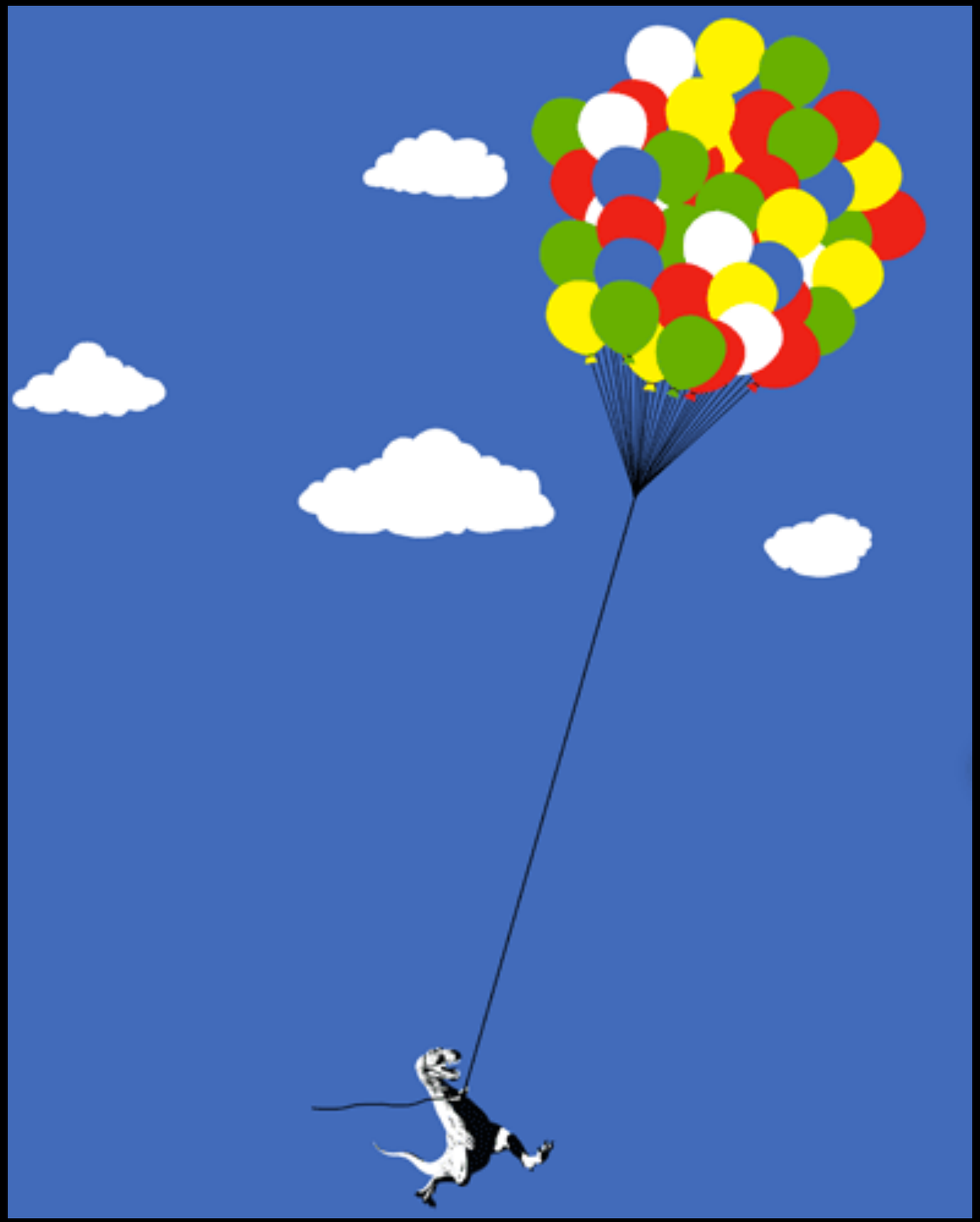

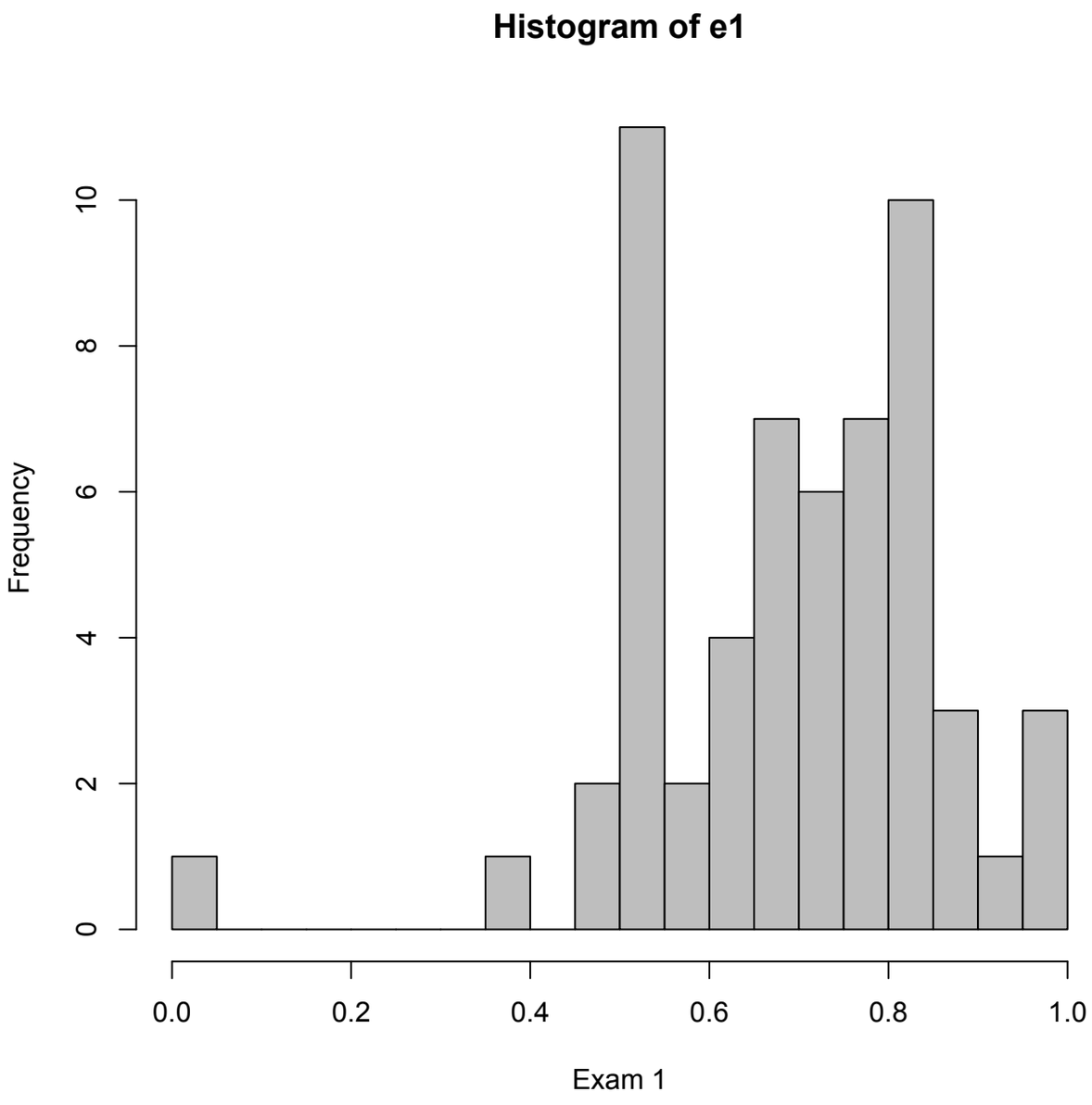

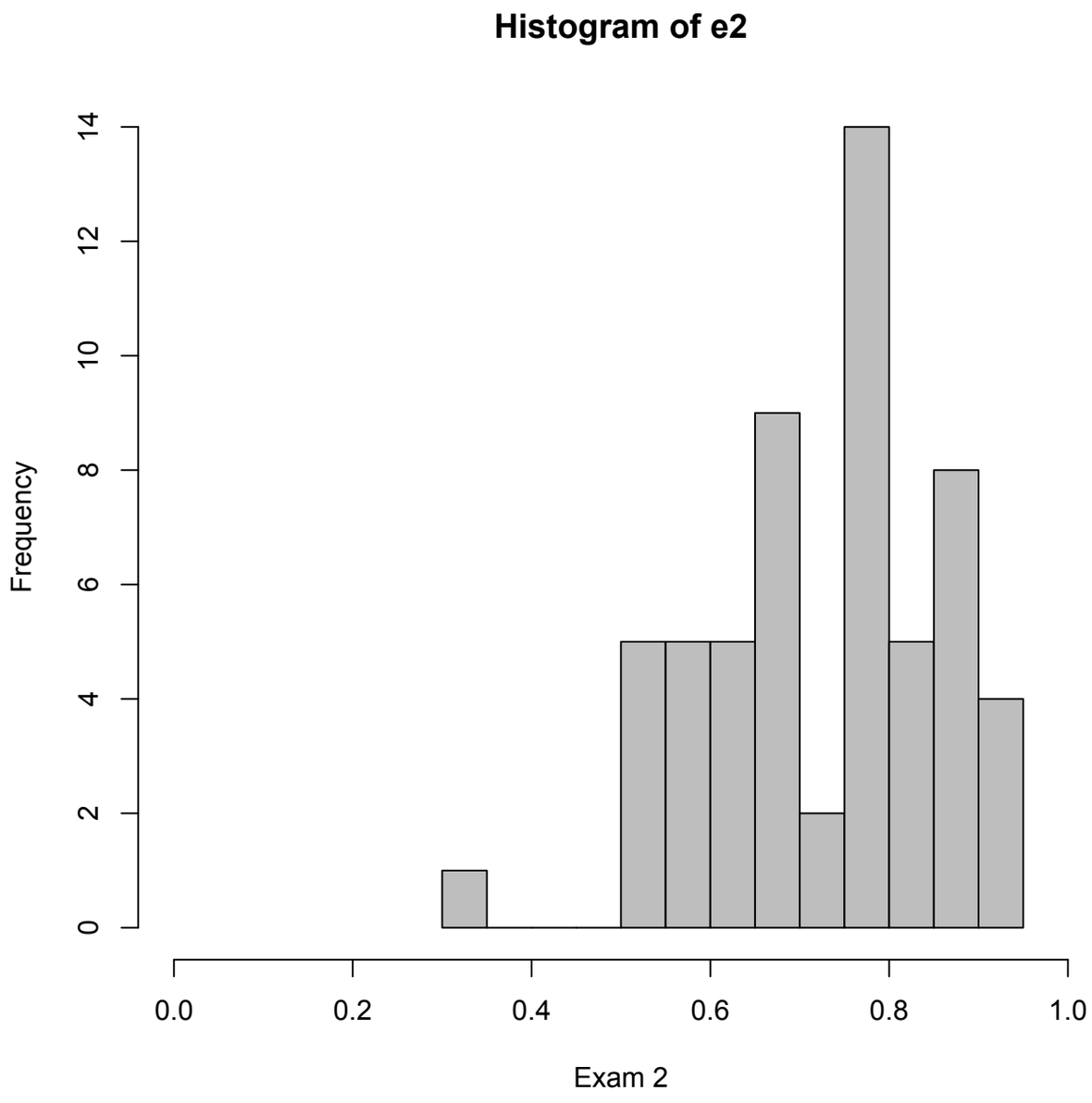

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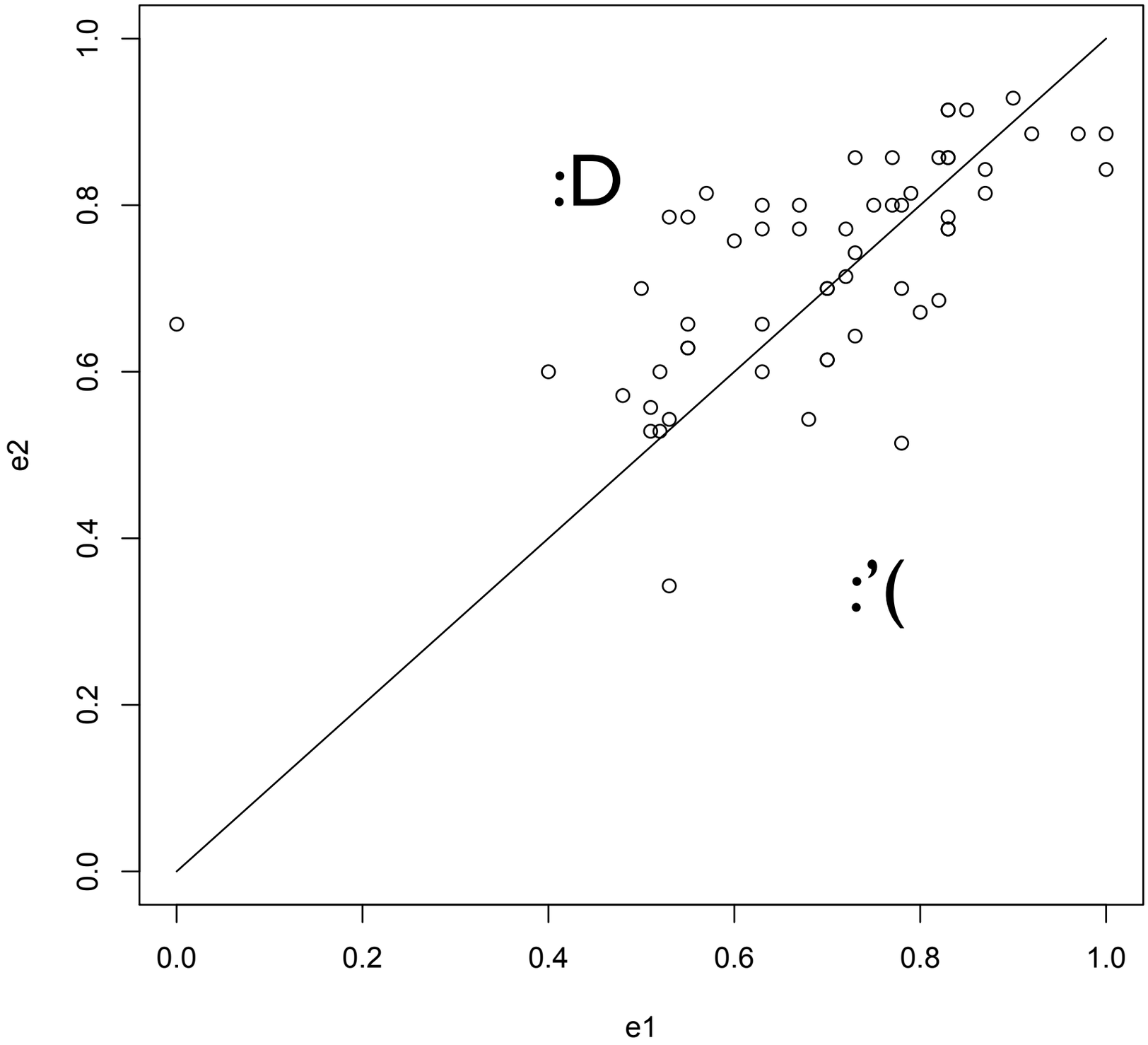
Mean: 73%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Walking with DINOSAURS: Spirits of the Ice Forest

The Ornithopod Players:

Leaellynasaura

Hypsilophodont (basal euornithopod) Ornithopod
Enlarged eyes (adaptation for low light conditions?)

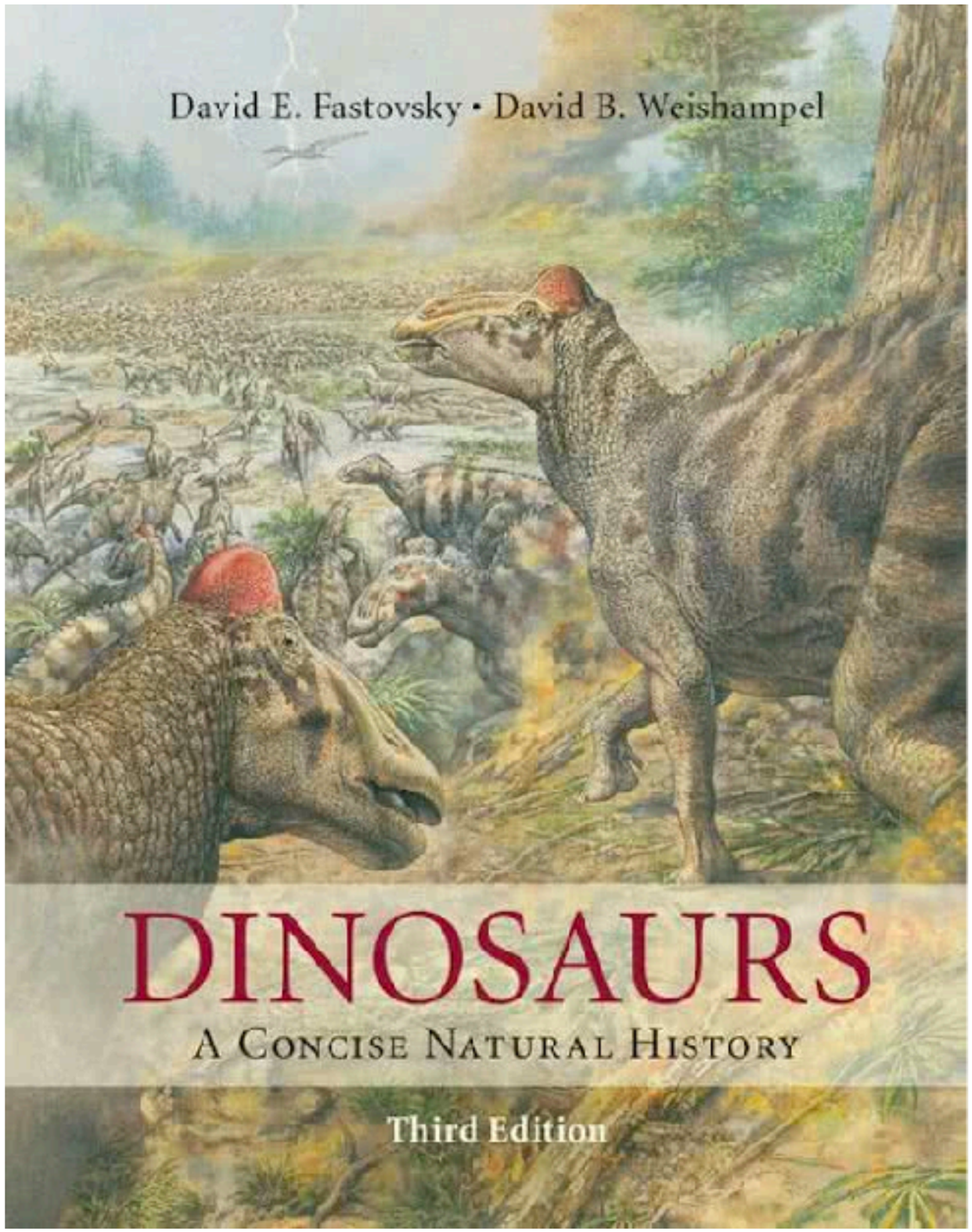
Muttaburrasaurus

Iguanodontine Ornithopod

Enlarged eyes (adaptation for low light conditions?)

Some things to look out for:

- Assumed sociality of *Leaellynasaura*
  - Here they've modeled them after Meerkats
- Herding behavior in *Muttaburrasaurus*
- Migration
- Nasal air sacs
- Group defense
- Bipedality vs. Quadrupedality within *Muttaburrasaurus*
  - *Middle digits of front foot => hoof-like pad*

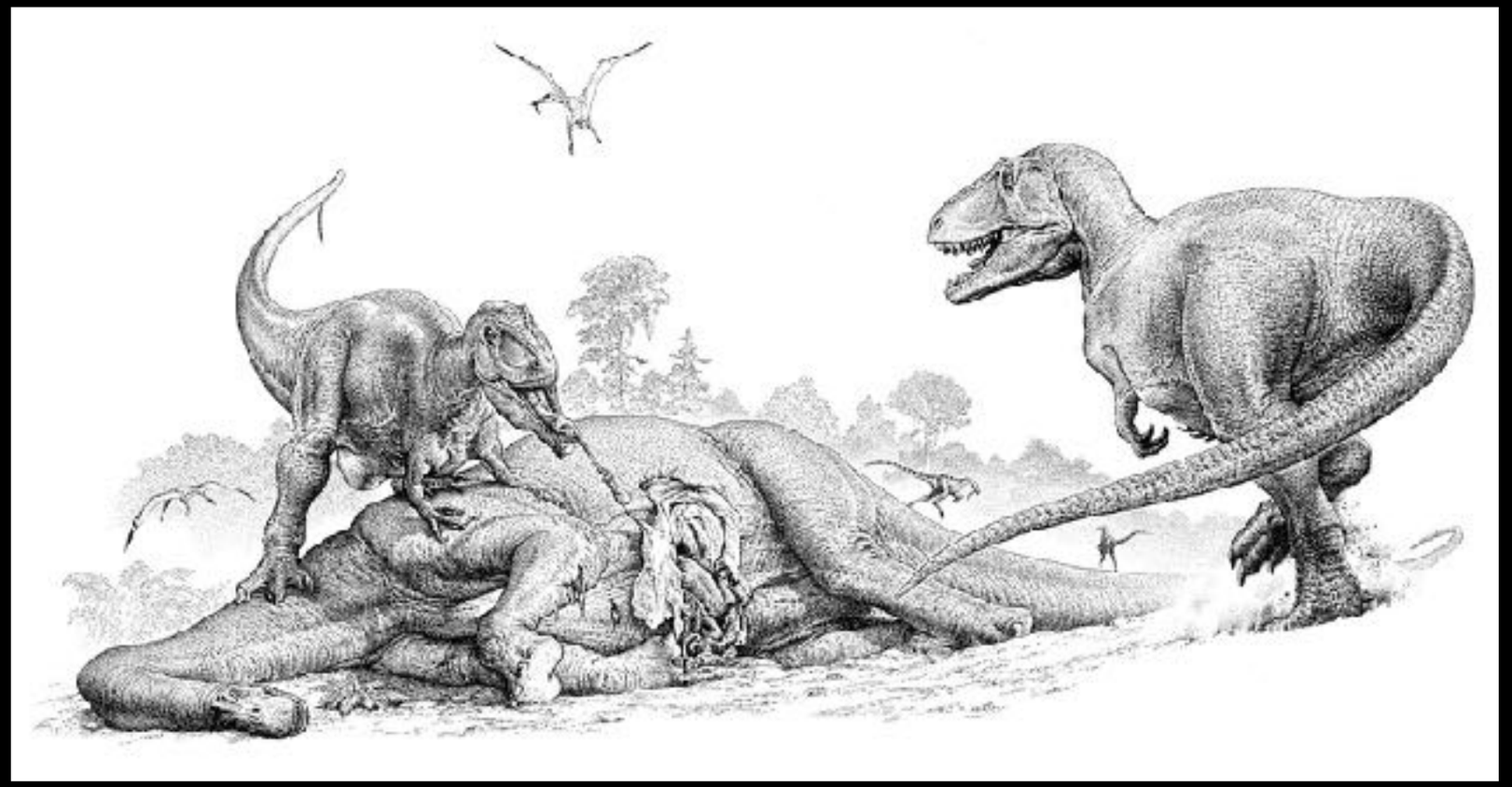


Reading for this week:
Fastovsky & Weishampel

Part II: Intro to Saurischia

Chapter 9: Sauropodomorpha

Enter Saurischia!



Saurischians:

Two major clades:

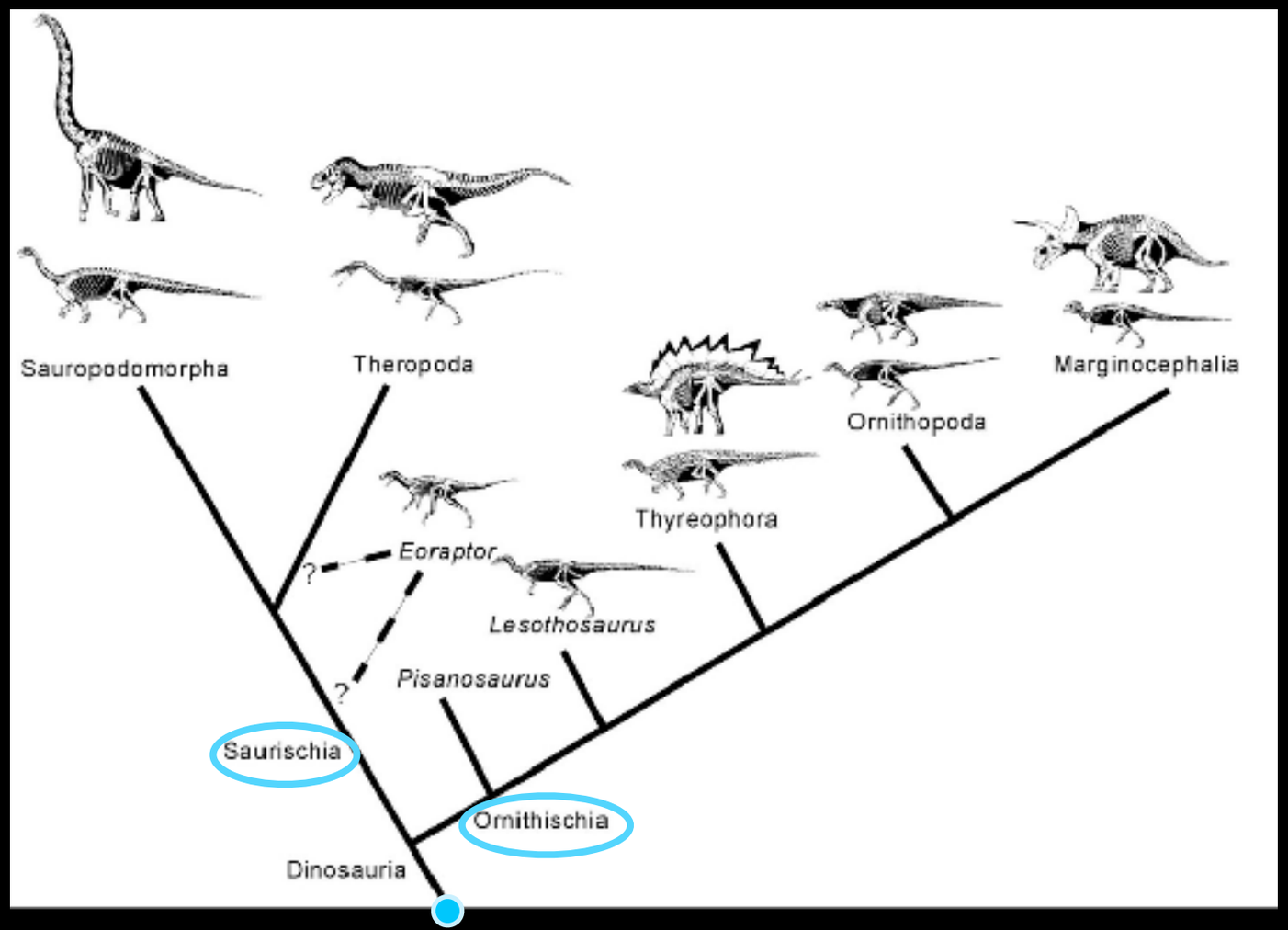
-Sauropodomorpha

The Big

-Theropoda

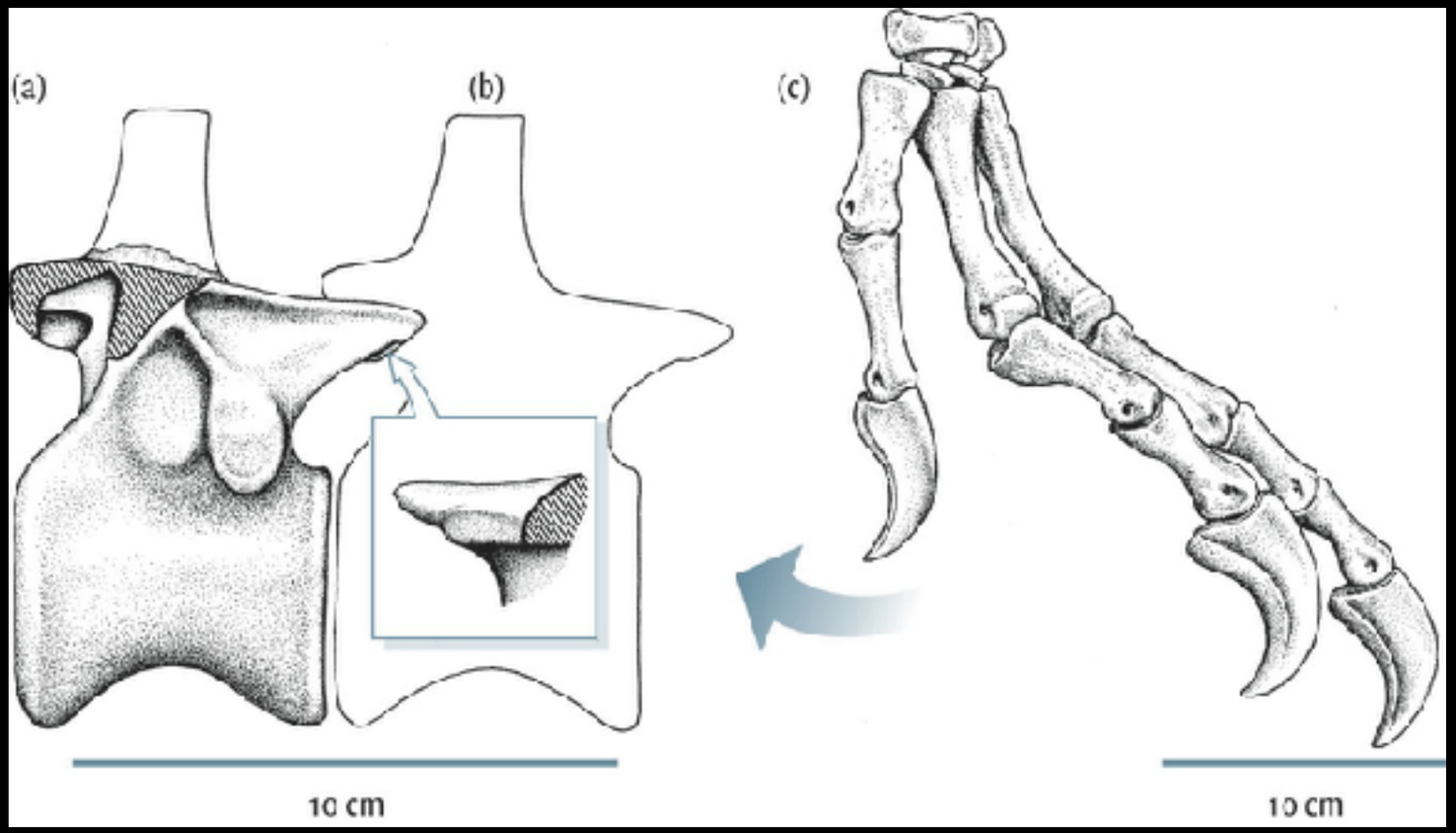
The Bad

The Ugly



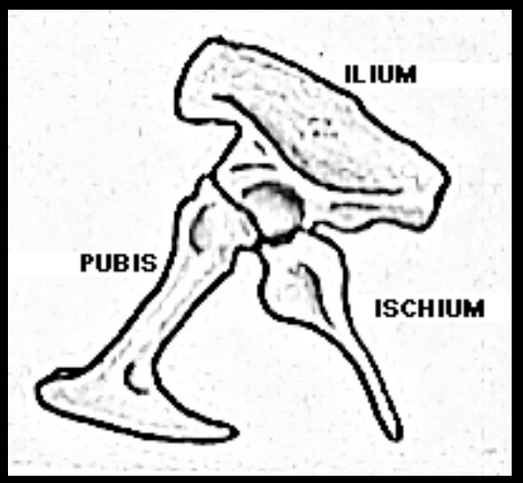
What characterizes Saurischian Dinosaurs?

1. Subnarial foramen
2. Extra articulation on dorsal vertebrae
3. Twisted thumb

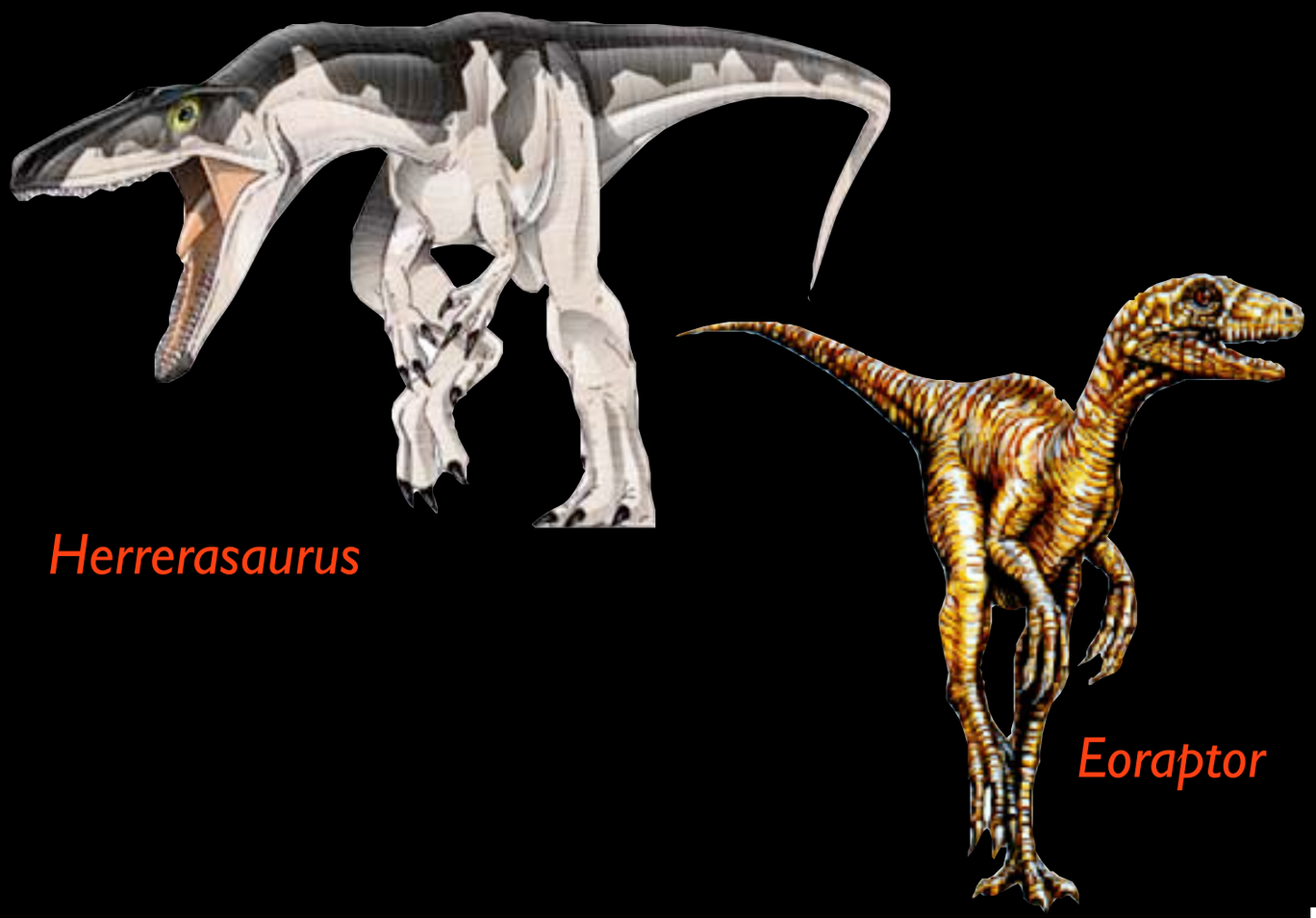


Tyrannosaurus

Ancestral characteristics:
-'Lizard Hip' three-pronged pelvis structure

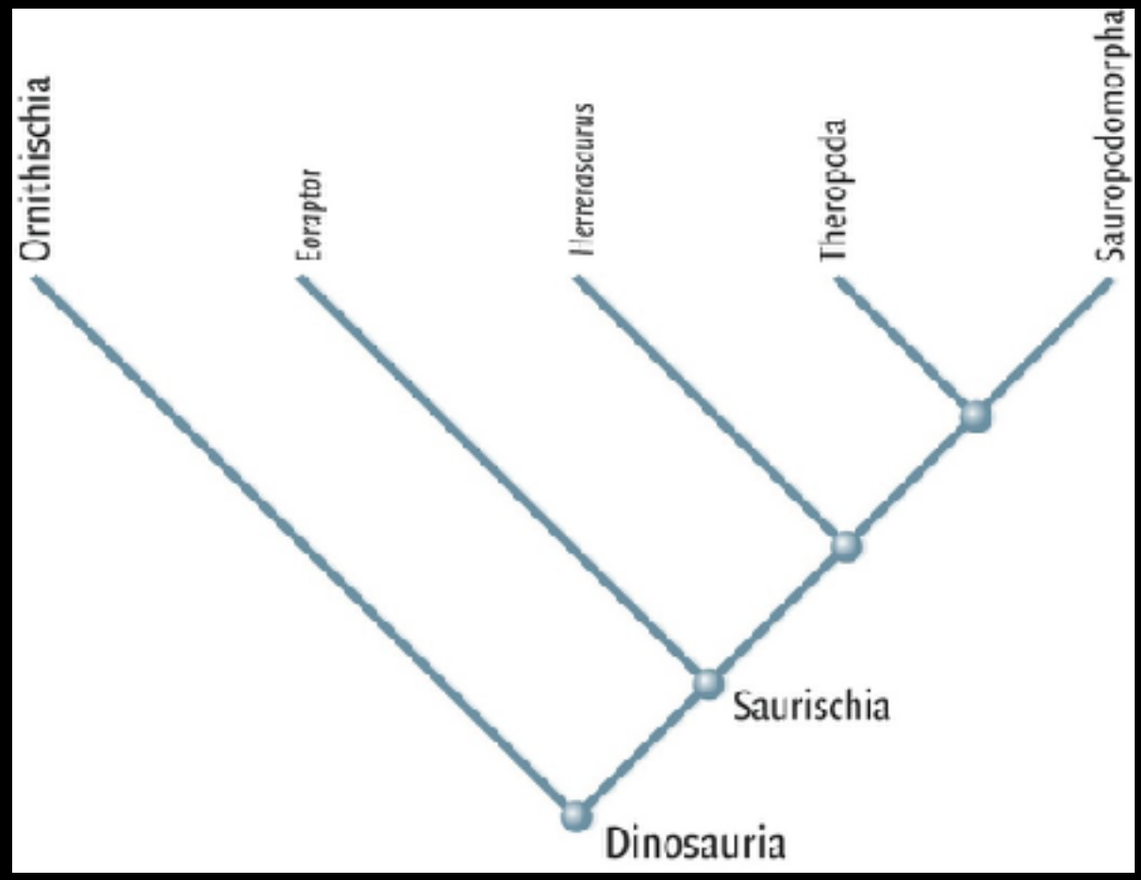


Basal, non-sauropoda Saurischians

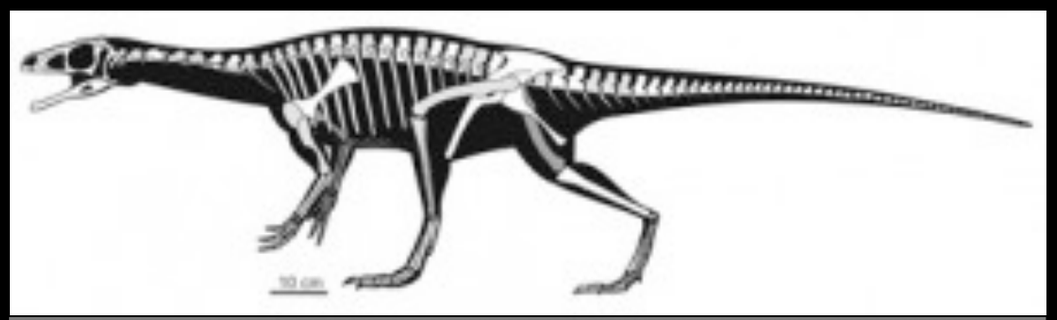


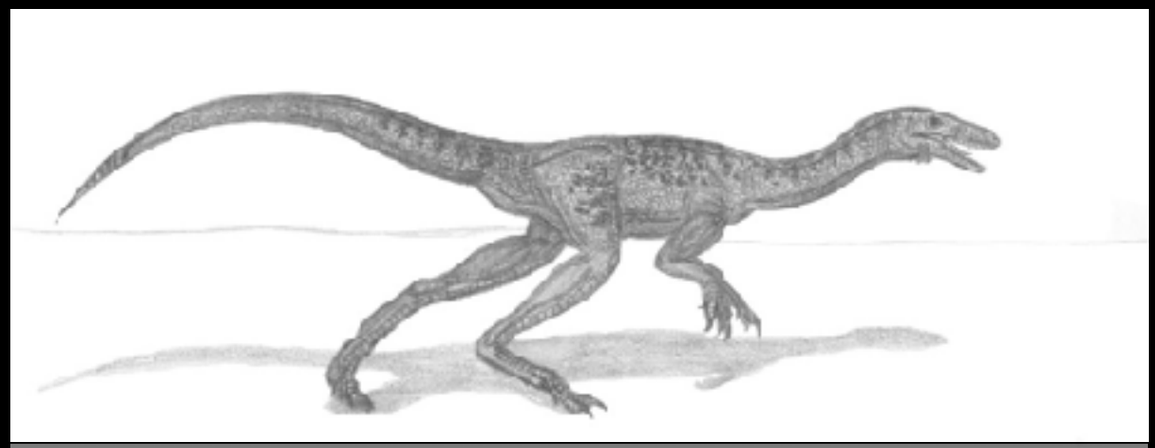
Herrerasaurus

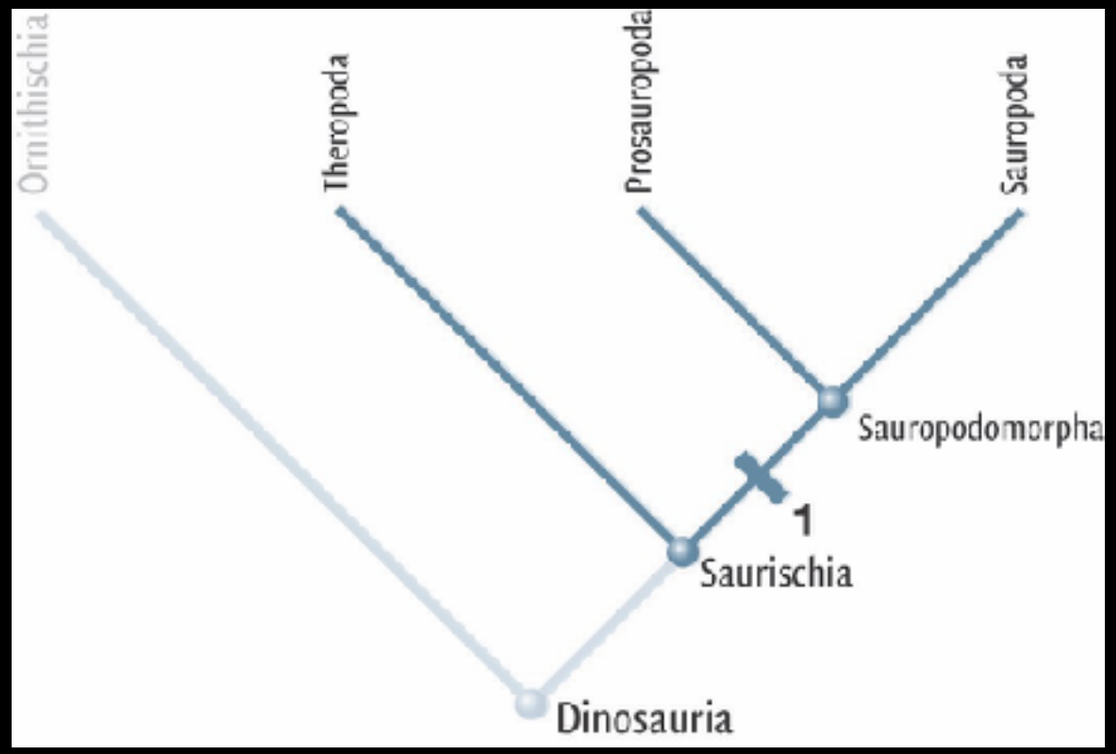
Eoraptor



Possibly a very early sauropodomorpha: *Saturnalia*

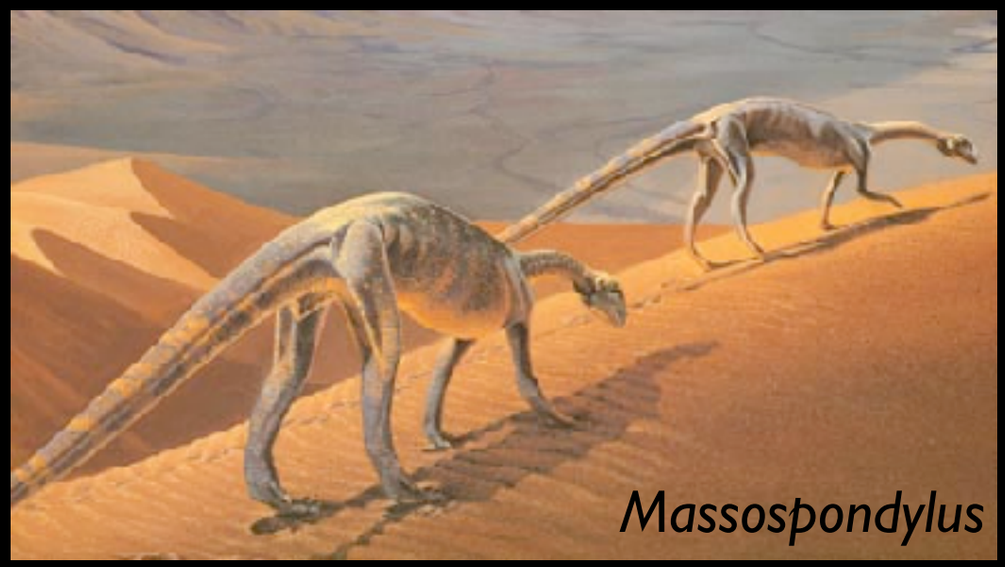




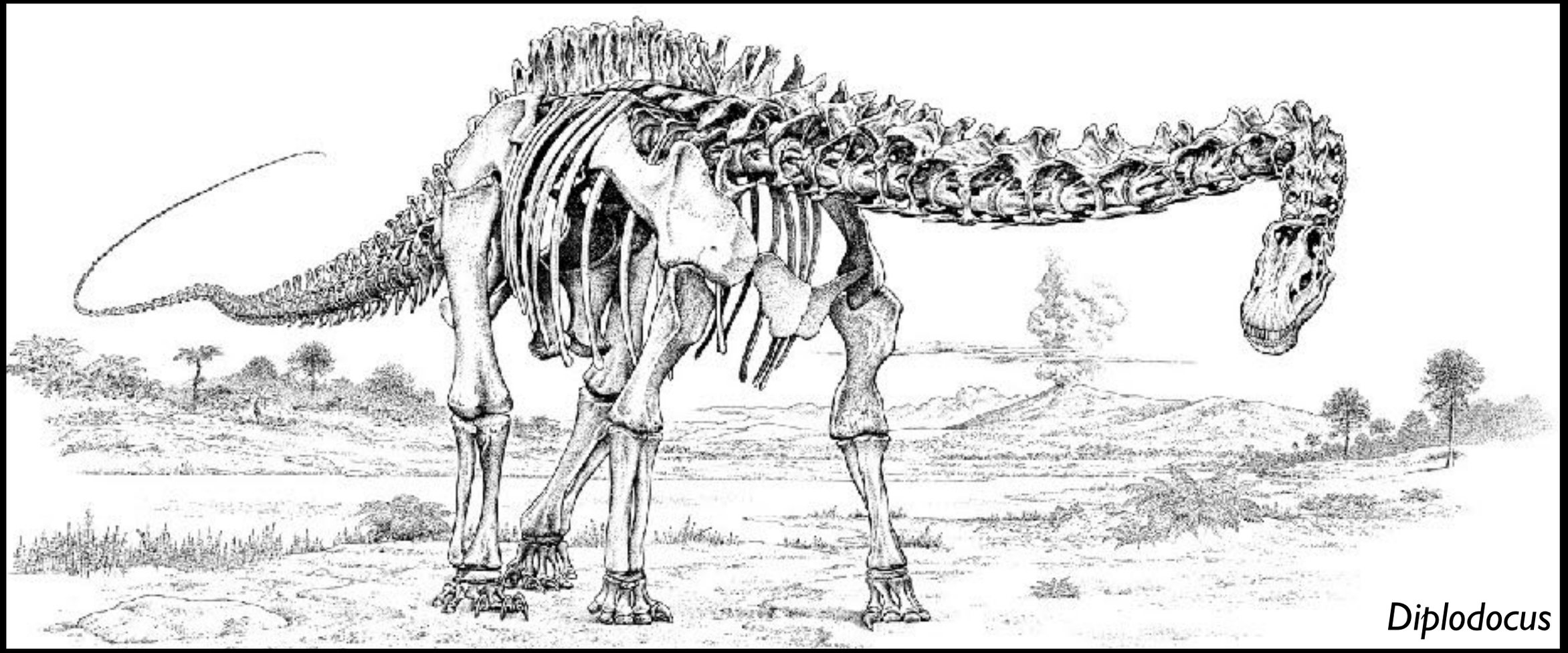


Sauropodomorpha

1. Prosauropoda
2. Sauropoda



Massospondylus



Diplodocus

Sauropodomorpha

Shared, derived characteristics

Relatively small skull

Long neck (10 vertebrae or more!)

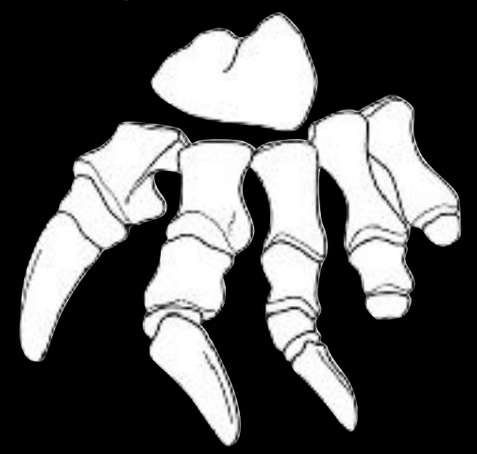
Deflected front end of lower jaw

Elongate, peg-like teeth

Added dorsal vertebrae in front of and behind the sacrum

Enormous thumb

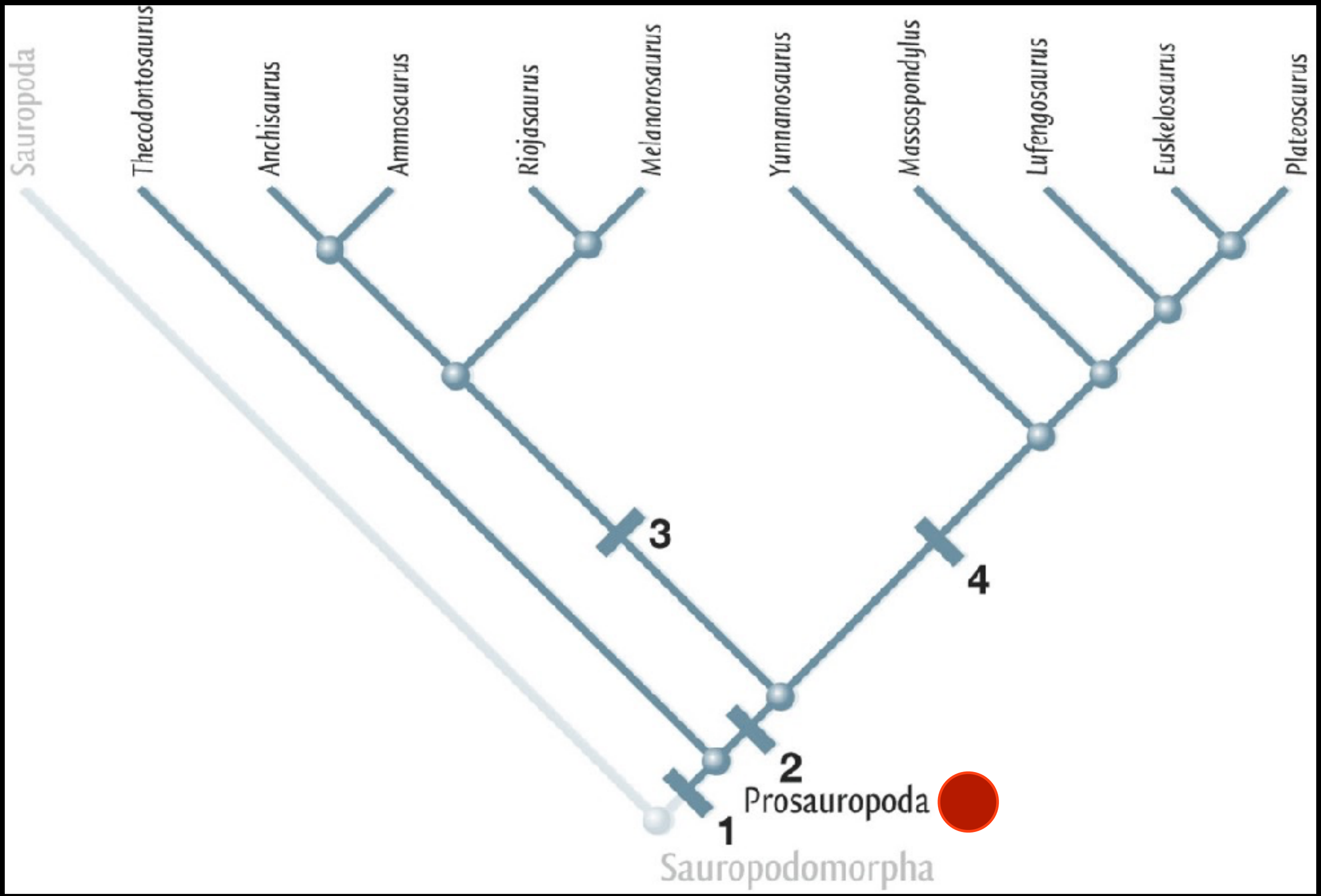
Elongate femur (upper leg bone)



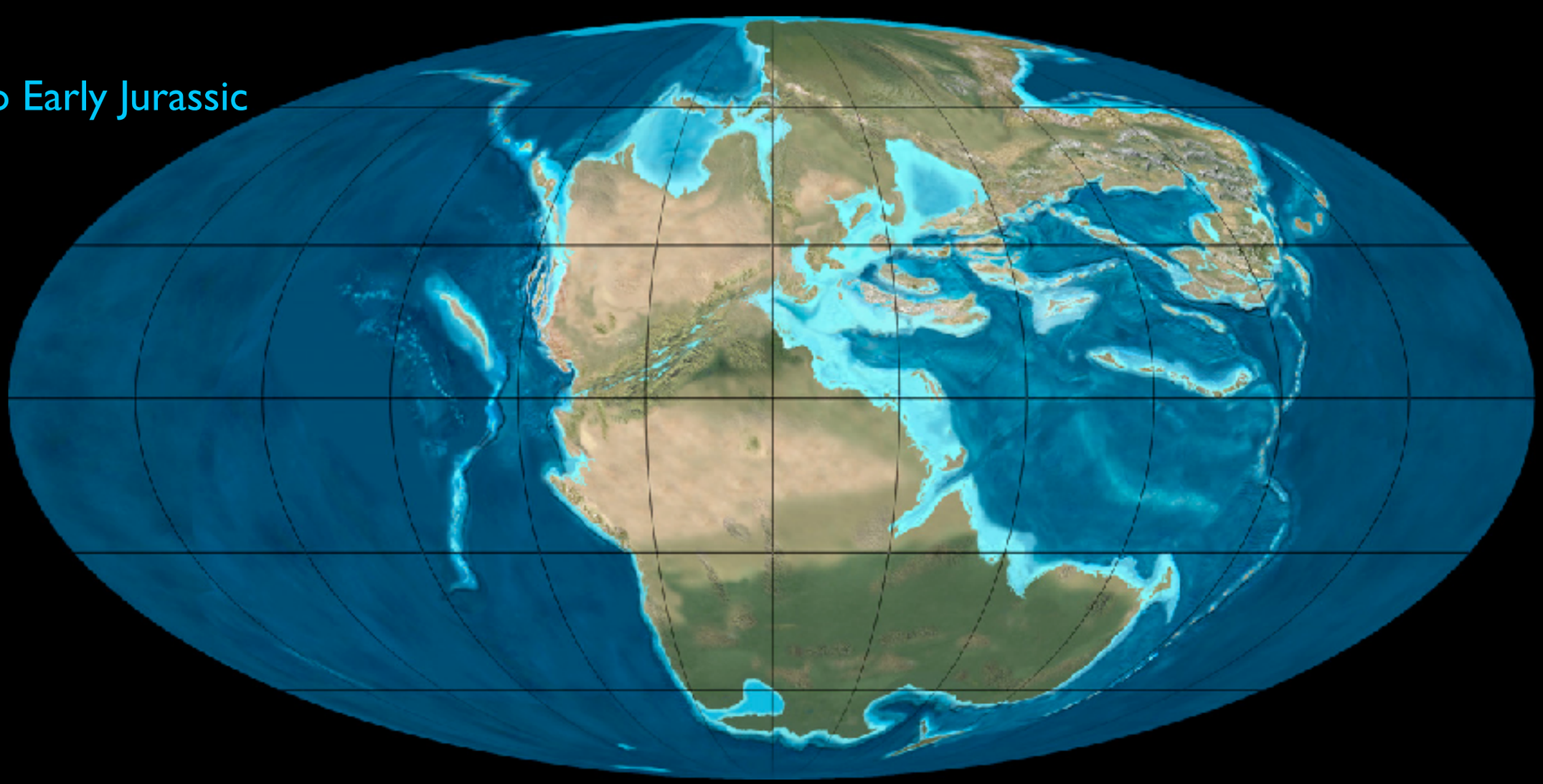
Plateosaurus
(prosauropod)

1 m

Prosauropoda



Prosauropods
Late Triassic to Early Jurassic



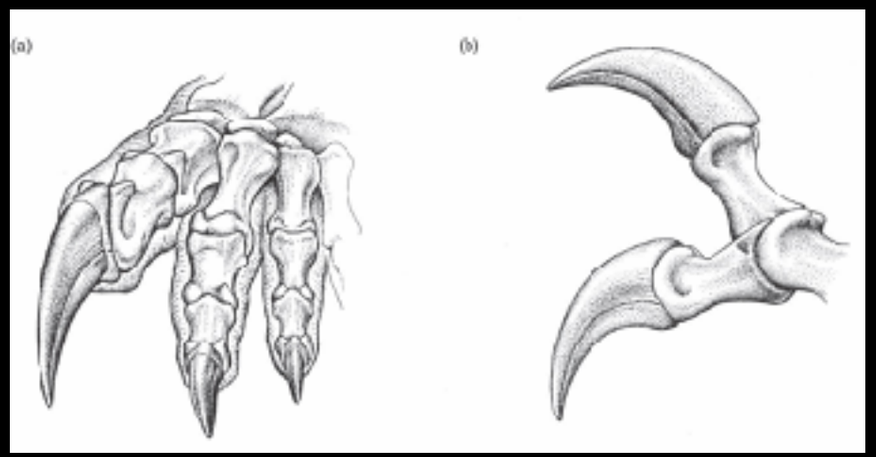
Squares = prosauropod fossil localities

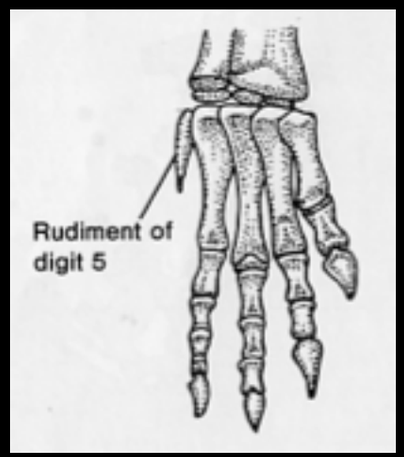
Dinosaur families that diversified early were able to spread around the globe (Pangea effect)

Prosauropoda

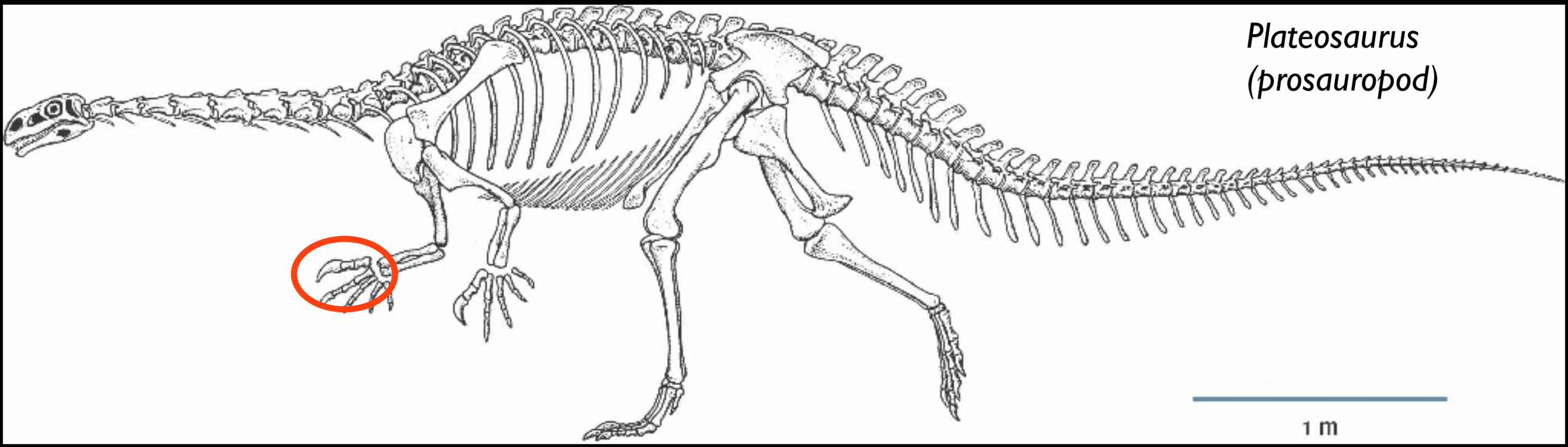
Shared, derived characteristics

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

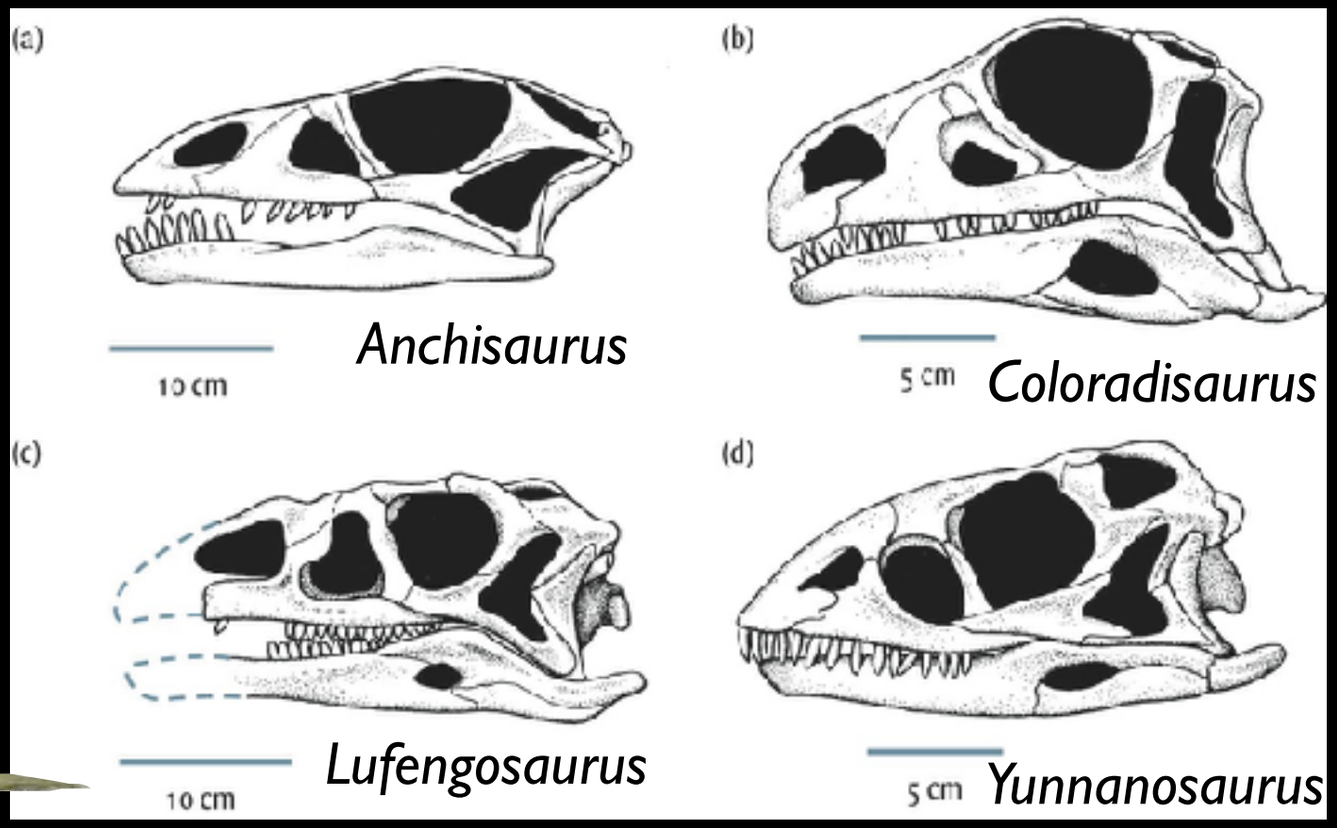


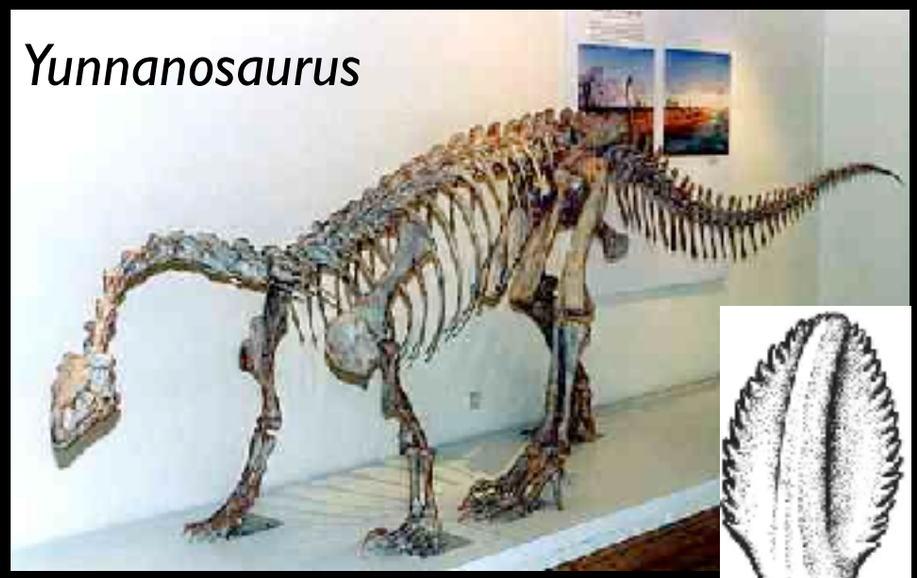


Plateosaurus



Plateosaurus
(prosauropod)





Skull:

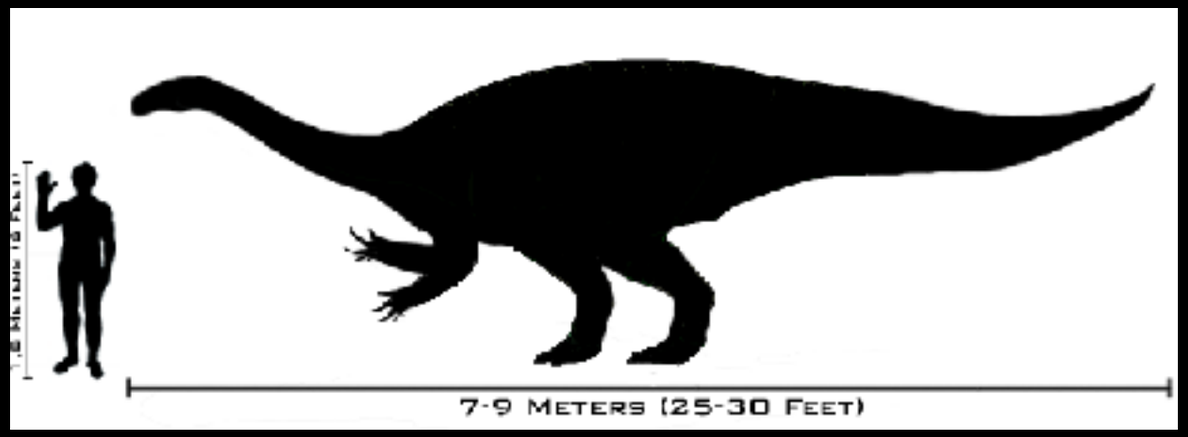
Not meant for chewing
Jaw joint below tooth row
Leaf-shaped teeth (few grinding marks)
NOT CHEWERS
Predominantly herbivorous, but some basal forms may have been omnivorous

Gastroliths, in situ

Gastroliths a-plenty
Likely utilized stomach fermentation
Stomach-contents finds and morphology suggest gymnosperms were likely important
The increase in diversity of prosauropods parallels gymnosperm diversity!

"*Perhaps amid the roar and crash of logging operations, the old forests recall the company of their vanished coevolvers; the rich, warm piny breath and gentle stupid eyes of the sauropods seem so much more elegantly suited to these cathedral woods than the bully-whiskered presence of the woodsman, the screaming violence of his saw.*" -John McLaughlin

Derived Prosauropoda

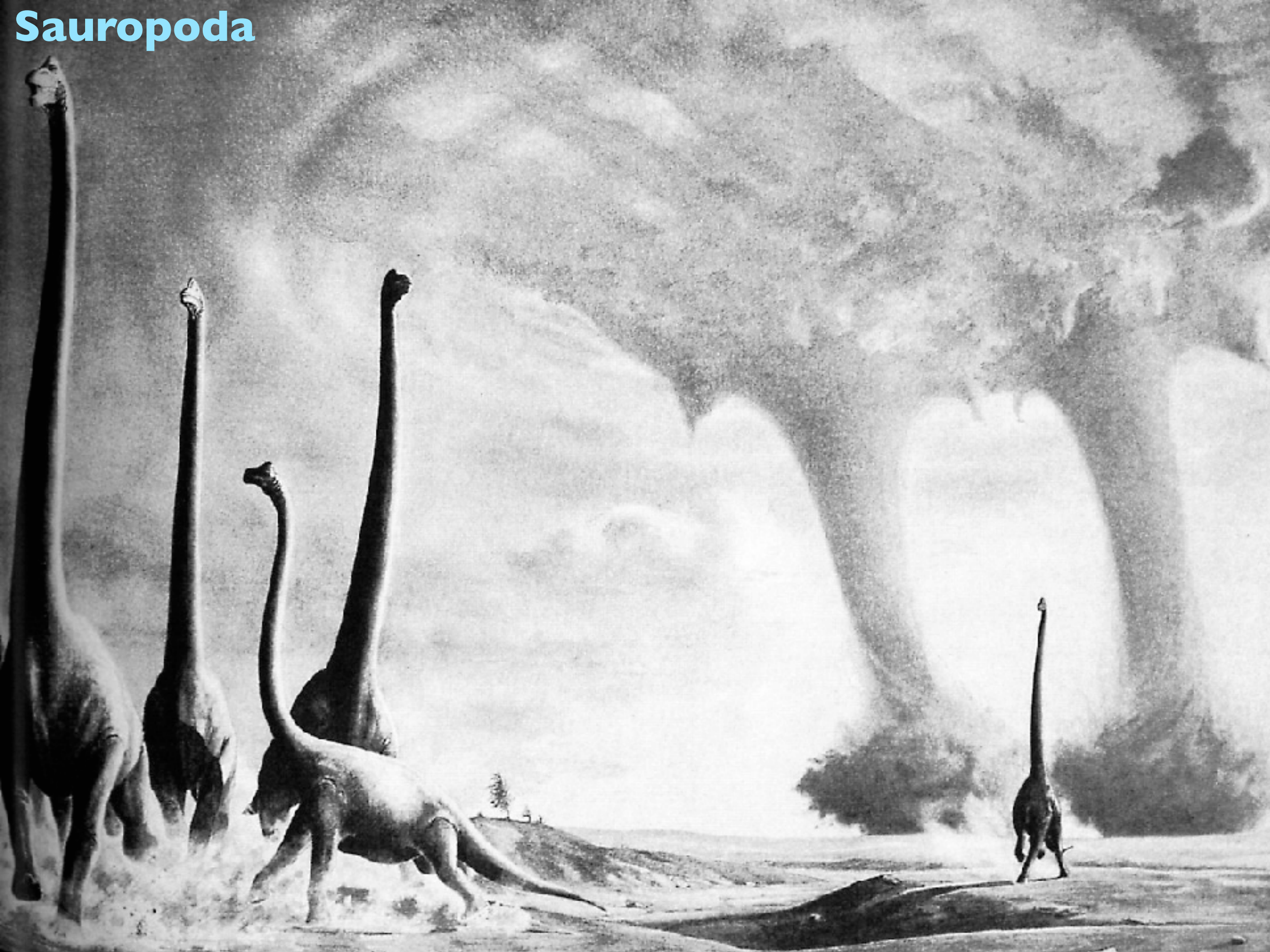


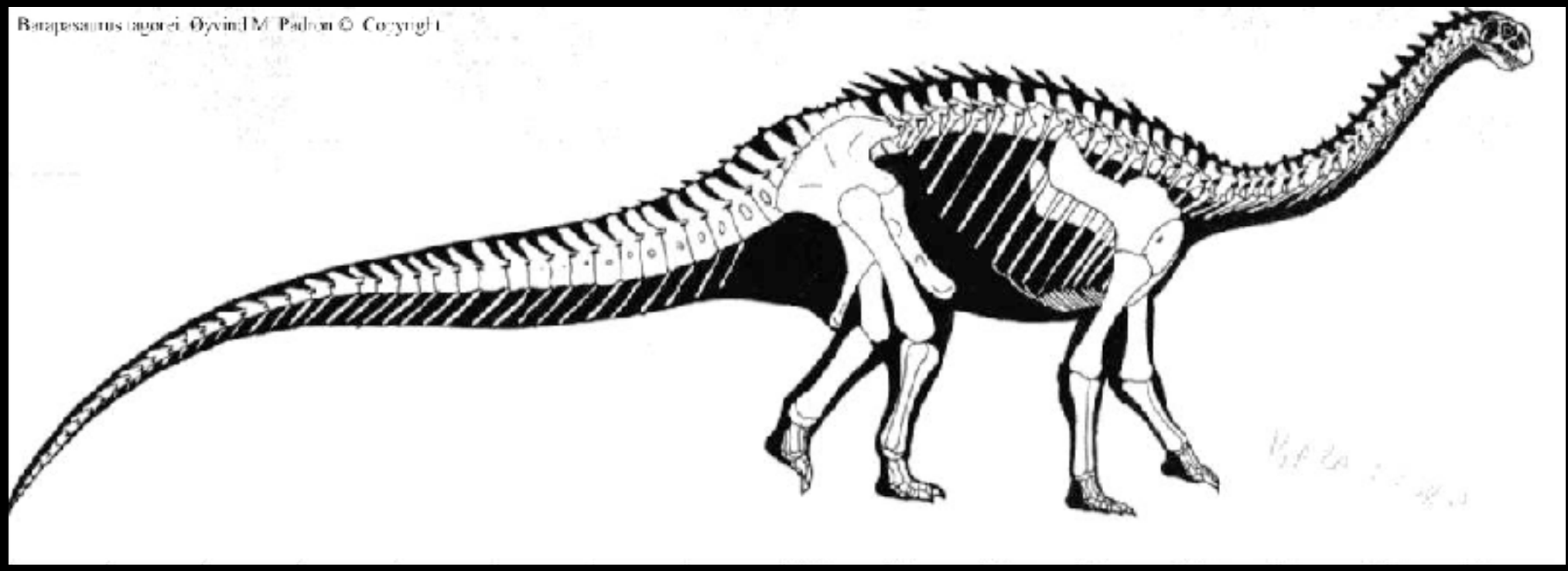
Riojasaurus *Fully quadrupedal*

Plateosaurus *Quadrupedal / Facultative bipedal*

Mussaurus
(late Triassic)
Adults probably 10 ft long

Sauropoda



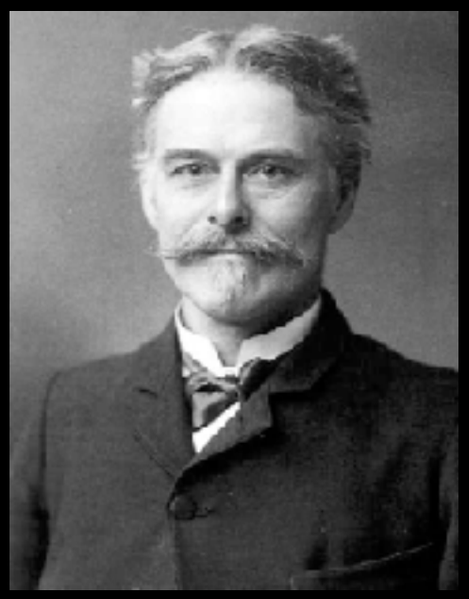


Cetiosaurus- first sauropod discovered

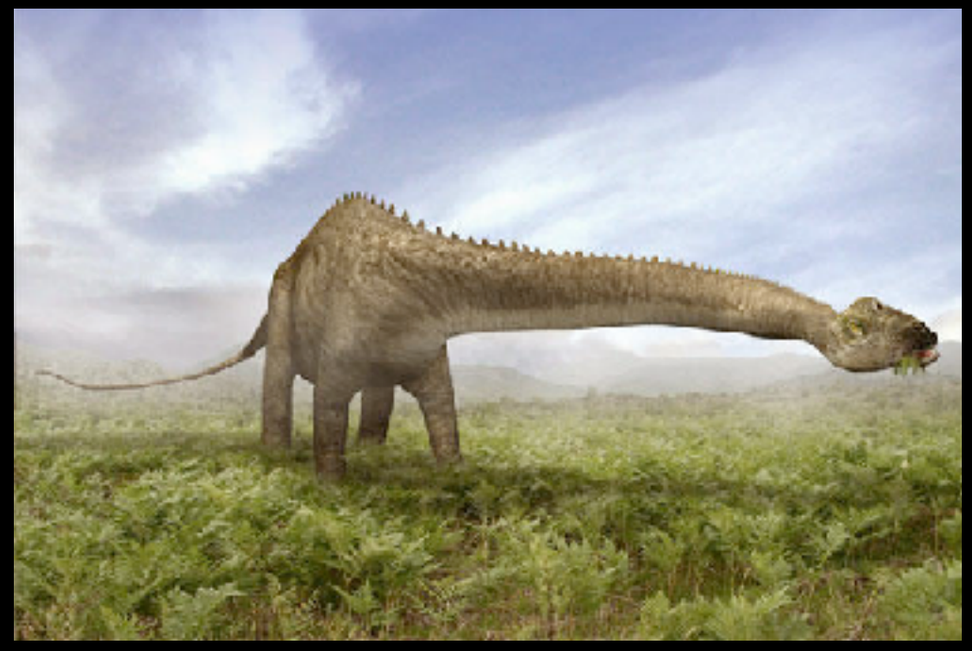
Had spongy bone (similar to whales), hence it's name

Thought to be strictly aquatic & related to crocodiles

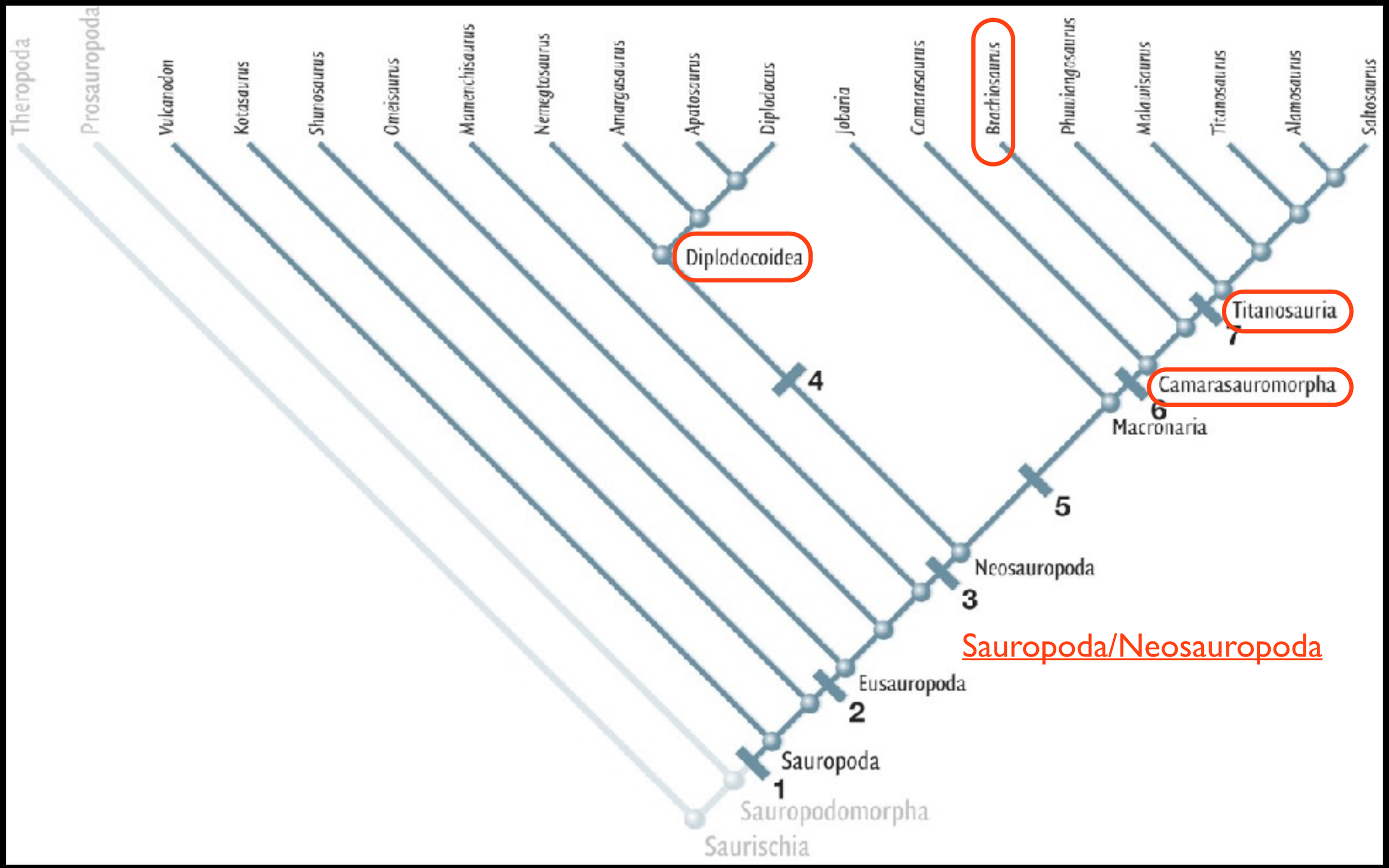
Later, finds of the leg bone suggested an upright stance, rather than a crocodilian sprawling posture



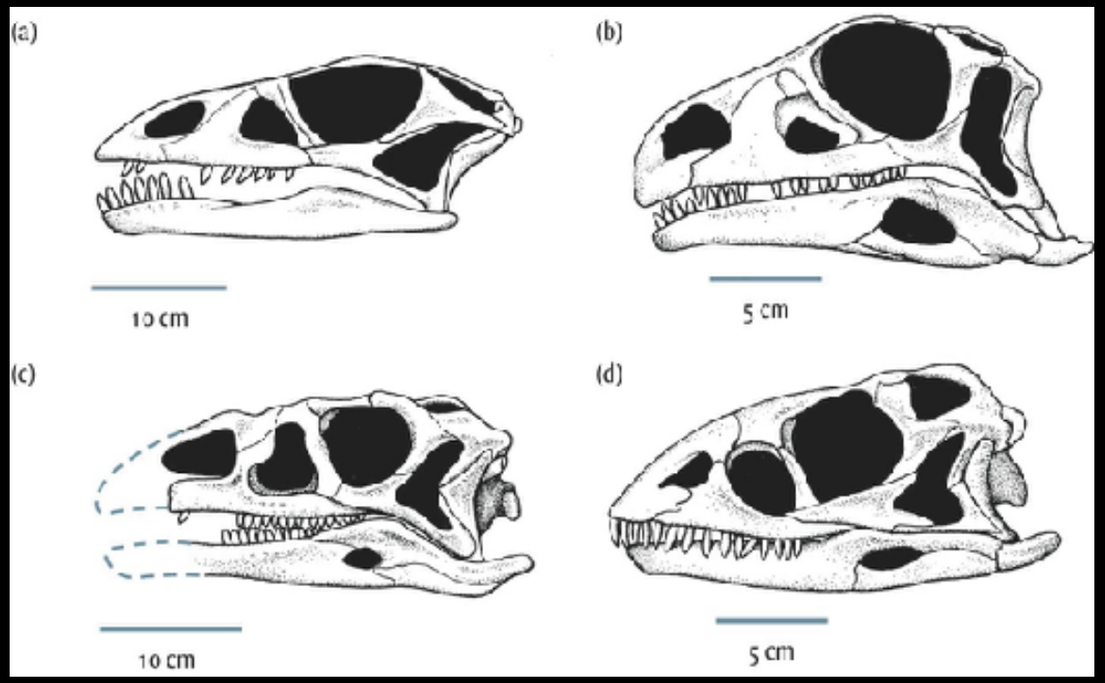
Edward Drinker Cope



Sauropoda



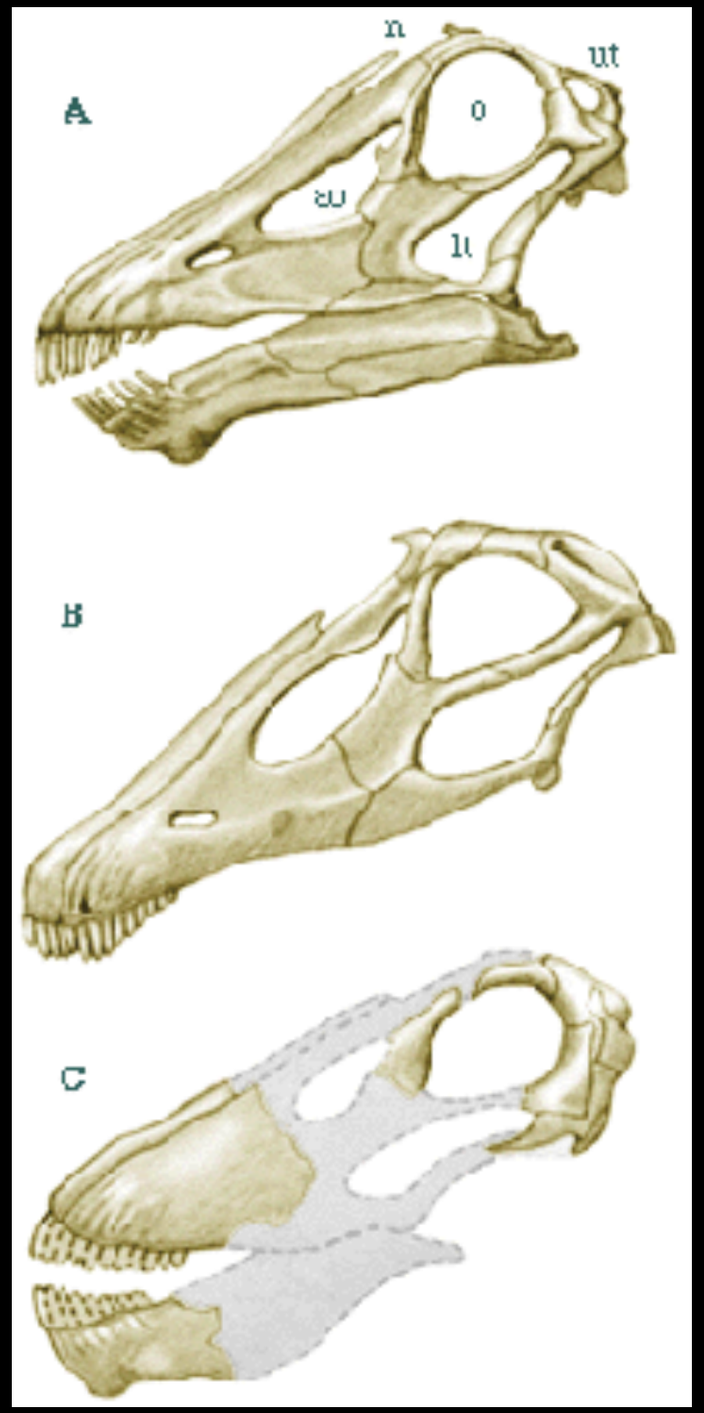
Sauropoda/Neosauropoda



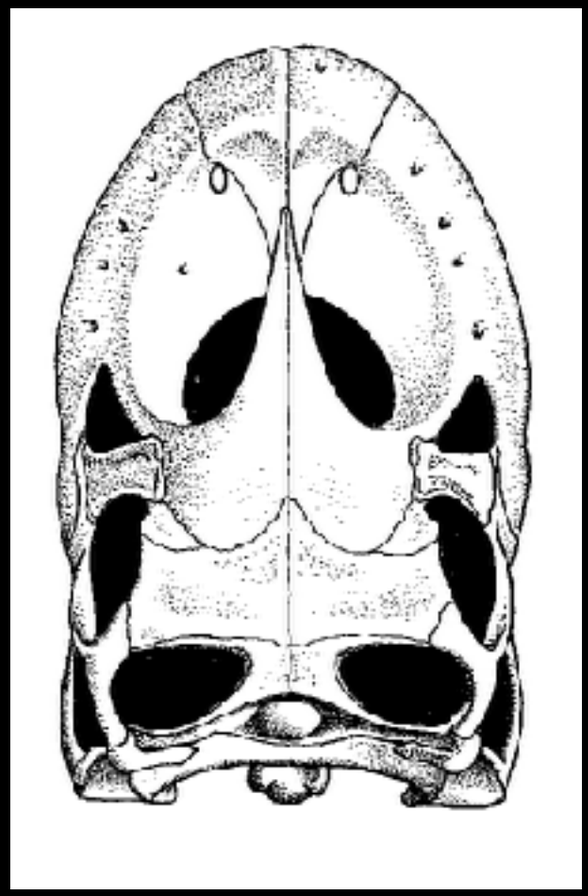
Prosauropods

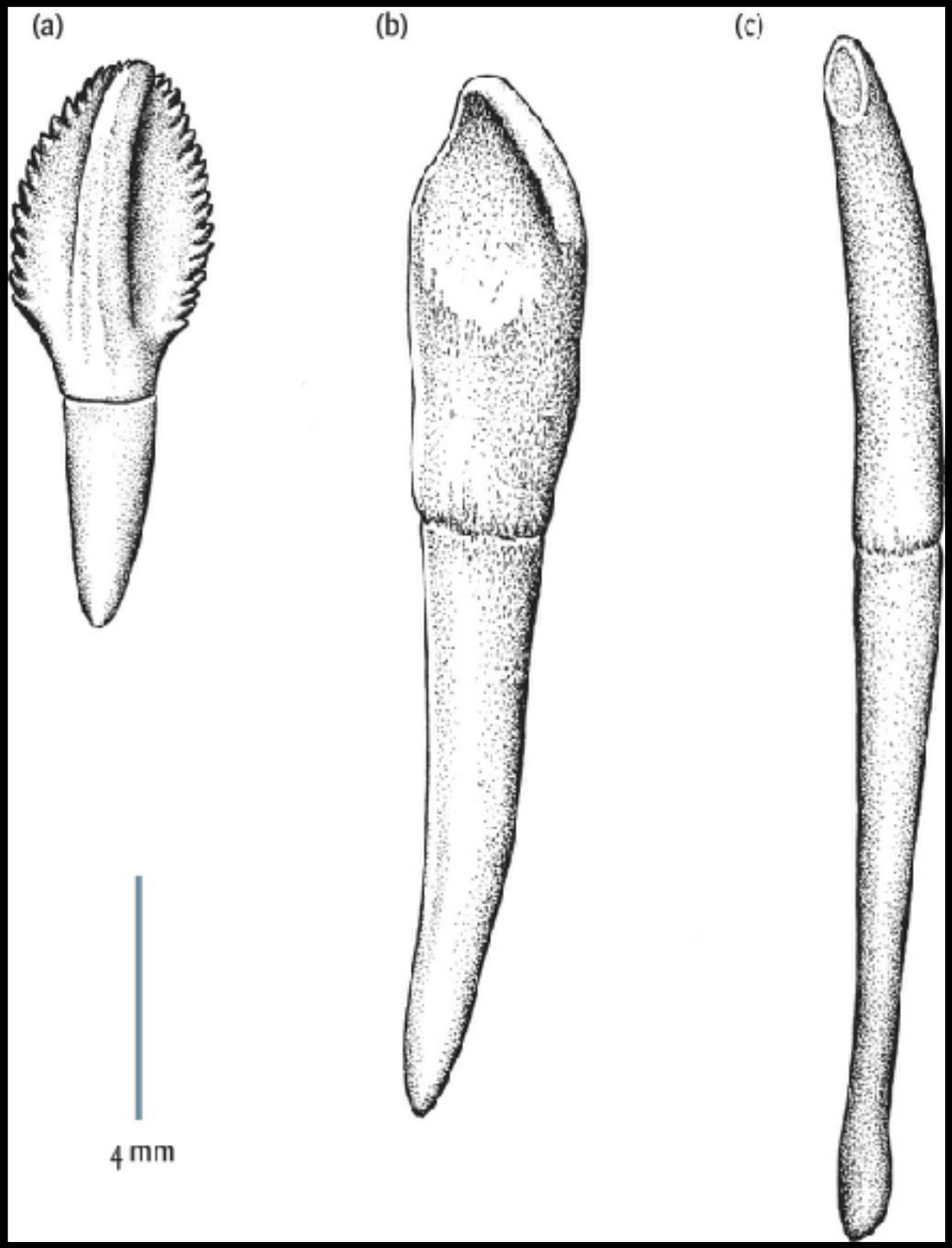
Sauropod Skulls

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



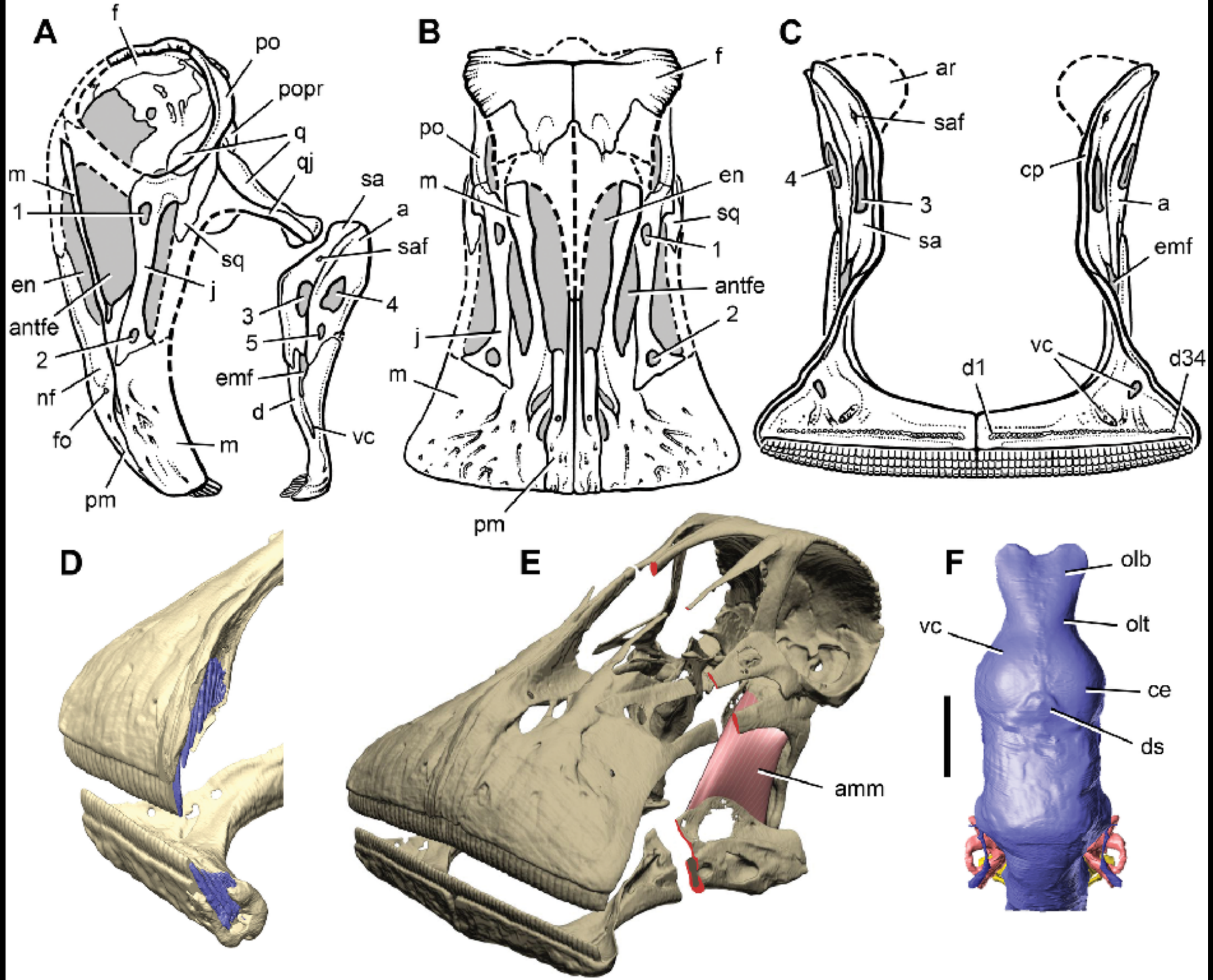
Sauropods





Triangulate, spatulate, or pencil-like teeth
In some clades, teeth are limited

Nigersaurus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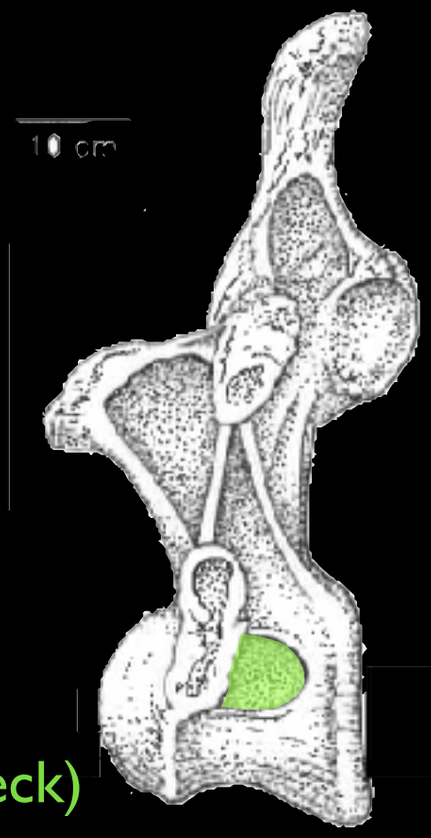
Sauropoda-Neosauropoda



Pleurocoels
(particularly in neck)

12+ cervical vertebrae

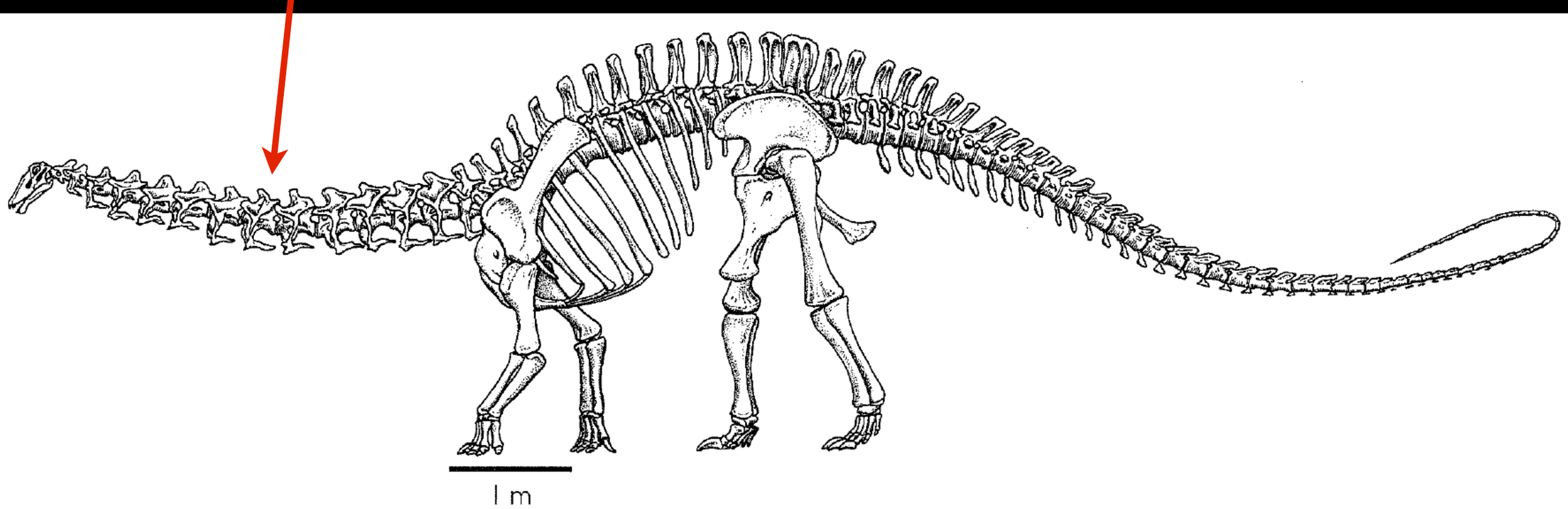
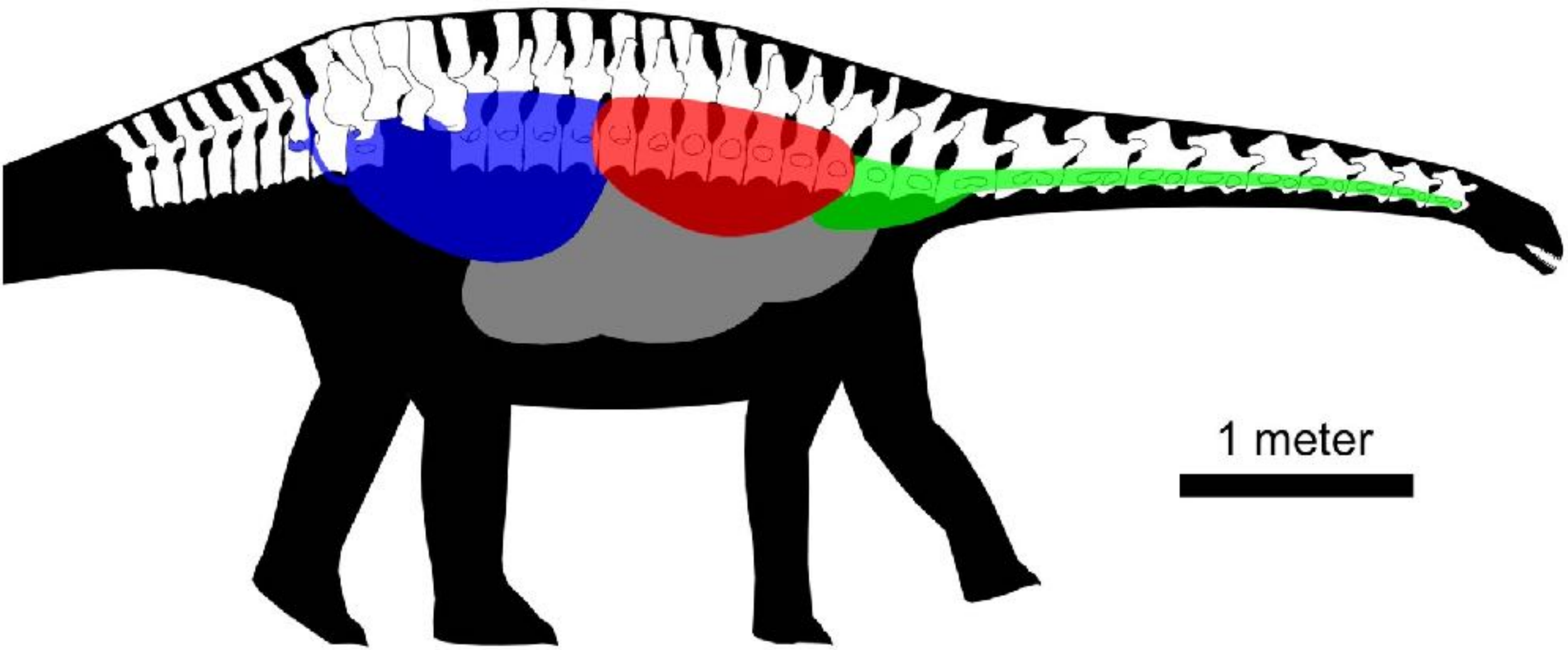


Figure 11.5. Left lateral view of the skull and skeleton of *Apatosaurus*.



Uni-Directional Breathing

Air flows in one direction

Pumped by auxiliary air sacs

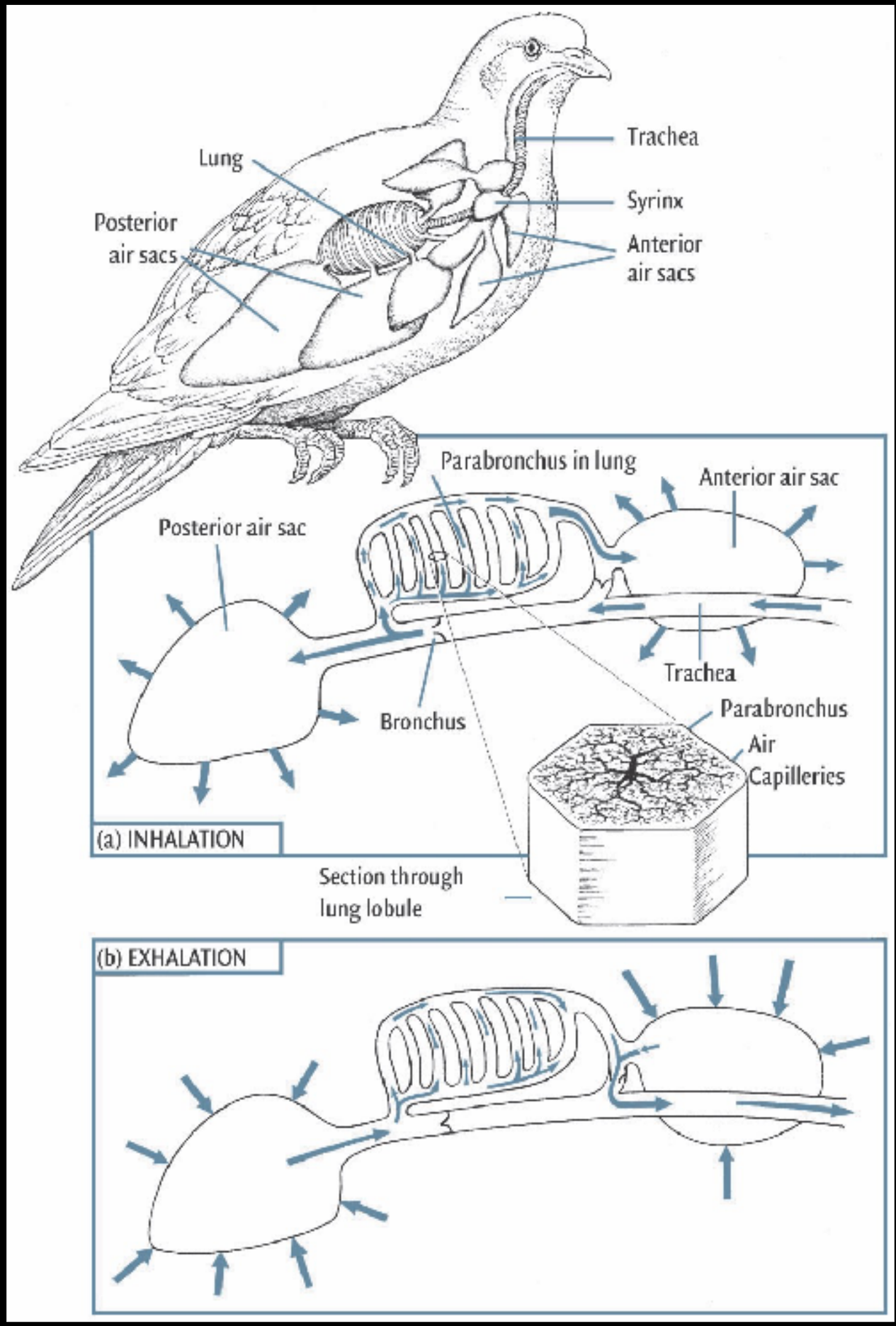
More O2 can be extracted

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

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

Uni-Directional Breathing

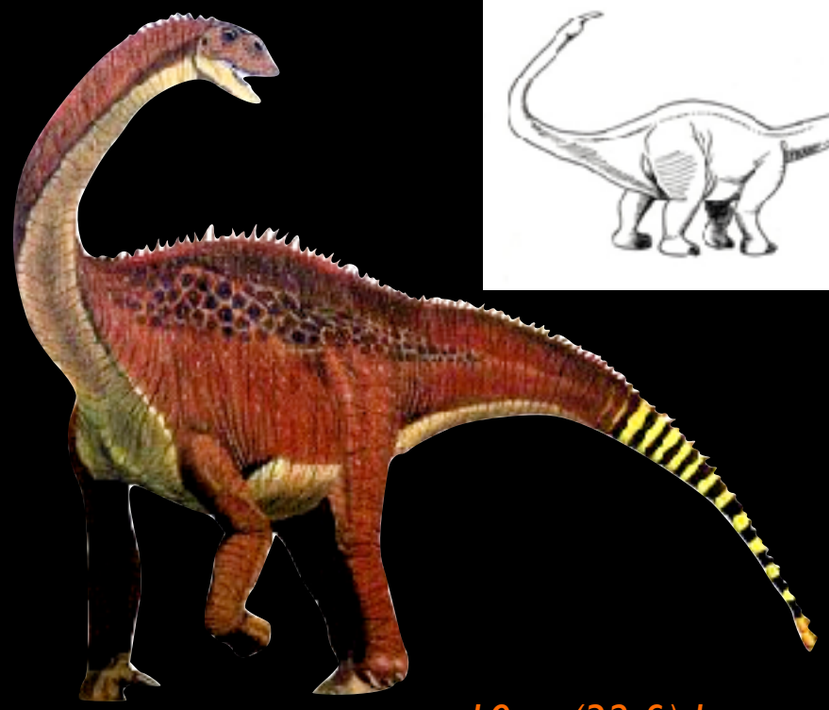
compared to bi-directional breathing
(Mammals, lizards, snakes, crocodiles)



Basal Sauropods

Vulcanodon
Early Jurassic

6.5 m (20 ft) long



Shunosaurus
Middle Jurassic

10 m (32 ft) long
Club Tail

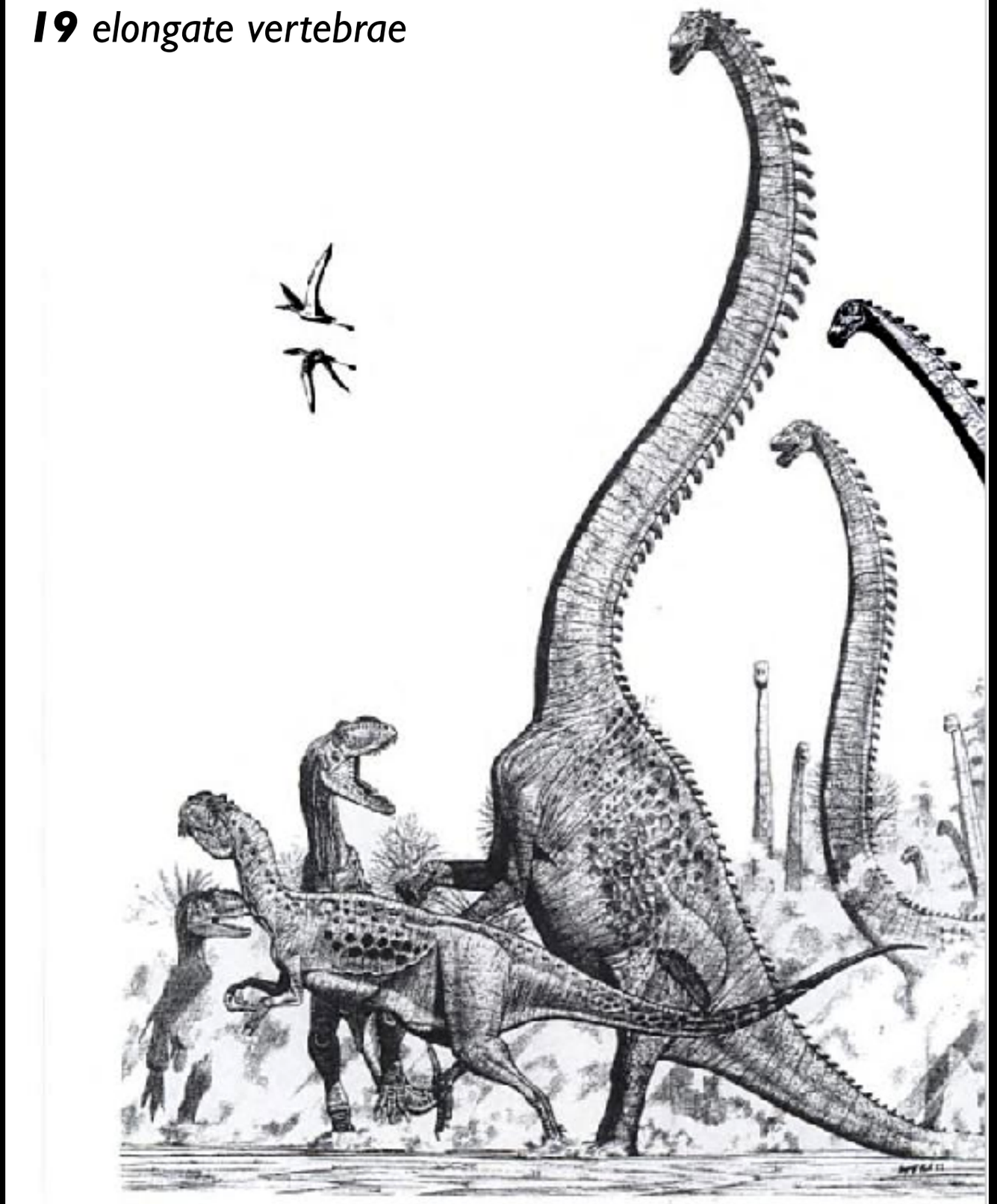
Omeisaurus
Late Jurassic

15.2 m (50 ft) long
4 m (12 ft) high

Omeisaurus in Hong Kong; 17 cervical vertebrae

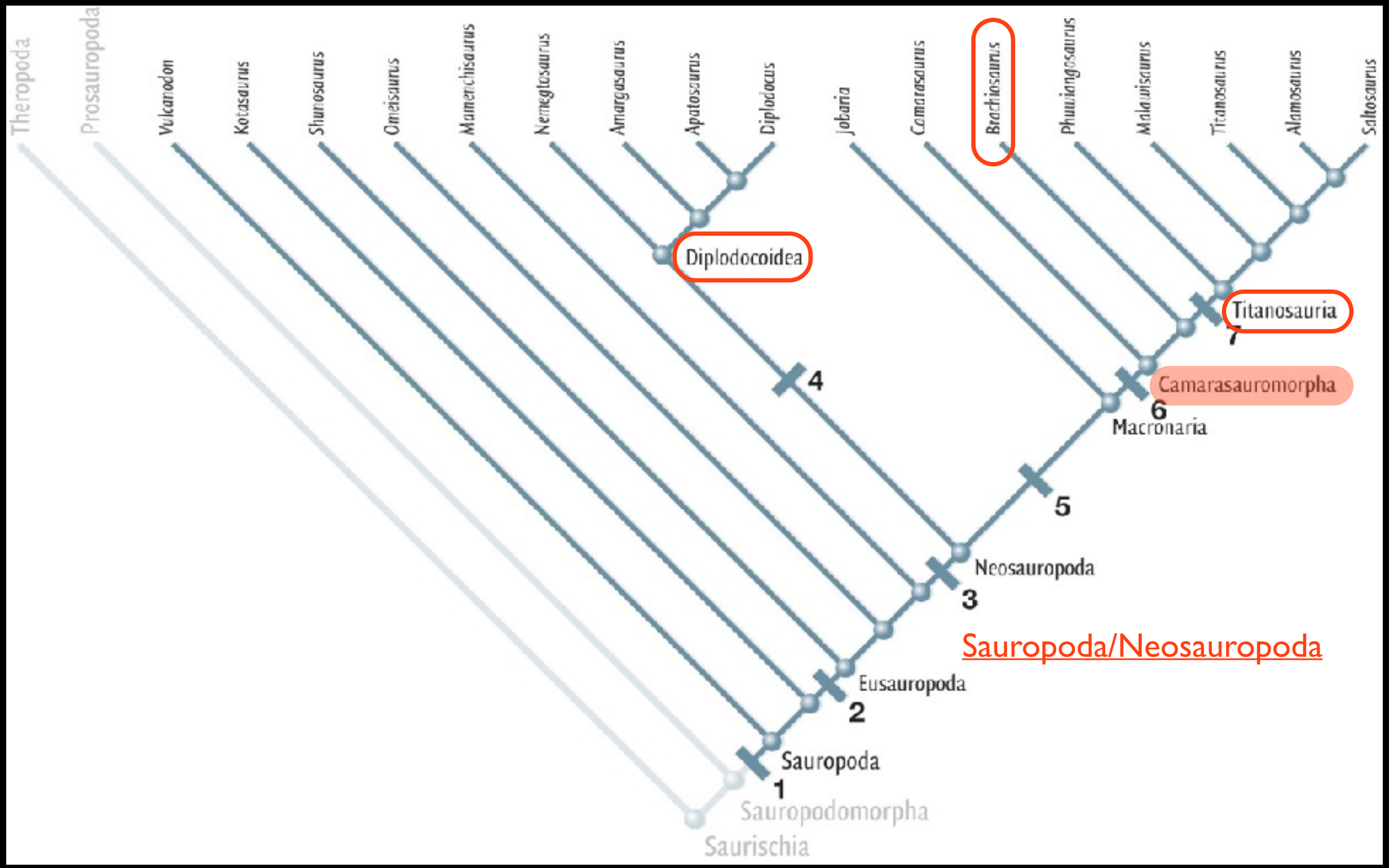
Omeisaurus
Late Jurassic

19 *elongate vertebrae*



Mamenchisaurus
Late Jurassic

Camarasauromorpha

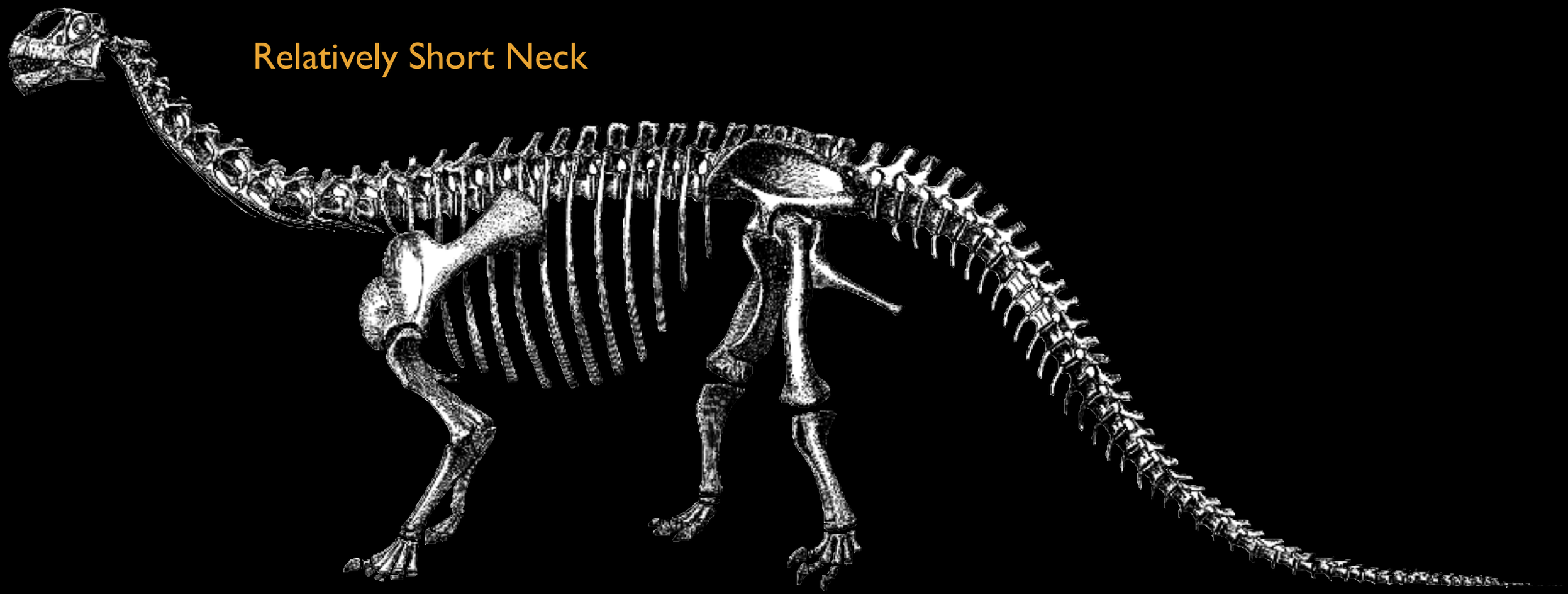


Sauropoda/Neosauropoda

Camarasauromorpha

Large Nares

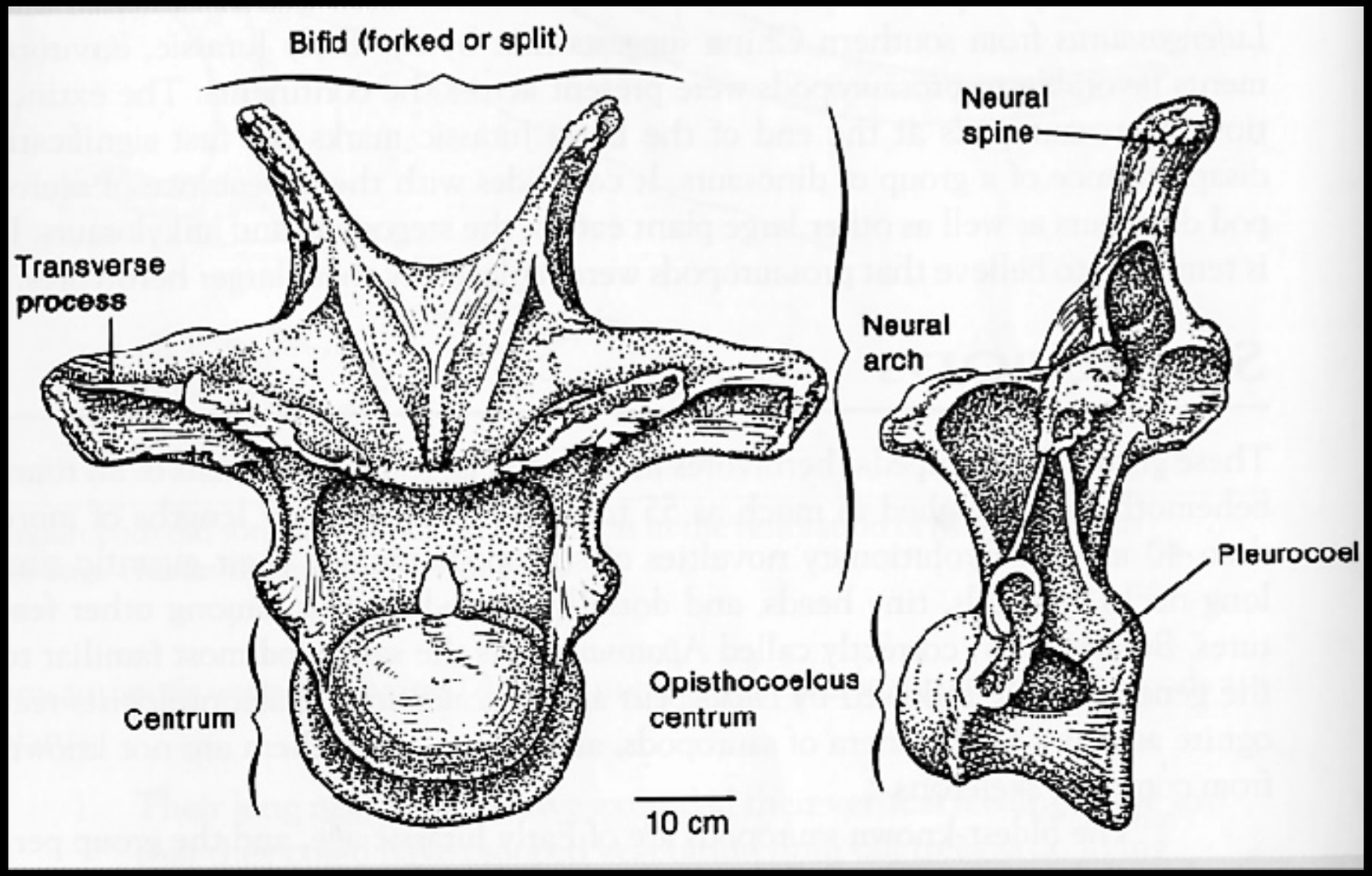
Relatively Short Neck

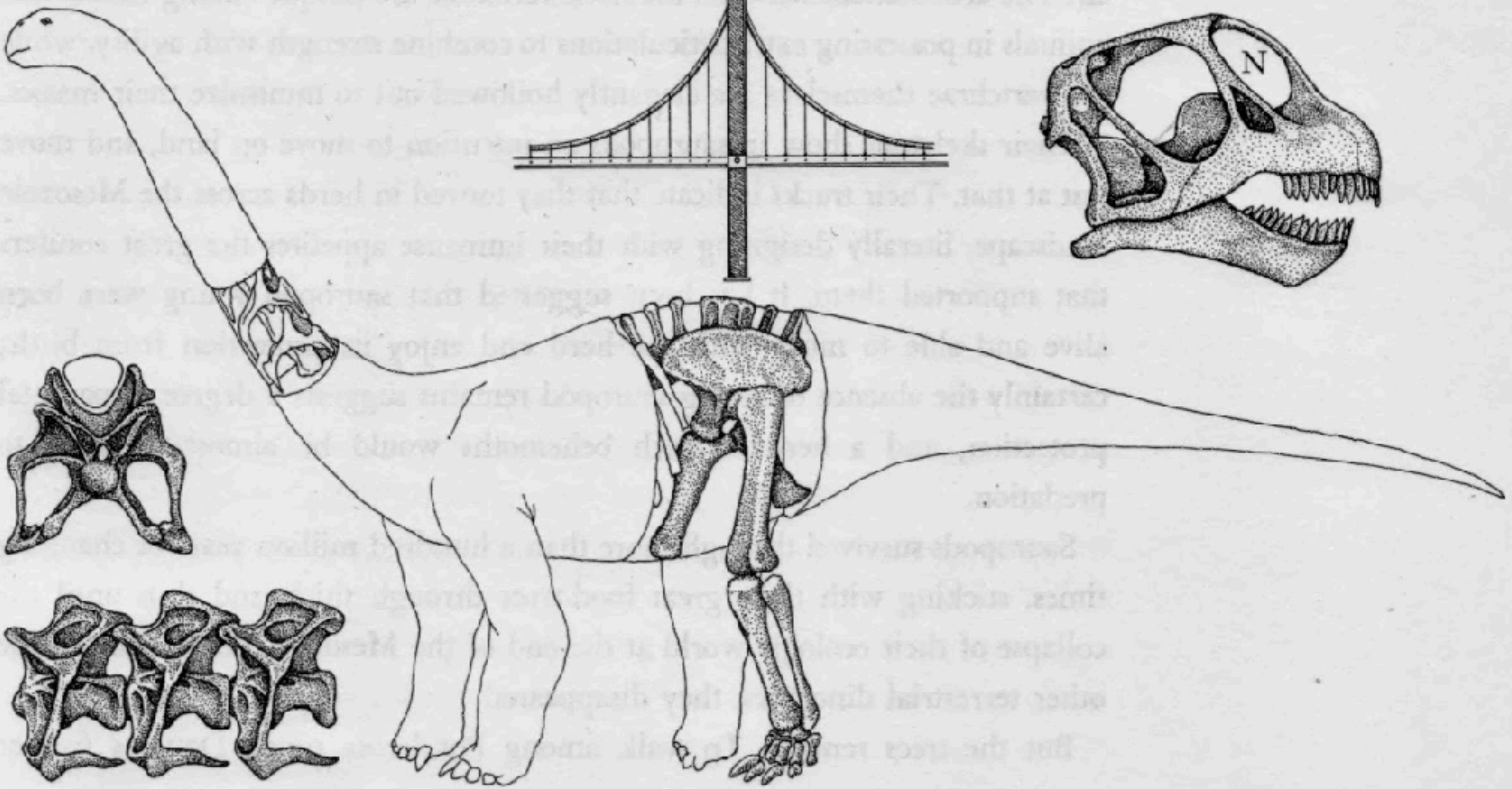


Relatively long forelimbs

Camarasauromorpha

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

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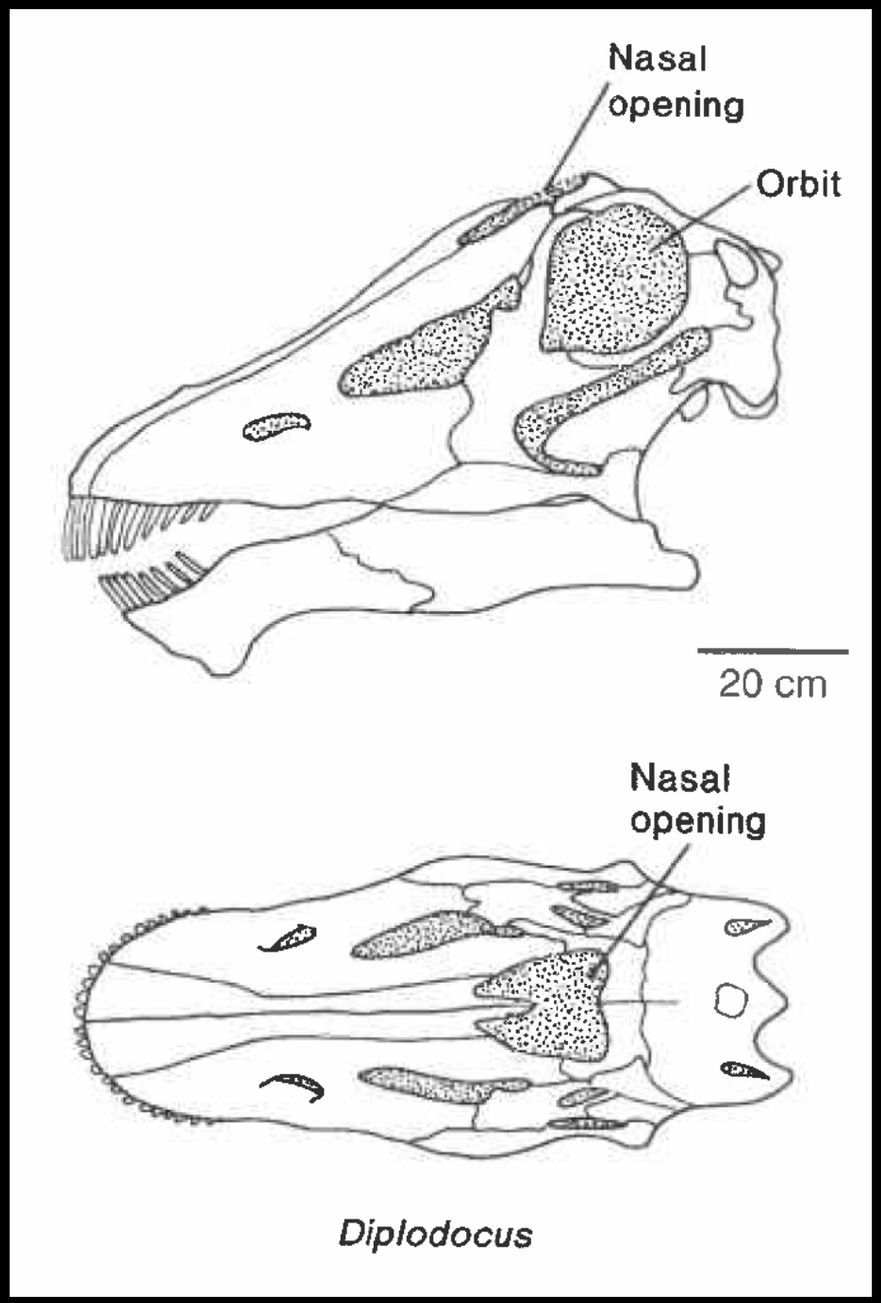
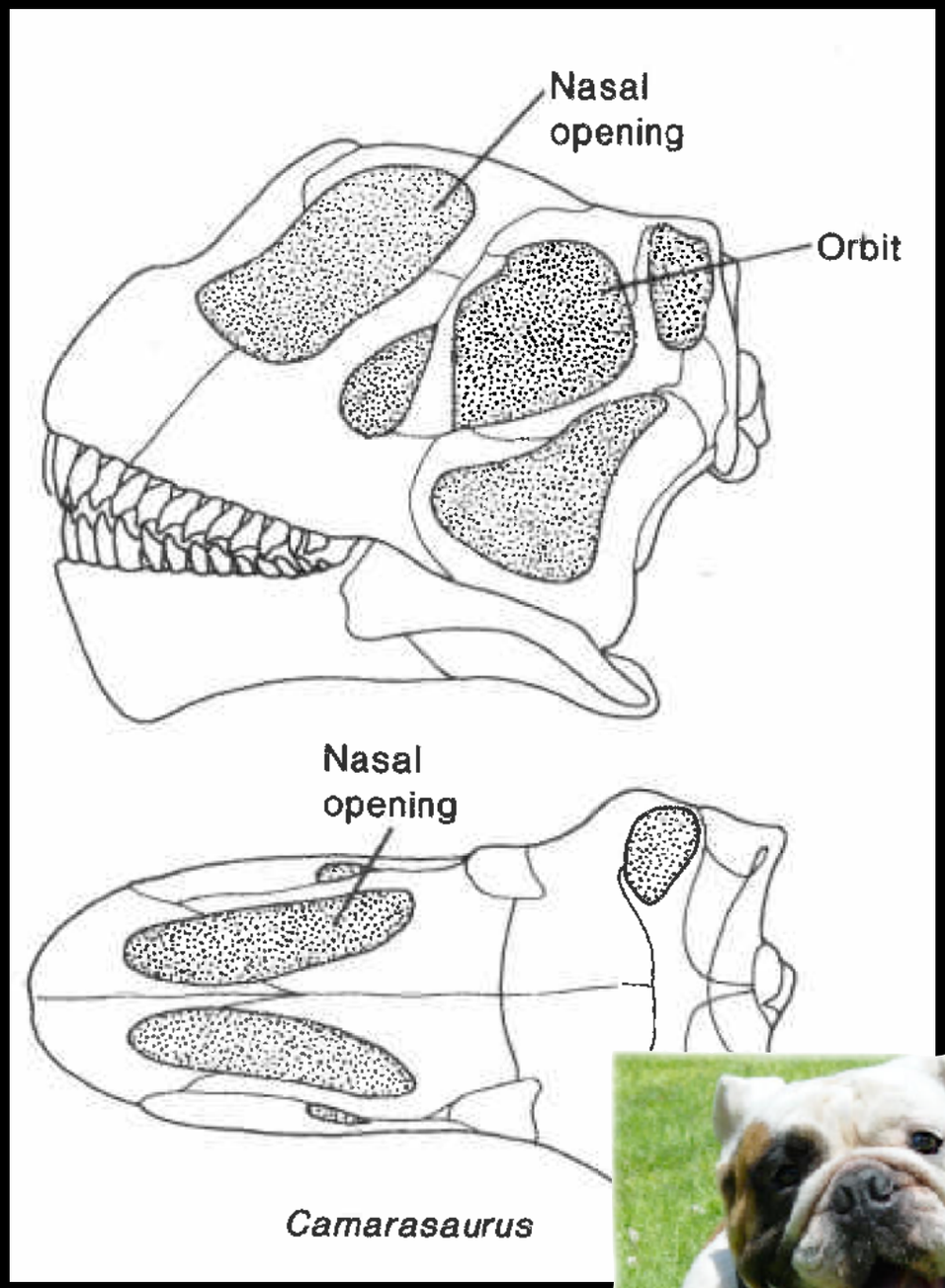
Camarasauromorpha

(not a camarasaur)

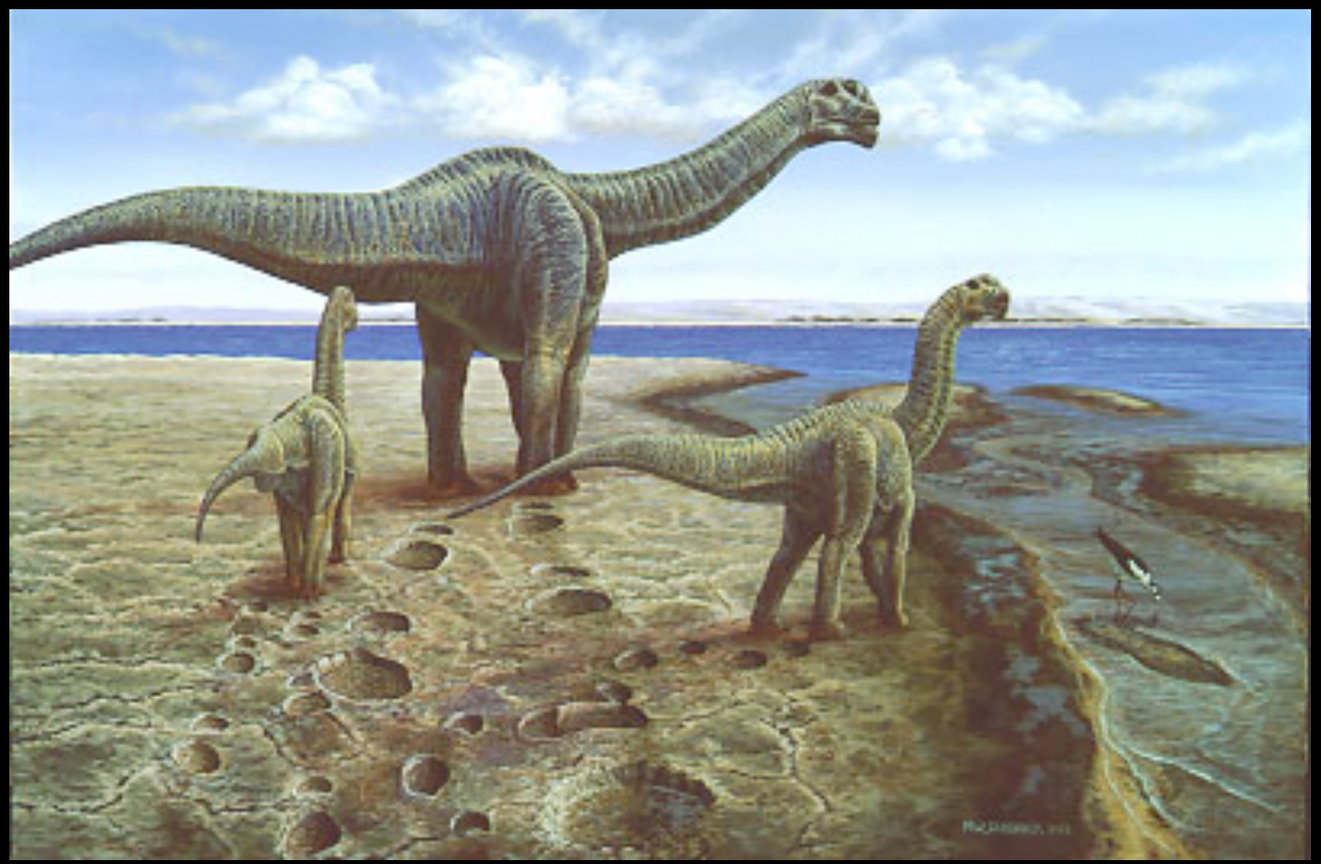


(camarasaur)



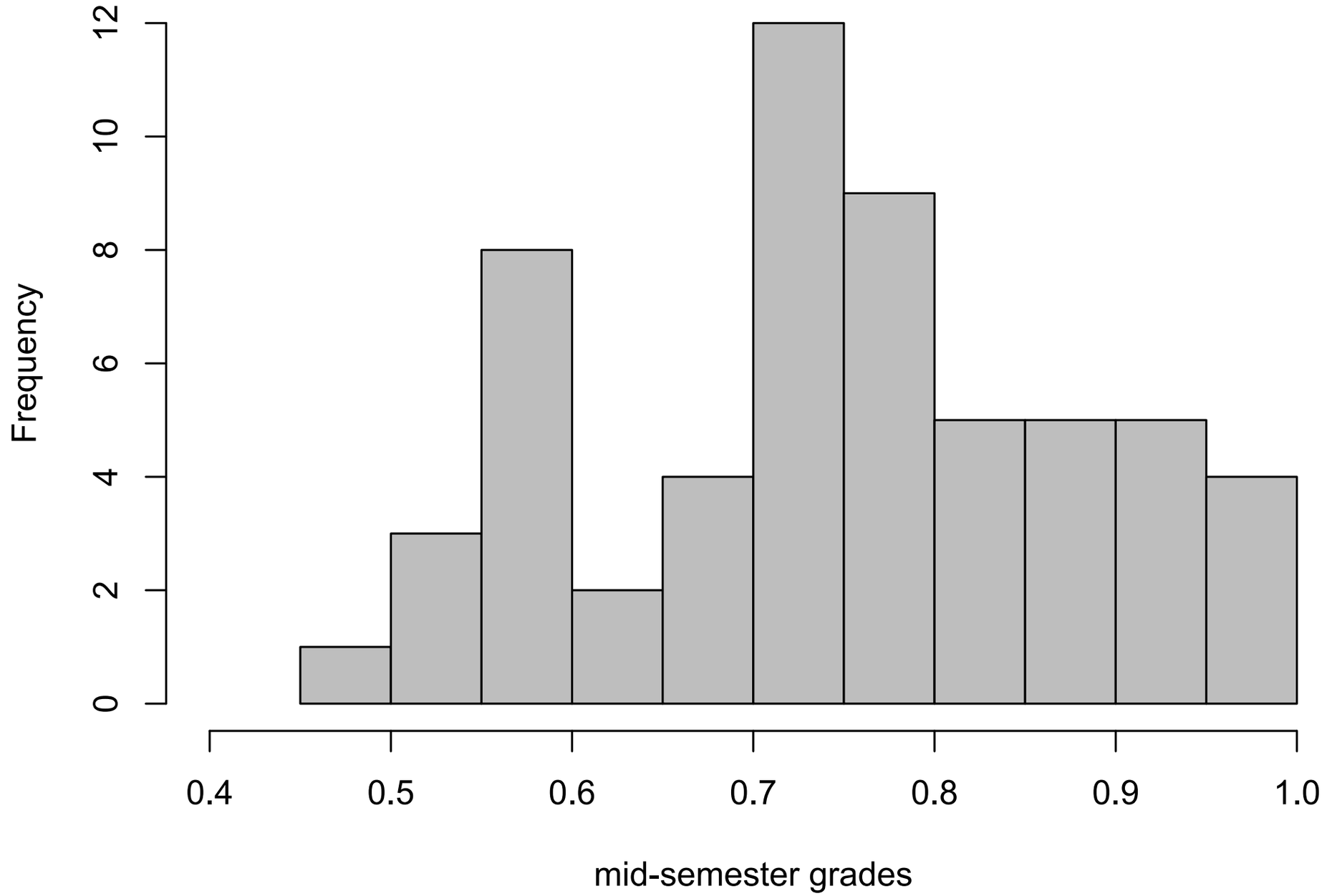
Shorter snout
Enlarged external nares

Camarasauromorpha

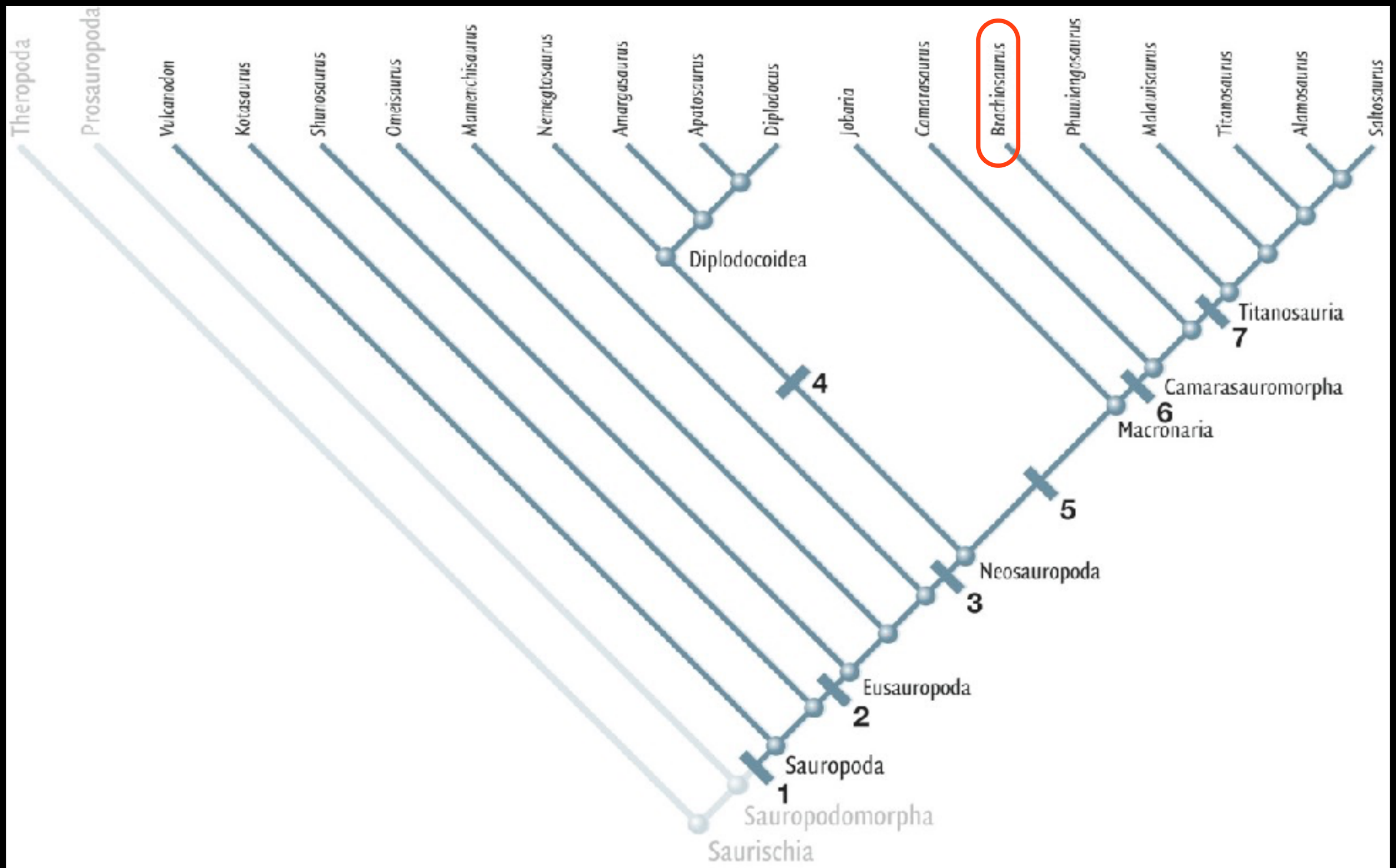


Camarasaurus

18 m (60 ft) long



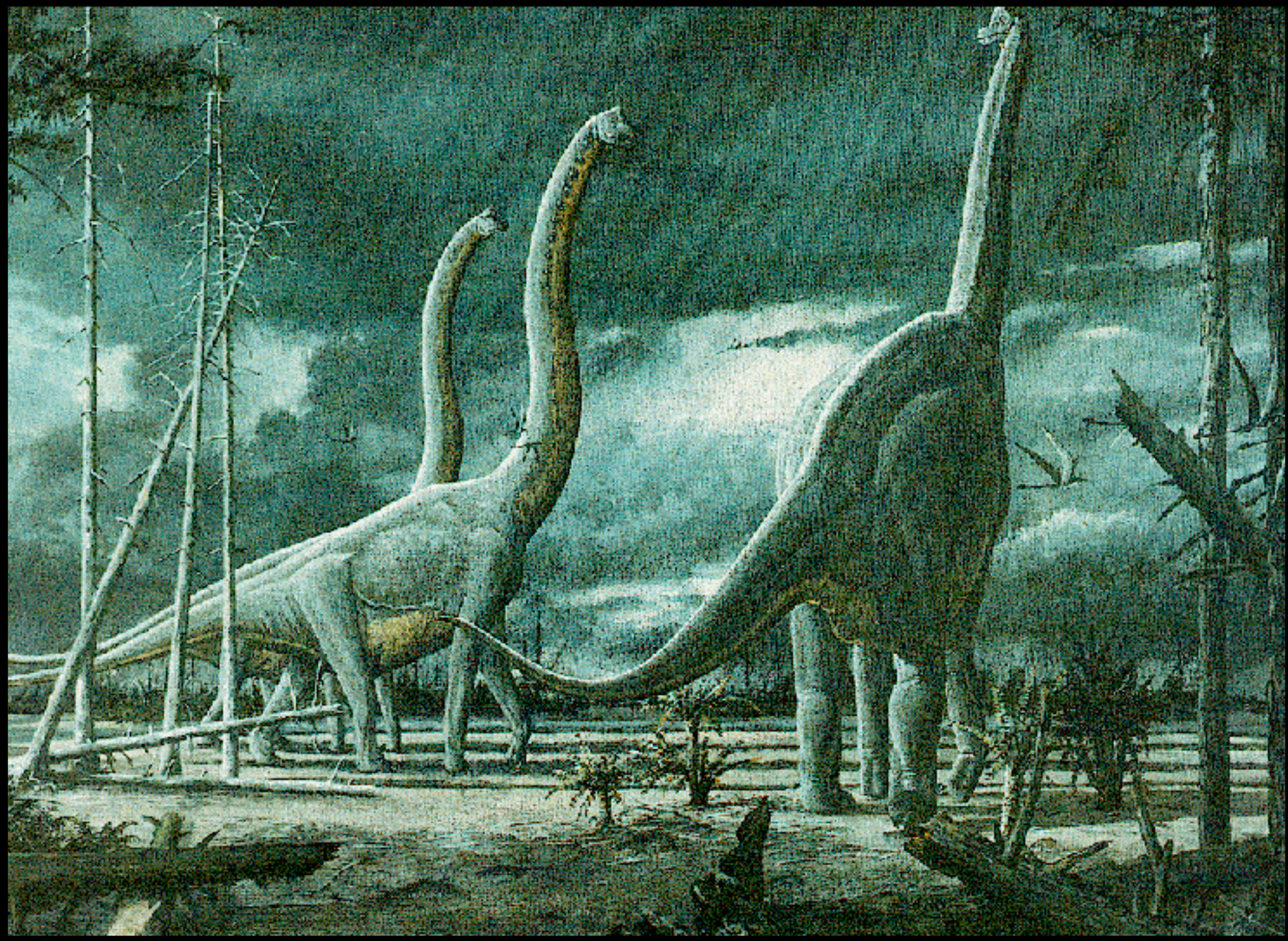
<50	50-60	60-75	75-90	75-90
F	D	C	B	A


Theropoda
Prosauropoda
Vulcanodon
Kotasaurus
Shunosaurus
Omeisaurus
Mamenchisaurus
Nemegtosaurus
Amargasaurus
Apatosaurus
Diplodocus
Jobaria
Camarasaurus
Brachiosaurus
Phuwiangosaurus
Malawisaurus
Titanosaurus
Alamosaurus
Saltosaurus
Diplodocoidea
4
Titanosauria
7
Camarasauromorpha
6
Macronaria
5
Neosauropoda
3
Eusauropoda
2
Sauropoda
1
Sauropodomorpha
Saurischia

Brachiosaurids

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

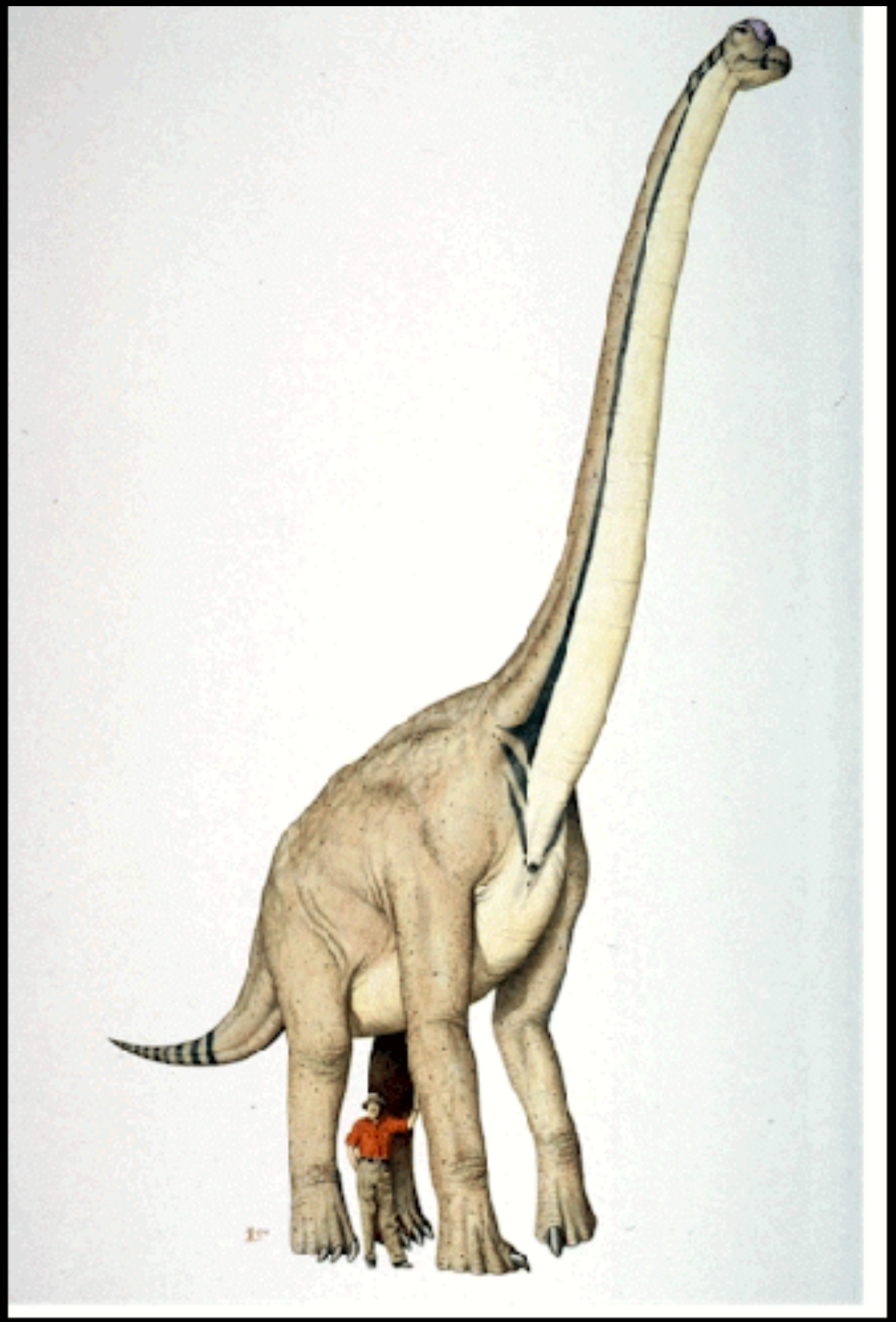
16 m (52 feet) tall

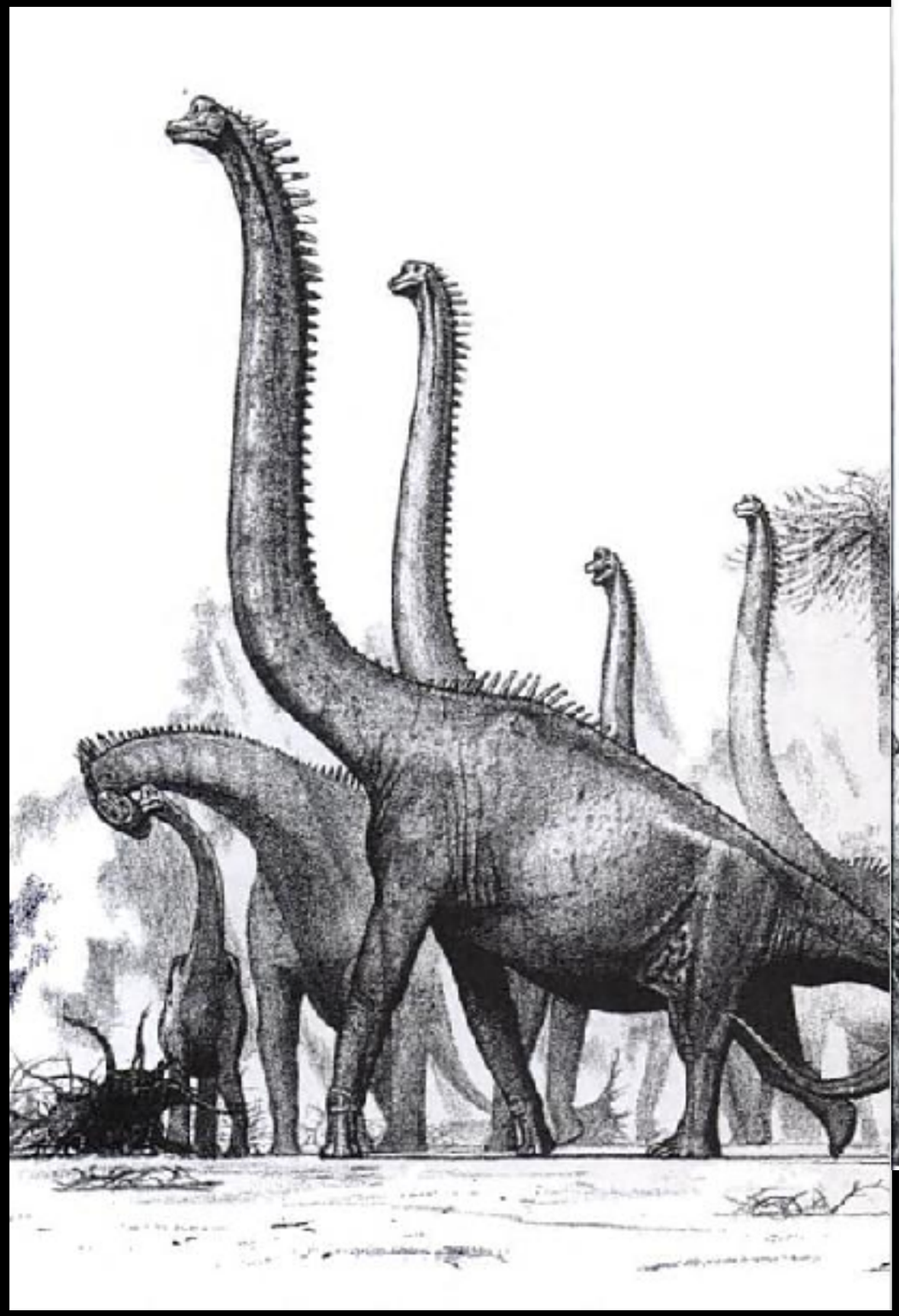


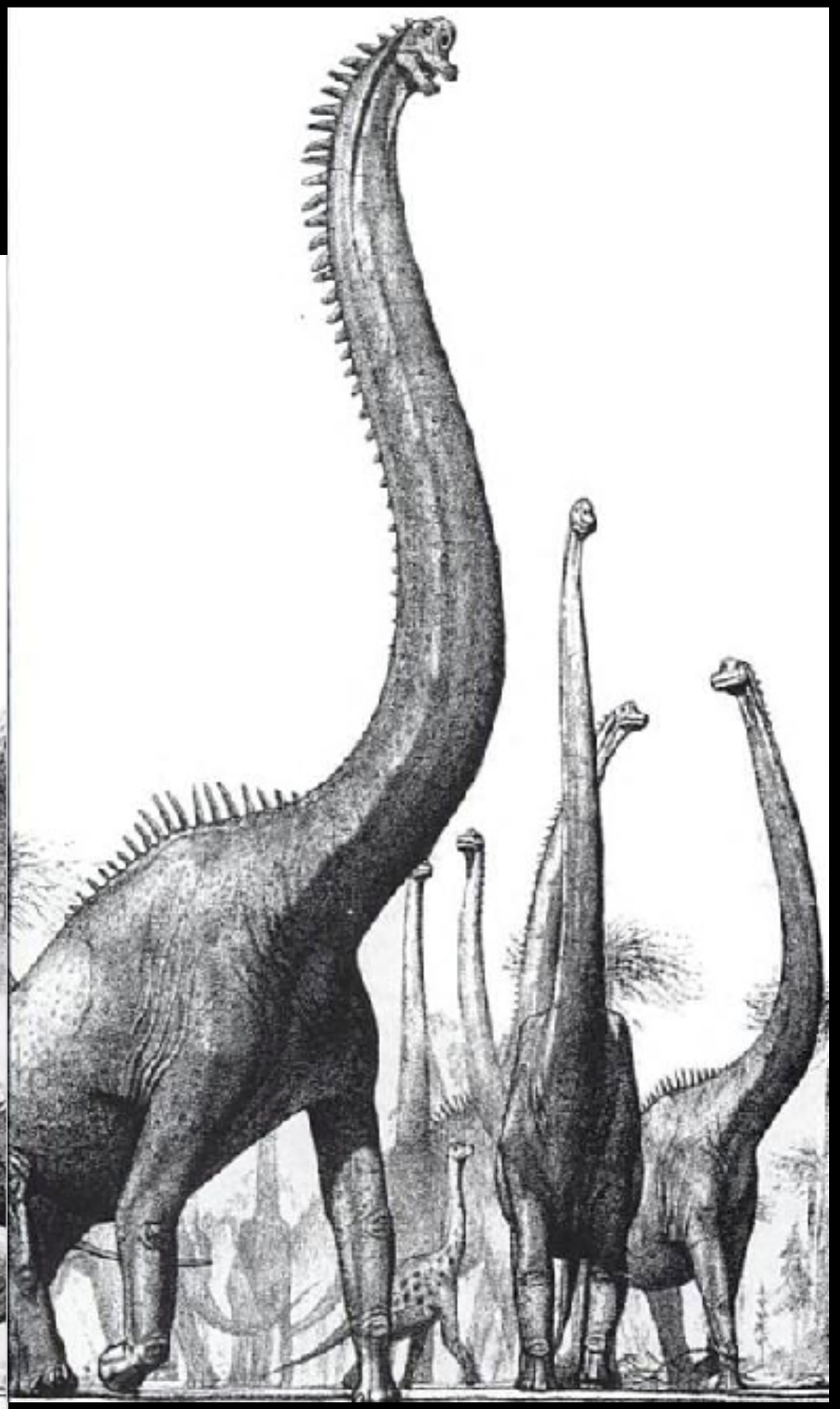
Brachiosaurus

Brachiosaurids

Brachiosaurus



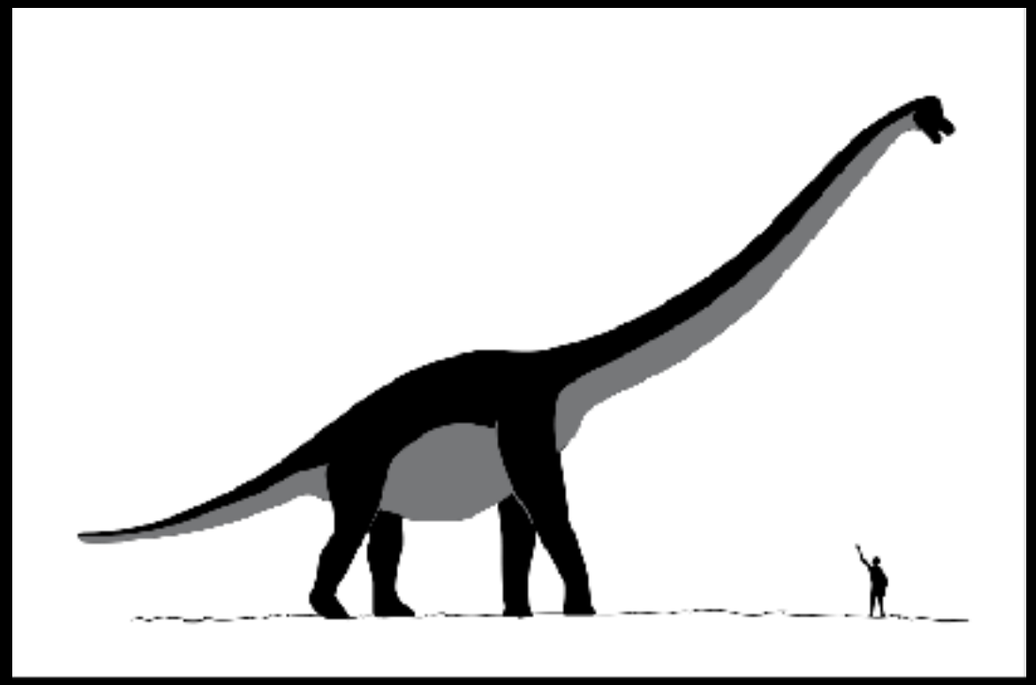


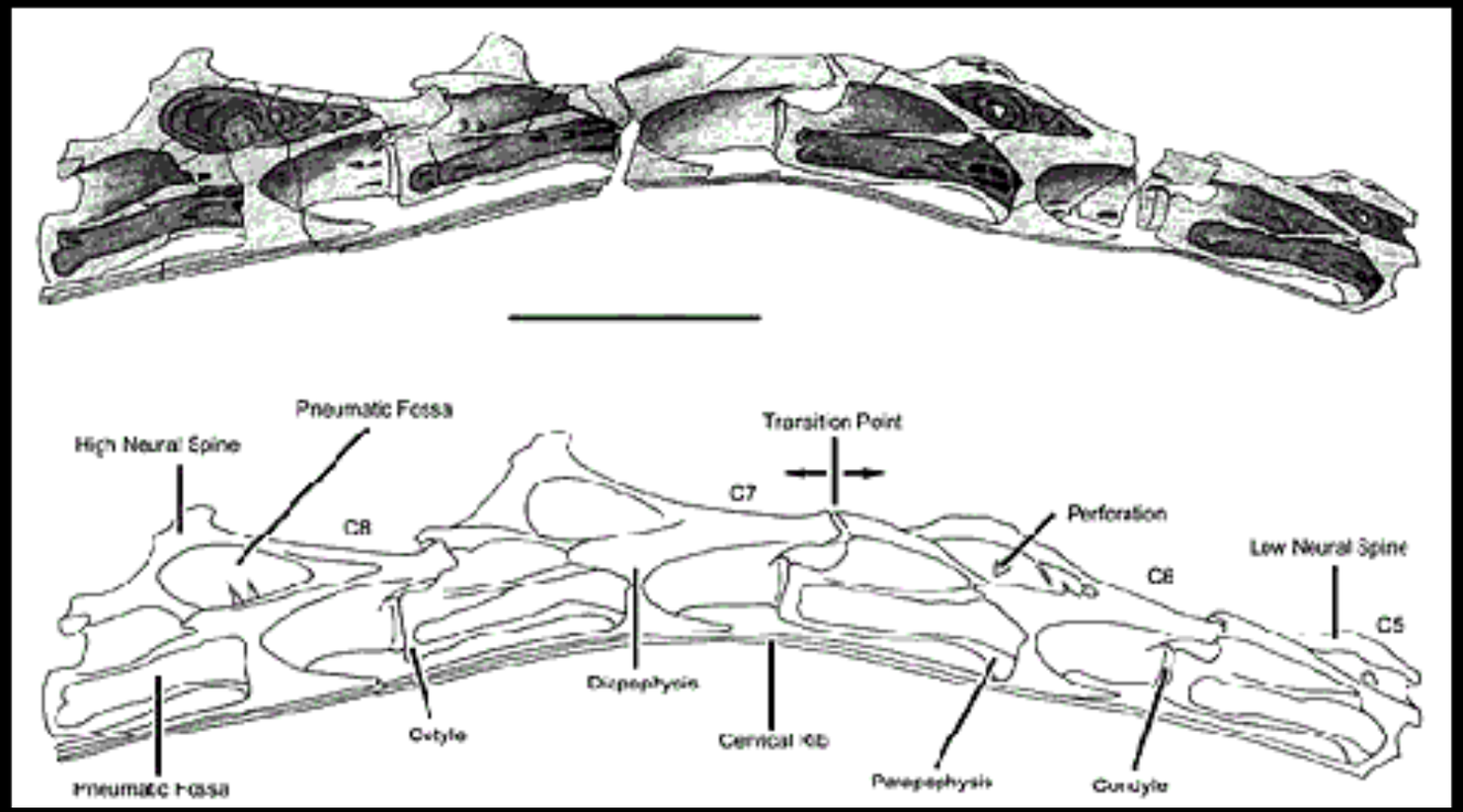


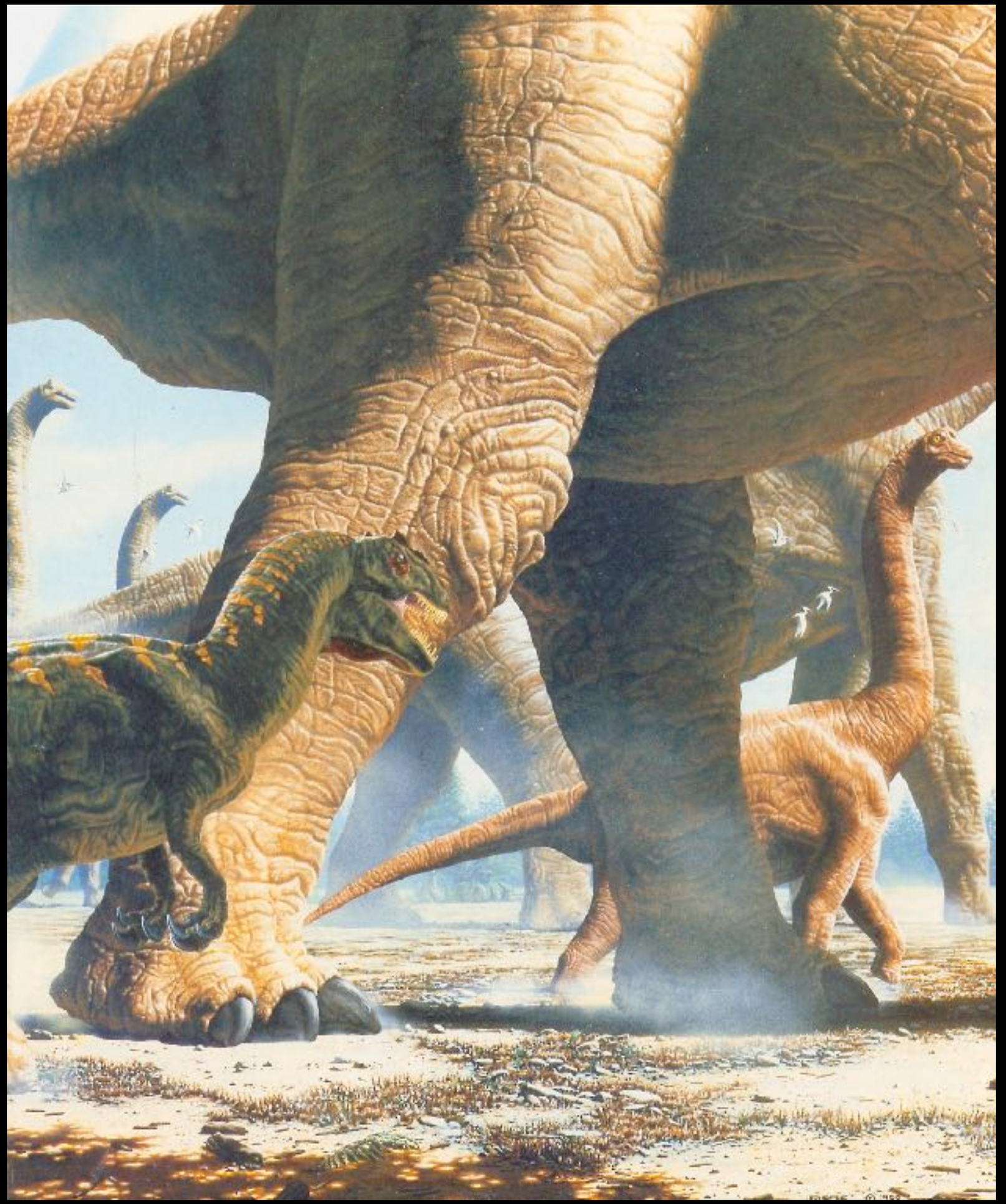
Brachiosaurids

Sauroposeidon

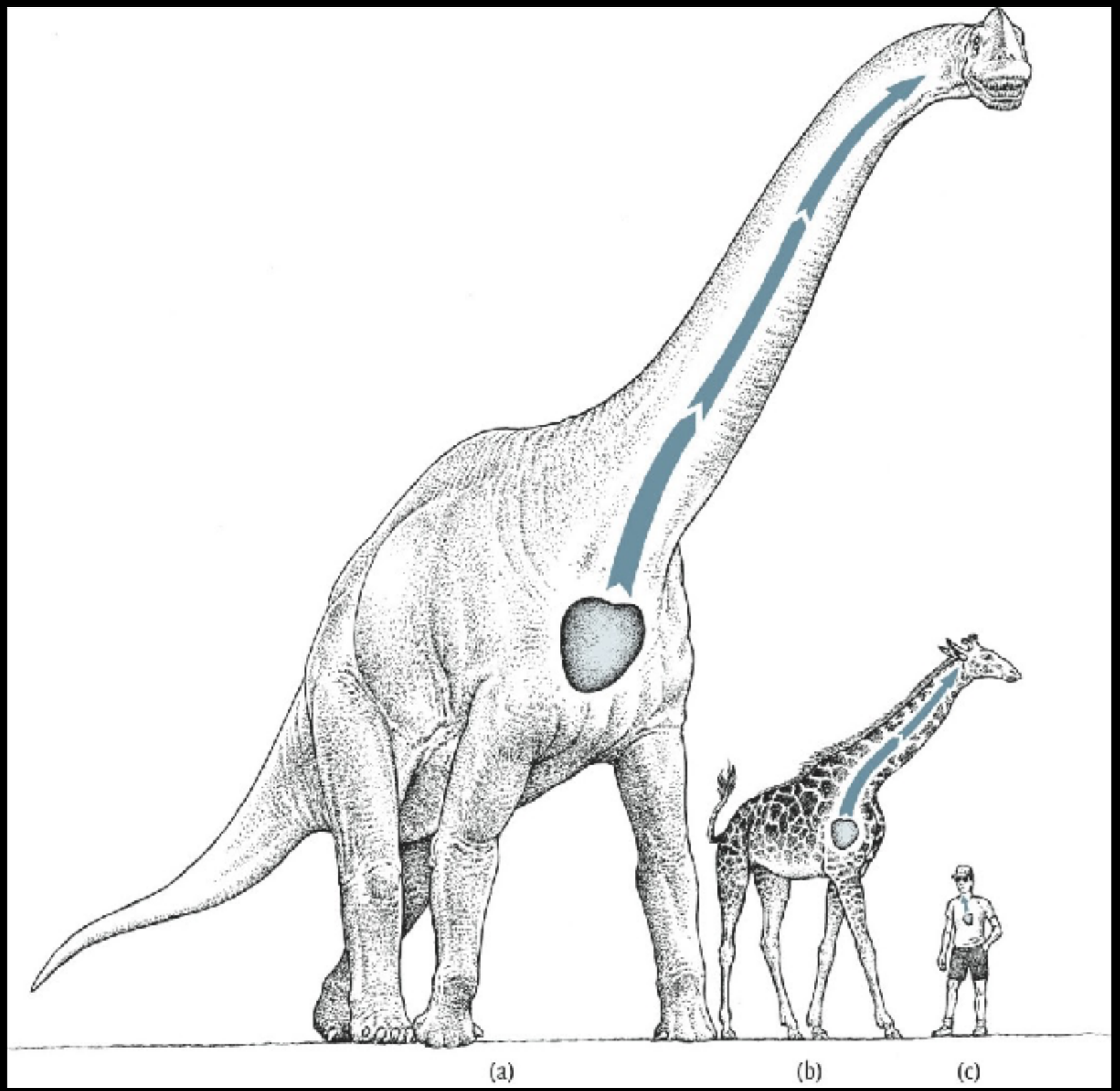
Late Jurassic
Neck: 37-40 ft long
Vertebrae EXTREMELY ELONGATED
Honeycombed with tiny air cells
    Bones very thin
Longest sauropod neck vertebrae on record
Likely able to raise it's head 6 stories high



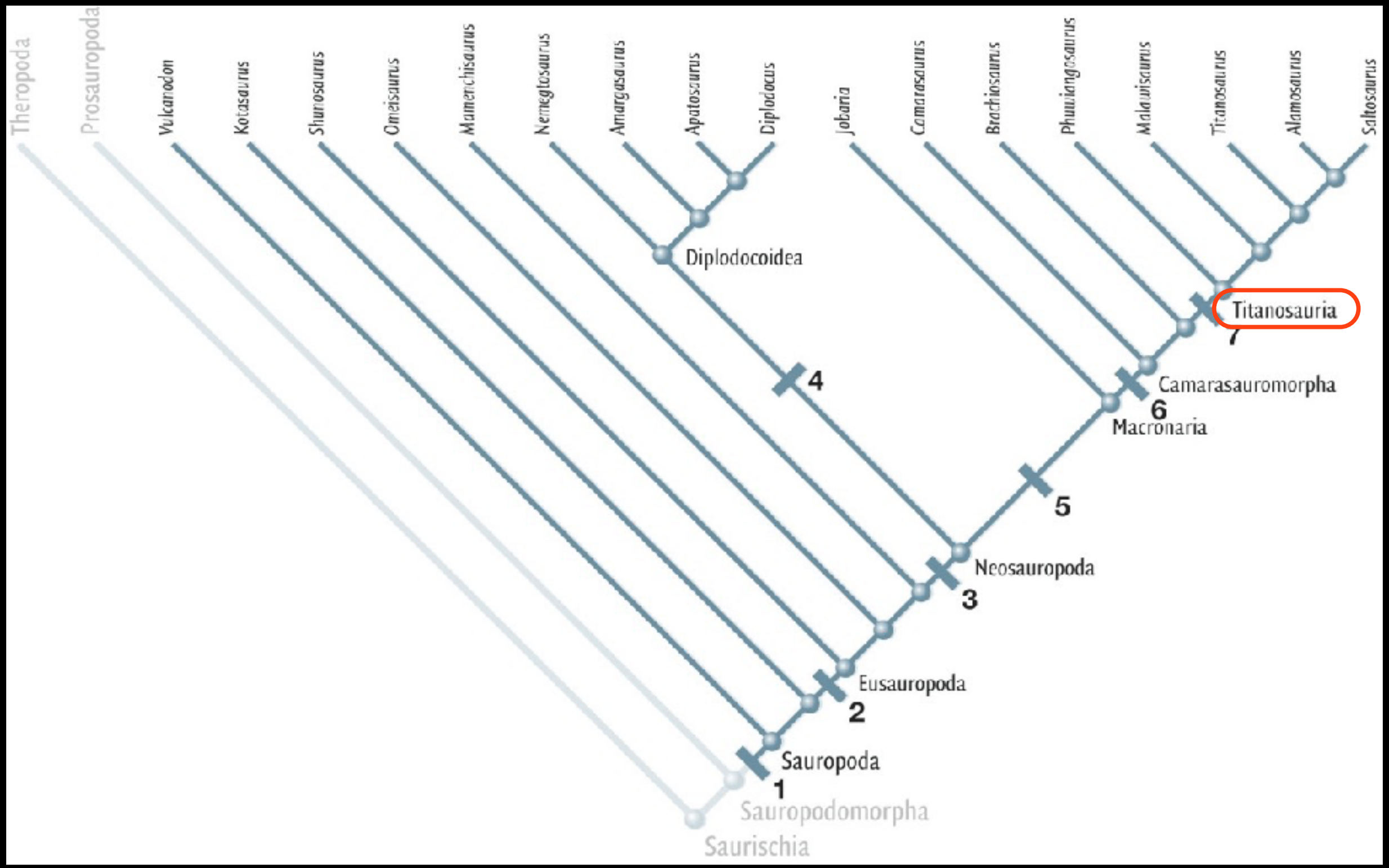




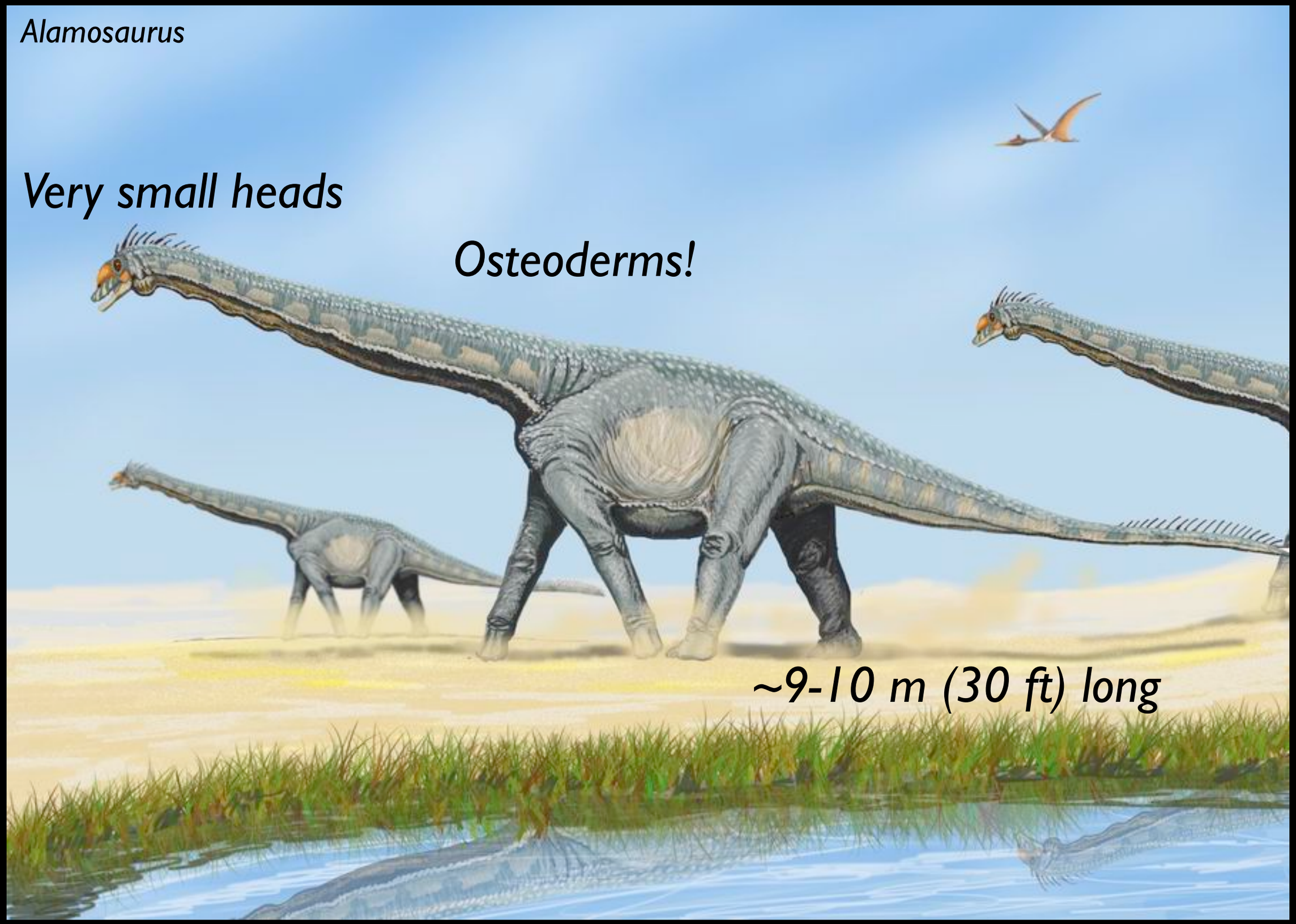
Brachiosaurids: an interesting physical problem...

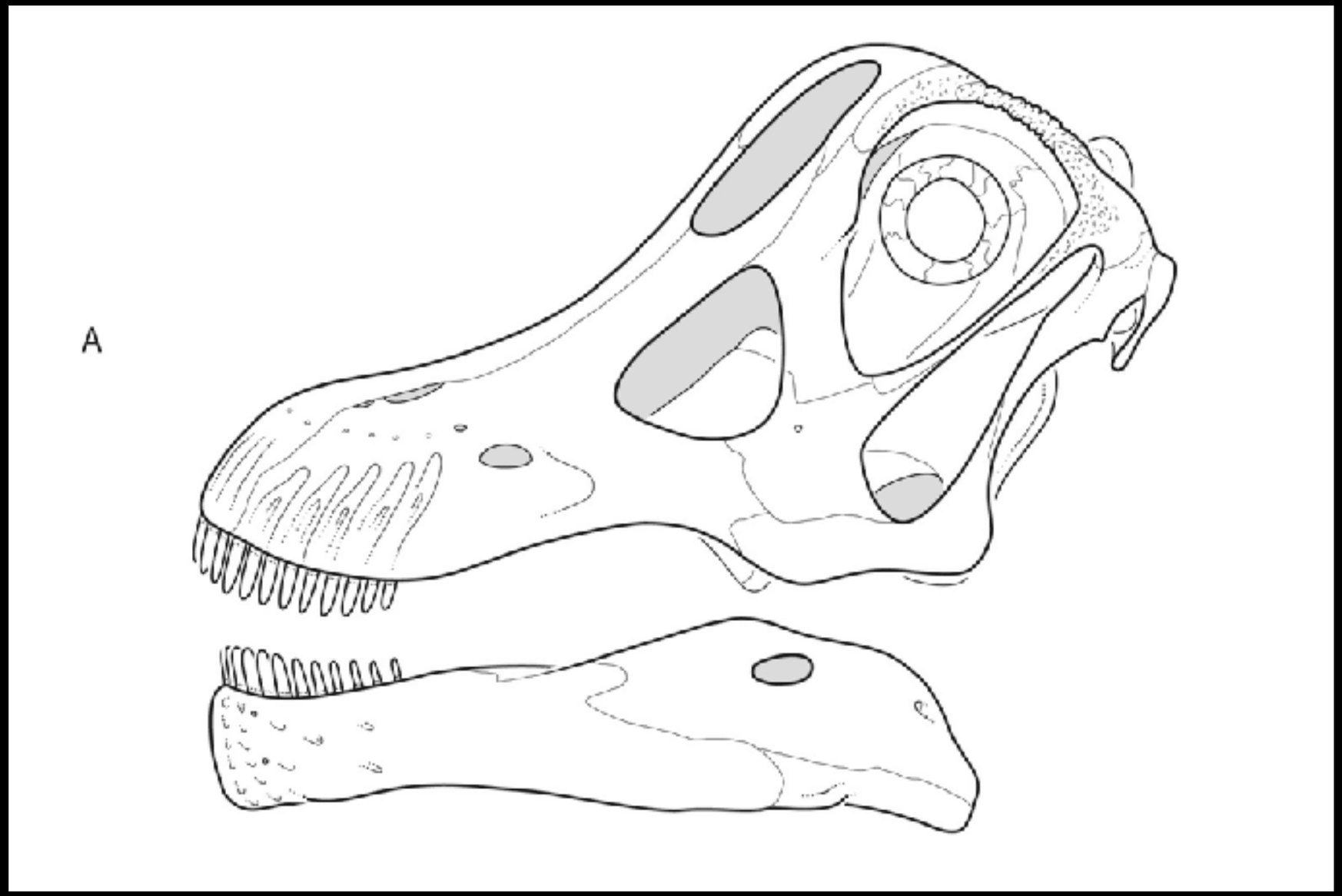


Titanosaurids



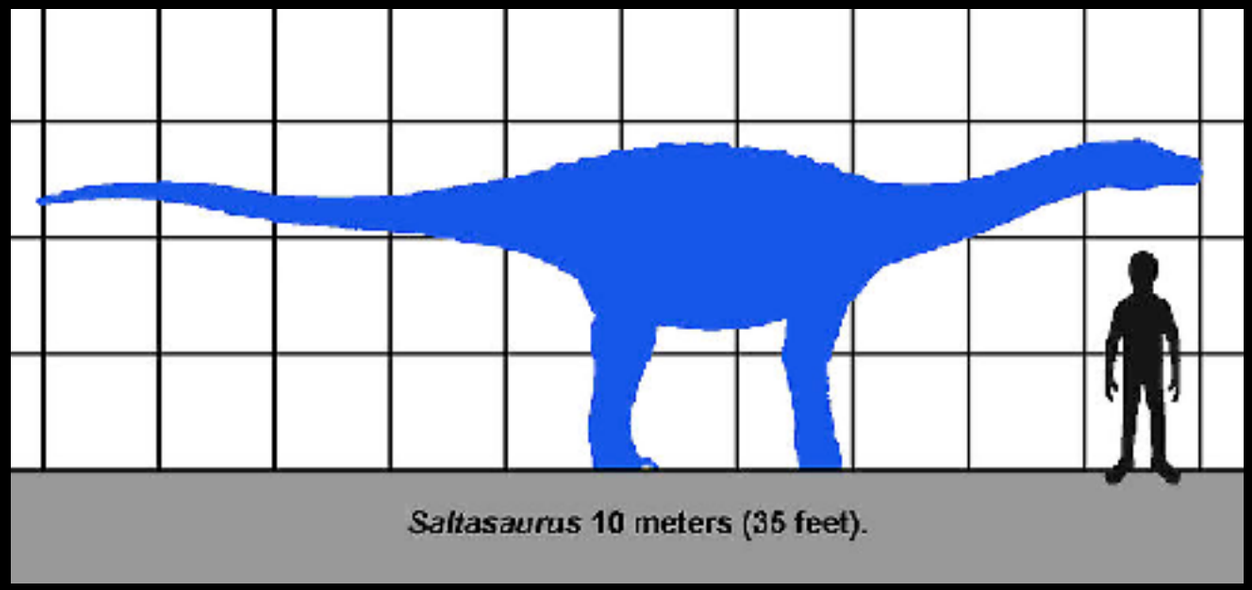
Titanosaurids: primarily in the Cretaceous





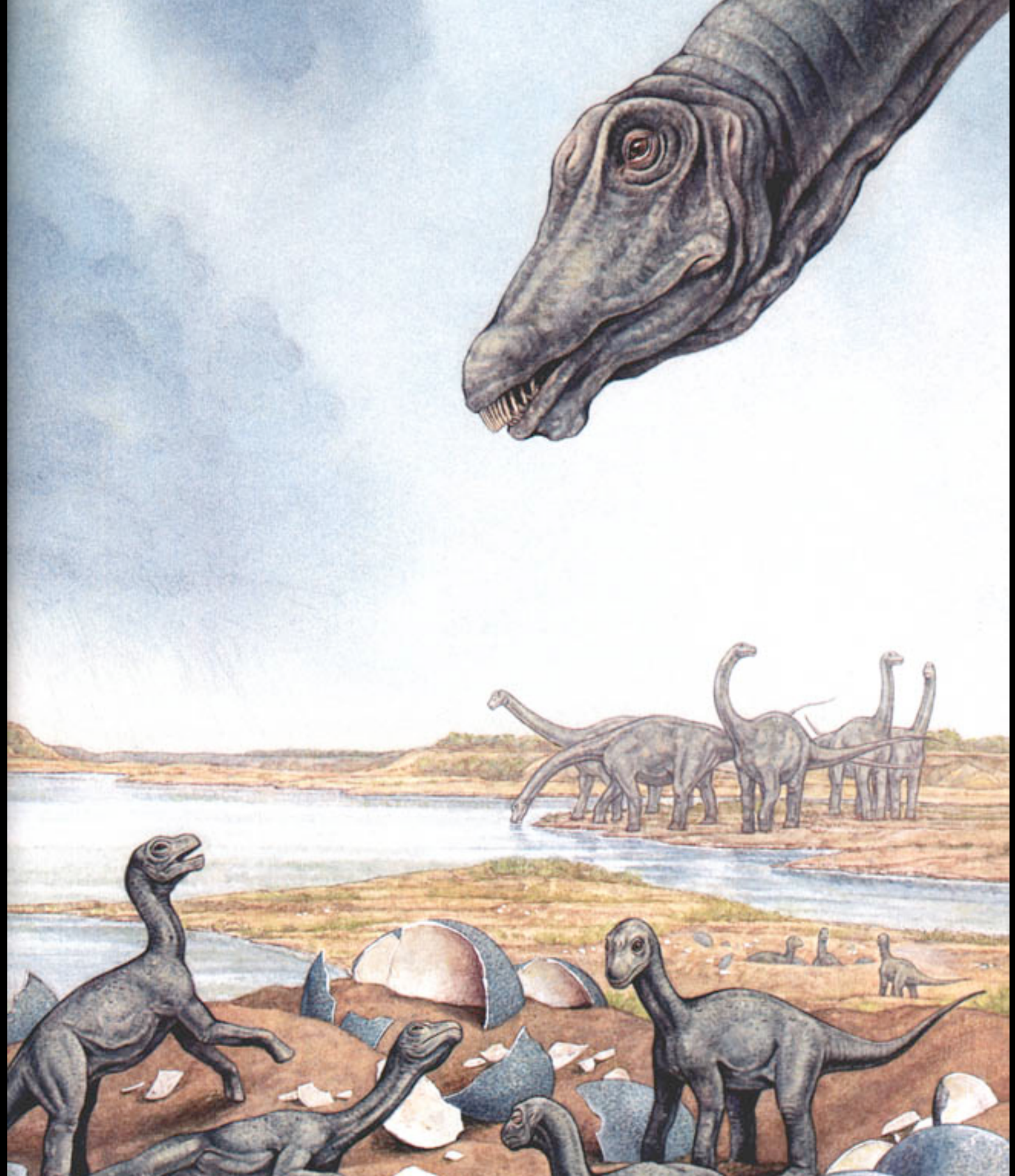
Nemegtosaurus
Pencil-like teeth; similar to Diplodocids
Probably convergent evolution (the rest of body is very different)

Titanosaurids: *Saltasaurus*



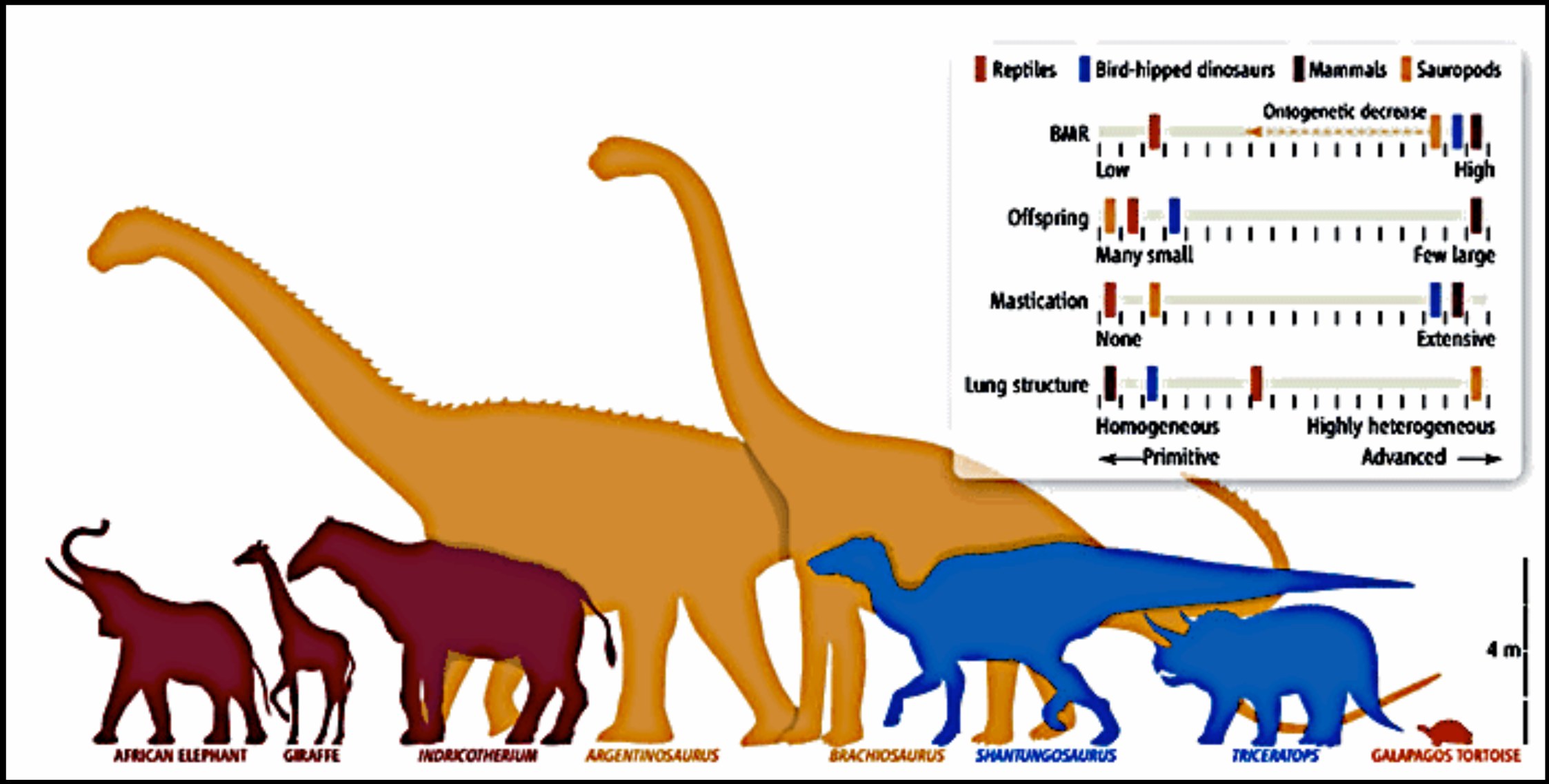
Saltasaurus egg

Nesting ground; implies herding
One of the only lines of evidence for sauropod reproduction

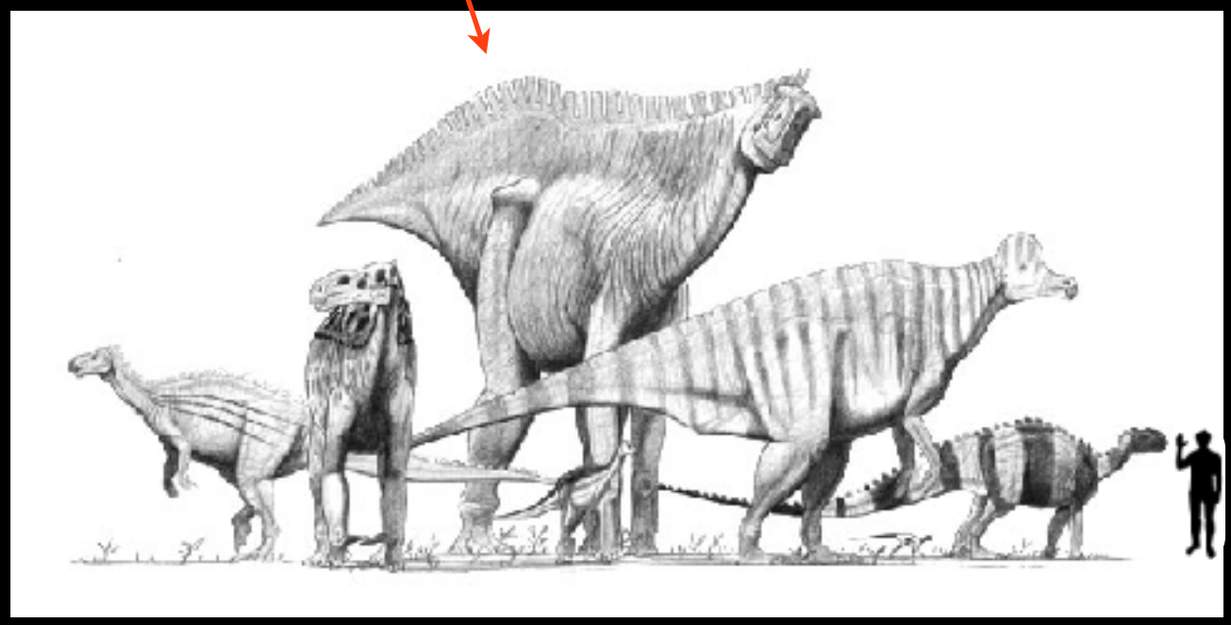


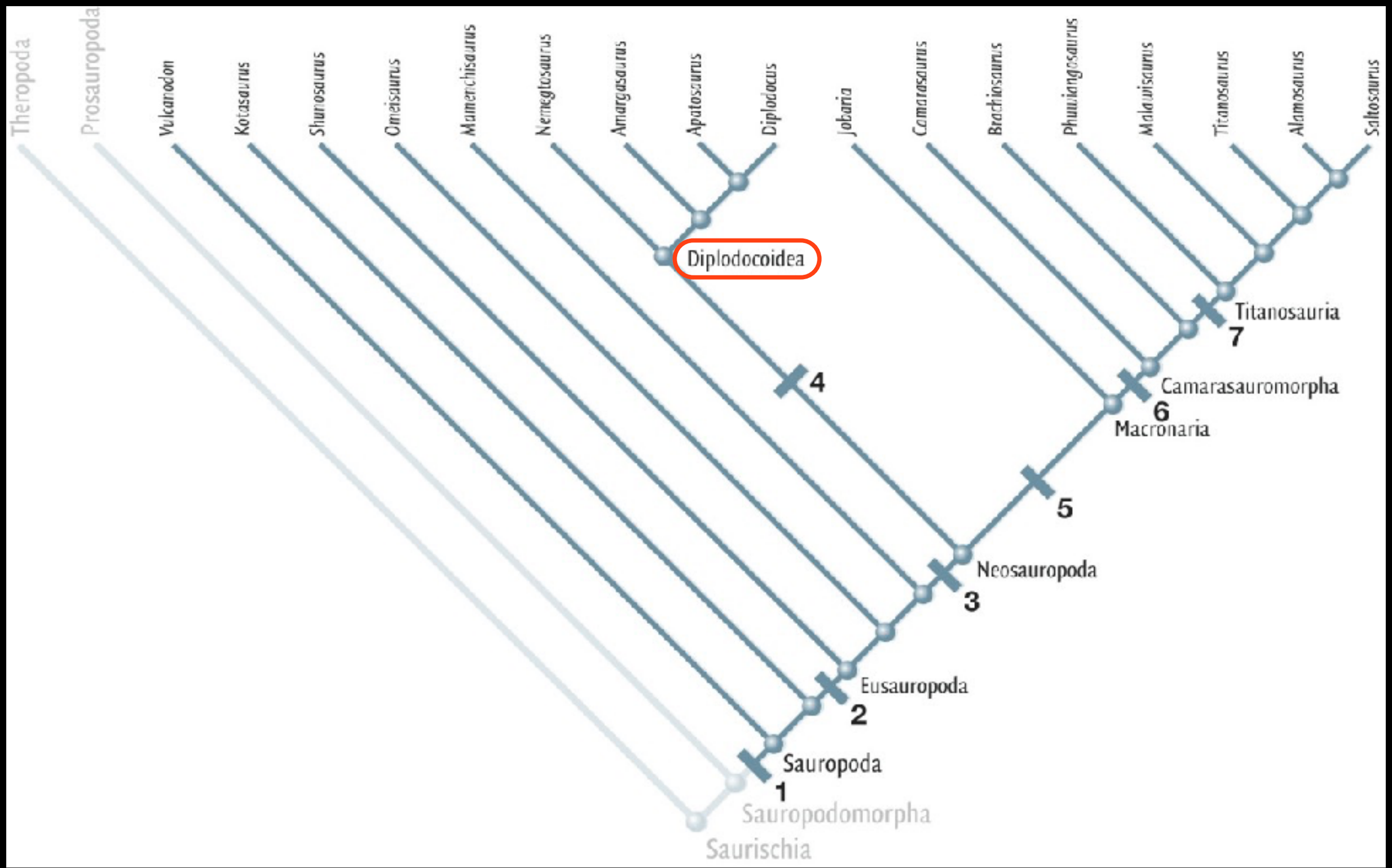
Titanosaurids: *Argentinosaurus*

Mid-Cretaceous
21-35 m (72-85 ft) long



Titanosaur *Brachiosaur*




Theropoda
Prosauropoda
Vulcanodon
Kotasaurus
Shunosaurus
Omeisaurus
Mamenchisaurus
Nemegtosaurus
Amargasaurus
Apatosaurus
Diplodocus
Jobaria
Camarasaurus
Brachiosaurus
Phuwiangosaurus
Malawisaurus
Titanosaurus
Alamosaurus
Saltosaurus
Diplodocoidea
4
Titanosauria
7
Camarasauromorpha
6
Macronaria
5
Neosauropoda
3
Eusauropoda
2
Sauropoda
1
Sauropodomorpha
Saurischia

Diplodocid traits

>12 vertebrae + bifurcate cervical neural spines

At least 80 caudals

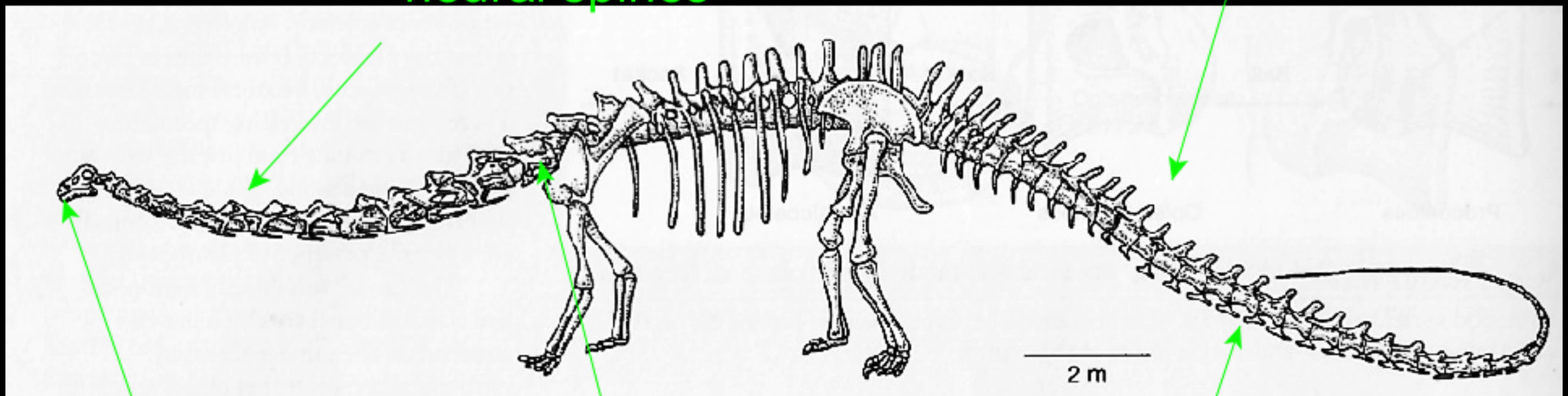


FIGURE 6.8

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

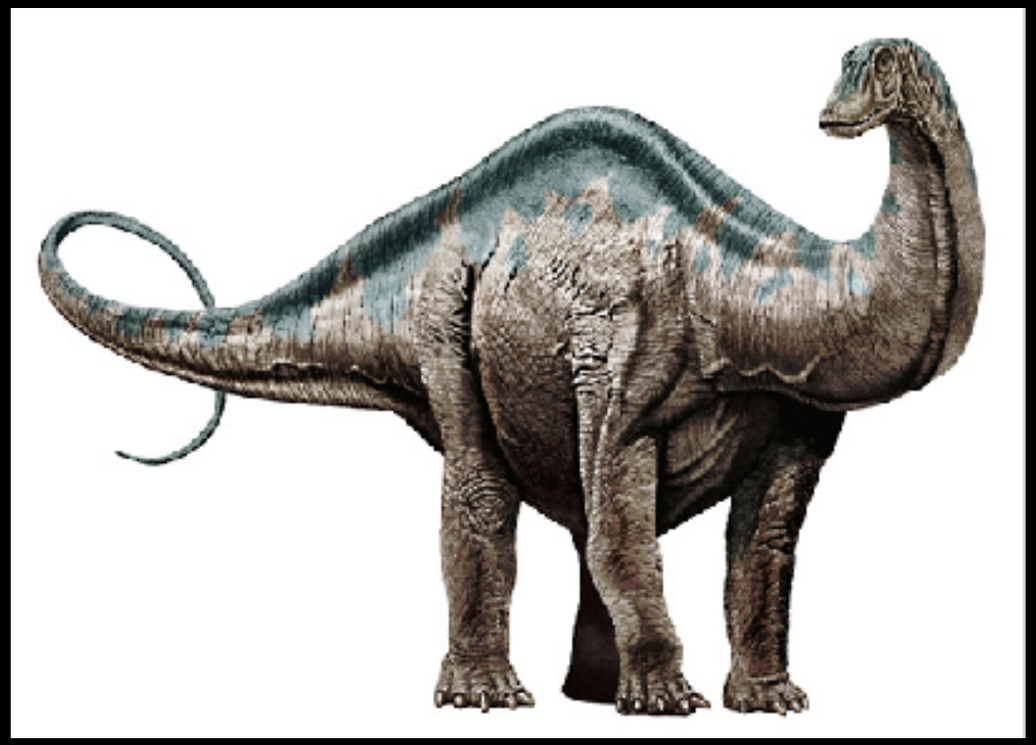
Relatively long skulls with peg-like teeth

Neck joint horizontally oriented

Odd chevrons

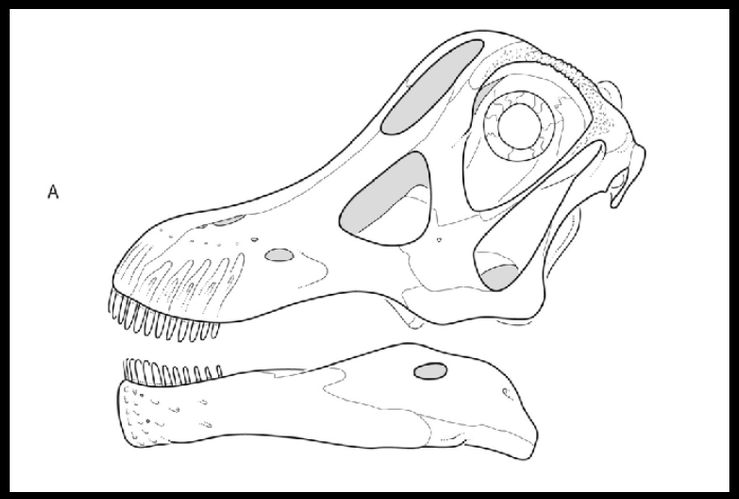
27 m = 90 ft; Blue whale length

Apatosaurus



Brontosaurus (but really Apatosaurus)

Camarasaur head vs. Diplodocid head

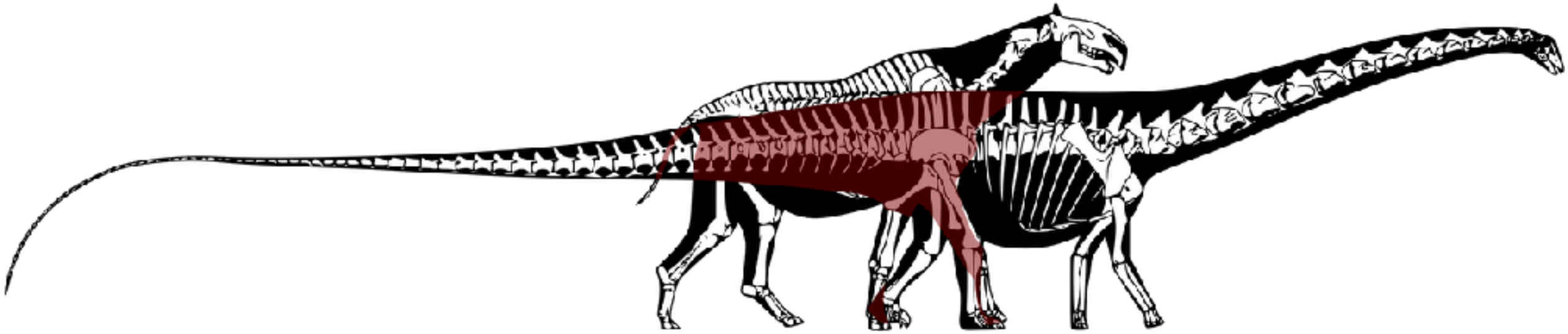


Brontosaurus may exist

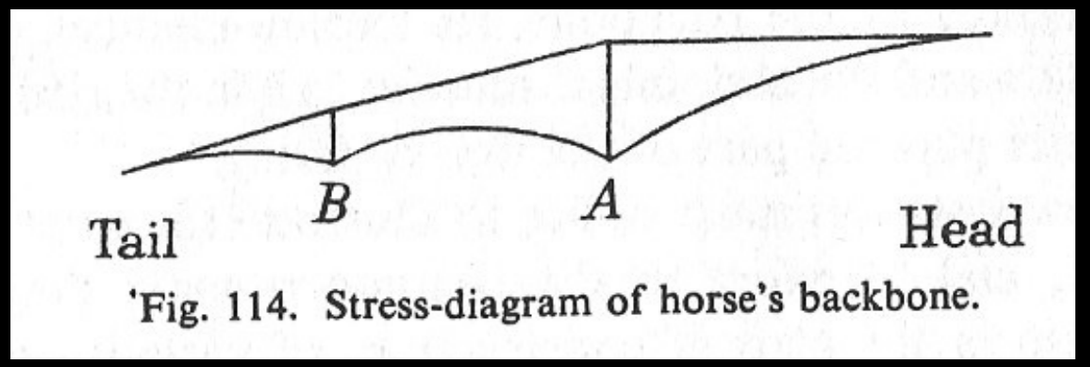
Walking with Dinosaurs:

Diplodocus laying eggs @ intro

Juveniles @ 6:45



Maximum stress centered over haunches



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

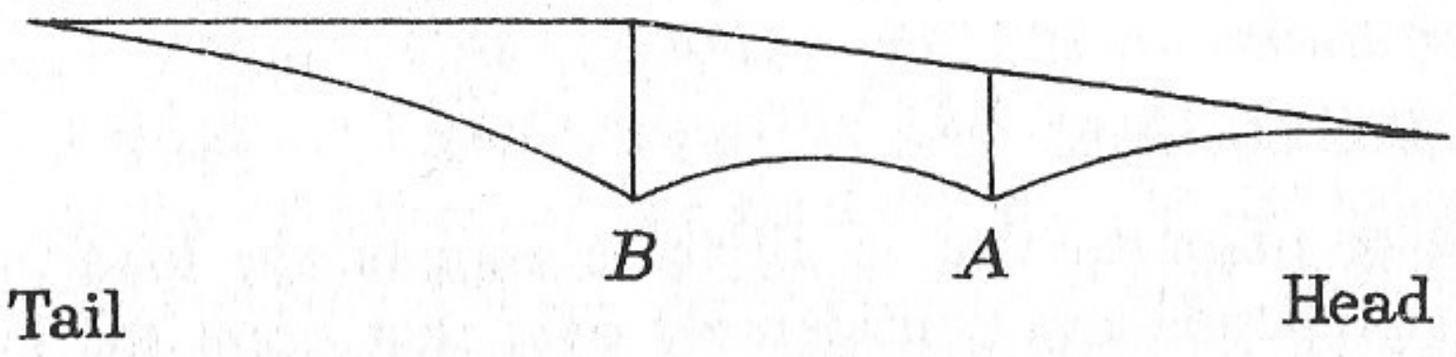
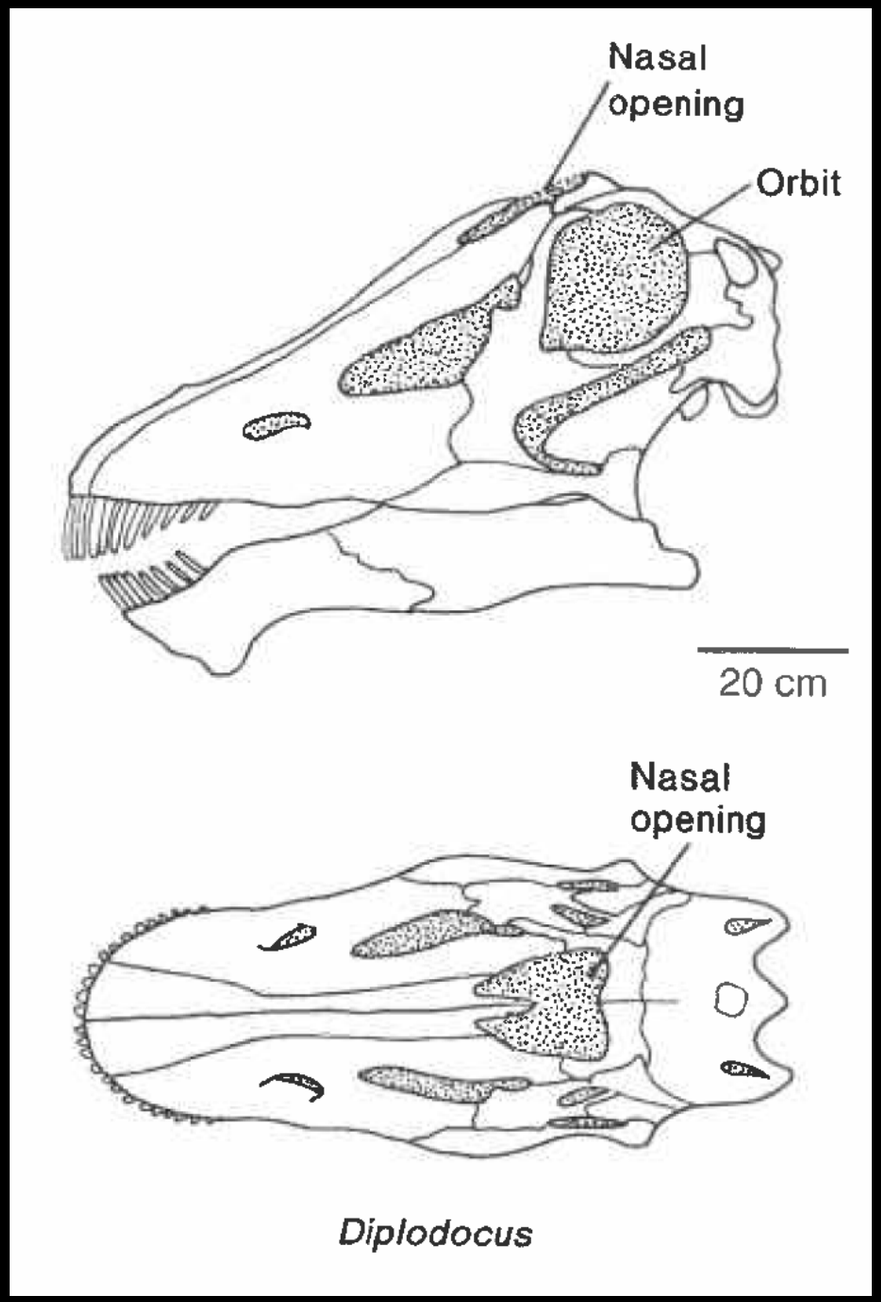
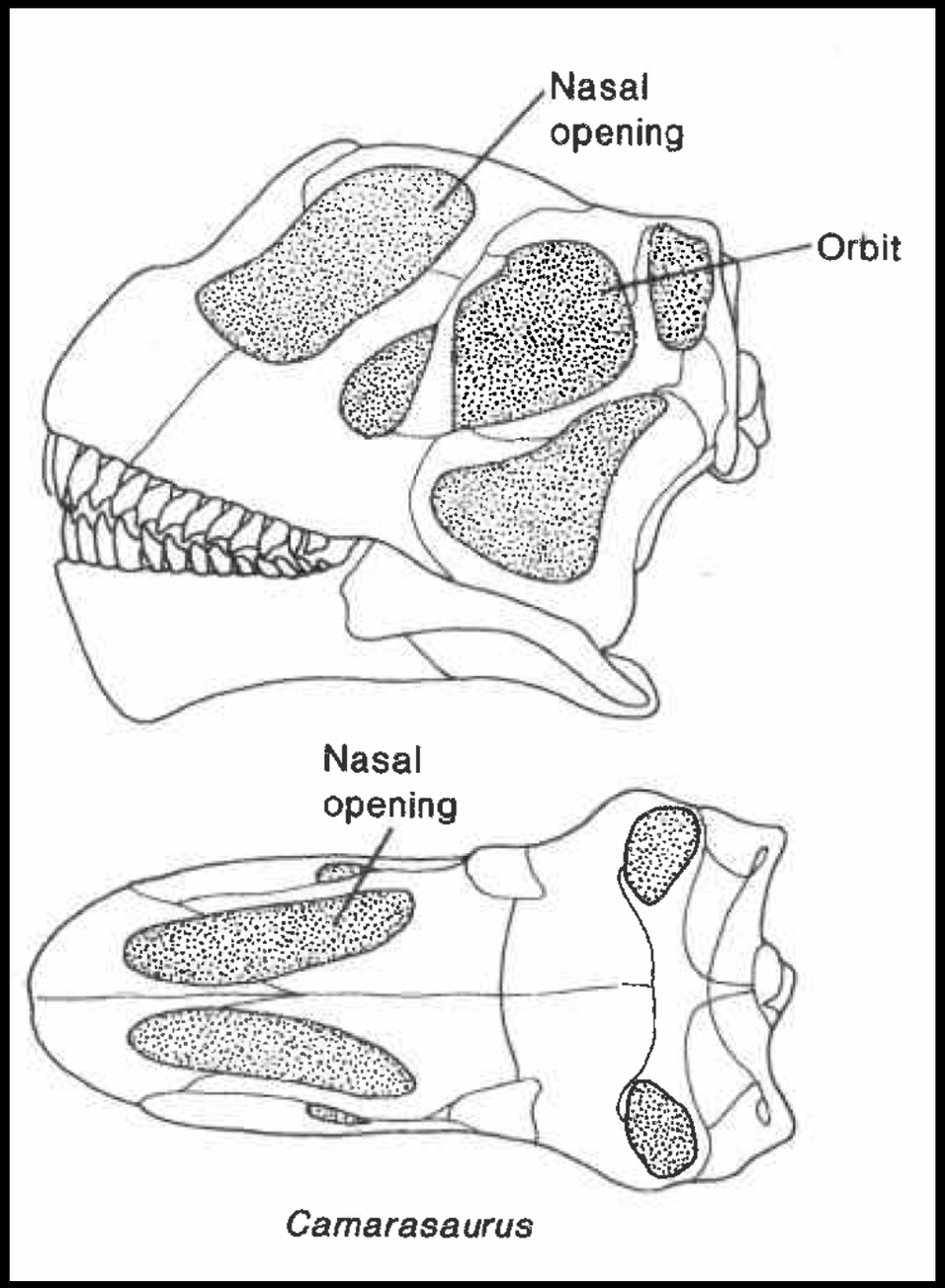


Fig. 115. Stress-diagram of backbone of Dinosaur.

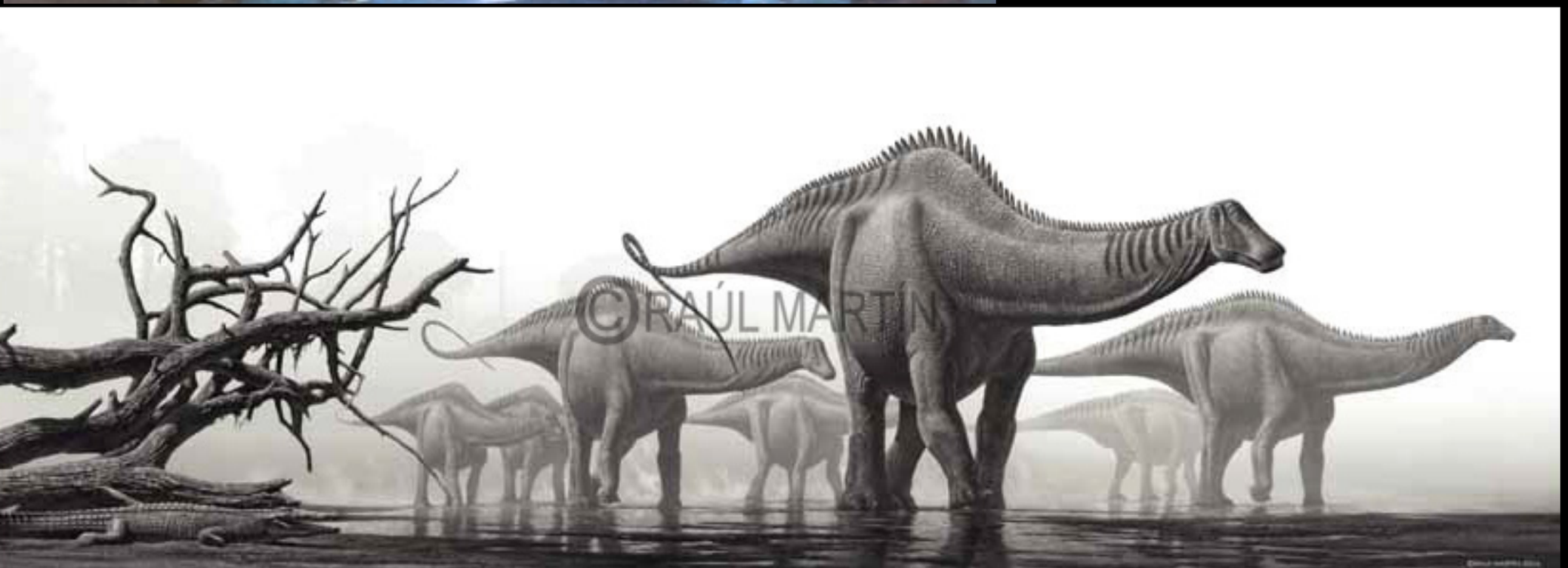
Diplodocids





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

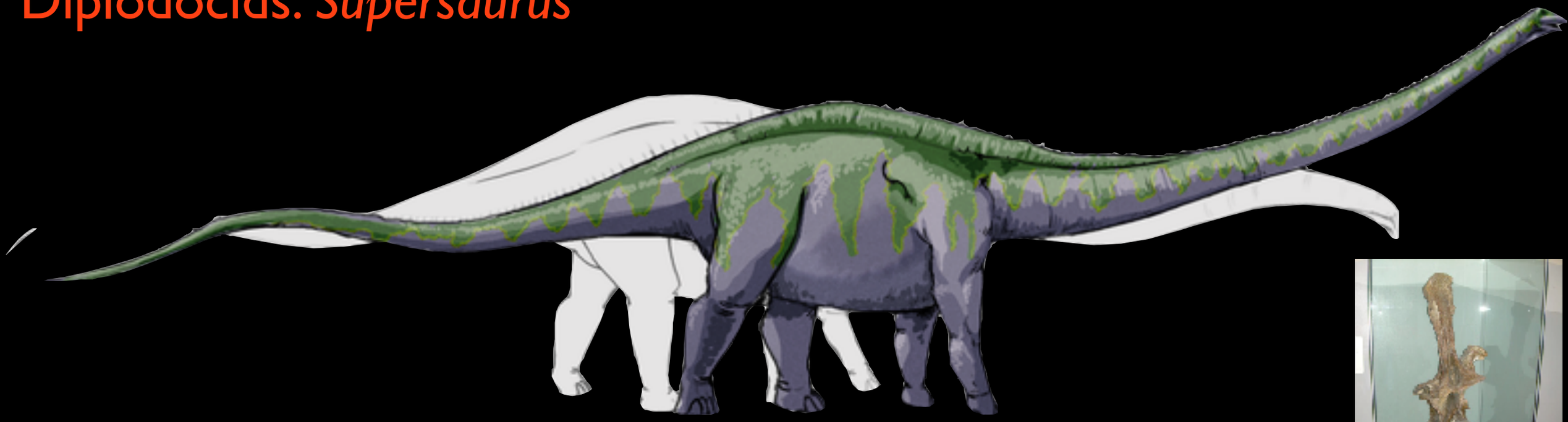
Diplodocids: *Apatosaurus*



Diplodocids: *Barosaurus*

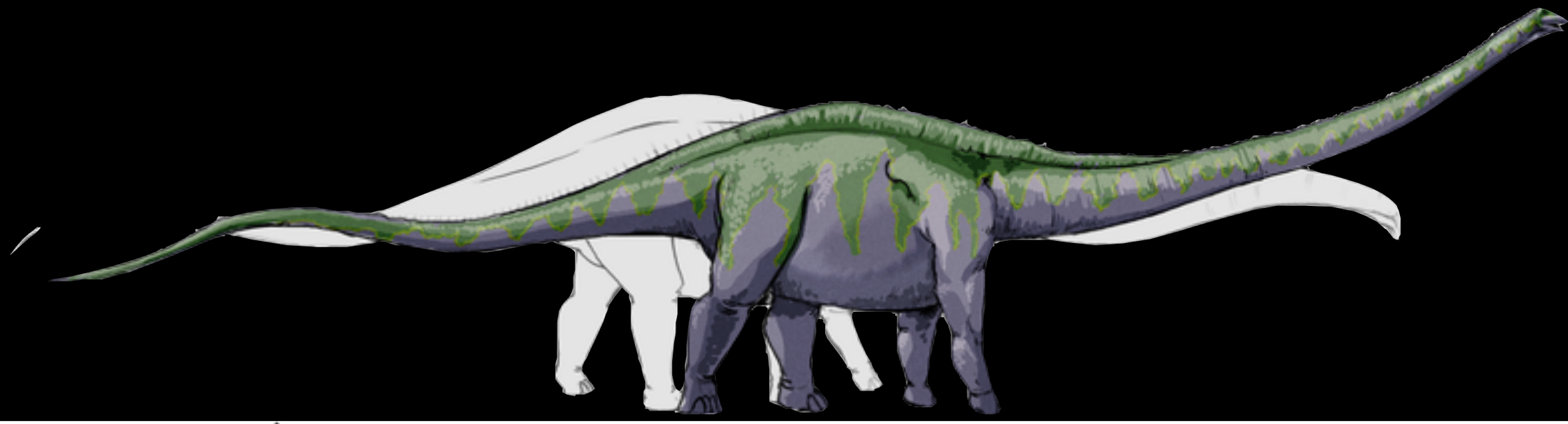
Late Jurassic
26 m (86 ft) long
Compared to Diplodocus, longer neck and shorter tail

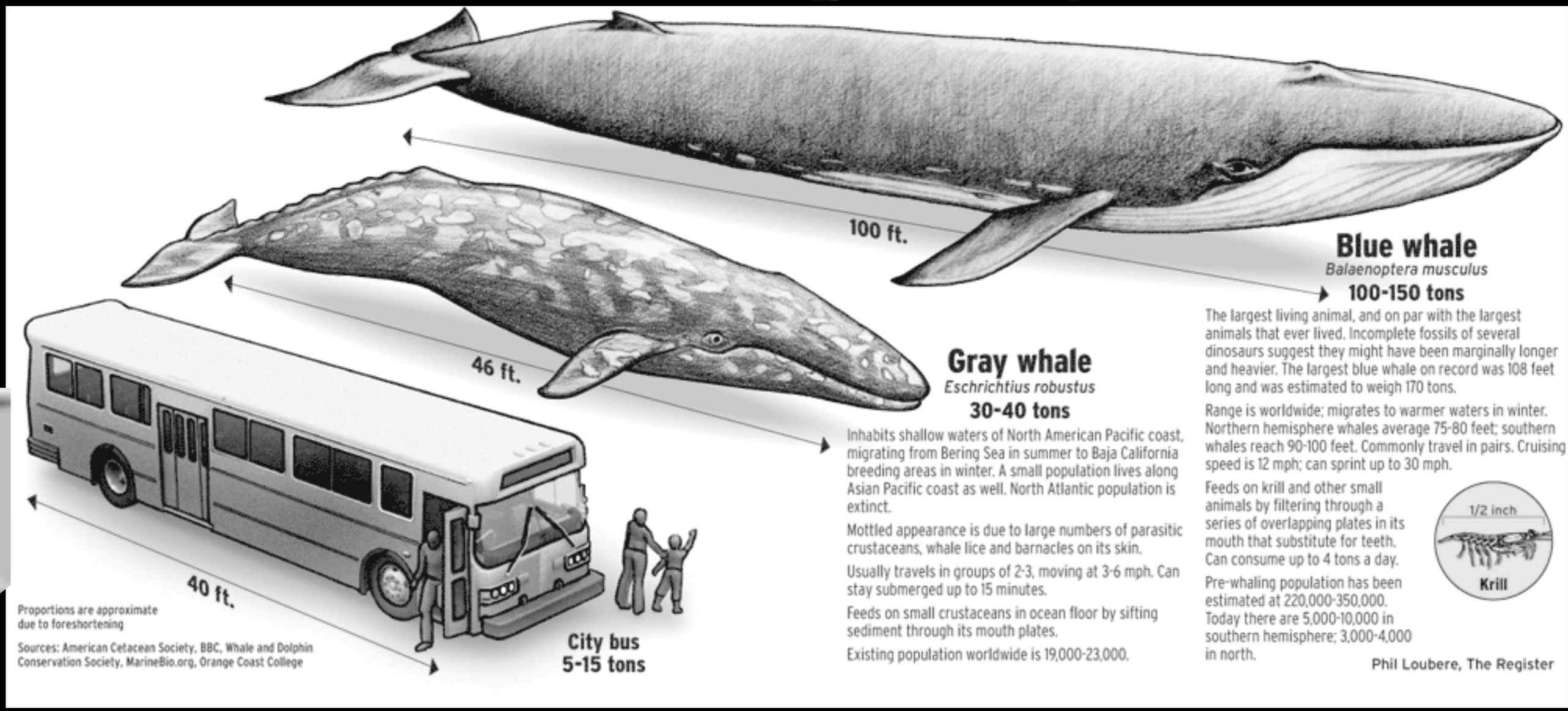
Diplodocids: *Supersaurus*



Late Jurassic

25-30 m (80-100 ft) long





Proportions are approximate due to foreshortening

Sources: American Cetacean Society, BBC, Whale and Dolphin Conservation Society, MarineBio.org, Orange Coast College

Blue whale

Balaenoptera musculus

100-150 tons

The largest living animal, and on par with the largest animals that ever lived. Incomplete fossils of several dinosaurs suggest they might have been marginally longer and heavier. The largest blue whale on record was 108 feet long and was estimated to weigh 170 tons.

Range is worldwide; migrates to warmer waters in winter. Northern hemisphere whales average 75-80 feet; southern whales reach 90-100 feet. Commonly travel in pairs. Cruising speed is 12 mph; can sprint up to 30 mph.

Feeds on krill and other small animals by filtering through a series of overlapping plates in its mouth that substitute for teeth. Can consume up to 4 tons a day.

Pre-whaling population has been estimated at 220,000-350,000. Today there are 5,000-10,000 in southern hemisphere; 3,000-4,000 in north.

Gray whale

Eschrichtius robustus

30-40 tons

Inhabits shallow waters of North American Pacific coast, migrating from Bering Sea in summer to Baja California breeding areas in winter. A small population lives along Asian Pacific coast as well. North Atlantic population is extinct.

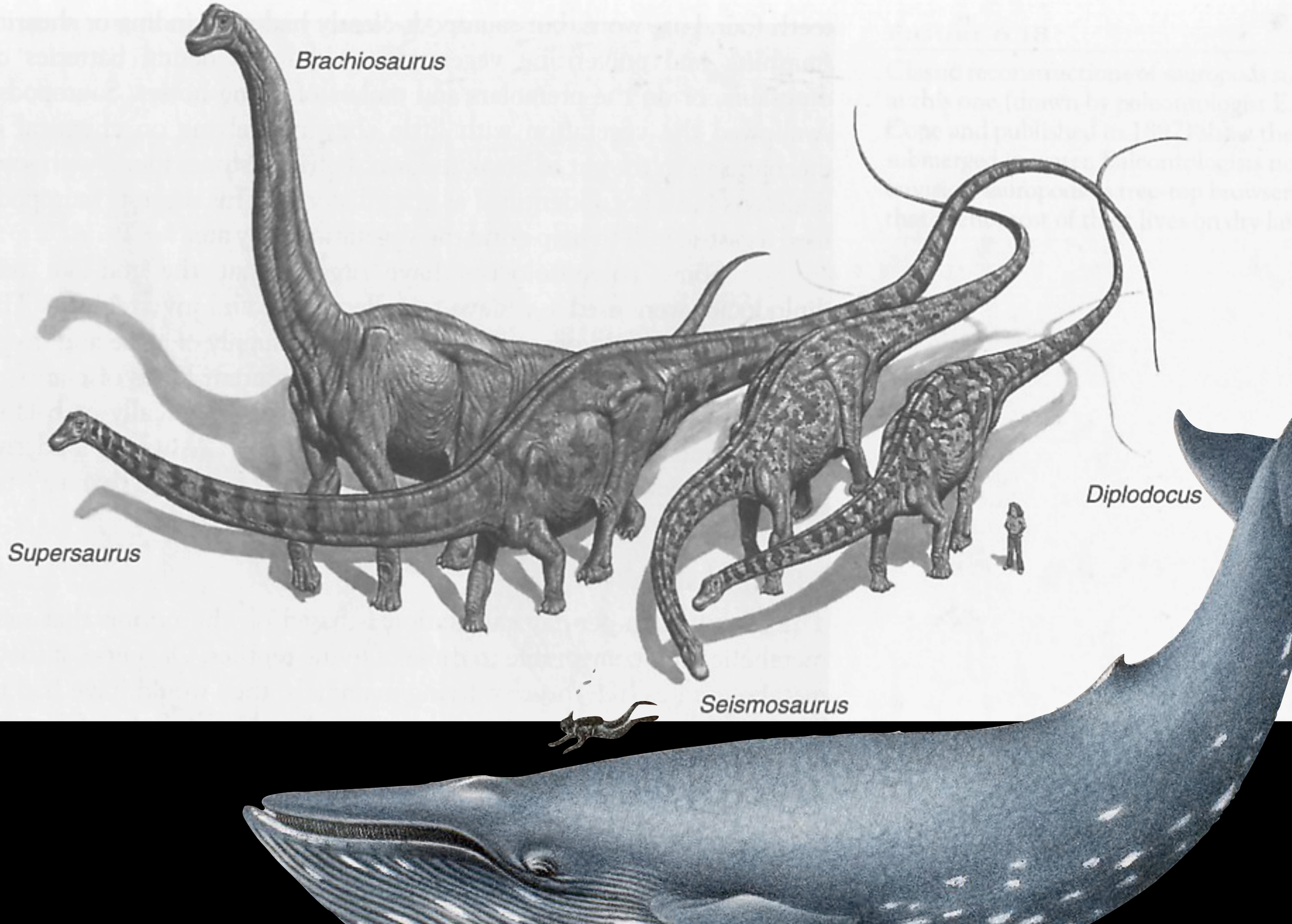
Mottled appearance is due to large numbers of parasitic crustaceans, whale lice and barnacles on its skin.

Usually travels in groups of 2-3, moving at 3-6 mph. Can stay submerged up to 15 minutes.

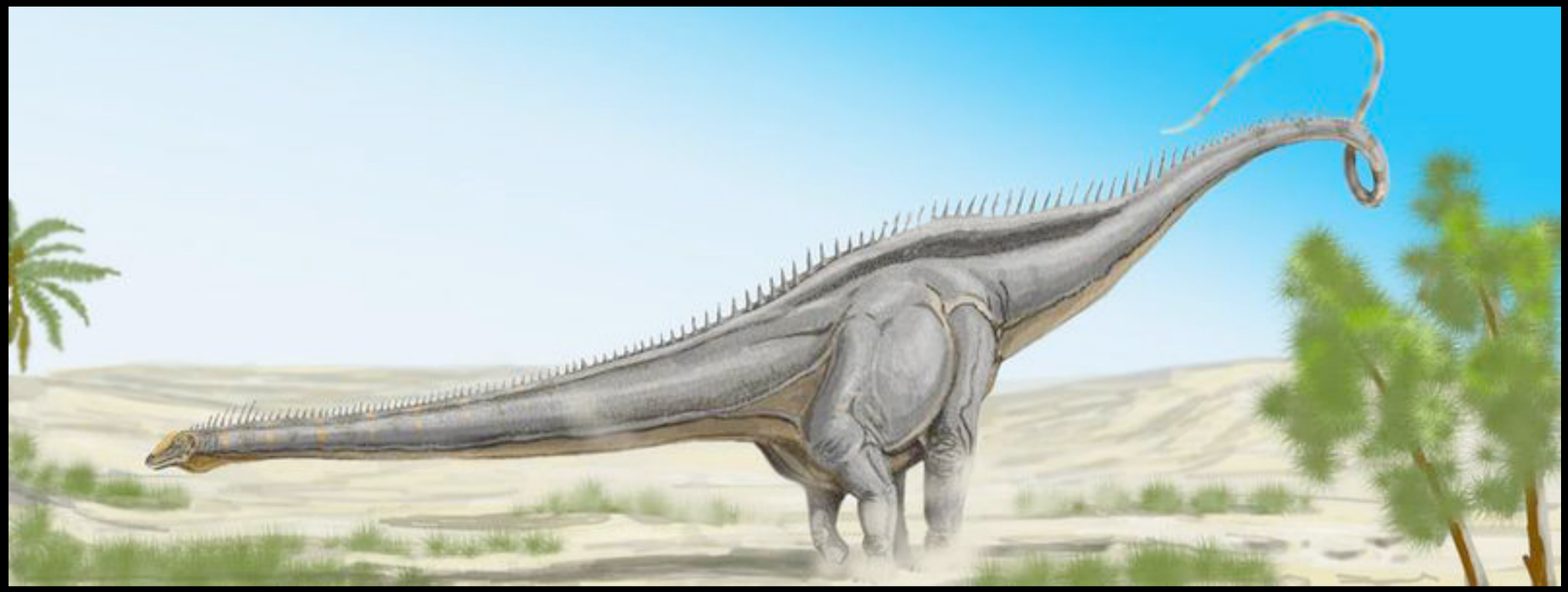
Feeds on small crustaceans in ocean floor by sifting sediment through its mouth plates.

Existing population worldwide is 19,000-23,000.

Phil Loubere, The Register


Brachiosaurus
Supersaurus
Diplodocus
Seismosaurus

Diplodocids: *Diplodocus*

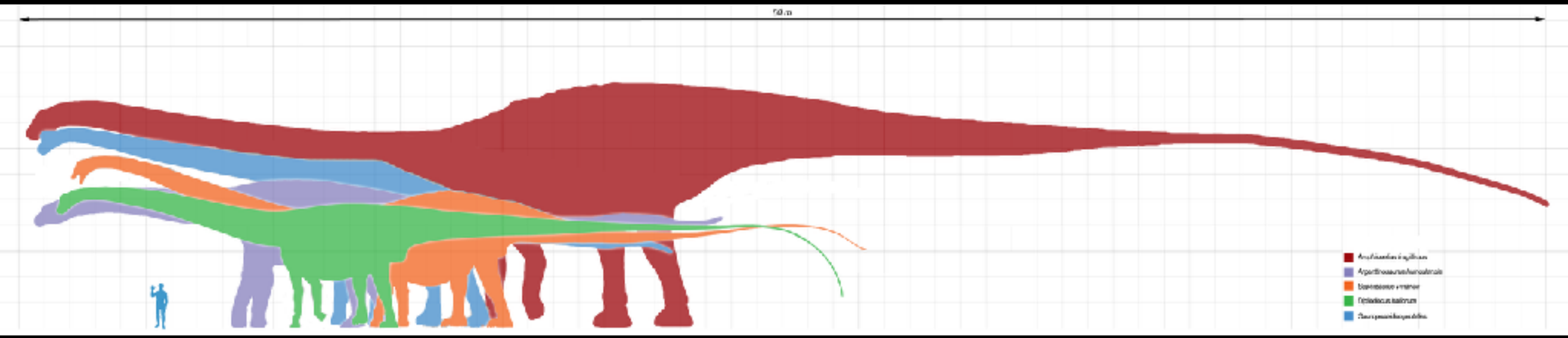


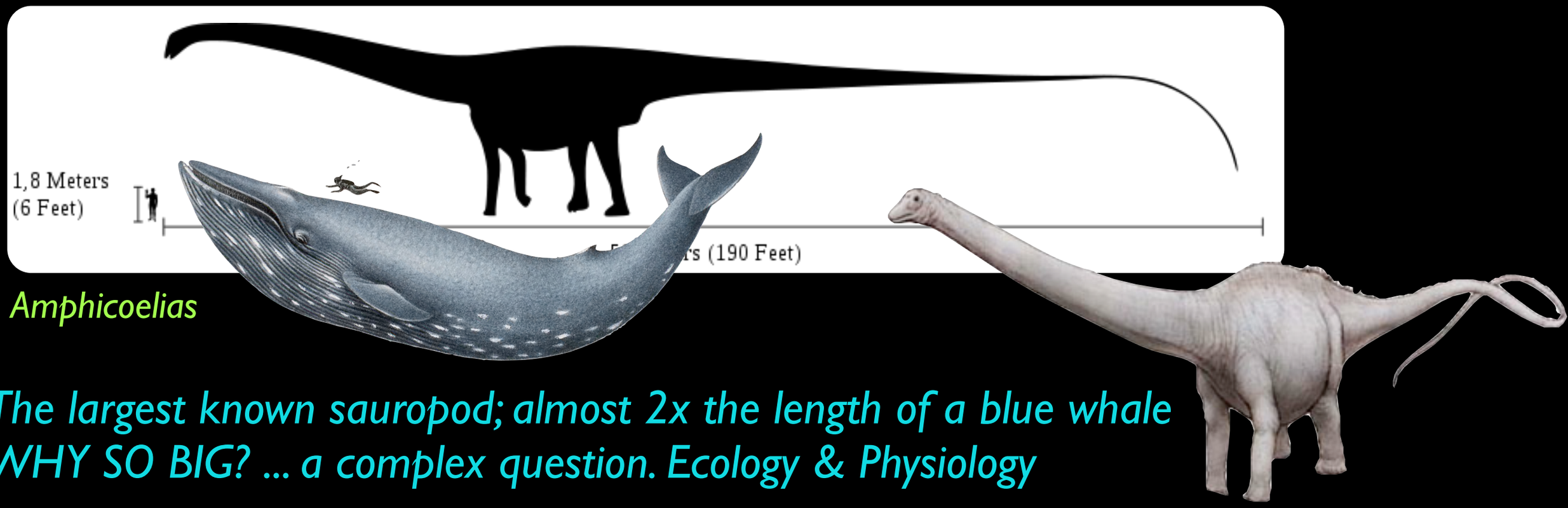
Late Jurassic

54 m (177 ft) long

Compared to Diplodocus, longer neck and shorter tail

Double-beamed chevrons


50 m

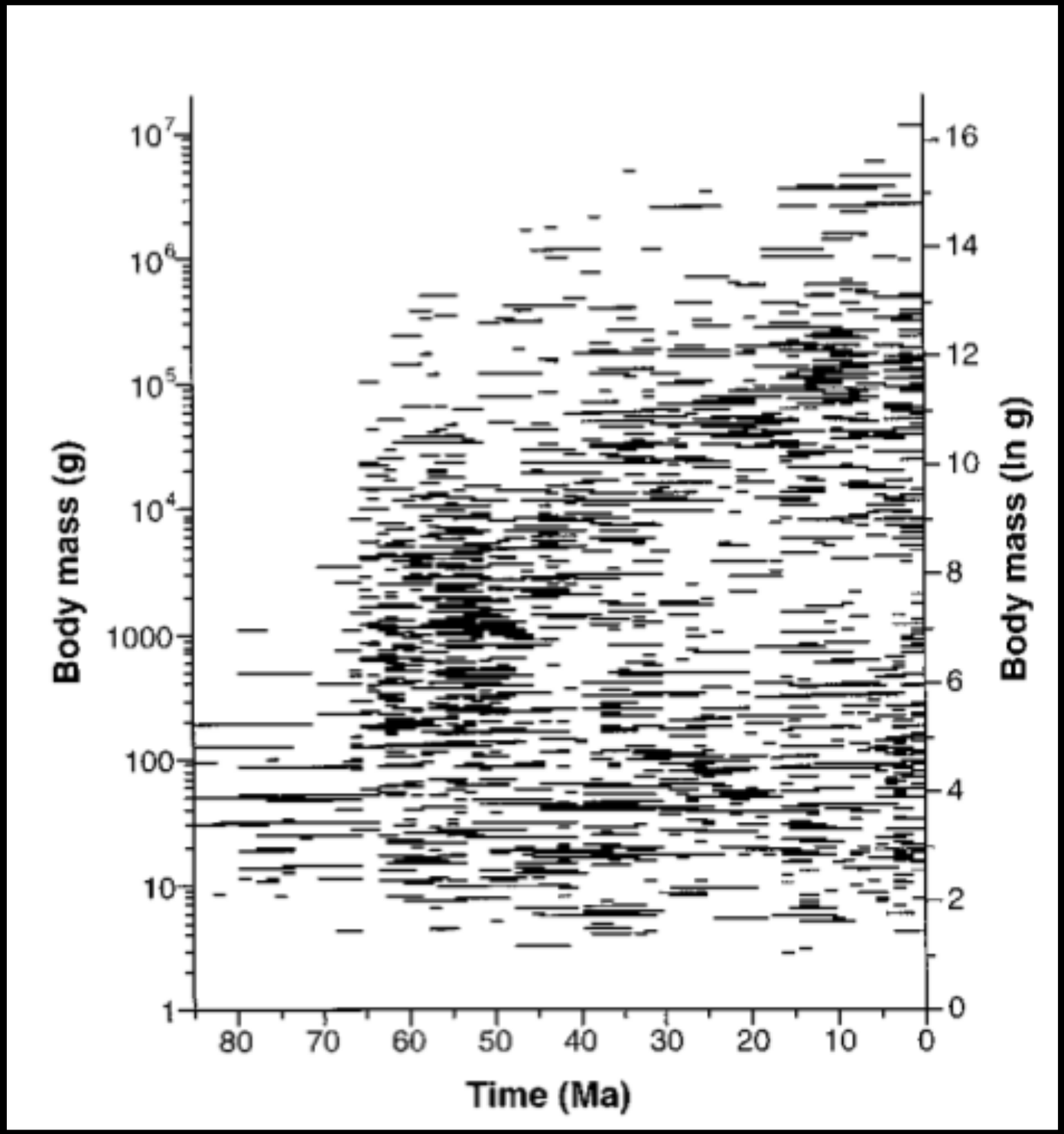


Amphicoelias

The largest known sauropod; almost 2x the length of a blue whale
WHY SO BIG? ... a complex question. Ecology & Physiology

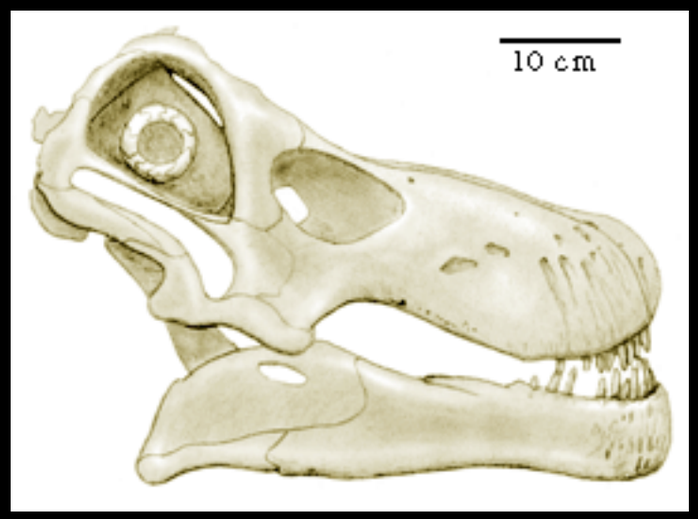
Sauropods attained large body size in the latest Triassic / early Jurassic...
i.e. quickly
Very large body size is found among Diplodocids, Titanosaurs,
Brachiosaurids
Benefits include
- *Obtain food that is out of reach for other animals*
- *Greater ability to digest low-nutrient foods*
- *Higher metabolic efficiency*
- *Escape from predation*

Cope's Rule: Animals tend to increase in body size over evolutionary time

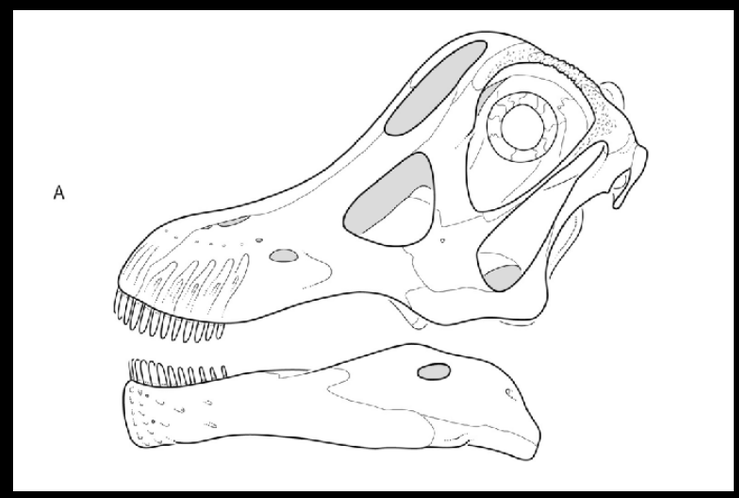


Cope's Rule and the evolution of large body size

Advantages of large body size? Disadvantages?

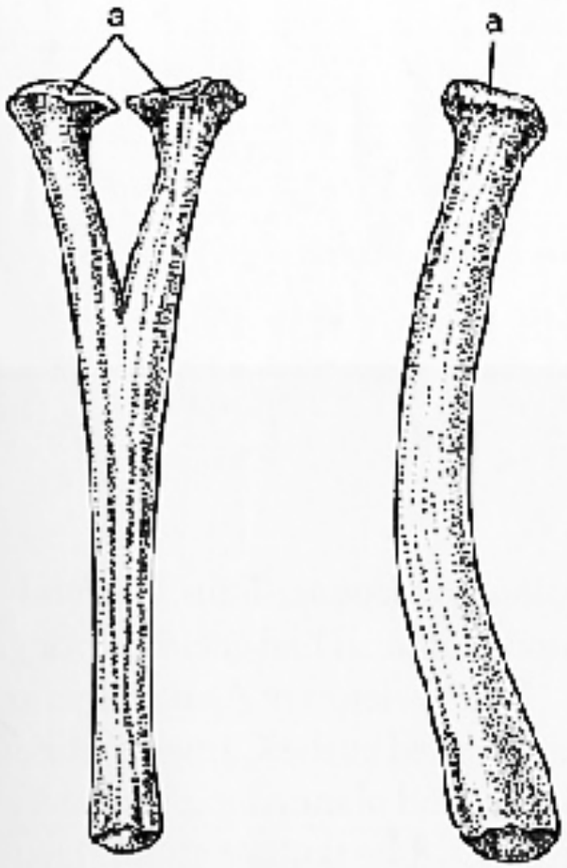


Diplodocid



Titanosaur

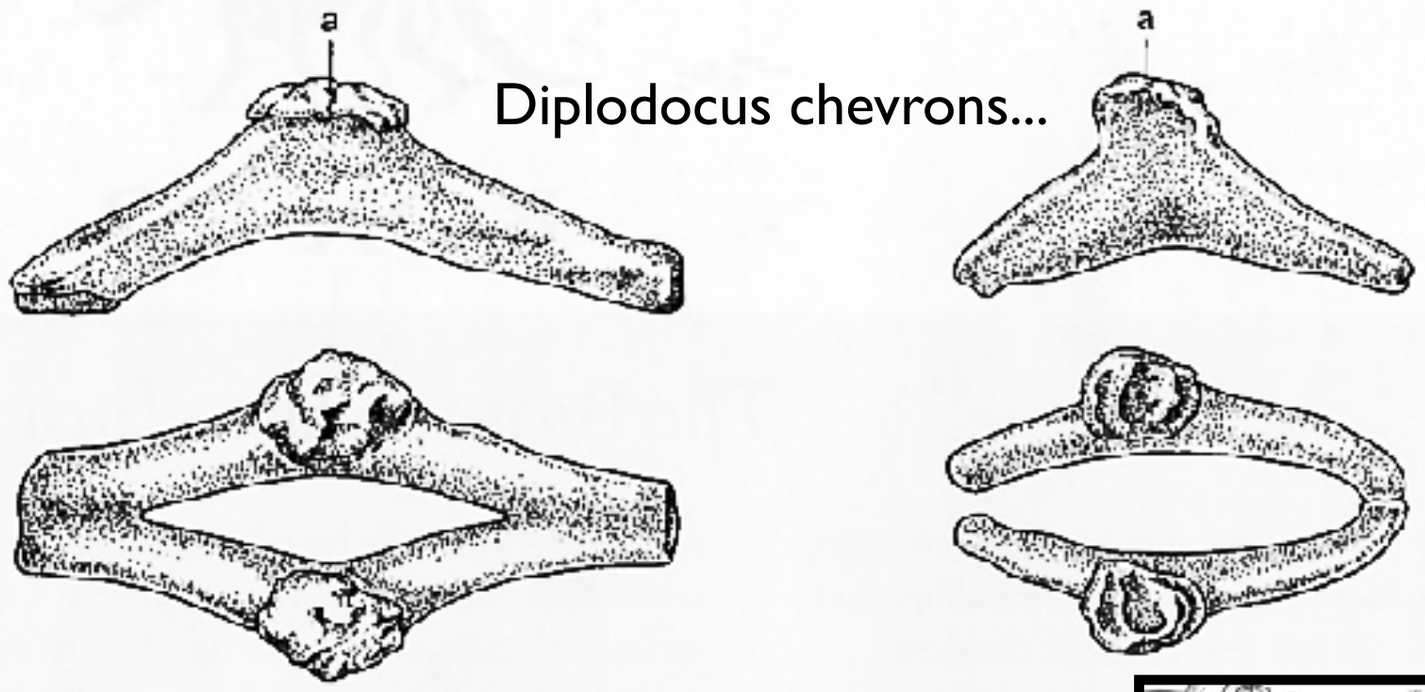
Diplodocid Tails: strange chevrons...



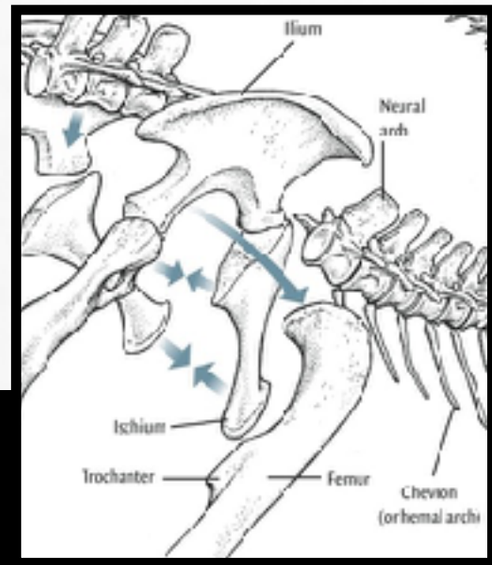
Camarasaurus chevrons

a = articular surface (where chevron connects to the body of the vertebra)

Diplodocus chevrons...



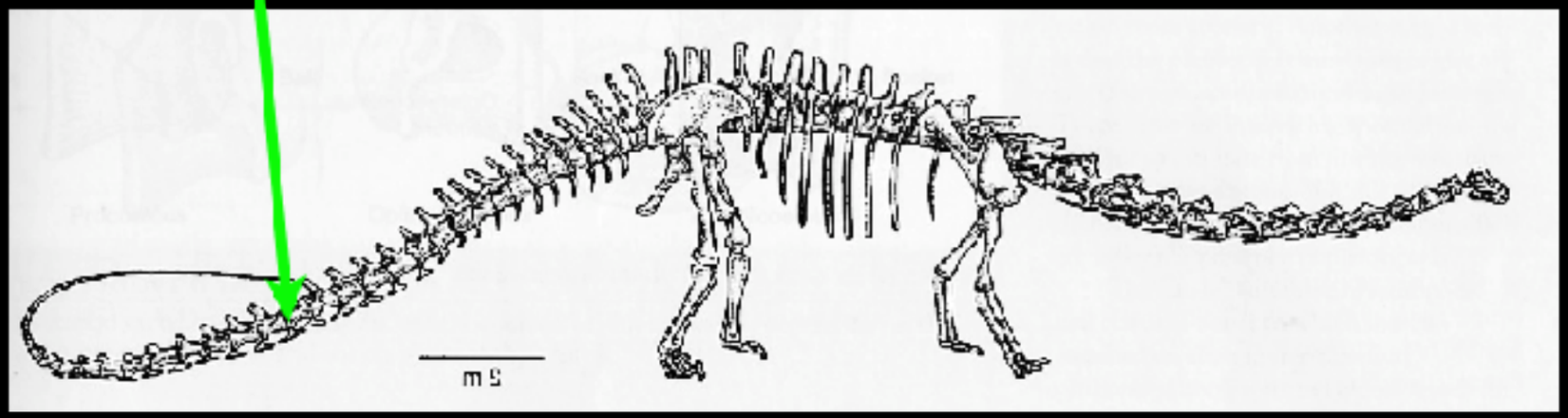
Diplodocus chevrons



Recall...

Modern animals with chevrons (kangaroos, manatees)
Their main function is to protect critical elements in the tail such as nerves and blood vessels from being damaged when the animal either supports its weight on its tail, or pushes it against a hard surface to propel itself.

An explanation for odd mid-caudal chevrons?



Walking with Dinosaurs:

Diplodocus clearing forest @ 15:00

Mating & defense @ 23:00

Herding?

Shunosaurus
Diplodocus
Camarasaurus

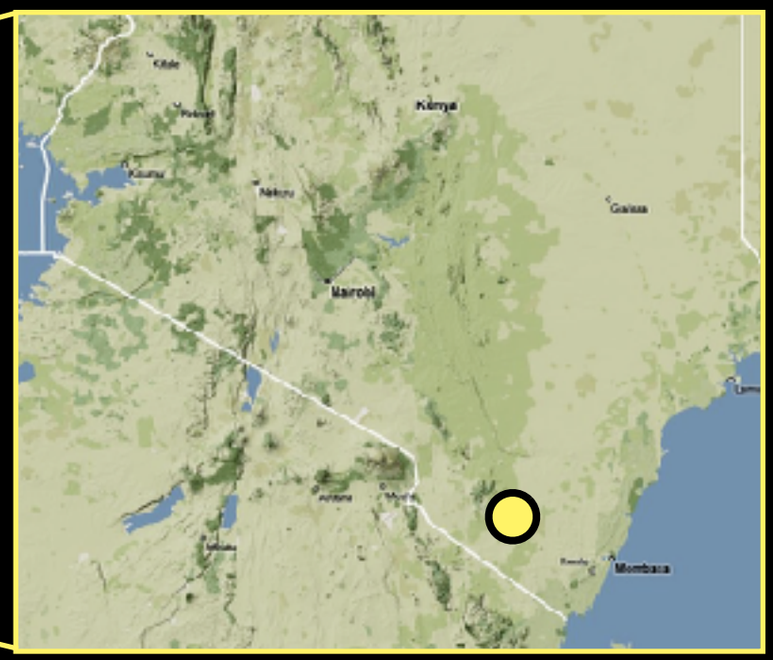
Ecosystem Engineers

Along the Tsavo Railroad: From Slave Trade to Ivory

Less Elephant poaching Tsavo: 1970

More Elephant poaching Tsavo: 1994

Tsavo, 1898



March, 1898

Arrival

April

Many Attacks

May

June

Few Incidents

September

November

"Reign of Terror"

December

December 9, 1898

First Lion Killed

December 29, 1898

Second Lion Killed

"WHEN THE TRAP WAS READY, I PITCHED A TENT OVER IT."

Tsavo 1898

- elephants

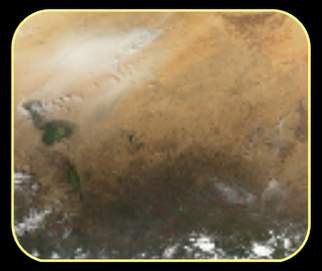
+ woodlands

Rinderpest

=

hungry lions

+ droughts

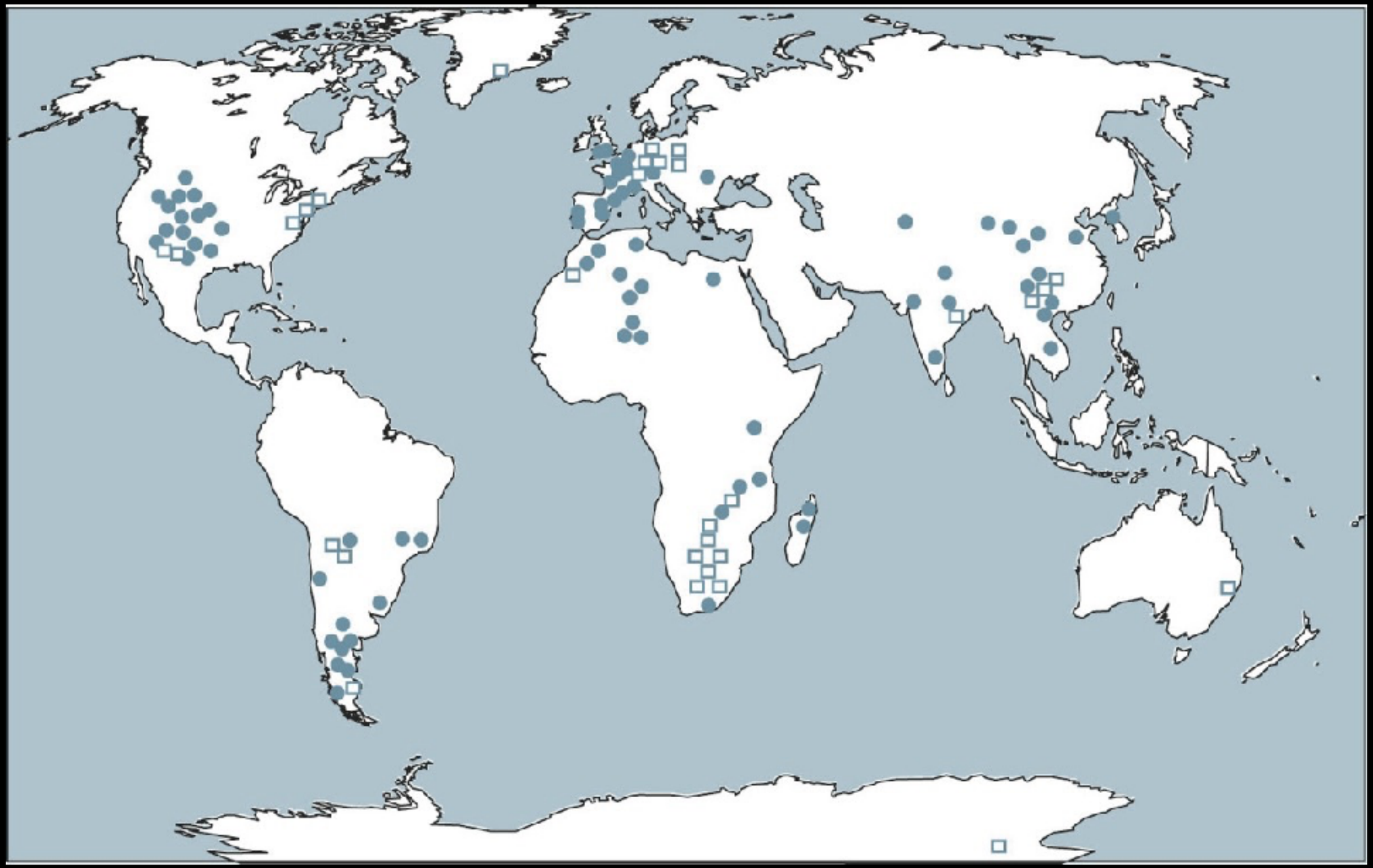


novel prey?

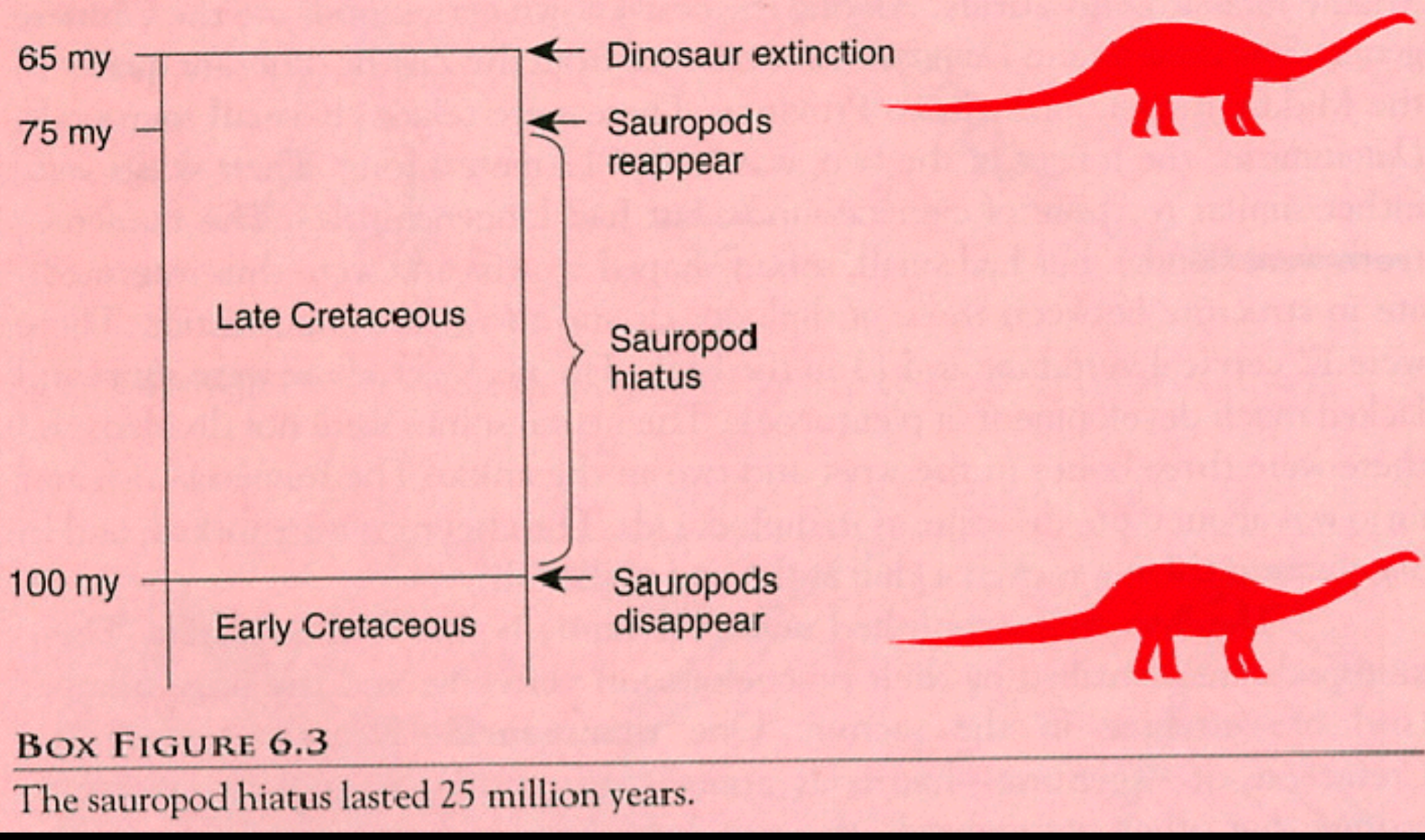
1st man-eater
FMNH 23970

2nd man-eater
FMNH 23969

Sauropod Lifestyles



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."


Illustration by Jon Taylor

Tail variations involve and increase in tail vertebrae from 44 - 80 (Apatosaurus & Diplodocus)
Why?

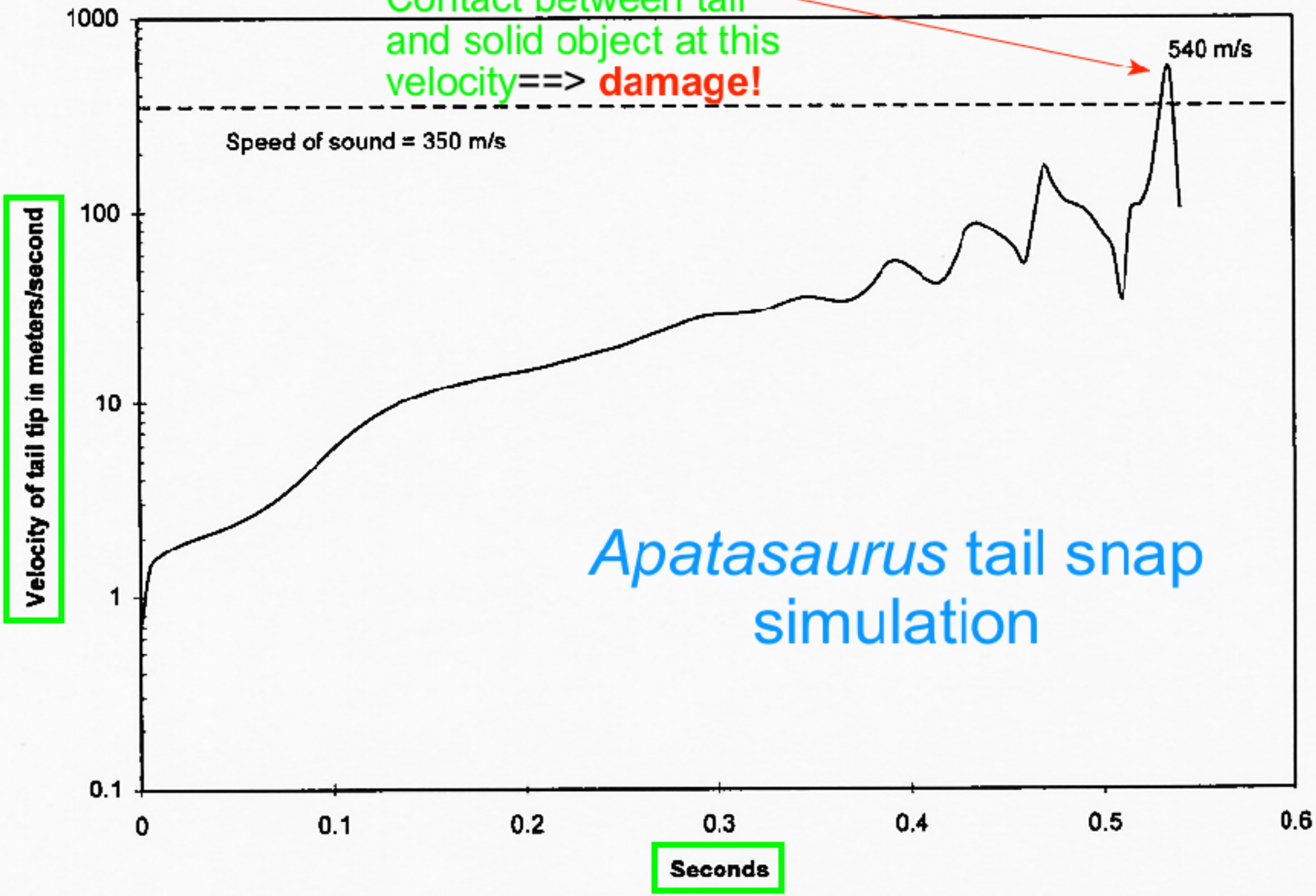


FIGURE 6. Distal tail tip velocity versus time from one simulation for the reconstructed tail of *Apatosaurus* CM 3018.

https://www.livescience.com/52538-supersonic-sauropods.html

Supersonic Diplodocid tails?

FOR

1. Tail proportions work
2. Extreme thinness and elongation of distal tail vertebrae
3. Unusually long, stiffened vertebrae at the very end of the tail

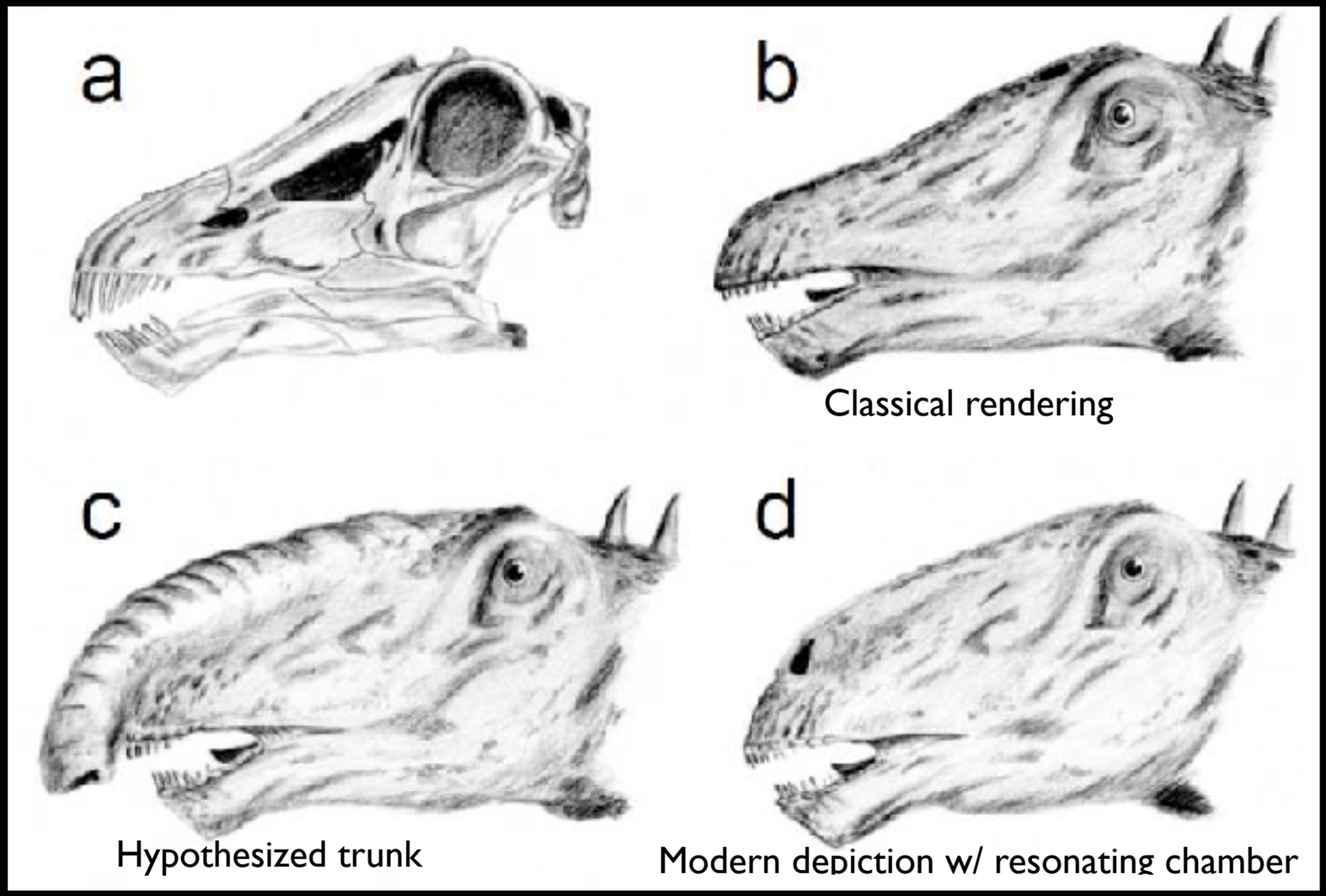
AGAINST

1. Tail tips highly vulnerable to damage on impact

"It is pleasant to think that the first residents of Earth to break the sound barrier were *not* humans."

Accessories

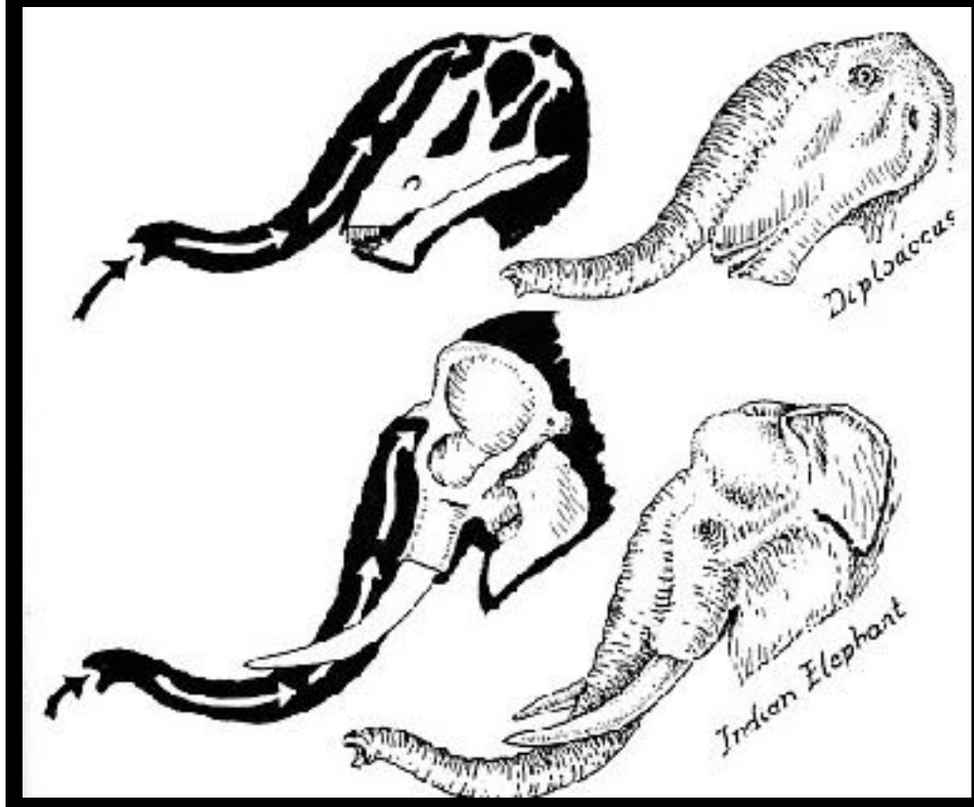
Accessories



Classical rendering

Hypothesized trunk

Modern depiction w/ resonating chamber



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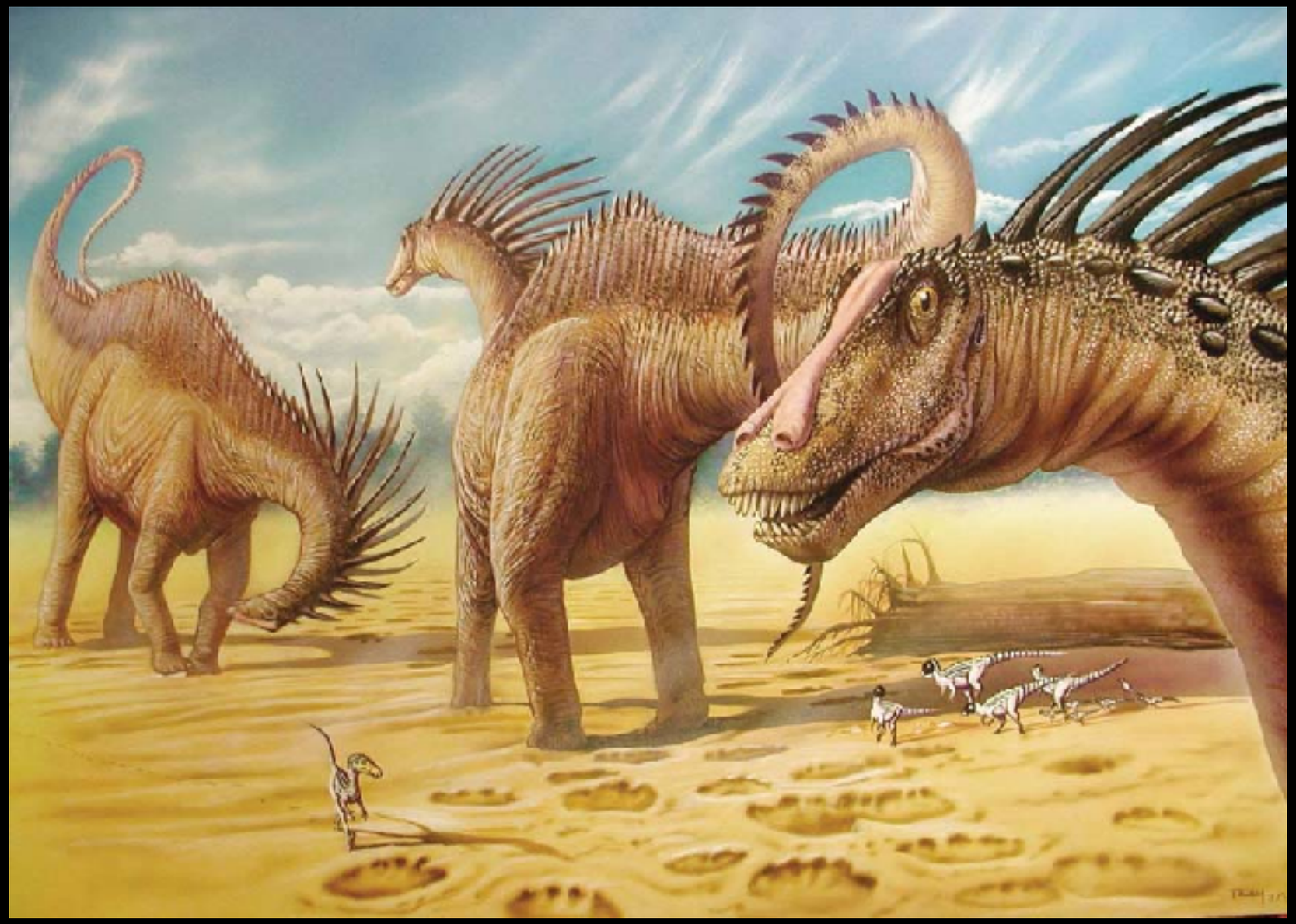
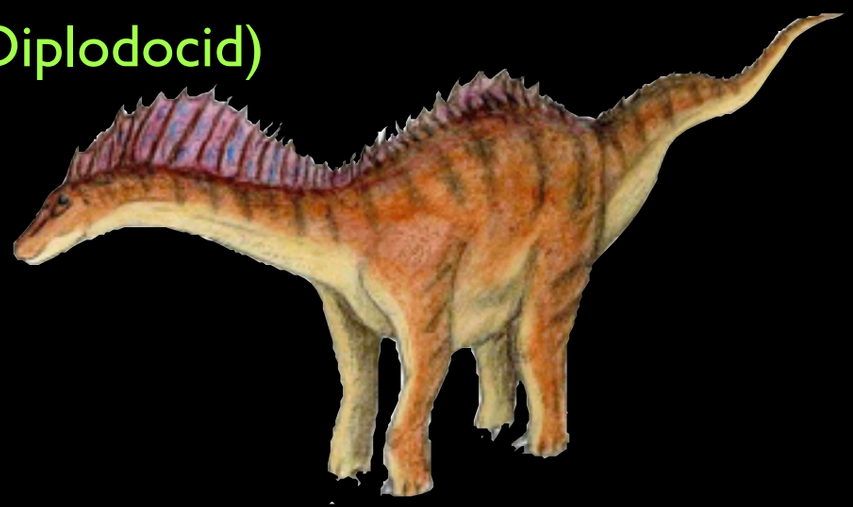


Vertebral spines: *Amargasaurus* (Diplodocid)



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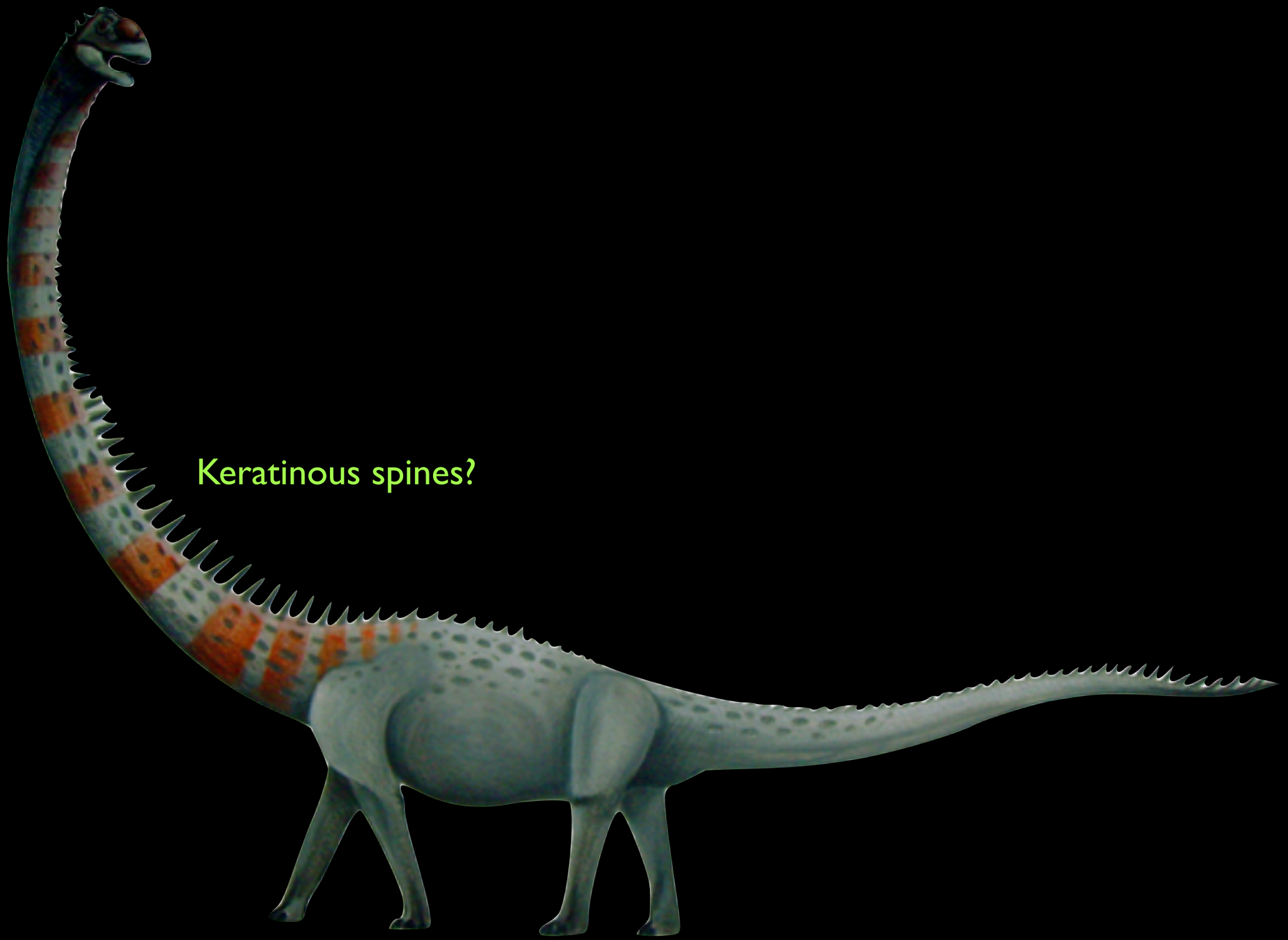
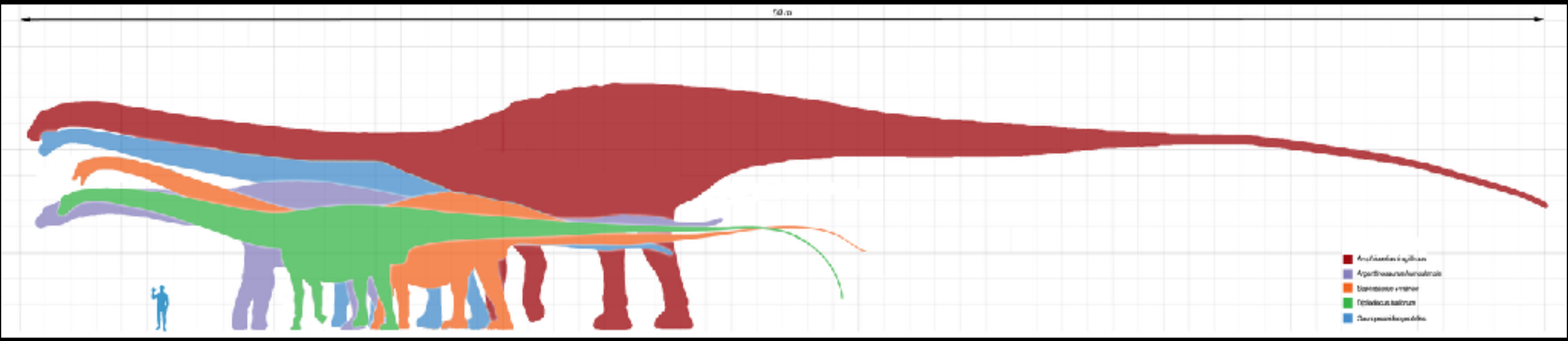


Keratinous spines?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