea.

Lambert, D (1983), **A Field Guide to Dinosaurs**. Avon Books. 256 pp. Dicraeosauridae, *Haplocanthosaurus*.

Langer, MC, F Abdala, M Richter, & MJ Benton (1999), *A sauropodomorph dinosaur from the Upper Triassic (Carnian) of southern Brazil.* **C. R. Acad. Sci. (Paris): Sci. de la Terre** 329: 511-517. Sauropodomorpha.

Langston, W (1965), ***Oedalops campi*** *(Reptilia: Pelycosauria) new genus and species from the Lower Permian of New Mexico, and the family Eothyrididae*. **Bull. Tex. Mem. Mus.** #9, 47 pp. Caseasauria, Caseidae, Eothyrididae, Jugals, Therapsida Overview.

Langston, W & RR Reisz (1981), ***Aerosaurus wellesi***, *new species, a varanopseid mammal-like reptile (Synapsida: Pelycosauria) from the Lower Permian of New Mexico*. **J. Vert. Paleontol.** 1: 73-96. *Aerosaurus*.

Laurin, M & RR Reisz (1996), *The osteology and relationships of* ***Tetraceratops insignis***, *the oldest known therapsid*. **J. Vert. Paleontol.** 16: 95-102. *Tetraceratops*, Therapsida, Therapsida Overview.

Laurin, M, M Girondot & A de Ricqlès (2000), *Early tetrapod evolution*. **Tree**15: 118-123. *Acanthostega*.

Lavocat, RJM (1954), *Sur les dinosauriens du continental intercalaire des Kem-Kem de la Doura*. **C.R. 19th Cong. Géol. Intern.** 15: 65-68. Rebbachisauridae; *Rebbachisaurus*.

Lebedev, OA & JA Clack (1993), *Upper Devonian tetrapods from Andreyeva, Tula Region, Russia*. **Paleontology**36: 721-734. Tetrapoda, Tetrapoda.

Lebedev, OA & MI Coates (1995), *The postcranial skeleton of the Devonian tetrapod* ***Tulerpeton curtum****Lebedev*. **Zool. J. Linn. Soc.**, 114: 307-348. *Acanthostega*, *Ichthyostega*, Tetrapoda, Tetrapoda.

LeDouarin, NM, C Ziller & GF Couly (1993), *Patterning of neural crest derivatives in the avian embryo:* ***in vivo*** *and* ***in vitro*** *studies*. **Devel. Biol.** 159: 24-49. The Basisphenoid.

Lee, MSY (1996), *Correlated progression and the origin of turtles*. **Nature**379: 812-815. Testudines

Lee, MSY (1997), *Pareiasaur phylogeny and the origin of turtles*. **Zool. J. Linnean Soc.**, 120: 197-280. Overview, Pareiasuria, Pythonomorpha, Velosauria.

Lee, MSY (1997a), *The phylogeny of varanoid lizards and the affinities of snakes.* **Phil. Trans. R. Soc. Lond. B**352: 53-91. Anguoidea, Dipnomorpha, Monstersauria, Pythonomorpha; Serpentes, Varanidae, Varanoidea.

Lee, MSY, GL Bell Jr. & MW Caldwell (1999a), *The origin of snake feeding*. **Nature** 655-659. Cylindrophiidae, Mosasauroidea, Pythonomorpha, Squamata.

Lee, MSY, MW Caldwell & JD Scanlon (1999), *A second primitive marine snake:* ***Pachyophis woodwardi*** *from the Cretaceous of Bosnia-Herzegovina*. **J. Zool. London** 248: 509-520. Serpentes, Pachyophiidae.

Leebens-Mack, J & C dePamphilis (2002), *Power analysis of tests for loss of selective constraint in cave crayfish and nonphotosynthetic plant lineages*. **Mol. Biol. Evol.**19: 1292-1302. *Acanthostega*.

Lehrmann DJ, P Enos, JL Payne, P Montgomery, J-Y Wei, Y-Y Yu, J-F Xiao & MJ Orchard (2004), *Permian and Triassic depositional history of the Yangtze platform and Great Bank of Guizhou in the Nanpanjiang basin of Guizhou and Guangxi, South China*. **Albertiana**33: 149-168.

Lelièvre, H & P Janvier (1988), *Un actinistien (Sarcopterygii: Vertebrata) dans le Dévonien Supérieur du Maroc*. **CR Acad. Sci. Paris**(sér. 2) 307: 1425-1430. Actinistia, *Diplocercides*.

Li, C-K, RW Wilson, MR Dawson & L Krishtalka (1987), *The origin of rodents and lagomorphs***in**HH Genoways [ed.], **Current Mammalogy.** Plenum Press, 1: 97-108. Glires.

Li, W-H (1997), **Molecular Evolution**, Sinauer Associates: 487 pp. Insectivora.

Liem, KF, WE Bemis, WF Walker & L Grande (2001), **Functional Anatomy of the Vertebrates: an Evolutionary Perspective**[3rd ed.]. Harcourt College, 703+ pp. *Eusthenopteron*, *Lupeosaurus*, Teeth, Tristichopteridae.

Leonard, L, GJ Dyke & M van Tuinen (2005), *A new specimen of the fossil palaeognath* ***Lithornis****from the Lower Eocene of Denmark*. **Amer. Mus. Nov.**No. 3491, 11 pp. *Dactylosaurus*.

Liu, F-GR, MM Miyamoto, NP Freire, PQ Ong, MR Tennant, TS Young, & KF Gugel (2001), *Molecular and Morphological Supertrees for Eutherian (Placental) Mammals* **Science**291: 1786-1789. Insectivora.

Livezey, BC, (1996), *A phylogenetic analysis of geese and swans (Anseriformes: Anserinae), including selected fossil species*. **Syst. Biol.**45: 415-450. *Cnemiornis*.

Livezey, BC (1997), *A phylogenetic analysis of basal Anseriformes, the fossil* ***Presbyornis****, and the interordinal relationships of waterfowl*. **Zool. J. Linn. Soc.** 121: 361-428. *Anatalavis*, Anatidae, Anatoidea, Anhimidae, *Anseranas*, Anseres, Anseriformes, *Presbyornis*.

Loeffler, EJ & DL Dineley (1976), *A new species of* ***Corvaspis****(Agnatha, Heterostraci) from the Upper Silurian to Lower or Middle Devonian of the North-West Territories, Canada*. **Palaeontology**19: 757-766. Corviaspididae, *Corvaspis*, *Corveolepis*.

Lohnes, D, M Mark, C Mendelsohn, P Dollé, A Dierich, P Gorry, A Gansmuller & P Chambon, (1994), *Function of the retinoic acid receptors (RARs) during development. I. Craniofacial and skeletal abnormalities in RAR double mutants*. **Development**120: 2723-2748. Triconodontidae

Long, JA (1993), *Morphological Characteristics of Paleozoic Vertebrates used in biostratigraphy,* **in**JA Long (ed.), **Palaeozoic Vertebrate Biostratigraphy and Biogeography**. Johns Hopkins Univ. Press, pp.3-24. Craniate Overview, Thelodonti.

Long, JA (1995), **The Rise of Fishes: 500 Million Years of Evolution**. Johns Hopkins Univ. Press, 223 pp. Actinistia, *Allenypterus*, Amphiaspidida, Antiarcha, Asterolepidoidei, Bothriolepidoidei, Canowindridae, Chimaeroidei, *Corvaspis*, Cyathaspidida, Hypohyal, Megalichthyidae, Osteolepididae, Osteolepiformes, Osteostraci, Porolepiformes, *Powichthys*, Rhenanida, Rhizodontiformes, Sinolepidae, The Sphenethmoid, *Youngolepis*, Yunnanolepidae.

Long, JA (2001), *On the relationships of* ***Psarolepis*** *and the onychodontiform fishes*. **J. Vert. Paleontol.** 21: 815-820. Gulars, Jugals, Onychodontiformes, *Onychodus*, Osteichthyes, *Psarolepis*, Sarcopterygii, Teleostomi Overview.

Long, JA & MS Gordon (2004) *The greatest step in vertebrate history: a paleobiological review of the fish-tetrapod transition*. **Physiol. Biochem. Zool.**, 77: 700-719. *Acanthostega*, Elpistostegalia, *Ichthyostega*, *Obruchevichthys*, *Ventastega*.

Long, JA, ME Anderson, R Gess & N Hiller (1997), *New placoderm fishes from the Late Devonian of South Africa.* **J. Vert. Paleontol.** 17: 253-268. Bothriolepidoidei.

Long, RA & KL Ballew (1985), *Aetosaur dermal armor from the Late Triassic of southwestern North America, with*

special reference to material from the Chinle Formation of Petrified Forest National Park, **Mus. N. Ariz. Bull.**, 54: 45-68. *Paratypothorax*, *Stagnolepis*.

Long, RA & PA Murry (1995), *Late Triassic (Carnian and Norian) Tetrapods from the Southwestern United States*. **N. Mex. Mus. Nat. Hist. & Sci. Bull.**4: 1-254. Phytosauridae, *Rutiodon*, *Stagnolepis*.

López, JA, P Bentzen & T. W. Pietsch (2000), *Phylogenetic relationships of esocoid fishes (Teleostei) based on partial cytochrome b and 16S mitochondrial DNA sequences*. **Copeia**2000: 420-431. Esociformes.

López, JA, W-J Chen & G Ortí (2004), *Esociform phylogeny*. **Copeia**2004: 449-464.

Lu, M-F, H-T Cheng, MJ Kern, SS Potter, B Tran, TGH Diekwisch & JF Martin (1999), ***prx-1*** *functions cooperatively with another* ***paired****-related homeobox gene,* ***prx-2****, to maintain cell fates within the craniofacial mesenchyme*. **Development** 126: 495-504 (abstract only). Meckel's Cartilage.

Lucas, SG (1998), *Global Triassic tetrapod biostratigraphy and biochronology*. **Paleogeog. Palaeoclimatol., Palaeoecol.** 143: 347-384. *Aetosaurus*, Phytosauridae, *Redondasuchus*, *Rutiodon*, *Stagonolepis*, *Typothorax*.

Lucas SG (2006), *Global Permian tetrapod biostratigraphy and biochronology*, in SG Lucas, G Cassinis & JW Schneider (eds.). **Non-Marine Permian Biostratigraphy and Biochronology**. **Geol. Soc. Lond. Spec. Publ.** 265: 65-93. *Edaphosaurus*, *Glaucosaurus*.

Lund, R (1977), *New information on the evolution of bradydont Chondrichthyes*. **Fieldiana Geol.**33: 521-539. Cochliodontidae, Holocephali.

Lund, R (1980), *Viviparity and interutarine feeding in a new holocephalan fish from the Lower Carboniferous of Montana*. **Science**209: 697-699. Chimaeriformes; Myriacanthoidei.

Lund, R (1988), *New information on* ***Squatinactis caudispinatus*** *(Chondrichthyes, Cladodontida) from the Chesterian Bear Gulch limestone of Montana.* **J. Vert. Paleontol.** 8: 340-342. Squatinactidae

Lund, R (1990), *Chondrichthyan life history styles as revealed by the 320 million years old Mississippian of Montana*. **Env. Biol. Fishes**27: 1-19. Chimaeroidei, Cochliodontidae, Holocephali.

Lund, R (2000), *The new actinopterygian order Guildayichthyiformes from the Lower Carboniferous of Montana (USA)*. **Geodiversitas** 22: 171-206. Actinopterygii, Cladistia, The Dermosphenotic, Eothyrididae, Guildayichthyiformes, The Opercular Series.

Lund, R & WL Lund (1984), *New genera and species of coelacanths from the Bear Gulch Limestone (Lower Carboniferous) of Montana (U.S.A.)*. **Geobios**, 17: 237-244. *Allenypterus*, *Caridosuctor*, *Hadronector*, *Lochmocercus*, *Polyosteorhynchus*, *Rhabdoderma*.

Lund, R & WL Lund (1985), *Coelacanths from the Bear Gulch Limestone (Namurian) of Montana and the evolution of the Coelacanthiformes*. **Bull. Carnegie Mus. Nat. Hist.**25: 1-74. *Hadronector*, *Polyosteorhynchus*, *Rhabdoderma*.

Luo, Z-X (1998), *Homology and transformation of cetacean ectotympanic structures* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 269-301. Autoceta, Basilosauridae, Cetacea, Mysticeti, Odontoceti, Pakicetidae, Physeteroidea, Protocetidae, Rhabdosteidae.

Luo, Z-X (1999), *A refugium for relicts*. **Nature**23-25.

Luo, Z-X & ER Eastman (1995), *Petrosal and inner-ear of a squalodontoid whale - implications for evolution of hearing in Odontocetes*. **J. Vert. Paleontol.**15: 431-442. Autoceta, Ear, Odontoceti, Squalodontidae.

Luo ZX (2001), *The inner ear and its bony housing in tritylodontids and implications for evolution of the mammalian ear*. **Bull. Mus. Comp. Zool.** 156: 81-97. Glossary.

Luo, Z-X, RL Cifelli & Z Kielan-Jaworowska (2001a), *Dual origin of tribosphenic mammals.* **Nature** 409: 53-57. Ausktribosphenida, Australosphenida, Cladotheria, Mammalia; Mammalia Overview, Spalacotheroidea, Symmetrodonta.

Luo, Z-X, AW Crompton, & A-L Sun (2001), *A new mammaliaform from the Early Jurassic and evolution of mammalian characteristics*. **Science** 292: 1535-1546. *Hadrocodium*, Multituberculata, Triconodonta.

Luo, Z-X, Z Kielan-Jaworowska & RL Cifelli (2002), *In quest for a phylogeny of Mesozoic mammals*. **Acta Palaeontol. Pol.** 47: 1-78. *Amphilestes*, Ausktribosphenidae, Docodontidae, *Gobiconodon*, *Jeholodens*, Kuehneotheriidae, Mammalia Overview, Mammaliaformes, *Priacodon*, Theriodonta, Triconodonta, Triconodontidae, *Trioracodon*, Trithelodontidae, Tritylodontidae.

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References

-M-

Maas, MC (1997), *Enamel microstructure in notoungulates*, **in** RF Kay *et al*. [eds.], **Vertebrate Paleontology in the Neotropics: the Miocene Fauna of La Venta, Colombia**. Smithsonian Inst. Press: pp. 319-334. Notostylopidae.

Maas, MC, JGM Thewissen, S Sen, N Kazanci & J Kappelman (2001), *Enigmatic new ungulates from the Early Middle Eocene central Anatolia, Turkey*. **J. Vert. Paleontol.** 21: 578-590. *Hilalia*.

Macey, JR, A Larson, NB Ananjeva & TJ Papenfuss (1997), *Replication slippage may cause parallel evolution in the secondary structures of mitochondrial transfer RNAs*. **Mol. Biol. Evol.** 14: 30-39. Anguimorpha

Macey, JR, JA Schulte II & A Larson (2000),*Evolution and phylogenetic information content of mitochondrial genomic structural features illustrated with acrodont lizards.* **Syst. Biol.** 49: 257-277. Acrodonta, Cuculiformes.

Macey, JR, JA Schulte II, A Larson, NB Ananjeva, Y Wang, R Pethiyagoda, N Rastegar-Puyani, & TJ Papenfuss (2000a), *Evaluating trans-Tethys migration: an example using acrodont lizard phylogenetics.* **Syst. Biol.** 49: 233-256. Acrodonta, Agamidae, Amphibolurinae, Draconinae.

MacFadden, BJ & GS Morgan (2003), *New oreodont (Mammalia, Artiodactyla) from the Late Oligocene (Early Arikareean) of Florida*. **Bull. Amer. Mus. Nat. Hist.**279: 368-396. WWW. Entelodontoidea, Oreodontoidea.

MacPhee, RDE & MJ Novacek (1993), *Definition and relationships of Lipotyphla*, **in**FS Szalay, MJ Novacek & MC McKenna [eds.], **Mammal Phylogeny: Placentals**, Springer 2: 13–31. Chrysochloroidea, Crocidurinae, Insectivora, Palaeoryctidae, Soricidae, Soricinae.

Macrini TE, C DeMuizon, RL Cifelli & T Rowe (2007), *Digital cranial endocast of* ***Pucadelphys andinus****, a Paleocene metatherian*, **J. Vert. Pal.** 27: 99–107. Glossary.

Madar, SI (1998), *Structural adaptations of early archaeocete long bones* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 353-378. *Basilosaurus*, *Dorudon*, Protocetidae.

Mader, B & R Bradley (1989), *A redescription and revised diagnosis of the syntypes of the Mongolian tyrannosaur* ***Alectrosaurus olseni***. **J. Vert. Paleontol.**9: 41-55. *Alectrosaurus*, Ornithomimosauria, Tyrannosauridae.

Maisey, JG (1977), *The fossil selachian fishes* ***Palaeospinax****Egerton, 1872 and* ***Nemacanthus****Agassiz, 1837*. **Zool. J. Linn. Soc.**60: 259-273. Cladoselachida, *Synechodus*.

Maisey, JG (1981), *Studies on the Paleozoic selachian genus* ***Ctenacanthus*** *Agassiz no. 1. Historical review and revised diagnosis of* ***Ctenacanthus****, with a list of referred taxa.* **Am. Mus. Nov.** 2718, 22 pp. Ctenacanthidae.

Maisey, JG (1982), *The anatomy and interrelationships of Mesozoic hybodont sharks*. **Amer. Mus. Nov.**No. 2724, 48 pp. Cladoselachida.

Maisey, JG (1983), *Cranial Anatomy of* ***Hybodus basanus****Egerton from the Lower Cretaceous of England*. **Am. Mus. Nov.** No. 2758, 64pp. Cladoselachida.

Maisey, JG (1984), *Higher elasmobranch phylogeny and biostratigraphy*. **Zool. J. Linn. Soc.**82: 33-54. Synechodontiformes, *Synechodus*.

Maisey, JG (1984a), *Chondrichthyan phylogeny: a look at the evidence*. **J. Vert Paleontol.** 4: 359-371. Cladoselachida, Synechodontiformes.

Maisey, JG (1985), *Cranial morphology of the fossil elasmobranch* ***Synechodus dubrisiensis***. **Amer. Mus. Nov.**2804, 28 pp. Synechodontiformes, *Synechodus*.

Maisey, JG (1988), *The phylogeny of early vertebrate skeletal induction and ossification patterns*. **Evol. Biol.** 22: 1-36. Osteichthyes.

Maisey, JG (1993), *The interrelationships of* ***Protospinax****(Elasmobranchii: Hypnosqualea) reviewed in light of new material*. **J. Vert. Paleontol.**13: 48A (Abstract) Hypnosqualea, *Protospinax*, Synechodontiformes.

Maisey, JG (2001), *CT-scan reveals new cranial features in Devonian chondrichthyan "****Cladodus****" wildungensis*. **J. Vert. Paleontol.**21: 807-810. Cladoselachida.

Maisey, JG (2004), *Morphology of the braincase in the broadnose sevengill shark* ***Notorynchus****(Elasmobranchii, Hexanchiformes), based on CT scanning*. **Amer. Mus. Nov.**3429, 52 pp. Glossary, *Psarolepis*, *Synechodus*.

Maisey, JG (2005), *Braincase of the Upper Devonian shark Cladodoides wildungensis (Chondrichthyes, Elasmobranchii), with observations on the braincase in early chondrichthyans*. **Bul. Am. Mus. Nat. Hist.**No. 288, 103 pp. Chondrichthyes Crown Group.

Makovicky, PJ, MA Norell, JM Clark & T Rowe (2003), *Osteology and relationships of* ***Byronosaurus jaffei****(Theropoda: Troodontidae)*. **Amer. Mus. Nov.** 3402, 21 pp. The Ear, Troodontidae.

Mallatt, J (1996), *Ventilation and the origin of jawed vertebrates: a new mouth*. **Zool. J. Linn. Soc.** 117: 329-404. Meckel's Cartilage.

Mallatt, J, J-Y Chen & ND Holland (2003), *Comment on "A new species of Yunnanozoan with implications for deuterostome evolution"*, **Science**1372c. WWW. *Haikouella*.

Manabe, M (1999), *The early evolution of the Tyrannosauridae in Asia*. **J. Paleontol.** 73: 1176-1178. Tyrannosauridae.

Mancum, DJ, EA Tuley, LA Westfield, NK Worrall, BB Shelton-Inloes, JM Sorace, YG Alevy & JE Sadler (1989), *Structure of the gene for human von Willebrand Factor*, **J. Biol. Chem.**264: 19514-19527. Insectivora

Manley, GA & JA Clack (2004), *Vertebrate systematics and an outline of the evolution of vertebrate hearing organs*, in **Evolution of the Vertebrate Auditory System**, GA Manley, A Popper & RR Fay (eds), Springer-Verlag, pp. 1-26. Tetrapoda.

Marivaux, L, J-L Welcomme, P-O Antoine, G Métais, IM Baloch, M Benammi, Y Chaimanee, S Ducrocq & J-J

Jaeger (2001), *A fossil lemur from the Oligocene of Pakistan*. **Science** 294: 587-591. Adapiformes, Lemuriformes, Lemuroidea.

Marsh, OC (1884), *Principal characters of American Jurassic dinosaurs. Part VIII. The order Theropoda*. **Am. J. Sci.** (3rd ser.) 27: 329-340. *Coelurus*.

Marsh, OC (1888), *Notes of a new genus of Sauropoda and other new dinosaurs from the Potomac Formation*. **Am. J. Sci.** (3rd ser.) 31: 89-94. *Coelurus*.

Marss, T (1986), *Squamation of the thelodont agnathan **Phlebolepis***. **J. Vert. Paleontol.**6: 1-11. Katoporida, Loganiidae, *Phlebolepis*, Thelodonti, Thelodontida.

Marss, T (1999), *A new Late Silurian or Early Devonian thelodont from the Boothia peninsula, Arctic Canada*, **Palaeontology**42: 1079-1099. Archipelepididae, Nikoliviidae.

Marss, T (2002), *Silurian and Lower Devonian anaspids (Agnatha) from Severnaya Zemlya (Russia)*, **Geodiversitas**24: 123-137. Cephalaspidida

Marss, T & VN Karatajute-Talimaa (2002), *Ordovician and Lower Silurian thelodonts from Severnaya Zemlya Archipelago (Russia)*, **Geodiversitas**24: 381-404. Loganiidae

Marss, T & A Ritchie (1998), *Articulated thelodonts (Agnatha) of Scotland*, **Trans. Roy. Soc. Edinburgh, Earth Sci.** 88: 143-195. Epibranchials, *Lanarkia*, *Loganellia*, *Shielia*.

Marss, T, MVH Wilson & R Thorsteinsson (2002), *New thelodont (Agnatha) and possible chondrichthyan (Gnathostomata) taxa established in the Silurian and Lower Devonian of the Canadian Arctic Archipelago*. **Proc. Estonian Acad. Sci.**51: 88-120. Teeth.

Maryanska, T, H Osmólska & M Wolsan (2002), *Avialan status for Oviraptorosauria*. **Acta Pal. Pol.**47: 97-116. Aves, Oviraptorosauria.

Mathur, AK & PD Polly (2000), *The evolution of enamel microstructure: how important is amelogenin?* **J. Mamm. Evol.**7: 23-42. Teeth

Mazan, S, D Jaillard, B Baratte & P Janvier (2000), ***Otx1**gene-controlled morphogenesis of the horizontal semicircular canal and the origin of the gnathostome characteristics*. **Evol. & Devel.**2: 186. Teeth.

McCauley, DW & M Bronner-Fraser (2003), *Neural crest contributions to the lamprey head*. **Development**130: 2317-2327 Teeth.

McEachran, JD, KA Dunn & T Miyake (1996), *Interrelationships of the batoid fishes (Chondrichthyes: Batoidea)*, **in**MLJ Stiassny, LR Parenti & GD Johnson (eds.), **Interrelationships of Fishes**. Academic Press, pp. 63-84. Batomorphii, Hypnosqualea.

McGowan, C (1991), **Dinosaurs, Spitfires and Sea Dragons**. Harvard Univ. Press, 365 pp. *Ichthyosaurus*, *Temnodontosaurus*.

McGowan, C (1995), *A remarkable small ichthyosaur from the Upper Triassic of British Columbia, representing a new genus and species*. **Can. J. Earth Sci.**32: 292-303. Eurhinosauria.

McGowan, C (1997), *A transitional ichthyosaur fauna*, **in**JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles**. Academic Press, pp. 61-80. *Ichthyosaurus*, Shastasauria, *Temnodontosaurus*, Thunnosauria.

McKenna, MC (1956), *Survival of primitive notoungulates and condylarths into the Miocene of Colombia*. **Amer. J. Sci.**254: 736-743. Notoungulata.

McKenna, MC (1963), *New evidence against tupaioid affinities of the mammalian family Anagalidae*. **Amer. Mus. Nov.**2158, 16 pp. Anagalidae

Mendoza, M, CM Janis & P Palmqvist (2002) *Characterizing complex craniodental patterns related to feeding*

behaviour in ungulates: a multivariate approach. **J. Zool.**258: 223-246. Stenomylinae.

Meylan, PA (1996), *Skeletal morphology and relationships of the early Cretaceous side-necked turtle,* ***Araripemys barretoi*** *(Testudines: Pelomedusoides: Araripemyidae), from the Santana formation of Brazil*. **J. Vert. Paleontol.** 16: 20-33. Podcnemoidae

Miao, D (1993), *Cranial morphology and multituberculate relationships*, in FS Szalay, MJ Novacek & MC McKenna (eds.), **Mammal Phylogeny: Mesozoic Differentiation, Multituberculates, Monotremes, Early Therians, and Marsupials**. Springer-Verlag, pp. 63-74. Allotheria; Cimolodonta; Multituberculata.

Michard, J-G (1988), *La dentine d'****Ouranosaurus nigeriensis*** *(Ornithischia, Iguanodontidae): étude en microscopie photonique et électronique*. **Bull. Mus. Nat. Hist. Paris (4^{me} sér.)** 10: 405-418. *Ouranosaurus*.

Miles, CA, K Carpenter & K Cloward (1998), *A new skeleton of* ***Coelurus fragilis*** *from the Morrison Formation of Wyoming*. **J. Vert. Paleontol.** 18: 64A. *Coelurus*.

Miller CG & T Marss (1999), *A conodont, thelodont and acanthodian fauna from the Lower Pridoli (Silurian) of the Much Wenlock area, Shropshire*. **Palaeontology**42: 691-714. Loganiidae.

Miller, RF, R Cloutier & S Turner (2003), *The oldest articulated chondrichthyan from the Early Devonian period*. **Nature**425: 501-504. *Psarolepis*.

Milner, AC & W Lindsay (1998), *Postcranial remains of* ***Baphetes****and their bearing on the relationships of the Baphetidae (=Loxommatidae)*. **Zool. J. Linn. Soc.**122: 211-235. *Baphetes*, Baphetidae.

Milner, AR (1980), *The Tetrapod assemblage from Nyrany, Czechoslovakia*, **in**AL Panchen (ed.), **The Terrestrial Environment and the Origin of Land Vertebrates**. Academic Press: pp.439-496. Cochleosauridae, Edopoidea.

Mindell, DP, MD Sorenson, CJ Huddleston, HC Miranda, Jr., A Knight, SJ Sawchuk & T Yuri (1997), *Phylogenetic relationships among and within select avian orders based on mitochondrial DNA,* in DP Mindell (ed.), **Avian Molecular Evolution and Systematics**. Academic Press. pp. 213-247. Acrodonta, Cuculiformes.

Mindell, DP, MD Sorenson & DE Dimcheff (1998),*Multiple independent origins of mitochondrial gene order in birds*. **Proc. Natl. Acad. Sci.** 95: 10693-10697. Cuculiformes.

Modesto SP (1994), *The Lower Permian synapsid* ***Glaucosaurus*** *from Texas*. **Paleontology** 37: 51–60. Edaphosauridae, *Edaphosaurus*, *Glaucosaurus*.

Modesto SP (1995), *The skull of the herbivorous synapsid* ***Edaphosaurus boanerges*** *from the Lower Permian of Texas*. **Palaeontology**, 38: 213–239. Edaphosauridae, *Edaphosaurus*,Sphenacodontia.

Modesto, SP, B Rubidge & J Welman (1999), *The most basal anomodont therapsid and the primacy of Gondwana in the evolution of the anomodonts*. **Proc. Roy. Soc. Lond, B** 266: 331-337. Neotherapsida.

Modesto SP & RR Reisz (1990), *A new skeleton of* ***Ianthosaurus hardestii****, a primitive edaphosaur (Synapsida: Pelycosauria) from the Upper Pennsylvanian of Kansas*. **Can. J. Earth Sci.** 27: 834-844. Edaphosauridae, *Edaphosaurus*,*Ianthasaurus*.

Modesto SP & RR Reisz (1990a), *Taxonomic status of* ***Edaphosaurus raymondi*** *Case*. **J. Paleontol.** 64: 1049-1051. *Edaphosaurus*,*Ianthasaurus*.

Modesto, SP & N Rybczynski (2000), *The amniote faunas of the Russian Permian: implications for Late Permian terrestrial vertebrate biogeography*, **in**MJ Benton, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**, Cambridge Univ. Press, pp. 17-34. Therapsida Overview.

Modesto, S, CA Sidor, BS Rubidge & J Welman (2001), *A second varanopseid skull from the Upper Permian of South Africa: implications for Late Permian 'pelycosaur' evolution*. **Lethaia** 34: 249-259. *Elliotsmithia*, Mycterosaurinae, Varanodontinae, Varanopseidae.

Moller, P (1995), **Electric Fishes: History and Behavior**, Chapman & Hall, 584 pp. Neoselachii Overview;

Torpediniformes.

Molnar, RE (1991), *Fossil reptiles of Australia*, **in** P Vickers-Rich, JM Monaghan, RF Baird & TH Rich (eds.), **Vertebrate Paleontology of Australia**. Pioneer Design Studio (Melbourne), pp.605-689. *Cimoliasaurus*, *Muttaburrasaurus*.

Monbaron, M (1978), *Nouveaux ossements de dinosauriens de grande taille dans le bassin Jurasso-Crétacé de Taguelft (Atlas de Beni-Mellal, Maroc)*. **C.R. Acad. Sci. Paris (Sér. D)** 287: 1277-1279. *Rebbachisaurus*.

Monbaron, M, DA Russell & P Taquet (1999), ***Atlasaurus imelakei*** *n.g., n.sp., a brachiosaurid-like sauropod from the Middle Jurassic of Morocco*. **C.R. Acad. Sci. Paris, Sci ter. plan.** 329: 519–526. *Atlasaurus*.

Montellano, M, A Weil & WA Clemens (2000), *An exceptional specimen of* ***Cimexomys judithae*** *(Mammalia: Multituberculata) from the Campanian Two Medicine Formation of Montana, and the phylogenetic status of* ***Cimexomys***. **J. Vert. Paleontol.** 20: 333-340. Cimolodonta.

Motani, R (1997), *Temporal and spatial distribution of tooth implantation in ichthyosaurs*, **in** JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles**. Academic Press. pp. 81-103. *Cymbospondylus*, Grippidia, Ichthyopterygia, Merriamosauria, *Mixosaurus*, Shastasauria, Tooth Implantation, *Utatsusaurus*.

Motani, R (1999), *On the evolution and homologies of ichthyopterygian forelimbs*. **J. Vert. Paleontol.** 19: 28-41. Shastasauria.

Motani, R, N Minoura & T Ando (1998), *Ichthyosaurian relationships illuminated by new primitive skeletons from Japan*. **Nature** 393: 255-257. Grippidia, Ichthyopterygia, Neodiapsida, *Utatsusaurus*.

Motta, PJ & CD Wilga (1999), *Anatomy of the feeding apparatus of the nurse shark,* ***Ginglymostoma cirratum***. **J. Morphol.** 241:33–60. *Diplocercides*.

Mouchaty, SK, A Gullberg, A Janke, & U Arnason, (2000), *Phylogenetic position of the Tenrecs (Mammalia: Tenrecidae) of Madagascar based on analysis of the complete mitochondrial genome sequence of* ***Echinops telfairi***, **Zool. Scripta** 29: 307-317. Insectivora, Tenrecoidea.

Mouchaty, SK, A Gullberg, A Janke, & U Arnason, (2000a), *The phylogenetic position of the Talpidae within Eutheria based on analysis of complete mitochondrial sequences*, **Mol. Biol. Evol.** 17: 60-67. Erinaceomorpha.

Moy-Thomas, JA & RS Miles (1971), **Palaeozoic Fishes** (2nd ed.). Chapman & Hall. Onychodontiformes, *Strunius*.

Müller, AH (1968), ***Lehrbuch der Paläozoologie***, **vol.II part 1 (Vertebrates)**. Rhinesuchidae.

Müller, AH (1985), **Lehrbuch der Paläozoologie - Bd.III, Vertebraten.** Gustav Fischer Verlag, 665 pp. *Anteosaurus*, *Deuterosaurus*

Müller, J & RR Reisz (2005), *An early captorhinid reptile (Amniota: Eureptilia) from the Upper Carboniferous of Hamilton, Kansas*. **J. Vert. Paleontol.** 23: 561-568. Amniota, Captorhinidae, *Concordia*, Eureptilia.

Murry, PA (1986), *Vertebrate paleontology of the Dockum Group* **in** K Padian (ed.), **The Beginning of the Age of Dinosaurs**. Cambridge Univ. Press. *Desmatosuchus*, *Longosuchus*, *Paratypothorax*, Poposauridae, *Pseudopalatus*, *Stagonolepis*.

-N-

Nelson, JS (1984), **Fishes of the World** (2nd ed.), Wiley, 523 pp. Torpediniformes

Nelson, JS (1994), **Fishes of the World** (3rd ed.), Wiley. Carcharhiniformes; *Dallia*, Esociformes, *Esox*, Galeomorphii; Heterodontiformes; Lamniformes; Neoselachii; *Novumbra*, Orectolobiformes, *Umbra*.

Newbrey MG, MVH Wilson & AC Ashworth (2005), *Growth characteristics of Cretaceous and Cenozoic North American Esociformes: implications for systematics*, **in**FJ Poyato-Ariza (ed.), **4th International Meeting on Mesozoic Fishes: Systematics, Homology, and Nomenclature: Extended Abstracts**, pp 201-204. Esociformes.

Nilsson, T. (1946), *A new find of* ***Gerrothorax rhaeticus*** *Nilsson a plagiosaurid from the Rhaetic of Scania*. **Lunds Univ. Årsskr.** N.F.(2) 42(10). Plagiosauridae.

Norman, DB (1990), *A review of* ***Vectisaurus valdensis****, with comments on the family Iguanodontidae*, **in** K Carpenter & PJ Currie (eds.), **Dinosaur Systematics: Perspectives and Approaches**. Cambridge Univ. Press, pp. 147-161. *Altirhinus*, Hadrosauridae, Hadrosauroidea, Jugals, *Nanyangosaurus*, *Ouranosaurus*.

Norman, DB & H-D Sues (2000), *Ornithopods from Kazakhstan, Mongolia and Siberia*, **in** MJ Benton, MA Shshkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**. Cambridge Univ. Press. pp. 462-479. *Altirhinus*

Norman, DB & DB Weishampel (1990), *Iguanodontidae and related ornithopods* **in** DB Weishampel, P Dodson, & H Osmólka (eds.), **The Dinosauria**. Univ. Calif. Press, pp. 510-533. *Ouranosaurus*.

Norman, JE & MV Ashley (2000), *Phylogenetics of Perissodactyla and tests of the molecular clock*. **J. Mol. Evol.**50: 11-21 Hippomorpha.

Nosotti, S & G Pinna (1999), *Skullanatomy of* ***Protenodontosaurus italicus****Pinna 1990 (Reptilia: Placodontia)*. **Paleontol. Lombarda n.s.**11 (17 pp.).

Novas, FE (1996), *Dinosaur monophyly*. **J. Vert. Paleontol.** 16: 723-741. Pterodactyloidea

Novas, FE (1997), *Anatomy of* ***Patagonykus puertai****(Theropoda, Avialae, Alvarezsauridae) from the Late Cretaceous of Patagonia*. **J. Vert. Paleontol.**17: 137-166. Alvarezsauridae, *Alvarezsaurus*, *Mononykus*, *Patagonykus*.

Новицкая, ЛИ (1986), "Древнейшие бесчелюстные СССР: Гетерострaки: Циатаспиды, Амфиаспиды, Птераспиды." **Труды ПИН**219: 159с. [Novitskaya, LI (1986), *The most ancient agnathans of the USSR: Heterostraci: Cyathaspidae, Amphiaspidae, Pteraspidae*. **Trudy Paleontol. Inst. Nauk** 219: 159 pp.] My thanks to Dr. Stella Fitzgibbon for assistance with the translation. Amphiaspidida, Amphiaspidoidei, *Ctenaspis*, Hibernaspidoidei, Siberiaspidoidei.

Nowak, RM (ed.) (1991), **Walker's Mammals of the World** (5th ed.), Johns Hopkins Univ. Press, 1629 pp. (2 vols). Autoceta, Cetacea, Chrysochloroidea, Erinaceinae, Erinaceomorpha, Hylomyinae, Insectivora, Lorisiformes, Macroscelidea, Mysticeti, Odontoceti, Physeteroidea, Solenodontidae, Soricidae, Talpoidea, Tenrecoidea.

Nydam, RL (2000), *A new taxon of helodermatid-like lizard from the Albian-Cenomanian of Utah* **J. Vert. Paleontol.** 20: 285-294. Anguimorpha; Monstersauria.

-O-

O'Keefe, FR, O Rieppel & PM Sander (1999) *Shape disassociation and inferred heterochrony in a clade of pachypleurosaurs (Reptilia, Sauropterygia)*. **Paleobiology**25: 504-517. *Neusticosaurus*, Pachypleurosauridae.

O'Reilly, JC, RA Nussbaum & D Boone (1996), *Vertebrate with protrusible eyes*. **Nature** 382: 33. H. Gymnophiona.

O'Reilly, JC, DA Ritter & DR Carrier (1997), *Hydrostatic locomotion in a limbless tetrapod*. **Nature** 386:269-272. Gymnophiona.

Olsen, PE & H-D Sues (1986), *The Triassic-Jurassic tetrapod transition*, **in**K Padian (ed.), **The Beginning of the Age of Dinosaurs**. Vulcanodontidae.

Olsen, PE, H-D Sues & MA Norell (2000), *First Record of* ***Erpetosuchus****(Reptilia: Archosauria) from the Late*

Triassic of North America. **J. Vert. Paleontol.** 20: 633–636. *Erpetosuchus*, *Gracilisuchus*.

Olshevsky, G (1994), *The origin and evolution of the heterodontosaurians* (unpub. English text). Genasauria.

Olson, EC (1962), *Late Permian terrestrial vertebrates, USA and USSR*, **Trans. Amer. Phil. Soc.**52(2). Anteosauria, *Doliosauriscus*, *Syodon*.

Olson EC (1968), *The family Caseidae*. **Fieldiana** 17: 225-349. *Edaphosaurus*, *Lupeosaurus*.

Olson, SL (1999), *The anseriform relationships of **Anatalavis** Olson and Parris (Anseranatidae), with a new species from the lower Eocene London Clay*. **Smithsonian Contribs. Paleobiol.**89: 231-243. *Anatalavis*, Anatidae, *Cnemiornis*, Presbyornithidae.

Olson, SL & A Feduccia (1980), ***Presbyornis** and the origin of the Anseriformes (Aves, Charadrimorphae)* **Smithsonian Contribs. Zool.**323, 24 pp. Galloanserae, *Presbyornis*.

Olson, SL & DC Parris (1987), *The Cretaceous birds of New Jersey.* **Smithsonian Contribs. Paleobiol.**63, 22 pp. *Anatalavis*, Anseres.

-P-

Padian, K (1997a), *Pterosauria*, **in**Currie, PJ and K Padian (eds.), **Encyclopedia of Dinosaurs** Academic Press, pp. 613-617. Pterosauria.

Padian, K, JR Hutchinson & TR Holtz, Jr. (1999), *Phylogenetic definitions and nomenclature of the major taxonomic categories of the carnivorous Dinosauria (Theropoda)*. **J. Vert. Paleontol.** 19: 69-80. Allosauridae, Allosauroidea, Aves Overview, Carinatae, Carnosauria, Ceratosauria, Coelurosauria, Maniraptora, Metornithes, Ornithothoraces, Ornithurae, Sinraptoridae, Tetanurae, Theropoda.

Padian, K & M Smith (1992), *New light on Late Cretaceous pterosaur material from Montana*. **J. Vert Paleontol.** 12: 87-92. Azhdarchoidea; Ornithocheiroidea, Pterodactyloidea, Pterosauria, Rhamphorhynchoidea

Page, LM & BM Burr (1991), **A Field Guide to Freshwater Fishes of North America North of Mexico**. Houghton Mifflin Co., 432 pp. *Dallia*, Esociformes, *Esox*, *Novumbra*, *Umbra*.

Paladino, FV, JR Spolita & P Dodson (1997), *A blueprint for giants: modeling the physiology of large dinosaurs*, in Farlow, JO & MK Brett-Surman (eds.), **The Complete Dinosaur**, pp. 491-504. Titanosauria.

Parks, P (1969), **Cranial Anatomy and Mastication of the Triassic Reptile *Trilophosaurus***. M.A. thesis, U. Texas. 88 pp. Braincase Overview, Trilophosauridae.

Parrish, JM (1993), *Phylogeny of the Crocodylotarsi, with reference to archosaurian and crurotarsan monophyly*, **J. Vert. Paleontol.**13: 287-308. Aetosauridae, Archosauria, *Batrachotomus*, Crocodylomorpha, Crurotarsi, Euparkeriidae, *Gracilisuchus*, Ornithodira, Ornithosuchidae, Poposauridae, Prestosuchidae, Proterochampsidae, Rauisuchia, Rauisuchidae, *Riojasuchus*, *Saurosuchus*, Suchia, *Ticinosuchus*.

Parrish, JM (1994), *Cranial osteology of **Longosuchus meadei** and the phylogeny and distribution of the Aetosauria*, **J. Vert. Paleontol.**, 14: 196-209 - abstract. *Aetosaurus*, *Longosuchus*, *Stagonolepis*.

Patterson B (1977), *A primitive pyrothere (Mammalia, Notoungulata) from the Early Tertiary of northwestern Venezuela*. **Fieldiana Geol.** 33: 397-422. Notoungulata.

Patterson, C (1965), *The phylogeny of the chimaeroids*. **Phil. Trans. Roy. Soc. Lond. B**249: 101-219. Chimaeriformes, Chimaeroidei, Holocephali, Menaspidae, Myriacanthoidei.

Patterson, C (1992), *Interpretation of the toothplates of chimaeroid fishes*. **Zool. J. Linn. Soc.**106: 33-61.

Holocephali.

Perle, A, MA Norell, LM Chiappe & JM Clark (1993), *Flightless bird from the Cretaceous of Mongolia*. **Nature**362: 623-626. Metornithes, *Mononykus*, Ornithothoraces

Peters, D (1997), *A new phylogeny for the Pterosauria*. **J. Vert. Paleontol.** 17: 69A [abstract]. Ctenochasmatoidea, Pterodactyloidea.

Peters, H, B Wilm, N Sakai, K Imai, R Maas & R Balling (1999), ***Pax1****and* ***Pax9****synergistically regulate vertebral column development*. **Development**126: 5399-5408. Teeth

Petronio, C (1995), *Note on the taxonomy of Pleistocene hippopotamuses*. **Ibex**3:53-55. WWW. Hippopotamidae.

Piotrowski, T & C Nüsslein-Volhard (2000), *The endoderm plays an important in patterning the segmented pharyngeal region in zebrafish (**Danio rerio**)*. **Devel. Biol.**225: 339–356. Teeth.

Piotrowski, T, TF Schilling, M Brand, Y-J Jiang, C-P Heisenberg, D Beuchle, H Grandel, FJM van Eeden, M Furutani-Seiki, M Granato, P Haffter, M Hammerschmidt, DA Kane, RN Kelsh, MC Mullins, J Odenthal, RM Warga & C Nüsslein-Volhard (1996), *Jaw and branchial arch mutants in zebrafish II: anterior arches and cartilage differentiation*. **Development** 123: 345-356 (abstract only). Meckel's Cartilage.

Pisani, D, AM Yates, MC Langer & MJ Benton (2001), *A genus-level supertree of the Dinosauria*. **Proc. R. Soc. Lond. B**01pb0724, 7 pp.

Pough, FH, CM Janis & JB Heiser (1999), **Vertebrate Life** (5th ed.), Prentice Hall, 733+ pp. Multituberculata, Neoselachii Overview, Theria, Trematosauroidea.

Poyato-Ariza, FJ & S Wenz (2002), *A new insight into pycnodontiform fishes*. **Geodiversitas**24: 139-248. WWW. Pycnodontiformes.

Prasad, GVR & BK Manhas (2002), *Triconodont mammals from the Jurassic Kota Formation of India*. **Geodiversitas**24: 445-464. *Jeholodens*.

Proctor, NS & PJ Lynch (1993), **Manual of Ornithology: Avian Structure & Function**. Yale Univ. Press, 340 pp. Aves Overview, Ornithurae.

Prothero, DR & RM Schoch (2002), **Horns, Tusks, and Flippers: the Evolution of Hoofed Mammals**. Johns Hopkins Univ. Press, 311 pp. Anthracotheroidea, Entelodontoidea, Hippopotamidae, Oreodontoidea, *Poebrotherium*, Suina.

Purnell, MA (1995), *Microwear on conodont elements and macrophagy in the first vertebrates*. **Nature** 374: 798-800. Conodonta, Euconodonta, Ozarkodinida.

Purnell, MA (2001), *Feeding in conodonts and other early vertebrates* **in**DEG Briggs & PR Crowther (eds.), **Paleobiology II**. Blackwell Science: 583 pp. Conodonta, Ozarkodinida

Purnell, MA (2001a), *Scenarios, selection and the ecology of early vertebrates* **in**PE Ahlberg (ed.), **Major Events in Vertebrate Evolution: Palaeontology, Phylogeny, Genetics, and Development**. Systematics Assoc. Spec. Vol. Ser. 61, pp. 187-208. Conodonta, Ozarkodinida

Purnell, MA (2001b), *Feeding in extinct jawless heterostracan fishes and testing scenarios of early vertebrate evolution*, **Proc. Roy. Soc. Lond. B**269: 83-88.

Purnell, MA & PCJ Donoghue (1997), *Architecture and functional morphology of the skeletal apparatus of ozarkodinid conodonts*. **Phil. Trans. Roy. Soc. Lond. B** 352: 1545-1564. Conodonta, Ozarkodinida.

Purnell, MA, PCJ Donoghue & RJ Aldridge (2000), *Orientation and anatomical notation in conodonts*. **J. Paleontol.**74: 113-122. Prioniodontida, Ozarkodinida.

-Q-

Quérouil, S, R Hutterer, P Barrière, M Colyn, JC K Peterhans, & E Verheyen (2001), *Phylogeny and Evolution of African Shrews (Mammalia: Soricidae) Inferred from 16s rRNA Sequences*, **Mol. Phylogen. & Evol.**20: 185-195. Crocidurinae, Insectivora, Soricidae, Soricinae.

-R-

Rae, TC (1999), *Mosaic evolution in the origin of the Hominoidea*. **Folia Primatol.**70: 125-135. WWW. Hominoidea.

Rage, J-C (2003), *Relationships of the Malagasy fauna during the Late Cretaceous: Northern or southern routes?* **Acta Pal. Pol.**48: 661-662. Ratites.

Rasmussen, TE & G Callison (1981), *A new species of triconodont mammal from the Upper Jurassic of Colorado.* **J. Paleontol.**55:628-634. *Priacodon*.

Reid, REH (1997), *Dinosaurian physiology: the case for "intermediate" dinosaurs*, in Farlow, JO & MK Brett-Surman (eds.), **The Complete Dinosaur**, pp. 449-473. Titanosauria.

Reif, WE (1980), *Development of dentition and dermal skeleton in embyronic* ***Scyliorhinus canicula***. **J. Morphol.**166: 275-288. Teeth

Reisz, RR (1972), *Pelycosaurian reptiles from the Middle Pennsylvanian of North America*. **Bull. Mus. Comp. Zool.** 144: 27-62. Synapsida, Varanopseidae.

Reisz, RR (1986), *Pelycosauria*, **Encylopedia of Paleoherpetology, Part 17A**, Fischer Verlag.

Reisz RR & VS Berman (1986), ***Ianthosaurus hardestii n. sp.***, *a primitive ephadosaur (Reptilia, Pelycosauria) from the Upper Pennsylvanian Rock Lake Shale near Garnett, Kansas.* **Can. J. Earth Sci.** 23: 77-91. Edaphosauridae, *Edaphosaurus*, *Ianthasaurus*, Ophiacodontidae.

Reisz, RR, DS Berman & D Scott (1992), *The cranial anatomy and relationships of* ***Secodontosaurus***, *an unusual mammal-like reptile (Synapsida: Sphenacodontidae) from the Early Permian of Texas*. **Zool. J. Linn. Soc.** 104: 127–184. Sphenacodontidae.

Reisz, RR, DW Dilkes & DS Berman (1998),*Anatomy and relationships of* ***Elliotsmithia longiceps*** *Broom, a small synapsid (Eupelycosauria: Varanopseidae) from the Late Permian of South Africa*. **J. Vert. Paleontol.** 18: 602-611. *Aerosaurus*, *Elliotsmithia*, Jugals, Mycterosaurinae, *Mycterosaurus*, Varanodontinae, *Varanops*, Varanopseidae.

Reisz, RR, H Wilson & D Scott (1997), *Varanopsieid synapsid skeletal elements from Richards Spur, a Lower Permian fissure fill near Fort Sill, Oklahoma.* **Okla. Geol. Notes** 56: 160-170. *Mycterosaurus*, Sphenacodontidae, Varanopseidae.

Reynoso, V-H (1996), *A Middle Jurassic* ***Sphenodon****-like sphenodontian (Diapsida: Lepidosauria) from Huizachal Canyon, Tamaulipas, Mexico*. **J. Vert. Paleontol.** 16: 210-221. Clevosaurs; Sphenodontidae; Sphenodontinae.

Reynoso, V-H (1997), *A "beaded" sphenodontian (Diapsida: Lepidosauria) from the Early Cretaceous of Central Mexico*. **J. Vert. Paleontol.** 17: 52-59. Sphenodontidae; Sphenodontinae.

Reynoso, V-H & JM Clark (1998), *A dwarf sphenodontian from the Jurassic La Boca formation of Tamaulipas, Mexico*. **J. Vert. Paleontol.** 18: 333-339. Clevosaurs; Sphenodontidae; Sphenodontinae.

Rich, TR, TF Flannery, P Trusler, L Kool, NA van Klaveren, & P Vickers-Rich (2001), *A second tribosphenic mammal from the Mesozoic of Australia*. **Rec. Queen Victoria Mus.** 110: 1-9. Ausktribosphenidae, Australosphenida, Mammalia Overview.

Rich, TR, RA Gangloff & WR Hammer (1997), *Polar dinosaurs* in PJ Currie & K Padian (eds.), **Encyclopedia of Dinosaurs**. Academic Press, pp. 562-573. *Cryolophosaurus*.

Rieppel, O (1989), *A new pachypleurosaur (Reptilia: Sauopterygia) from the Middle Triassic of Monte San Giorgio, Switzerland*. **Phil. Trans. Roy. Soc. Lond. B** 323: 1-73. *Anarosaurus*, *Dactylosaurus*, Diapsida, *Keichousaurus*, Lepidosauromorpha, Neodiapsida, *Neusticosaurus*, Nothosauria, Pachypleurosauridae, *Serpianosaurus*, *Simosaurus*.

Rieppel, O (1995), *Studies on skeleton formation in reptiles: implications for turtle relationships*. **Zoology -- Analysis of Complex Systems**98: 298-308. Testudines.

Rieppel, O (1995), *The pachypleurosaur **Neusticosaurus**(Reptilia, Sauropterygia) from the Middle Triassic of Perledo, Northern Italy*. **N. Jahrb. Geol. Pal. Mon.**1995: 205-216. *Neusticosaurus*, Pachypleurosauridae, *Serpianosaurus*.

Rieppel, O (1997), *Sauropterygia: Introduction*, in JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles** Academic Press, pp. 107-119. Eusauropterygia

Rieppel, O & H Hagdorn (1997), *Paleobiogeography of Middle Triassic Sauropterygia in Central and Western Europe*, in Callaway, JM & EL Nicholls (eds), **Ancient Marine Reptiles**, Academic Press, pp. 121-44. Pachypleurosauridae.

Rieppel, O & L Kebang (1995), *Pachypleurosaurs (Reptilia, Sauropterygia) from the lower Muschelkalk, and a review of the Pachypleurosauroidea*. **Fieldiana (Geology)** No. 1473, N.S.32:1-44. Pachypleurosauridae.

Rieppel, O & R Wild (1996), *A revision of the genus **Nothosaurus**(Reptilia: Sauropterygia) from the Germanic Triassic, with comments on the status of **Conchiosaurus clavatus***. **Fieldiana (Geology)**No.1479, 82 pp. Nothosauridae

Rieppel, O & H Zaher (2000), *The braincases of mosasaurs and **Varanus,** and the relationships of snakes*. **Zool. J. Linn. Soc.** 129: 489-514. Dipnomorpha, The Opisthotic, The Prootic, Varanoidea.

Rijli FM, M Mark, S Lakkaraju, A Dierich, P Dolle & P Chambon (1993), *A homeotic transformation is generated in the rostral branchial region of the head by disruption of **Hoxa-2**, which acts as a selector gene.* **Cell** 31: 1333-49 (abstract only) Meckel's Cartilage.

Ritchie, A (1967), ***Ateleaspis tessellata** Traquair, a non-cornuate cephalaspid from the Upper Silurian of Scotland*. **Zool. J. Linnean Soc.**47: 69-81. [This issue, no. 311, was published as a separate *festschrift* volume for Dr. Errol I. White and is sometimes cited -- and filed by librarians – as "Patterson, C & PH Greenwood (eds.) (1967) , **Fossil Vertebrates**. Academic Press"] *Ateleaspis*

Robinson, JA (1975), *The locomotion of plesiosaurs*. **N. Jb. Geol. Palaont. Abh.**149: 286-332. Plesiosauria

Robinson, JA (1977), *Intercorporal force transmission in plesiosaurs*. **N. Jb. Geol. Palaont. Abh.**153: 88-128. Plesiosauria

Rodrídguez-Vázquez, JF, JR Mérida-Velasco, LA Arráez-Aybar & J Jiménez-Collado (1997), *A duplicated Meckel's cartilage in a human fetus*. **Anat. Embryol.**195: 497-502 (abstract only). Meckel's Cartilage.

Rogers, KC & CA Forster (2001), The last of the dinosaur titans: a new sauropod from Madagascar. Nature 412: 530-534. Nemegtosauridae, *Rapetosaurus*, Saltasaurinae, Somphospondylii, Titanosauria, Titanosauriformes.

Romer, AS (1947) **Vertebrate Paleontology**, (3rd ed.1966) Univ. Chicago Press. *Uranocentradon*.

Romer, AS (1956), **Osteology of the Reptiles.** Krieger Publ. Co. (1997 ed.): 772 pp. Ankylosauria, Hypohyal, Jugals, *Lupeosaurus*, Sphenodontia Overview, Septomaxilla, Stegosauria, Stegosauridae, Thyreophora.

Romer, AS & LW Price (1940), *Review of the Pelycosauria*. **Geol. Soc. Amer. Spec. Papers** 28: 1-538. *Aerosaurus*, Amiiformes, Edaphosauridae, *Edaphosaurus*, *Elliotsmithia*, *Ianthasaurus*, Jugals, *Varanops*, Varanopseidae

Rose KD, RL Cifelli & TR Lipka (2001), *Second tricondont dentary from the Early Cretaceous of Maryland.* **J. Vert. Paleontol.**21: 628-632. Triconodontidae.

Rosen, DE (1974), *Phylogeny and zoogeography of salmoniform fishes and relationships of* ***Lepidogalaxias salamandroides***. **Bull. Am. Mus. Nat. Hist.**153: 265-326. Argentiniformes, *Dallia*, Esociformes, *Esox*, *Novumbra*, *Umbra*.

Ross, CF (2000), *Into the light: the origin of Anthropoidea*. **An. Rev. Anthropol.**29: 147-194. Anthropoidea, Haplorhini.

Rowe, T (1996), *Coevolution of the mammalian middle ear and neocortex*. **Science**273: 651-654. Procynosuchidae

Ruben, J, A Leitch, W Hillenius, N Geist & Terry Jones (1997), *New insights into the metabolic physiology of Dinosaurs*, **in**JO Farlow & MK Brett-Surman [eds.], **The Complete Dinosaur**. Univ. Indiana Press, pp. 505-518. Ethmoid

Rubidge, BS & CA Sidor (2001), *Evolutionary patterns among Permo-Triassic therapsids.* **Ann. Rev. Ecol. Syst.** 32: 449-480. Anteosauria, Biarmosuchia, Cynodontia, Cynognathia, Dinocephalia, Eucynodontia, Eutherapsida, Eutheriodontia, Gorgonopsia, Jugals, Neotherapsida, Probainognathia, Sphenacodontidae, Tapinocephalia, Therapsida, Theriodontia, Tritylodontidae.

Russell, DA & Z-M Dong (1993), *The affinities of a new theropod from the Alxa Desert, Inner Mongolia, People's Republic of China*. **Can. J. Earth Sci.** 30: 2107-2127. *Alxasaurus*, Therizinosauroidea.

Ruta, M, MI Coates & DLJ Quicke (2003), *Early tetrapod relationships revisited*.**Biol. Rev.**78: 251-345. *Acanthostega*, Elpistostegalia, *Ichthyostega*, Lepospondyli, *Ventastega*.

Ruxton GD (2001), *Heat loss from giant extinct reptiles*. **Proc. R. Soc. Lond. B** 268: 1921–1924. *Ianthasaurus*.

-S-

Sachs, S (2005), ***Tuarangisaurus australis*** *sp. nov. (Plesiosauria: Elasmosauridae) from the Lower Cretaceous of northeastern Queensland, with additional notes on the phylogeny of the Elasmosauridae*. **Mem. Queensl. Mus.**, 50: 425-440. Elasmosauridae.

Salgado, L, S Apesteguía & SE Heredia (2005), *A new specimen of* ***Neuquensaurus australis****, a Late Cretaceous saltasaurine titanosaur from North Patagonia*. **J. Vert. Paleontol.** 25: 623-634. Neosauropoda, *Neuquensaurus*, Saltasaurinae, *Saltasaurus*, Sauropoda, Titanosauria.

Sander, PM (1989), *The pachypleurosaurids (Reptilia: Nothosauria) from the Middle Triassic of Monte San Giorgio (Switzerland) with the description of a new species.* **Phil. Trans. Roy. Soc. Lond. B** 325: 561-666. *Neusticosaurus*, *Serpianosaurus*.

Sander, PM (1997), *The paleogeography of* ***Shastasaurus***, **in**JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles**. Academic Press, pp. 17-43. *Californosaurus*, *Cymbospondylus*, *Mixosaurus*, Shastasauria, Thunnosauria

Sanger, TJ & AR McCune (2002), *Comparative osteology of the* ***Danio****(Cyprinidae: Ostariophysi) axial skeleton with comments on* ***Danio****relationships based on molecules and morphology*. **Zool. J. Linn. Soc.**135: 529-546. WWW. Ostariophysi, Otophysi.

Sanmartín, I & F Ronquist (2004), Southern Hemisphere biogeography inferred by event-based models: Plant versus animal patterns. **Syst. Biol.**53:216–243. Ratites.

Sansom, IJ & DK Elliott (2002), *A thelodont from the Ordovician of Canada*, **J. Vert. Paleontol.**22: 867–870. Loganiidae, Thelodontida, Thelodontidae.

Sansom, IJ, MM Smith, & MP Smith (1996), *Shark and thelodont scales from the Ordovician of Colorado*, **Nature**379: 628-630. Loganiidae.

Sansom, IJ, MP Smith, HA Armstrong & MM Smith (1992), *Presence of the earliest vertebrate hard tissues in conodonts*. **Science**256: 1308-1311. Teeth

Santos-Ruiz, L, JA Santamaría & J Becerra (2001), *Differential expression of FGF receptors during zebrafish fin regeneration*. **Int. J. Dev. Biol.**45 (S1): S131-S132. WWW.

Scanlon, JD & MSY Lee (2000), *The Pleistocene serpent* ***Wonambi*** *and the early evolution of snakes*. **Nature** 403: 416-420. Aniliidae, Madtsoiidae, Serpentes.

Schaeffer, B (1981), *The xenacanth shark neurocranium, with comments on elasmobranch monophyly*. **Bul. Amer. Mus. Nat. Hist.**No. 169, 66 pp. Cladoselachida.

Schilling, TF & CB Kimmel (1997), *Musculoskeletal patterning in the pharyngeal segments of the zebrafish embryo.* **Development**124: 2945-2960. Opercular.

Schultze, H-P (1973), *Crossopterygier mit heterzerker schwanzflosse aus dem Oberdevon Kanadas, nebst einer beschreibung von Onychodontida-Resten aus dem Mittledevon Spaniens und aus dem Karbon der USA* **Palaeontographica Abt. A.**143: 188-208. *Grossius*, Onychodontiformes, *Onychodus*, *Strunius*, Teeth.

Schultze, H-P (1994), *Comparison of hypotheses on the relationship of sarcopterygians.* **Syst. Biol.** 43: 155-173. *Diabolepis*; Dipnomorpha, Varanoidea.

Schultze, H-P & M Arsenault (1985), *The panderichthyid fish* ***Elpistostege****: a close relative of tetrapods?* **Palaeontology**28: 293-309. Elpistostegalia, Osteolepiformes, Septomaxilla.

Schultze H.-P & M Arsenault (1987), ***Quebecius quebecensis*** *(Whiteaves), a porolepiform crossopterygian (Pisces) from the Late Devonian of Quebec, Canada*. **Can. J. Earth Sci**. 24: 2351-2361. Onychodontiformes.

Schultze, H-P & J Chorn (1997), *The Permo-Carboniferous genus* ***Sagenodus*** *and the beginning of modern lungfish*. **Contrib. Zool.** 61: 9-70. Dipnoi.

Schweitzer, MH, JA Watt, R Avci, L Knapp, L Chiappe, M Norell & M Marshall (1999), *Beta-keratin specific immunological reactivity in feather-like structures of the Cretaceous alvarezsaurid,* ***Shuvuuia deserti***. **J. Exper. Zool.** 285: 146-157. *Shuvuuia*

Seeb, JE, LW Seeb, DW Oates & FM Utter (1987), *Genetic variation and post glacial dispersal of populations of Northern Pike (****Esox lucius****) in North America*. **Can. J. Fish. Aquat. Sci.**44: 556-561. Esociformes

Seeley, HG (1888), *On* ***Thecospndylus daviesi*** *(Seeley), with some remarks on the classification of the Dinosauria*. **Quart. J. Geol. Soc. (Lond.)** 44: 79-87. *Coelurus*.

Seiffert, ER & EL Simons (2000), ***Widanelfarasia****, a diminutive placental from the late Eocene of Egypt*, **Proc. Nat. Acad. Sci. (USA)**97: 2646-2651 WWW. Insectivora.

Seo, H-S, M Kube, RB Edvardsen, MF Jensen, A Beck, E Spriet, G Gorsky, EM Thompson, H Lehrach, R Reinhardt & D Chourrout (2001), *Miniature genome in the marine chordate* ***Oikopleura dioica***. **Science** 294: 2506. Oikopleuridae.

Sereno, PC (1991), ***Lesothosaurus***, *"fabrosaurids" and the early evolution of the Ornithischia*. **J. Vert. Paleontol.** 11: 168-197. Genasauria.

Sereno PC (1991a), *Basal archosaurs: phylogenetic relationships and functional implications*. **J. Vert. Paleontol.** 11 (Supp) Mem. 2, 53 pp. Archosauria, Archosauriformes, Crurotarsi, Euparkeriidae, Ornithodira, Ornithosuchidae, *Ornithosuchus*, Phytosauridae, Proterochampsidae, Rauisuchiformes, *Riojasuchus*, *Scleromochlus*, Suchia.

Sereno, PC (1997), *The origin and evolution of dinosaurs*. **Ann. Rev. Earth & Planet Sci.** 25: 435-489. Carnosauria; Sinraptoridae, Tyrannosauroidea.

Sereno, PC (1998), *A rationale for phylogenetic definitions, with application to the higher level taxonomy of Dinosauria*. **Neues Jahrbuch für Geol. & Paläont. (Abh.)** 210: 41-83. Neodiapsida.

Sereno, PC (1999), *The evolution of the dinosaurs*. **Science** 284: 2137-2147. Carnosauria, Diplodocoidea, Euhelopodidae, Eurypoda, Genasauria, *Jobaria*.

Sereno, PC, AL Beck, DB Dutheil, HCE Larsson, GH Lyon, B Moussa, RW Sadleir, CA Sidor, DJ Varricchio, GP Wilson, & JA Wilson (1999), *Cretaceous sauropods from the Sahara and the uneven rate of skeletal evolution among dinosaurs*. **Science** 286: 1342-1347. *Jobaria*, *Nigersaurus*, Rebbachisauridae.

Sereno, PC & Z-M Dong (1992), *The skull of the basal stegosaur **Huayangosaurus taibii** and a cladistic diagnosis of Stgosauria*. **J. Vert Paleontol.** 12: 318-343. Huayangosauridae, Stegosauria.

Sereno, PC, HCE Larsson, CA Sidor & B Gado (2001), *The giant crocodyliform **Sarcosuchus** from the Cretaceous of Niger*. **Science** 294: 1516-1519. *Sarcosuchus*, *Terminonaris*.

Sereno, PC, JA Wilson & JL Conrad (2004), *New dinosaurs link southern landmasses in the Mid-Cretaceous*. **Proc. Roy. Soc. London B** 03PB1064 (on line). Ratites

Shaffer, HB, P Meylan & ML McKnight (1997), *Tests of turtle phylogeny: molecular, morphological, and paleontological approaches*. **Syst. Biol.** 46: 235-268. *Meiolania*, Testudines.

Shear, WA & PA Selden (2001), *Rustling in the undergrowth: animals in early terrestrial ecosystems* **in** PG Gensel & D Edwards [eds.], **Plants Invade the Land**, Columbia Univ. Press, pp. 29-51. Tetrapoda.

Shirai, S (1996), *Phylogenetic interrelationships of neoselachians (Chondrichthyes: Euselachii)*, in Stiassny, MLJ, LR Parenti & GD Johnson (eds.), **Interrelationships of Fishes**, pp. 9-34. Academic Press. Batomorphii, Carcharhiniformes, Galeomorphii, Heterodontiformes, Hypnosqualea, Lamniformes, Neoselachii, Neoselachii Overview, Orectolobiformes, Squalea, Synechodontiformes.

Shishkin, MA, IV Novikov & YM Gubin (2000), *Permian and Triassic temnospondyls from Russia* **in**MJ Benton, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia**, Cambridge Univ. Press, pp. 35-59. *Angusaurus*, *Inflectosaurus*, Luzocephalidae, *Prothoosuchus*, Septomaxilla, *Thoosuchus*, Trematosauridae, Trematosauroidea, *Yarengia*.

Shishkin, MA & Rubridge, BS (2000), *A relict rhinesuchid (Amphibia: Temnospondyli) from the Lower Trassic of South Africa*. **Palaeontology**43: 653-670. *Broomistega*.

Shoshani, J & MC McKenna (1998), *Higher taxonomic relationships among extant mammals based on morphology, with selected comparisons of results from molecular data*. **Mol. Phylog. & Evol.** 9: 572-584. Altungulata, Eparctocyona, Ungulata.

Shu, D-G & SC Morris (2003), *Response to comment on "A new species of Yunnanozoan with implications for deuterostome evolution"*, **Science**1372d. WWW. *Haikouella*.

Shu, D-G, H-L Luo, SC Morris, X-L Zhang, S-X Hu, L Chen, J Han, M Zhu, Y Li & L-Z Chen (1999),*Lower Cambrian vertebrates from South China*. **Nature** 402: 42-46. Craniata; Hyperoartia; Vertebrata.

Shu, D-G, S Conway Morris, J Han, Z-F Zhang, K Yasui, P Janvier, L Chen, X-L Zhang, J-N Liu, Y Li & H-Q Liu (2002), *Head and backbone of the Early Cambrian vertebrate **Haikouichthys***. **Nature**421: 526-529. Conodonta

Shubin, NH (1995), *The evolution of paired fins and the origin of tetrapod limbs*. **Evol. Biol.**28: 39–85. Dipnomorpha, *Panderichthys*, Tetrapodomorpha.

Shubin, NH, EB Daeschler, & MI Coates (2004The early evolution of the tetrapod humerus. **Science**304: 90-93. *Acanthostega*, Elpistostegalia, *Panderichthys*, Tetrapoda, Tetrapoda, *Ventastega*.

Shufeldt, RW (1901), *On the osteology and systematic position of the screamers (Palamedea: Chauna)*. **Amer. Naturalist**, 35: 455-461. Anhimidae.

Shum, L, Y Sakakura, P Bringas, Jr., W Luo, ML Snead, M Mayo, C Crohin, S Millar, Z Werb, S Buckley, FL Hall, D Warburton & HC Slavkin (1993) *EGF abrogation-induced **fusilli**-form dysmorphogenesis of Meckel's cartilage during embryonic mouse mandibular morphogenesis in vitro*. **Development** 118: 903-917. Meckel's Cartilage.

Sidor, CA (2001), *Simplification as a trend in synapsid cranial evolution*. **Evolution**55: 1419-1442. Cynodontia, Epicynodontia.

Sidor CA (2003), *Evolutionary trends and the origin of the mammalian lower jaw*. **Paleobiology** 4: 605-640. *Edaphosaurus*.

Sidor, CA & JA Hopson (1998), *Ghost lineages and "mammalness": assessing the temporal pattern of character acquisition in the Synapsida*. **Paleobiology**24: 254-273. Cynodontia, *Dvinia*, Epicynodontia, Galesauridae, *Procynosuchus*, *Thrinaxodon*.

Sidor, CA & RMH Smith (2004), *A new galesaurid (Therapsida: Cynodontia) from the Lower Triassic of South Africa*. **Palaeontology**47: 535-556. Epicynodontia, *Progalesaurus*.

Sigogneau-Russell, D (1989), *Theriodontia I - Phthinosuchia, Biarmosuchia, Eotitanosuchia, Gorgonopsia*, **in Encyclopedia of Paleoherpetology**.Gutsav Fischer Verlag, Part 17 B I. Biarmosuchidae.

Sigogneau-Russell, D (1995), *Two possibly aquatic triconodont mammals from the Early Cretaceous of Morocco*. **Acta Pal. Pol.**40: 149-162. *Amphilestes*, *Gobiconodon*, Triconodonta, Triconodontidae.

Sigogneau-Russell, D & P Ensom (1998), ***Thereuodon** (Theria, Symmetrodonta) from the Lower Cretaceous of North Africa and Europe, and a brief review of symmetrodonts*. **Cretaceous Res.** 19: 445-470. Kuehneotheriidae, Spalacotheriidae, Symmetrodonta, Thereudontidae, Tinodontidae.

Sill, WD (1974), *The anatomy of **Saurosuchus galilei** and the relationships of the rauisuchid thecodonts*. **Bull. Mus. Comp. Zool.**146: 317-362. Prestosuchidae, *Saurosuchus*, *Ticinosuchus*.

Sillman, AJ, AK Beach, DA Dahlin & ER Loew (2005), *Photoreceptors and visual pigments in the retina of the fully anadromous green sturgeon (**Acipenser medirostrus**) and the potamodromous pallid sturgeon (**Scaphirhynchus albus**)*. **J. Comp. Physiol. A**191: 799-811. Chondrostei

Simmons, NB (1993), *Phylogeny of Multituberculata* in FS Szalay, MJ Novacek & MC McKenna (eds.), **Mammal Phylogeny: Mesozoic Differentiation, Multituberculates, Monotremes, Early Therians, and Marsupials**. Springer-Verlag, pp. 146-164. Cimolodonta; Multituberculata; Paulchoffatiidae.

Simpson, GG (1948), *The beginning of the age of mammals in South America. Part 1. Introduction. Systematics: Marsupialia, Edentata, Condylarthra, Litopterna and Notioprogonia*. **Bull. Amer. Mus. Nat. Hist.**91: 1-232. Didolodontidae, *Didolodus*, Henricosborniidae, Litopterna, Notostylopidae, Notoungulata.

Sire, J-Y & M-A Akimenko (2004), *Scale development in fish: a review, with description of **sonic hedgehog** (**shh**) expression in the zebrafish (**Danio rerio**)*. **Int. J. Dev. Biol.**48: 233-247. Teeth.

Sire, J-Y, S Marin & F Allizard (1998), *Comparison of teeth and dermal denticles (Odontodes) in the teleost **Denticeps clupeoides** (Clupeomorpha)*. **J. Morphol.**237: 237-255. Teeth

Slikas, B (1998), *Recognizing and testing homology of courtship displays in storks (Aves: Ciconiiformes: Ciconiidae)*. **Evolution** 52: 884-893. Ciconiidae; Ciconiiformes, Cuculidae.

Small, BJ (2002), *Cranial anatomy of **Desmatosuchus haplocerus** (Reptilia: Archosauria: Stagonolepididae)*, **Zool. J. Linn. Soc.**, 136: 97-111 abstract. Aetosauridae, *Desmatosuchus*.

Smith, JB (1997), *Heterodontosauridae*, in PJ Currie & K Padian (eds.), **Encyclopedia of Dinosaurs**. Academic Press, pp. 317-319. Heterodontosauridae.

Smith, JB, MC Lamanna, KJ Lacovara, P Dodson, JR Smith, JC Poole, R Glegengack & Y Attia (2001), *A giant sauropod dinosaur from an Upper Cretaceous mangrove deposit in Egypt*, **Science** 292: 1704-1706. Dactylosaurus, Titanosauria, Titanosauriformes

Smith, MM. & ML Coates (2001) *The evolution of vertebrate dentitions: phylogenetic pattern and developmental models* **in**PE Ahlberg [ed.] **Major Events in Early Vertebrate Evolution**, Taylor & Francis, pp. 223-240. Teeth

Smith, MM & PC Heemstra (eds.) (1986), **Smith's Sea Fishes**, Springer-Verlag, 1047 pp. Torpediniformes

Smith, MM & BK Hall (1990), *Development and evolutionary origins of vertebrate skeletogenic and odontogenic tissues*. **Biol. Rev.** 65: 277-373. Osteichthyes.

Soehn, KL & MVH Wilson (1990), *A complete, articulated heterostracan from Wenlockian (Silurian) beds of the Delorme Group, Mackenzie Mountains, Northwest Territories, Canada*. **J. Vert. Paleontol.**10: 405-419 *Ctenaspis*.

Soehn, KL, T Marss, MW Caldwell & MVH Wilson (2001), *New and biostratigraphically useful thelodonts from the Silurian of the Mackenzie Mountains, Northwest Territories, Canada*, **J. Vert. Paleontol.**21: 651-650. Archipelepididae, Katoporida, Turiniidae.

Springer, MS & E Douzery (1996), *Secondary Structure and patterns of evolution among mammalian mitochondrial 12S rRNA molecules*, **J. Mol. Evol.** 43: 357-373. Insectivora.

Springer, MS, LJ Hollar & A Burk (1995), *Compensatory substitutions and the evolution of the mitochondrial 12S rRNA gene in mammals*, **Mol. Biol. Evol.** 12: 1138-1150. Insectivora.

Stahl, BJ (1988), *Reconstruction of the head skeleton of the fossil elasmobranch,* ***Phoebodus heslerorum*** *(Pisces, Chondrichthyes).* **Copeia** 1988: 858-866. Phoebodontidae.

Štamberg, S [Stamberg]& J Zajíc [Zajic] (2000), *New data on the osteology of actinopterygian fish* ***Sphaerolepis kounoviensis***. **Vestník Ceského Geol. Ústavu**75: 455-458. Chondrostei.

Stanhope MJ, VG Waddell, O Madsen, WW deJong, SB Hedges, GC Cleven, D Kao, & MS Springer (1998), *Highly congruent molecular support for a diverse superordinal clade of endemic African mammals*, **Mol. Phylogen. & Evol.**9: 501-508. Insectivora.

Stanhope, MJ, VG Waddell, O Madsen, WW deJong, SB Hedges, GC Cleven, D Kao & MS Springer (1998a), *Molecular evidence for multiple origins of Insectivora and for a new order of endemic African insectivore mammals*, **Proc. Natl. Acad. Sci. USA** 95: 9967-9972. Insectivora.

Stanley, SM (1998), **Earth System History**. WH Freeman & Co., 615 pp. Corviaspididae.

Stensiö, EA (1964), *Les Cyclostomes fossiles ou Ostracodermes* **in**J Piveteau [ed.], **Traité de Paléontologie**. Masson, 4: 96-383. Amphiaspidida, Amphiaspidoidei, Corviaspididae, *Corveolepis*, *Ctenaspis*, Hibernaspidoidei.

Steyer, JS (2000), *Ontogeny and phylogeny in temnospondyls: a new method of analysis*. **Zool. J. Linn. Soc.** 130: 449-467. Lepospondyli, Temnospondyli, Tyrannosauroidea.

Steyer, JS (2002), *The first articulated trematosaur "amphibian" from the Lower Triassic of Madagascar: implications for the phylogeny of the group*. **Palaeontology**45: 771-793. WWW. *Angusaurus*, *Inflectosaurus*, Luzocephalidae, Septomaxilla, Trematosauridae, *Trematosaurus*.

Storrs, GW (1997), *Morphological and taxonomic clarification of the genus* ***Plesiosaurus***, in JM Callaway & EL Nicholls (eds.), **Ancient Marine Reptiles** Academic Press, pp. 145-190. *Plesiosaurus*.

Storrs, GW & MA Taylor (1996), *Cranial anatomy of a new plesiosaur genus from the lowermost Lias (Rhaetian/Hettangian) of Street, Somerset, England*. **J. Vert. Paleontol.**16: 403-420. *Eurycleidus*.

Sudre, J & G Lecomte (2000), *Relations et position systématique du genre* ***Cuisitherium****Sudre et al., 1983, le plus dérivé des artiodactyles de l'Éocène inférieur d'Europe*. **Geodiversitas**22: 415-432. WWW. Dichobunidae.

Sues, H-D (1992), *A remarkable new armored archosaur from the Upper Triassic of Virginia*. **J. Vert. Paleontol.**12: 142-149. Aetosauridae, Crocodylomorpha, *Doswellia*, *Euscolosuchus*, Ornithosuchidae, Phytosauridae, Prestosuchidae.

Sues, H-D & DB Norman (1990) *Hypsilophodontidae*, ***Tenontosaurus***, *Dryosauridae*. DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press, pp. 498-509. Muttaburrasaurus.

Sues, H-D, NH Shubin & PE Olsen (1994), *A new sphenodontian (Lepidosauria: Rhynchocephalia) from the McCoy Brook Formation (Lower Jurasic) of Nova Scotia, Canada*. **J. Vert. Paleontol.** 14: 327-340. Clevosaurs.

Sulimski, A (1968), *Paleocene genus* ***Pseudictops****Mathew, Granger & Simpson 1929 (Mammalia) and its revision.* **Palaeontologia Polonica**19: 101-129. Anagalidae, Pseudictopidae.

Sumida SS (1989), *New information on the pectoral girdle and vertebral column in* ***Lupeosaurus*** *(Reptilia, Pelycosauria)*. **Can. J. Earth Sci.** 26: 1343-1349. Edaphosauridae.

Summers, AP & JC O'Reilly (1997), *A comparative study of locomotion in the caecilians* ***Dermophis mexicanus*** *and* ***Typhlonectes natans*** *(Amphibia: Gymnophiona).* **Zool. J. Linnean Soc.** 121-65-76. Gymnophiona

Sun, AL & KH Cui (1986), *The Lower Lufeng Saurischian fauna*, **in**K Padian (ed.), **The Beginning of the Age of Dinosaurs**. Vulcanodontidae.

Surkov, MV, NN Kalandadze & MJ Benton (2005), ***Lystrosaurus georgi****, a dicynodont from the Lower Triassic of Russia*, **J. Vert. Pal.**25: 402-413.

Suzuki, S, LM Chiappe, GJ Dyke, M Watabe, R. Barsbold & K Tsogtbaatar (2002), *A new specimen of* ***Shuvuuia deserti****Chiappe* ***et al****., 1998 from the Mongolian Late Cretaceous with a discussion of the relationships of alvarezsaurids to other theropod dinosaurs*. **Contribs. Sci.**No. 494, 20 pp. . *Parvicursor*.

Swalla, BJ, CB Cameron, LS Corley & JR Garey (2000), *Urochordates are monophyletic within deuterostomes.* **Sys. Biol.** 49: 52-64. Larvacea, Urochordata

Sweet, WC & PCJ Donoghue (2001), *Conodonts: past present, future*. **J. Paleontol.**75: 1174-1184. Conodonta, Ozarkodinida, Paraconodontida.

Szyndlar, Z (1994), *Oligocene snakes of southern Germany*. **J. Vert. Paleontol.** 14: 24-37. Aniliidae

-T-

Takuma, N, HZ Sheng, Y Furuta, JM Ward, K Sharma, BLM Hogan, SL Pfaff, H Westphal, S Kimura & KA Mahon (1998), *Formation of Rathke's Pouch requires dual induction from the diencephalon.* **Development** 125: 4835-4840. The Basisphenoid.

Tang, C & JH Pantel (2005), *Combining morphometric and paleoecological analyses: Examining small-scale dynamics in species-level and community-level evolution*. **Pal. Elect.**8: 33A, 10 pp. **WWW**. *Holopterygius*.

Taquet, P (1998), **Dinosaur Impressions: Postcards from a Paleontologist**, K Padian (trans). Cambridge Univ. Press. 244 pp. *Ouranosaurus*

Tarduno, JA, DB Brinkman, PR Renne, RD Cottrell, H Scher, & P Castillo (1998), *Evidence for extreme climatic warmth from Late Cretaceous arctic vertebrates*. **Science** 282: 2241-2244. Neochoristodera.

Tarlo, LBH (1964), *Psammosteiformes (Agnatha): a review with descriptions of new material from the Lower Devonian of Poland. I. General part* **Paleontol. Pol.** 13: 1-135. *Drepanaspis*, Guerichosteidae, Protaspididae, *Psammolepis*, Psammosteida, Psammosteidae, Pycnosteidae, Teeth.

Tarlo, LBH (1967), *Agnatha*, **in**WB Harland *et al.* (eds.), **The Fossil Record**, The Geological Society, pp.629-636. Craniate Overview.

Tarsitano, S & Riess, J (1982), *Plesiosaur locomotion -- underwater flight versus rowing*. **N. Jb. Geol. Palaont. Abh.**164: 193-194. Plesiosauria.

Tatarinov, LP (1968), *Morphology and systematics of the northern Dvinia cynodonts (Reptilia, Therapsida; Upper Permian)*. **Postilla**126: 1-51. *Dvinia*.

Tatarinov, LP (1999), *A new eotitanosuchid (Reptilia, Therapsida) from the Kazanian Stage (Upper Permian) of Udmurtia*. **Paleonotol. J.** 33: 660-666. Eotitanosuchia.

Taverne, L (2000), ***Tselfatia formosa**, téléostéen marin du Crétacé (Pisces, Actinopterygii), et la position systématique des Tselfatiiformes ou Bananogmiiformes*. **Geodiversitas** 22: 5-22. Clupeocephala

Taylor, MA (1981), *Plesiosaur rigging and ballasting*. **Nature**290: 628-9 Plesiosauria, Plesiosauroidea.

Taylor, MA (1986), *Lifestyle of plesiosaurs.* **Nature**319: 179. Plesiosauria.

Taylor, MA (1992), *Functional anatomy of the head of a large aquatic predator **Rhomaleosaurus zetlandicus**(Plesiosauria: Reptilia) from the Toarcian (Lower Jurassic) of Yorkshire, England.* **Phil. Trans. Roy. Soc. Lond. B**335: 247-280. *Rhomaleosaurus*.

Taylor, MA & ARI Cruickshank (1993), *A plesiosaur from the Linksfield Erratic (Rhaetian, Upper Triassic) near Elgin, Morayshire*. **Scot. J. Geol.**29: 191-196. *Eretmosaurus*.

Tchernov, E, O Rieppel, H Zaher, MJ Polcyn & LL Jacobs (2000), *A fossil snake with limbs*. **Science** 287: 2010-2012. Aniliidae, Anomalepididae, Alethinophidia, *Dinilysia*, Leptotyphlopidae, Macrostomata, Pachyophiidae; Scolecophidia; Serpentes, Typhlopidae.

tenBerge, D, A Brouwer, J Korving, JF Martin & F Meijlink (1998) ***Prx1** and **Prx2** in skeletogenesis: roles in the craniofacial region, inner ear and limbs.* **Development** 125: 3831-3842. Meckel's Cartilage.

Testaz, S, A Jarov, KP Williams, LE Ling, VE Koteliansky, C Fournier-Thibault, & J-L Duband (2001), ***Sonic hedgehog**restricts adhesion and migration of neural crest cells independently of the **Patched**-Smoothened-Glisignaling pathway*. **Proc. Nat. Acad. Sci. (USA)**98: 12521–12526. Teeth

Thewissen, JGM (1998), *Cetacean origins: evolutionary turmoil during the invasion of the oceans* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 451-464. Ambulocetidae, Cetacea, Pakicetidae, Protocetidae, Remingtonocetidae.

Thewissen, JGM & ST Hussain (1993), *Origin of underwater hearing in whales*. **Nature**361: 444-445. Cetartiodactyla, Cetatea, Incus, Protocetidae.

Thewissen, JGM, EM Williams, LJ Roe & ST Hussain (2001), *Skeletons of terrestrial cetaceans and the relationship of whales to artiodactyls*. **Nature** 413: 277-281. Ambulocetidae, Artiodactyla, Basilosauridae, *Basilosaurus*, Cetartiodactyla, Cetatea, Pakicetidae, Protocetidae, Raoellidae, Remingtonocetidae, Sirenia.

Thies, D (1991), ***Palaeospinax, Synechodus**and/or **Paraorthacodus**? The problem of palaeospinacid genera (Pisces, Neoselachii, Palaeospinacidae)*. **N. Jb. Geol. Paläont. Mh.**1991: 549-552. Synechodontiformes.

Thies, D (1993), ***Palaeospinax, Synechodus**and/or **Paraorthacodus**. Is the problem of palaeospinacid genera (Pisces, Neoselachii) solved?*. **N. Jb. Geol. Paläont. Mh.**1993: 724-732. Synechodontiformes.

Thies, D (1995), *Placoid scales (Chondrichthyes: Elasmobranchii) from the Late Jurassic (Kimmeridgian) of Northern Germany*. **J. Vert. Paleontol.**15: 463-481. Synechodontiformes.

Tsuda Y, C Nishida-Umehara, J Ishijima, K Yamada & Y Matsuda (2007), *Comparison of the Z and W sex chromosomal architectures in elegant crested tinamou (**Eudromia elegans**) and ostrich (**Struthio camelus**) and the process of sex chromosome differentiation in palaeognathous birds*. **Chromosoma**116: 159-173. Neornithes.

Tumanova, TA (2000), *Armoured dinosaurs from the Cretaceous of Mongolia*, in Benton, MJ, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia** Cambridge Univ. Press, pp. 517-532. Ankylosauria.

Turner, S (1997), *Sequence of Devonian thelodont scale assemblages in East Gondwana*, **in**G Klapper, MA Murphy & J Talent [eds.], **Paleozoic sequence Stratigraphy, biostratigraphy and biogeography: studies in honor of Dr J. Granville ("Jess") Johnson. Spec. Pap. Geol. Soc. Amer.**321: 1-45. Turiniidae.

Turner, S (1999), *Early Silurian to Early Devonian thelodont assemblages and their possible ecological significance*, **in**AJ Boucot & J Lawson [eds.], **Palaeocommunities, International Geological Correlation Programme 53, Project Ecostratigraphy, Final Report**. Cambridge University Press, pp. 42-78. Archipelepididae, *Loganellia*, Loganiidae, *Shielia*, Thelodonti, Thelodontidae.

Turner, S, JJ Kuglitsch & DL Clark (1999), *Llandoverian thelodont scales from the Burnt Bluff Group of Wisconsin and Michigan*, **J. Paleontol.**73: 667–676. Katoporida, Loganiidae, *Phlebolepis*.

-U-

Uhen, MD (1998), *Middle to Late Eocene basilosaurines and dorudontines* **in**JGM Thewissen [ed.], **The Emergence of Whales**, Plenum Press pp 29-61. Ambulocetidae, Autoceta, Basilosauridae, *Basilosaurus*, Mysticeti, Protocetidae, Remingtonocetidae.

Uhen, MD (1998a), *New protocetid (Mammalia, Cetacea) from the late Middle Eocene Cook Mountain Formation of Louisiana* **J. Vert. Paleontol.**18: 664-668. Protocetidae.

Uhen, MD (1999), *New species of protocetid archaeocete whale,* ***Eocetus wardii****(Mammalia: Cetacea) from the Middle Eocene of North Carolina*. **J. Paleont.**73: 512-528. Protocetidae.

Underwood, CJ (2002), *Sharks, rays and a chimaeroid from the Kimmeridgian (Late Jurassic) of Ringstead, Southern England*. **Palaeontology**45: 297-325. Palaeospinacidae.

Unwin, DM (1999), *Pterosaurs: back to the traditional model?* **Tree**14: 263-268. Azhdarchoidea, Dimorphodontidae; Ornithodira, Pterodactyloidea, Pterosauria.

Unwin, DM & NN Bakhurina (2000), *Pterosaurs from Russia, Middle Asia and Mongolia*, in Benton, MJ, MA Shishkin, DM Unwin & EN Kurochkin (eds.), **The Age of Dinosaurs in Russia and Mongolia** Cambridge Univ. Press, pp. 420-433. Azhdarchoidea; Dimorphodontidae, Ornithocheiroidea; Rhamphorhynchoidea.

Upchurch, P (1995), *The evolutionary history of the sauropod dinosaurs*. **Phil. Trans. R. Soc. Lond. B** 349: 365-390. Nemegtosauridae, Vulcanodontidae.

Upchurch, P (1998), *The phylogenetic relationships of sauropod dinosaurs*. **Zool. J. Linnean Soc.** 124: 43-103. Diplodocimorpha, Diplodocoidea; Nemegtosauridae, *Rebbachisaurus*; Vulcanodontidae.

Upchurch, P. (1999), *The phylogenetic relationships of the Nemegtosauridae (Saurischia, Sauropoda).* **J. Vert. Paleontol.** 19: 106-125. Nemegtosauridae.

-V-

Vallin, G & M Laurin (2004), *Cranial morphology and affinities of Microbrachis, and a reappraisal of the phylogeny and lifestyle of the first amphibians*. **J. Vert. Paleontol.**, 24: 56-72. Lepospondyli.

Van der Brugghen, W & P Janvier (1993), *Denticles in thelodonts*. **Nature**364: 107. Epibranchials, *Loganellia*, Teeth.

VanHeerden, J (1997), *Prosauropods* in JO Farlow & MK Brett-Surman (eds.) **The Complete Dinosaur.** Indiana Univ. Press, pp. 242-263. *Anchisaurus*.

van Tuinen, M & EA Hadly (2004), *Error in estimation of rate and time inferred from the early amniote fossil record and avian molecular clocks*. **J. Mol. Evol.**59: 267-276. *Archaeothyris*.

van Tuinen, M, CG Sibley & SB Hedges (1998), *Phylogeny and biogeography of ratite birds inferred from DNA sequences of the mitochondrial ribosomal genes*. **Mol. Biol. Evol.**15: 370–376. Ratites.

Varricchio, DJ (2001), *Gut contents from a Cretaceous tyrannosaurid: implications for theropod dinosaur digestive tracts*. **J. Paleontol.**75: 401-406. Tyrannosauroidea.

Vaughan, TA, JM Ryan & NJ Czapelewski (2000), **Mammalogy** (4th ed.), Saunders, 564+ pp. Autoceta, Cetacea, Chrysochloroidea, *Dorudon*, Erinaceinae, Erinaceomorpha, Hylomyinae, Indrioidea, Insectivora, Lorisiformes, Mysticeti, Odontoceti, Physeteroidea, Solenodontidae, Soricidae, Soricinae, Strepirhini, Talpoidea, Tenrecoidea.

Vickers-Rich, P & TH Rich (1999), **Wildlife of Gondwana**. Indiana Univ. Press., 304 pp. Canowindridae.

Villarroel, C & JC Danis (1997), *A new leontiniid notoungulate* **in** RF Kay *et al*. [eds.], **Vertebrate Paleontology in the Neotropics: the Miocene Fauna of La Venta, Colombia**. Smithsonian Inst. Press pp. 303-318. Notoungulata.

von Zittel, KA (1932), **Textbook of Paleontology**, CR Eastman (transl. and ed), 2nd edition, vol.2, MacMillan & Co. *Aetosaurus*, *Desmatosuchus*, *Mystriosuchus*, *Nicrosaurus*, *Rhinesuchus*; *Uranocentradon*.

Vorobyeva, EI (1980), *Observations on two rhipidistian fishes from the Upper Devonian of Lode, Latvia*. **Zool. J. Linn. Soc.**70: 191-201. *Panderichthys*.

Vorobyeva, EI & H-P Schultze (1991), *Description and systematics of panderichthyid fishes with comments on their relationship to tetrapods*, **in**H-P Schultze & L Trueb (eds.), **Origins of the Higher Groups of Tetrapods**Comstock, pp 68-109. *Elpistostege*, Osteolepiformes, *Panderichthys*, Rhipidistia, Septomaxilla, Tetrapodomorpha.

-W-

Waddell, PJ, Y Cao, M Hasegawa & DP Mindell (1999), *Assessing the Cretaceous superordinal divergence times within birds and placental mammals by using whole mitochondrial protein sequences and an extended statistical framework*. **Syst. Biol.**48: 119–137. Ratites.

Walker AD (1964), *Triassic reptiles from the Elgin area:* ***Ornithosuchus****and the origin of carnosaurs,* **Phil. Trans. Roy. Soc. Lond.**, B248: 53-134. Archosauria, Ornithosuchidae, *Ornithosuchus*.

Walker, AD (1970), *A revision of the Jurassic crocodile* ***Hallopus****, with remarks on the clas-sification of crocodiles.* **Phil. Trans. Roy. Soc. Lond.**B257: 323–372. *Erpetosuchus*, *Scleromochlus*.

Wall, CE & DW Krause (1992), *A biomechanical analysis of the masticatory apparatus of* ***Ptilodus*** *(Multituberculata)*. **J. Vert. Paleontol.** 12: 172-187. Cimolodonta; Multituberculata.

Wall, WP & JA Hauptman (2001), *A craniodental interpretation of the dietary habits of* ***Poebrotherium wilsoni****(Camelidae) from the Oligocene of Badlands National Park, South Dakota.* **Proc. 6th Fos. Resource Conf.** (NPS/NRGRD/GRDTR-01/01) pp. 76-82. *Poebrotherium*.

Walter RM & DR Carrier (2002), *Scaling of rotational inertia in murine rodents and two species of lizard*. **J. Exper. Biol.** 205: 2135-2141. *Ianthasaurus*.

Wang, Y-Q, Y-M Hu, J Meng & C-K Li (2001), *An ossified Meckel's Cartilage in two Cretaceous mammals and origin of the mammalian middle ear*. **Science** 294: 357-361. *Hadrocodium*, Triconodonta

Wang, Z-L & X Xu (2001), *A new iguanodontid (**Jinzhousaurus yangi** gen. et sp. nov.) from the Yixian Formation of western Liaoning, China*. **Chi. Sci. Bull.** 46: 1669-1672. *Ouranosaurus*.

Warren, AA (1985), *Triassic Australian plagiosauroid*. **J. Paleontol.** 59: 236-241. Plagiosauridae.

Warren, AA (1995), ***Plagiosternum granulosum** E. Fraas: a plagiosaurid temnospondyl from the Middle Triassic of Crailsheim, Germany*. **Stuttgarter Beiträge zur Naturkunde Ser. B** #229. 8 pp. Plagiosauridae.

Warren, AA (1998), ***Laidleria** uncovered: a redescription of **Laidleria gracilis** Kitching (1957), a temnospondyl from the **Cynognathus** Zone of South Africa*. **Zool. J. Linn. Soc.** 122: 167-185. Jugals, *Laidleria*, The Opisthotic, Plagiosauridae, Plagiosauroidea, The Sphenethmoid.

Warren, AA & L Davey (1992), *Folded teeth in temnospondyls -- a preliminary study*. **Alcheringa** 16: 107-132. Plagiosauridae.

Warren, AA & C Marsicano (2000), *A phylogeny of the Brachyopoidea (Temnospondyli, Stereospondyli)*. **J. Vert. Paleontol.** 20: 462-483. Dendrogram, Plagiosauridae.

Waters, JM & MS Roy (2004), *Out of Africa: The slow train to Australasia*. **Syst. Biol.**53: 18-24. Ratites.

Watterson, B (1989), **Yukon Ho!**Andrews & McMeel, 126 pp. Rebbachisauridae.

Webb PW & Skadsen JM (1980), *Strike tactics of **Esox***. **Can. J. Zool.**58: 1462-1469. Esociformes.

Weems, RE (1980), *An unusual newly discovered archosaur from the Upper Triassic of Virginia, U.S.A*. **Amer. Phil. Soc. Trans.**70: 1-53. *Doswellia*.

Weishampel, DB (1984), *Evolution of jaw mechanisms in ornithopod dinosaurs*. **Adv. Anat. Embryol. Cell Biol.**87: 1-110. Heterodontosauridae.

Weishampel, DB & JR Horner (1990), *Hadrosauridae* in DB Weishampel, P Dodson, & H Osmólka (eds), **The Dinosauria**. Univ. Calif. Press, pp. 534-561. Hadrosauridae, *Ouranosaurus*, Palatines.

Welles, SP (1962), *A new species of elasmosaur from the Aptian of Columbia, and a review of the Cretaceous plesiosaurs*. **Univ. Calif. Publ. in Geol. Sci.**46: 54. *Brachauchenius*.

Westphal, F (1976) *Phytosauria*, **in**O Kuhn (ed.), **Handbuch der Palaeoherpetologie Teil 13: Thecondontia**, Gustav Fisher-Verlag, Stuttgart. *Angistorhinus*, *Nicrosaurus*, Phytosauridae, *Rutiodon*, *Smilosuchus*.

Whistler, DP & SD Webb (2005), *New Goatlike camelid from the Late Pliocene of Tecopa Lake Basin, California*. **Contrib. Sci.**No. 503, 40 pp. *Poebrotherium*, Stenomylinae.

White, AT (2001), *"What is a dinosaur?" -- the evolution of a question*. **Paleozoica** 2001: 18-24. Pterodactyloidea.

White, SA (2004), *Swine, souls, and salt: the western pig in historical perspective* (unpub.). Artiodactyla.

White, TE (1940), *Holotype of **Plesiosaurus longirostris**Blake and the classification of the plesiosaurs*. **J. Paleontol.**14: 451-467. *Macroplata*, *Microcleidus*, *Sthenarasaurus*.

Whitehead, PJ & K Saalfeld (2000), *Nesting phenology of the Magpie Goose **Anseranas semipalmata**: responses to antecedent rainfall*. **J. Zool., Lond.**251: 495-508. *Anseranas*.

Whittaker, CA & RO Hynes (2002), *Distribution and Evolution of von Willebrand/Integrin A Domains: Widely Dispersed Domains with Roles in Cell Adhesion and Elsewhere*, **Mol. Biol. Cell**13: 3369-3387. Insectivora.

Wilkinson, M & RA Nussbaum (1997), Comparative morphology and evolution of the lungless caecilian Atretochoana eiselti (Taylor) (Amphibia: Gymnophiona: Typhlonectidae). Biol. J. Linn. Soc. 62: 39-109. Gymnophiona.

Williams, ME (1998), *A new specimen of* ***Tamiobatus vestustus****(Chondrichthyes, Ctenacanthoidea) from the Late Devonian Cleveland Shale of Ohio*. **J. Vert. Paleontol.**18: 251-260. Cladoselechida.

Williston SW & EC Case (1913), *A description of* ***Edaphosaurus*** *Cope*, in EC Case, SW Williston & MG Mehl, **Permo-Carboniferous Vertebrates from New Mexico**. **Carnegie Inst. Publ.** 181: 71-81. Edaphosauridae.

Wilson, MVH (1980), *Oldest known* ***Esox****(Pisces: Esocidae), part of a new Paleocene teleost fauna from western Canada*. **Can. J. Earth Sci.**17: 307-312. *Esox*.

Wilson, MVH (1984), *Osteology of the Paleocene teleost* ***Esox tiemani***. **Palaeontology**27: 597-608. *Dallia*, Esocidae, Esociformes, *Esox*, *Novumbra*, *Umbra*.

Wilson, MVH & MW Caldwell (1993), *New Silurian and Devonian fork-tailed 'thelodonts' are jawless vertebrates with stomachs and deep bodies*, **Nature**361: 442-444. Epibranchials, Furcacaudiformes, Thelodonti.

Wilson, MVH & MW Caldwell (1998), *The Furcacaudiformes: a new order of jawless vertebrates with thelodont scales, based on articulated Silurian and Devonian fossils from Northern Canada*. **J. Vert. Paleontol.** 18: 10-29. Craniata Overview, Epibranchials, Furcacaudiformes, Thelodonti.

Wilson, MVH & P Veilleux (1982), *Comparative osteology and relationships of the Umbridae (Pisces: Salmoniformes)*. **Zool. J. Linn. Soc.**76: 321-352. *Dallia*, Epibranchials, Esociformes, *Esox*, *Novumbra*, *Umbra*.

Wilson, MVH, DB Brinkman & AG Neuman (1992), *Cretaceous esocoidei (Teleostei): early radiation of the pikes in North American fresh waters*. **J. Paleontol.** 66: 839-846. Esocidae, Esociformes, *Estesesox*.

Withington, S, R Beddington & J Cooke (2001), *Foregut endoderm is required at head process stages for anteriormost neural patterning in chick*. **Development** 128: 309-320. The Basisphenoid.

Witmer, LM (1995), *Homology of facial structures in extant archosaurs (birds and crocodilians), with special reference to paranasal pneumaticity and nasal conchae*. **J. Morphol.**225: 269-327. Ethmoid.

Witmer, LM (1997), *Craniofacial air sinus systems* **in**PJ Currie & K Padian [eds.], **Encyclopedia of Dinosaurs**. Academic Press, pp. 151-159. Tyrannosauridae.

Wolfram, S (2002), **A New Kind of Science**. Wolfram: 1197+ pp. Amiiformes

Woodward, AS (1906), *On a new specimen of the chimeroid fish,* ***Myriacanthus paradoxus****, from the Lower Lias near Lyme Regis (Dorset)*. **Quart. J. Geol. Soc. Lond.**52: 1-4. Myriacanthoidei.

Worthy, TH, RN Holdaway, MD Sorenson & AC Cooper (1997), *Description of the first complete skeleton of* ***Cnemiornis calcitrans****Owen, (Aves: Anatidae), and a reassessment of the relationships of****Cnemiornis***. **J. Zool., Lond.**243: 695-723. Anatidae, *Anseranas*, *Cnemiornis*.

Wu, C-H & Z-J Huang (1986), *Morphological comparison of* ***Shinisaurus crocodilurus****and* ***Xenosaurus grandis***. **Sinozoologica**4: 41-50 Septomaxilla

Wu, P, L-H Hou, M Plikus, M Hughes, J Scehnet, S Suksaweang, RB Widelitz, T-X Jiang & C-M Chuong (2004), *Evo-Devo of amniote integuments and appendages*. **Int. J. Dev. Biol.**48: 249-270. Teeth.

Wuyts, J, Y Van de Peer & R De Wachter (2001), *Distribution of substitution rates and location of insertion sites in the tertiary structure of ribosomal RNA*. **Nucl. Acids Res.**29: 5017-5028. Cuculiformes

-X-

Xu, X, Z-L Tang & X-L Wang (1999), *A thrizonosauroid dinosaur with integumentary structures from China*.

Nature 399: 350-354. *Beipiaosaurus*, Therizinosauroidea.

-Y-

Yang, Z-H & AD Yoder (1999), *Estimation of the transition/transversion rate bias and species sampling*, **J. Mol. Evol.**48: 274-283. WWW. Insectivora.

Yates, AM (1999), *The Lapillopsidae: a new family of small temnospondyls from the Early Triassic of Australia*. **J. Vert. Paleontol.** 19: 302-320. The Opisthotic, Stereospondyli, Temnospondyli Dendrogram.

Yates, AM (2000), *A new tiny rhytidosteid (Temnospondyli: Stereospondyi) from the Early Triassic of Australia and the possibility of hidden temnospondyl diversity*. **J. Vert Paleontol.**20:484-489. Rhytidosteidae.

Yates, AM & AA Warren (2000), *The phylogeny of the 'higher' temnospondyls (Vertebrata: Choanata) and its implications for the monophyly and origins of the Stereospondyli*. **Zool. J. Linnean Soc.** 128: 77-121. Jugals, *Laidleria*; Limnarchia; Luzocephalidae; Metoposauroidea, Plagiosauridae; Plagiosauroidea, Temnospondyli; Temnospondyli Dendrogram; Temnospondyli Overview, Thoosuchinae; Trematosauria, Trematosauroidea.

Young, GC (1993), *Vertebrate faunal provinces in the Middle Palaeozoic*, **in**JA Long [ed.] **Palaeozoic Vertebrate Biostratigraphy and Biogeography**. Belhaven Press: pp. 293-323. Amphiaspidida.

Young, GC (2005), *New phyylolepids (placederm fishes) from the Middle-Late Devonian of Southeastern Australia*. **J. Vert. Paleontol.** 25: 261-273. Phyllolepida.

Young, GC, VN Karatajute-Talimaa & MM Smith (1996), *A possible Late Cambrian vertebrate from Australia*. **Nature** 383: 810-812. *Anatolepis*.

Young, GC & G-R Zhang (1996), *New information on the morphology of yunnanolepid antiarchs (placoderm fishes) from the Early Devonian of South China*. **J. Vert. Paleontol.** 16: 623-641. Antiarcha, Yunnanolepidae.

Yu, X (1998), *A new porolepiform-like fish, **Psarolepis romeri**, gen. et sp. nov. (Sarcopterygii, Osteichthyes) from the Lower Devonian of Yunnan, China*. **J. Vert. Paleontol.** 18: 261-274. Porolepiformes, *Psarolepis*, Sphenethmoid.

-Z-

Zack, SP (2004), *An Early Eocene arctostylopid (Mammalia: Arctostylopida) from the Green River Basin, Wyoming*. **J. Vert. Paleontol.**24: 498:501. Arctostylopida.

Zack, SP, TA Penkrot, JI Bloch & KD Rose (2005), *Affinities of 'hyopsodontids' to elephant shrews and a Holarctic origin of Afrotheria*. **Nature**434: 497-501. Hyopsodontidae.

Zaher, H (1998), *The phylogenetic position of **Pachyrachis** within snakes (Squamata, Lepidosauria)*. **J. Vert. Paleontol.** 18: 1-3. Macrostomata, Pachyophiidae, Serpentes.

Zalmout, IS, HA Mustafa & PD Gingerich (2000), *Priabonian **Basilosaurus isis**(Cetacea) from the Wadi Esh-Shallala Formation: first marine mammal from the Eocene of Jordan*. **J. Vert. Paleontol.**20: 201-204. *Basilosaurus*.

Zangerl, R (1969), ***Bandringa rayi**: a new ctenacanthoid shark from the Pennsylvanian Essex fauna of Illinois*. **Fieldiana Geol.** 12: 157-169. Bandringidae.

Zangerl, R (1981), **Chondrichthyes I: Paleozoic Elasmobranchii**. in H-P Schultze & O Kuhn (eds.), **Handbook of**

Paleoichthyology, vol. 3B, GV Verlag, 114 pp. Bandringidae; Chondrichthyes, Ctenacanthidae; Ctenacanthiformes; Epibranchials, Euselachii, Menaspidae, Phoebodontidae; Symmoriida

Zangerl, R (1990), *Two new stethacanthid sharks (Stethacanthidae, Symmoriida) from the Pennsylvanian of Indiana, U.S.A.*. **Paleontographica Abt. A** 213: 115-141. Symmoriida.

Zhang, Y (1985), *A new plesiosaur from Middle Jurassic of Sichuan Basin*. **Vertebrata PalAsiatica** 23: 235-240. *Yuzhoupliosaurus*

Zhang, Y-D, Z-Y Zhang, X Zhao, X-Y Yu, Y-P Hu, B Geronimo, SH Fromm & Y-P Chen (2000), *A new function of **BMP4**: dual role for **BMP4** in regulation of **Sonic hedgehog** expression in the mouse tooth germ*. **Development** 127: 1431-1443. Teeth.

Zhao, S-L, Q Chen, F-C Hung & PA Overbeek (2002), ***BMP** signaling is required for development of the ciliary body*. **Development** 129: 4435-4442. Teeth.

Zhou, Z-G & F-C Zhang (2001), *Two new ornithurine birds from the Early Cretaceous of western Liaoning, China*. **Chin. Sci. Bull.** 48: 1258-1264. Orinithurae.

Zhu, M & P Janvier (1994), *Un onychodontide (Vertebrata, Sarcopterygii) du Dévonien Inferieur de Chine*. **C.R. Séances Acad. Sci.** sér 2, 319: 951-956. Onychodontiformes.

Zhu, M & P Janvier (1996), *A small antiarch, **Minicrania lirouyii** gen. et sp. nov., from the Early Devonian of Qujing, Yunnan (China), with remarks on antiarch phylogeny*. **J. Vert. Paleontol.** 16: 1-15. Antiarcha, Euantiarcha, *Minicrania*, Sinolepidae, Yunnanolepidae, Yunnanolepidoidei.

Zhu, M. & H-P Schultze (1997), *The oldest sarcopterygian fish*. **Lethaia** 30: 293-304. *Psarolepis*, *Strunius*.

Zhu, M & X-B Yu (2002), *A primitive fish close to the common ancestor of tetrapods and lungfish*. **Nature** 418: 767-770. *Achoania*, Actinistia, Sarcopterygii, *Styloichthys*, *Youngolepis*.

Zhu, M, PE Ahlberg, W Zhao & L Jia (2002), *First Devonian tetrapod from Asia*. **Nature** 420: 760-761. Tetrapoda, *Ventastega*.

Zhu, M, X-B Yu & PE Ahlberg (2001), *A primitive sarcopterygian fish with an eyestalk*. **Nature** 410: 81-84. *Achoania*.

Zhu, M, X-B Yu & P Janvier (1999), *A primitive fossil fish sheds light on the origin of bony fishes*. **Nature** 397: 607-610. Onychodontiformes, Osteichthyes, Porolepiformes, *Psarolepis*, Teleostomi Overview.

Zhu M, W-J Zhao, L-T Jia, J Lu, T Qiao & Q-M Qu (2009), *The oldest articulated osteichthyan reveals mosaic gnathostome characters*. **Nature** 458: 469-474. Gulars.

Zimmer, C (1998), **At the Water's Edge**. Simon & Shuster, 290 pp. Basilosauridae, *Basilosaurus*, Cetacea

Zimmer, C (2000), *In search of vertebrate origins: beyond brain and bone*, **Science** 287: 1576. Craniata, Euconodonta.

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