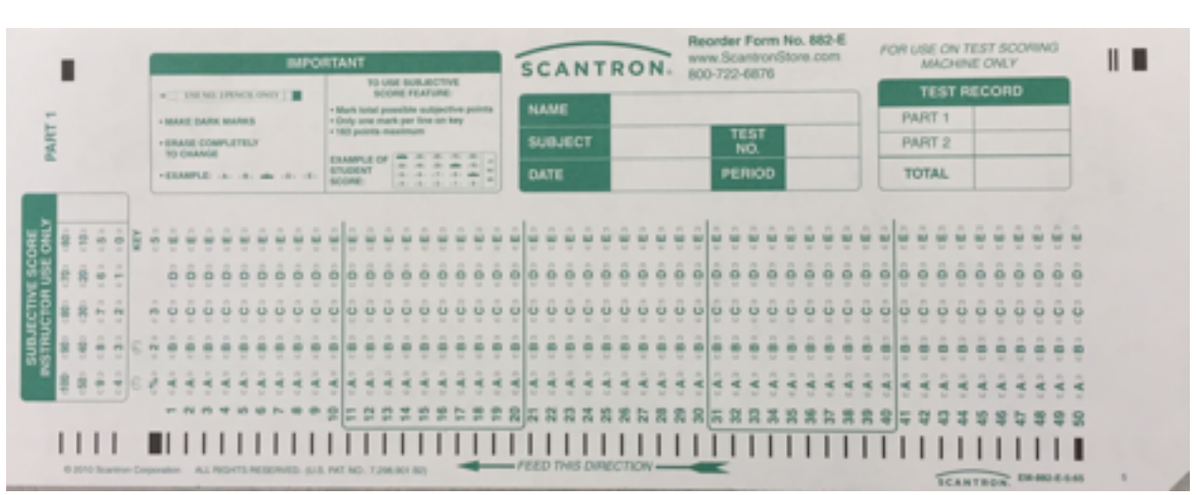
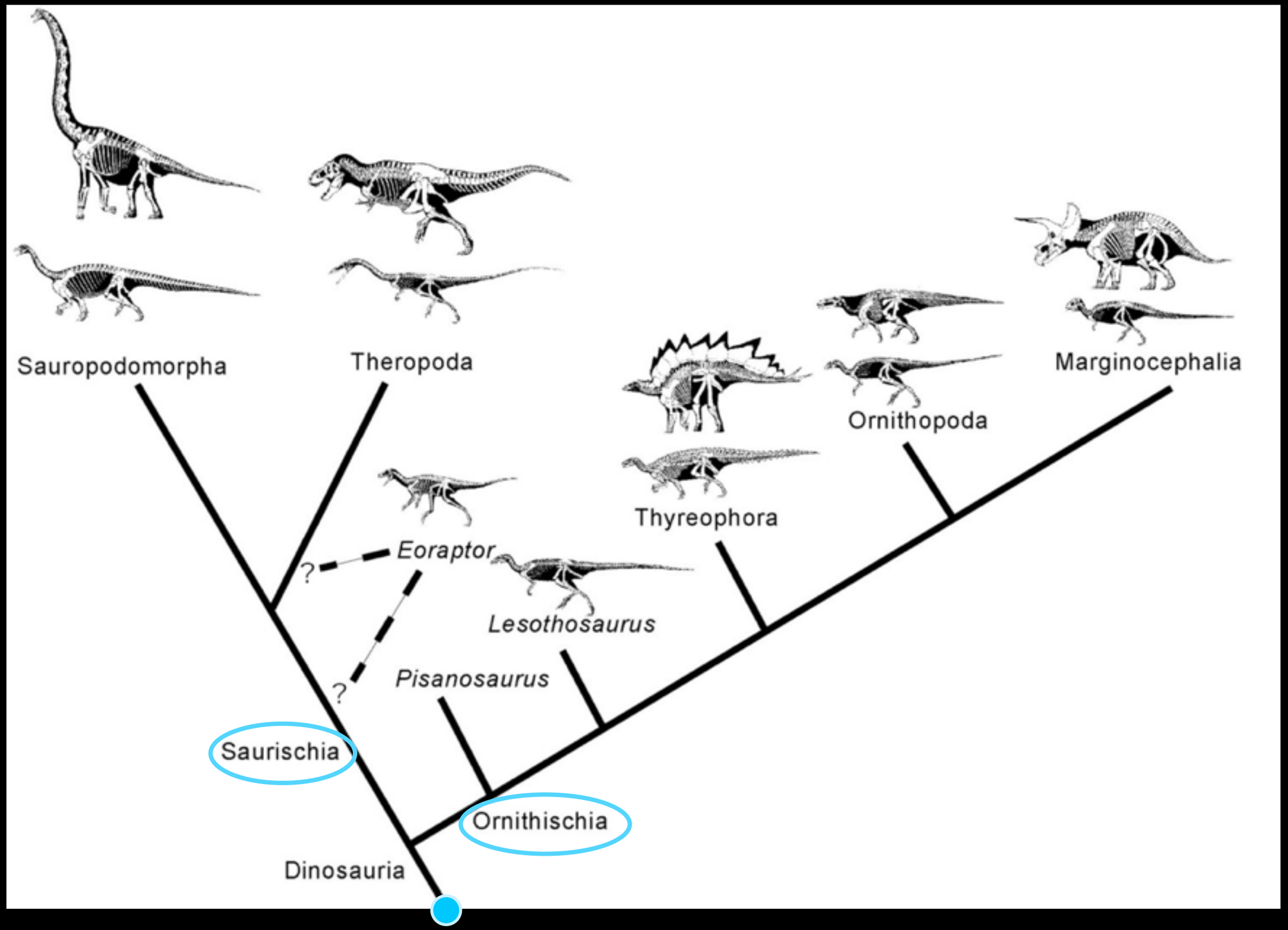
The Natural History of Dinosaurs

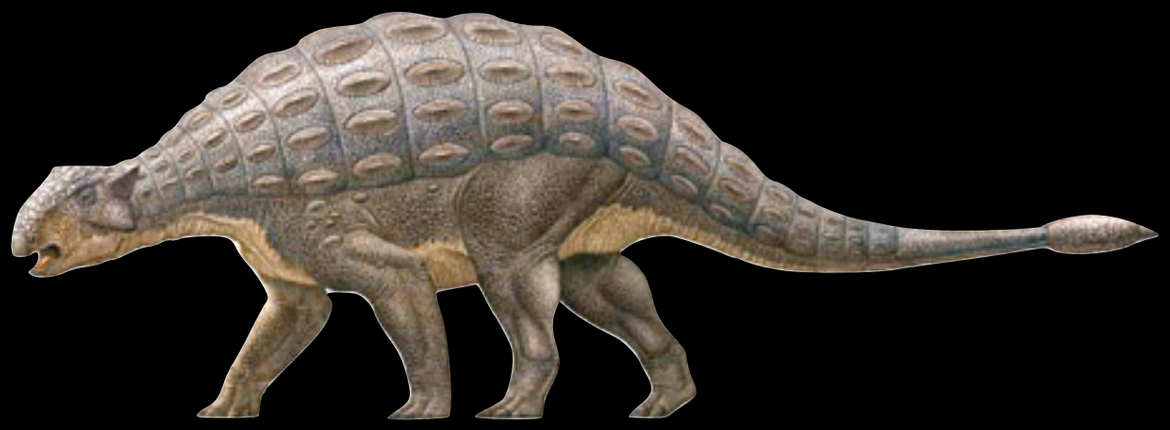
Exam 2: Friday, March 11 2016
Need: Long-green Scantron + #2 pencil



Today: Review

DINOSAURS


Sauropodomorpha
Theropoda
Ornithopoda
Marginocephalia
Thyreophora
Eoraptor
?
Lesothosaurus
?
Pisanosaurus
Saurischia
Ornithischia
Dinosauria



Ankylosauridae

Nodosauridae

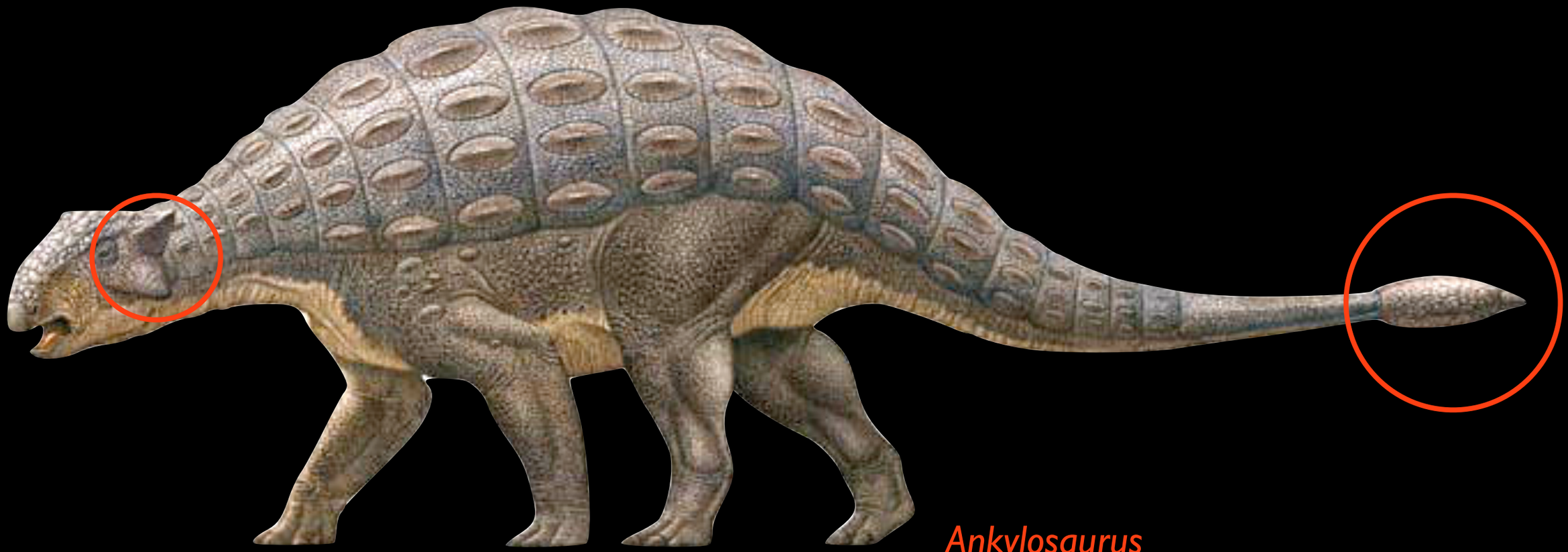
Ankylosaurus
Late Cretaceous

Sauropelta
Early Cretaceous

Ankylosauria = GROUP
Ankylosaurs = GROUP
Ankylosauridae
Ankylosaurids

Ankylosauria

Loss fenestra
Armour fused to lower jaw
Broad pelvis
Wide gut
Dorsal osteoderms



Ankylosaurus

Late Cretaceous

Ankylosauridae

Shared, derived characteristics

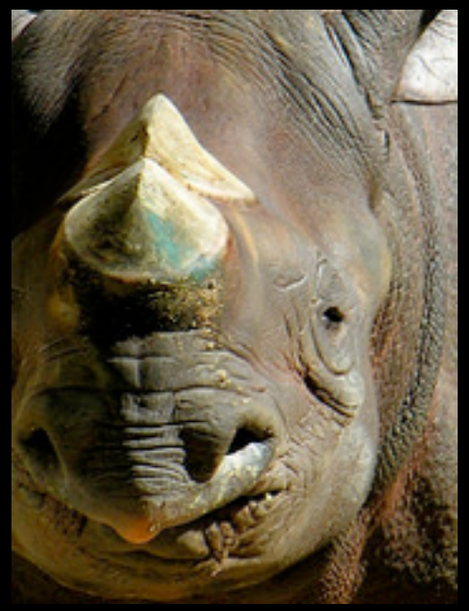
- Well armoured, but fewer spines
- Tail CLUB
- Shorter, knobbier skull than Nodosaurs
- Squamosal horns
- In some species: asymmetrically arranged scutes (*variable*)

Sauropelta
Early Cretaceous

Nodosauridae

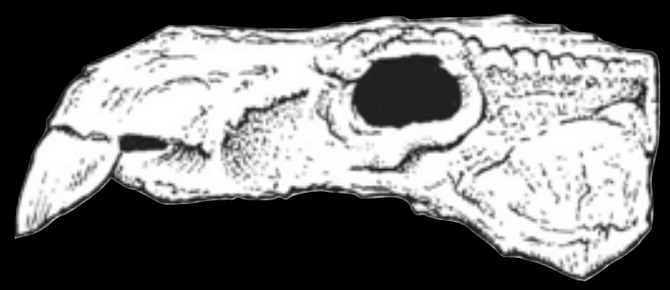
Shared, derived characteristics
- Spines are emphasized
- No tail club
- Longer, thinner skull than Ankylosaurs
- No squamosal horns
- Symmetrically arranged scutes
- Acromial process for heavily muscled foreleg

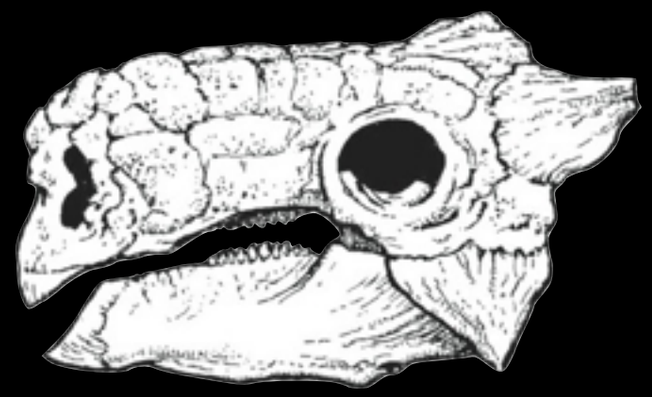
Diet

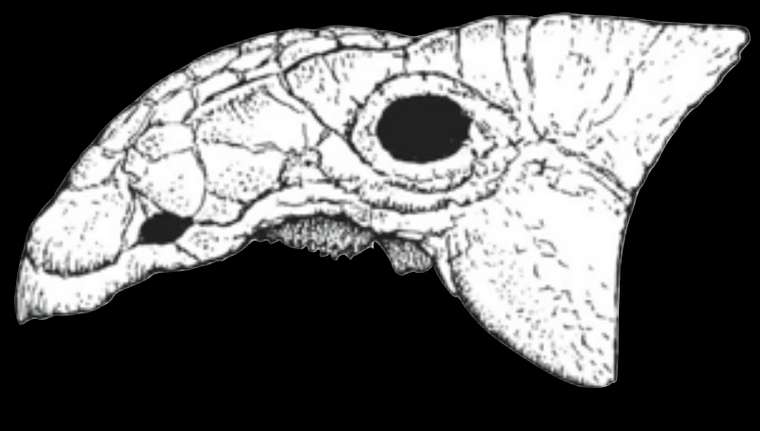


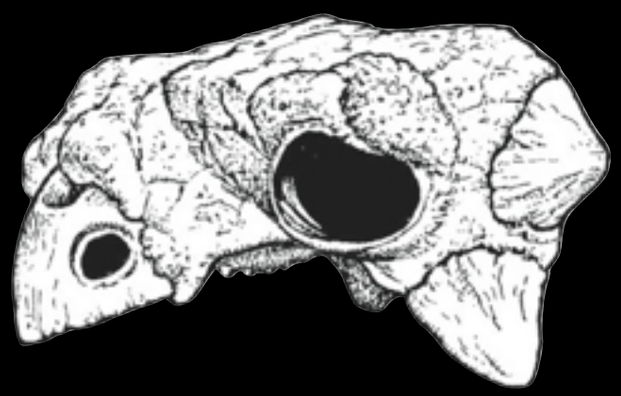
'Black' Rhino

'White' Rhino



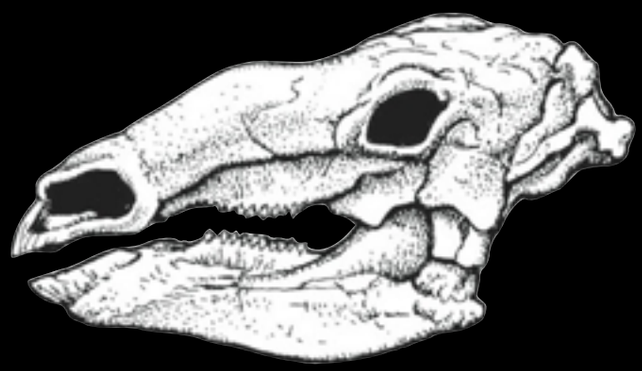






<u>Ankylosaurids</u>

Generalist-feeders



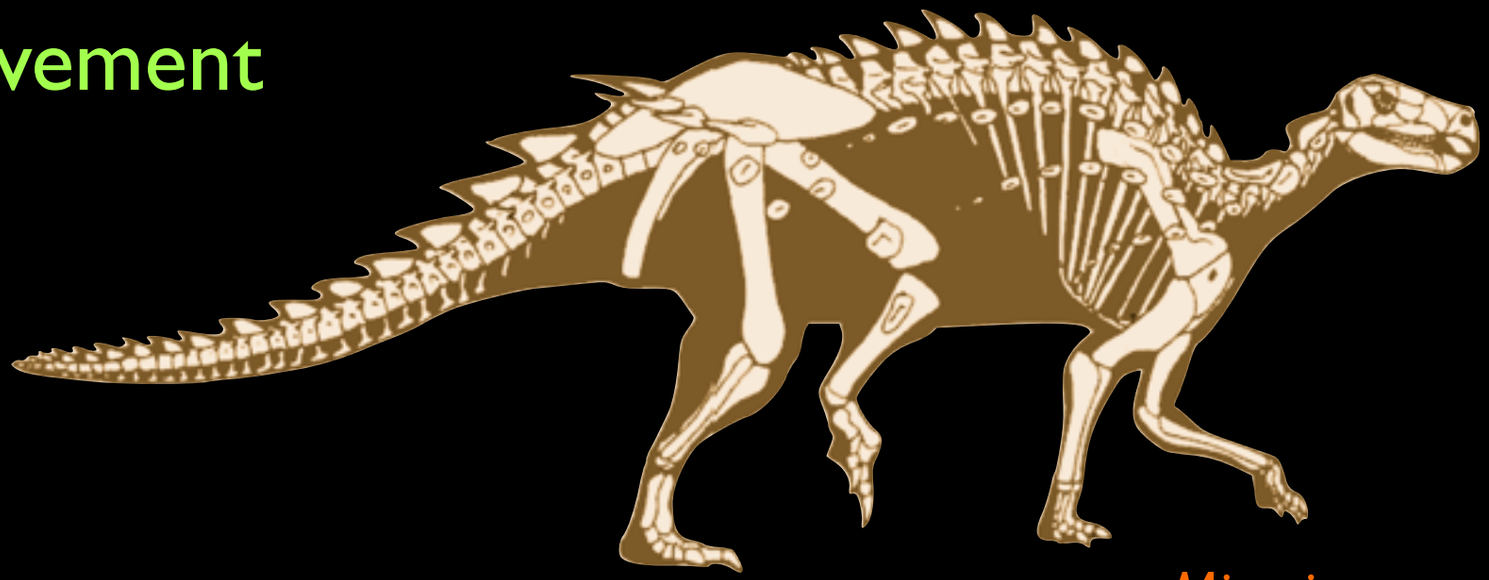
<u>Nodosaurids</u>

Selective-feeders

Movement

Ankylosaurids

less derived



Minmi

Gastonia

Euoplocephalus

more derived

Nodosaur's

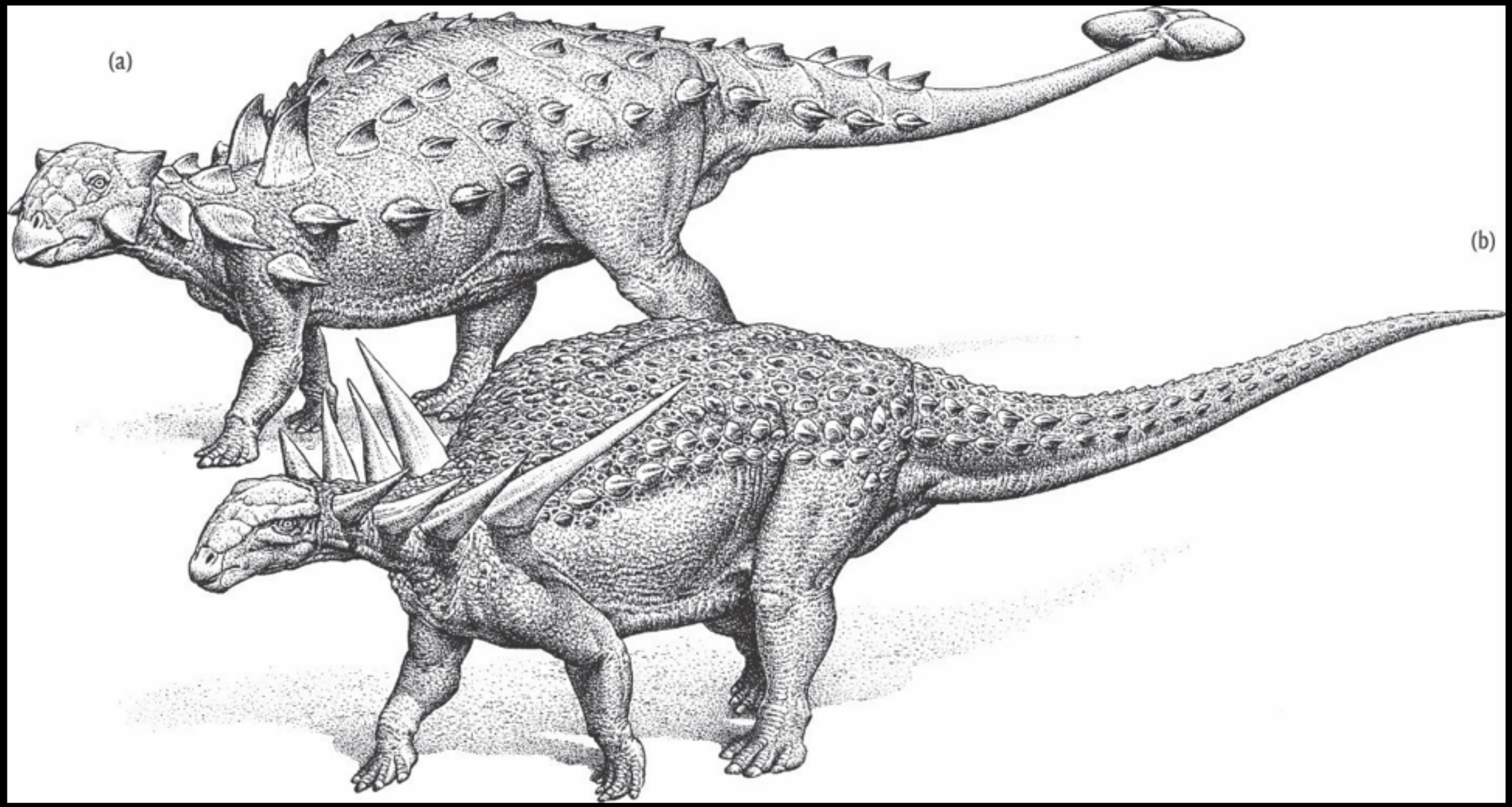
less derived

Pawpawsaurus

Sauropelta

more derived

Edmontonia


(a)
(b)

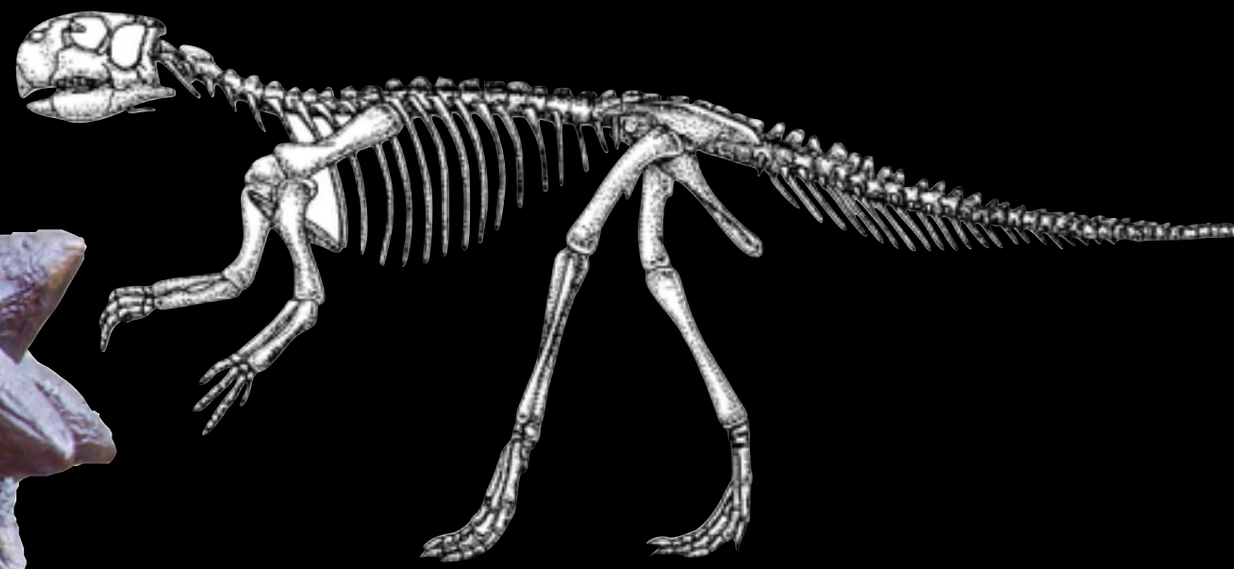
Ornithopoda

Ceratopsia

Pachycephalosauria

Marginocephalia

Cerapoda

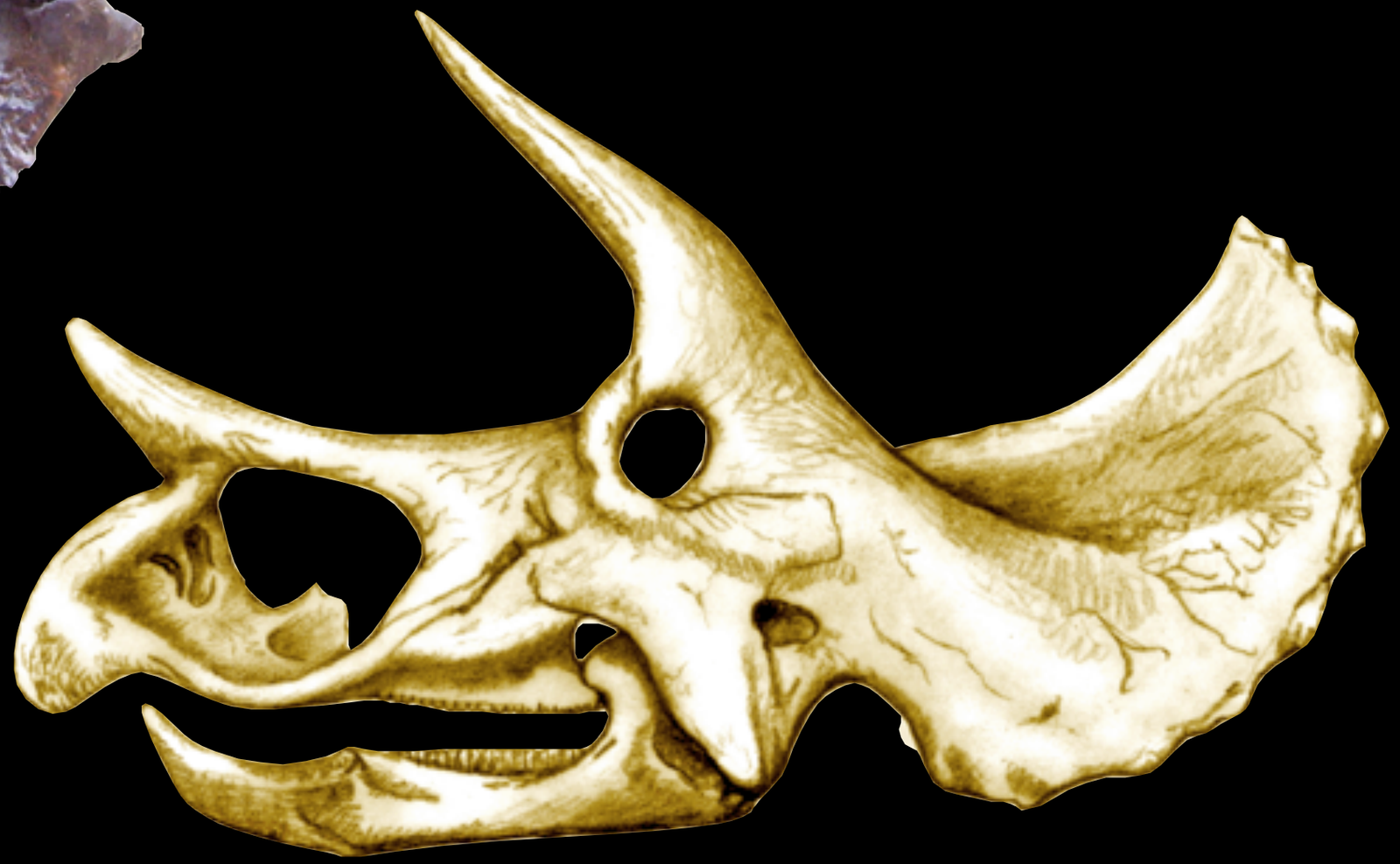


Shared, derived characteristics

Overhanging shelf, or MARGIN

Short Pubis

Marginocephalia



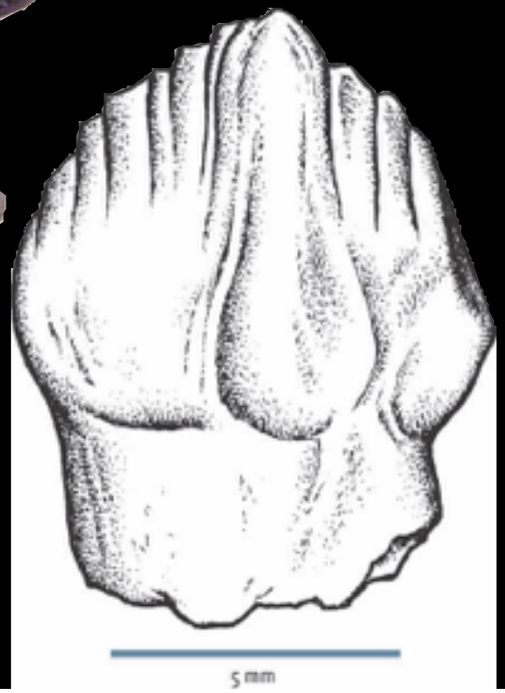
Ornithischia
Genosauria
Ceropoda
Marginocephalia
Pachycephalosauria

Shared, derived characteristics
Thickened skull roof
Ornamentation of ext. skull
Ridges/Grooves on vertebrae
Ossified tendons at end of tail

Primitive characteristics:
Pronounced diastem
Expanded skull Margin

Stegoceras

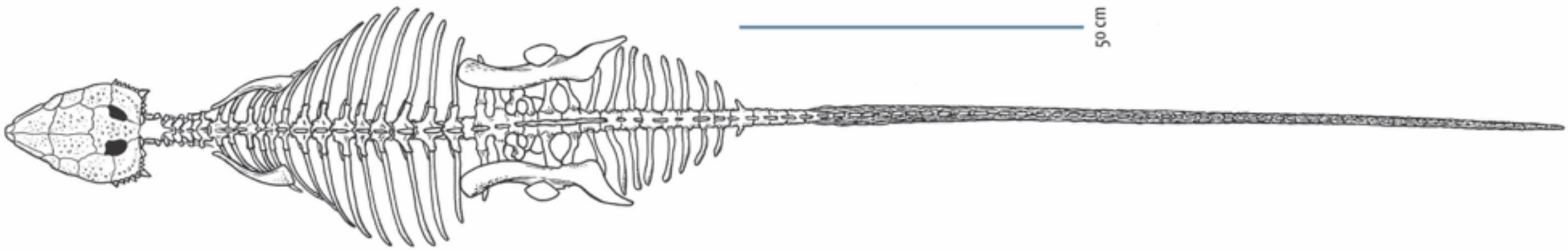
Diet



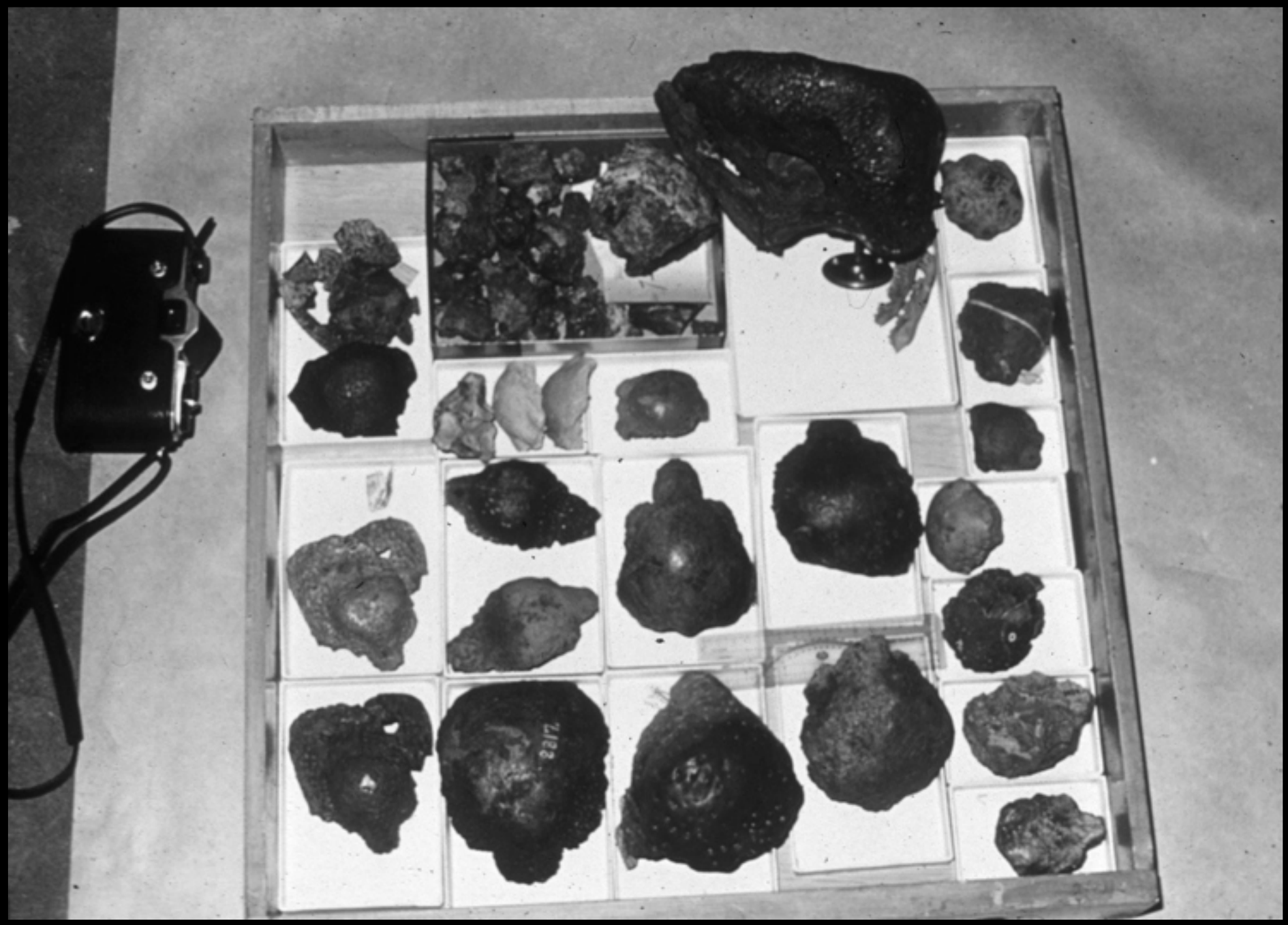
Typical Ornithischian teeth: herbivore
Front jaws: peg-like gripping teeth
surrounded by small beak
Small, canine-type teeth in front
Diastem is emphasized
Cheek teeth uniformly shaped

BROAD rib cage
Extended to base of tail
Indicates that the digestive organs were positioned around the hind legs
Food digested less by chewing, more by fermentation (similar to Thyreophorans)

Homalocephale

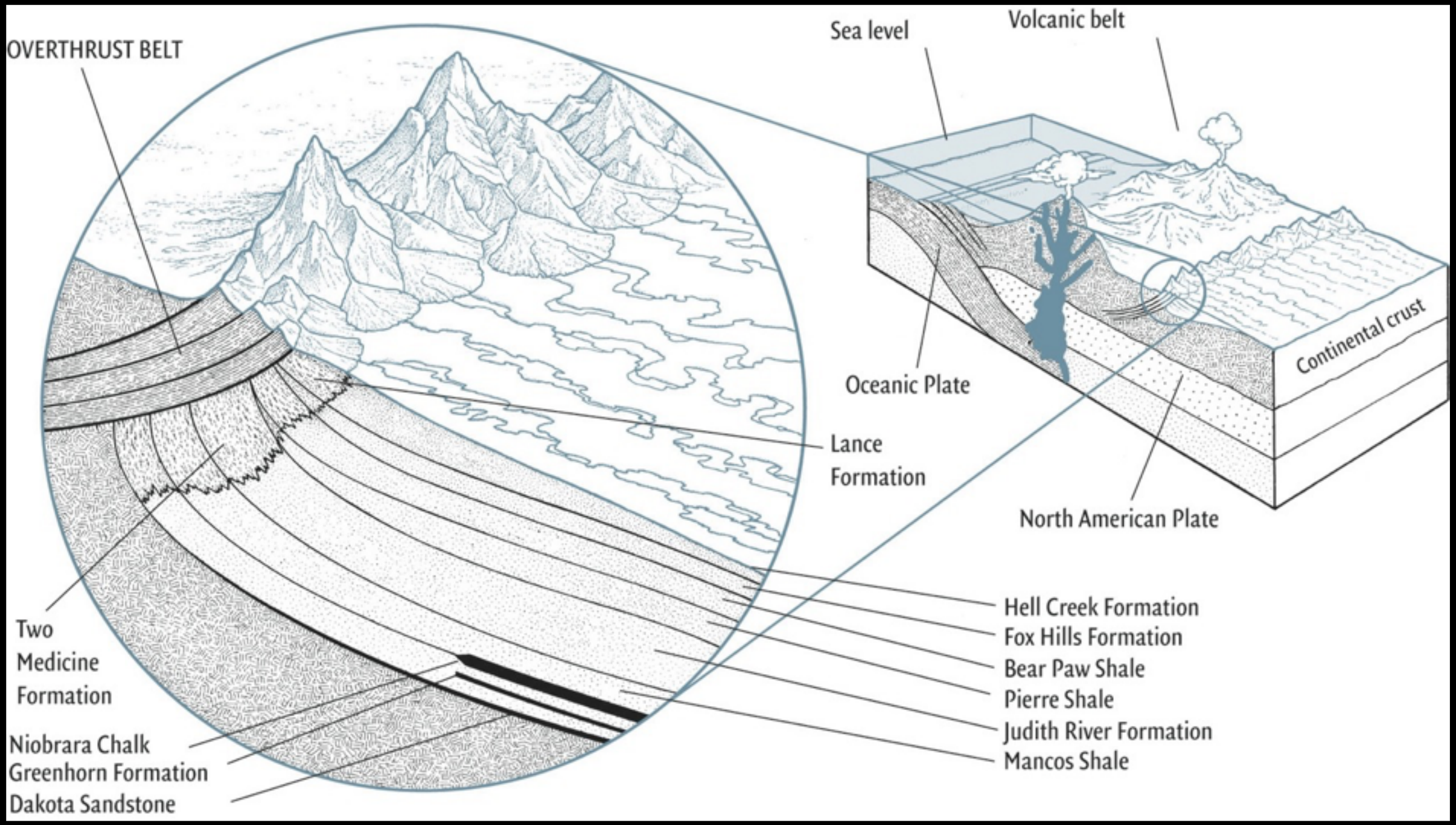


Taphonomy



North America: Skull Caps
Asia: Some skeletal remains: no complete!

Taphonomy



Why are there no skeletal remains other than skull caps found in North America? *Allochthonous*

A Battering Ram?

All evidence suggests that Pachycephalosaur skulls were built to withstand extreme forces

- 9 inches of solid bone
- Bone organized in a radial arrangement- structural support
- Articulation btw back of skull and vertebrae oriented to transfer forces linearly
- Articulation btw back of skull and vertebral column built to withstand sideways forces
- Vertebral column has tongue and groove articulations
- Spinal column is an S-shaped shock absorber

BUT

- There is no 'locking' mechanism on skull to keep battering heads aligned
- Some Pachycephalosaurs have imprinted blood vessels on dome
- These factors suggests that head-butting may not be likely

Intraspecies Competition (typically male-male)

Females are typically choosey
- Why?
- Because they have more to loose

Common rule in biology: Females are expensive to lose, males are cheap (e.g. deer hunting)
Females choose the male most likely to provide the most successful offspring

Males compete with each other for access to female vs. female chooses the strongest male

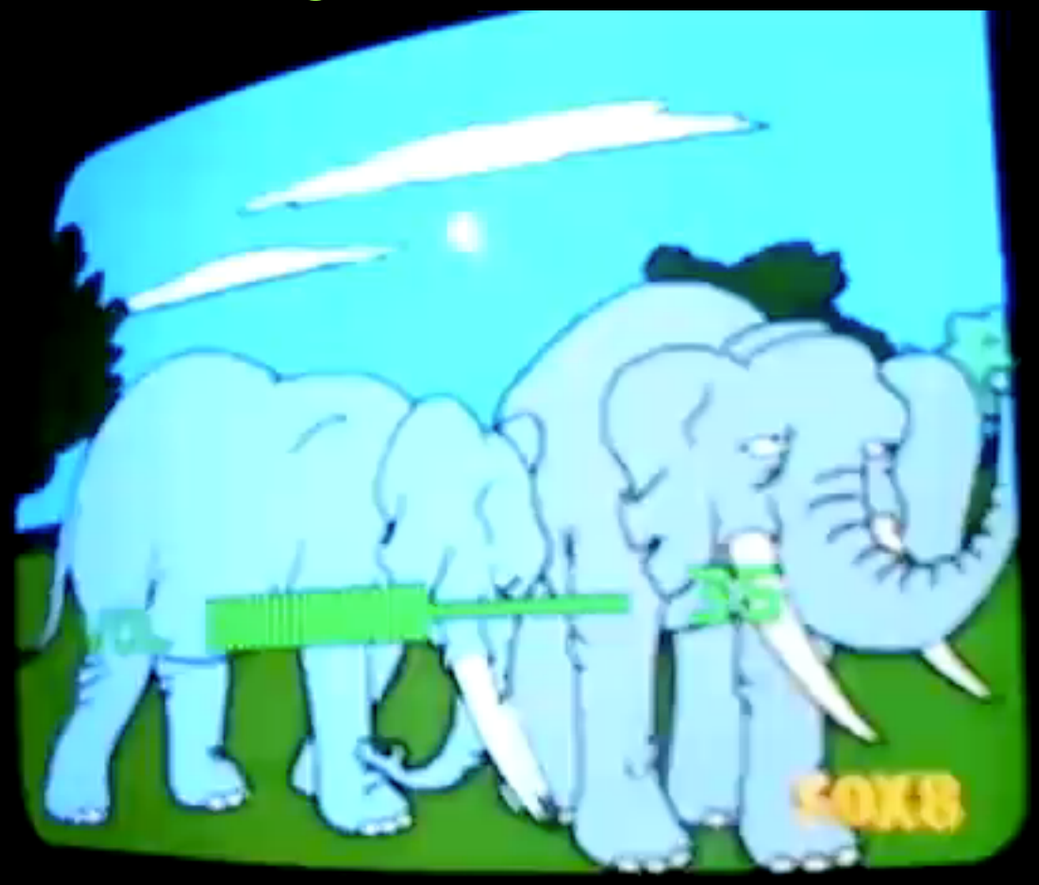
Choosey females // Strong males have more offspring => SEXUAL selection
Many ways to do this...
But: In general, maximize competition and minimize accidental deaths (= no fitness)

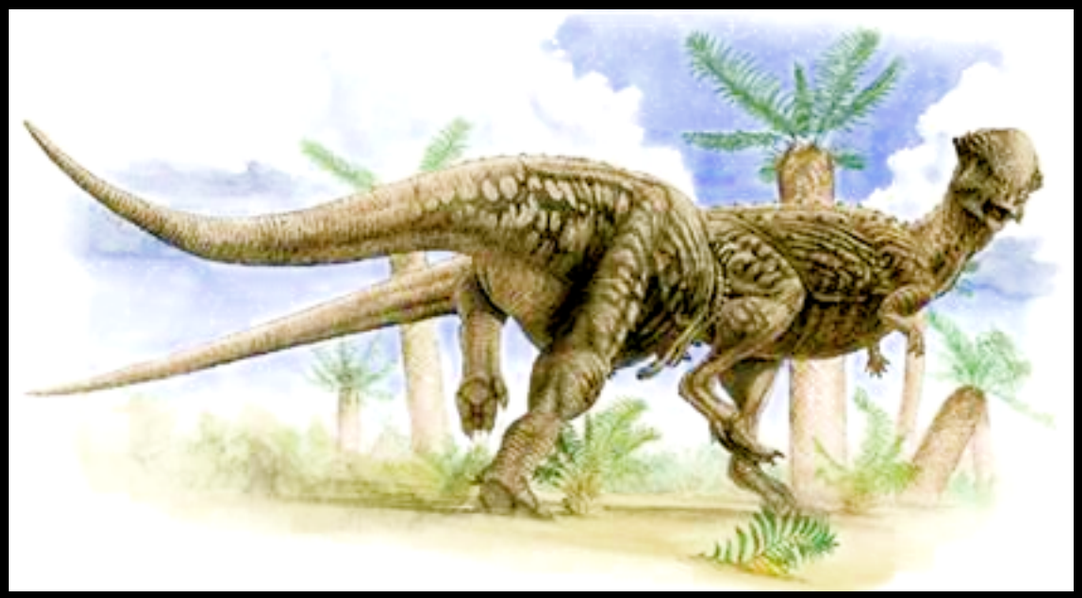
Head butting Pachycephalosaurs

Bone structure was probably strong enough to withstand collision

Convex nature would favor glancing blows

Instead, dome and spines seem better suited for “flank butting”





So... if head butting is the result of male-male competition, what should we expect to find?

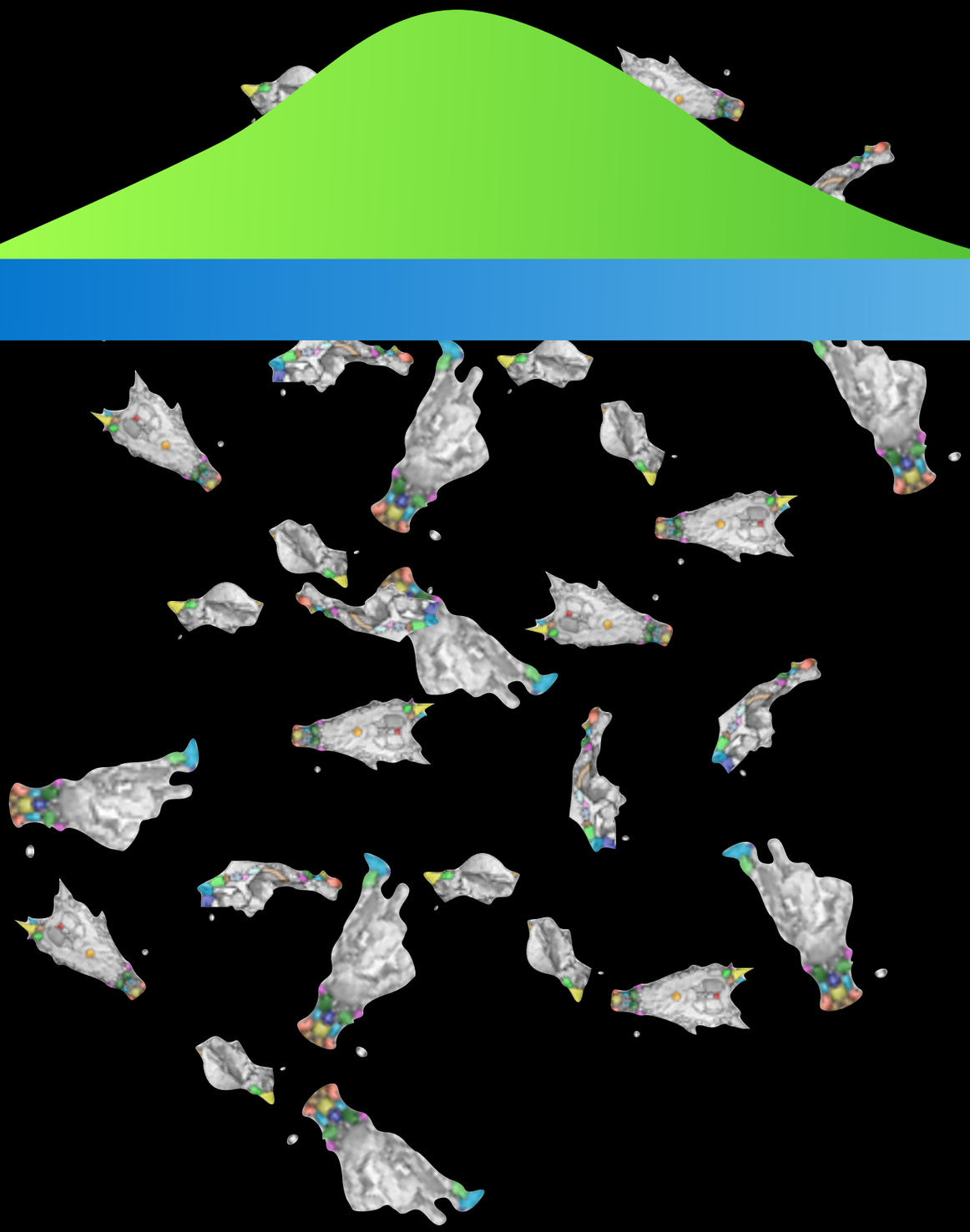
Sexual dimorphism...

if males are primarily using their domes to headbutt, male domes will be under strong selective forces, while female domes will not.

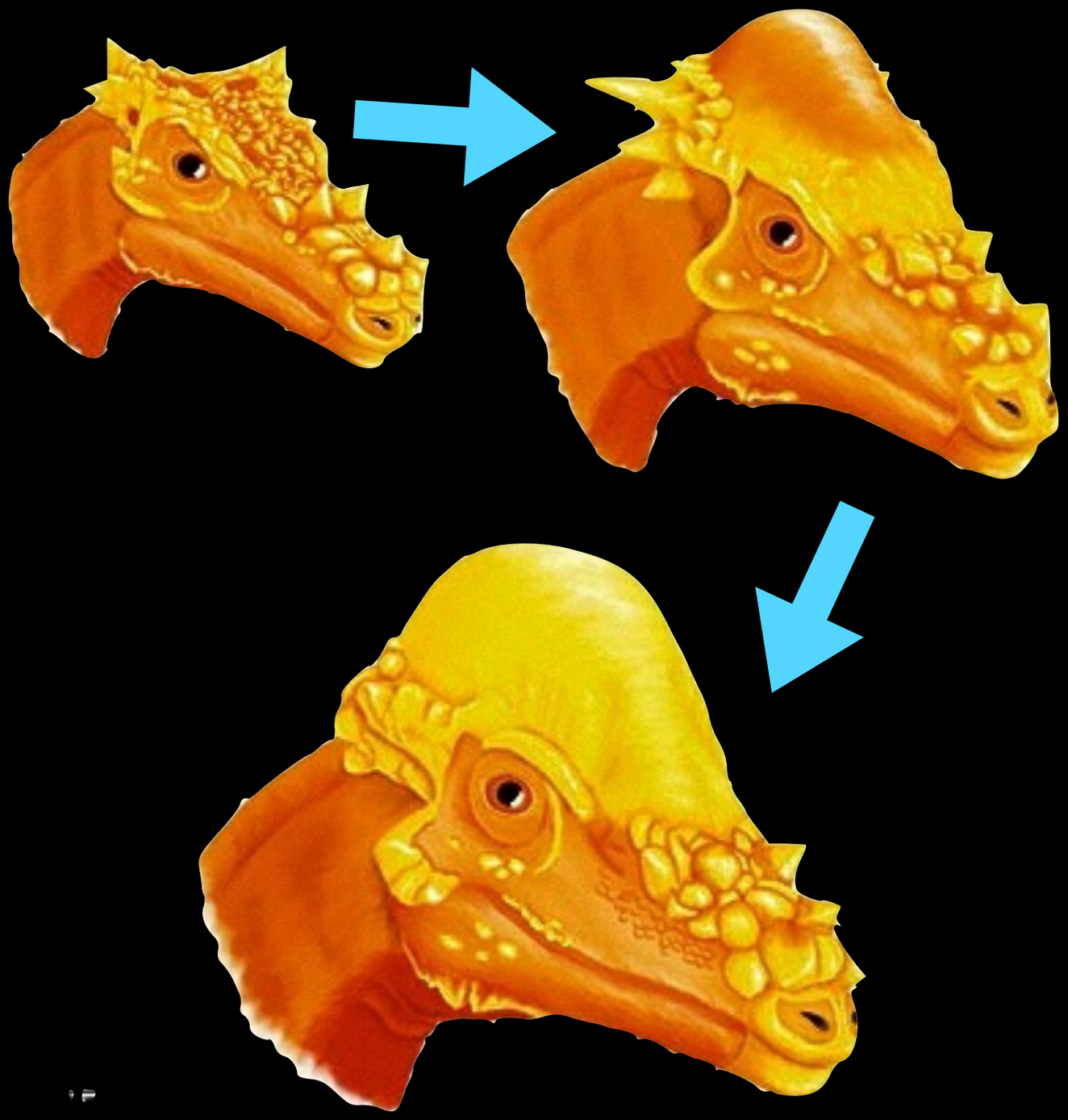
Smaller

Larger

1:1



The strange case of Hell's Creek.



Two Hypotheses:

1. These animals are independent species
2. These animals are an ontogenetic series
   GROWTH

Protoceratopsians

Gondwana Studios

Pachycephalosauria

Psittacosaurus

Archaeoceratops

Bagaceratops

Protoceratops

Asia

Leptoceratops

Montanoceratops

North America

Ceratopsidae

2

1

Neoceratopsia

Ceratopsia

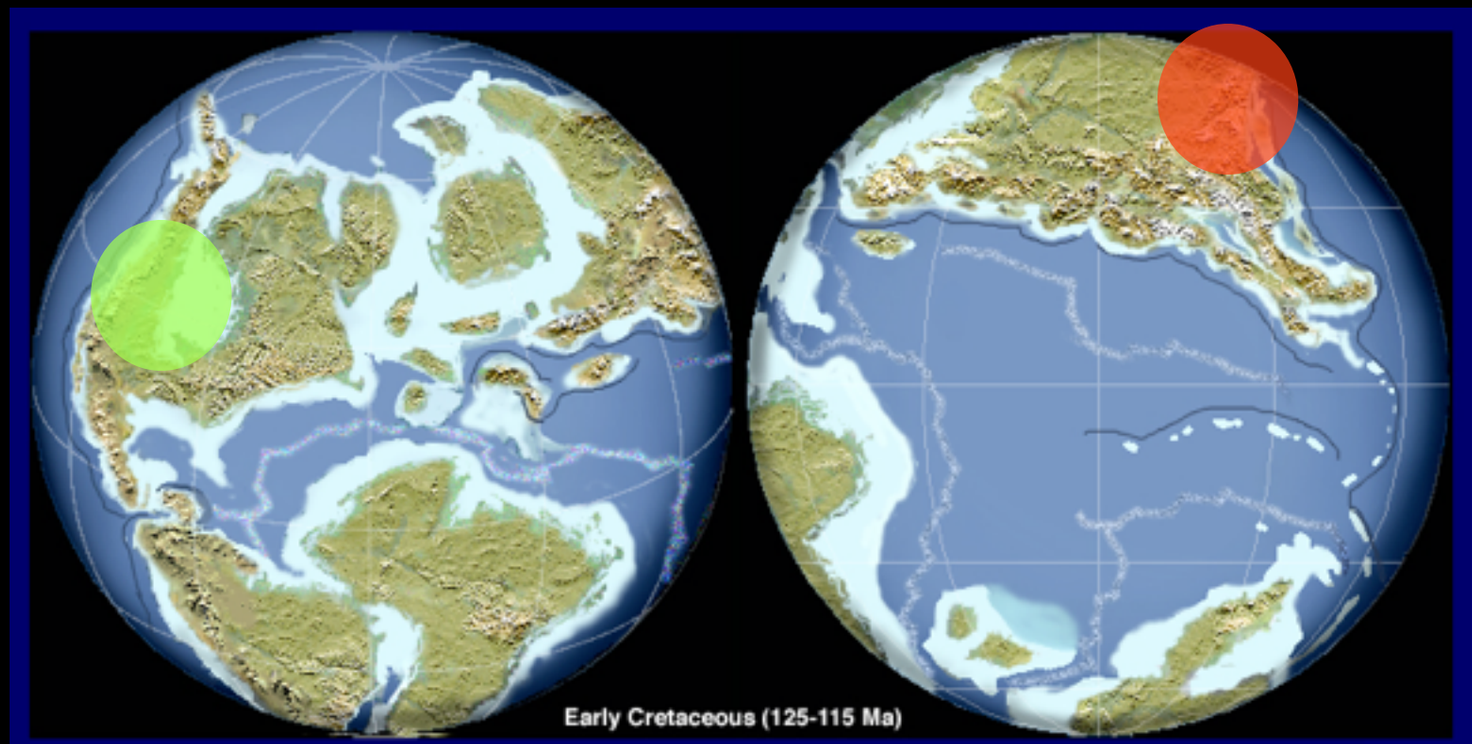

First eastward migration
early-mid Cretaceous

Bagaceratops

Protoceratops

Leptoceratops

Montanoceratops



Achelousaurus
Pachyrhinosaurus
Einiosaurus
Styracosaurus
Centrosaurus
Chasmosaurus
Pentaceratops
Arrhinoceratops
Anchiceratops
Torosaurus
Triceratops
?
Centrosaurinae
Chasmosauridae
Psittacosaurus
Protoceratopsians
2
1
Ceratopsidae

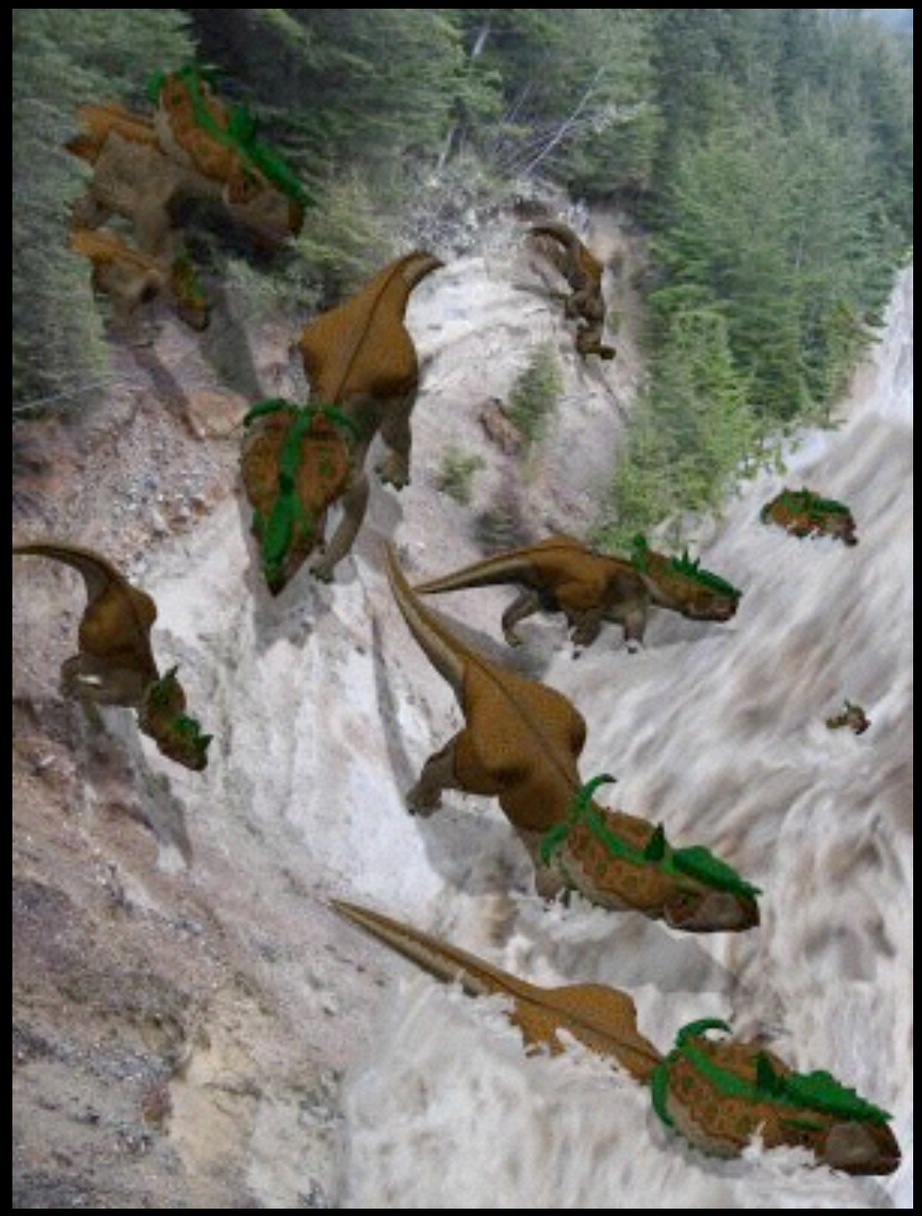
Ceratopsidae is divided into 2 major subgroups:
Centrosaurs
Chasmosaurs

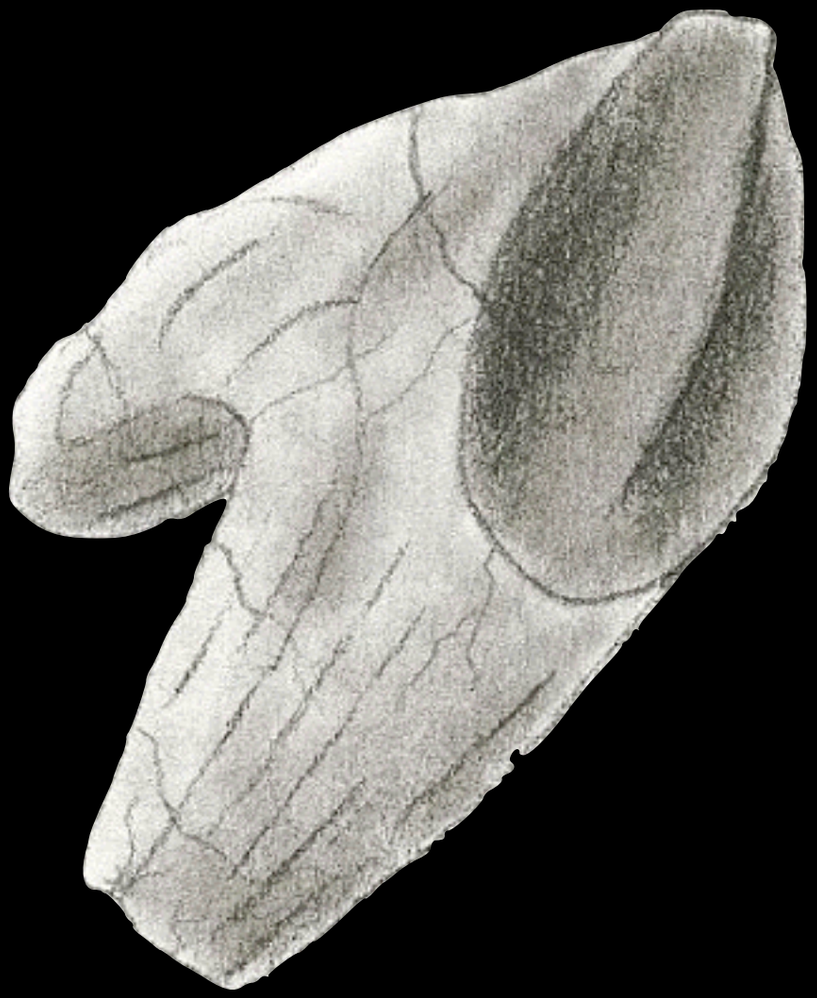
ALL NORTH AMERICAN
LATE CRETACEOUS

Shared, derived traits of Ceratopsidae

Enormous skulls (up to 8.5 ft among Torosaurus)
Western North America (Alaska => New Mexico)
Latest Cretaceous

Large frills
Orbital or nasal horns/protuberances
Large nasal openings
Complex dental battery





Triceratops teeth

Ceratopsidae dental battery...
Analogous to the Hadrosaur dental battery
Not related- convergent evolution!

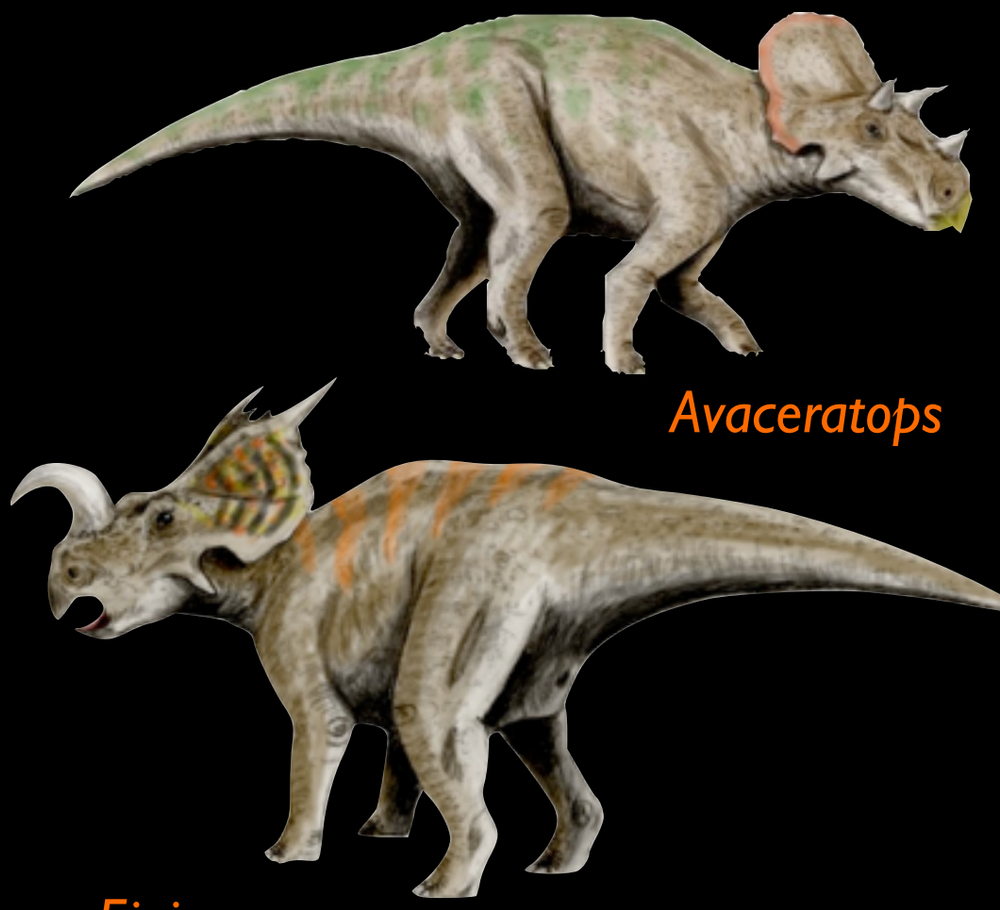
Hadrosaur teeth

Centrosaurs (short-frilled)

Long nasal horns
Hooks and processes on the parietal frill (sometimes SPIKES!)
Some (Pachyrhinosaurus) had pitted/grooved pads

Centrosaurus

Achelousaurus



Avaceratops

Einiosaurus

Styracosaurus

Pachyrhinosaurus

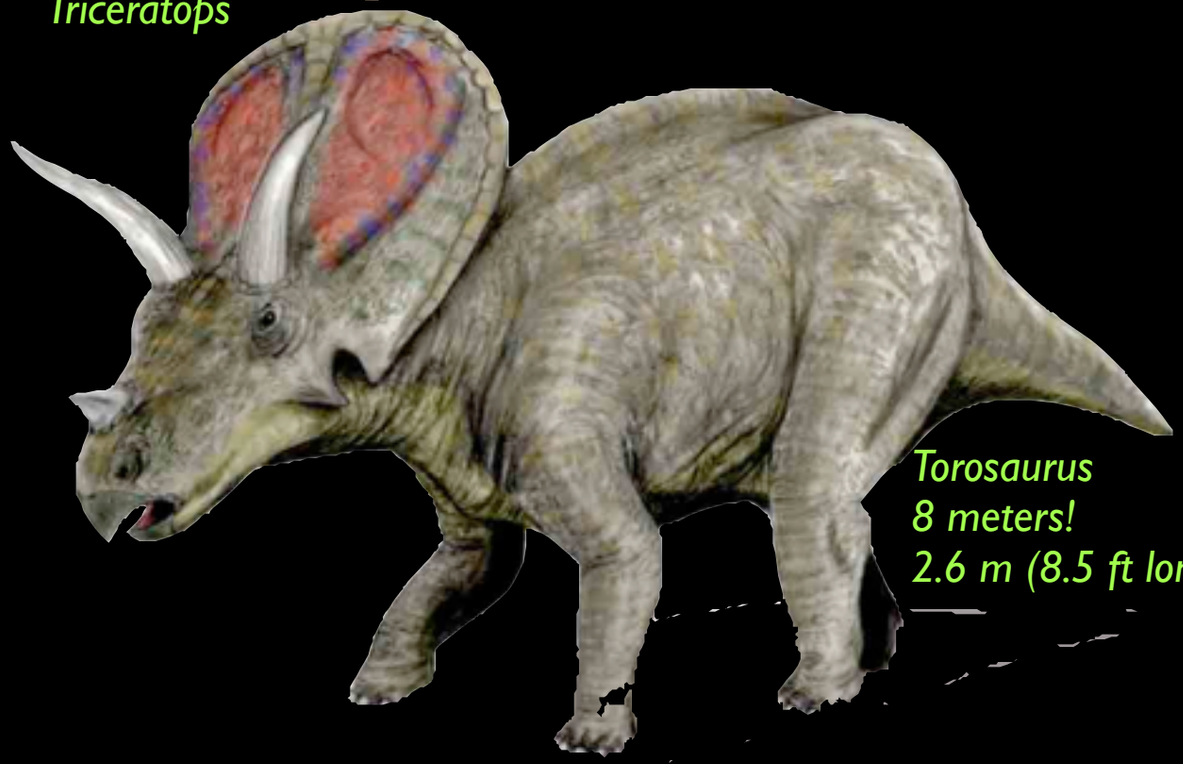
Chasmosaurs (long-frilled)

Long **orbital horns**
Short nasal horns
Complex sinus cavities in skull
Not found in Bone Beds

Triceratops

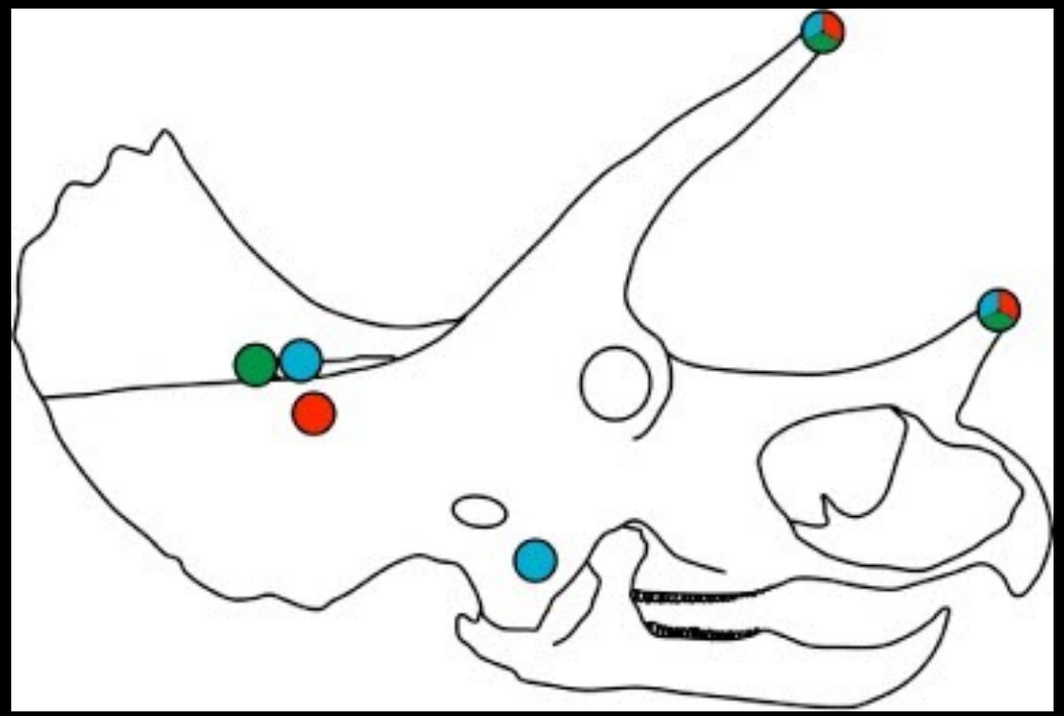
Pentaceratops

Chasmosaurus
Kind of a badass

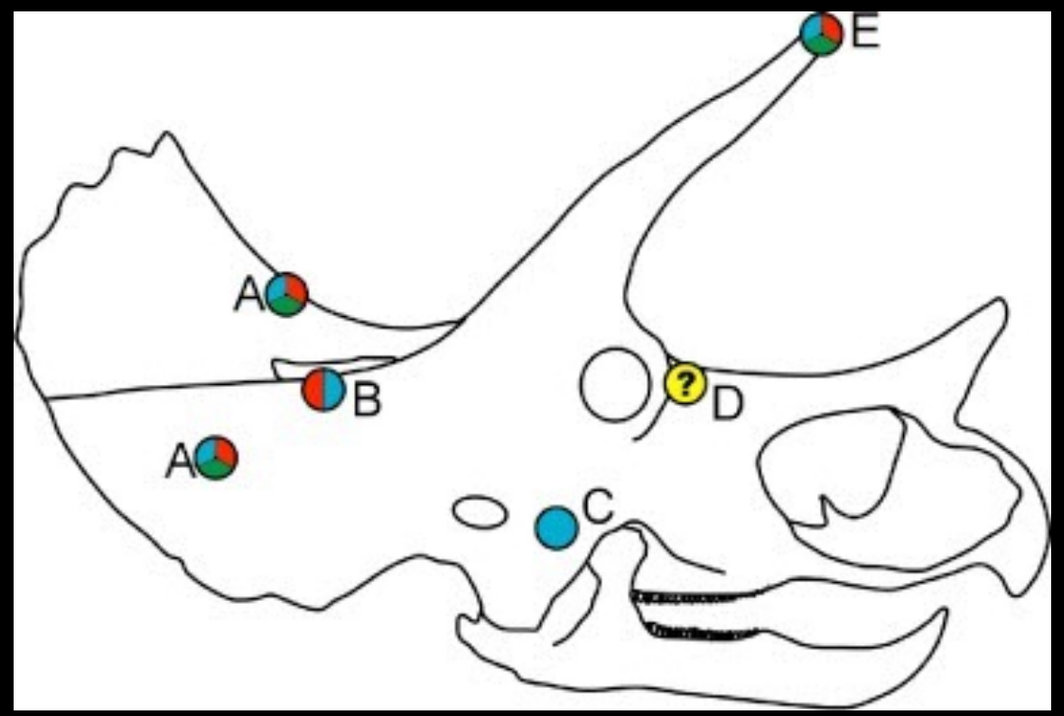


Torosaurus
8 meters!
2.6 m (8.5 ft long skull)

Arrhinoceratops



Where you predict to find damage if they were horn-locking



Where you find damage

Genosauria
Cerapoda
Marginocephalia
Pachycephalosauria
Ceatopsia
Ornithopoda: ‘bird feet’

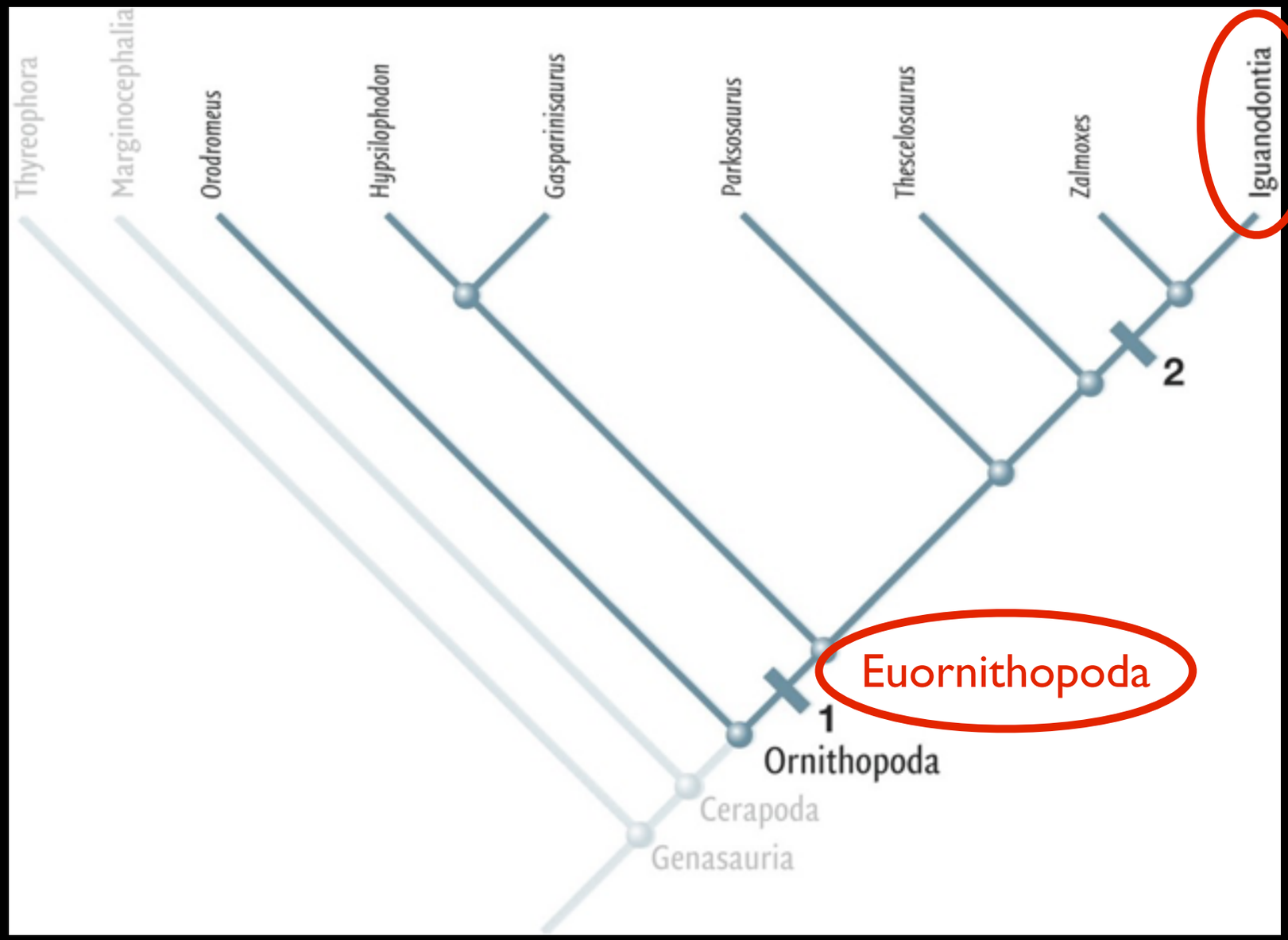
Iguanodon

Edmontosaurus

Primitive Characteristics: basal Ornithopods are ‘typical’ Ornithischians
Opisthopubic condition
No fenestra in mandible

Small, bipedal

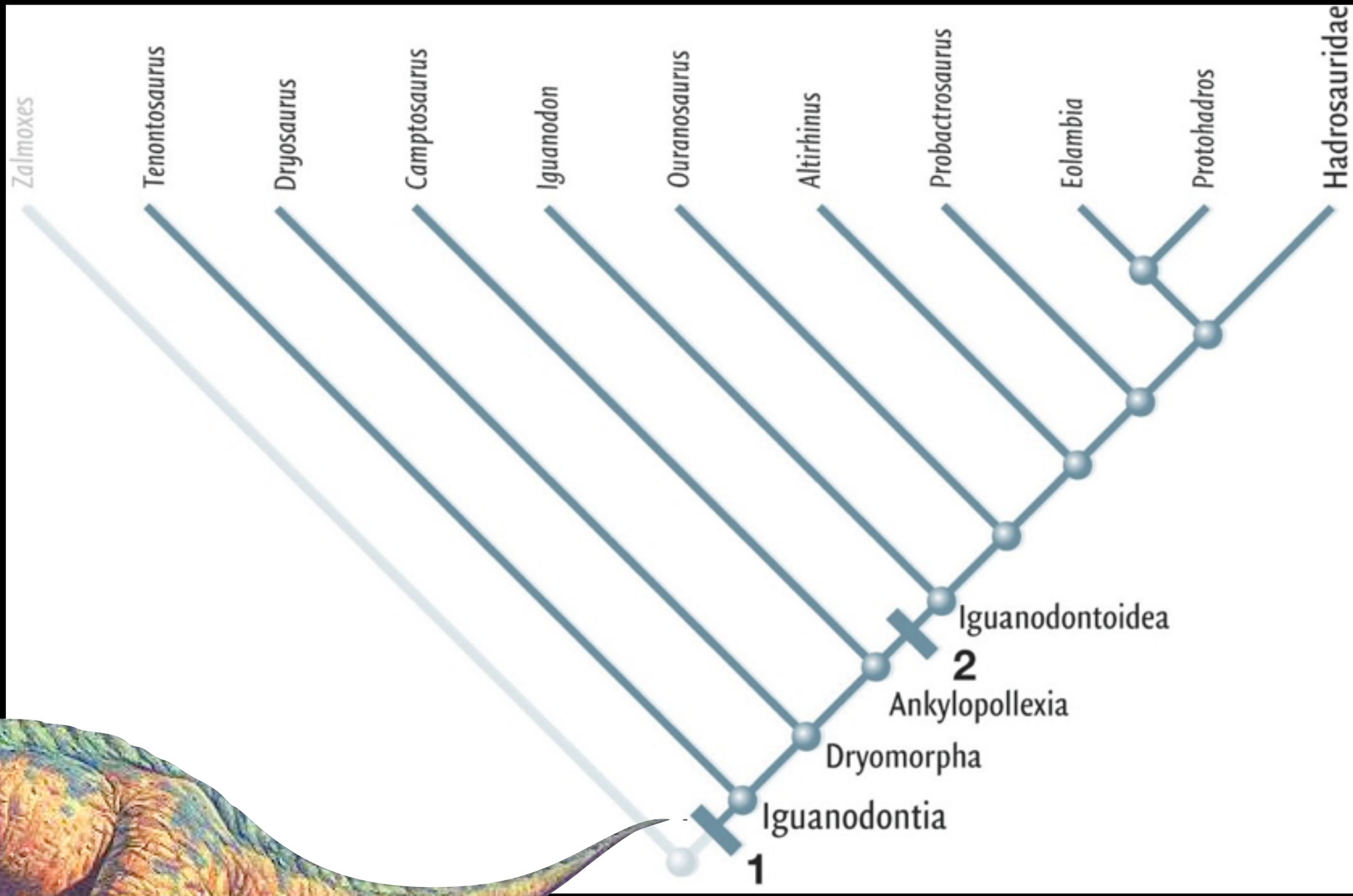
Derived: Larger, mainly quadrupedal



Early Ornithopods & Euornithopods

Small, bipedal

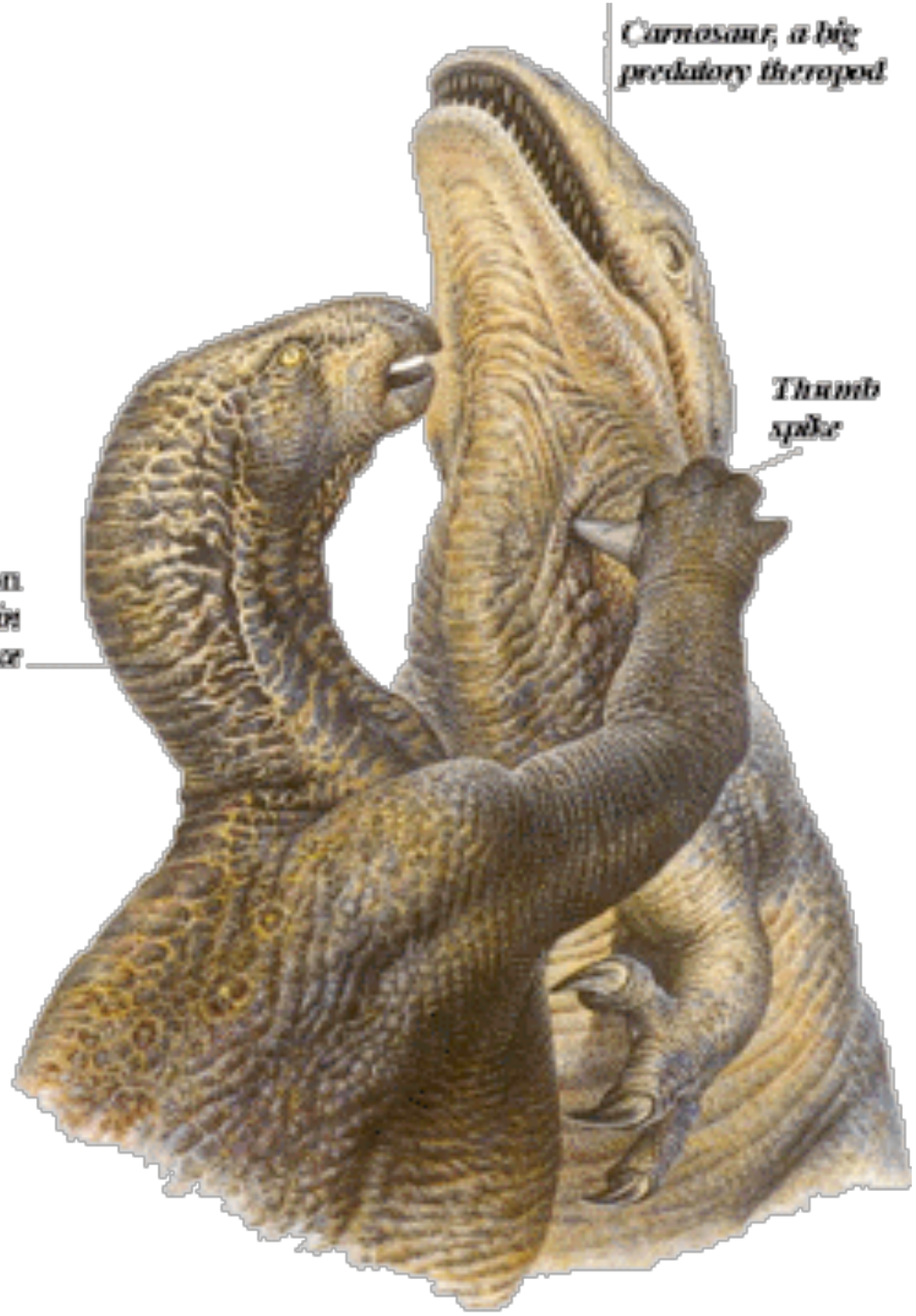
Tenontosaurus



Iguanodontia: the most diverse clade

- Toothless premaxilla
- Smooth, rounded predentary
- Generally larger
- Derived forms (Ankylopollexia): Expanded dental batteries & spiked thumb

Thumb spike

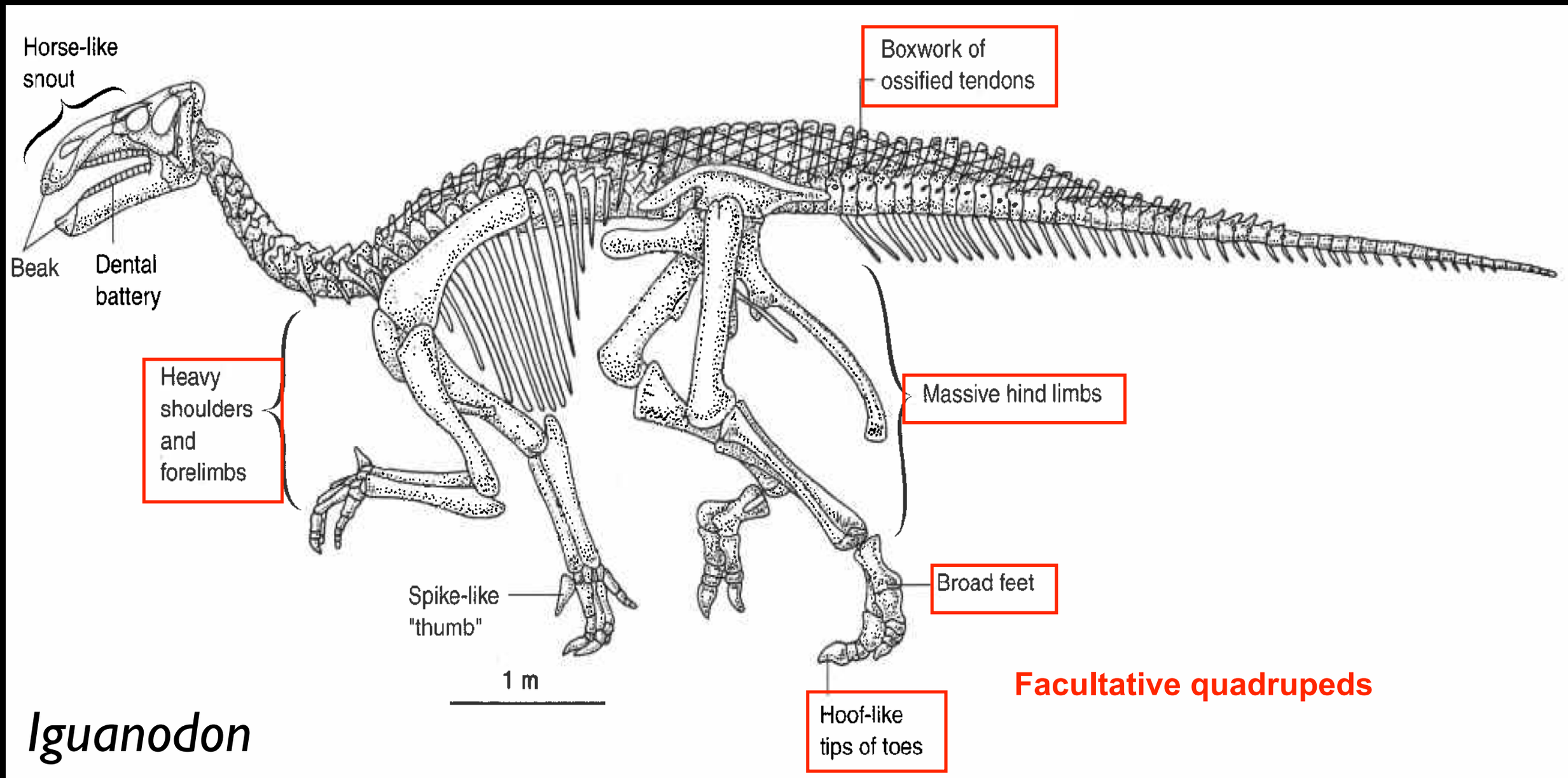


SPIKED THUMB

If attacked by a large, sharp-toothed, sharp-clawed theropod, *Iguanodon* might have reared up on its hind limbs and counterattacked with its spiked thumb. Strong, bony, and stiletto-like, this thumb could have penetrated the attacker's scaly hide or inflicted wounds on the throat, eyes, or belly.

Defense? Comp

Big, with appropriate modifications.



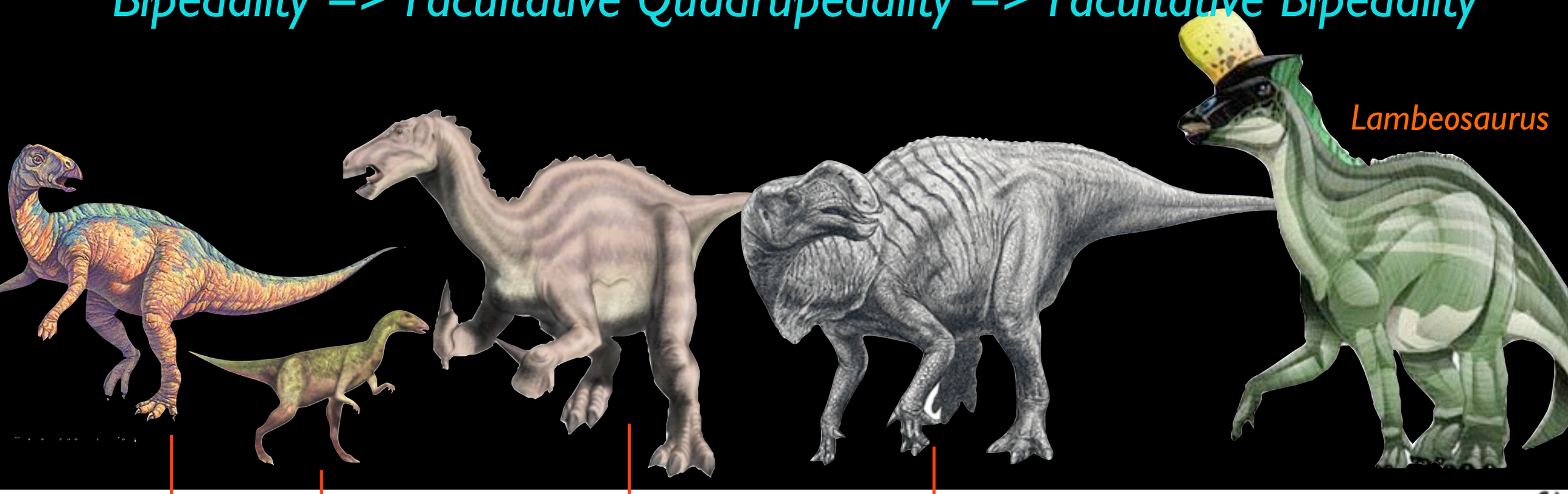
Iguanodon

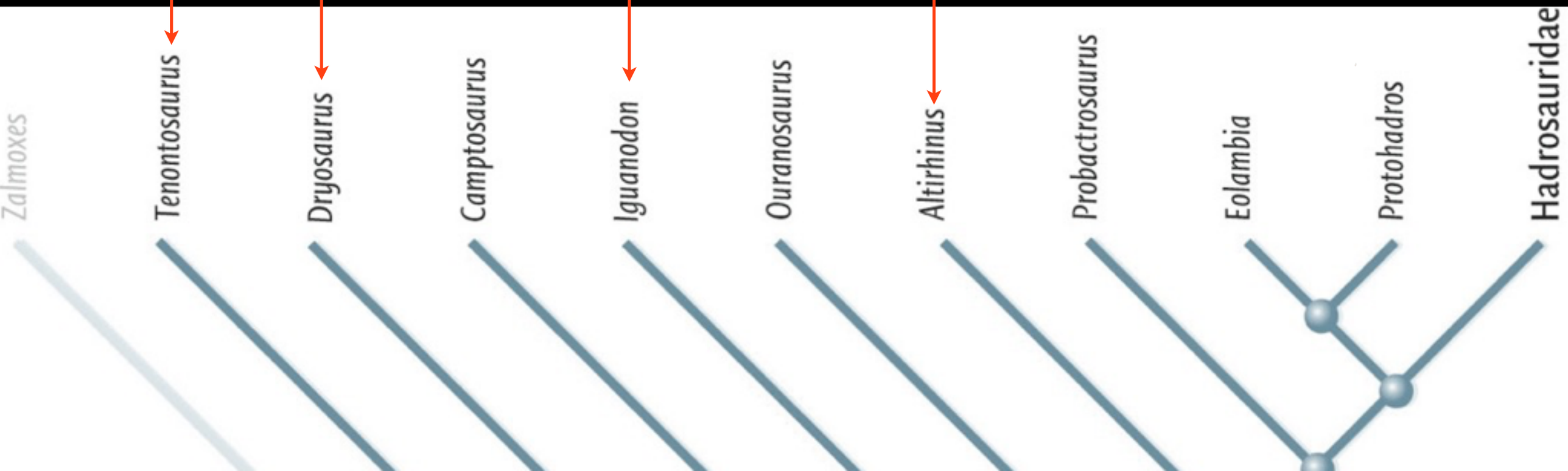
Facultative quadrupeds

Major Evolutionary Trends

1. *Efficient, robust dental battery*
2. *Larger body size*

Bipedality => Facultative Quadrupedality => Facultative Bipedality

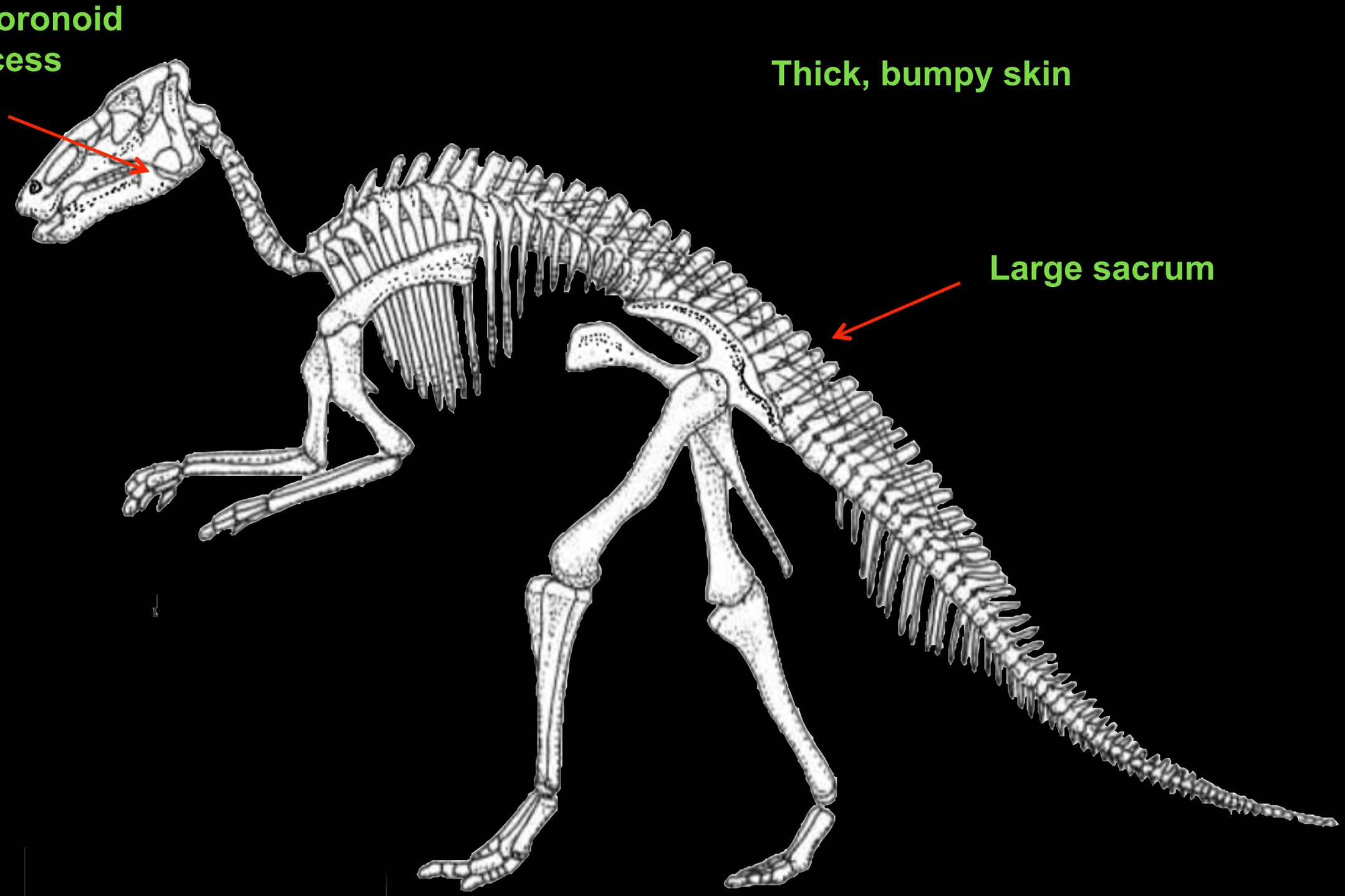




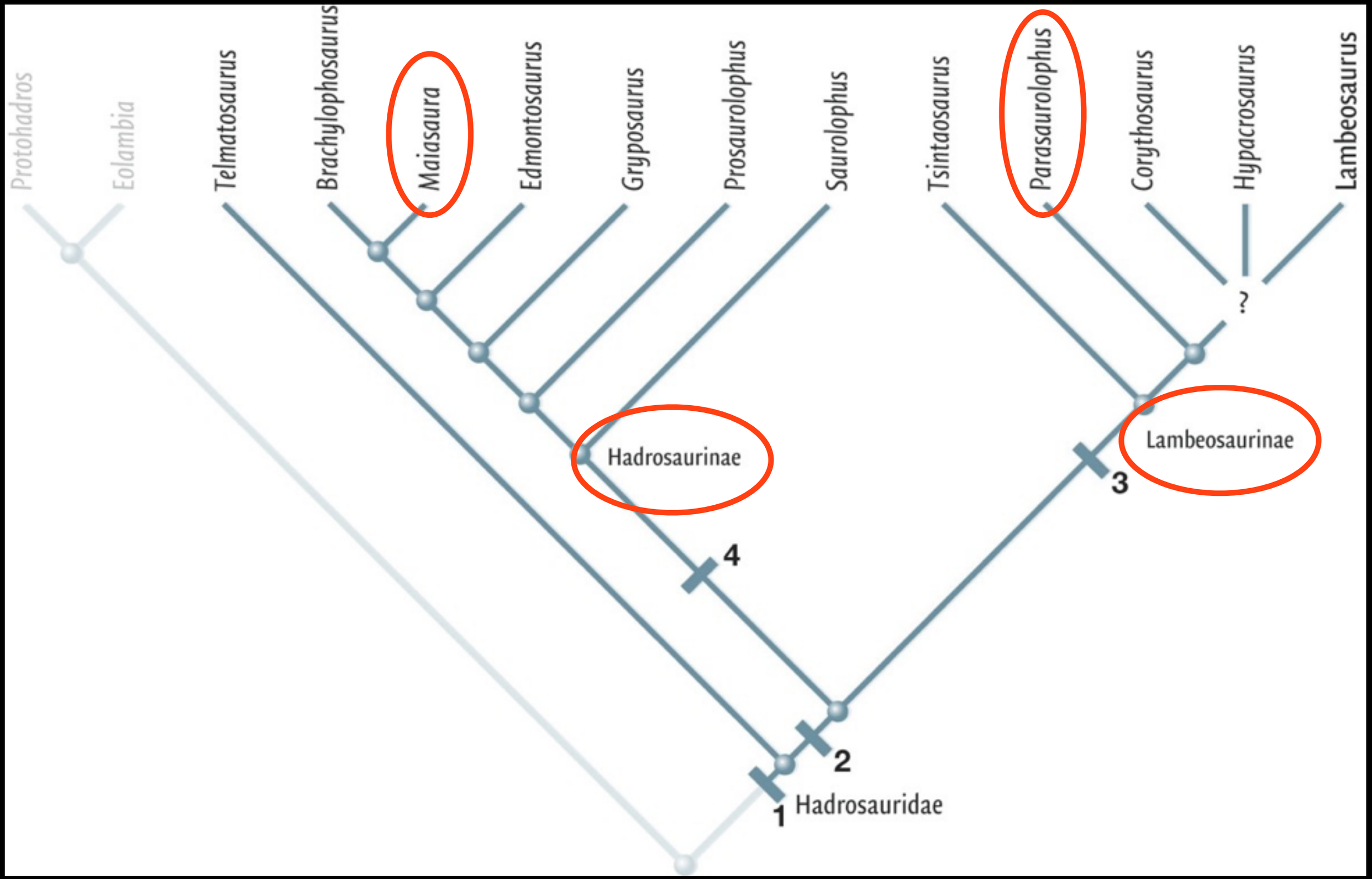
Hadrosaurids

Well developed dental battery

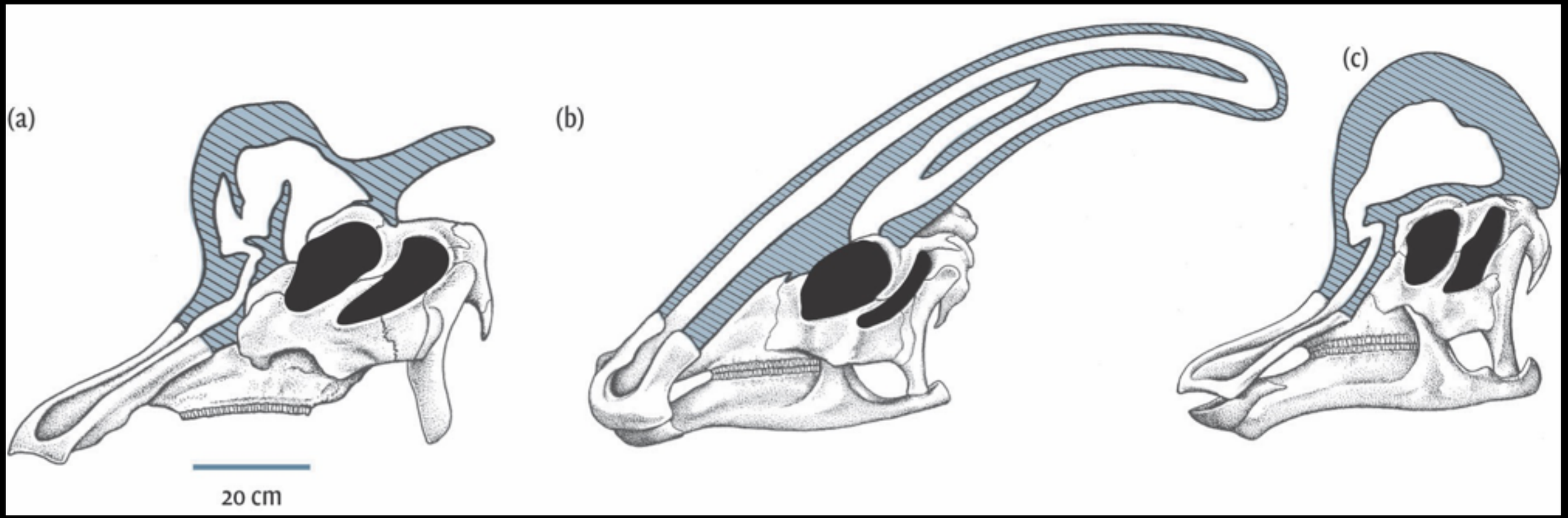
Modifications to skull and mandible to enhance chewing efficiency



Hadrosaur front foot
Anatotitan


Protohadros
Eolambia
Telmatosaurus
Brachylophosaurus
Maiasaura
Edmontosaurus
Gryposaurus
Prosaurolophus
Saurolophus
Hadrosaurinae
Tsintaosaurus
Parasaurolophus
Corythosaurus
Hypacrosaurus
Lambeosaurus
?
Lambeosaurinae
3
4
2
1
Hadrosauridae

Lambeosaurinae
hollowed horns



Lambeosaurus *Parasaurolophus* *Corythosaurus*

Hadrosaurinae
w/o hollowed crests/horns

Behavior!

1) Hadrosaur head gear

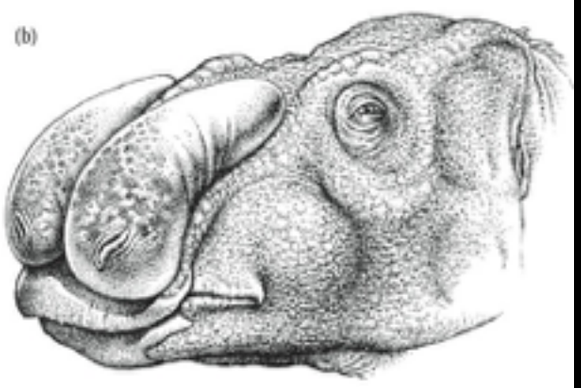
Vocal adaptations

Air sacs?

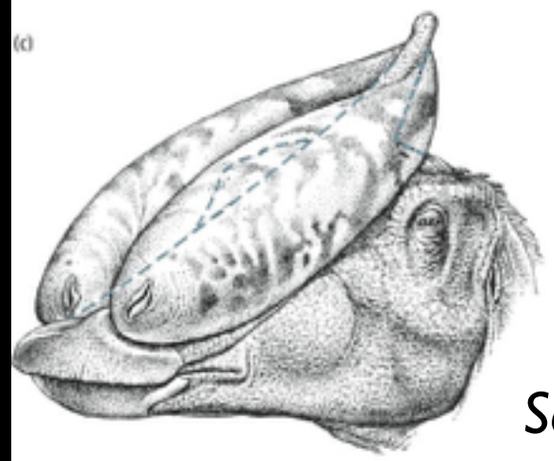
Visual adaptations

Saurolophus

Gryposaurus



Gryposaurus



Saurolophus

Species specific (recognition)

Male-male competition (competition for mating)

Intimidation

Physical head-butting?

Attract females (competition for mating)

Altirhinus

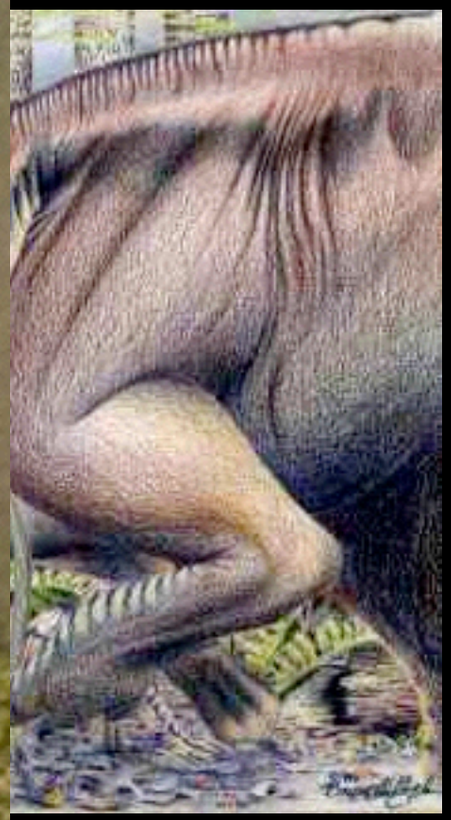
Behavior!

3) Reproductive Behavior

"R-selected

Orodromeus

K-selected"

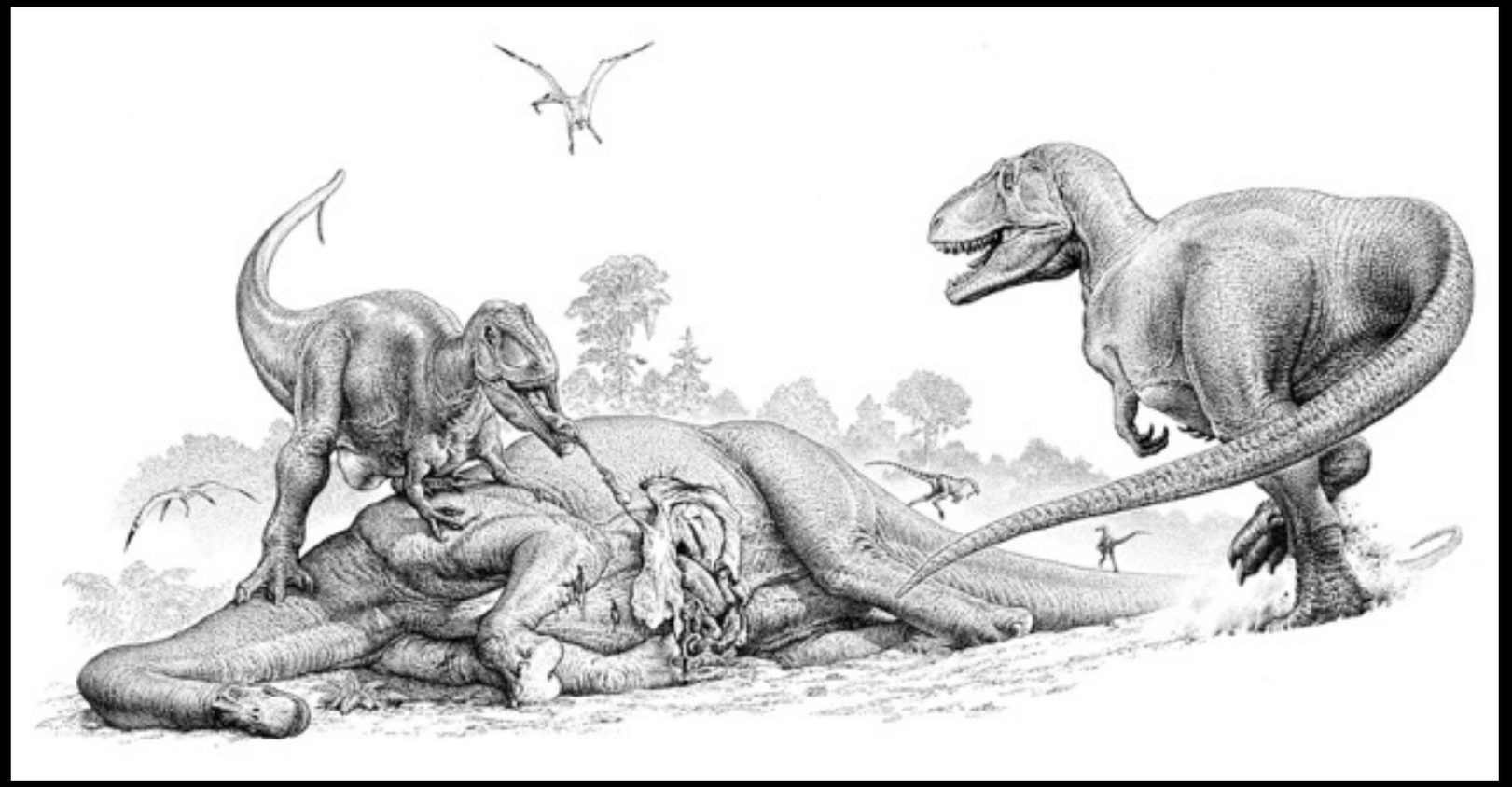


Maiasaura

Hatchlings have well-developed limb bones
Fully formed joint surfaces
Parental care assumed to be minimal
But still groups
= Precocial

Nested in colonies
Usually 17 (30 max) eggs in each nest
Hatchlings have poorly developed limbs; likely needed constant parental care for 8-9 months after birth
= Altricial

Enter Saurischia!



Saurischians:

Two major clades:

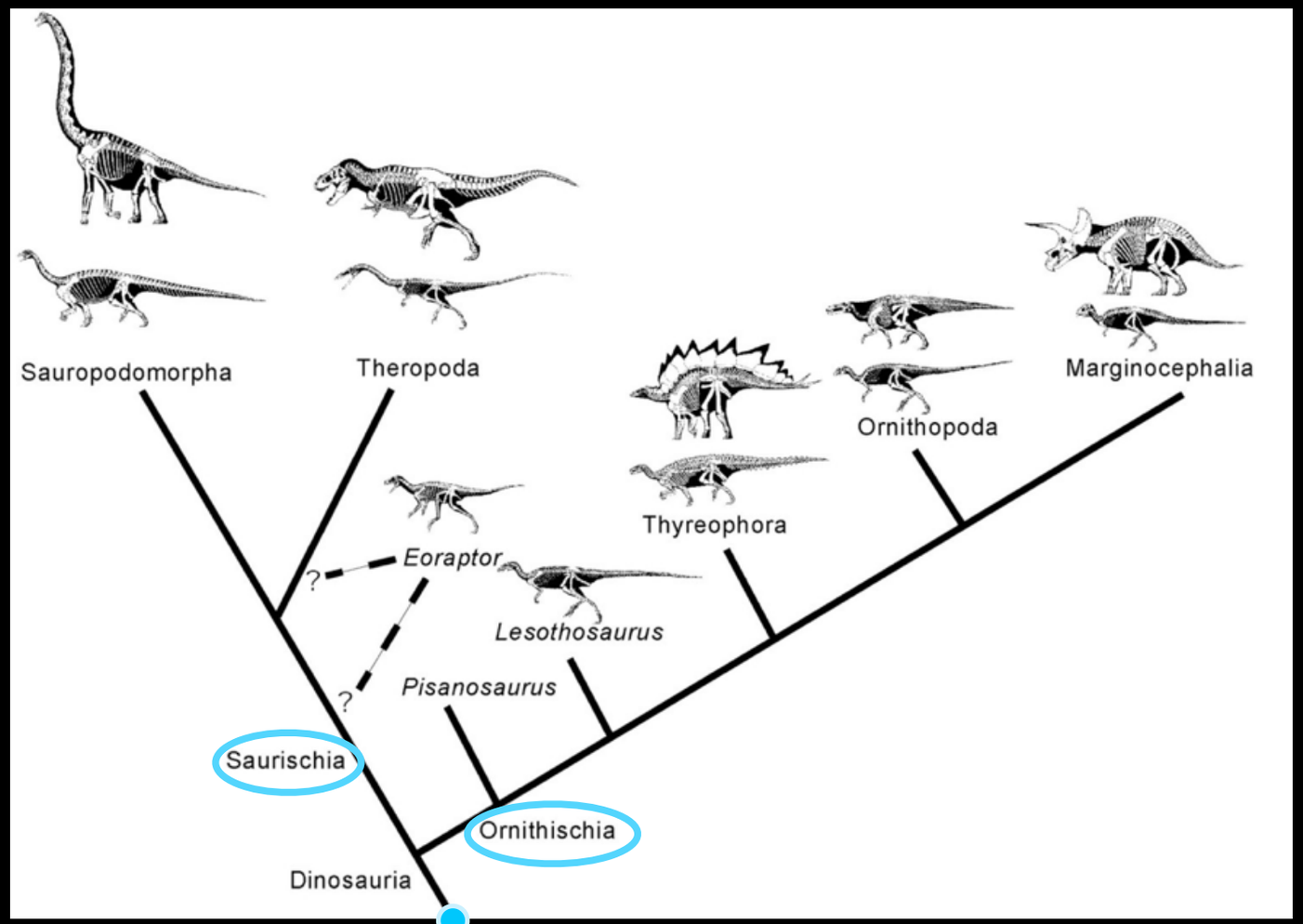
-Sauropodomorpha

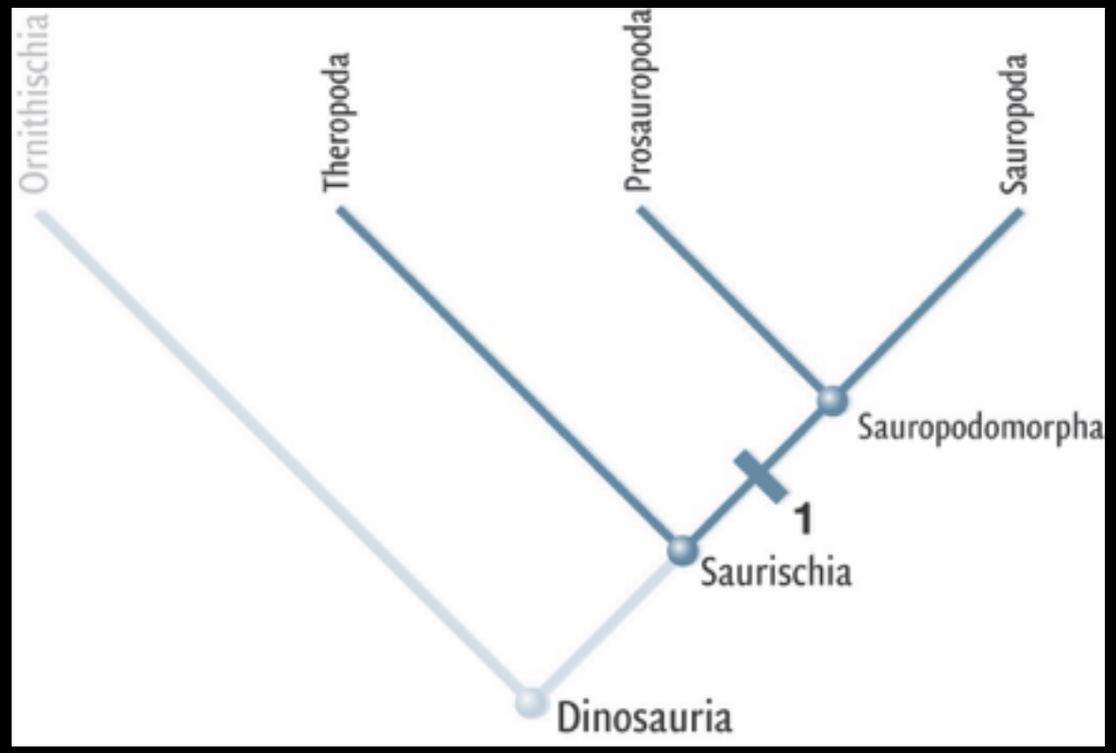
The Big

-Theropoda

The Bad

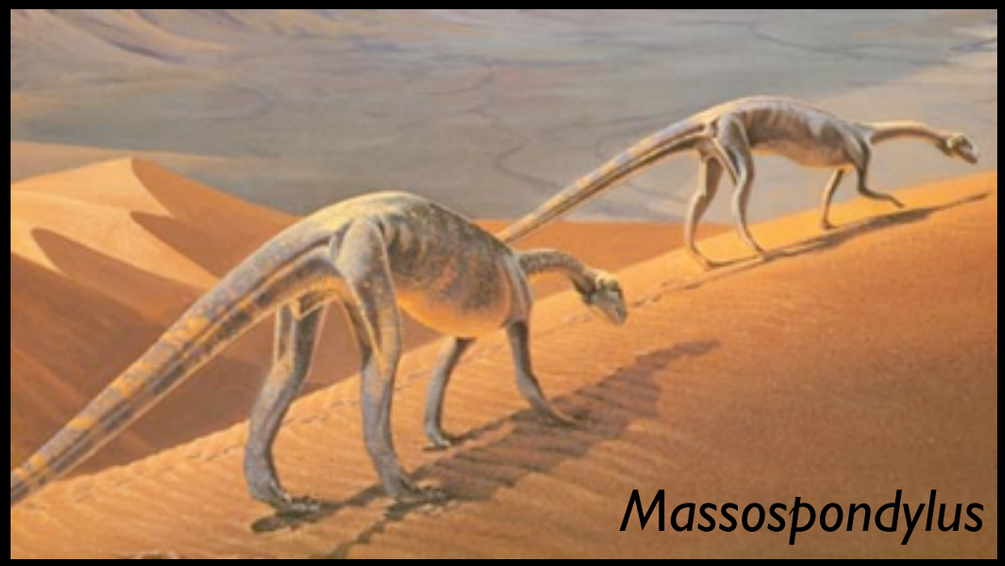
The Ugly



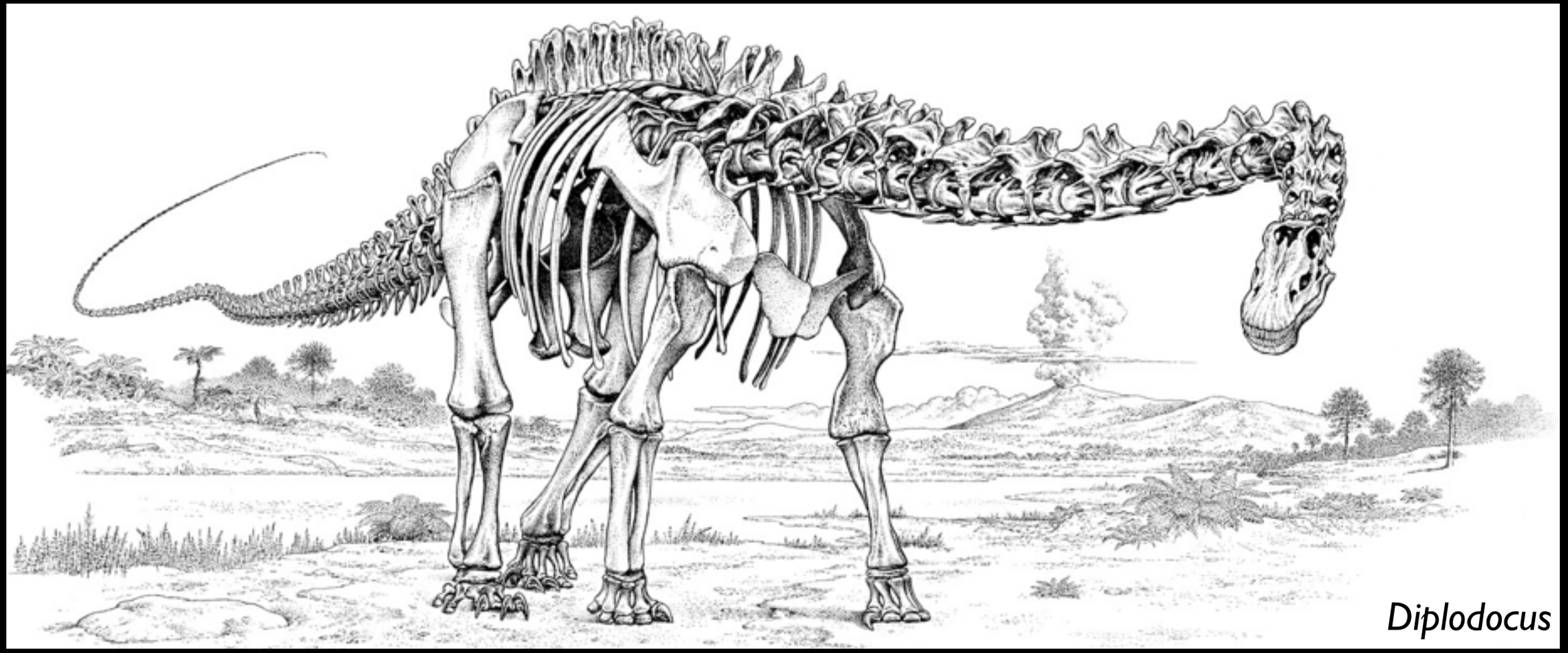


Sauropodomorpha

1. Prosauropoda
2. Sauropoda



Massospondylus

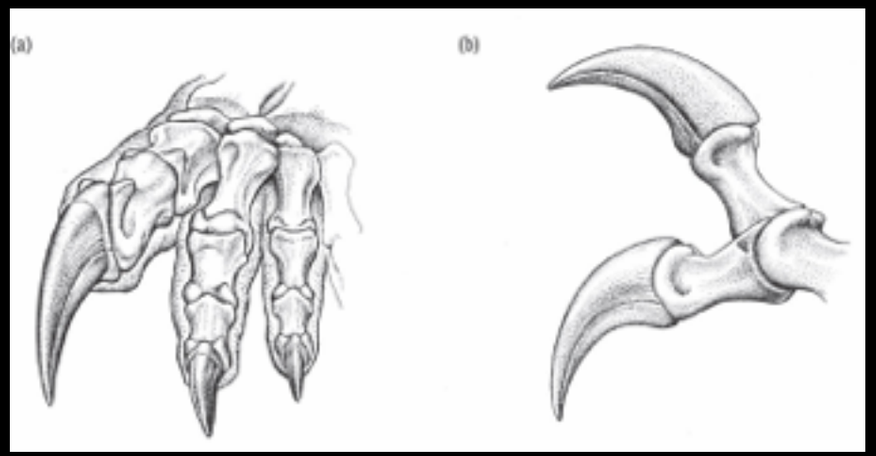


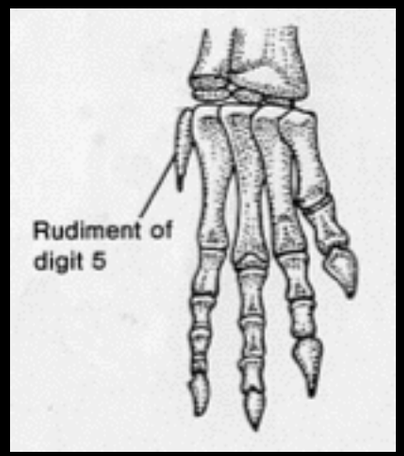
Diplodocus

Prosauropoda

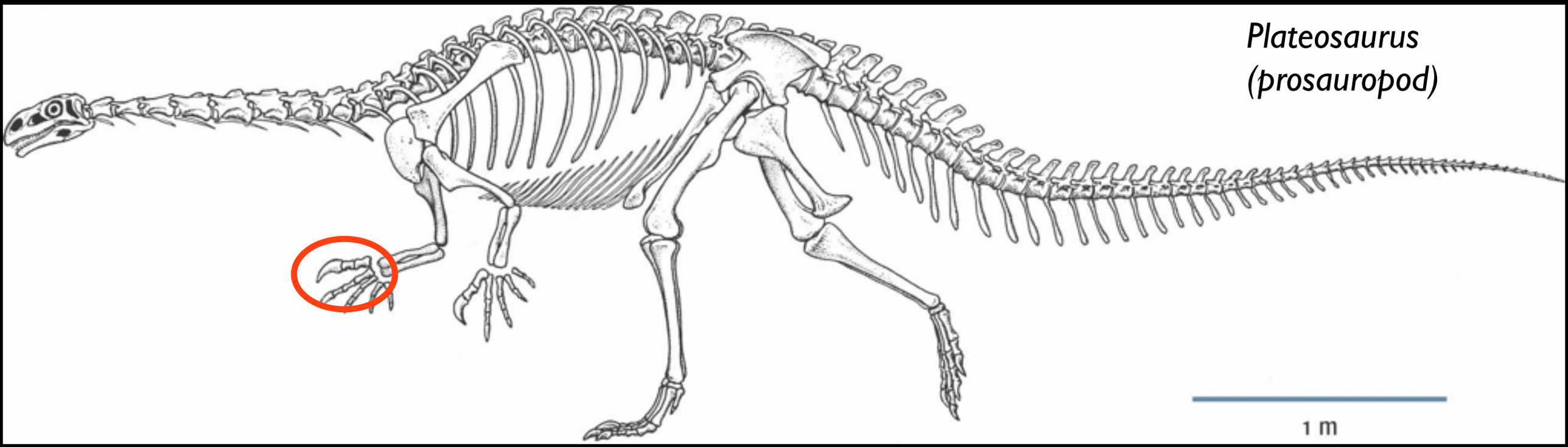
Shared, derived characteristics

Whopping big claw on thumb
Reduced pinky toe
Front limbs shorter than hind limbs

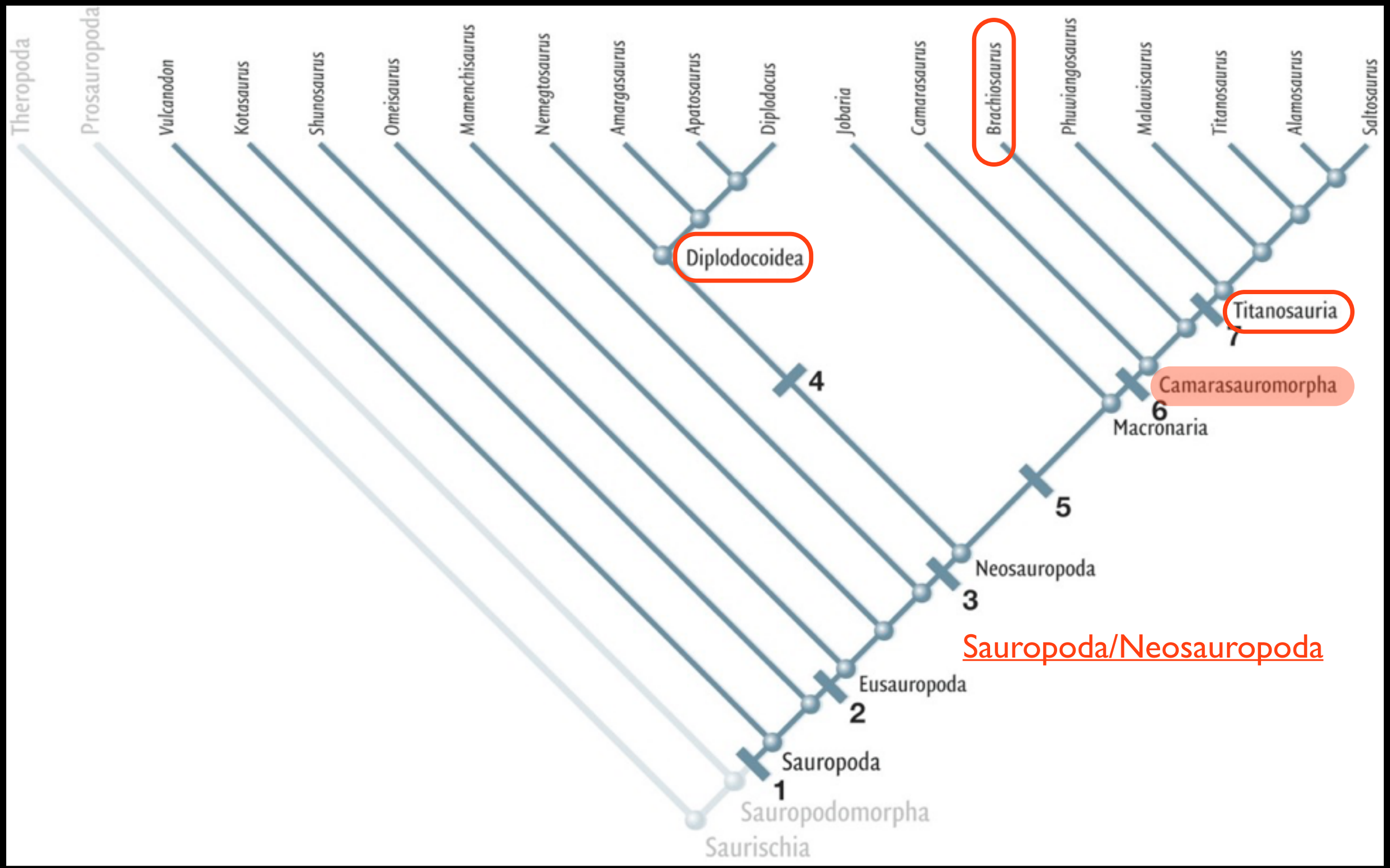




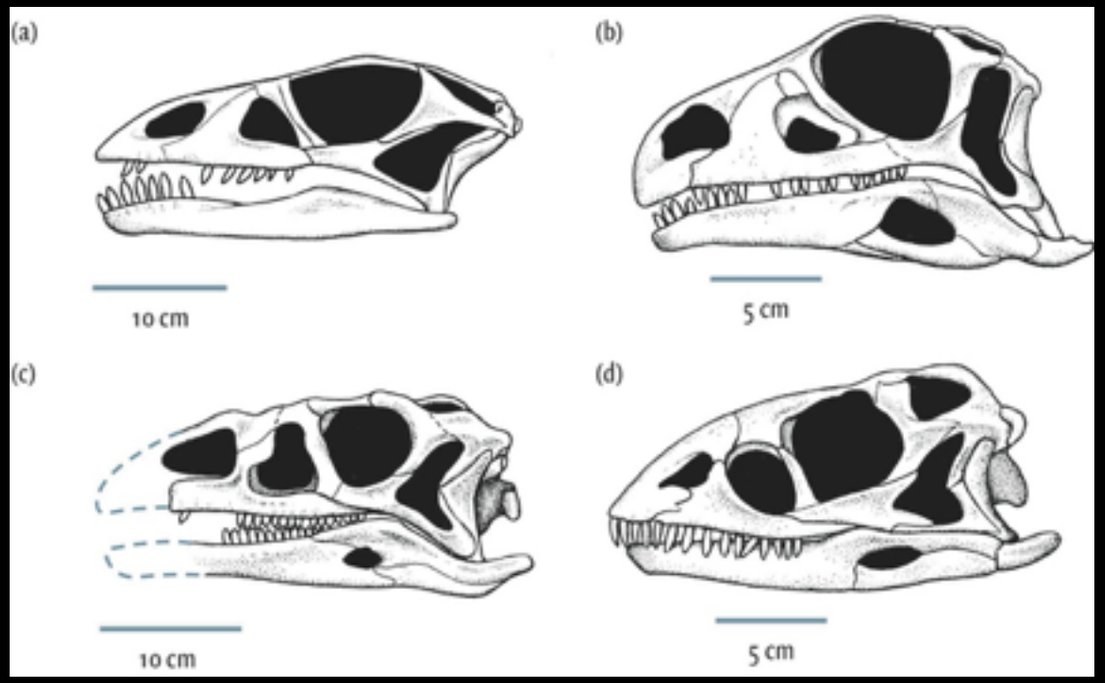
Plateosaurus



Camarasauromorpha



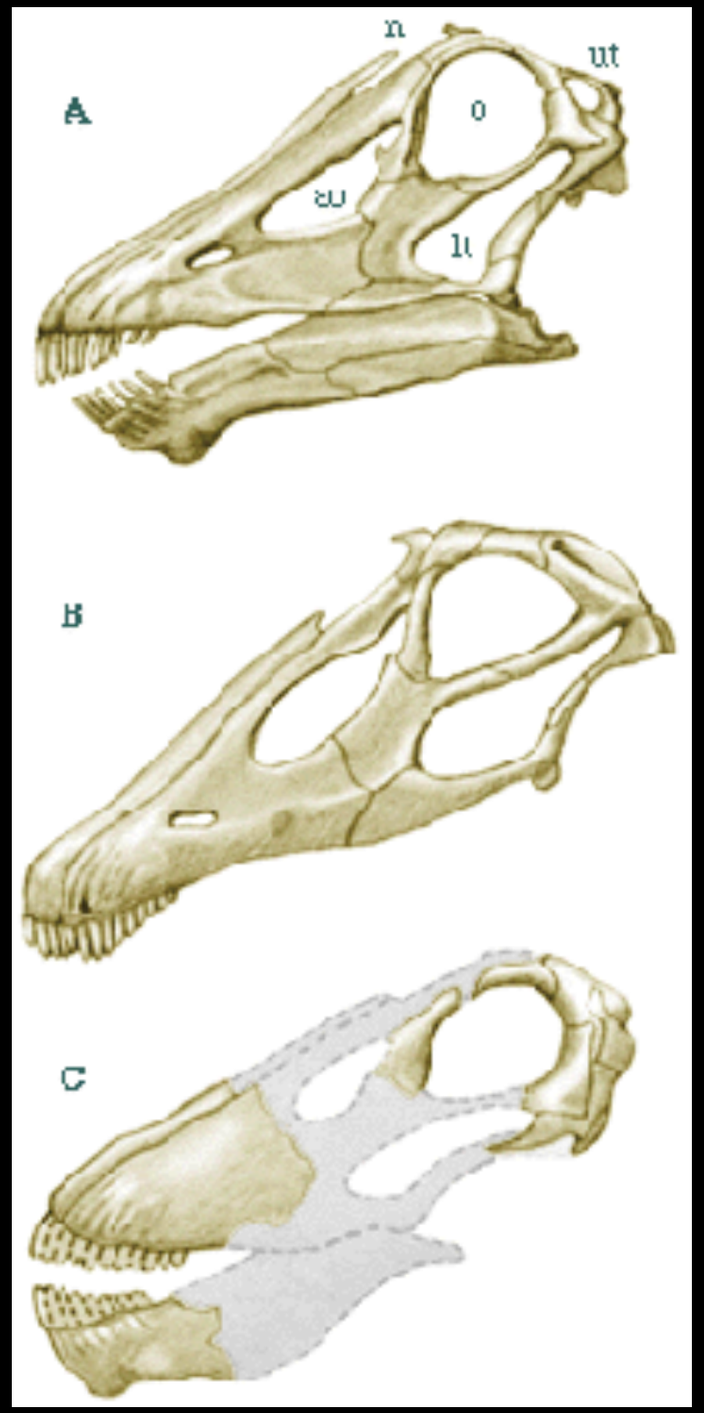
Sauropoda/Neosauropoda



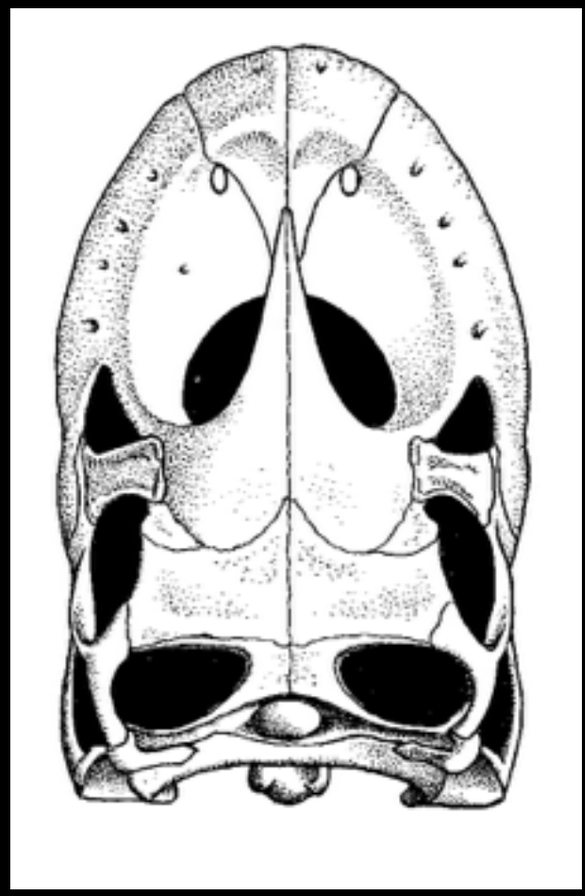
Prosauropods

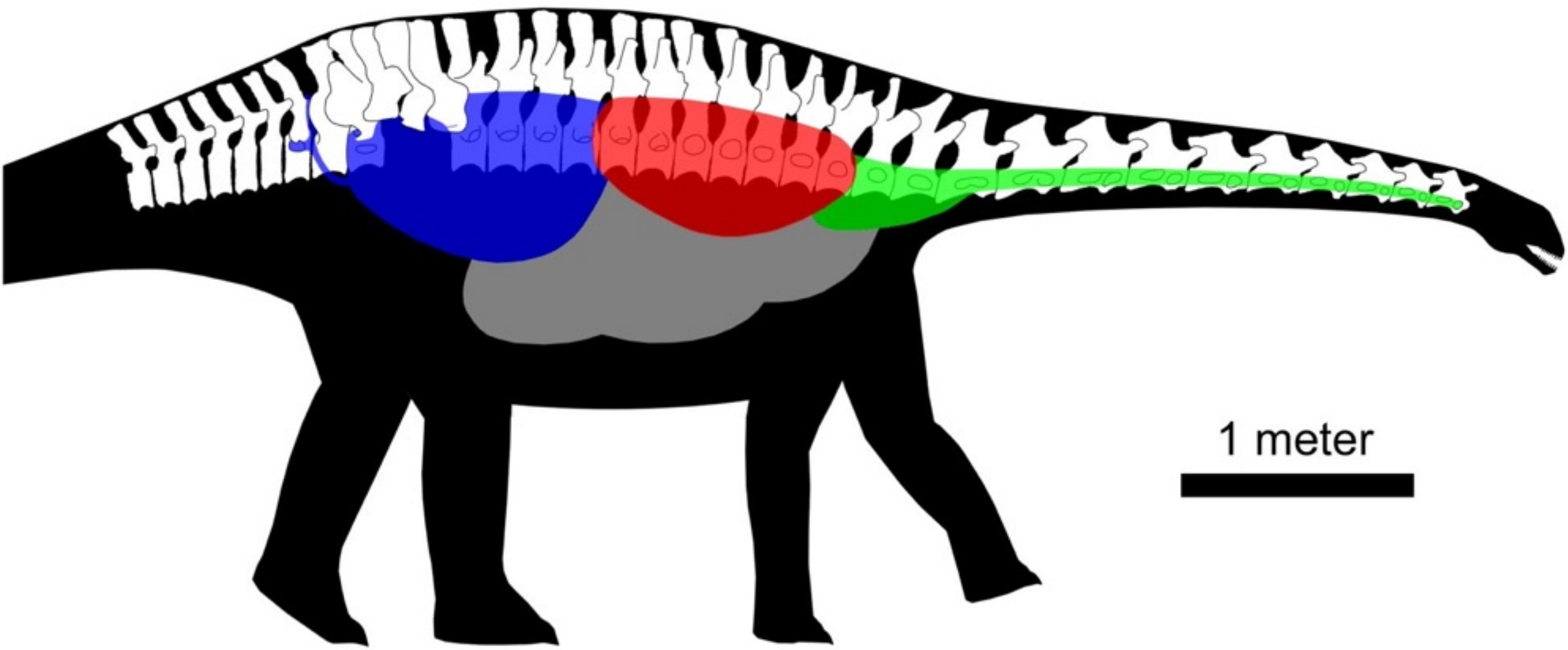
Sauropod Skulls

Shortened head
Rounded snout
Lower temporal fenestra below orbit
No inset cheek teeth
-not chewers
Delicate- not built to withstand large forces
Evolutionary trend: nares gradually move to the top of the skulls



Sauropods





Uni-Directional Breathing

Air flows in one direction

Pumped by auxiliary air sacs

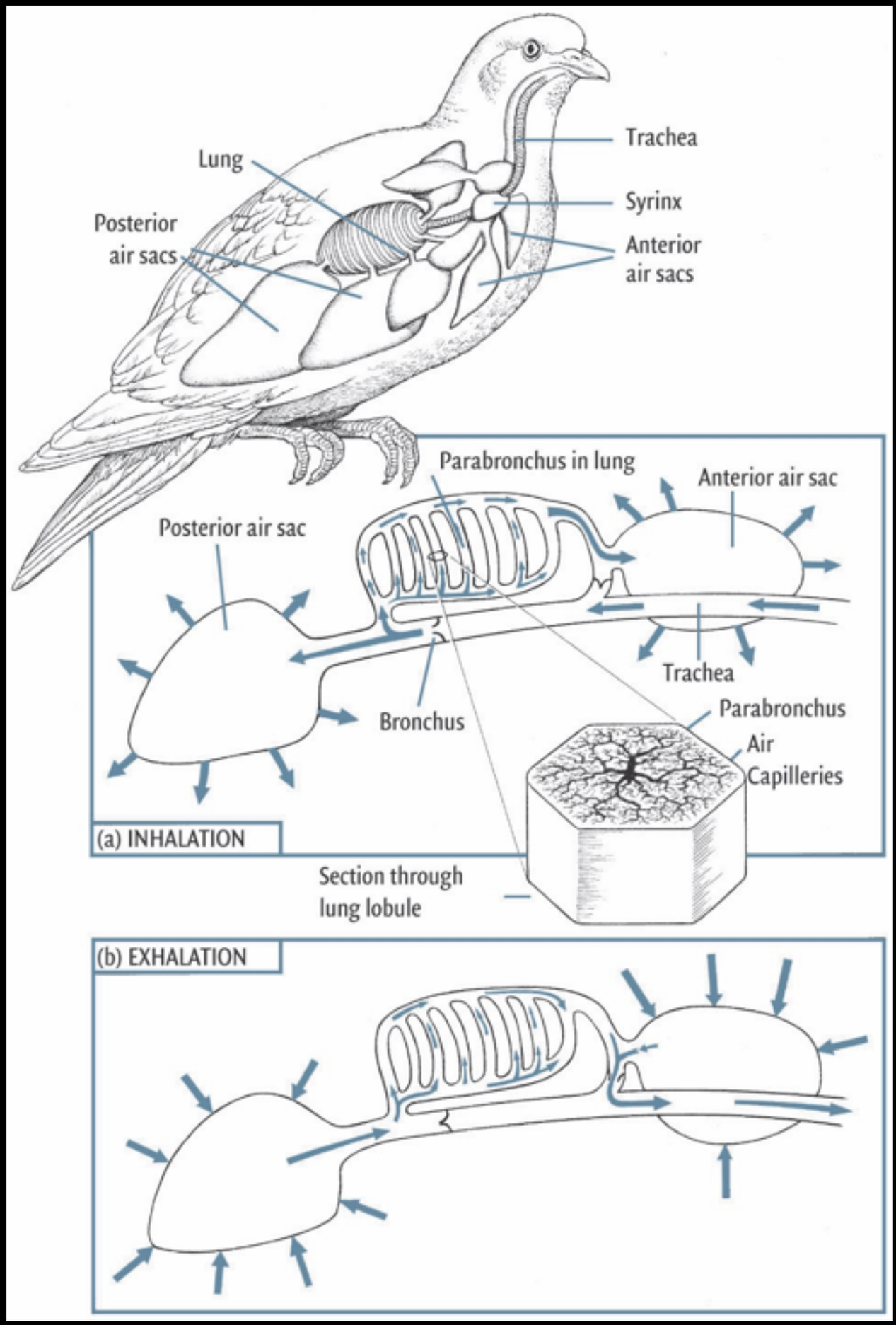
More O2 can be extracted

Auxiliary airsacs partly housed in cavities within bones (sinuses) ~ pneumatic foramen

Sauropods have these cavities in their backbones... dual purpose

Uni-Directional Breathing

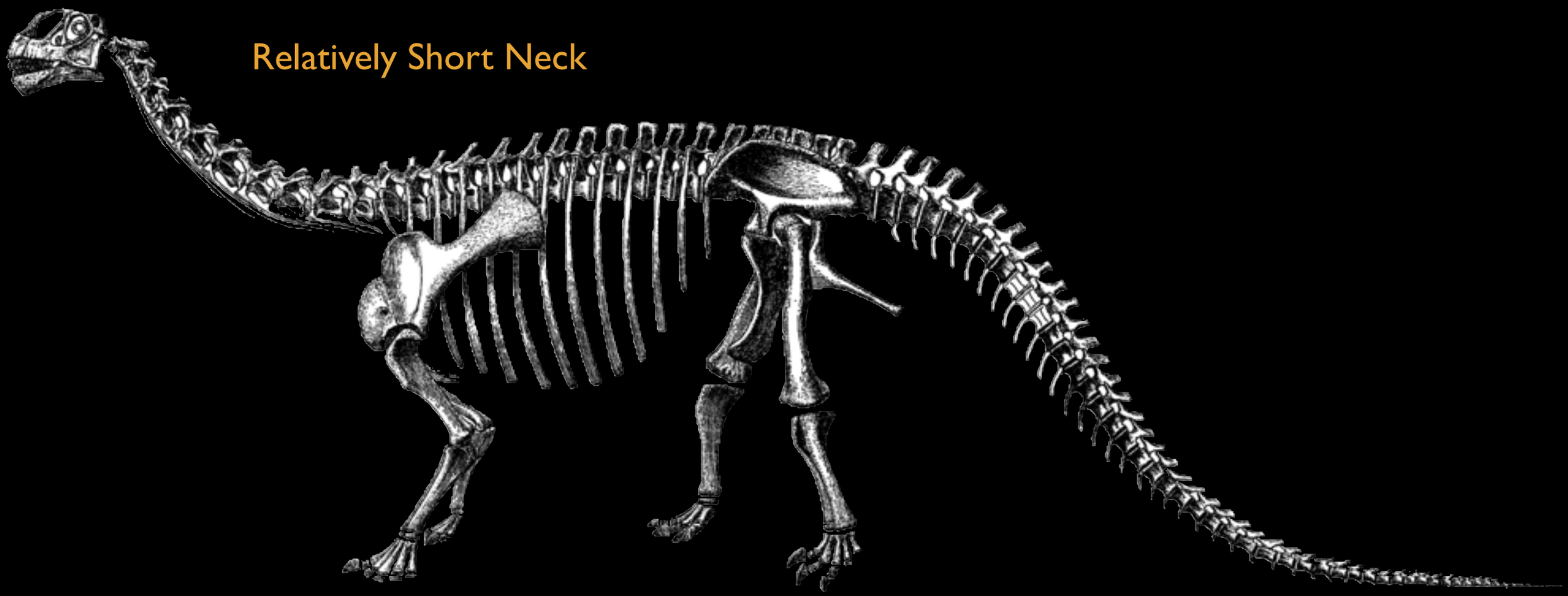
compared to bi-directional breathing
(Mammals, lizards, snakes, crocodiles)



Camarasauromorpha

Large Nares

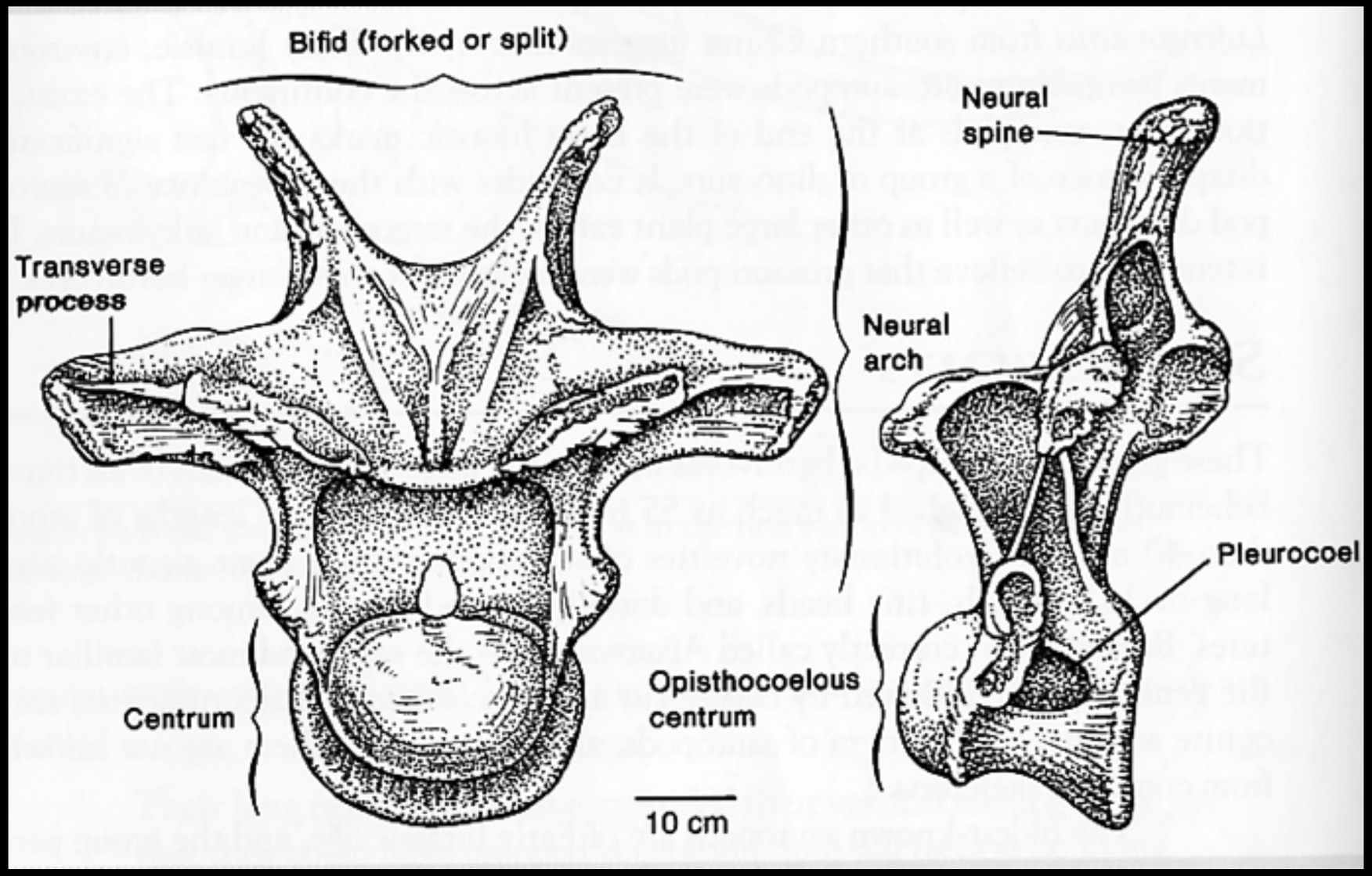
Relatively Short Neck



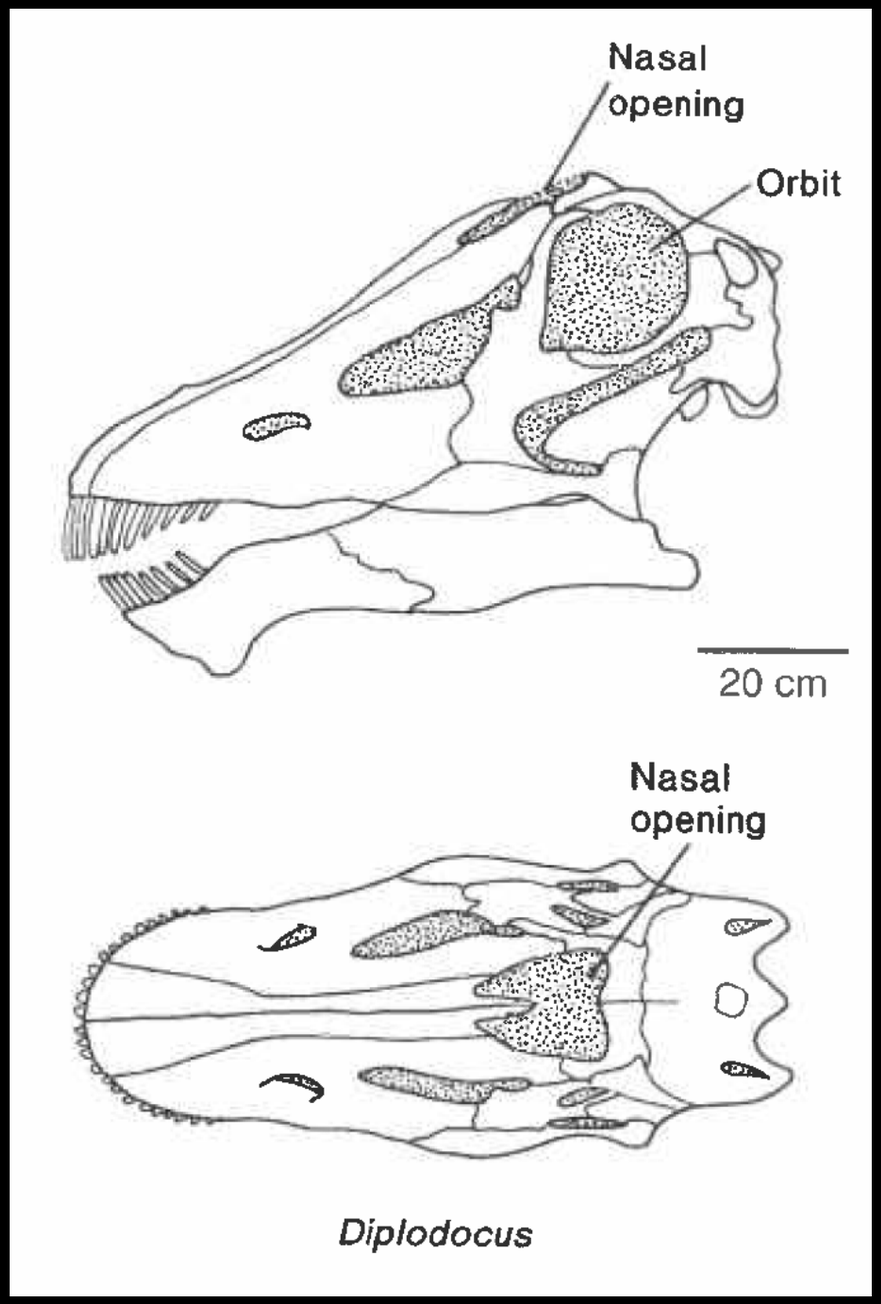
Relatively long forelimbs

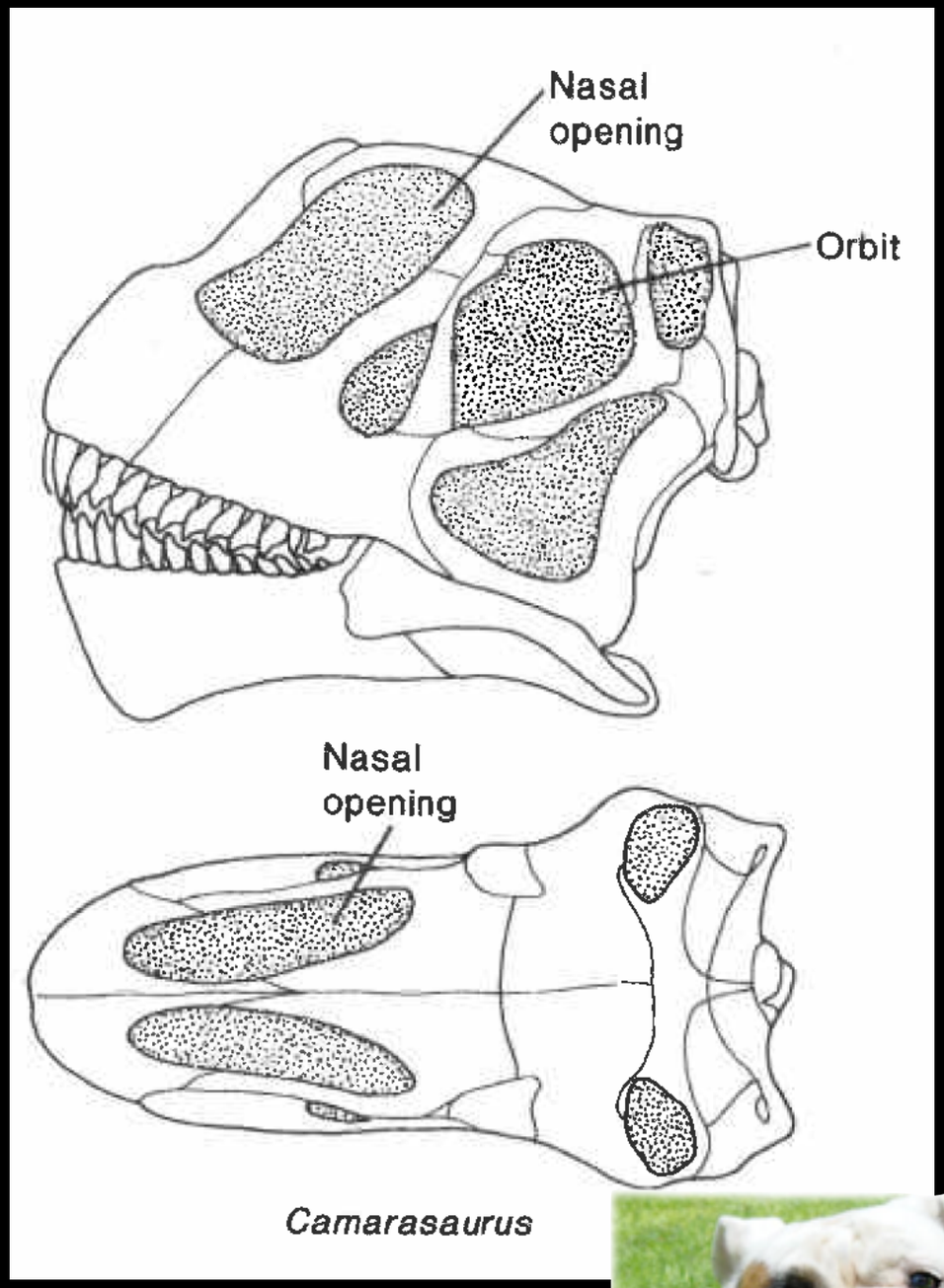
Camarasauromorpha

U-shaped neck vertebrae
To house strong, thick neck ligaments!



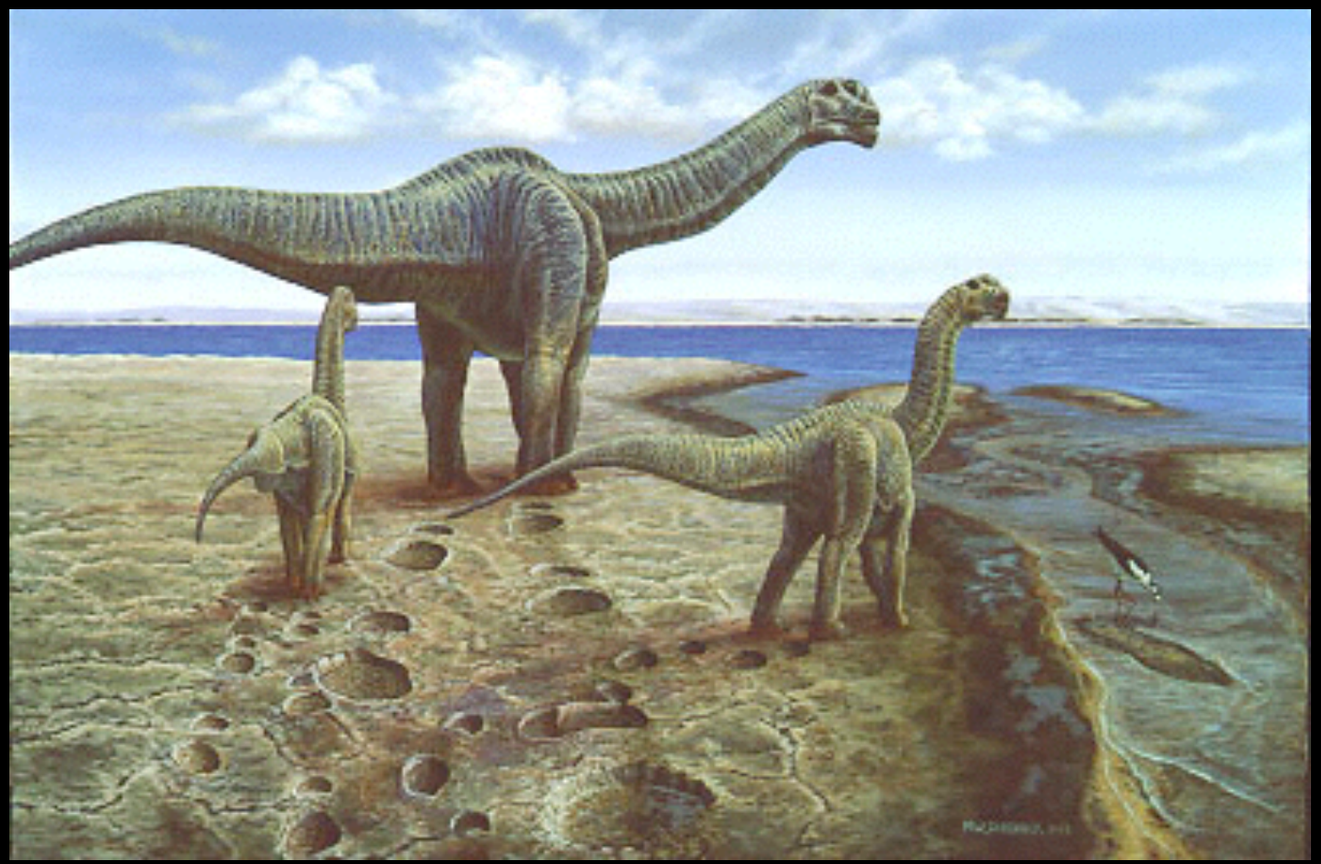
Camarasauromorpha

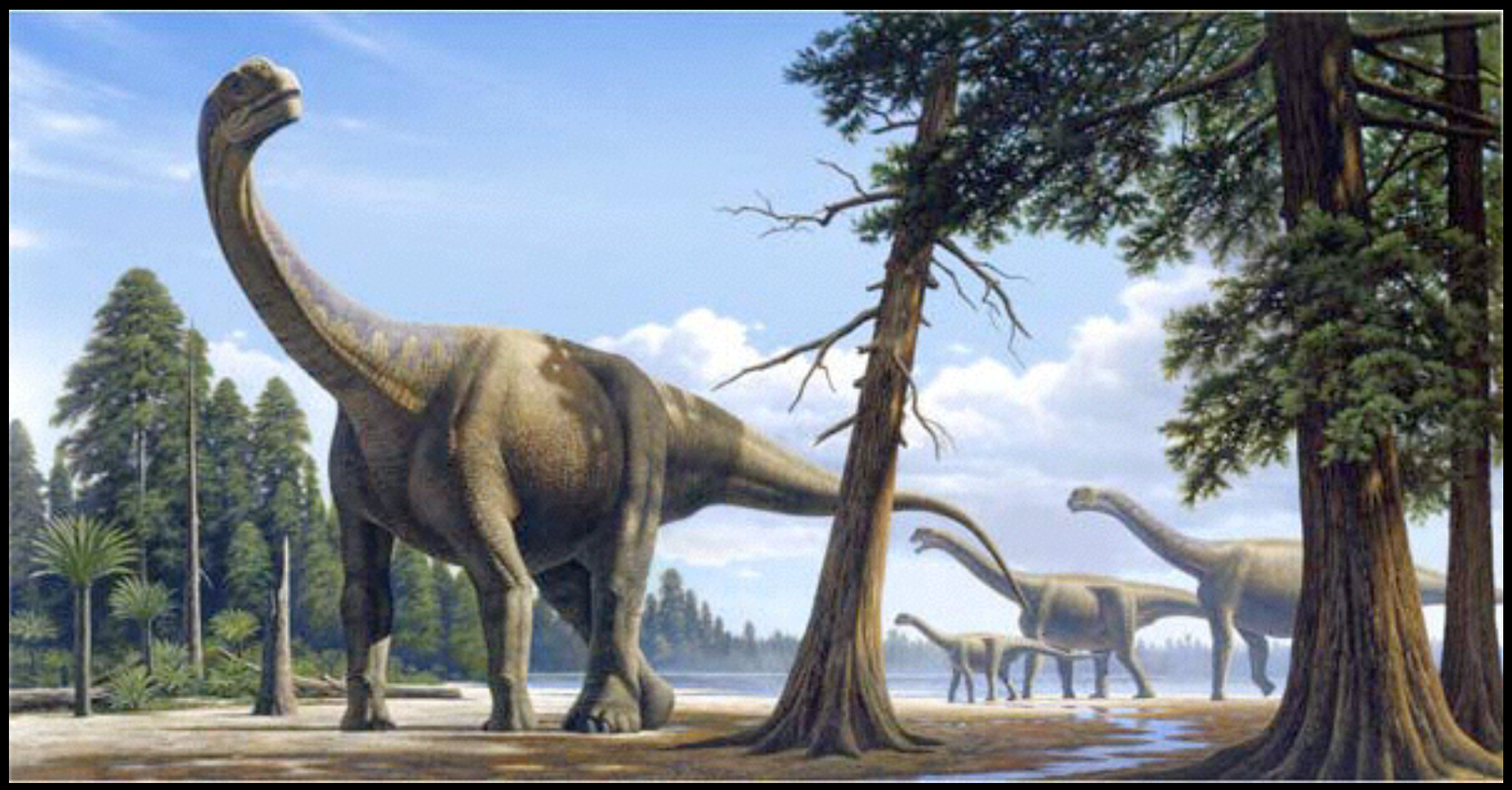




Shorter snout
Enlarged external nares

Camarasauromorpha





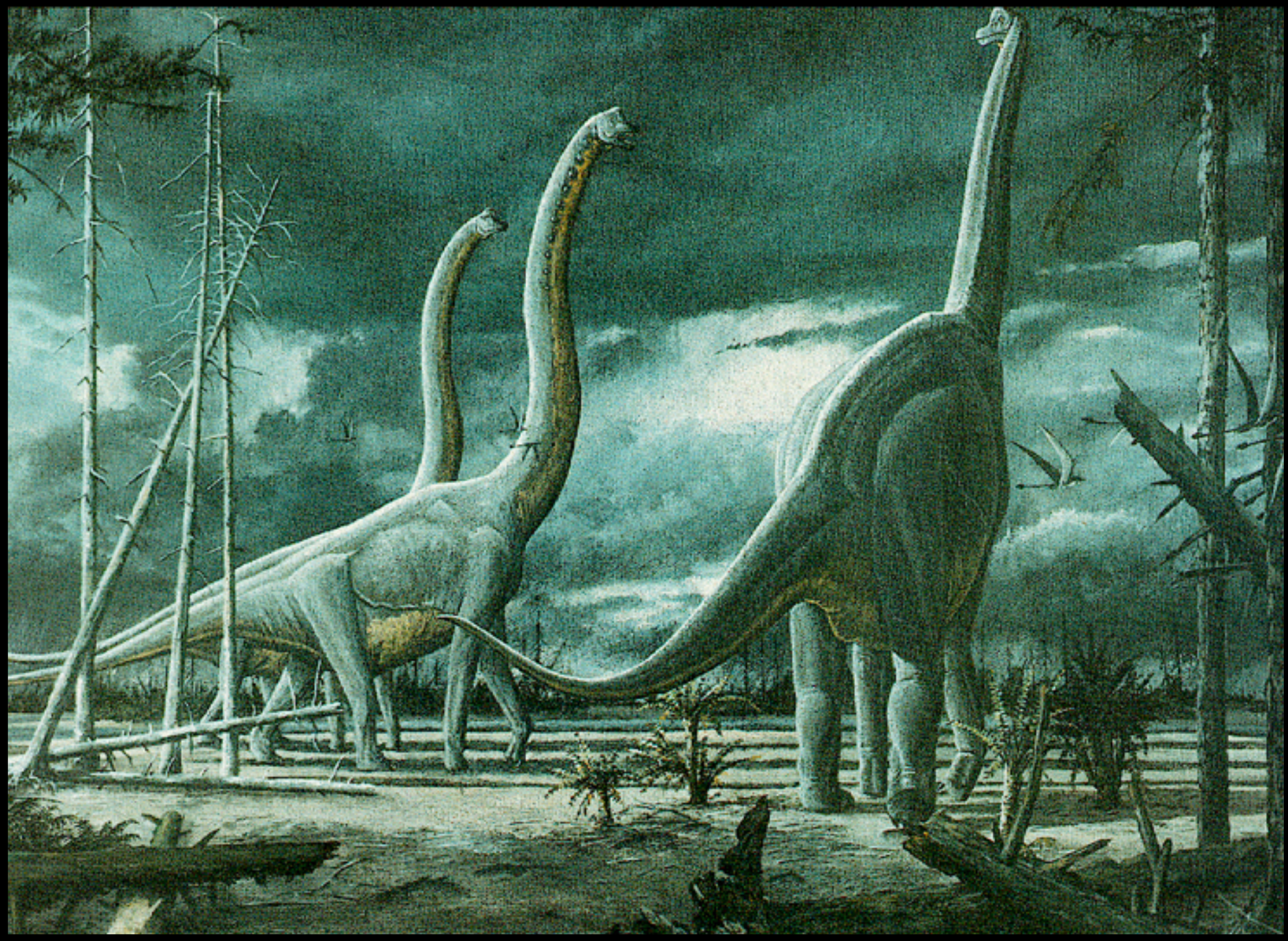
Camarasaurus

18 m (60 ft) long

Brachiosaurids

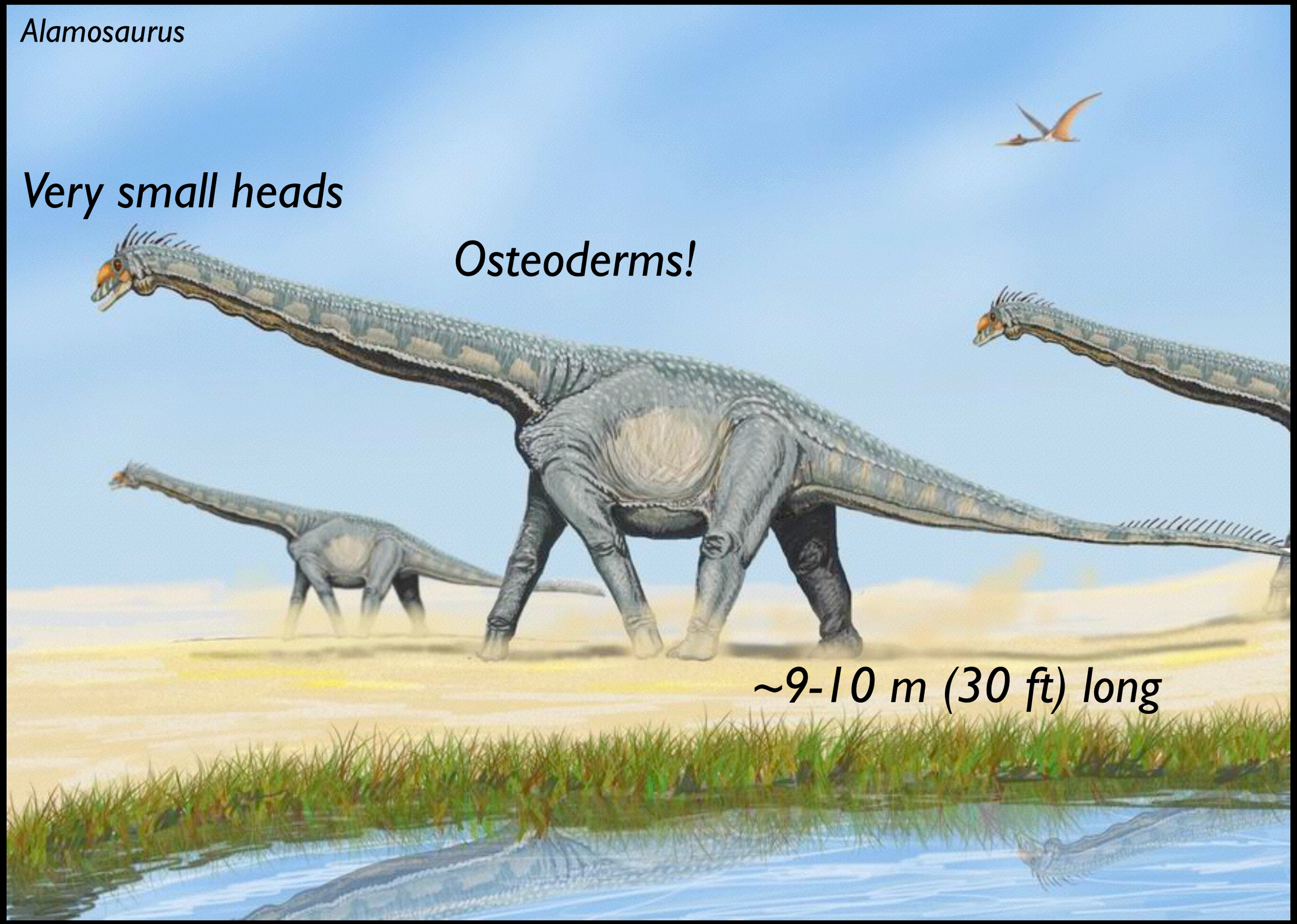
13 elongate vertebrae
Distinct snout
Vaulted skull
Very long forelimbs
Neck held vertically

16 m (52 feet) tall



Brachiosaurus

Titanosaurids: primarily in the Cretaceous



Diplodocid traits

>12 vertebrae + bifurcate cervical neural spines

At least 80 caudals

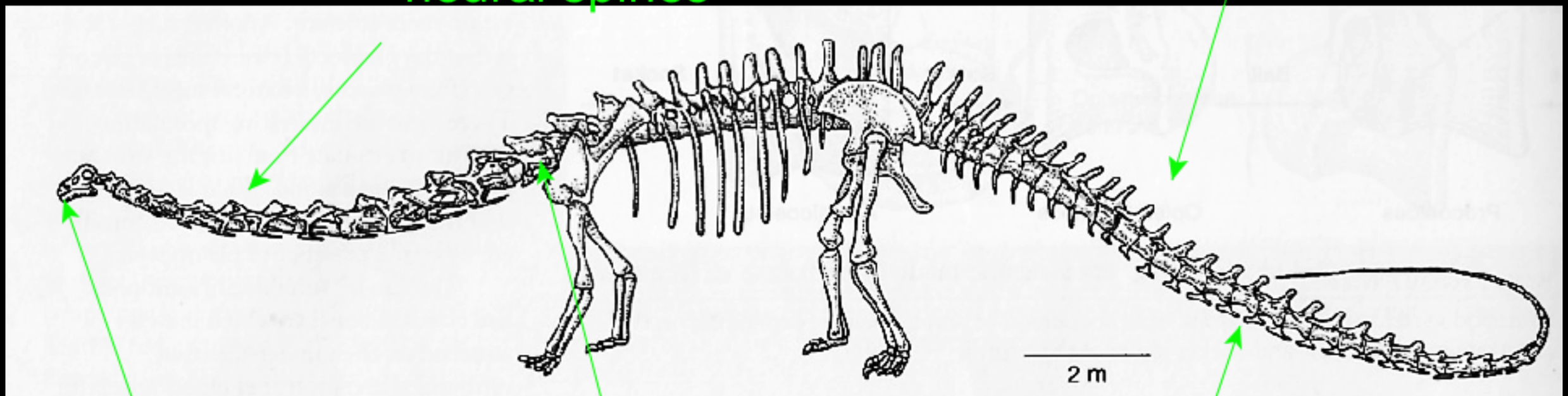


FIGURE 6.8

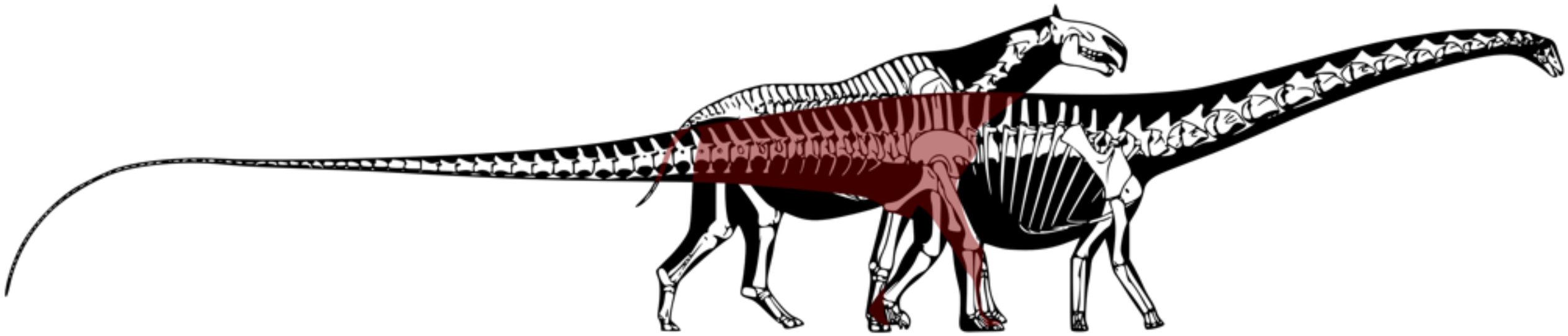
An adult *Diplodocus* was a 27-meter-long, lightly built sauropod, characteristic of the diplodocids.

Relatively long skulls with peg-like teeth

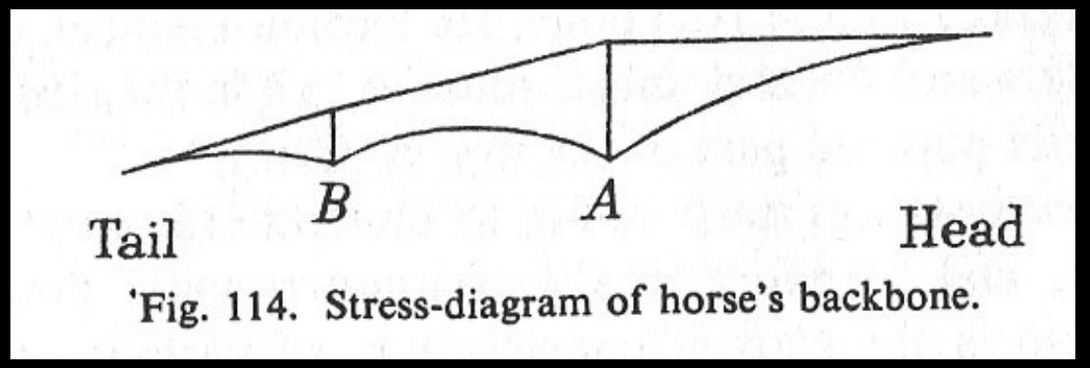
Neck joint horizontally oriented

Odd chevrons

27 m = 90 ft; Blue whale length



Maximum stress centered over haunches



'Fig. 114. Stress-diagram of horse's backbone.

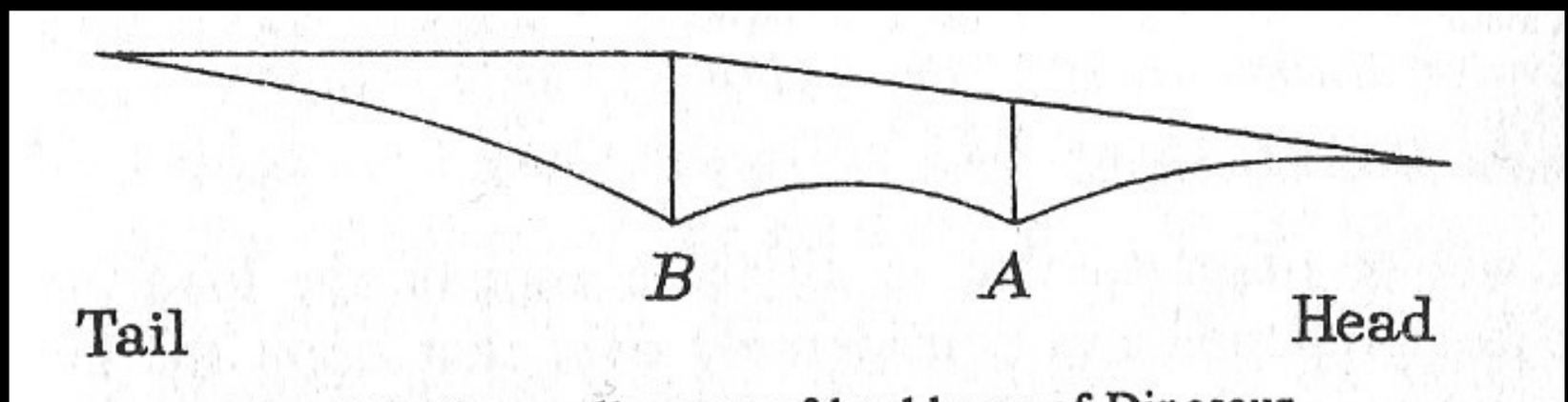
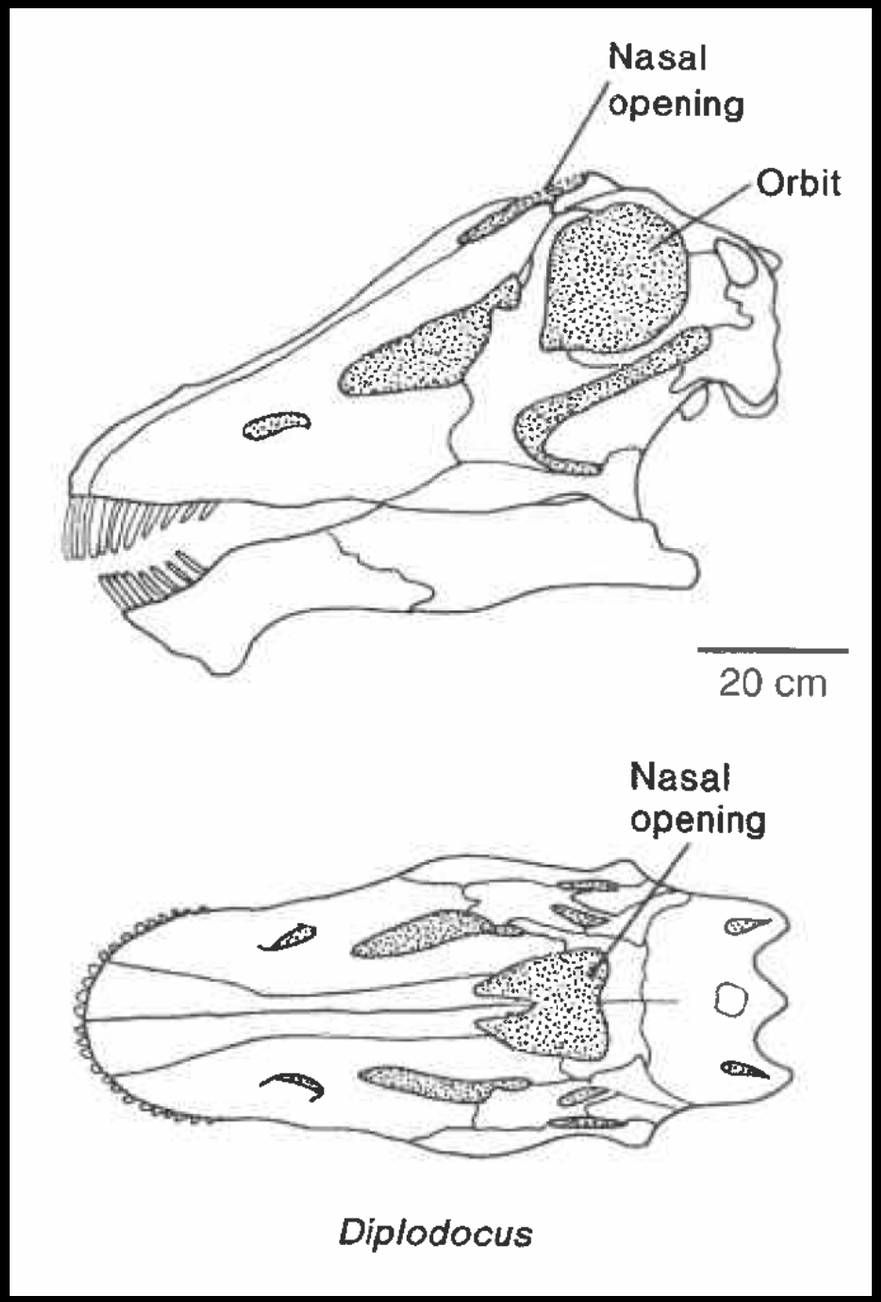
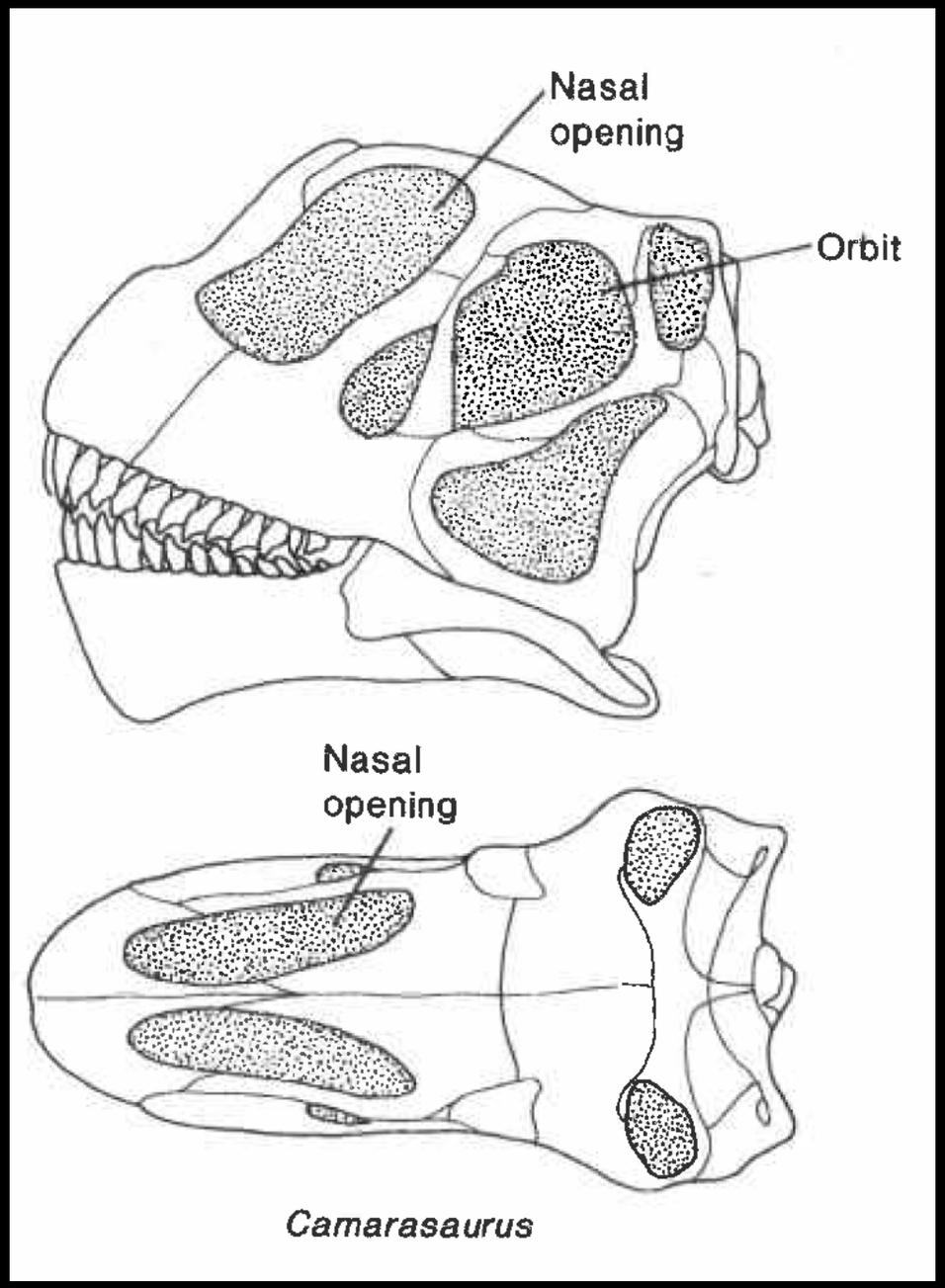


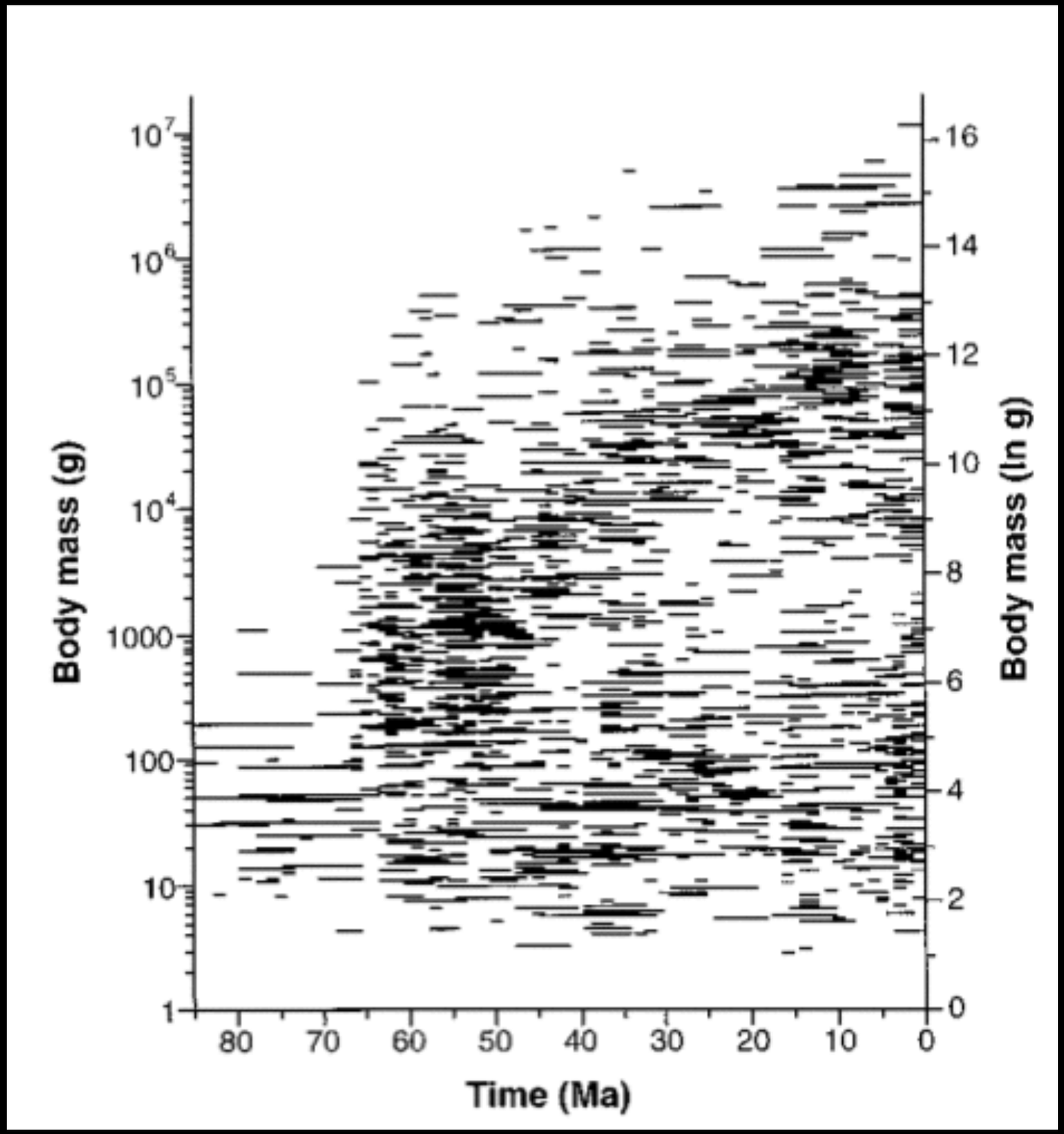
Fig. 115. Stress-diagram of backbone of Dinosaur.

Diplodocids





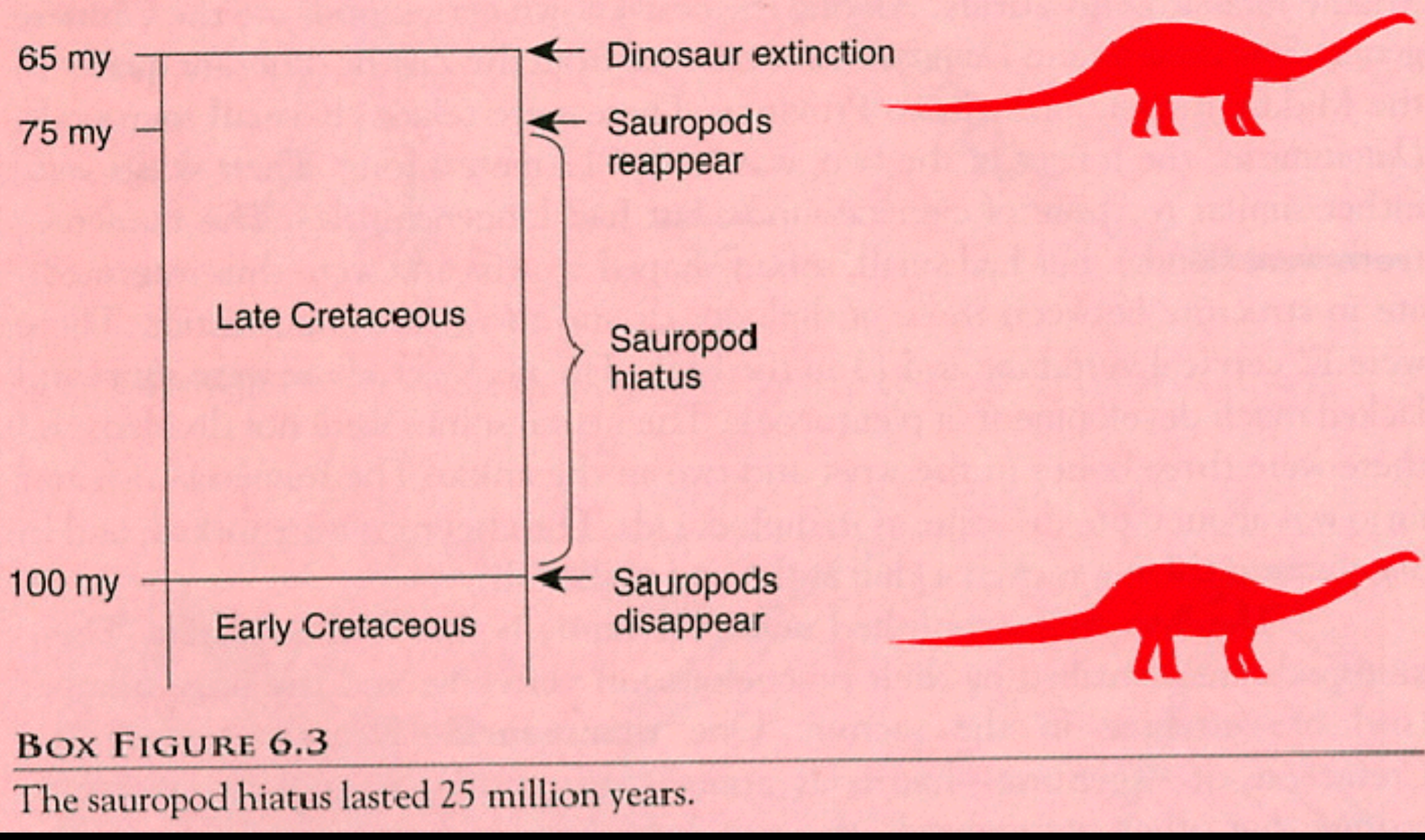
Long sub-rectangular skulls
Fully retracted Nares (on roof of skull)



Cope's Rule and the evolution of large body size

Advantages of large body size? Disadvantages?

The Sauropod Hiatus



BOX FIGURE 6.3

The sauropod hiatus lasted 25 million years.

"The start of the sauropod hiatus is interpreted as the result of a genuine continent-wide extinction, coincident with the appearance of (and perhaps attributable to competition with) advanced ornithischian herbivores, decrease in habitat due to the incursion of the Western Interior Seaway, or both."

Herding?

Shunosaurus
Diplodocus
Camarasaurus

Ecosystem Engineers