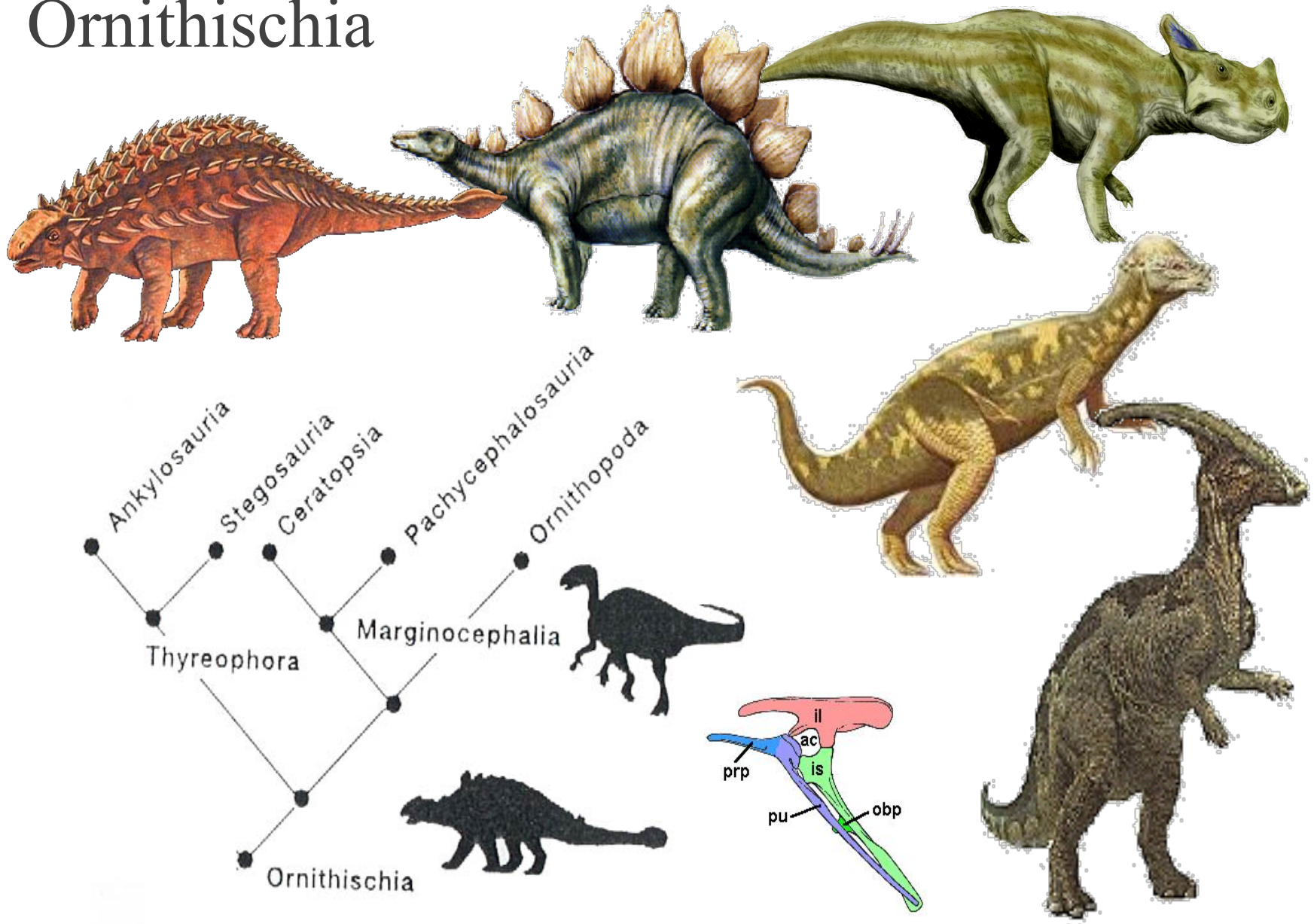
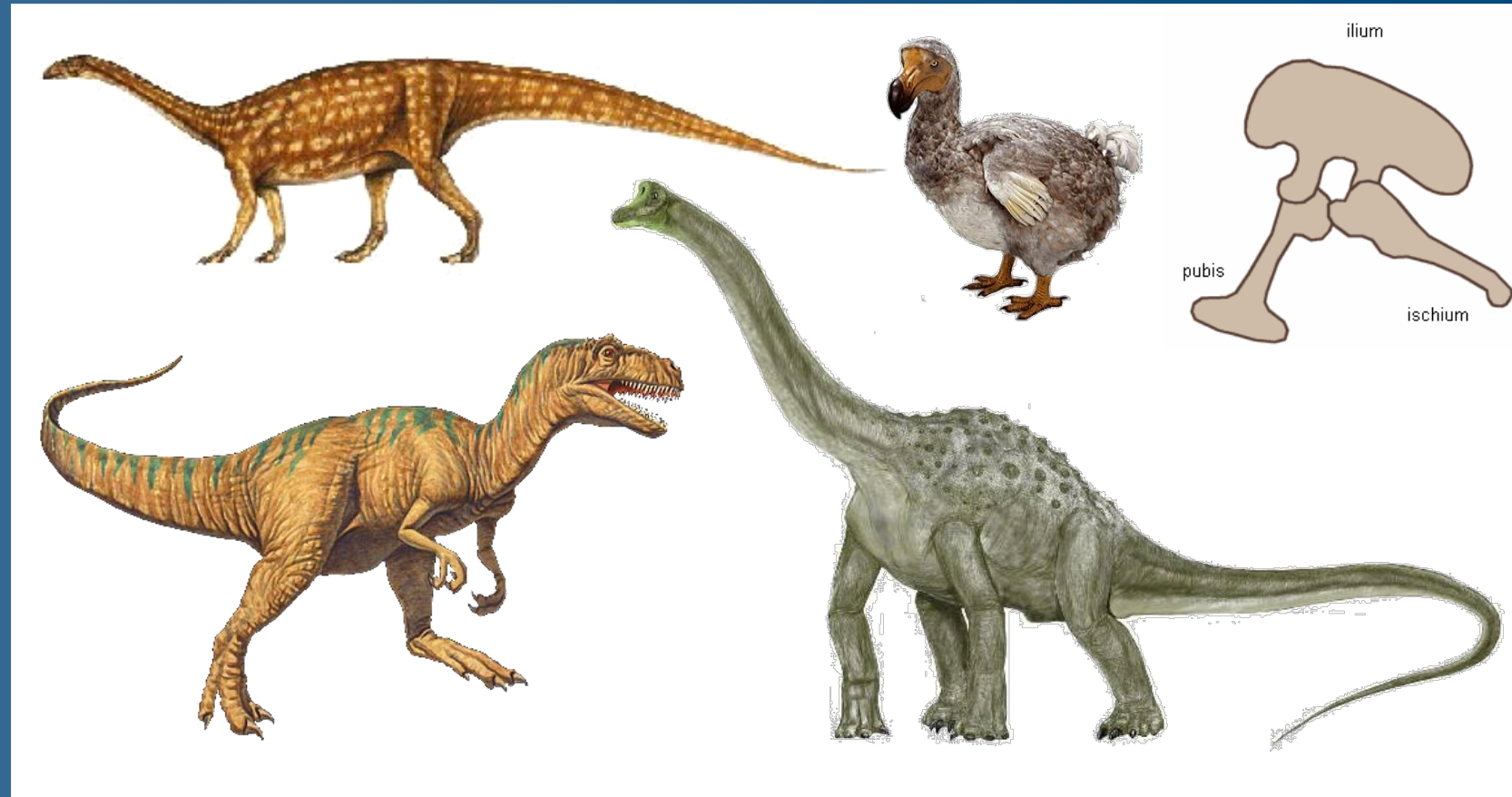


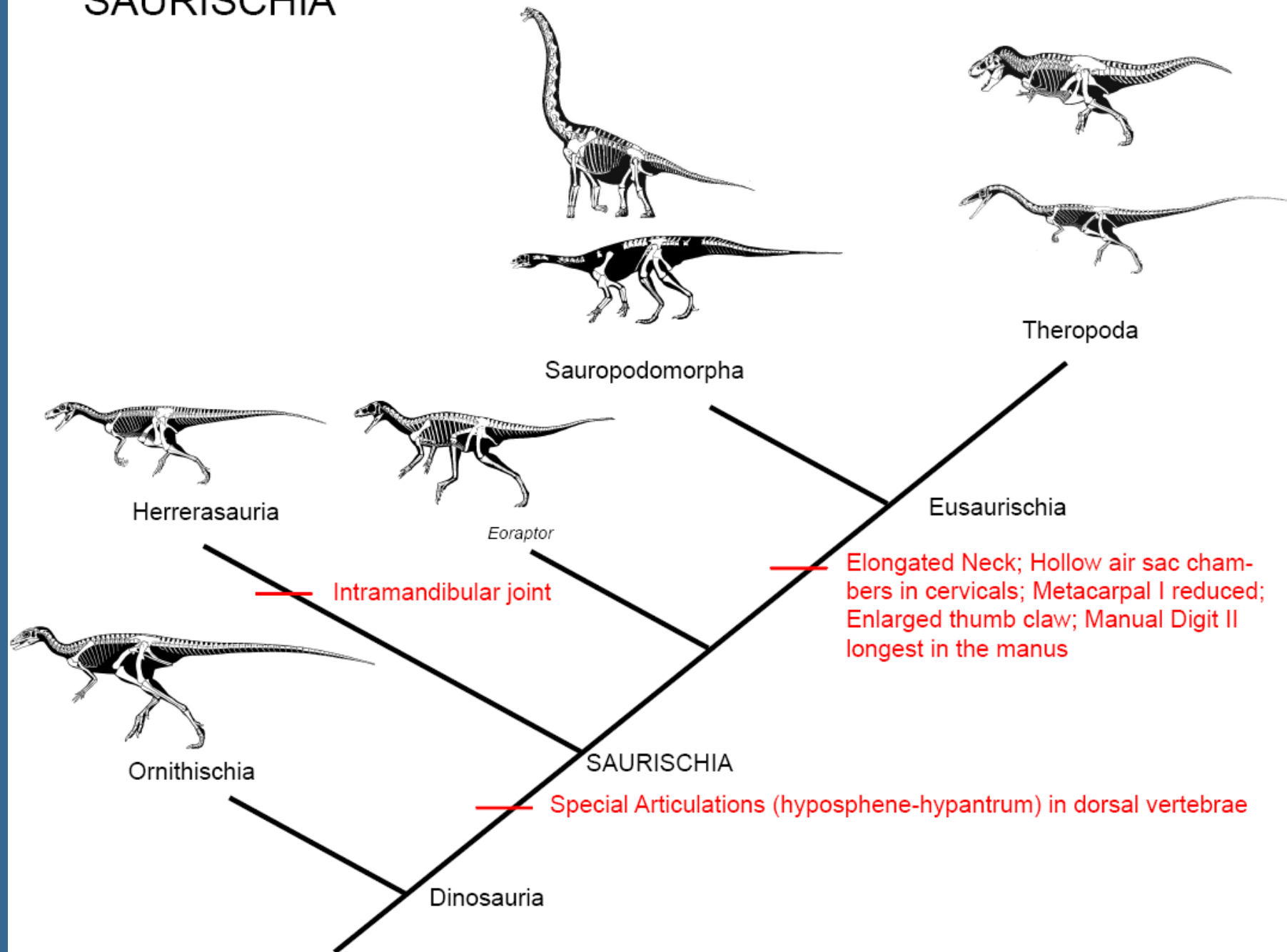
Ornithischia



Saurischia

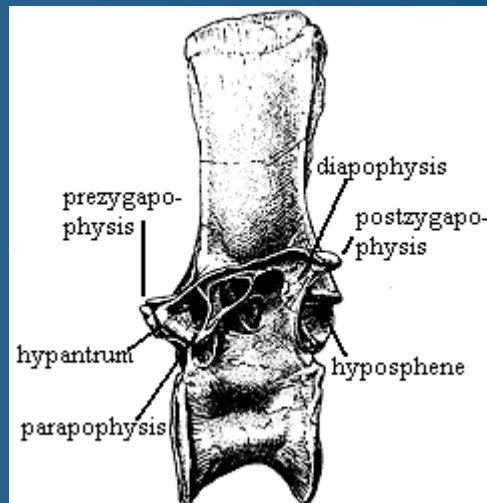
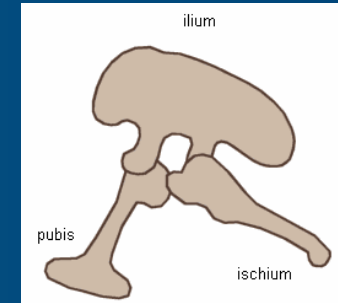


SAURISCHIA

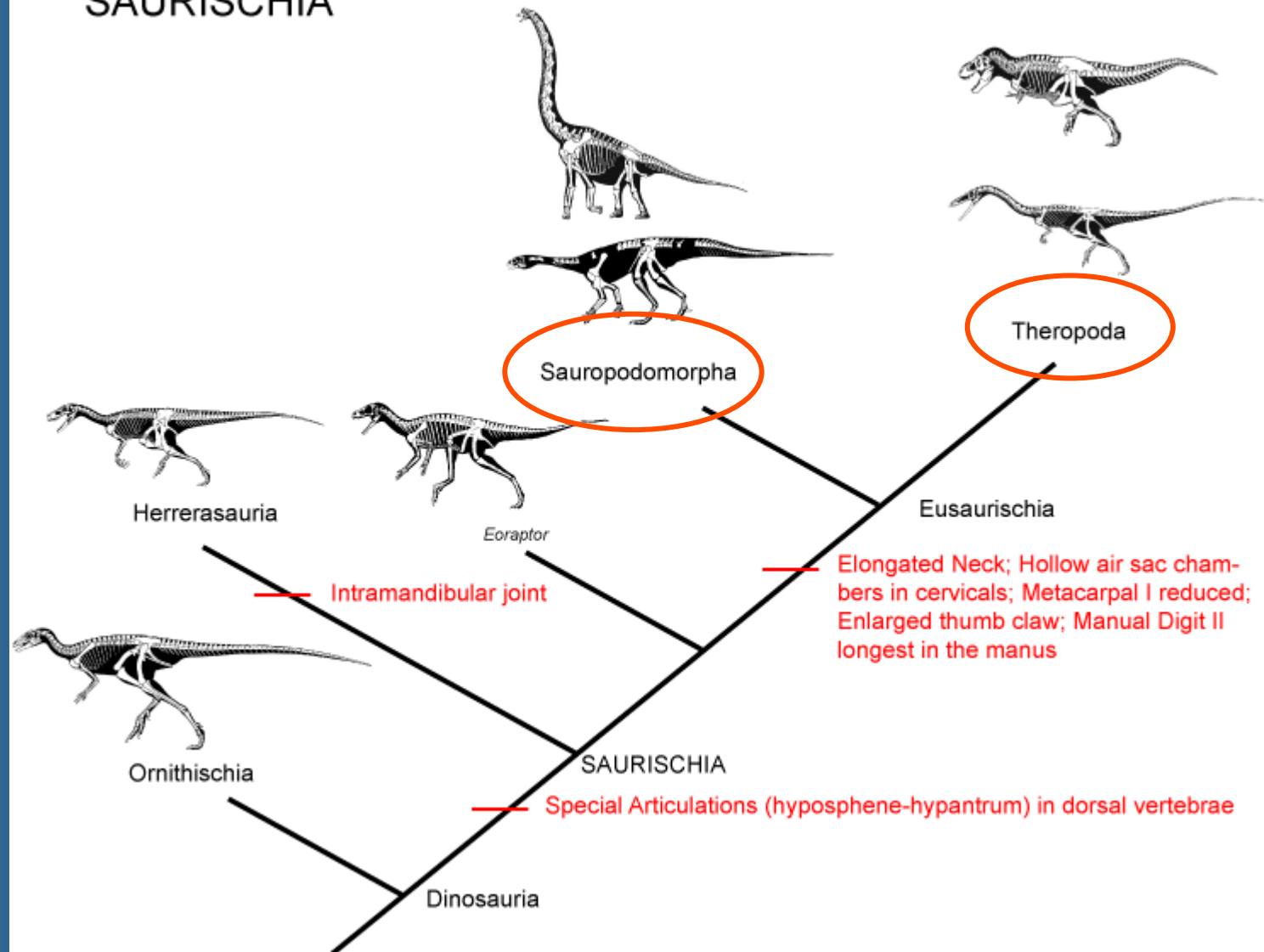


What are saurischian dinosaurs?

- have a saurischian hip (keep ancestral configuration)
- Special articulations between dorsal vertebrae (called hyposphene-hypantrum articulations)
- Complex chambers in vertebrae
- **Elongate necks** with posterior cervicals longer than anterior ones
- Manus with an **enlarged digit I ungual** (thumb claw)
- **Manual digit II is the longest in the hand**



SAURISCHIA

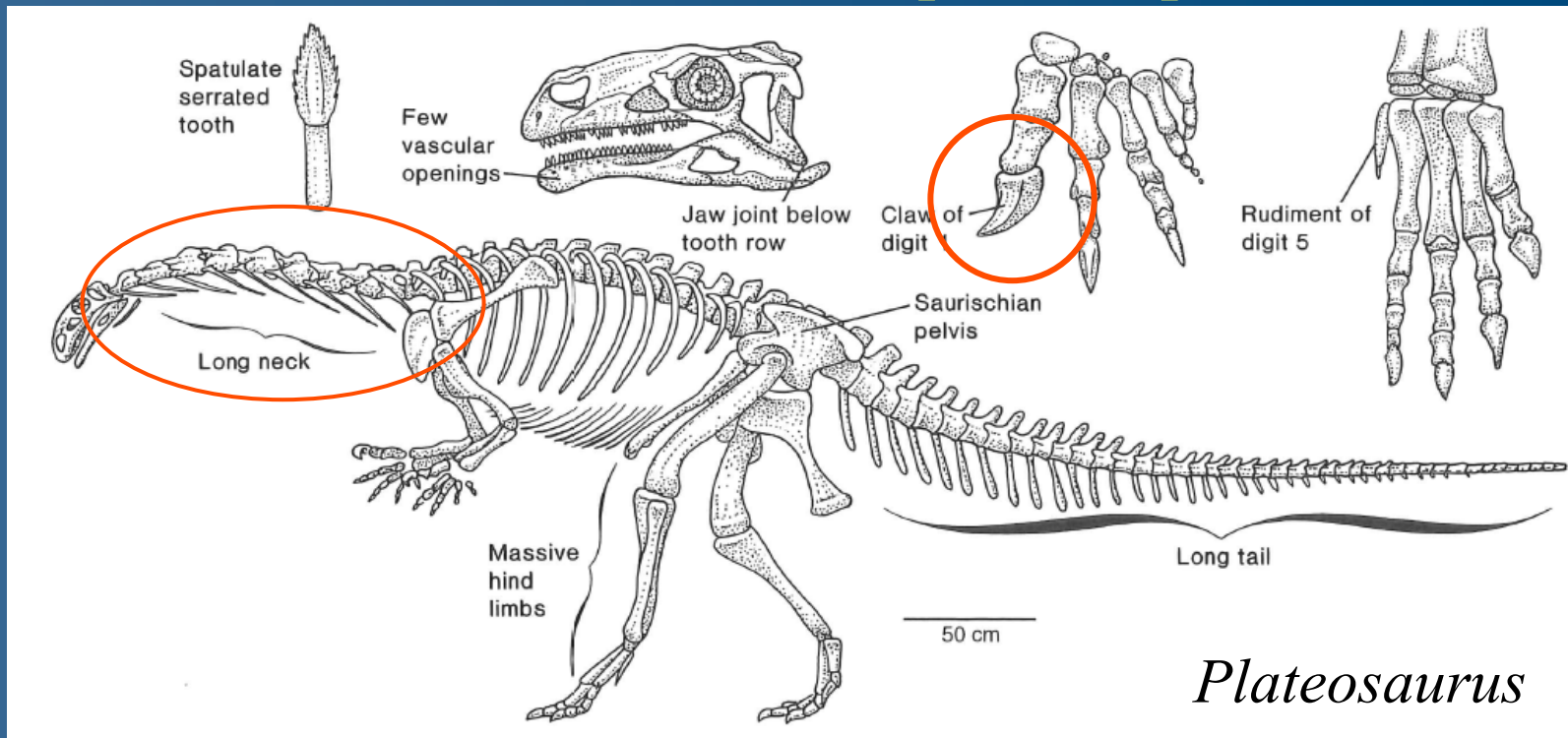
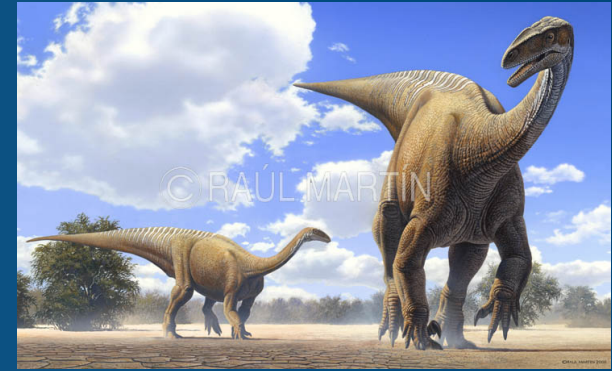


Saurischia: group 1

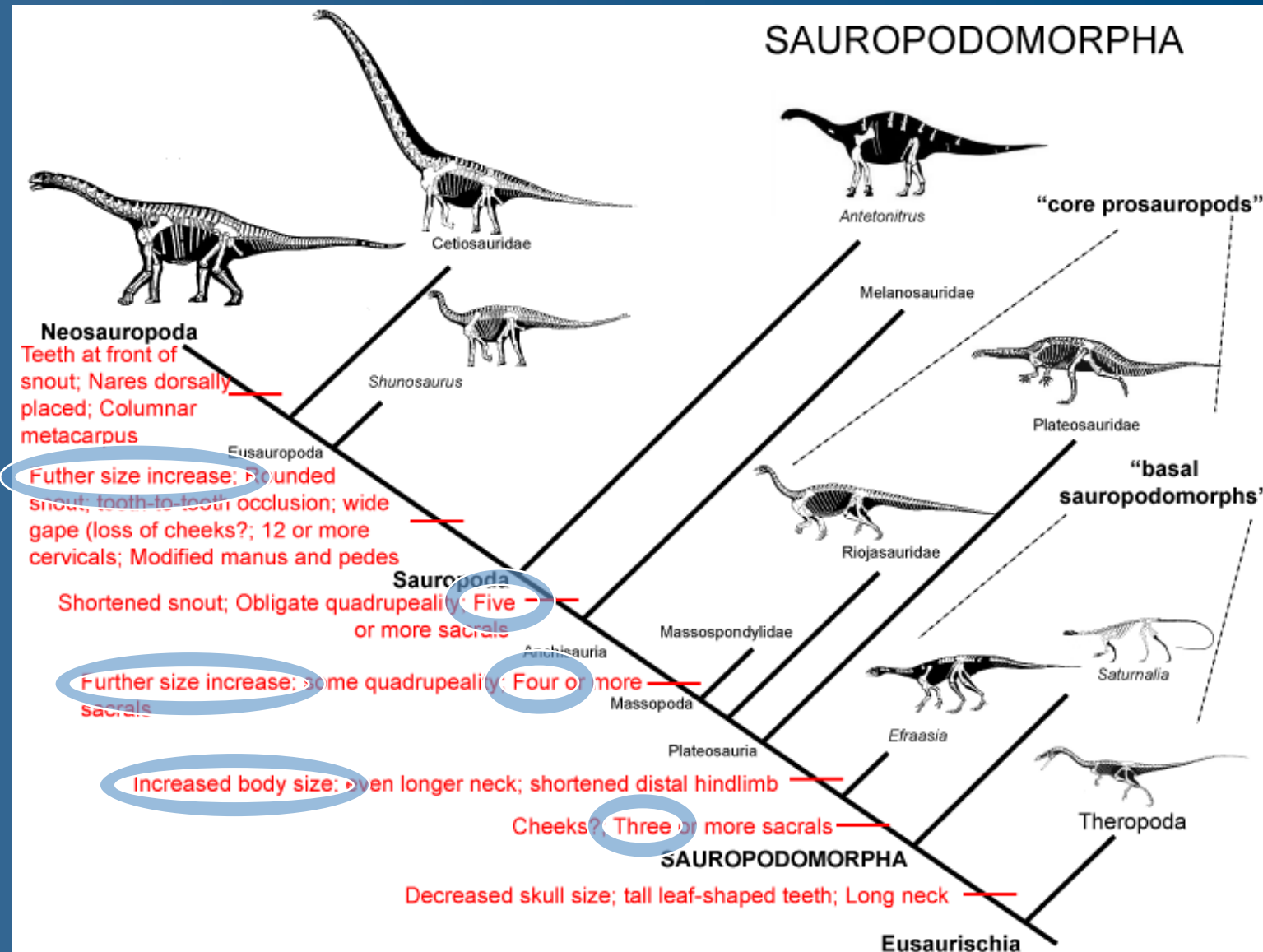


Sauropodomorpha

- plant eaters → tall, **leaf-shaped teeth**
- decreased skull size
- **elongated neck**
- include the largest land animal of all time (35 m, 100 t)
- since the Late Triassic (world-wide distribution, except Antarctica))
- evolution starts with the so called **prosauropods**

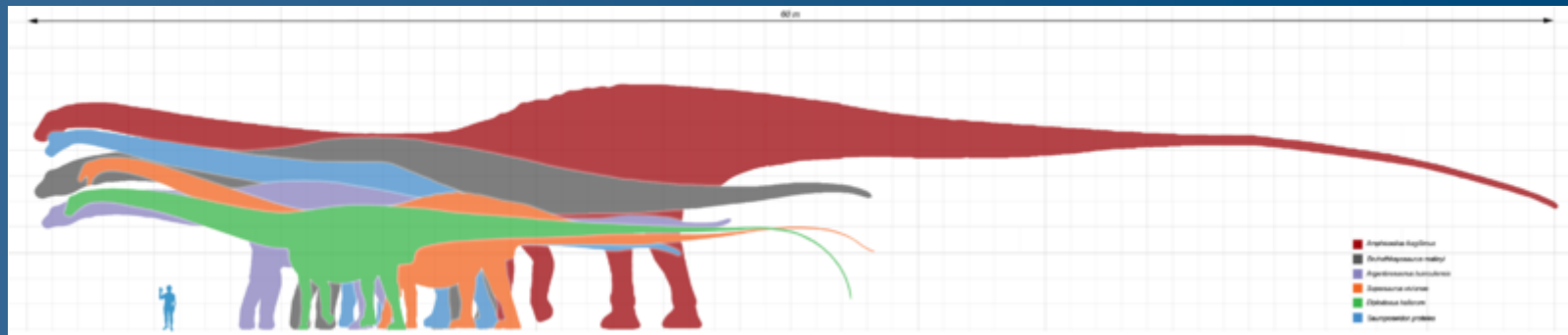


Sauropodomorpha

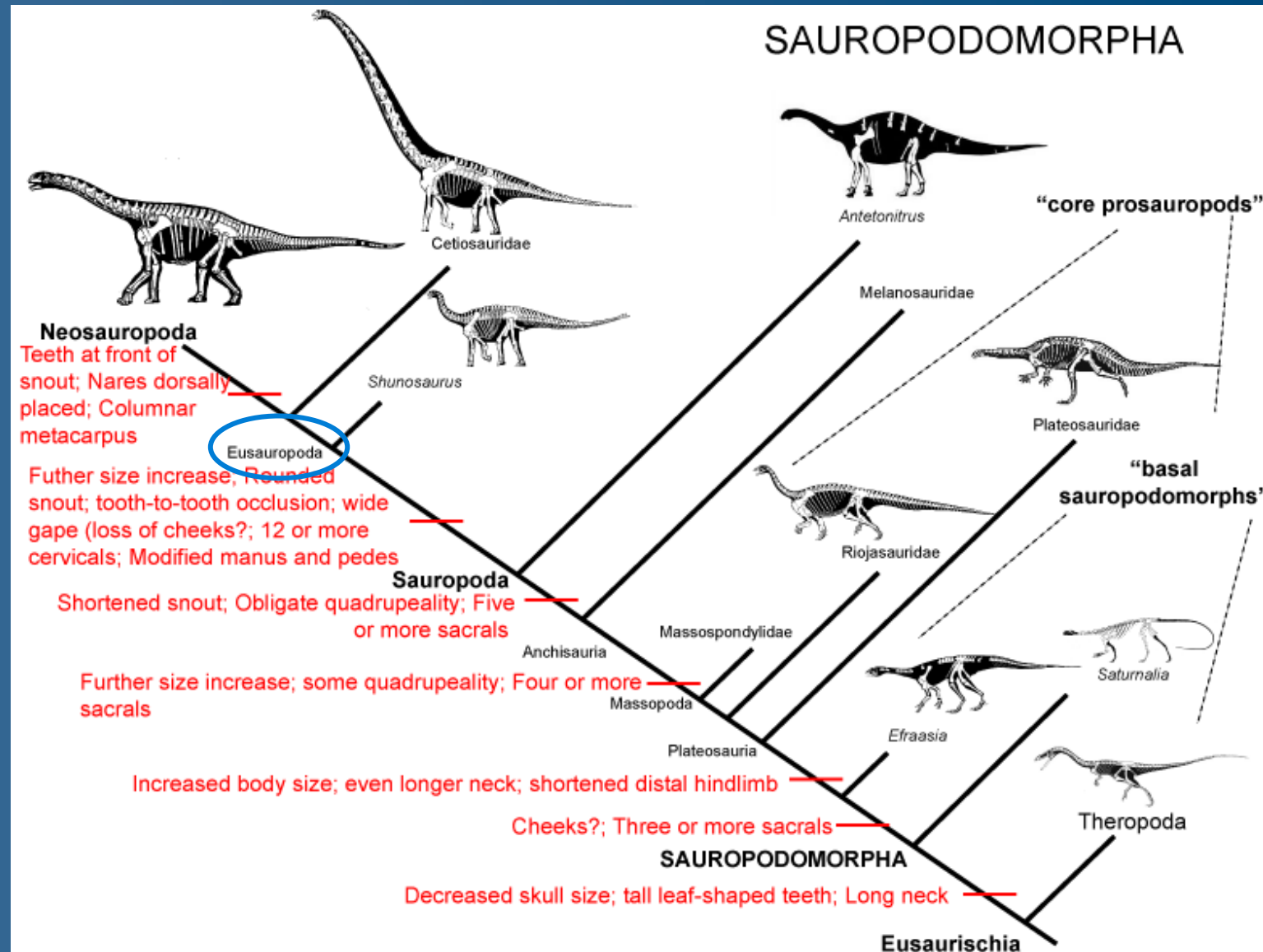


Sauropoda

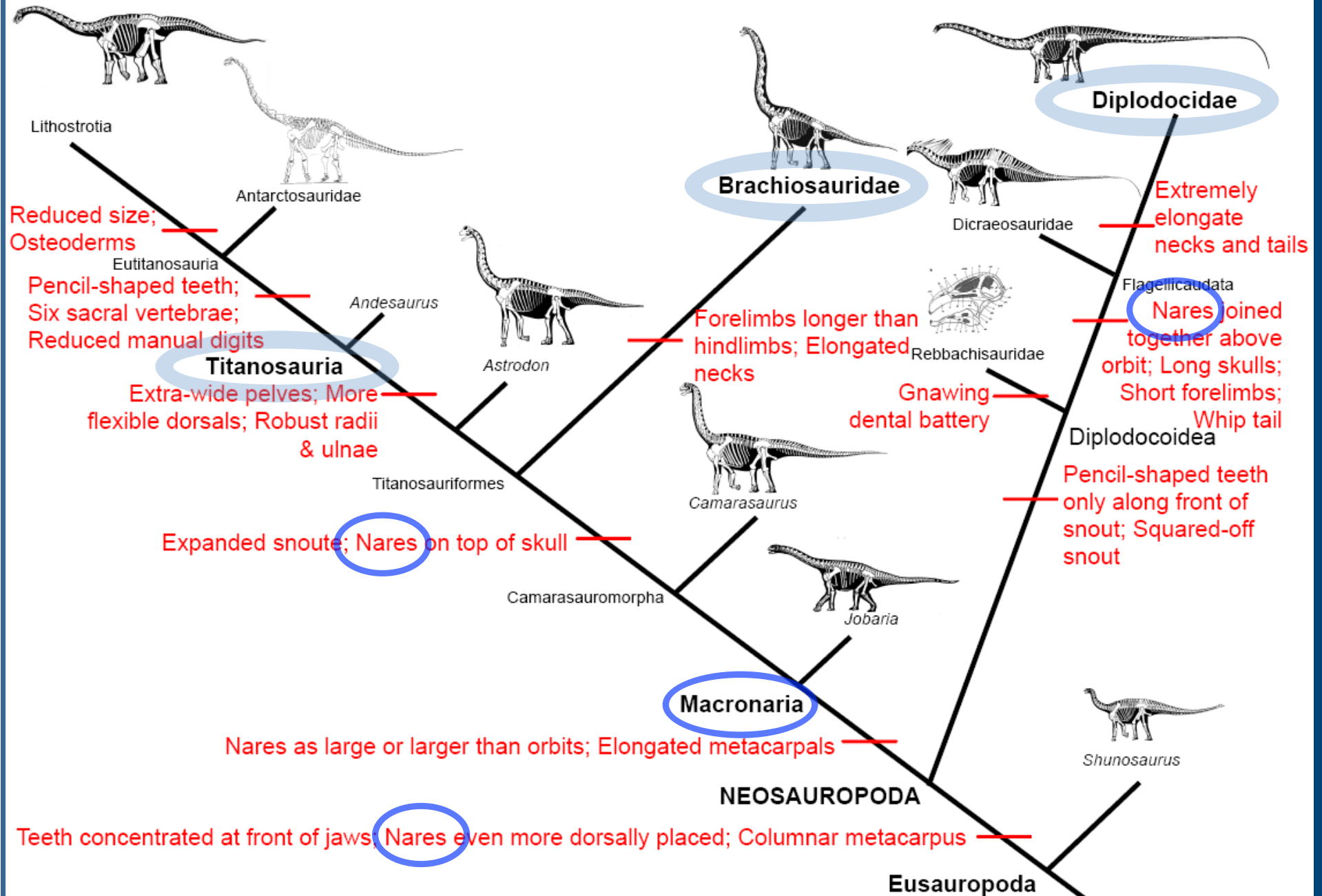
- the snout gets shorter and shorter
- increase in size, sacral vertebrae, neck length
- obligate **quadrupedal**
- **teeth** change from leaf-shaped with big denticles to **spoon-shaped** with few or no denticles
- Loss of grasping ability – hand becomes just a "front foot"
- since the Late Triassic but become common not before the Middle Jurassic



Sauropodomorpha



NEOSAUROPODA

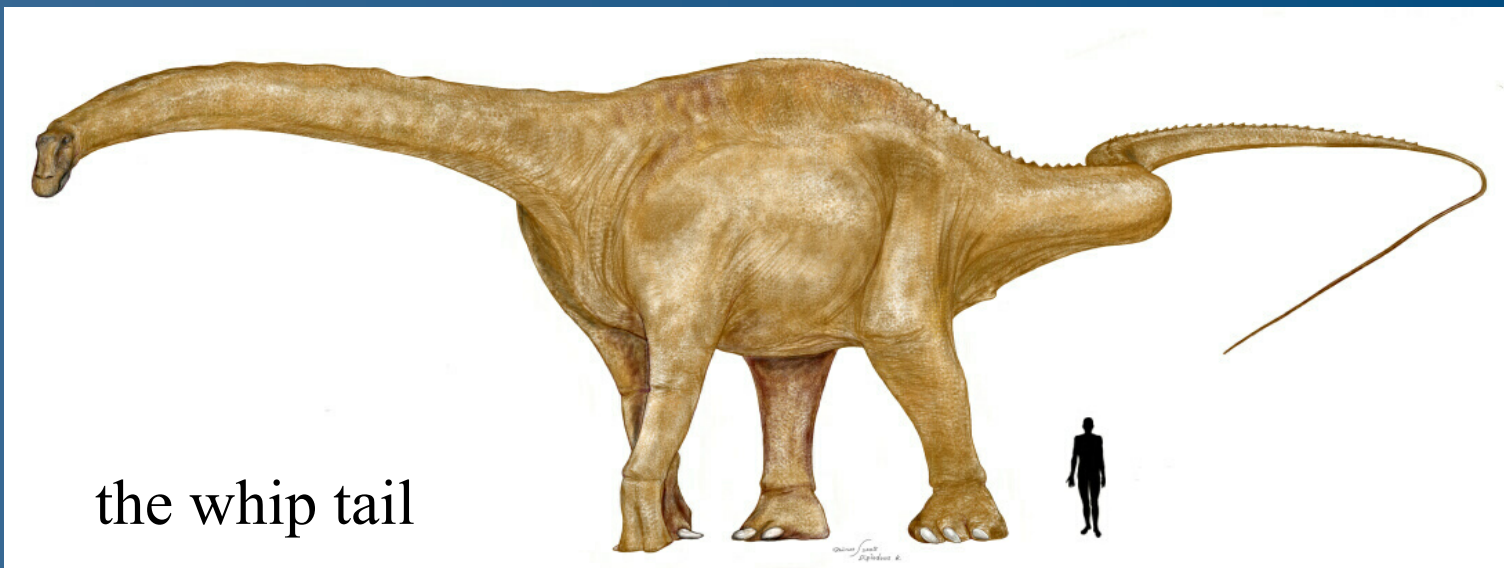


Diplodocus

Marsh, 1887

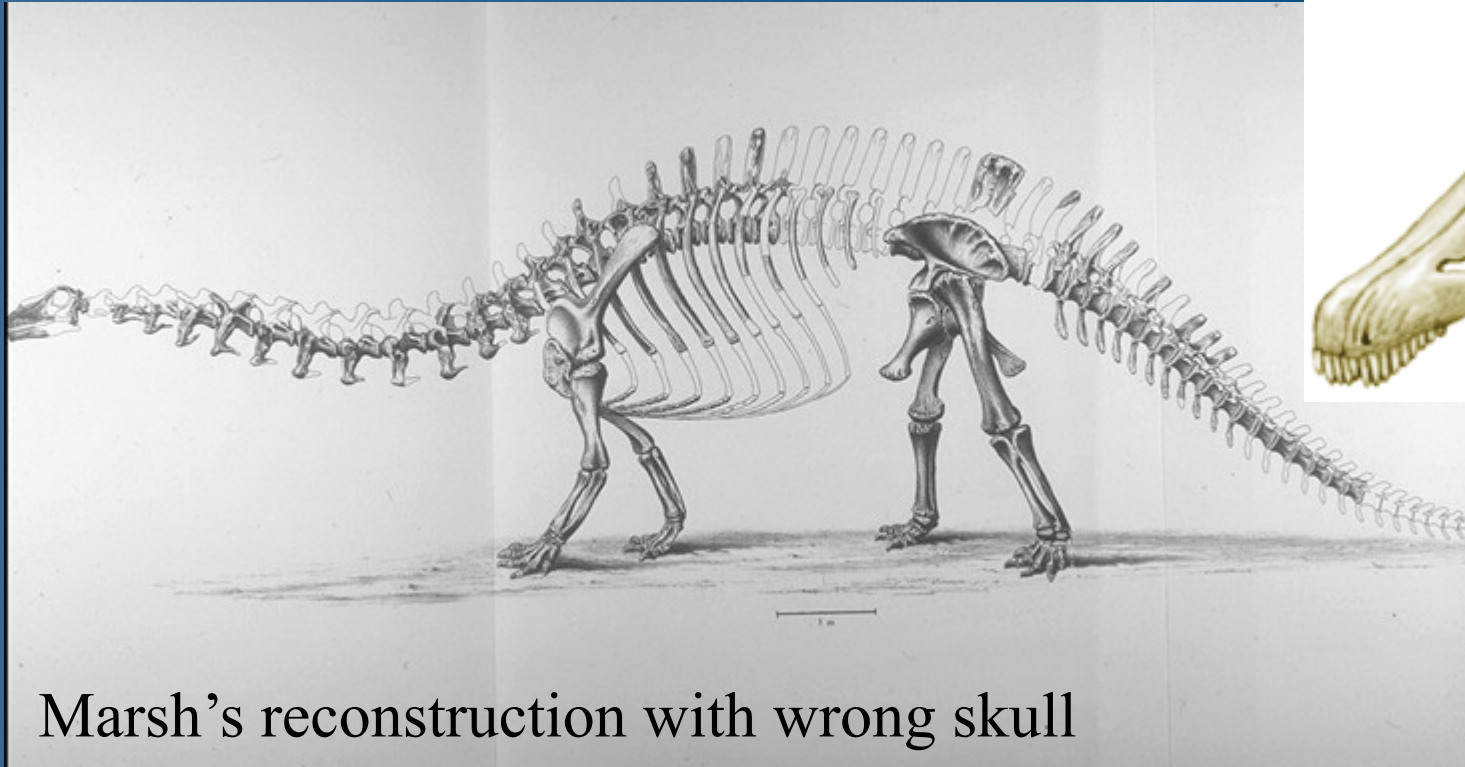


pencil-shaped teeth and long sloping skull



the whip tail

Apatosaurus Marsh, 1877 (= *Brontosaurus* Marsh, 1879)



Marsh's reconstruction with wrong skull

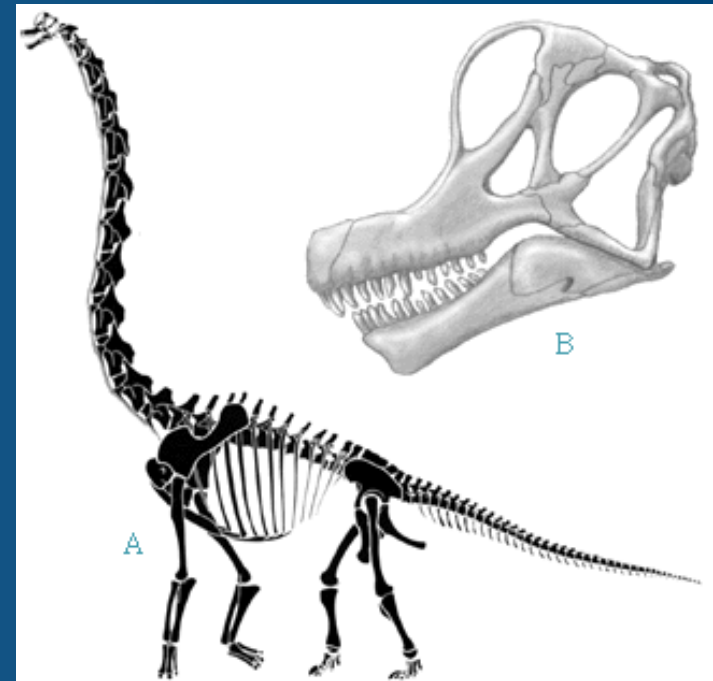


Forelimbs much shorter than hindlimbs

Brachiosaurus

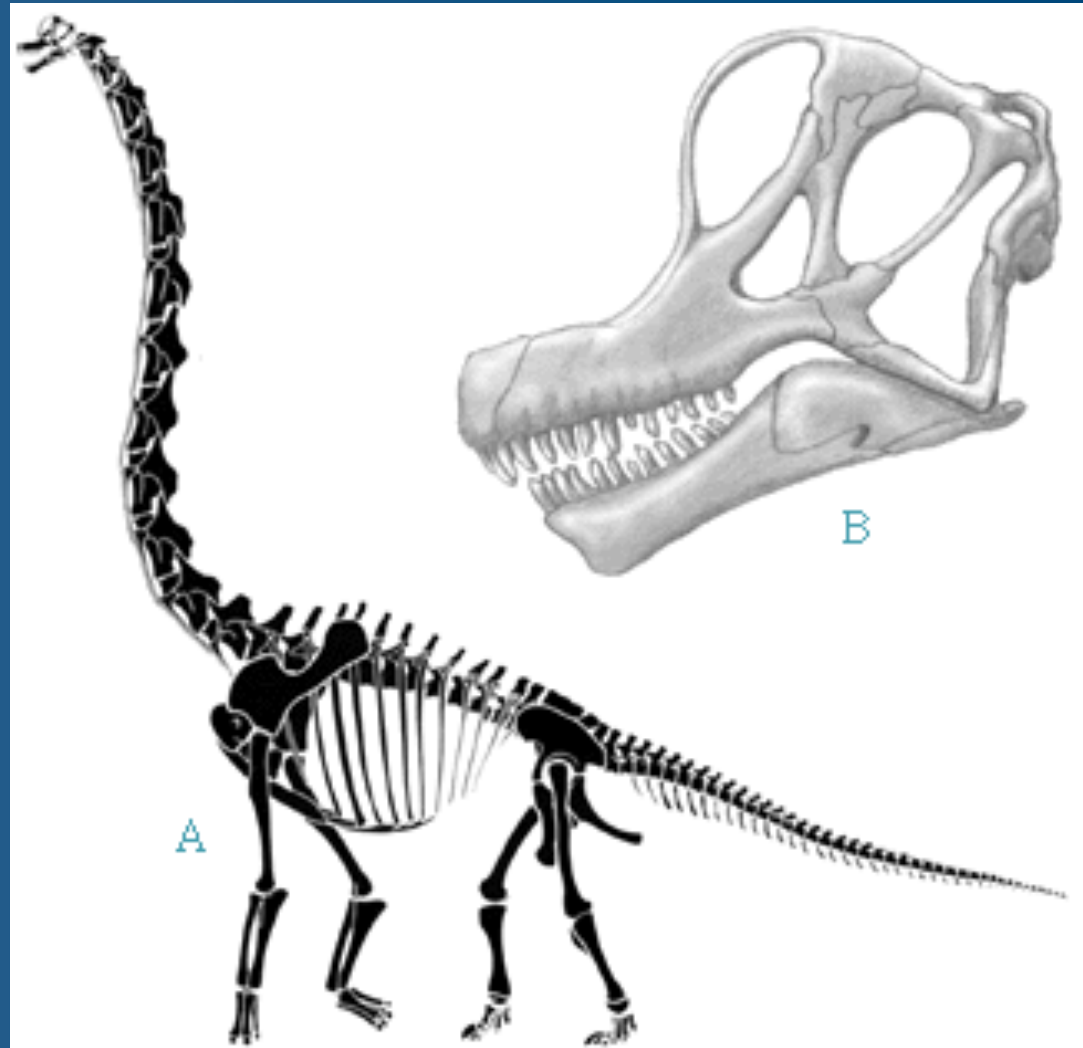
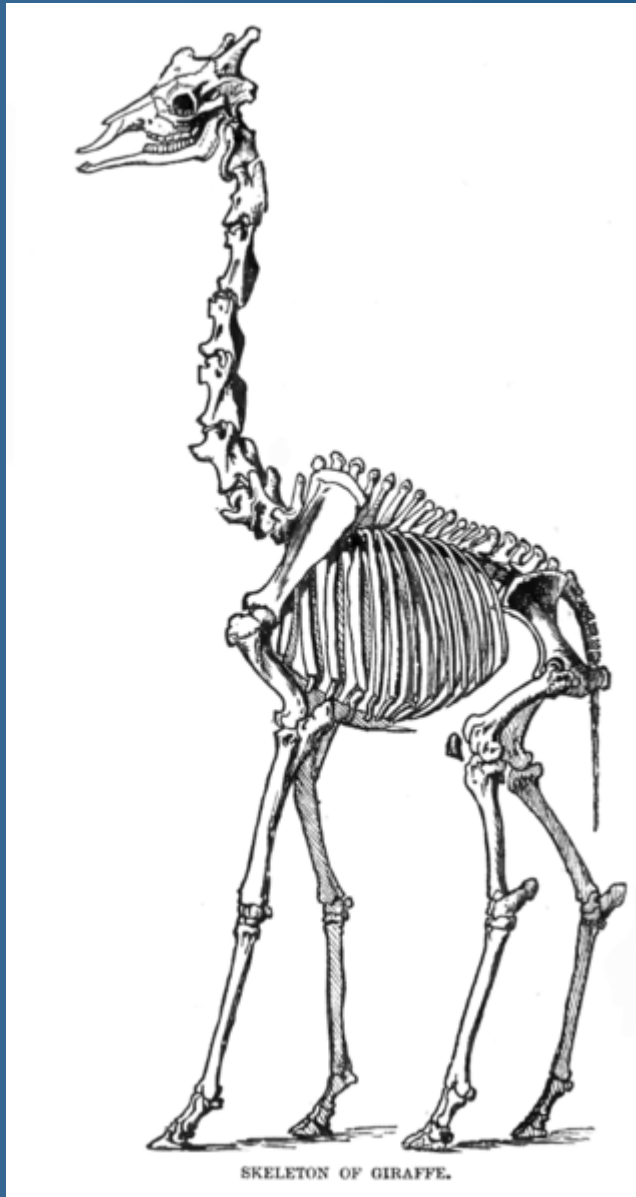


forelimbs longer than hindlimbs



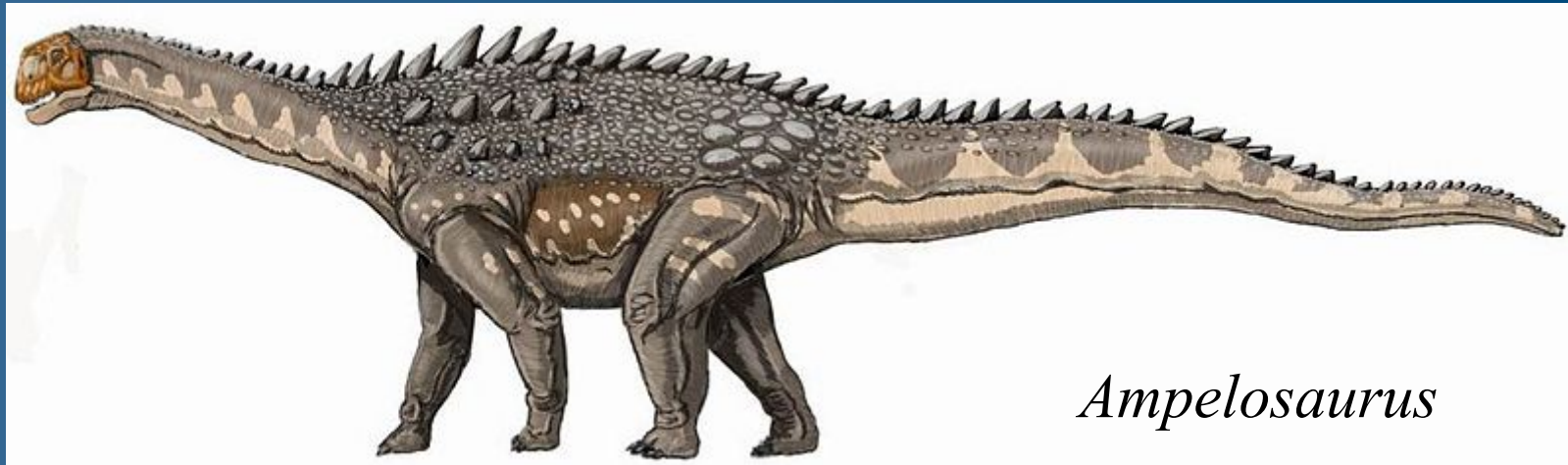
nares move dorsally
onto the forehead

Brachiosaurs – the giraffes among the dinosaurs?



Armor in sauropods

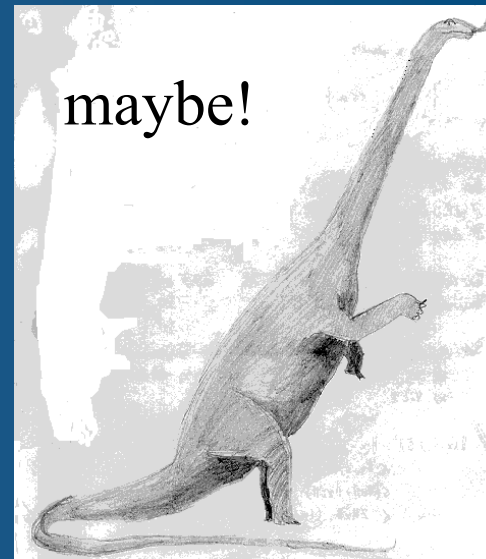
- some species had armor: spines, tail clubs, and osteoderms (especially titanosaurs)
- maybe (almost) all armored ?
 - uncertain as complete skeletons are rare



Ampelosaurus

Sauropod lifestyle

- herbivorous
 - 50 kg of vegetation every day
 - no grinding teeth
- gastroliths (in addition to bacterial and chemical breakdown)



Gastroliths



but!

- gastroliths are rare in sauropods; whereas often found in birds under similar taphonomic circumstances
 - high abrasion and polished surfaces (not in birds!)
 - extremely low mass of gastroliths in comparison to body size
 - often gastroliths too small, rock types too soft
- number and weight of gastroliths in sauropods negligible for stomach function as a gastric mill!

now what?

- accidental or pathologic ingestion?
- intentional ingestion for mineral uptake, especially calcium supply?

How did they process food?

Sauropods possibly secured sufficient nutrient uptake by extremely prolonged food retention times permitted by their large body size

Evolutionary patterns within the sauropodomorpha

- loss of ancestral carnivorous diet and evolution of **herbivory**
- **Gigantism**: early forms 2 m → up to 30 m in length
- ancestral bipedal state becomes **obligate quadrupedal**
- **transformation of the hand** into only locomotory function



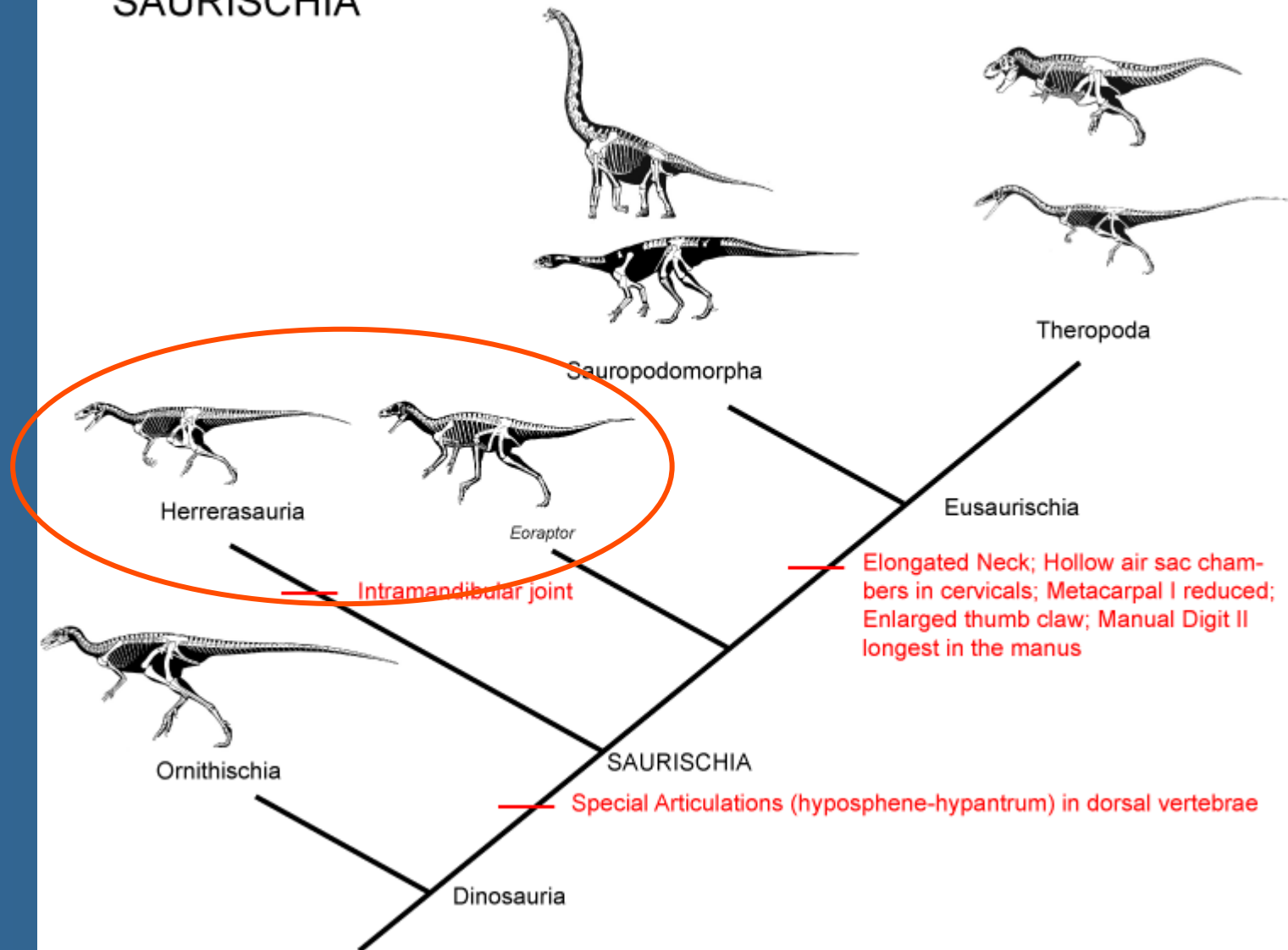
Saurischia: group 2

Theropoda

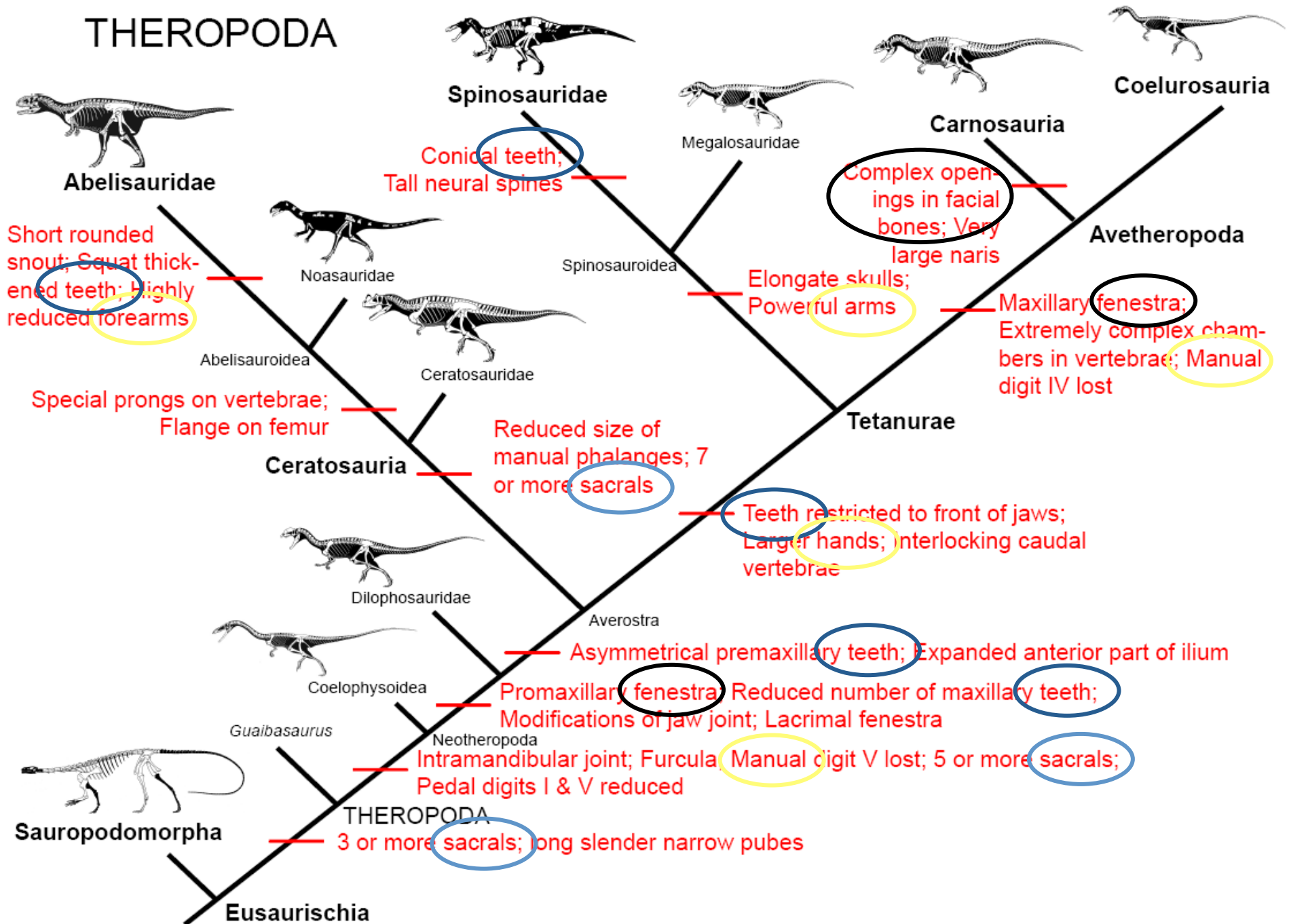
("beast-feet" – "skräckföt")



SAURISCHIA



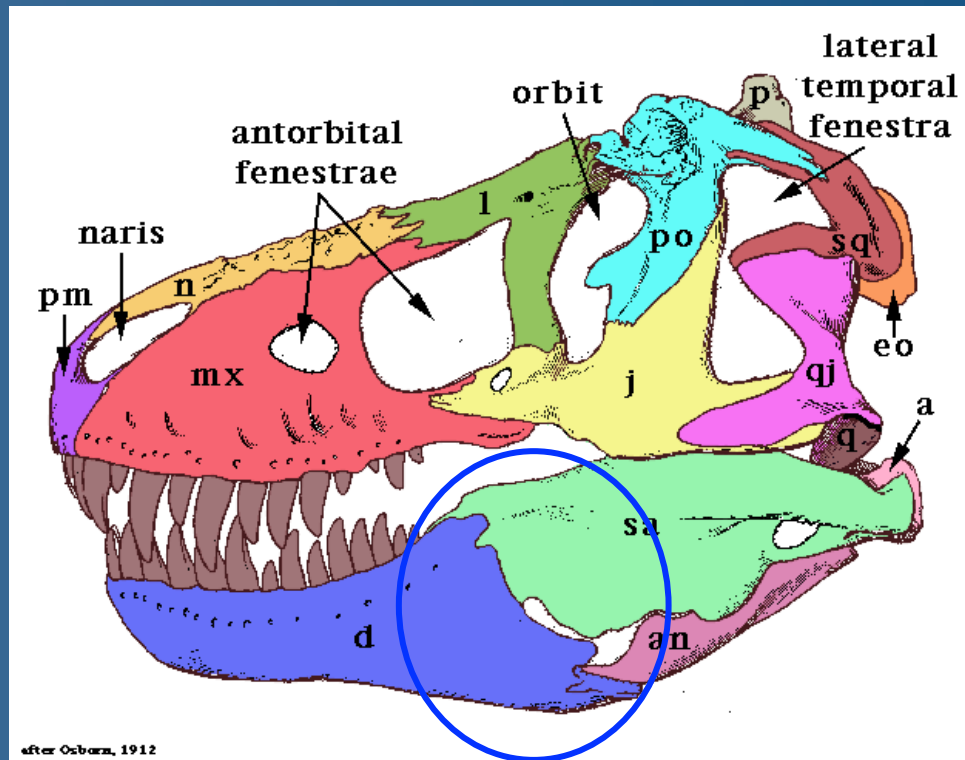
THEROPODA



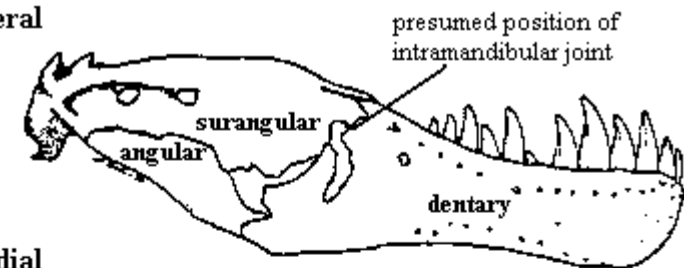
Theropoda or Neotheropoda

- **intramandibular joint**: hinge between the dentary and the postdentary bone, → shock absorber for holding struggling prey ?
- **furcula** ("wishbone"): clavicles are fused into a single mid-line bone
→ spring/shock absorber (to deal with stresses on the forelimbs and shoulders from struggling prey)
- **Manual digit V lost** (four fingers or fewer)
- Five or more **sacrals**
- **Pedal digits I and V reduced** (making the foot functionally tridactyl ("three toed")): metatarsal V lacks a toe, while metatarsal I is reduced with a small digit I
- Basal theropods all have blade-like serrated teeth

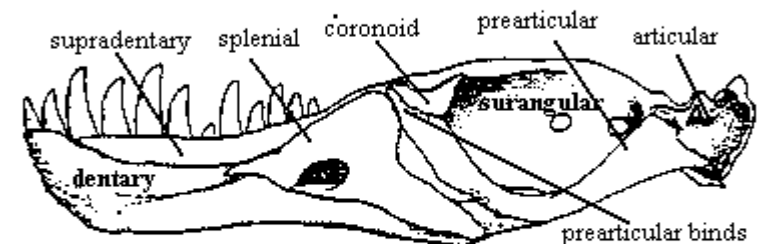
Intramandibular joint



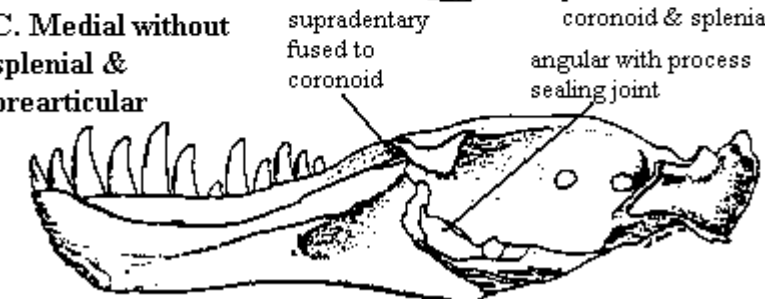
A. Lateral



B. Medial



C. Medial without splenial & prearticular

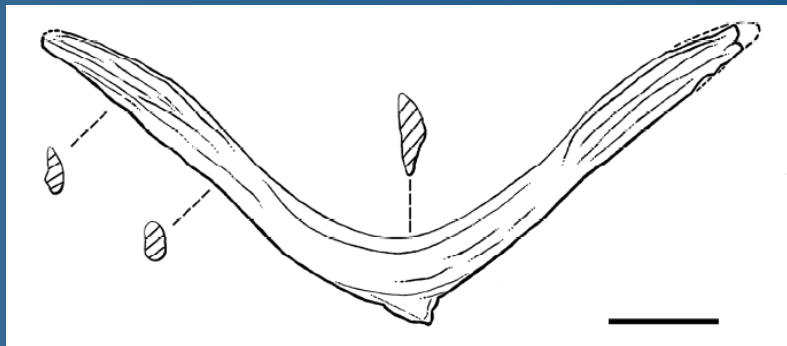
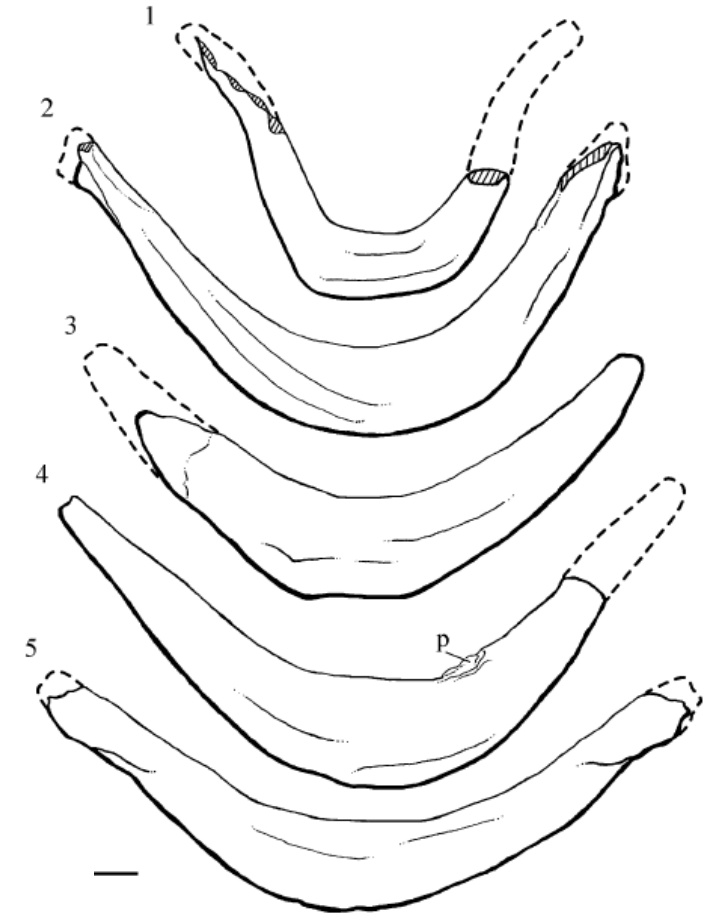


Tyrannosaurus: lower jaw showing features locking intramandibular joint. Adapted from Hurum & Currie (2000).

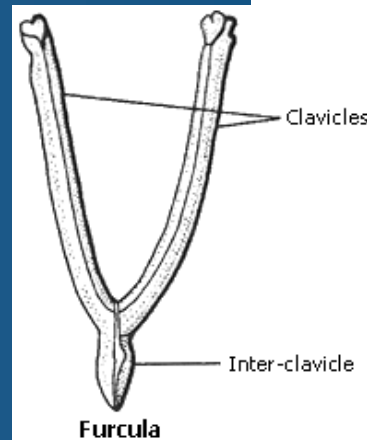
The furcula

- forked bone found in birds and theropod dinosaurs
- formed by the fusion of the two clavicles (collar bone, *nyckelben*)

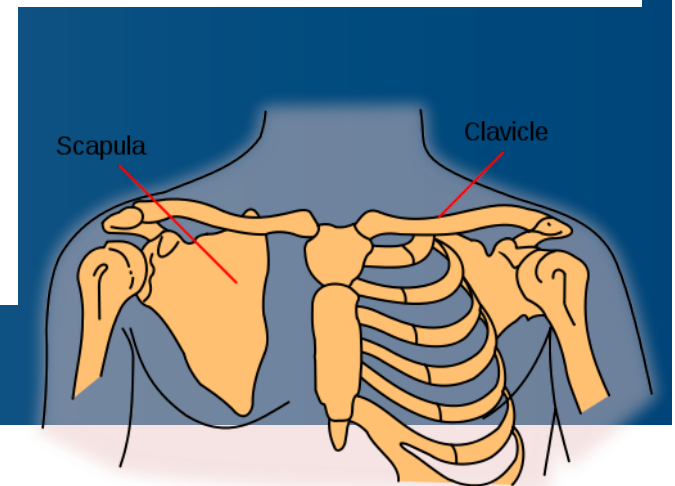
T. rex

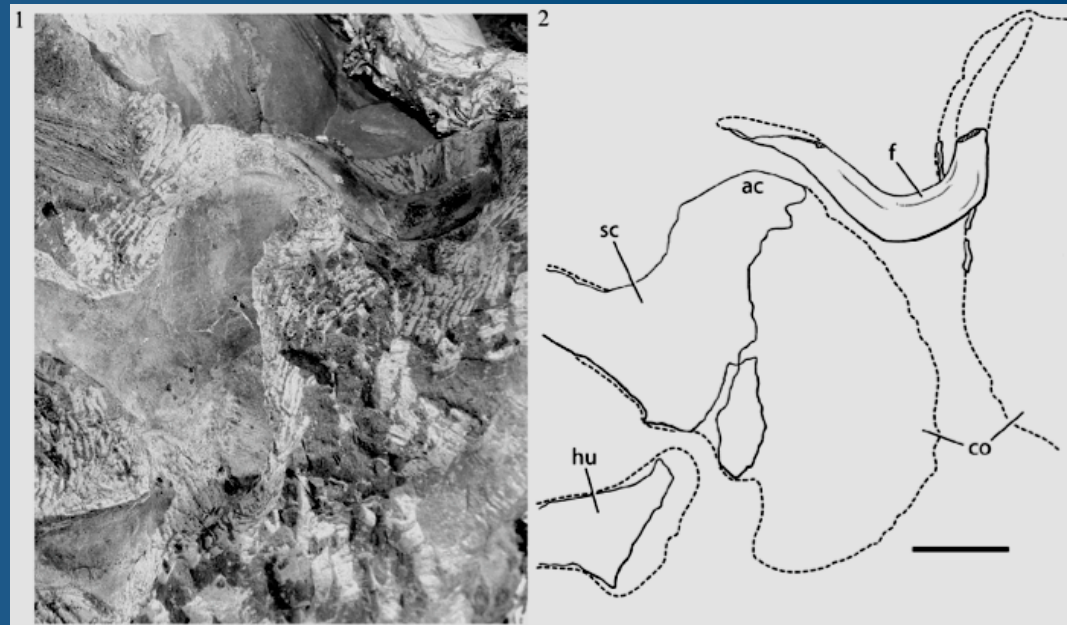


Suchomimus (a spinosaur)



chicken



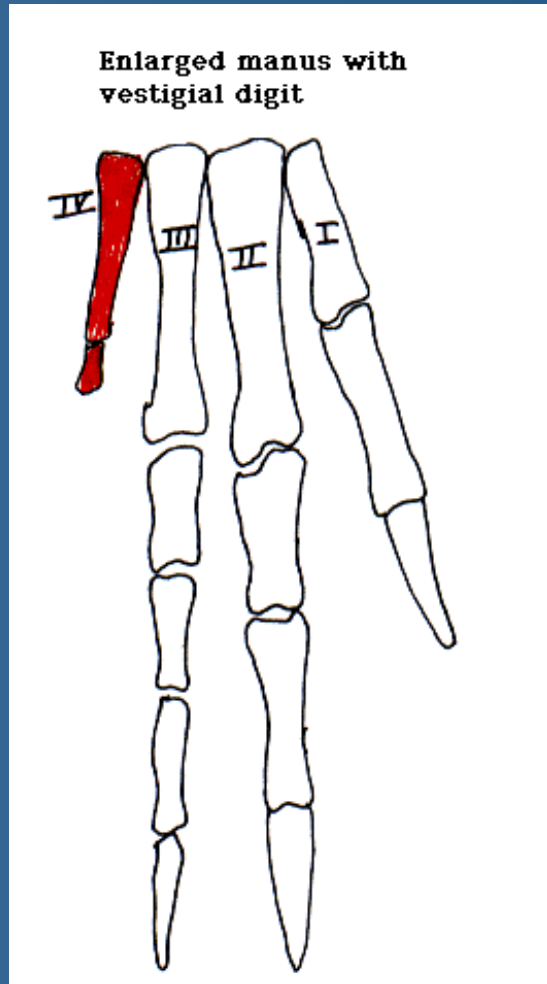


T. rex



T. rex

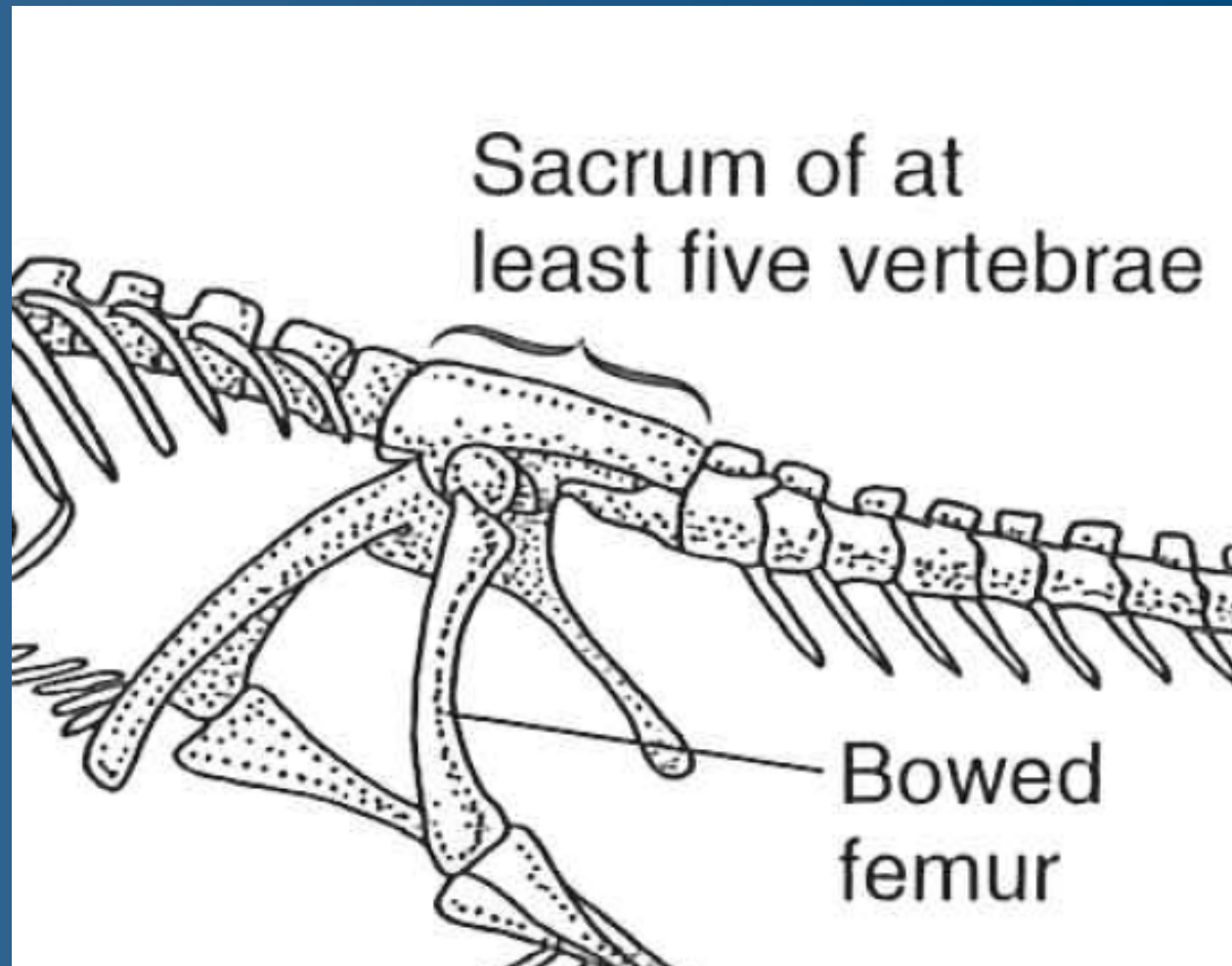
Manual digit V lost



- digit V lost and tendency to reduce digit IV
- could grip things (except if only two digits left)



Five or more sacral



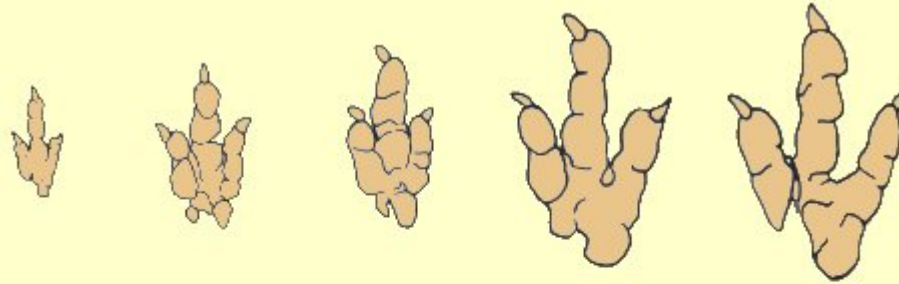
Pedal digits I and V reduced



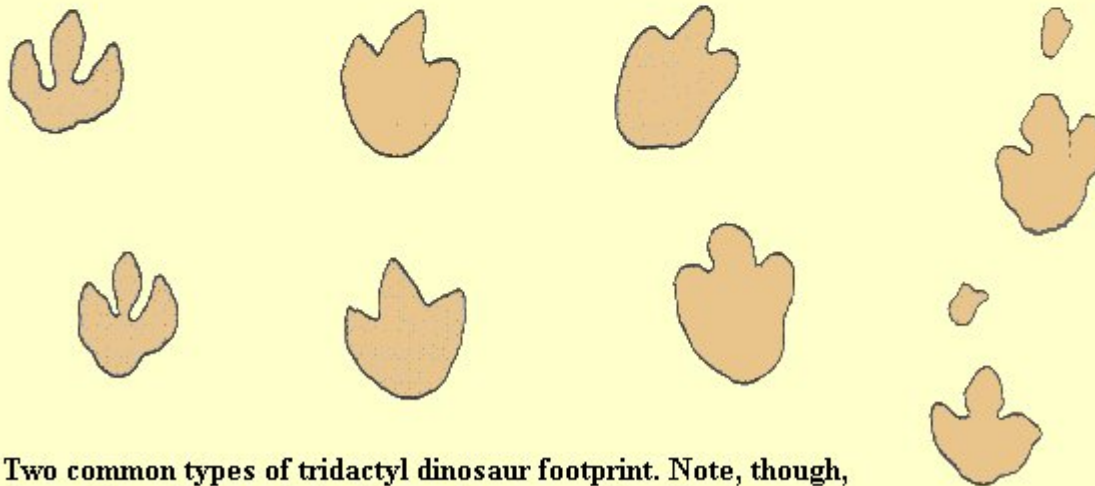
Pedal digits I and V reduced



Narrow-toed footprints of Theropod dinosaurs (bipedal carnivores)



Broad-toed footprints of Ornithopod dinosaurs (bipedal herbivores like *Iguanodon*)



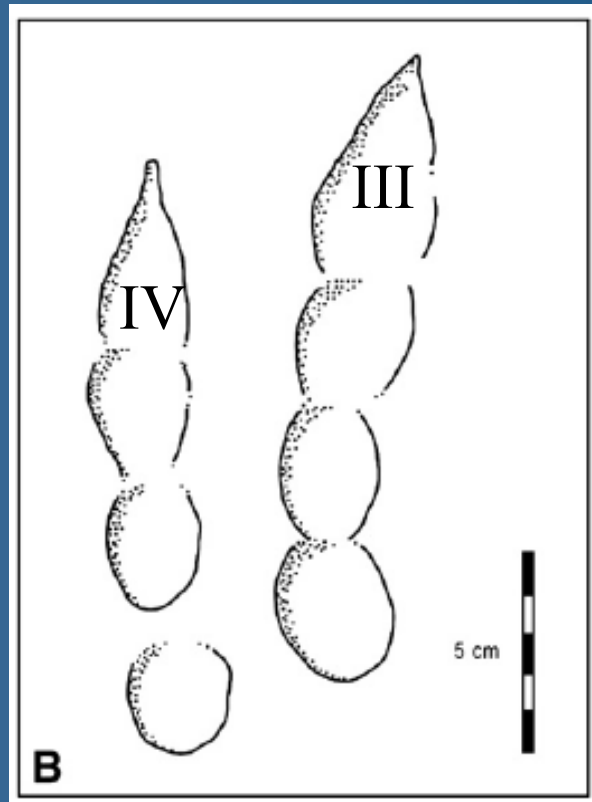
Two common types of tridactyl dinosaur footprint. Note, though, that soft mud or parallel undertracks may produce impressions that are falsely broad. (After Lockley, 1991, in part). *IMW* 2003.



theropod



hadrosaur



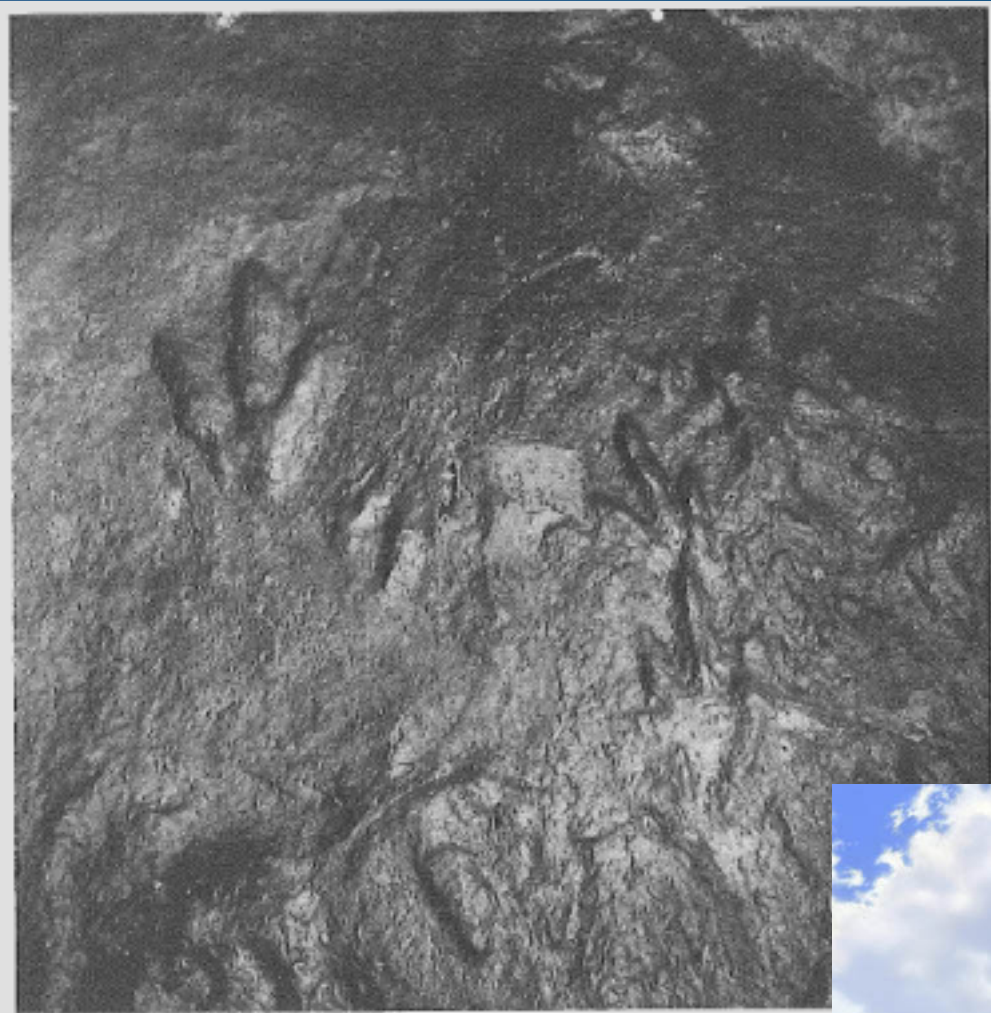
imprint of digit III and IV



Utahraptor



Sauronitholestes (Late Cretaceous, Alberta)



Plateosaurus
primitive sauropod!



Other characters of typical theropods

Broadly exposed
lachrymal bone

Sacrum of at
least five vertebrae

Bowed
femur

Narrow compact
hind foot

Three
functional
digits

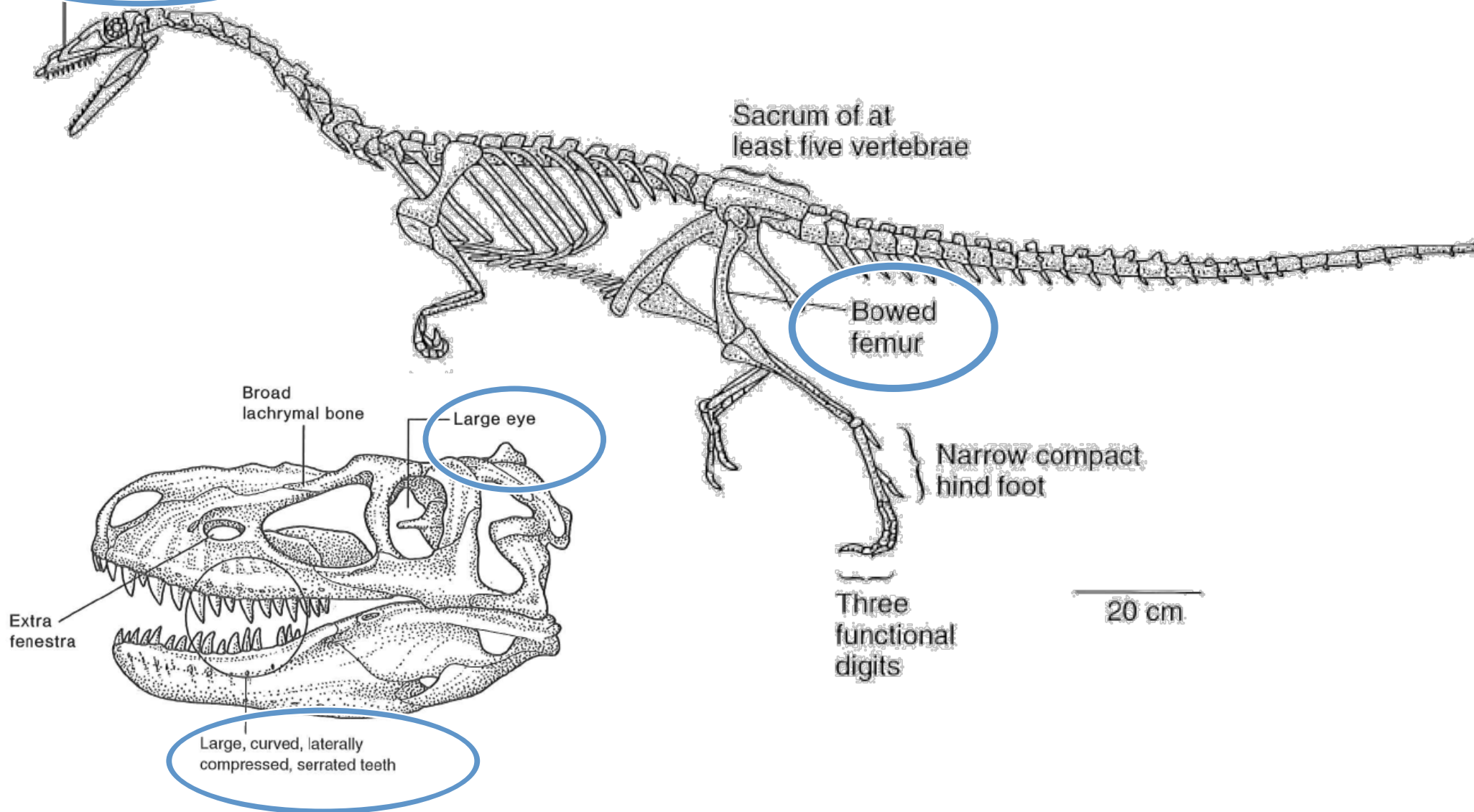
20 cm

Broad
lachrymal bone

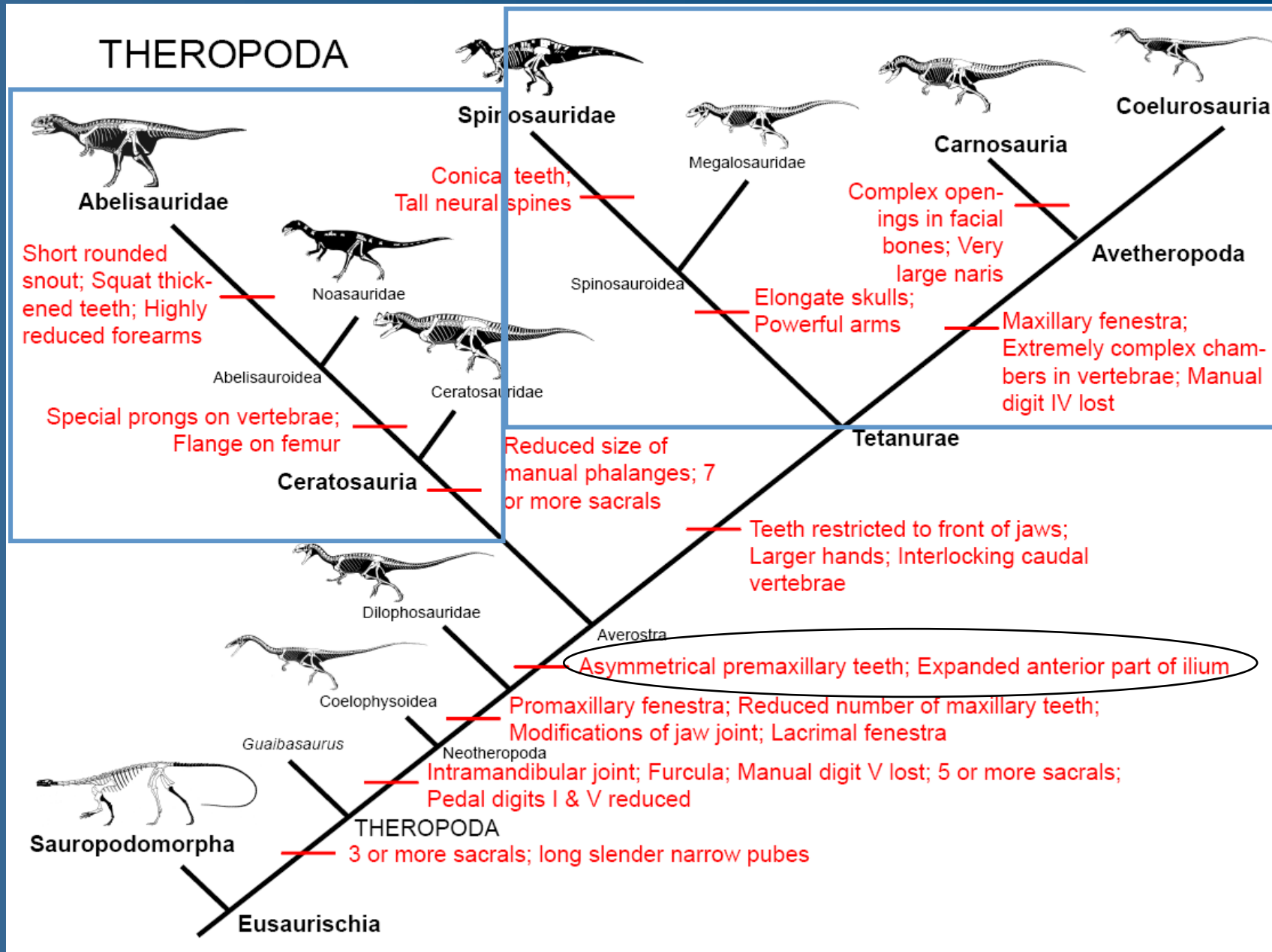
Large eye

Extra
fenestra

Large, curved, laterally
compressed, serrated teeth



Major groups of theropods



Ceratosauria

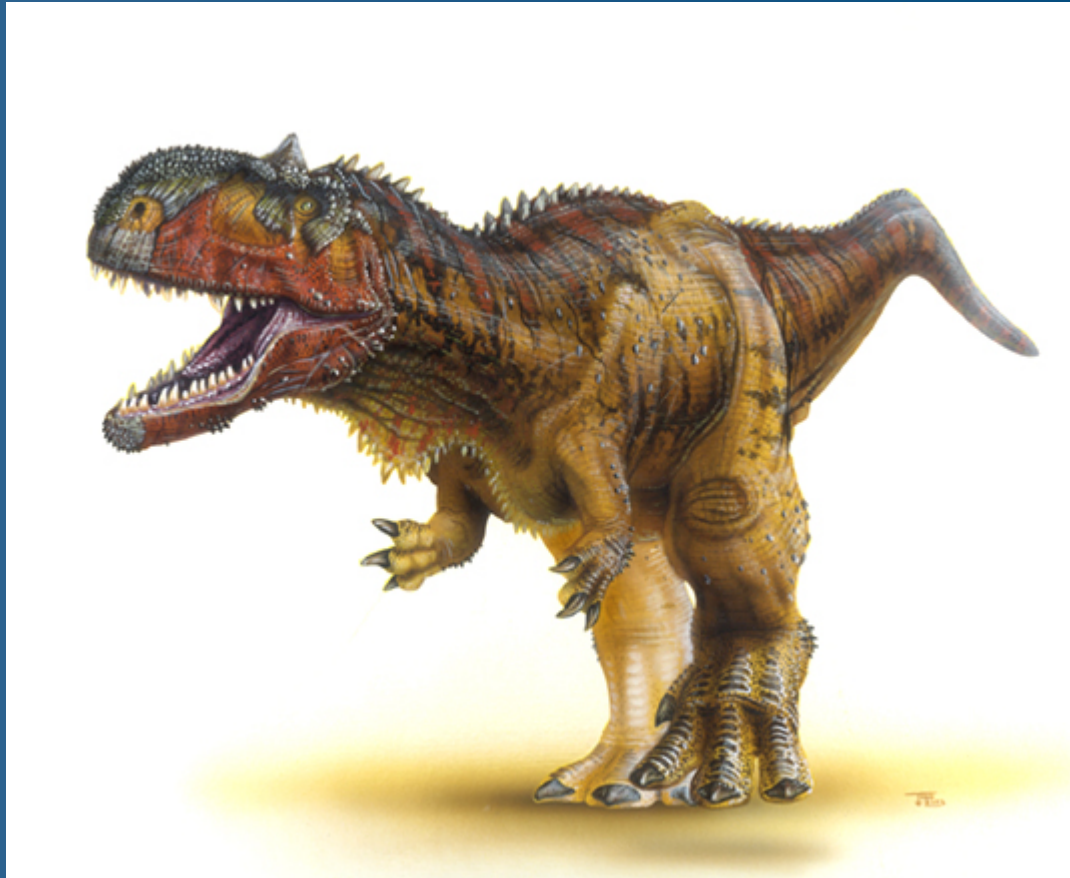
- Reduced size of manual phalanges (finger bones)
 - weak to functionless hands
- 7 or more sacral vertebrae
- short teeth
- Ceratosauridae, Noasauridae, and **Abelisauridae**

→ **Abelisauridae (middle Jurassic to late Cretaceous)**

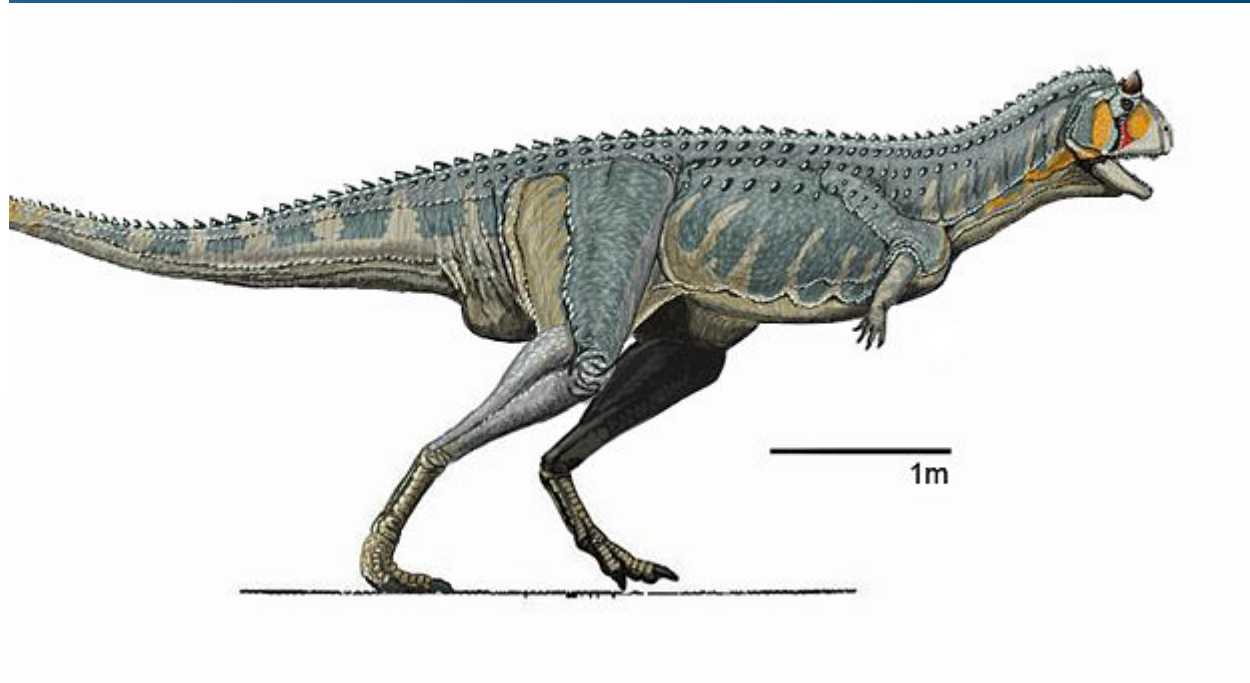
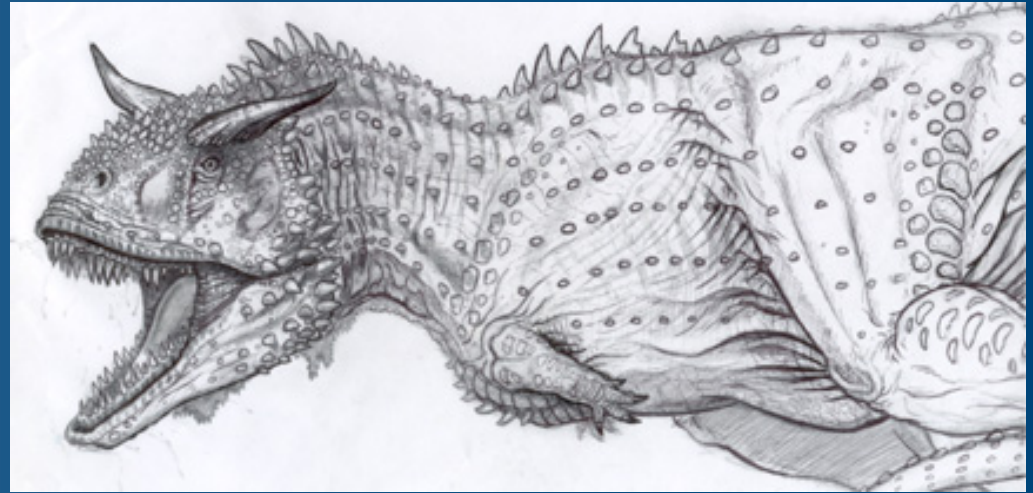
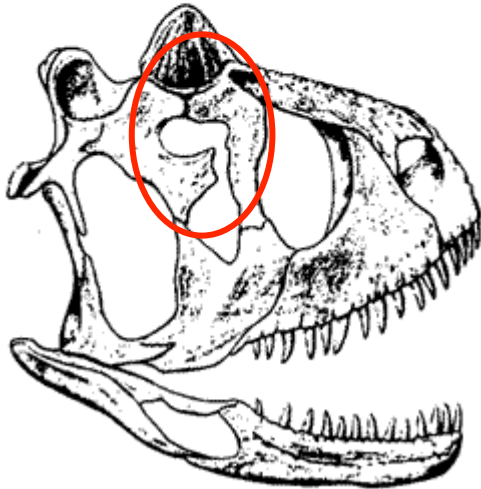
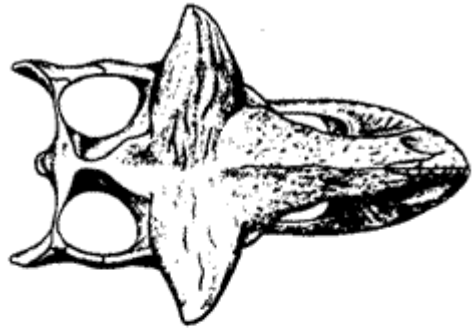
- Rugose texture of the face bones (tissue support?)
- Short rounded snouts
- Thickened skull roof
- Short, thickened teeth
- Forearms highly reduced
 - (ulnae and radii are practically no more than carpals)



Rajasaurus (Late Cretaceous, India)



Rajasaurus (Late Cretaceous, India)



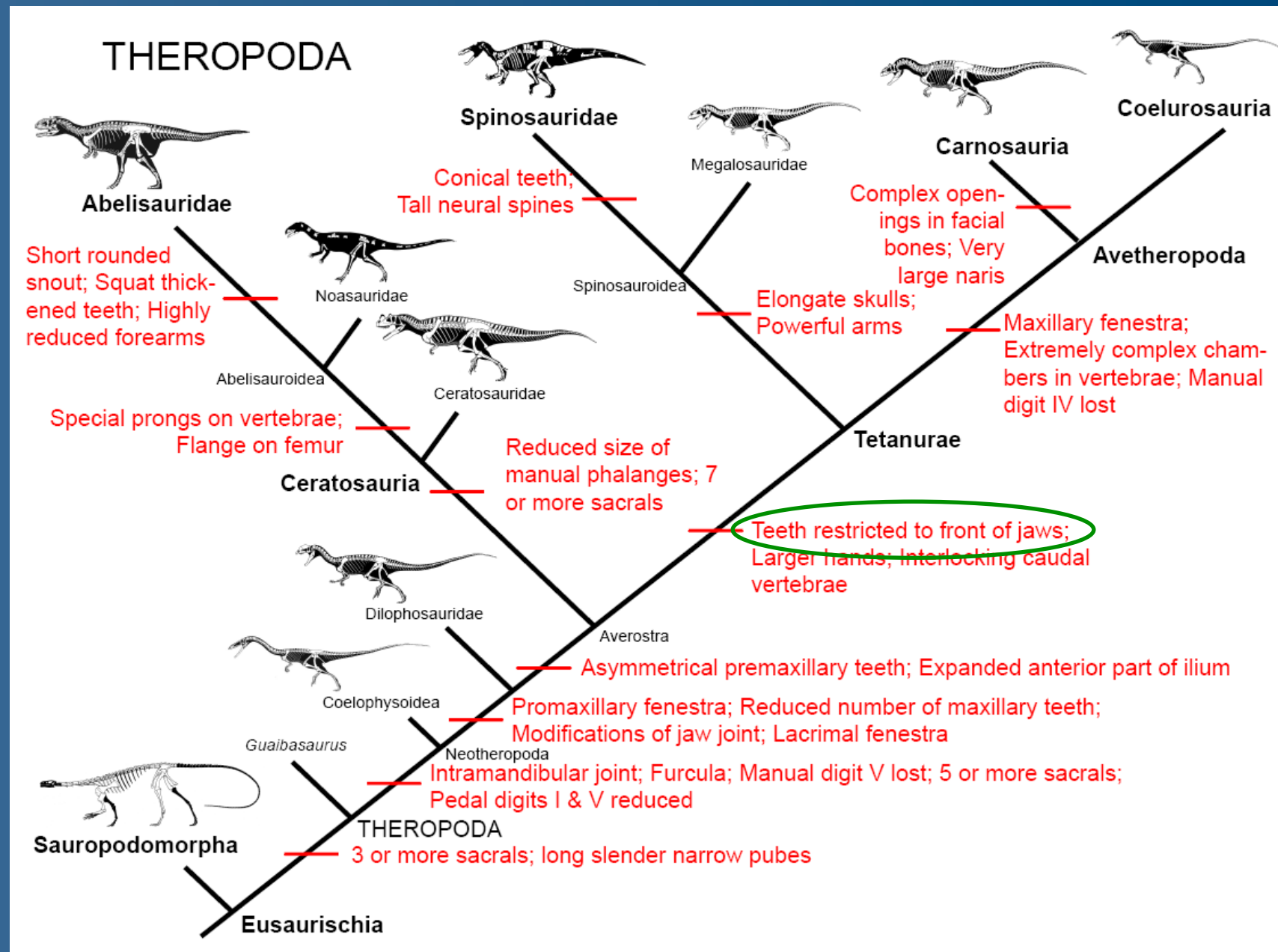
Carnotaurus (Late Cretaceous, South America)

Aucasaurus garridoi (Coria et al., 2002)

Restored after type specimen, MCF-PVPF 236, with missing tail elements restored after *Carnotaurus*.

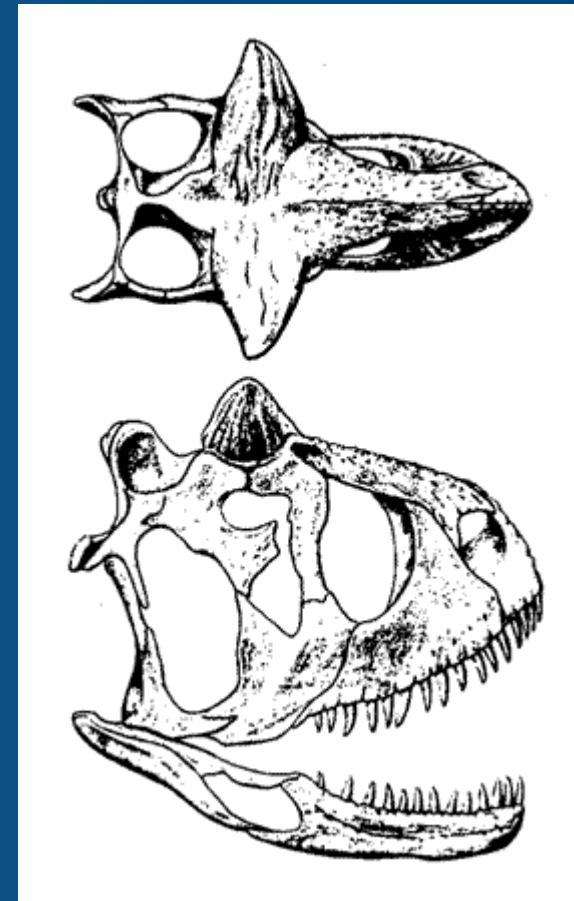
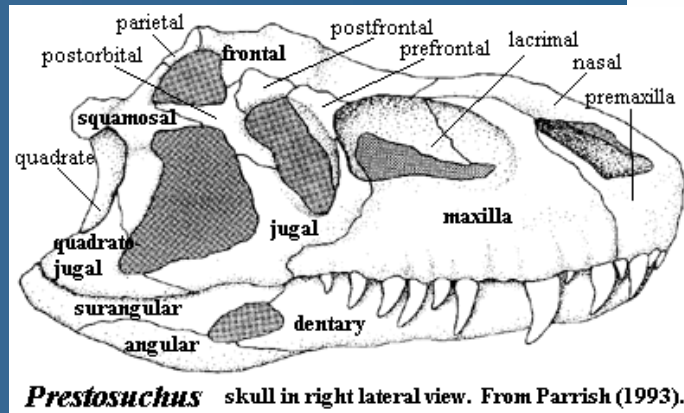
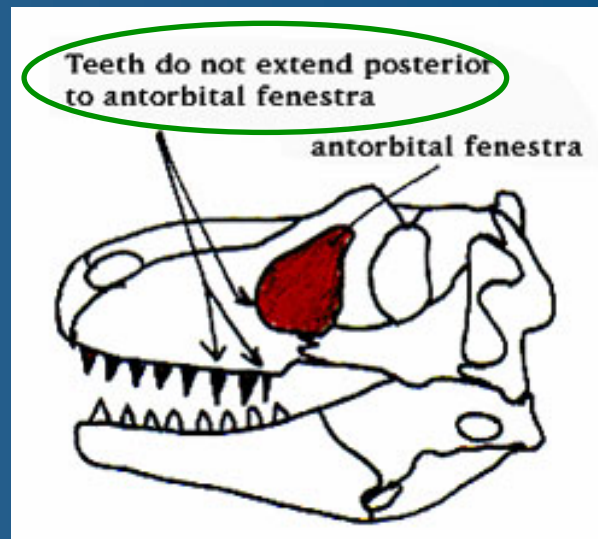


Copyright Scott Hartman, 2003.

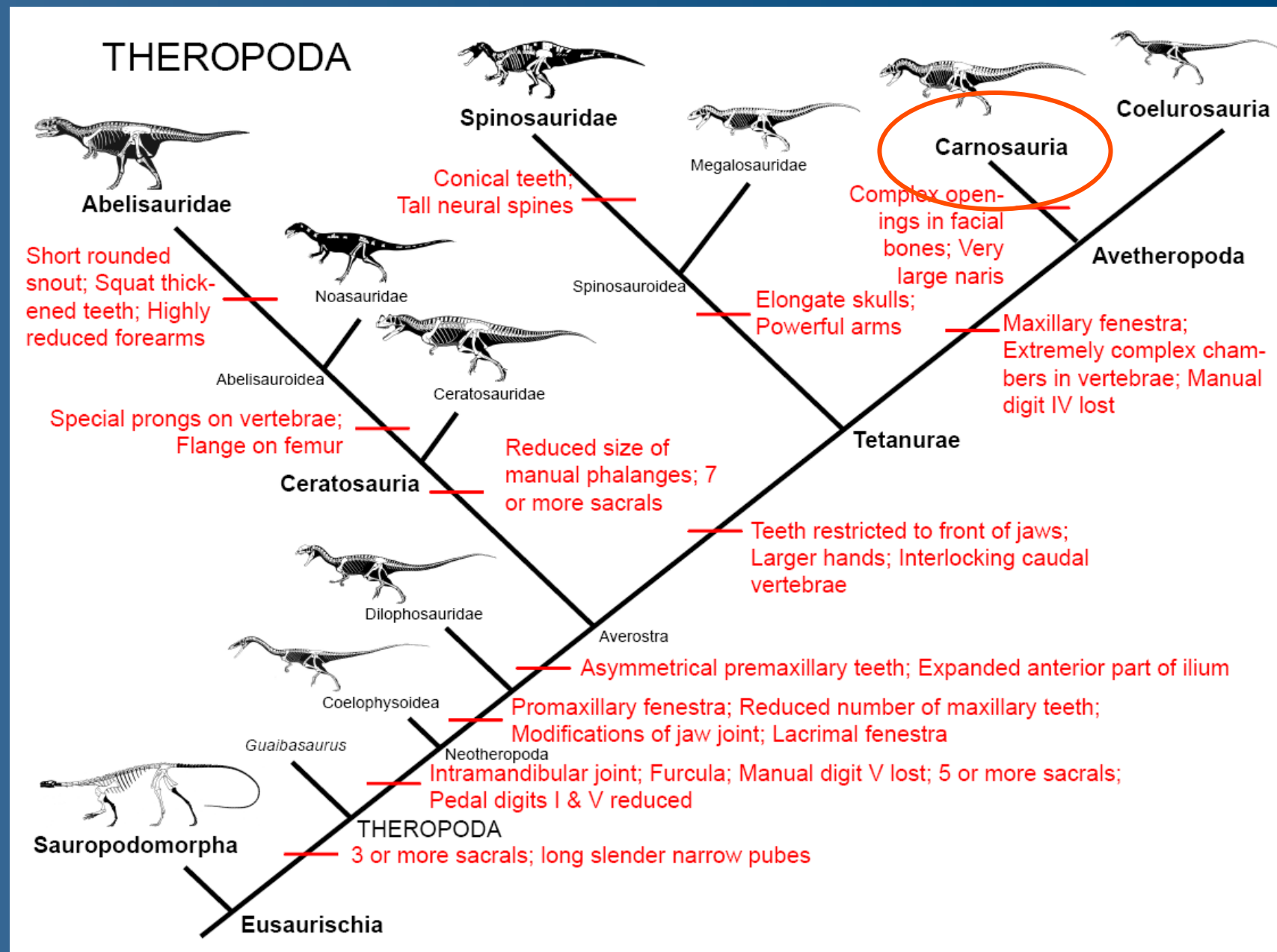


Tetanurae

- Carnosaurs, coelurosaurs, and spinosaurs
- include all the famous meat eaters and the birds



Carnotaurus, ceratosaur

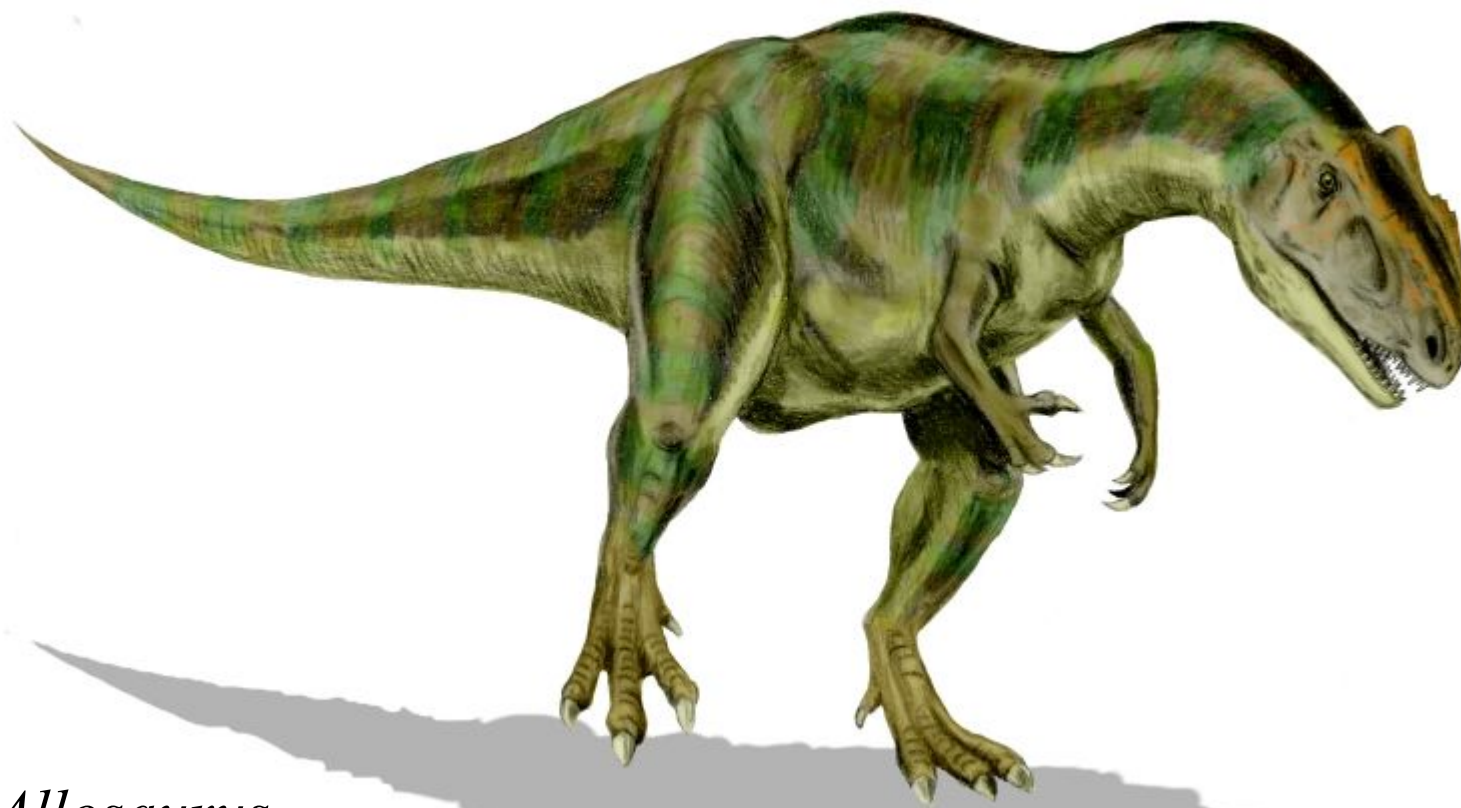


Carnosauria

- Dominant group of large theropods from the Middle Jurassic through the Early Cretaceous
 - Extra openings on the maxillae and nasals
 - Very large nares
 - Long and narrow skull
 - Large orbital fenestrae
 - Often with crests and horns on their skull
-
- Has been once huge group for all sorts of theropods



Allosaurus



Allosaurus



THEROPODA

- Abelisauridae**
 - Short rounded snout; Squat thickened teeth; Highly reduced forearms
- Abelisauroidea**
 - Noasauridae**
 - Ceratosauridae**
 - Special prongs on vertebrae; Flange on femur
- Ceratosauria**
 - Reduced size of manual phalanges; 7 or more sacra
- Dilophosauridae**
- Coelophysoidea**
 - Guaibasaurus**
- Sauropodomorpha**
- Eusaurischia**
 - THEROPODA**
 - 3 or more sacra; long slender narrow pubes
 - Neotheropoda**
 - Intramandibular joint; Furcula; Manual digit V lost; 5 or more sacra; Pedal digits I & V reduced
 - Averostra**
 - Asymmetrical premaxillary teeth; Expanded anterior part of ilium
 - Tetanurae**
 - Teeth restricted to front of jaws; Larger hands; Interlocking caudal vertebrae
 - Spinosauroidae**
 - Spinosauridae**
 - Conical teeth; Tall neural spines
 - Megalosauridae**
 - Avetheropoda**
 - Complex openings in facial bones; Very large naris
 - Carnosauria**
 - Coelurosauria**
 - Maxillary fenestra; Extremely complex chambers in vertebrae; Manual digit IV lost

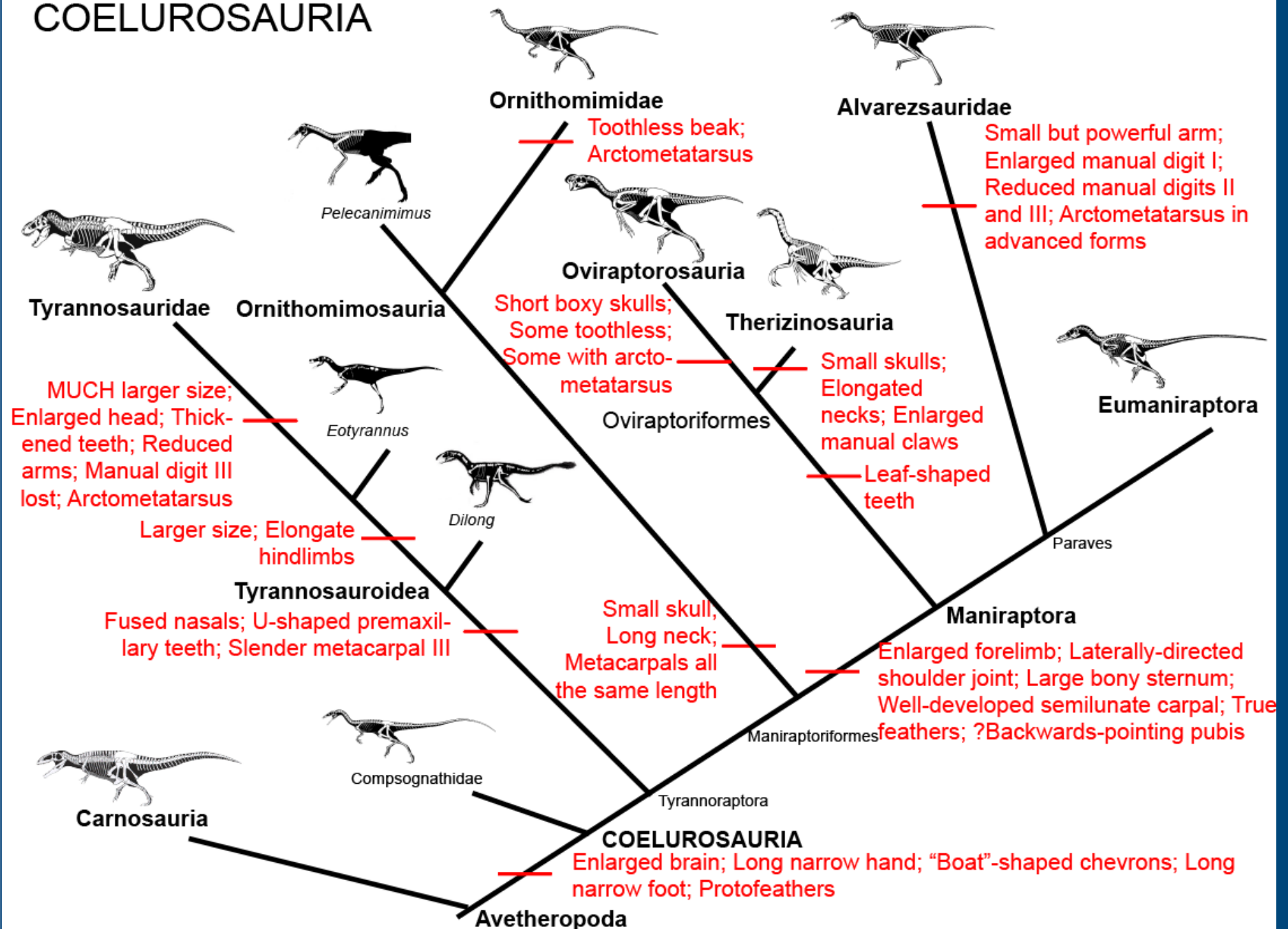
Coelurosauria

Coelurosauria

- Since the Middle Jurassic (not extinct!!)
- Global distribution, all sorts of environments
- Ancestrally carnivorous, but various subclades evolve numerous omnivorous & herbivorous lineages
- Remain obligate bipeds throughout their entire history



COELUROSAURIA



Coelurosauria — differences to other theropods

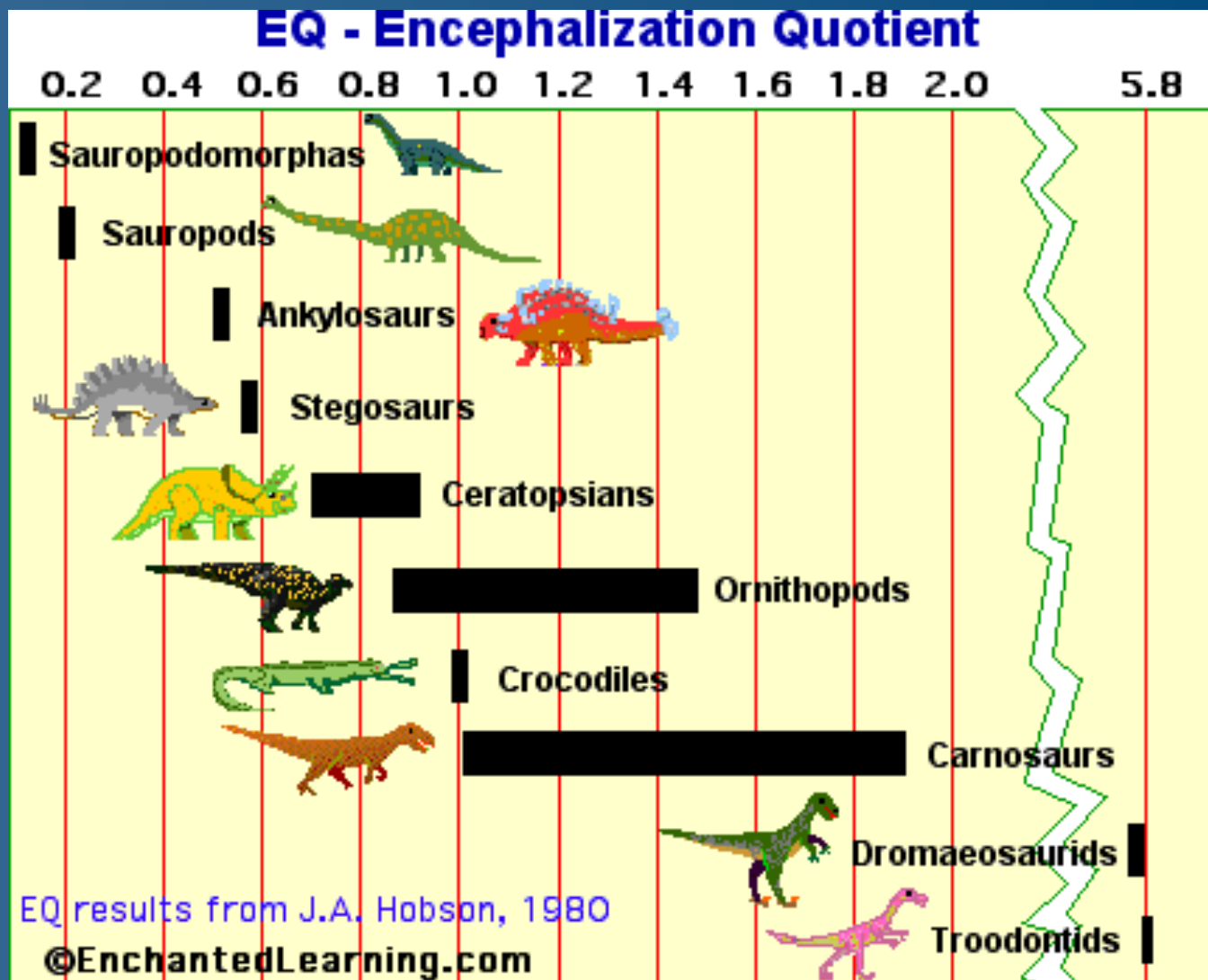
- Long slender tridactyl manus
- Enlarged brain (twice the size)
- Long narrow metatarsals
- Protofeathers: simple apparently hollow down-like tufts on the body as well as scales
- Relatively long arms

Long slender tridactyl manus

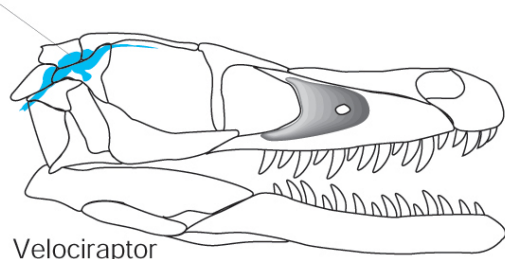


Gallimimus

Enlarged brain



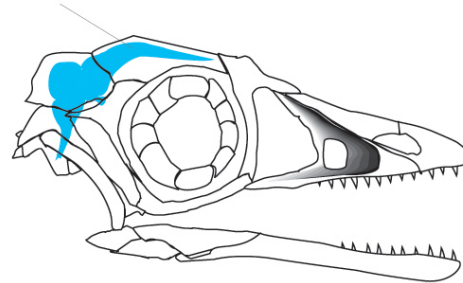
brain



Velociraptor

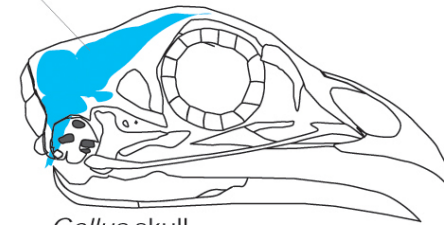
Dromaeosauridae

brain



Archaeopteryx

brain



Gallus skull

Aves

Avialae

Maniraptora

”Boat” shaped chevrons

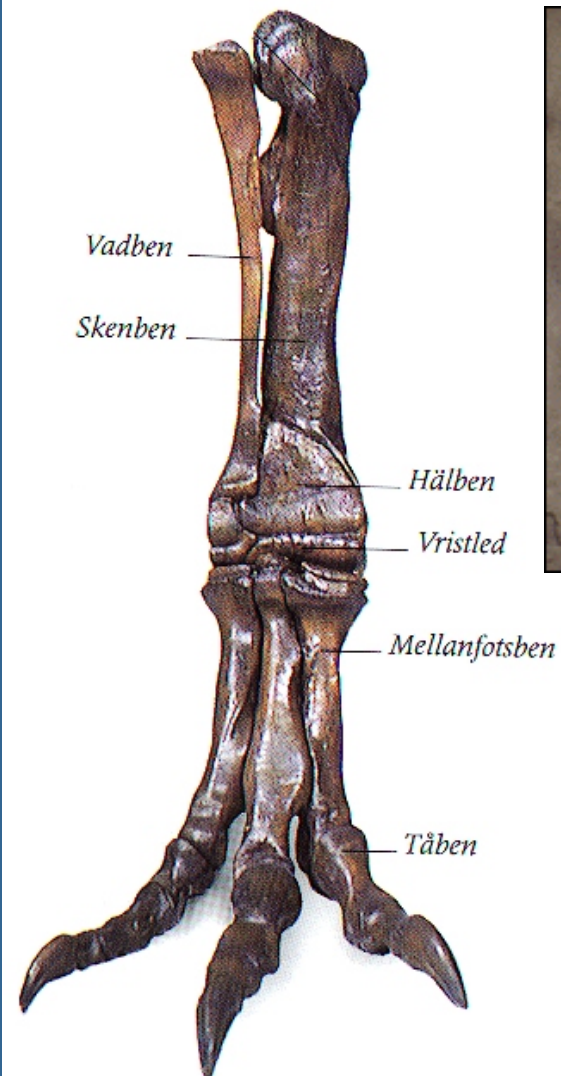


Tyrannosaurus



Diplodocus

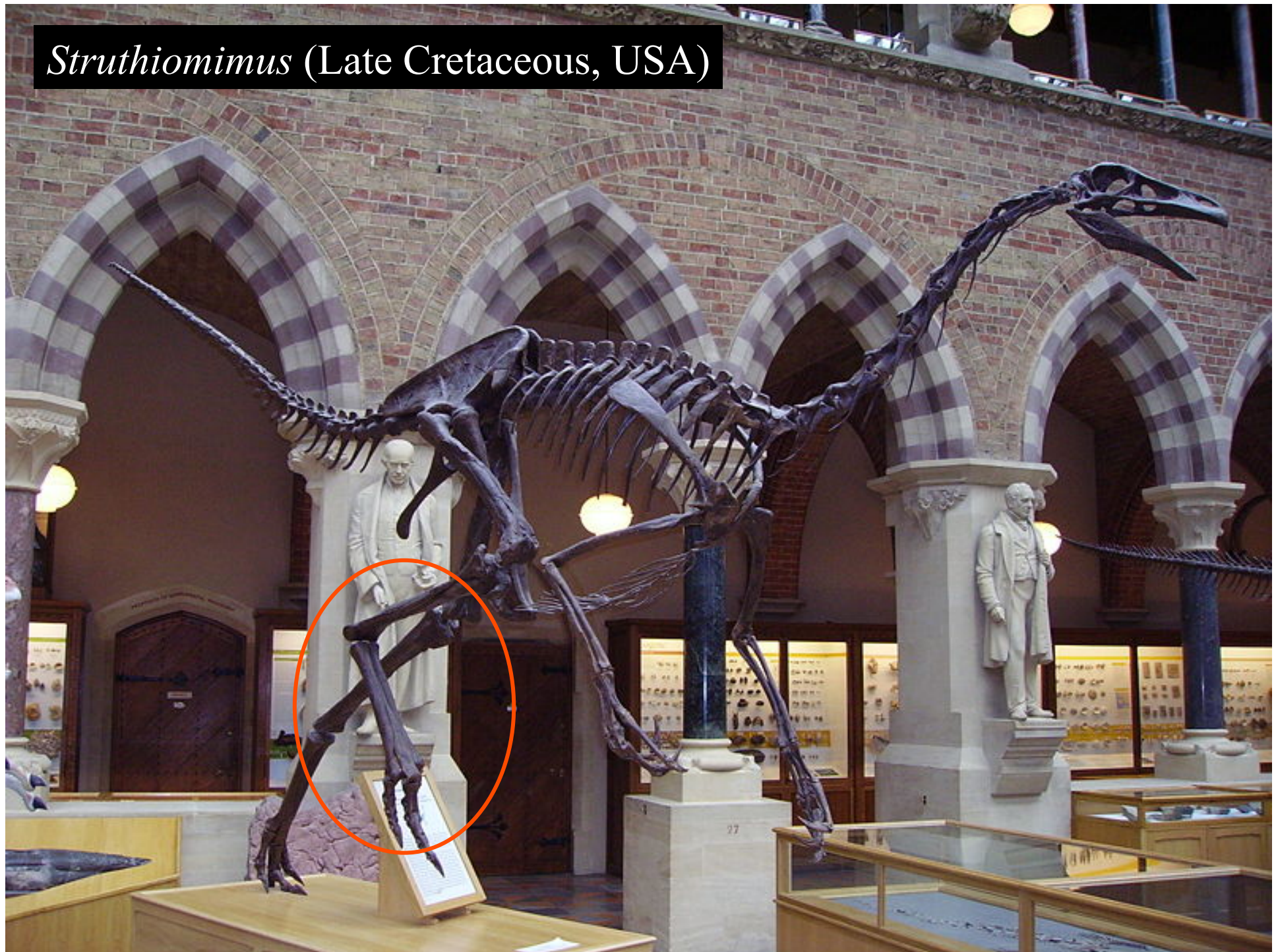
Long narrow metatarsals



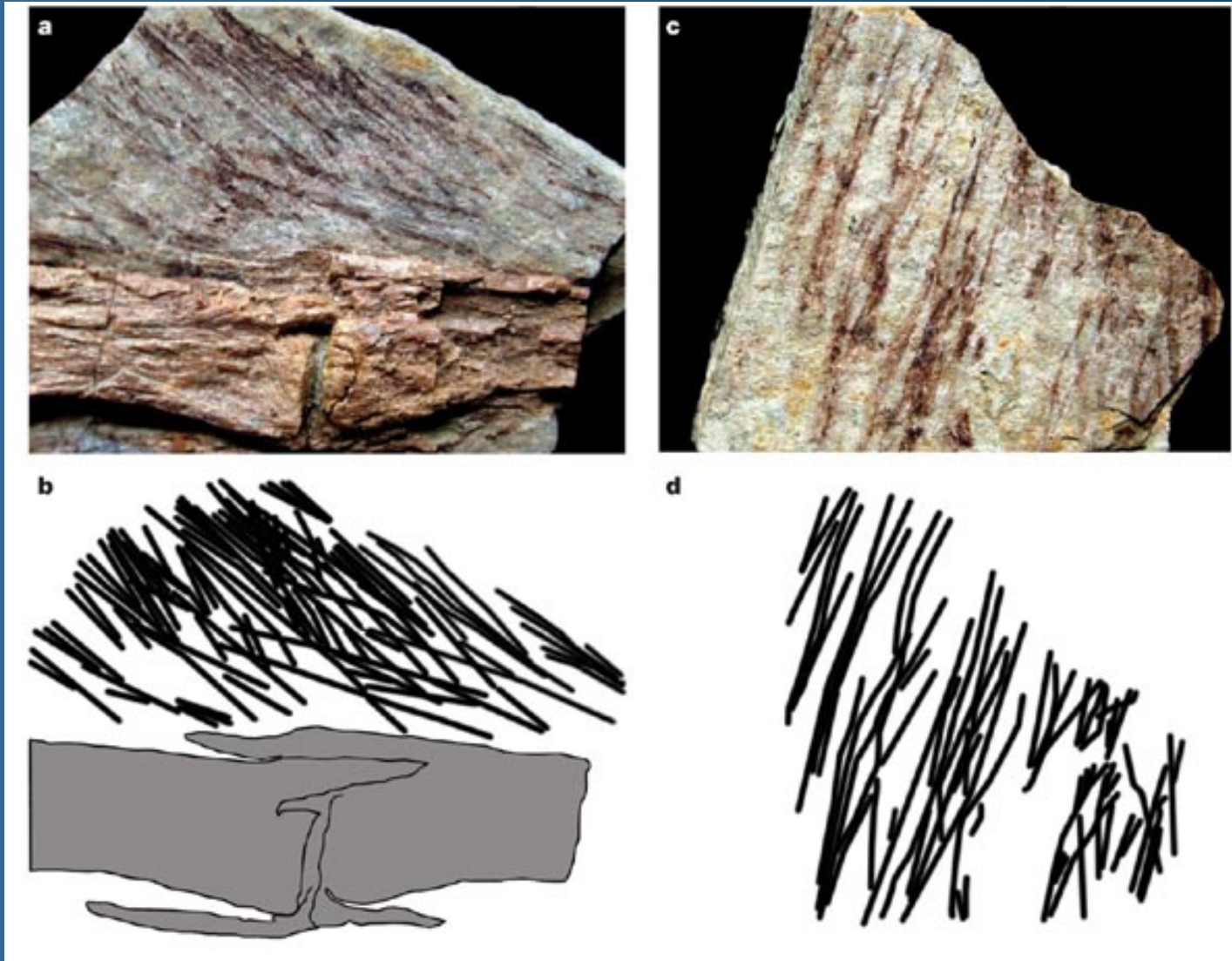
Struthiomimus (Late Cretaceous, USA)

T. rex

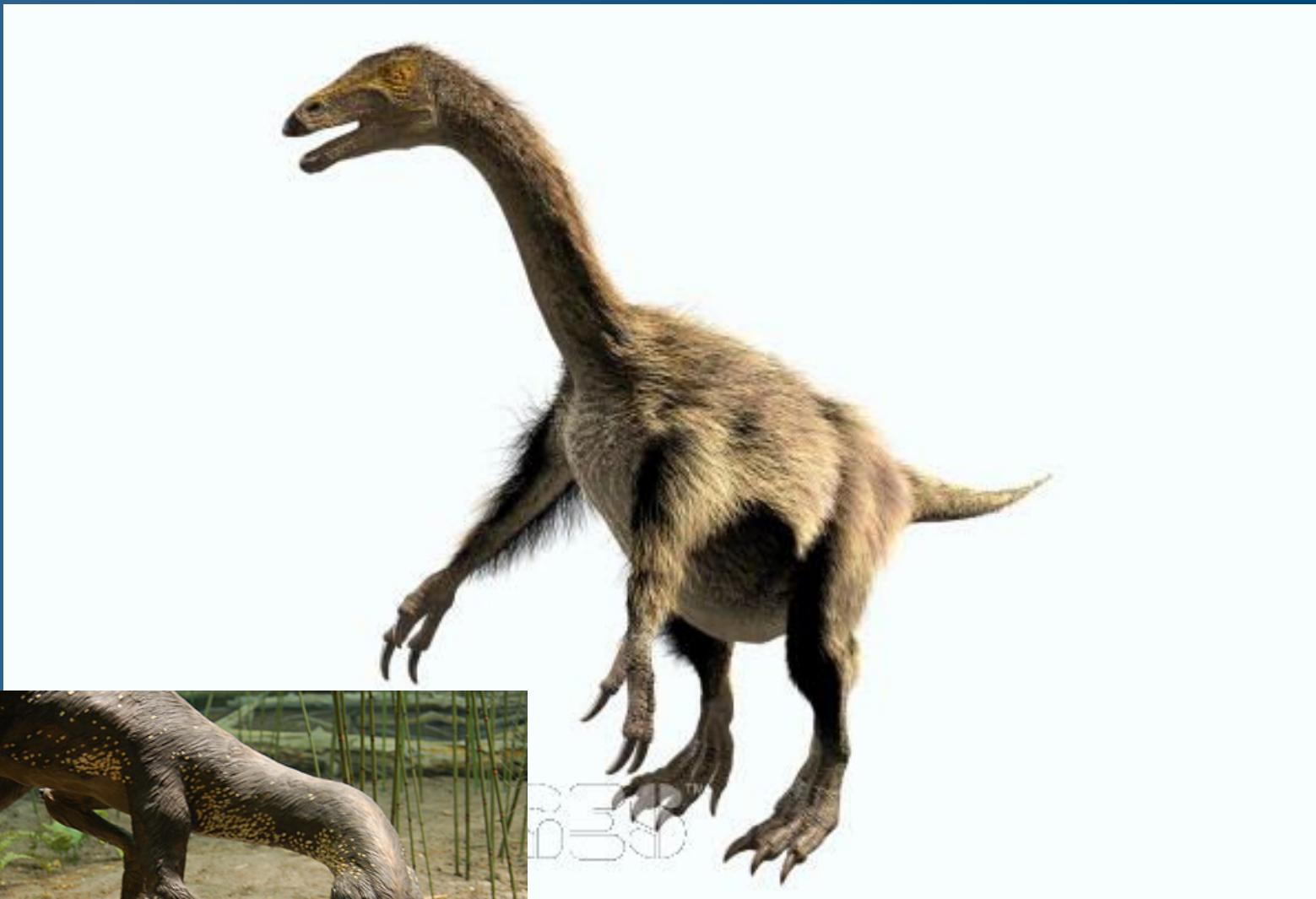
Struthiomimus (Late Cretaceous, USA)



Protofeathers



basal tyrannosaurid (*Dilong*)

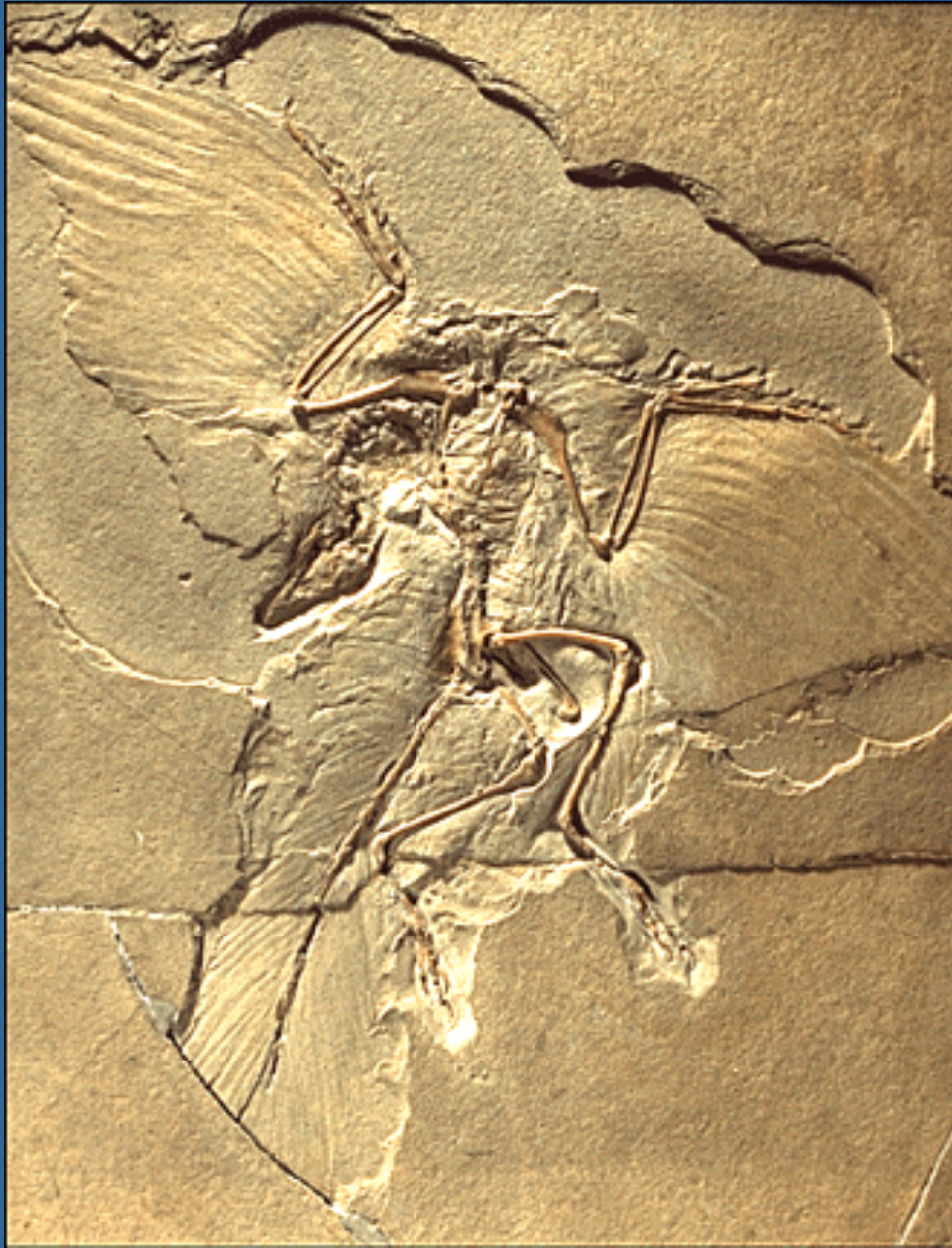




Most primitive feathered dinosaur?
or structural fibers, probably collagen?



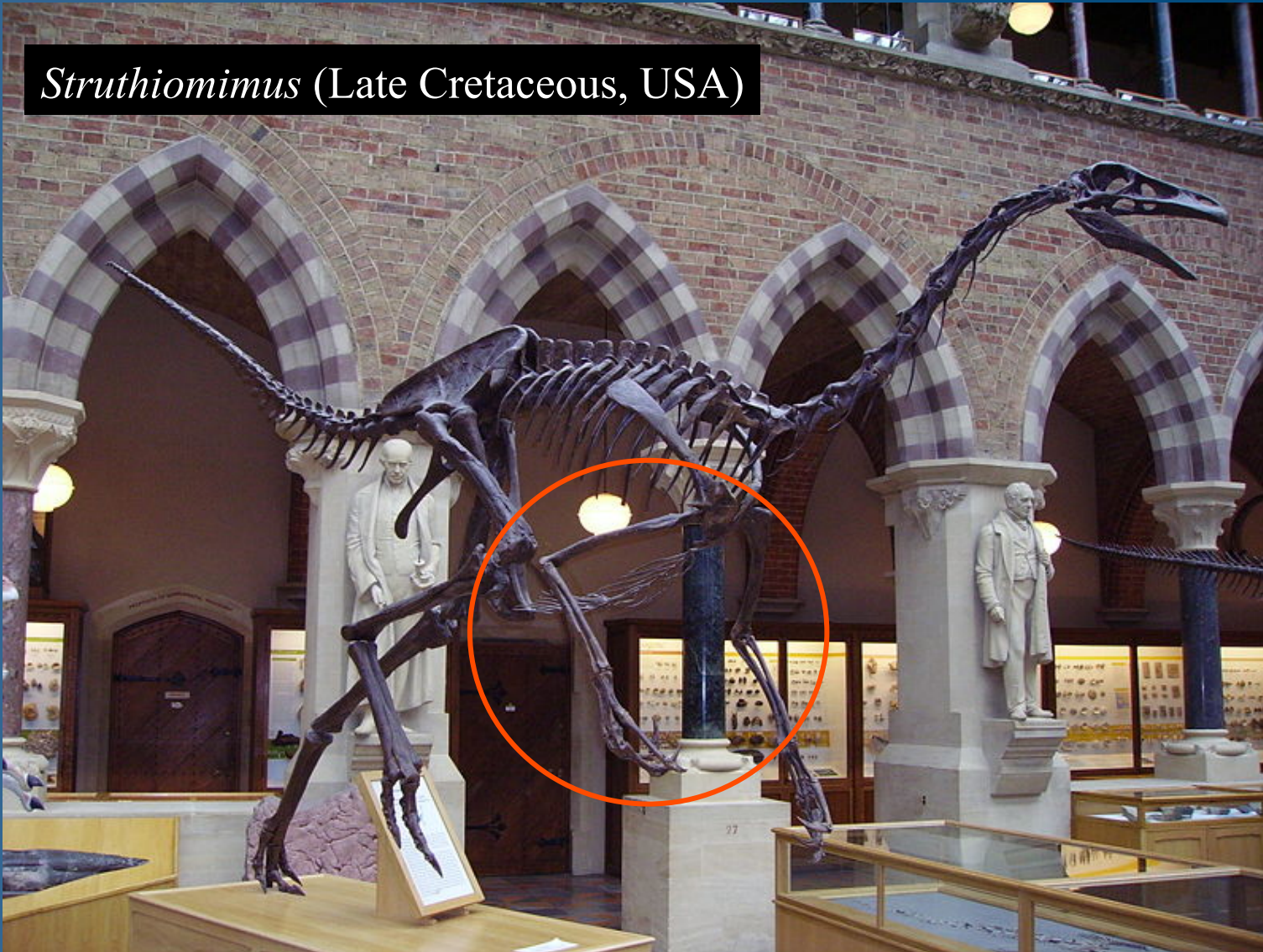
Sinosauropteryx (Early Cretaceous, China)



Archeopteryx (Upper Jurassic, Germany)

Relatively long arms

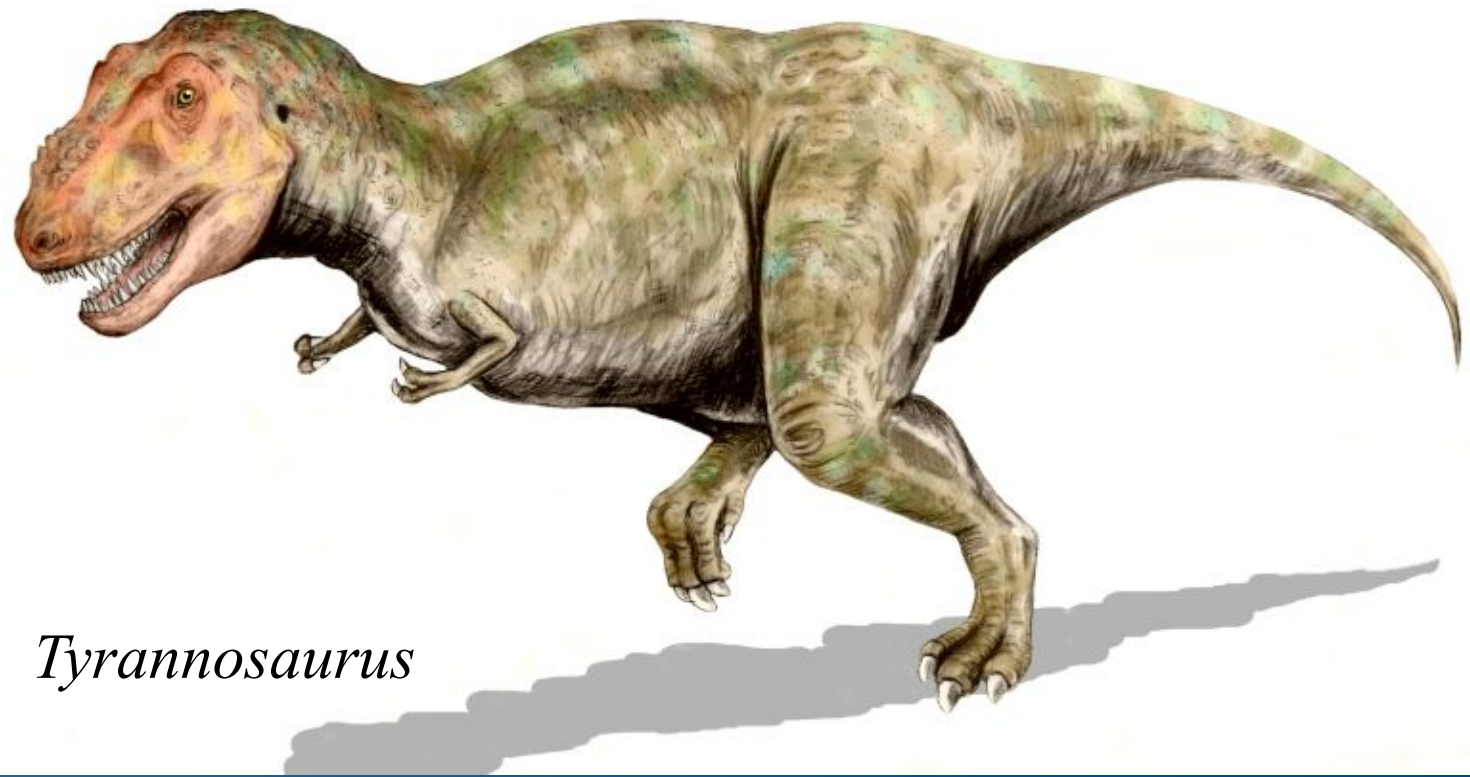
Struthiomimus (Late Cretaceous, USA)





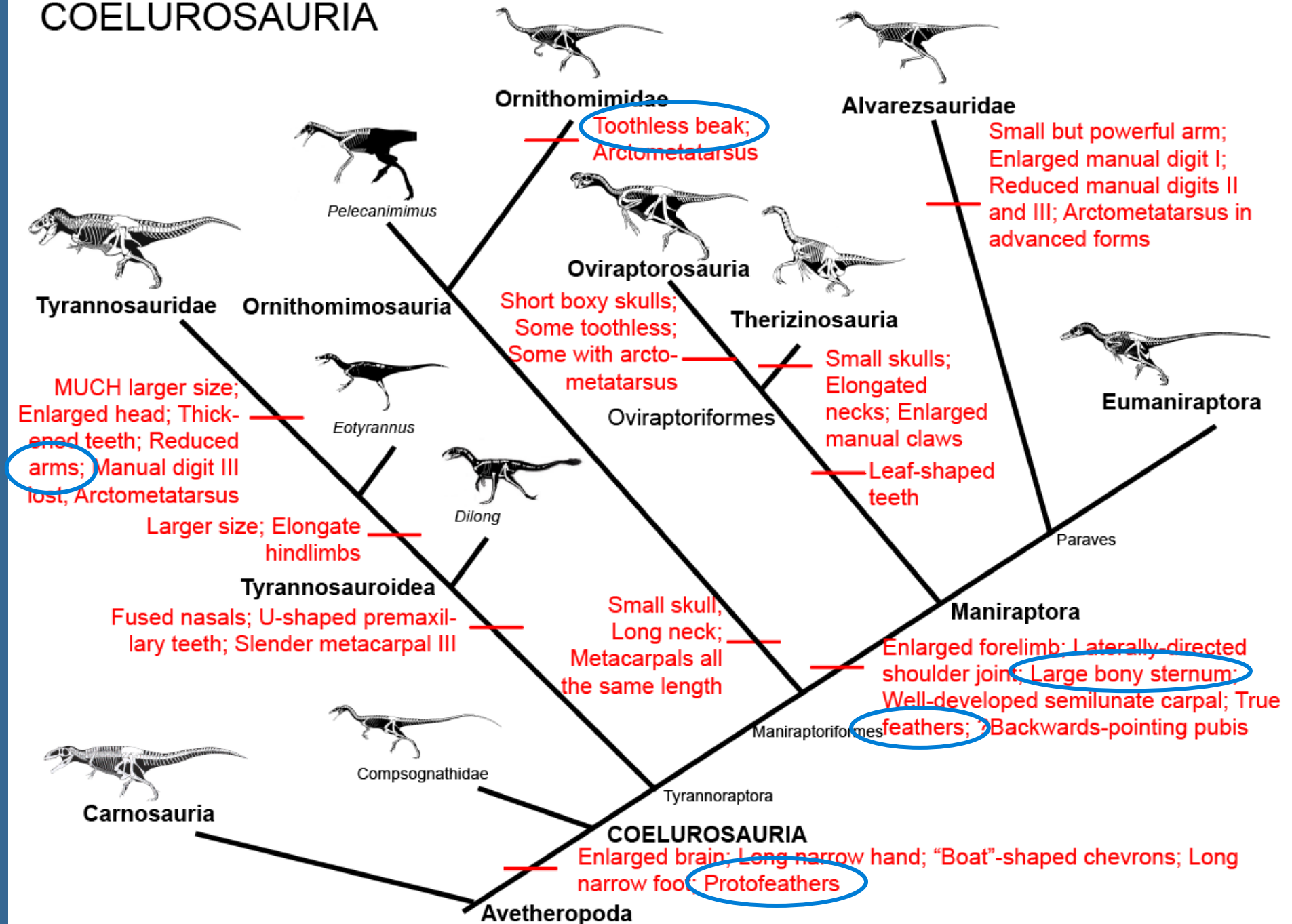
Dromaeosaurus (Eumaniraptora) (Late Cretaceous, Canada)

Long arms ????



Tyrannosaurus

COELUROSAURIA





EUMANIRAPTORA

- Troodontidae
 - Increase in number of teeth; Leaf-shaped teeth in some; Reduced arms; Elongate legs; Most have backwards-pointing pubis
- Dromaeosauridae
 - Enlarged prongs in caudal vertebrae
- Deinonychosauria
 - Sickle claw on retractable pedal digit II; Some with arctometatarsus
- Alvarezsauridae
- Archaeopteryx
- Avialae
 - Scapula fused to coracoid; Humerus longer than scapula; Ulna longer than femur
- Paraves
 - VERY long arms & hands, tail very mobile near base; distally-placed backwards-facing pedal digit I; backwards-facing pubis; long leg feathers; ?Gliding flight?
- Hesperornithes
 - Forearms lost
- Enantiornithes
- Yanornithiformes
- Ornithurae
 - Manual unguals lost; Syntarsus
- Aves
 - Toothless beak; Tibiotarsus
 - Keeled sternum
- Euornithes
 - Tail fan; Short pygostyle; Loss of long leg feathers
- Ornithothoraces
 - Carpometacarpus; Alula; Increased sternum size; Tarsometatarsus; Backwards-facing pedal digit I; ?Active powered flight?
- Pygostylia
 - Caudal count greatly reduced; Pygostyle

EUMANIRAPTORA

Increase in number of teeth; Leaf-shaped teeth in some; Reduced arms; Elongate legs; Most have forwards-pointing pubis

Sickle claw on retractable
pedal digit II; Some with
arctometatarsus

Dromaeosauridae

- Enlarged prongs in caudal vertebrae

Toothless beak

Forearms lost

Hesperornithes

Aves

◦ **Toothless beak:**

Tibiotarsus

- Keeled sternum

- Manual unguals lost;
Synsacrum

Euornithes

- Tail fan; Short pygostyle; Loss of long leg feathers

Ornithothoraces

- Carpometacarpus; Alula; Increased sternum size; Tarsometatarsus; Backwards-facing pedal digit I; ?Active powered flight?

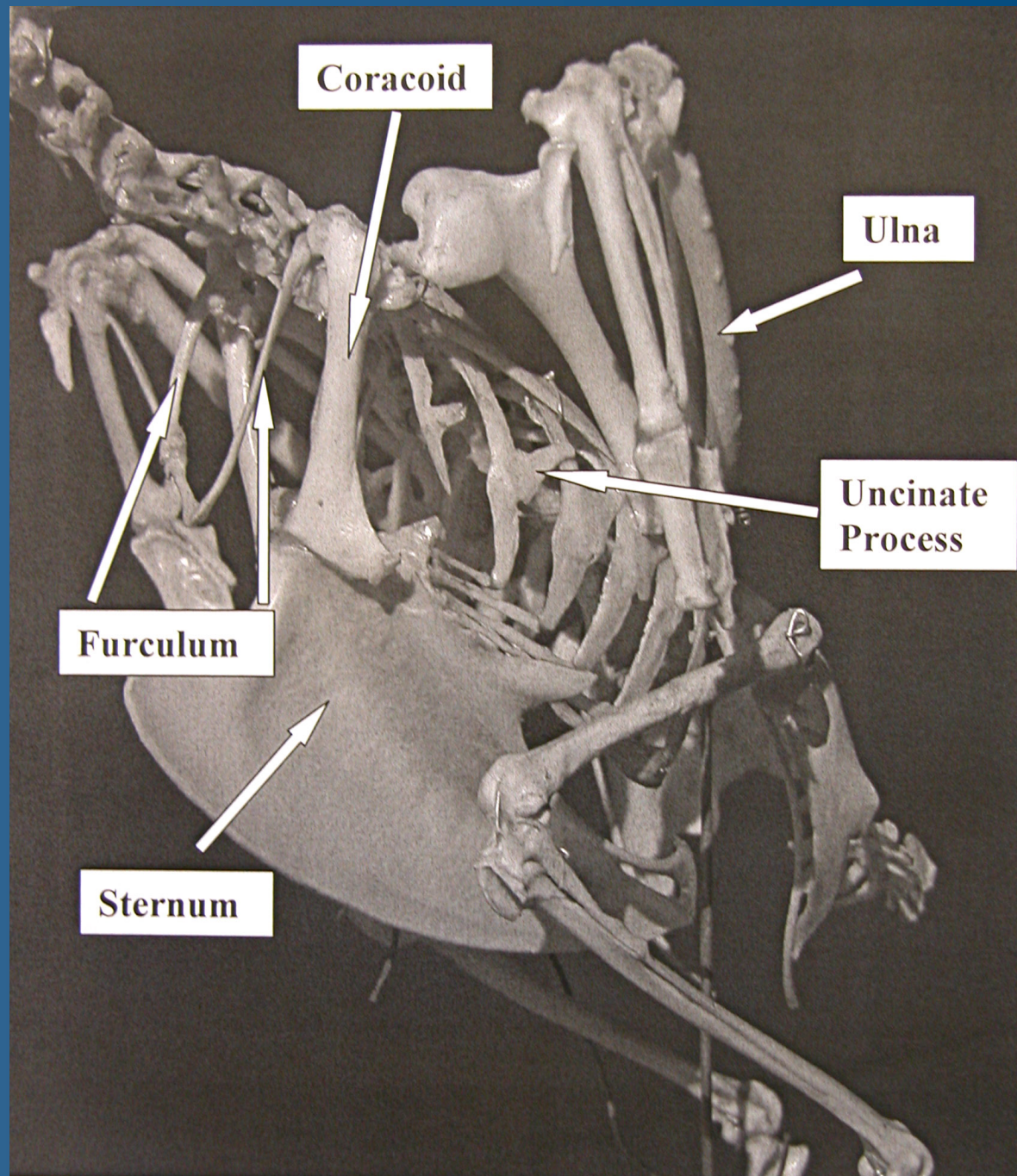
- Caudal count greatly reduced; Pygostyle

~~Avialae~~

Scapula fused to coracoid; Humerus longer than scapula;
Ulna longer than femur

EUMANIRAPTORA

VERY long arms & hands, tail very mobile near base; distally-placed backwards-facing pedal digit I; backwards-facing pubis; long leg feathers; s?Gliding flight?



Caudipteryx (Early Cretaceous, China)

Oviraptor from the Jehol-fauna



a.

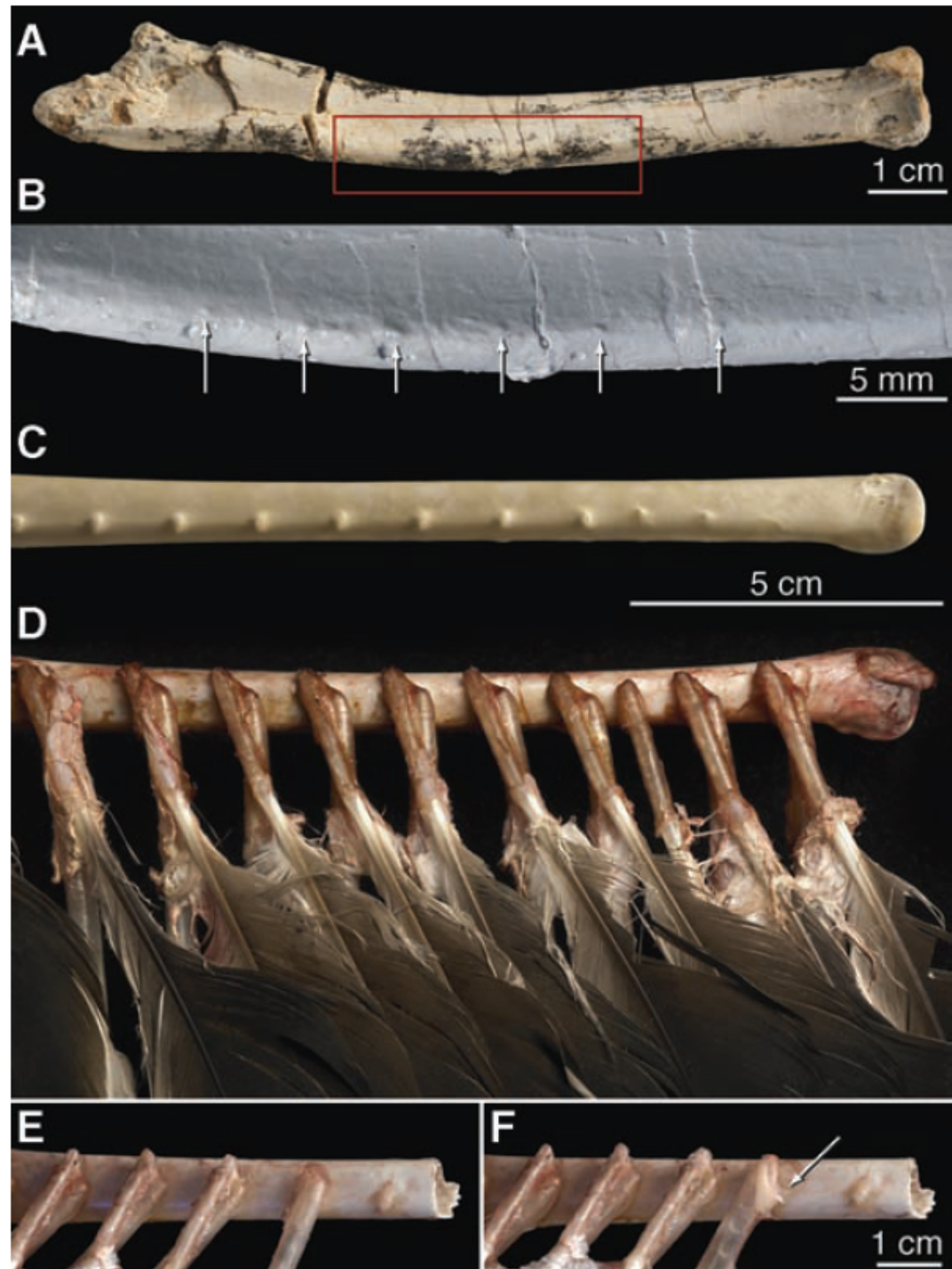


b.

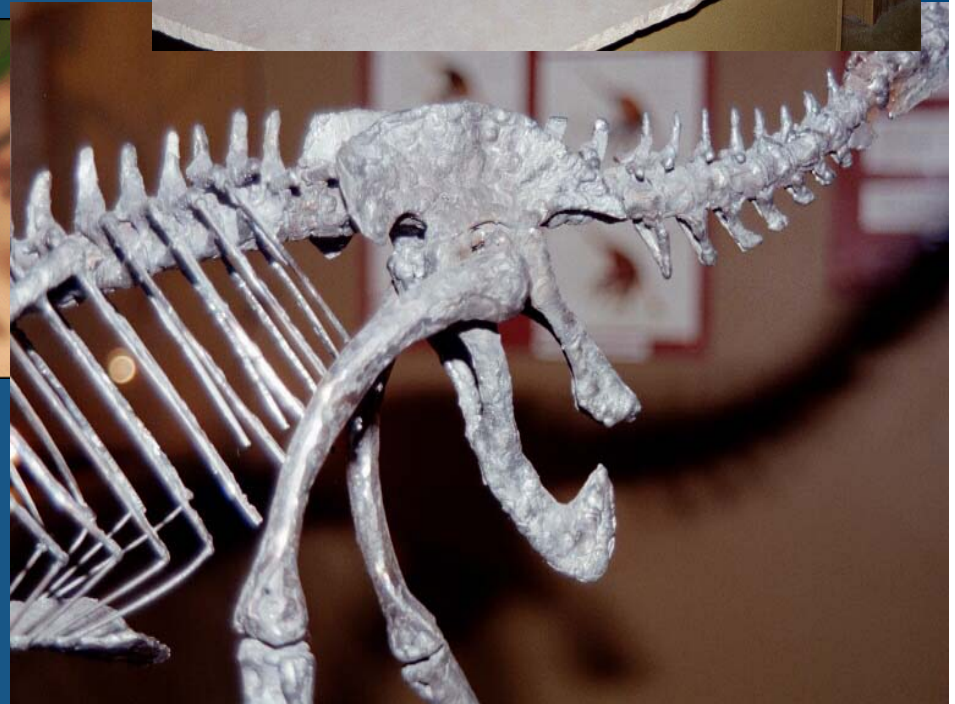
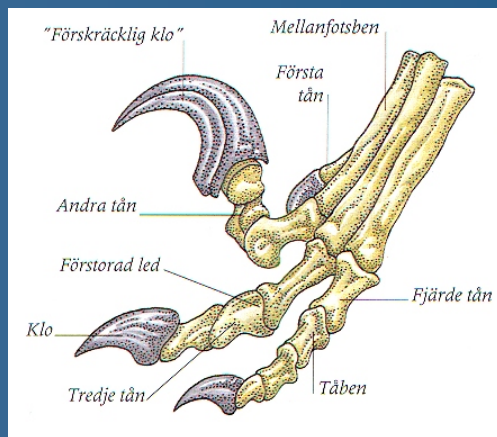
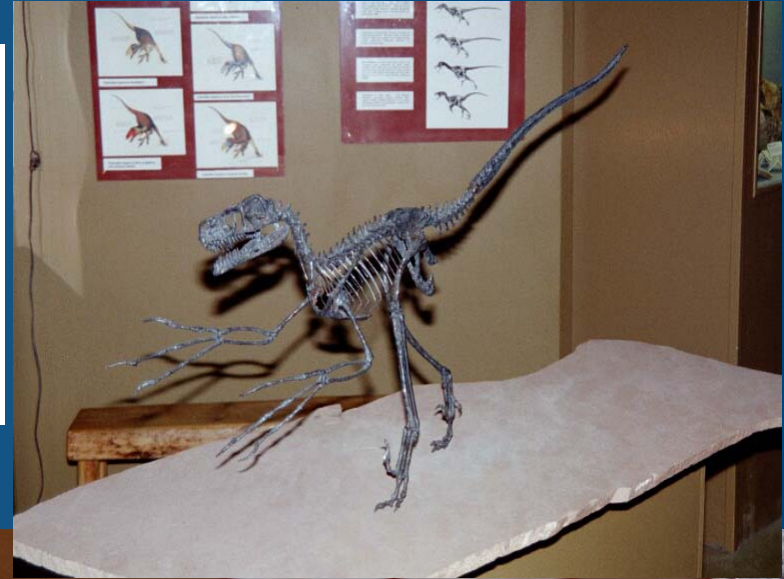
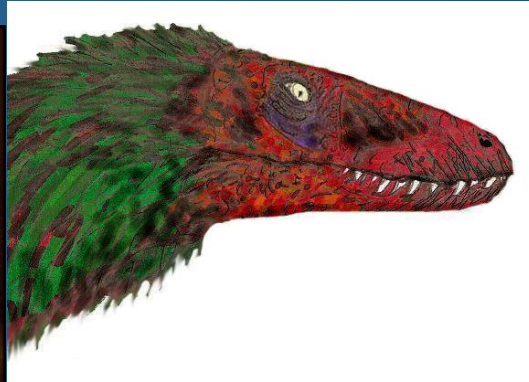
Velociraptor

Upper Cretaceous
Mongolia

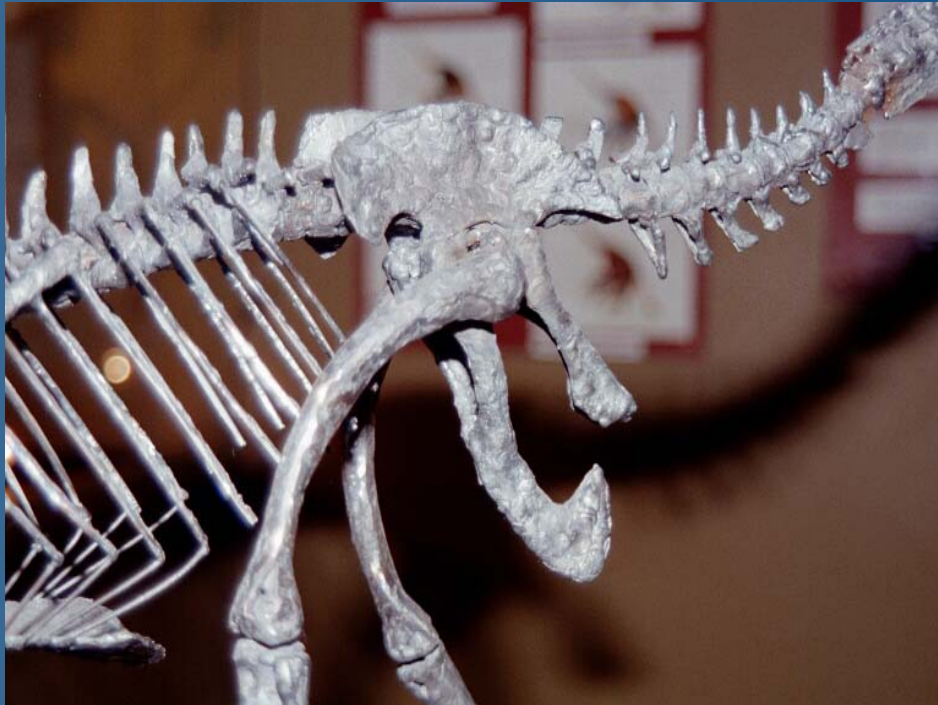
presence of
quill knobs



Deinonychus (Middle Cretaceous, USA)



most likely to be feathered

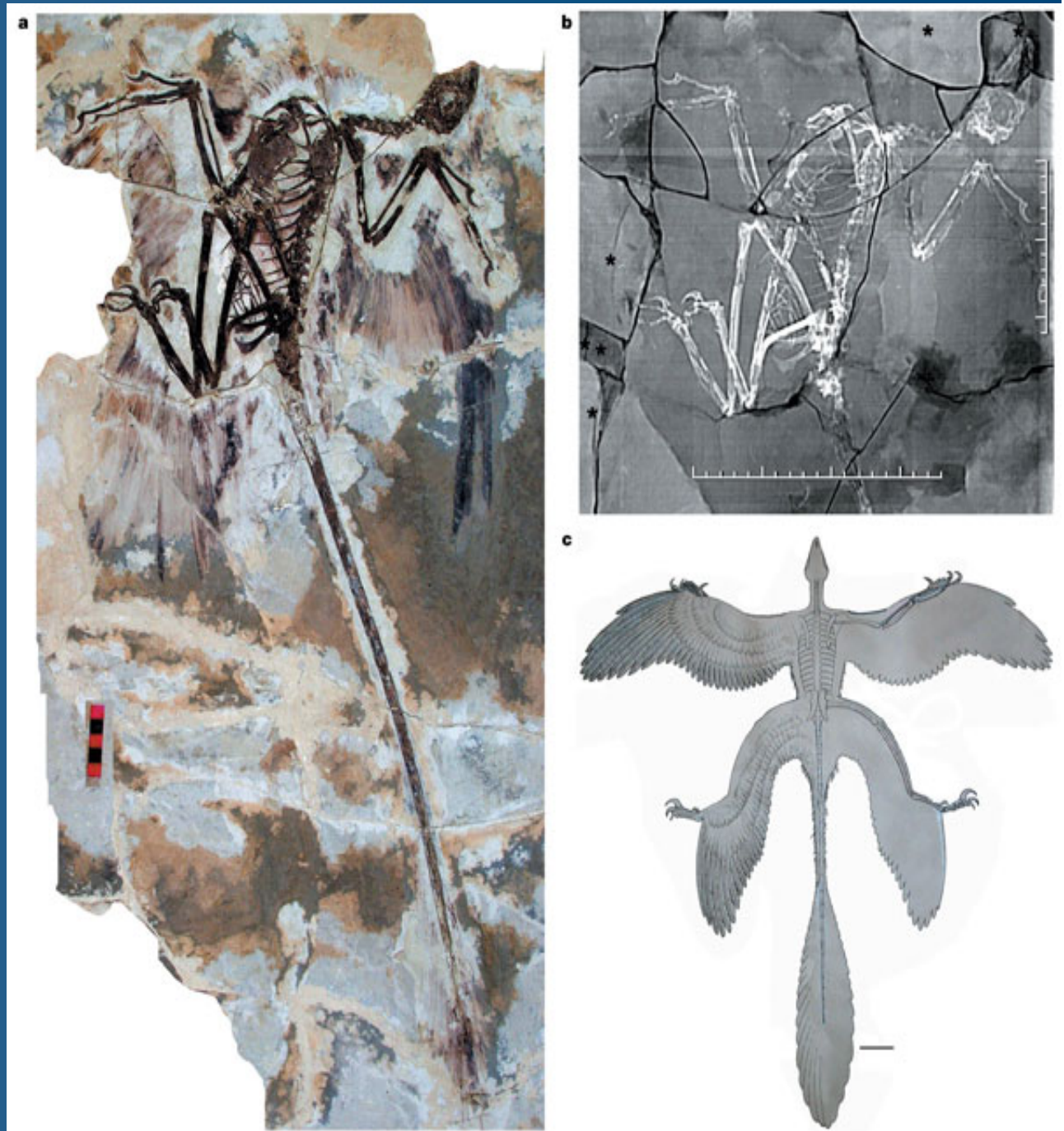


■ *Deinonychus*
(Cretaceous)

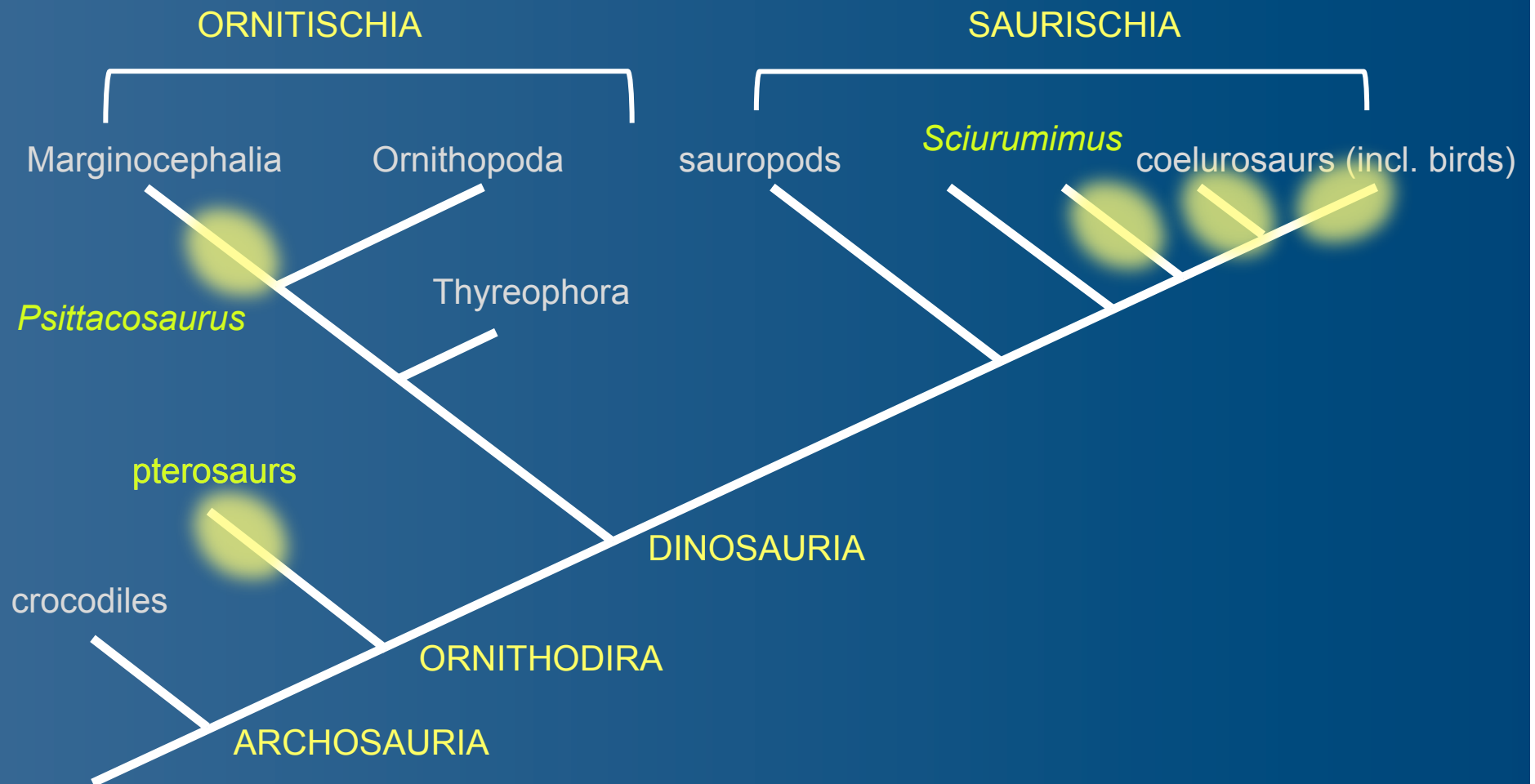


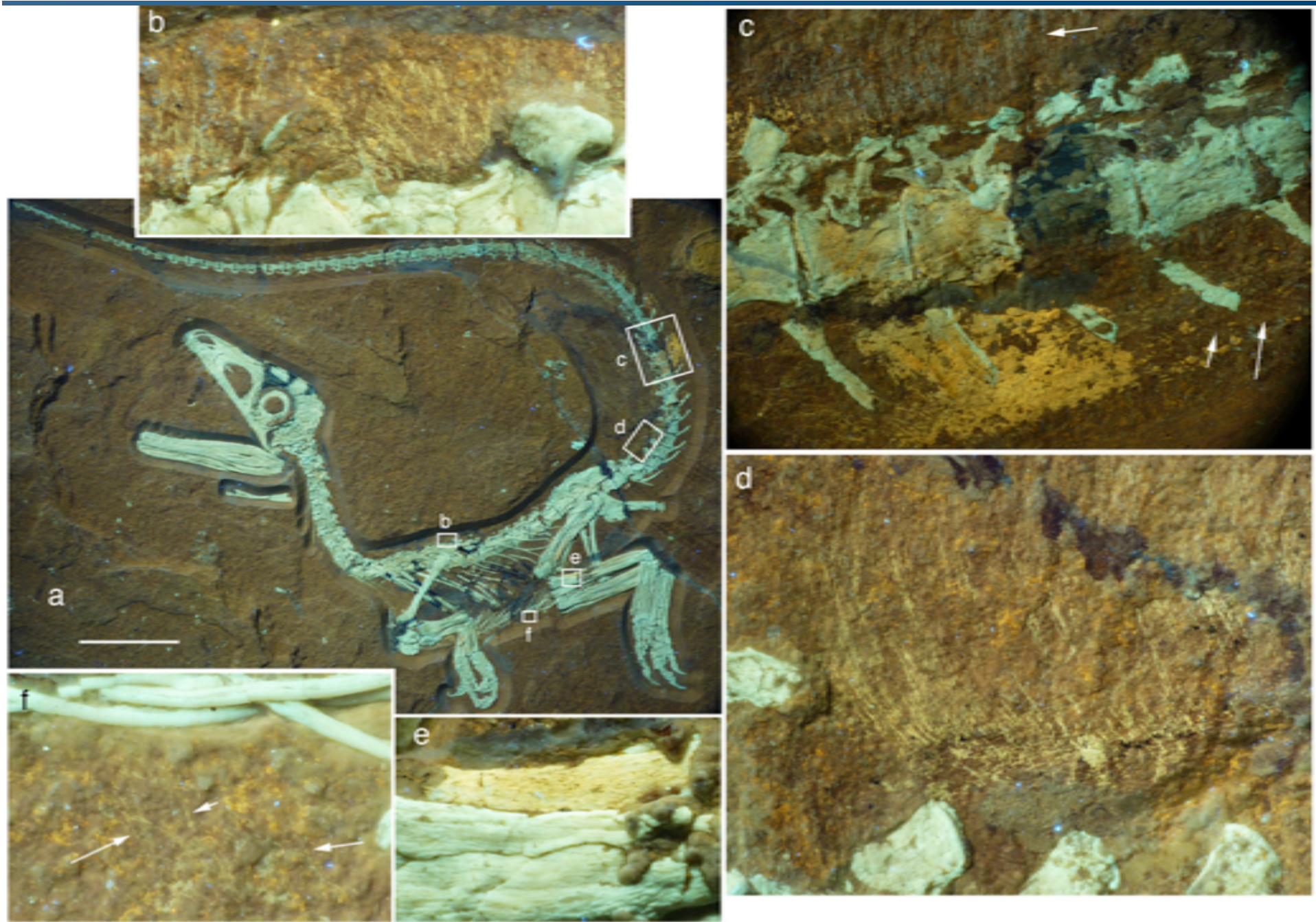
■ *Moa* (Pliocene)

Microraptor
Early Cretaceous
China



More feathers...





Sciurumimus albersdoerferi , Late Jurassic, Germany

Implications?

If ...

...pycnofibres of pterosaurs,
...tail bristles of psittacosaur,
...protofeathers of megalosaurs and tyrannosaurs
...and feathers of coelurosaurs are homologue ...

then...

..."feathers" could be an ancestral character of all Ornithodira
...which in turn would/could mean they are all warm-blooded.