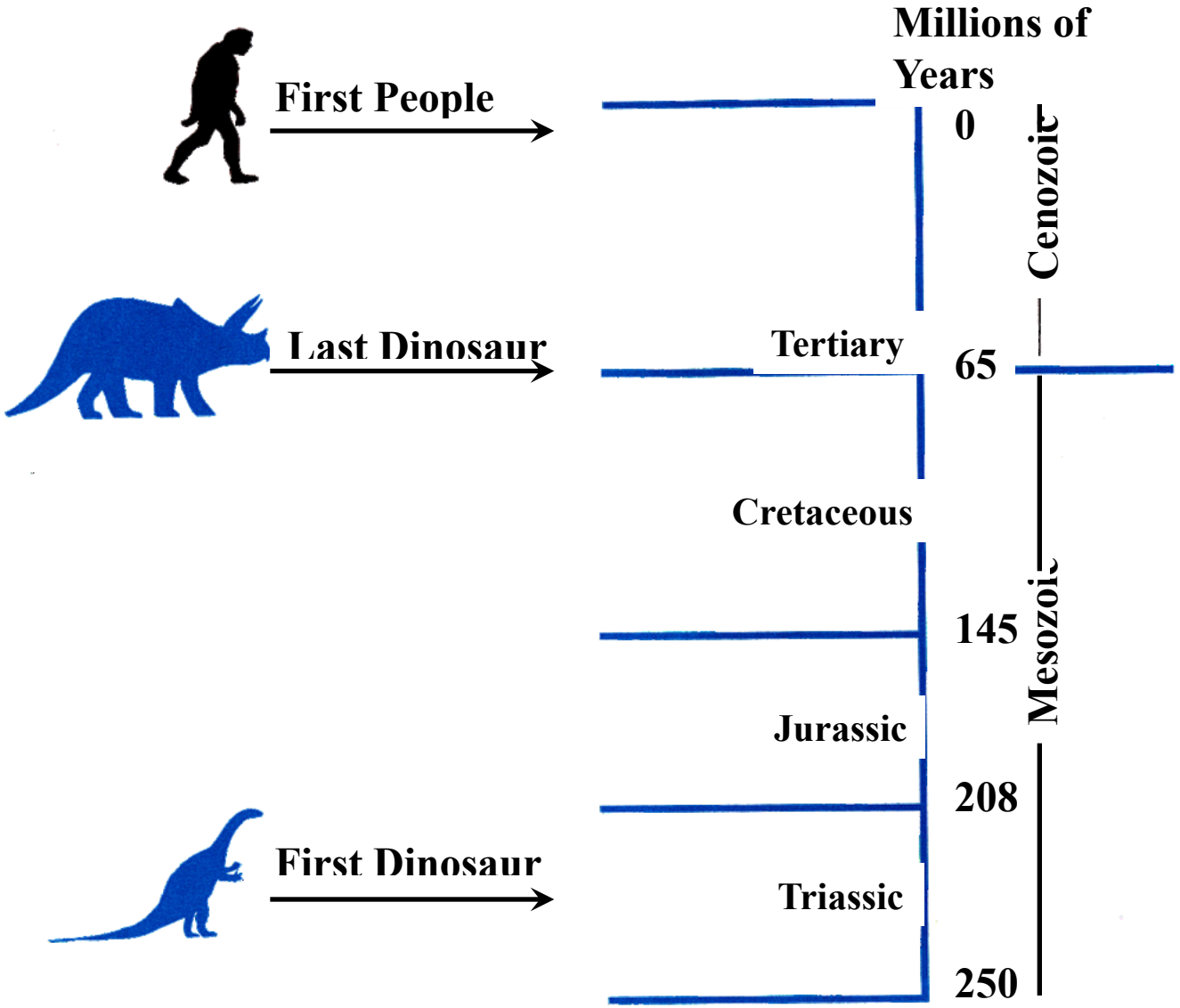
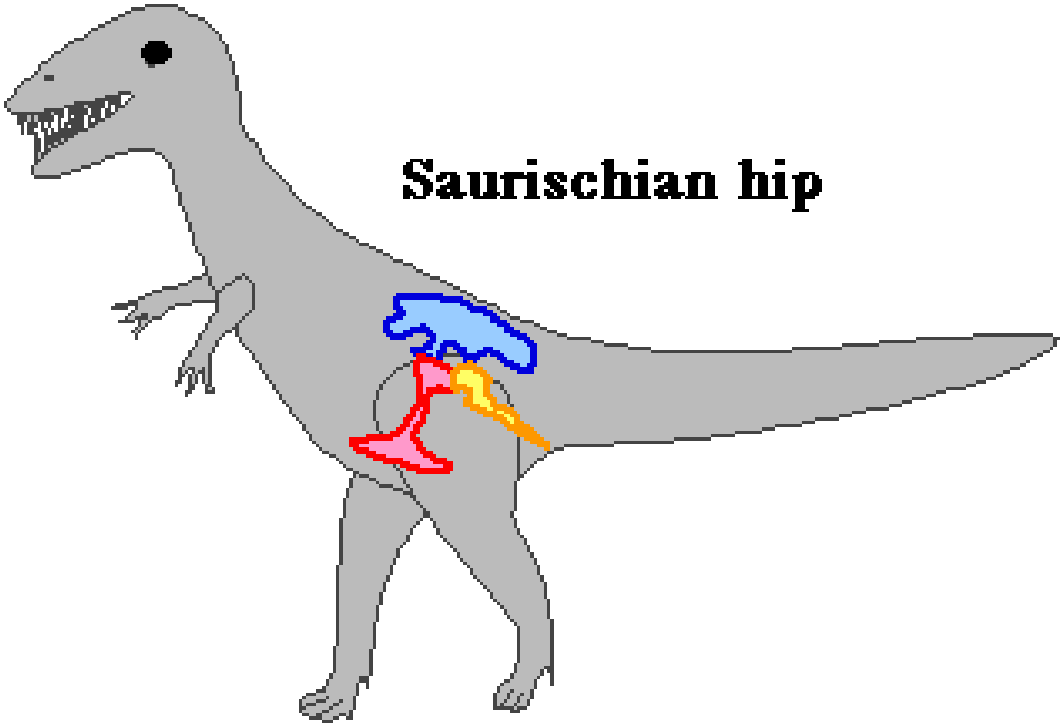
When did dinosaurs live?

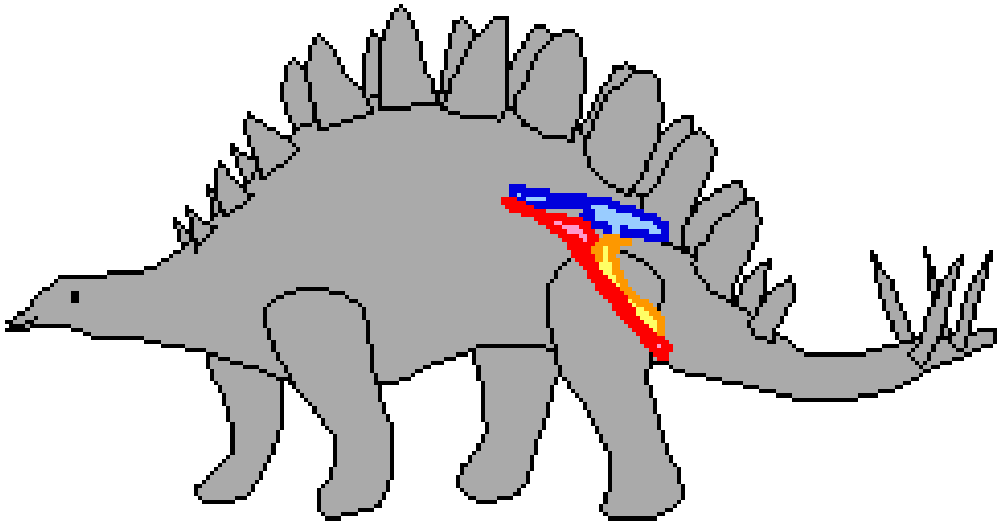


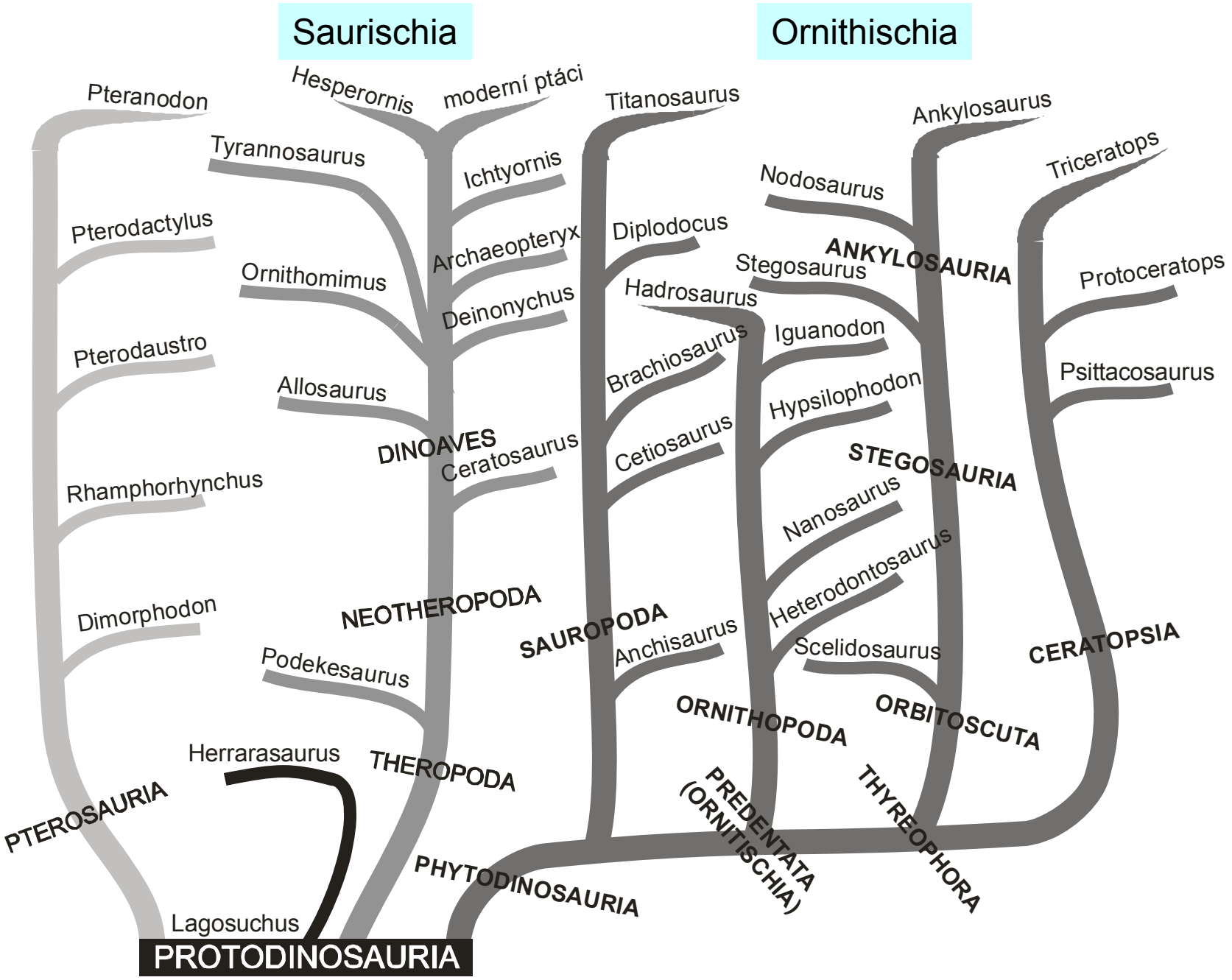
What are dinosaurs?

- Technically: no such thing as dinosaurs
- Classification:
  - Class – Reptilia (reptiles)
  - Order – Archosauria
  - Suborders
    - Saurrischia – lizard hips
    - Ornithischia – bird hips

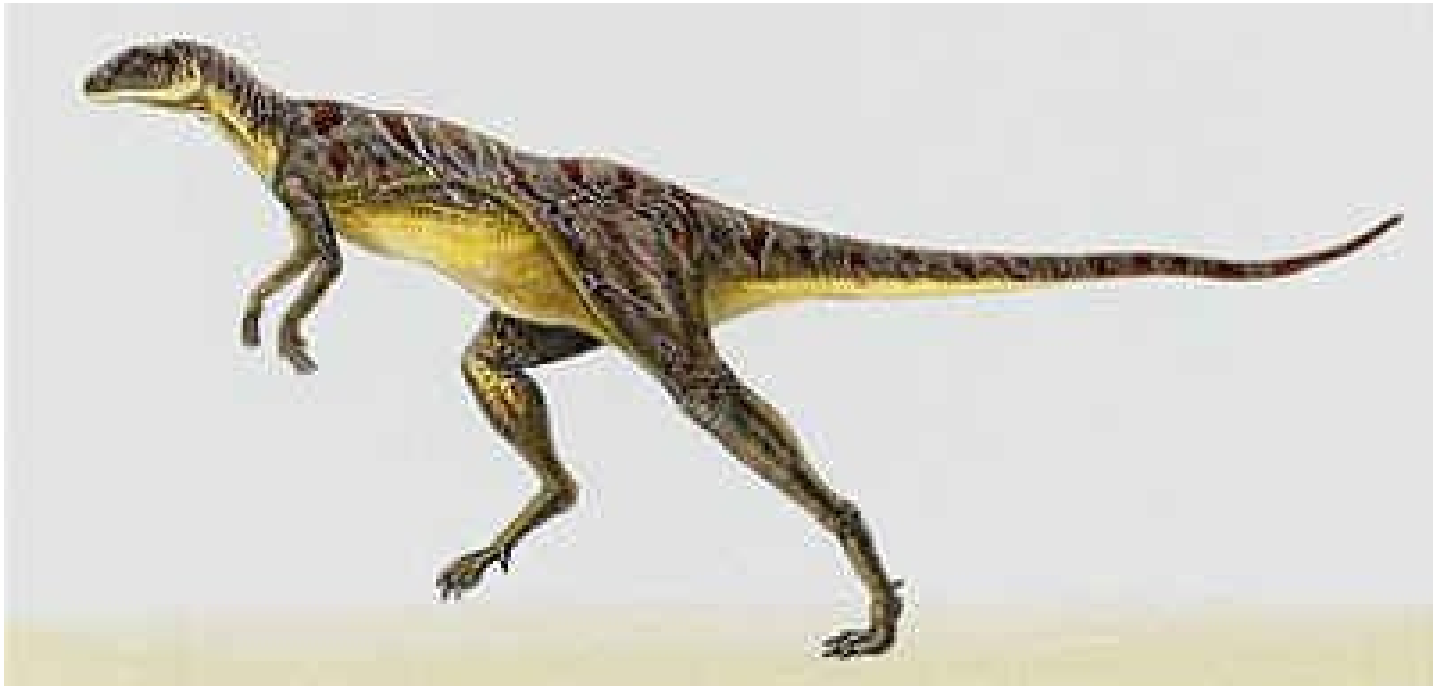
Dinosaurs in popular sense


Saurischian hip


Ornithischian hip


Saurischia
Ornithischia
Pteranodon
Hesperornis
moderní ptáci
Titanosaurus
Ankylosaurus
Tyrannosaurus
Ichtyornis
Nodosaurus
Triceratops
Pterodactylus
Archaeopteryx
Diplodocus
ANKYLOSAURIA
Stegosaurus
Ornithomimus
Deinonychus
Hadrosaurus
Protoceratops
Pterodaustro
Iguanodon
Brachiosaurus
Psittacosaurus
Allosaurus
Hypsilophodon
DINOAVES
Cetiosaurus
Ceratosaurus
STEGOSAURIA
Rhamphorhynchus
Nanosaurus
Heterodontosaurus
Dimorphodon
NEOTHEROPODA
SAUROPODA
Anchisaurus
Scelidosaurus
CERATOPSIA
Podekesaurus
ORNITHOPODA
ORBITOSCUTA
Herrarasaurus
THEROPODA
PREDENTATA (ORNITISCHIA)
THYREOPHORA
PTEROSAURIA
PHYTODINOSAURIA
Lagosuchus
PROTODINOSAURIA

Skupina dinosaurů se od svých **thekodontních** předků oddělila někdy ve středním triasu. První primiticní dinosauři jsou řazeni do skupiny **Protodinosauria**. jejich oddělení od thekodontních předků je podobně jako v případě therapsidů a savců velmi obtížné. Některými autory jsou dnes jsou mezi první dinosaury řazeni zástupci čeledi Lagosuchidae dříve považovaní za thecodonty. I když mají ještě některé archaické znaky thekodontů dominují podle nich rozhodující znaky dinosaurů. Za prvního dinosaura je jimi považovaný **Lagosuchus talampanyensis (235 Ma)**. Tento 40-50 cm velký rychlý, vytrvalý běžec se pohyboval po zadních nohách. lovil hmyz a savce, přepadal i mláďata thekodontů. Jiní autoří za prvního dinosaura ale považují až zástupce rodu **Eoraptor a Herrerasaurus**, který se objevil až o něco později (232 Ma). Postupně se objevují i čím dál větší formy protodinosaurů reprezentování zástupci čeledi Herrerasauridae. Největší z nich Aliwalia rex dosáhla ve svrchním triasu velikosti 12 m. Ve svrchním triasu se od protodinosaurů odštěpili 3 větve - **Pterosauria** čili ptakoještěři, **Theropoda** reprezentující dravé formy dinosaurů a **Phytodinosauria** representující býložravé formy dinosaurů.

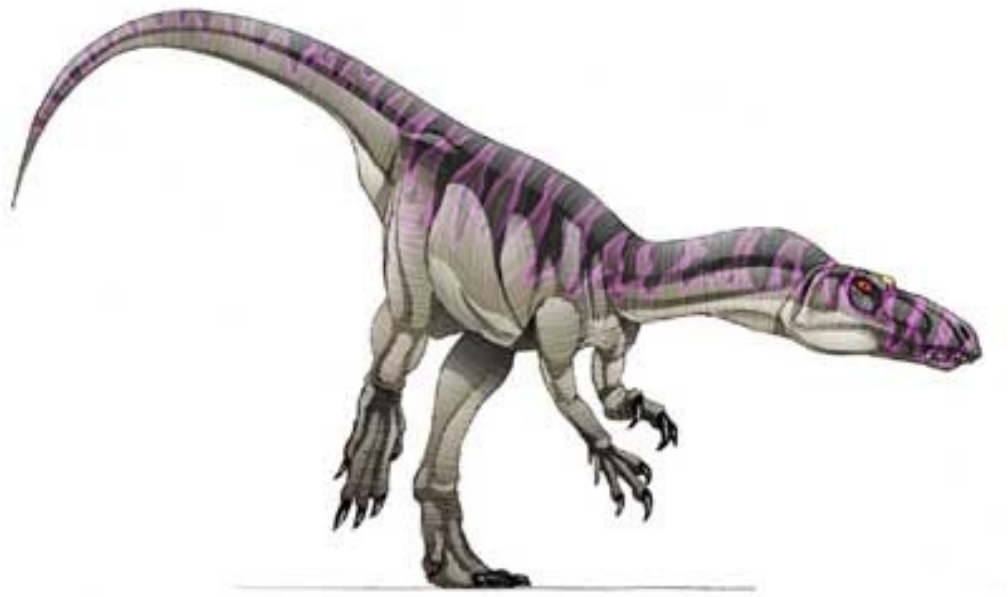


Lagosuchus talampanyensis

Eoraptor

A very early dinosaur, about the size of a cat.

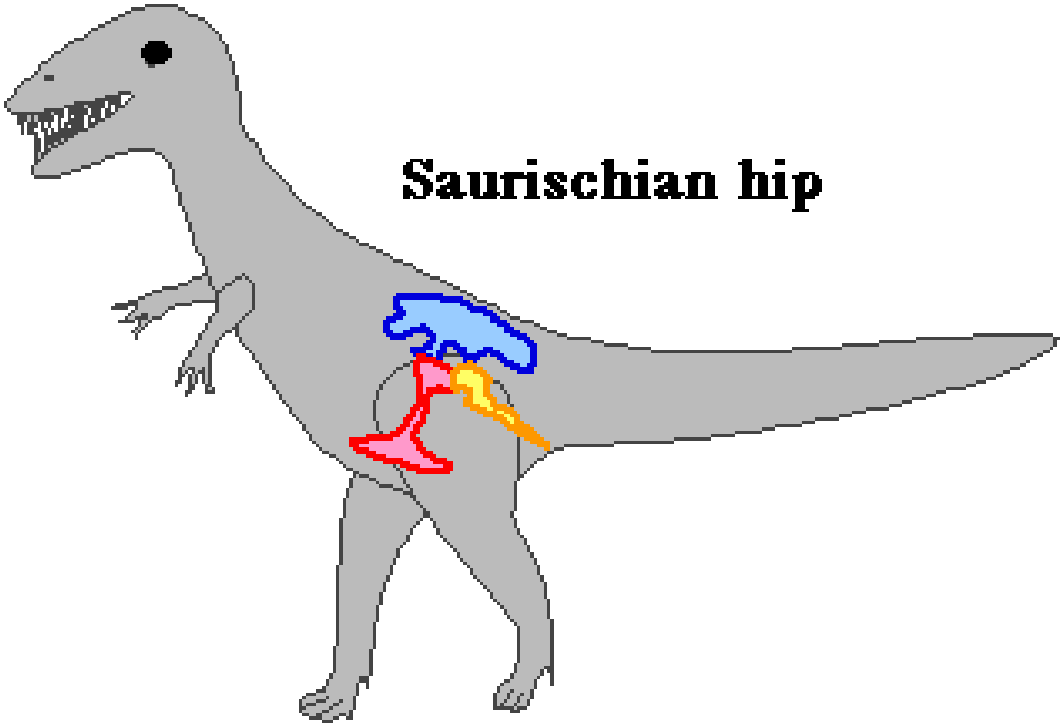
It is believed that **Herrerasaurus** was one of the earliest dinosaurs. Its body shape suggests that this dinosaur was a very fast hunter, and that it could turn quickly from side to side.

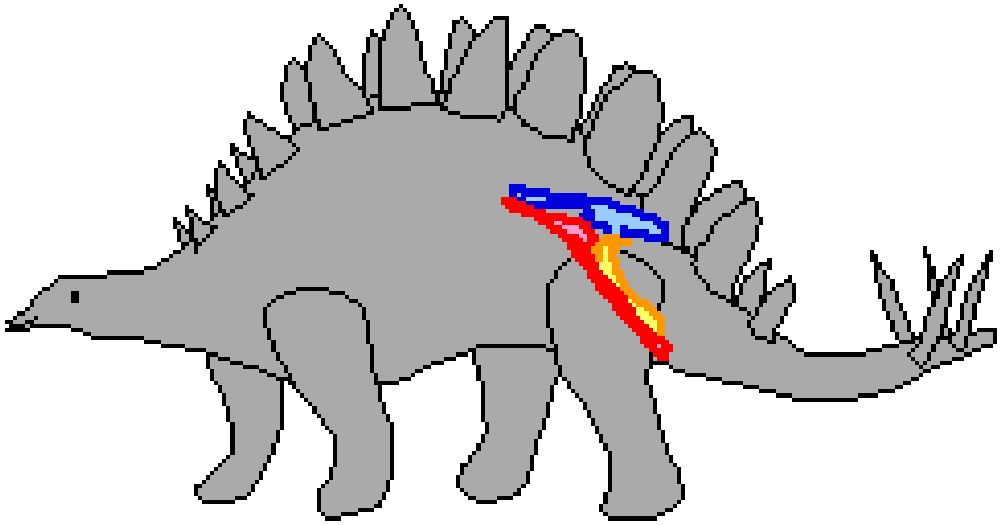


Aliwalia rex
Length: 38 ft. (12 m)
Height: 12 ft. (3.5 m)
Weight: 1.5 tons (1,400 kg)
Time: Late Triassic - 220 MYA
Location: Africa

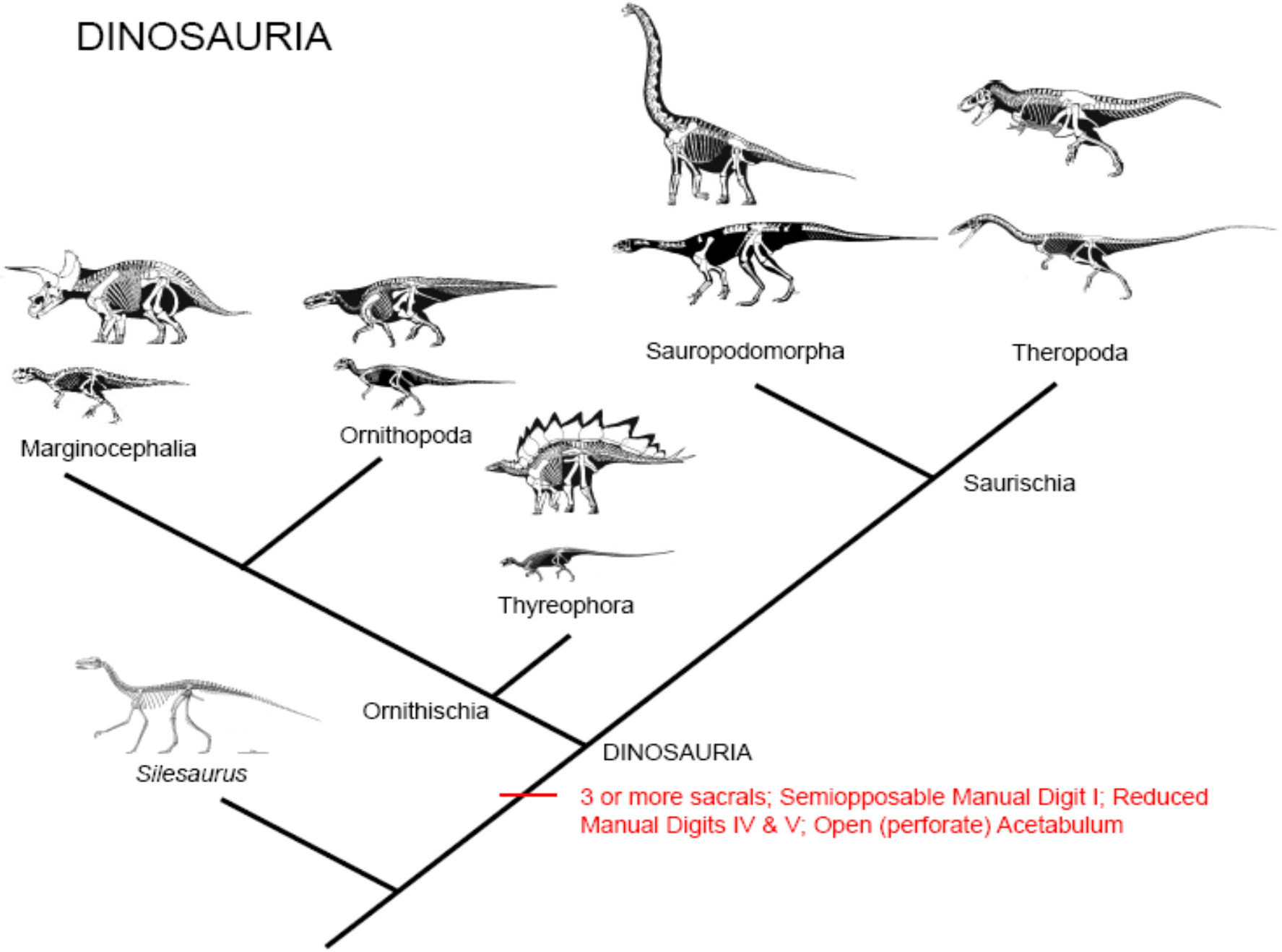
Order Saurischia

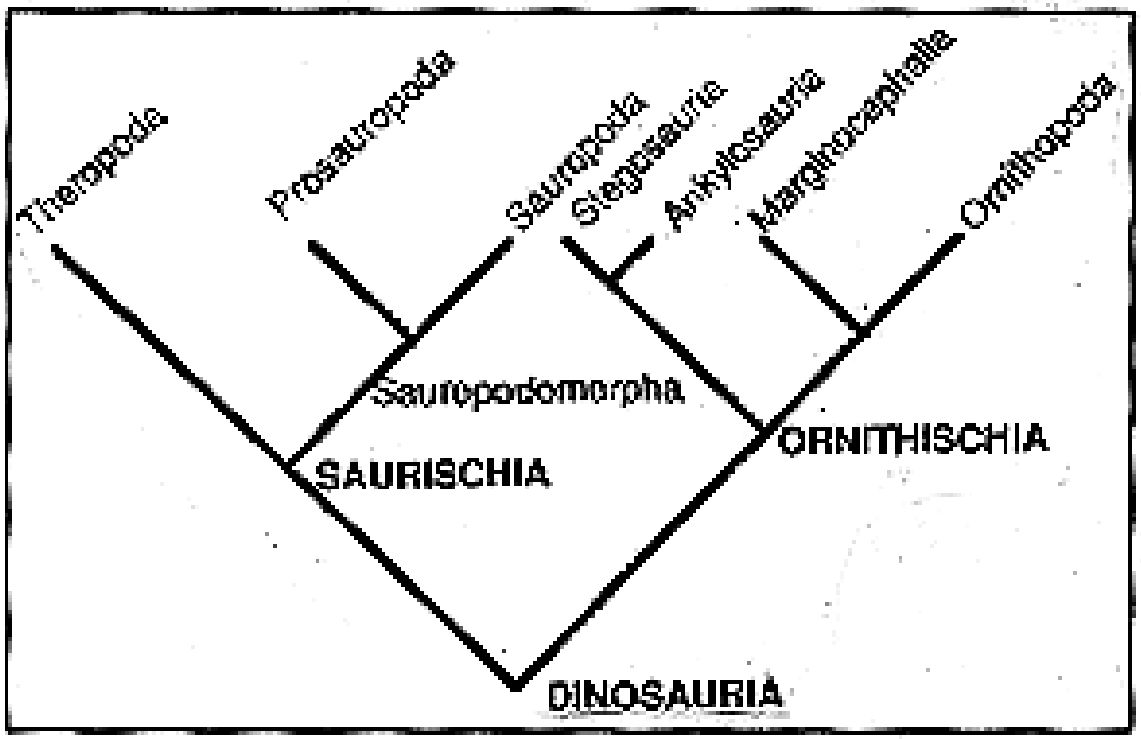
- Characterized by 3 part hip structure similar to that of lizards

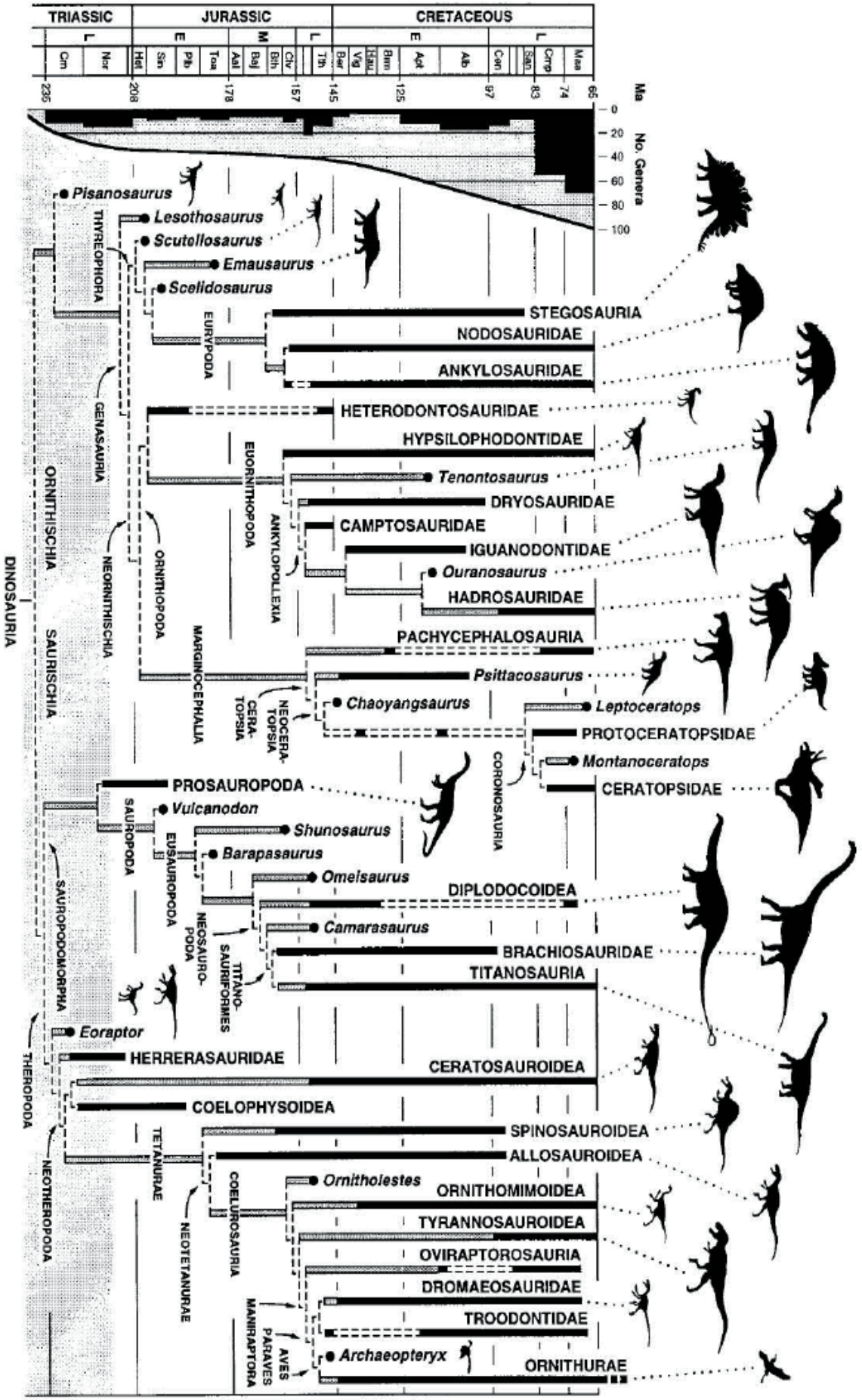

Saurischian hip


Ornithischian hip

DINOSAURIA


Sauropodomorpha
Theropoda
Marginocephalia
Ornithopoda
Saurischia
Thyreophora
Ornithischia
Silesaurus
DINOSAURIA
3 or more sacrals; Semiopposable Manual Digit I; Reduced Manual Digits IV & V; Open (perforate) Acetabulum


Theropoda
Prosauropoda
Sauropoda
Stegosauria
Ankylosauria
Marginocephalia
Ornithopoda
Sauropodomorpha
SAURISCHIA
ORNITHISCHIA
DINOSAURIA


TRIASSIC
JURASSIC
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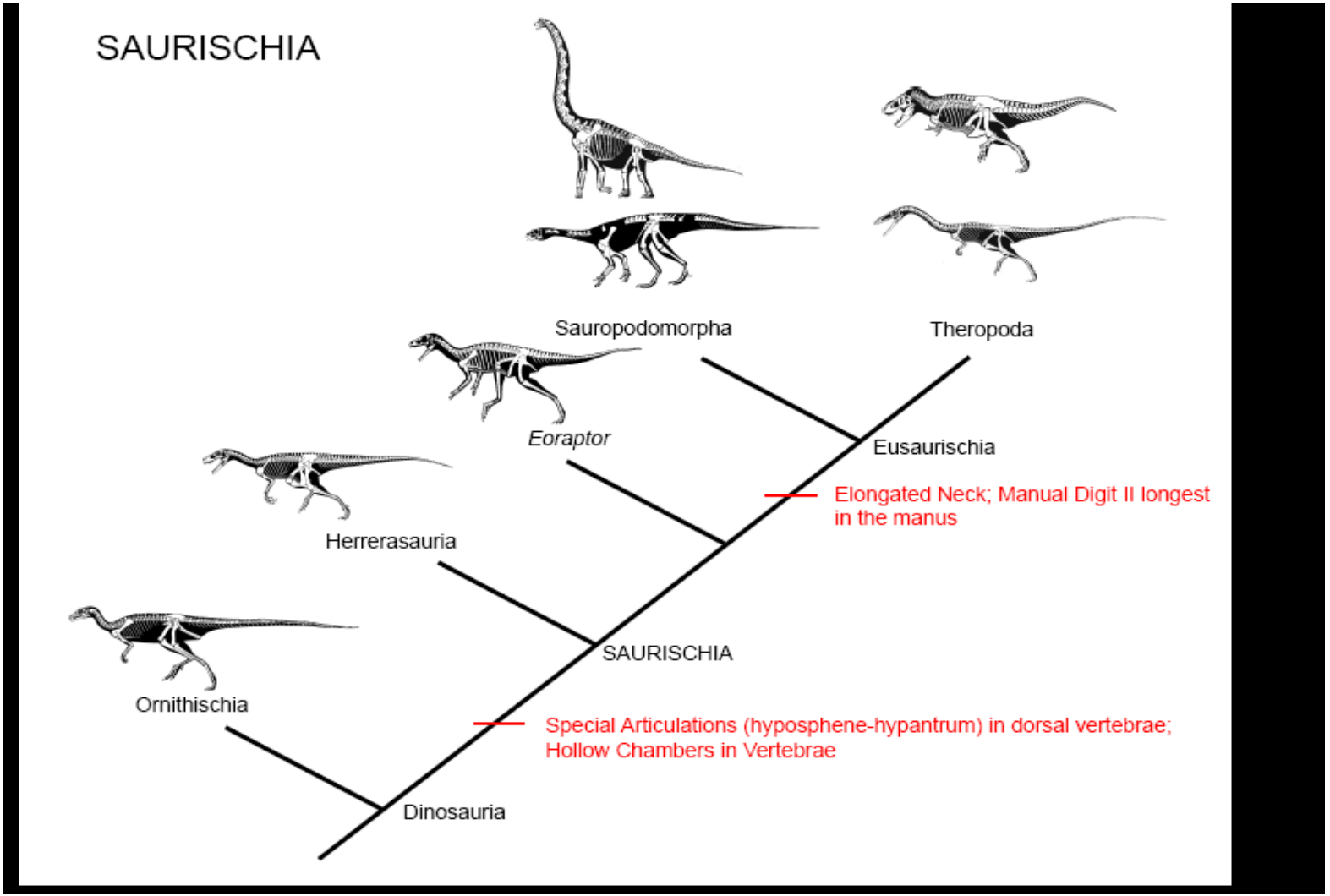
Camp
Maa
235
208
178
157
145
125
97
83
74
65
Ma
No. Genera
0
20
40
60
80
100
Pisanosaurus
Lesothosaurus
Scutellosaurus
Emausaurus
Scelidosaurus
THYREOPHORA
STEGOSAURIA
NODOSAURIDAE
ANKYLOSAURIDAE
EURYPODA
GENASAURIA
HETERODONTOSAURIDAE
HYPSILOPHODONTIDAE
Tenontosaurus
DRYOSAURIDAE
CAMPTOSAURIDAE
IGUANODONTIDAE
Ouranosaurus
HADROSAURIDAE
EUORNITHOPODA
ANKYLOPOLLEXIA
ORNITHOPODA
NEORNITHISCHIA
ORNITHISCHIA
PACHYCEPHALOSAURIA
Psittacosaurus
Chaoyangsaurus
Leptoceratops
PROTOCERATOPSIDAE
Montanoceratops
CERATOPSIDAE
MARGINOCEPHALIA
CERA-TOPSIA
NEOCERA-TOPSIA
CORONOSAURIA
DINOSAURIA
PROSAUROPODA
Vulcanodon
Shunosaurus
Barapasaurus
Omeisaurus
DIPLODOCOIDEA
Camarasaurus
BRACHIOSAURIDAE
TITANOSAURIA
SAURISCHIA
SAUROPODA
EUSAUROPODA
NEOSAURO-PODA
TITANO-SAURIFORMES
SAUROPODOMORPHA
Eoraptor
HERRERASAURIDAE
CERATOSAUROIDEA
COELOPHYSOIDEA
SPINOSAUROIDEA
ALLOSAUROIDEA
THEROPODA
TETANURAE
NEOTHEROPODA
Ornitholestes
ORNITHOMIMOIDEA
TYRANNOSAUROIDEA
OVIRAPTOROSAURIA
DROMAEOSAURIDAE
TROODONTIDAE
COELUROSAURIA
NEOTETANURAE
MANIRAPTORA
PARAVES
AVES
Archaeopteryx
ORNITHURAE

Další velkou skupinou dinosaurů, která se od ostatních skupin výrazně lišila stavbou pánve jsou **Ornithischia**, čili ptakopánevní dinosauři. Zatímco prosauropodi a theropodi měli stavbu pánve podobnou svým plazím předkům u ptakopánevních došlo k stočení stydké kosti dozadu. Byl to nutný vývoj, protože předchůdci ptakopánevních dinosaurů se pohybovali po dvou a tato změna umožnila vytvoření nového střevního prostoru. Značný střevní prostor byl vzhledem k nedokonalému zpracování potravy v čelistech nutností u všech býložravých forem.

Order Saurischia

Characterized by 3 part hip structure similar to that of lizards



Who were the Theropods

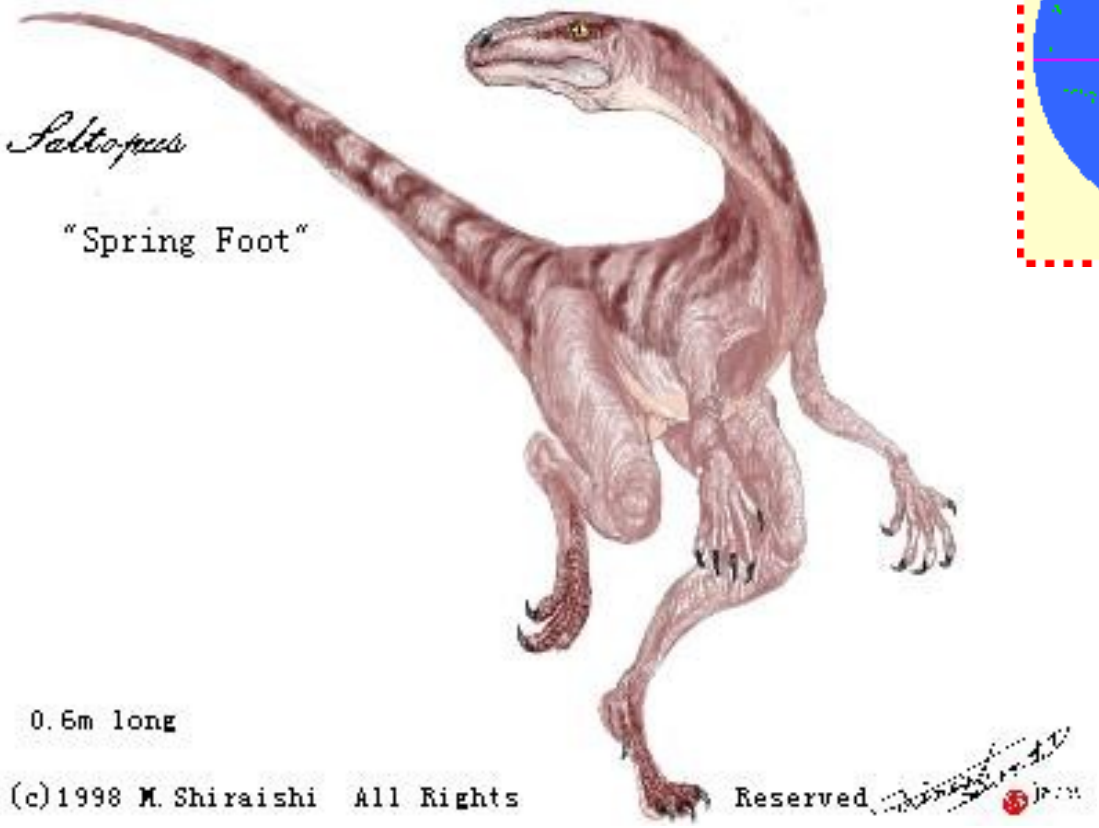
Theropoda
Rozdìlení Theropodů na **Carnosauria** a **Celurosauria** je umělé, podobně jako bychom rozdělili velké dravé savce do jedné skupiny a malé do druhé skupiny. Ukazuje se, že malé jurské formy mìly bližší vztahy k velkým jurským theropodùm než k malým křídovým formám, které naopak mìly blíže k tyranosaurùm.

Velcí masožraví **Carnosauria**, kteří se objevili v juře do křídy přežívají jen vzácně. Většina z nich měla shodnou stavbu těla - pohyb po zadních nohách, velká lebka s prostorem pro objemnou ústní dutinu. Velké ostře špičaté zuby - každý z nich byl na přední a zadní straně opatřen pilovitým ostřím. Velkoui hlavu vyvažoval svalnatý ocas.

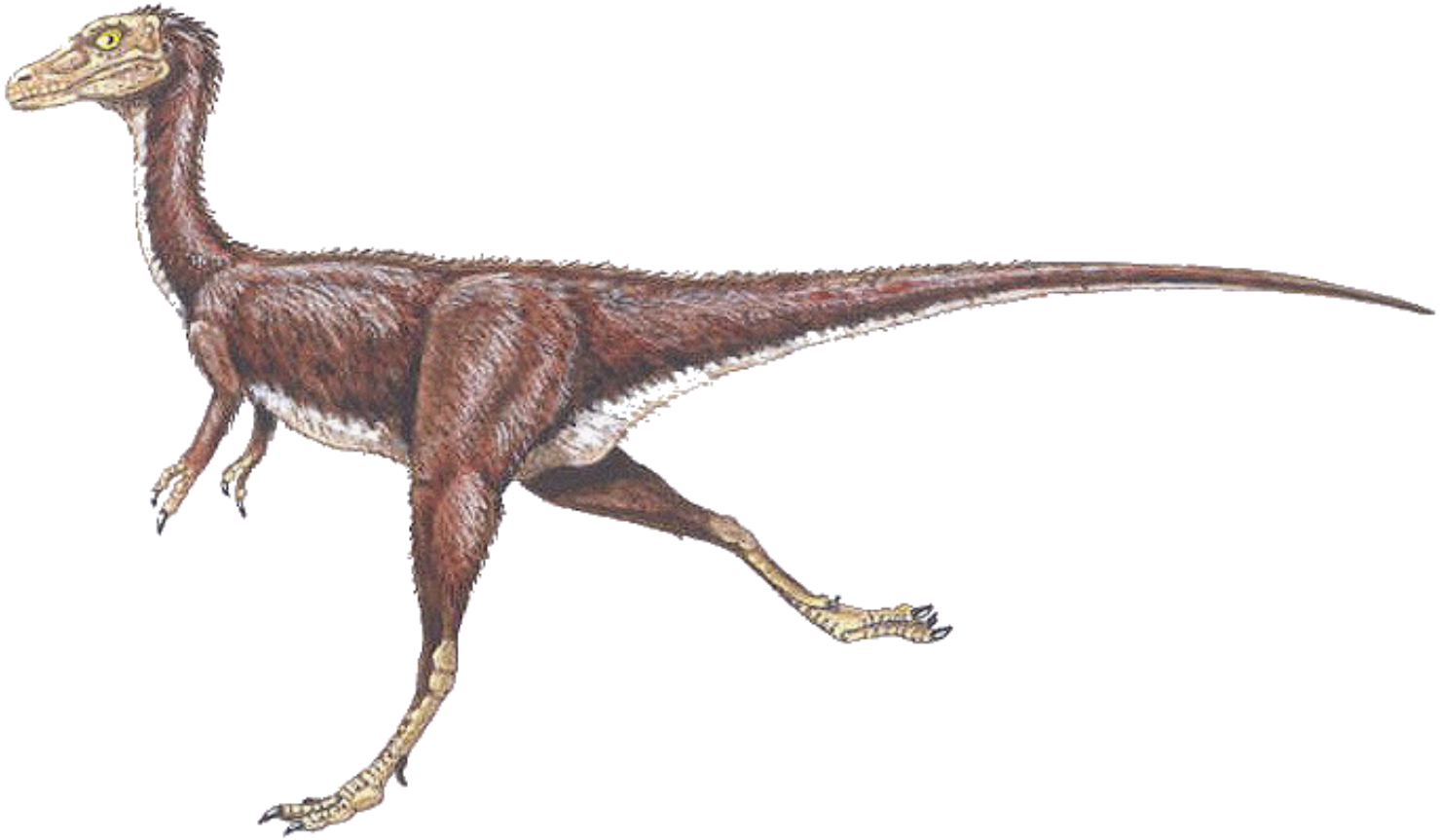
Earliest forms of Coelurosauria of Triassic

Coelophysis was a small (about 1 m), compact dinosaur that lived about 210 million years ago. It was a quick and agile hunter that had hollow bones and a hole-ridden skull, which helped to reduce its weight and increase its speed. Some fossils have been found with other small Coelophysis bones inside, and at first, it was thought that Coelophysis might have given birth to live young. It is now believed, however, that it was probably a cannibal that occasionally devoured its own young.

Typical Coelurosauria: Saltopus



Svrch trias-spodní Jura,



Compsognathus longipes - with feathers
Weight:6 pounds (3 kilos) Length:3 feet (1 m) Late Jurassic 155 - 145 MYA Where found: Bavaria, Germany

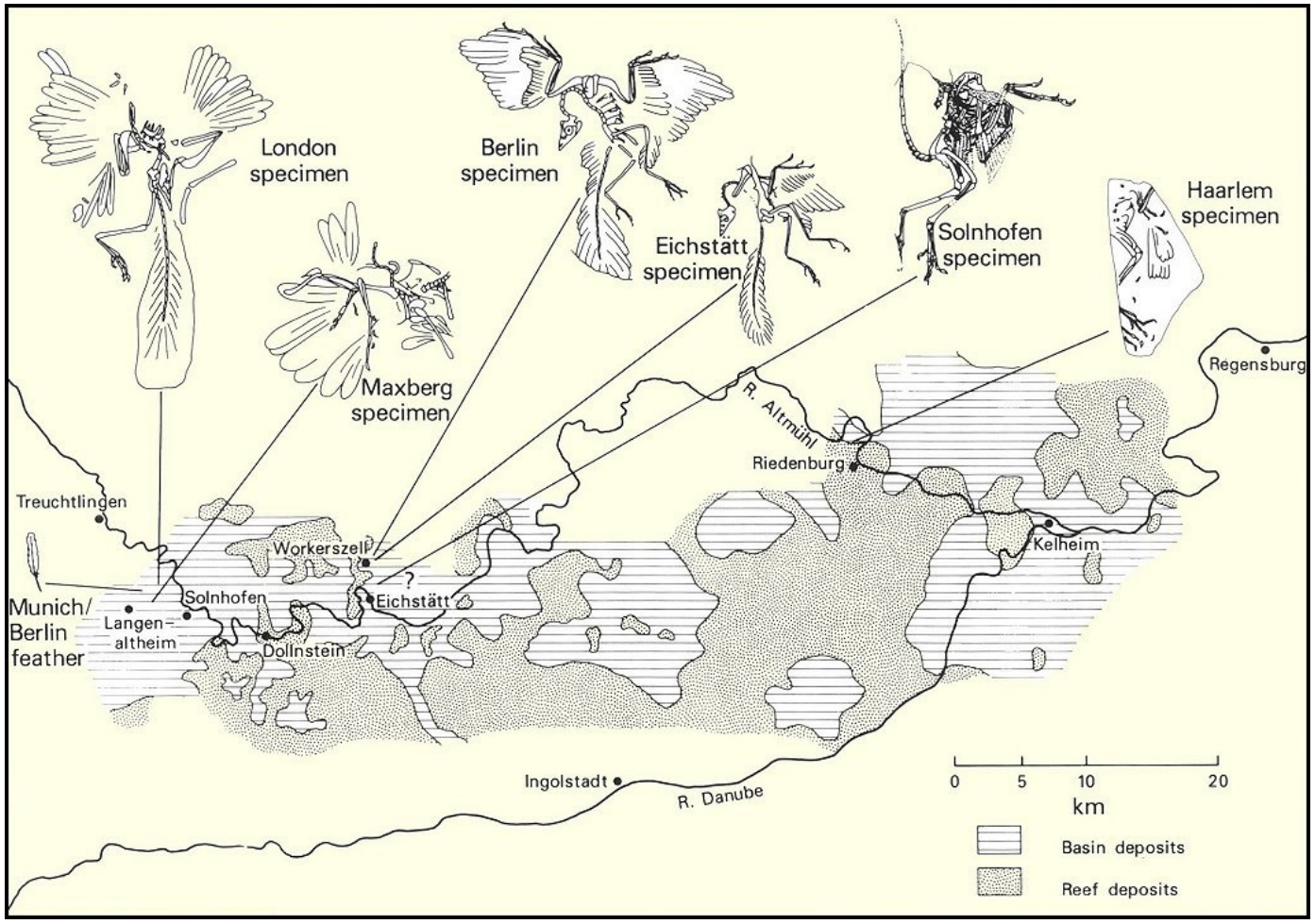
Archaeopteryx

Fossil

Maybe…?

Where are Archaeopteryx found?

Mostly in Germany



Cretaceous Coelurosaurs

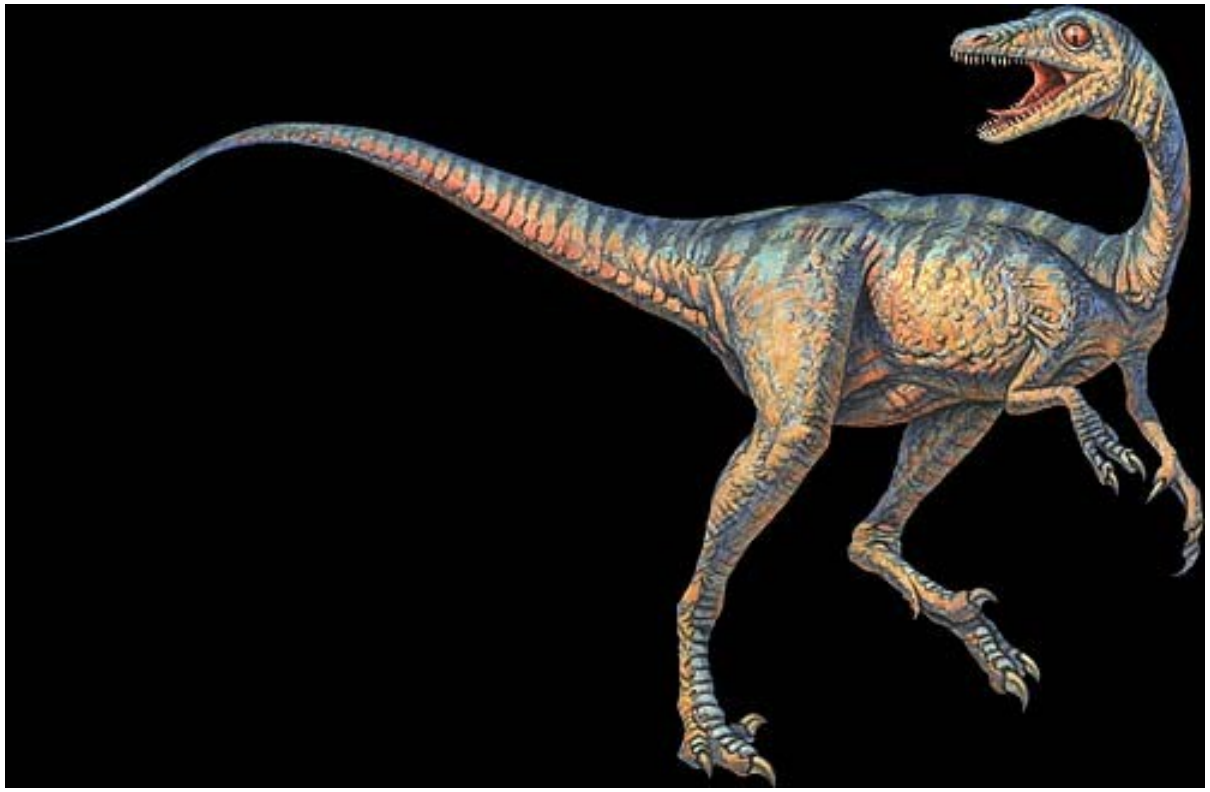
- Some species became very specialized

Velociraptor (Jurassic Park)

Deinonychus

Or?

Deinonychus 3-4 m, stř. křída



Genus Name: **Troodon**
("wounding tooth")
Type Species: * *T. formosus*
(Leidy, 1856)
Length: 2 meters
Weight: 100-125 pounds
Time: Late Cretaceous
Place:
Canada, Mexico, United States,
Tadzhikistan,

Uzbekistan
Diet: meat-eater (carnivore

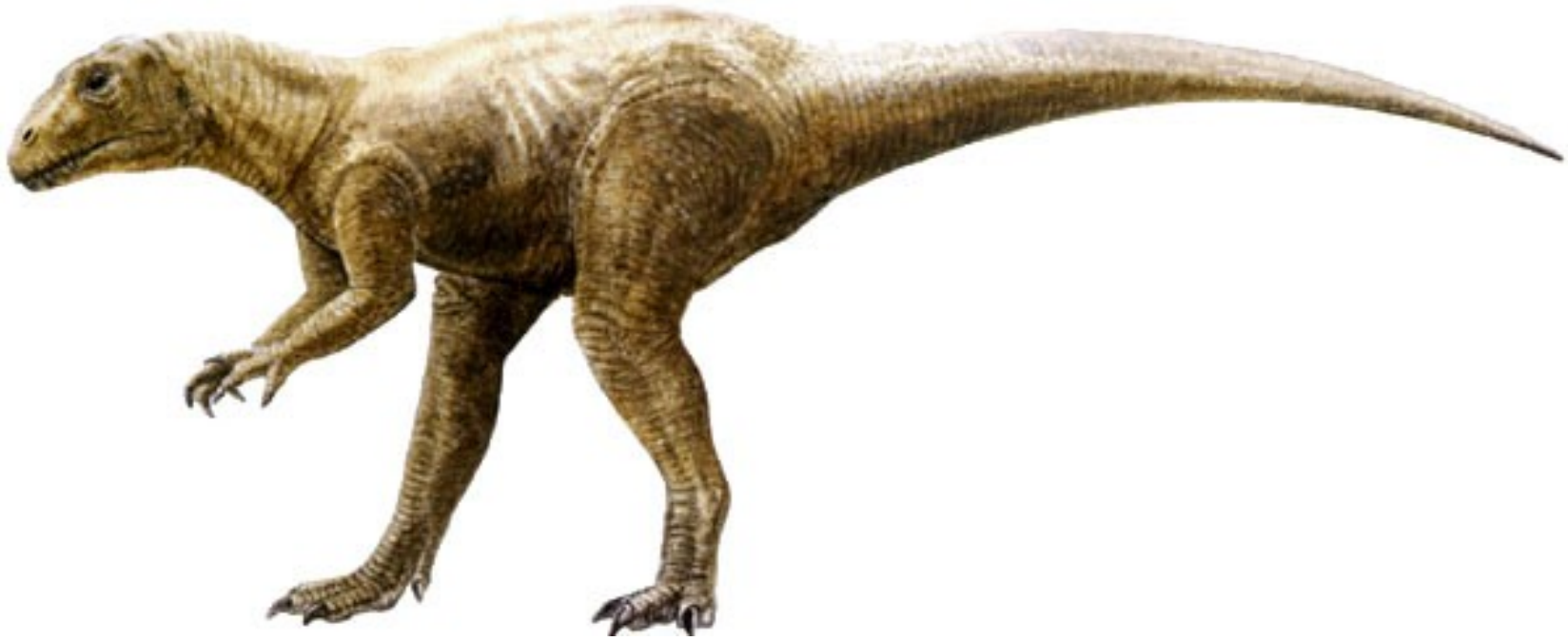
Troodon was a small but deadly hunter. Unlike most dinosaurs, its big eyes faced partly forward, probably giving Troodon the same kind of binocular vision used by modern predators like cats. Opposable fingers enabled it to grasp its prey, something few other dinosaurs could do. The second toe on each foot had a large slashing claw like those carried by raptors. Finally, the ratio of its brain weight to its body weight was greater than that of almost any other dinosaur.

2nd Theropod Group

- Flesh-like spectacular forms
- Famous because of their starring role in Japanese movies

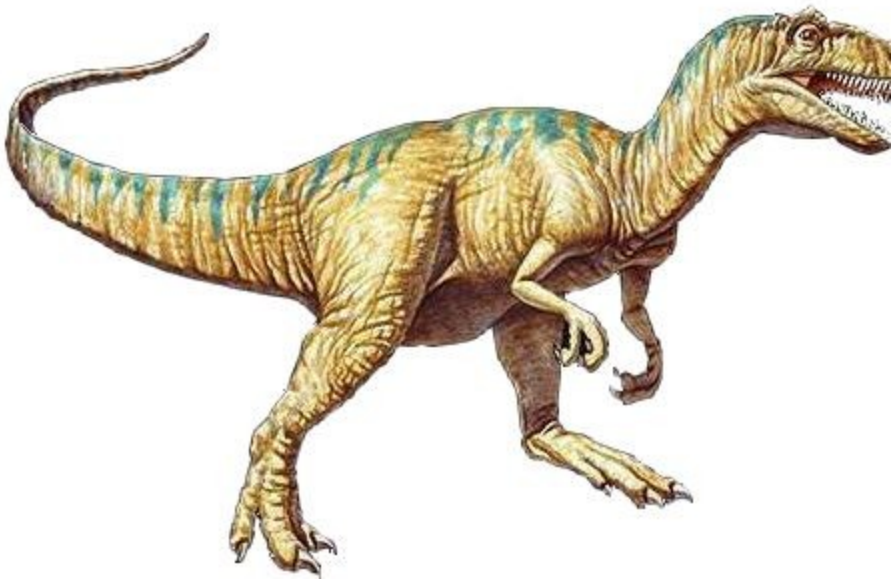
Teratosaurus

Earliest species – Triassic, 6 m

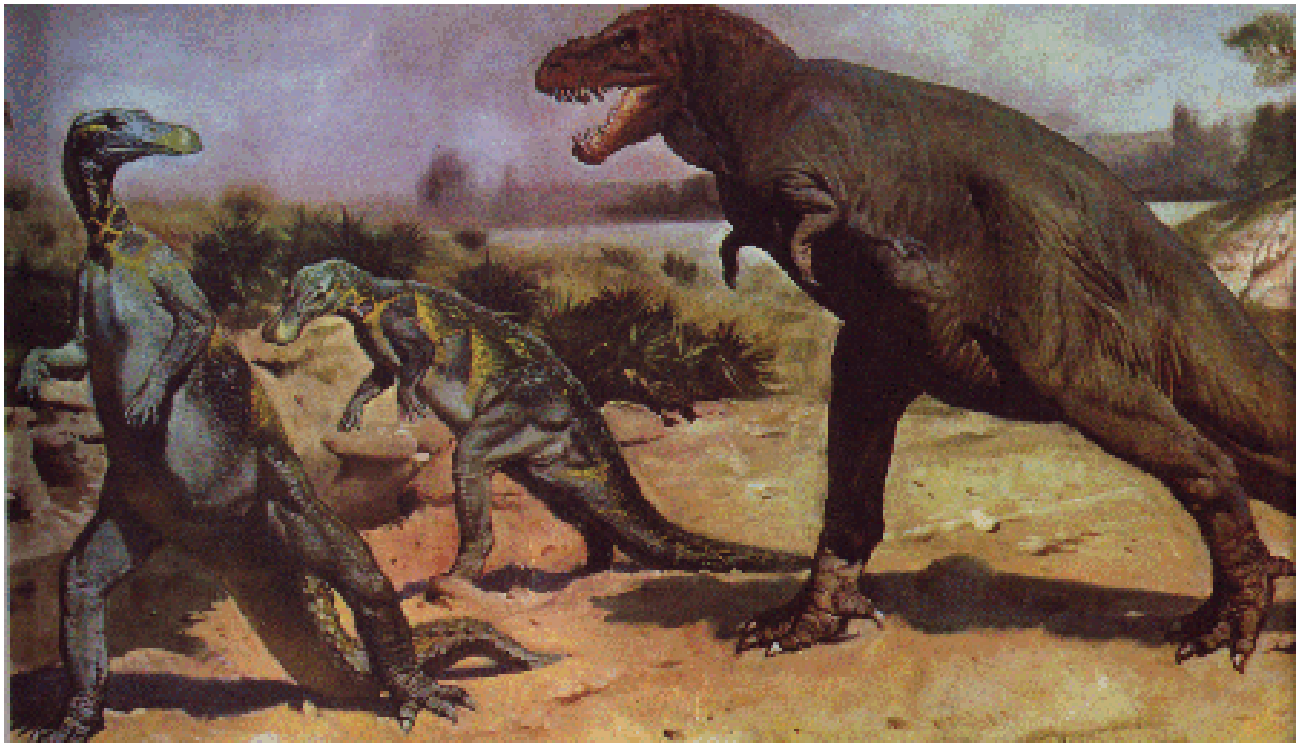


Teratosaurs

Allosaurus was a powerful predator that walked on two powerful legs, had a massive tail, a bulky body, and heavy bones. Its arms were short and had three-fingered hands with sharp claws that were up to 6 inches (15 cm) long. Allosaurus was up to 38 feet long (12 m) and 16.5 feet tall (5 m). It weighed about 1400 kg. An Apatosaurus vertebrae was found with Allosaurus tooth marks etched into it, evidence of an ancient Allosaurus attack. Allosaurus was a very common, and was the biggest meat-eater in North America during the late Jurassic period. It may have faced competition from the meat-eating Ceratosaurus.

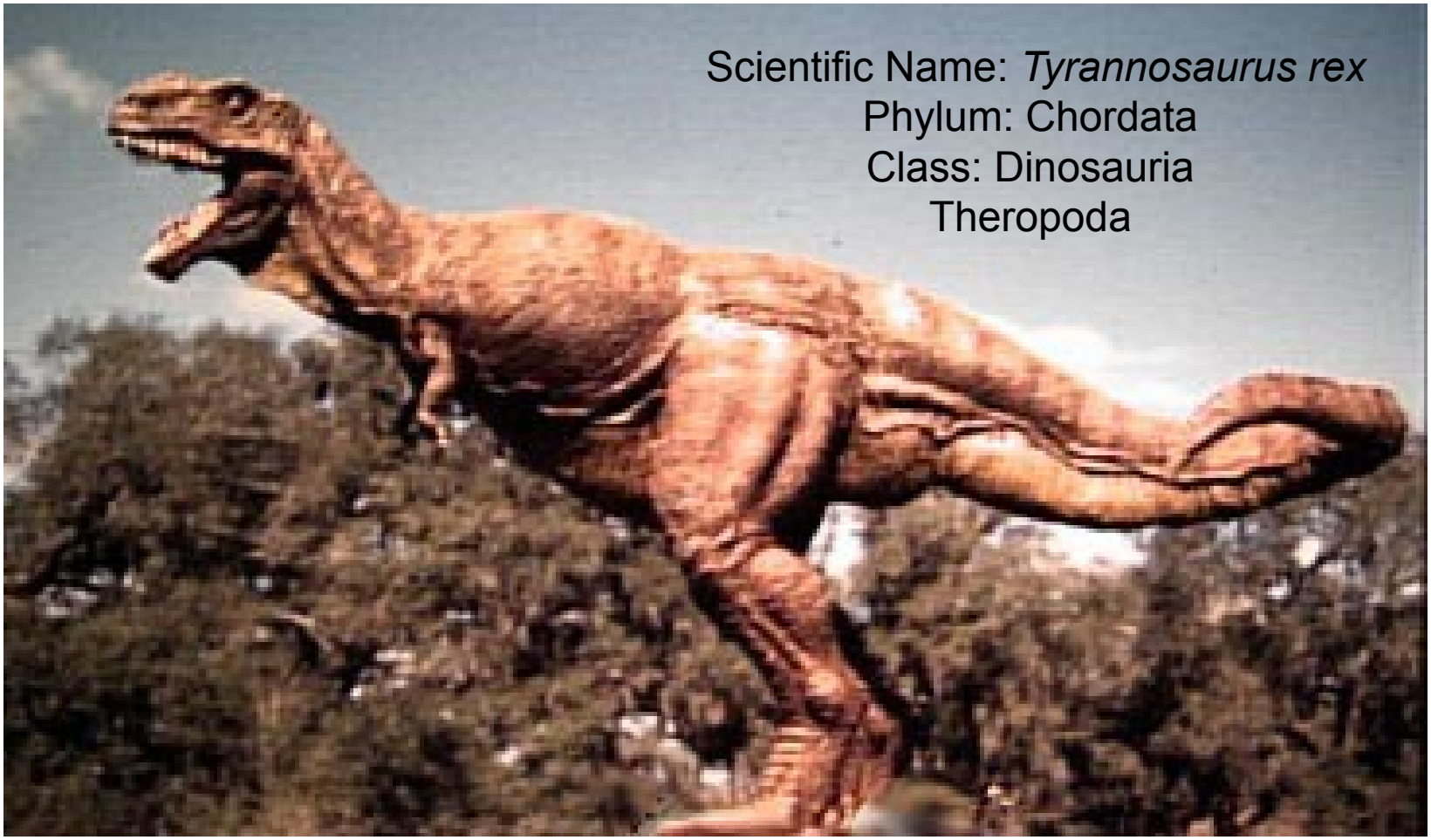


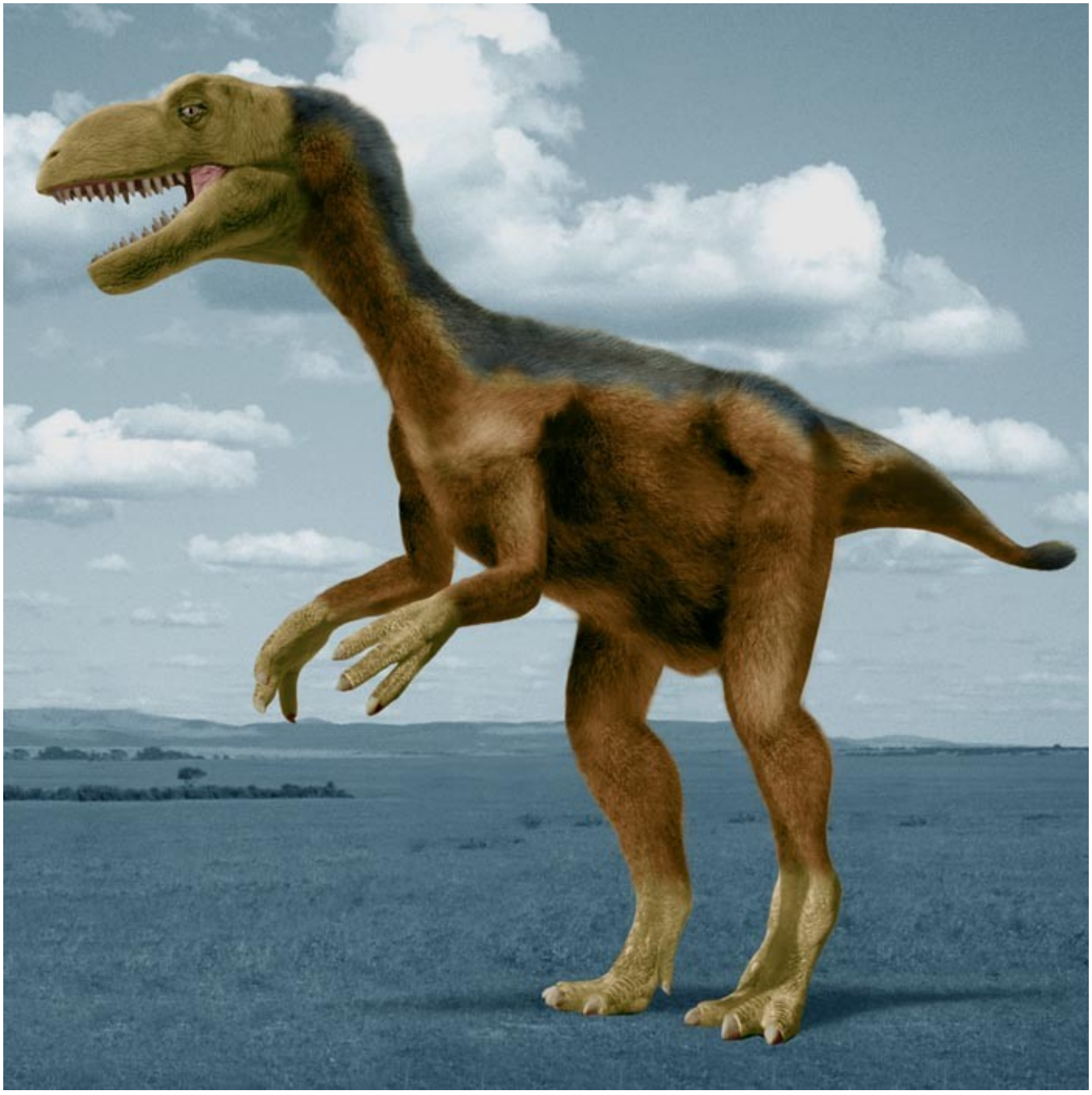
Tyrannosaurides (T-Rex)



The **Tyranosaurus Rex** ("tyran lizard"), who try to attack, here, a **Trachodon** ("duck beak"), was one of the biggest bipeds having ever existed : its length was about 12 meters and its height about 5 meters. His teeth in forms of knives helped him to cut up the fleshes. The **Trachodon**, although of a similar size, was without defence against this kind of ennemy : his alone hope must be water where he could swim. The **Trachodon** had a long skull and a flat muzzle.

And T-Rex

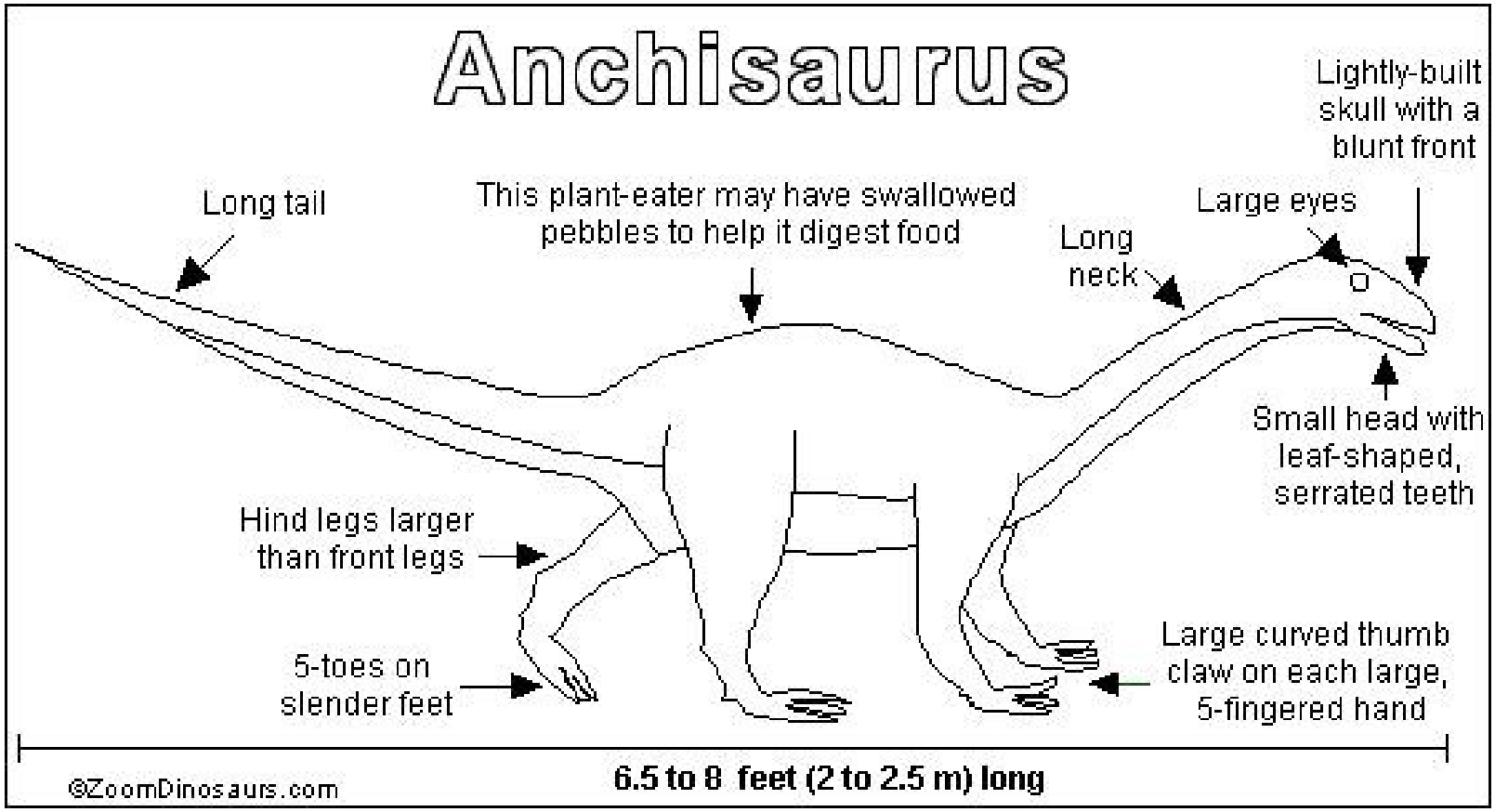

Scientific Name: *Tyrannosaurus rex*
Phylum: Chordata
Class: Dinosauria
Theropoda



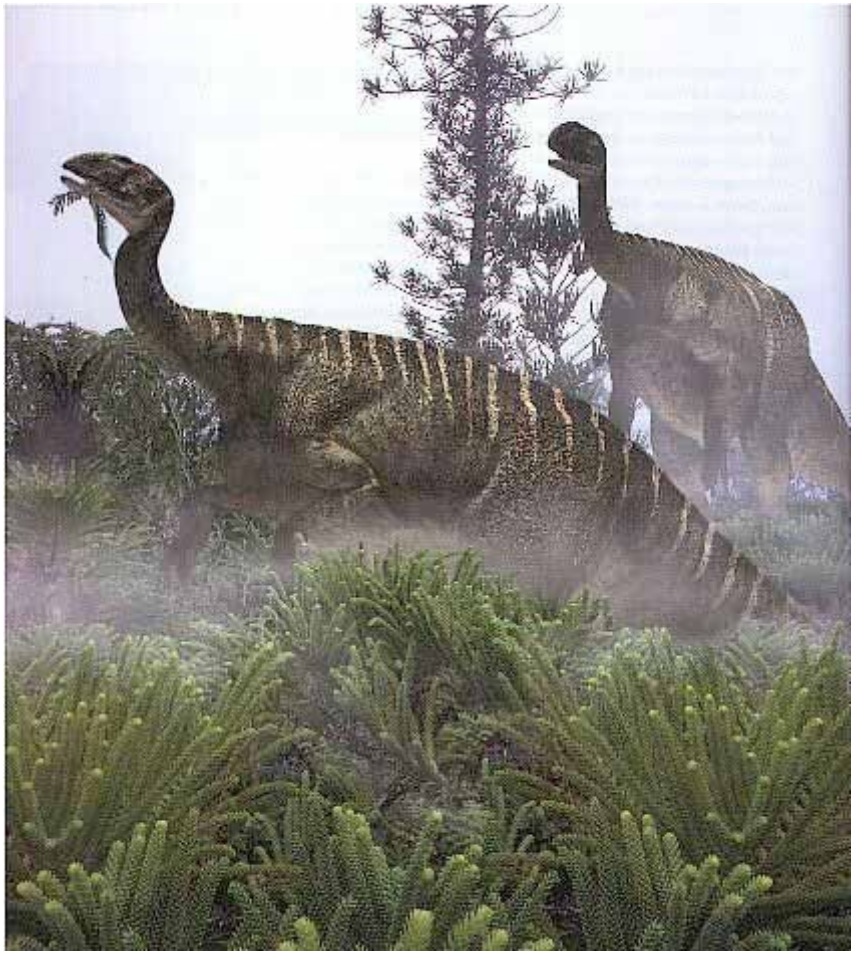
Nález 130 milionů let staré lebky a dalších částí kostry spolu s otisky jasně dokládajícími opeření, který se povedl čínským paleontologům ve vyhlášené lokalitě Liaoning, je nejstarším nálezem ostatků dinosaura ze skupiny tyranosaurů. Vyhynulý tvor dostal jméno **Dilong paradoxus**. Jménem „dilong" byl ve staré Číně označován drak, jméno paradoxus odráží fakt, že u tyranosaurů by peří čekal jen málokdo. Dinosaurus byl velký asi jako větší pes a byl to zdatný masožravec. Na rozdíl od svého mnohem většího a slavnějšího následníka druhu Tyranosaurus rex měl ještě plně vyvinuté přední končetiny, takže si jimi mohl přidržovat potravu

Sauropodomorpha

Prosauropoda


Anchisaurus
Lightly-built skull with a blunt front
Long tail
This plant-eater may have swallowed pebbles to help it digest food
Large eyes
Long neck
Small head with leaf-shaped, serrated teeth
Hind legs larger than front legs
5-toes on slender feet
Large curved thumb claw on each large, 5-fingered hand
©ZoomDinosaurs.com
6.5 to 8 feet (2 to 2.5 m) long

Prosauropoda (Plateosaurus)



Plateosaurus (small head)

Plateosaurus was the most common early dinosaur that we know. Dozens of skeletons of this large 26-foot-long (8m) animal have been collected all over central Europe. Some of these are beautifully preserved. Plateosaurus had a fairly long and light skull with small, leafshaped teeth spaced out along its jaws. It had quite a long neck and strong limbs. Plateosaurus had broad hands with a thumb claw that was large and curved. Plateosaurus could have moved on all fours, and reared up on its hind legs to feed in trees

Sauropoda

Sauropoda

Období jejich hlavního rozkvětu byla jura, v křídě ustupují do pozadí. V severní Americe např, ke konci jury vymírají a nová kolonizace sem pronikla z jižní Ameriky v podobě titanosauridů.

Tato skupina patří mezi největší zvířata, která na zemi žila - nejdelší byli delší než 5Om (Seismosaurus) a nejtěžší vážili okolo 130 tun (Ultrasaurus). Tvar jejich těla byl podobný jako u prosauropodů. Na malé hlavě byly většinou vysoko položené nozdry, podobně jako u dnešního slona nebo tapíra. Někteří paleontologové předpokládají, že i tito sauropodi mohli mít orgán podobný chobotu. Zuby kolíčkovitého nebo lžícovitého tvaru bez kousacích nebo rozmělňovacích ploch sloužili podobně jako u prosauropodů ke strhávání a rozlámání potravy, zatímco hlavní zpracování probíhalo ve svalnatých útrobách pomocí gastrolitů. Některé z nich se neustálým třením o sebe vybrousili do vysokého lesku. Mozek byl ve srovnání s velikostí těla neuvěřitelně malý. Je však třeba si uvědomit, že přes tuto gigantickou velikost počet svalů, kloubů atd. a tím pádem i pohybových funkcív podstatě byl stený jako u menších živočichů. Obecně tedy u gigantických forem není potřeba nějakého velkého nárůstu objemu mozku. Podrobná studia v posledních letech výrazně pozměnili představu o přihlouplých pomalých tvorech - složité vzory chování sauropodů ukazují, že jejich mozek byl mnohem výkonnější než se dříve předpokládalo.

Rozšíření míchy v oblasti křížové páteře souviselo s pohybem zadních končetin a nemělo funkci řídícího centra.

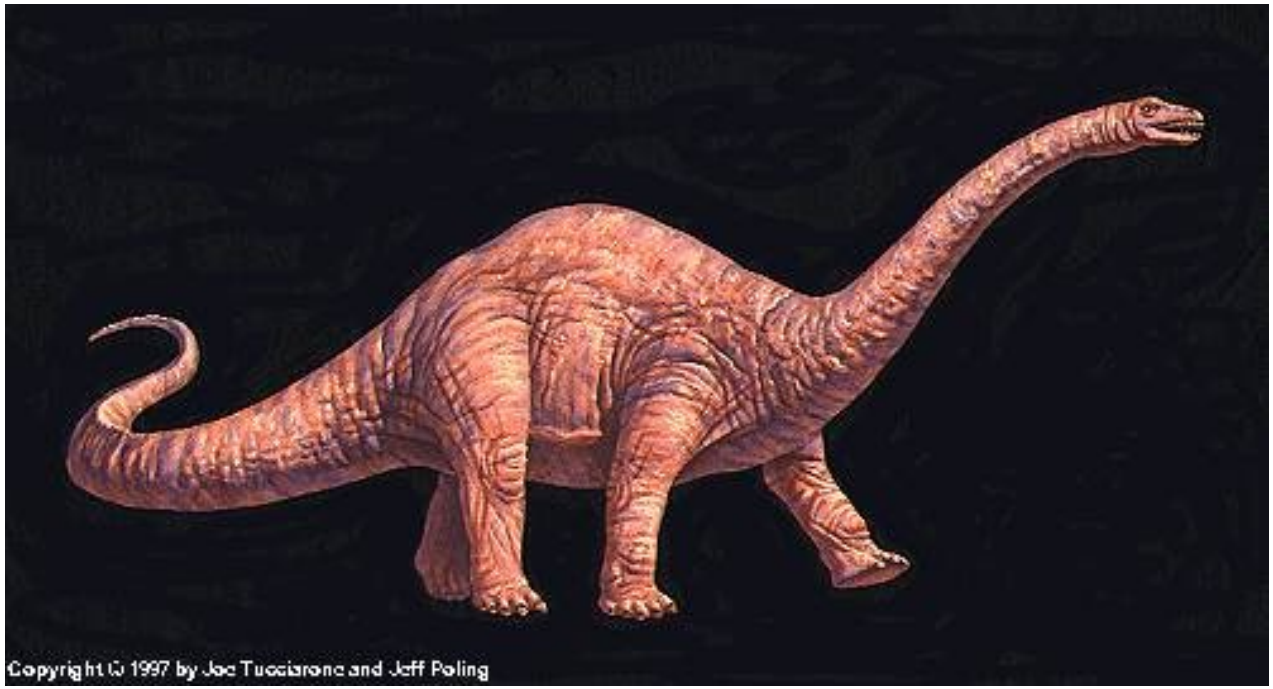
Podobně jako u prosauropodů se i sauropodi vyznačovali dlouhým krkem, který byl však většinou ještě delší než u jejich předchůdců. V některých případech byl podstatně delší než trup. Délka krku určovala i velikost hlavy, která musela být malá aby ji sauropod unesl. Podobně i ocas dosahoval značnýchrozměrů. U některých forem dlouhý bičovitý ocas sloužil jako zbraň. Některé formy měly domonce na jeho lonci kostěné palice. Končetiny bylu podsunuty kolmo přímo pod tělem aby unesly obrovskou váhu živočicha. Přední končetiny byly většinou kratší než zadní (až na čeleď Brachiosauridae). Pohybovali se po 4, pouze při spásání potravy v korunách velmi vysokých stromů mohl ocas sloužit jako opora při postavení se na zadní nohy.

Na rozdíl od dřívějších představ se ukazuje že sauropodi obývali spíše sušší oblasti, rozbahněné území v okolí vodních ploch při jejich velké hmotnosti znesnadňovalo jejich pohyb a hrozilo i že zde mohou uvíznout.

Who were the Sauropods?

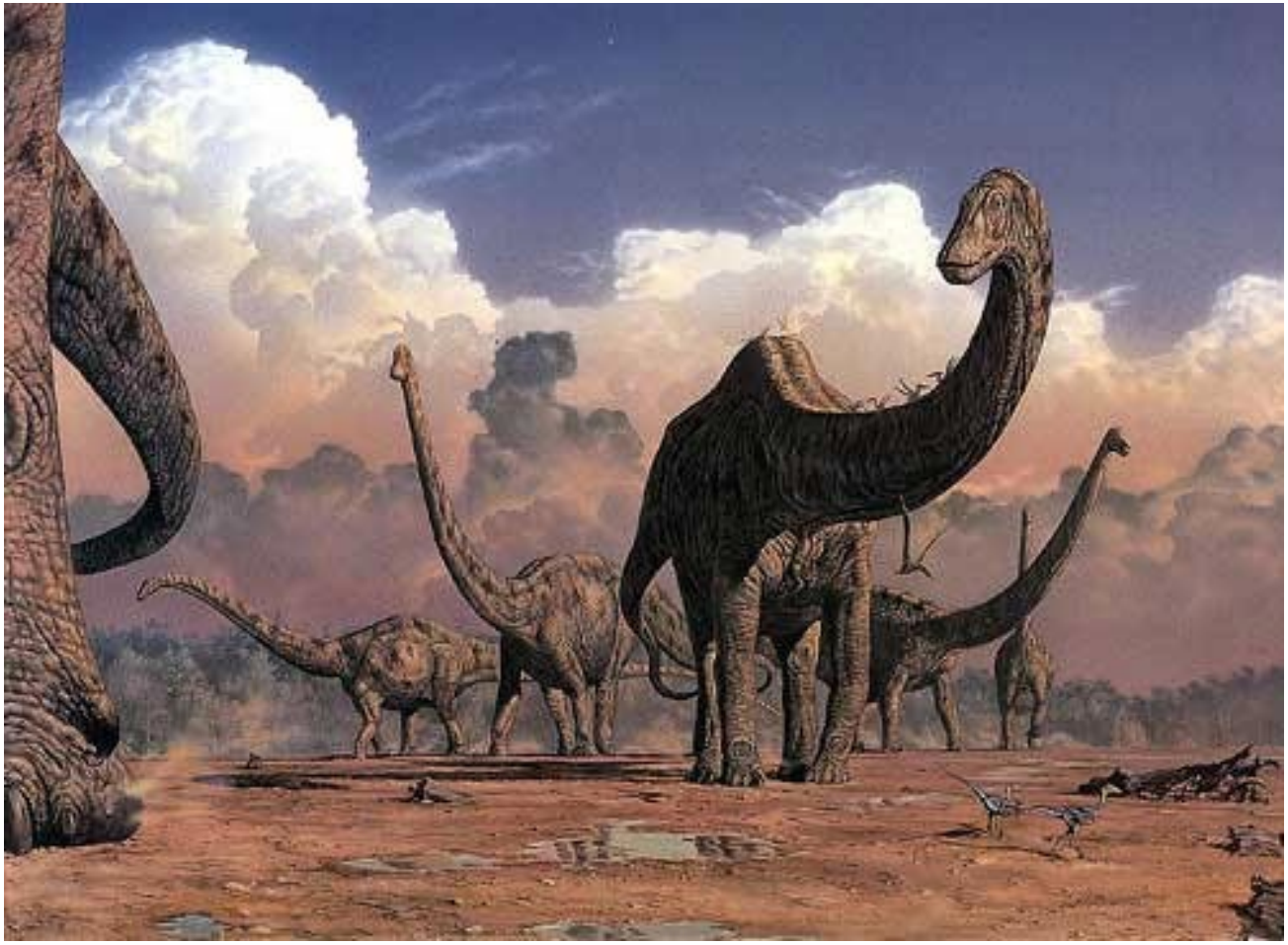
Brontosaurus

Who were the Sauropods



Apatosaurus

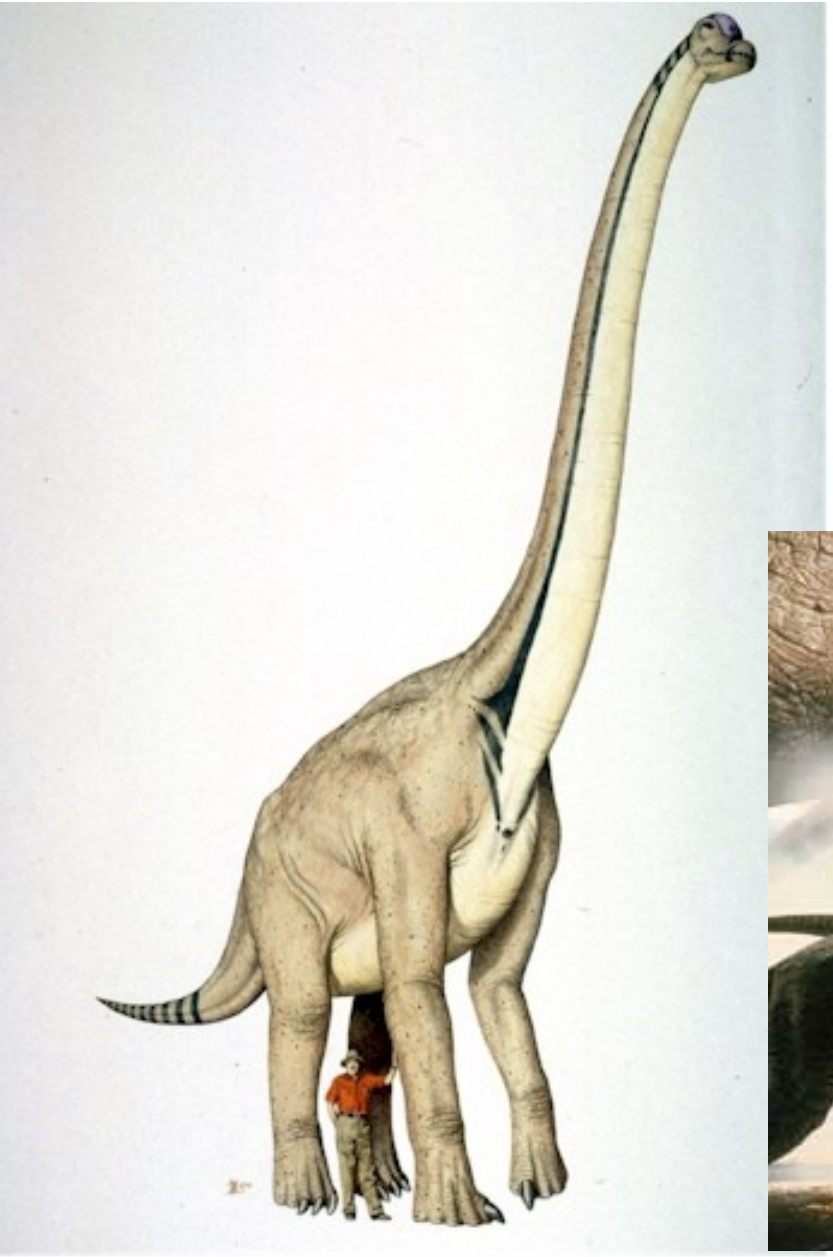
Diplodocus



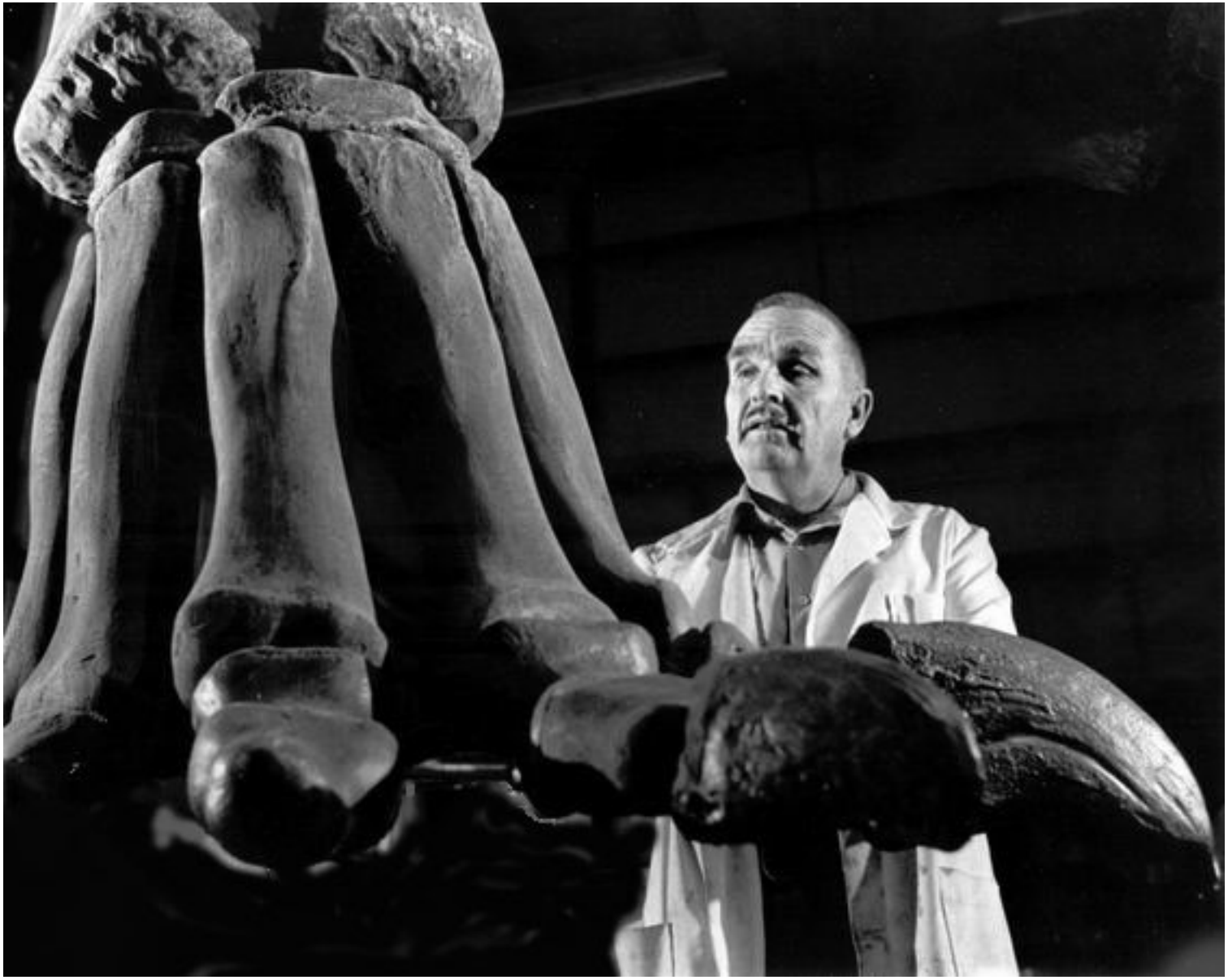
Seismosaurus was an enormous, long-necked, whip-tailed, small-headed dinosaur. It measured about 130-170 feet (39-52 m) long and was roughly 18 feet (5.5 m) tall (measured from the ground to the top of the shoulder). This giant may have weighed about 30 tons (roughly 60,000 pounds). It was among the longest land animals that ever lived. Seismosaurus lived during the late Jurassic Period, from 156-145 million years ago.

Who were the Sauropods?

Brachiosaurus was one of the biggest land animals ever. Its weight has been estimated at about 80 tonnes, twenty times as heavy as a large elephant. Unlike other dinosaurs it had front legs longer than the hind ones, so that its back sloped upwards towards the head. In the Natural History Museum in Berlin there is a mounted skeleton of *Brachiosaurus*; the head is 13 metres above the ground, its upper arm bone is over 2 metres long, and it dwarfs the *Diplodocus* standing next to it.



Two Allosaurus individuals cruise the perimeter of a herd of Ultrasaurus



Right Front Foot- Ultrasaurus

The Ornithischians (bird-hip structure)

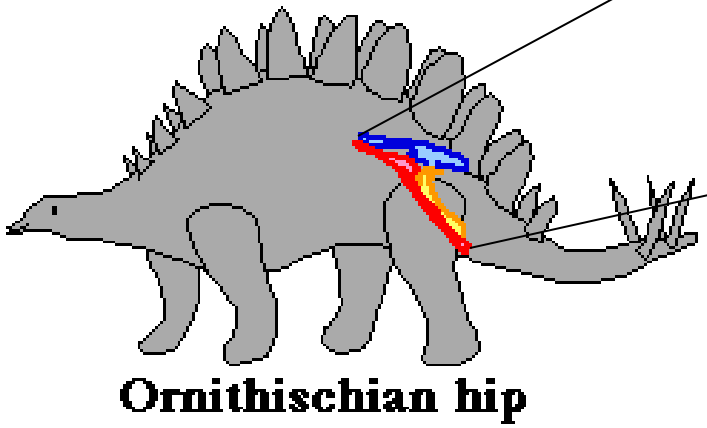
There were five basic kinds of ornithischians

- (1) stegosaurs
- (2) ankylosaurs
- (3) ornithopods
- (4) pachycephalosaurs
- (5) ceratopsians
- Each group included many different species.

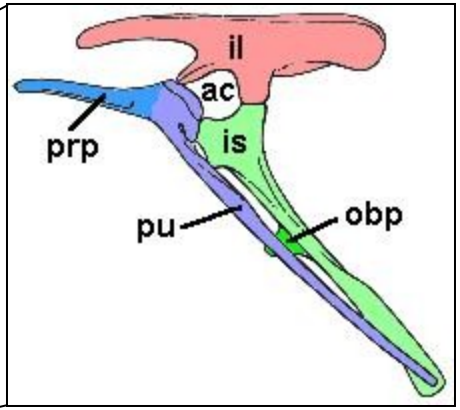
Entirely vegetarians

- Exploited vegetation low to the ground

Pelvis characteristics



Ornithischian hip



(1) stegosaurs

Stegosaurus

Ankylosaurs

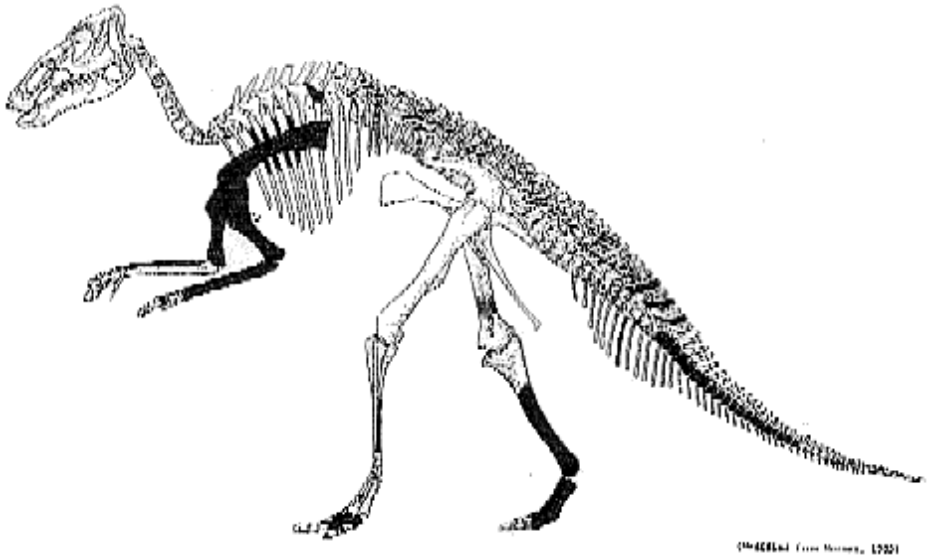
Ornitopoda

Iguanodonts

Iguanodon

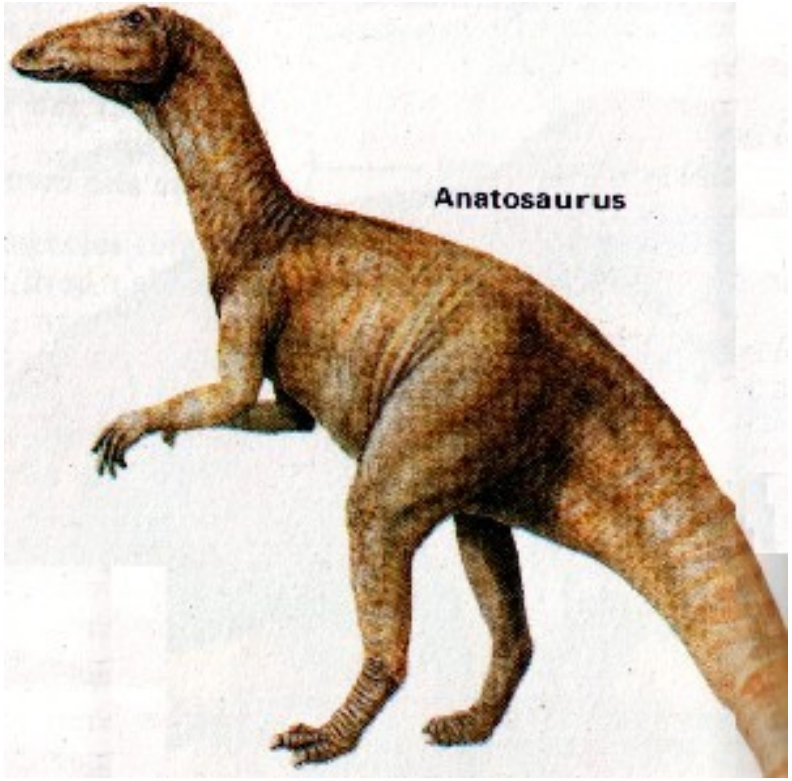

© DK 2003

Hadrosaurs

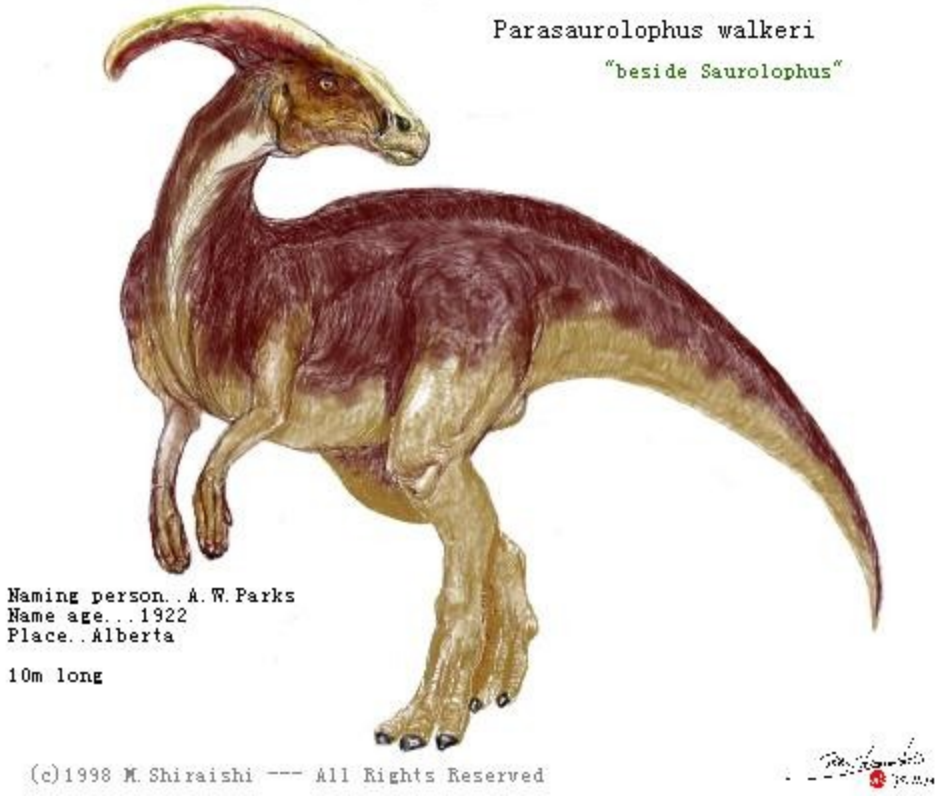


Duck Bill Idea – Sometimes called Duck-billed dinosaur

Types of Hadrosaurs



Anatosaurus



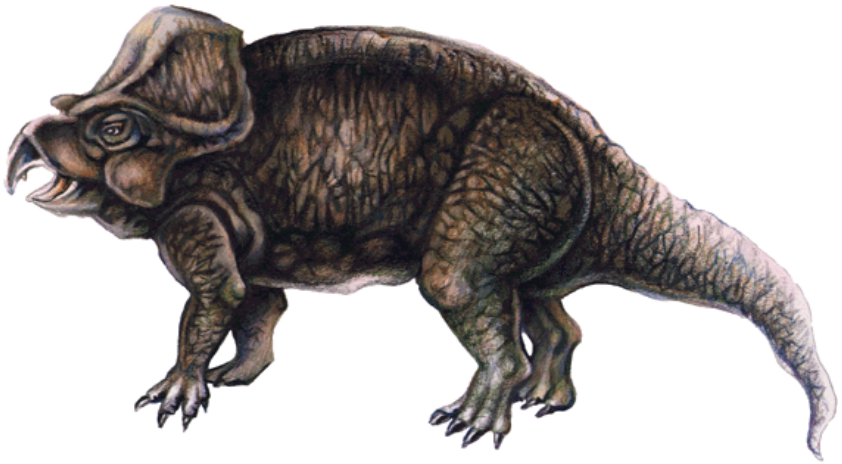
Parasauro

Pachycephalosaurs

Pachycephalosaurus
tzv trkaví dinosauři s mimořádně zesíleným temenem lebečním, tvořícím často nápadnou kopuli. Pravděpodobně údery do měkkého těla dravce nebo protivníka. U samců větší.. Měli poměrně krátké nohy a nedokázali dobře běhat. Primirtivní listovité zuby, potrava pravděpodobně měkká, bylinná. Nálezy hlavně v Severní Americe a Asii, vzácně Evropa a Afrika. Nejběžnějším rodem byl Stegoceras, asi 2m dlouhý. Hlavní rozvoj proběhl ve svrchní křídě.

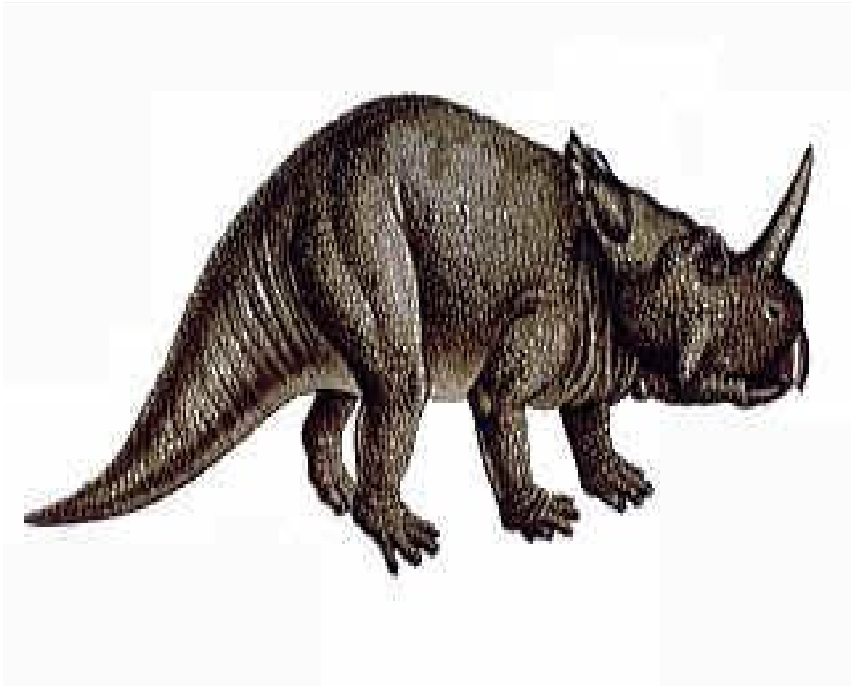
Ceratopsia

Types of Ceratopsia



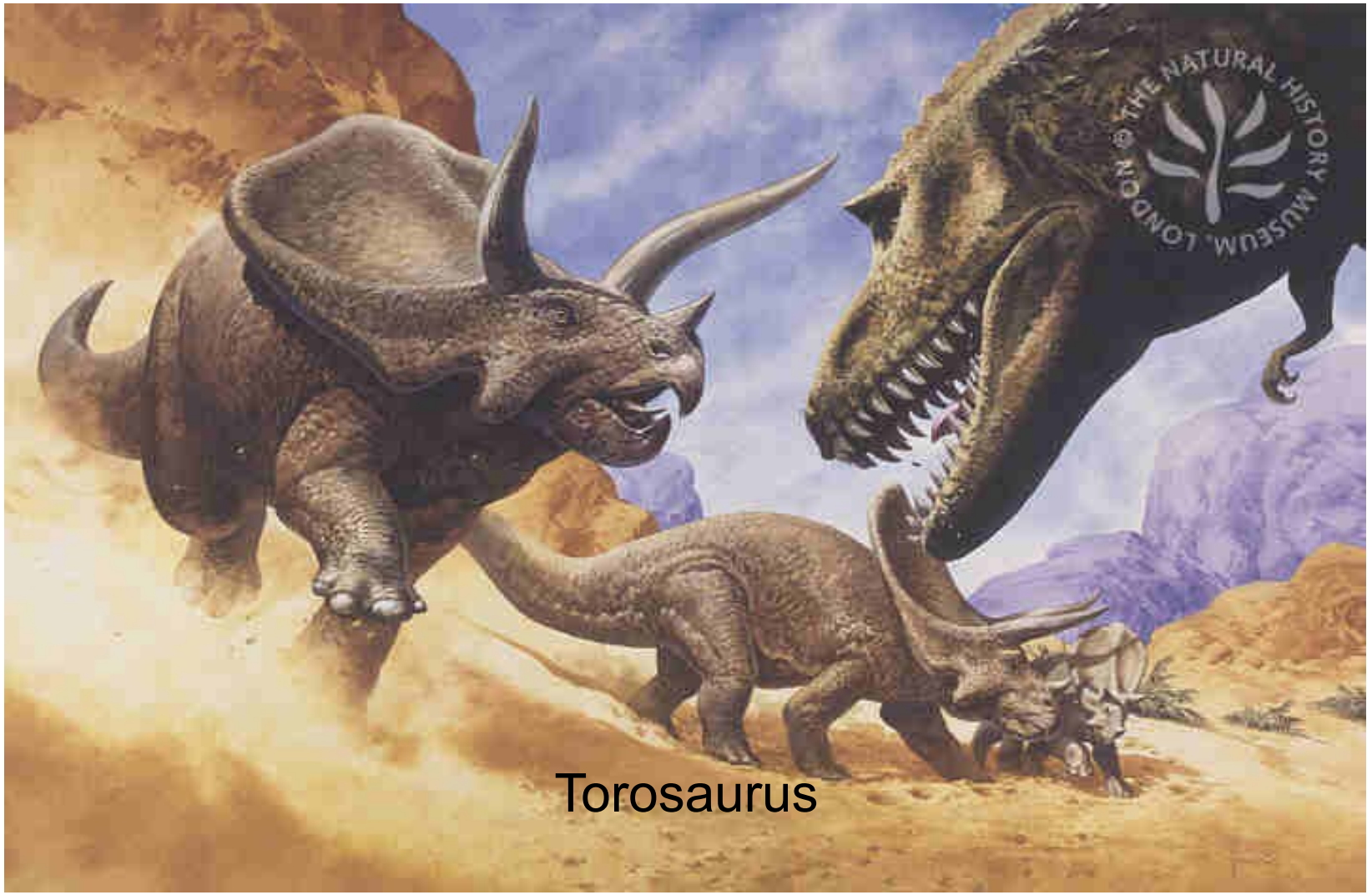
Protoceratops

Types of Ceratopsia



Monoclonius

Types of Ceratopsia

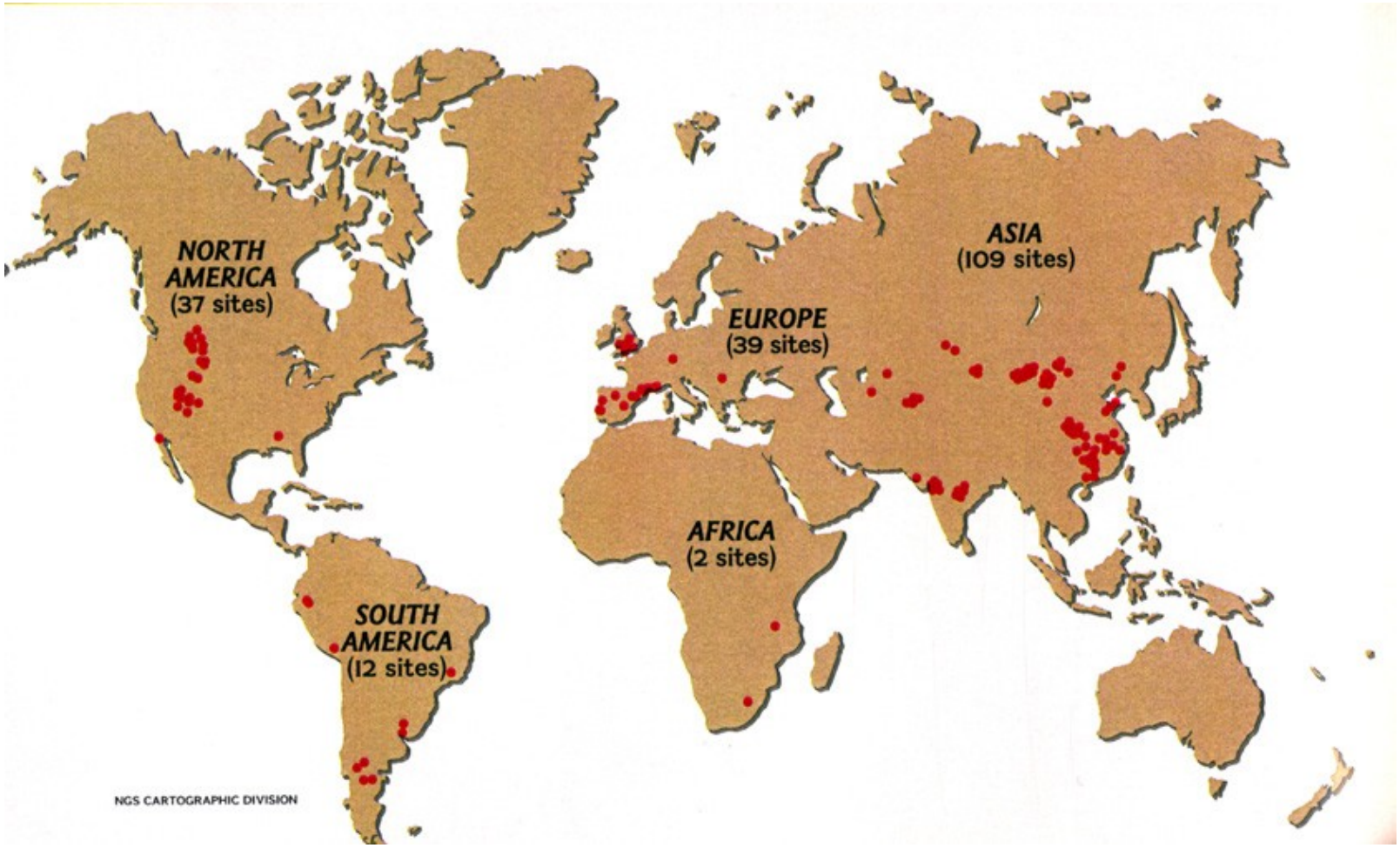


Torosaurus

Triceratops

Styracosaurus

Geographic Distribution



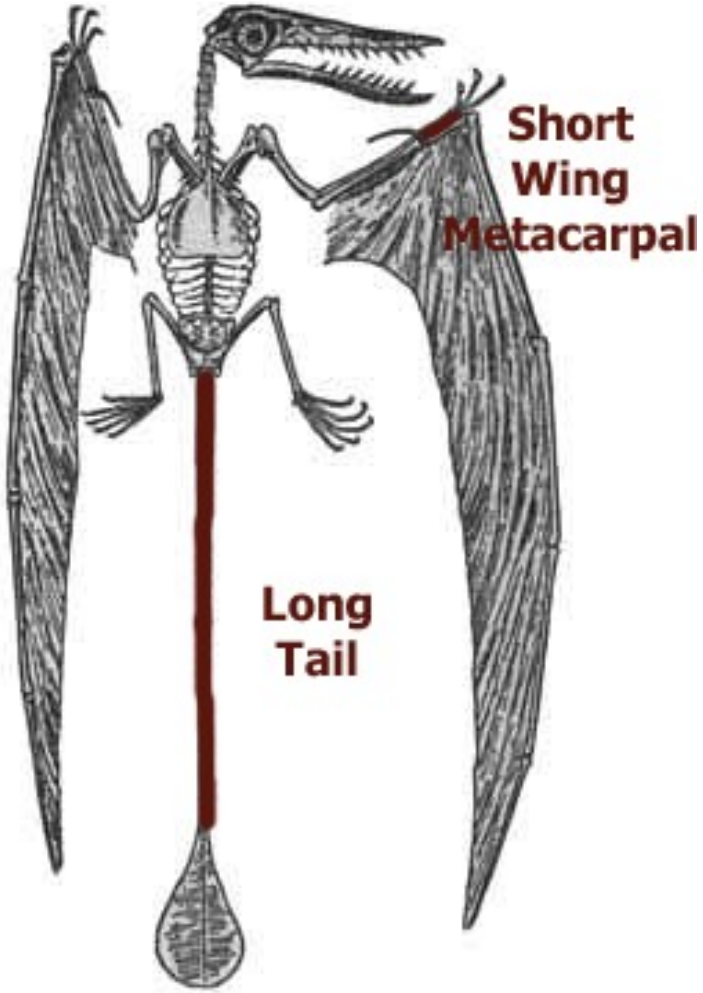
Pterosauria

Pterosaurs are divided into two sub-orders. The first one is;

Rhamphorhynchoidea

(Ram-for-rink-oid-eah)

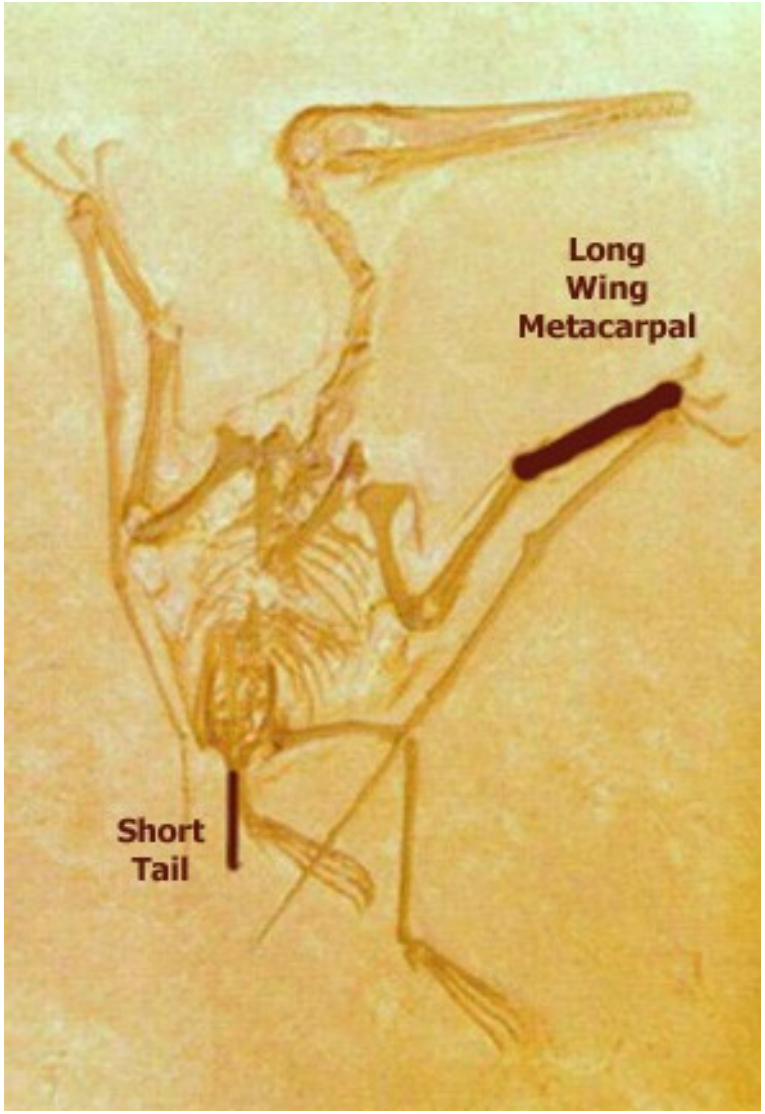
Early pterosaurs with **long** tails and **short** wing metacarpals.



Pterosaurs are divided into two sub-orders. The second one is;

Pterodactyloidea
(terro-dactyle-oid-eah)

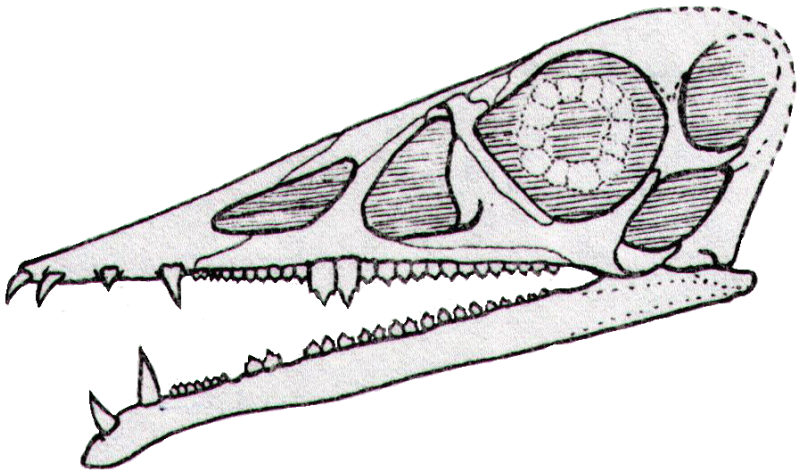
Later pterosaurs with **short** tails and **long** wing metacarpals.



Triassic Pterosaurs

Eudimorphodon Ranzii

(***Zorzino Limestone, Italy***)



Eudimorphodon is a typical Triassic pterosaur, with different size teeth and some teeth with three cusps.

The earliest known pterosaurs were fully formed flying animals with long tails and well developed wings. They all appear to have been carnivores.

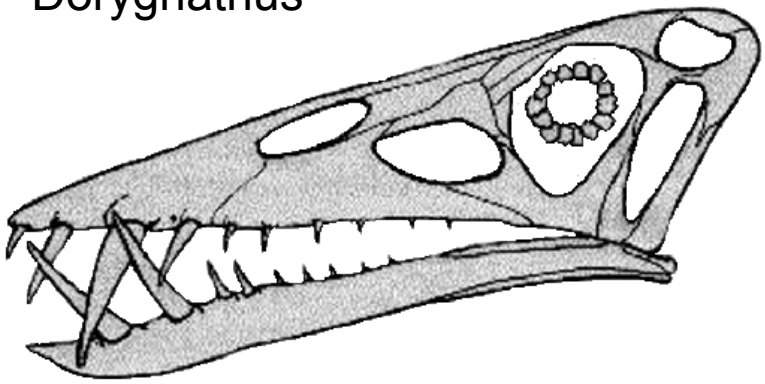
Most of the larger Triassic pterosaurs were about the size of large crows or buzzards.

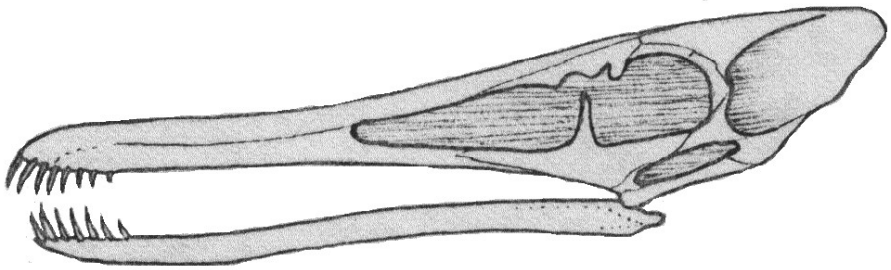
Jurassic Pterosaurs

During the Jurassic Period there were a large number of different types of pterosaurs. Some were as big as small birds and others were larger than eagles. Many forms had very large teeth.

Rhamphorhynchus and Pterodactylus lived side by side in the late Jurassic era. This was when the large dinosaurs roamed the land.

Dorygnathus



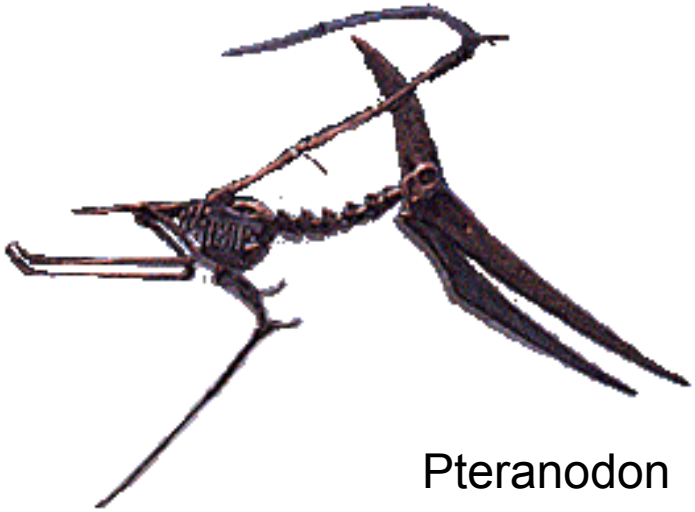


Gallodactylus

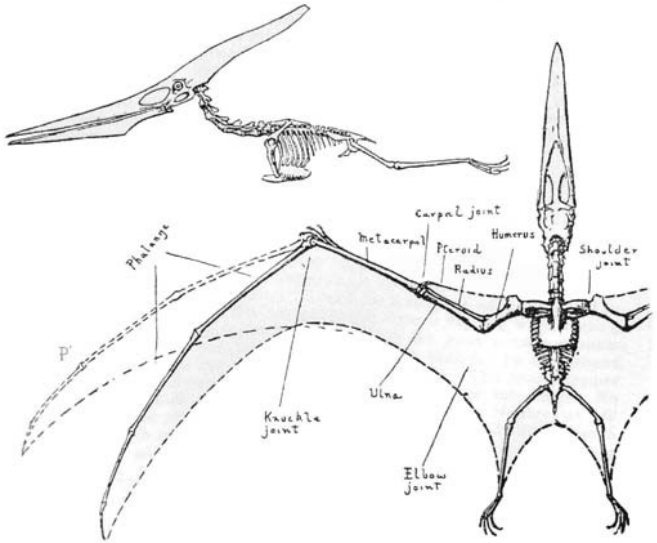
Cretaceous Pterosaurs

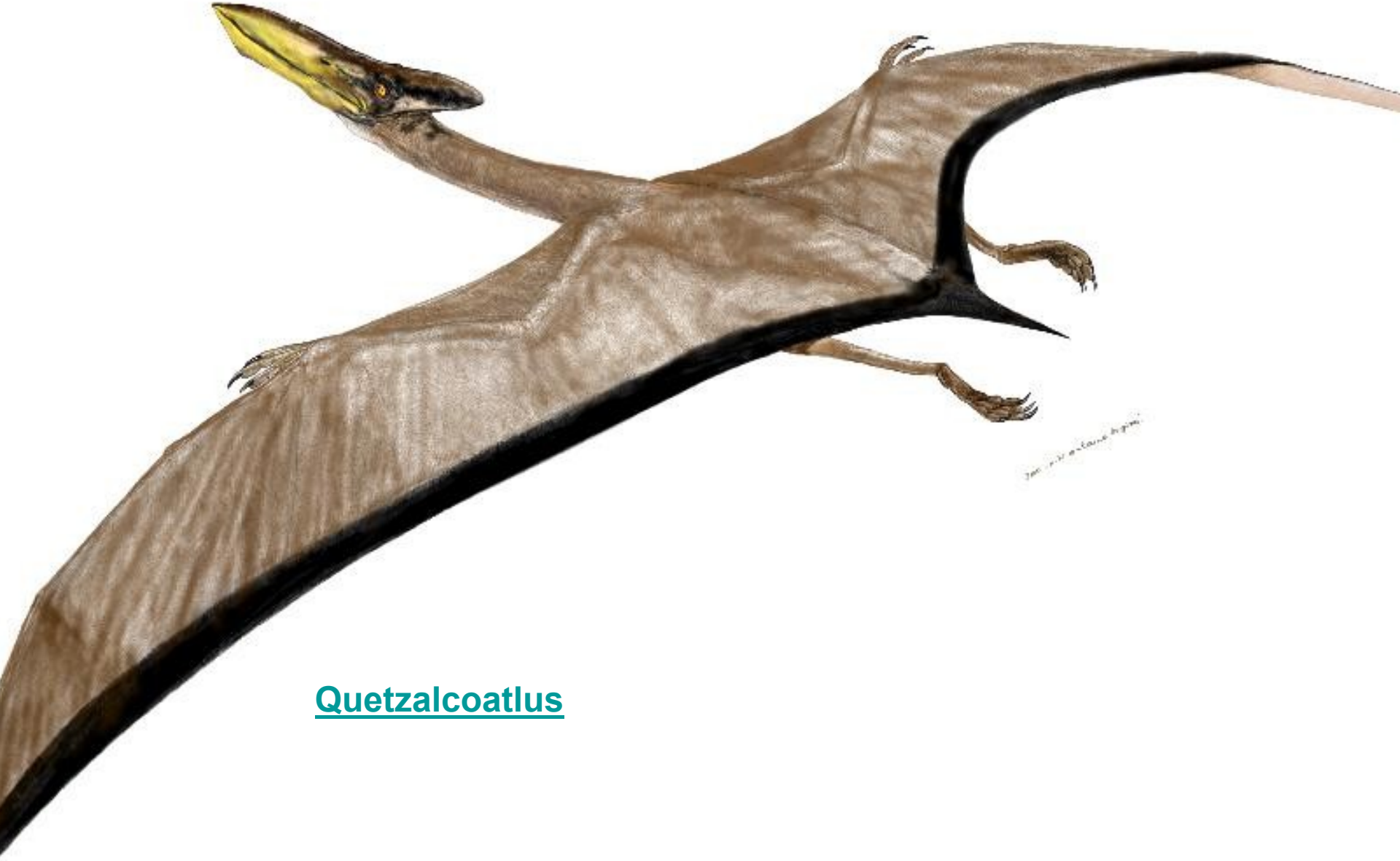
During the Cretaceous Era the pterosaurs became larger than ever. Some species had wingspans equal to those of a small aeroplane.

Small pterosaurs had almost disappeared, they were probably unable to compete with the newly evolved birds.



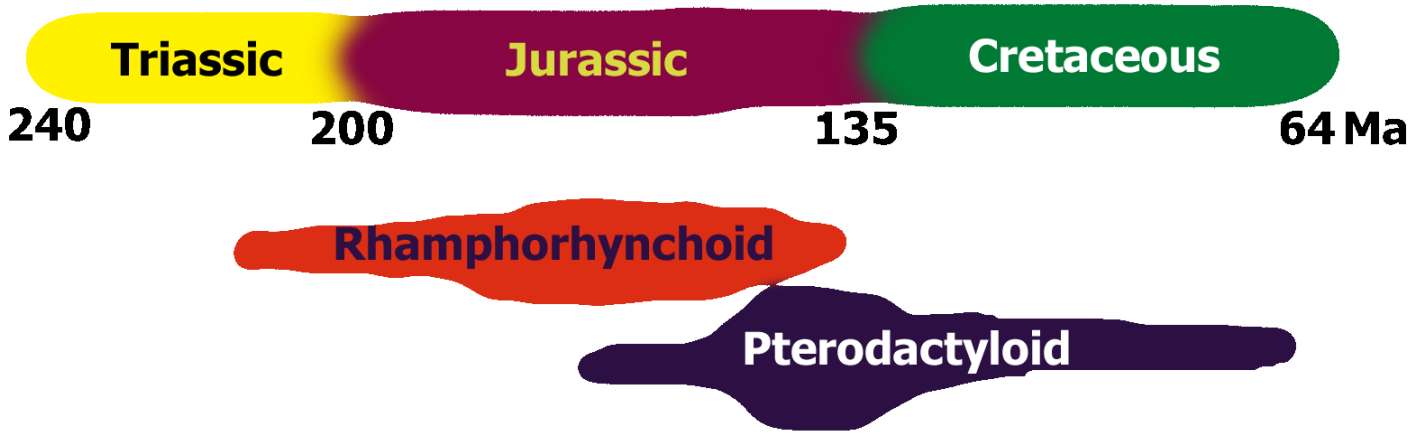
Pteranodon





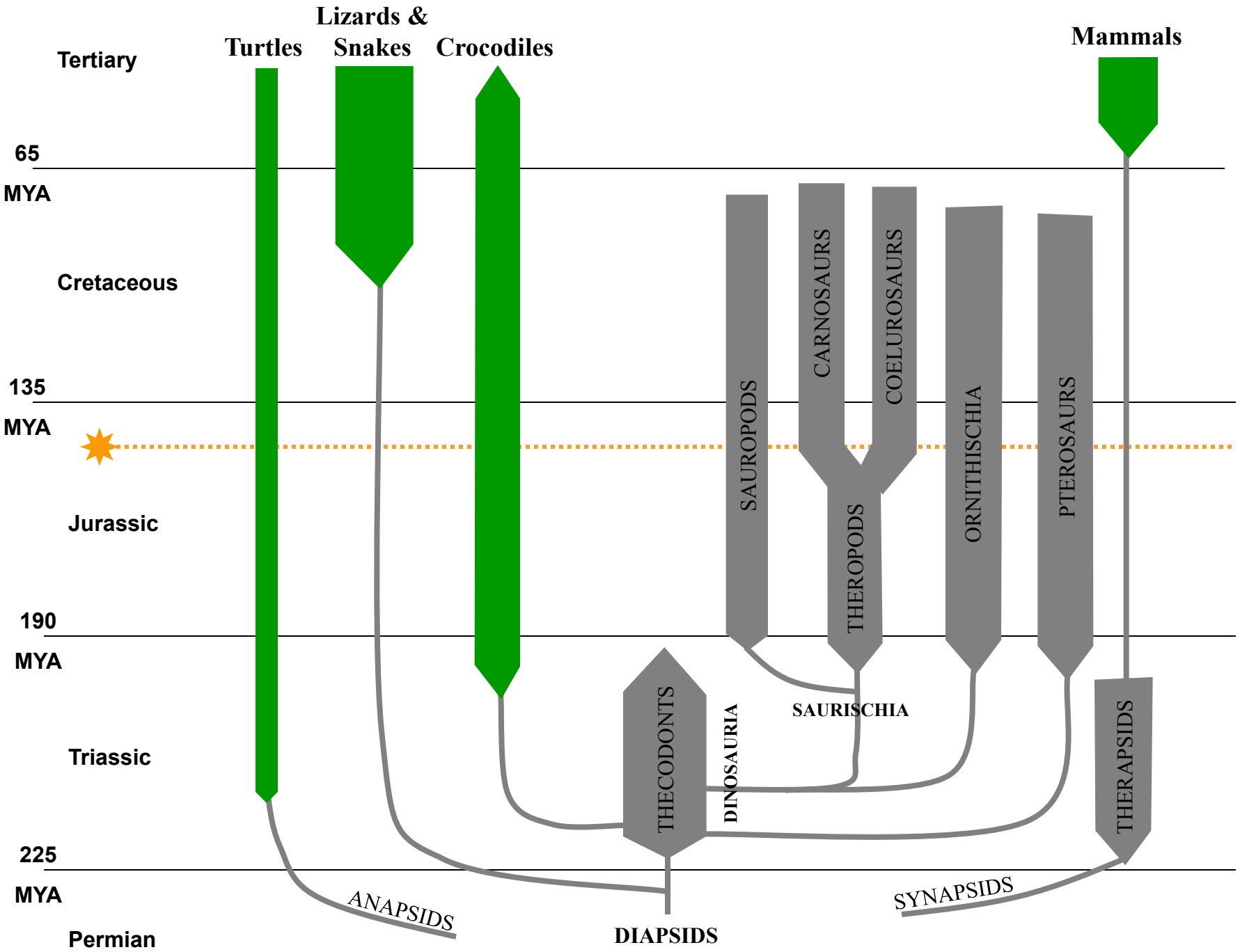
Quetzalcoatlus

Pterosaur Timeline



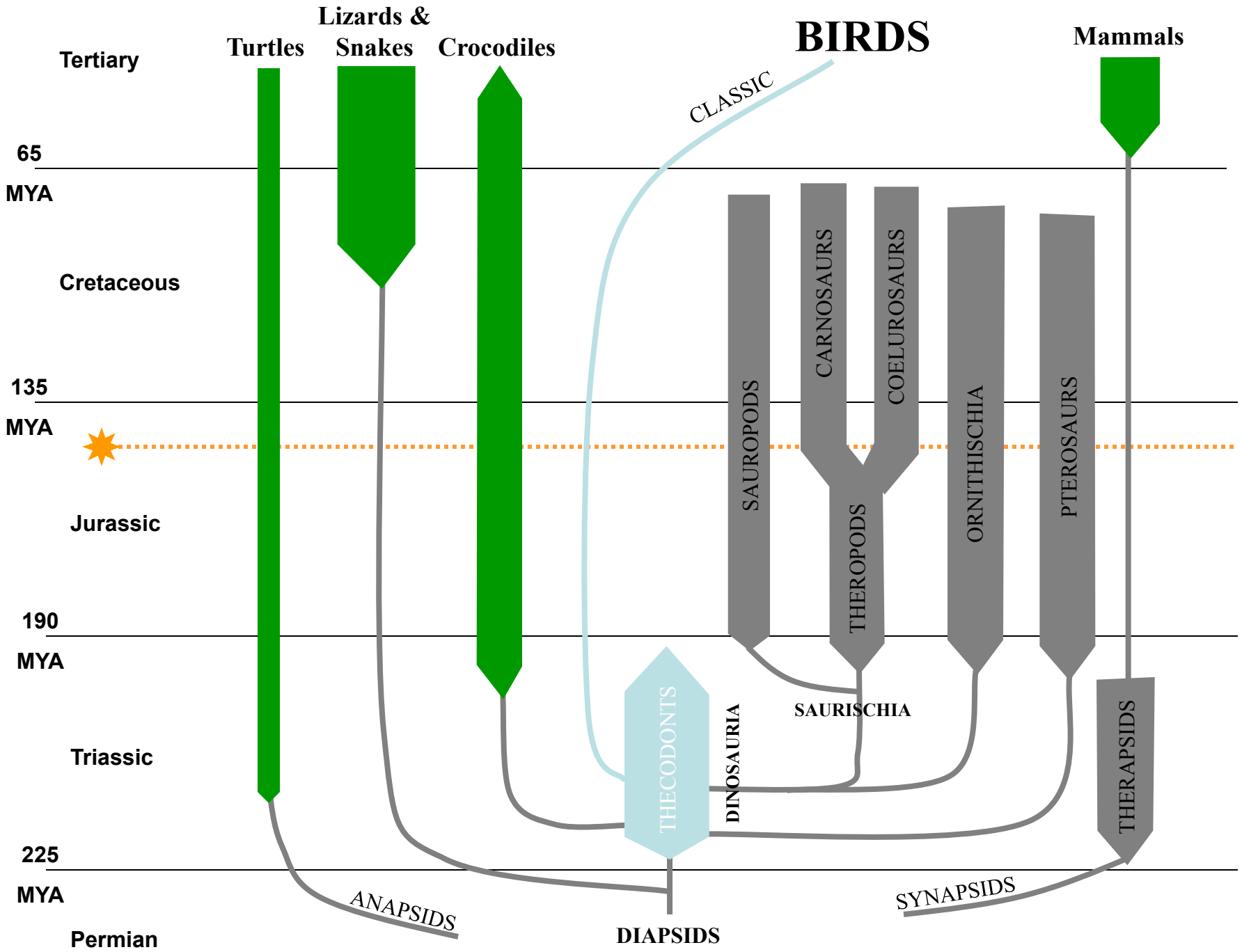
Pterosaurs were at their height in the Late Jurassic Era.

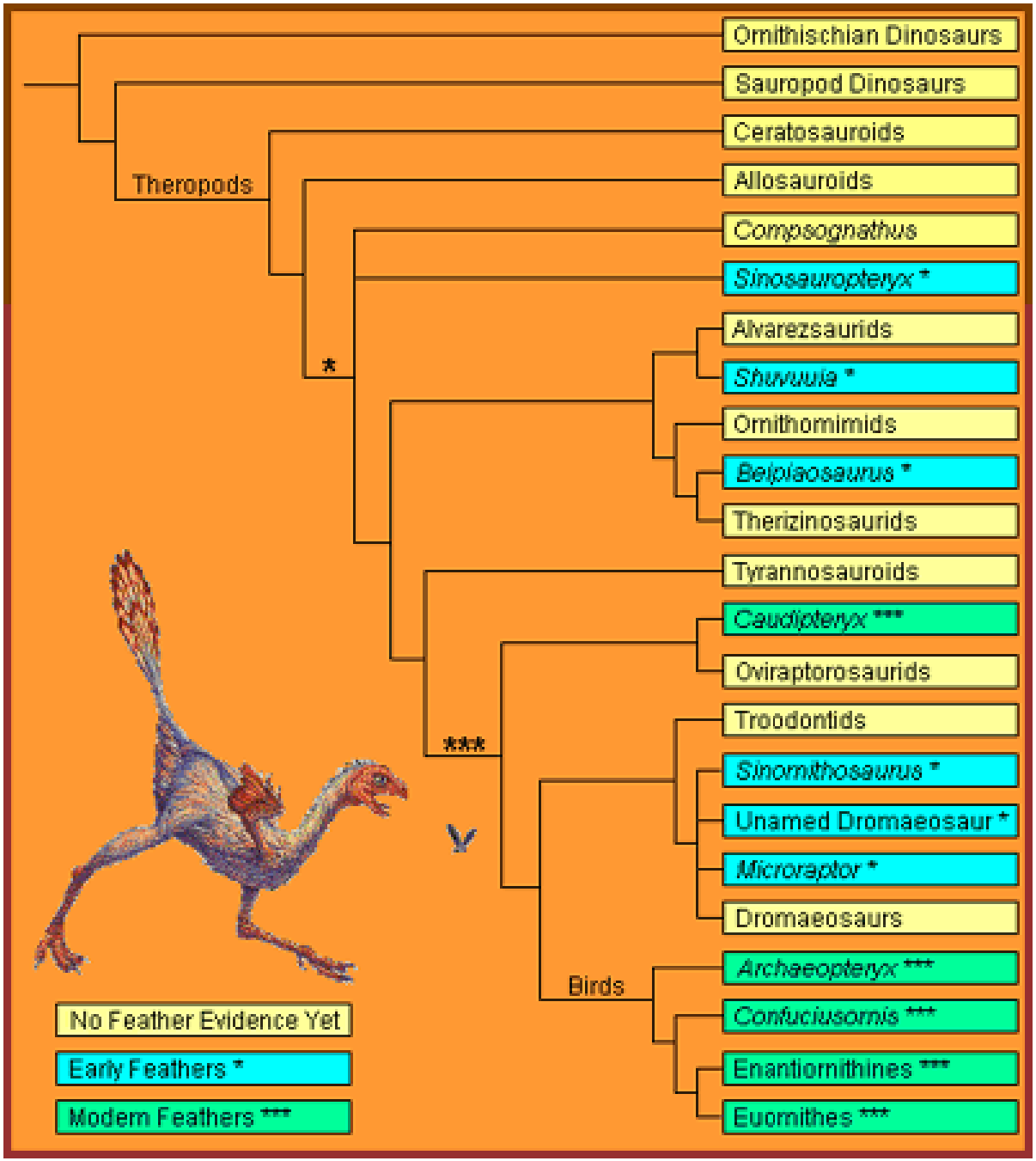
Only the large pterosaurs remained until the end of the Cretaceous Era.

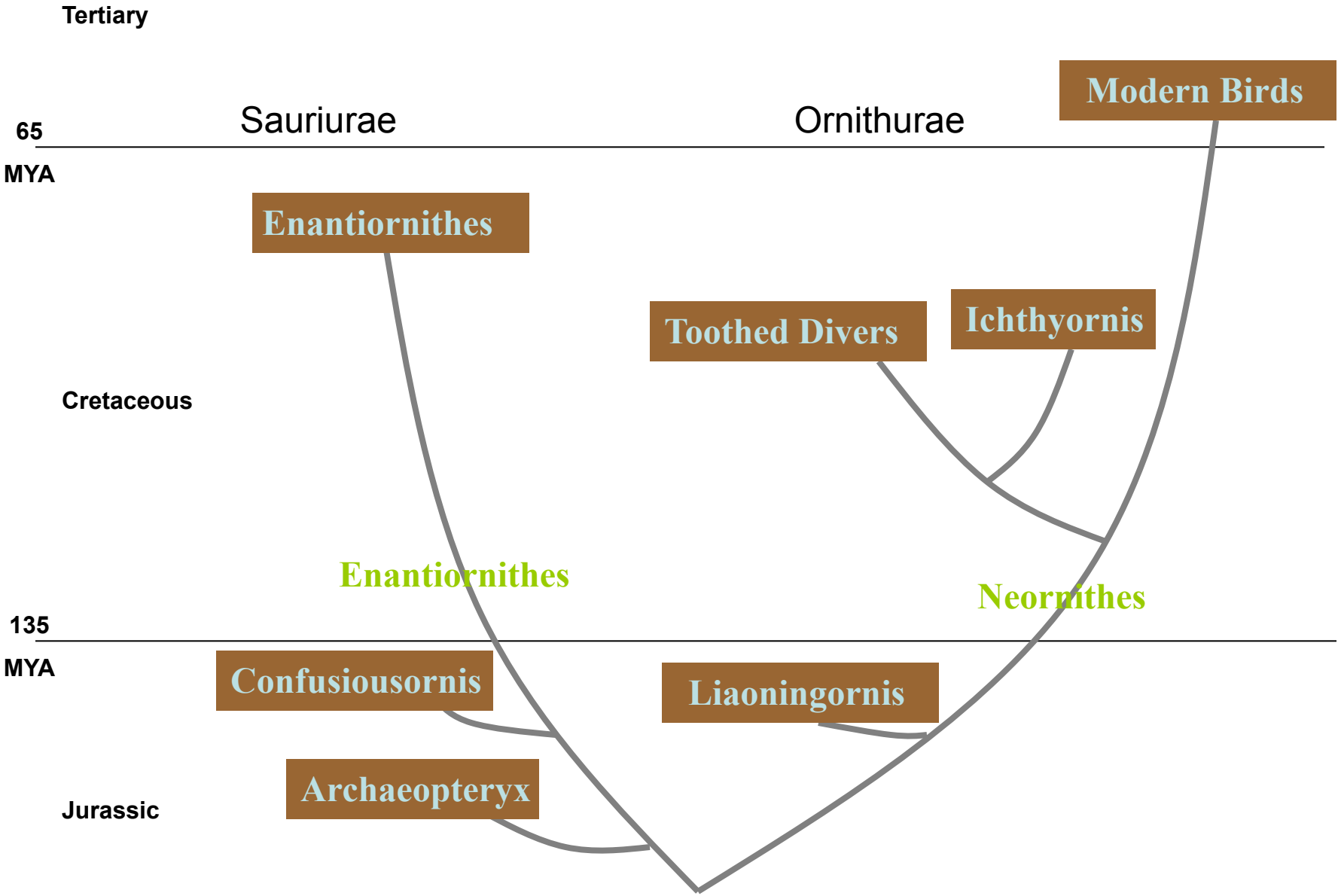

Tertiary
Turtles
Lizards &
Snakes
Crocodiles
Mammals
65
MYA
Cretaceous
135
MYA
Jurassic
190
MYA
Triassic
225
MYA
Permian
SAUROPODS
CARNOSAURS
COELUROSAURS
ORNITHISCHIA
PTEROSAURS
THEROPODS
THECODONTS
DINOSAURIA
SAURISCHIA
THERAPSIDS
ANAPSIDS
DIAPSIDS
SYNAPSIDS

Aves

Historie ptáků (Aves) začíná během **jury** (všechny starší údaje se ukázaly jako neopodstatněné). Úsvit této skupiny je ještě zahalen řadou nejasností vyplývajících z obtížné fosilizace i z nejisté datace nejstarších nálezů. Zmíněný *Archaeopteryx* je v této souvislosti považován buď za zástupce jedné skupiny dinosaurií (viz výše) nebo za sesterskou skupinu některých tzv. **opozitních ptáků** (tři kůstky jejich chodidla srůstají odshora dolů, tj. opačně než u moderních ptáků). Ptačí předek se tedy mohl odštěpit od nelétavých dinosaurií už před archeopteryxem. Každopádně při hranici jura/křída dochází k radiaci různých skupin ptáků, z nichž dnes již dobře doložený *Confuciusornis* zastupuje opozitní ptáky (nebo také Sauriurae) a *Chaoyangia, Liaoningornis, Hesperornis a Ichthyornis* již sesterskou skupinu Ornithurae zahrnující i **moderní ptáky**.


Tertiary
Turtles
Lizards &
Snakes
Crocodiles
BIRDS
CLASSIC
Mammals
65
MYA
Cretaceous
135
MYA
Jurassic
190
MYA
Triassic
225
MYA
Permian
SAUROPODS
CARNOSAURS
COELUROSAURS
ORNITHISCHIA
PTEROSAURS
THEROPODS
THECODONTS
DINOSAURIA
SAURISCHIA
THERAPSIDS
ANAPSIDS
DIAPSIDS
SYNAPSIDS


Ornithischian Dinosaurs
Sauropod Dinosaurs
Ceratosauroids
Allosauroids
Compsognathus
Sinosauropteryx *
Alvarezsaurids
Shuvuuia *
Ornithomimids
Beipiaosaurus *
Therizinosaurids
Tyrannosauroids
Caudipteryx ***
Oviraptorosaurids
Troodontids
Sinornithosaurus *
Unamed Dromaeosaur *
Microraptor *
Dromaeosaurs
Archaeopteryx ***
Confuciusornis ***
Enantiornithines ***
Euornithes ***
Theropods
*
***
Birds
No Feather Evidence Yet
Early Feathers *
Modern Feathers ***

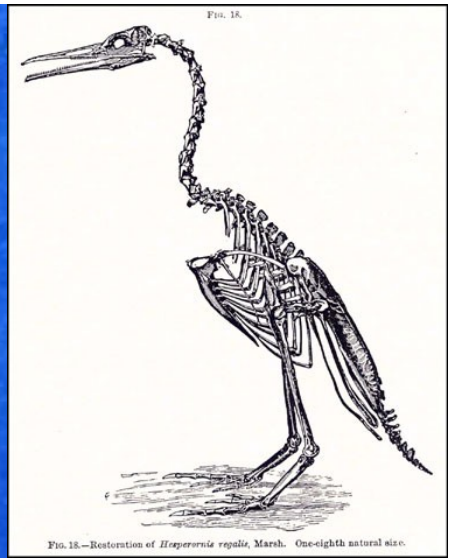

Tertiary
Sauriurae
Ornithurae
Modern Birds
65
MYA
Enantiornithes
Toothed Divers
Ichthyornis
Cretaceous
Enantiornithes
Neornithes
135
MYA
Confusiousornis
Liaoningornis
Archaeopteryx
Jurassic

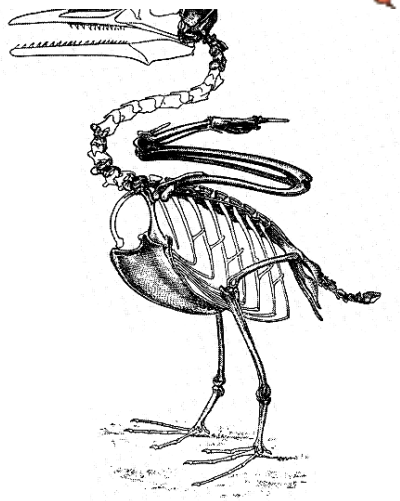
Two Major Bird Lineages

- Enantiornithes
  - Fusion of tarsometatarsus in opposite d
  - Most Diverse avian group in Cretaceou
- Neornithes

Two Major Bird Lineages

- Enantiornithes
- Neornithes
  - Predecessors to modern birds
  - Toothed Divers – Hesperornis
  - Tern-like – Ichthyornis

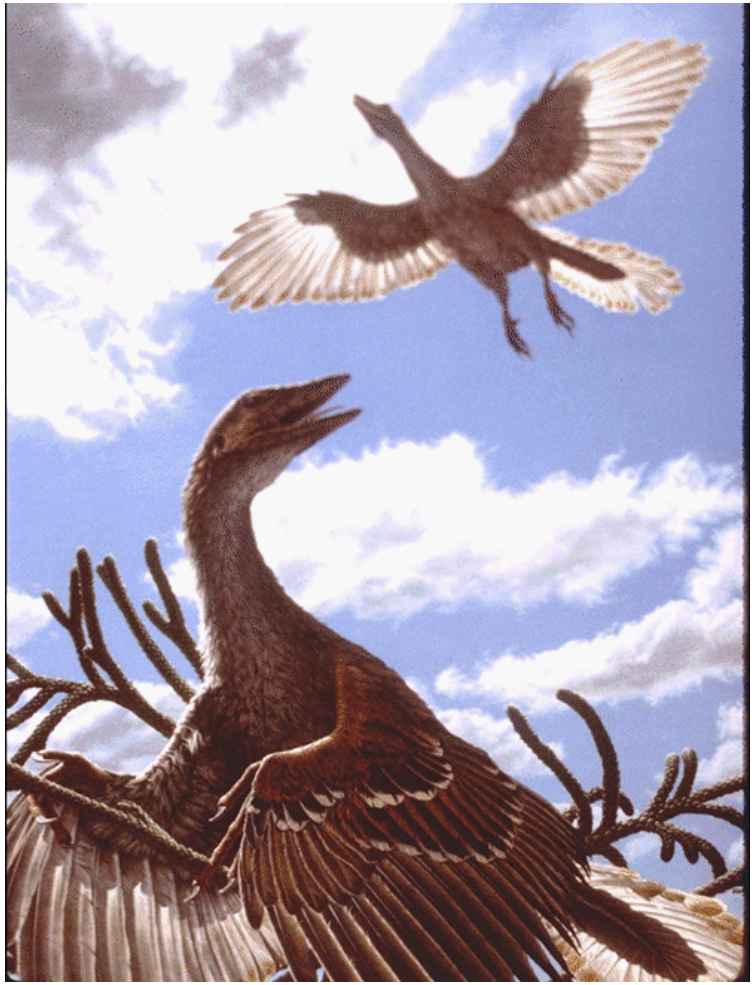




True Birds (Aves)

- Archaeopteryx long thought to be a bird ancestor
- Still hotly debated
- Ground-Up vs. Trees-Down models of flight
- This one is Trees-Down

Archaeopteryx



This one is a Ground-Up representation - they could have started flight with long leaps

Archaeopteryx is somewhat advanced, and could have made some longish flights, but likely not really well or all day.

Archaeopteryx with no artist's interpretation - (note the feathers!)

Feathers

- Feathers are obviously good for flight
- Feathers are also good insulators
- It’s not clear which property was the impetus for their evolution - Archaeopteryx might well have just been trying to keep warm.

Timing of Birds

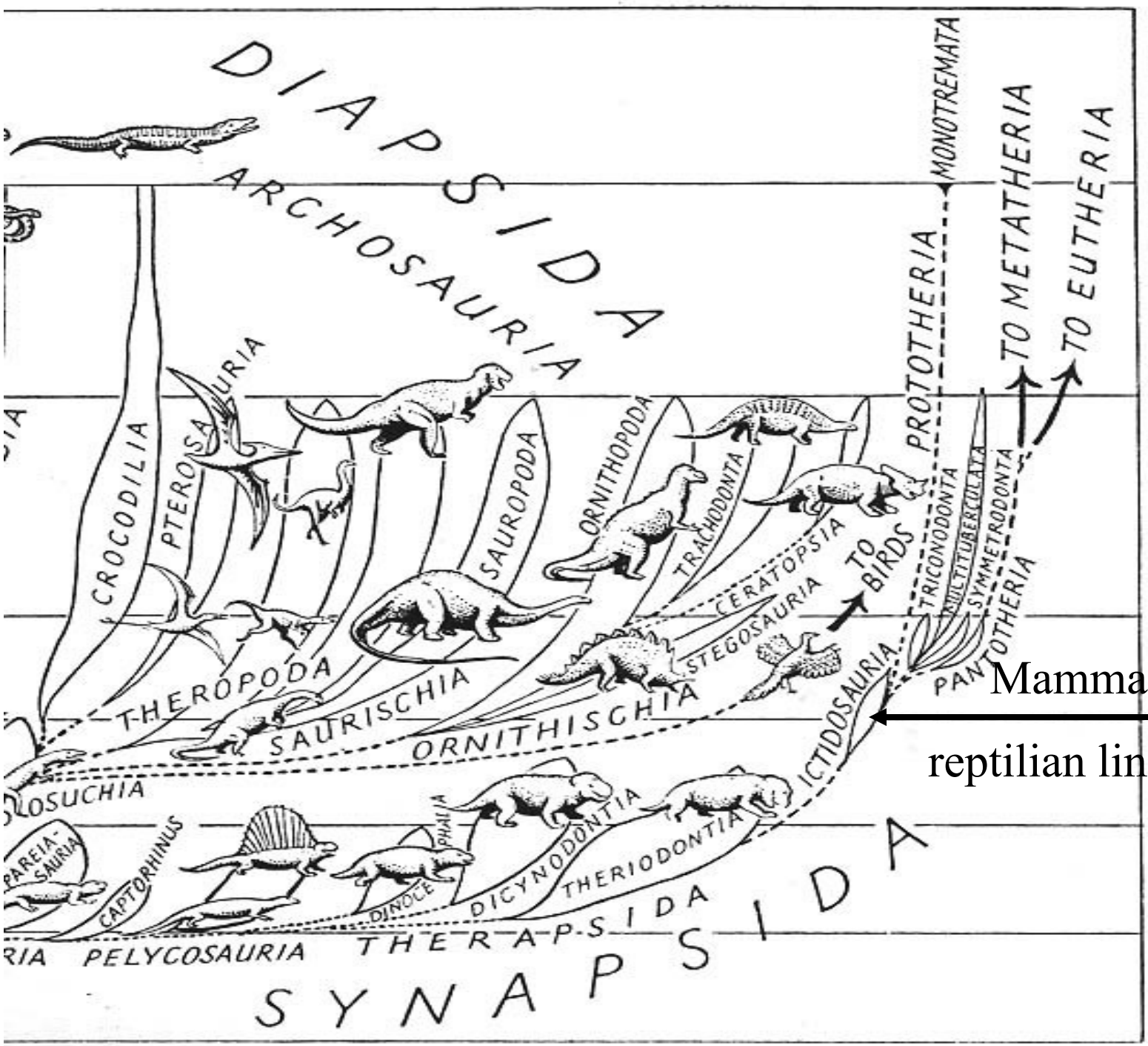
- Birds don’t fossilize well - they have weak, light bones that are often hollow.
- From 1990-1995, the number of known bird fossils doubled.
- When did they start?
- Archaeopteryx is from Late Jurassic
- There were lots of birds, flying and flightless, by the end of the Cretaceous, including members of modern groups

Timing of Birds

- Lots of bird diversification in the Cenozoic, although most fossils are incomplete.
- By the Early Oligocene (35 Ma), most modern bird groups had arrived.
- There were unusual forms, e.g. phororhachids from South America - present for much of Cenozoic

Timing of Birds

- Controversy -*Protoavis* from Late Triassic
- This would move back bird evolution about 80 million years to the earlier parts of the Mesozoic
- Not everybody thinks this is a real bird, although its discoverer (Chaterjee) claims it is closer to modern birds than Archaeopteryx is
- Birds have lots of fans - creates interest


DIAPSIDA
ARCHOSAURIA
CROCODILIA
PTEROSAURIA
SAUROPODA
ORNITHOPODA
TRACHODONTA
CERATOPSIA
STEGOSAURIA
THEROPODA
SAURISCHIA
ORNITHISCHIA
LOSUCHIA
PAREIA-SAURIA
CAPTORHINUS
DINOCE
PHALIA
DICYNODONTIA
THERIODONTIA
ICTIDOSAURIA
PELYCOSAURIA
THERAPSIDA
SYNAPSIDA
MONOTREMATA
PROTOTHERIA
TO METATHERIA
TO EUTHERIA
TO BIRDS
TRICONODONTA
MULTITUBERCULATA
SYMMETRODONTA
PANTOTHERIA
Mammalian-reptilian line

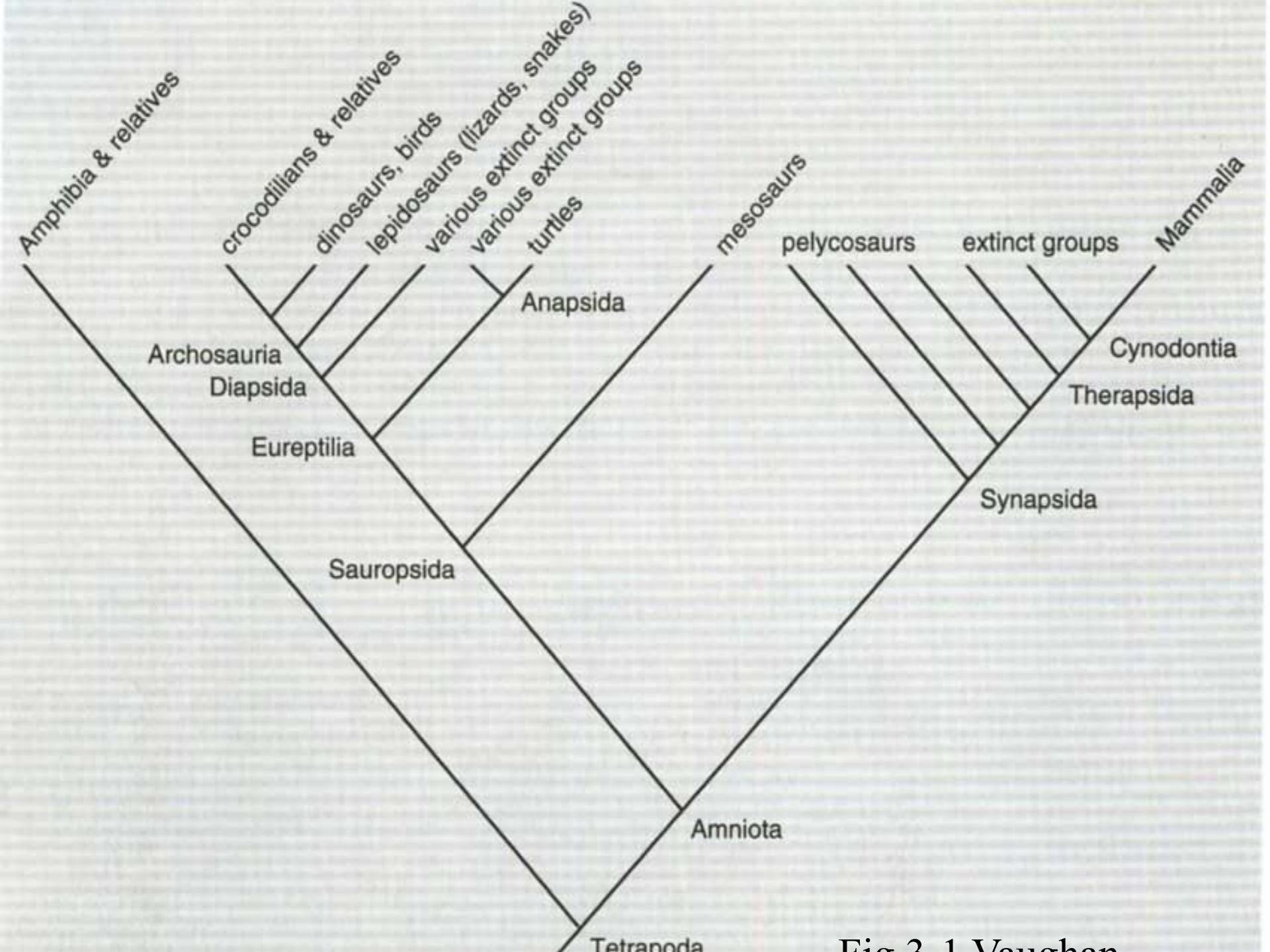


Fig 3-1 Vaughan

ProtoAvis

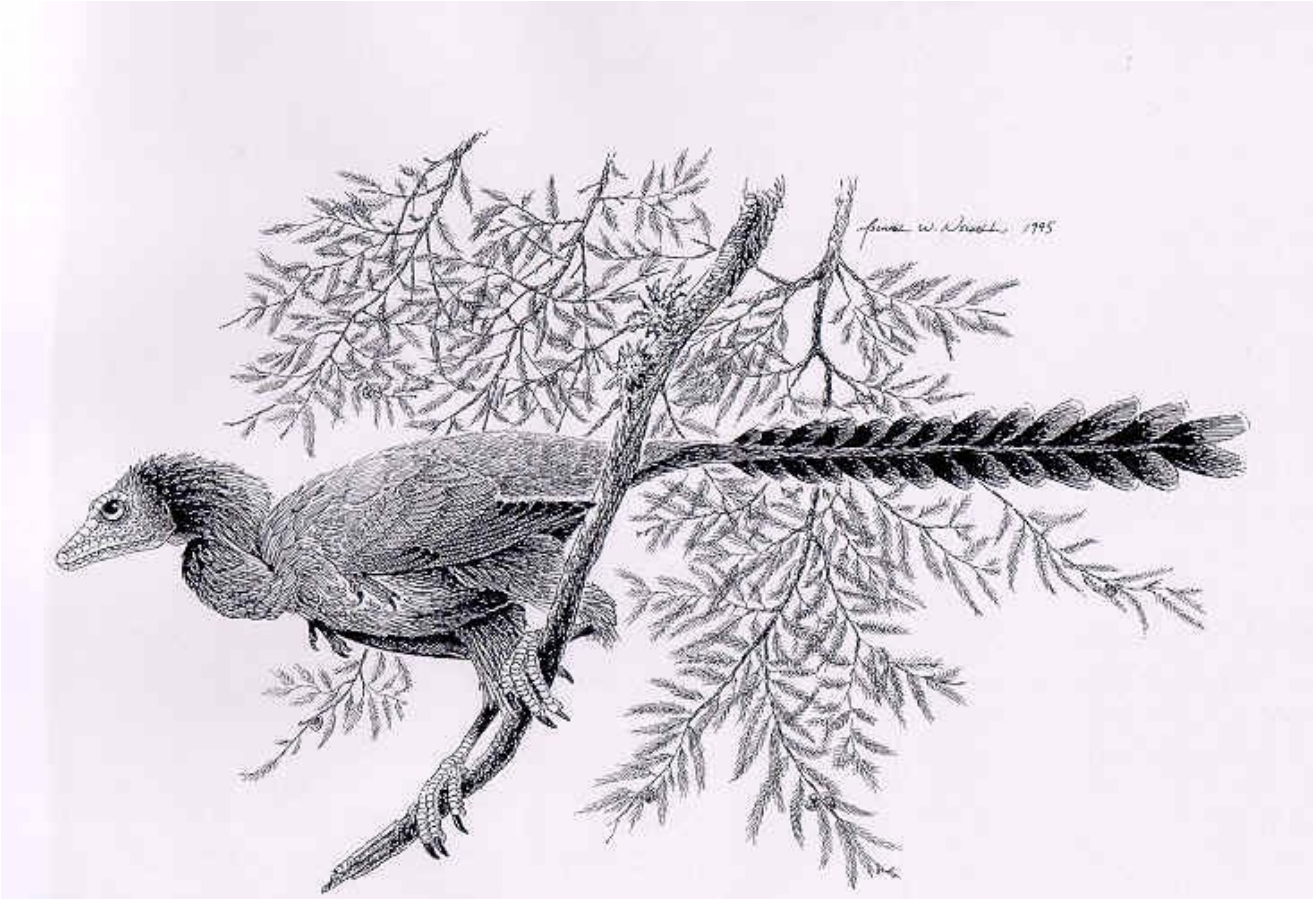
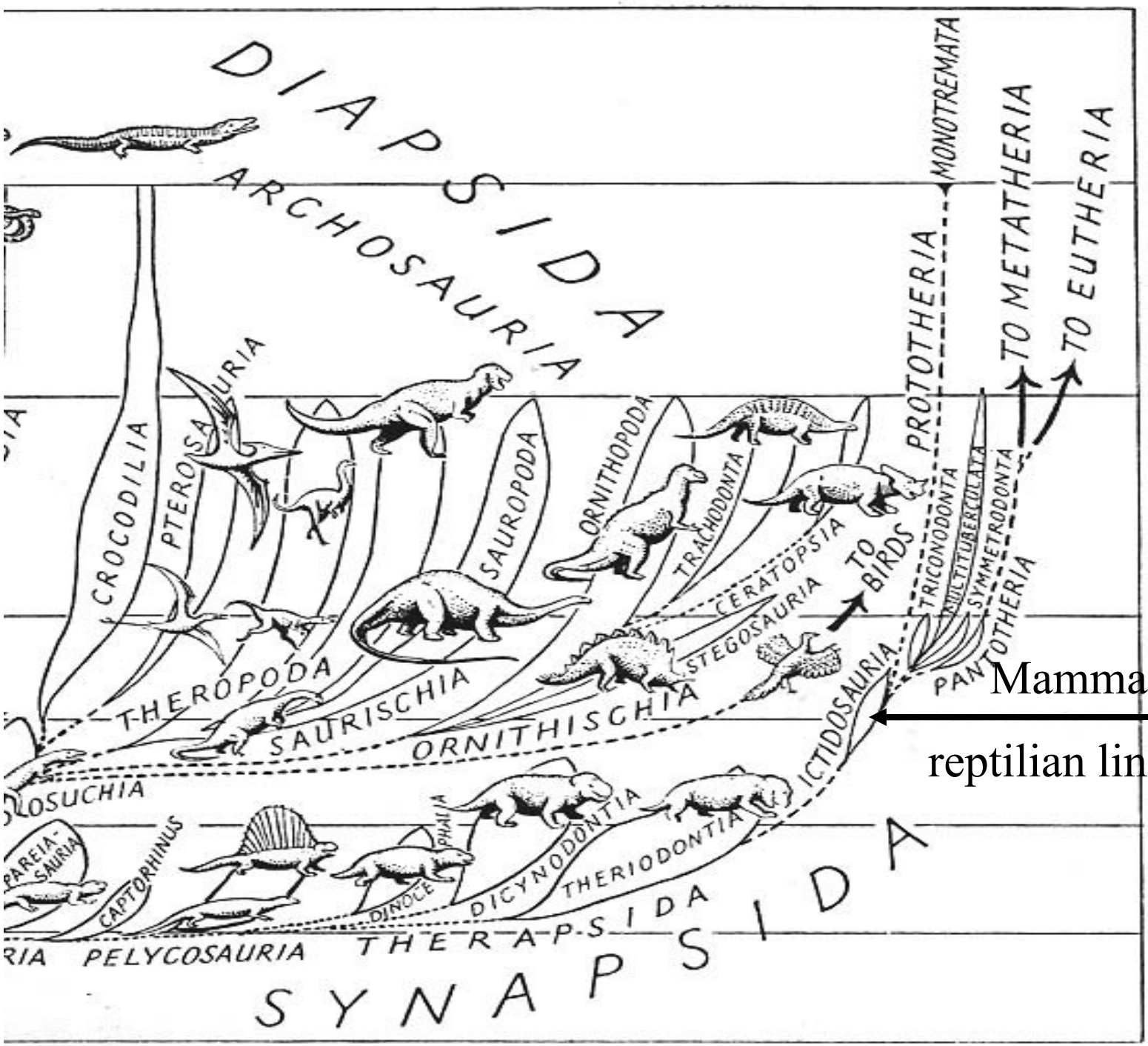


Fig. 23. Life restoration of *Protoavis texensis* in the Late Triassic Dockum landscape of Texas some 225 million years ago; the presence of feather is inferred from quill knobs and feather pattern is based on *Archaeopteryx*.


DIAPSIDA
ARCHOSAURIA
CROCODILIA
PTEROSAURIA
SAUROPODA
ORNITHOPODA
TRACHODONTA
CERATOPSIA
STEGOSAURIA
THEROPODA
SAURISCHIA
ORNITHISCHIA
LOSUCHIA
PAREIA-SAURIA
CAPTORHINUS
DINOCE
PHALIA
DICYNODONTIA
THERIODONTIA
ICTIDOSAURIA
PELYCOSAURIA
THERAPSIDA
SYNAPSIDA
MONOTREMATA
PROTOTHERIA
TO METATHERIA
TO EUTHERIA
TO BIRDS
TRICONODONTA
MULTITUBERCULATA
SYMMETRODONTA
PANTOTHERIA
Mammalian-reptilian line

Primitive
Therapsid Repile

Cynodont
Mammal

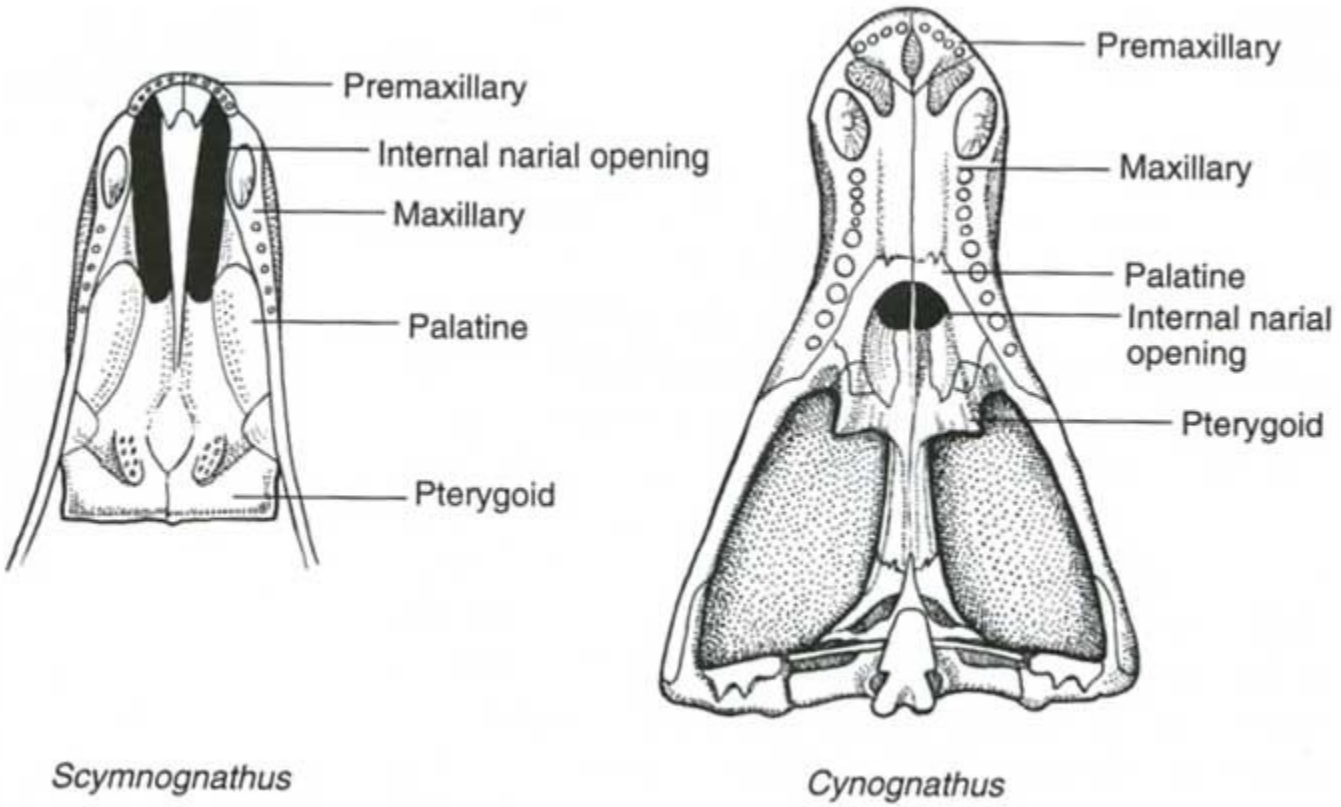
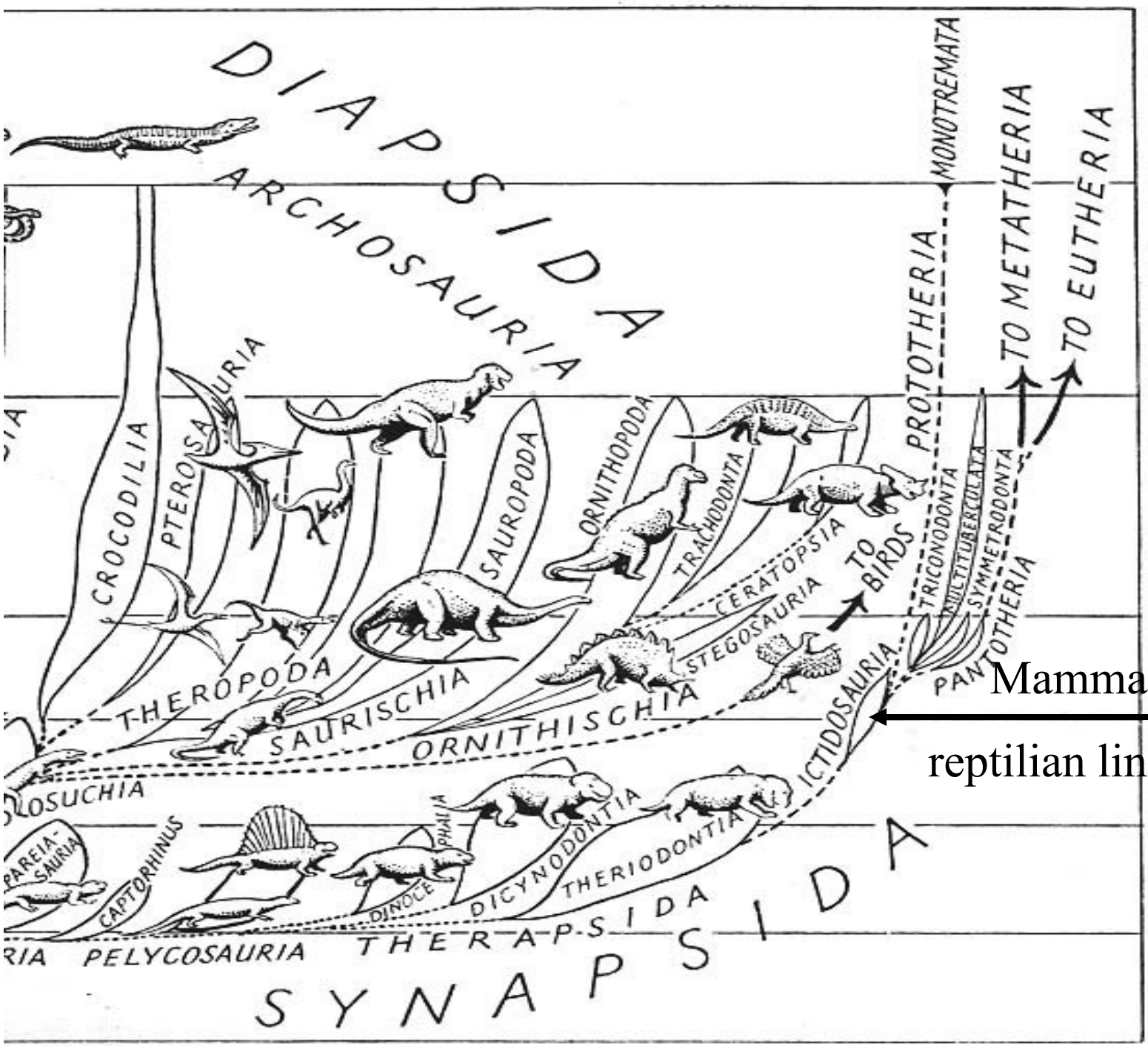


Fig. 3-4


DIAPSIDA
ARCHOSAURIA
CROCODILIA
PTEROSAURIA
SAUROPODA
ORNITHOPODA
TRACHODONTA
CERATOPSIA
STEGOSAURIA
THEROPODA
SAURISCHIA
ORNITHISCHIA
LOSUCHIA
PAREIA-SAURIA
CAPTORHINUS
DINOCE
PHALIA
DICYNODONTIA
THERIODONTIA
ICTIDOSAURIA
PELYCOSAURIA
THERAPSIDA
SYNAPSIDA
MONOTREMATA
PROTOTHERIA
TO METATHERIA
TO EUTHERIA
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TRICONODONTA
MULTITUBERCULATA
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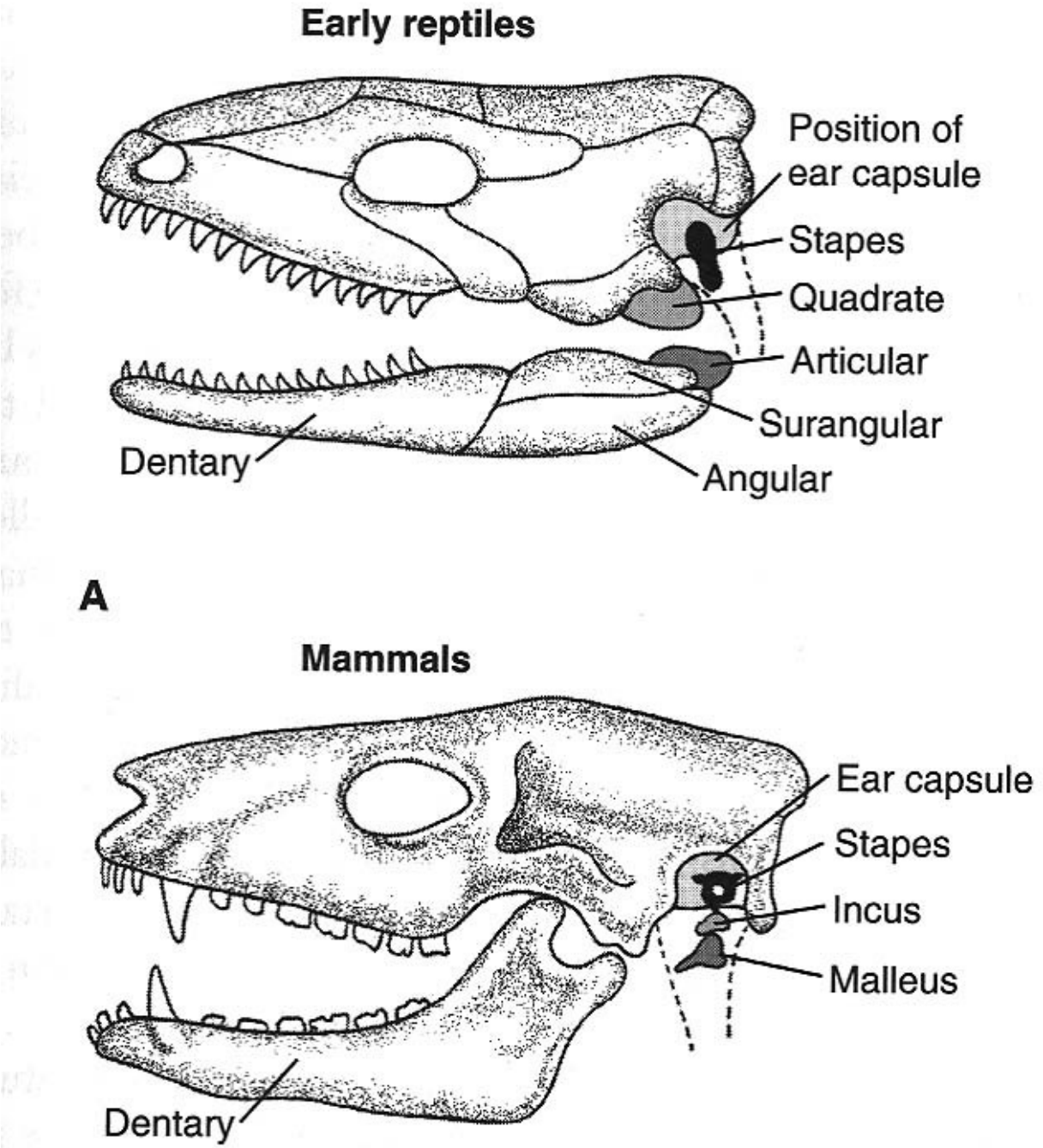
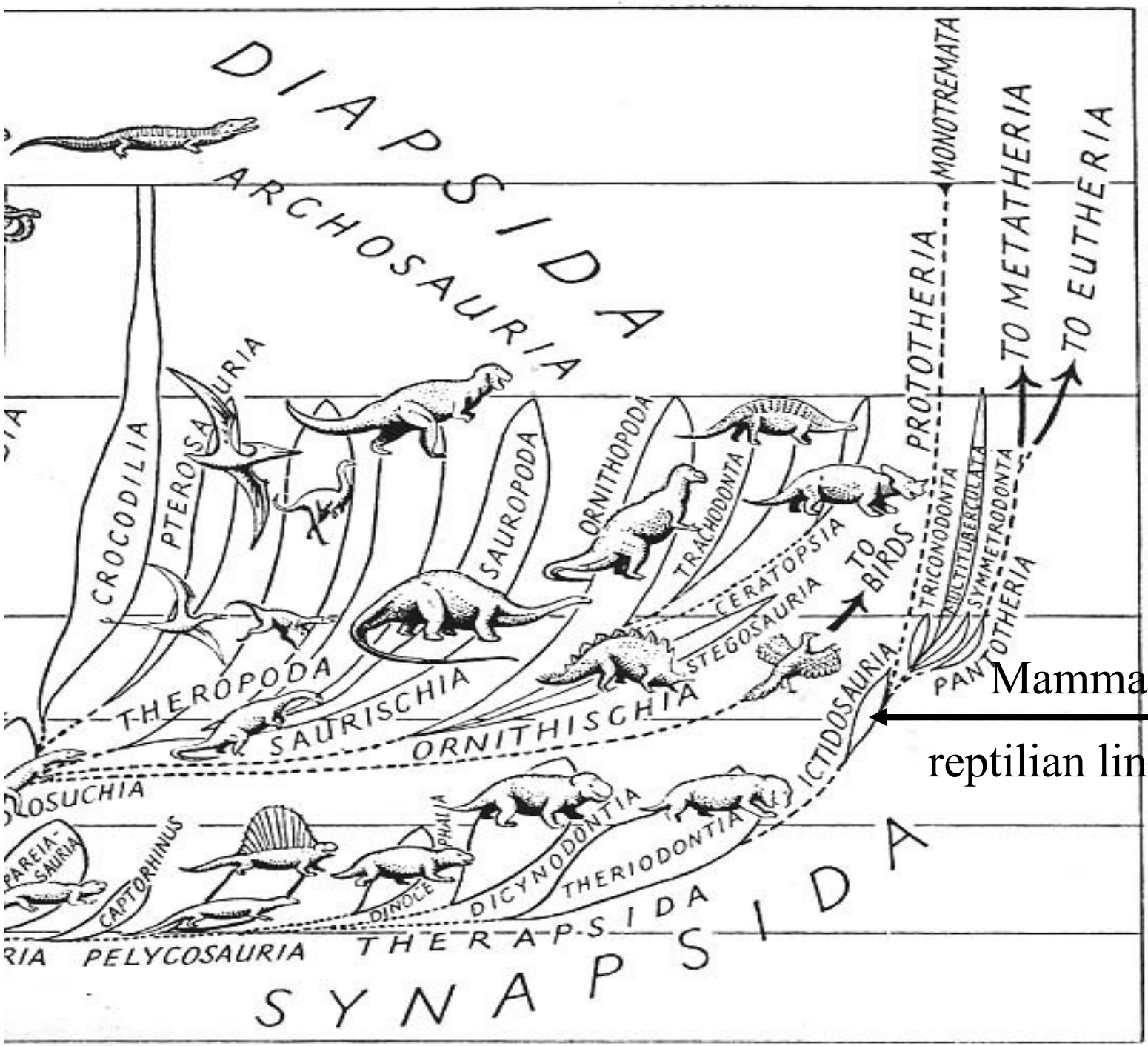


Fig 4.5 Feldhamer


DIAPSIDA
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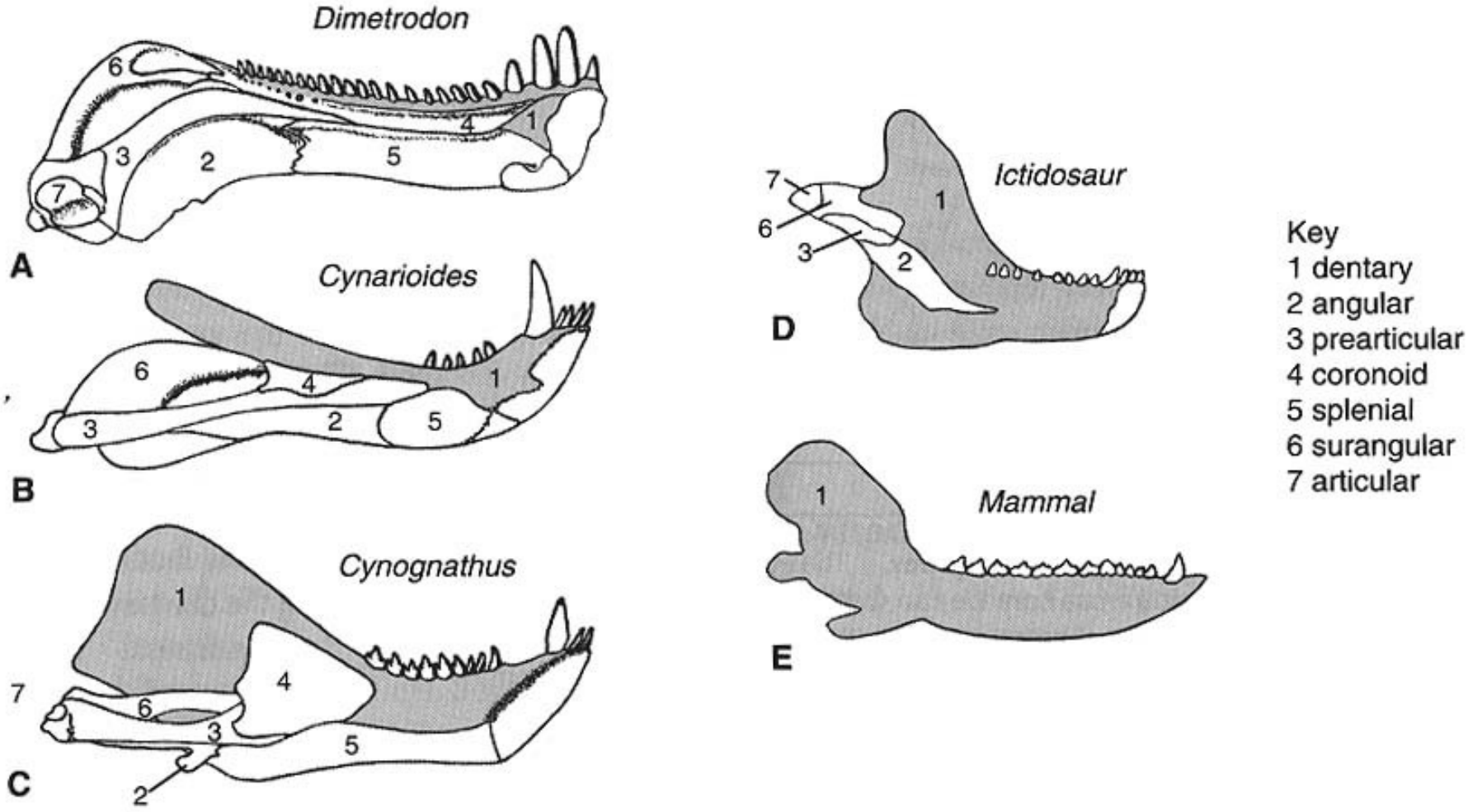
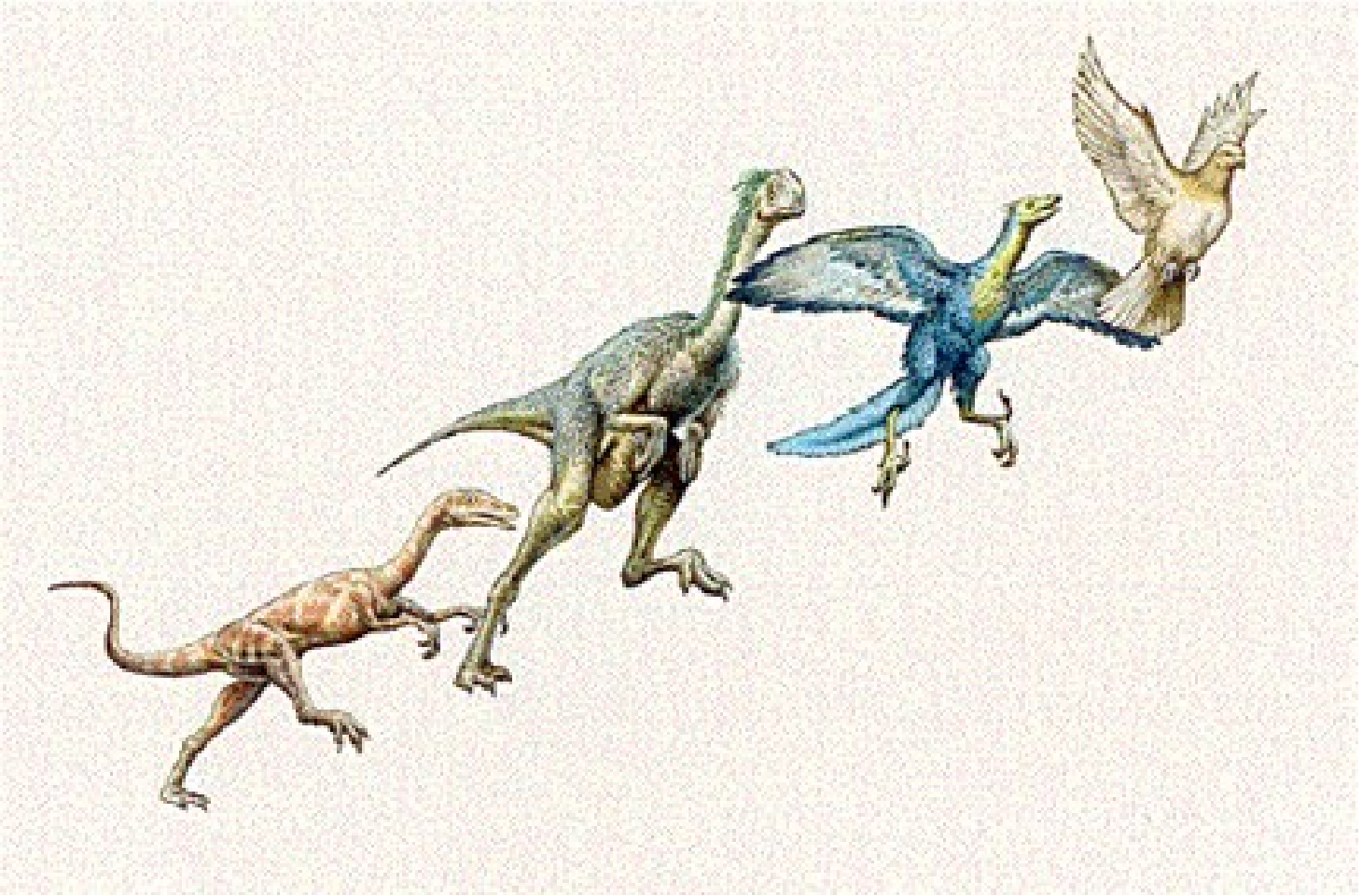


Figure 4.4 Enlargement of the dentary bone. The progressive enlargement of the dentary bone (shaded) and reduction in postdentary bones is evident when comparing jaws of primitive mammal-like reptiles: (A) *Dimetrodon,* an early Permian pelycosaur; (B) Cynarioides, a late Permian therapsid; (C) *Cynognathus,* an early Triassic cynodont; and (D) *Ictidosaur,* a late Triassic–early Jurassic cynodont. The dentary is the sole bone in the jaw of mammals (E).

Warm Blooded Dinosaurs, Reptile Biology, Archosaurs vs. Reptiles



The Warm Blooded Dinosaurs

?
=

Bone structure

- Haversian Canals
- Most cold blooded animals lack this bone structure.

Predator-Prey Ratios: ectothermic?

- Require far less food/energy than warm blooded animals

An adult female rubber boa from southeastern Idaho

Dinosaur Communities

Size of dinosaurs

Superiority of predators

- Mammals generally superior to reptiles

Warm blooded vs. Cold blooded Dinosaurs...

Definitions

- Endothermic: creates heat from inside
- Ectothermic: absorbs heat from outside
- Homeothermic: maintains a constant internal temperature
- Poikilothermic: temperature fluctuates depending on outside conditions

Evidence for endothermic dinosaurs

- Fast things need to have heat available. Many dinosaurs appear to be fast-moving.
- Today, endotherms normally outcompete ectotherms. Since dinosaurs coexisted with known endotherms, they must also have been endothermic.
- Dinosaurs were upright walkers with legs below their bodies - typical of endotherms

Evidence for endothermic dinosaurs

- Dinosaurs had big brains, and endotherms tend to have big brains (but not always, and brain size is correlated with other things, too).
- Ectotherms aren't usually found at high latitudes, and dinosaurs were (but it was warmer)
- Endotherm predator/prey ratio is usually low, and dinosaur ratios match mammals

Evidence for endothermic dinosaurs

- Dinosaurs were big and had large, complex hearts. Complex heart matches modern endotherms.
- Dinosaurs were ancestral to birds, and birds are endotherms.
- Endotherms tend to grow fast, and dinosaurs were big (but who knows how long they lived?
- Dinosaur bone structure matches modern endotherms better than modern ectotherms

Evidence for ectothermic dinosaurs

- Dinosaurs were huge - could have been effectively homeothermic w/o endothermy
- Dinosaurs were huge - couldn't possibly have been endothermic because they'd burn up.
- Mesozoic was warm - dinosaurs didn't need to be endothermic
- Ectotherms tend to be scaly, and dinosaurs were (but so are birds!)

Evidence for ectothermic dinosaurs

- Some dinosaurs show lines of arrested growth (LAGs) in bones. Modern endotherms don't have LAGs (unless stressed), but modern ectotherms do.
- Dinosaurs didn't have respiratory turbinates - bony structures at front of nasal cavity which are covered in mucus, which modern endotherms have.

Five current thermal hypotheses (from UCMP)

- Dinosaurs were complete endotherms, just like birds, their descendants.
- Some or all dinosaurs had some intermediate type of physiology between endothermy and ectothermy.
- We know too little about dinosaurs to hazard a guess at what their physiology was like.
- Dinosaurs were mostly inertial homeotherms; they were ectothermic but maintained a constant body temperature by growing large. Small dinosaurs were typical ectotherms, maybe with a slightly elevated metabolic rate.
- All dinosaurs were simple ectotherms, enjoying the warm Mesozoic climate. But that's okay; many ectotherms are quite active, so dinosaurs could be active, too.