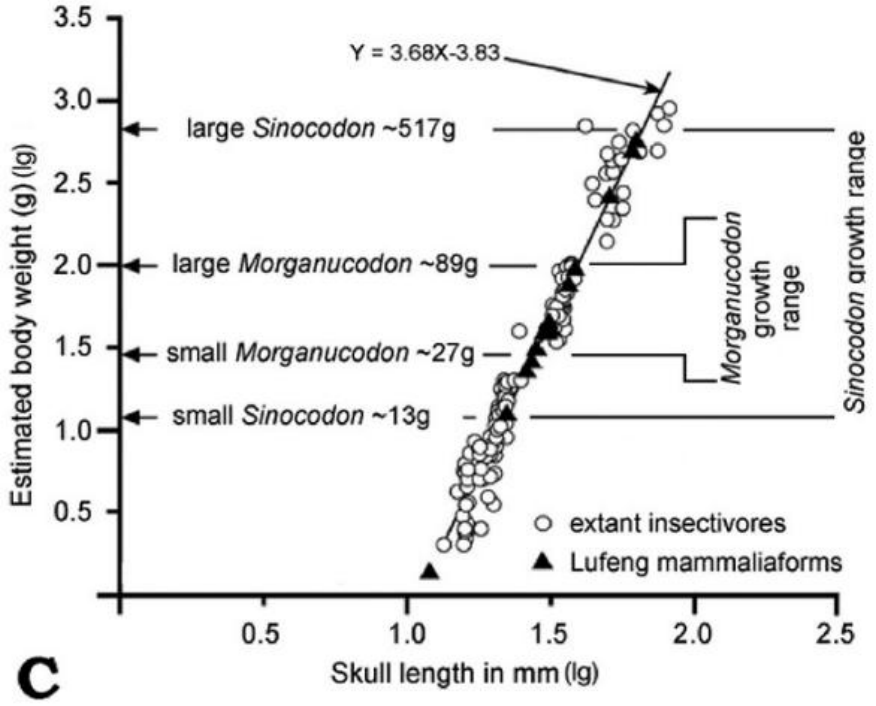
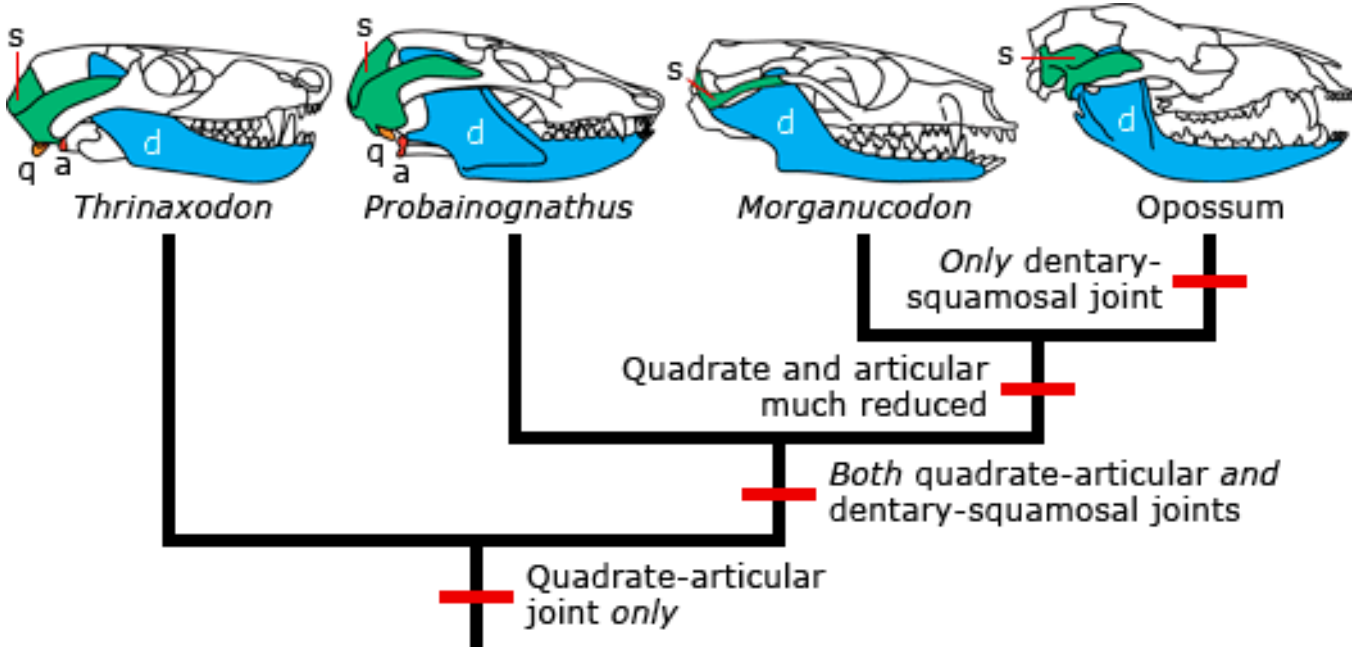
Mammaliaformes

- **DEFINING** adaptation = Dentary-Squamosal Jaw Joint (Morganucodon/Sinoconodon)
- Dental Occlusion (originally in Tritylodontid cynodonts)
- Loss of constant tooth replacement – Polyphyodonty -> Diphyodonty (Morganucodon)
- Accelerated juvenile growth and restricted growth curve – associated with provisioning young (Morganucodon)
- Impedance matching by adapting post-dentary-unit into middle ear:

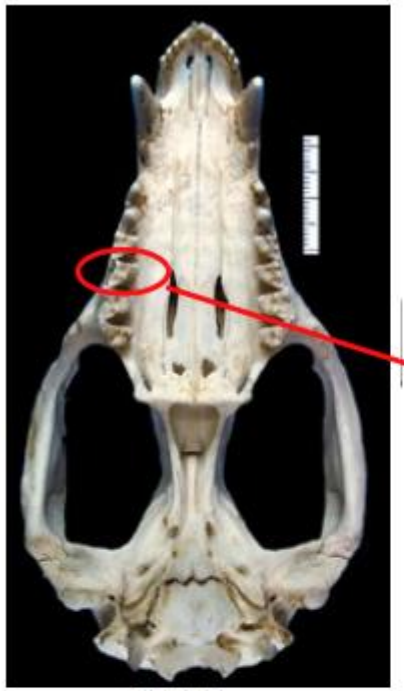
- Articular => Malleus
- Quadrate => Incus
- Hyomandibular => Stapes (Columella in amphibians & from same embryological origin as Meckel's cartilage and 2nd pharyngeal arch)
- Angular => Tympanic



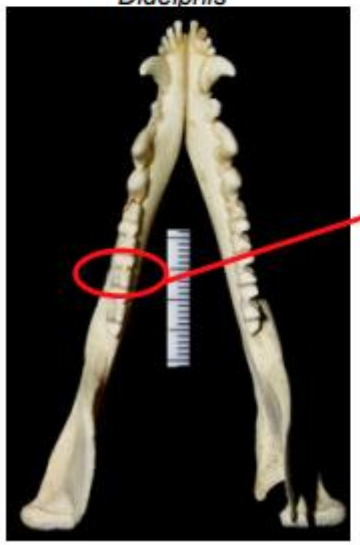


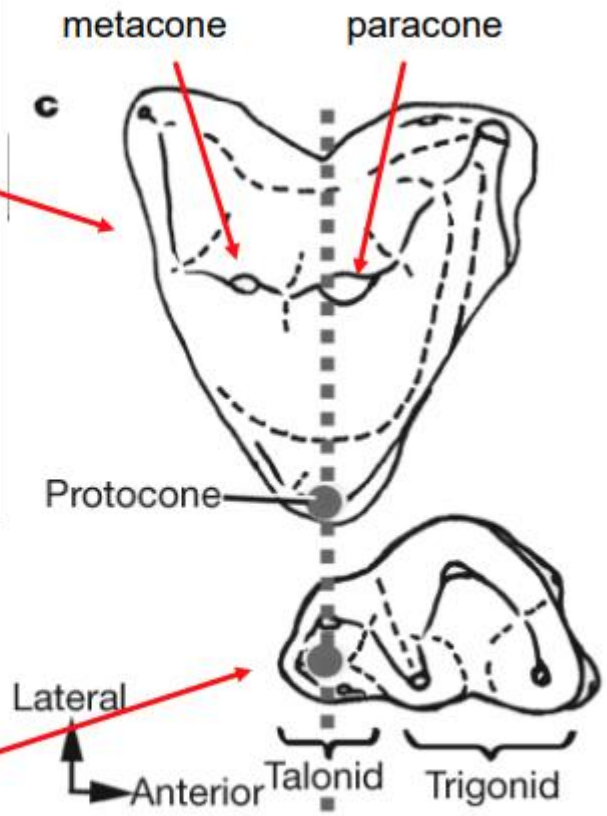
Dental Occlusion

- The interlocking of teeth likely aided with more efficient mastication
- However, it made replacement more costly as it risked mis-alignment => Diphyodonty
- This also changed the growth curve for mammaliaformes
- Tribosphenic occlusion (shared between therians) is the most well understood and is characterised by:
- Protocone (upper tooth, e.g. P4) occluding into the talonid basin (lower tooth e.g. M1)
- Paracone (upper tooth) occluding into the ectoflexid (lower tooth)
- Generally if a feature ends with “-id” (e.g. taloned/exoflexid/protoconid) it’s on the lower jaw teeth.



Didelphis





Cusp terminology after VanValen 1966 *Bulletin AMNH* 132: fig. 1

Mammalian Hearing

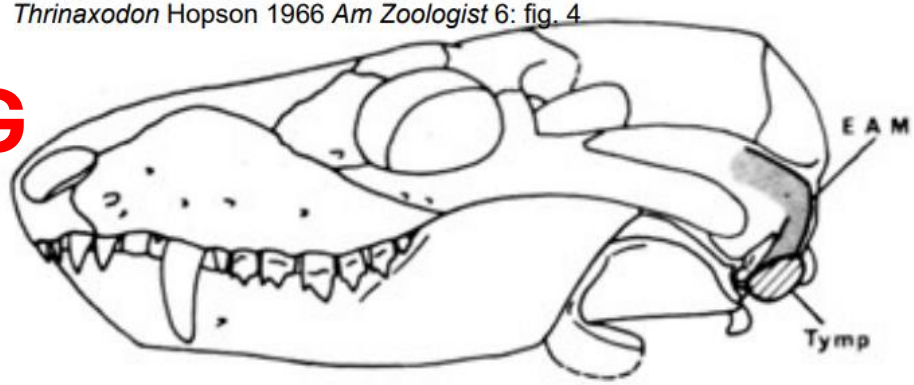
- Hopson said Thrinaxodon possessed the same impedance matching mechanism as reptiles – a post-quadrate tympanum
- Alin argued that Thrinaxodon used the angular to convey sound to the stapes via the articular and quadrate
- They did a unified middle-ground-theory where hearing was largely an angular tympanum with a small postquadrate component, but it was wrong – Alin was right.
- Shows that the way the ear ossicles in modern mammals articulate to carry sound is in the same arrangement as their precursor bones in their synapsid ancestors.

Evidence:

Archeothyris had a structurally relevant columella (hyomandibular/stapes) but no otic notch (invagination in non-mammalian amniotes that likely acted as a tympanum)

WRONG

Thrinaxodon Hopson 1966 *Am Zoologist* 6: fig. 4

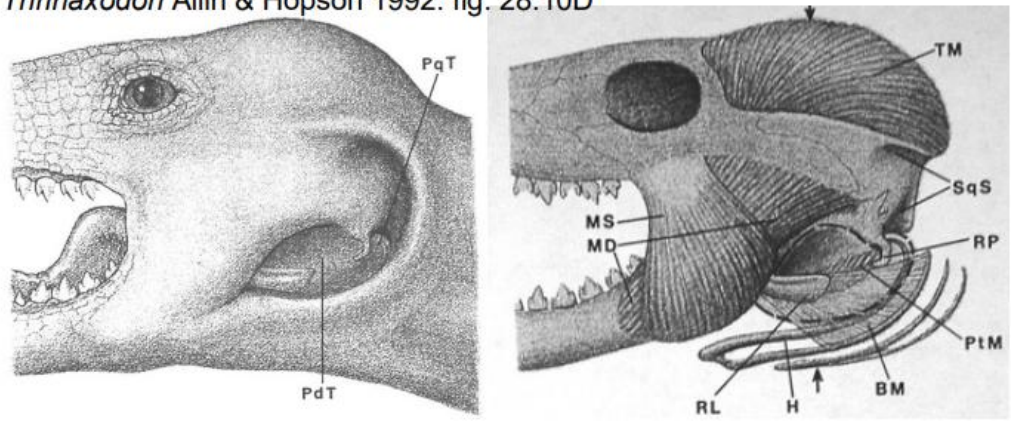


RIGHT

Thrinaxodon after Allin 1975 *J Morphology* 147: plate 6

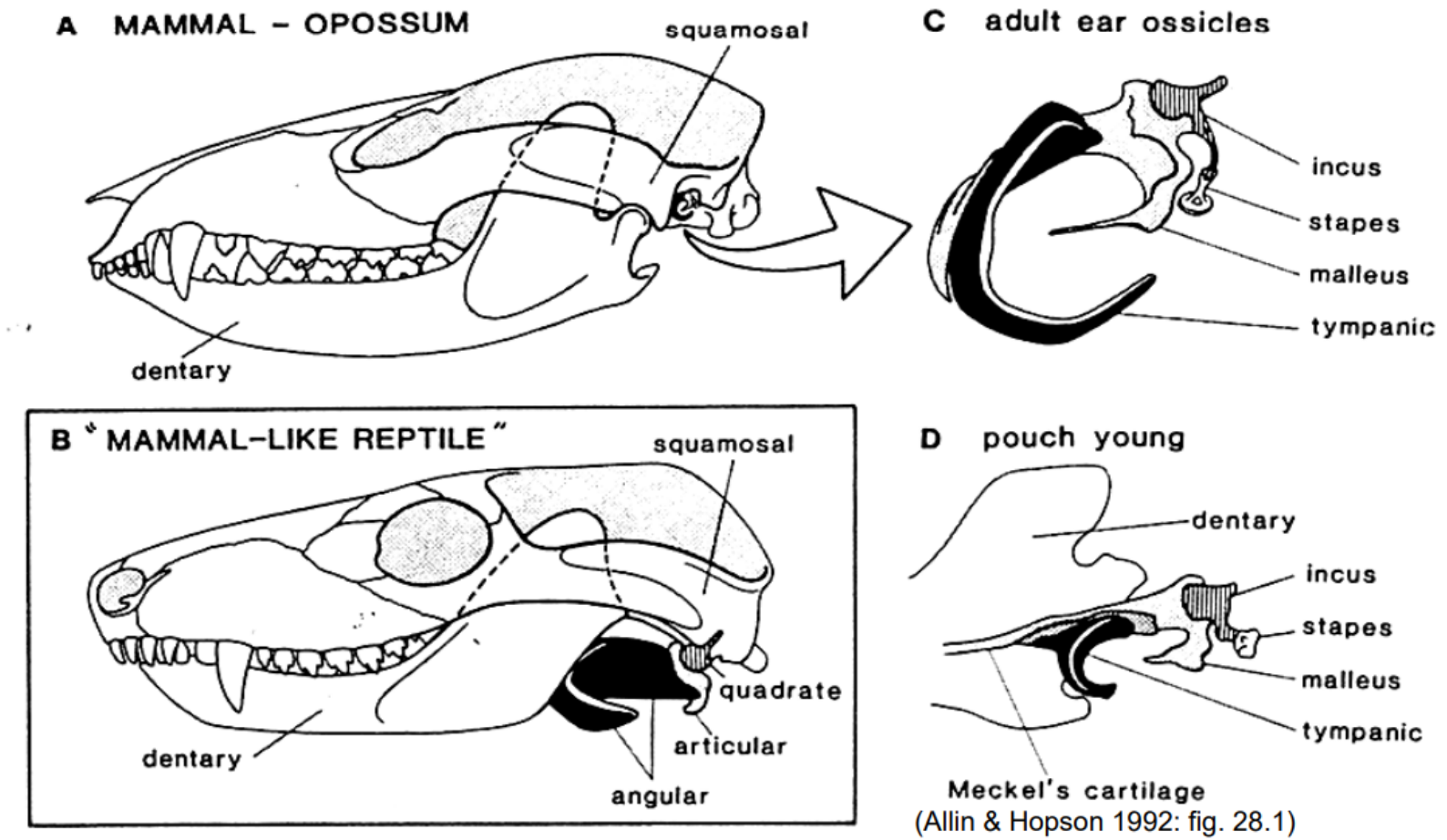
ALSO WRONG

Thrinaxodon Allin & Hopson 1992: fig. 28.10D



Mammalian Hearing

- As dentary expanded, the postdentary unit could get smaller.
- Eventually with Mammaliaformes its only role was hearing (impedance matching) so it completely specialised to it.
- Through ontological study, it's clear that the ear ossicles went through an intermediate stage where they were separate from the dentary but supported by Meckel's cartilage.
- The groove on the dentary of Morganucodon is interpreted to be where Meckel's cartilage once sat.
- Urban DJ et al. 2017 shows evidence that Meckel's cartilage likely broke down independently in metatherians and eutherians.
- This means a detached middle ear evolved twice in therians and 4 times overall.



(Allin & Hopson 1992: fig. 28.1)

“Ontogeny recapitulates Phylogeny” - Haeckel

- The 1st and 2nd visceral arches (the developmental tissues that form gills, jaws, facial bones, clavicles, ribs, etc) contain the originations of all the bones in mammalian and non-mammalian hearing
- The 1st visceral arch contains precursors for the following in Mammals & Non-mammals

- Meckel’s cartilage
- Malleus/Articular
- Incus/Quadrate
- Tympanic/Angular

- The 2nd visceral arch contains the precursors for the following in Mammals and Non-Mammals

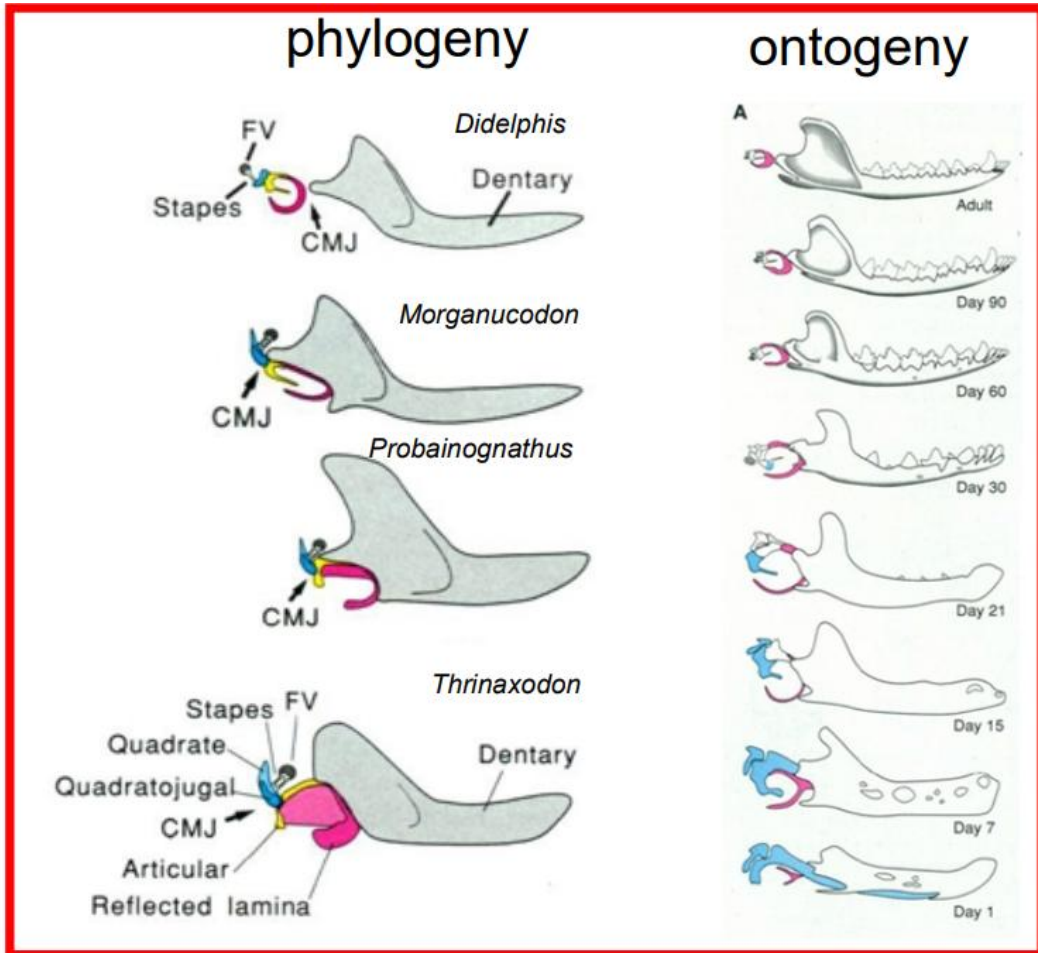
- Reichert’s cartilage (actual precursor of below elements)
- Stapes/Columella (Hyomandibular)
- Dorsal Hyoid

Paedomorphosis

- Adult descendent resembles juvenile ancestor

Peramorphosis

- Juvenile descendent resembles adult ancestor

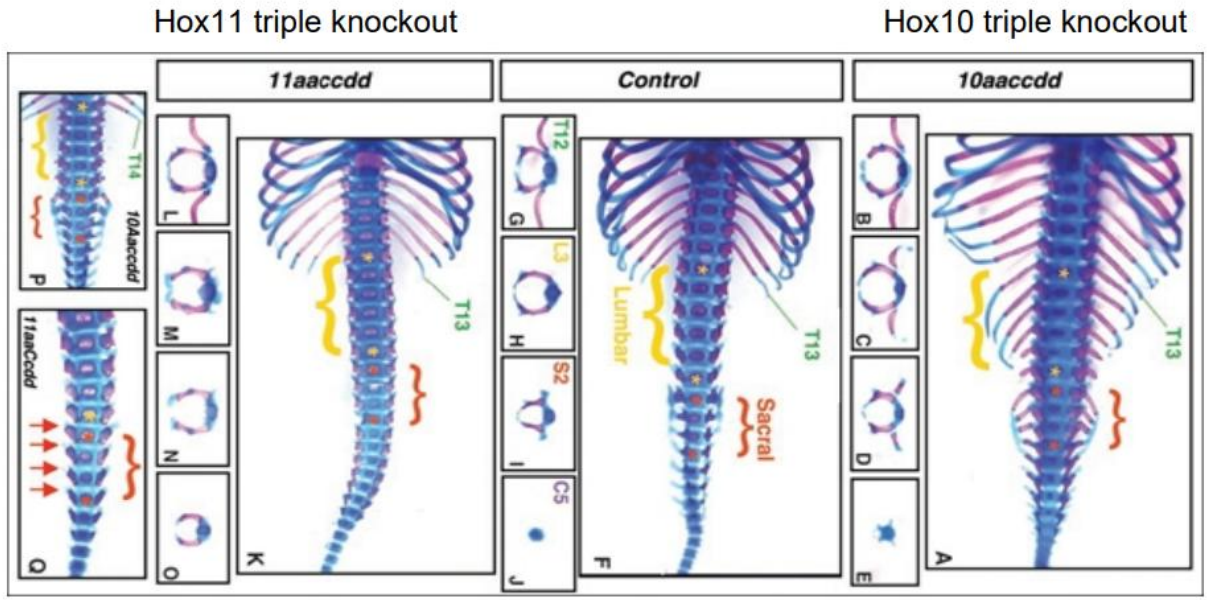


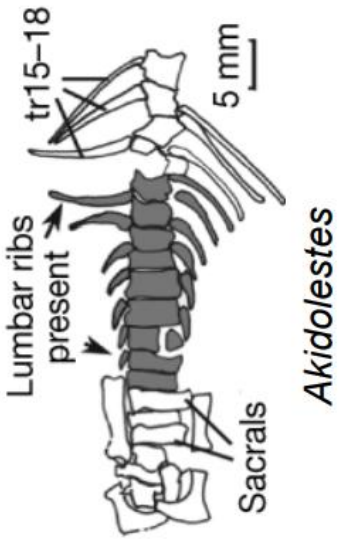
Interesting Cases

- Brasilodon (Cynodont) – appears to exhibit diphyodonty before a dentary squamosal jaw joint => convergent evolution
- Fossil Australosphenidans – convergently evolved apparent “pseudotribosphenic” occlusion
- DMME (definitive mammalian middle ear) occurred multiple times independently in mammaliaformes (spalacotheroids, therians, Liaoconodon – possbile monotreme ancestor)
- Monotremes then regained a partially attached middle ear.

Skeletal evolution in Mammalia

Monotremes/Australosphenidans	Therians
Interclavicle	Lack interclavicle
Separate coracoids	Fused coracoids
Elliptical humeral head	Scapular Spine + Supraspinatous fossa
Re-evolution of lumbar ribs (in certain groups)	Spherical humeral head
Pseudotribosphenic occlusion + edentulous	Tribosphenic Occlusion





Mesozoic Mammaliaformes exhibit lumbar ribs similar to those of Hox10 transgenic mice

Monotremata & Australosphenidae

Key features

- Cynodont pectoral girdle
- Cloaca
- Oviparous
- Enclosed cochlea (petrosal)
- Detached post-dentary-unit w/ no meckelian groove
- Ossicles within middle ear
- Provision young with milk (no nipples)
- Typically, edentulous

Key Taxa

- Echidnas (Tachyglossidae - extant)
- Platypus (Ornithorhynchidae - extant)
- Steropodon (stem Monotreme/Ornithorhynchid – extinct)
- Obdurodon (stem Ornithorhynchid – extinct)

Tachyglossidae:

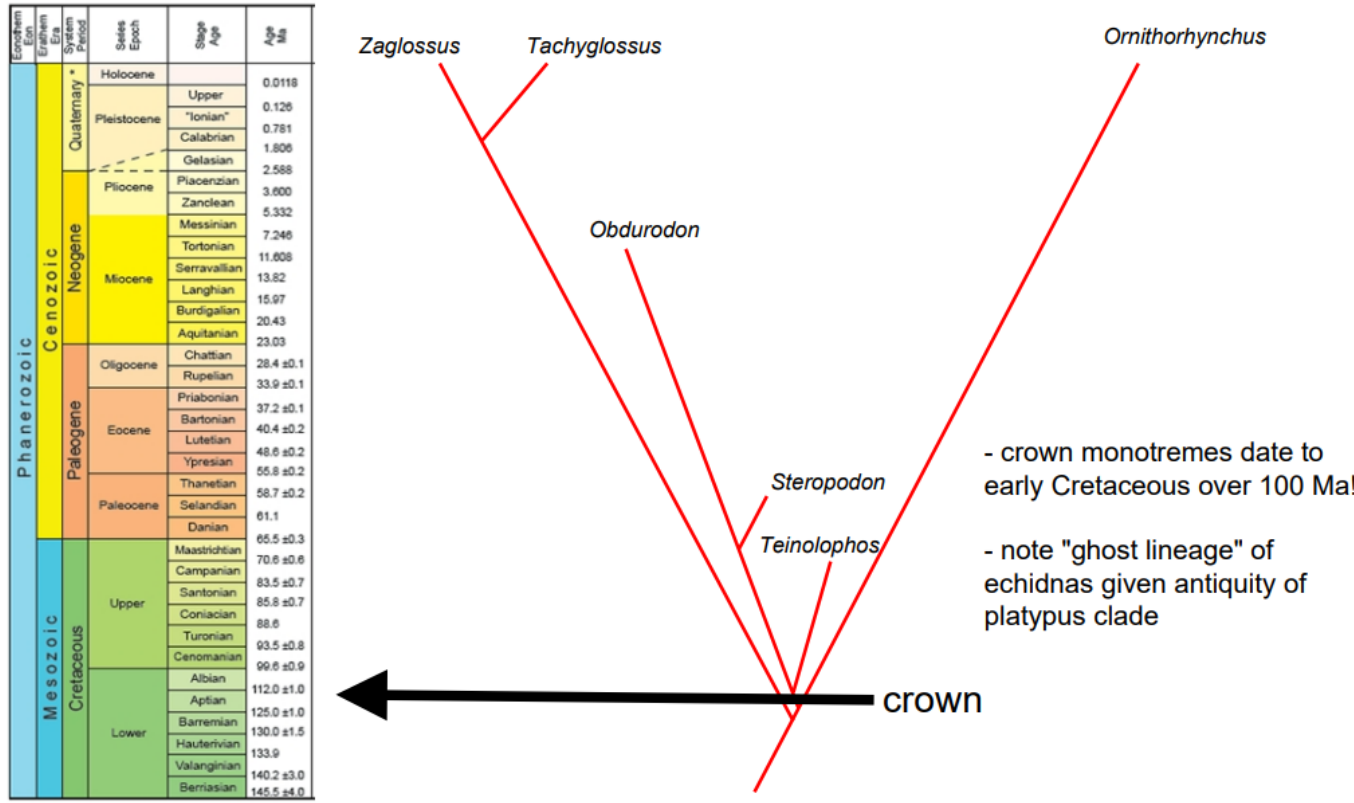
- Insectivorous
- Protrusible tongue like an anteater
- Mastication is at rear of mouth between keratinous base of tongue and roof of mouth
- Seasonally developed pouch to rear young.

Ornithorhynchidae:

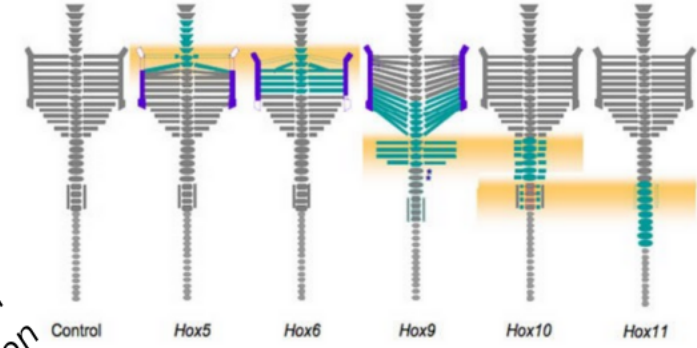
- Semi-aquatic (eyes and ears covered by skin during dives)
- Venomous hindfoot-spur in males used in intraspecific competition
- Eggs are laid in burrow (no pouch)
- Young develop in burrow after hatching ~4mon
- Electrosensitive bill (rostrum)

Rowe et al. 2008: ornithorhynchids have ancient history, independent from echidnas

Teinolophos as a crown monotreme (Rowe et al. 2008)



Mammaliaformes



partial reaquisition of lumbar ribs

pseudotribosphenic occulsion
(pseudo trigonid basin)

Tritylodontidae
Sinoconodon
Morganucodon
Docodonts
Haramiyida
Steropodon
Tachyglossidae
Obdurodon
Ornithorhyncidae
Eutriconodonta
Multituberculata
Spalacotheriida
Dryolestida
Tribactonodon
Aegialodon

Monotremata
Australosphenidae

Metatheria
Eutheria
Theria
Tribosphenida

coiled
cochlea

definitive (DMME)

Tribosphenic occulsion

Loss of
interclavicle

Theriiformes

Protocone → Talonid basin
Paracone → Ectoflexid

spherical humeral head

scapula spine
(supraspinatous fossa)

Loss of coracoids
(fusion)

Mammalia

Dental occulsion

Single replacement of molars

detached middle ear

dentary-squamosal

determinate growth - indicate
provisioning young, by lactation?

erect limbs
parasagital

Mammaliaformes