Saving the World with Phylogenetics

36-149 The Tree of Life

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Plan

- Review and finish last time
- Data activity
- Phylogenetic stories

Cladistics Intro Review

- The Problem
- The Representation
  - Trees and tree parts
  - Clades
- The Terminology
  - Types of characters
  - Taxa and how to define them (part I, groups)

Cladistics (cont'd)

In practice – because we do not observe the organisms (or their remains) at most of the nodes in the tree – there is some flexibility in the definition of a taxon.

Three basic methods are used to define taxonomic groups in practice:

- Node-based taxon: as above, all the organisms descended from and including some basal node.

  Example: Aves (birds) are defined as *Archaeopteryx*, the Neornithes (modern birds), their common ancestor, and all its descendants.

- Stem-based taxon: all descendants from a particular splitting (cladogenesis) event.

  Example: *Ornithischia* (a dinosaur group) is defined as all dinosaurs more closely related to *Triceratops* than to *Tyranosaurus*.

Cladistics (cont'd)

- Apomorphy-based taxon: defined by the presence of one or more specified characters.

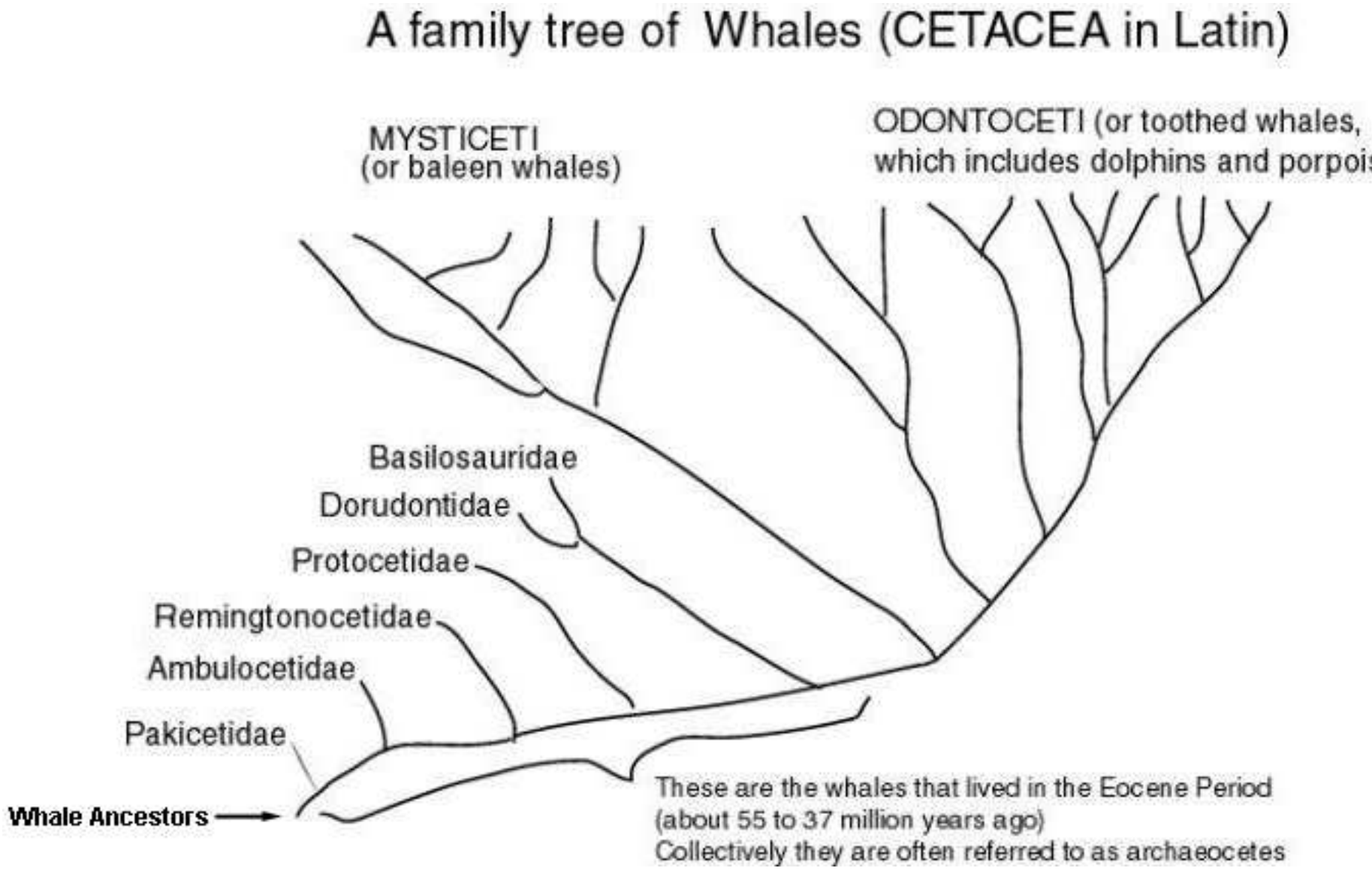
  Example: Aves (birds) consists of all archosaurs with feathered wings.

In addition, a clade defined in terms of living organisms is called a crown group.

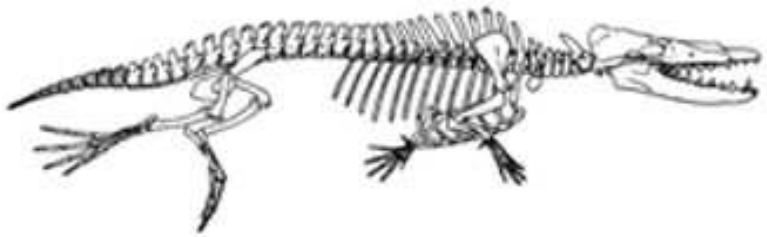
Example: The clade defined by living birds (Neornithes) is a crown-group taxon that does not include *Archaeopteryx*. (Compare above.)

Phylogenetic Stories

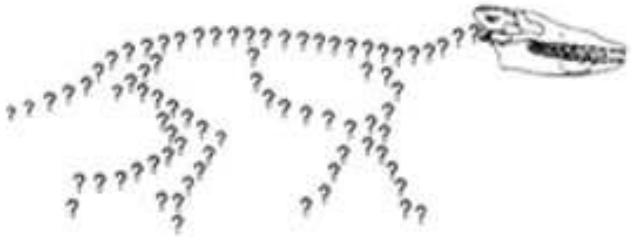
- The Whippo
- The Venom Doctor
- Beetles (Again, and briefly)
- Acoelomorphs


A family tree of Whales (CETACEA in Latin)
MYSTICETI
(or baleen whales)
ODONTOCETI (or toothed whales,
which includes dolphins and porpoi
Basilosauridae
Dorudontidae
Protocetidae
Remingtonocetidae
Ambulocetidae
Pakicetidae
Whale Ancestors
These are the whales that lived in the Eocene Period
(about 55 to 37 million years ago)
Collectively they are often referred to as archaeocetes

D. *Dorudon* (Basilosauridae) from the middle to late Eocene of Egypt



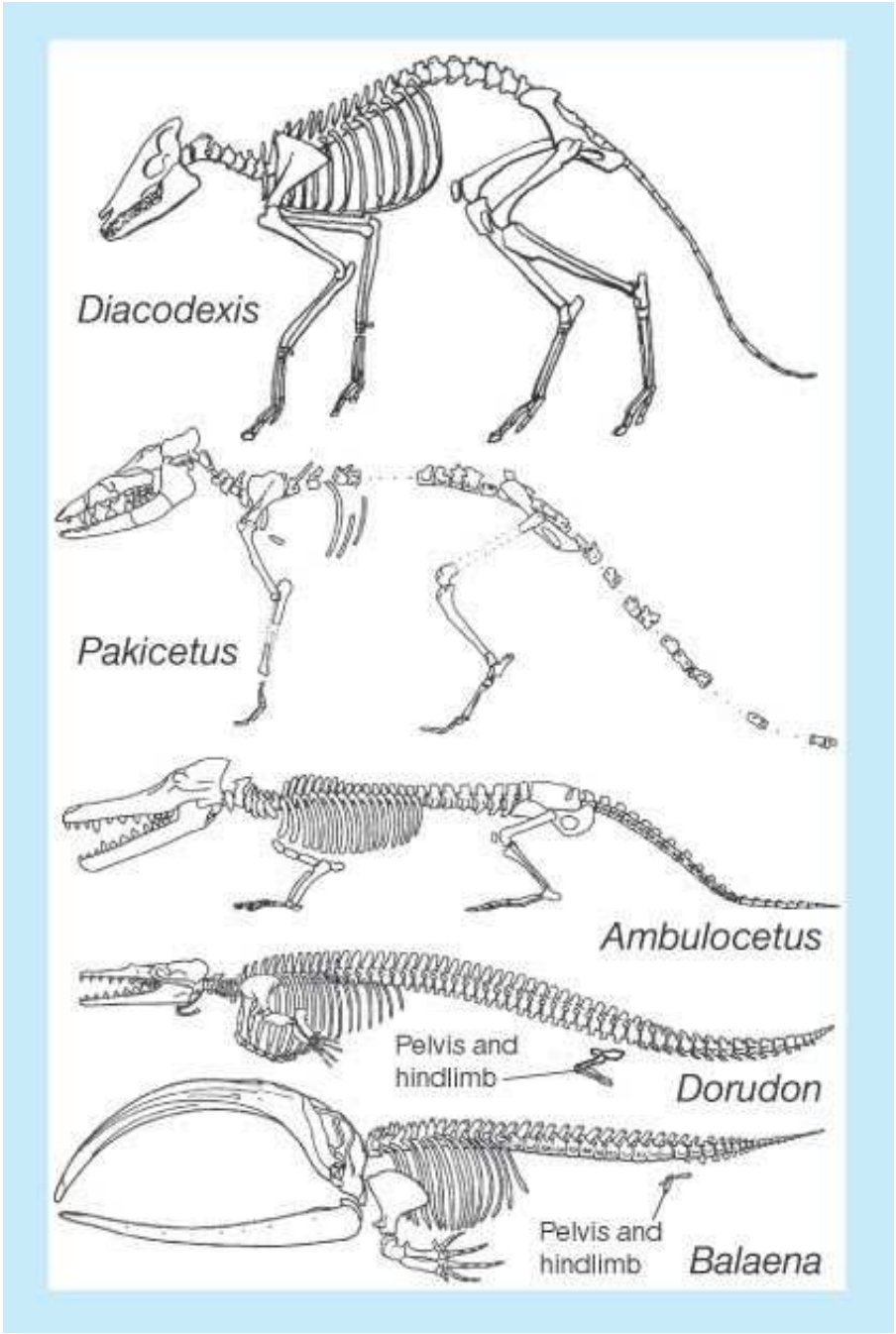
C. *Rodhocetus* (Protocetidae) from the early middle Eocene of Pakistan



B. *Pakicetus* (Pakicetidae) from the earliest middle Eocene of Pakistan

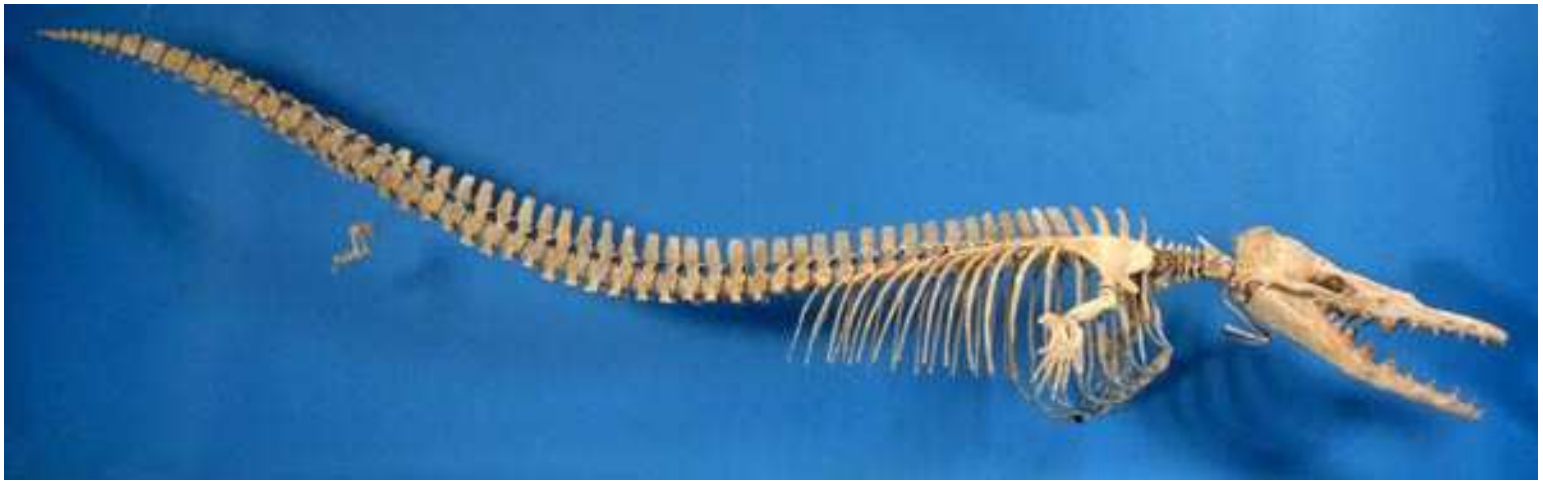
A. *Elomeryx* (Anthracotheriidae) from the Oligocene of Europe, North America, Asia

The Mesonychid View of Whale Ancestors

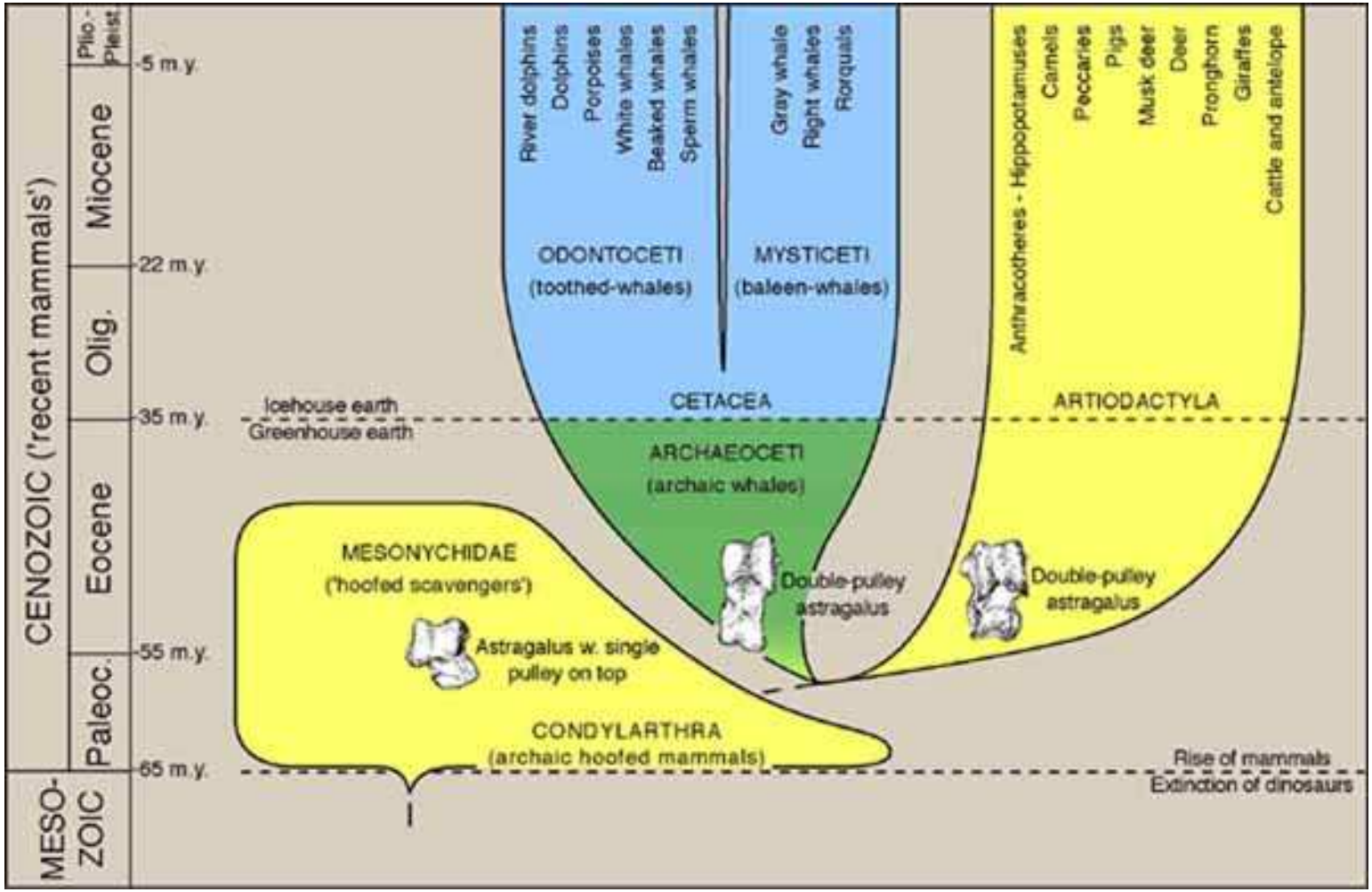


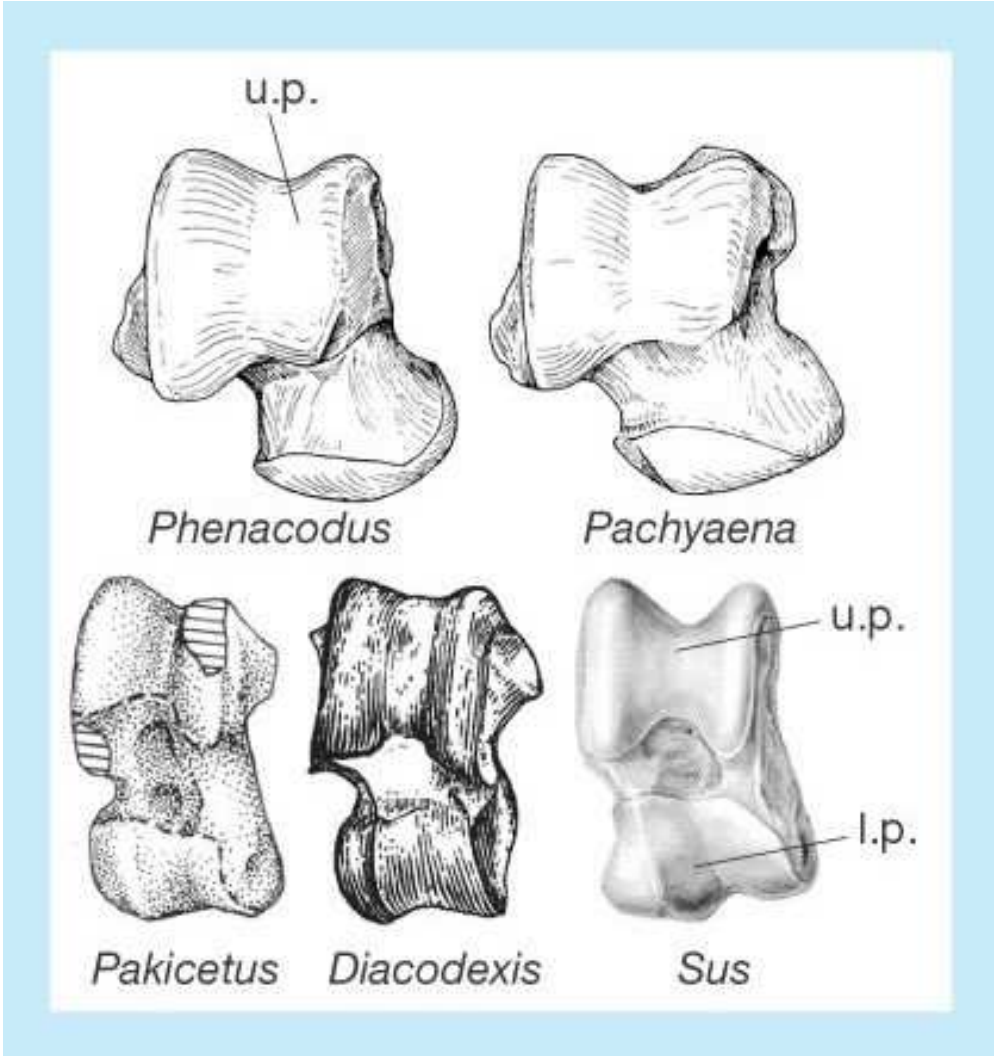
Diacodexis was a primitive even-toed ungulate (hoofed mammal); Pakicetus is one of the terrestrial cetaceans described by Thewissen et al.; Ambulocetus was amphibious; Dorudon was a fully aquatic archaeocete (early cetacean), but retained an articulated elbow and vestigial hindlimbs; and Balaena is a recent whale. Skeletons are not drawn to scale.

Basilosaurus



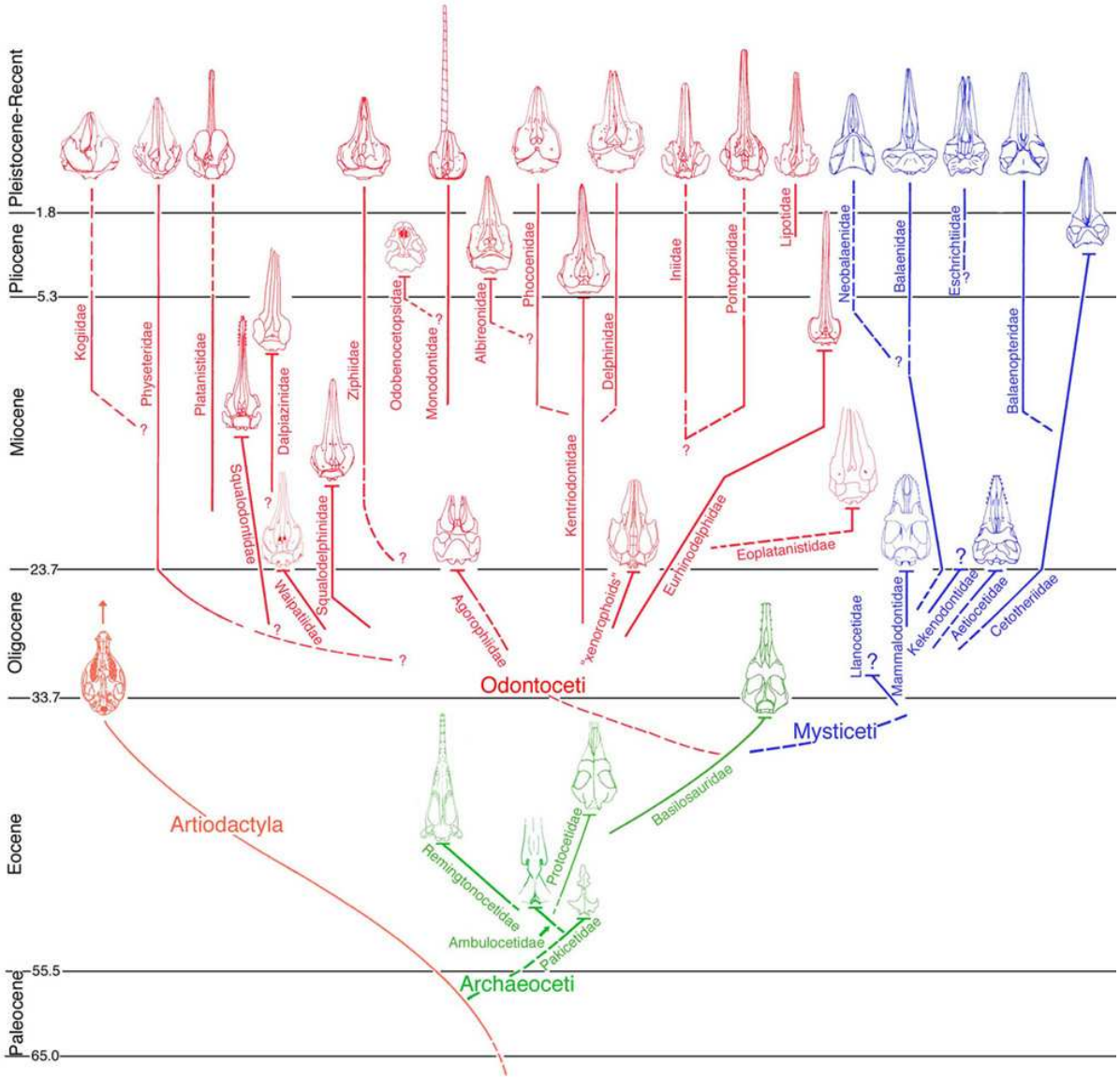
Dorudon

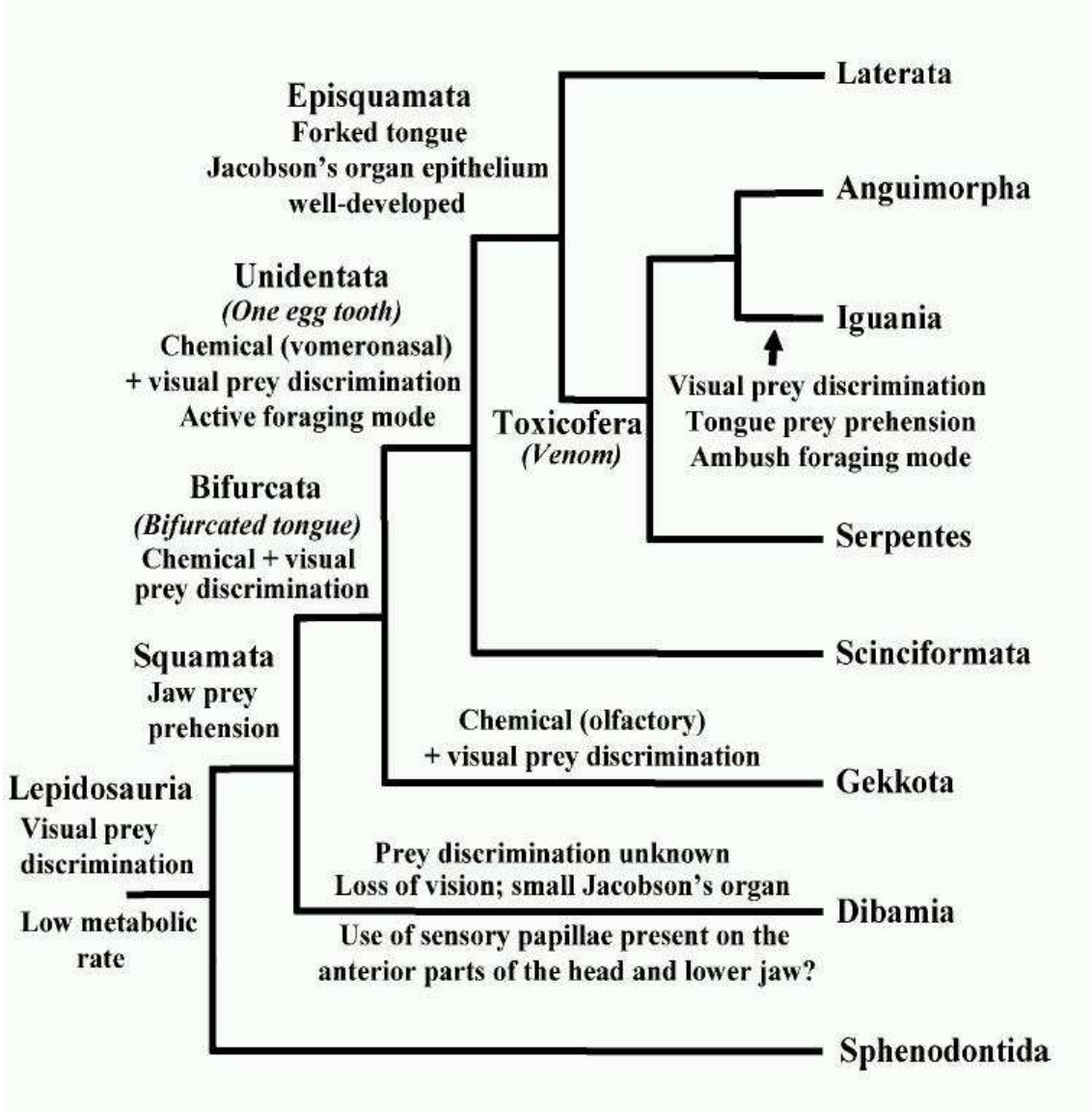

CENOZOIC ('recent mammals')
MESO-ZOIC
Plio.-Pleist.
Miocene
Olig.
Eocene
Paleoc.
5 m.y.
22 m.y.
35 m.y.
55 m.y.
65 m.y.
Icehouse earth
Greenhouse earth
River dolphins
Dolphins
Porpoises
White whales
Beaked whales
Sperm whales
Gray whale
Right whales
Rorquals
ODONTOCETI
(toothed-whales)
MYSTICETI
(baleen-whales)
CETACEA
ARCHAEOCETI
(archaic whales)
Anthracotheres - Hippopotamuses
Camels
Peccaries
Pigs
Musk deer
Deer
Pronghorn
Giraffes
Cattle and antelope
ARTIODACTYLA
Double-pulley astragalus
Double-pulley astragalus
MESONYCHIDAE
('hoofed scavengers')
Astragalus w. single pulley on top
CONDYLARTHRA
(archaic hoofed mammals)
Rise of mammals
Extinction of dinosaurs

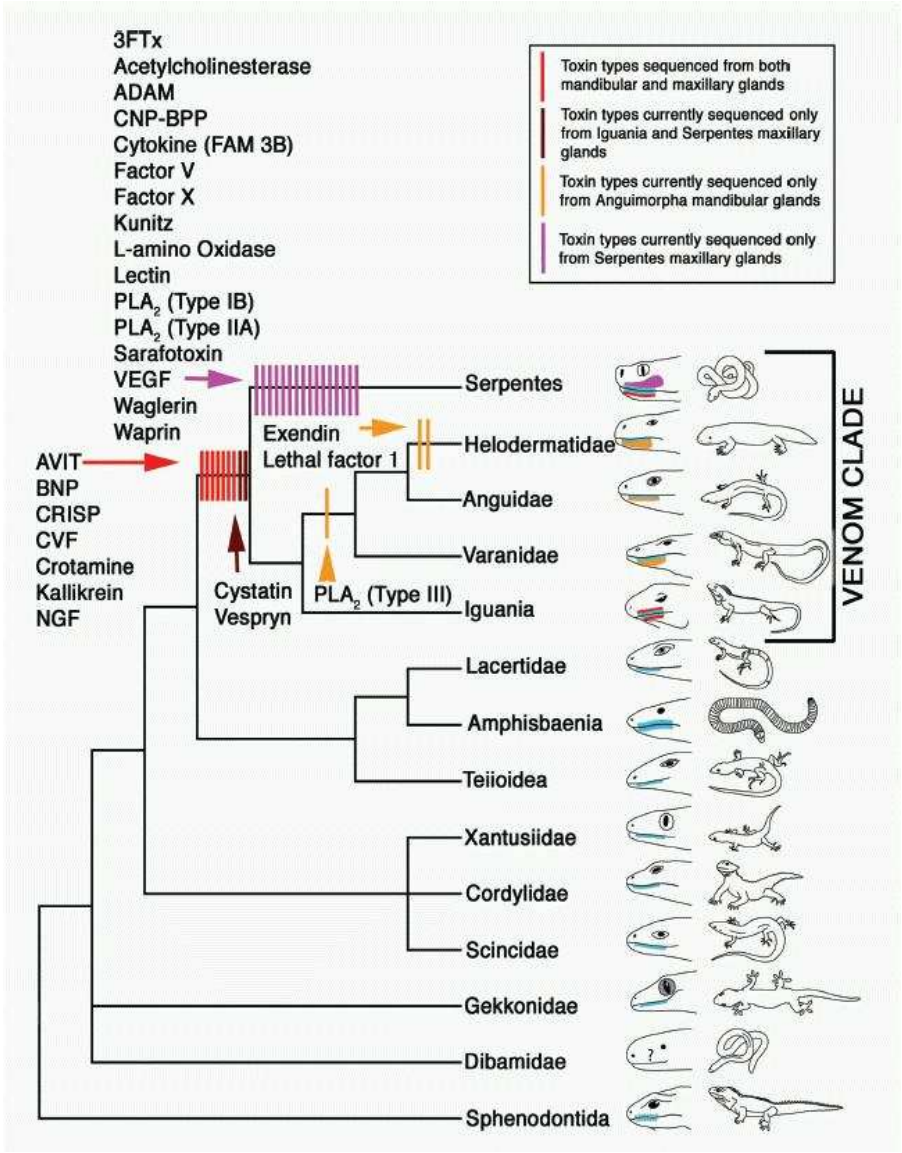


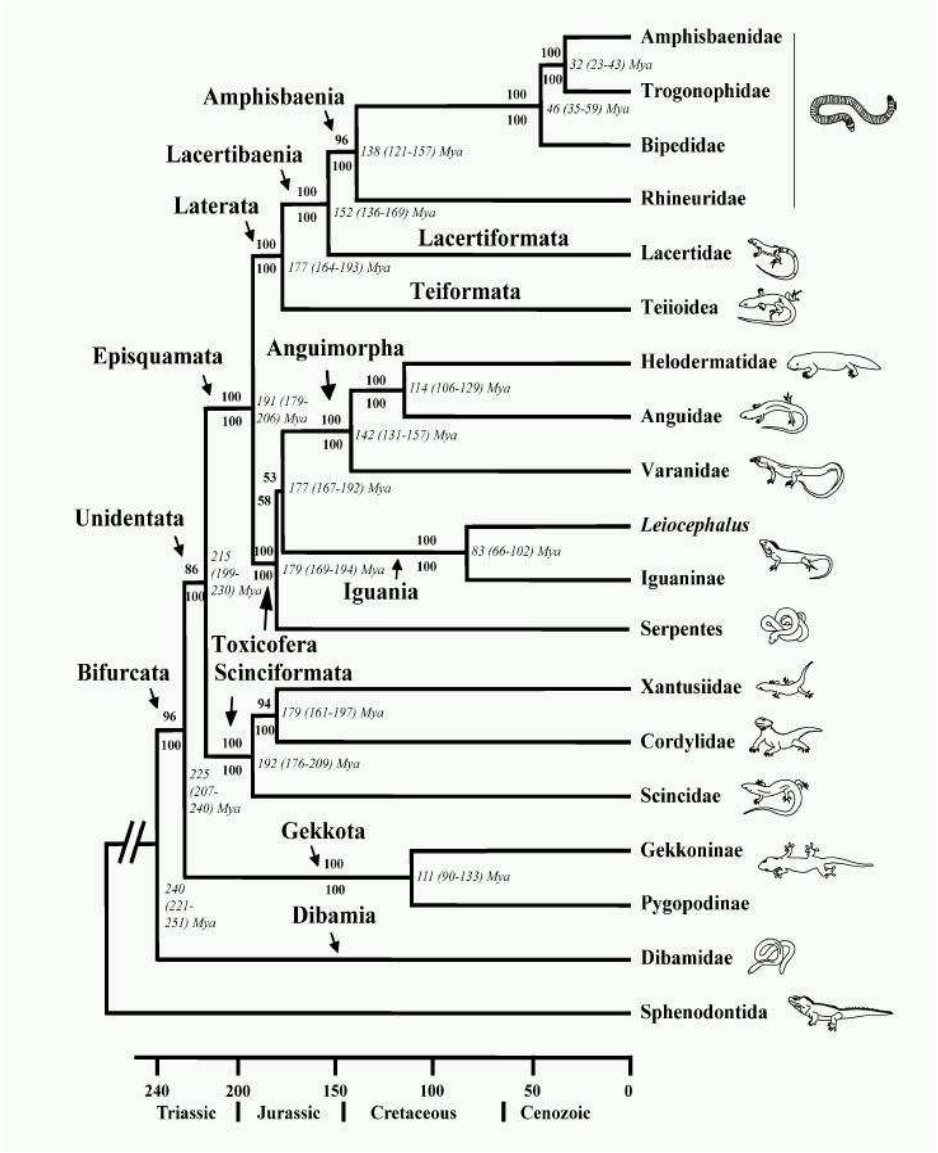
Phenacodus, a primitive ungulate, had an unspecialized ankle bone that resembles that of Pachyaena, a mesonychian ungulate from 50 million years ago. The double-pulleyed astragali of Pakicetus (one of the fossil cetaceans described by Thewissen et al.1), Diacodexis (the oldest known even-toed ungulate), and Sus (the pig) indicate a close relationship between these species. Bones are not shown to scale. u.p., upper pulley, articulates with tibia. l.p., lower pulley, articulates with distal ankle bones.

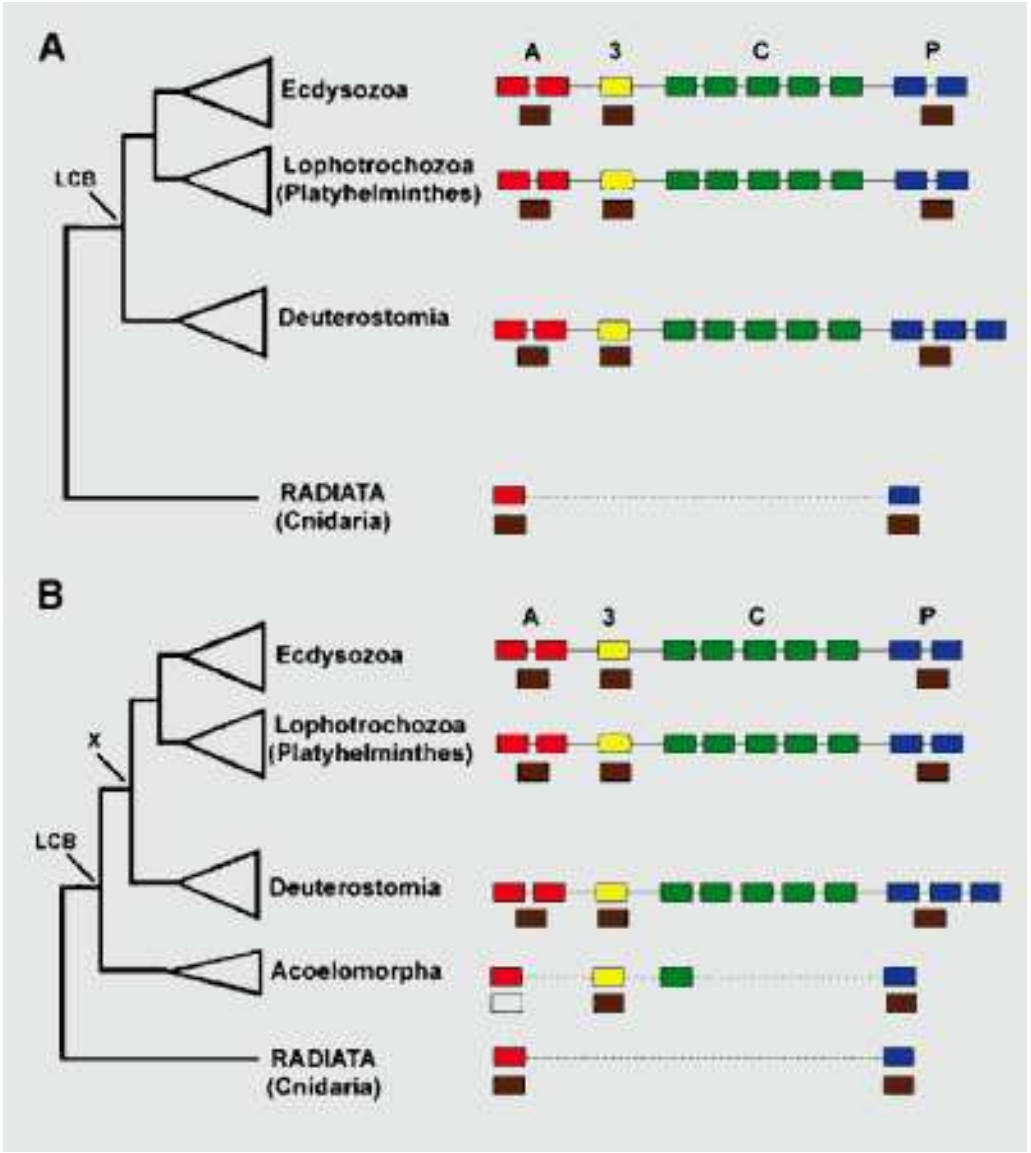

10 CM

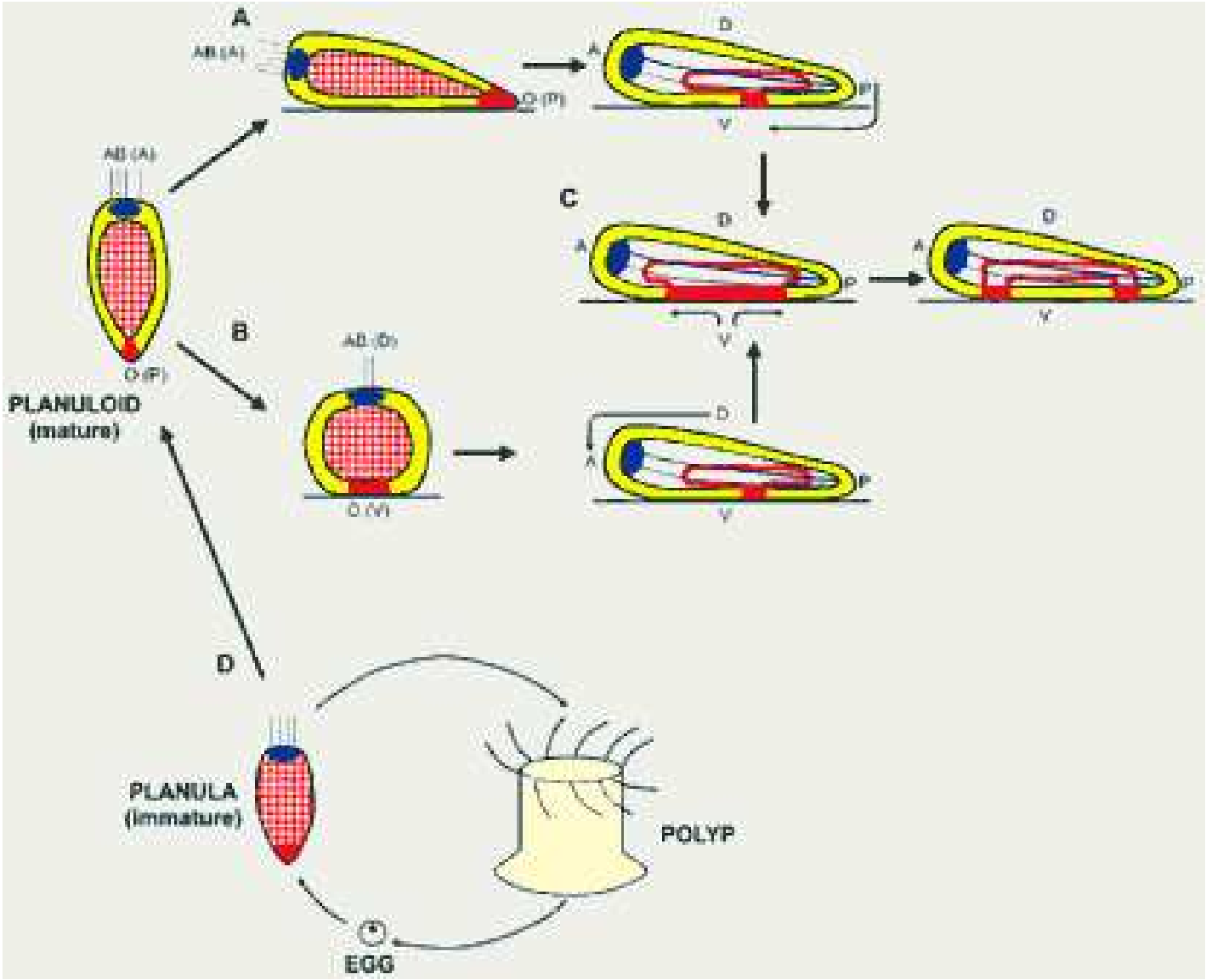

Pleistocene-Recent
1.8
Pliocene
5.3
Miocene
23.7
Oligocene
33.7
Eocene
55.5
Paleocene
65.0
Kogiidae
Physeteridae
Platanistidae
Squalodontidae
Dalpiazinidae
Waipatiidae
Squalodelphinidae
Ziphiidae
Odobenocetopsidae
Monodontidae
Albireonidae
Phocoenidae
Delphinidae
Kentriodontidae
Iniidae
Pontoporiidae
Lipotidae
Neobalaenidae
Balaenidae
Eschrichtiidae
Balaenopteridae
Eurhinodelphidae
Eoplatanistidae
Agorophiidae
"xenorophoids"
Llanocetidae
Mammalodontidae
Kekenodontidae
Aetiocetidae
Cetotheriidae
Odontoceti
Mysticeti
Basilosauridae
Artiodactyla
Remingtonocetidae
Protocetidae
Ambulocetidae
Pakicetidae
Archaeoceti


Episquamata
Forked tongue
Jacobson's organ epithelium
well-developed
Laterata
Anguimorpha
Iguania
Unidentata
(One egg tooth)
Chemical (vomeronasal)
+ visual prey discrimination
Active foraging mode
Visual prey discrimination
Tongue prey prehension
Ambush foraging mode
Toxicofera
(Venom)
Serpentes
Bifurcata
(Bifurcated tongue)
Chemical + visual
prey discrimination
Squamata
Jaw prey
prehension
Scinciformata
Chemical (olfactory)
+ visual prey discrimination
Gekkota
Lepidosauria
Visual prey
discrimination
Prey discrimination unknown
Loss of vision; small Jacobson's organ
Dibamia
Low metabolic
rate
Use of sensory papillae present on the
anterior parts of the head and lower jaw?
Sphenodontida


3FTx
Acetylcholinesterase
ADAM
CNP-BPP
Cytokine (FAM 3B)
Factor V
Factor X
Kunitz
L-amino Oxidase
Lectin
PLA2 (Type IB)
PLA2 (Type IIA)
Sarafotoxin
VEGF
Waglerin
Waprin
AVIT
BNP
CRISP
CVF
Crotamine
Kallikrein
NGF
Cystatin
Vespryn
Exendin
Lethal factor 1
PLA2 (Type III)
Toxin types sequenced from both mandibular and maxillary glands
Toxin types currently sequenced only from Iguania and Serpentes maxillary glands
Toxin types currently sequenced only from Anguimorpha mandibular glands
Toxin types currently sequenced only from Serpentes maxillary glands
Serpentes
Helodermatidae
Anguidae
Varanidae
Iguania
Lacertidae
Amphisbaenia
Teiioidea
Xantusiidae
Cordylidae
Scincidae
Gekkonidae
Dibamidae
Sphenodontida
VENOM CLADE


Amphisbaenidae
32 (23-43) Mya
Trogonophidae
46 (35-59) Mya
Bipedidae
Rhineuridae
Amphisbaenia
Lacertibaenia
138 (121-157) Mya
Laterata
152 (136-169) Mya
Lacertiformata
Lacertidae
177 (164-193) Mya
Teiformata
Teiioidea
Episquamata
Anguimorpha
Helodermatidae
114 (106-129) Mya
Anguidae
191 (179-206) Mya
142 (131-157) Mya
Varanidae
177 (167-192) Mya
Unidentata
Leiocephalus
83 (66-102) Mya
Iguaninae
215 (199-230) Mya
179 (169-194) Mya
Iguania
Serpentes
Toxicofera
Bifurcata
Scinciformata
Xantusiidae
179 (161-197) Mya
Cordylidae
192 (176-209) Mya
225 (207-240) Mya
Scincidae
Gekkota
Gekkoninae
111 (90-133) Mya
Pygopodinae
240 (221-251) Mya
Dibamia
Dibamidae
Sphenodontida
240
200
150
100
50
0
Triassic
Jurassic
Cretaceous
Cenozoic


A
A
3
C
P
Ecdysozoa
Lophotrochozoa
(Platyhelminthes)
LCB
Deuterostomia
RADIATA
(Cnidaria)
B
A
3
C
P
Ecdysozoa
Lophotrochozoa
(Platyhelminthes)
X
LCB
Deuterostomia
Acoelomorpha
RADIATA
(Cnidaria)


A
AB (A)
D (P)
A
D
P
V
C
D
A
P
V
D
A
P
V
AB (A)
D (P)
PLANULOID
(mature)
B
AB (D)
D (V)
D
A
P
V
D
PLANULA
(immature)
POLYP
EGG