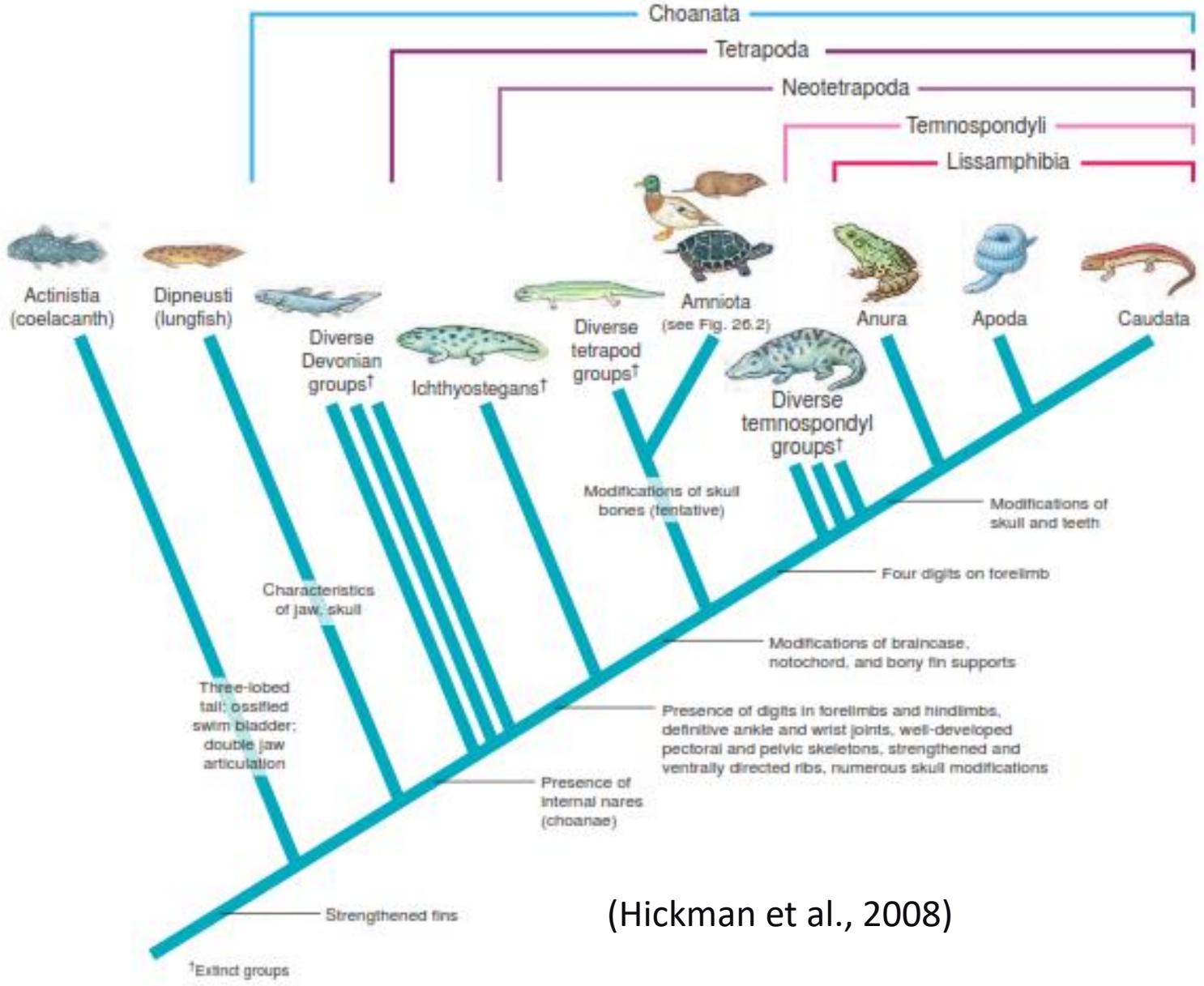
Palaeontology

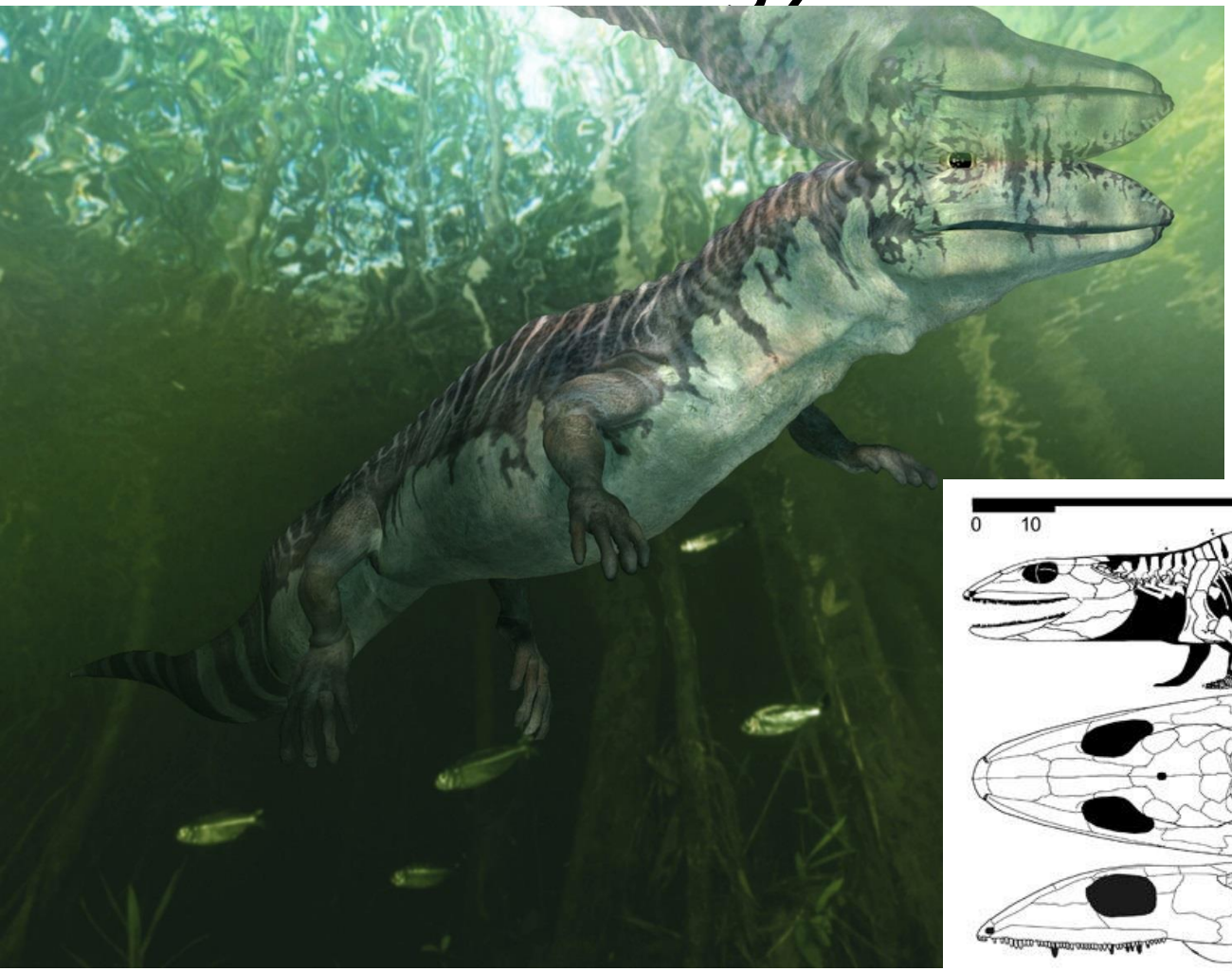
Lecture 9

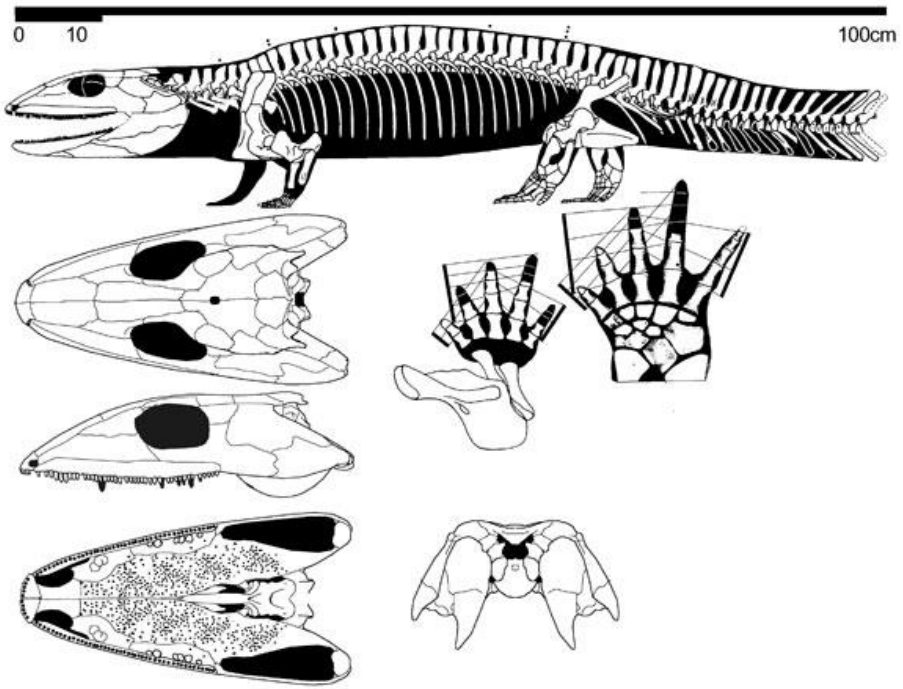
Animal Kigdom: Chordates, Tetrapods, Amniotes



(Hickman et al., 2008)

Proterogyrinus shceelei





Anthracosauria, the clade towards Amniota

Eryops megacephalus

Temnospondyli the clade that led to Lisamphibians

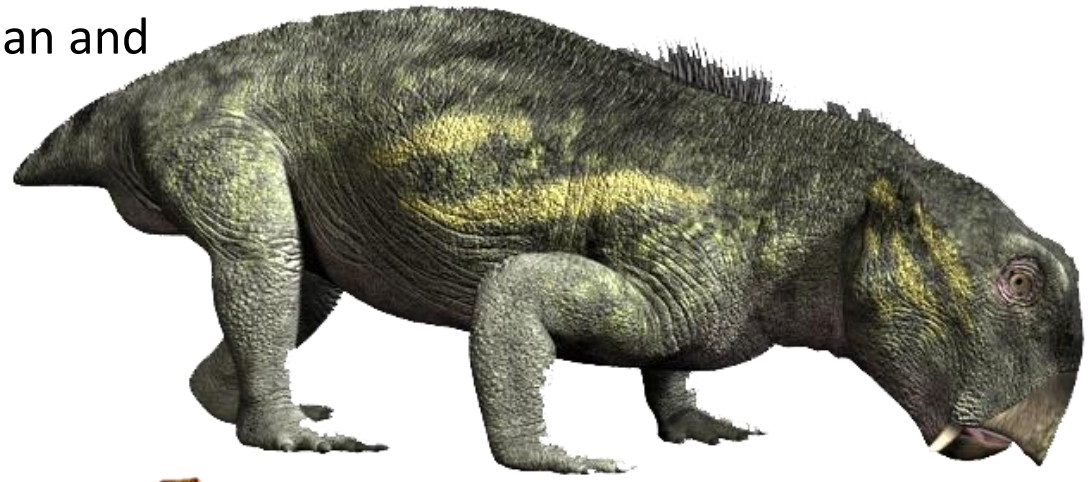
Cacops aspidephorus

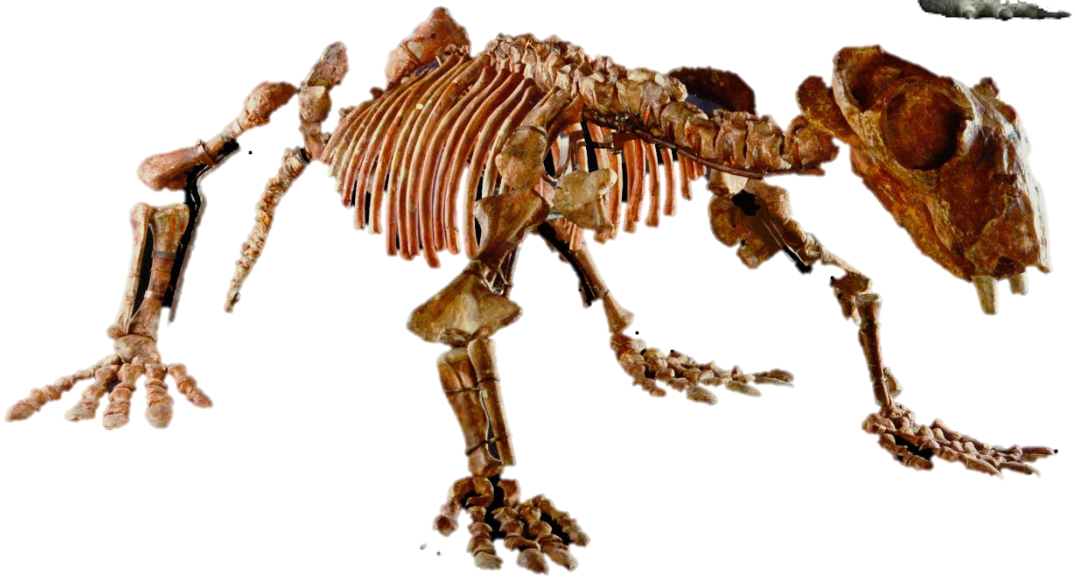
Field Museum,

Small amphibian of the Late Permian.

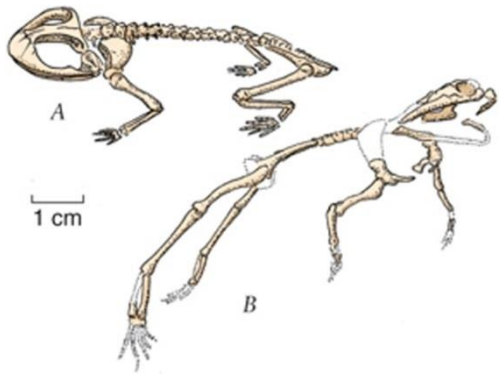
Lystrosaurus

Large amphibian of Late Permian and Triassic





Lisamphibians



- Order Anura (Late Triassic– Recent) frogs and toads, the ilia project anteriorly and the posterior vertebrae are fused into a rod called urostyle, forming a strong pelvic basket
- Order Urodela (Late Jurassic – Recent)

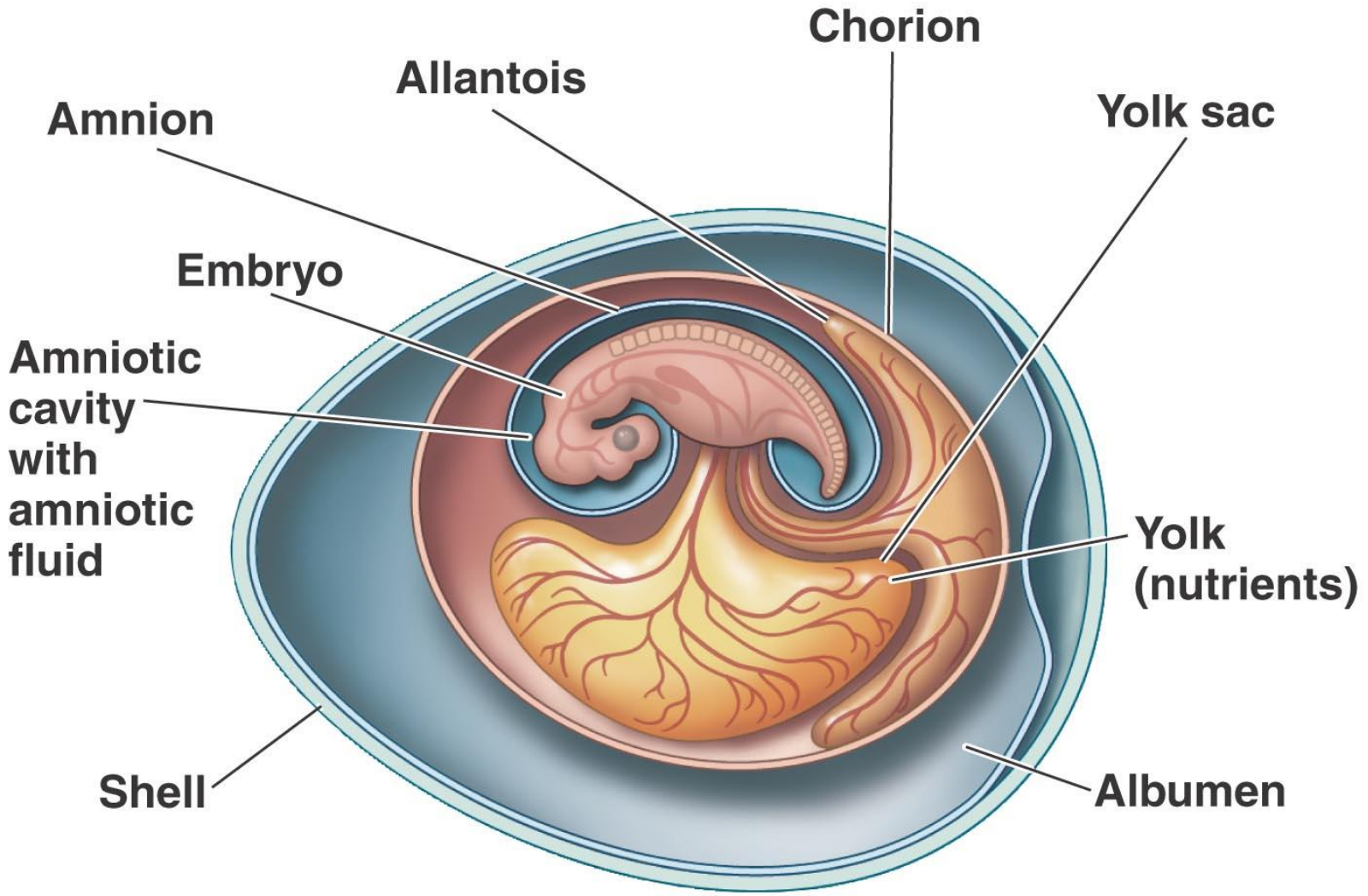
  Newts and salamanders
- Order Gymnophiona (Early Jurassic – Recent)

  Caecilians, strange, little, legless, earthworm-like amphibians

Vertebrates

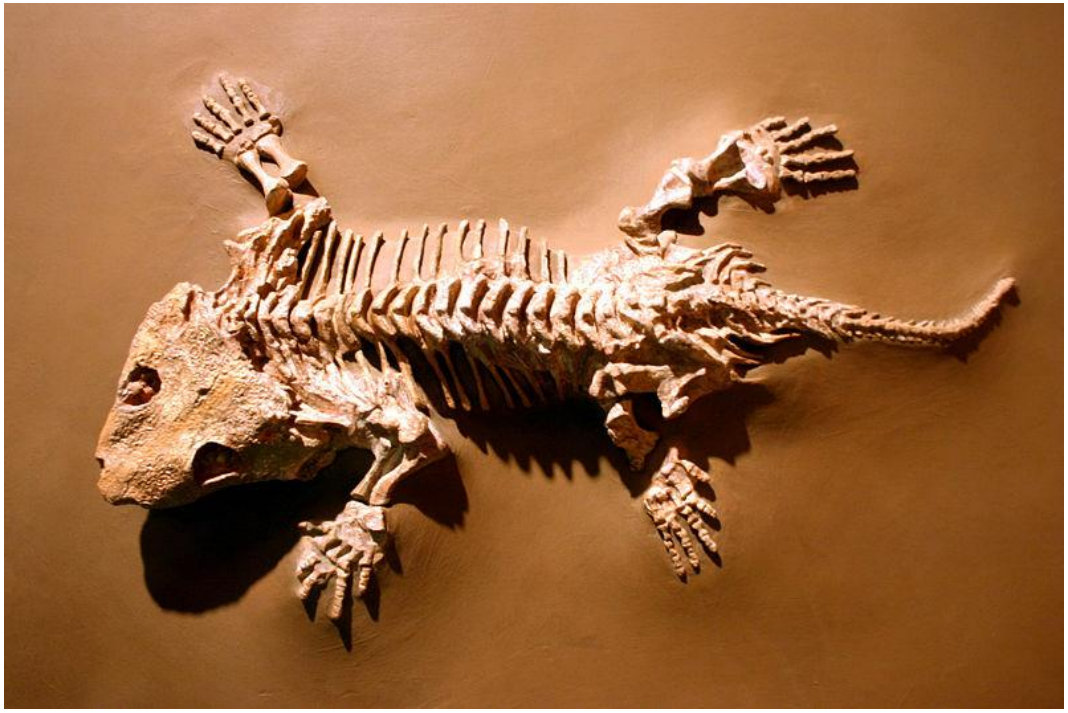
- Non-amniotic vertebrates - Egg without cover that is fertilized externally. It must be either in liquid or in water for reproduction.
  - Fish
  - Amphibia
- Amniotes. Internal fertilization and amniotic egg. No water needed for reproduction.
  - Reptiles
  - Birds
  - Mammals

Amniotic egg



It’s importance

- It allowed the possibility to live away from the water.
- It allowed vertebrates to live in different types of terrestrial environments.
- The amniotic egg evolved during the Carboniferous.
  The first fossilized eggs at L. Permian.



- Amphibians such as Seymouria (Permian), present mixed characters of amphibians and reptiles. A primitive amphibian that looked like Seymouria was probably the ancestor of the reptiles.

Reptiles

- The first entirely terrestrial tetrapods
  Age: Late Carboniferous - today.
  The oldest fossils in the genera Hylonomus and Paleothyris (310 my) in Canada in fossilized hollow trees full of sediment. Length 24 cm and looked like lizards.

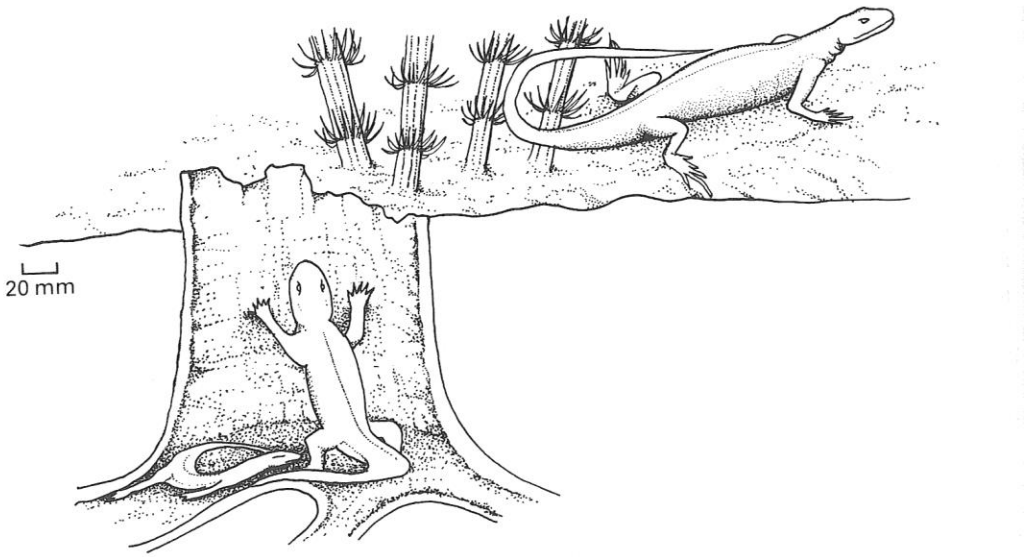
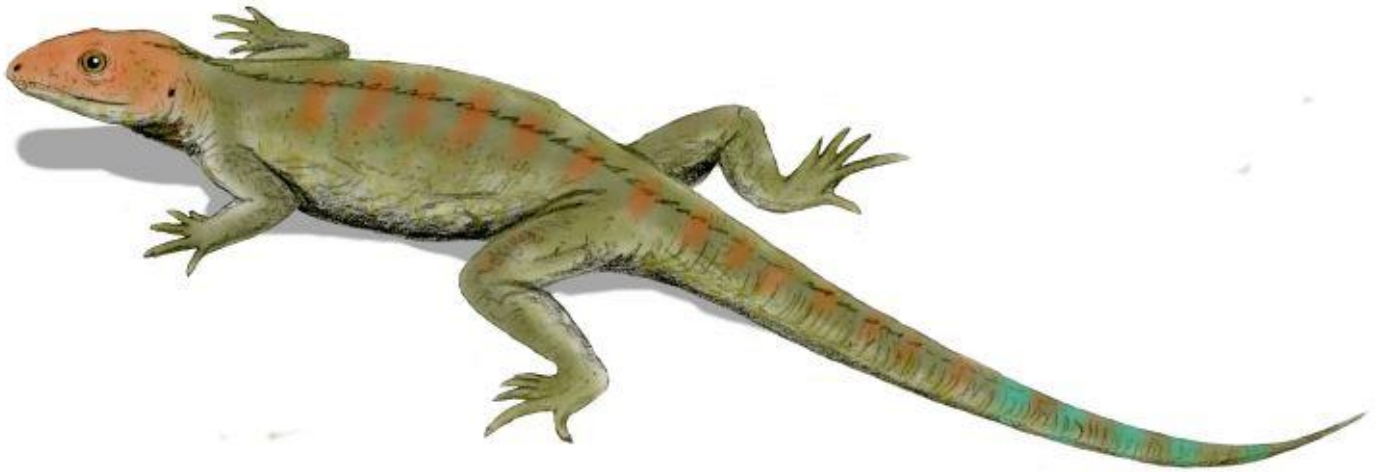
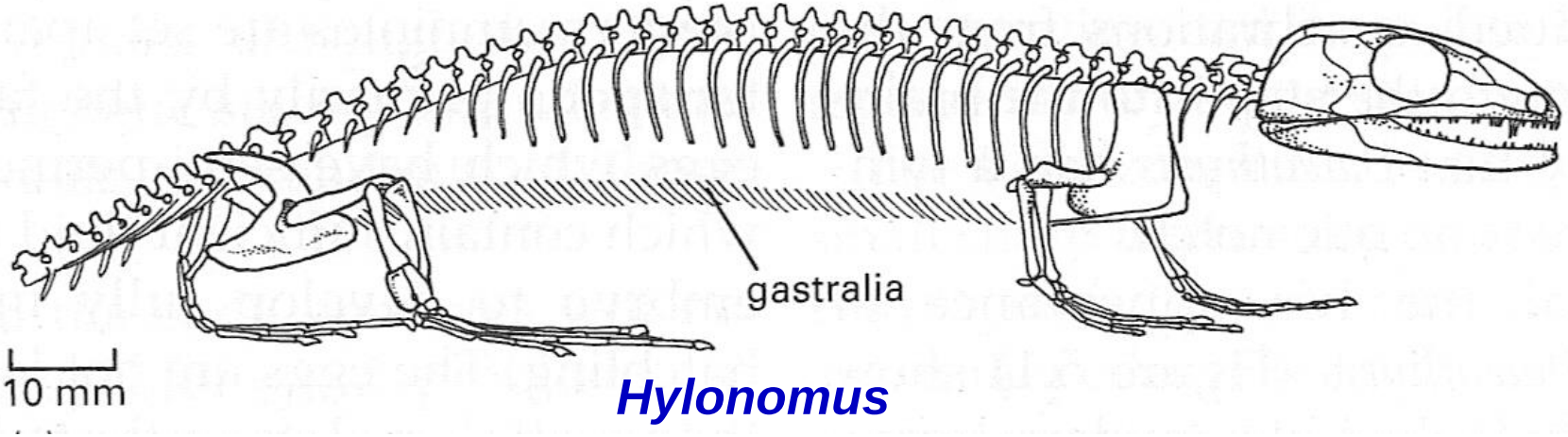


Fig. 5.1 The mode of preservation of the early amniotes *Hylonomus* and *Paleothyris* which were trapped in hollow tree stumps in the mid Carboniferous of Nova Scotia. (After Carroll, 1970 and other sources.)

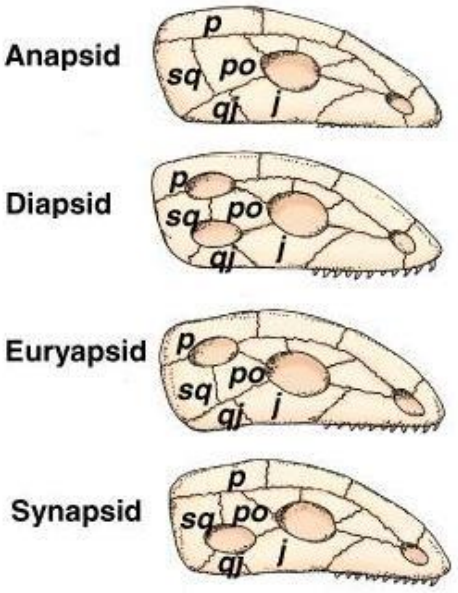


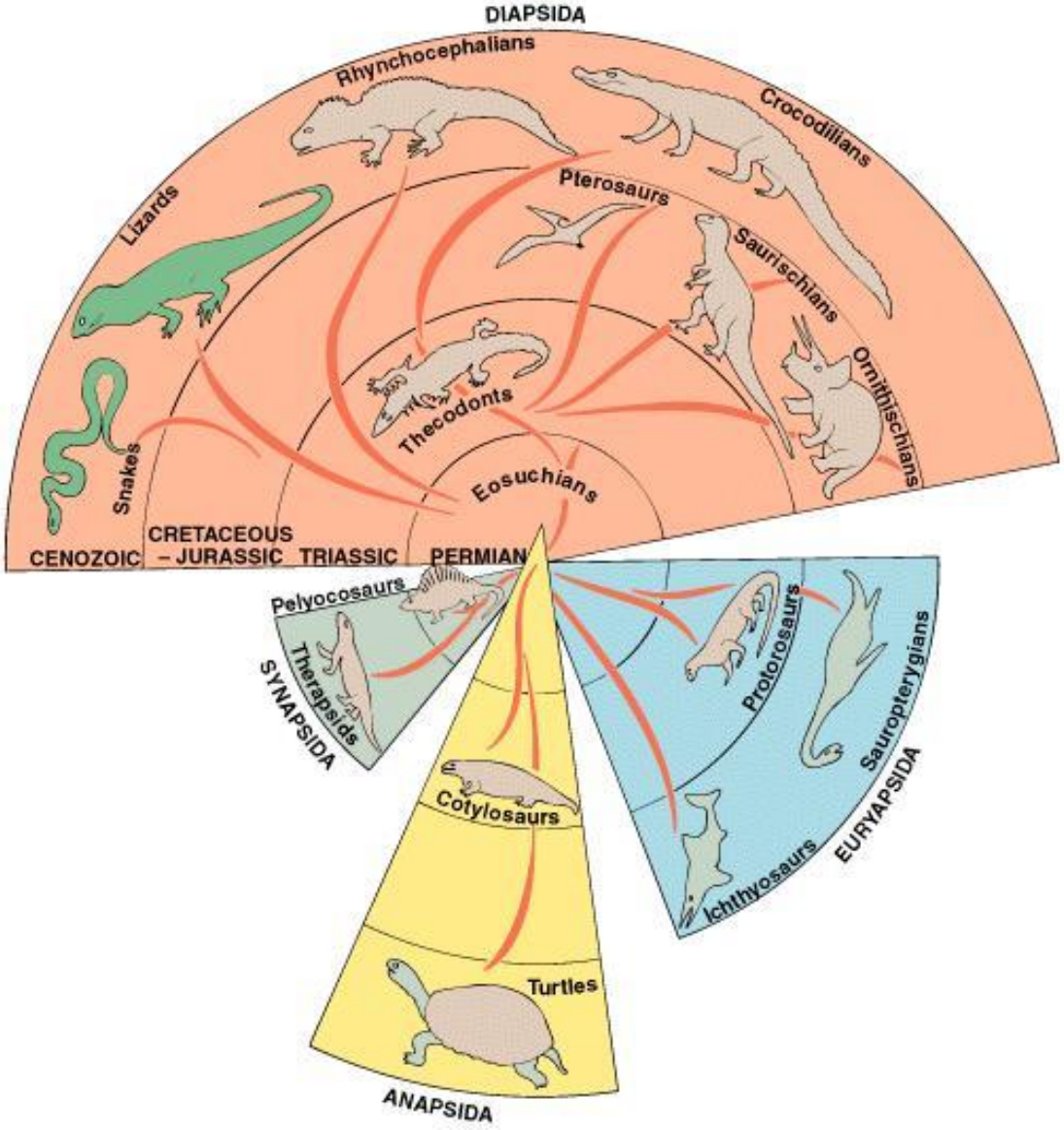


Hylonomus

Vertebrate skulls

- Anapsid (with no temporal fenestrae) - amphibians, first reptiles, and turtles.
- Diapsid (with two temporal fenestrae) - dinosaurs, pterosaurs, birds, and modern reptiles (except turtles).
- Euryapsid (with one upper temporal fenestra) - Marine reptiles (plesiosaurs, icthyosaurs).
- Synapsid (with one lower temporal fenestra) - pelycosaurs, therapsids, and mammals.




DIAPSIDA
Rhynchocephalians
Crocodilians
Lizards
Pterosaurs
Saurischians
Ornithischians
Thecodonts
Snakes
Eosuchians
CENOZOIC
CRETACEOUS – JURASSIC
TRIASSIC
PERMIAN
Pelycosaurs
Therapsids
SYNAPSIDA
Protorosaurs
Sauropterygians
EURYAPSIDA
Cotylosaurs
Ichthyosaurs
Turtles
ANAPSIDA

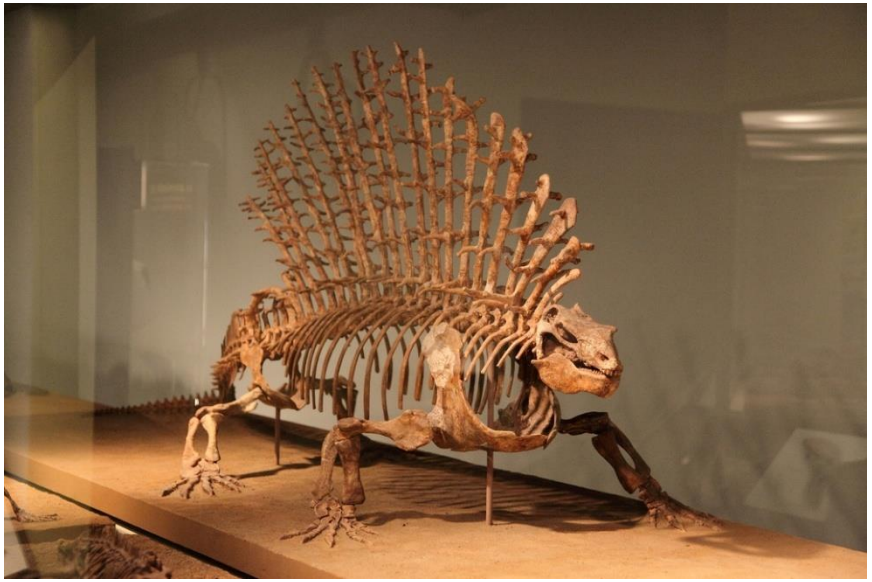
Synapsids

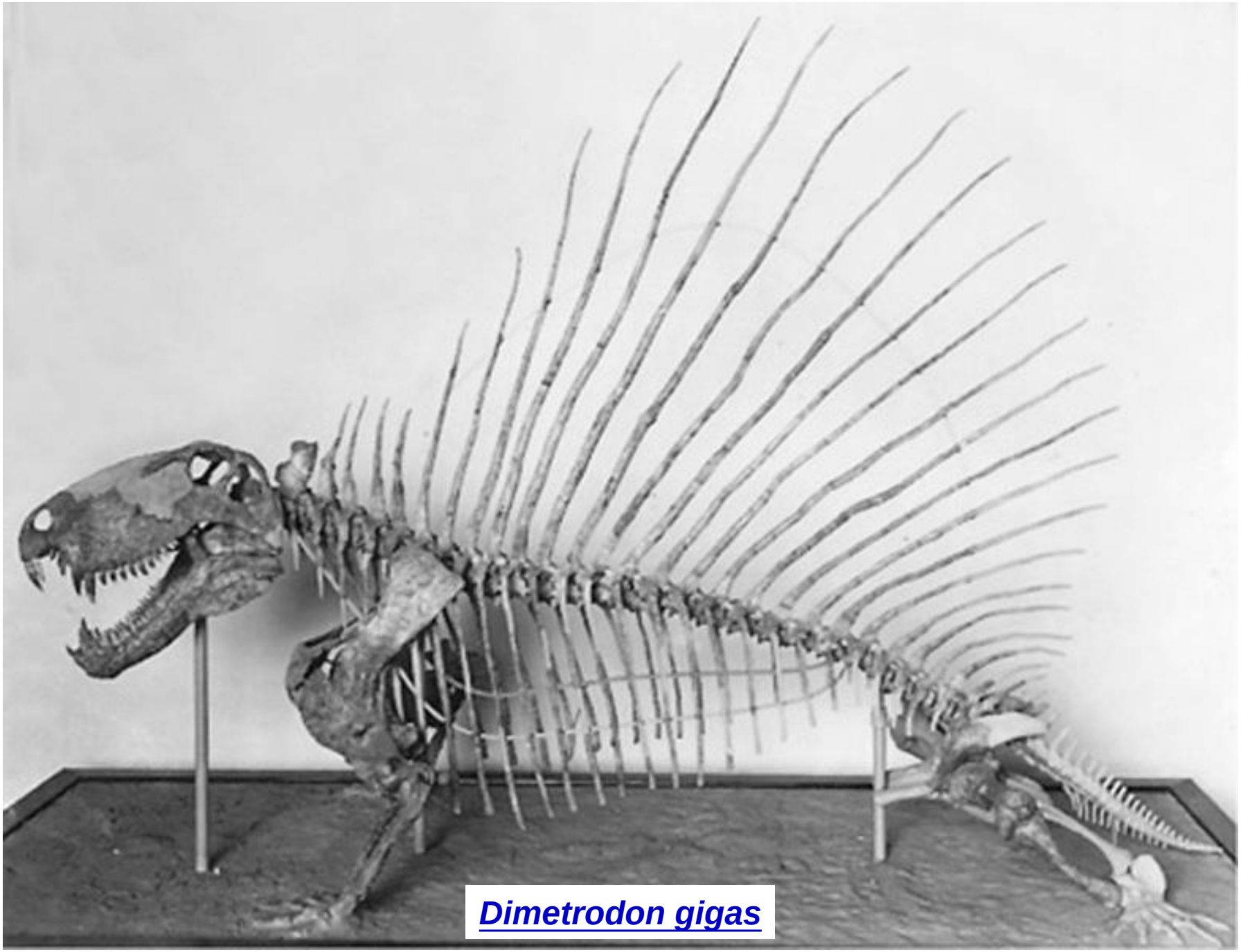
- They distinguished from the rest of the reptiles in the Late Carboniferous .
- The dominant terrestrial vertebrates of the Permian.
- Also known as "mammal-like" reptiles, different from all other reptiles.
- They include the pelycosaurs and the therapsids.

Pelycosaurs

- They are characterized by the developed "fins" on their backs, which are supported by vertebral spines. They probably functioned as temperature regulators.
- Carnivores (*Dimetrodon*) and herbivores (*Edaphosaurus)*

Edaphosaurus pogonius, Field Museum




Dimetrodon gigas

Dimetrodon **και** ***Edaphosaurus*****, ερπετά του Περμίου.**

Therapsids

Age: Permian – Triassic

Medium size with mammalian characteristics:

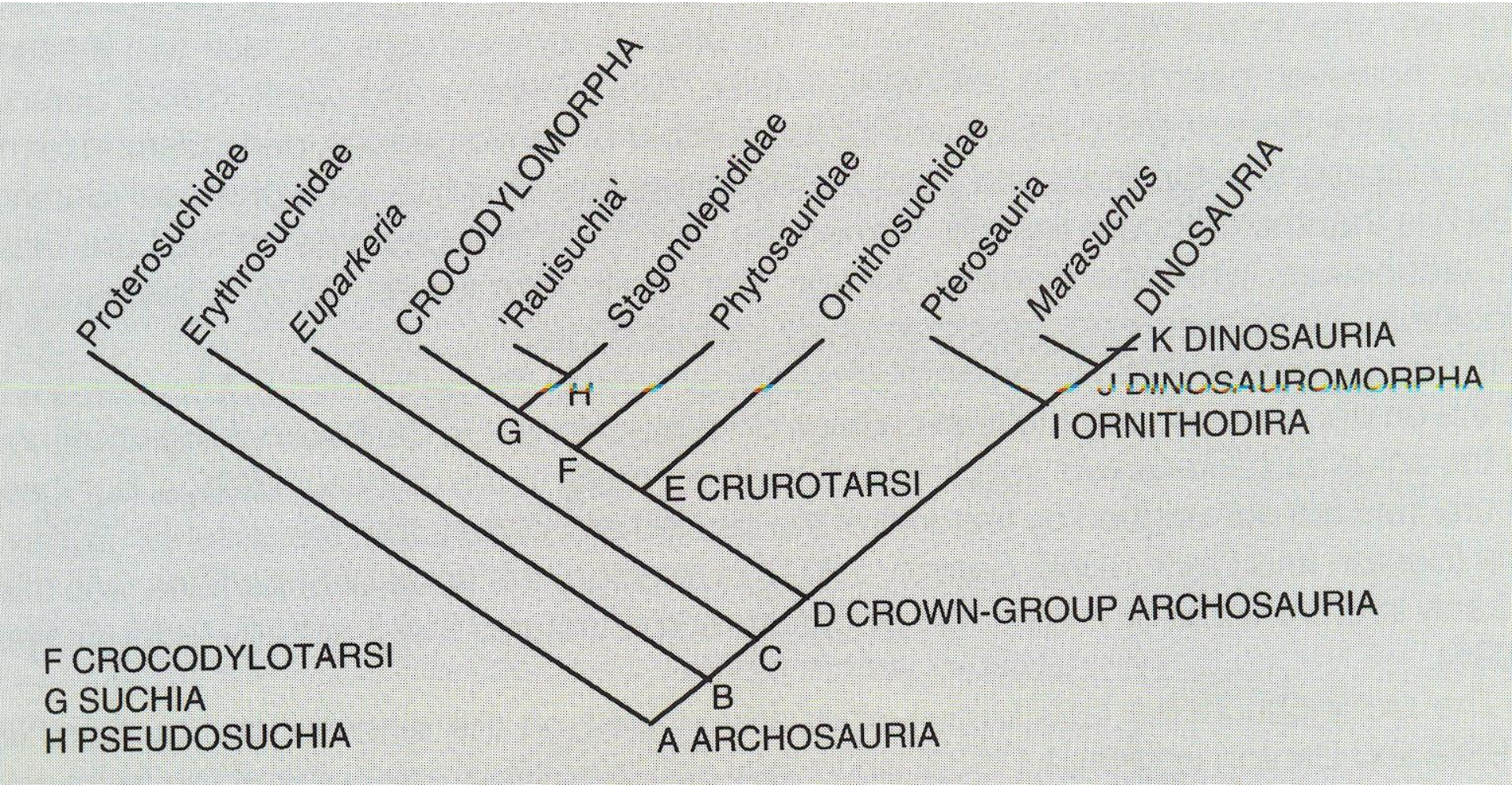
1. Fewer bones in the skull
2. Jaw structure like mammals
3. Differentiated teeth (incisors, canines, molars)
4. limbs placed under the body
5. Reduced ribs
6. Articulation between the skull and the atlas with two tubercles
7. Bony palate that allowed breathing during chewing
8. Holes for "whiskers" in the muzzle (so hairs)

Cynognathus

Cynognathus crateronotus, από το Τριαδικό της Ν. Αφρικής.

Reptiles

- Great diversity in the Mesozoic.
- Many new groups appeared in the Mesozoic, dominating in land, sea and air.
- The most interesting group of the Mesozoic was the archosaurs, a group of diapsids that included the crocodiles, the pterosaurs, the dinosaurs, and the Thecodonts.


Proterosuchidae
Erythrosuchidae
Euparkeria
CROCODYLOMORPHA
'Rauisuchia'
Stagonolepididae
Phytosauridae
Ornithosuchidae
Pterosauria
Marasuchus
DINOSAURIA
K DINOSAURIA
J DINOSAUROMORPHA
I ORNITHODIRA
H
G
F
E CRUROTARSI
D CROWN-GROUP ARCHOSAURIA
C
B
A ARCHOSAURIA
F CROCODYLOTARSI
G SUCHIA
H PSEUDOSUCHIA

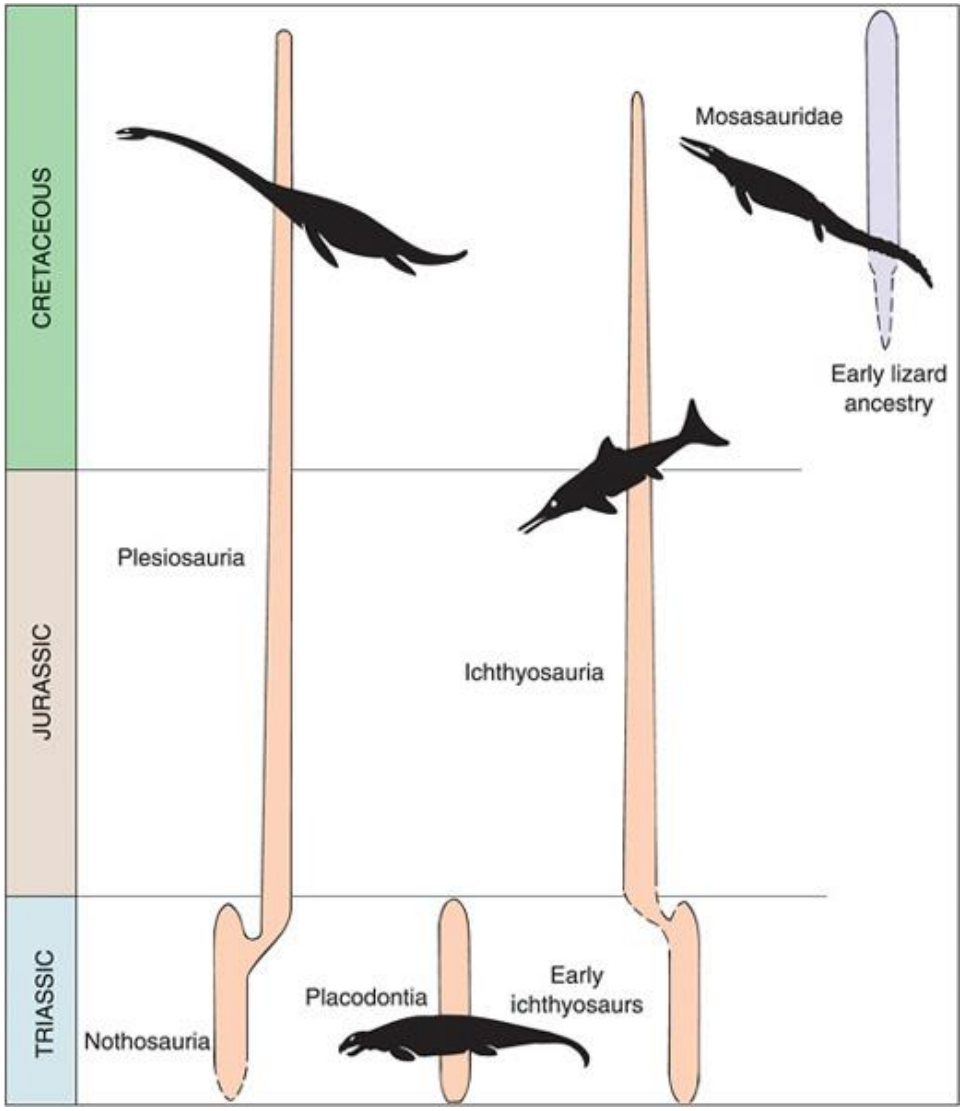
Reptiles colonize the sea

- Many reptile groups have successfully adapted to the marine environment.
- Settlement seems to have worked as a retrograde adaptation since reptiles were the first tetrapods that developed adaptations to live exclusively on land without having to return to the water for reproduction.
- In this case reptiles as predators have settled in the sea to exploit the abundance of food.
- They fed on ammonites, sharks, osteicthyans and other animals inhabiting the seas.

Marine reptiles

- Adaptations to the marine environment included:
- Flat finned limbs
- Hydrodynamic bodies
- Modified lungs for greater efficiency
- Reproductive adaptations in some groups to give birth in the sea (ovoviviparous).
- Others like sea turtles have returned to land to give birth.

Marine reptiles



1. Prolacertiformes
2. Pachypleurosauria
3. Nothosauria
4. Placodontia
5. Plesiosaurs,
6. Icthyosaurs
7. Mosasaurs
8. Crocodiles
9. Marine turtles

Marine reptiles

1. Prolacertiformes
2. Pachypleurosauria
3. Nothosauria
4. Placodontia (wide teeth to crush shells of mollusks). They lived only in the Triassic The first reptile that returned to the sea was Mesosaurus in the early Permian

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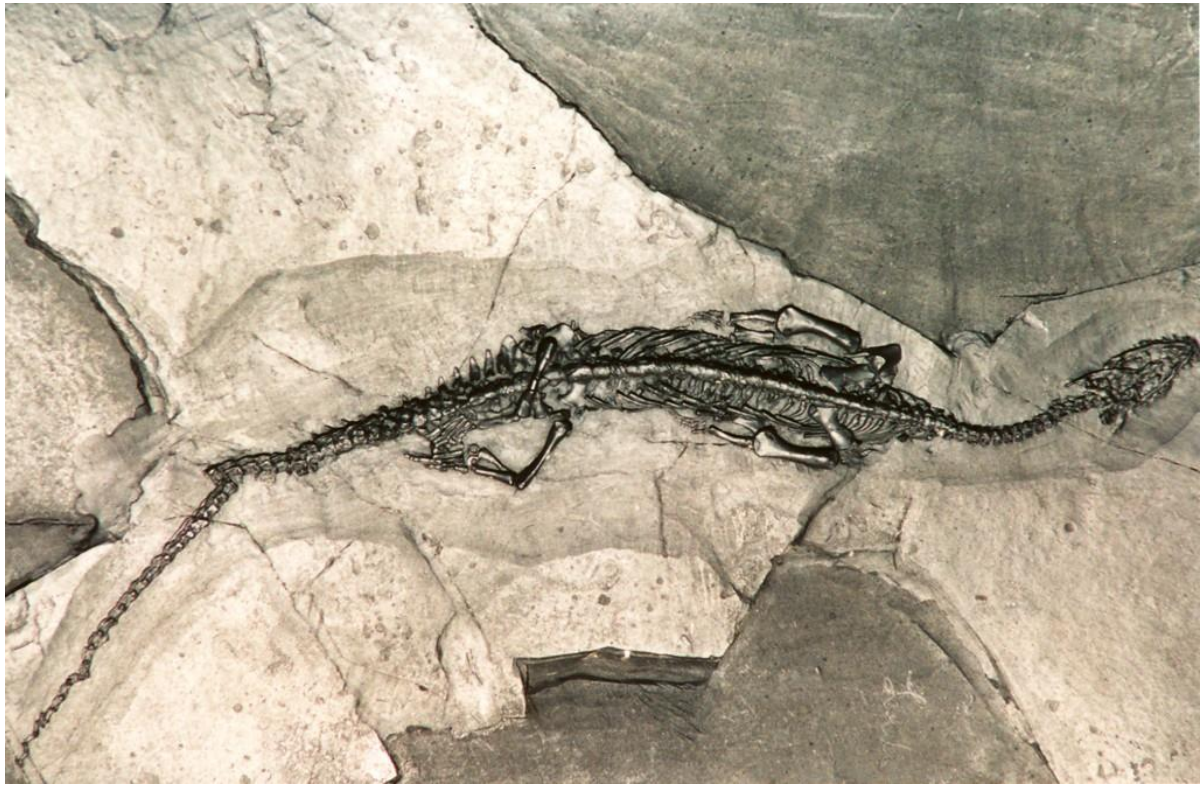
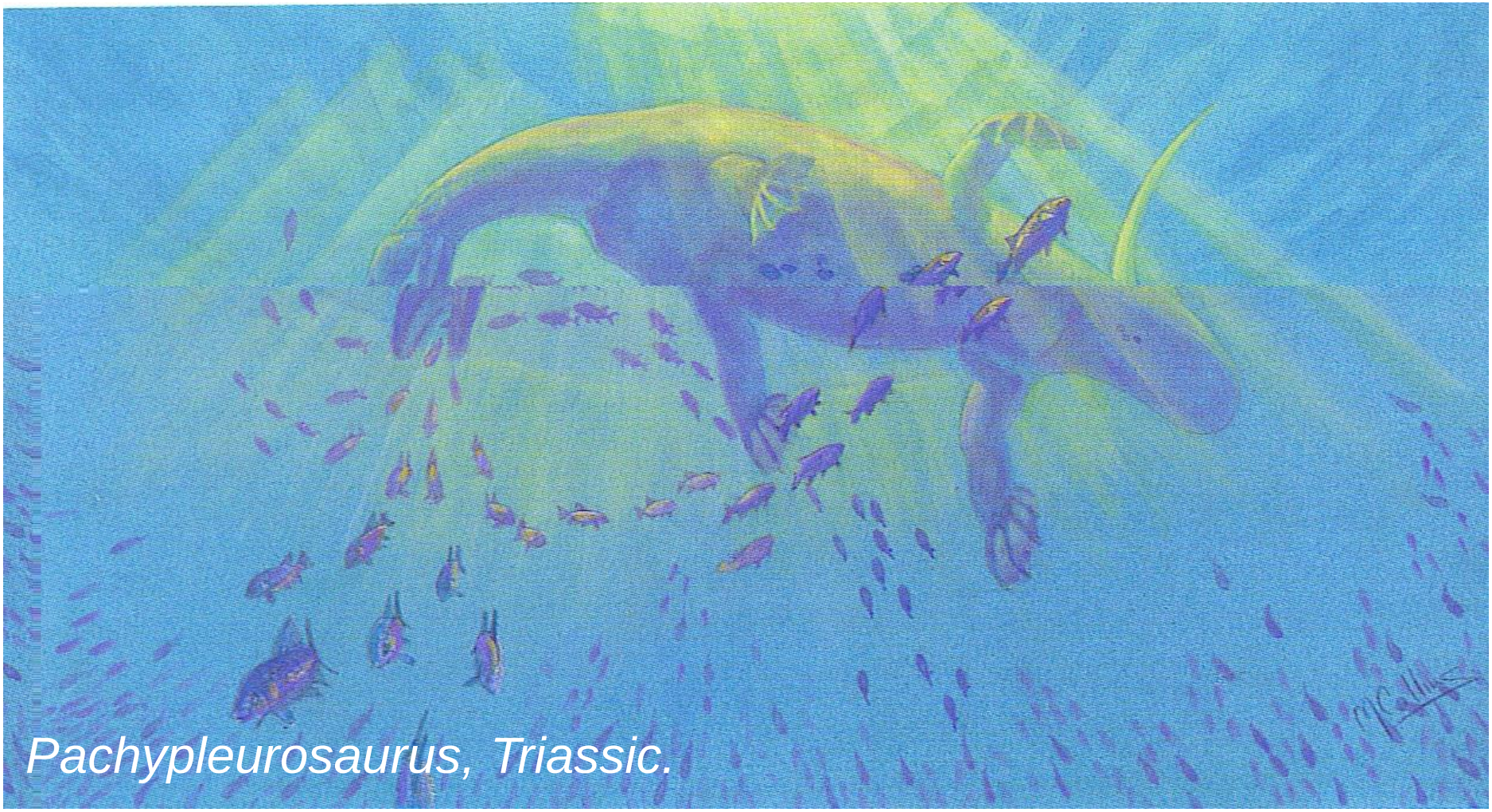
Mesosaurus, Early Permian

Tanystropheus, Prolacertiform reptile of the Triassic

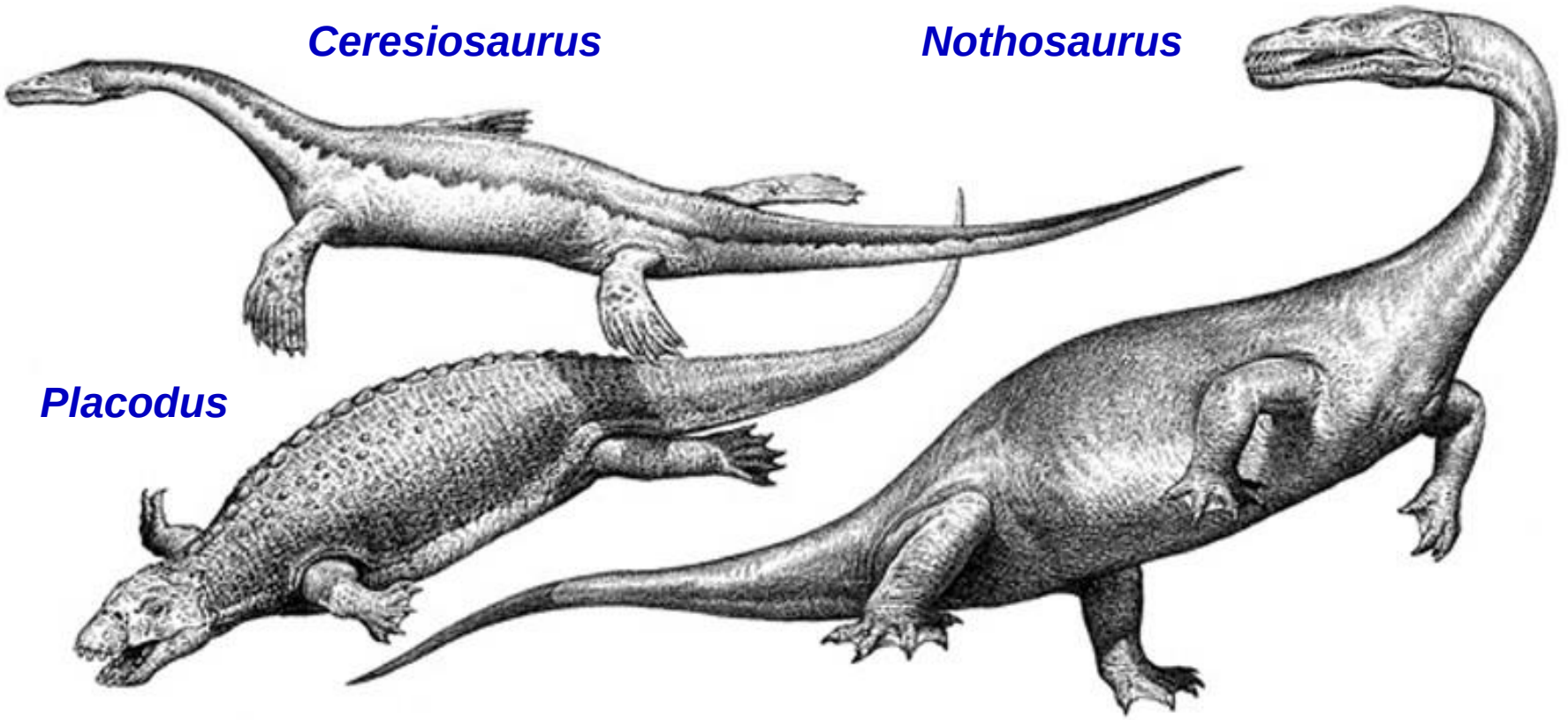
Pachypleurosauria



Pachypleurosaurus edwarsi

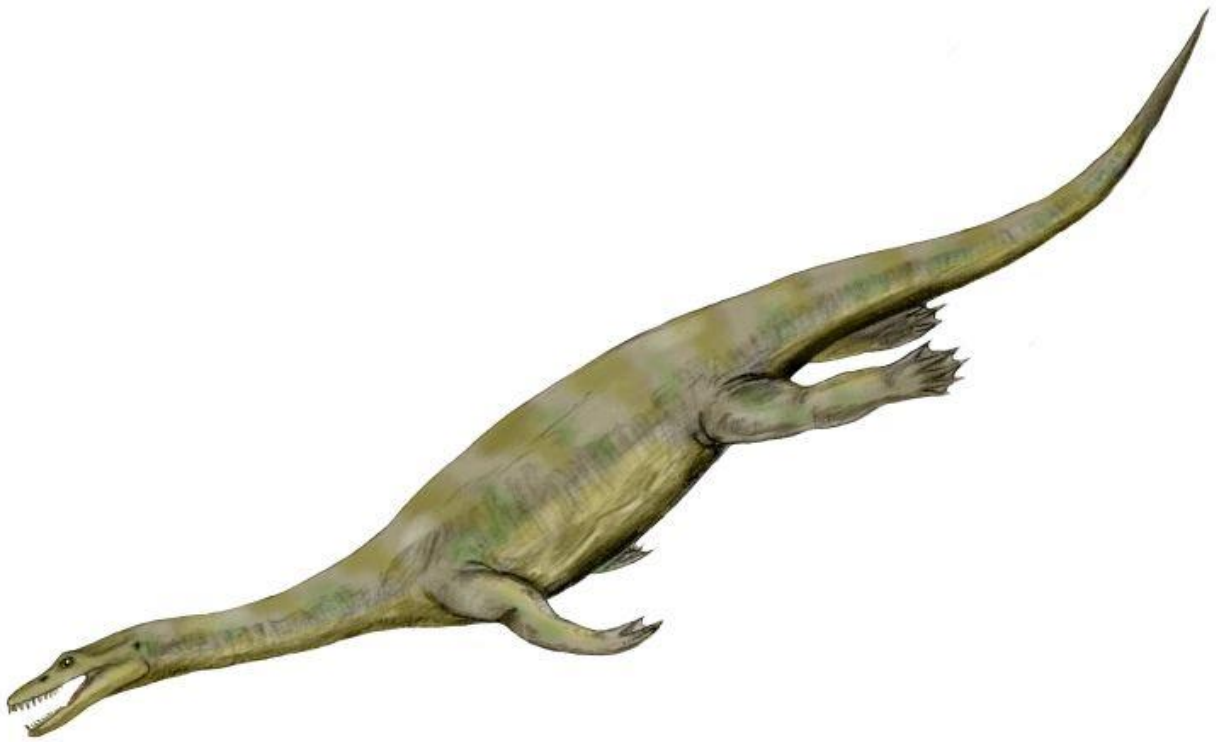


Pachypleurosaurus, Triassic.



Triassic Nothosauria and Placodontia

Nothosauria



Nothosaurus mirabilis,
Triassic

5. **Plesiosaurs**

- They evolved from the Nothosauria
- They fed mainly with fish and invertebrates.
- Two forms, one with a short and wide body with an extremely long neck with a small head, and one with a large, sturdy body with a short neck and a large head with strong jaws (Pliosaurs)
- They reached a length of 14 meters.
- Large, with many bones, fin shaped limbs.

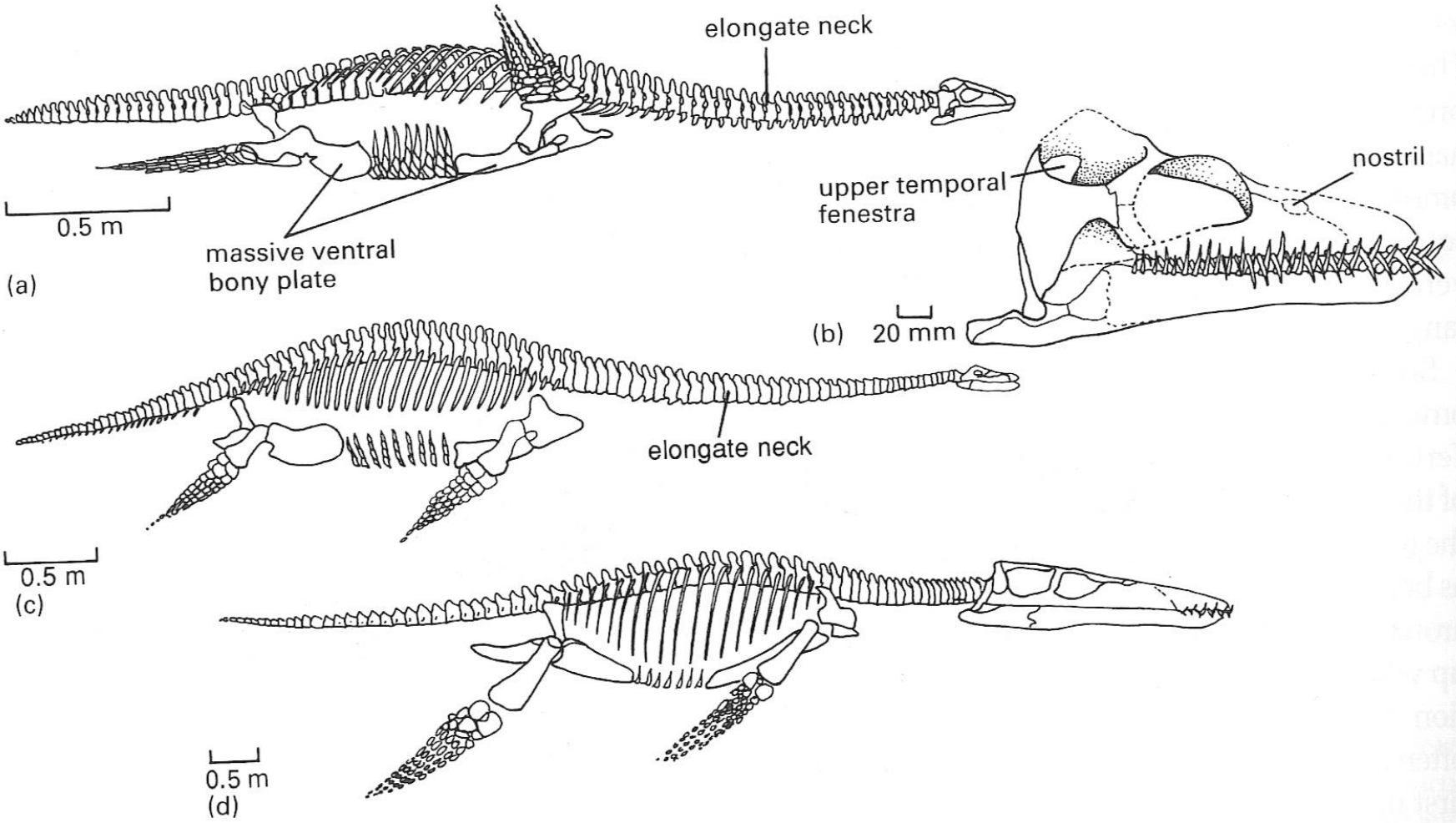
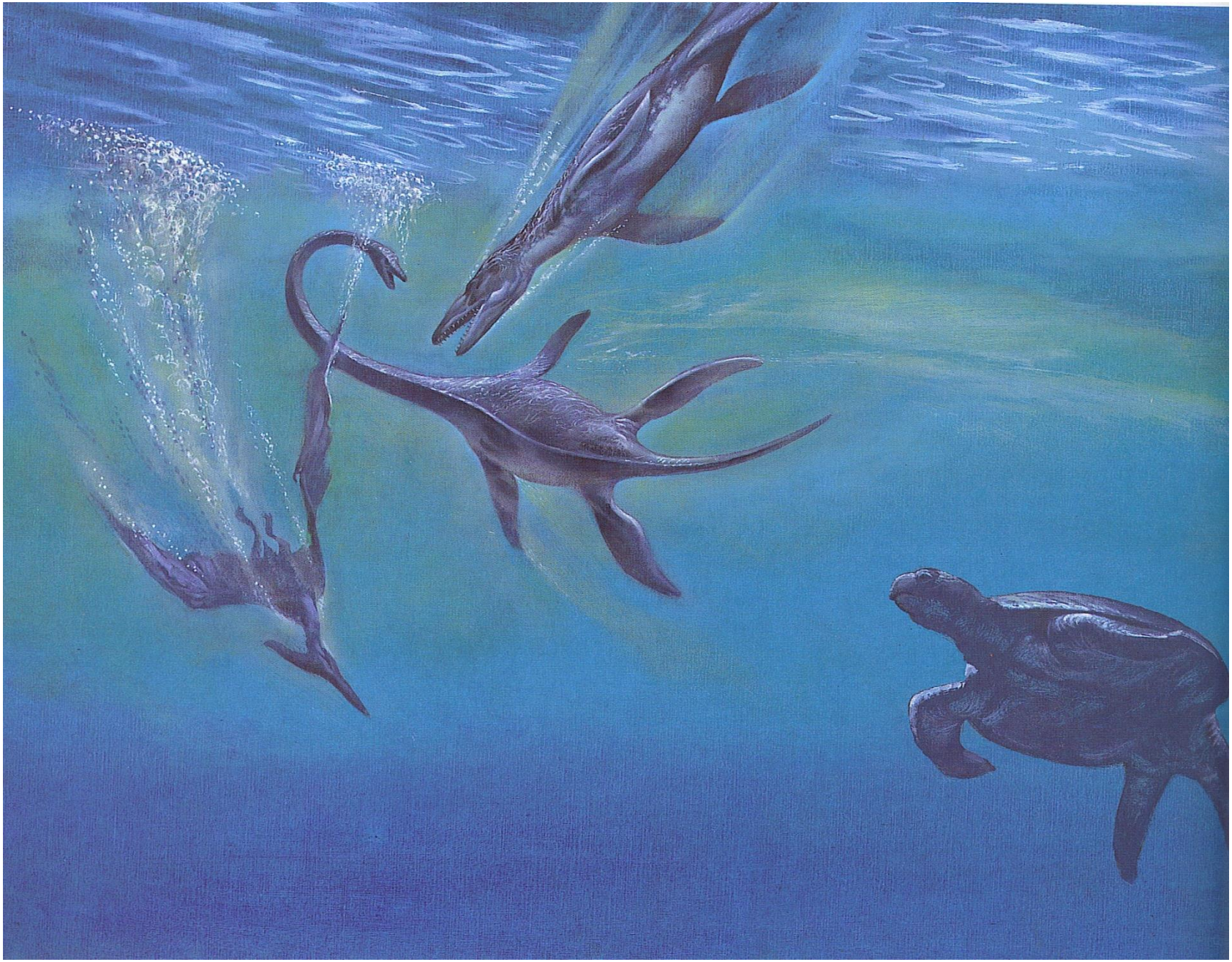


Fig. 8.30 The plesiosaurs: (a, b) the Late Jurassic cryptoclidid *Cryptoclidus*, skeleton in swimming pose and skull in lateral view; (c) the Late Jurassic elasmosaur *Muraenosaurus*; (d) the Late Jurassic pliosaur *Liopleurodon*. [Figures (a, b) after Brown, 1981; (c, d) after Robinson, 1975.]

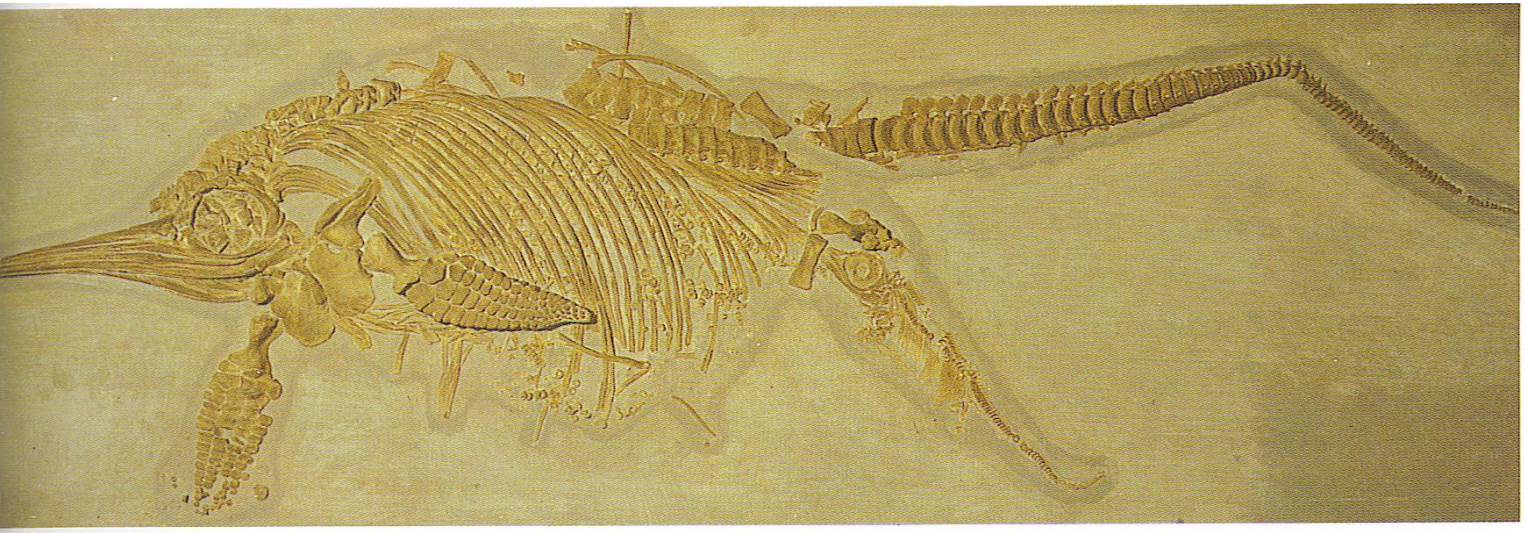

Cretaceous plesiosaur



6. **Icthyosaurs**

- The most fish-like reptiles of the Mesozoic
- They look like dolphins but with vertical rather than horizontal tail fins.
- Top predators in the oceans
- Large eyes to locate prey.
- Ability to maneuver and control buoyancy
- They gave birth to offspring and not eggs
- Length from 1-14 meters


Large Jurassic Icthyosaur, *Grendelius*

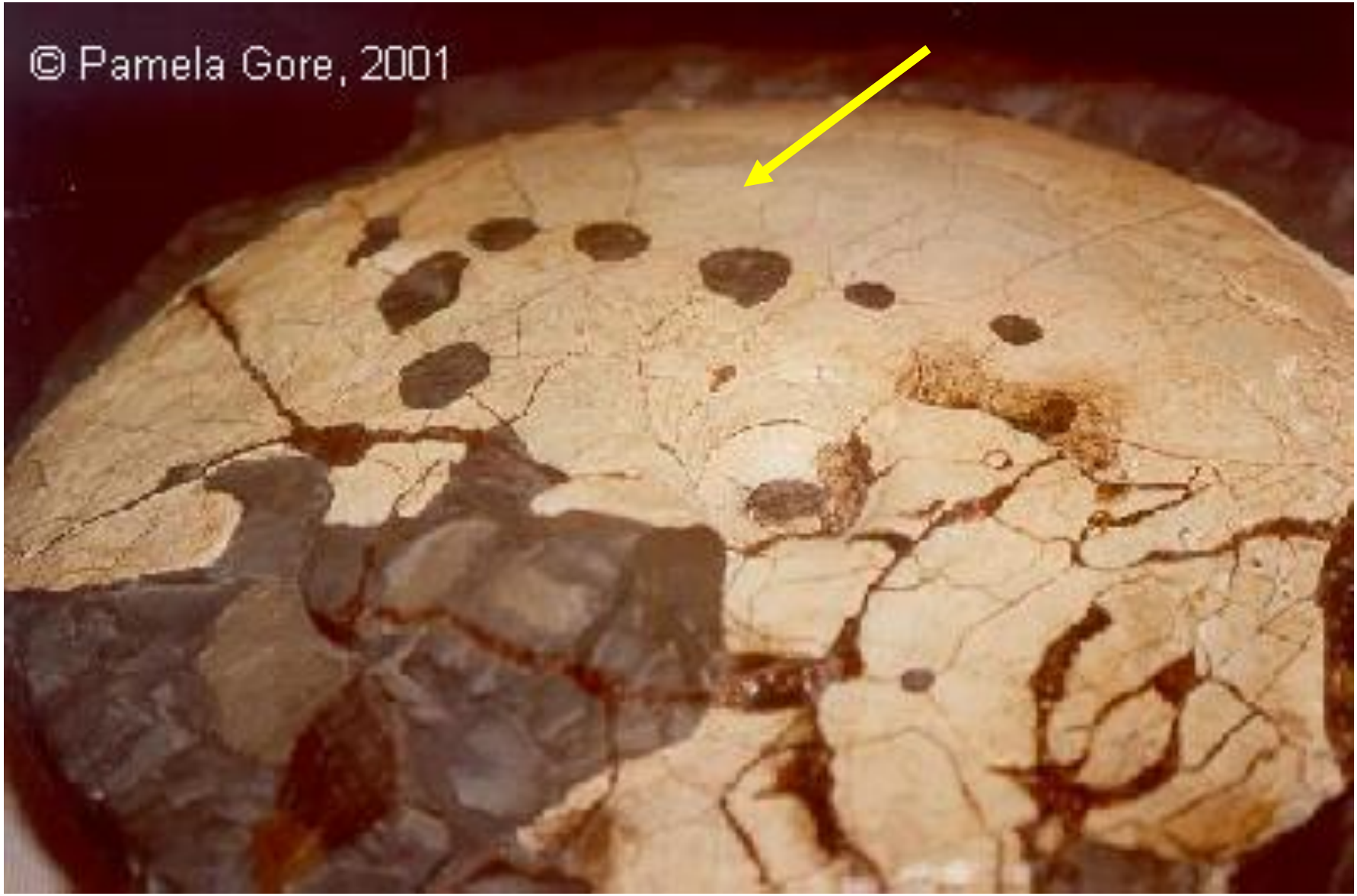


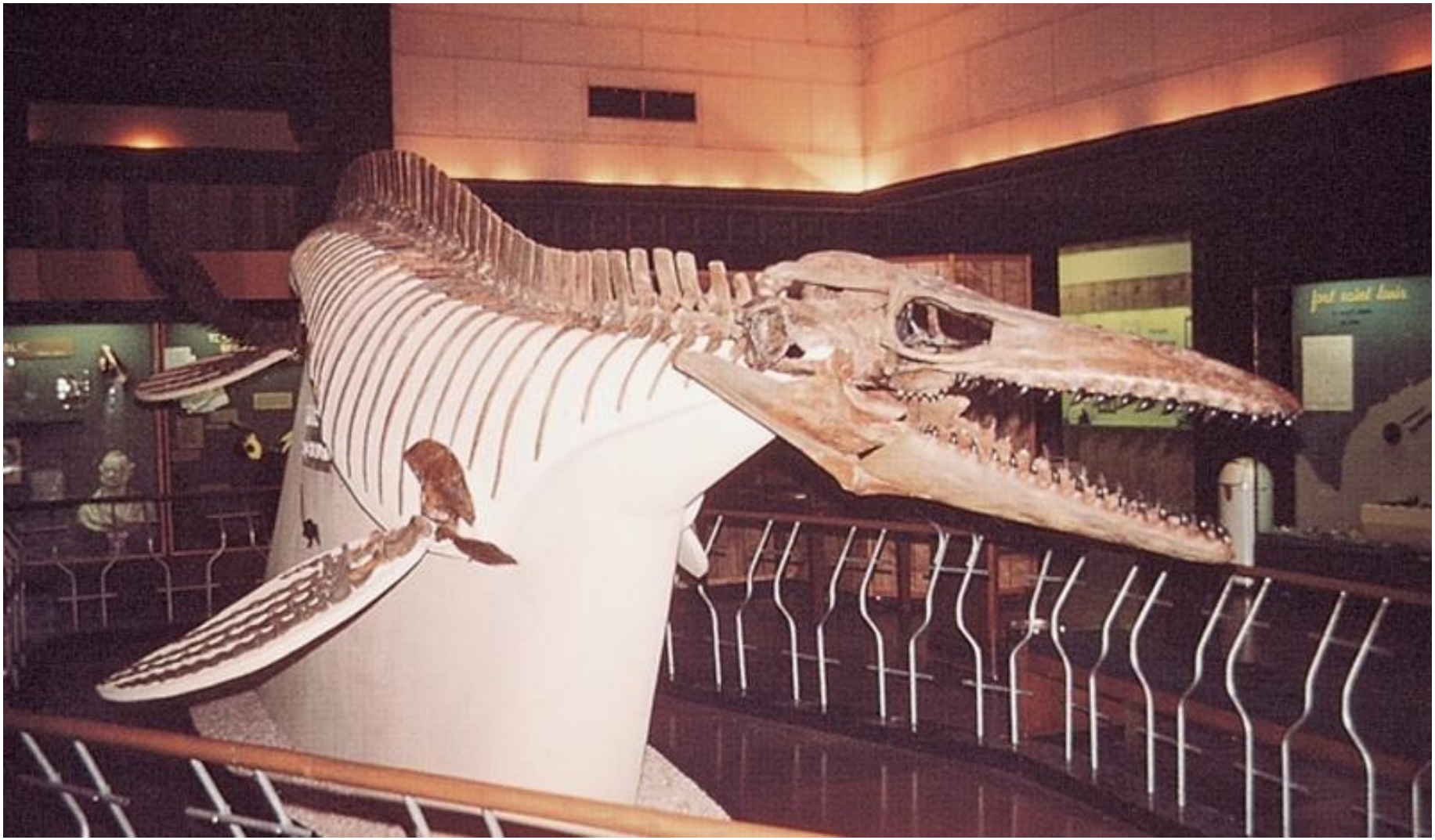
An icon of the Jurassic, and one of the most astounding fossils of all time. Here a female ichthyosaur, about 10 ft (3 m) long, is fossilized apparently in the process of giving birth. Three tiny skeletons may be counted inside her rib cage, and a fourth lies outside her body. This is one of fifty or more mothers with embryo young that have been found in the

7. Mosasaurs

- Only in Cretaceous
- They reached a length of 15 m
- Largest lizards they've ever lived related to the modern varanid lizzards (they had a common ancestor).
- Probably top predators
- They attacked ammonites, as evidenced by bite marks in ammonite shells.


© Pamela Gore, 2001


© Pamela Gore, 2001



8. Crocodiles

- They evolved in the Triassic as land animals
- It was the last important group of marine reptiles of the Triadic that evolved.
- Some got adapted to the marine environment in the Lower Jurassic.
- In the Cretaceous Rare.
- Fast swimmers.
- They have evolved from the Archosaurs, relatives of dinosaurs.

9. Marine Turtles

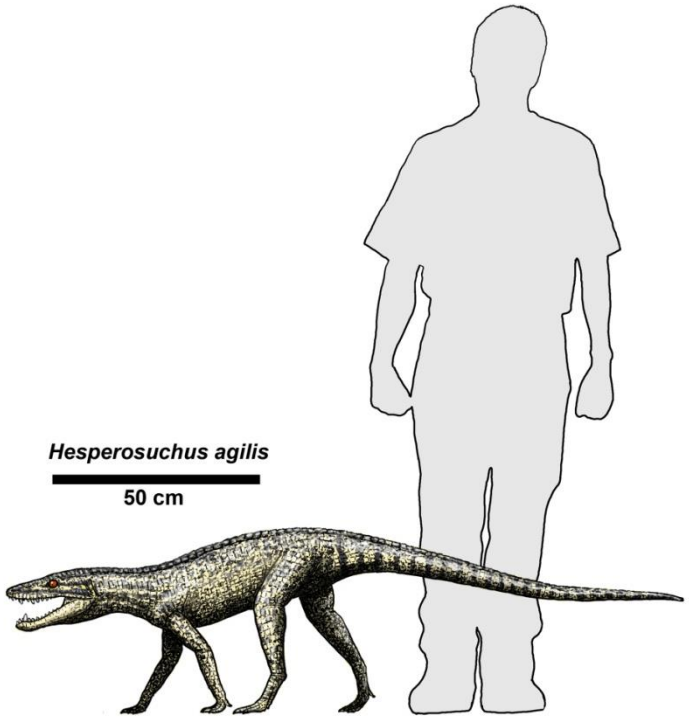
- Evolved in the Cretaceous
- Reached 4 m in length such as the genus *Archelon*


Protostega gigas, Κρητιδικό
© Pamela Gore 1996

Lower Archosaurs (Thecodonts)

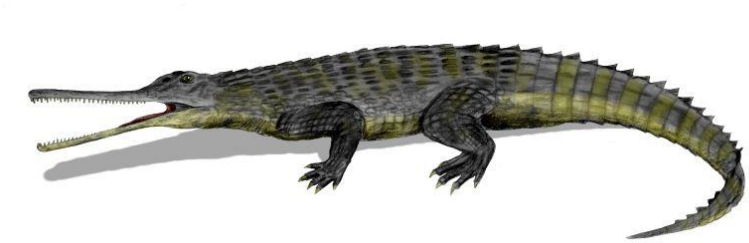
- The Archosaurs are diapsid reptiles of the Triassic. They are divided into two groups:
  - Lepidosauria (lizards, snakes, etc.)
  - Archosauria (Dinosaurs, Pterosaurs, Crocodiles and Birds)
- Small agile reptiles with long tails and short forelimbs.
- Several of them were bipedal. This meant that the front ends were released and could be used for other activities such as catching prey and later using them for flight.

Hesperosuchus



Hesperosuchus agilis
lower archosaur

Phytosaurs

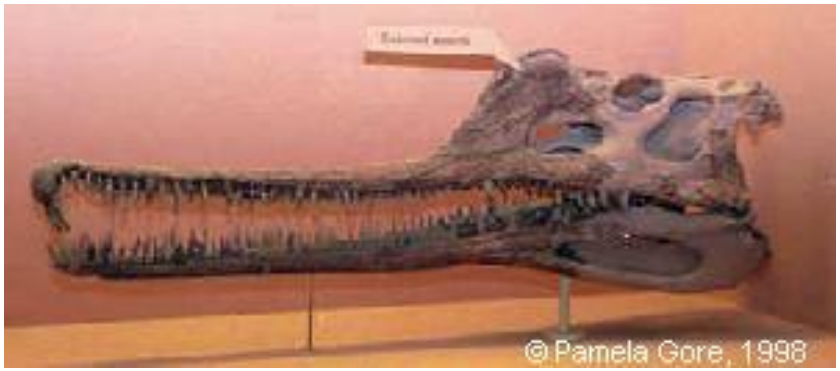


Rutiodon carolinensis,
L. Triassic

- Some Archosaurs returned to the tetrapod locomotion and evolved into:
  Armoured terrestrial carnivores, or
  Crocodylomorph aquatic reptiles the Phytosaurs.
- Their skull was elongated with sharp teeth, and most likely fed with fish.
- They lived in the Late Triassic

Phytosaurs and Crocodiles

- A clear difference between them is the position of the nostrils.
  - In crocodiles they are placed at the edge of their muzzle.
  - In Phytosaurs they were placed right in front their eyes.



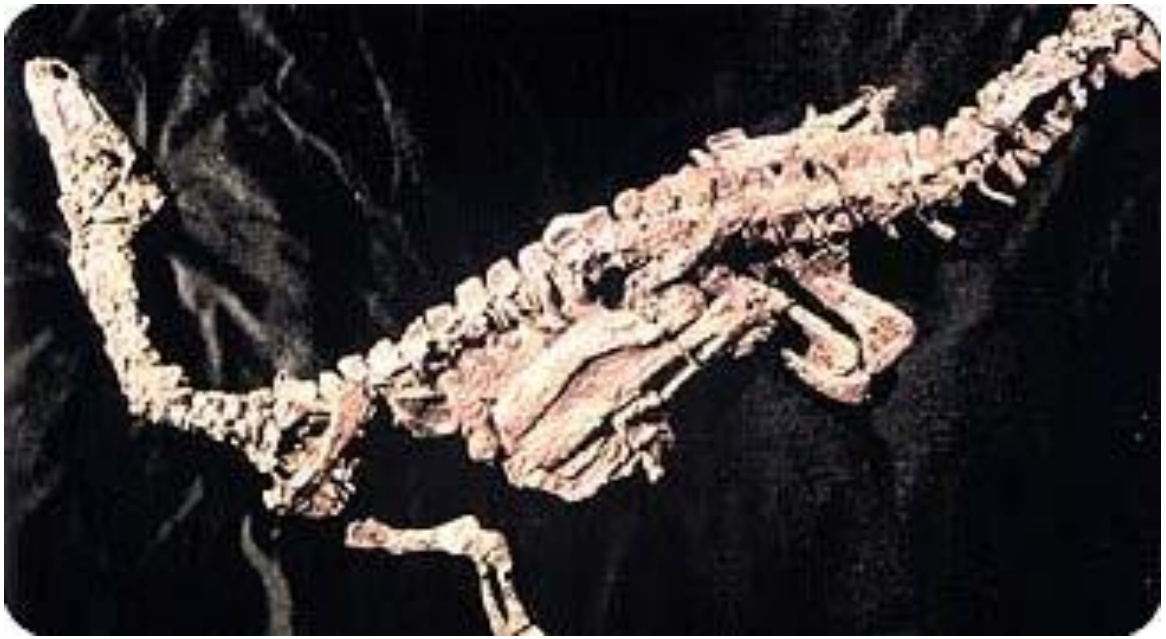
Dinosaurs

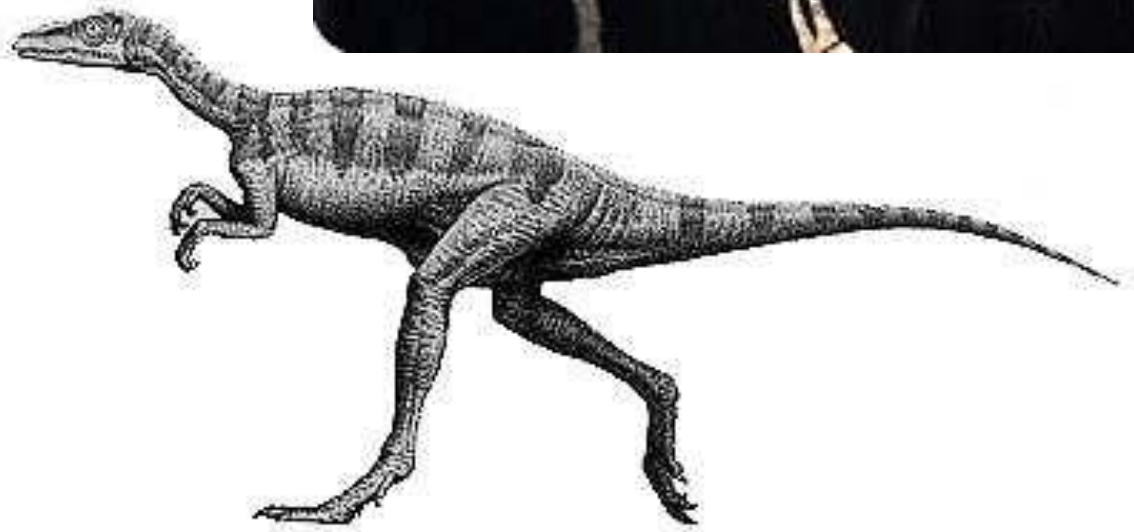
- The "Terrible Lizards" appeared for the first time at the beginning of the L. Triassic (230-225 million years ago) in various parts of the world.
- The first dinosaurs were small in size, smaller and one meter in length.
- Until the end of the Triassic they reached 6 to 7 meters in length.
- They grew even more in size during Jurassic and Cretaceous.

The first dinosaurs

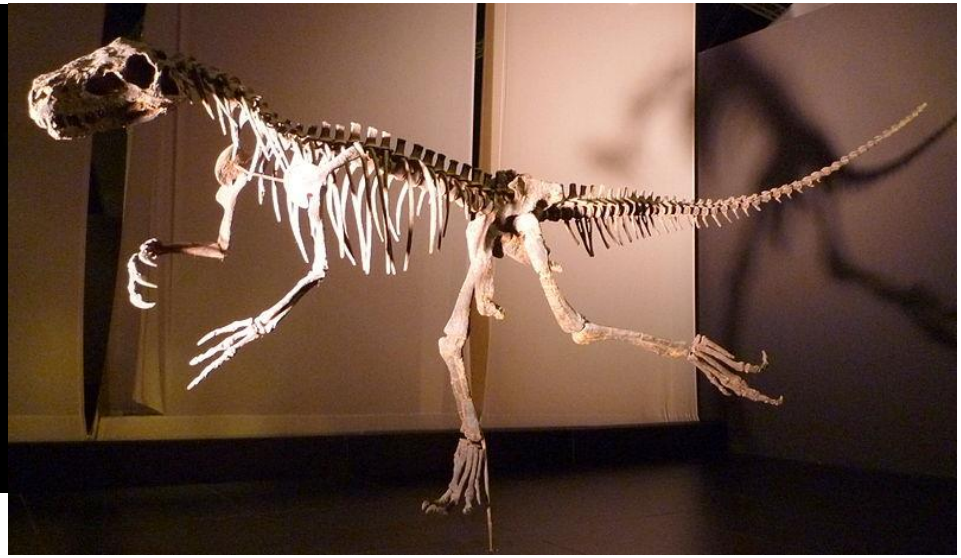
- Dinosaurs were thought to have first appeared in the Early Triassic, from skeletons and walking footprints. However, it is more likely that this were erroneous determinations.
- The best samples, the theropods Eoraptor and Herrerasaurus, come from Argentina (228 my) and are considered as the first dinosaurs.
- Prosauropod specimens of 230 my old Years from Madagascar could be the first.

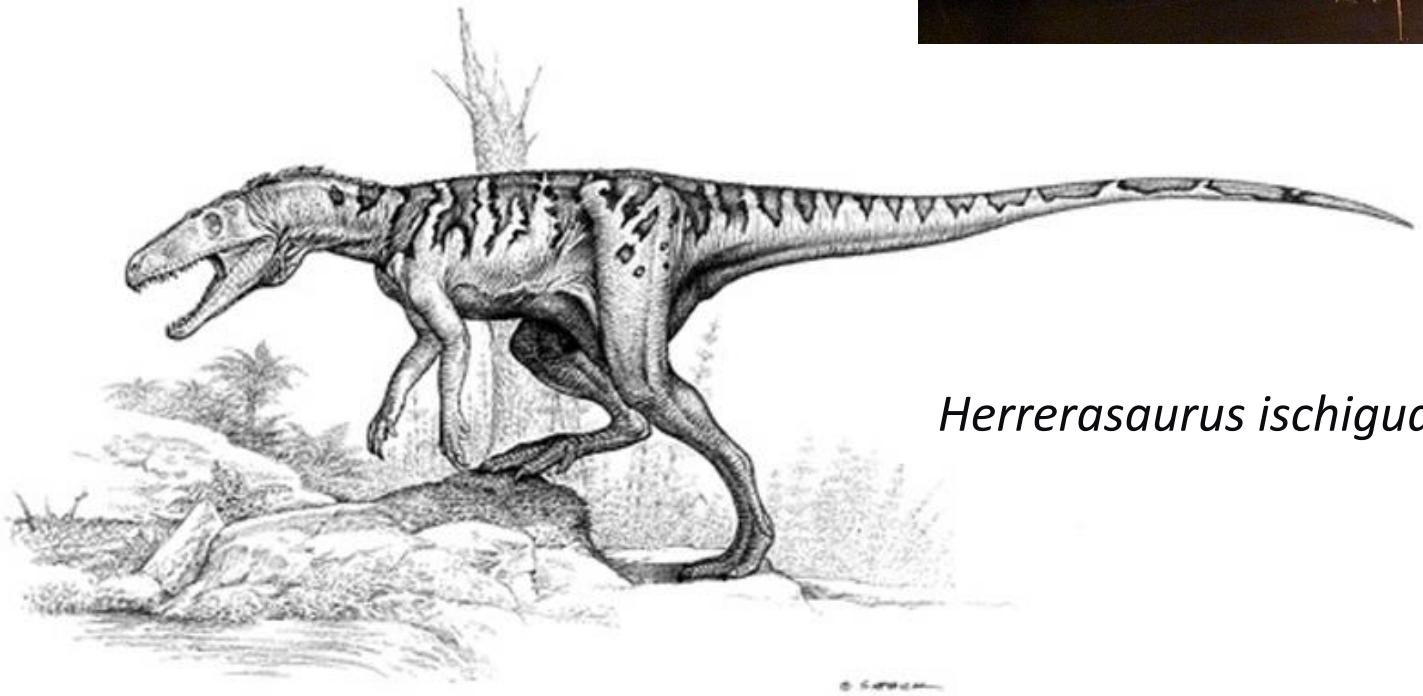
Eoraptor





Herrerasaurus





Herrerasaurus ischigualastensis

Nyasasaurus parringtoni, the oldest deinosaur?

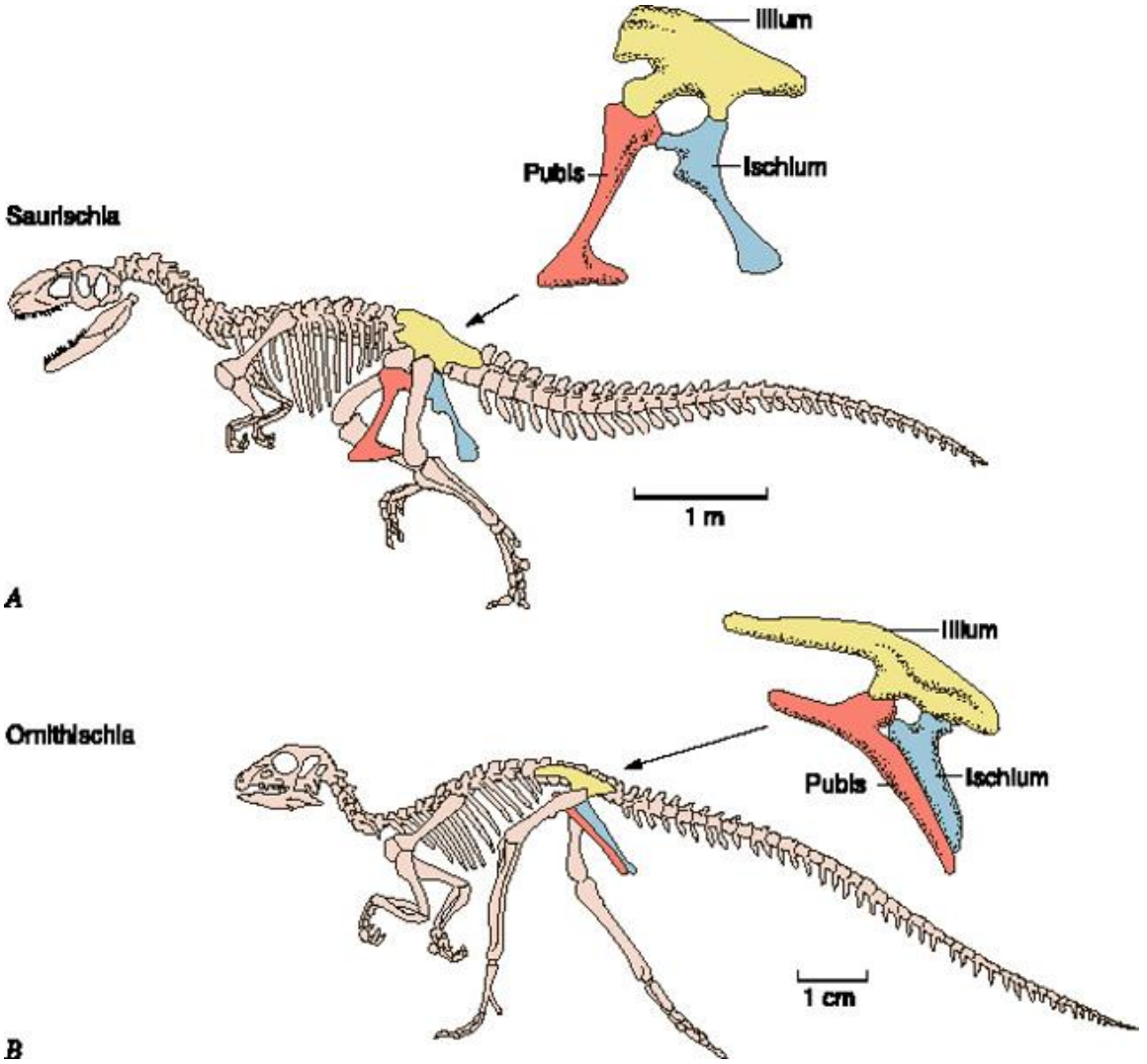
- Found in 2012 in Tanzania
- Age: Middle Triassic (Anisium) ~245 my
- Similarities with dinosaurs
- Either the oldest dinosaur or a sister taxon
- Ή ο αρχαιότερος δεινόσαυρος ή αδελφό τάξο των Δεινοσαύρων

They are separated into two large groups. The separation is based on the arrangement of the pelvic bones.

- Saurischian (ischium is turned downwards and backwards, while the pubic is also turned downwards but forwards)
- Ornithischian ischium is turned downwards and backwards, while the pubic is also turned downwards and backwards, it is thus parallel with the ischium ,

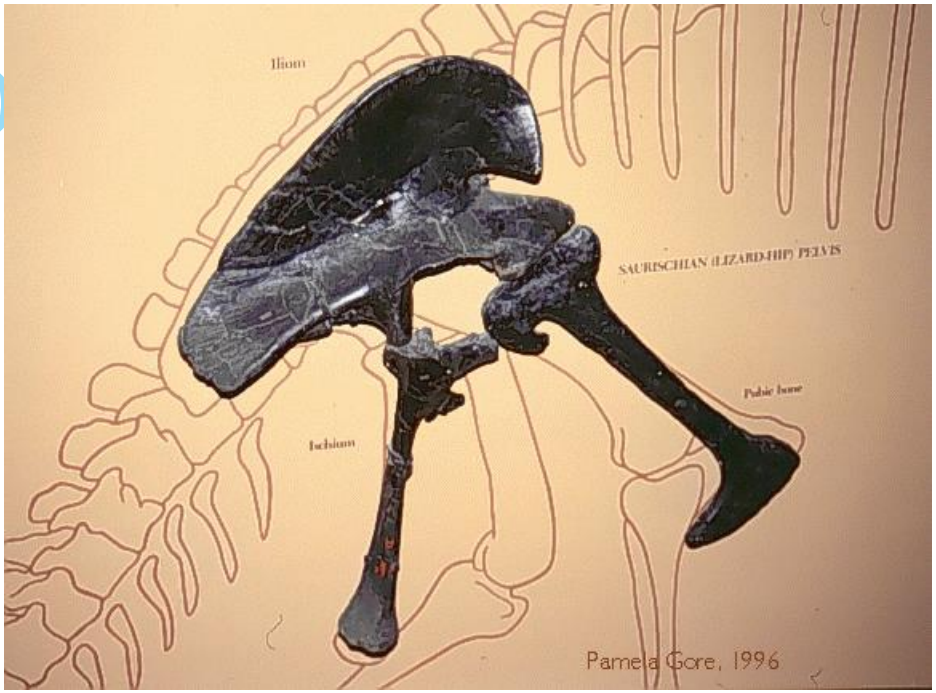
Οι Δεινόσαυροι

- Saurischian
- Ornithischian



O

- Saurischian



- Ornithischian

Dinosaurs

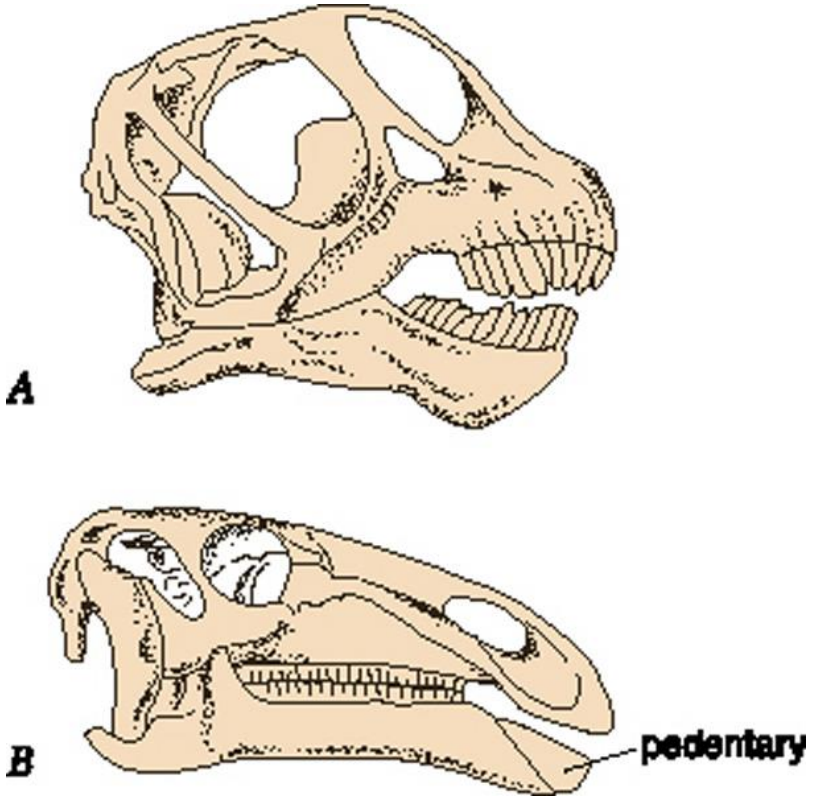
Another important difference between the two groups is their teeth.

- In saurischian the teeth either extend along the whole length of the jaws or they are confined at the front part. In ornithischian the teeth are absent from the front part of the two jaws.

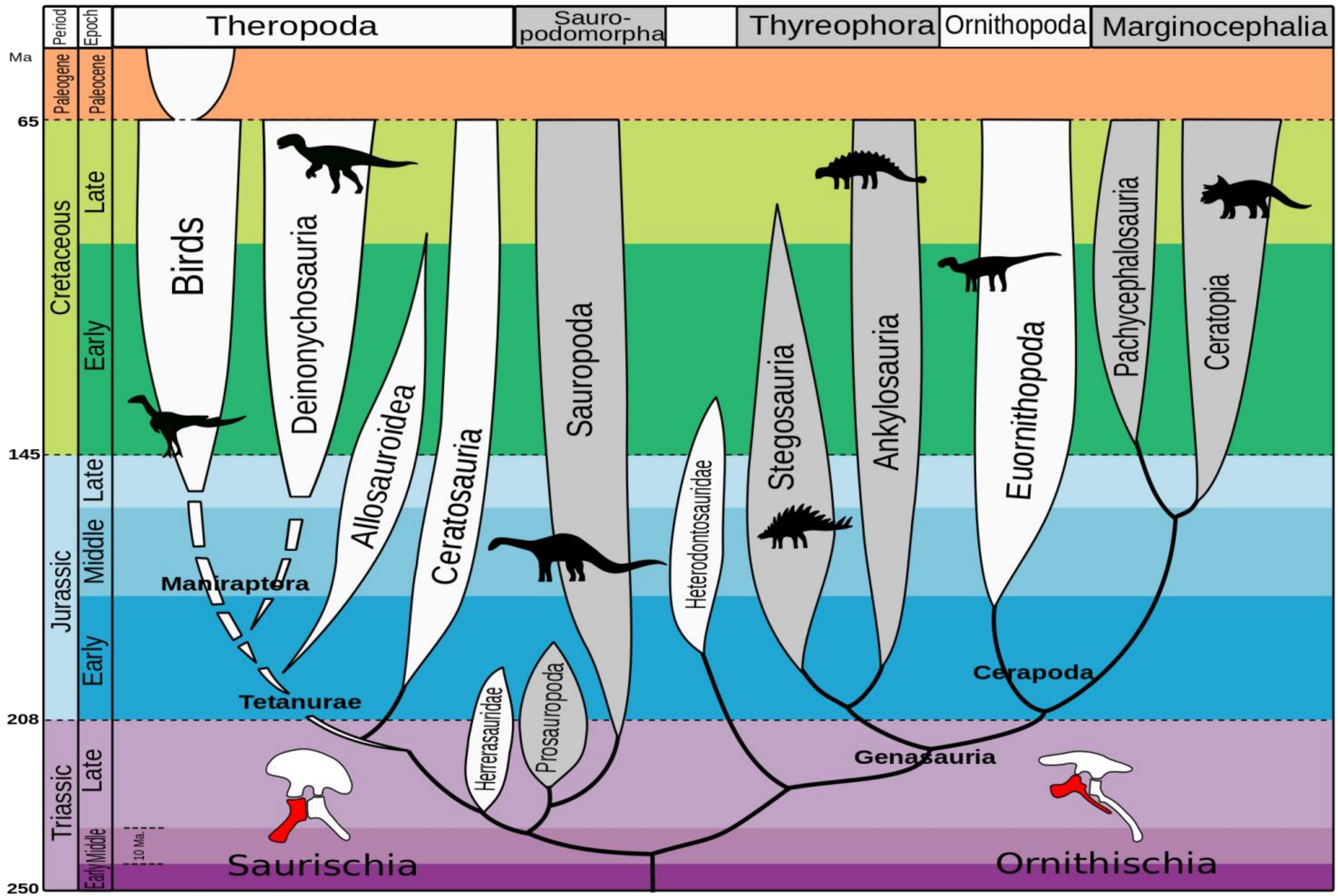
Dinosaurs

- In saurischian the teeth and their jaws had been adjusted to cutting and tearing and not in chewing. Even herbivores swallowed whole and unchewed parts of plants. Their processing was achieved in the prolovus of their stomach from stones that they swallowed (gastrolites). ,
- In ornithischian the teethless front part of the jaws was transformed into beak that helped in the cutting of the vegetation. A new bone the predentary was added in the lower jaw. The dentition was limited to the posterior of the jaw and was adjusted to the smashing and grinding of the plant food. ,

Dinosaurs



comparison of skulls and dentitions between saurischian (A) and ornithischian (B).



Period
Epoch
Theropoda
Sauro-podomorpha
Thyreophora
Ornithopoda
Marginocephalia
Ma
65
145
208
250
Paleogene
Paleocene
Cretaceous
Late
Early
Jurassic
Late
Middle
Early
Triassic
Late
Middle
Early
Birds
Deinonychosauria
Allosauroidea
Ceratosauria
Sauropoda
Heterodontosauridae
Stegosauria
Ankylosauria
Euornithopoda
Pachycephalosauria
Ceratopia
Maniraptora
Tetanurae
Herrerasauridae
Prosauropoda
Cerapoda
Genasauria
10 Ma.
Saurischia
Ornithischia

Saurischian

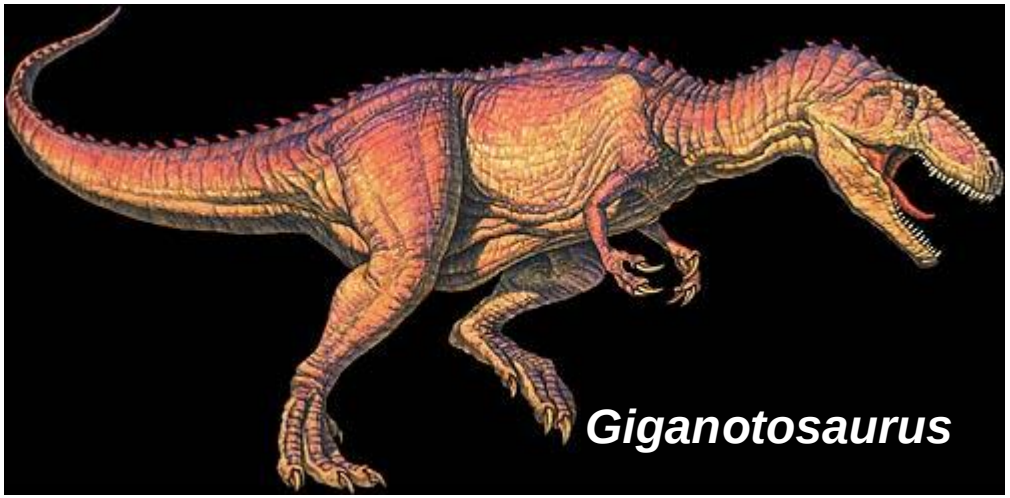
- Bipedal as well as quadrupedal forms.
- Herbivores and carnivores.
- The first dinosaurs and their protoarchosaur ancestors were saurischian.
- They are separated into two groups:

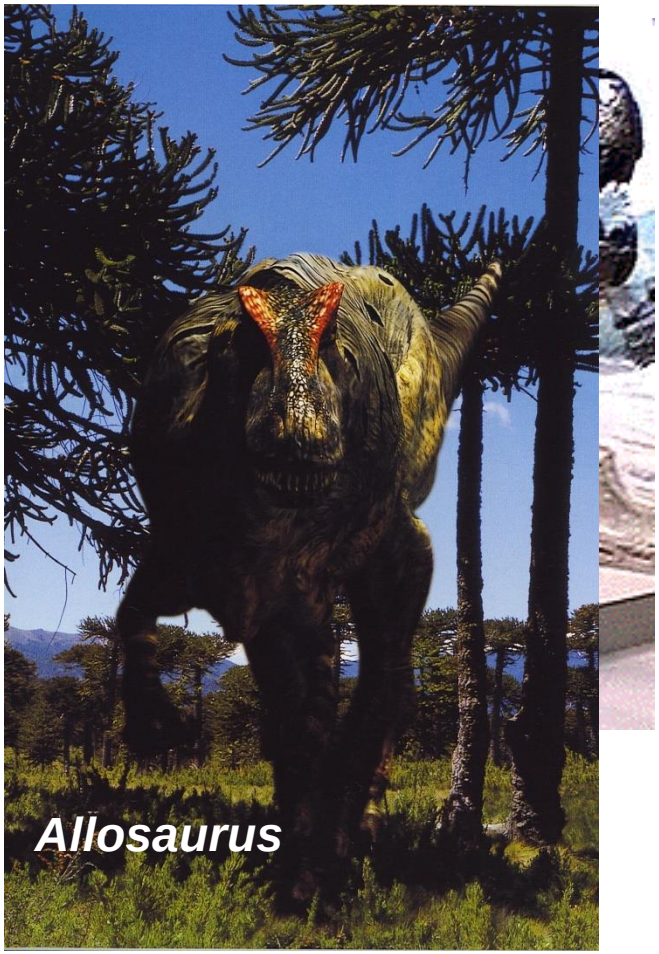
1. Theropoda, bipedal, carnivorous dinosaurs.
2. Sauropoda, large, quadrupedal , herbivorous dinosaurs with long necks

Theropoda

- *Coelophysis*
- *Ornithomimus*
- *Giganotosaurus*
- *Allosaurus*
- *Tyrannosaurus*
- *Deinonychus*
- *Velociraptor*
- *Spinosaurus* (the largest, 17-20 m length, >20 tones)

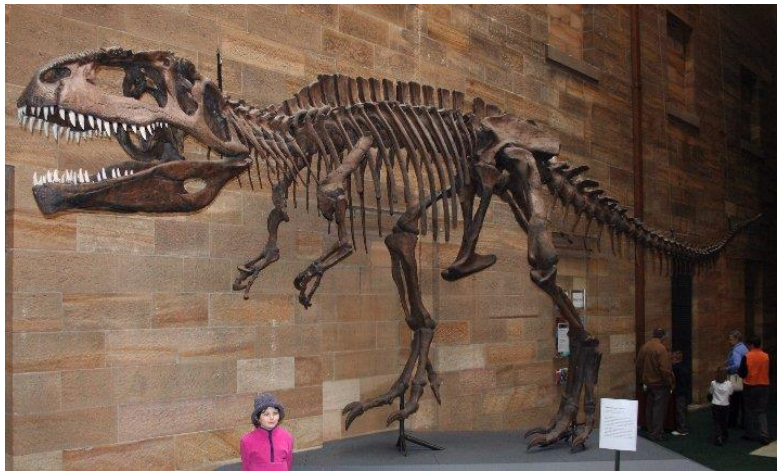
Theropoda





Tyrranosaurus & Giganotosaurus

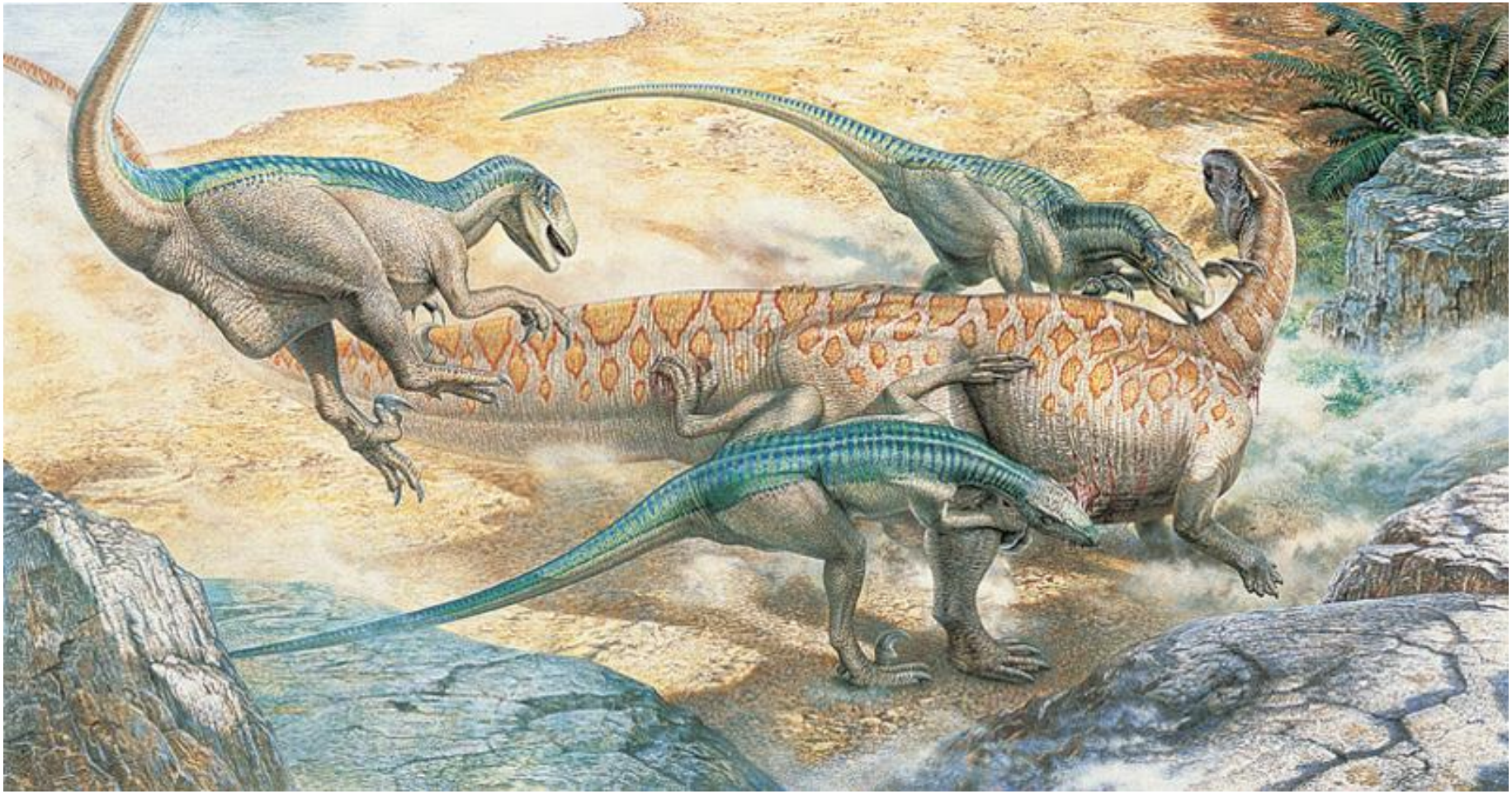
T. rex,
Carnegie Museum of Natural History, Pittsburgh



Giganotosaurus

Spinosaurus

- Subaquatic theropod dinosaur with an elongated crocodile like head (to be able to catch fishes in the water – lakes and rivers) and his dorsal fin was used as a thermoregulatory device.
- The largest carnivore deinosaur with a size >17m



A group of *Deinonychus* with the typical "terrible claw" are attacking the ornithischian *Tenontosaurus*

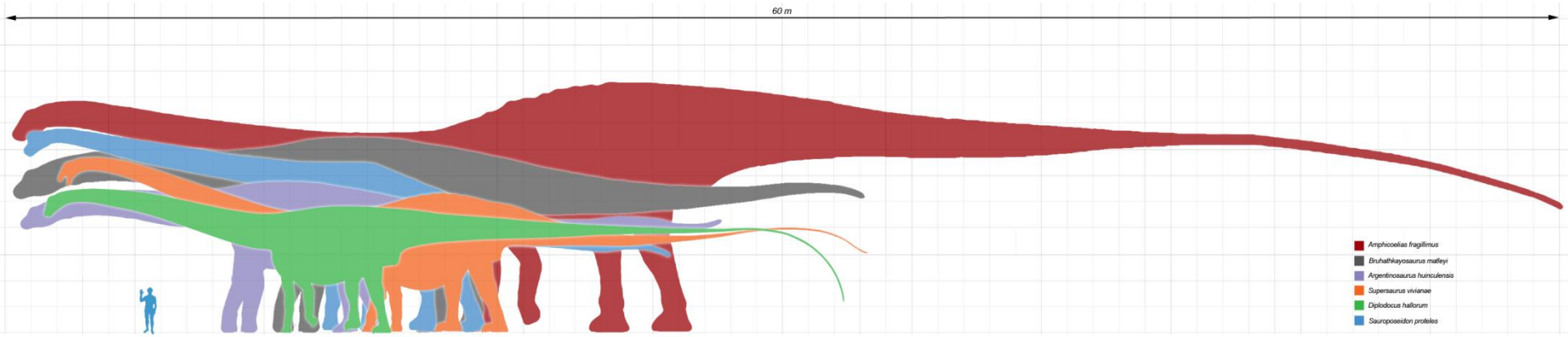
Sauropoda

- *Apatosaurus*
- *Brachiosaurus*
- *Supersaurus*
- *Bruhathkayosaurus*

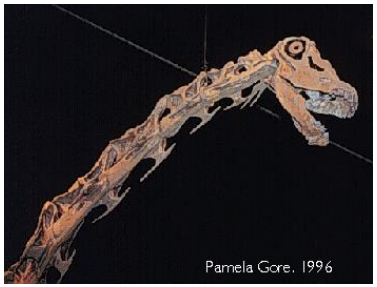
(35 m length, 140 tones)

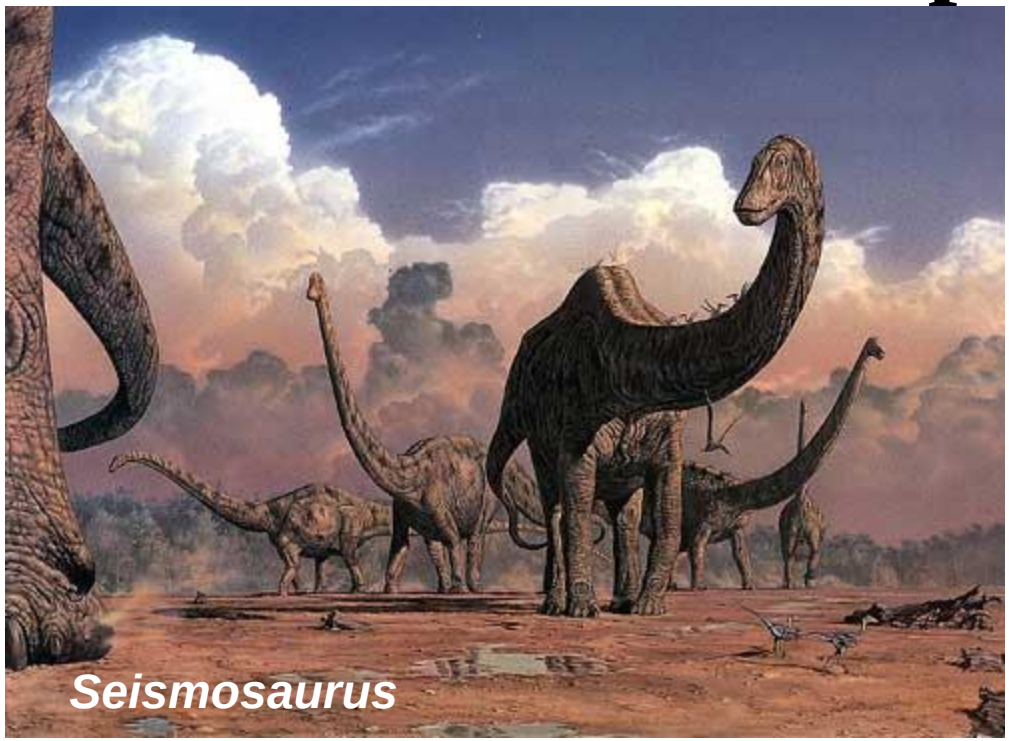
- *Seismosaurus*
- *Argentinosaurus*
- *Nuoerosaurus*
- *Diplodocus*
- *Amphicoelias*

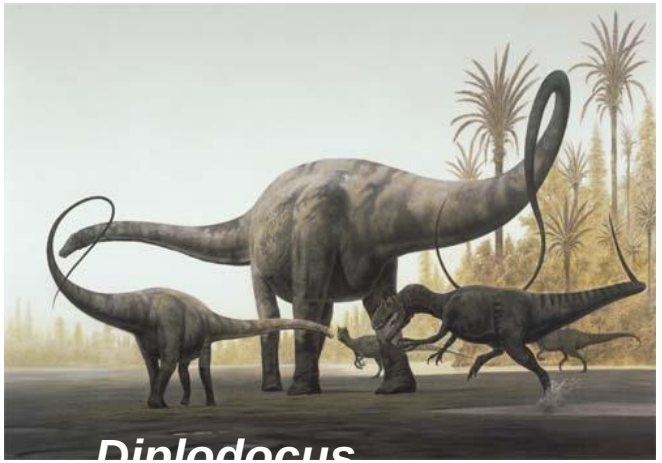
(56 m length, 120 tones)

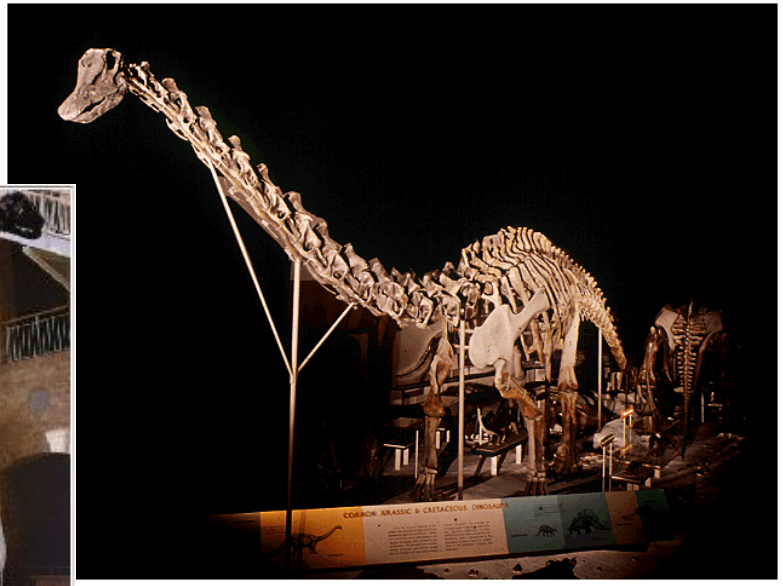


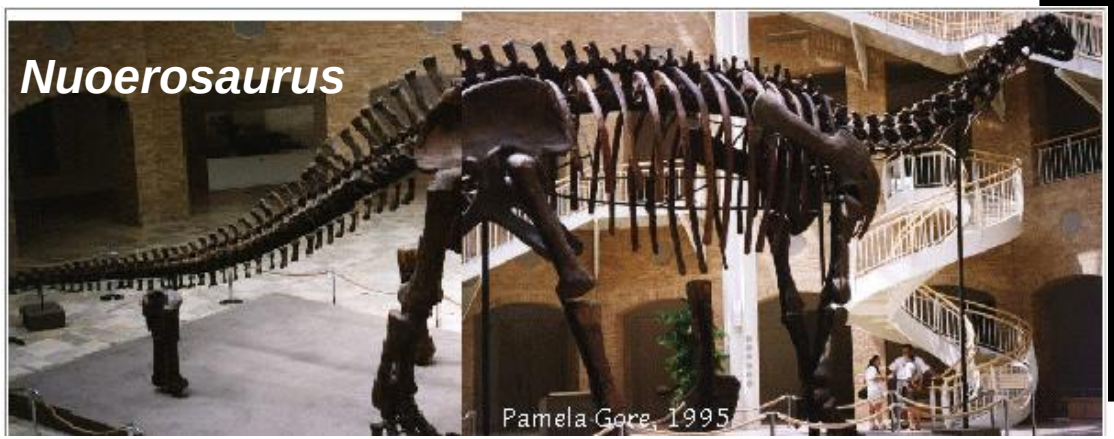
Sauropoda


Pamela Gore. 1996

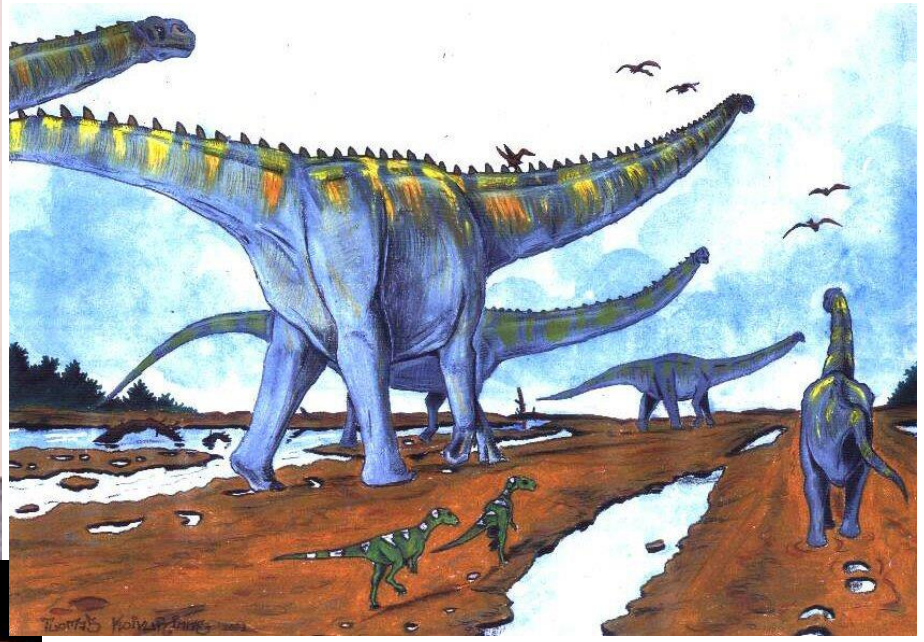

Seismosaurus

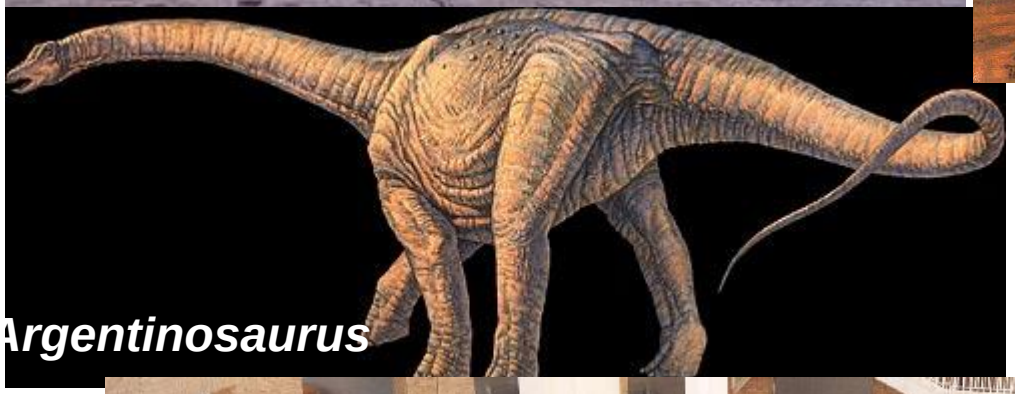

Diplodocus



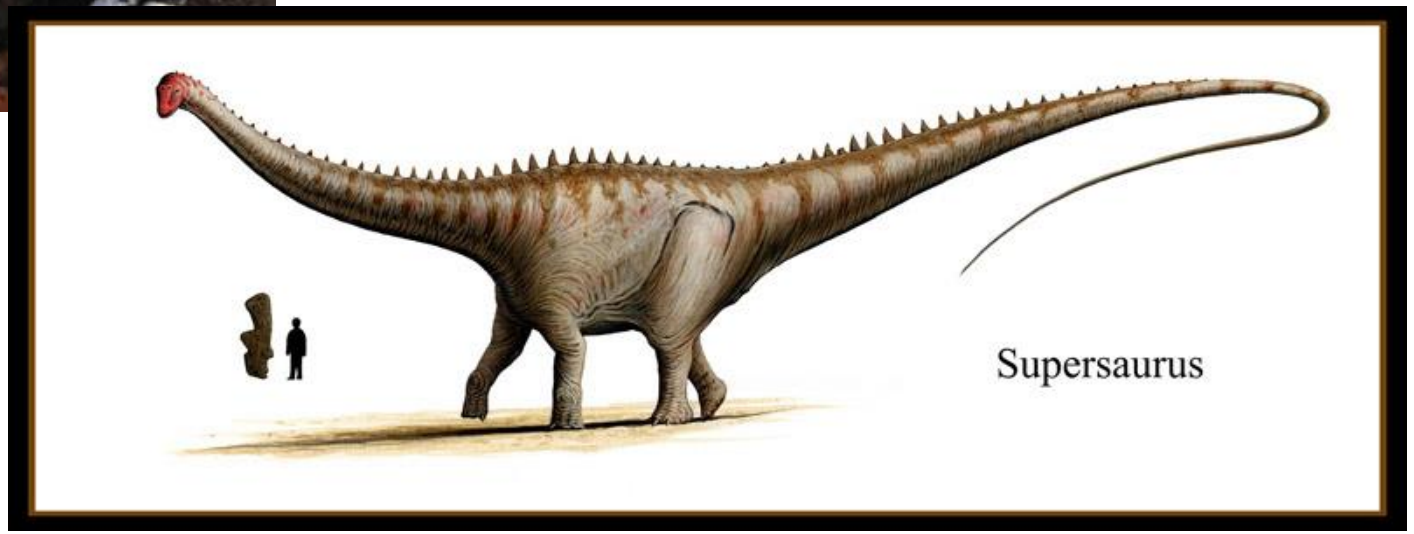

Nuoerosaurus
Pamela Gore. 1995

Amphicoelias fragillimus

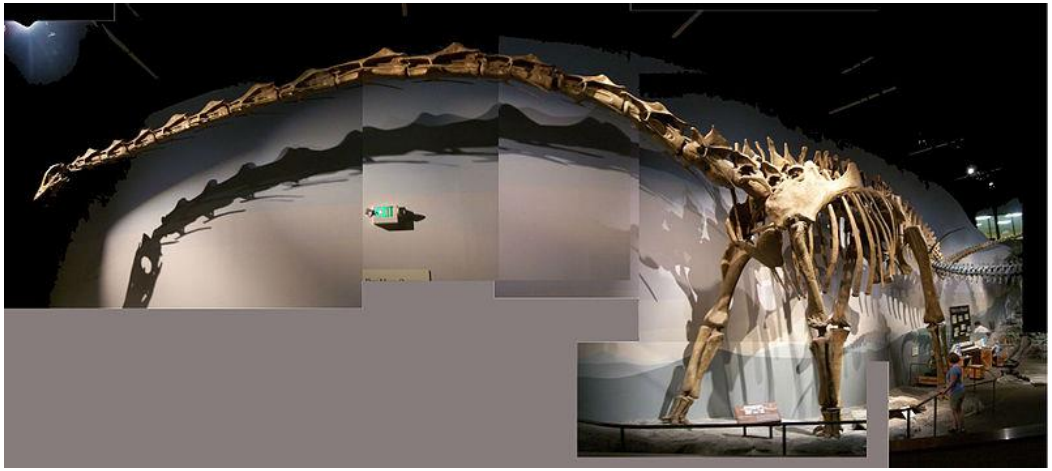




Argentinosaurus


Supersaurus

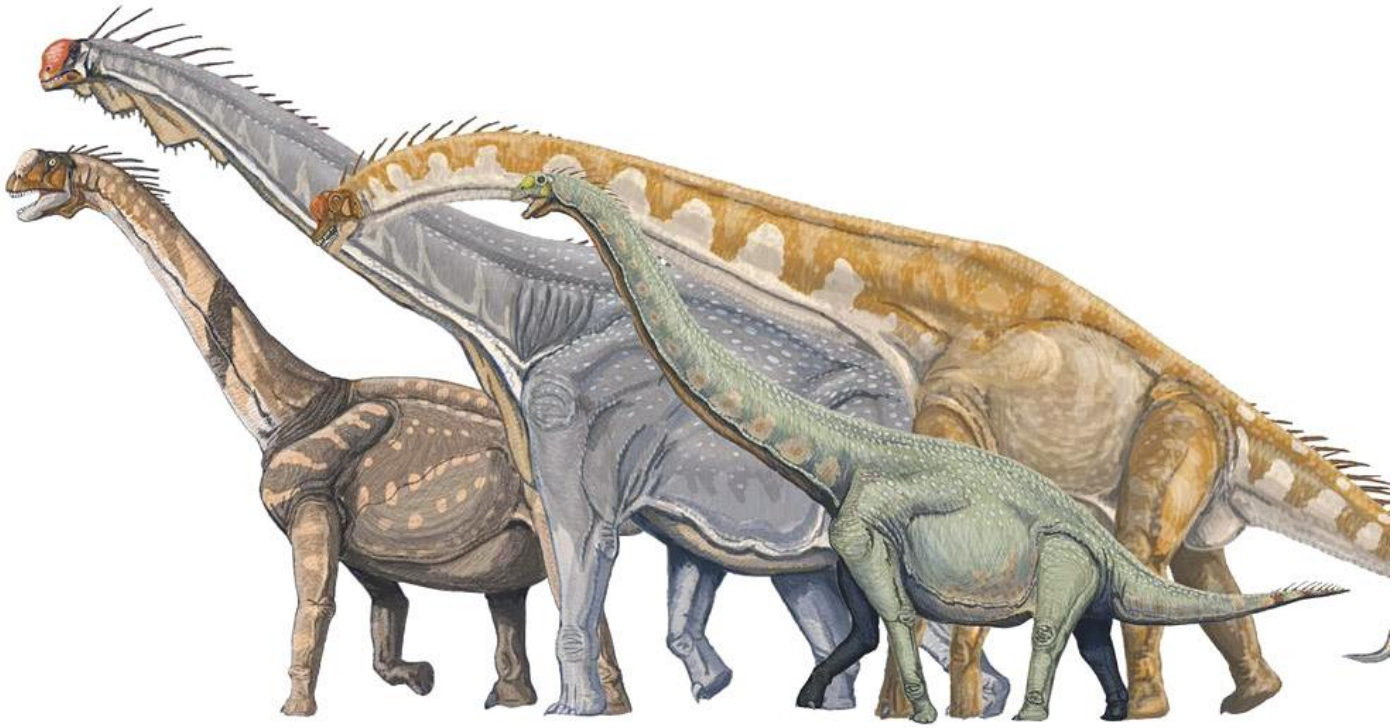
Supersaurus & Argentinosaurus



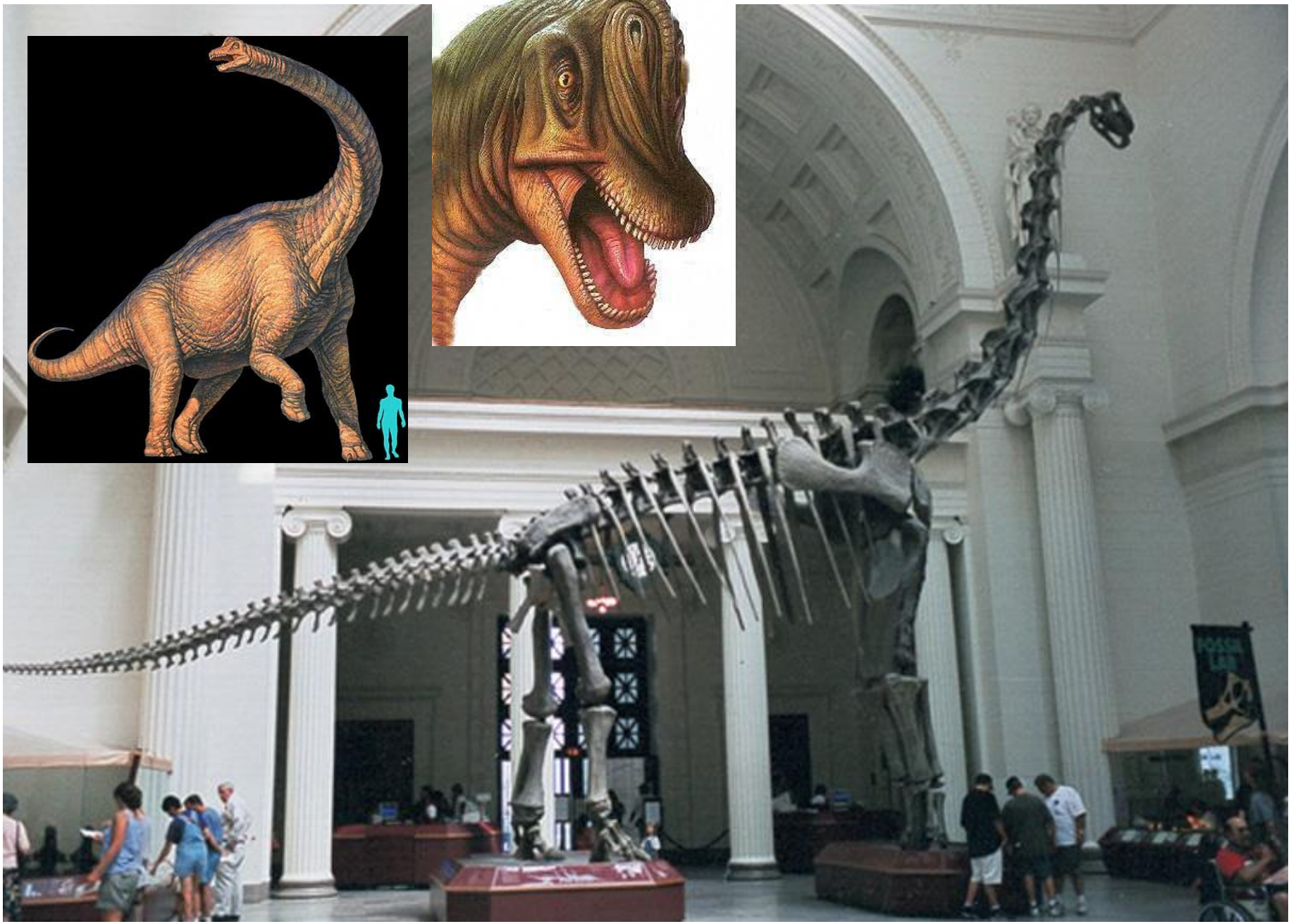
Supersaurus, North American Museum of Ancient Life

Argentinosaurus, Naturmuseum Senckenberg.

Brachiosaurus



From left to right, Camarasaurus, Brachiosaurus, Giraffatitan and Euhelopus.



Brachiosaurus

Sauropoda and Presauropoda

- Presauropoda were the possible ancestral forms of sauropoda, that lived from the Late Triassic to the Early Jurassic
- Their front limbs were shorter than their hind limbs although they were quadrupedal .
- In the lower Jurassic they were replaced by giant sauropoda.

Plateosaurus

P. engelhardti in Sauriermuseum, Frick,
Late Triassic presauropod

Ornithischia

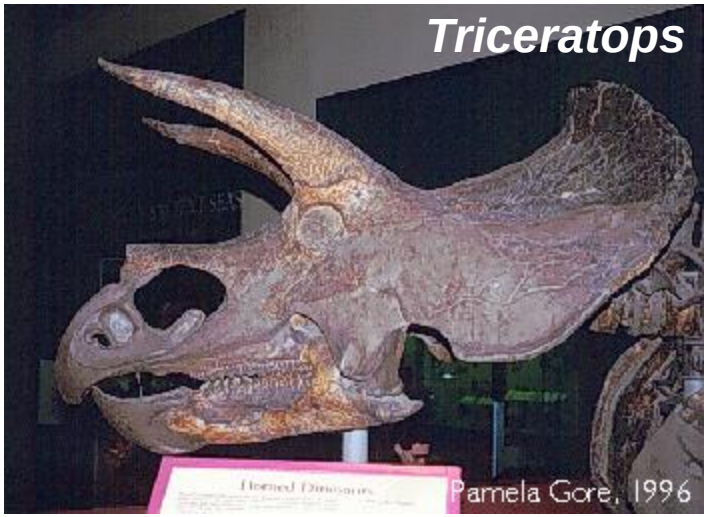
- They evolved at the end of the Triassic.
- The structure of the pelvis looks like that of the modern birds.
- It includes bipedal as well as quadrupedal forms.
- All of them herbivores.
- The front limbs shorter, showing their ancestry from bipedal forms.

Ornithischia

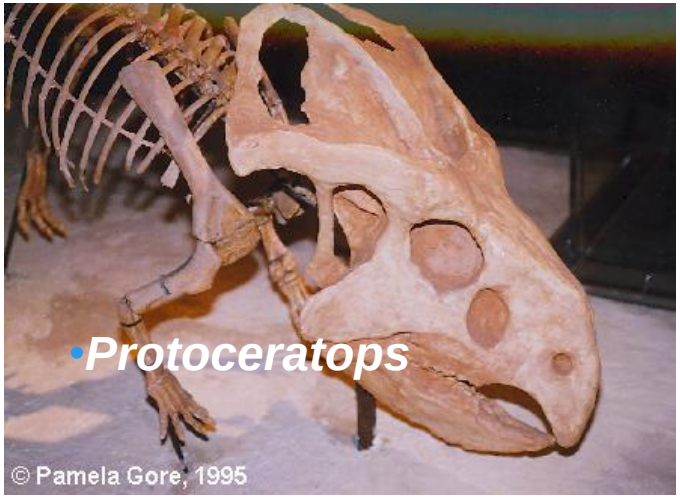
1. Ceratopsia
2. Stegosauria
3. Ankylosauria
4. Pachycephalosauria
5. Ornithopodia

Ceratopsia

- *Triceratops*
- *Pachyrhinosaurus*
- *Styracosaurus*
- *Protoceratops*
- *Monoclonius*

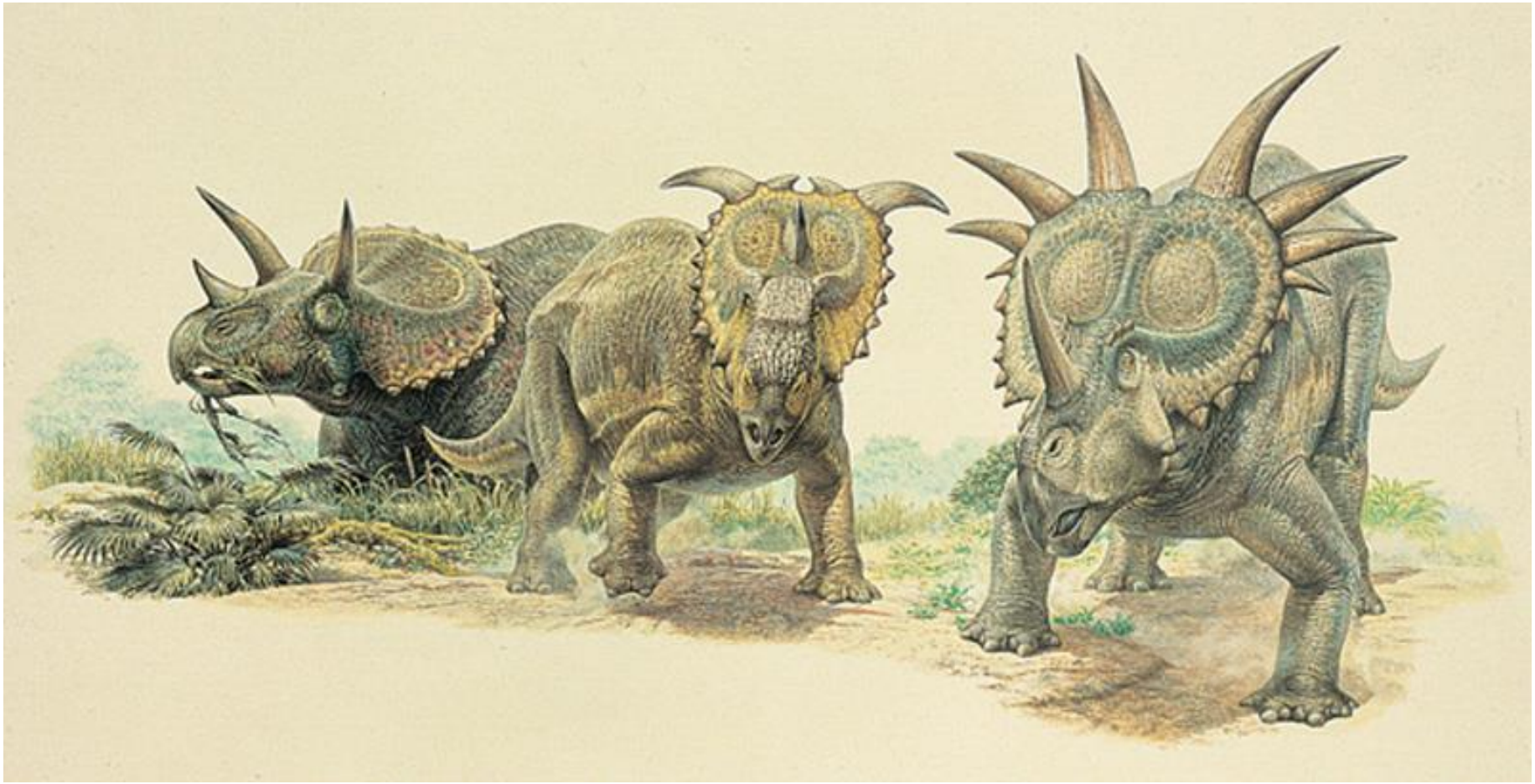


They mainly lived during the L. Cretaceous



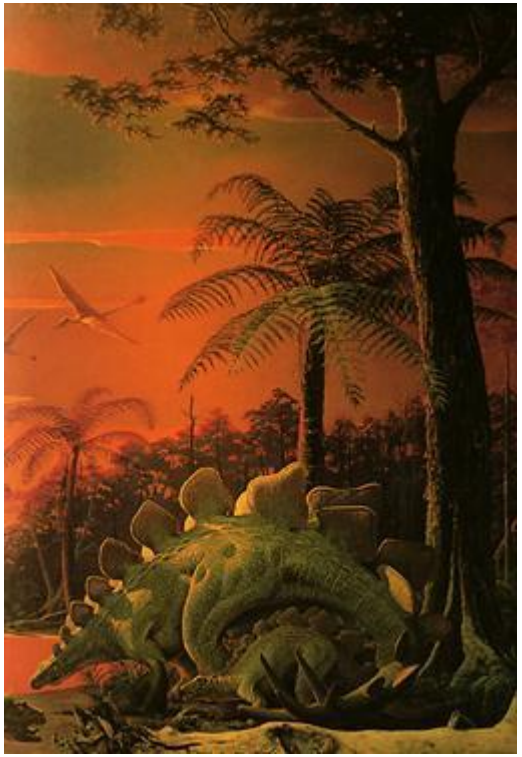
Ceratopsia

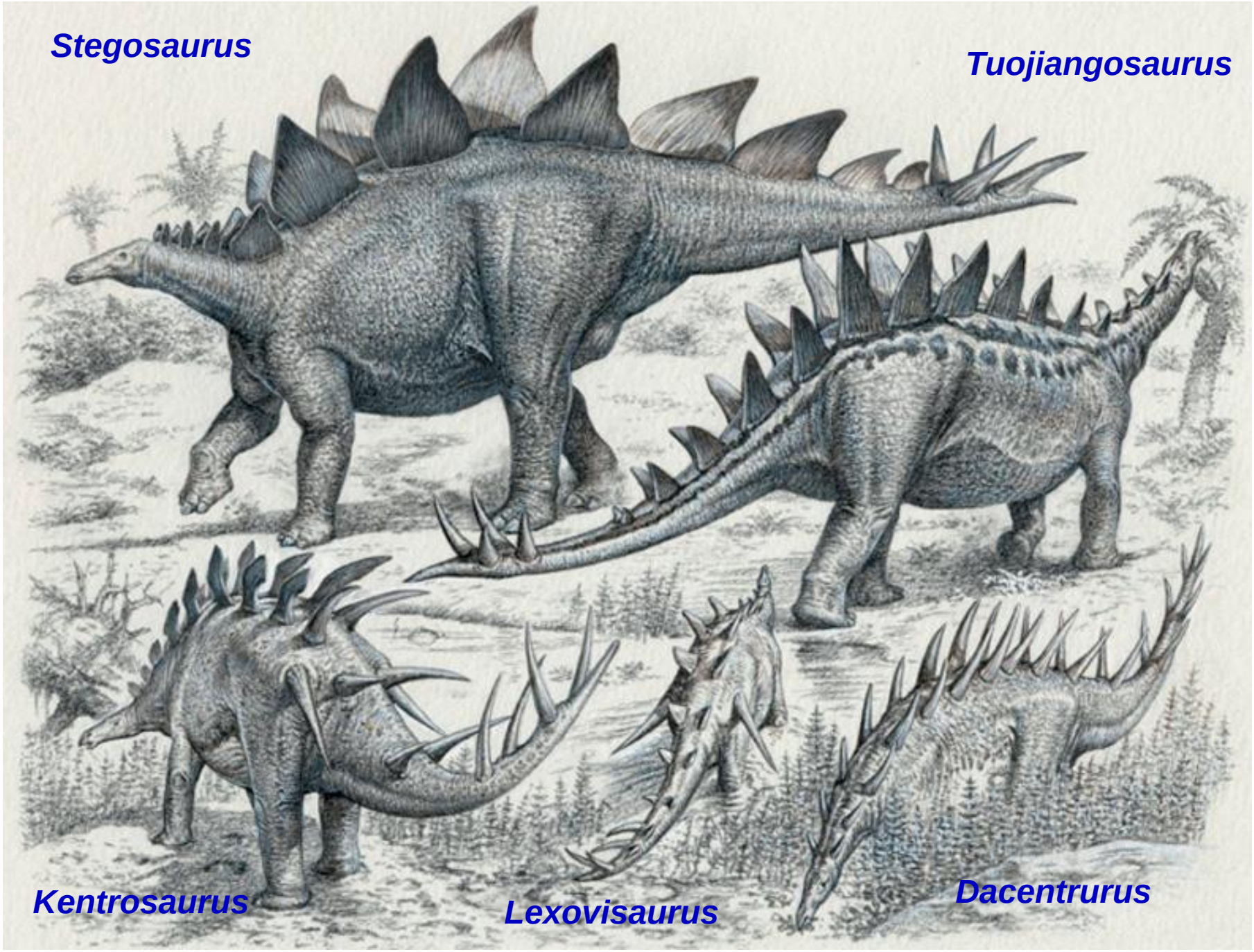
Styracosaurus



Stegosauria

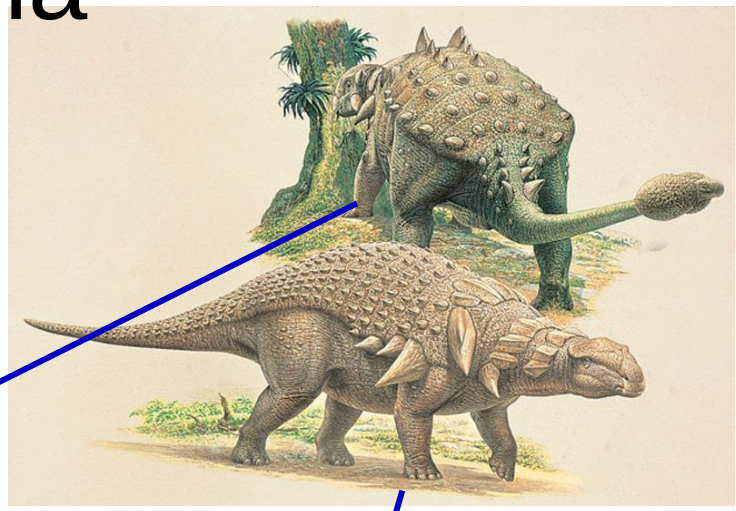
They are characterised by the bony plates along their back. The plated were used as regulators of their body temperature, either to remove body heat or to collect heat from the sun.

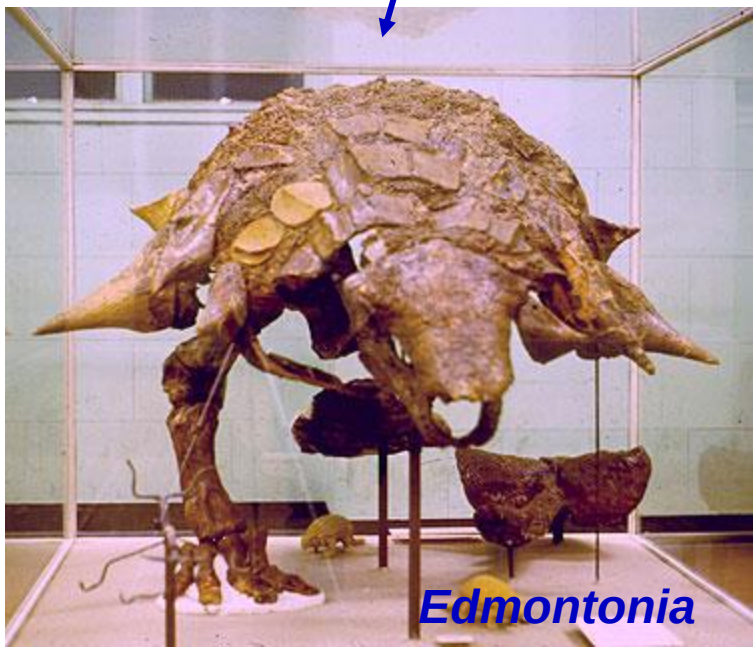



Stegosaurus
Tuojiangosaurus
Kentrosaurus
Lexovisaurus
Dacentrurus

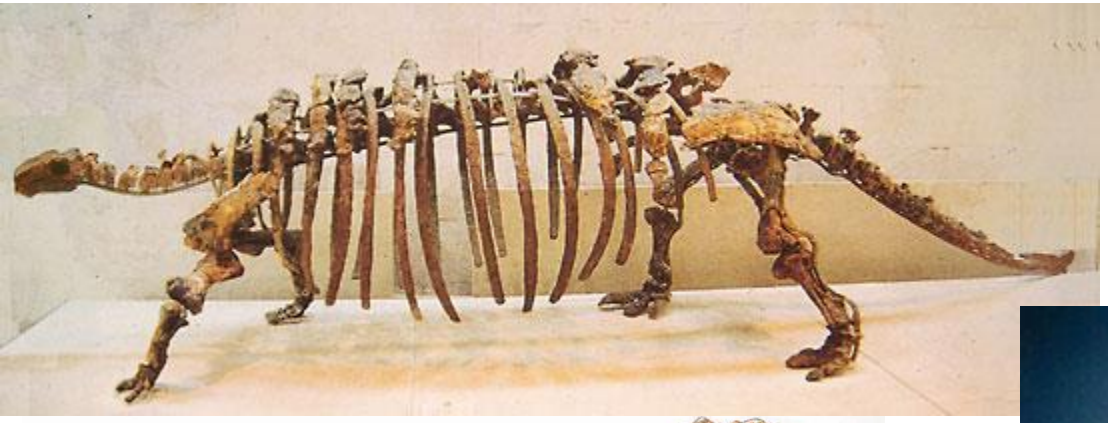
Ankylosauria

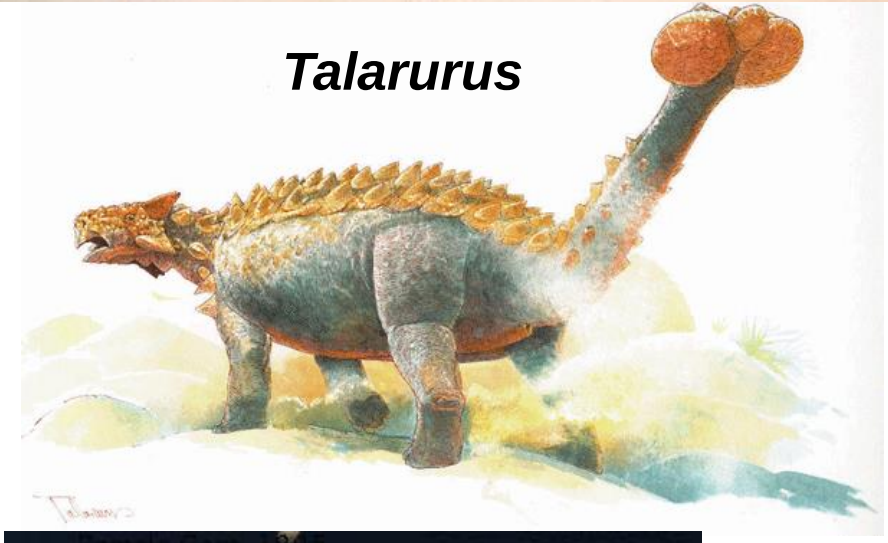
They appeared during the M. Jurassic. Glob like bony structures at the end of the tail, «armoured» back and skull covered from bony plates.





Edmontonia





Talarurus

Gastonia

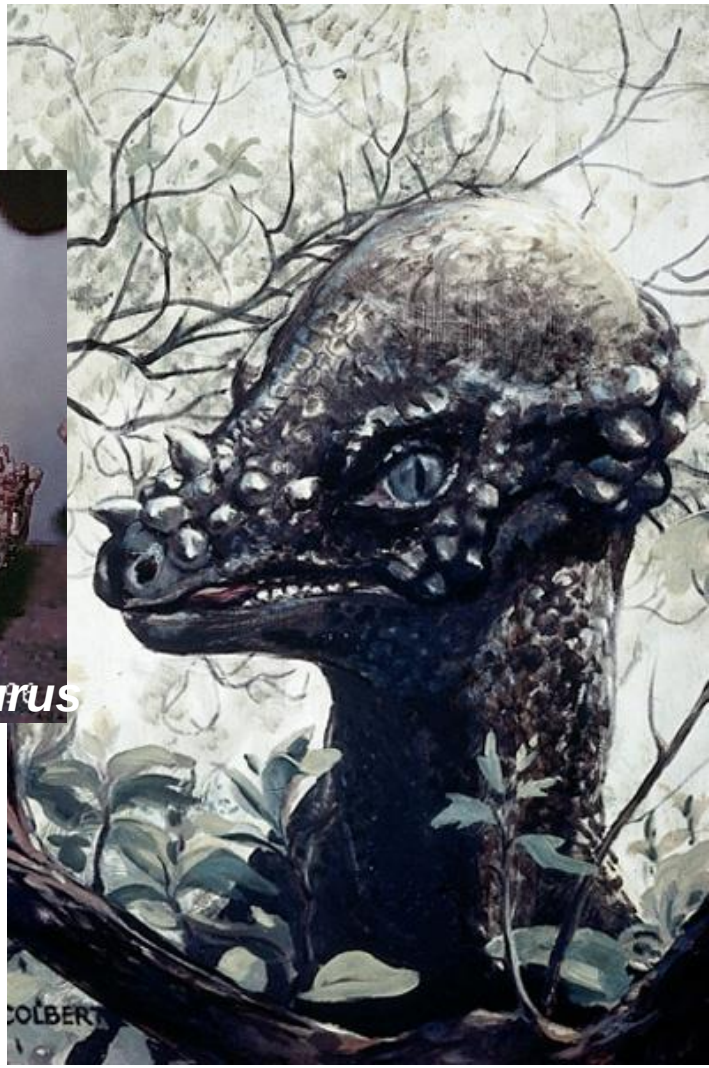
Pinacosaurus

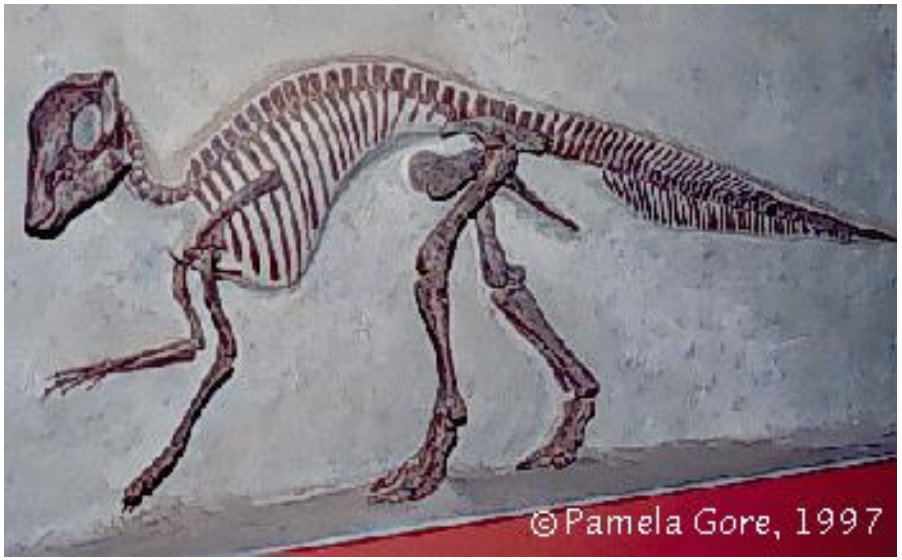
Tarchia

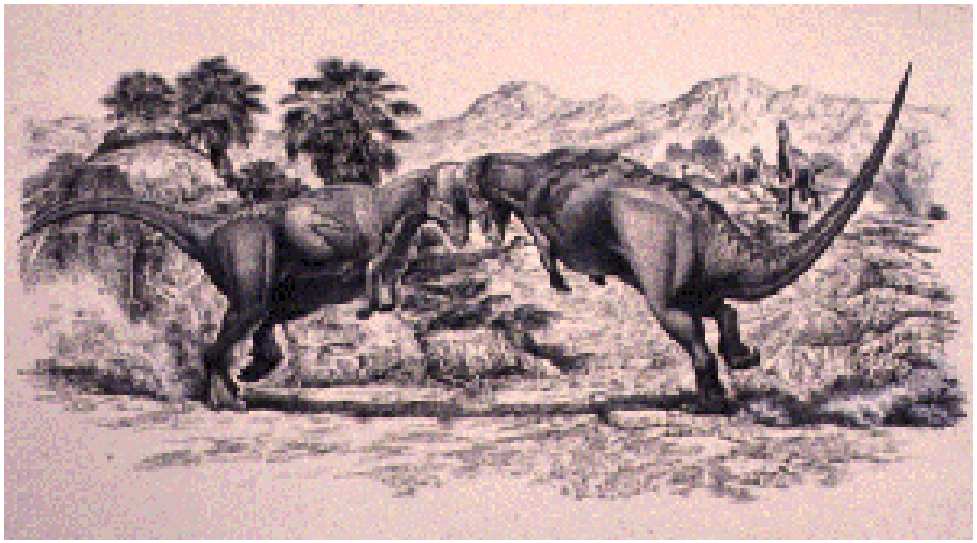
Pachycephalosauria

- *Pachycephalosaurus*
- *Stegoceras*

Pachycephalosaurus



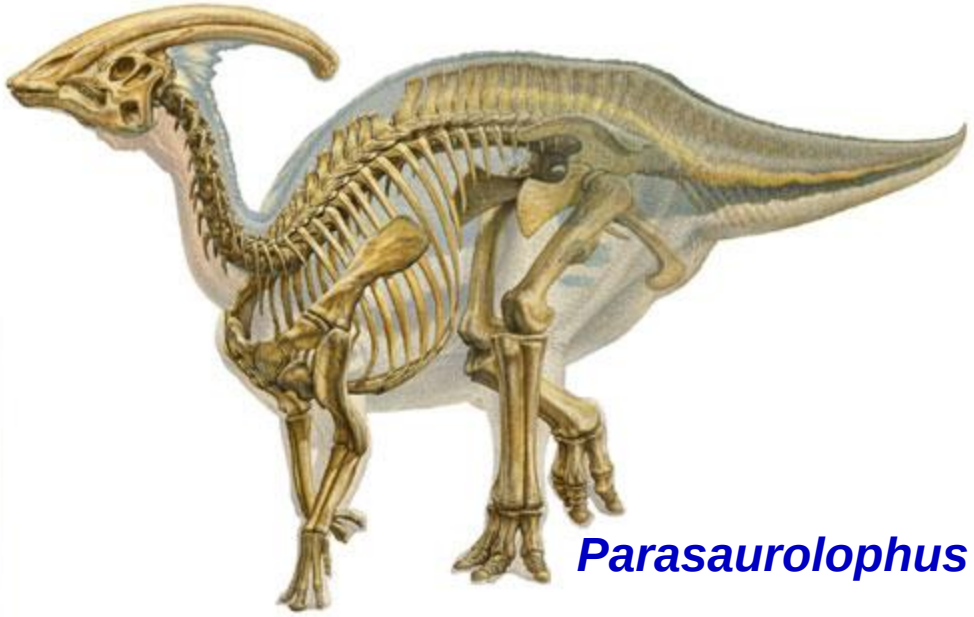

©Pamela Gore, 1997



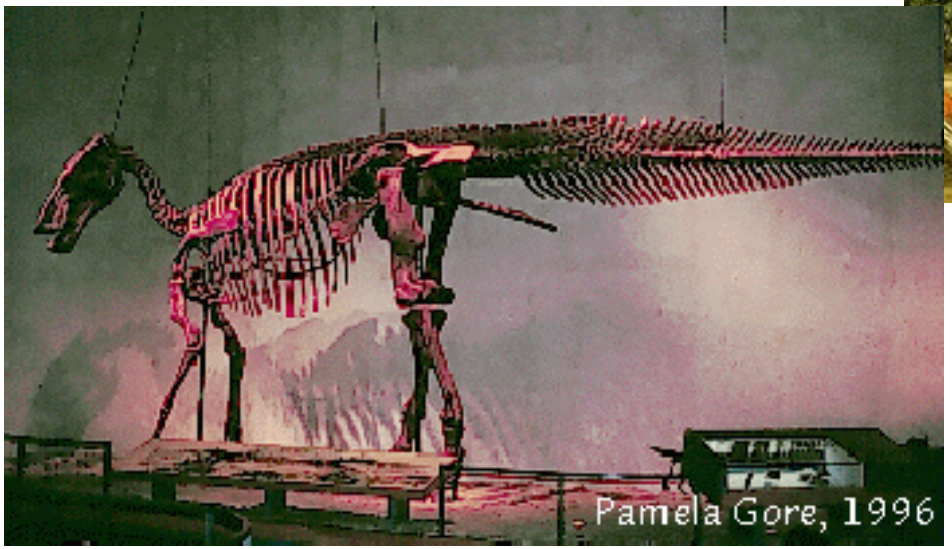
Ornithopodia

Bipedal as well as quadrupedal herbivore dinosaurs

- *Camptosaurus*
- *Iguanodon*
- Hadrosaurs in the Cretaceous such as *Parasaurolophus*, *Edmontosaurus*, *Bactrosaurus*, and *Maiasaura*

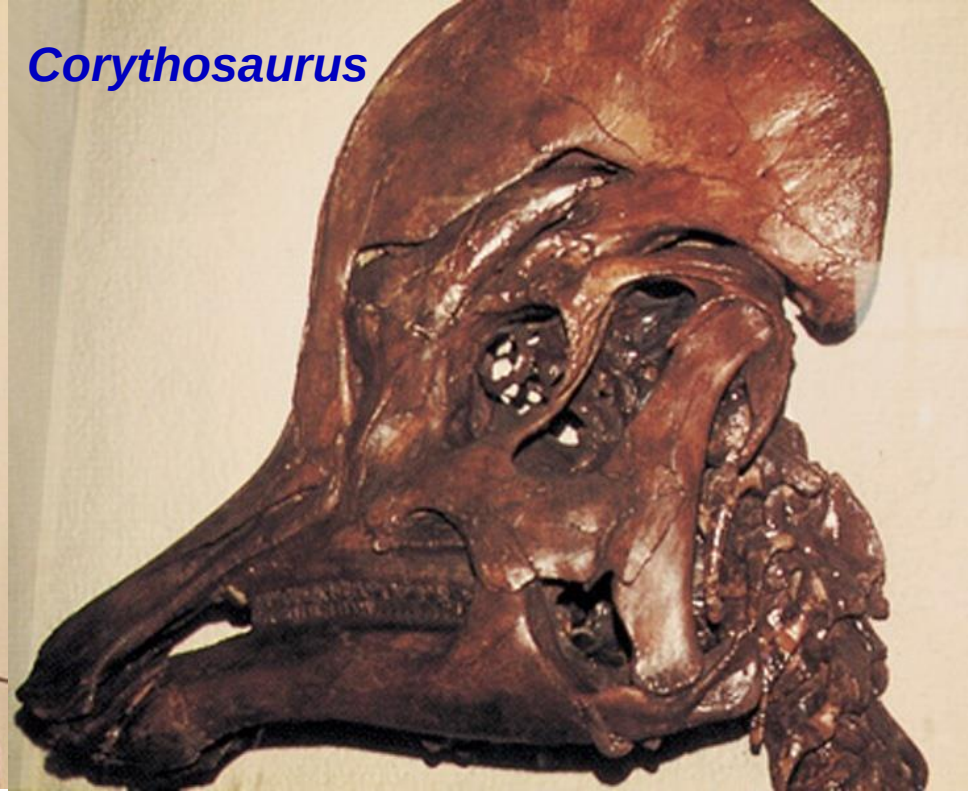


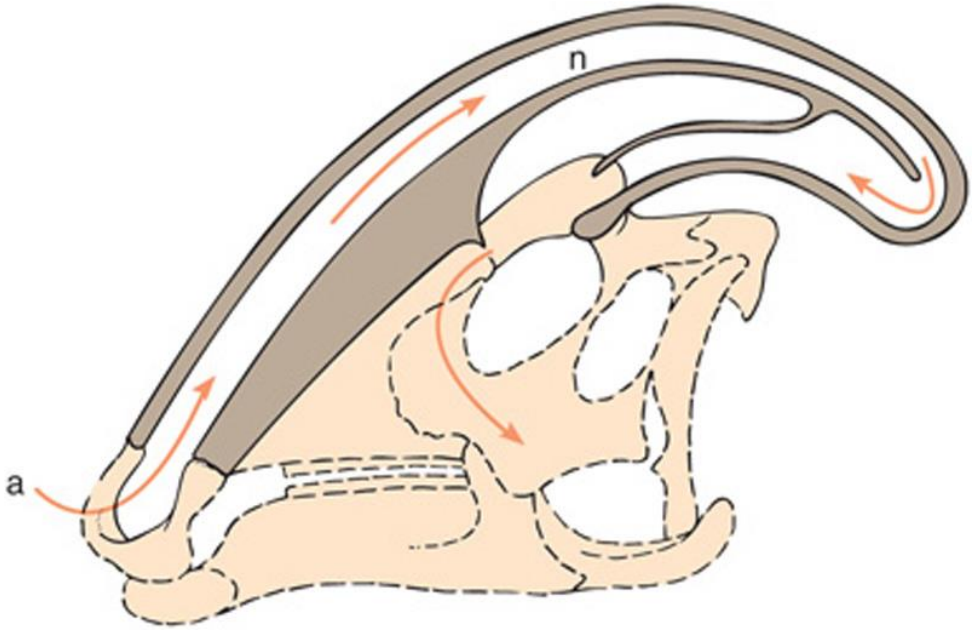
Parasaurolophus



Saurolophus


Lambeosaurus


Corythosaurus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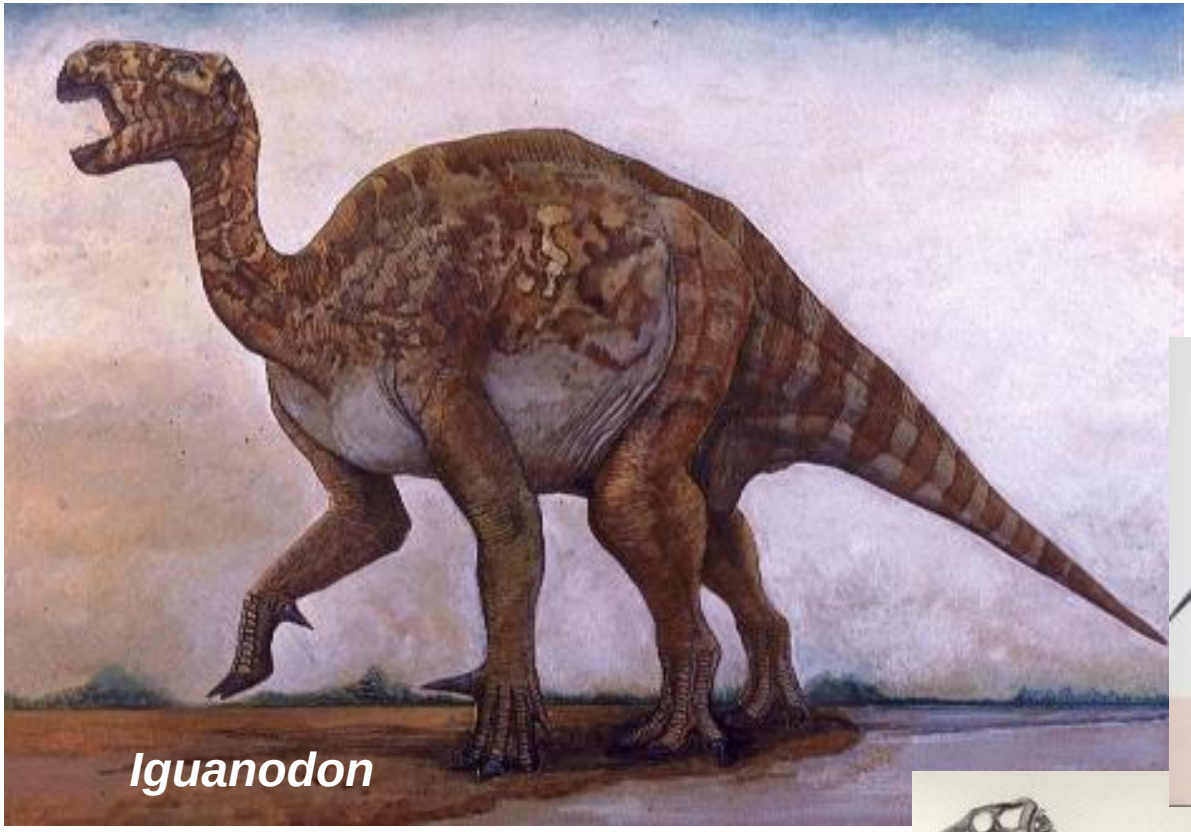
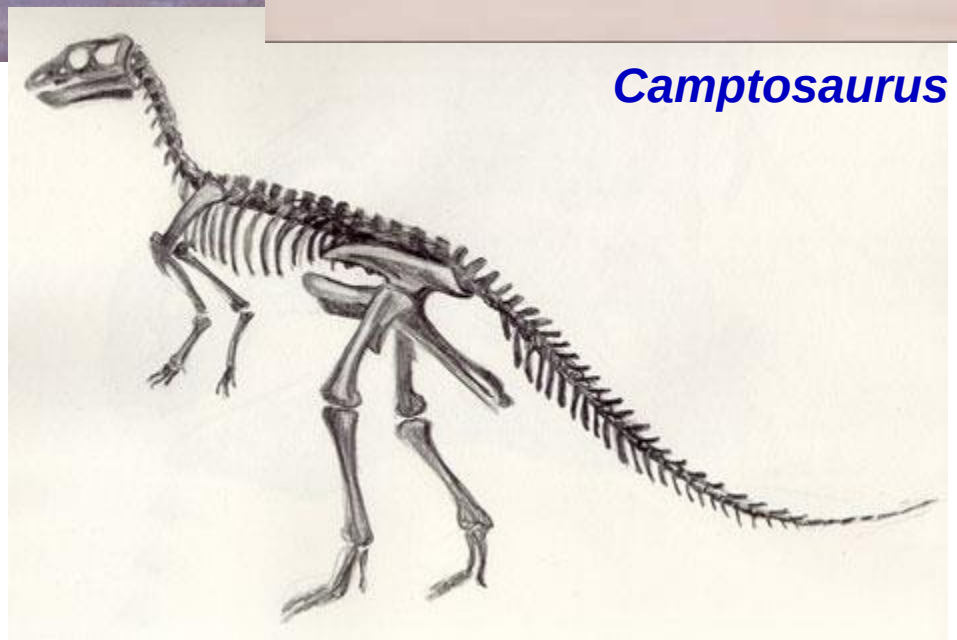


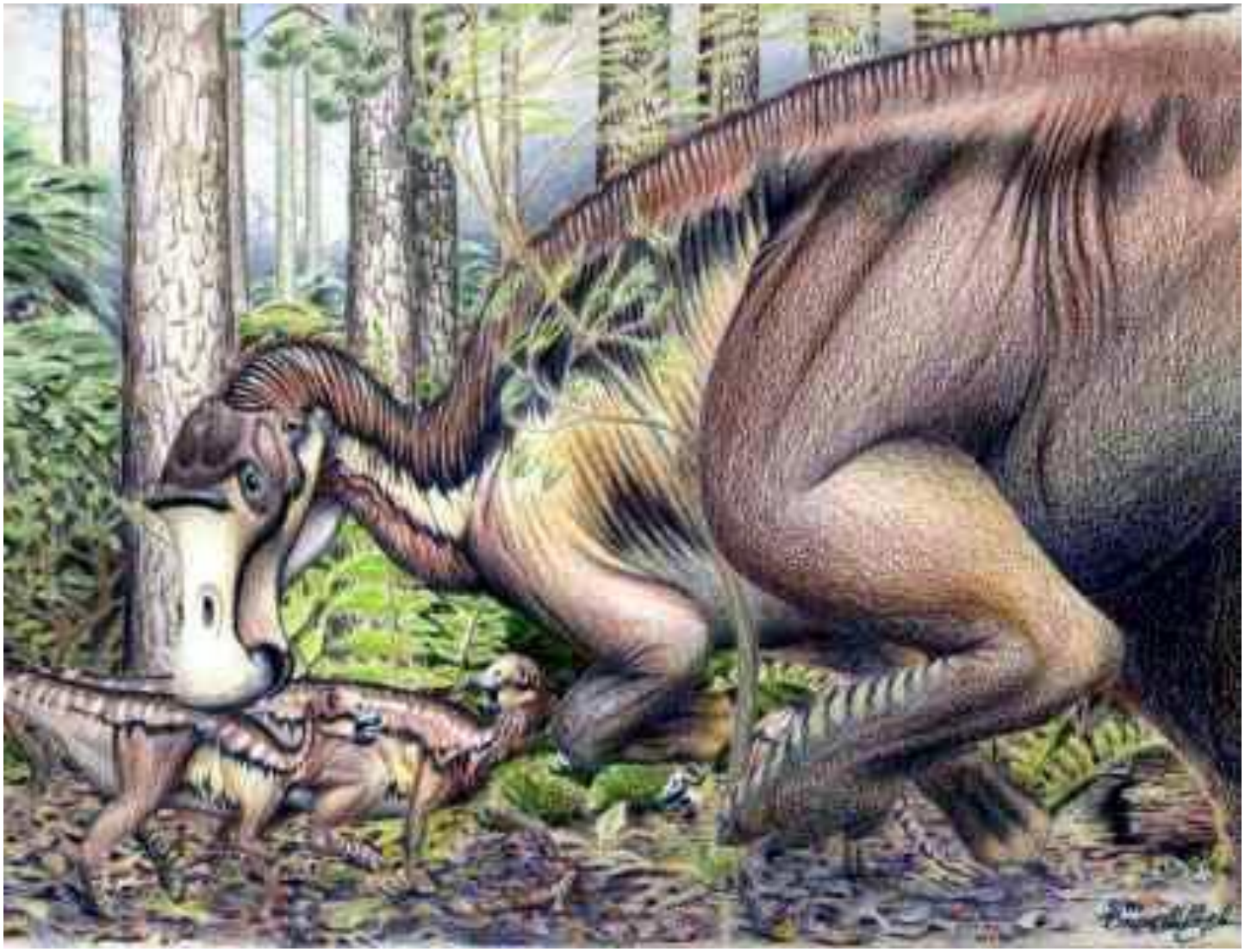
Camptosaurus



Dinosaur biology

- Some lived in herds
- Sexual dimorphism. Males could be separated from females.
- Dinosaur eggs very common, even eggs with embryos have been found in Mongolia and Portugal.
- Nests with eggs show that some dinosaurs showed parental care. *Maiasaura* should have been such a group of dinosaurs, as their little ones remained in the nest and grew up after the eggs erupted.

Dinosaur eggs



Maiasaura

Dinosaur biology

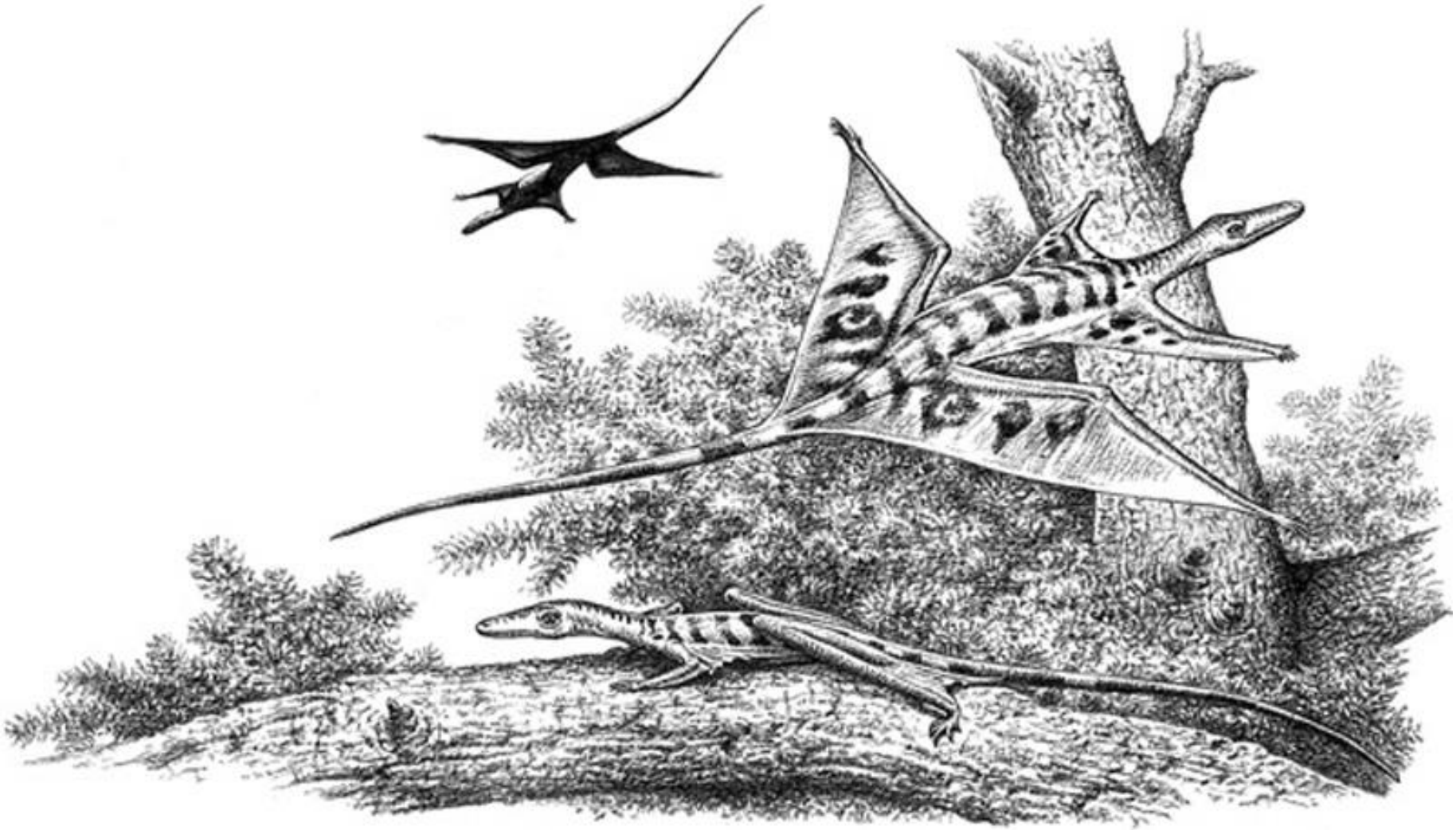
- Sauropoda had long necks to be able to feed from the leaves of tall trees. Their heads were proportionately small to reduce the weight that their long necks lifted.
- Their large size gave them advantage against the carnivores, and to loose energy at a lower rate.

Endothermy

- Since 1968 palaeontologist Robert Bakker supports the idea that dinosaurs are endotherm animals.
- Evidence for this include:
  - Their posture and their walking
  - The histology of their bones.
  - Isotope analyses in their bones.
  - The analogies of predators and preys.

Pterosauria

- The first flying reptiles were probably gliders.
- Later they developed their ability to move their wings and became competent flying animals.
- There are two groups of pterosaurs:
  - Ramphorynchoids, with long tails with a romboid edge (older).
  - Pterodactyls more advanced without a tail (such as *Pteranodon)*.



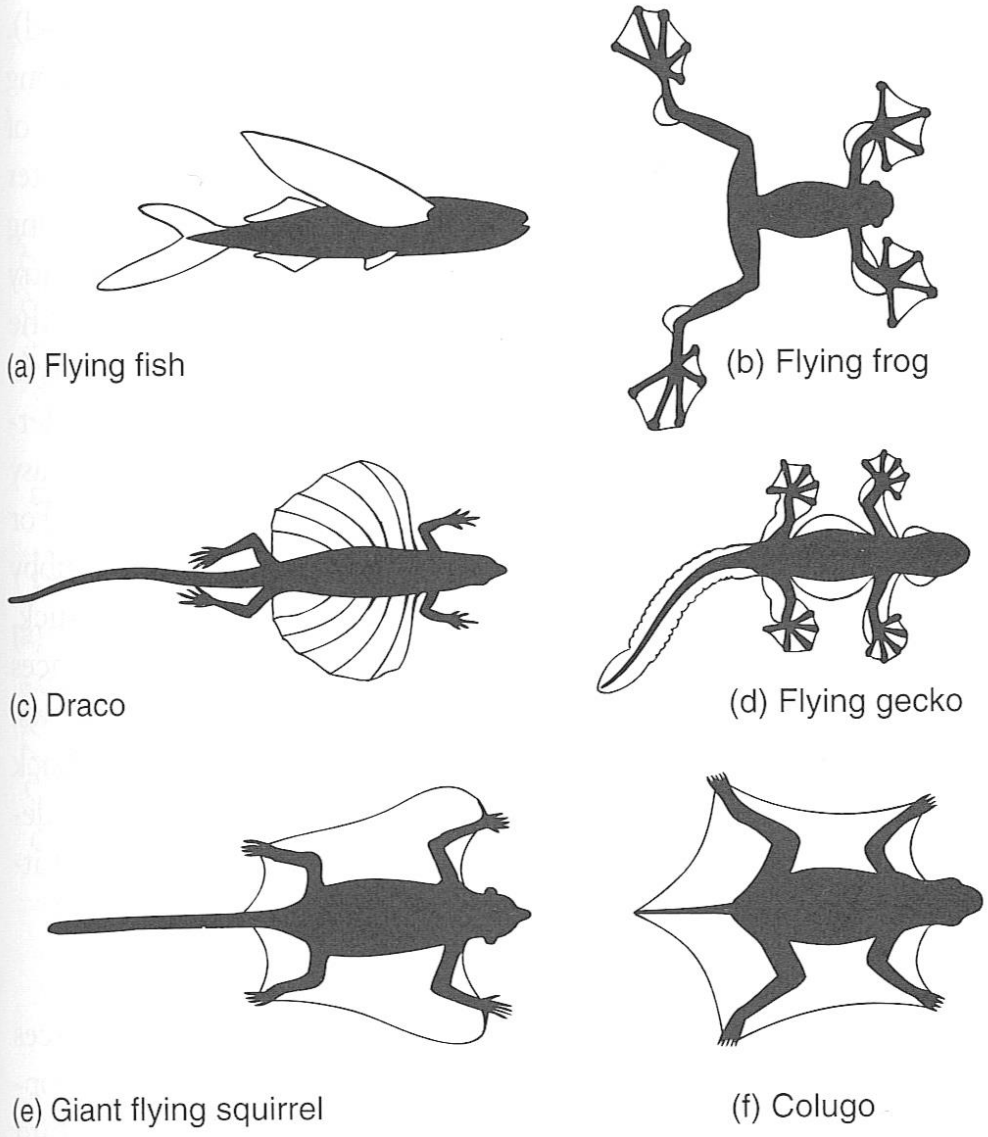


FIGURE 9.41 **Gliding and parachuting.** In all classes of vertebrates, at least a few species can be found that occasionally take to the air. (a) Fish. (b) Amphibian. (c,d) Reptiles. (e,f) Mammals.

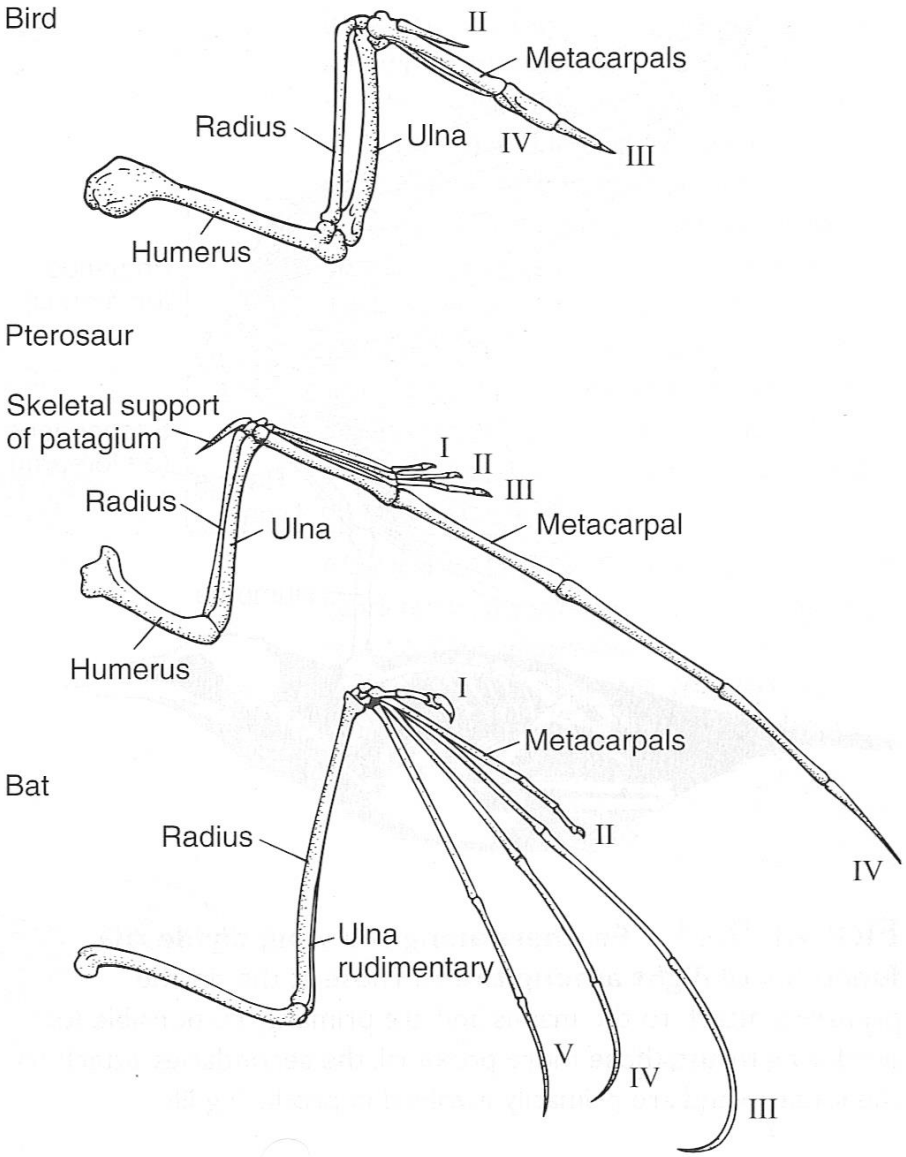
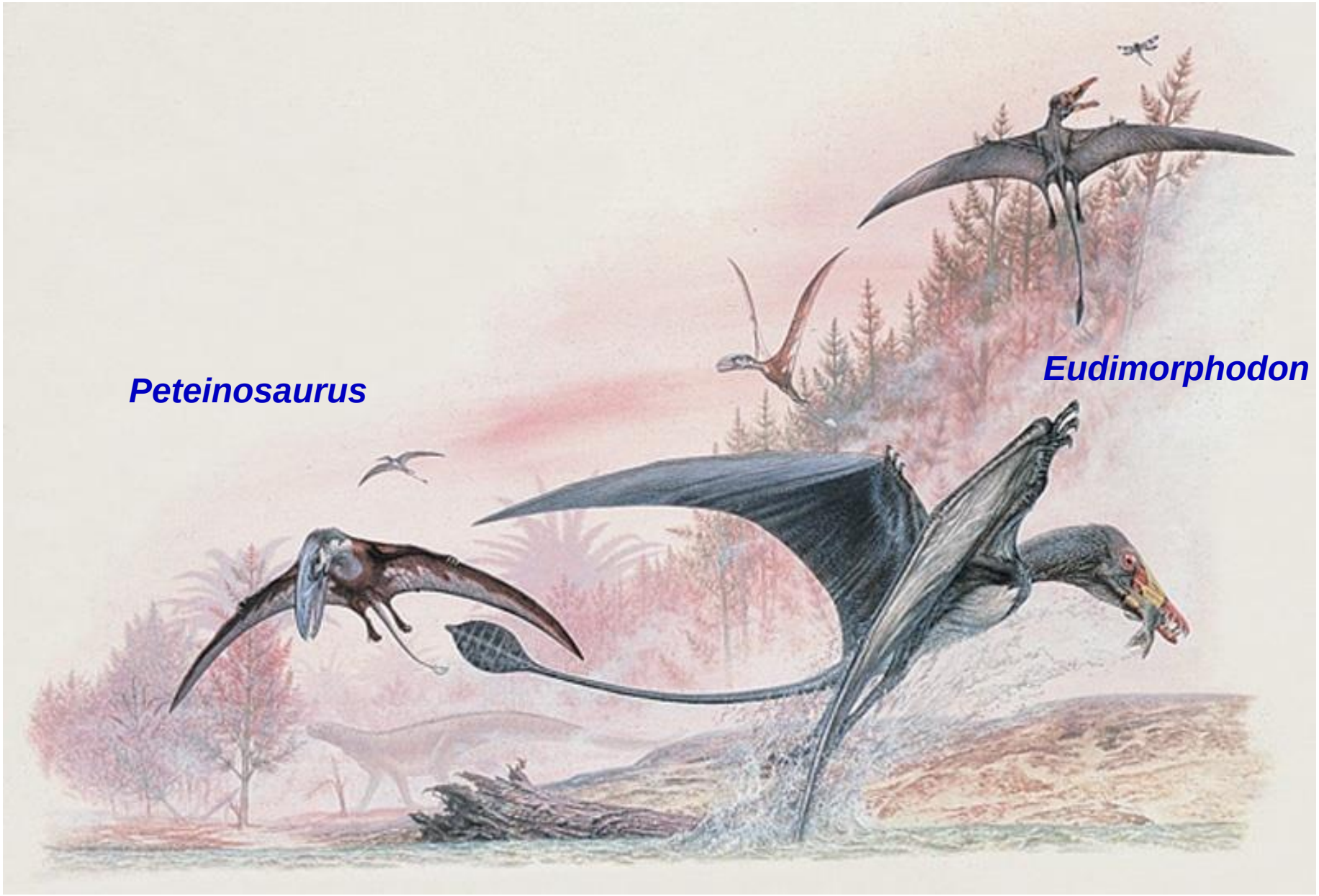
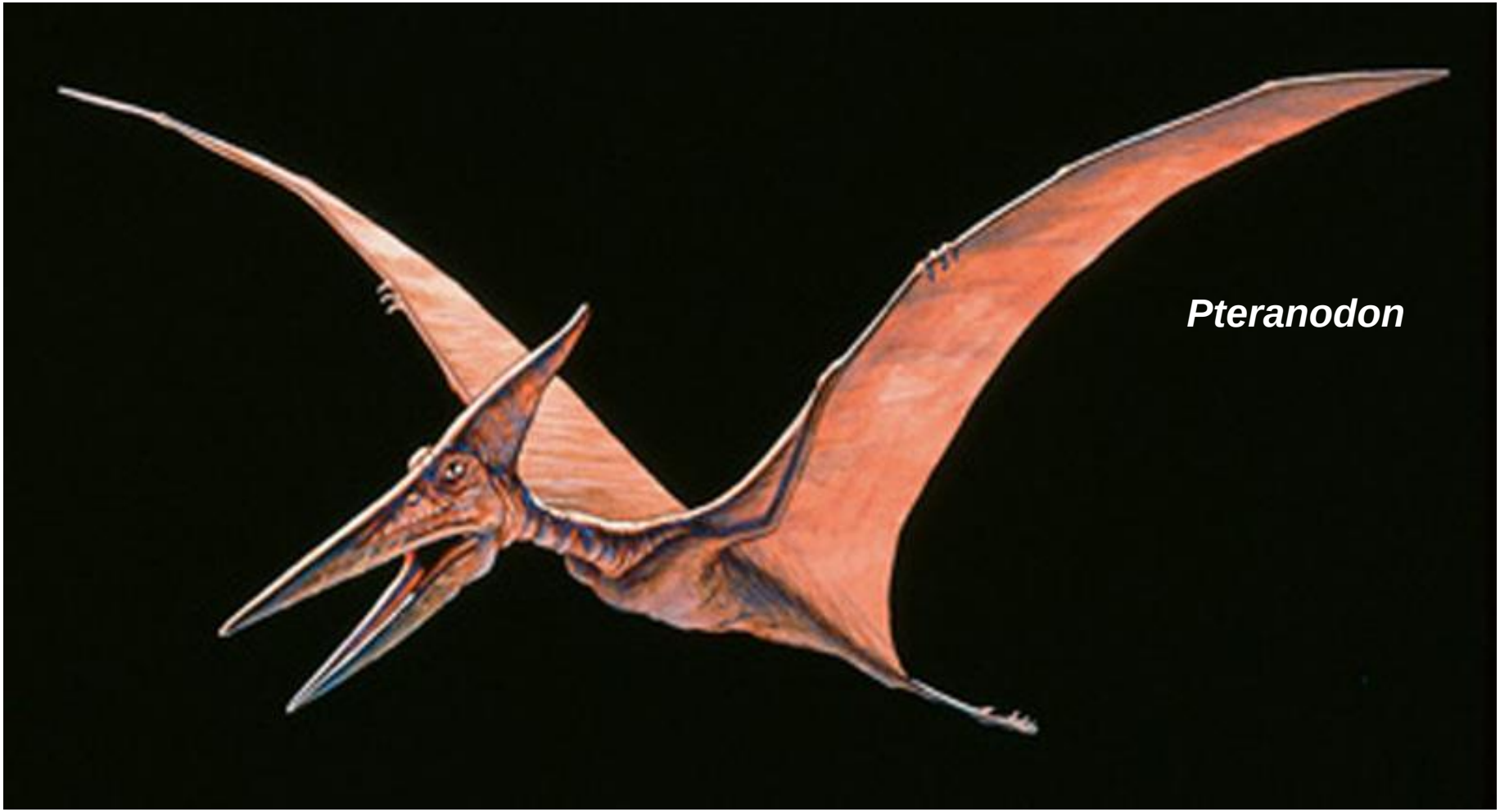


FIGURE 9.42 **Modifications of the forelimb in bird, pterosaur, and bat to support the aerodynamic surface.** Generally, the participating digits are lengthened and bones lightened.


Peteinosaurus
Eudimorphodon


Pteranodon

Pterosauria

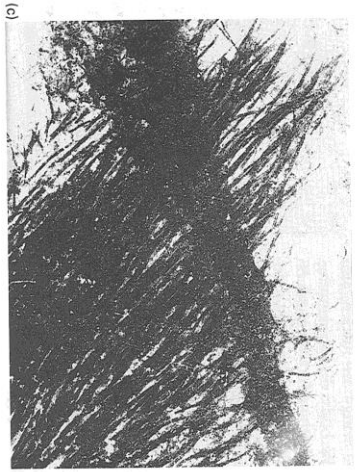
- They dominated the skies for more than 100 my. They first appeared in the L. Triassic.
- In the Jurassic and the Cretaceous they had developed large heads and eyes, and long jaws with thin sharp teeth.
- The digits of the 4th finger were extended to support the wings' membrane.

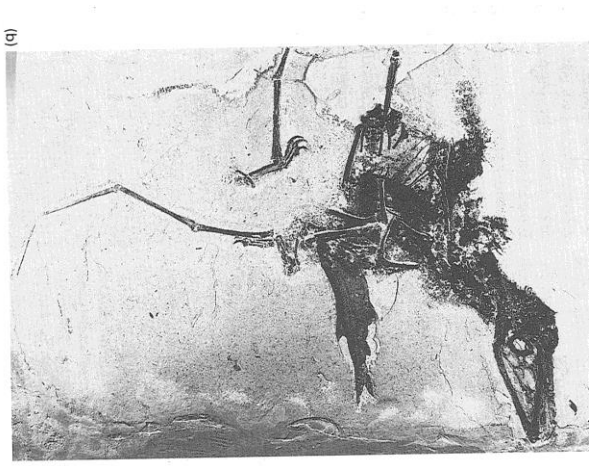

© Pamela Gore, 2001


Pterodaustro

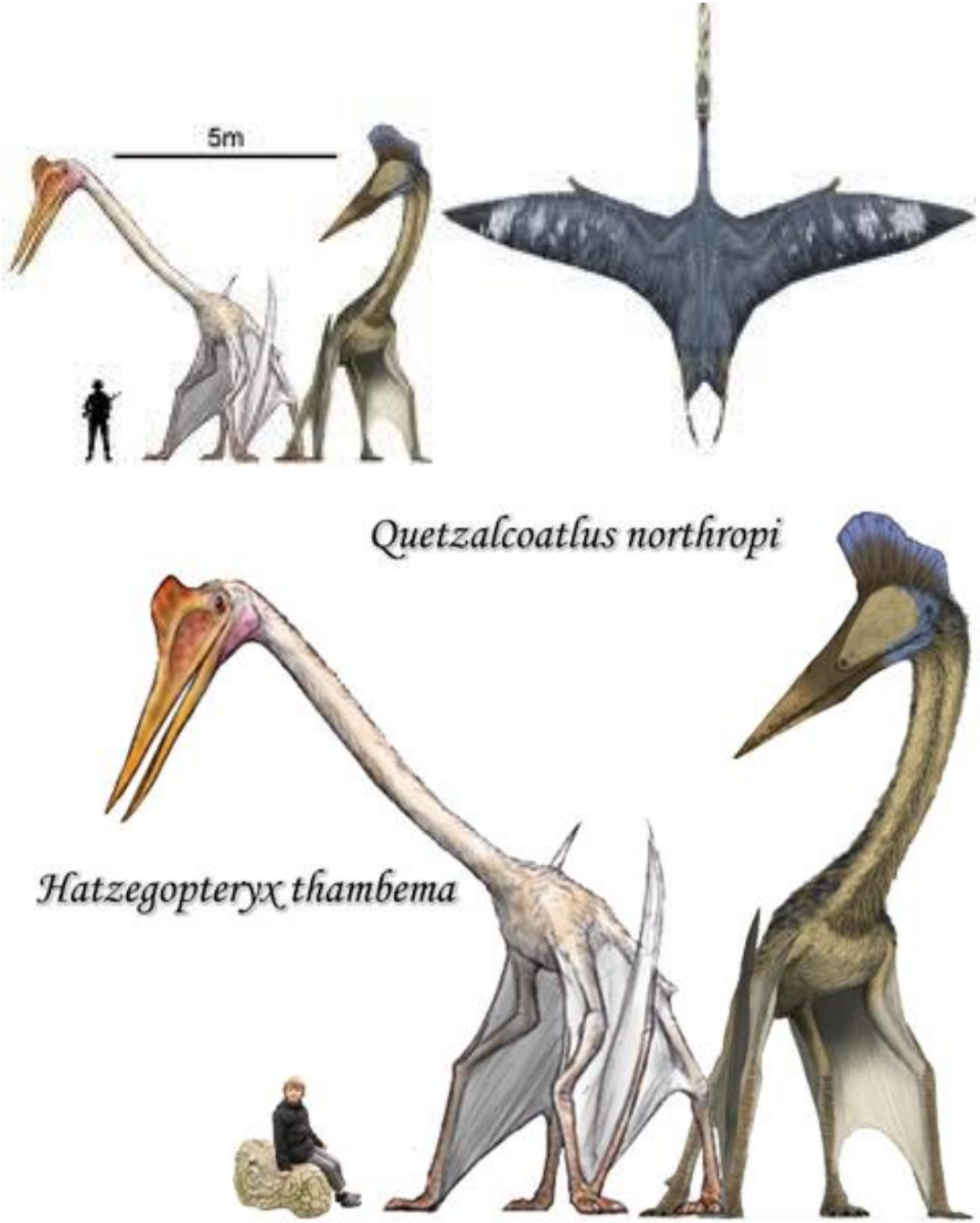
Pterosauria

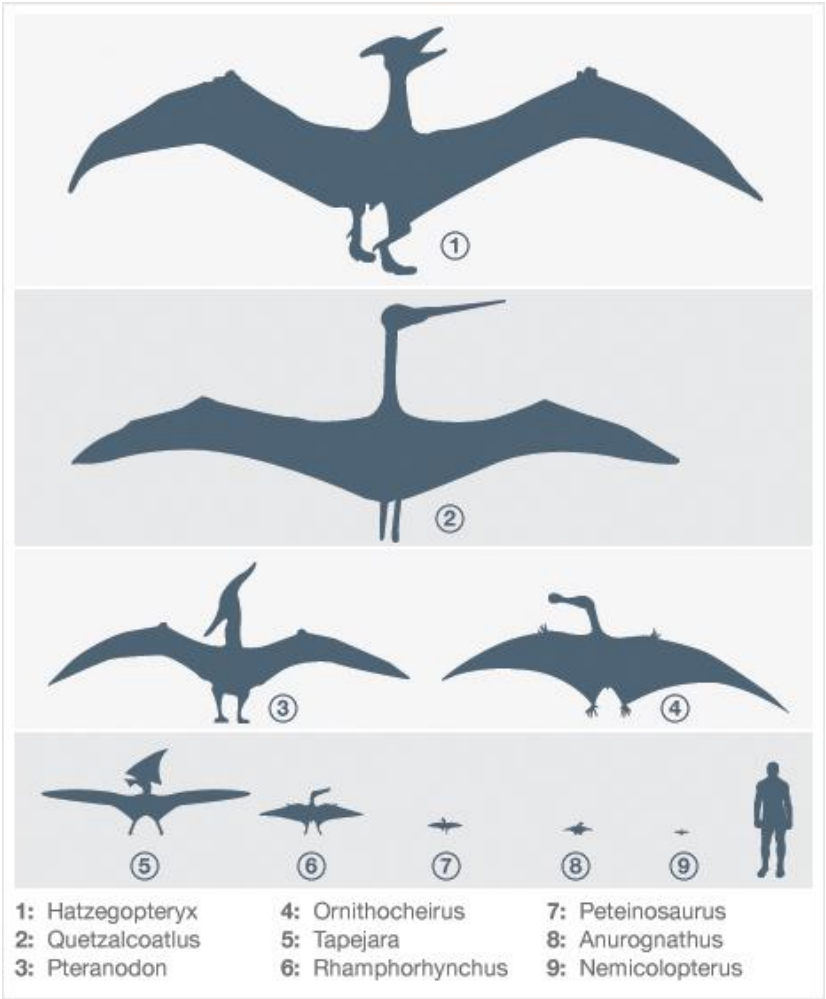
- The largest pterosaur was ***Quetzalcoatlus*** with a wing span of 17-18 m, from the L. Cretaceous. Recently in Romania the even largest ***Hatzegopteryx thambema*** has been found***.*** It was the largest flying vertebrate ever lived.
- Some of them were covered with hair or fur maybe, indicating that they were probably endotherm animals. Such an example was *Sordes pilosus* (hairy devil).






Quetzalcoatlus


5m
Quetzalcoatlus northropi
Hatzegopteryx thambema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8
9
1: Hatzegopteryx
2: Quetzalcoatlus
3: Pteranodon
4: Ornithocheirus
5: Tapejara
6: Rhamphorhynchus
7: Peteinosaurus
8: Anurognathus
9: Nemicolopterus

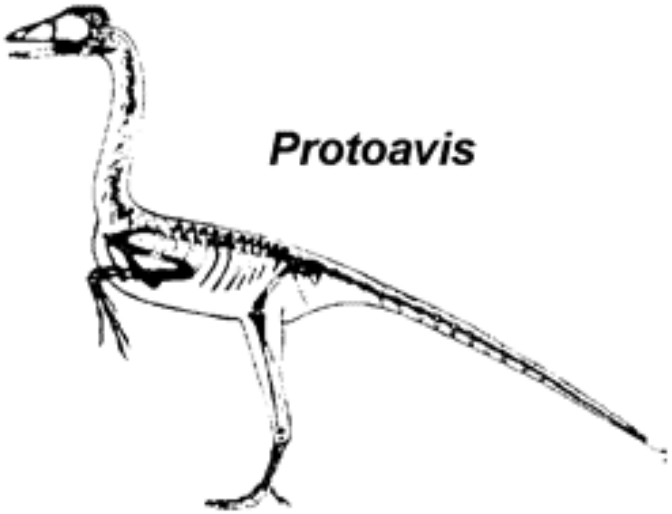
Nemicolopterus the smallest pterosaur

Aves

- Endotherm animals, with wings and feathers, they possess a beak and lay eggs. Most fly but not all.
- Bird bones are thin and hollow, thus their preservation is difficult.
- Two views for their ancestry, either from theropod dinosaurs, or primitive archosaurs (both bipedal)
- However, there are several theropods with feathers, hollow and thin bones, and carinated sternum.

Protoavis

Found in the L. Triassic of Texas and considered as the connection with the Lower archosaurs and for some ancestor of the birds.



Class Aves

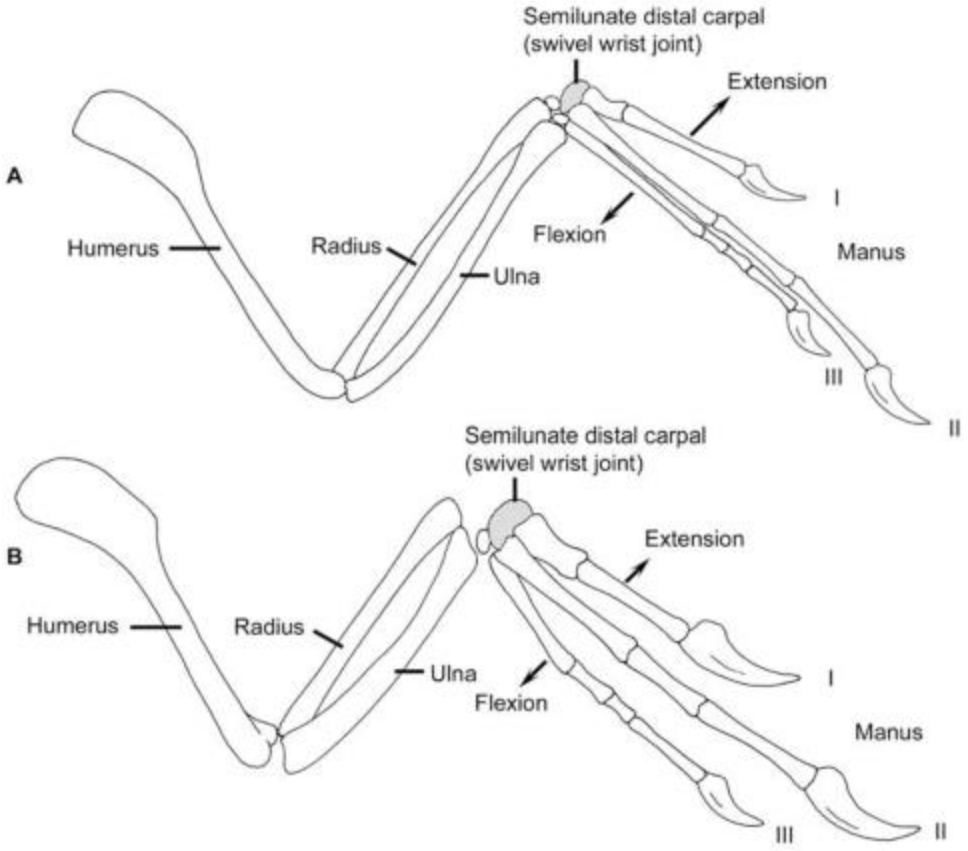
- The feathers evolved from the reptile scutes. Originally they were used for insulation, camouflage, showing of and not for flight.
- It has been proposed that the birds are connected with the dinosaurs and that they should be placed together in the Class Dinosauria. This is not widely accepted yet.

Archaeopteryx

- The most known fossil is *Archaeopteryx*, which although not the older it was the first one.
- It was found in a 150 my Jurassic limestone in Solnhofen Germany in 1861.
- Since then 12 specimens have been found.
- It possesses some bird and some reptile features (Tansitional fossils).

Archaeopteryx

- Bird features:
  - Feathers
  - Wings
- Reptile features:
  - Theropod like skeleton
  - teeth
  - Long tail like a lizzard
  - Front limbs with nails
  - From the breastbone the carina is missing, which means that it didn’t have strong muscles for a long flight.



Archaeopteryx

Deinonychus

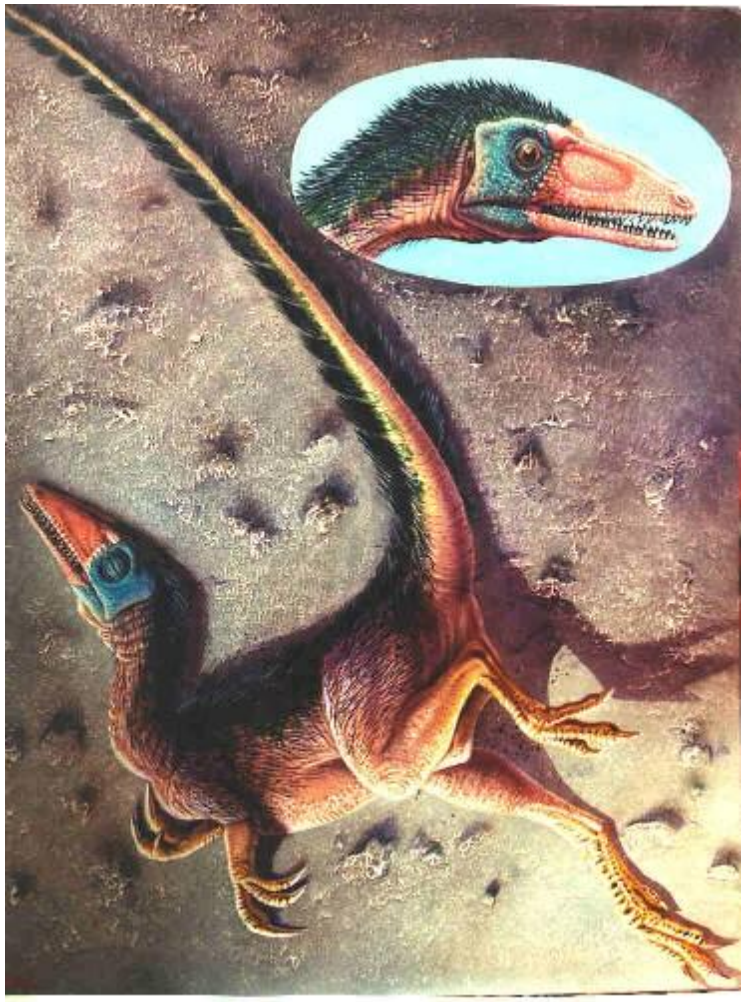
Archaeopteryx

Velociraptor

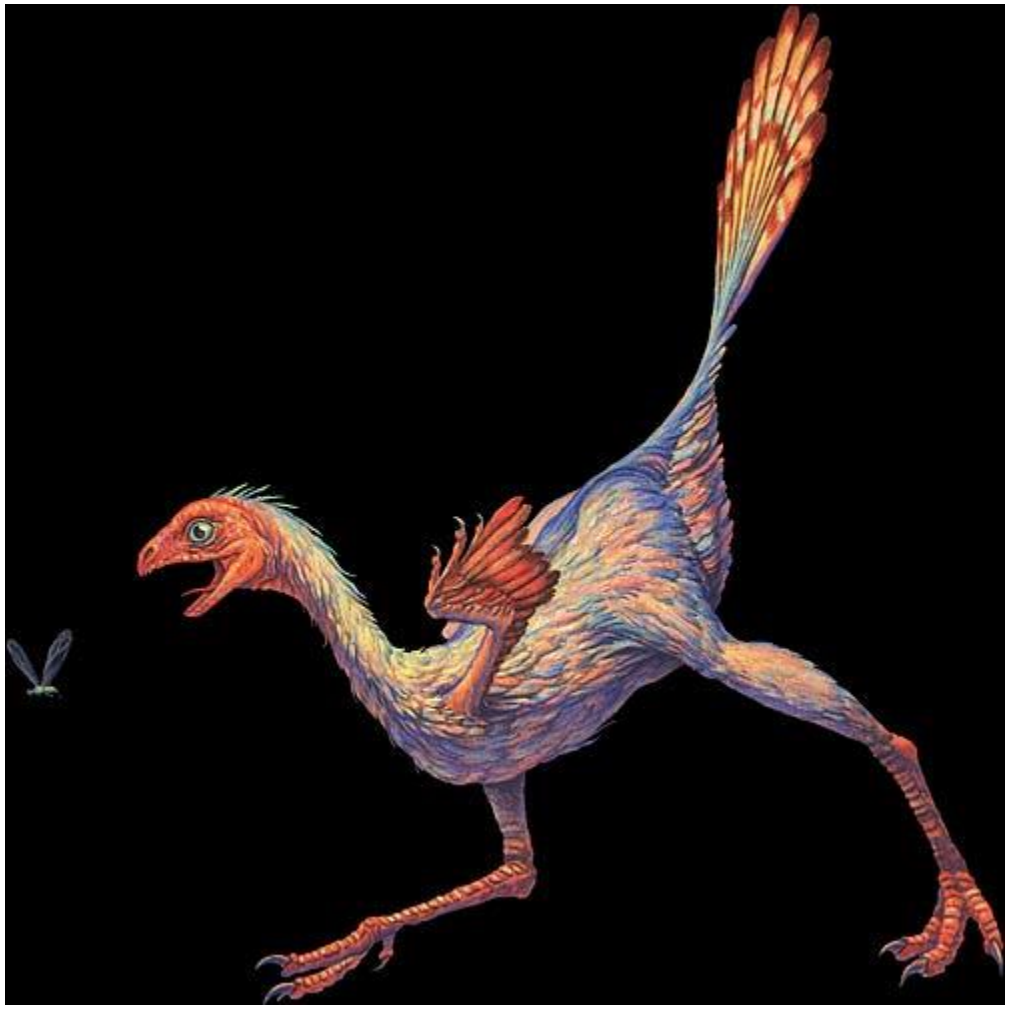
Bird origin

- Bird like features in some dinosaurs, such as feathers and primitive feathers in 120my *Sinosauropteryx prima*, and *Caudipteryx zoui*, a dinosaur with a feathered tail.
- The clade of the dinosaurs with the birds with the new discoveries has become unclear and it is difficult to say when the first bird appeared..
- Probably birds first appeared near the end of the Jurassic.
- Several different forms of birds lived during the Cretaceous.
- The group of *Congfuciusornis, Liaoningornis* (E. Cretaceous) are considered the direct ancestors of modern birds. They present characters such as sternum with carina, bird like ribs, beak.

Sinosauropteryx



Caudipteryx



Aviales και Enantiornithes

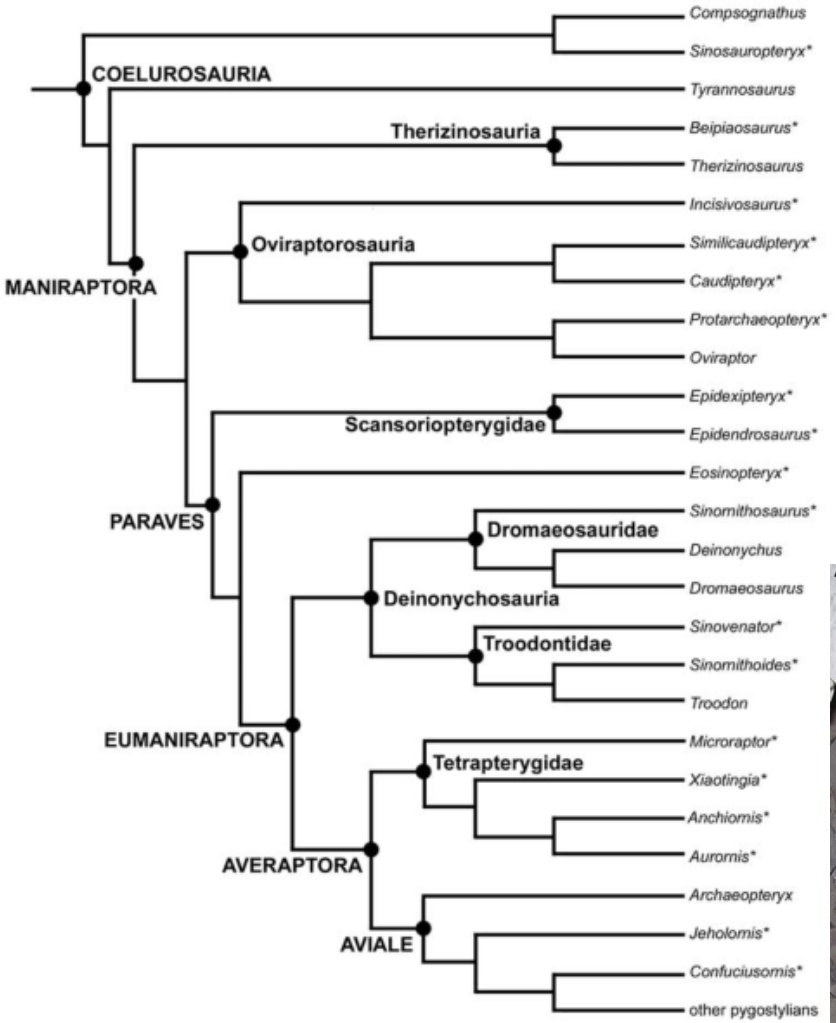
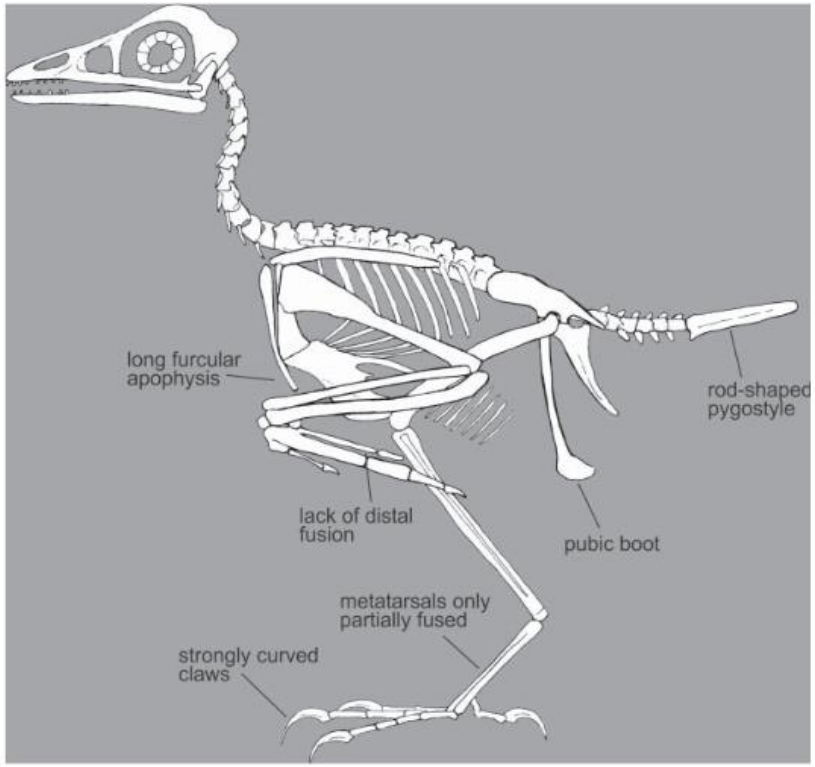
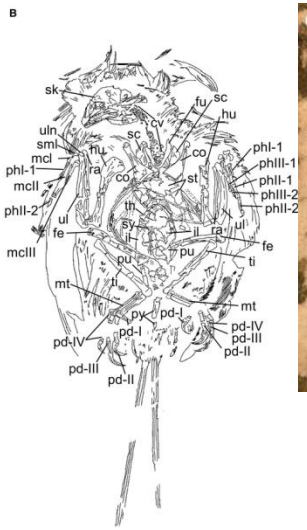
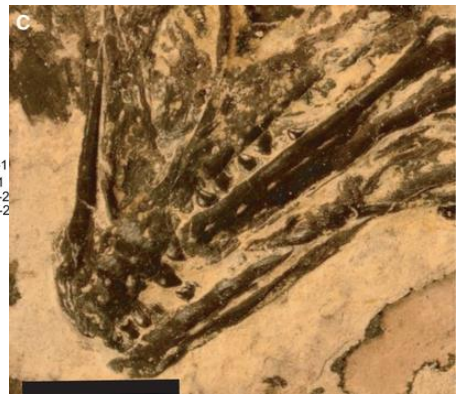


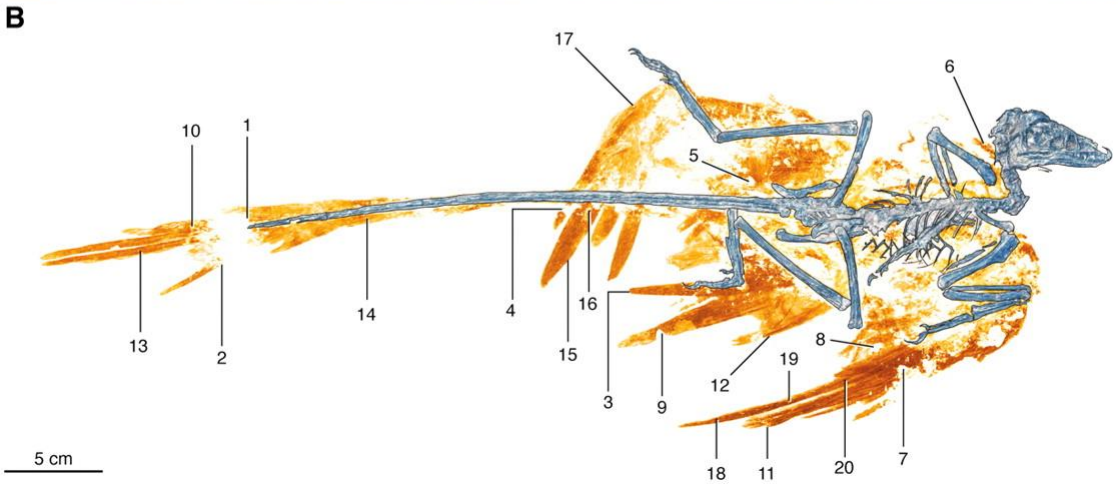
Figure 3.6 Skeleton of the enantiornithine *Sinornis* from the Early Cretaceous Jehol Biota.

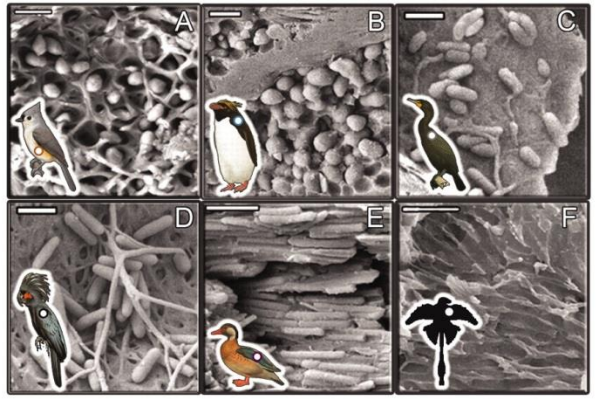


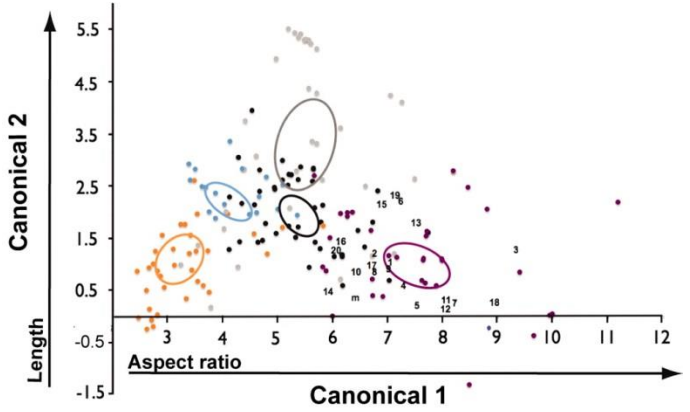




Microraptor a coloured dromeosaur!



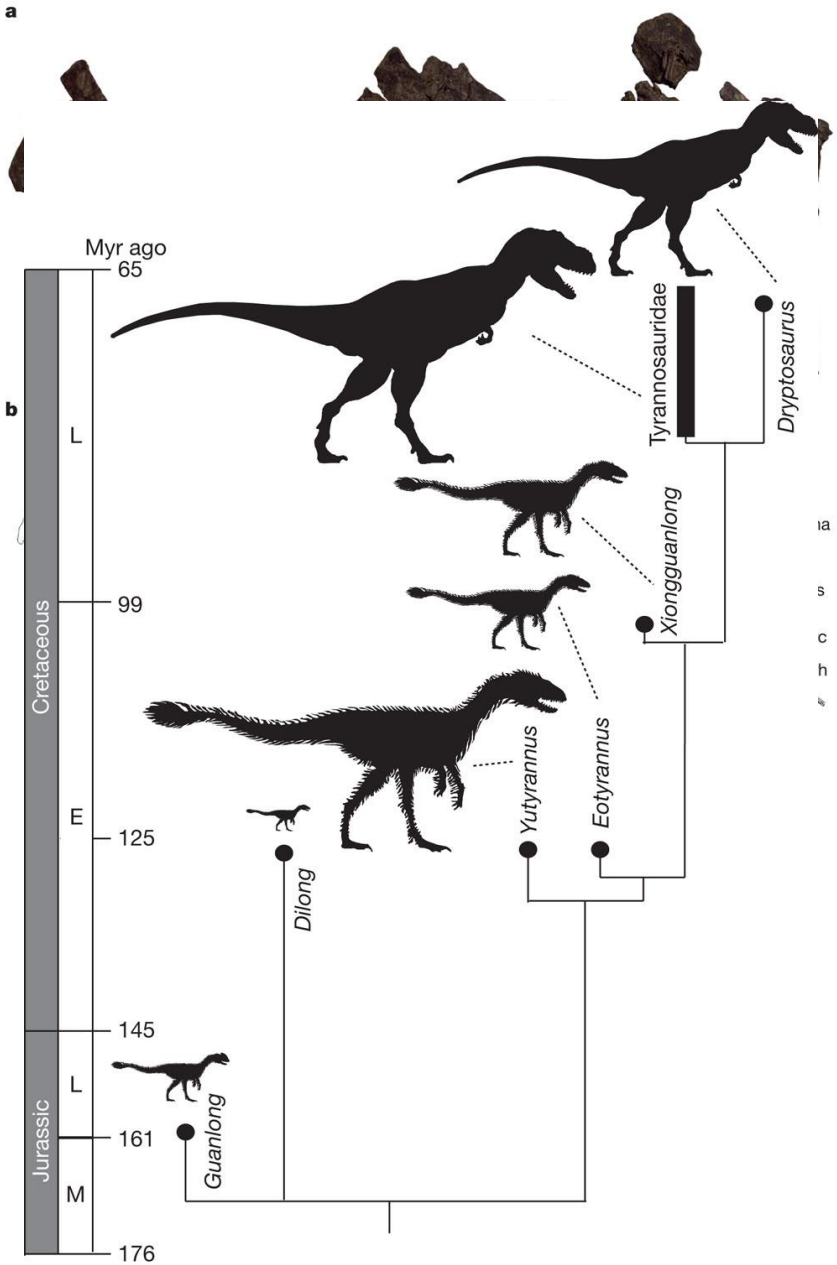


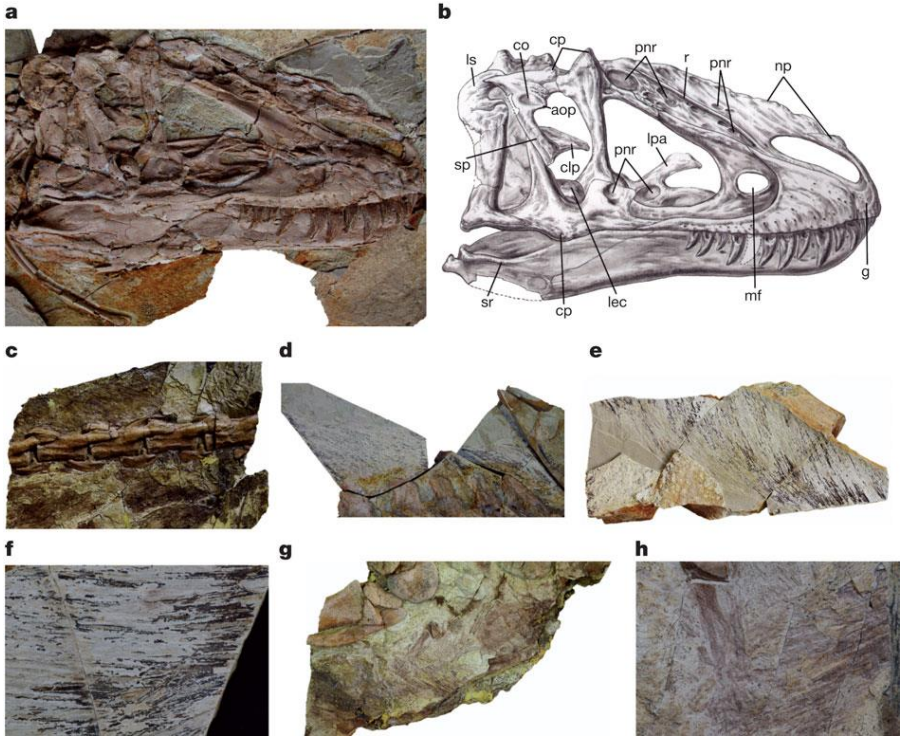


Microraptor a *dromeosaur*

We believe that birds came from a group related with the dromeosaurs, relatives of *Deinonychus* and*Velociraptor.*
Something that would look like *Microraptor* (Tetrapterigidae)

Yutyrannus huali (ZCDM V5000 and ZCDM V5001).





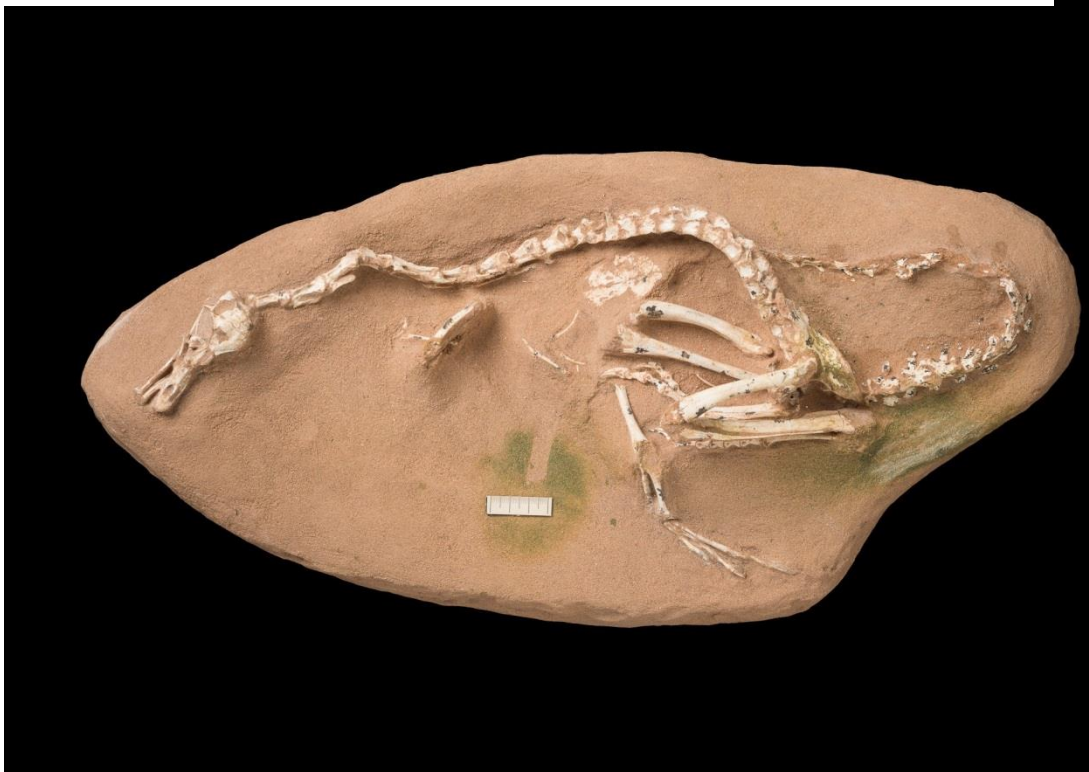
It belongs to Tyrannosauroidea!

X Xu *et al*. *Nature* **484**, 92-95 (2012)

nature

Halszkaraptor escuilliei

- Semiaquatic small dromeosaur from the L. Cretaceous of Mongolia, with finlike front limbs that enabled him to swim.



Enantiornithes and Neornithes

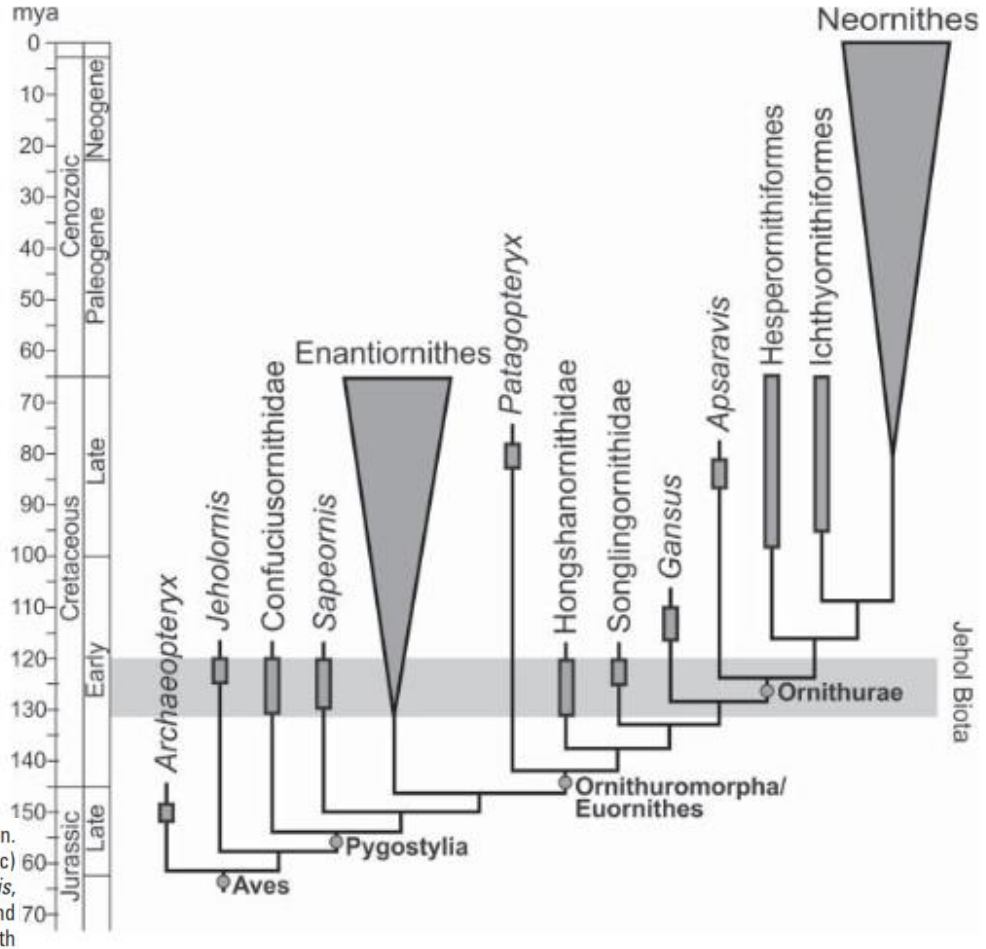
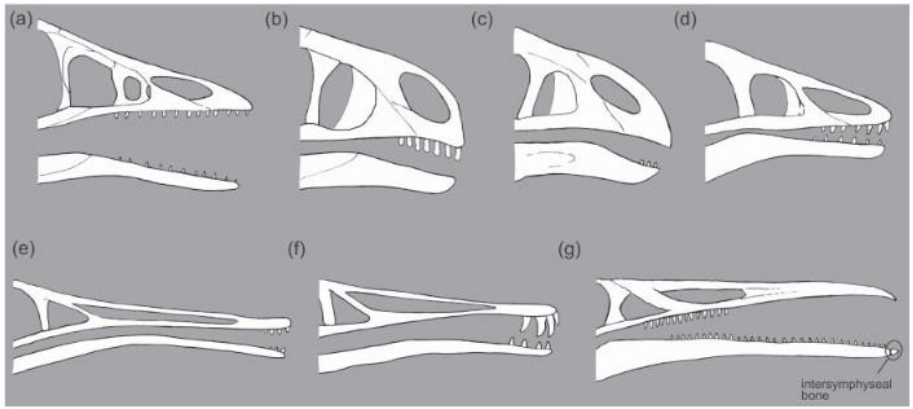
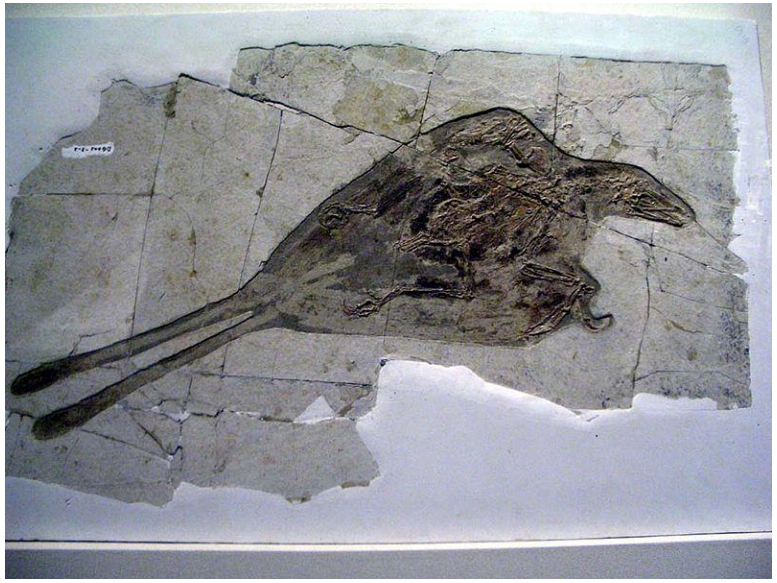


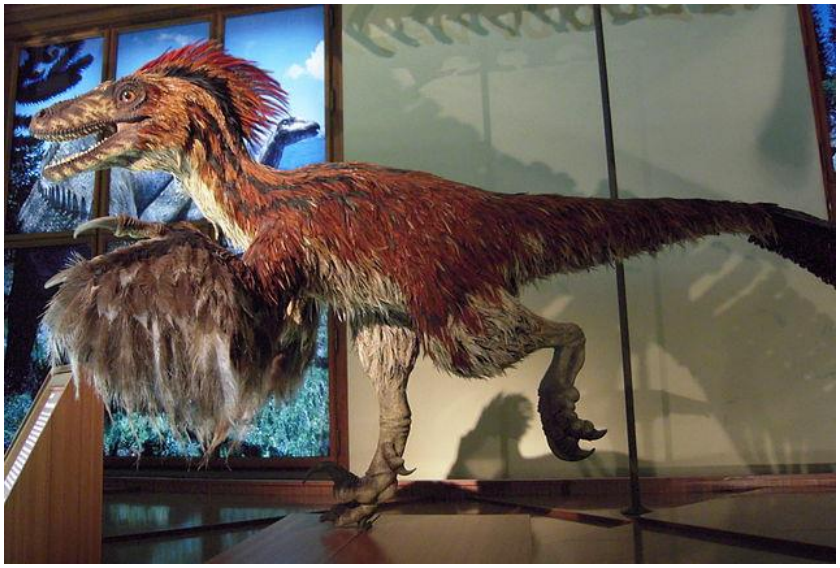
Figure 4.5 Different patterns of tooth reduction in Mesozoic birds. (a) *Archaeopteryx* with a full dentition. (b) *Sapeornis*, in which teeth are restricted to the praemaxillae and the rostral portions of the maxillae. (c) *Jeholornis*, where teeth are only present at the tips of the lower jaws. (d) The enantiornithine *Bohaiornis*, which has teeth in the maxillary, praemaxillary, and dentary bones. In the enantiornithines (e) *Rapaxavis* and (f) *Longipteryx*, the dentition is restricted to the tip of the snout. In (g) *Hesperornis*, the praemaxillae lack teeth and an intersymphyseal bone is situated on the tips of the lower jaws. Not to scale.



Confuciusornis & Deinonychus

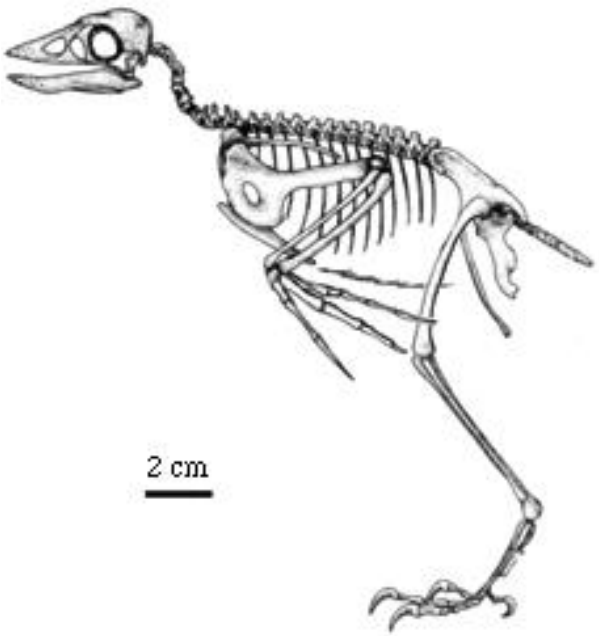


Confuciusornis sanctus

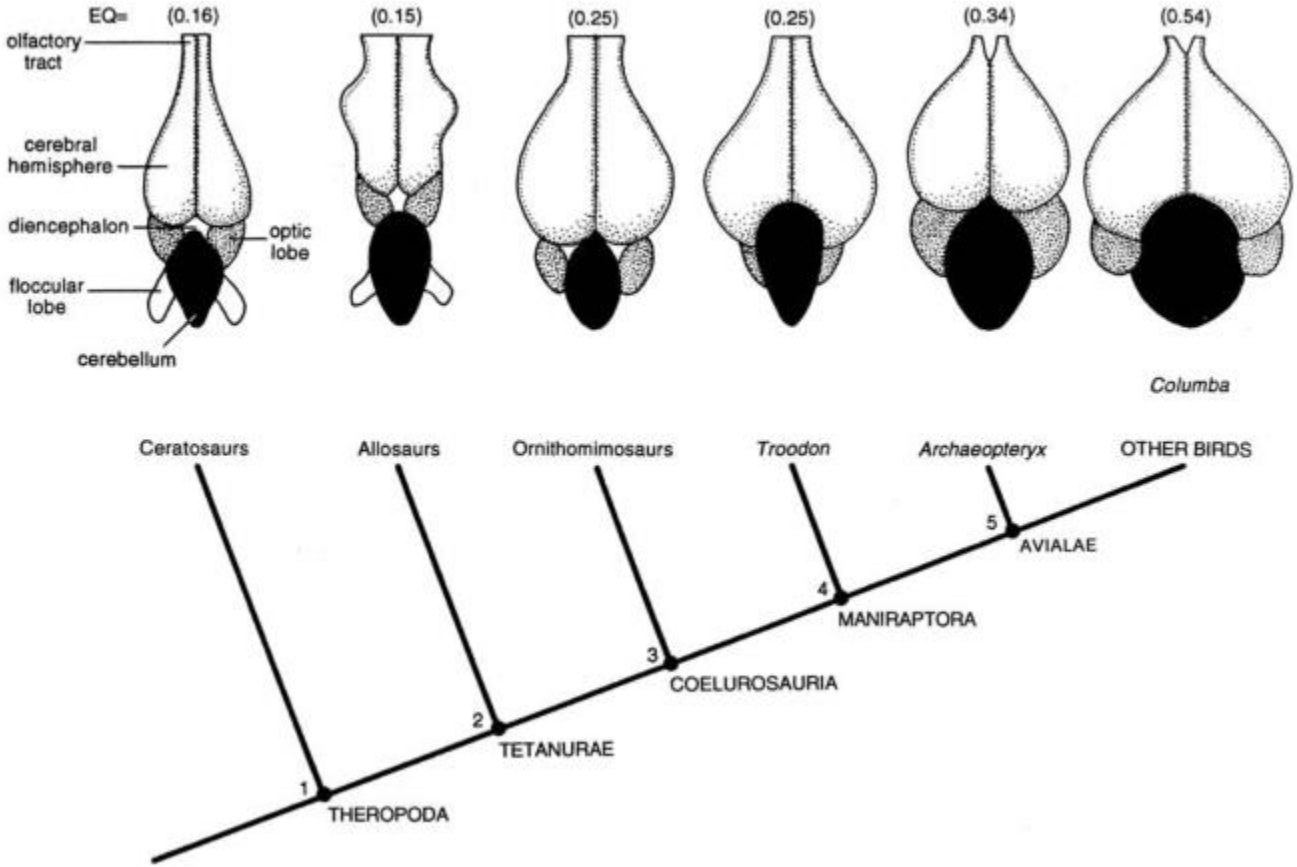


Feathered Deinonychus, Life History Museum ,Vienna

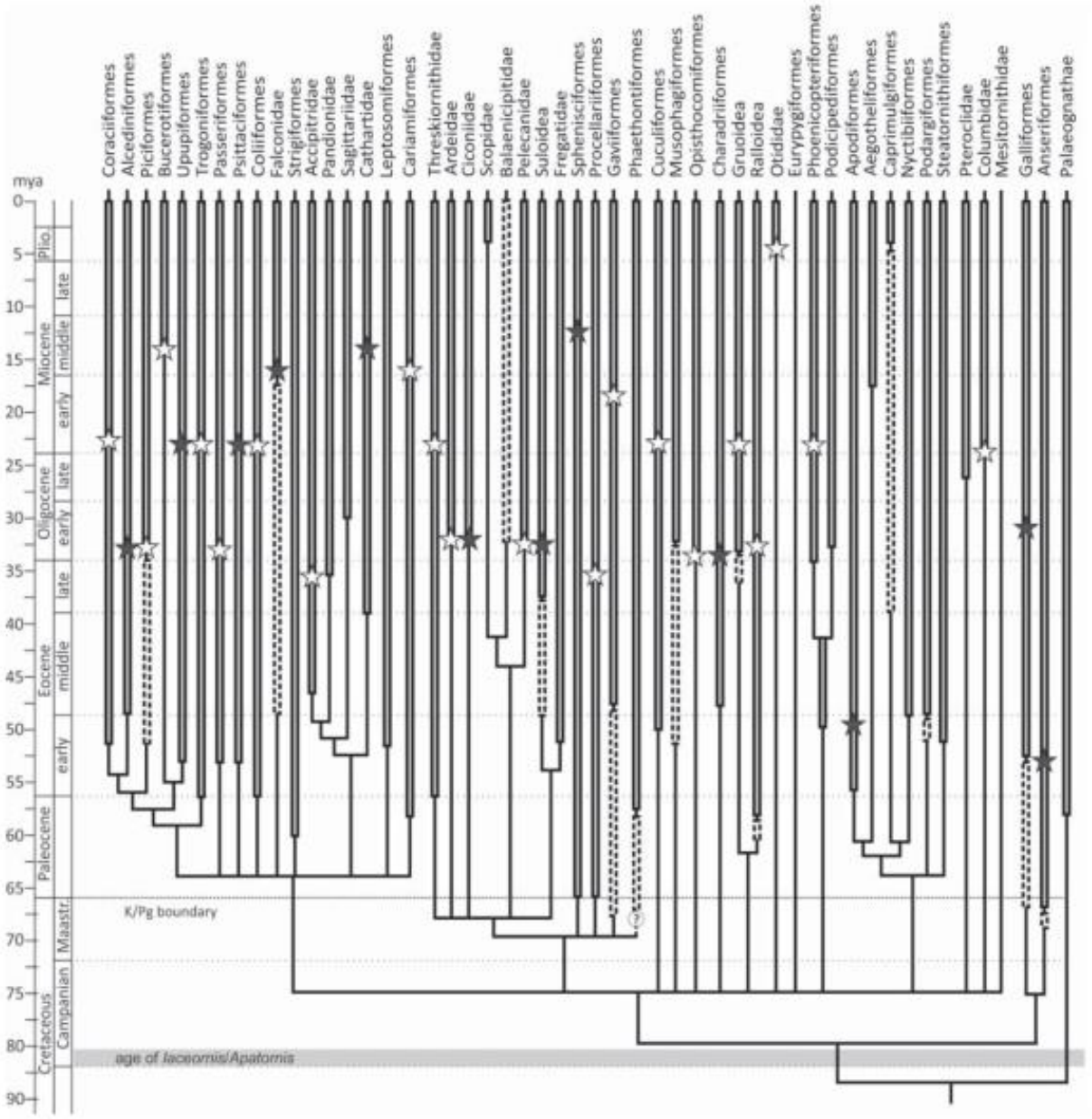
Confuciusornis




Feathered Dinosaurs



- Gradual enlargement of the brain in theropods, originally in the arboreal Coelurosauria which continued in Avialae and birds
- Adjustment to locomotion in three dimensions in the tree habitat
- In Avialae and birds the cerebral cortex gradually increases for balance and coordination, the optic lobes increase for optic acuteness and the olfactory bulbs on the other head are reduced showing less dependence from olfaction



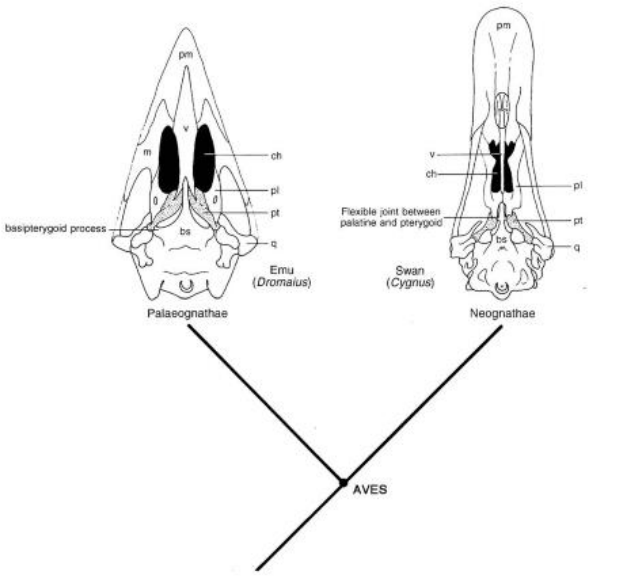


Figure 11.6. Cladogram showing the basal dichotomy of the Aves into Palaeognathae and Neognathae on the basis of palatal structure. Reduction of the vomer and basipterygoid process and development of the flexible joint between the pterygoid and the palatine are novelties for the neognaths. bs, basisphenoid; ch, choana; m, maxilla; pl, palatine; pm, premaxilla; pt, pterygoid; q, quadrate; v, vomer (after Chatterjee 1997)

Palaeognatha differ from Neognatha in the form of their palatal bones in the skull. They were separated 85 my

Aves

- Bird fossils are rarely preserved, thus the Cenozoic fossil archive is poor.
- During the Cenozoic significant adaptive radiation.
- Fossils are more easily preserved in the large flightless birds that some times are taller than 2 m. Some of them are, *Diatryma (*Eocene*), Aepyornis* (Pleistocene),

Andalgalornis

Diatryma

Late Eocene, Messel