Mesozoic

Modern marine fauna – dominated by bivalves, gastropods, Actinopterygii – Holostei, Teleostei, gymnolemate bryozoans, desmospongians, echimoids, ammonoids, belemnites, hexacoralla, marine reptiles, new crustaceans present (lobsters, crabs), planctonic foraminifers, cocolitophorids

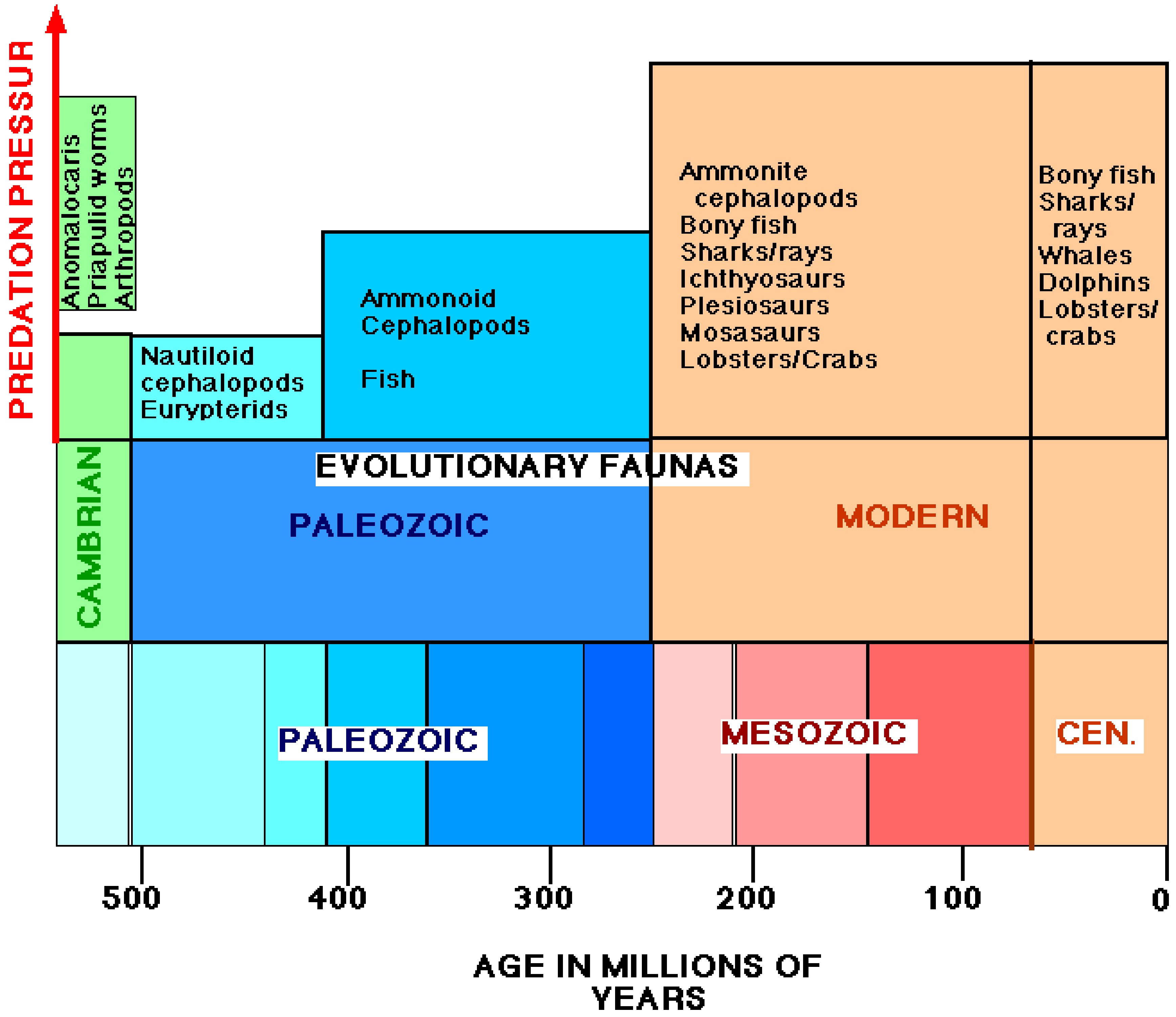
Land – dinosaurs, air - pterosaurs

First mammals – beginning of the Mesozoic, Jurrasic – birds.

Diversification of angiosperms since early Cretaceous, boundary between Mesophytikum and Caenofytikum in middle Cretaceous.

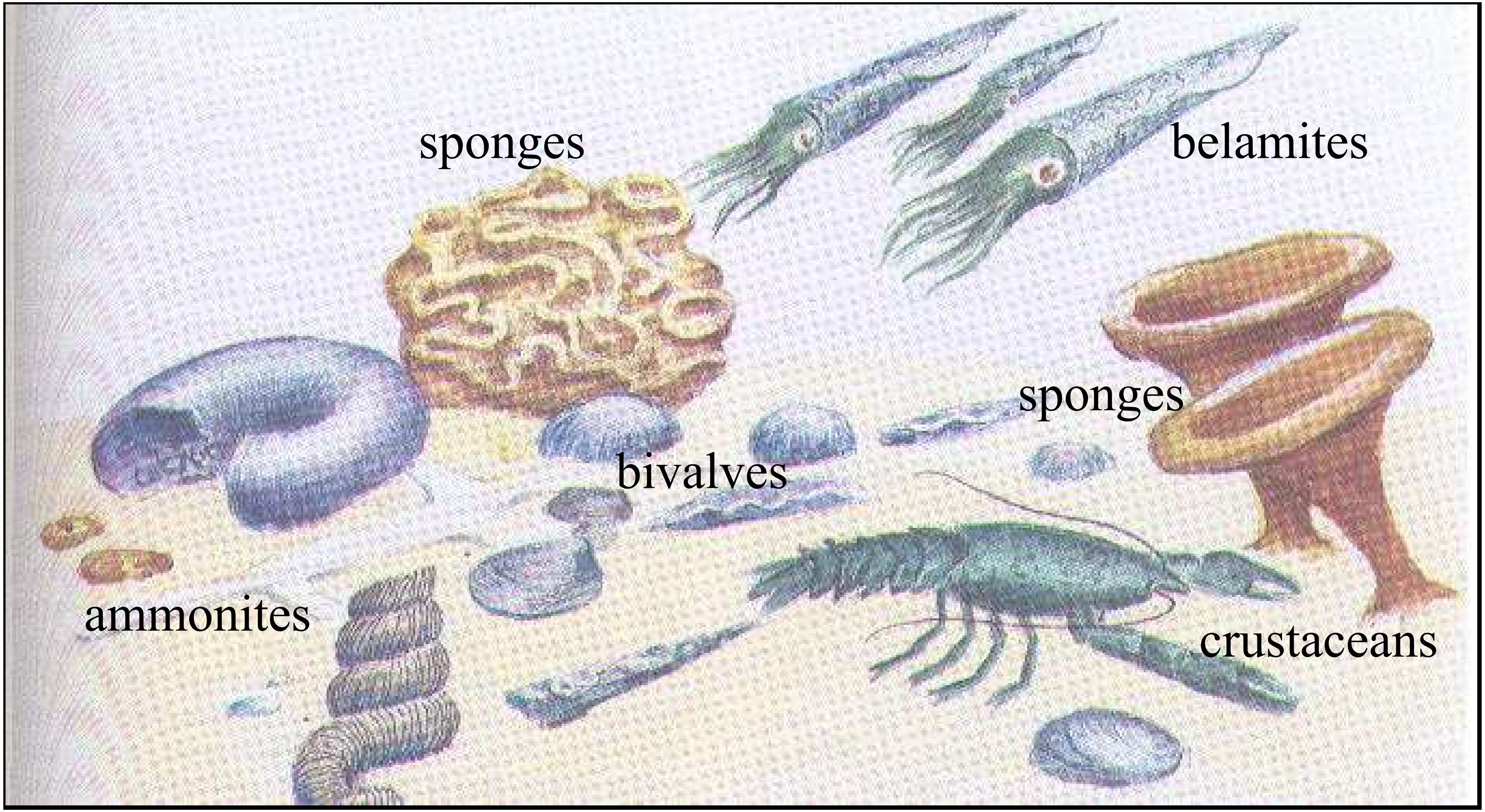
Break-up of Pangea, new oceans(tethys, Indian ocean, North Ice ocean)

Alpine orogeny – closure of Tethys, young mountain belts, nappes. From Atlas to Himalayas.

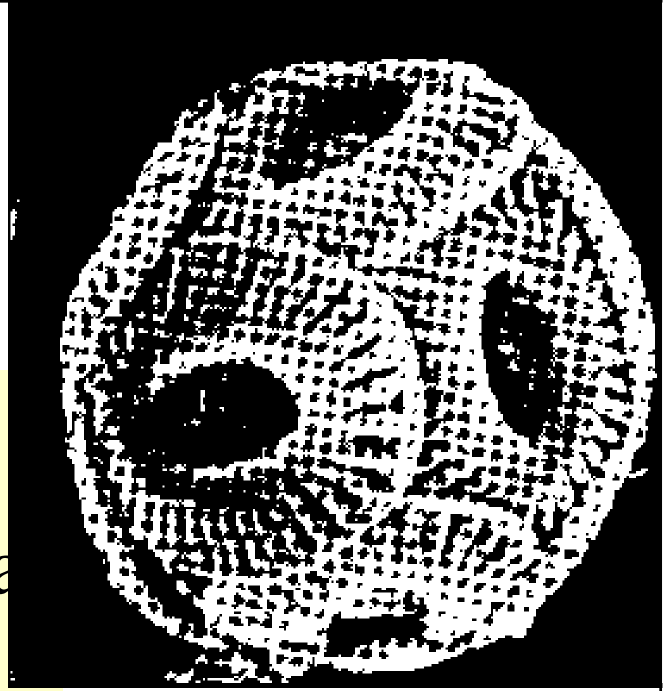

PREDATION PRESSUR
Anomalocaris
Priapulid worms
Arthropods
Nautiloid cephalopods
Eurypterids
Ammonoid Cephalopods
Fish
Ammonite cephalopods
Bony fish
Sharks/rays
Ichthyosaurs
Plesiosaurs
Mosasaurs
Lobsters/Crabs
Bony fish
Sharks/ rays
Whales
Dolphins
Lobsters/ crabs
CAMBRIAN
EVOLUTIONARY FAUNAS
PALEOZOIC
MODERN
PALEOZOIC
MESOZOIC
CEN.
500
400
300
200
100
0
AGE IN MILLIONS OF YEARS

Invertebrate Mesozoic fauna

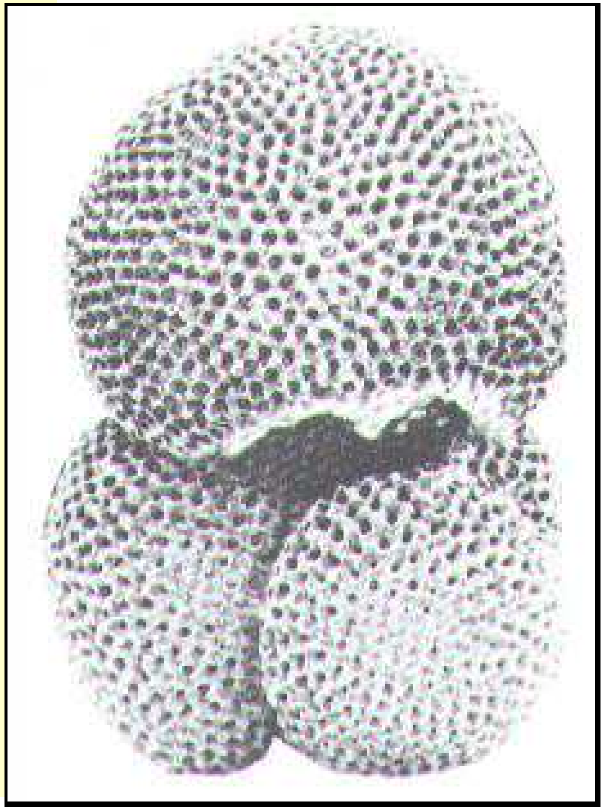
Rudistid clams



Microfossils



- Coccolithophoroids
  - extremely small single-shelled algea
  - produced tiny plates called coccoliths
  - fell to bottom and produced great chalk deposits
- Foraminifera continued to thrive
  - globigerinids built shells of bubble-shaped chambers



Marine vertebrates

- Early Mesozoic had primitive bony fish
- Modern teleost fishes
  - developed by late Jurassic
  - highly mobile jaws and swim bladder
- Marine reptiles (not dinosaurs)
  - plesiosaurs (long necked fish-catchers)
  - icthyosaurs (fish-lizards, dolphin-like reptiles)
  - mosasaurs (related to monitor lizards)

Terrestrial flora

Gymnosperms (seed-bearing plants)

- dominated most of Mesozoic
- modern conifers are members of this class
- Angiosperms (flowering plants)
  - began to dominate in Late Cretaceous
    - flowers to attract pollinating birds and insects
    - fruit eaten by animals to help spread seeds
    - generally grew, regenerated, and reproduced faster
    - better adapted for surviving grazing by dinosaurs

Mammals

- Developed from latest Late Triassic synapsids
  - remained mouse-sized
  - did not compete with dinosaurs in their niches
    - developed mammary glands
    - endothermic and homothermic--required high food intake
    - jaw muscles and teeth well adapted for catching prey
    - soft palate to separate breathing from eating passages
  - mid-Cretaceous divergence into two groups
    - placentals (young carried in uterus until ready for birth)
    - marsupials (pouched mammals)
      - young crawl to pouch to finish development
        - » oppossum, kangaroo, koala, etc.

Dinosaur groups

- Two major groups based on pelvis shape
  - Saurischian (lizard-hipped)
    - sauropods (brontosaurus, etc.)
    - theropods (two-legged carnivores)
    - birds eventually developed from this line
  - Ornithiscian (bird-hipped)
    - all herbivorous
      - Anklyosaurs
      - Stegosaurs
      - Hadrosaurs, Pachycephalosaurs
      - Iguanodonts
      - Ceratopsids

STÁŘÍ (Ma)	ERATEM	ÚTVAR	ODDĚLENÍ	STUPEŇ
65	MESOZOIKUM	KŘÍDA	SVRCHNÍ	maastricht
				campan
				santon
				coniac
				turon
				cenoman
			SPODNÍ	alb
				apt
				barrem
				hauteriv
				valangin
				berrias
144		JURA	SVRCHNÍ (MALM)	tithon
				kimmeridž
				oxford
			STŘEDNÍ (DOGGER)	callov
				bathon
				bajok
				aalen
			SPODNÍ (LIAS)	toark
				pliensbach
				sinemur
				hettang
208		TRIAS	SVRCHNÍ	rhaet
				nor
				carn
			STŘEDNÍ	ladin
				anis
245			SPODNÍ	scyth (werfen)

Keuper

Muschelkalk

Buntsandstein

Obr. 62. Základní členění mesozoika.

The base of the Triassic System is defined at the first occurrence of the conodont species *Hindeodus parvus* in the evolutionary lineage *Hindeodus latidentatus - Hindeodus parvus - Isarcicella isarcica* at the base of Bed 27c in the Meishan Section, Changxing County, Zhejiang Province, China

Base of Jurrasic - Guide event is undecided

Base of Cretaceous - Guide event is undecided

Base of Tertiary - Iridium geochemical anomaly. Associated with a major extinction horizon (foraminifers, calcareous nannofossils, dinosaurs, etc.);

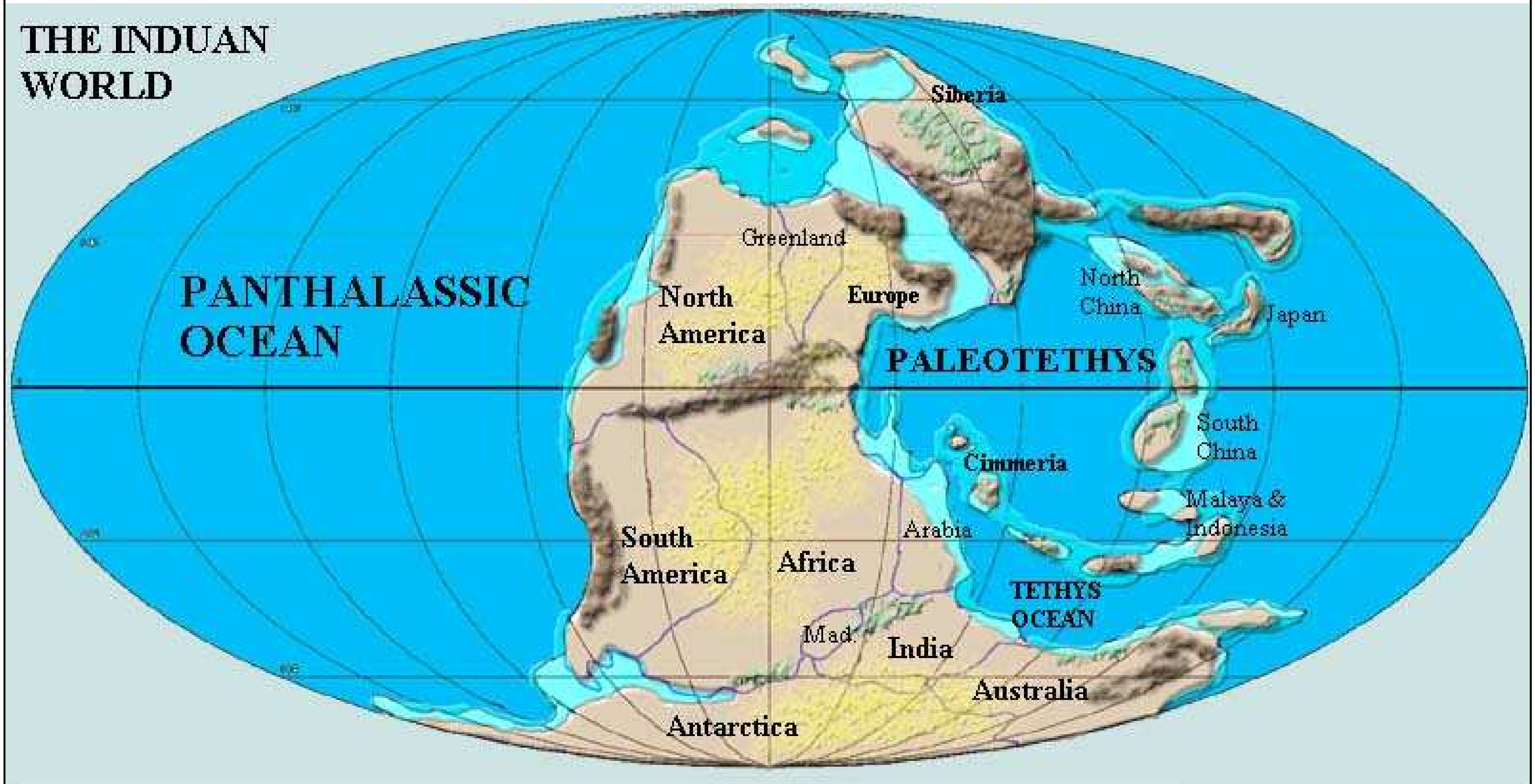
Triassic – Buntsandstein, Muschelkalk, Keuper, German development. Alpine development – Vindelic land,. Communication – Burgund and Moravian gate.

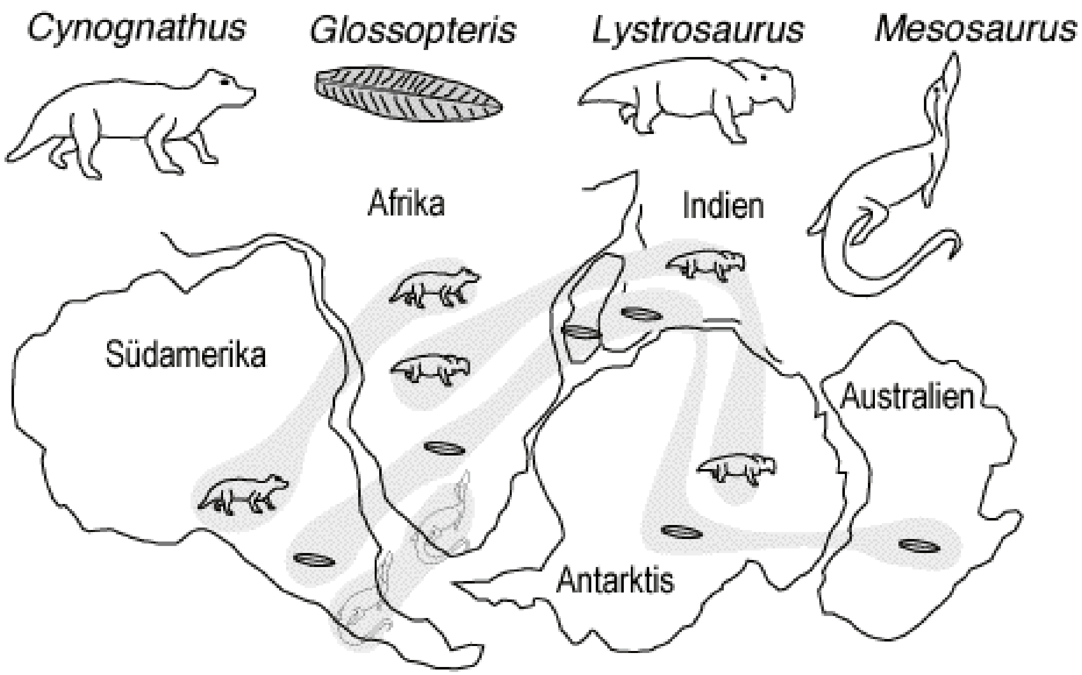
Jurrasic –Jura Mountains. Old Cimmer phase, Young Cimmer phase. Black, brown and white Jurrasic. 70 ammonite zones

Cretaceous – chalk. Extinction. Neokomian, Senonian.

Paleogeography and tectonic processes

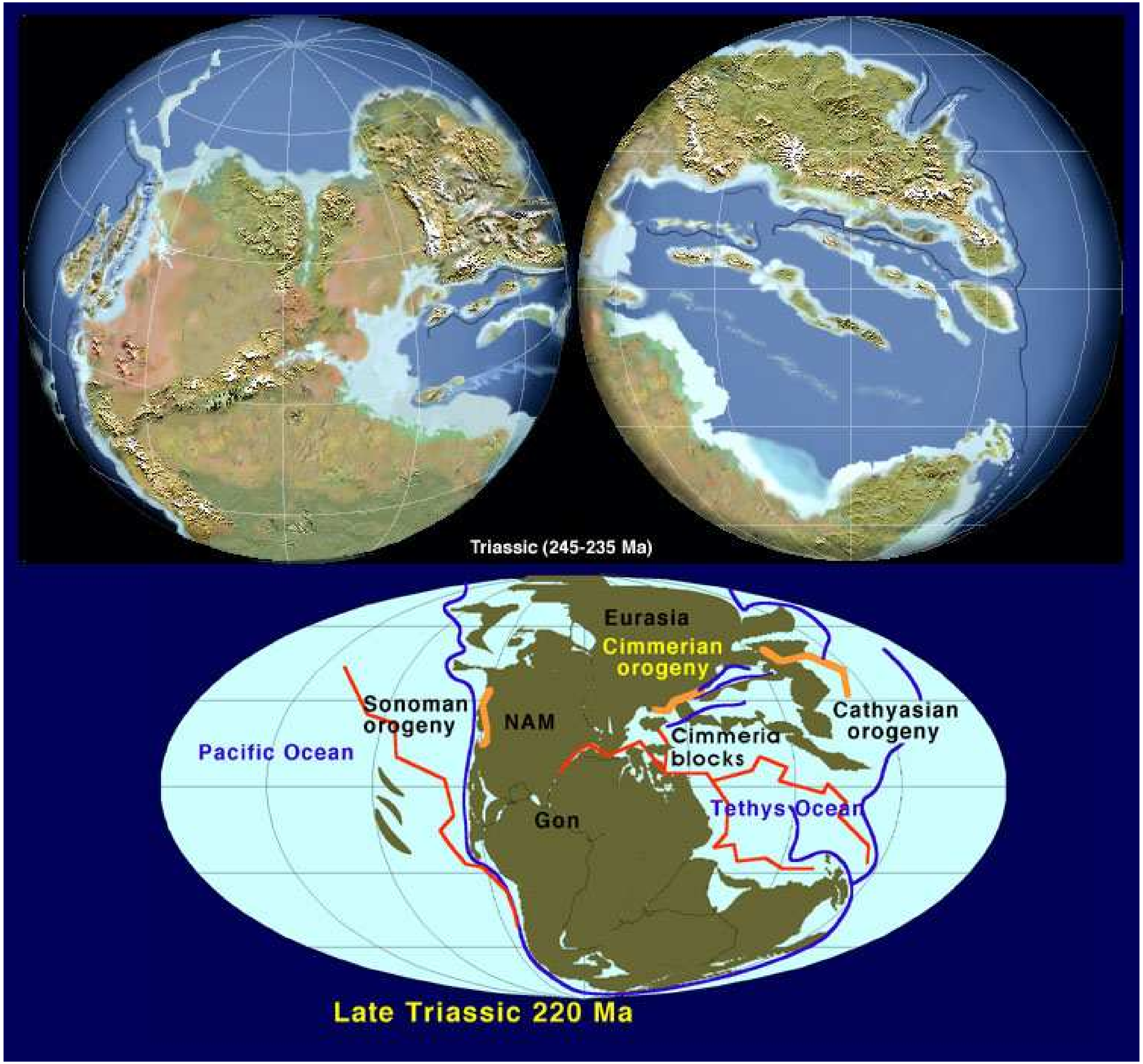
Pangea – Lystrosaurus, aride climate.

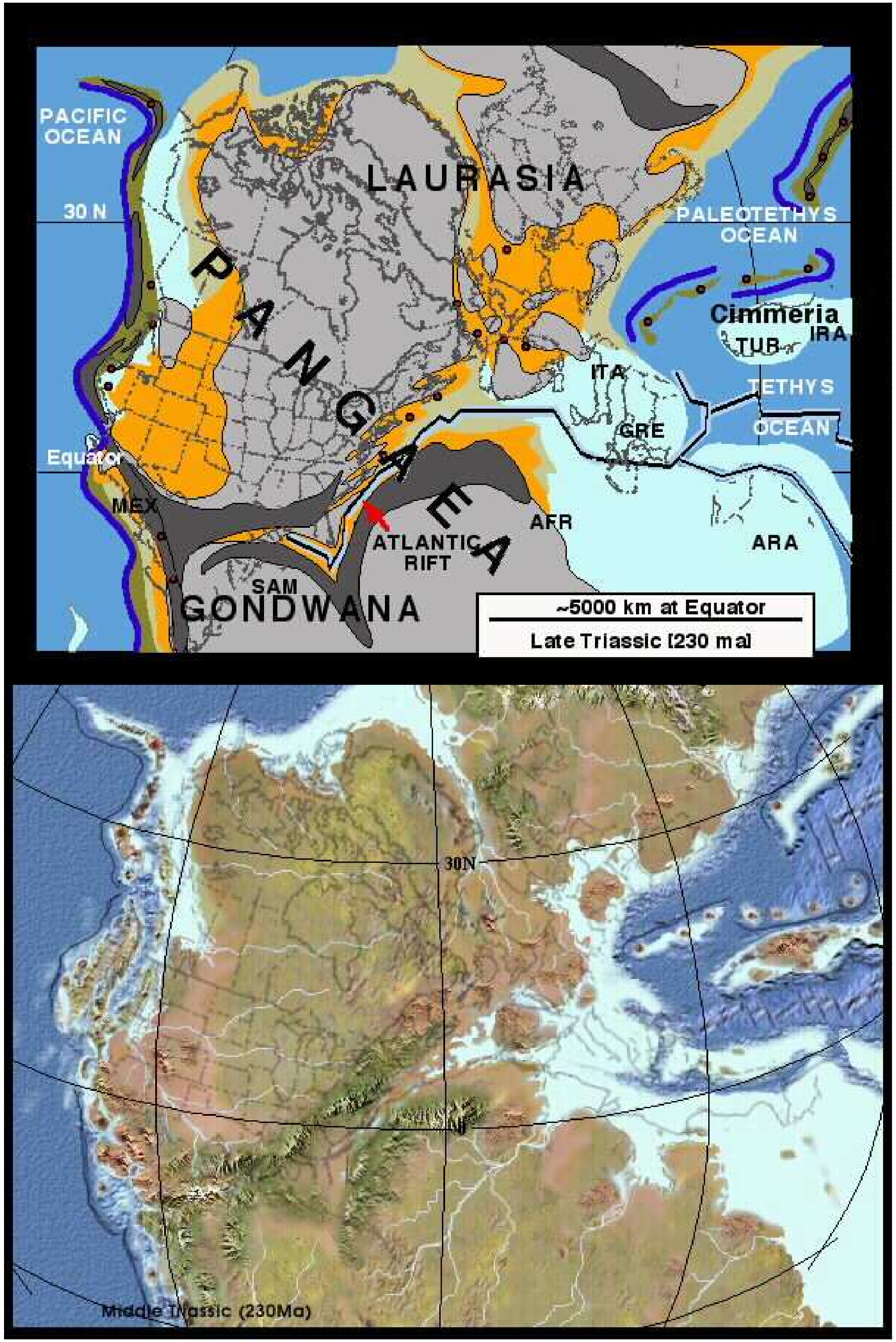




Verbreitung von Fossilien über die südlichen Kontinente von Pangaea

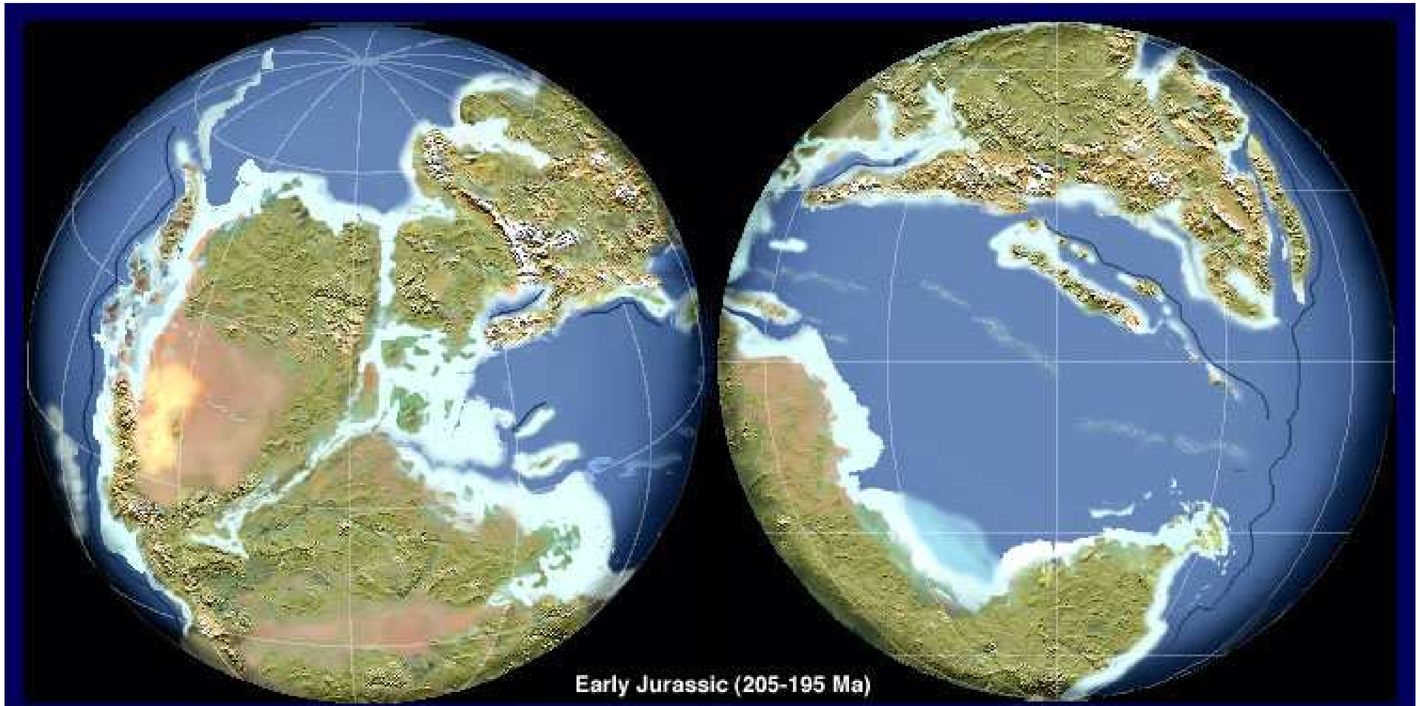
Otevírání Atlantiku začalo vytvářením příkopů a halfgrabenů již v permu a triasu.

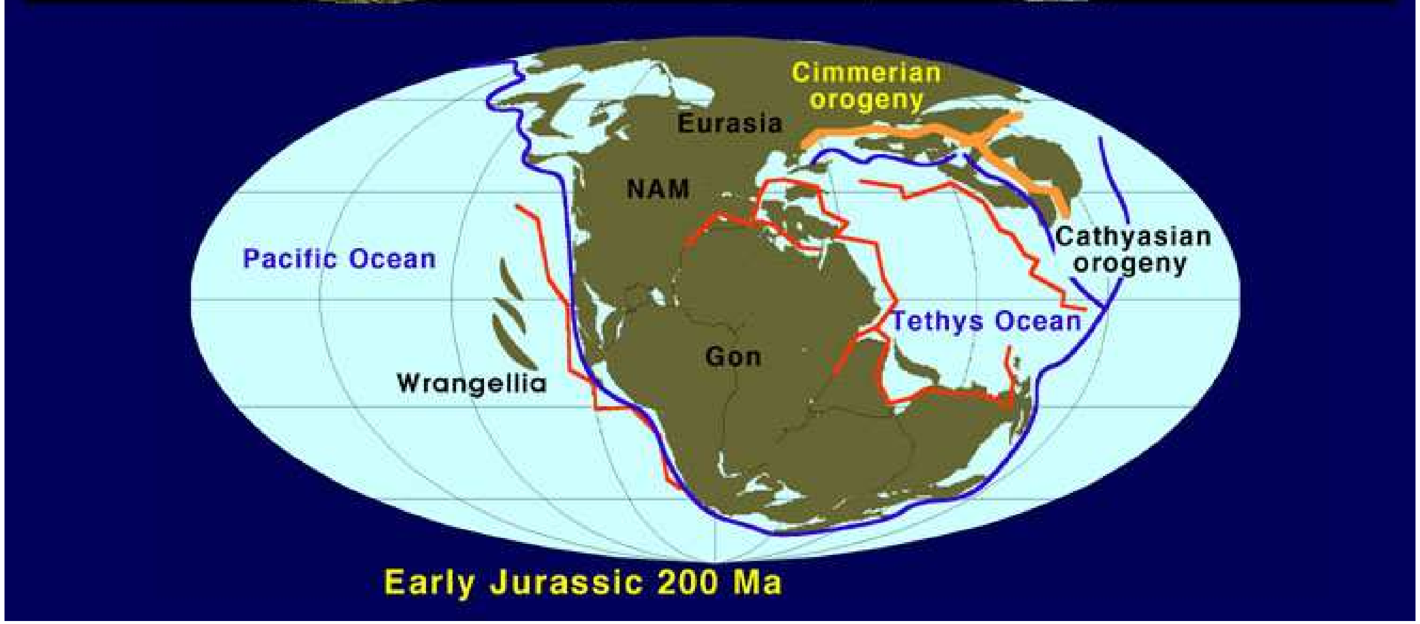


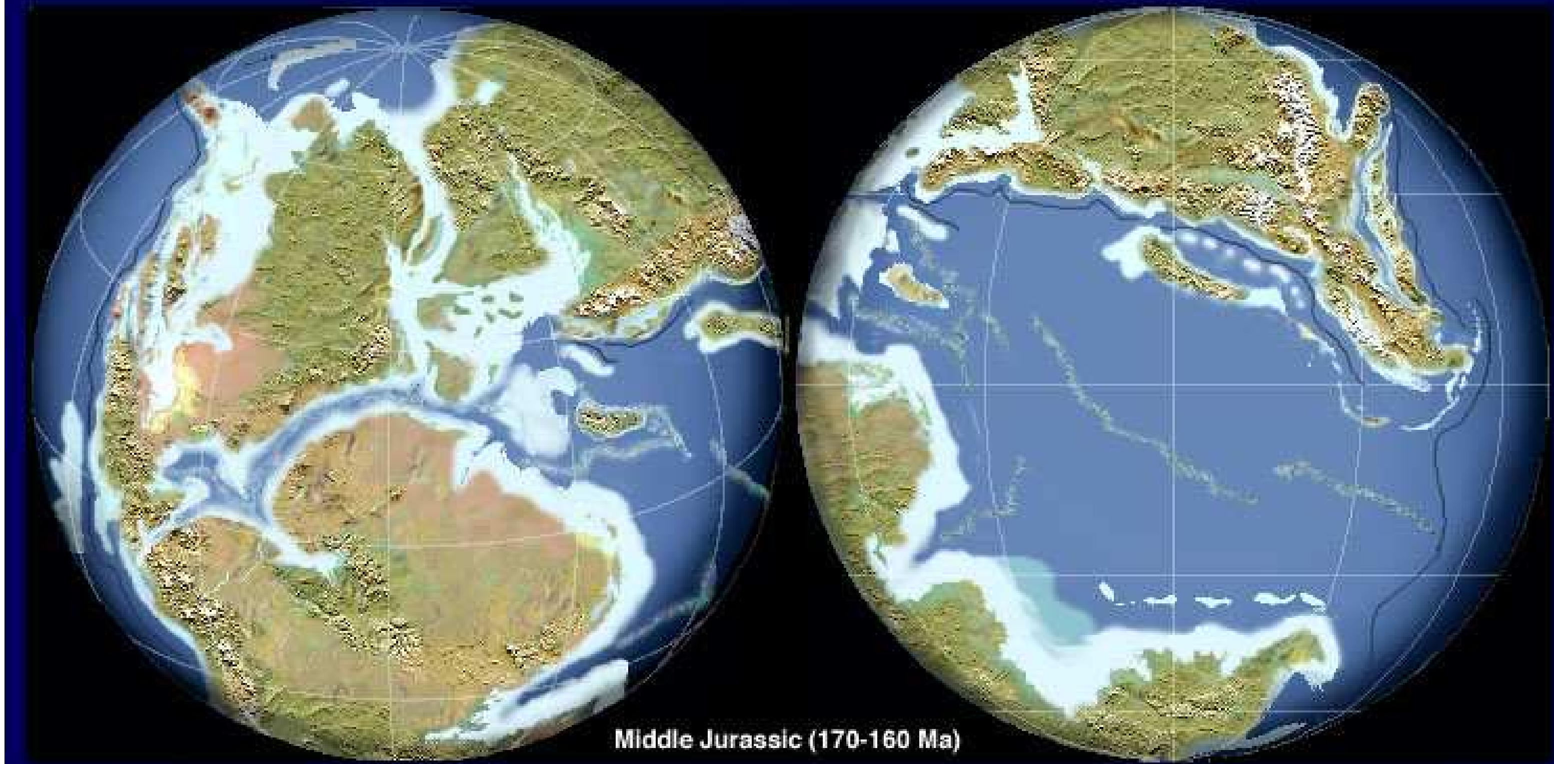


During latest Triassic: **rifting in mid-Pangaea** (between North America + Europe and Africa).

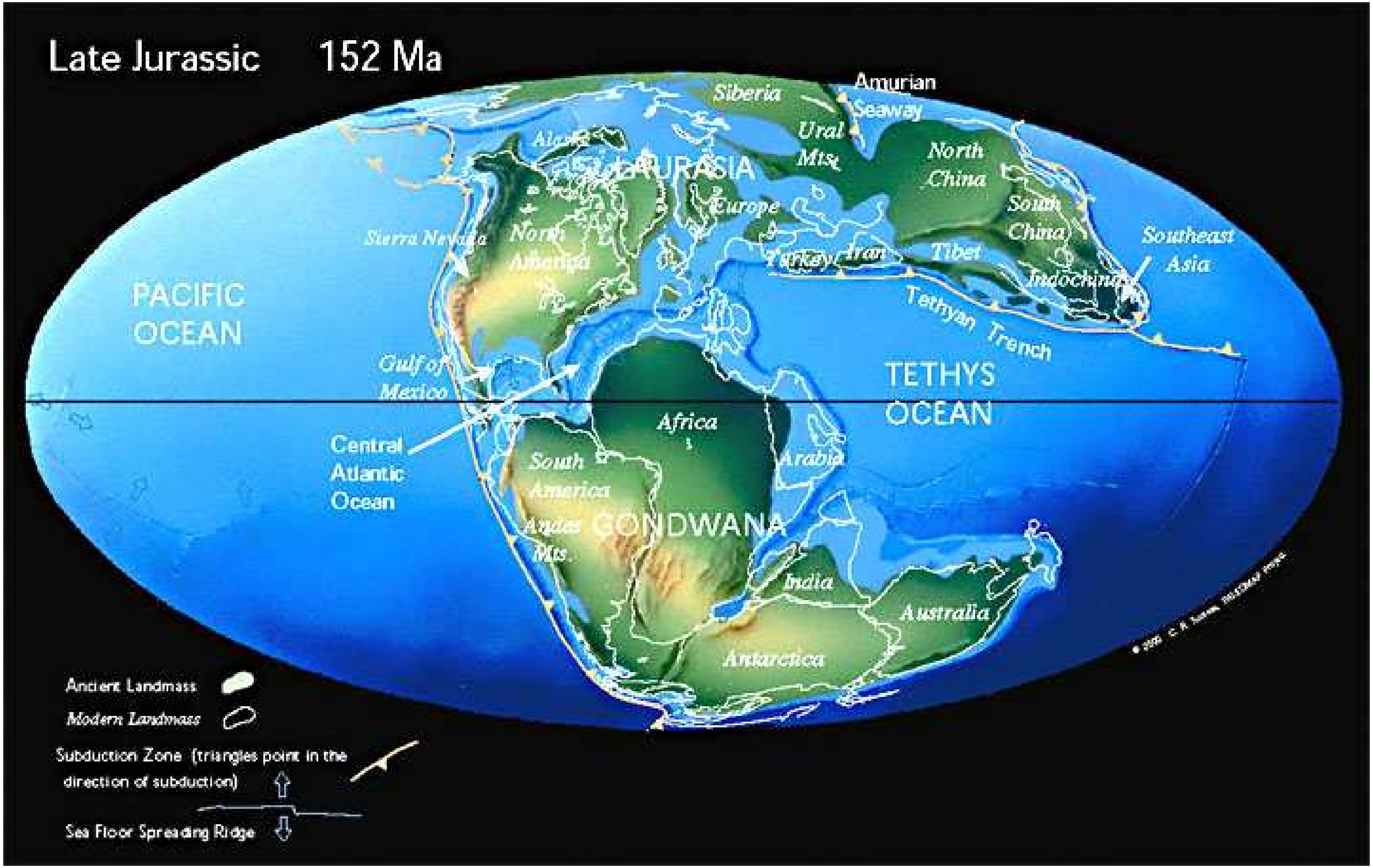
At the beginning of Jurrasic Pangea was still relatively compact.
During Jurrasic Tethys opened progressively more to the west to western Europe Basic and ultrabasic volcanism, radiolarites.







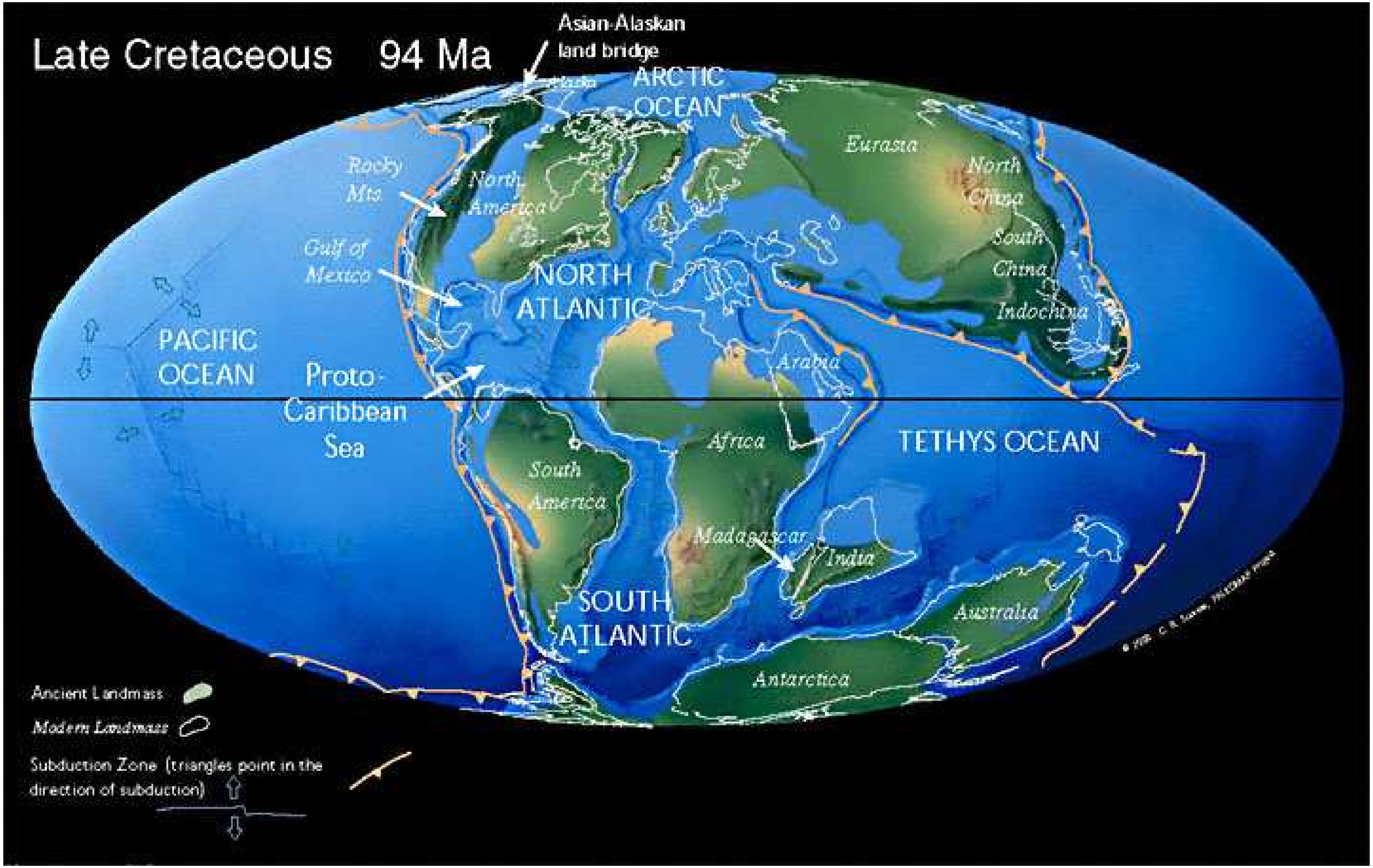
Middle Jurassic160 Ma



In the Late Jurassic the Central Atlantic Ocean was a narrow ocean separating Africa from eastern North America. Eastern Gondwana had begun to separate form Western Gondwana

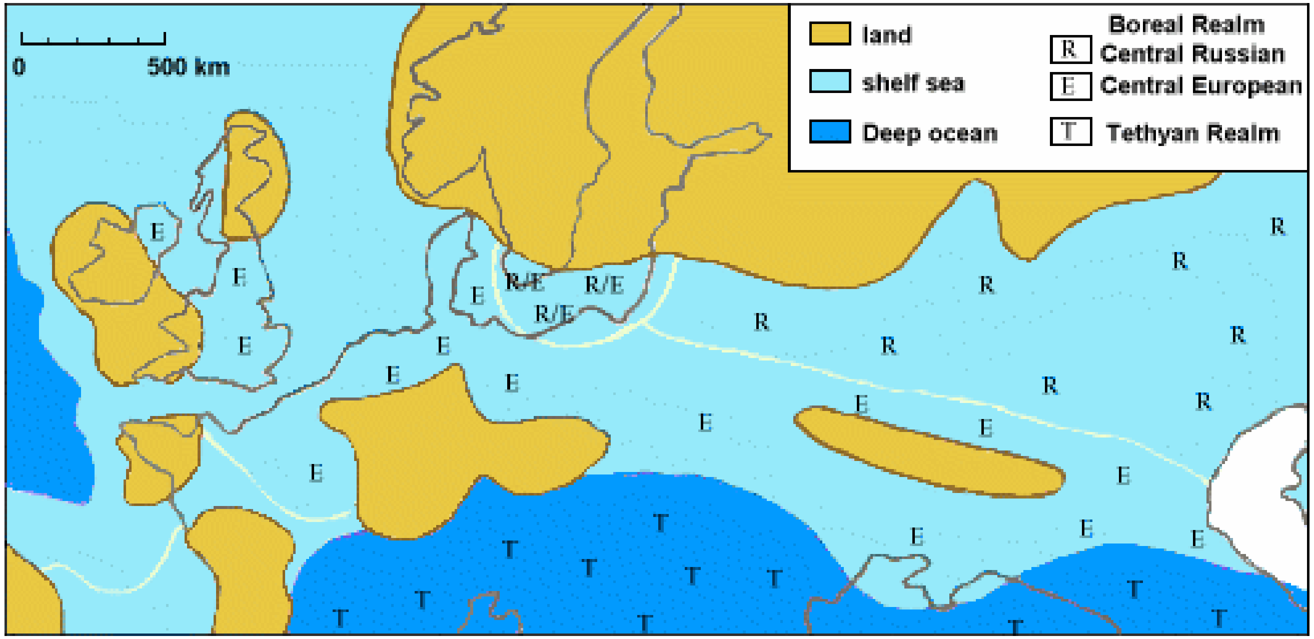
During Cretaceous a block
of Antarctida, Australia and
India separated from Africa.
Distribution of placentals
and marsupials.

Early Cretaceous130 Ma



During the Cretaceous the South Atlantic Ocean opened. India separated from Madagascar and raced northward on a collision course with Eurasia. Notice that North America was connected to Europe, and that Australia was still joined to Antarctica.

Tethyan Realm – Diceras, Nerinea in Jurrasic, other rudists, Nerinea and Globotruncana in Cretaceous.



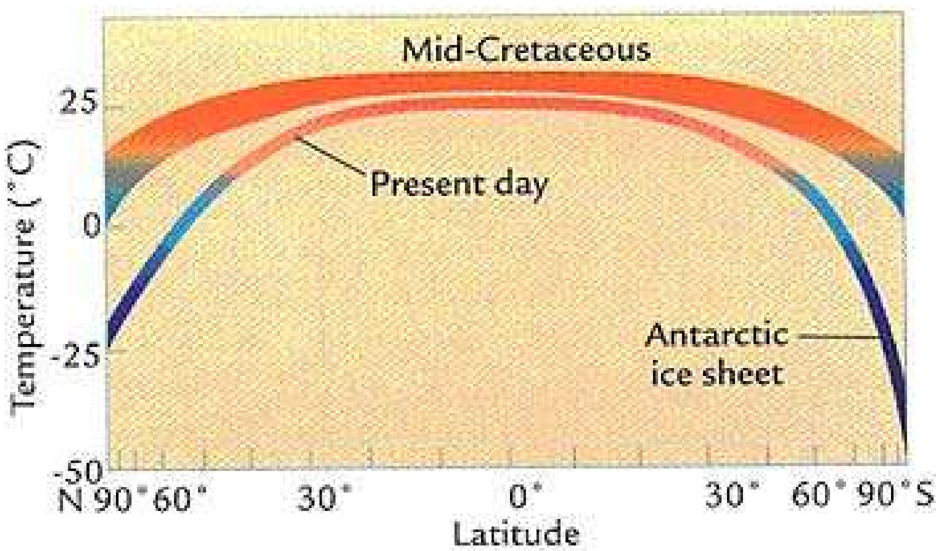
Boreal Realm – clastic sedimenst, Virgatites, Cylindroteuthis, Bositra in Jurrasic, Globigerina in Cretaceous.

Climate

Triassic – aride, similar to Permian

Jurrasic - warmer than today thermophilous cycases up to 60 degrees northern latitude, thermophilous flora even in Gondwana and Siberia.

Cretaceous – warm and humid, subtropic vegetation up to 70 degrees of northern latitude. End of Cretaceous – cooling.



Alpine orogeny

Closing oceans between Gondwana and Eurasia.

7 phases

1) Labine – carn
2) Old Cimmerian – Triassic/Jurassic
3) Young Cimmerian – Jurassic/Cretaceous
4) Austrid – before Cenomanian
5) Mediterranean – before Senonian
6) Subhercyn – Senonia
7) Laramid – Cretaceous/Teriary

Cimmerian orogeny – eastern Tethys

During Triassic to early Cretaceous divergent movements predominated between Africa and Epivariscan platform of Europe. Late Cretaceous – convergence, main phases of folding

Mesozoic flora

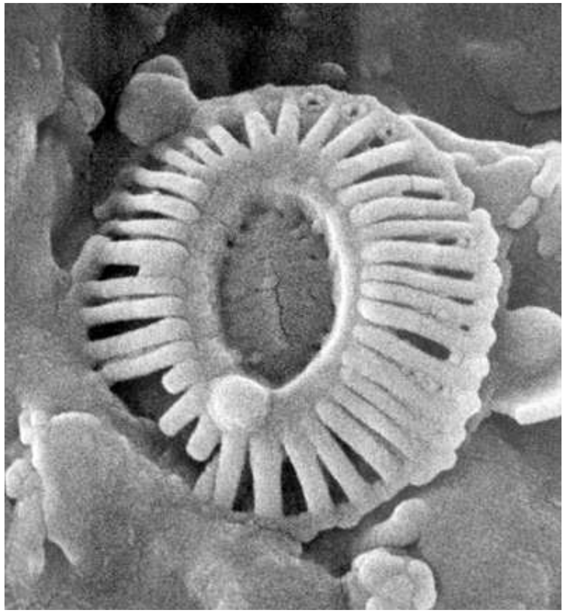
Algae

Triassic – rock-forming and stratigraphic role of Dasycladaceans. Wetterstein Limestones.

Red algae – the beginning of Mesoczoic still Solenoporacea, maximal development in Jurassic, in Cretaceous dominance of Corallinacea.

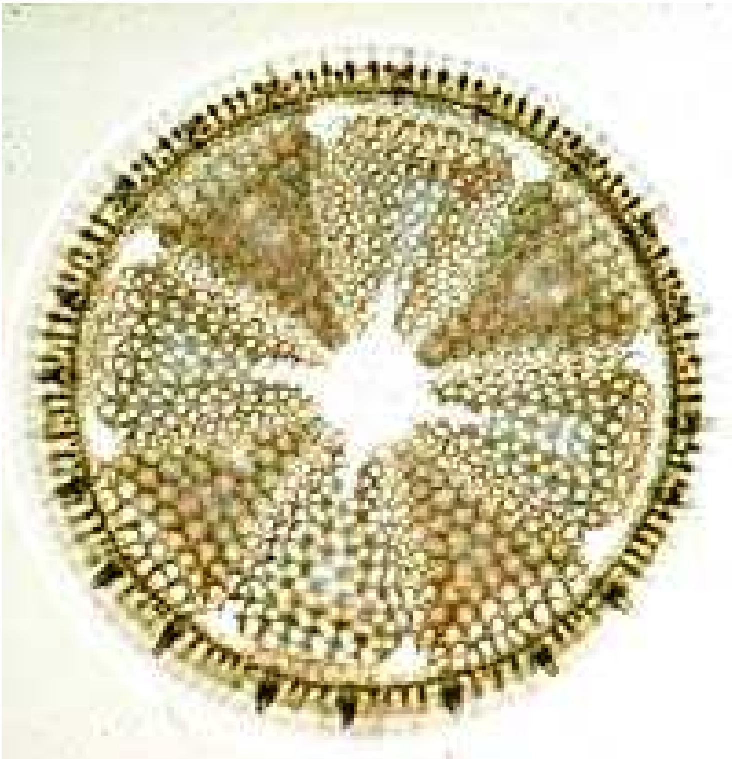
In Jurassic and especially Cretaceous diversification of marine microflora. In Jurrassic – explosive evolution of Dinoflagellates, another explosive phase in Cretaceous. Cretaceous last expansion of acritarchs. Growing role of calcareous nanoplankton in Jurassic and especially Cretaceous.

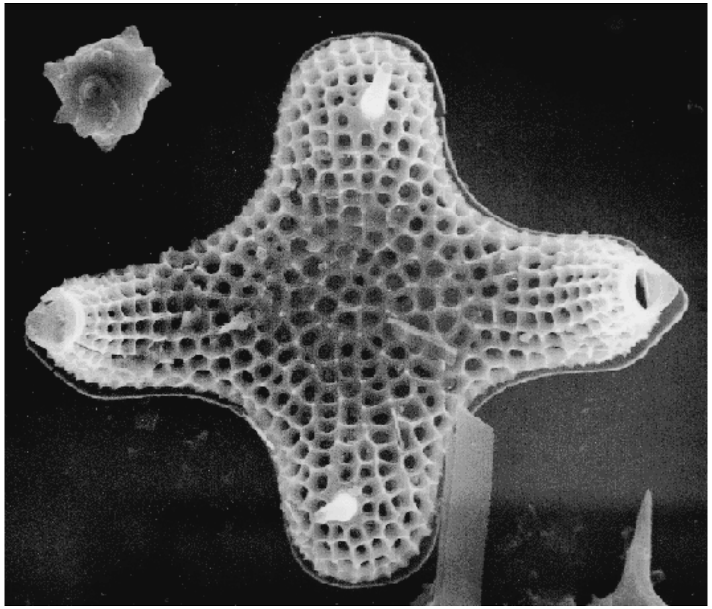
Chalk – epicontinental seas, 200-300m depth



Expansion of Diatomaceae in Cretaceous, together with dinoflagellates and calcareous nannoplankton Main photosynthetic group.

Bacillariophyta (The Diatoms)





Algae

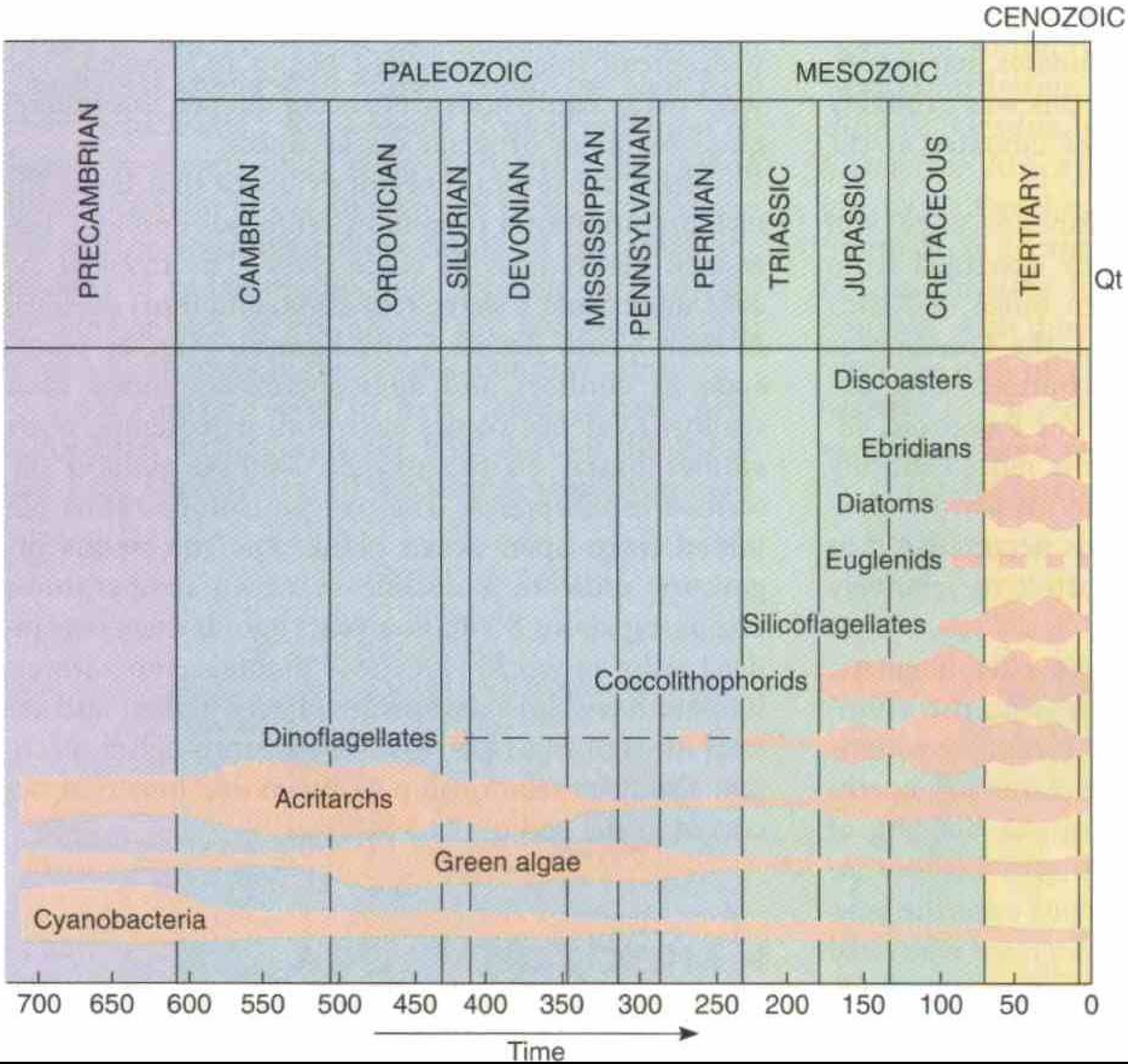
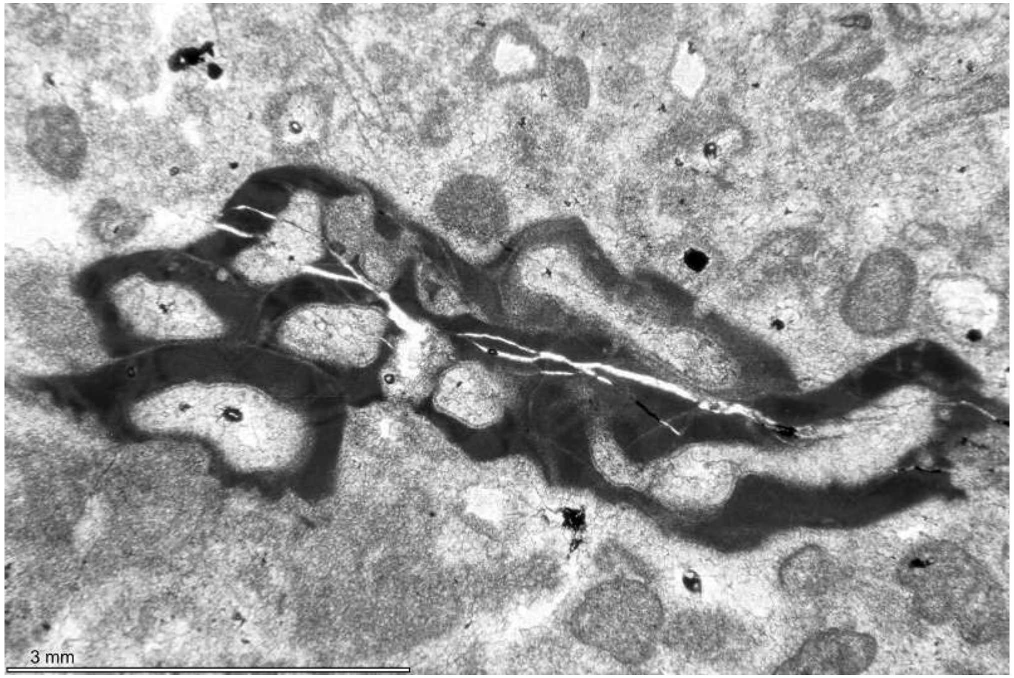


FIGURE 12–2 Geologic distribution and abundances of phytoplankton. *(From Tappan, H., and Leoblich, A. R., Jr. 1970.* Geol. Soc. Am. Special Paper *127:257.*

Triassic – rock-forming Tubiphytes, rock-forming and stratigraphic role of Dasycladaceans. Wetterstein Limestones.

Tubiphytes



Higher plants

Mesophytikum – dominance of gymnosperms.

In **Triassic** 3 groups – cycases, conifers, and ginkgos. Cycases – similar to palms, their dominance up to Jurassic. In Jurassic expansion of related group bennetites (extinct in late Cretaceous). Since early Cretaceous retreat.

Conifers – in Triassic still Voltziales (Voltzia). During Triassic nearly all modern families appear. Expansion in Jurassic, in early Cretaceous dominant group of gymnosperms. Since late Cretaceous higher latitudes,

Ginkgos – abundant especially in Jurrasic-early Cretaceous.Today only Ginkgo biloba.

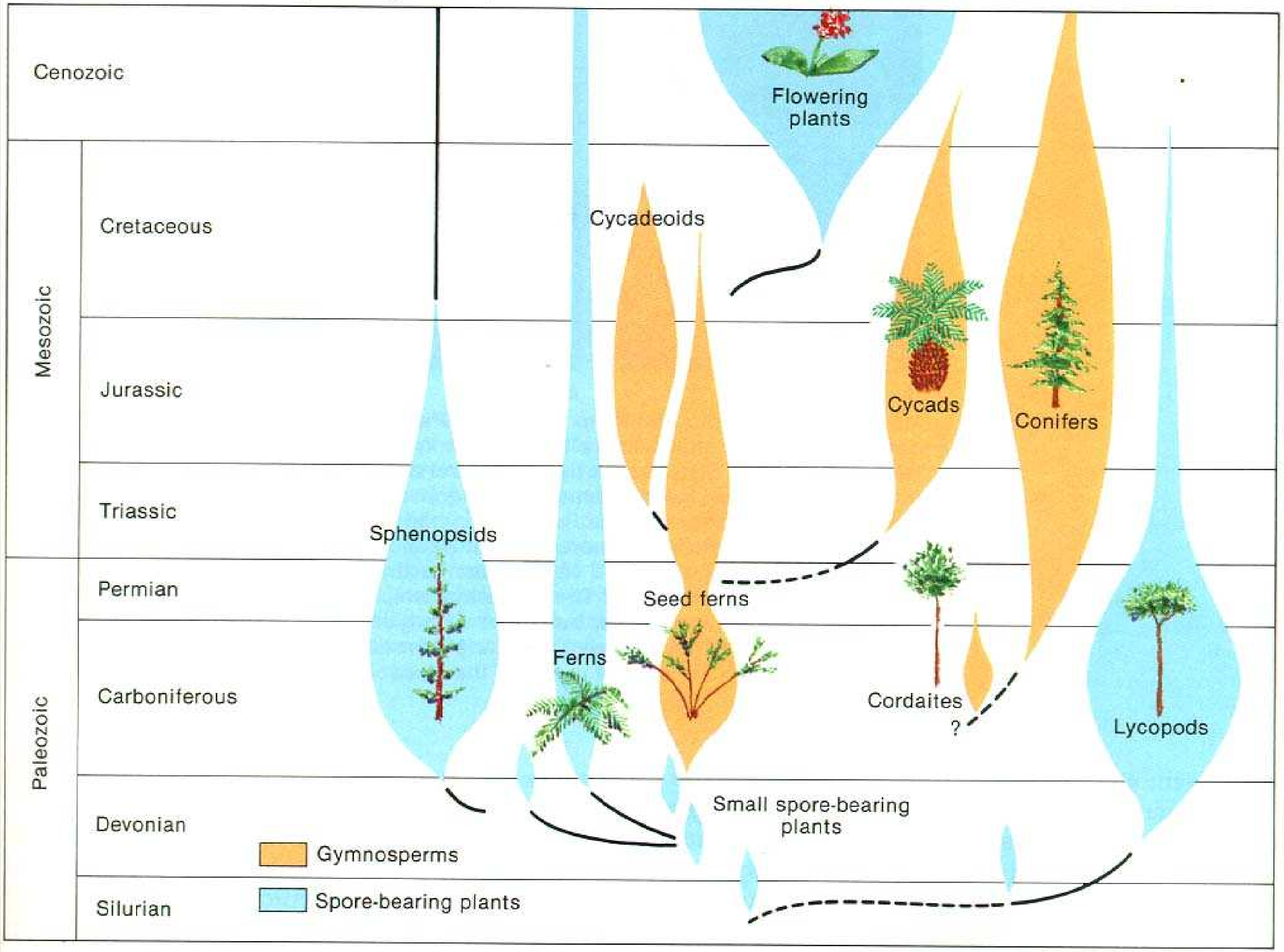
In Triassic still abundant ferns and lycopods.

First angiosperms – latest Jurassic., in early Cretaceous quick diversification, since middle Cretaceous dominant flora - Caenophytikum.

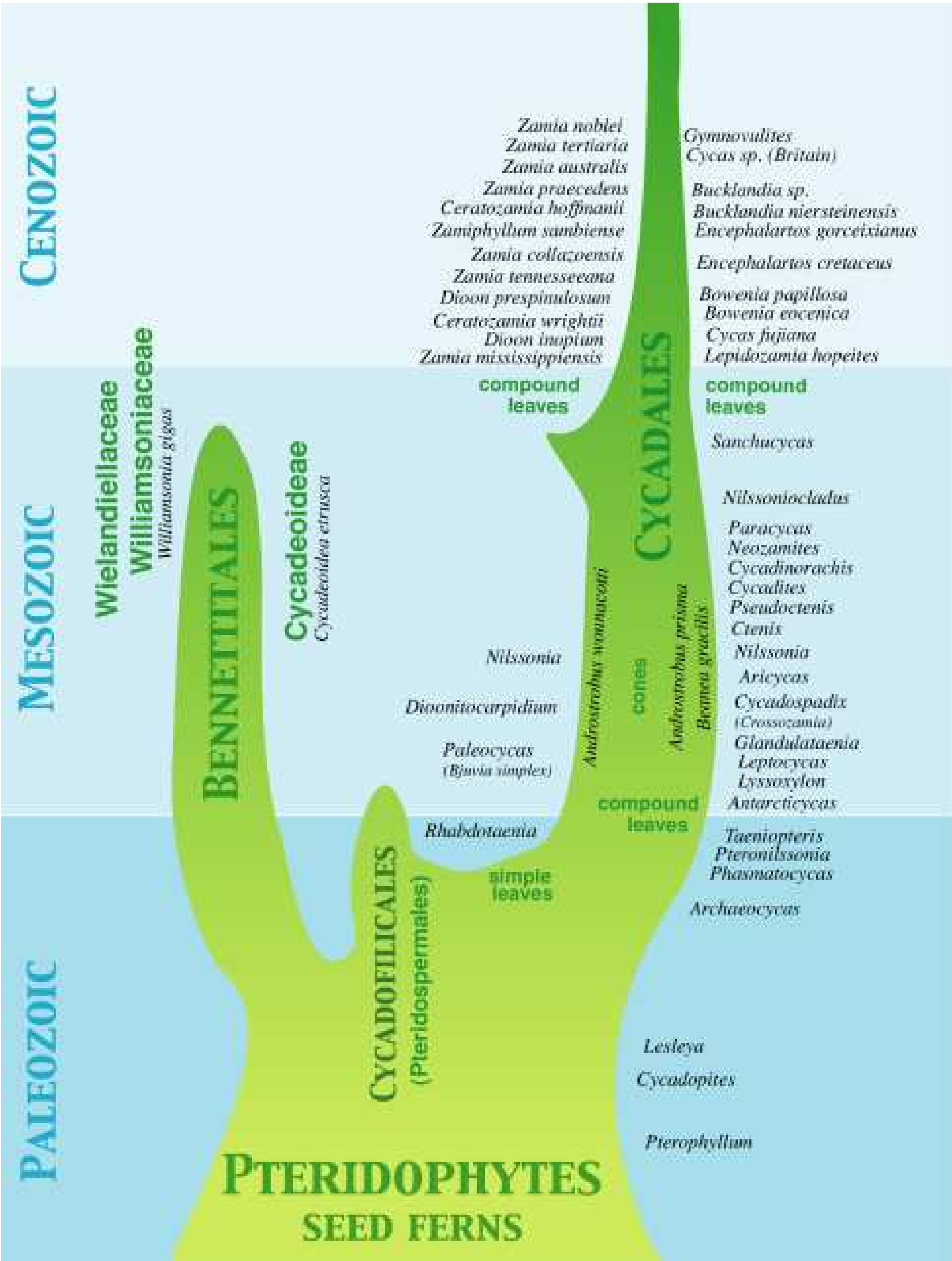
Great advantages – short reproduction cycle, polination by insects

Absence of grasses and savana, prairie and meadow biotopes.

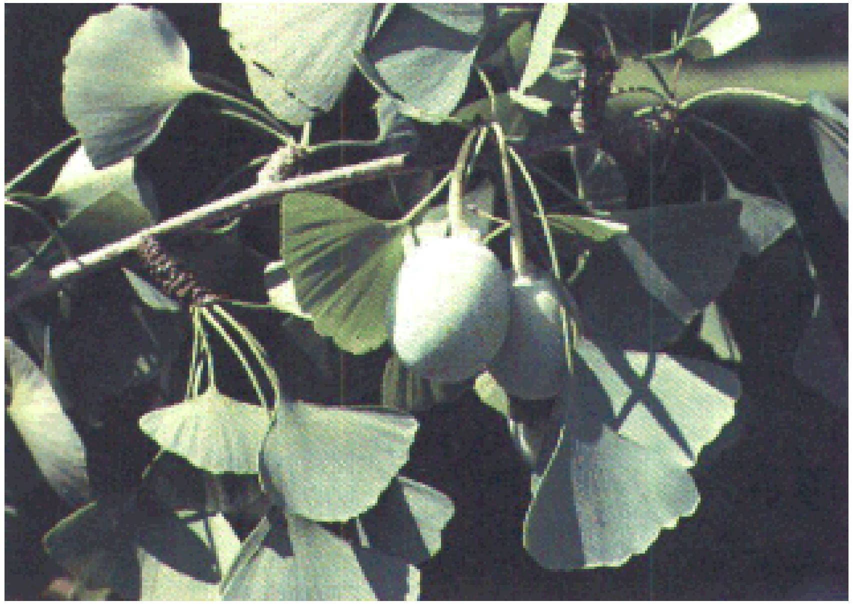
Czech Cenomanian – subtropic genera as Magnolia, Lurus, Platanus, Ficus,

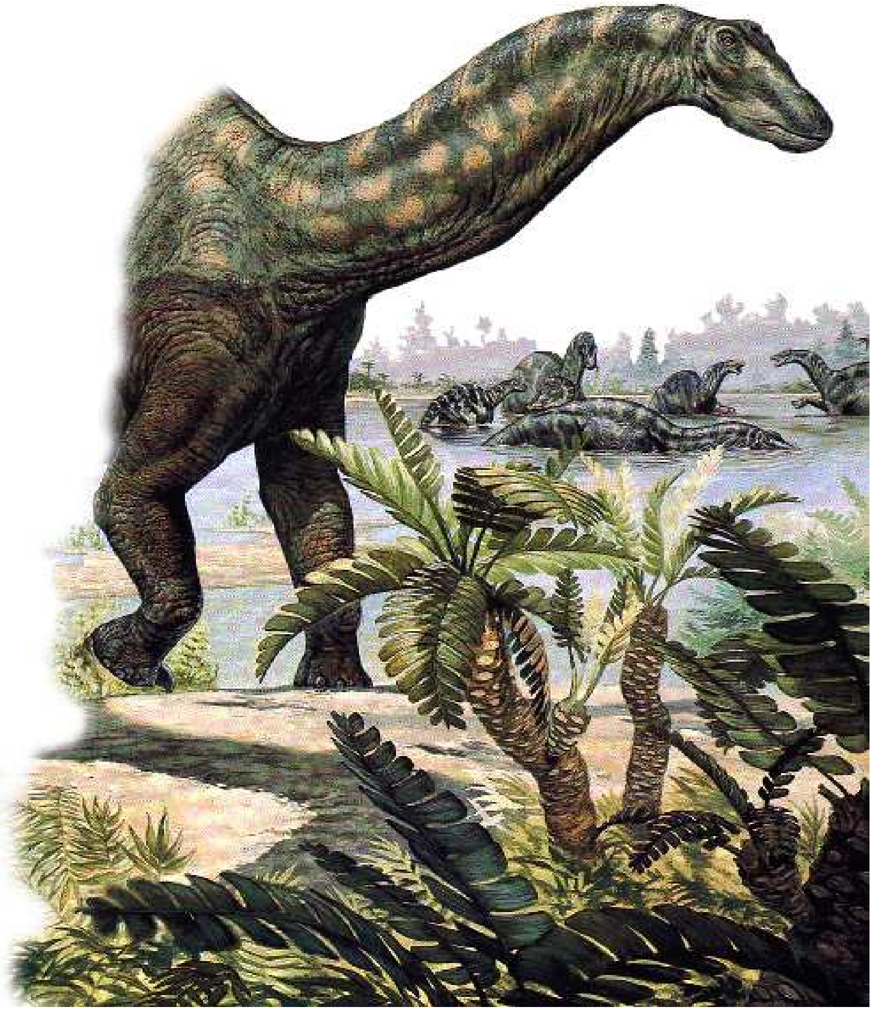


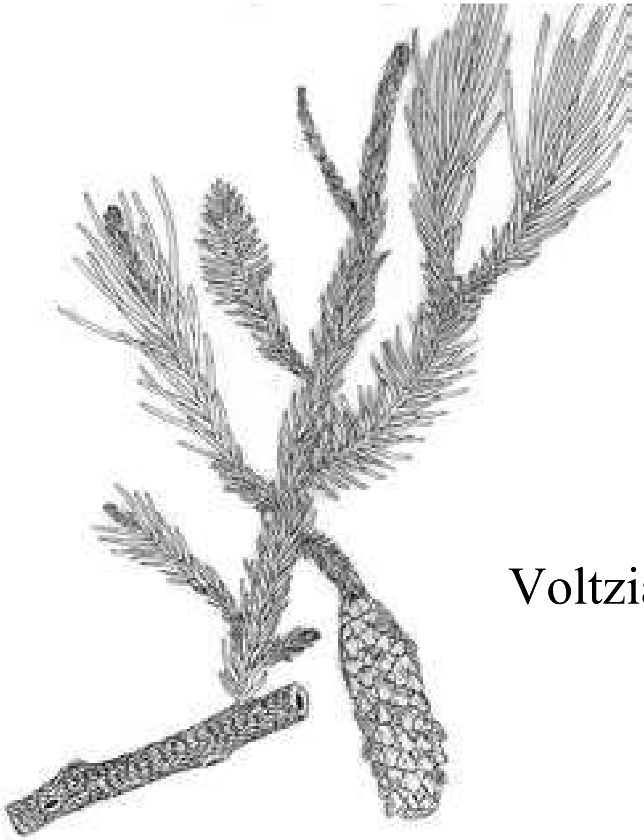
Cenozoic
Mesozoic
Cretaceous
Jurassic
Triassic
Paleozoic
Permian
Carboniferous
Devonian
Silurian
Flowering plants
Cycadeoids
Cycads
Conifers
Sphenopsids
Seed ferns
Ferns
Cordaites
?
Lycopods
Small spore-bearing plants
Gymnosperms
Spore-bearing plants



Cenozoic
Mesozoic
Paleozoic
Zamia noblei
Zamia tertiaria
Zamia australis
Zamia praecedens
Ceratozamia hoffmanii
Zamiphyllum sambiense
Zamia collazoensis
Zamia tennesseeana
Dioon prespinulosum
Ceratozamia wrightii
Dioon inopium
Zamia mississippiensis
Gymnovulites
Cycas sp. (Britain)
Bucklandia sp.
Bucklandia niersteinensis
Encephalartos gorceixianus
Encephalartos cretaceus
Bowenia papillosa
Bowenia eocenica
Cycas fujiana
Lepidozamia hopeites
compound leaves
compound leaves
Sanchucycas
Wielandiellaceae
Williamsoniaceae
Williamsonia gigas
Bennettitales
Cycadeoideae
Cycadeoidea etrusca
Cycadales
Nilssoniocladus
Paracycas
Neozamites
Cycadinorachis
Cycadites
Pseudoctenis
Ctenis
Nilssonia
Aricycas
Cycadospadix
(Crossozamia)
Glandulataenia
Leptocycas
Lyssoxylon
Antarcticycas
Androstrobus wonnacotti
Androstrobus prisma
Beania gracilis
cones
Nilssonia
Dioonitocarpidium
Paleocycas
(Bjuvia simplex)
compound leaves
Rhabdotaenia
simple leaves
Taeniopteris
Pteronilssonia
Phasmatocycas
Archaeocycas
Cycadofilicales
(Pteridospermales)
Lesleya
Cycadopites
Pterophyllum
Pteridophytes
Seed Ferns







Voltzia

Oldest flowering plant fossil

Archaefructus liaoningensis

*140-million-year-old fossil from northeast China. The leafy,seed-containing pods (carpels) are the defining characteristic of angiosperms ("seeds in vessels").

*Petals are apparently absent, but leaf-like structures subtending each fruiting axis define them as flowers.

Enlarged view of the carpels (each is about 1 mm long) showing seeds in carpel (Sun, Dilcher, Zheng & Zhou. 1998. Science 282:1692).

FAUNA

Dominant group of benthos – **bivalves**. Early Triassic – Clarai claraia

Early Triassic – Calrai claraia.
Fiber microfacies – pseudoplanktonic Halobia

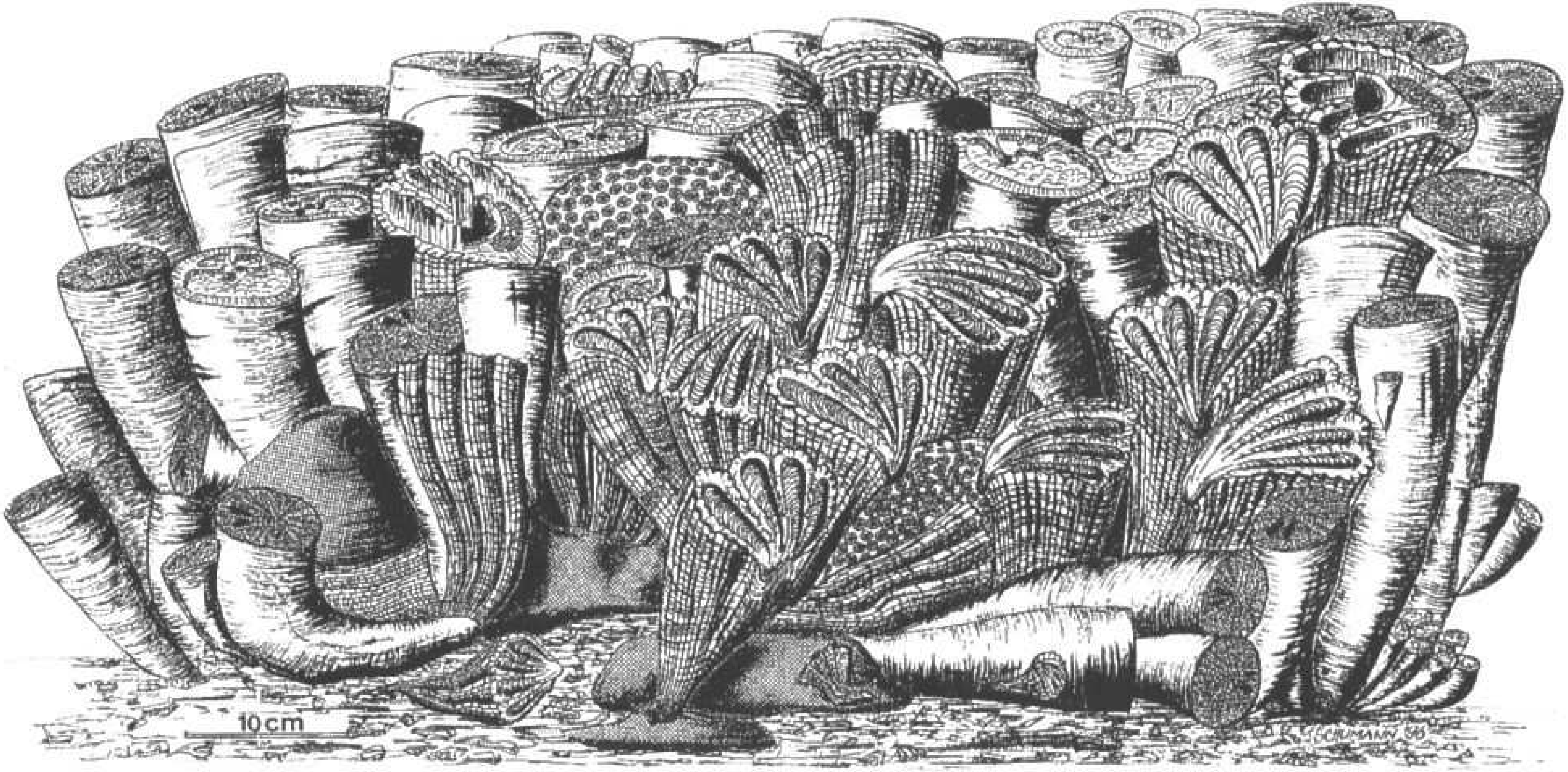
Jurassic – first **rudists**. **Diceras**. Boring bivalves. Planktonic **Bositra** – black Jurassic, fiber microfacies.

Cretaceous - **rudist reefs** - Urgon facies. Stratigraphically important - Inoceramus

Claraia

Diceras

Biostrome of *Vaccinites vesiculosus* (Woodward, 1855); Campanian of Saiwan, Oman (from Schumann & Steuber 1997)



Association of *Vaccinites*, *Torreites*, corals and stromatoporoids; Campanian of Saiwan (from

Gryphaea

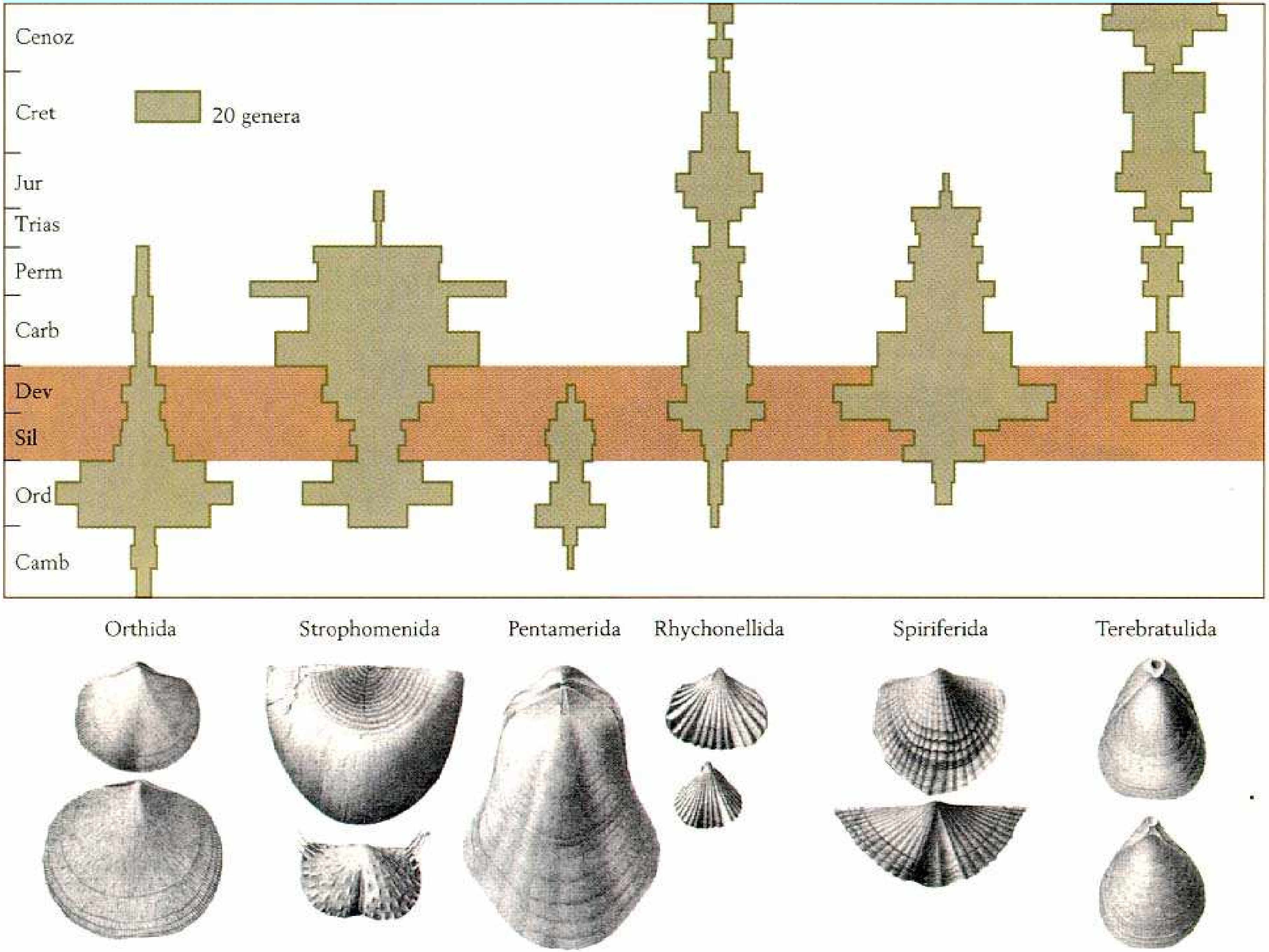
Inoceramus sp.

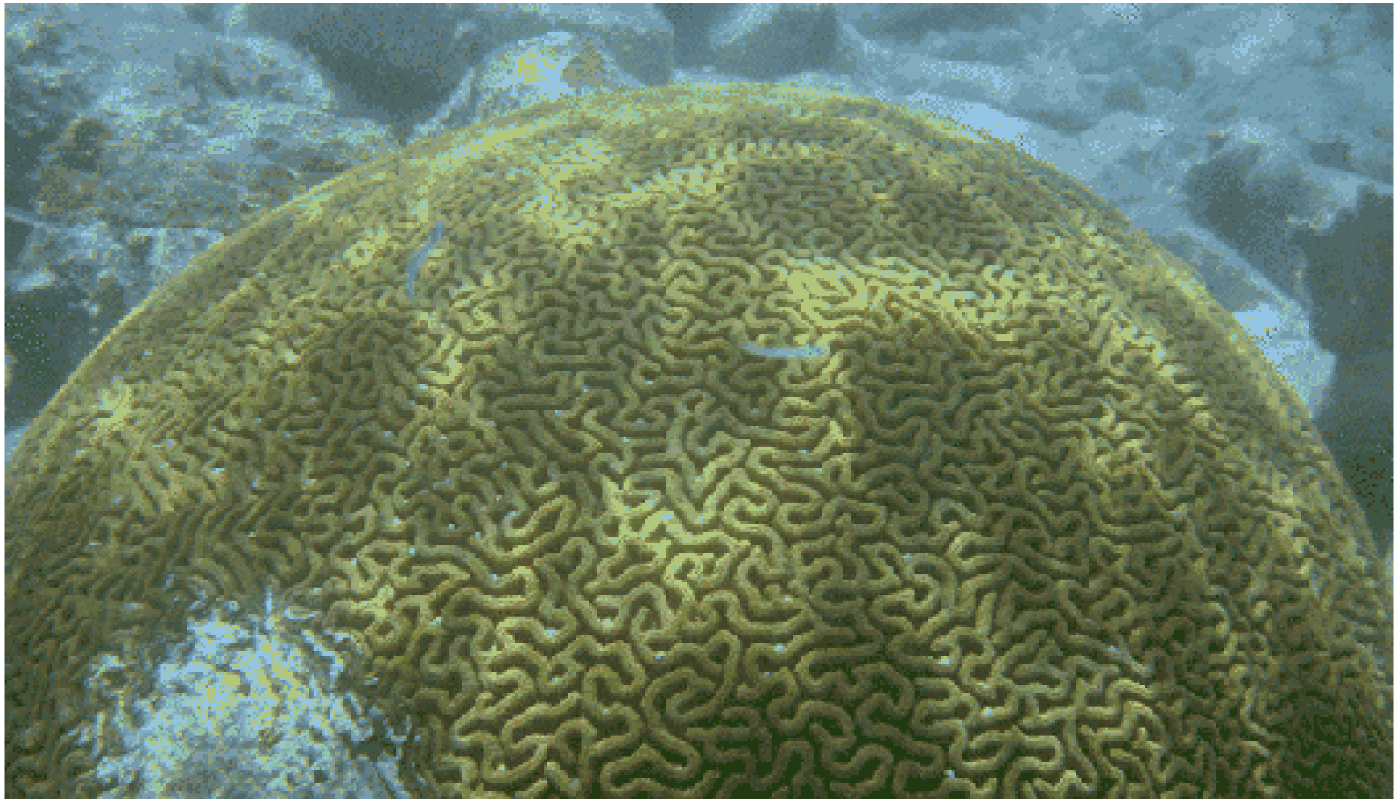
Sponges – expansion in Mesozoic. **Reef builders** in Triassic and Jurassic – siliceous desmospongiids. Cretaceous – great **rock-forming** role. **Spongolites** and arenaceous marls (opuky).

Gastropods – typical genus for Tethyan Realm **Nerinea**. In Cretaceous gastropods associations obtain Caenozoic character.

Echinoderms – increasing representation of echinoids. In Jurassic established themselves especially irregular echinoids. Crinoids nearly extinct after P/Tr extinction. Slow diversification in Triassic, In Jurassic regain rick-forming role. In Cretaceous retreat.

Brachiopods – Triassic small diversification, especially rynchonellids and terebratulids. Since Triassic retreat.



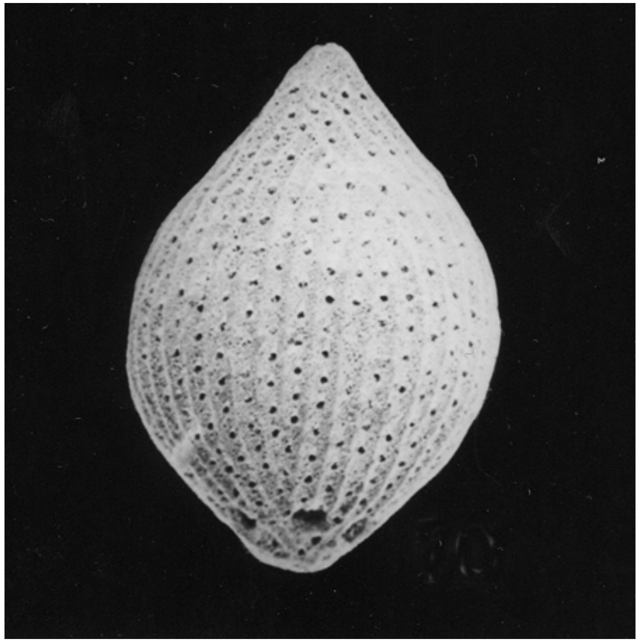


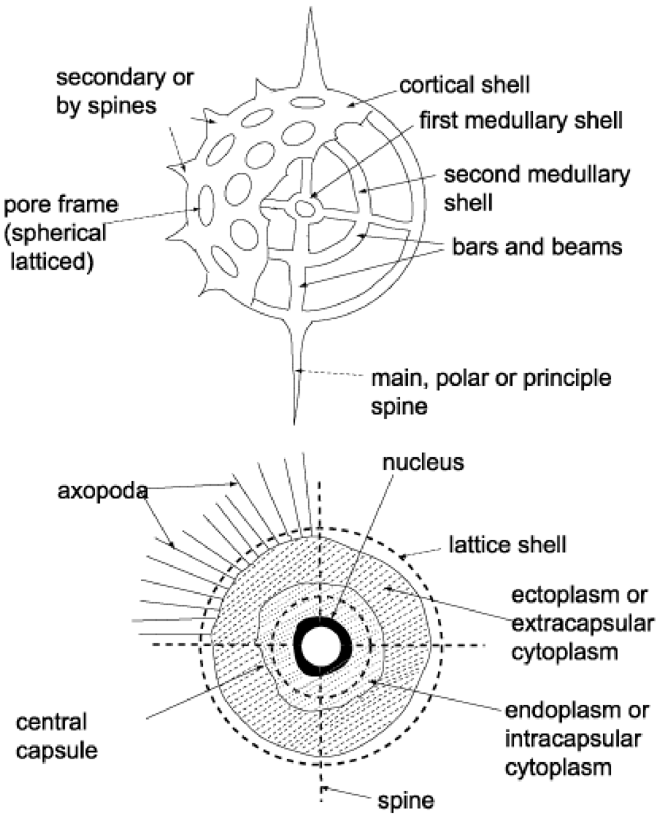
Scleractinian ("hard-rayed") corals first appeared in the **Middle Triassic** and refilled the ecological niche once held by tabulate and rugose corals. They are probably not closely related to the extinct tabulate or rugose corals, and probably arose independently from a sea anemone-like ancestor. Their pattern of septa differs markedly from that of the Rugosa, being basically six-rayed. For this reason, scleractinians are sometimes referred to as **hexacorals**. **First deep water**, **since malm shallow water** and **reef forming**.

Foraminifers – extinction. Triassic only benthonic. Since Jurassic **planktonic**, expansion of benthic forms to bathyal zone. Radiation of planktonic forms in Cretaceous. Globotruncanas, 20 foraminiferal zones.

Globotruncana

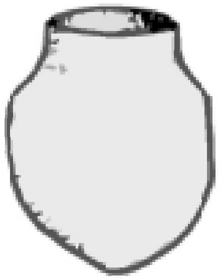
Radiolaria – expansion in Jurassic, Spumellaria.





Diagrammatic cross-sections of spumullarian radiolaria.

Calpionells (Infusoria) – biostraigraphic and **rock-forming role** in late Jurassic-early Cretaceous. Pelagic limestones of Tethyan province. **Calpionella**.



Arthropods

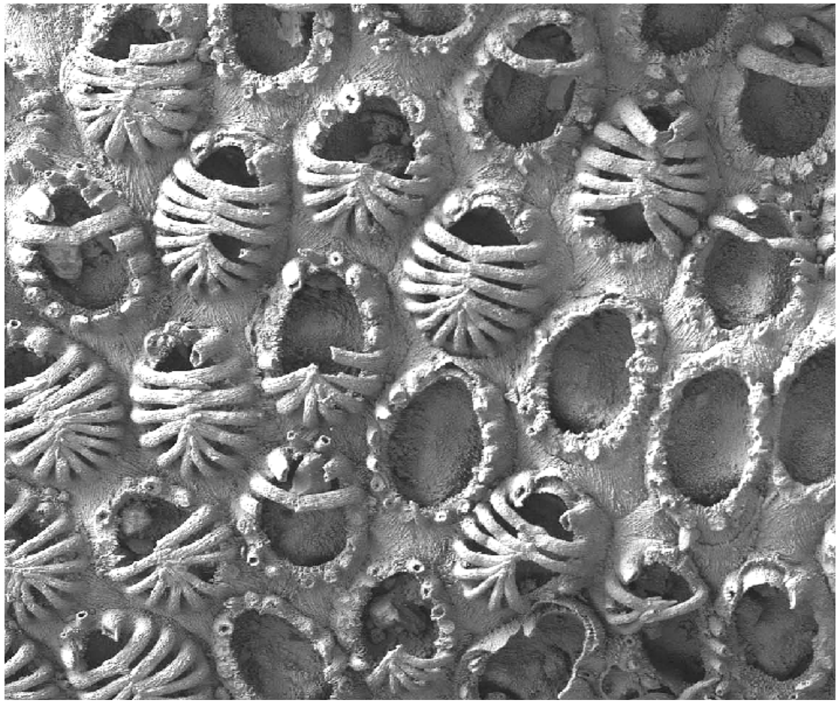
Malacostraca - Crabs, shrimps, lobsters, etc

Ostracods – low diversity after end Triassic extinction, greater role in late Cretaceous.

Insects – coevolution with angiosperms, bees, ants, mosquitos

Bryozoans –End of Triassic – **last Stenolemata** disappear (Cryptostomata, Treptostomata). Diversification of **Cyclostomata** in Jurassic, end Jurassic first **Cheilostomata**

Cheilostome bryozoan



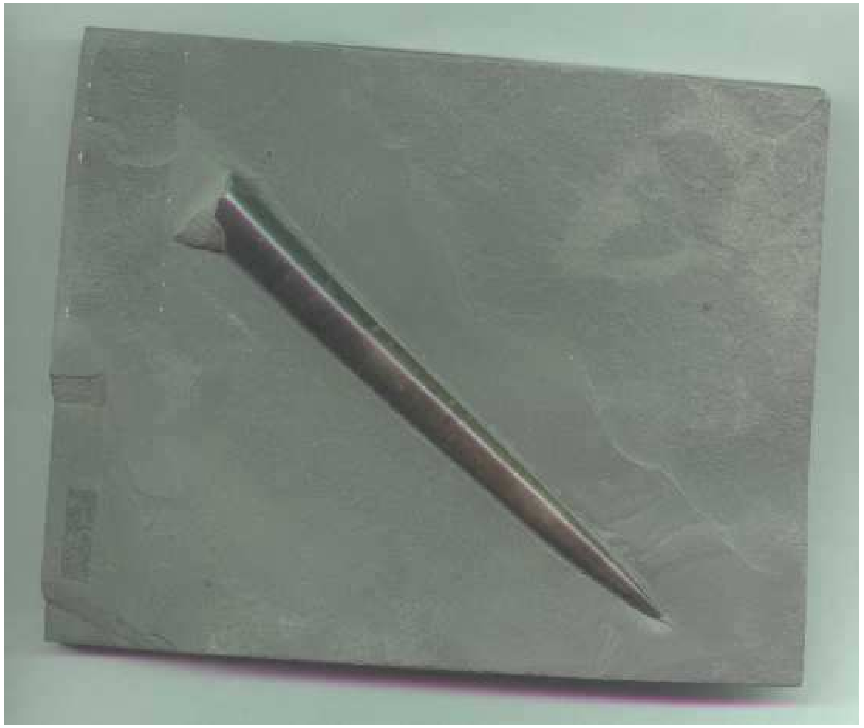
Ammonites

Nearly extincy during P/tr extinction event. **2 genera survive**, adaptive **radiation** of **ceratites** in early Triassic. **End Triassic extinction**, nearly all ammonite genera. Since beginning of **Jurassic** new adaptive **radiation**, **ammonite** type of suture appears. 70 ammonite zones, **ammonite limestones** (Calcare ammonitico rosso), **Aptych** limestones. End Jurassic **extinction**.
Cretaceous – last expansion of ammonites. Also **gigantic** forms as Parapachydiscus or Lewesiceras. Heteromorph species

Lewesiceras peramplum

Nautiloid cephalopods – retreat. End Triassic extinction of orthocers.

Belemnites -appear in late Paleozoic. Expansion in **Jurassic** and **Cretaceous**, C/Ter boundary – **most of the extinct**.



Conodonts – end Triassic **extinction**.

Actinopterygii

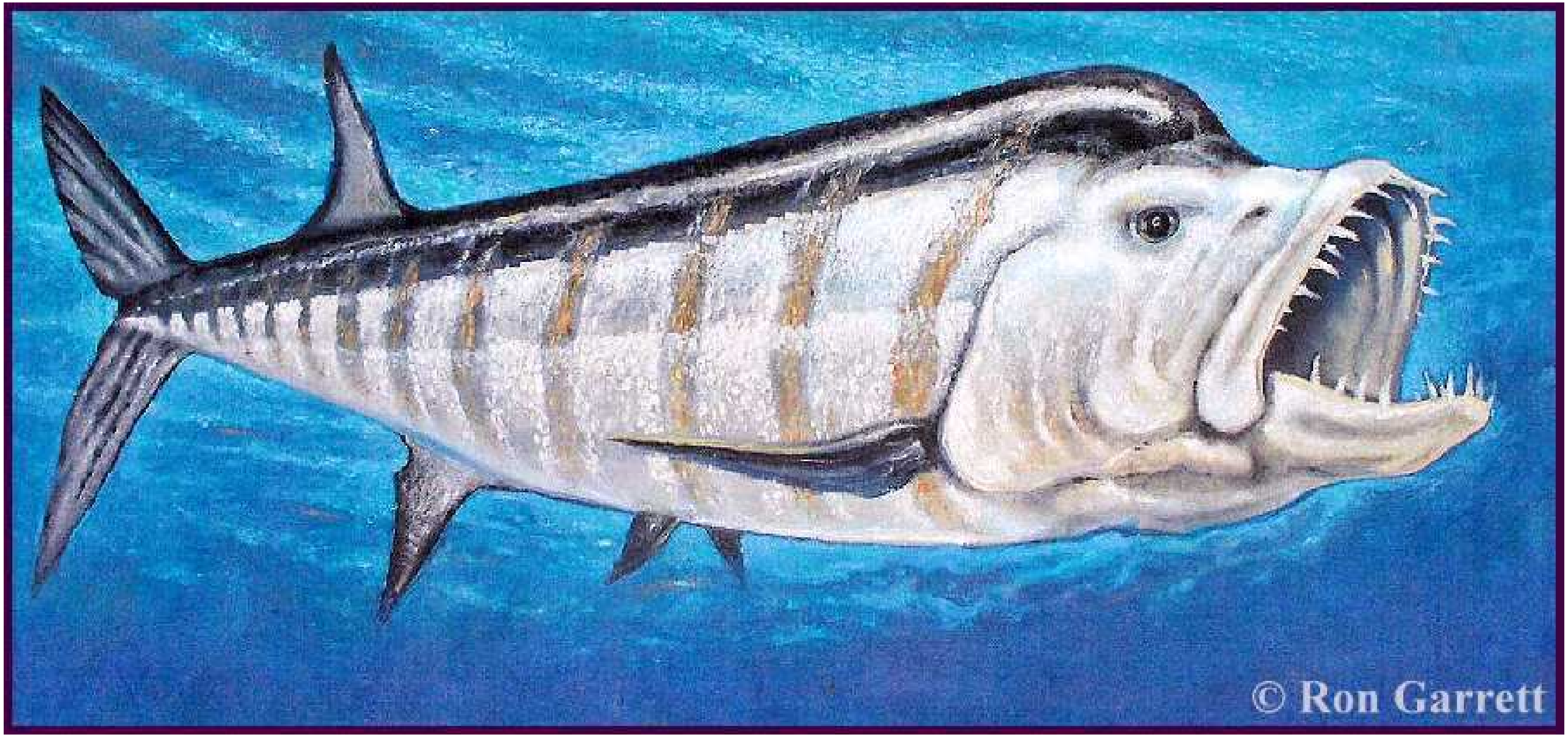
In **Triassic Holostei** domination. In **Jurassic** expansion of **Teleostei** which become the dominant Fish group. Other groups of actinopterygii retreat. In Cretaceous e.g. Paleoniscida become extinct.

Actinopterygii

- Chondrostei – dominat late Paleozoic fish group
- Holostei- dominant in Triassic
- Teleostei- dominant since Jurrasic

Sharks – In Triassic important hybodonts, button-like teeth, crushing of bivalve test. In Jurassic expansion. And modern families appear. In Cretaceous 12 of 16 recent families.

Crossopterygii, Dipnoi – Triassic last system in which higher representation
Today – „living fossils“



Xiphactinus audax, (**Teleostei**) or as it is more commonly called, the "Bulldog Fish", was a species of very large predatory fish that lived in the ocean during the Late **Cretaceous**.
18 to 20 feet (1feet=30,5 cm), and some 'giant vertebrae' from marine deposits in Arkansas indicate that some individuals that were even larger**.**

The large shark (6m) at the top is ***Cretoxyrhina mantelli***, while the two smaller sharks at lower right waiting their turn are *Squalicorax falcatus*.

Amphibians – in Triassic still Paleozoic group **Temnospondyli**, retreat and end Triassic extinction, reduced survival till mid Jurassic. New **modern groups** appear in **Triassic**.
First **frogs** – Triadobatrachus massinoti, Caudata. Gradual entry of **other modern groups** in **Jurassic** and **Cretaceous**.

Reptile Subclasses:

1 – **Anapsida**

O. Cotylosauria- stem reptiles

O. Chelonia - turtles & tortoises

•unchanged for about 175 million years

•identified by bony dermal plates to which ribs & trunk vertebrae are fused

2 - **Lepidosauria**

O. Rhynchocephalia (Sphenodonta) - only living representative is the Tuatara

O. Squamata - lizards, geckos, & snakes

3 -**Archosauria**

O. Thecodontia – stem archosaurs

O. Pterosauria

O. Saurischia- 2 major groups: sauropods & theropods

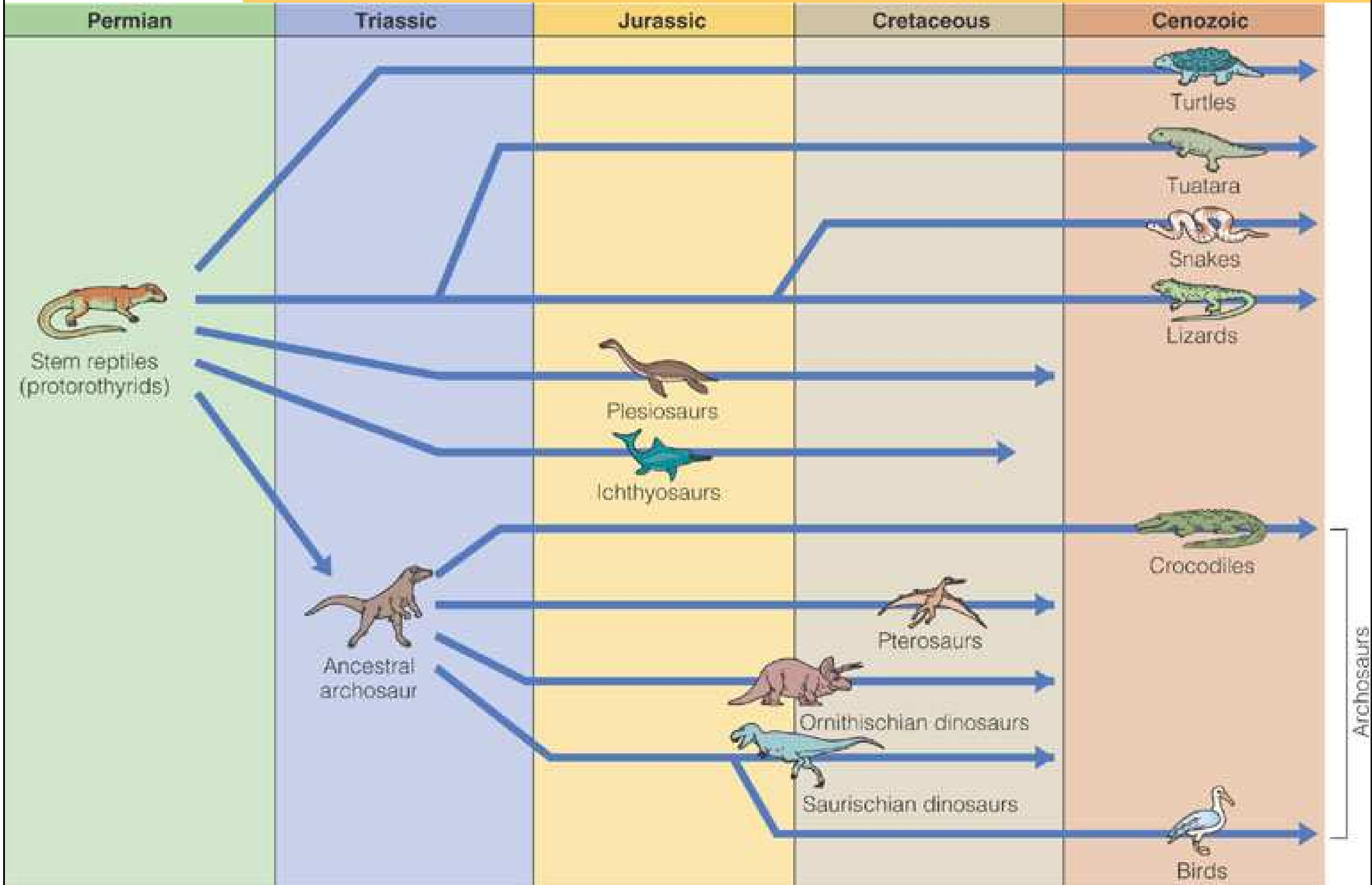
O. Ornithischia

O. Crocodilia

Dinosauria

4 - **Euryapsida** - marine reptiles, includes the plesiosaurs & ichtyosaurs

Reptiles and Birds



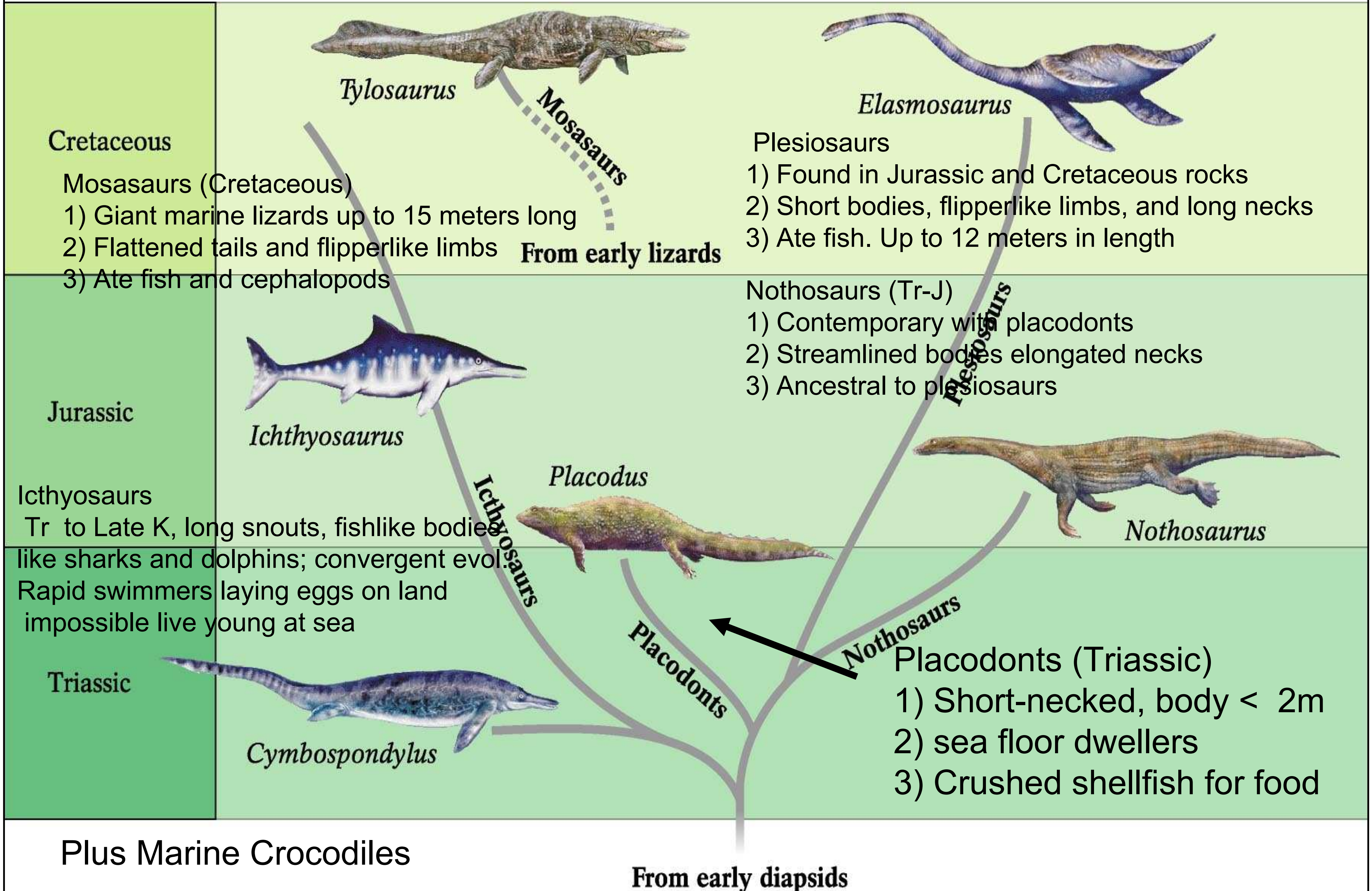
Euryapsids

Euryapsid Include *Ichthyopterygia* and *Sauropterygia* (nothosaurs and plesiosaurs). convergence, not common ancestry; derived from diapsid.]

Sauropterygia – Placodontia
Notosauria
Plesiosauria
Ichtyosauria

Ichthyosaurs and plesiosaurs had inhabited the oceans since the **Triassic**, evolving into many diverse forms and surviving several major extinction events. For unknown reasons, ichthyosaurs declined significantly in early Cretaceous and are thought to have been extinct by the time that the earliest **mosasaurs** re-entered the water**. Plesiosaurs** were also less numerous in the late Cretaceous than during the Jurassic, and had evolved into some very specialized forms like the **long-necked *Elasmosaurus*.** Even the **short-necked plesiosaurs (pliosaurs)** were much smaller than their Jurassic cousin, *Liopleurodon,* and an early Cretaceous relative, *Kronosaurus*. It is possible that both the ichthyosaurs and the plesiosaurs were losing the evolutionary battle of "who eats who" to faster, larger and more advanced varieties of fish such as *Xiphactinus* and the giant Ginsu sharks (*Cretoxyrhina mantelli*). Several other groups of reptiles, including marine **crocodiles**, teleosaurs, placodonts and turtles had also enjoyed limited successes in the marine environment, but none approached the world-wide domination that mosasaurs would attain in the late Cretaceous.

Euryapsid Marine reptiles



Mosasaurs (Cretaceous)
1) Giant marine lizards up to 15 meters long
2) Flattened tails and flipperlike limbs
3) Ate fish and cephalopods

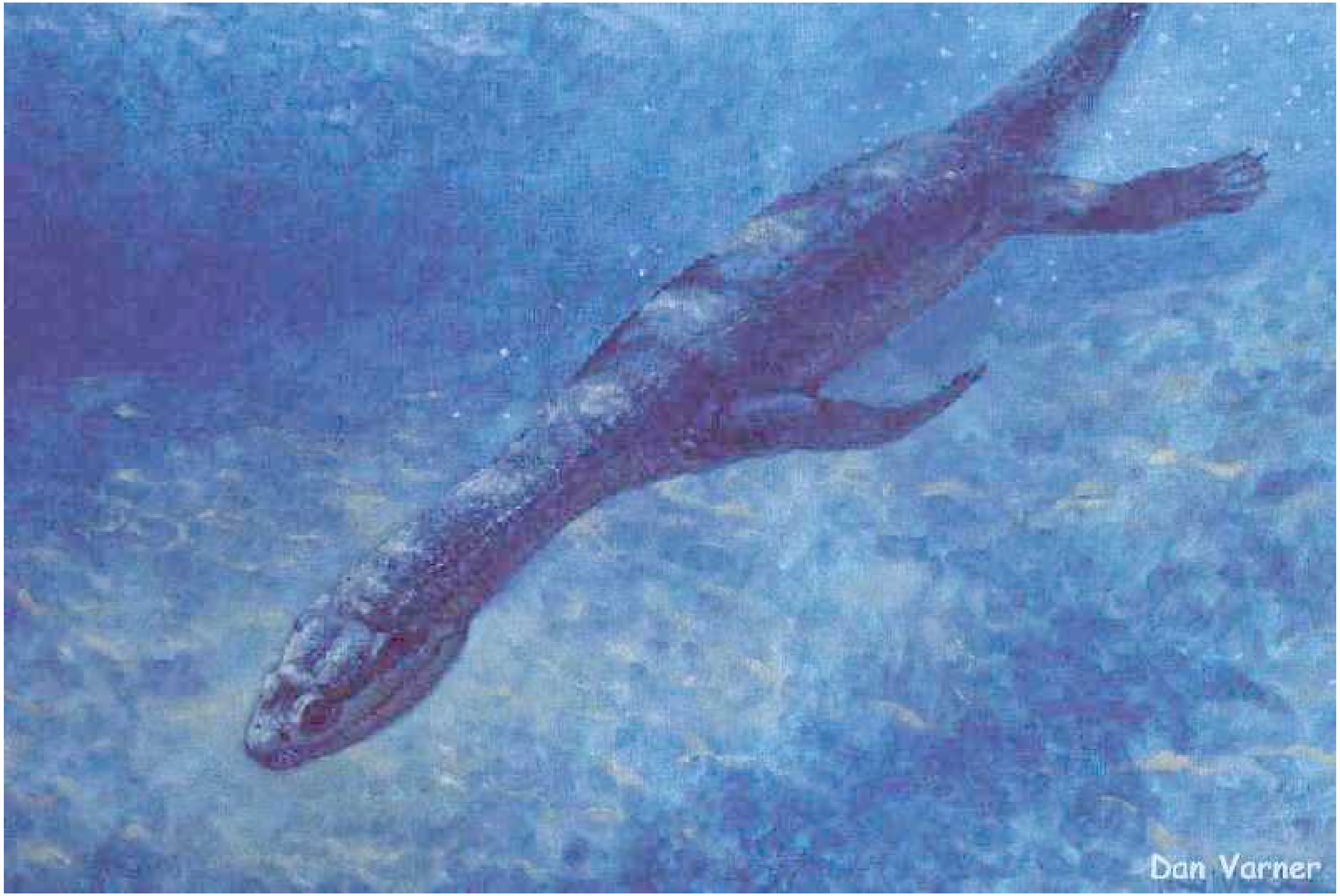
Plesiosaurs
1) Found in Jurassic and Cretaceous rocks
2) Short bodies, flipperlike limbs, and long necks
3) Ate fish. Up to 12 meters in length

Nothosaurs (Tr-J)
1) Contemporary with placodonts
2) Streamlined bodies elongated necks
3) Ancestral to plesiosaurs

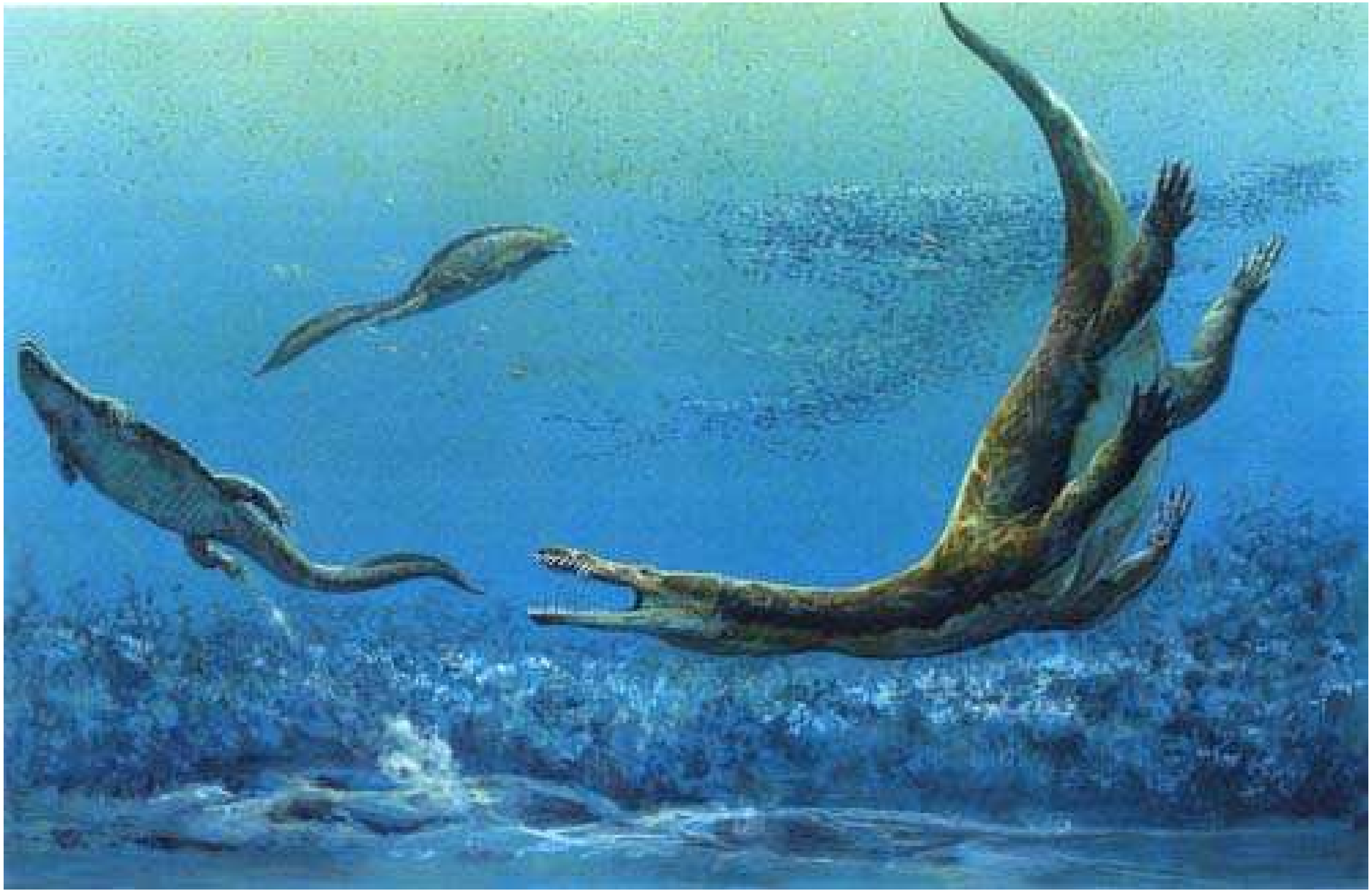
Icthyosaurs
Tr to Late K, long snouts, fishlike bodies like sharks and dolphins; convergent evol.
Rapid swimmers laying eggs on land impossible live young at sea

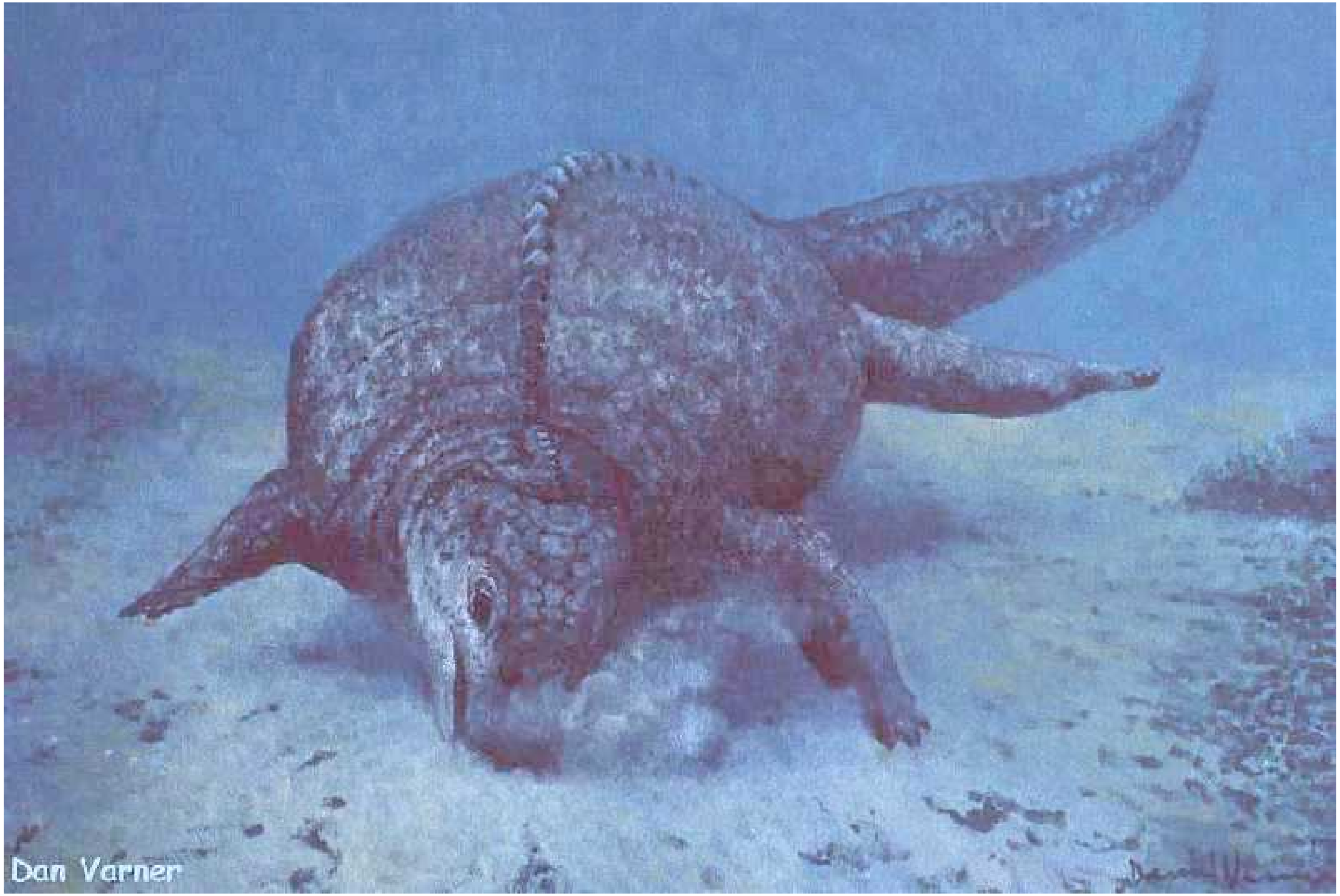
Placodonts (Triassic)
1) Short-necked, body < 2m
2) sea floor dwellers
3) Crushed shellfish for food

Plus Marine Crocodiles



A nothosaur (early to late Triassic) prowls the shallow sea for food. These semi-marine lizards reached lengths of about 3 meters. Their remains are found in many places around the world, including China, Russia, Germany, the Netherlands and North Africa. Instead of paddles, Nothosaurs had webs between their long toes





***Placodus*, a placodont from the early to middle Triassic of Europe grubs for clams and other shellfish in the mud of a near-shore sea bottom. While placodonts fed in the ocean, they probably spent a large portion of their lives on land**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•**Plesiosauroids** - had long, snake-like necks, tiny heads, and wide bodies. They ate small sea creatures, probably using their long necks like a snake to catch their prey. They included:

•**Plesiosaurus** - 7.6 feet (2.3 m) long - with a long neck, 4 wide, paddle-shaped flippers, and a tapered body. From England and Germany during the early Jurassic period.

•**Cryptocleidus** - 13 feet (4 m) long - with curved, interlocking teeth and large flippers. From England during the late Jurassic period.

•**Muraenosaurus** - 20 feet (6 m) long - with a very long neck, and a wide body. From England and France during the late Jurassic period.

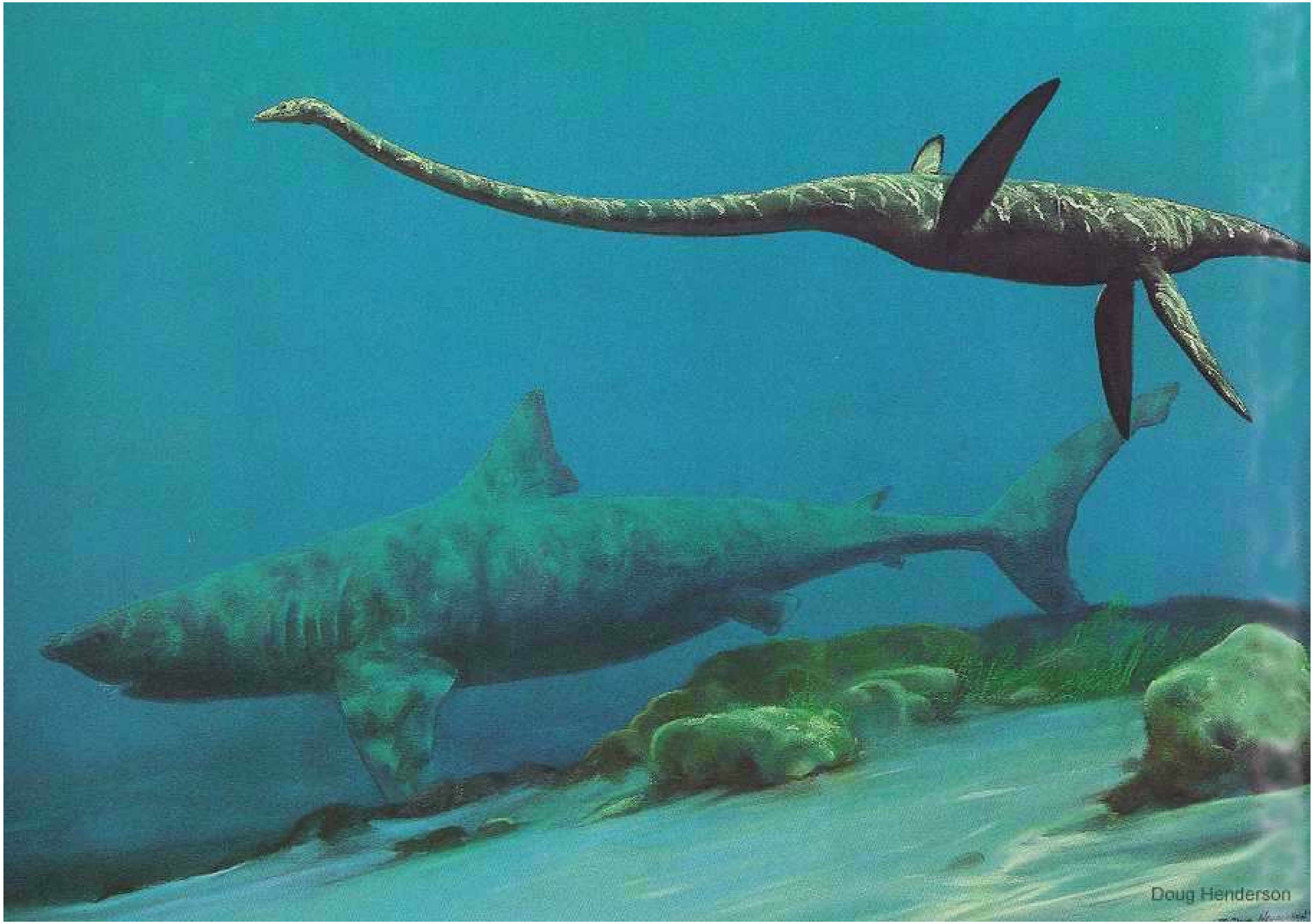
•**Woolungosaurus** - 26-33 feet (8-10 m) long - with a very long neck. From Queensland, Australia, during the early Cretaceous period, about 110 million years ago.

• **Elasmosaurus** - 46 feet (14 m) long with an extremely long neck that was up to half of its length. It had and had 71 vertebrae, 28 of which were in its neck. It had four very long paddle-like flippers, and a short, pointed tail. From Japan and Kansas, USA, during the late Cretaceous period.

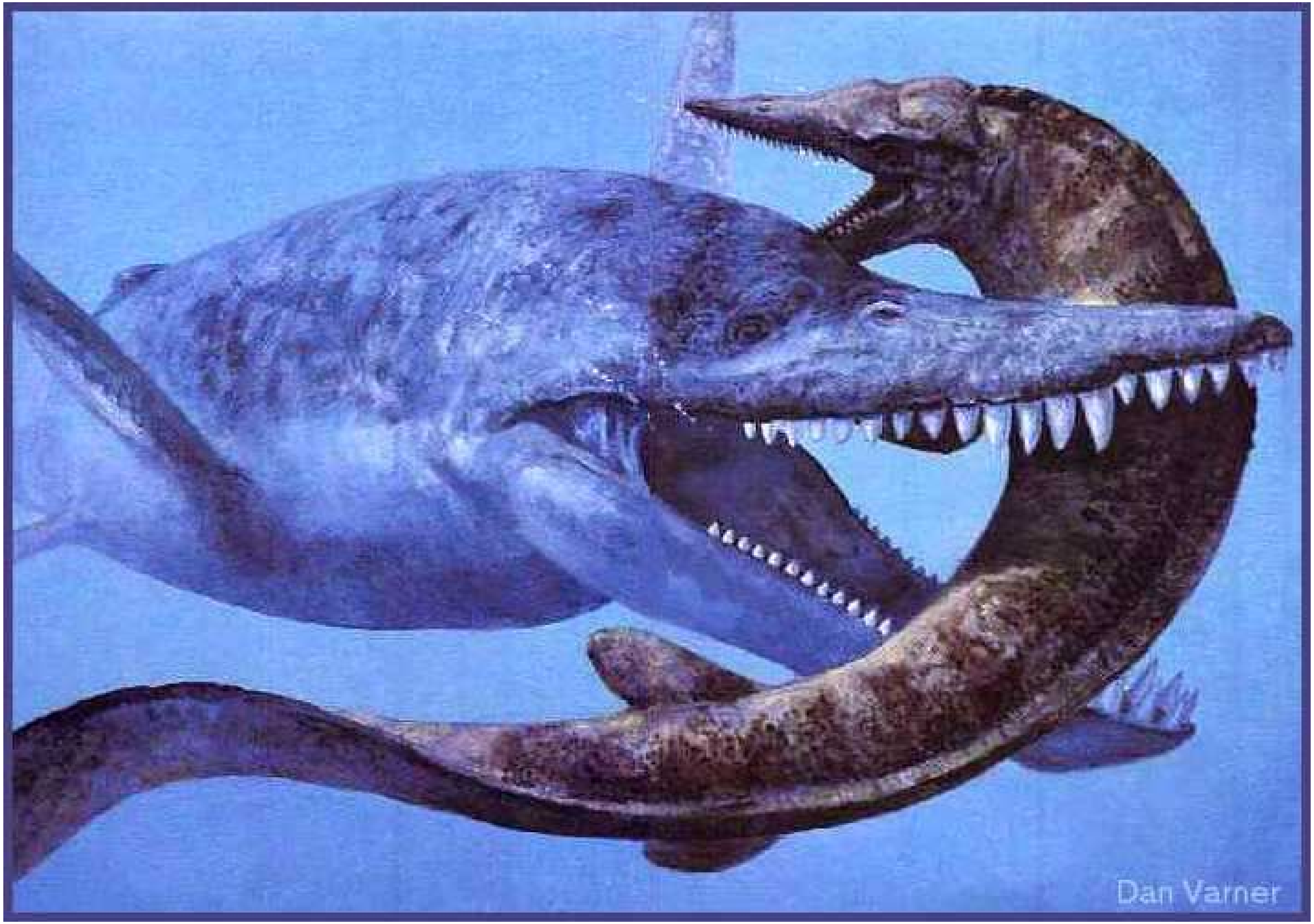
•**Thalassomedon** - 40 feet (12 m) long with a very long neck (the neck had 63 vertebrae). From Colorado, USA, during the late Cretaceous period

•**Pliosauroids** - had large heads with very strong jaws, short necks, and resembled modern-day whales. They ate larger sea creatures. They included:

•**Kronosaurus** - 30 feet (9 m) long with a short neck and huge head and jaws. The flat-topped head was up to 9 feet (2.7 m) long, about 1/4 of the entire length of the body. From Queensland, Australia during the early Cretaceous period.

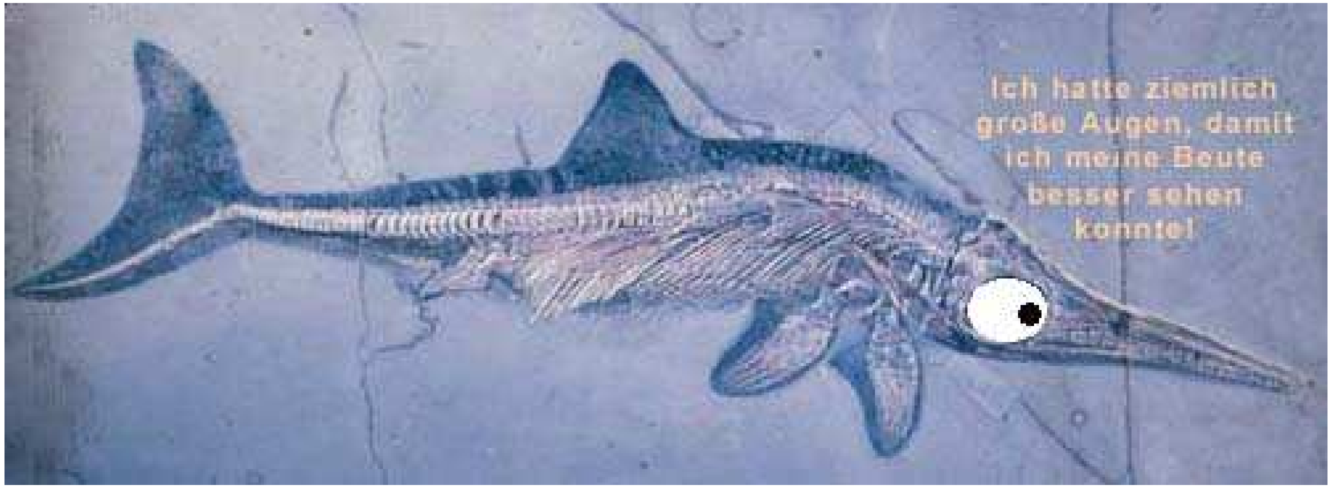


The plesiosaurs, including this long-necked *Elasmosaurus*, used their rigid, bony paddles like wings to 'fly' through the water. This half-grown juvenile is swimming rather close to a huge (18') shark called *Cretoxyrhina mantelli*. Whether or not these sharks attacked living prey or only scavenged the carcasses of the dead is not known for certain, but the marks made by their large, sharp teeth have been found on mosasaur and plesiosaur bones.

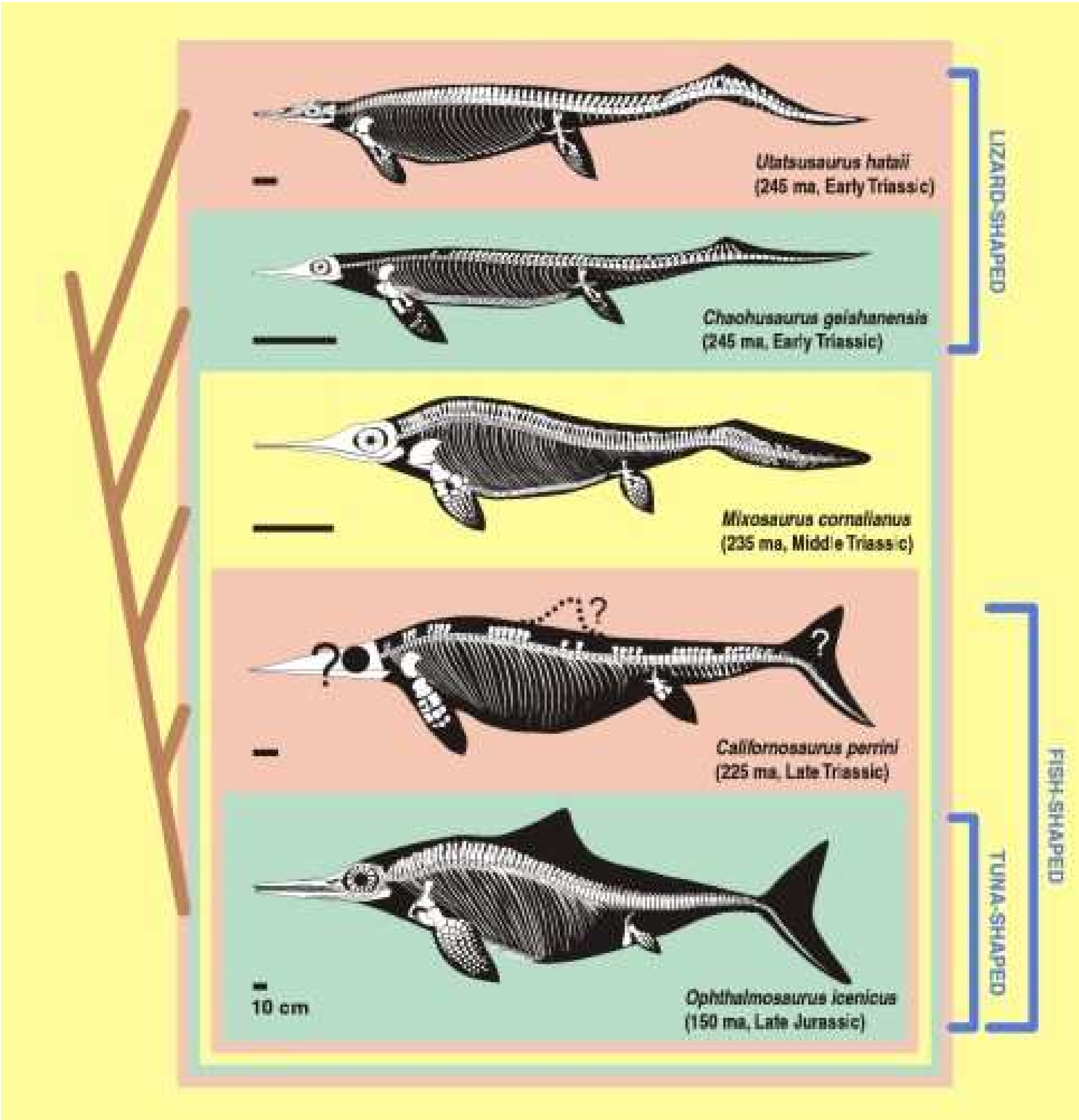


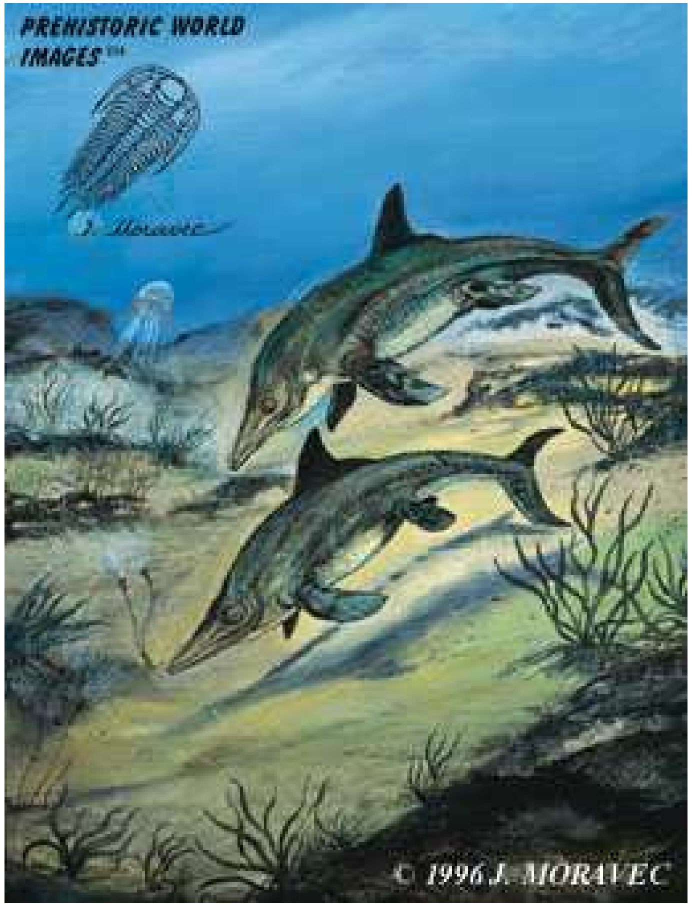
This picture shows what happens when the hunter becomes the hunted; a giant pliosaur Kronosaurus attacks a juvenile mosasaur. Even though mosasaurs were top predators, their young were often preyed upon by sharks, large fish, pliosaurs and even other species of mosasaurs. Life could be short for the unwary

Ichtyosaurs- maximal expansion in Jurassic,Holzmaden. Stenopterygius abundant. 11m Letopterygius. Rare in Cretaceous, extinct at the end.



Ichthyosaurs diversified very quickly once they appeared. Several different body plans emerged in the Early and Middle **Triassic**. But, if you simplify the matter, you can see that there was a general transition from lizard-shaped body plan to fish-shaped one through the evolution of ichthyosaurs, as in the figure below.

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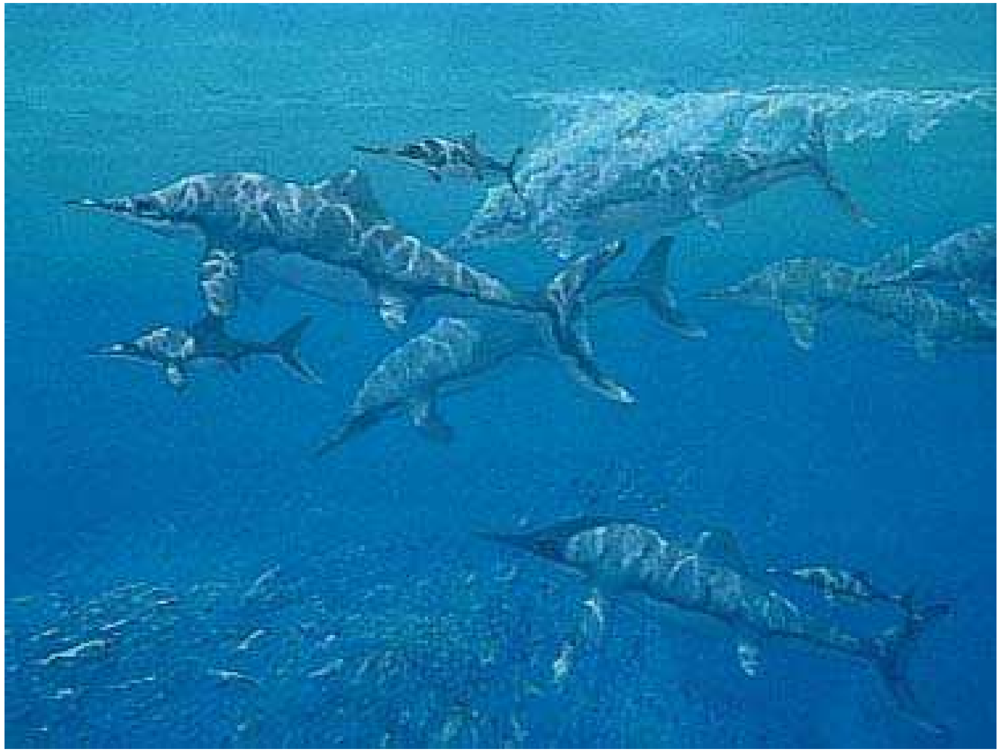
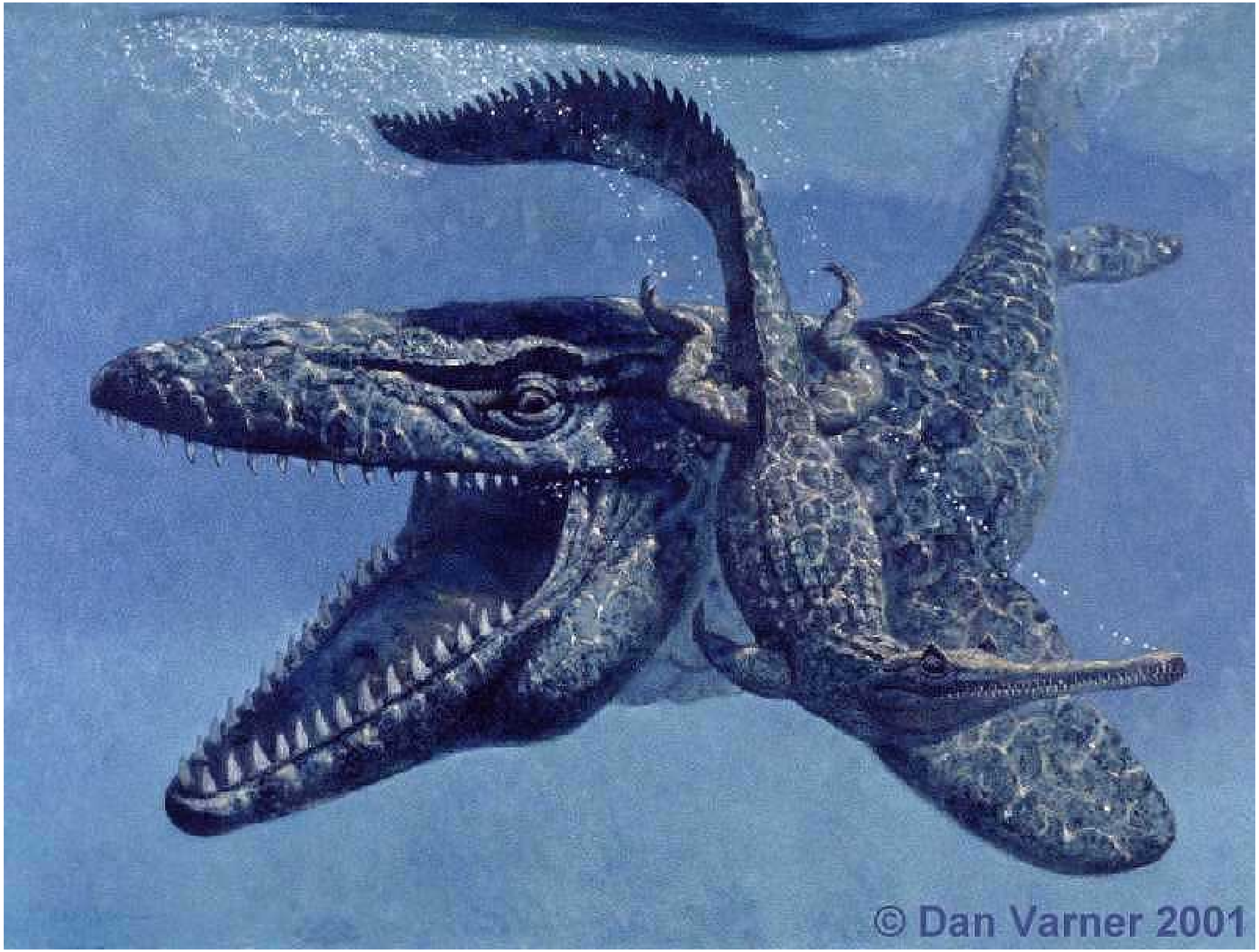


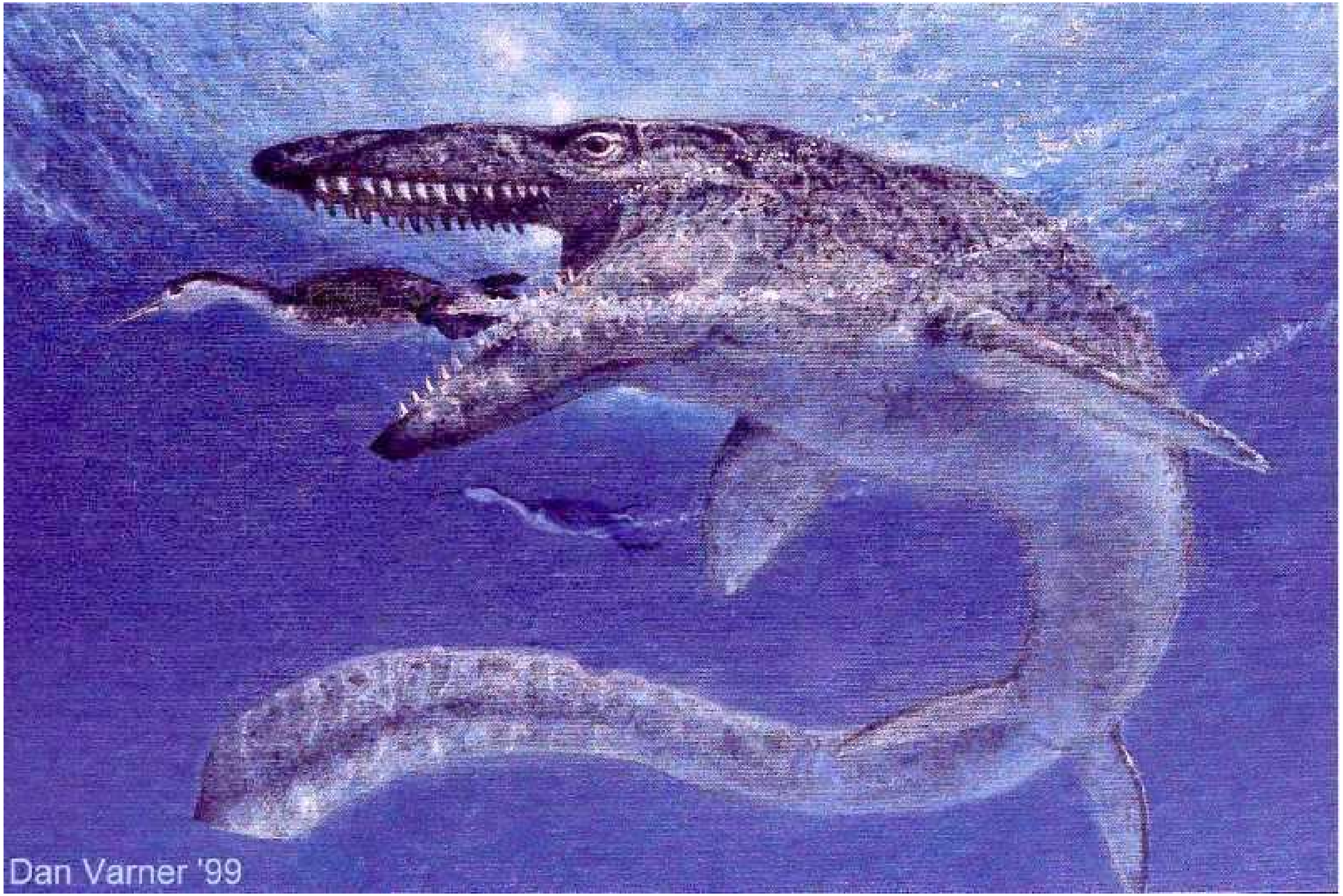
Mosasaurs - Cretaceous

The early ancestors of mosasaurs probably fed in the ocean and returned to land much like the marine iguanas that are found today in the Galapagos Islands. Over a relatively short period of time, however, these ancestral mosasaurs became larger and more specialized, evolving rapidly into several genera of highly successful predators. By the beginning of Coniacian time (about 90 million years ago - mya), there were three major genera (*Tylosaurus*, *Platecarpus* and *Clidastes*) living in the Western Interior Seaway. **Tylosaurs -** by the Campanian, Tylosaurs were even larger (**13-14 meters**) and many more species were making their appearance. Within the space of a few more million years, by Maastrichtian time (70 mya), mosasaurs were truly huge, with several lineages (*Mosasaurus* and *Hainosaurus* – a close relative of *Tylosaurus*) reaching nearly **15 meters** (50 feet). One giant specimen (*Hainosaurus bernardi*) found in Europe was **17 meters** (almost 55 feet) in length. There was no doubt who were the **biggest and baddest predators in the oceans 70 million years ago.**

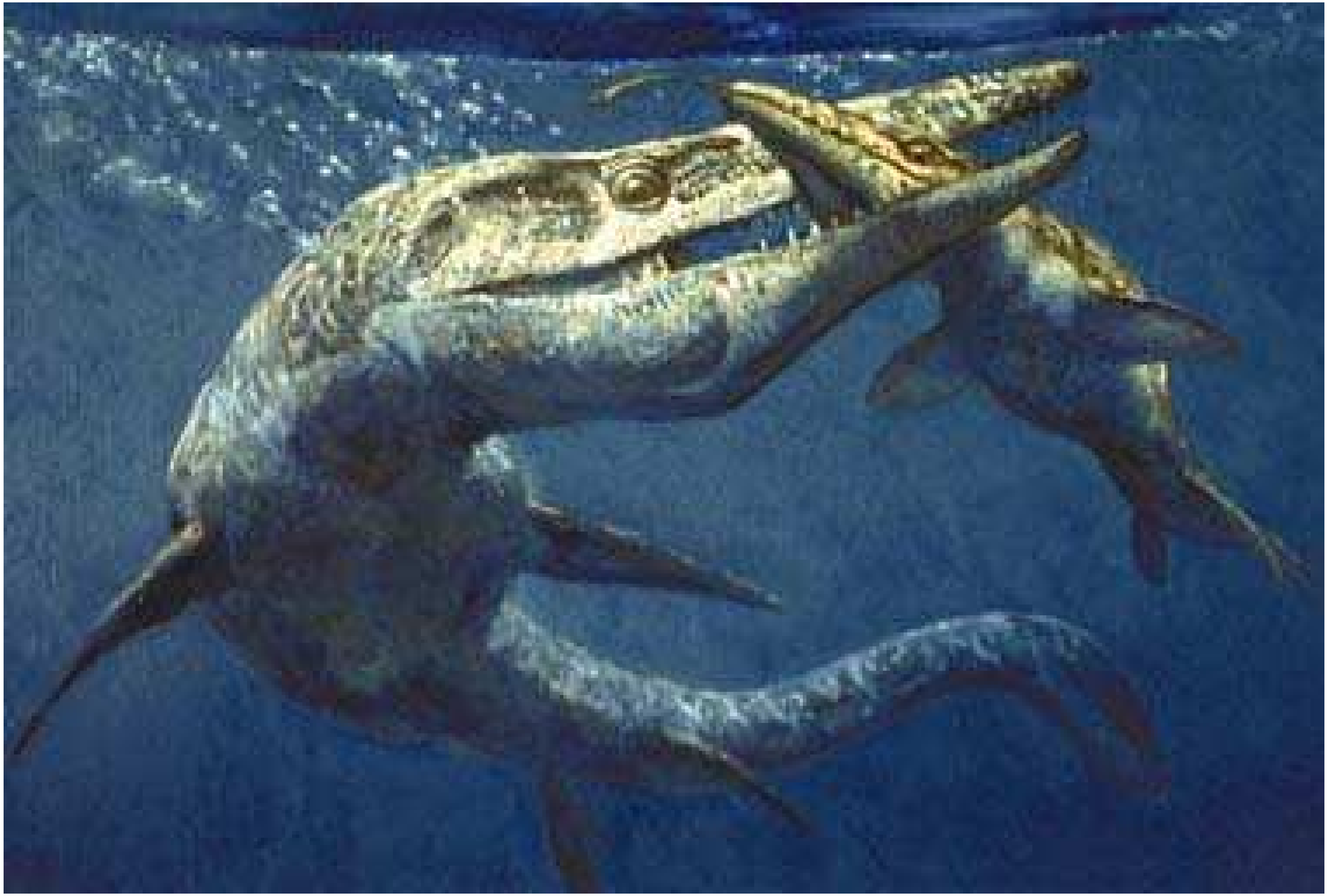
The open jaws of the shark ***Cretoxyrhina mantelli*****, hit the mosasaur on the right side, just behind the rib cage, and the impact lifted the wounded animal almost completely out of the water.**



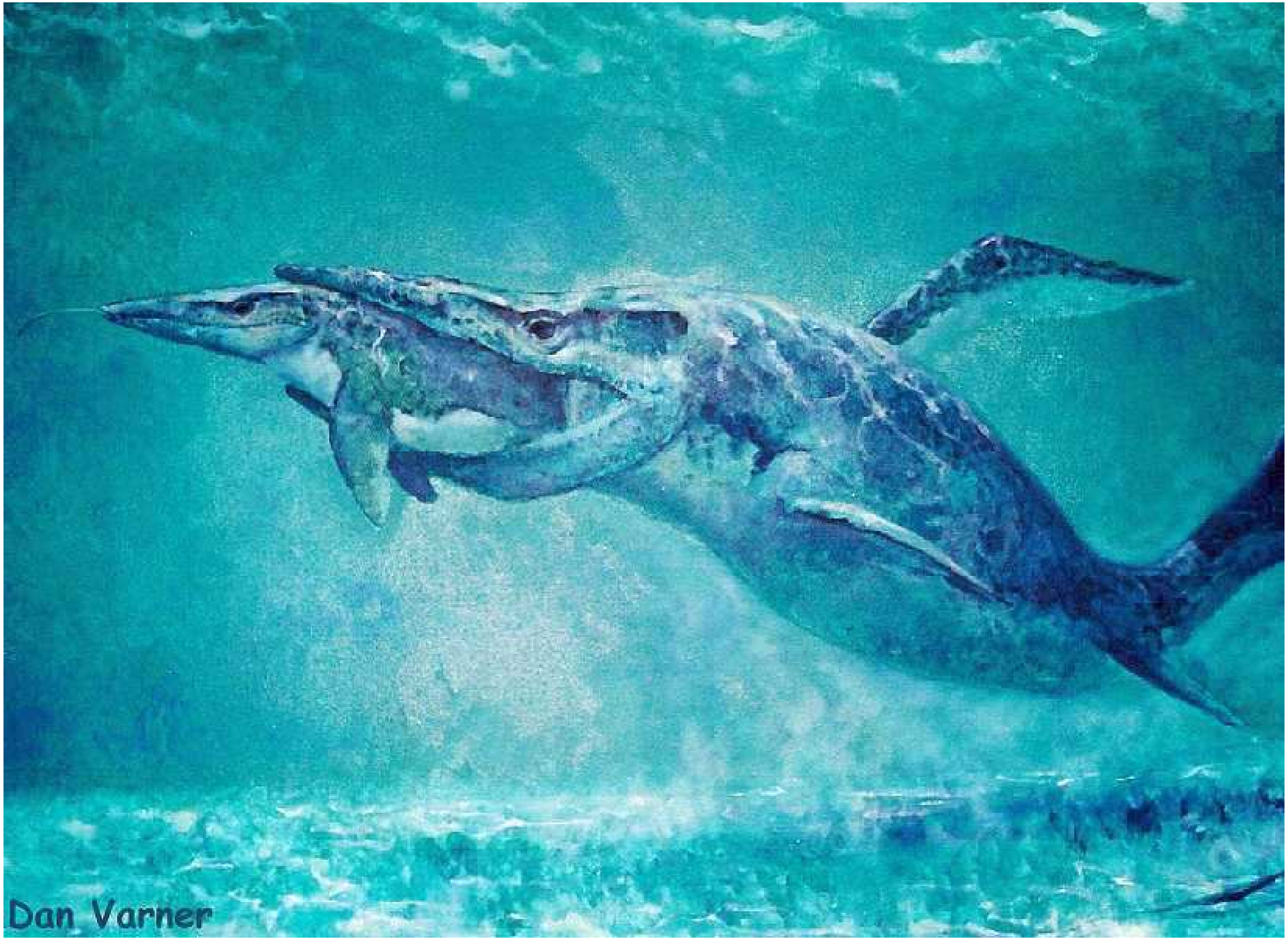
Here a *Mosasaurus hoffmanni* just misses the mark in an attack on the marine crocodile, *Thoracosaurus*,



the little swimming birds (*<u>Hesperornis</u>*) are about 5 feet long and the *Tylosaurus* ... well, it's huge. Modeled after the largest specimen on exhibit (<u>The Bunker Tylosaur</u>), this beast was at least 45 feet long and had a skull that was 6 feet in length.



This picture shows an attack by a very large (30'+) mosasaur called ***Tylosaurus proriger*** on a much smaller *Platecarpus* mosasaur. Tylosaurs occasionally killed and ate other species of mosasaurs but there is no evidence to show that any of the mosasaurs were cannibalistic toward their own species.

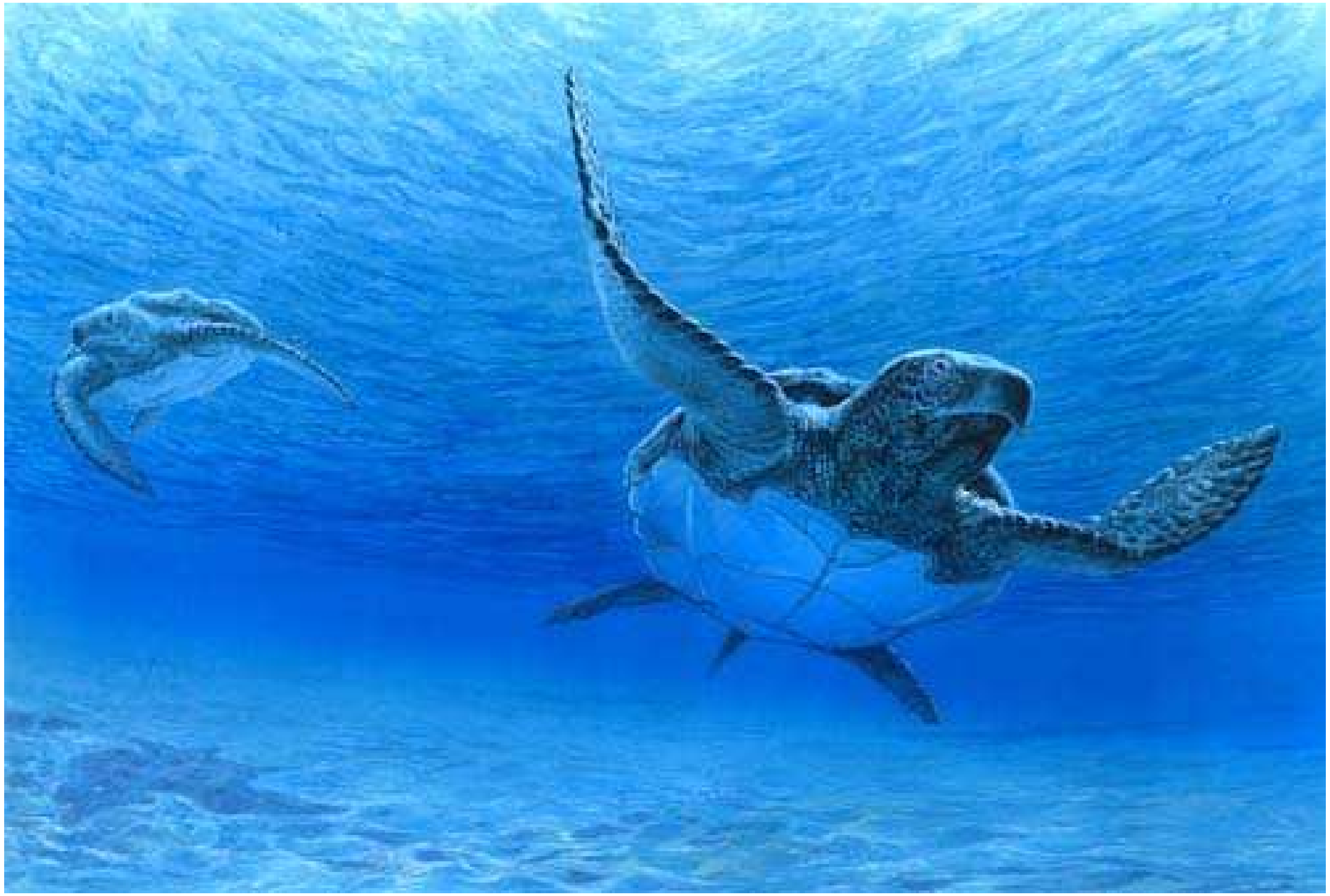


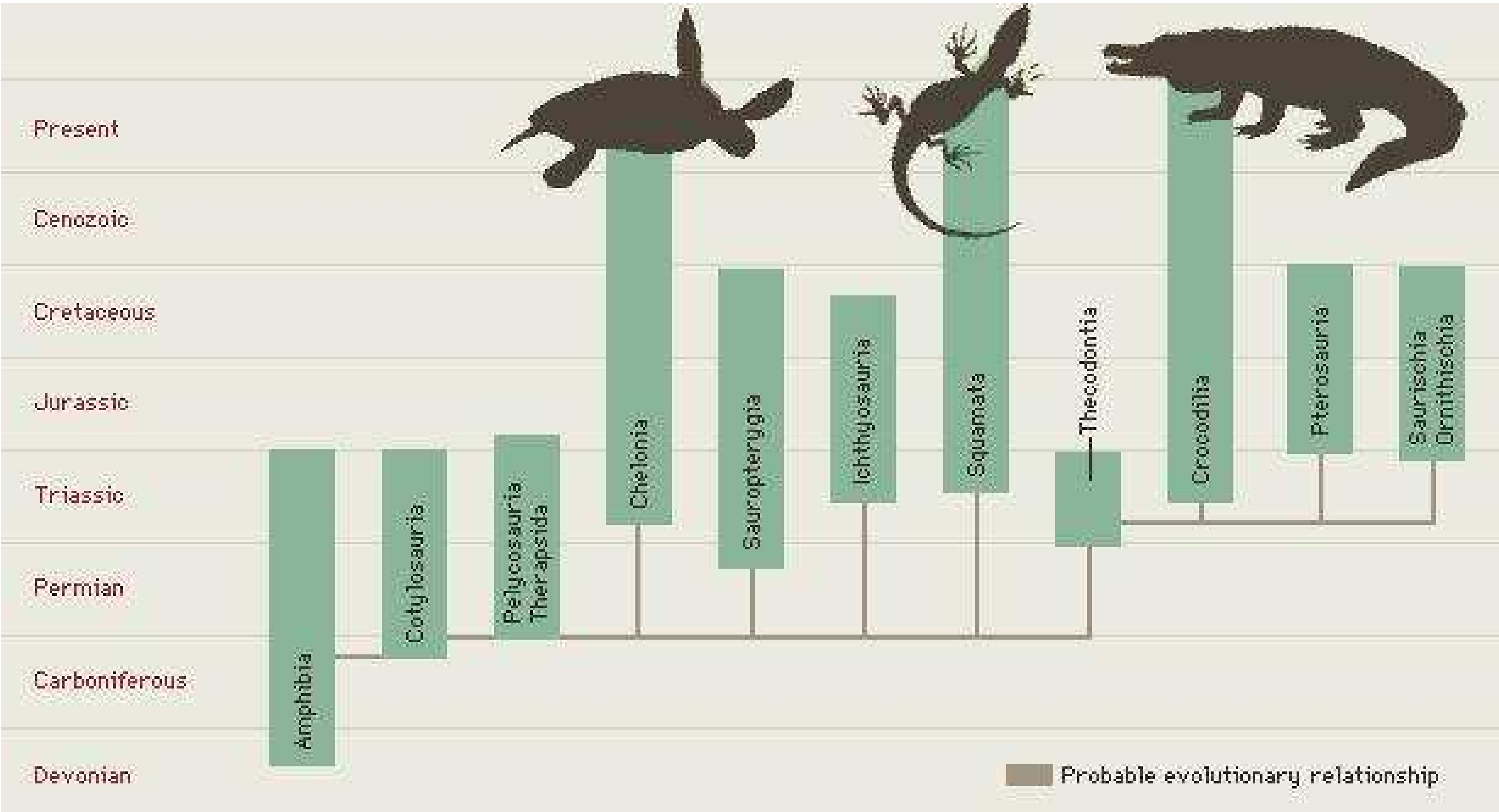
Here a large *Tylosaurus* is about to make lunch of a smaller mosasaur called *Halisaurus sternbergi*. Like their modern relatives, the snakes, mosasaurs were capable of swallowing large prey whole because of the unique design of their skull and very flexible lower jaws.

Land Reptiles

Cotylosaurs – end Triassic extinction

Chelonia – originally terrestrial animals, late Jurassic transition tomarine environment.
Cretaceous – 4m Archelon





Present
Cenozoic
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Amphibia
Cotylosauria
Pelycosauria
Therapsida
Chelonia
Sauropterygia
Ichthyosauria
Squamata
Thecodontia
Crocodilia
Pterosauria
Saurischia
Ornithischia
Probable evolutionary relationship

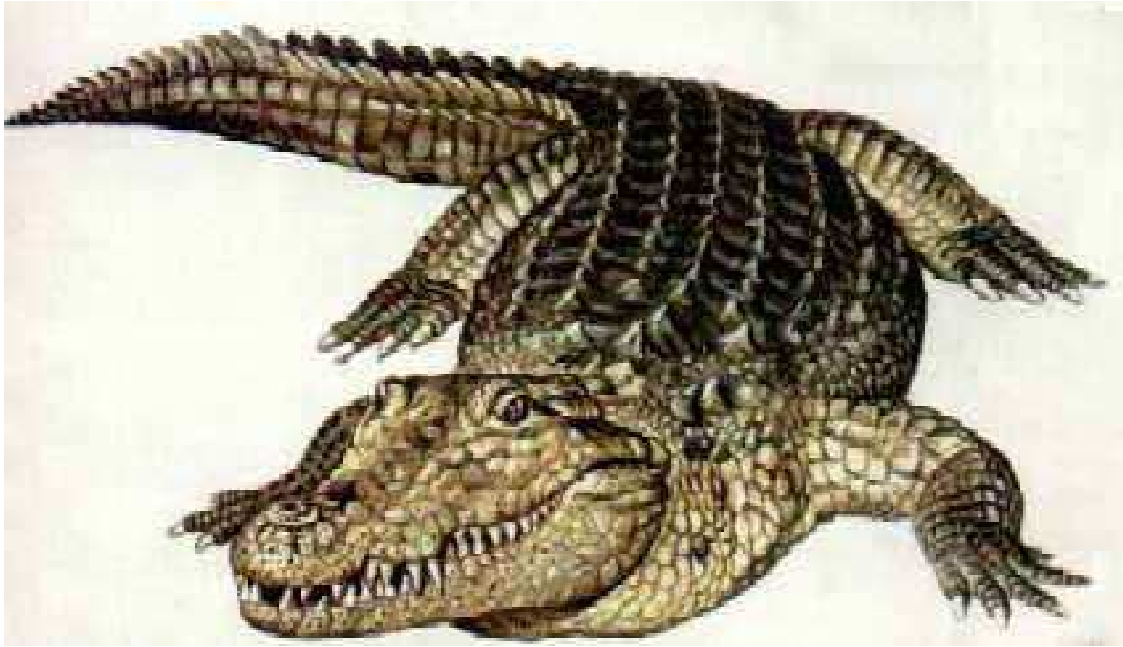
2 - **Lepidosauria**
O. Rhynchocephalia (Sphenodonta) - only living representative is the Tuatara
O. Squamata - lizards, geckos, & snakes
3 -**Archosauria**
O. Thecodontia – stem archosaurs
O. Pterosauria
O. Saurischia- 2 major groups: sauropods & theropods
O. Ornithischia
O. Crocodilia
4 - Euryapsida - marine reptiles, includes the plesiosaurs & ichtyosaurs

Lepidosaurs – radiation at the beginning of Triassic, Small lizard-like reptiles. Predecessors of thecodonts (Permian) and **Squamata** (Triassic)

Thecodonts – wide expansion in early and middle Triassic. End Triassic extinction (dinosaurs?)

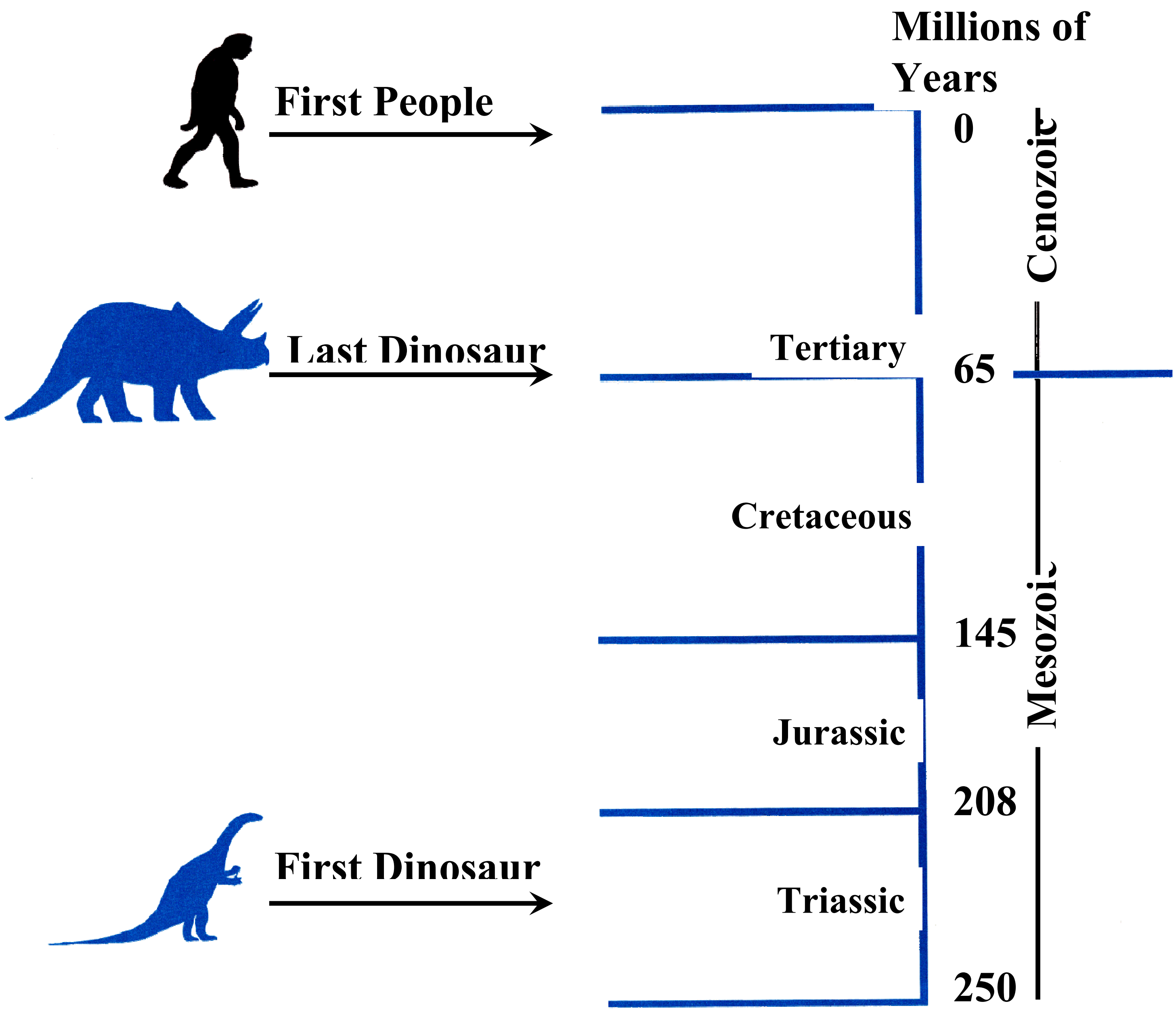
Crocodiles – Triassic, thecodont predecessors. Originally land animals, secondary to water environment. Great **expansion** in **Jurassic**, mostly in **seas**. In **Cretaceous gigantic forms** as 15m Phobosuchus.

An early and very 'fish-like' crocodile (*Geosaurus*) swims in the shallow **seas** covering Germany in the Middle to Late **Jurassic**. Although not closely related to the ichthyosaurs, the tails of member of the Metriorhynch family were adapted for swimming in the same way, even to the noticeable down bend in the posterior caudal vertebrae.



Phobosuchus

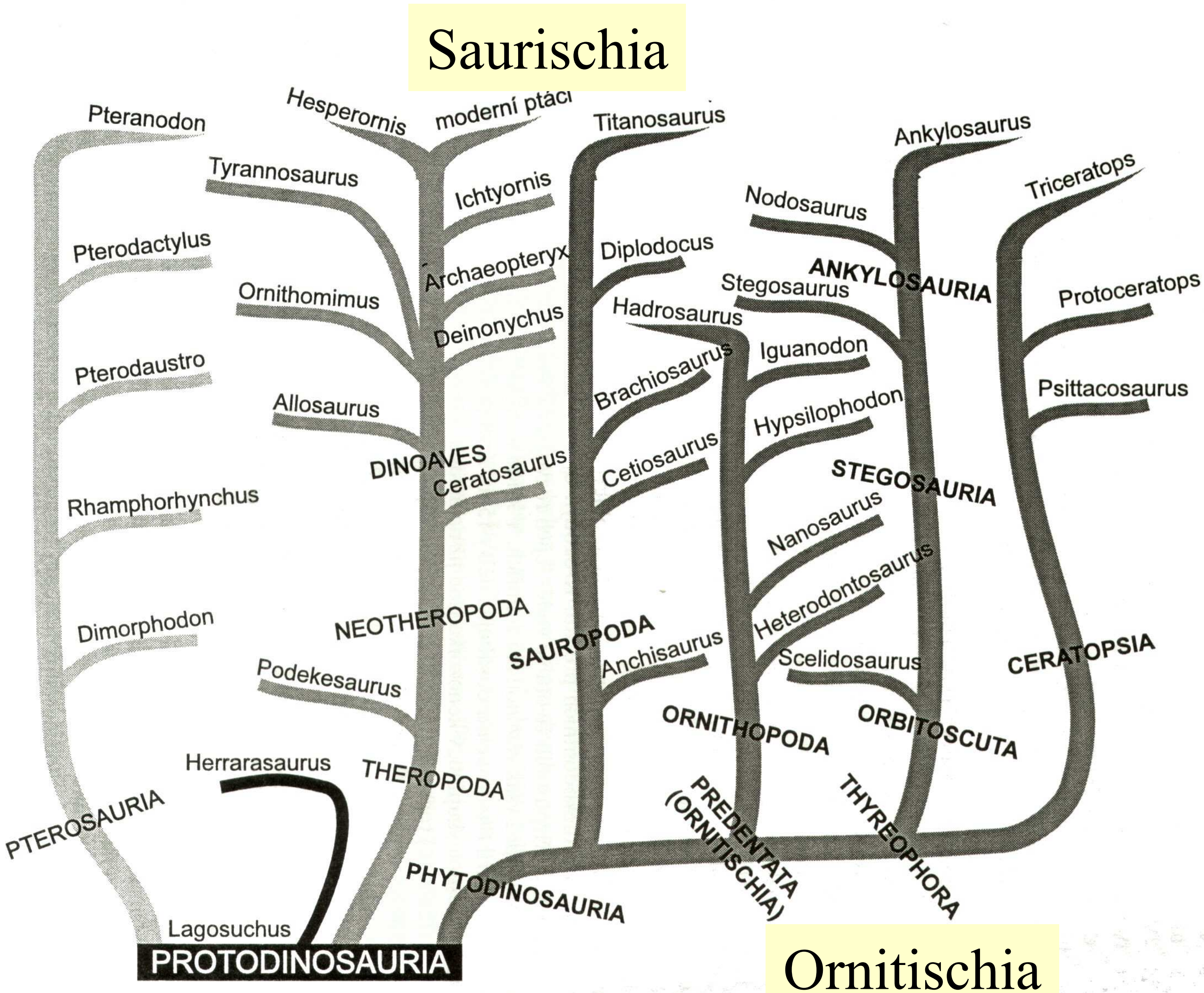
When did dinosaurs live?



What are dinosaurs?

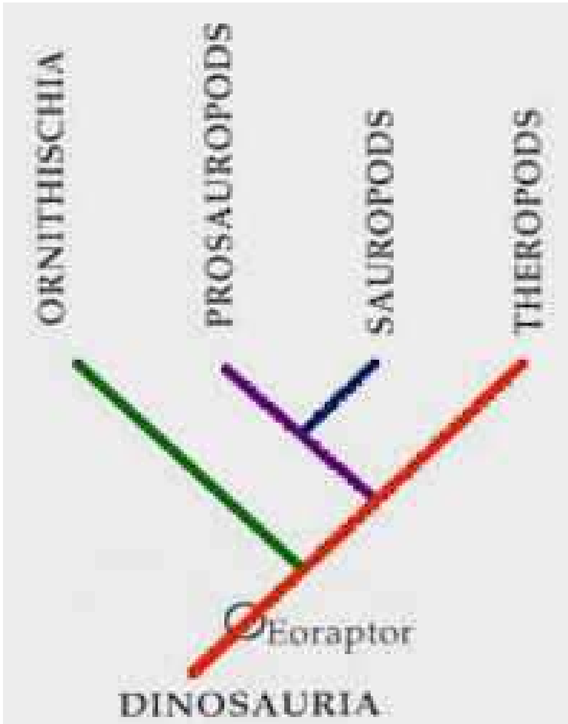
- Technically: no such thing as dinosaurs
- Classification:
  - Class – Reptilia (reptiles)
  - Order – Archosauria
  - Suborders
    - Saurrischia – lizard hips
    - Ornithischia – bird hips

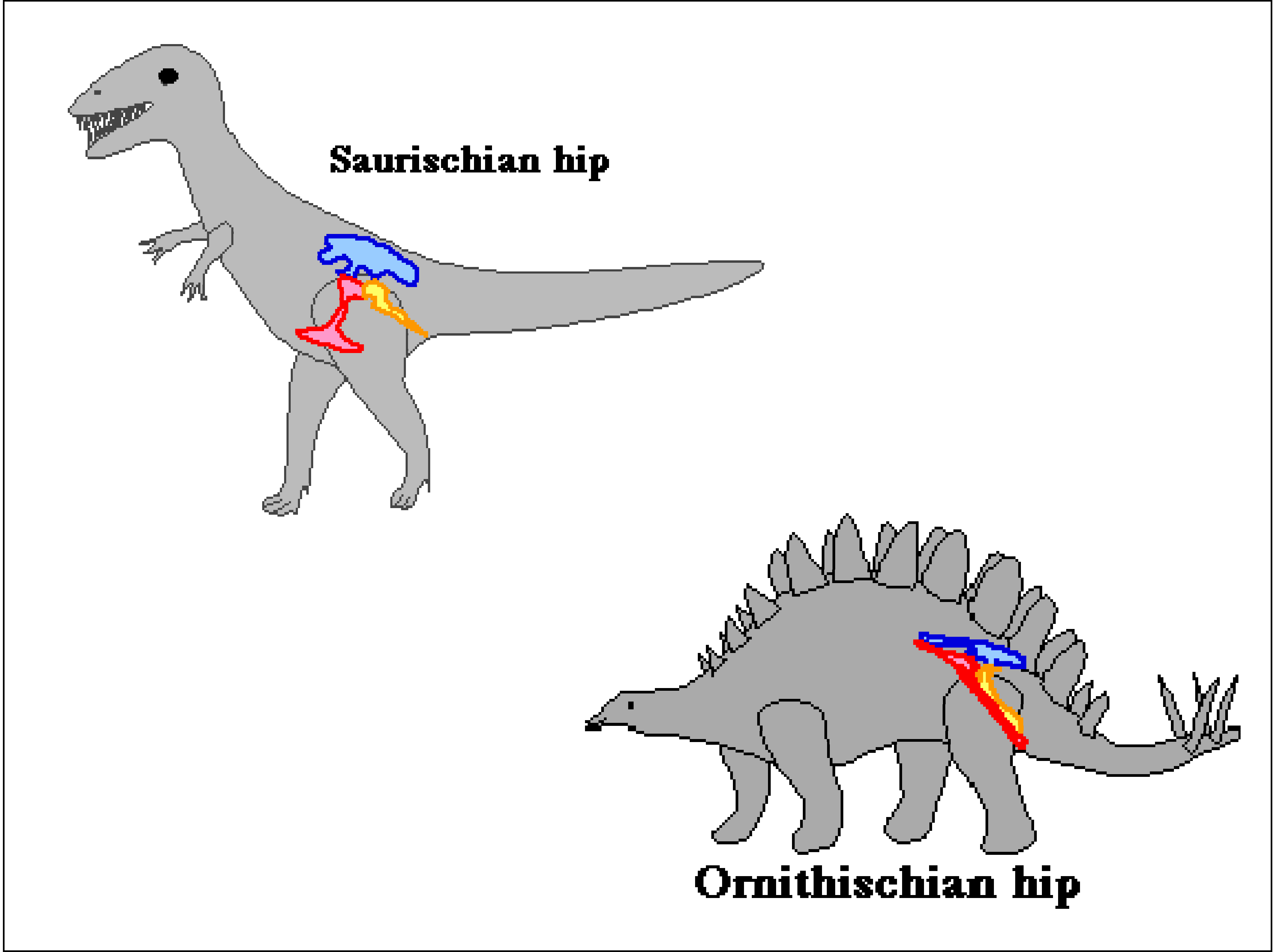
Dinosaurs in popular sense



Obr. 71. Schematické znázornění evoluce dinosaurů (zjednodušeno podle Bakker, 1986).

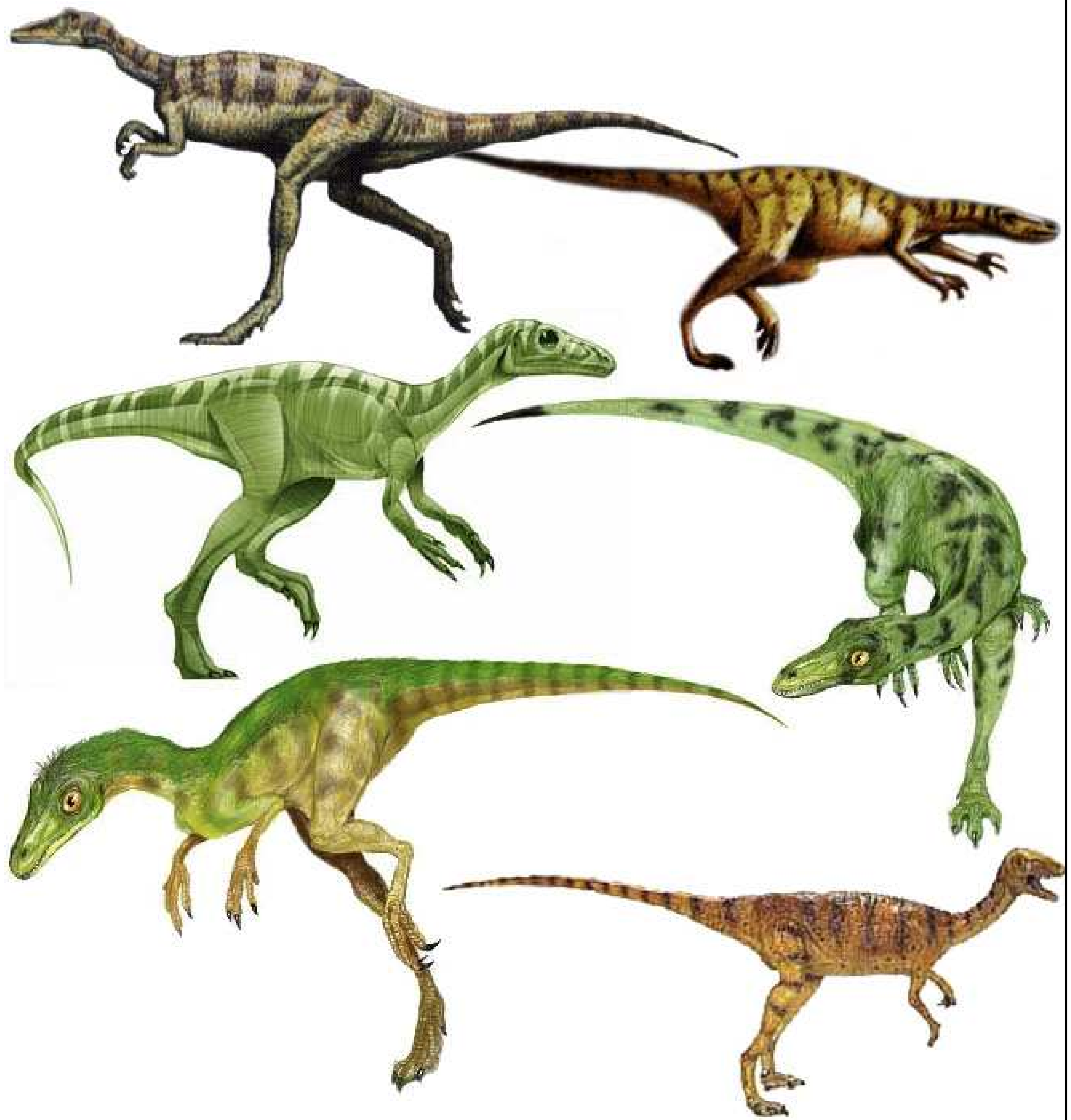
Saurischia

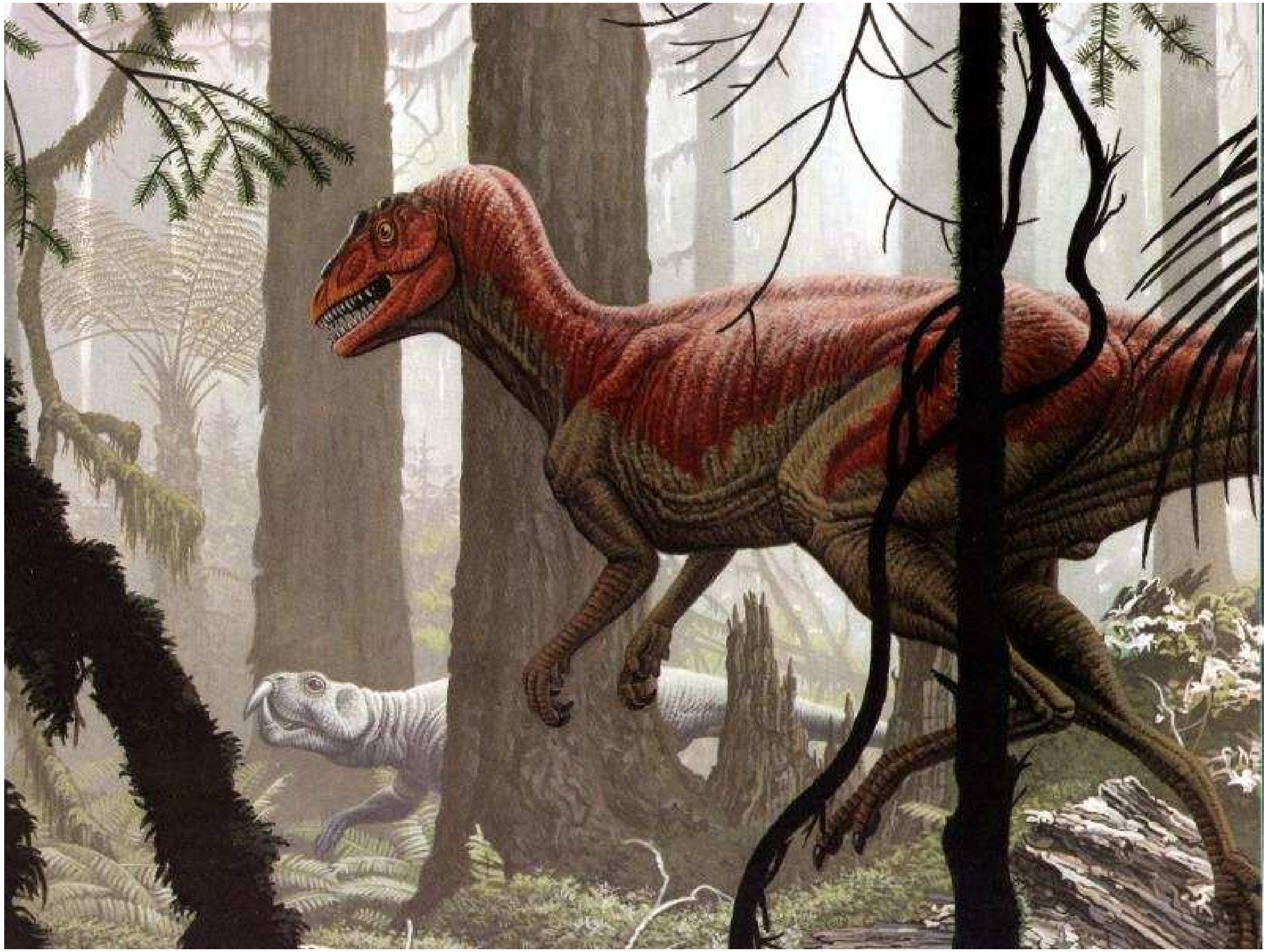

ORNITHISCHIA
PROSAUROPODS
SAUROPODS
THEROPODS
Eoraptor
DINOSAURIA


Saurischian hip
Ornithischian hip

Protodinosauria

Eoraptor





Herrerasaurus

Order Saurischia

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

Who were the Theropods

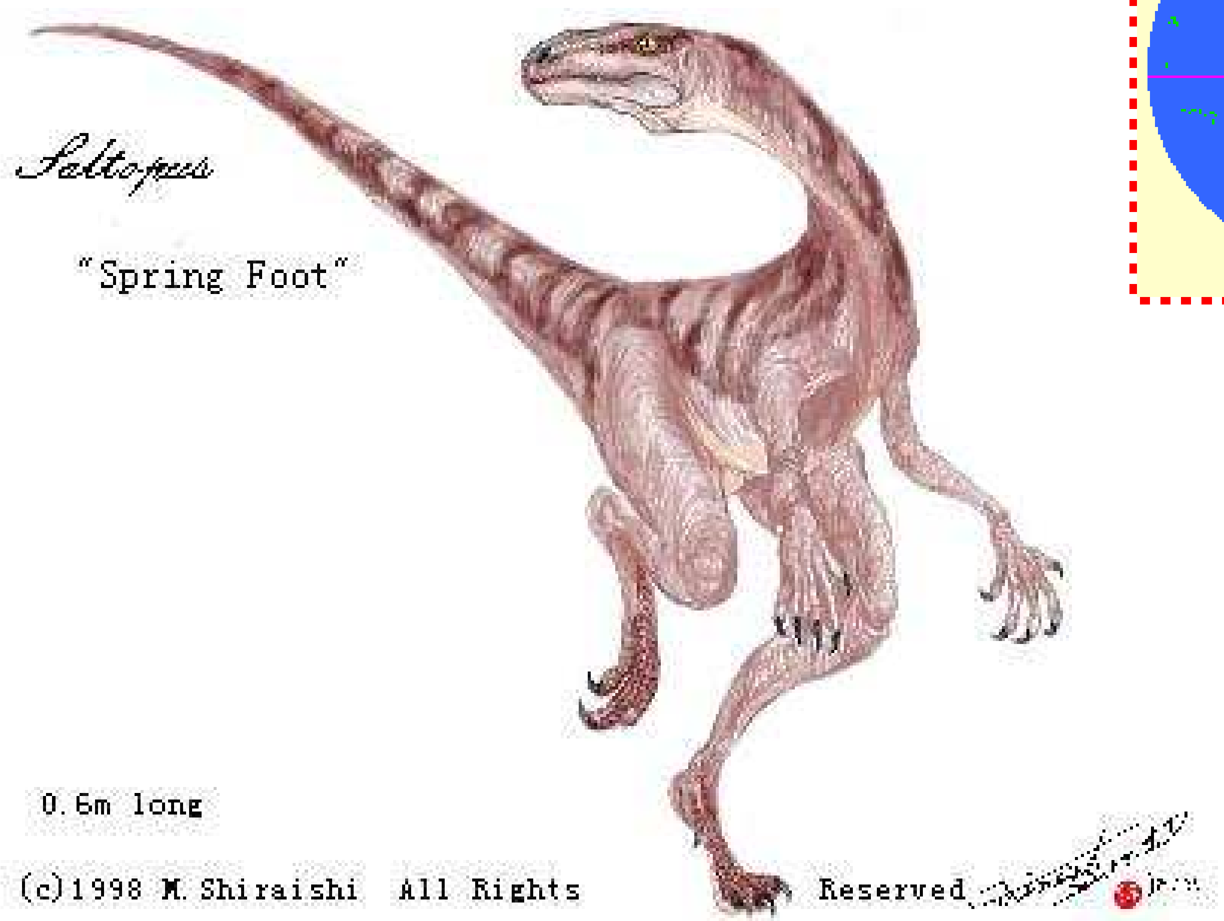
- Contained all of the meat eating dinosaurs of the Mesozoic
- Also contained some plant eaters having primitive characteristics

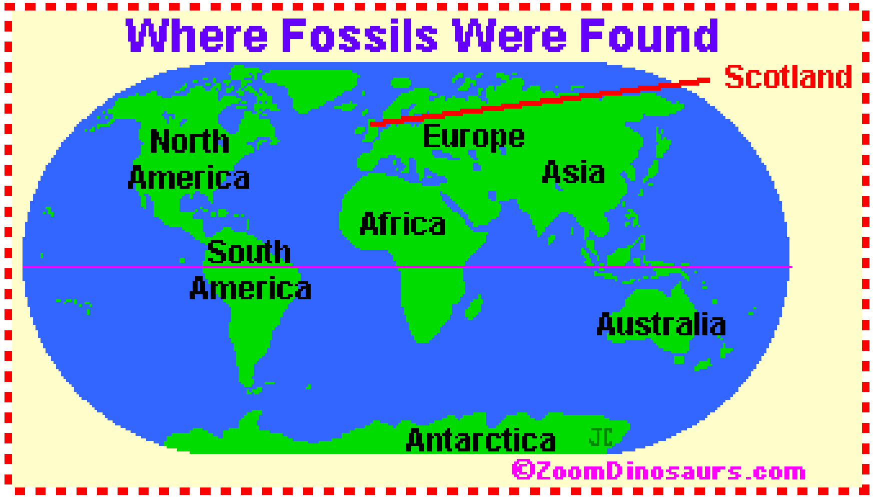
Celurosauria and Carnosauria

Celurosauria

Coelophysis

Typical Coelurosauria: Saltopus



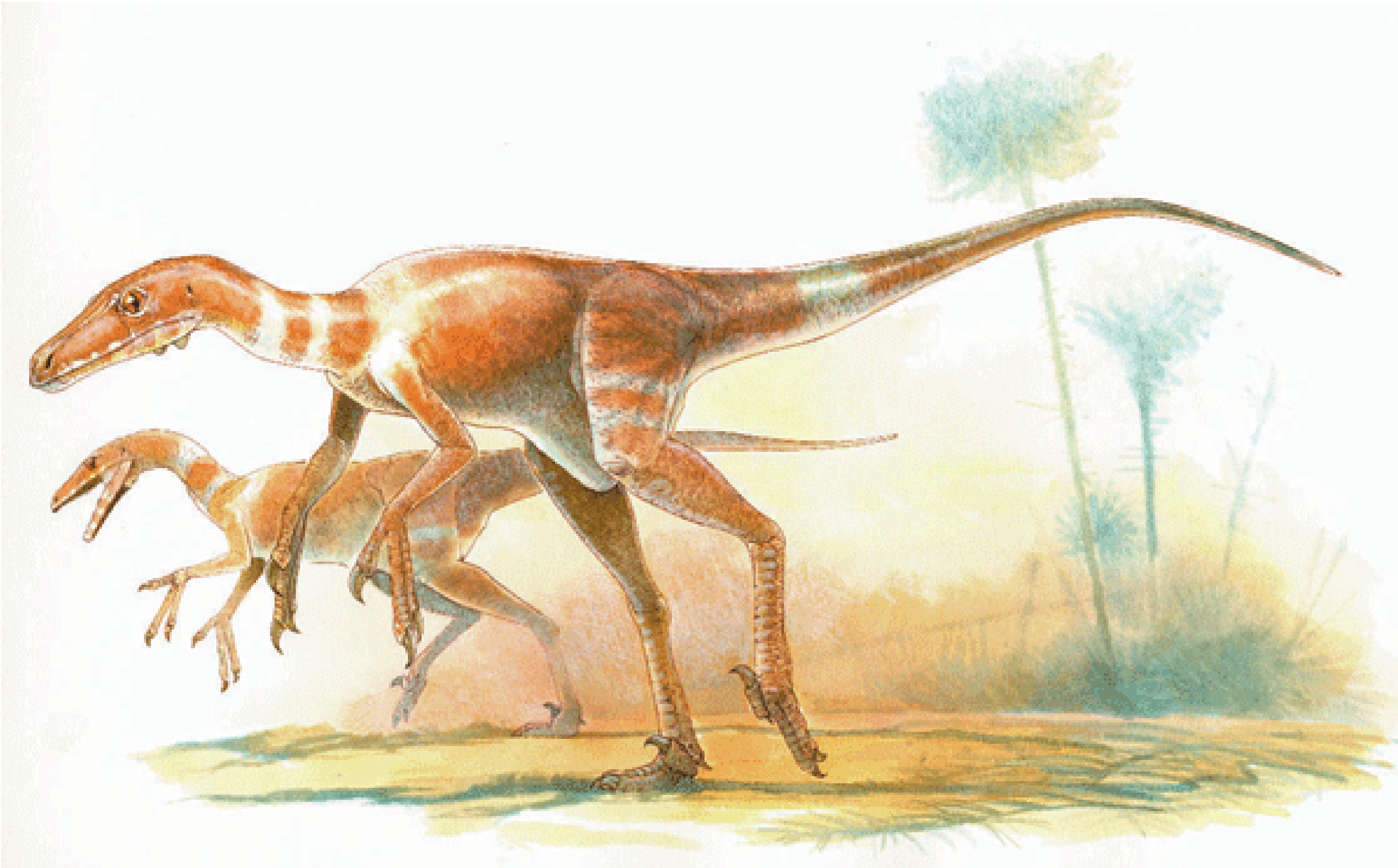


Coeleurosaurs

- Very successful in Mesozoic
- Coelurosauria

Velociraptor (Jurassic Park)

Troodon



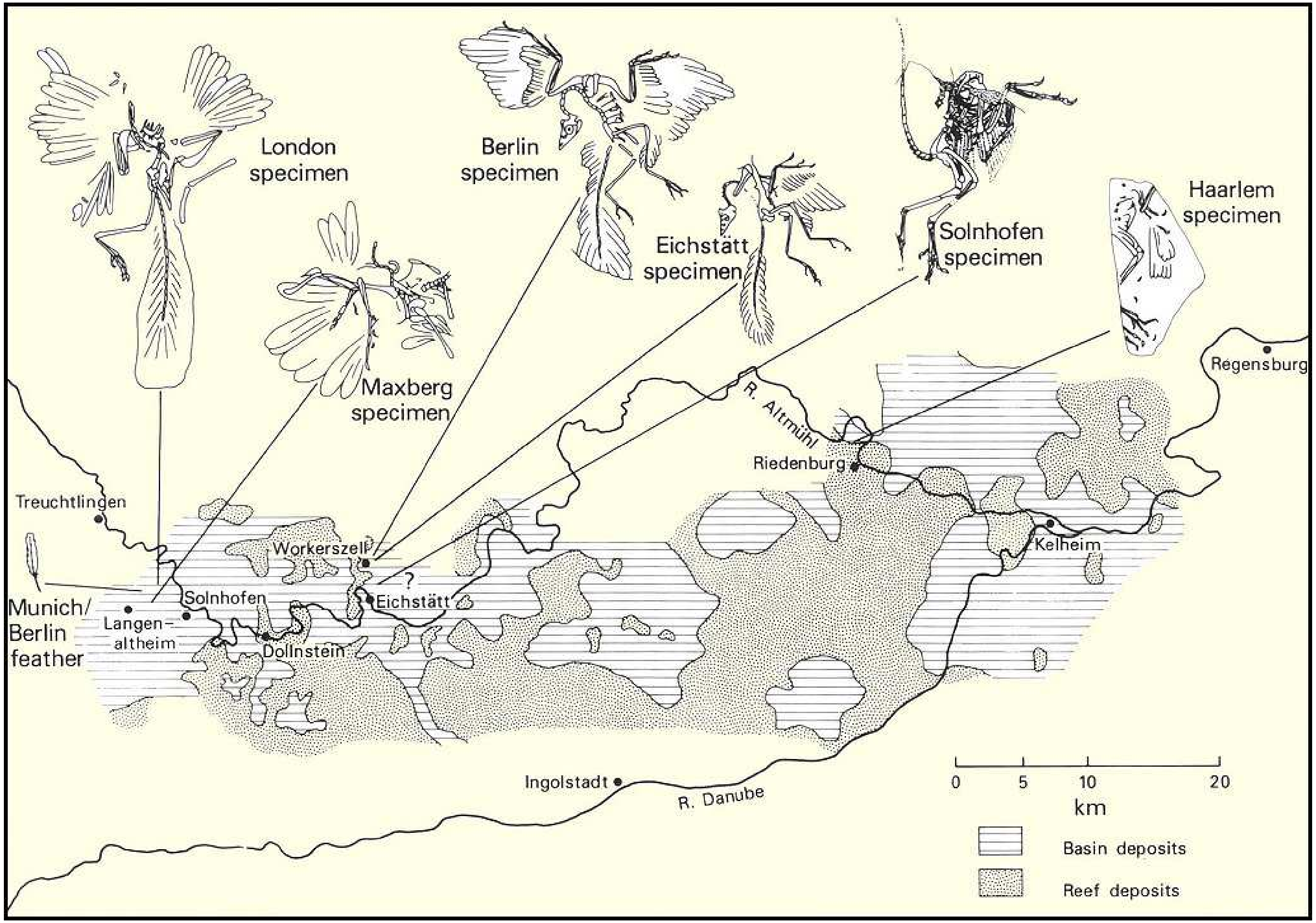
Archaeopteryx

Fossil

Maybe…?

Where are Archaeopteryx found?

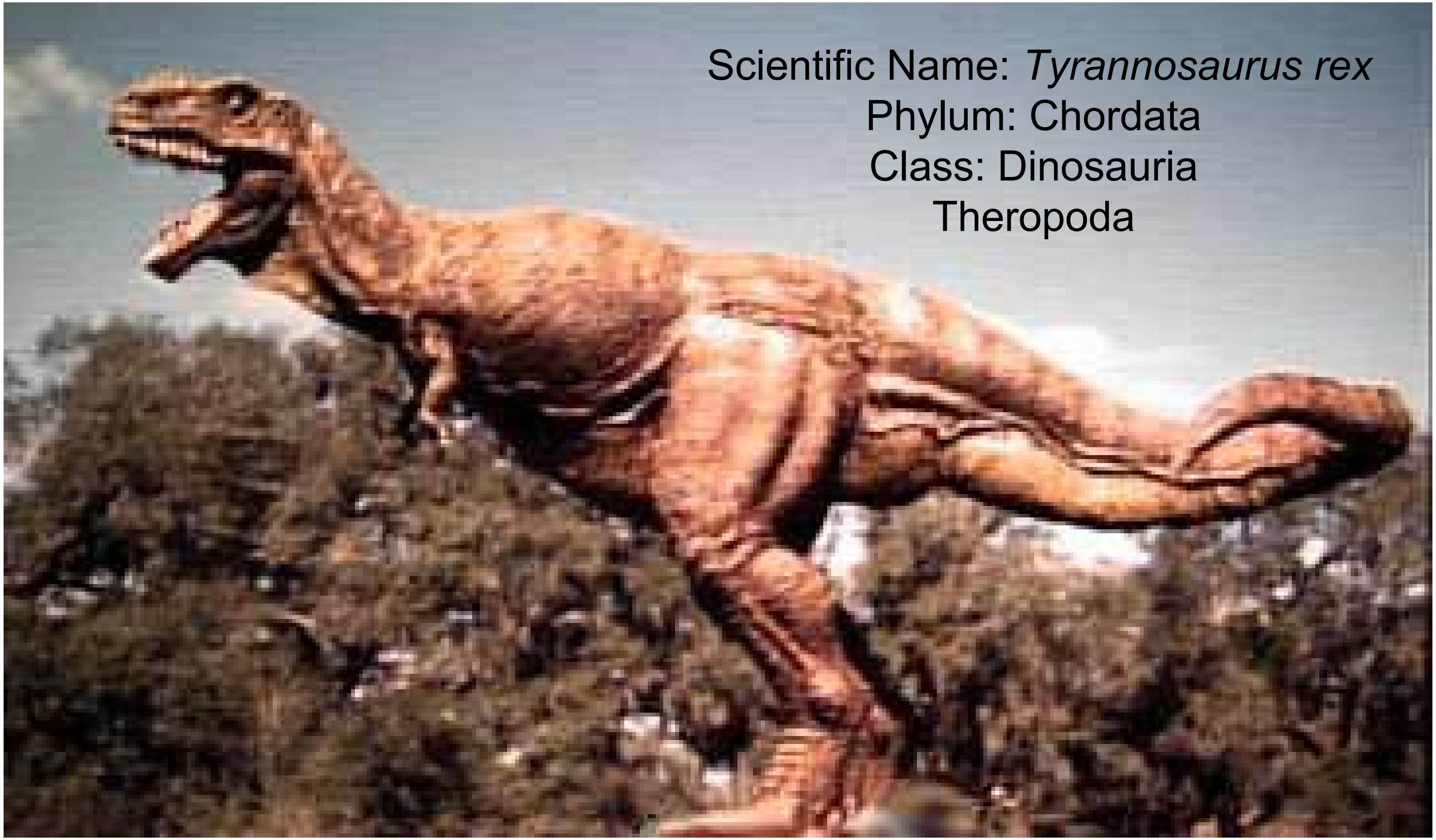
Mostly in Germany



Carnosauria

Allosaurus

And T-Rex

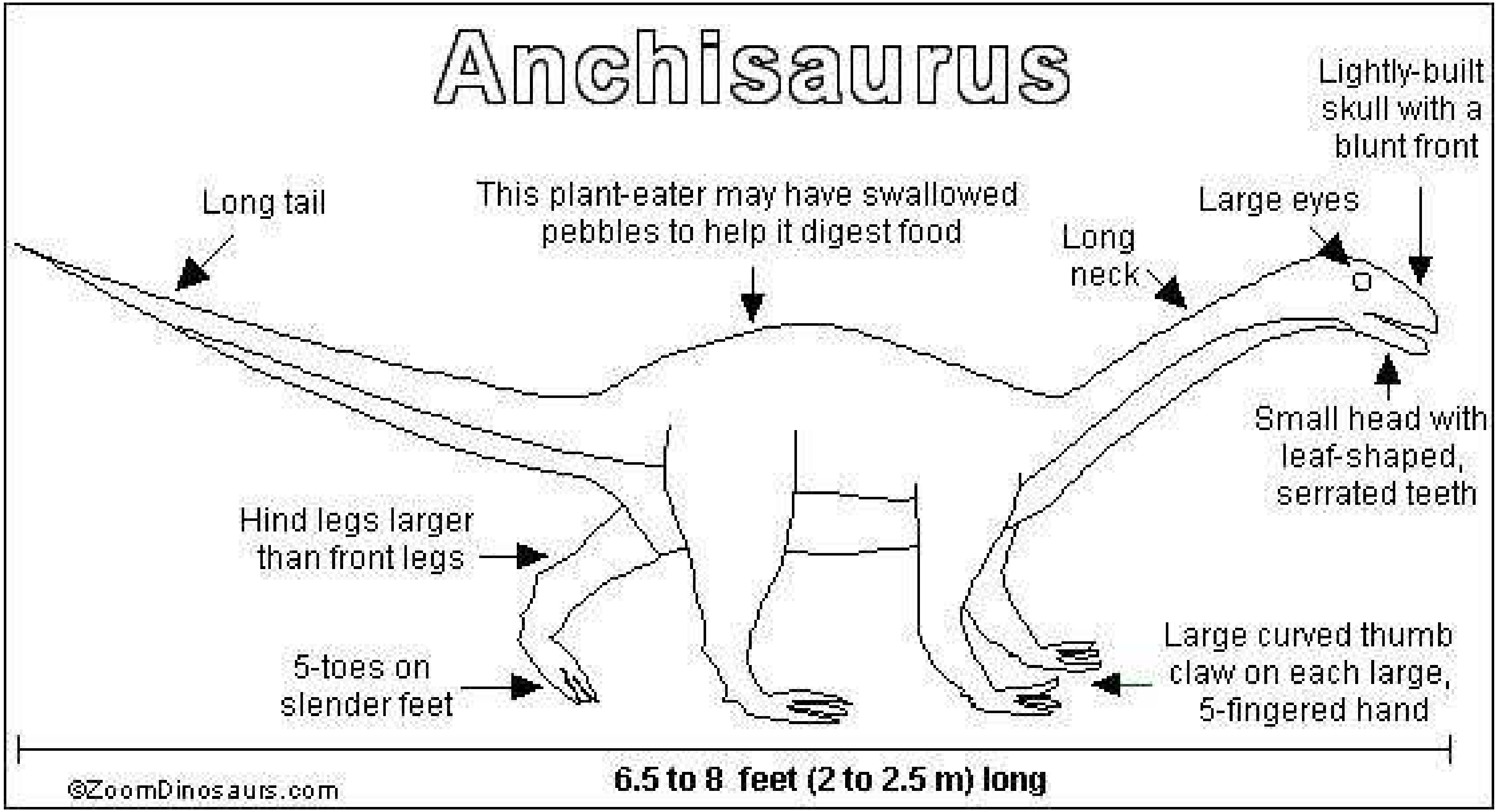

Scientific Name: *Tyrannosaurus rex*
Phylum: Chordata
Class: Dinosauria
Theropoda

Tyrannosaurides (T-Rex)

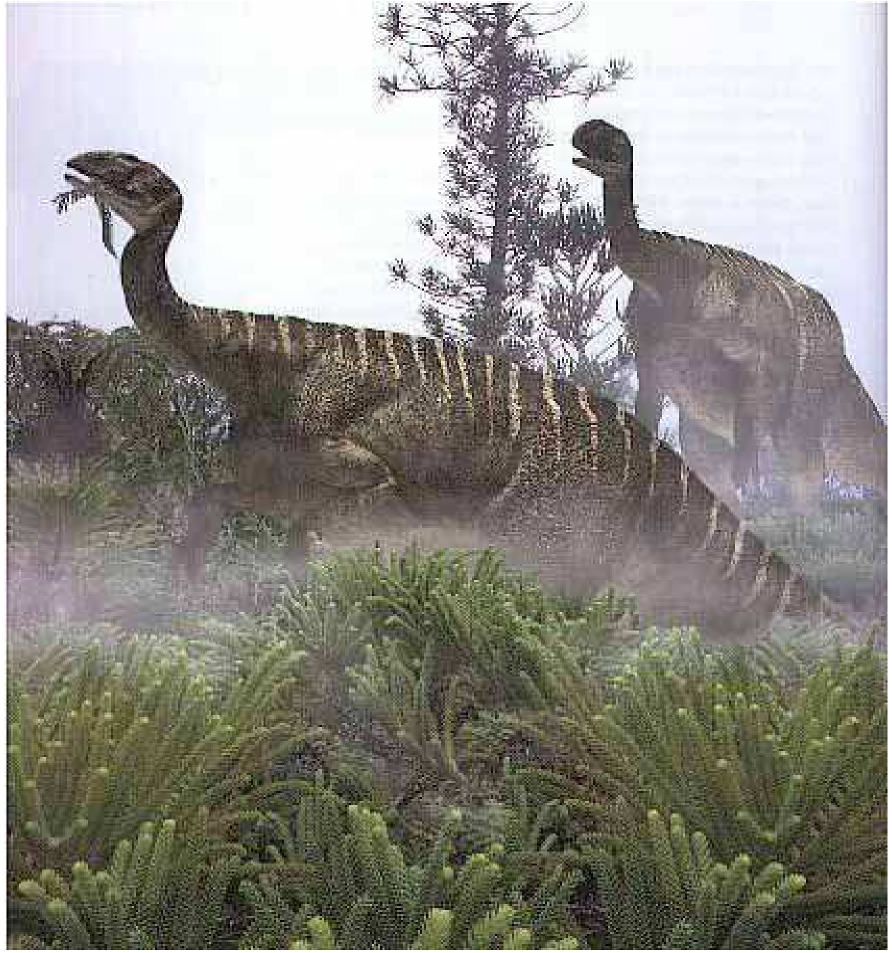
PHYTODINOSAURIA

Prosauropoda

Plateosaurus (flat-lizard)



Prosauropoda (Plateosaurus)



Plateosaurus (small head)

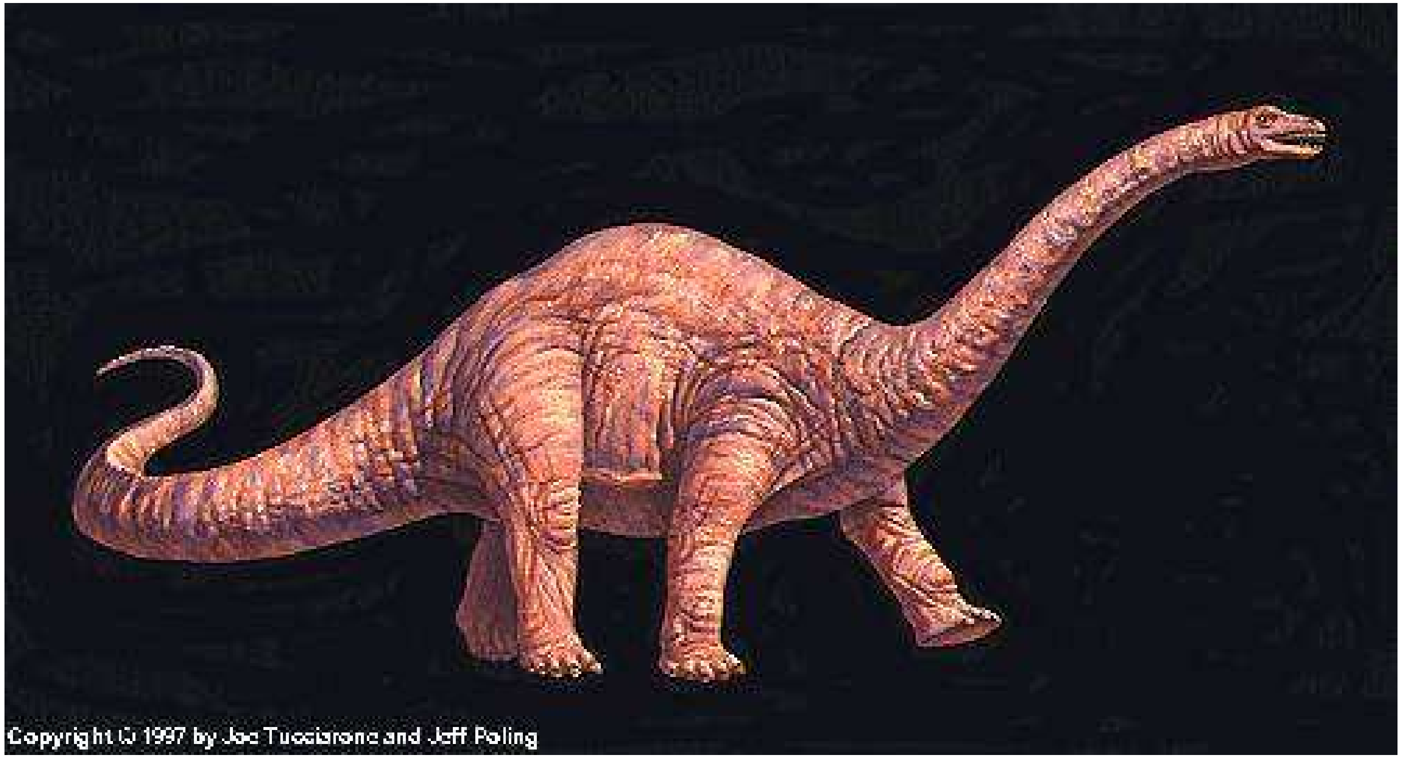
Sauropods

Who were the Sauropods?

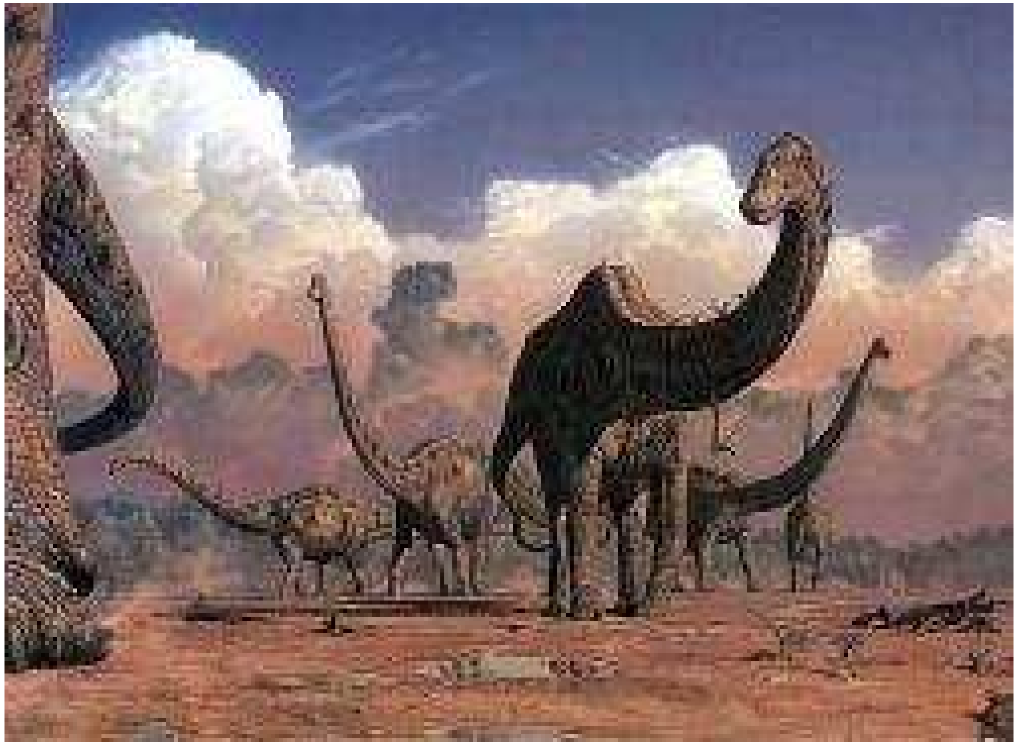
Mainly Jurrasic

„Brontosaurus“

Who were the Sauropods



Apatosaurus



Z 55 na 33 metrů se zmenšil „nejdelší“ známý dinosaurus poté, co vědci přehodnotili svůj původní nález.

Na úžasnou délku dinosaura usoudili objevitelé jeho neúplné kostry z umístění 20. až 27. ocasního obratle. Lucas ale dokázal, že ve skutečnosti jde o 12. až 19. ocasní obratel a že zvíře bylo celkově mnohem kratší. Lucas navíc objevil v blízkosti nálezu kostry ještě kost zadní nohy a i její velikost potvrzuje, že původní odhady délky seismosaura byly přehnané. Srovnání detailů kostry s kostrami diplodoků zase naznačuje, že seismosaurus patřil do jejich blízkého příbuzenstva. Původní vědecké jméno Seismosaurus hallorum by se tedy mělo změnit na Diplodocus hallorum, ale Lucas si nedělá iluze, že by se „zemětřesné“ jméno ztratilo ze světa.

Scientific Name: *Brachiosaurus*
Phylum: Chordata
Class: Dinosauria
Sauropoda

ウルトラサウルス

Ultrasaurus macintosh

1979年、やはりコロラドで2.7mもある肩甲骨が発見され、ブラキオサウルス科の恐竜と考えられこのような復元がなされた。これこそ史上最大の陸棲動物として話題になったが現在ではこれもスーパーサウルスの骨だとされて幕となった。

The Ornithischians (bird-hip structure) - Phytodinosauria

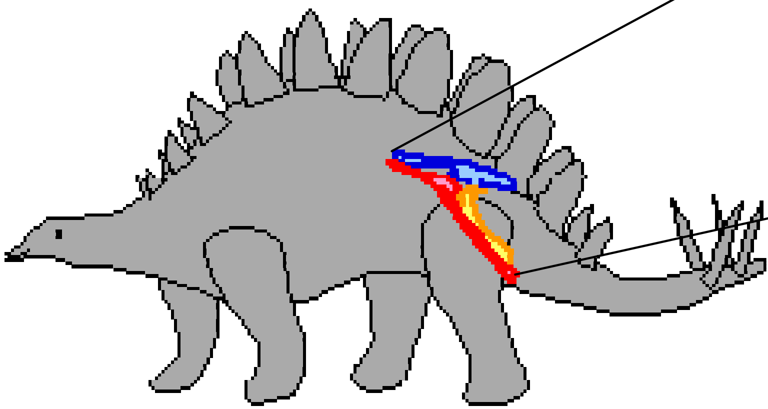
There were five basic kinds of ornithischians

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

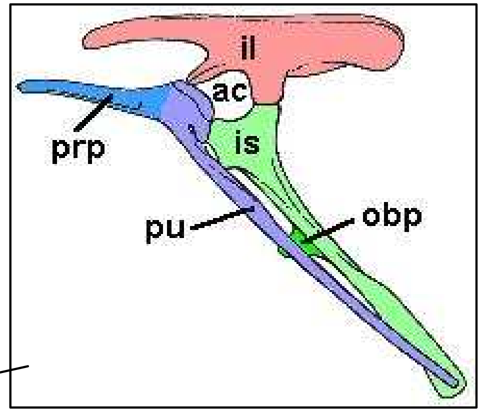
Entirely vegetarians

- Exploited vegetation low to the ground

Pelvis characteristics



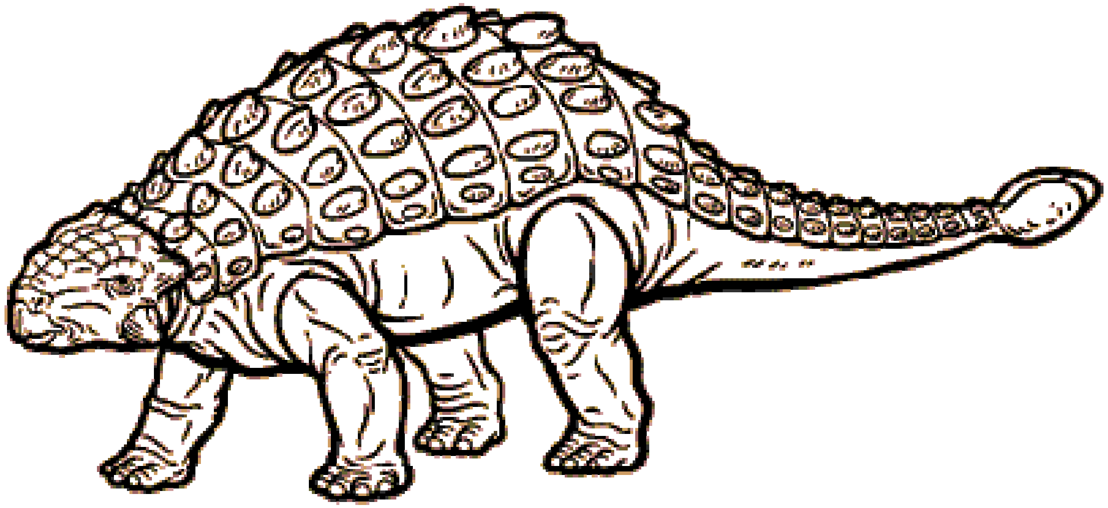
Ornithischian hip



Stegosauria

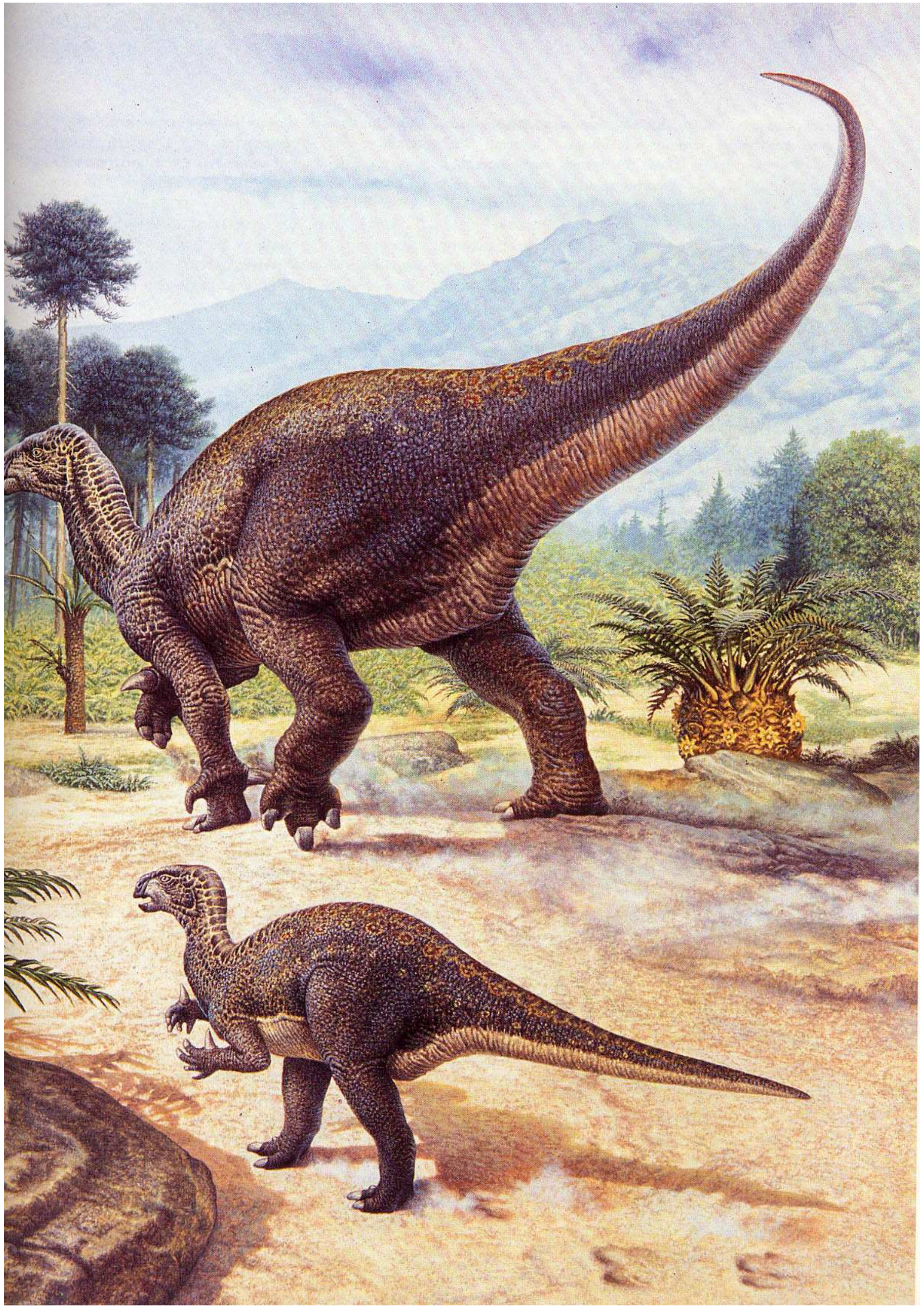
Stegosaurus

ANKYLOSAURS

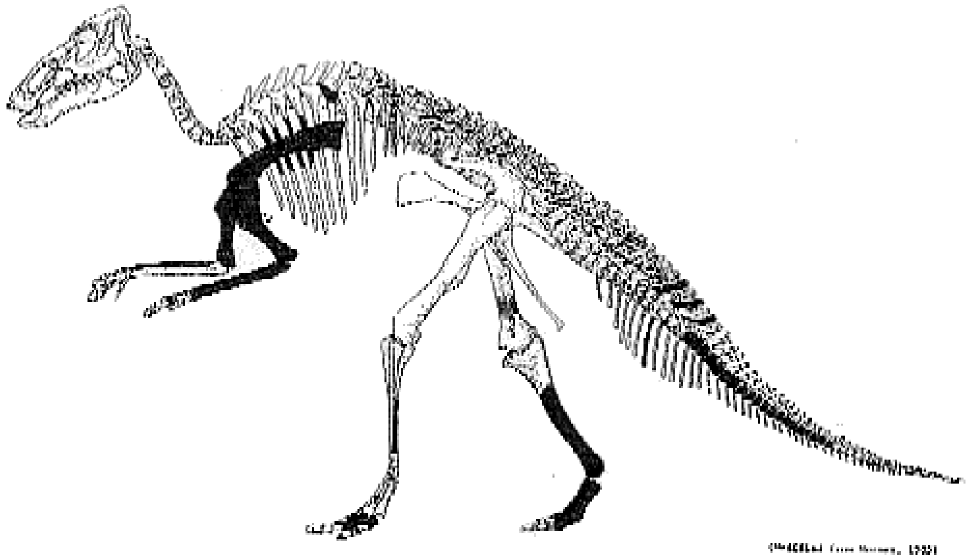


Ornithopoda

Iguanodonts

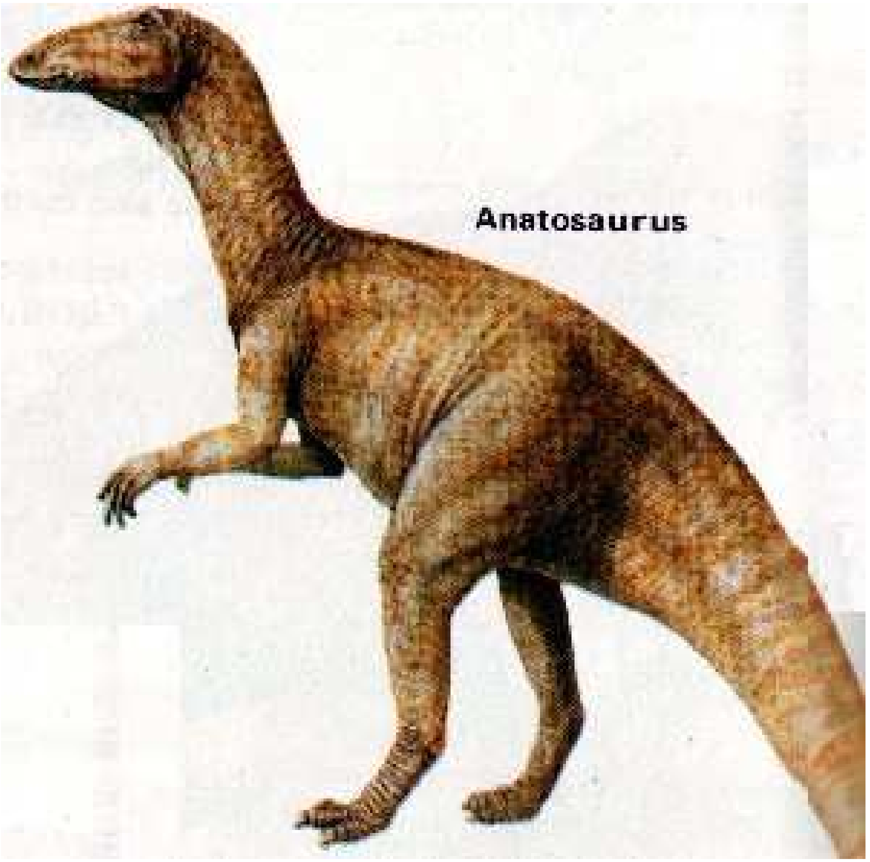


Hadrosaurs

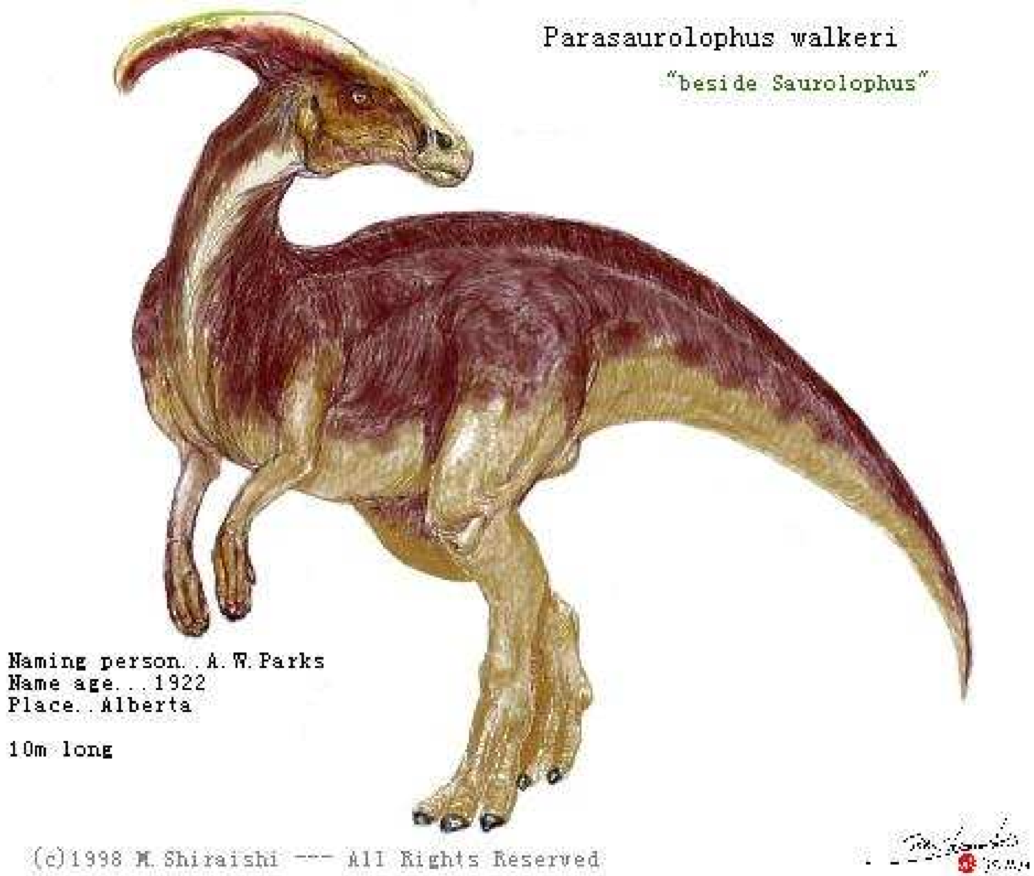


Duck Bill Idea – Sometimes called Duck-billed dinosaur

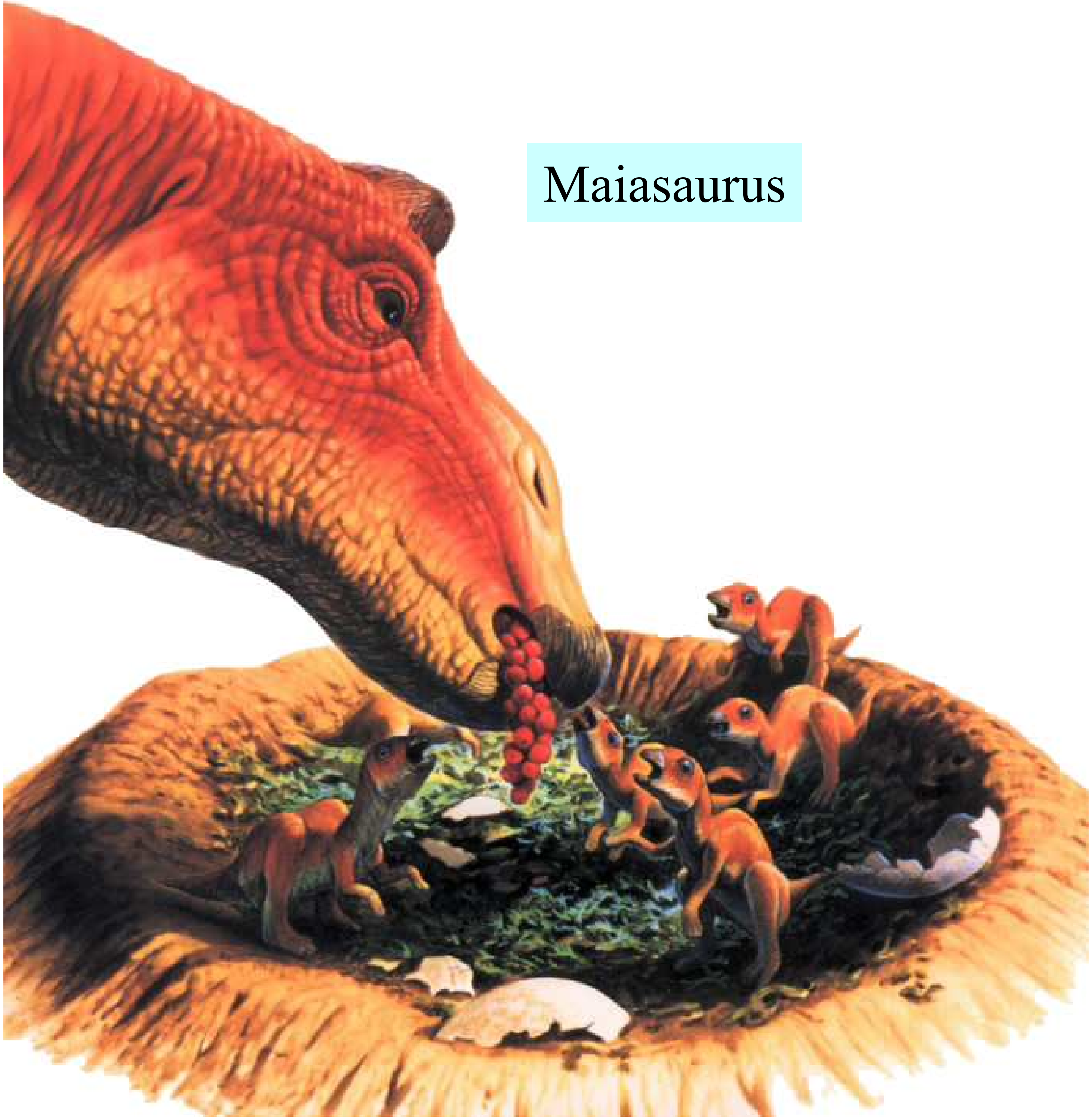
Types of Hadrosaurs



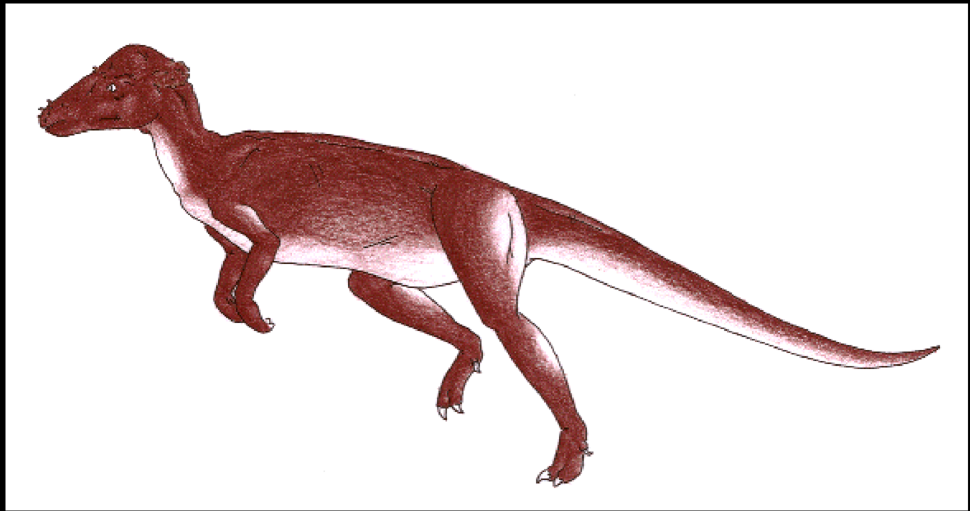
Anatosaurus



Parasauro

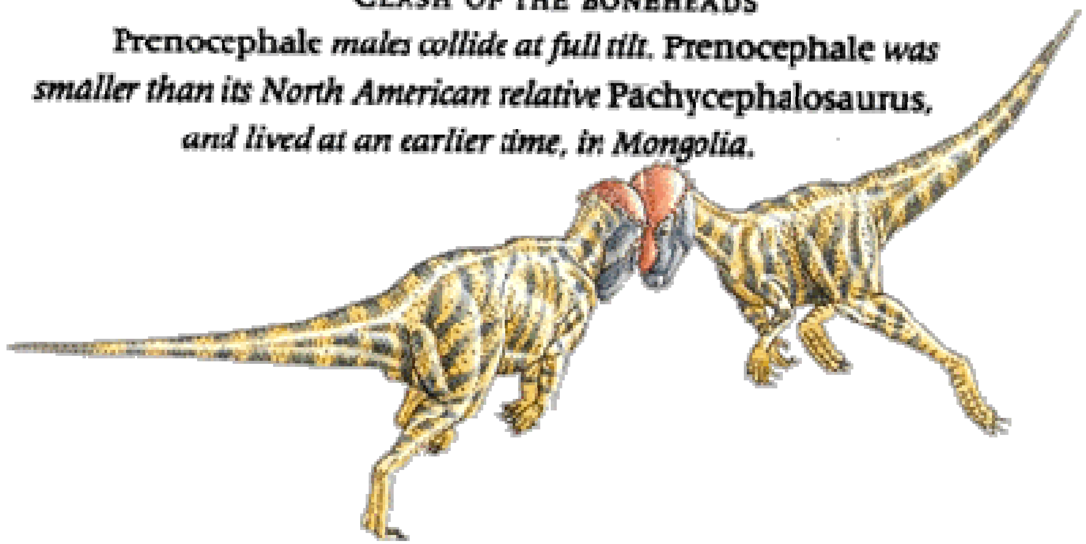

Maiasaurus

Pachycephalosaurs



Clash of the boneheads

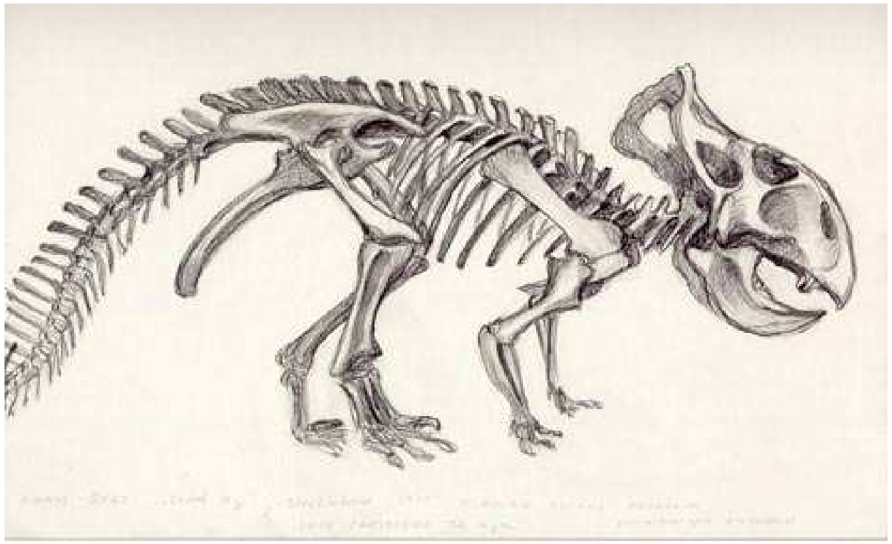
Prenocephale *males collide at full tilt.* Prenocephale *was smaller than its North American relative* Pachycephalosaurus, *and lived at an earlier time, in Mongolia.*

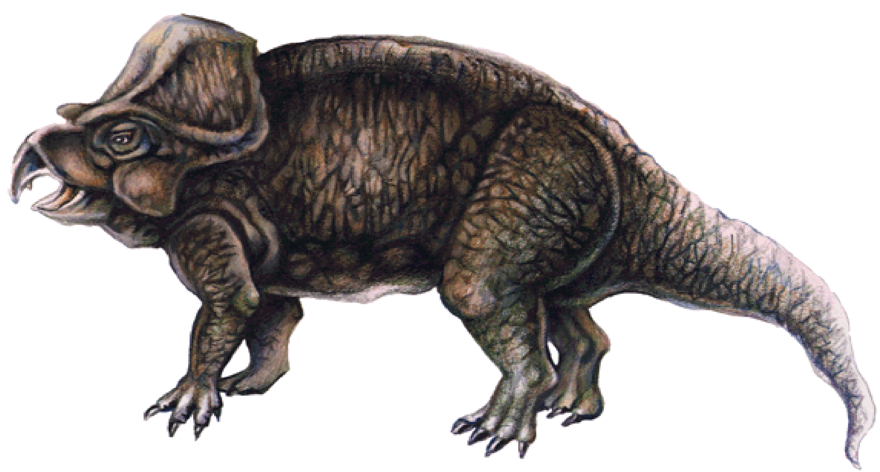


Ceratopsia

Ceratopsia

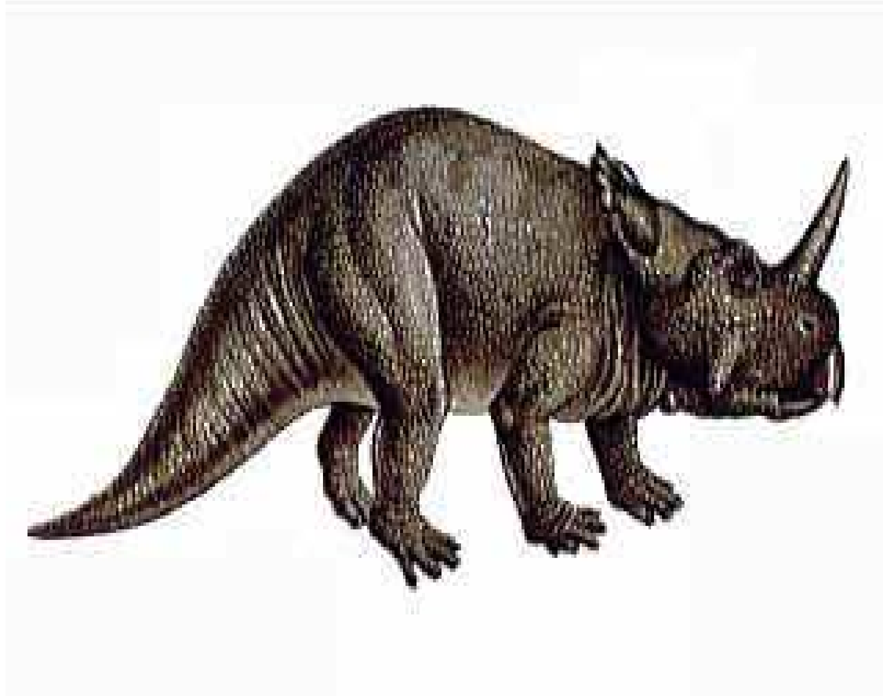
Types of Ceratopsia





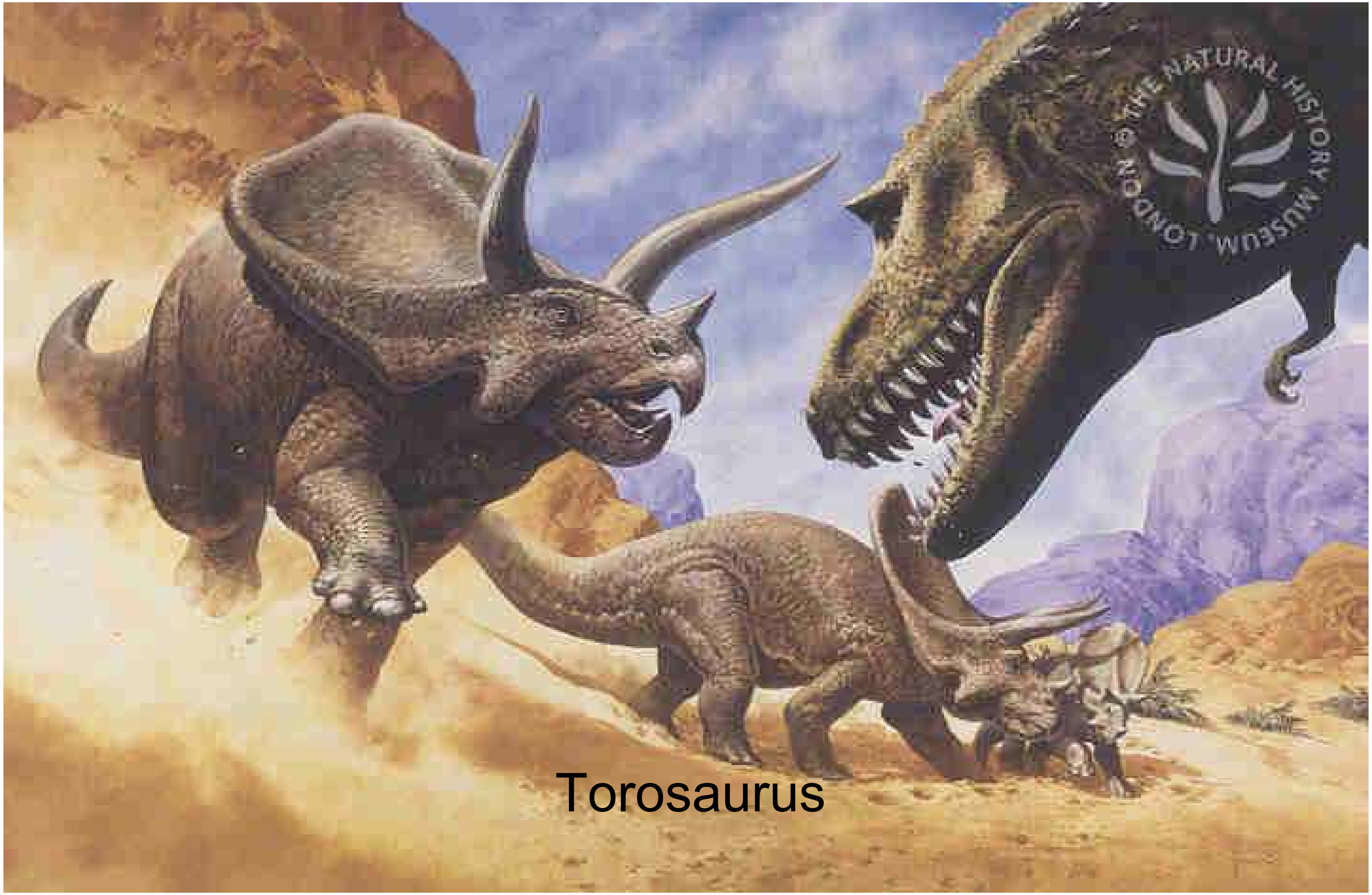
Protoceratops

Types of Ceratopsia



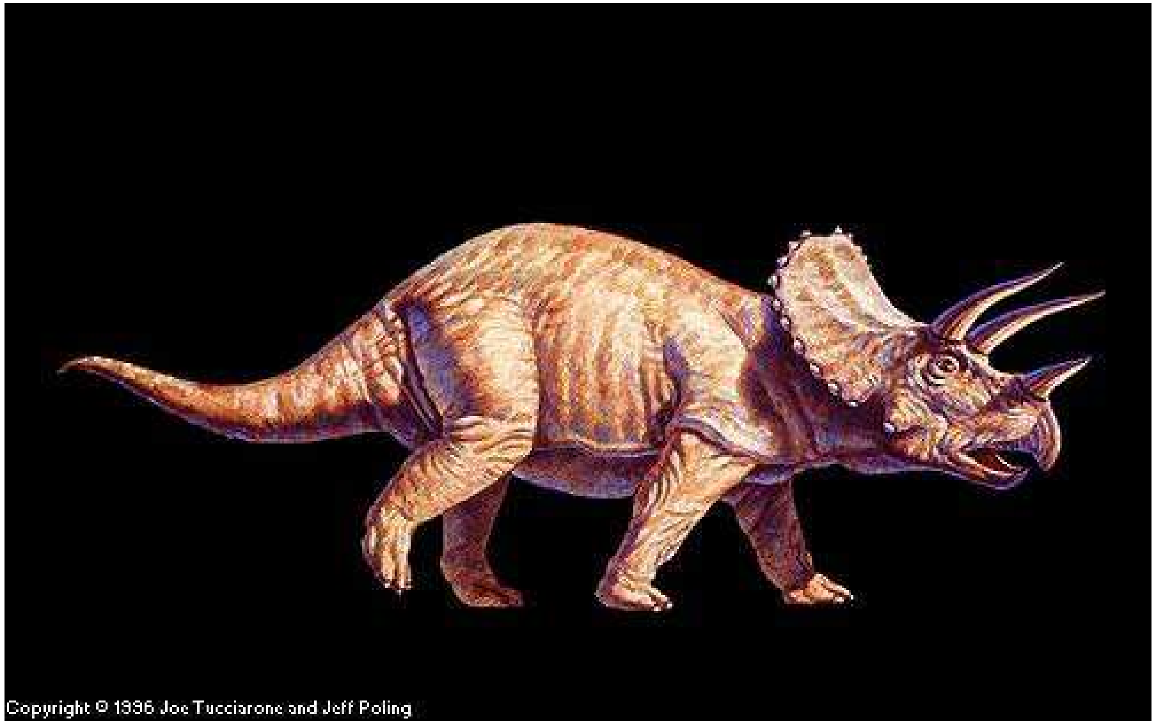
Monoclonius

Types of Ceratopsia



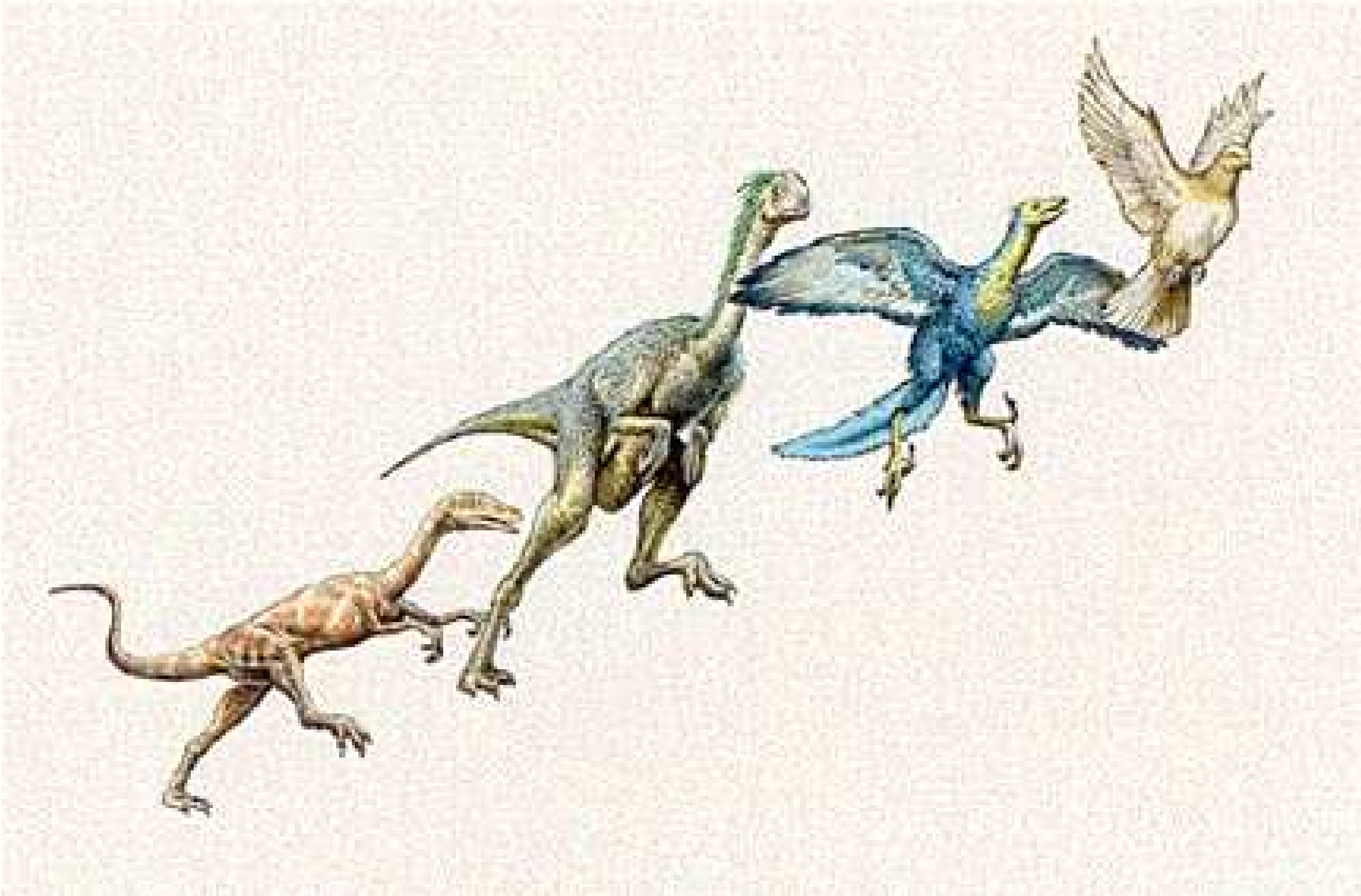
Torosaurus

Types of Ceratopsia



Triceratops

Warm Blooded Dinosaurs, Reptile Biology, Archosaurs vs. Reptiles



The Warm Blooded Dinosaurs

?
=

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

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

Superiority of predators

- Mammals generally superior to reptiles

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

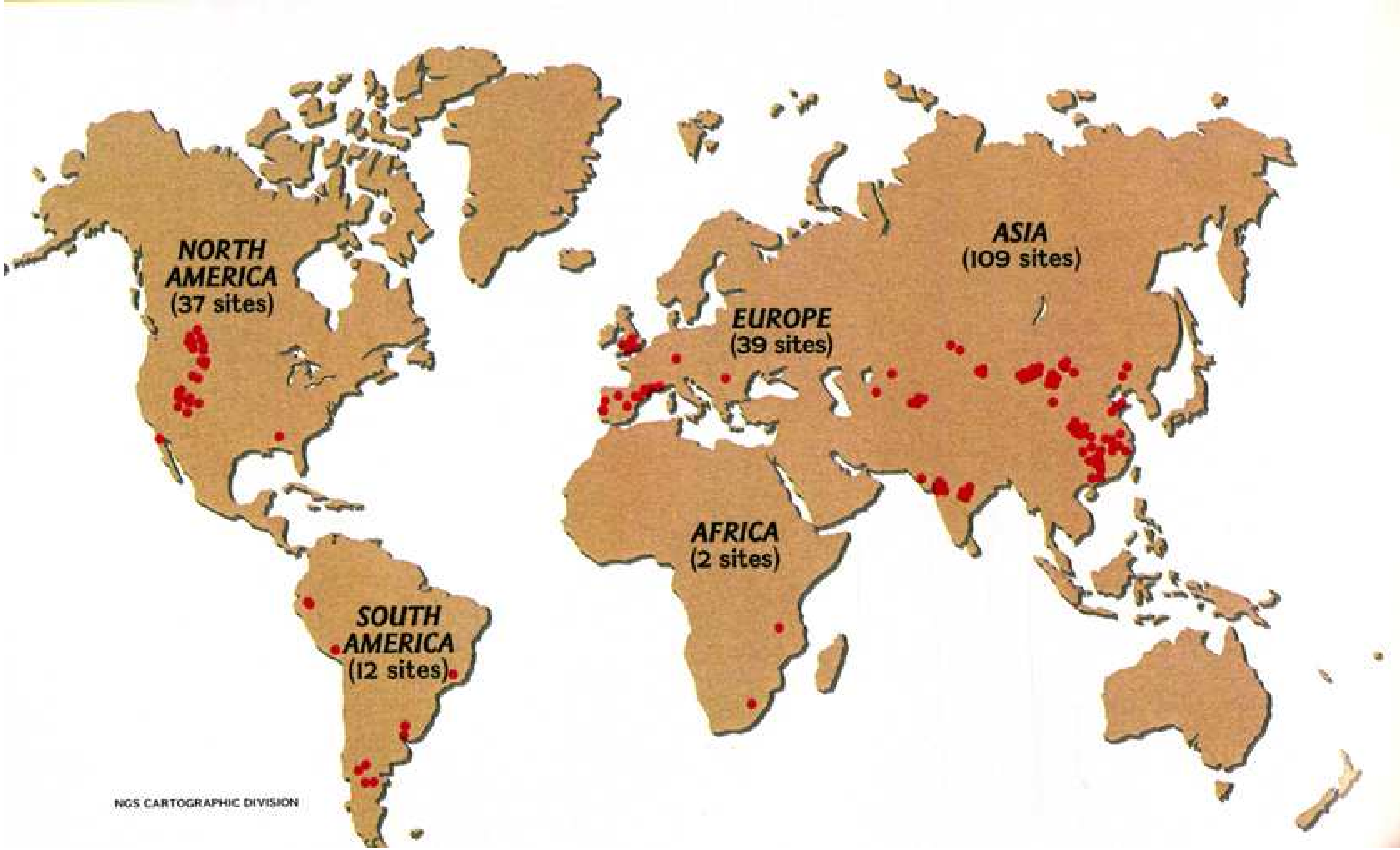
Evidence for ectothermic dinosaurs

- 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!)

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.

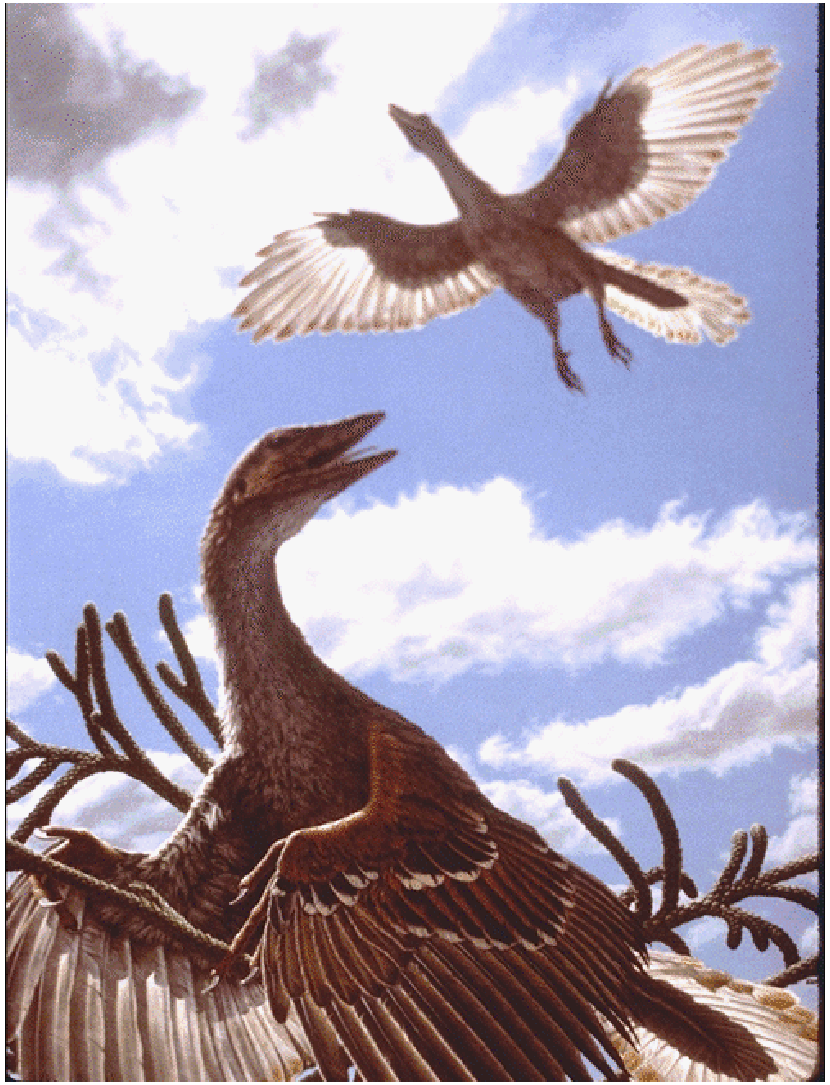
Geographic Distribution



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

Sauriurae (oposite birds) - ? Archeopteryx(Jurrasic),Confuciusornis (Jurrasic-Cretaceous)

Ornithurae (modern birds) – Hesperornis, Ichtyornis (Cretaceous)


Dan Varner

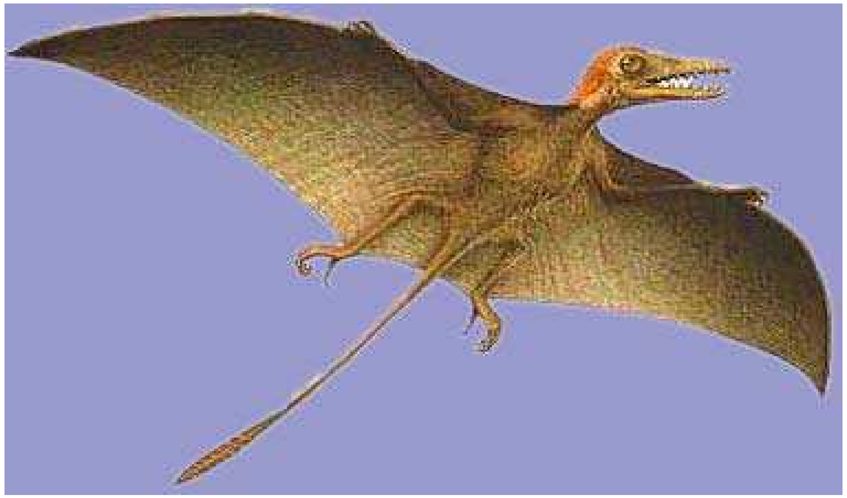
Pterosauria

Triassic-Cretaceous

Jurrasic with tail

Rhamphorhynchus

Sordes pilosus



Quetzalcoatlus

Geological Time and the Evolution of Mammals: Pelycosaurs Therapsids Cynodontia: the transitional Infraorder

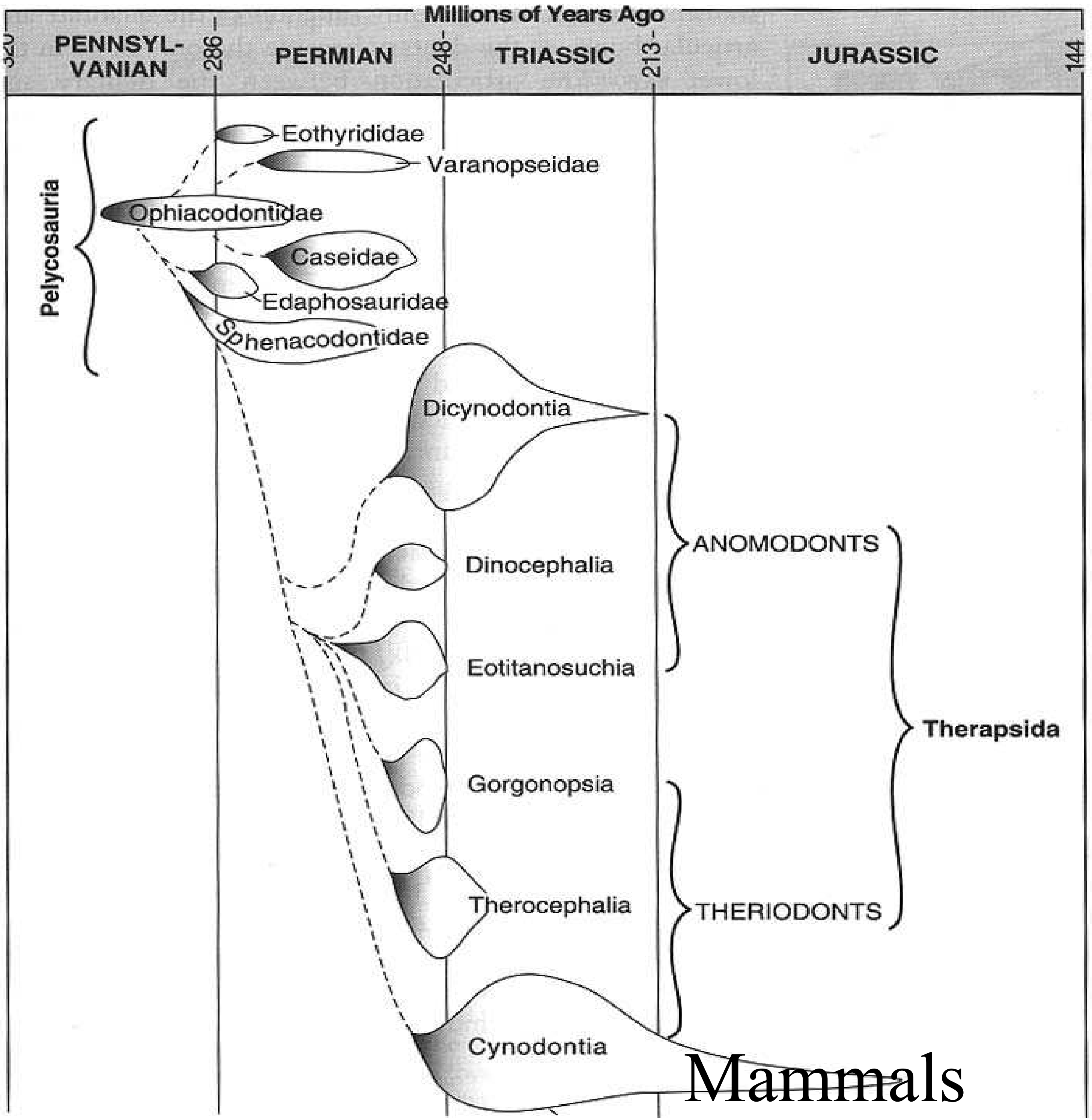


Fig 4.2, Feldhamer

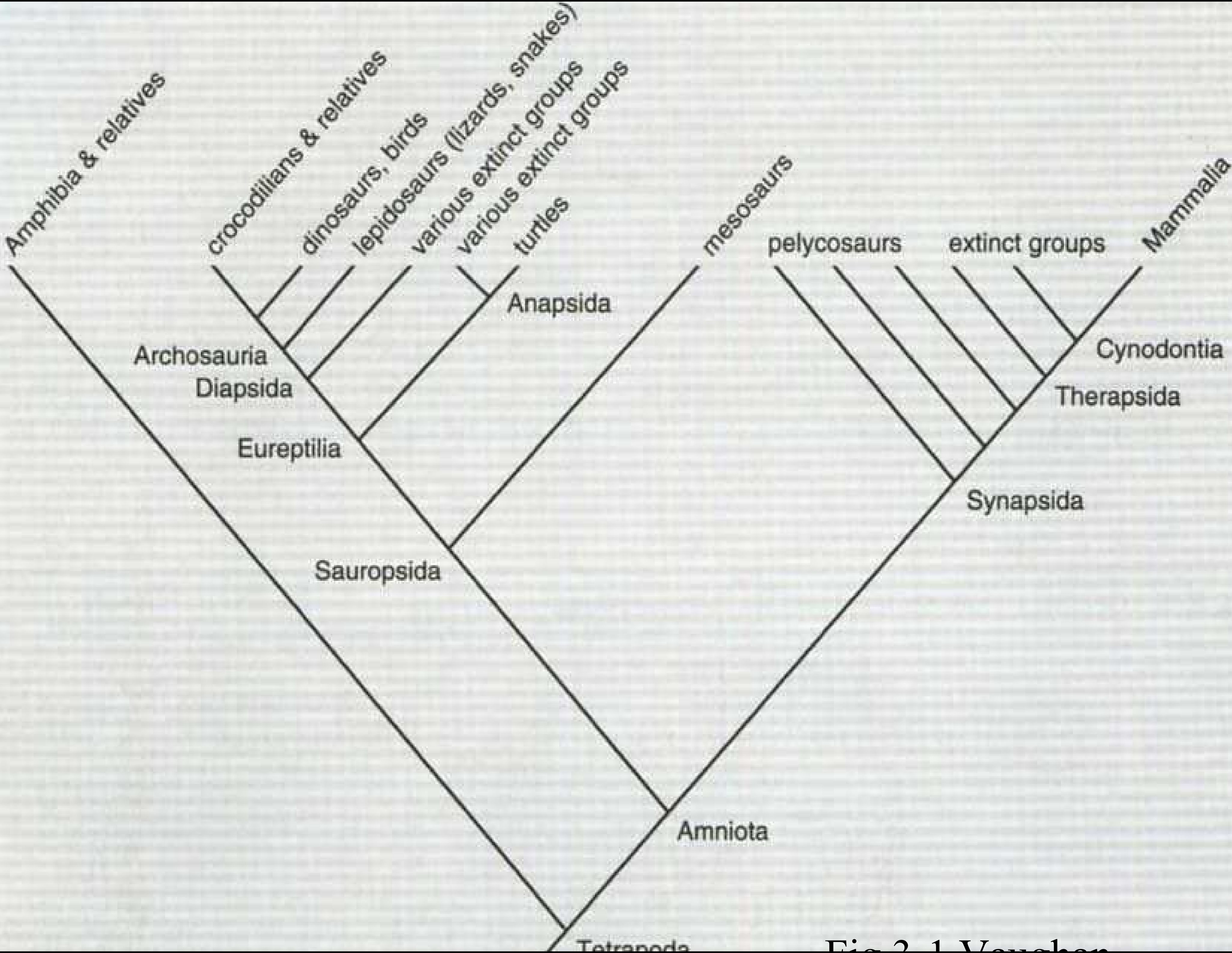
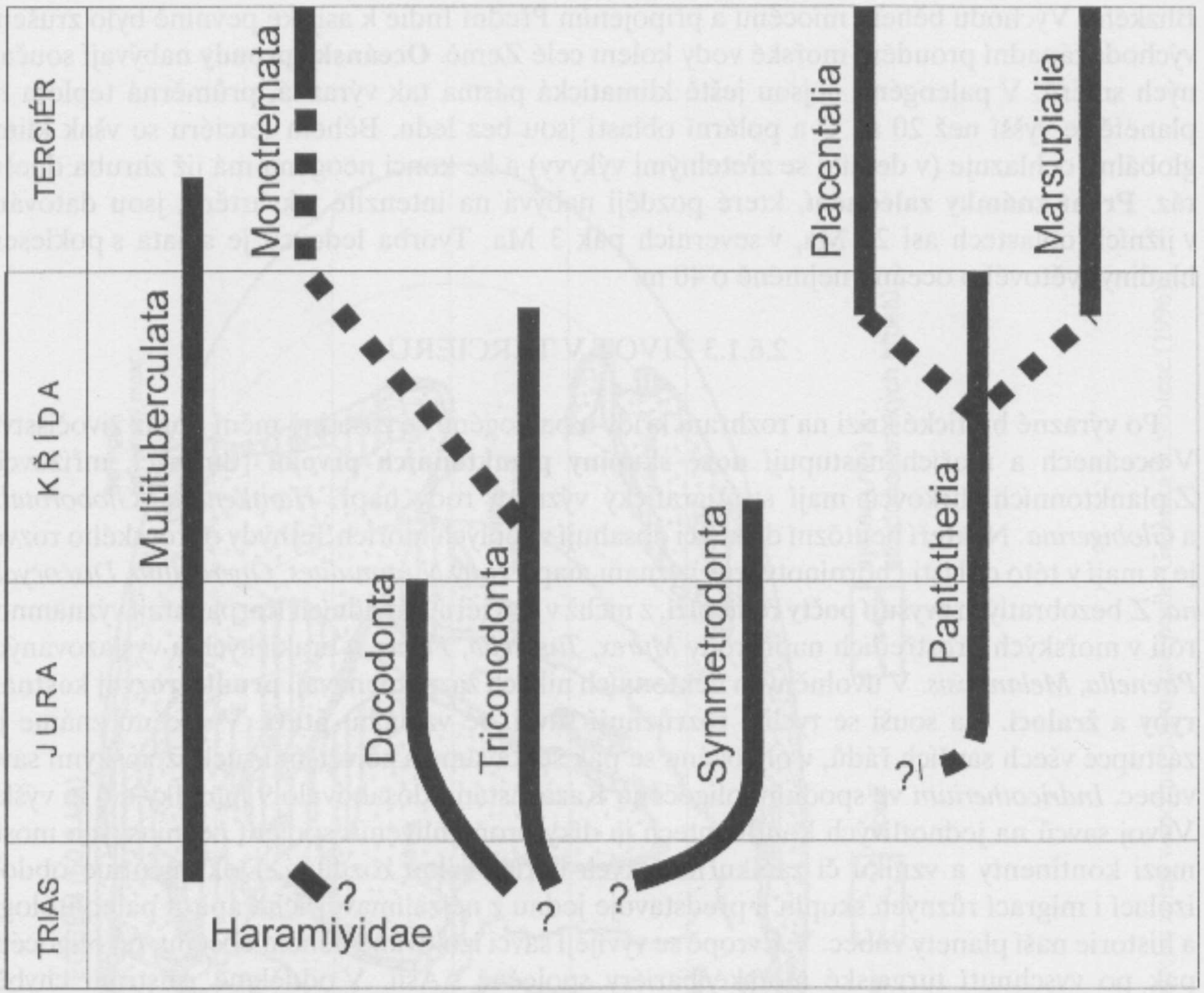


Fig 3-1 Vaughan

Prototheria Theria



Obr. 85. Vývojové vztahy a stratigrafický rozsah hlavních skupin savců. Upraveno podle Wicander & Hourae (1989).

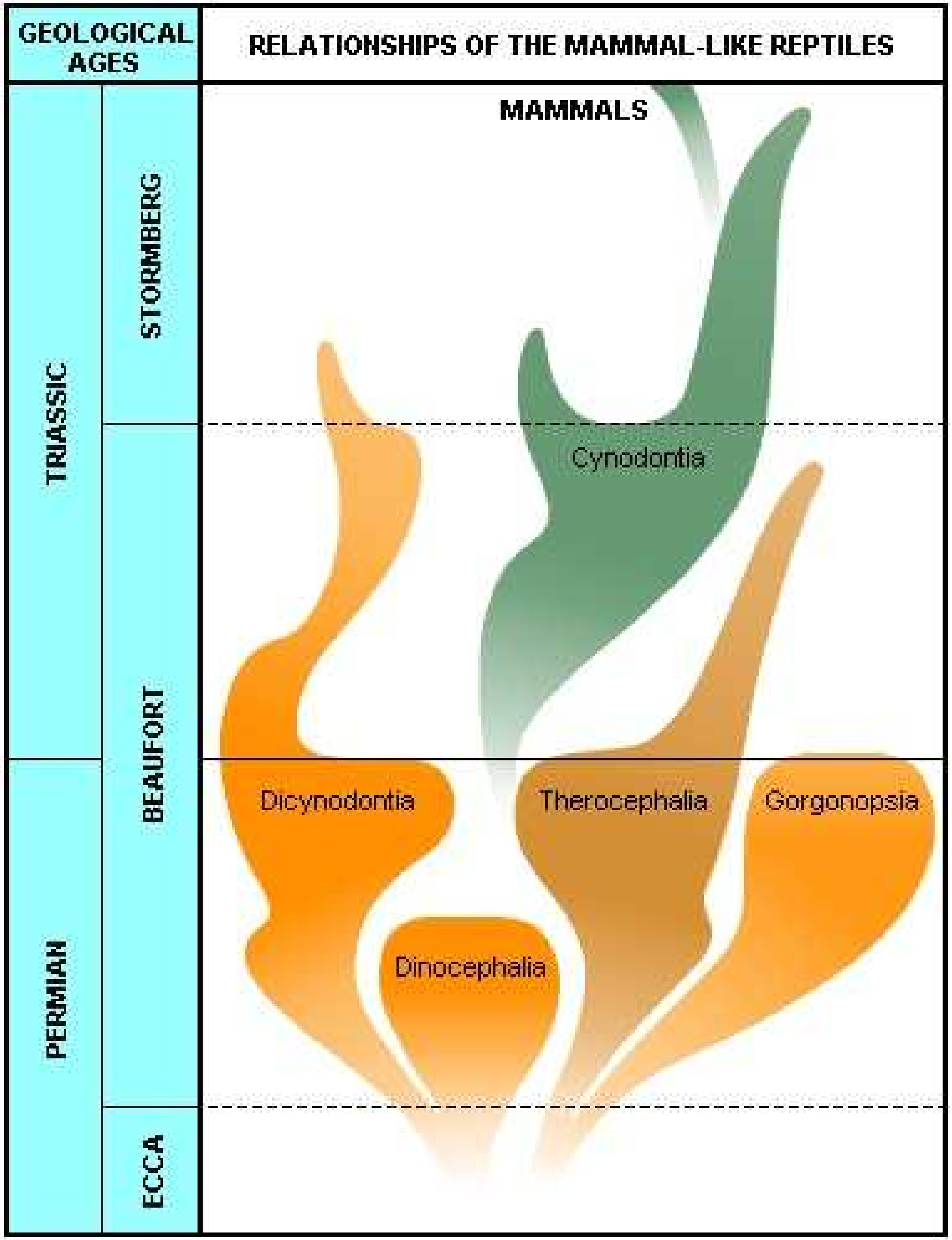


Diagram showing the relationships between the various mammal-like reptiles. Mammal-like reptiles did not survive beyond the end of the Triassic period, but one group, the Cynodontia, gave rise to the first mammals at the end of the Triassic, about 200 million years ago

Archaic Mammals of the Jurassic

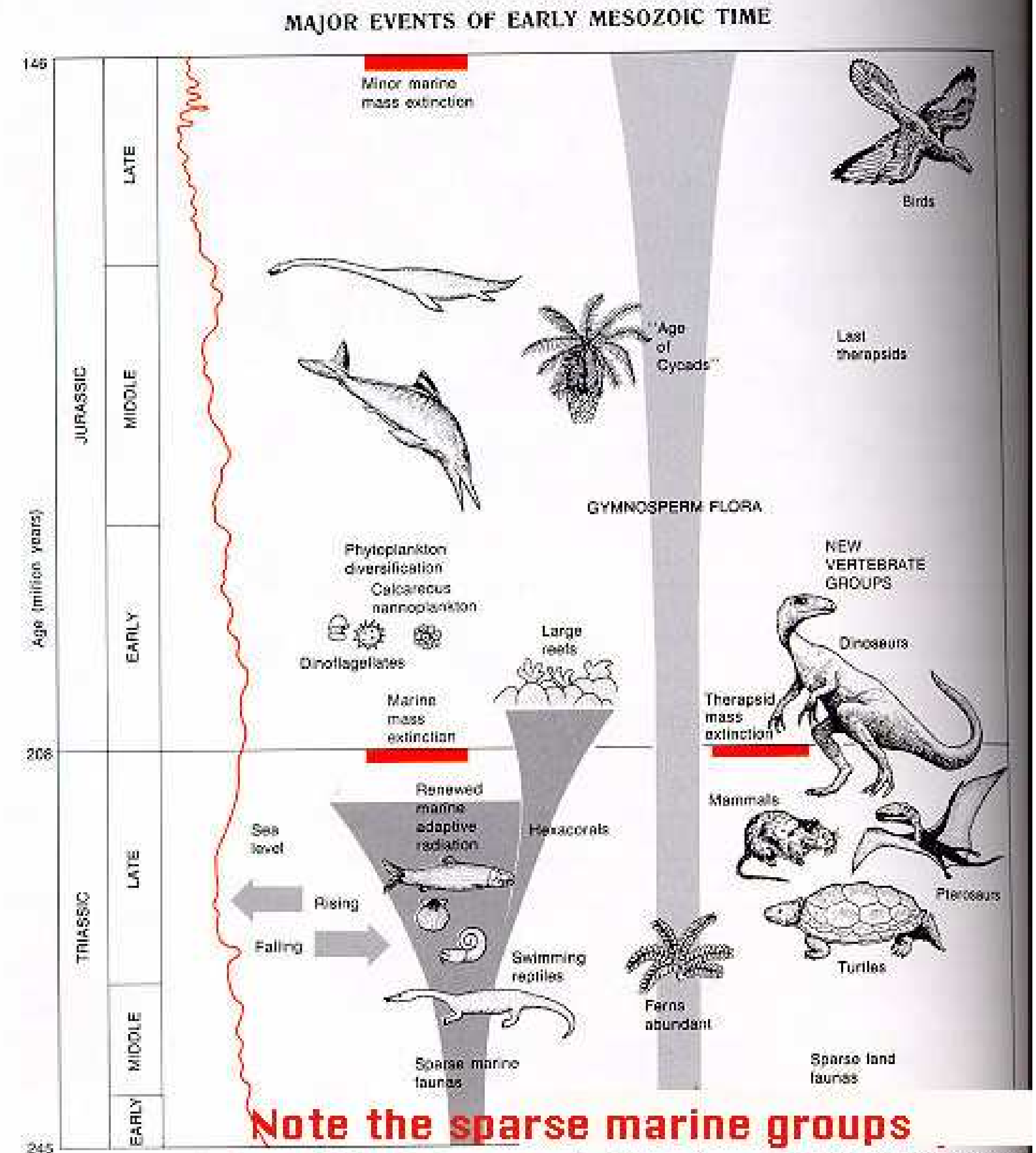
Mammalian radiation of the early Jurassic

- Tricondodontia (3 cusps in a row) large (750 g), predaceous mammals of early Triassic
- Monotremata: A living example of Mesozoic mammals

  Fossil record is poor, beginning in early Cretaceous

  Thought have diverged in Jurassic
- Multituberculata: herbivorous, molars w/ multiple cusps

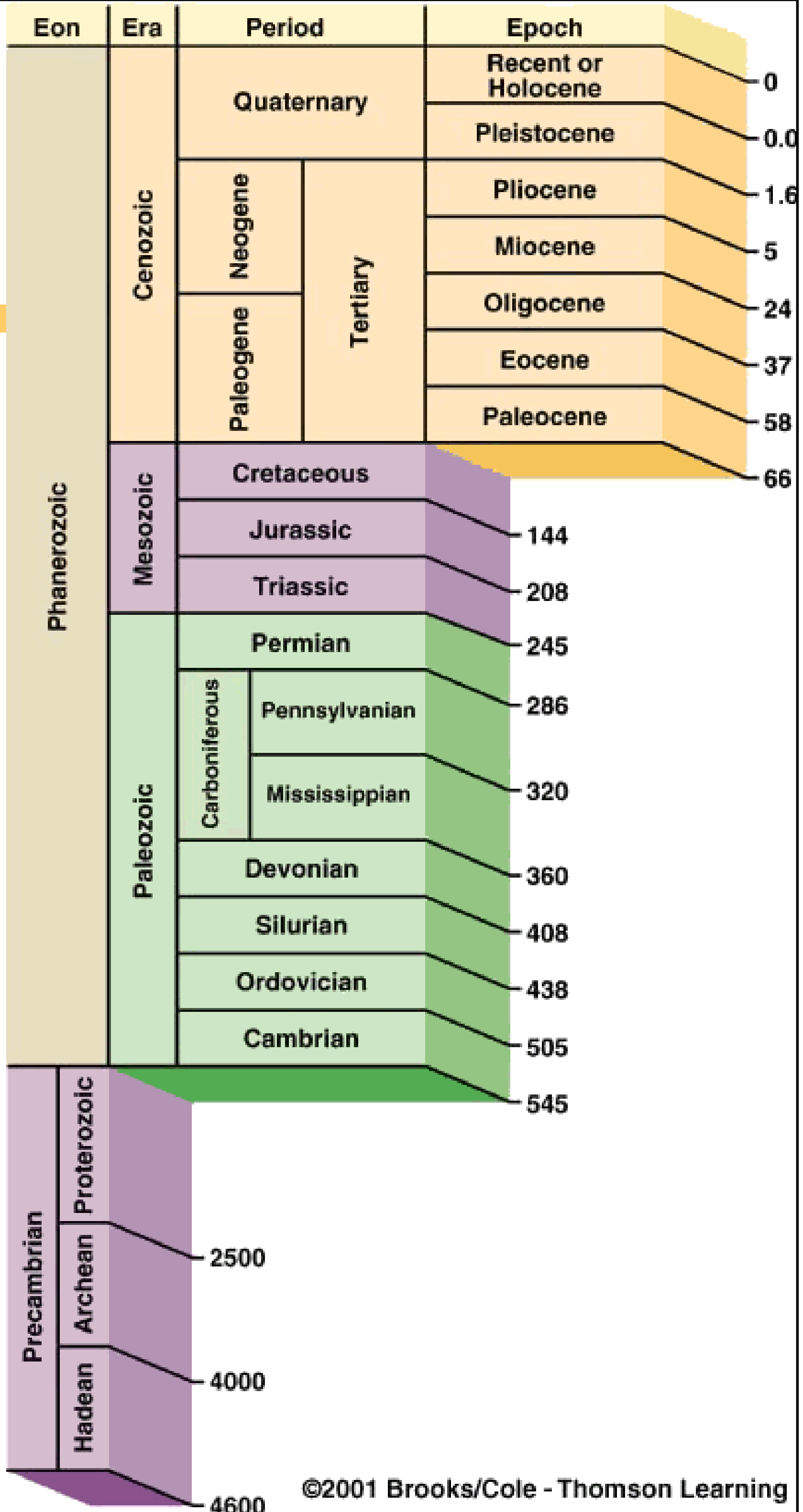
  Highly successful: from Jurassic to Oligocene (100 m yr)
- Zatheria: includes *Aegialodon* (with tribospenic molar) & ancestor of therian mammals (Eutheria & Metatheria)



Sea level rose gradually during early Mesozoic time. mals, including dinosaurs, occupied Late Triassic terre-

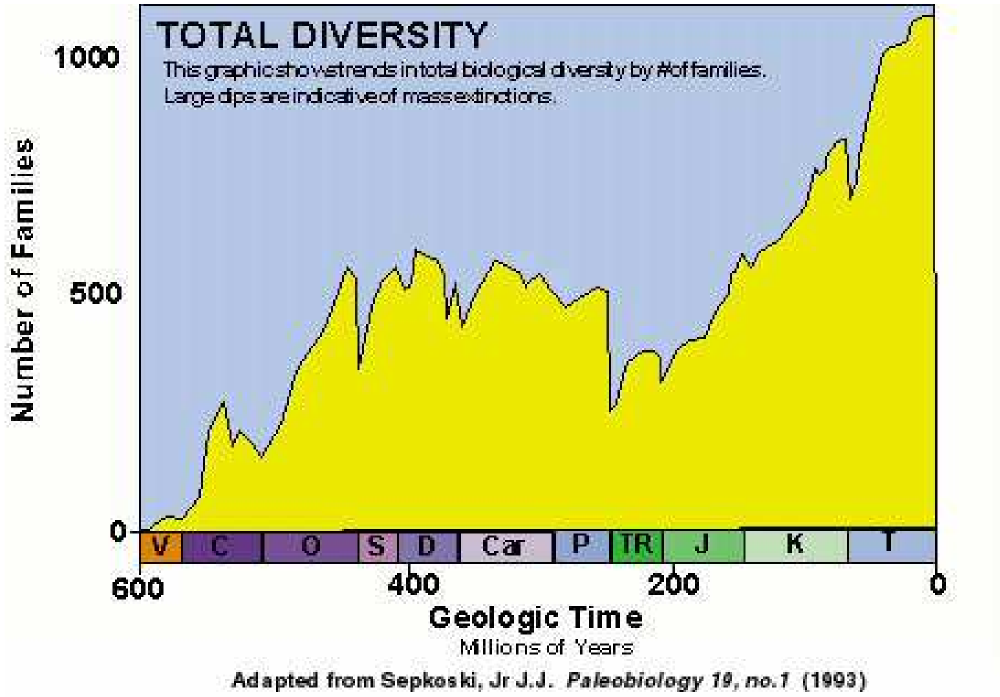
K/T Boundary

- Cretaceous-Tertiary (K/T) boundary (~65 Ma)
- Second largest mass extinction in Earth's history
- Half of life on Earth died out (3/4 species)



Mass Extinctions — Crises in the History of Life

- Greatest mass extinction took place at the end of the Paleozoic Era
- K/T extinction has attracted more attention because it affected dinosaurs



http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/totaldiversity.jpg

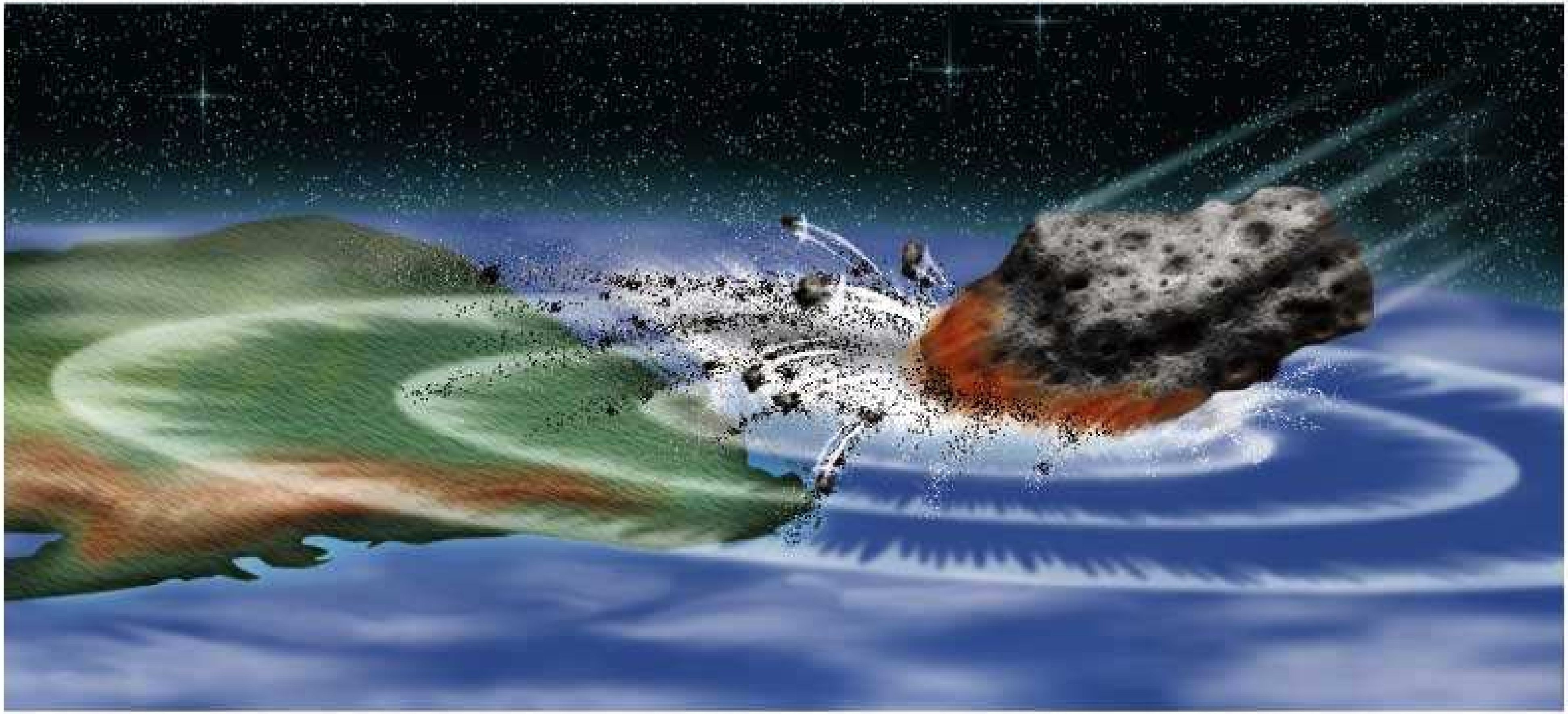
K/T Boundary Extinction

- Tropical groups suffered most
- Seawater cooling, global regression
- Mammals, birds, turtles, crocodiles, lizards, snakes and amphibians unaffected

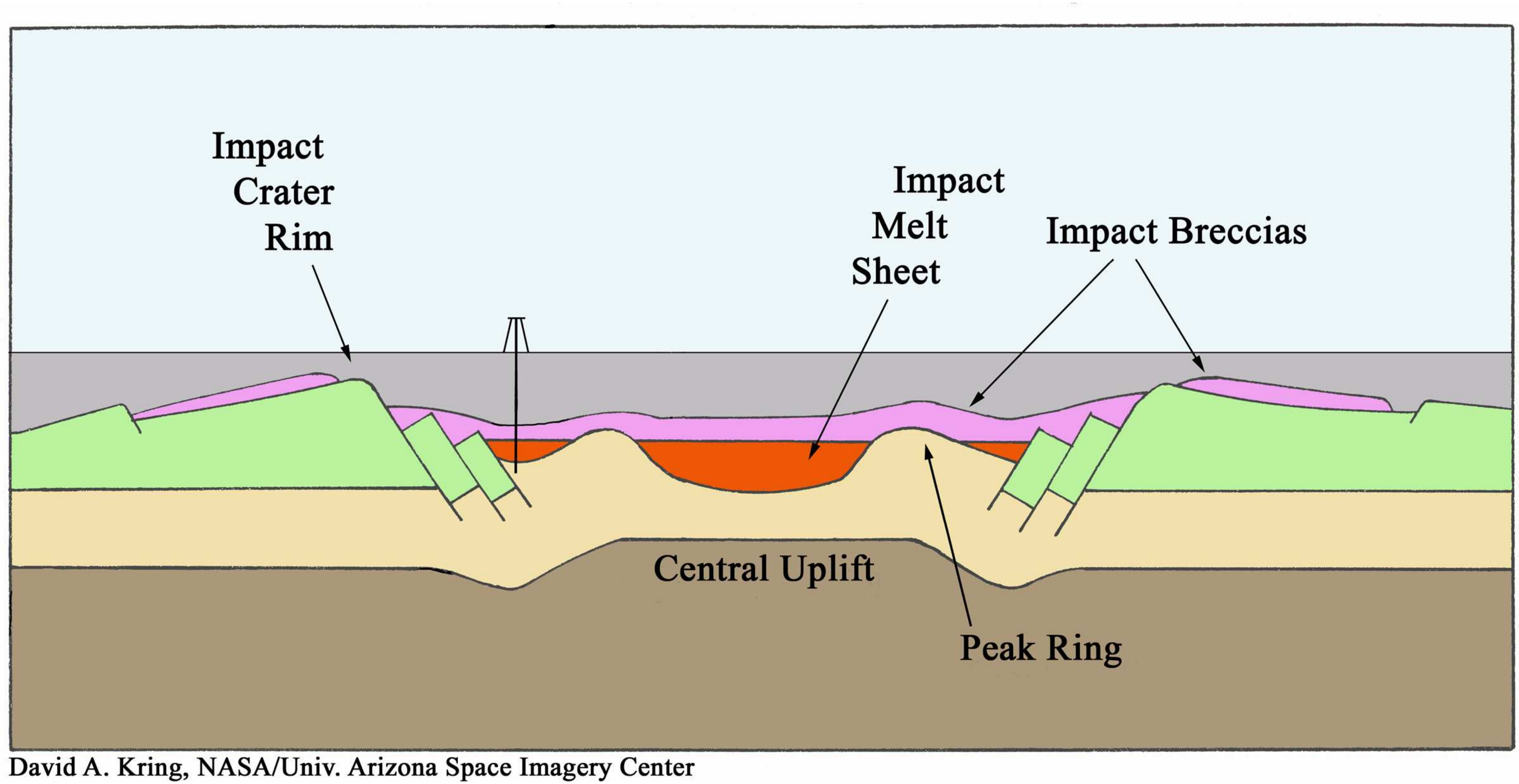
Meteorite Impact Crater

- Proposed meteorite impact crater
- Centered on Chicxulub on the Yucatán Peninsula of Mexico
- Discovered in 1950's, interpreted to be volcanic

Figure 24.14



Chicxulub Crater



http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulubprpage/Chicxulub_drilling_hires.jpg

What happened?

The moment of impact 65 million years ago near what is now the Yucatan Peninsula ...

... and the Chicxulub crater, a few days later. Note the inner ring.

http://www.space.com/scienceastronomy/planetearth/asteroid_jello_001122.html

Acid Rain

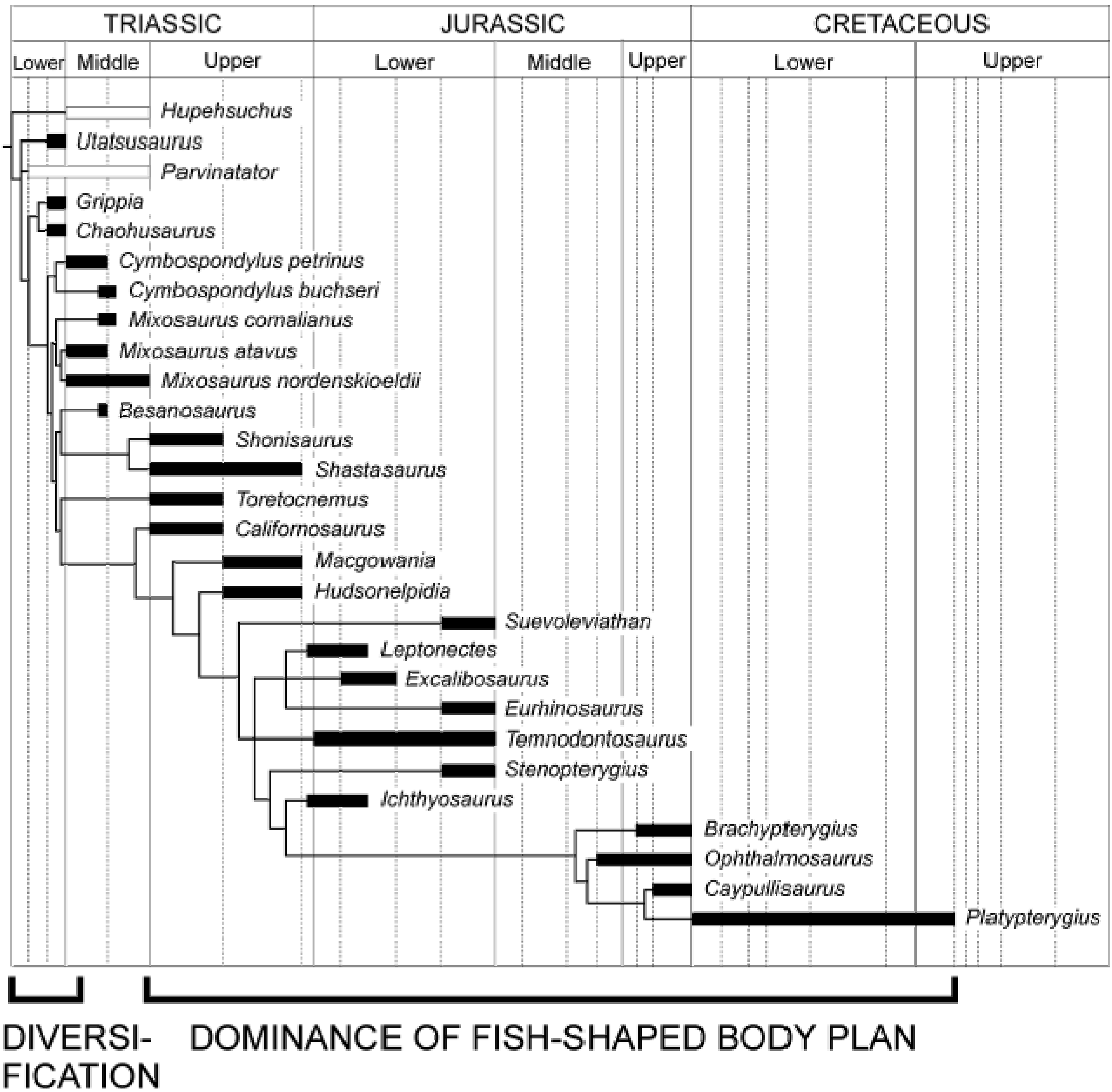
- With sunlight greatly diminished, Earth's surface temperatures were drastically reduced, adding to the biologic stress
- Another proposed consequence of an impact is that sulfuric acid (H_2SO_4) and nitric acid (HNO_3) resulted from vaporized rock and atmospheric gases
- Both would have contributed to strongly acid rain that might have had devastating effects on vegetation and marine organisms

According to the impact hypothesis

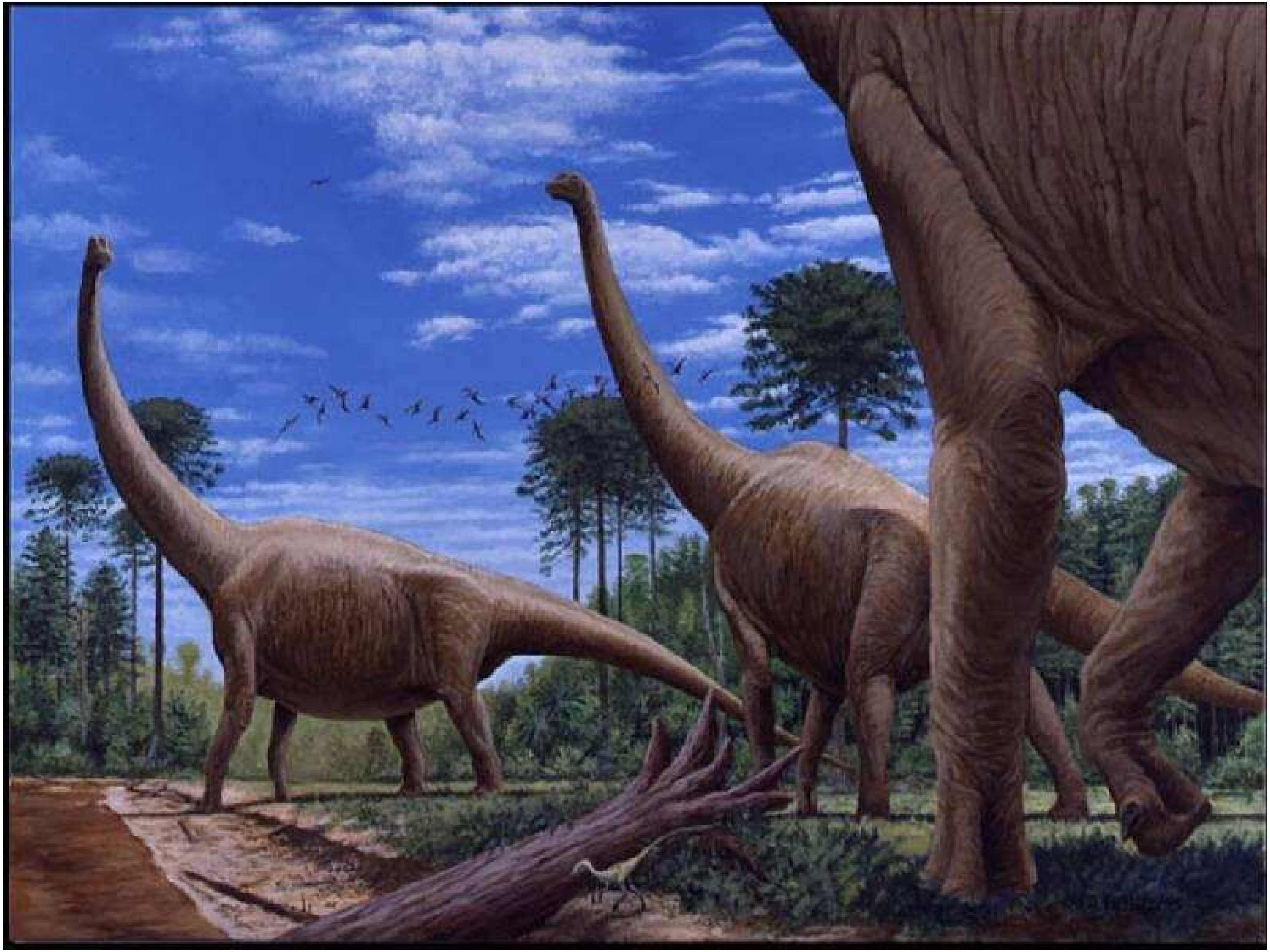
- 60 times the mass of the meteorite was blasted from the crust high into the atmosphere
- heat generated at impact started raging forest fires that added more particulate matter to the atmosphere

- Sunlight was blocked for several months
  - caused a temporary cessation of photosynthesis
  - food chains collapsed and extinctions followed

Shonisaurus popularis and probably *Himalayasaurus tibetensis* (both Late Triassic), exceeding 15m, are the largest ichthyosaurs that have been described, but there are undescribed specimens that are larger. Among the smallest ichthyosaurs is *Chaohusaurus geishanensis* (Early Triassic; the figure above), which probably did not reach 70 cm.



TRIASSIC
JURASSIC
CRETACEOUS
Lower
Middle
Upper
Lower
Middle
Upper
Lower
Upper
Hupehsuchus
Utatsusaurus
Parvinatator
Grippia
Chaohusaurus
Cymbospondylus petrinus
Cymbospondylus buchseri
Mixosaurus cornalianus
Mixosaurus atavus
Mixosaurus nordenskioeldii
Besanosaurus
Shonisaurus
Shastasaurus
Toretocnemus
Californosaurus
Macgowania
Hudsonelpidia
Suevoleviathan
Leptonectes
Excalibosaurus
Eurhinosaurus
Temnodontosaurus
Stenopterygius
Ichthyosaurus
Brachypterygius
Ophthalmosaurus
Caypullisaurus
Platypterygius
DIVERSI-
FICATION
DOMINANCE OF FISH-SHAPED BODY PLAN



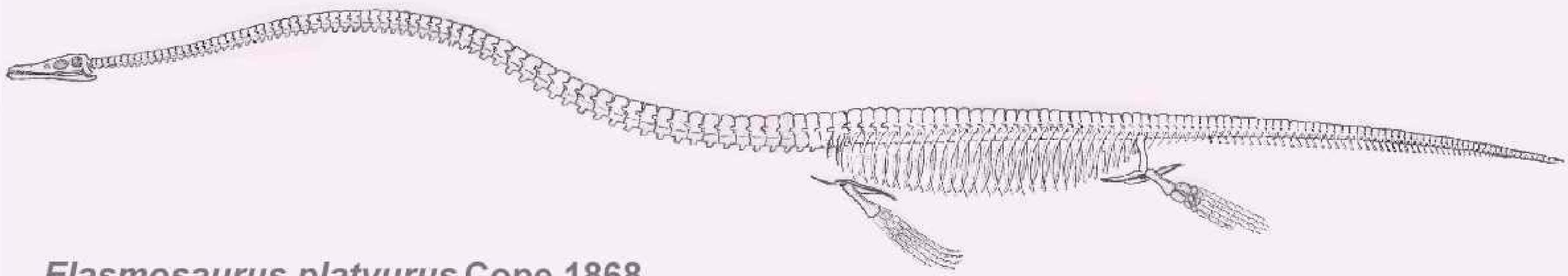
Liopleurodon ferox

There is an unofficial 'Premier League' in vertebrate palaeontology which consits of the animals which attract a lot of public attention. It's members include *T.rex*, *Seismosaurus*, *Argentinosaurus*, *Giganotosaurus* and so on - the biggest and fiercest extinct animals. When the BBC broadcast 'Walking with Dinosaurs' they moved *Liopleurodon ferox* firmly into the Premier League. Here was an animal that made *T.rex* look like a kitten - 25 meters long and weighing 150 tons, an awesome predator that dwarfs anything before or since.

The problem is that *Liopleurodon ferox* was not 25 meters long, and did not weigh 150 tons.

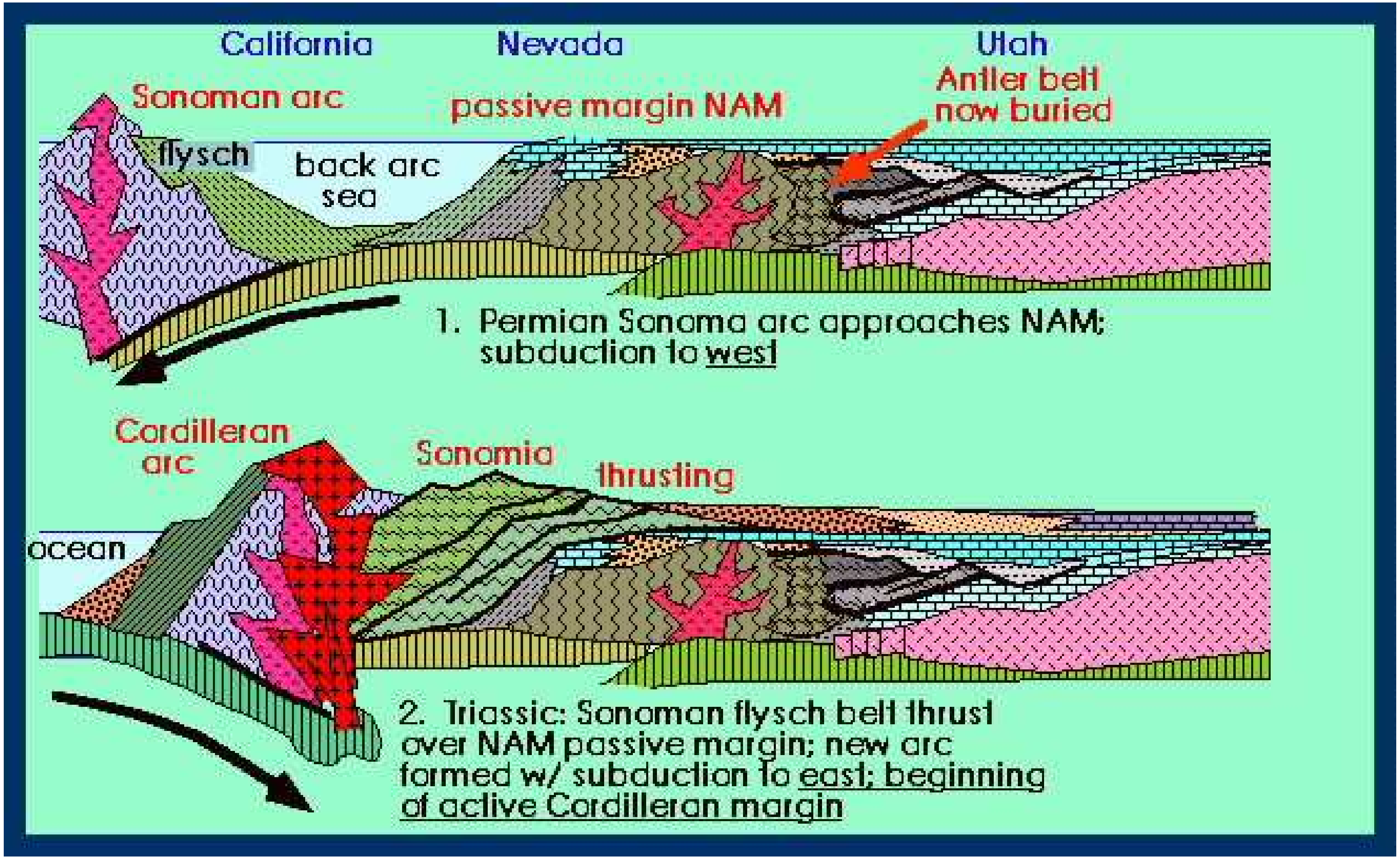
What was *Liopleurodon*?

Liopleurodon was a large predatory marine reptile. It's remains are found in the Callovian Oxford Clay of Eastern England and Northern France, and date from about 160 million years ago.

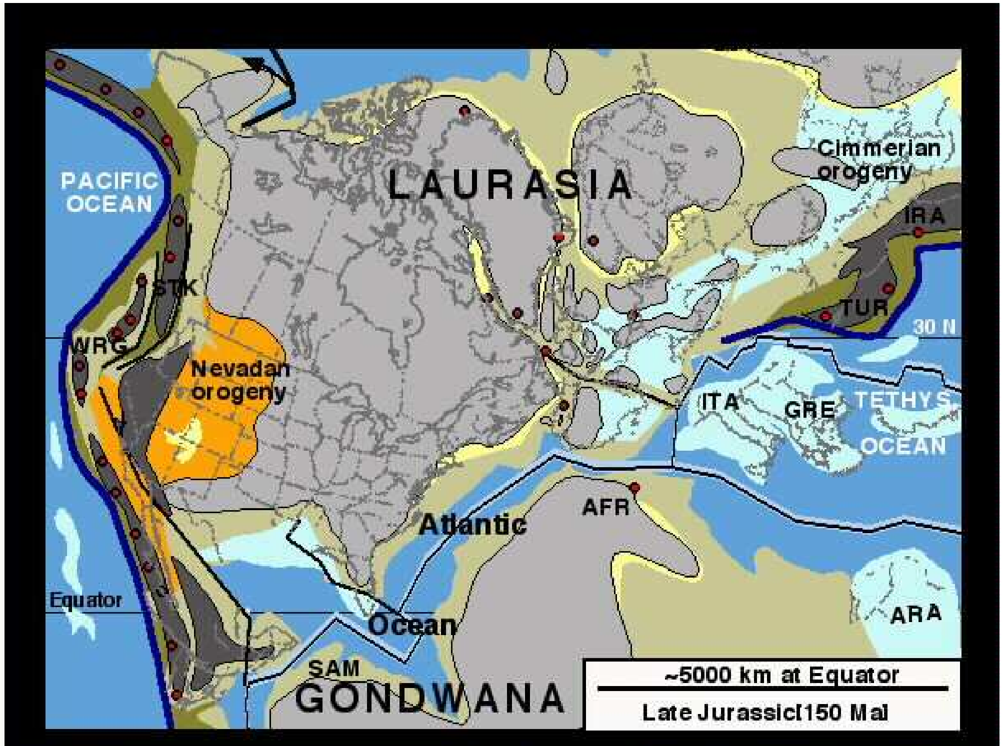


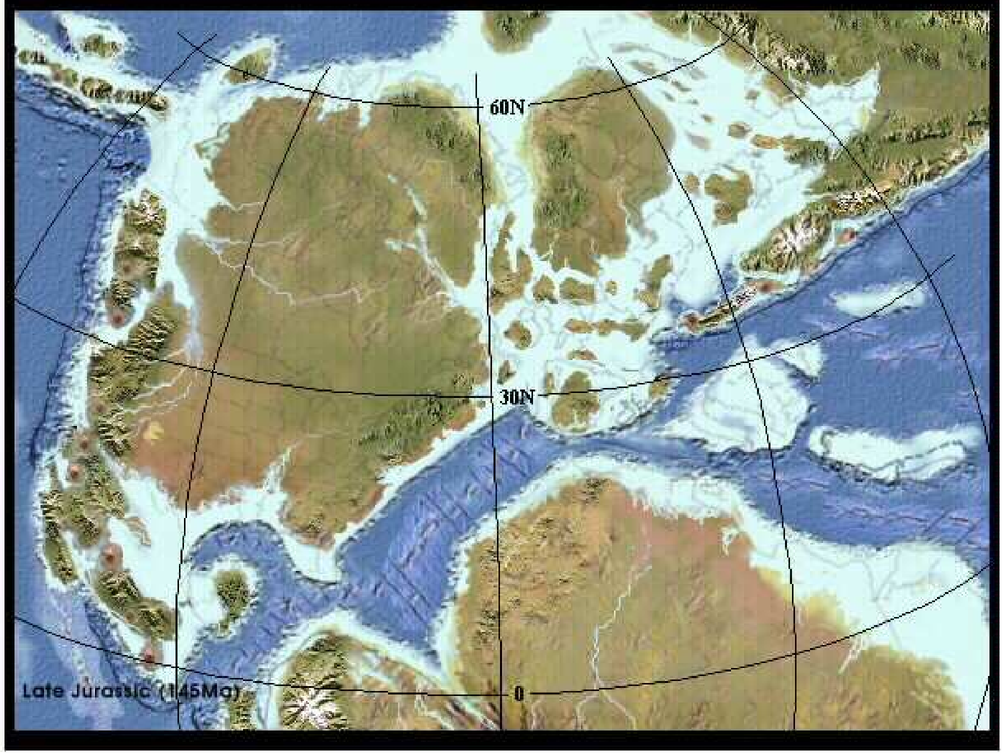
Elasmosaurus platyurus Cope 1868

Marine crocodilians appear in Early Jurassic. Heyday of the ichthyosaurs; high diversity of plesiosaurs (including forms over 14 m long!!).



California
Nevada
Utah
Sonoman arc
passive margin NAM
Antler belt
now buried
flysch
back arc
sea
1. Permian Sonoma arc approaches NAM;
subduction to west
Cordilleran
arc
Sonomia
thrusting
ocean
2. Triassic: Sonoman flysch belt thrust
over NAM passive margin; new arc
formed w/ subduction to east; beginning
of active Cordilleran margin



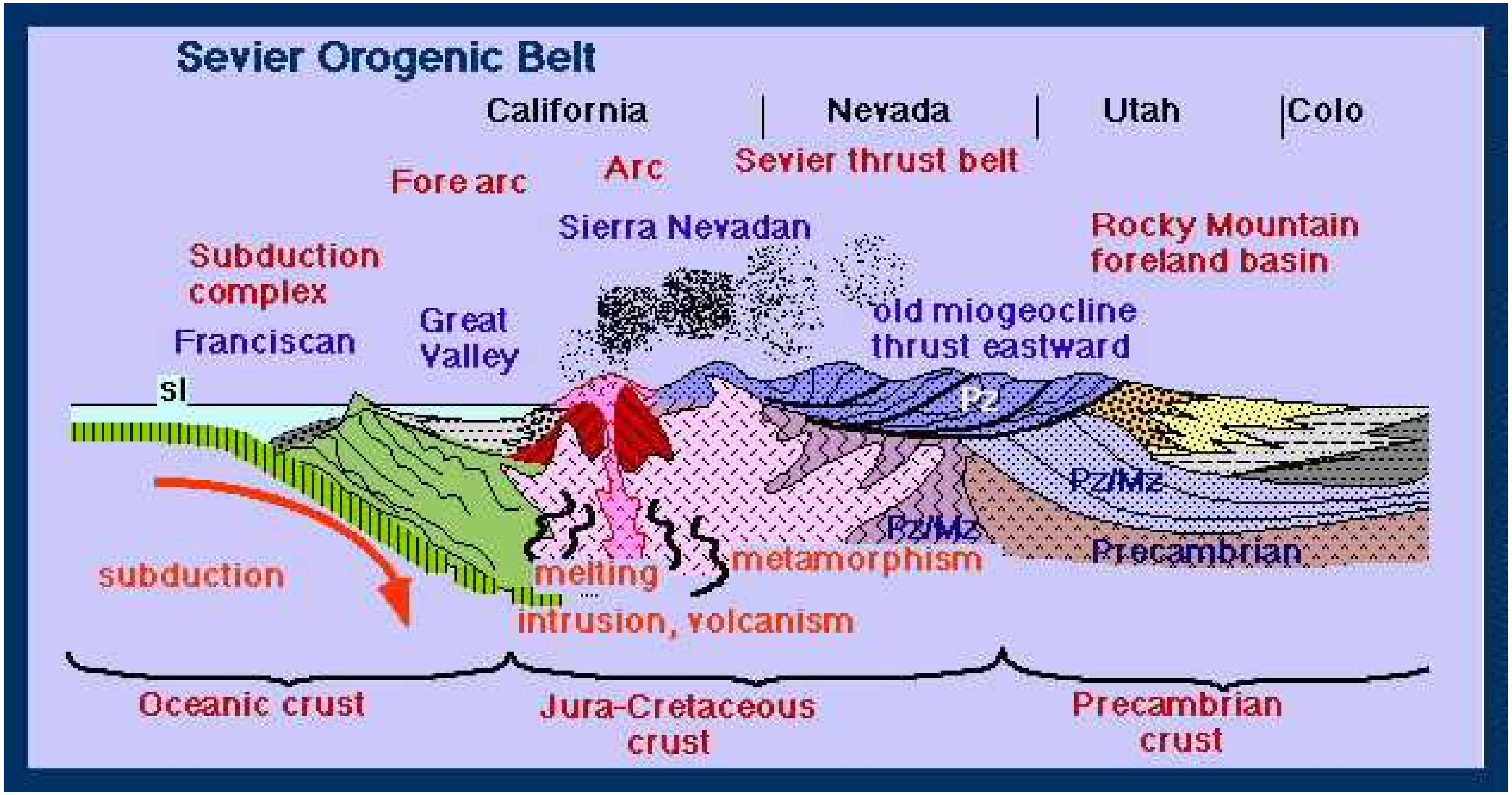


During Late Jurassic, **<u>Nevadan Orogeny</u>**:

•A large accretionary wedge, the **Franciscan Ophiolite & Mélange**, is thrust up onto western North America

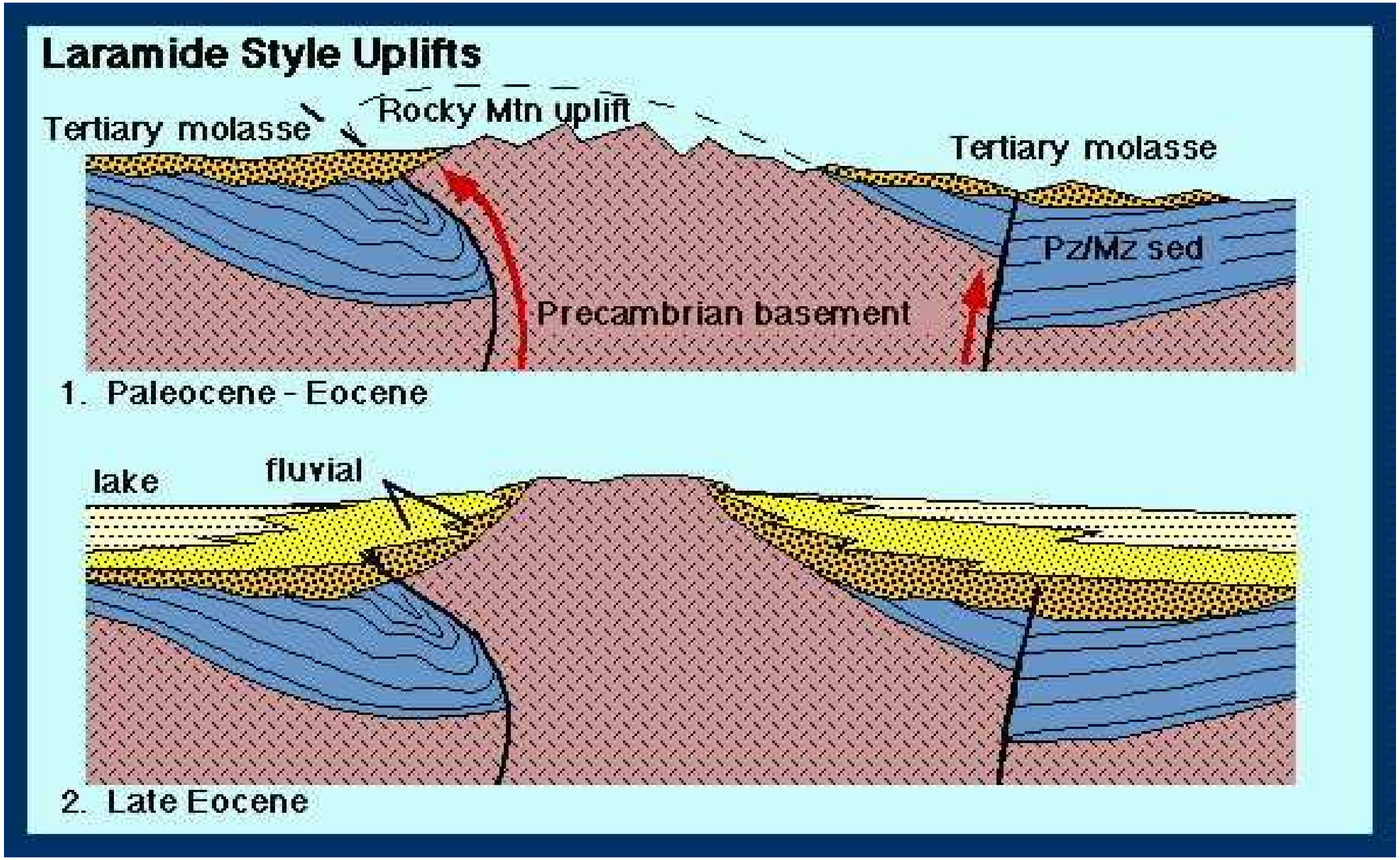
•Fold and thrust belt pushes up the plutons of the ancestral Sierra Nevada

•Molasse from this event forms huge clastic wedge from Montana to Arizona and as far east as South Dakota and Oklahoma: the **<u>Morrison Formation</u>**



During the <u>mid-Cretaceous</u>:

- •Increased speed of sea-floor spreading means subduction along Pacific margin of North America at a lower angle
- •Various small microplates swept up by western margin of North America
- •Subducting **Farallon Plate** reaches melting point are regions further eastward
- •Eastward migration of mountain range from Washington/Oregon to Idaho
- •This new style is called **<u>Sevier Orogeny</u>**: lasts until near the end of the Late Cretaceous
- •Within forearc basin, many regional transgression-regression events

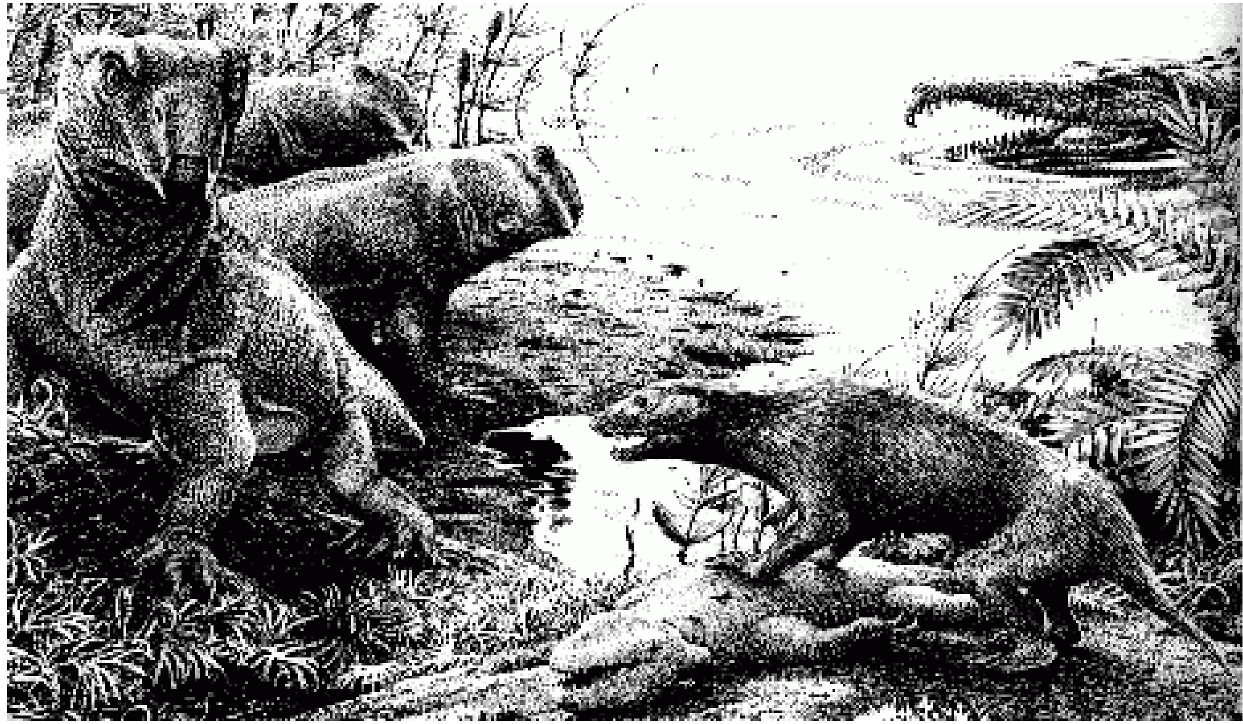


During <u>Maastrichtian</u>:

•Beginning of **<u>Laramide Orogeny</u>** in Cordilleran system: foundering Farallon Plate brings uplift of region, some volcanism as far east as Colorado, Wyoming, New Mexico: continues well into Tertiary

The Deccan Traps are one of the largest volcanic provinces in the world. It consists of more than 6,500 feet (>2,000 m) of flat-lying basalt lava flows and covers an area of nearly 200,000 square miles (500,000 square km) (roughly the size of the states of Washington and Oregon combined) in west-central India. Estimates of the original area covered by the lava flows are as high as 600,000 square miles (1.5 million square km). The volume of basalt is estimated to be 12,275 cubic miles (512,000 cubic km)(the 1980 eruption of Mount St. Helens produced 1 cubic km of volcanic material). The Deccan Traps are flood basalts similar to the Columbia River basalts of the northwestern United States. This photo shows a thick stack of basalt lava flows north of Mahabaleshwar. ***Photograph by Lazlo Keszthelyi, January 28, 1996.***

During the Induan age, the survivors of the greatest disaster the Phanerozoic biosphere had faced emerged to inherit the Earth. The Mesozoic Era had begun



The drawing above shows some of the animals that were around at this time. Many of these forms had a cosmopolitan distribution. All these animals are known from the Middle Beaufort *Lystrosaurus* Assemblage Zone (Karoo Basin of South Africa). The herbivores were squat quadrupedal forms, belonging to the genus *Lystrosaurus*, an animal a little over a meter in length (above, and left on the drawing on the right). The small (about 50 cm) carnivorous and insectivorous cynodont *Thrinaxodon* represents a more mammalian form; one is shown here about to feed on a dead temnospondyl amphibian. The semi-aquatic *Proterosuchus* (1.5 metres in length) populated the rivers and streams, these resembled small crocodiles but lacked the armoured scutes (note - in this drawing the *Proterosuchus* appears much too large; it was only a little longer than a large Lystrosaur and a fraction the weight, and is also incorrectly shown with armour on its neck).

- Reptiles source of therapsids and thecodonts at end of Paleozoic
- Triassic - therapsids gave rise to mammals

  -thecodonts - gave rise to dinosaurs

- Dinosaurs
  - -Saurischia and Ornithischia
  - -Endotherms or Ectotherms?
    - •bone histology
    - •latitudinal zonation
    - •predator prey ratio
    - •cruising speed
    - •growth rates
    - •nose and lungs

- Pterosaurs
- Marine Reptiles
  - -mosasaurs
  - -plesiosaurs
  - -ichthyosaurs
- Birds
  - -Archaeopteryx

Following several million years' recovery, diversity has returned to the oceans during the Triassic. Fully adapted marine reptiles swim the seas, and some bivalves and echinoderms have now developed burrowing skills, a clever adaptation that protects them from predators. Life takes another hit, though, in what are thought to be successive extinctions at the end of the Triassic. While some scientists argue that amphibians and aquatic reptiles are severely affected by the events, others do not support this. Destruction of marine invertebrate life, however, is certain. Cephalopods and bivalves absorb major hits, as do sponges, gastropods, conodonts, and brachiopods. Global cooling, meteor impact, and sea-level changes are among the proposed causes.

Insects of the Mesozoic:

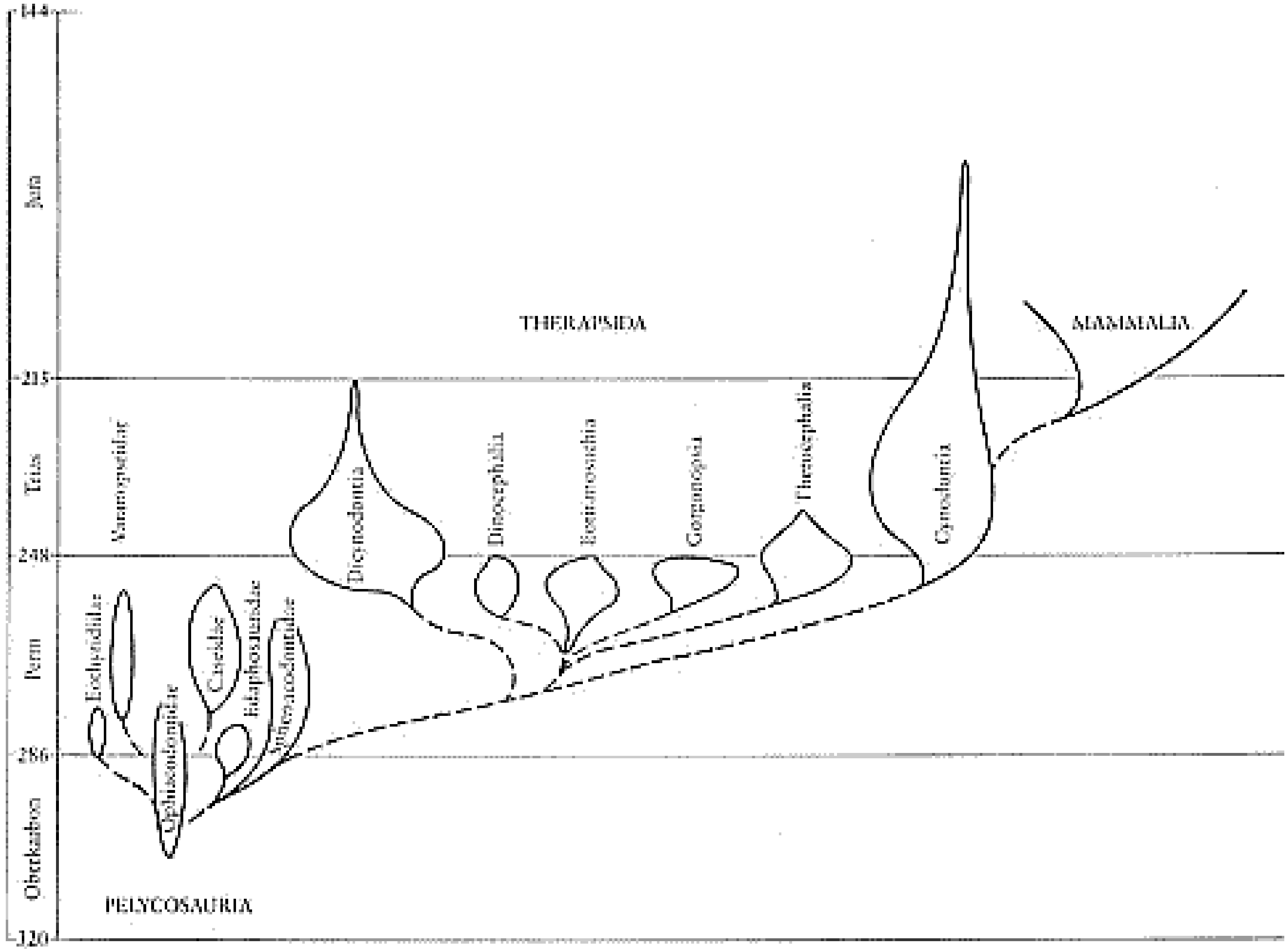
Continued insect diversification throughout the Mesozoic, including:

- The first **flies** (Diptera) in the Triassic
- The first **moths & butterflies** (Lepidoptera) questionably in the Jurassic, and definitely in the Cretaceous
- The first **wasps** (Hymenoptera) in the Jurassic, evolving into **bees & ants** in the Cretaceous
- Diversification of **beetles** (Coleoptera), **roaches, mantids & termites** (Blattaria), and others during the Cretaceous

Early Triassic therapsids included large bodied herbivores and smaller carnivores and omnivores. Circumstantial evidence suggests some of the latter were furry and whiskered.

Many of the features that characterize modern mammals don't fossilize, and were probably more broadly distributed among therapsids than

- Warm-blooded
- Covered with fur
- Sweat glands
- Mammary glands
- Parental care of young



144
Jura
213
Trias
248
Perm
286
Oberkarbon
320
PELYCOSAURIA
Eothyrididae
Varanopsidae
Ophiacodontidae
Caseidae
Edaphosauridae
Sphenacodontidae
THERAPSIDA
Dicynodontia
Dinocephalia
Biarmosuchia
Gorgonopsia
Therocephalia
Cynodontia
MAMMALIA

Prototheria (**<u>monotremes</u>** and their relatives):

- Oldest fossils Early Cretaceous; survive today in Australasia as platypus and echidna
- Still **lay eggs** (only living mammals to do so)
- Very simple mammary glands
- Today's monotremes have lots of primitive features, but many specializations of their own
- No evidence that monotremes were ever a dominant group of mammals

Triconodonta (**tricodonts**)

- Very primitive clade of mammals, restricted to the Mesozoic
- Lived from Jurassic into the Cretaceous
- Not known if egg layers, pouched, placental birth, etc.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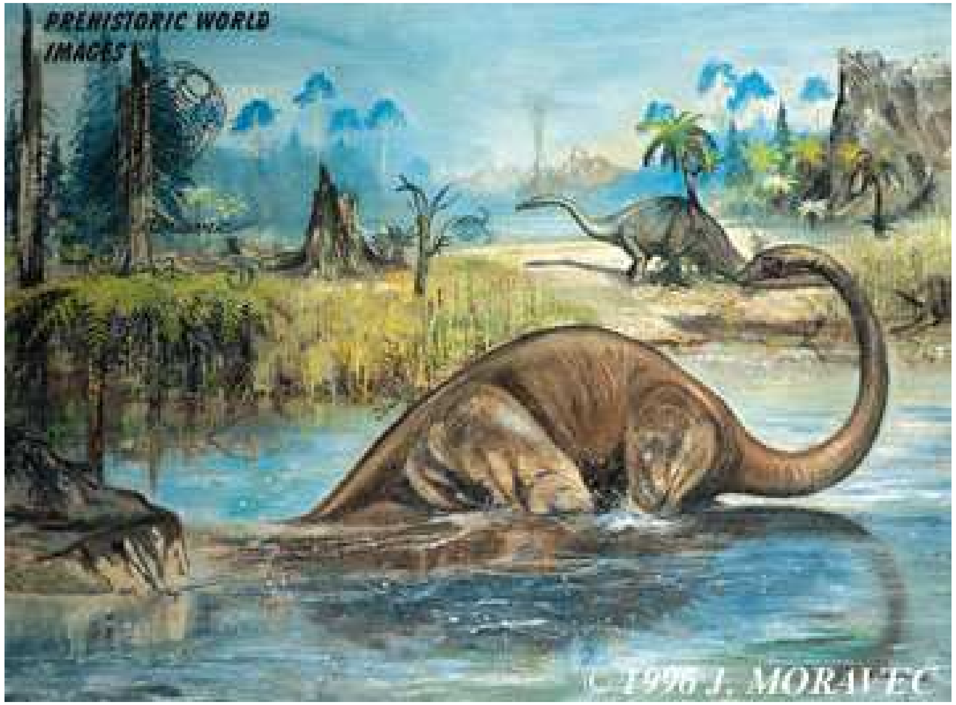
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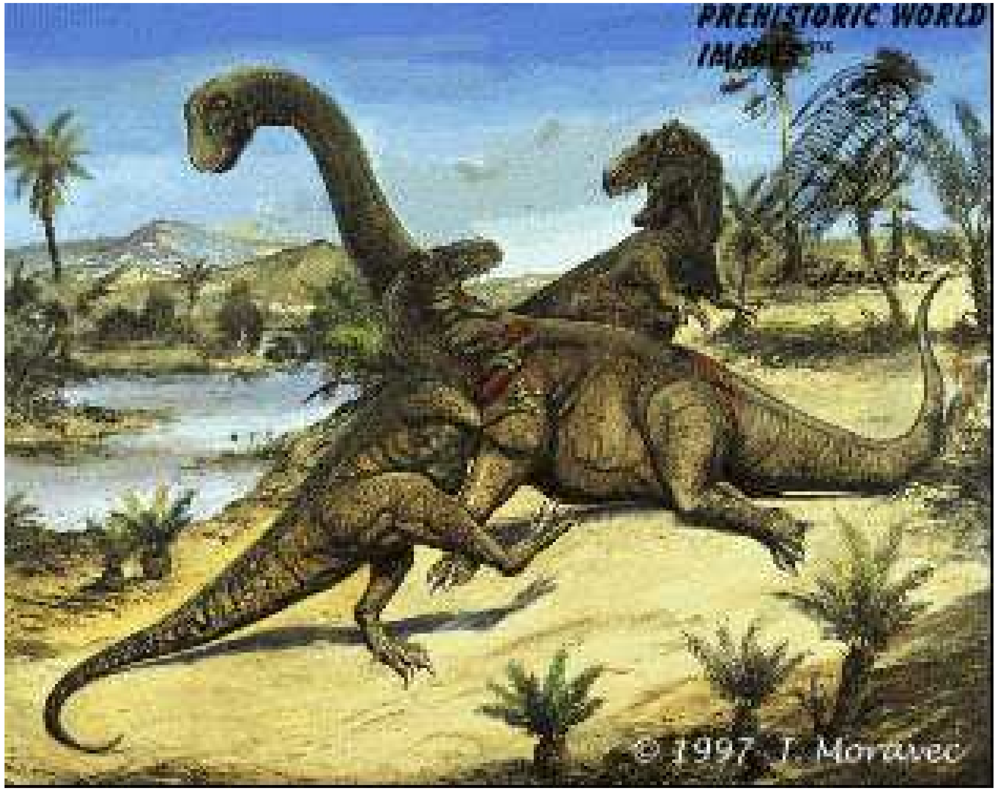


CAMARASAURUS supremus & ALLOSAURUS fragilis

CERATOSAURUS nasicornis & STEGOSAURUS armatus

RHAMPHO RHYNCHUS


COELOPHYSIS

Figure 10.9: (A) Reconstuction of *Williamsonia sewardiana* with spirally arranged leaf scars. (B) *Cycadeoidea* trunk and foliage drawn for comparison of proportions.

Fruit fossil

A fossil from the Clarno (Late Cretaceous-Early Tertiary)

http://www.ucmp.berkeley.edu/IB181

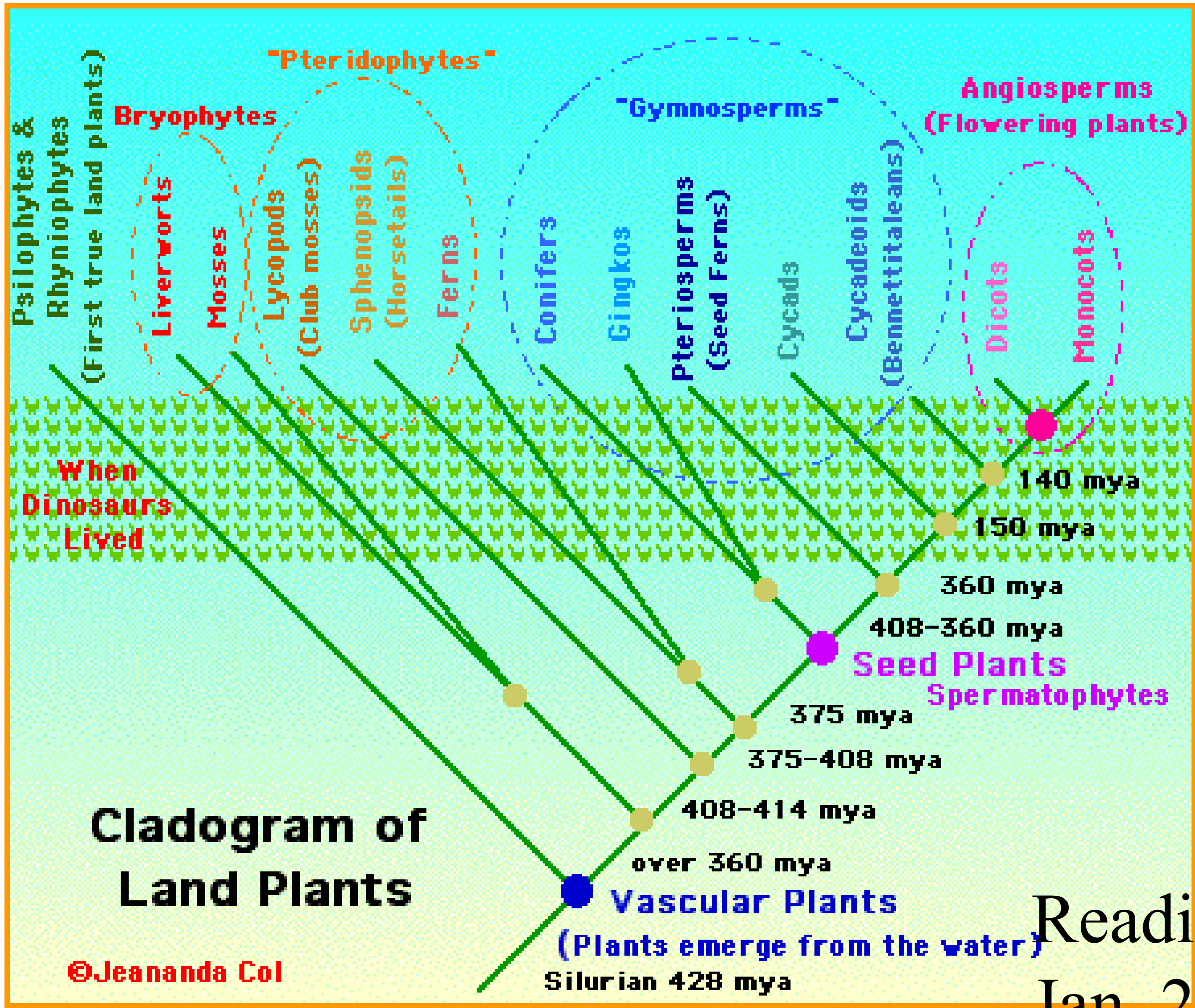
Oldest flowering plant fossil

Archaefructus liaoningensis

*140-million-year-old fossil from northeast China. The leafy,seed-containing pods (carpels) are the defining characteristic of angiosperms (“seeds in vessels”).

*Petals are apparently absent, but leaf-like structures subtending each fruiting axis define them as flowers.

Enlarged view of the carpels (each is about 1 mm long) showing seeds in carpel (Sun, Dilcher, Zheng & Zhou. 1998. Science 282:1692).



Reading: Chap. 1

Jan. 28 <u>Every Rock is Lithology</u>

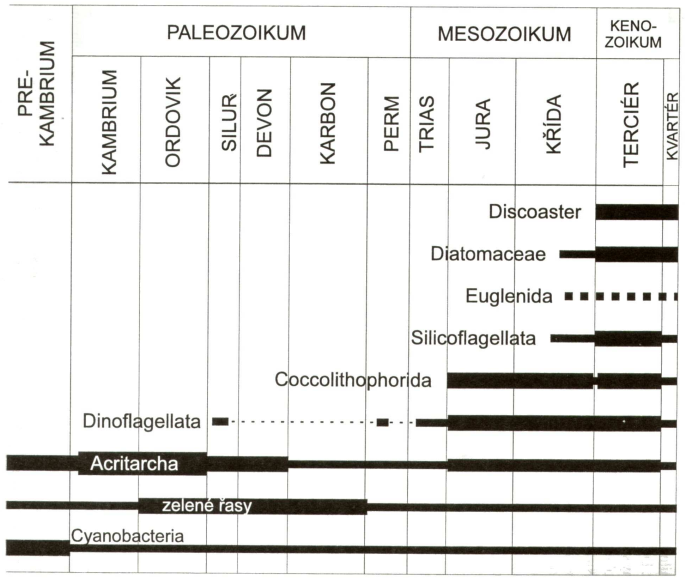
Reading: Chap. 2

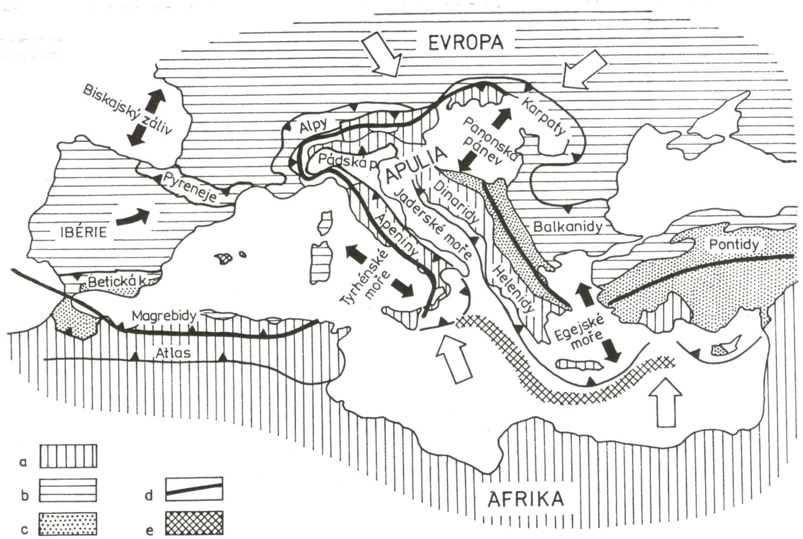
LAB: Description and

- Cordilleran Highlands
  - Triassic - Sonoma - CA, Nev, ID
  - Jurassic - Nevadan - CA, Nev, ID
  - Jurassic/Cretaceous - Sevier - Nev,Ut
  - Cretaceous/Tertiary - Laramide

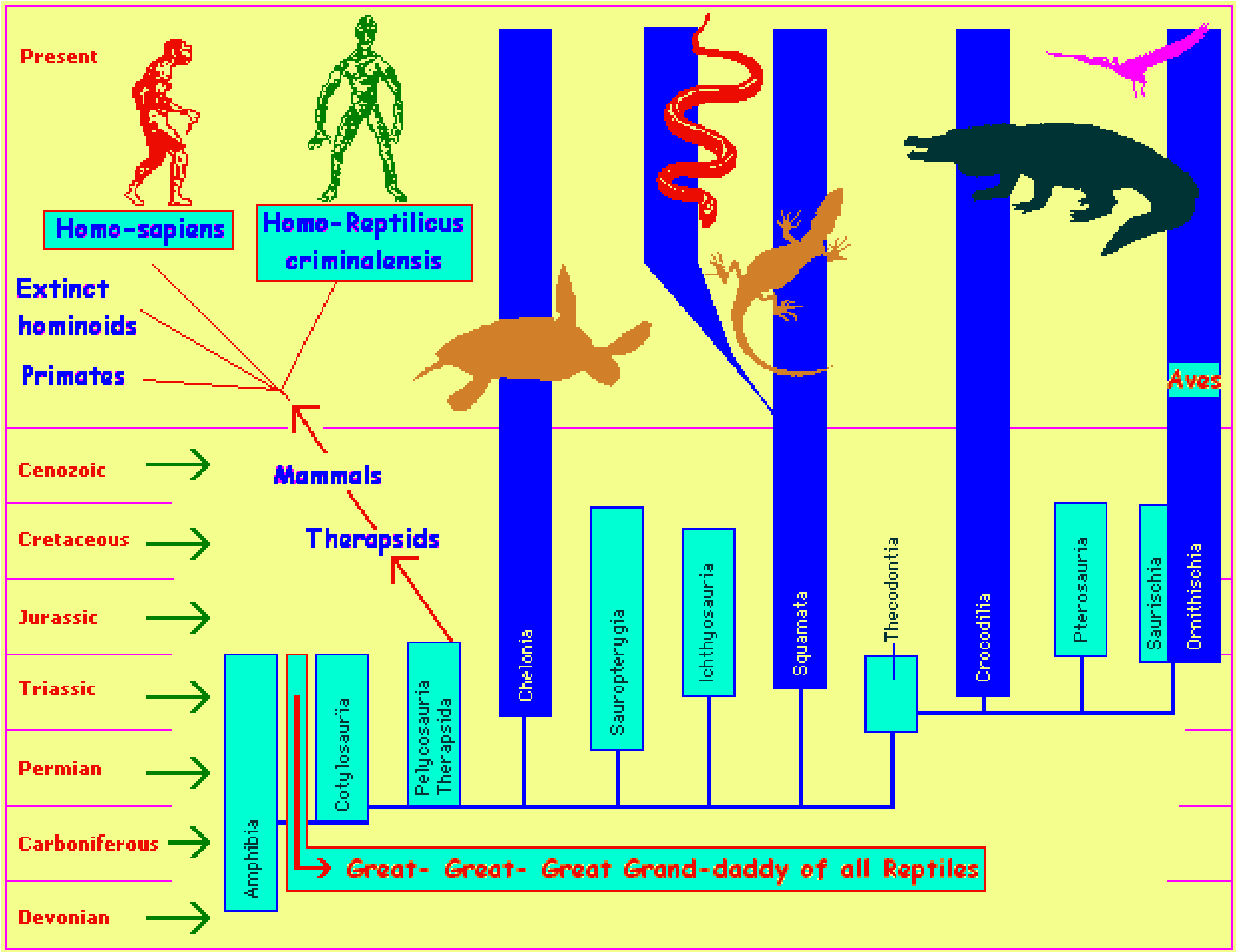
STÁŘÍ (Ma)	ERATEM	ÚTVAR	ODDĚLENÍ	STUPEŇ
65	MESOZOIKUM	KŘÍDA	SVRCHNÍ	maastricht
				campan
				santon
				coniac
				turon
				cenoman
			SPODNÍ	alb
				apt
				barrem
				hauteriv
				valangin
144				berrias
		JURA	SVRCHNÍ (MALM)	tithon
				kimmeridž
				oxford
			STŘEDNÍ (DOGGER)	callov
				bathon
				bajok
				aalen
			SPODNÍ (LIAS)	toark
				pliensbach
				sinemur
208				hettang
		TRIAS	SVRCHNÍ	rhaet
				nor
				carn
			STŘEDNÍ	ladin
				anis
245			SPODNÍ	scyth (werfen)

Obr. 62. Základní členění mesozoika.


PRE-KAMBRIUM
PALEOZOIKUM
MESOZOIKUM
KENO-ZOIKUM
KAMBRIUM
ORDOVIK
SILUR
DEVON
KARBON
PERM
TRIAS
JURA
KŘÍDA
TERCIÉR
KVARTÉR
Discoaster
Diatomaceae
Euglenida
Silicoflagellata
Coccolithophorida
Dinoflagellata
Acritarcha
zelené řasy
Cyanobacteria

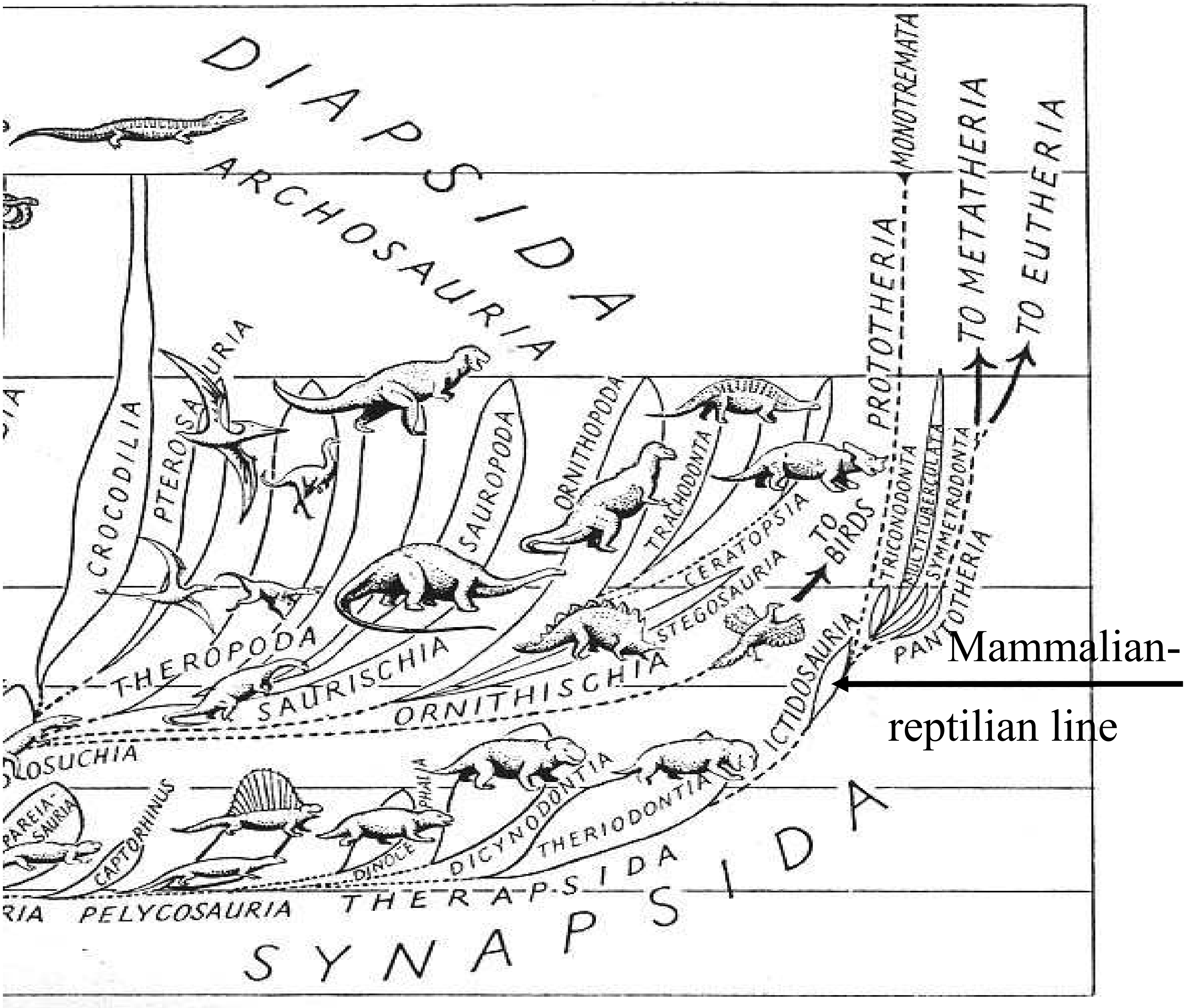


Obr. 72. Alpinský orogén v Evropě a Malé Asii. Legenda: a – africká platforma a deformované horniny afrického okraje, b – evropská platforma a deformované horniny evropského okraje, c – tethydní oceánské horniny, d – okraje desek, e – středomořský hřbet, prázdné šipky – hlavní směry konvergence, plné šipky – hlavní směry divergence, zubaté čáry – hlavní násunové linie. Upraveno podle Rogers (1994).


Present
Homo-sapiens
Homo-Reptilicus criminalensis
Extinct hominoids
Primates
Mammals
Therapsids
Aves
Cenozoic
Cretaceous
Jurassic
Triassic
Permian
Carboniferous
Devonian
Amphibia
Cotylosauria
Pelycosauria Therapsida
Chelonia
Sauropterygia
Ichthyosauria
Squamata
Thecodontia
Crocodilia
Pterosauria
Saurischia
Ornithischia
Great- Great- Great Grand-daddy of all Reptiles

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


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