

Mesozoic

Modern marine fauna — dominated by bivalves, gastropods, ammonoids, belemnites
Actinopterygii – Holostei (mnohokostnatí), Teleostei (kostnatí), gymnolemate bryozoans,
desmospongians, echinoids, Hexacoralla, marine reptiles, sharks, new crustaceans present (lobsters,
crabs), planctonic foraminifers, coccolithophorids

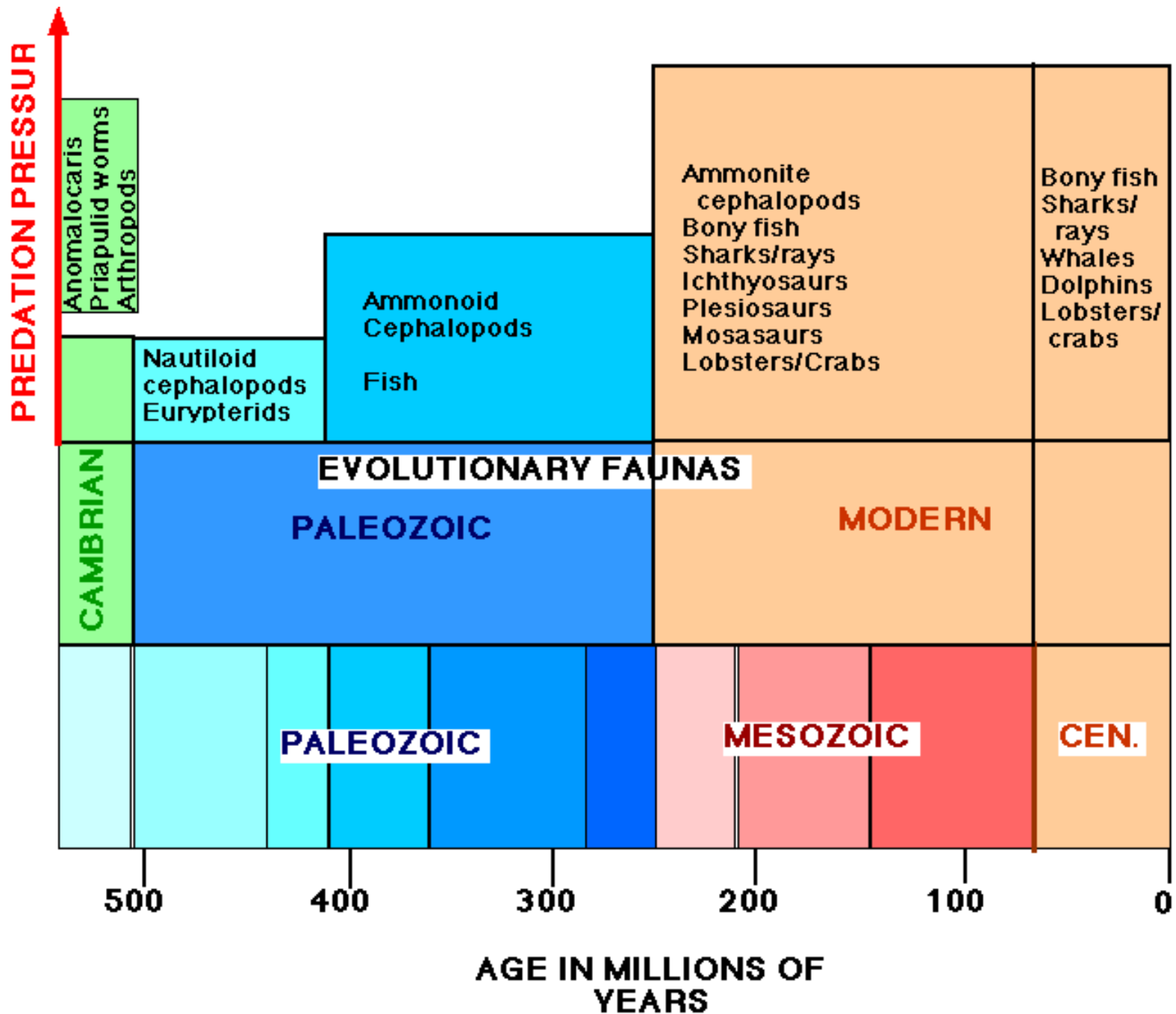
Land – dinosaurs, air - pterosaurs

First mammals – beginning of the Mesozoic, Jurassic – 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)

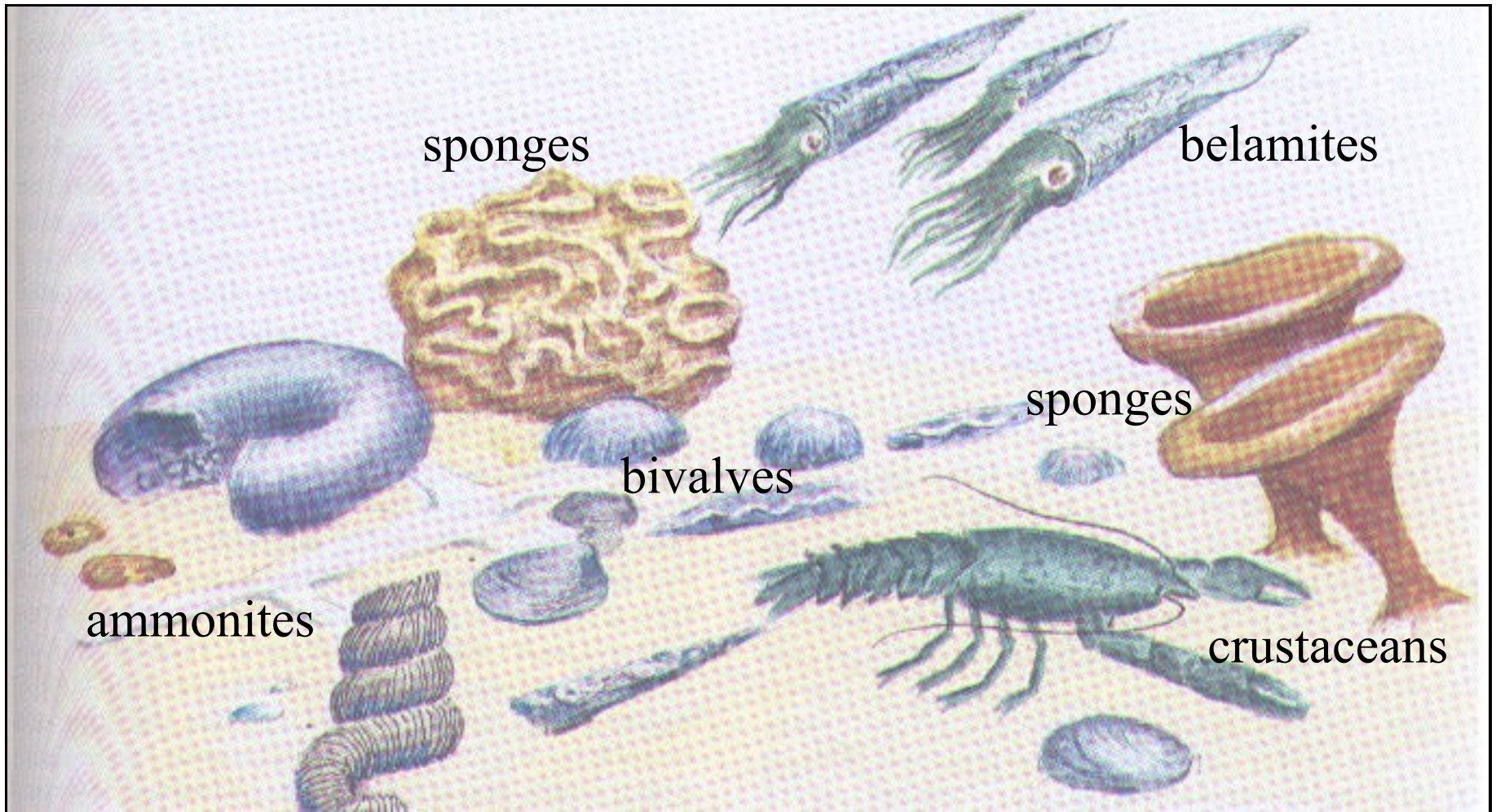
Alpine orogeny – closure of Tethys, young mountain belts, nappes. From Atlas to Himalayas.



Invertebrate Mesozoic fauna



Rudistid clams



sponges

belamites

sponges

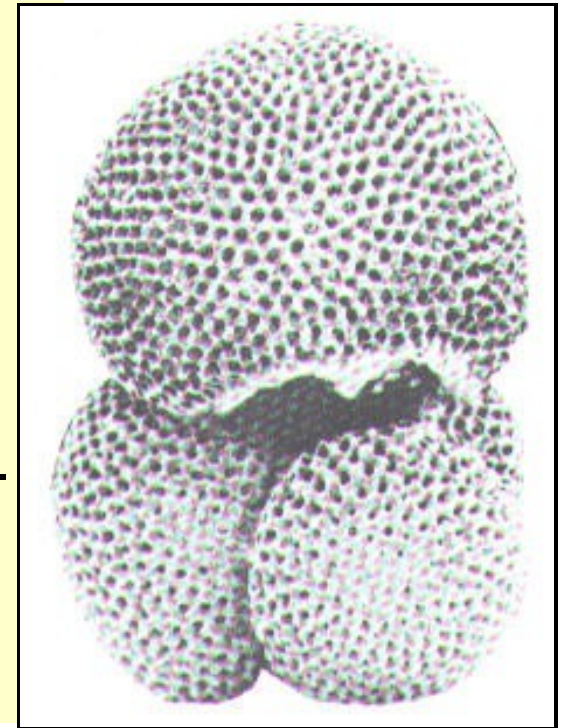
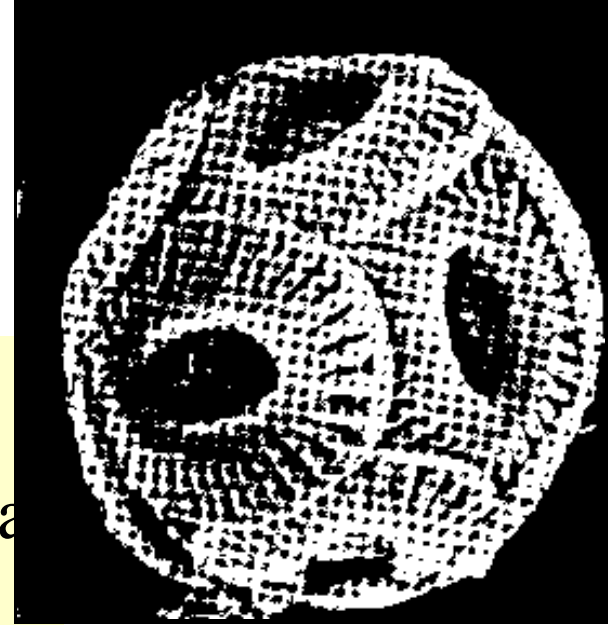
bivalves

ammonites

crustaceans

Microfossils

- Coccolithophoroids
 - extremely small single-shelled algae
 - 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 Holostei
- Modern teleost fishes
 - developed by late Jurassic
 - highly mobile jaws and swim bladder
- Marine reptiles (not dinosaurs)
 - plesiosaurs (long necked fish-catchers)
 - ichthyosaurs (fish-lizards, dolphin-like reptiles)
 - mosasaurs (related to monitor lizards)

Terrestrial flora

Gymnosperms (seed-bearing plants)

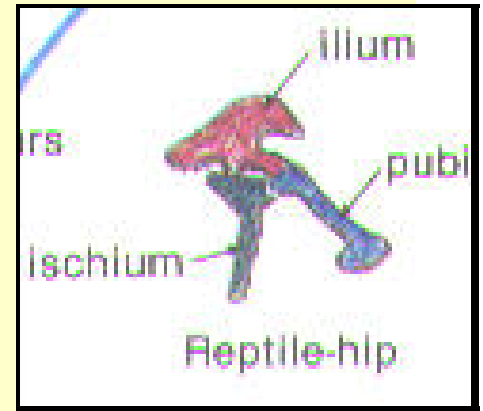
- dominated most of Mesozoic
- modern conifers are members of this class
- Angiosperms (flowering plants)
 - began to dominate in Late Cretaceous
 - flowers to attract pollinating birds and insects
 - fruit eaten by animals to help spread seeds
 - generally grew, regenerated, and reproduced faster
 -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

Mammals

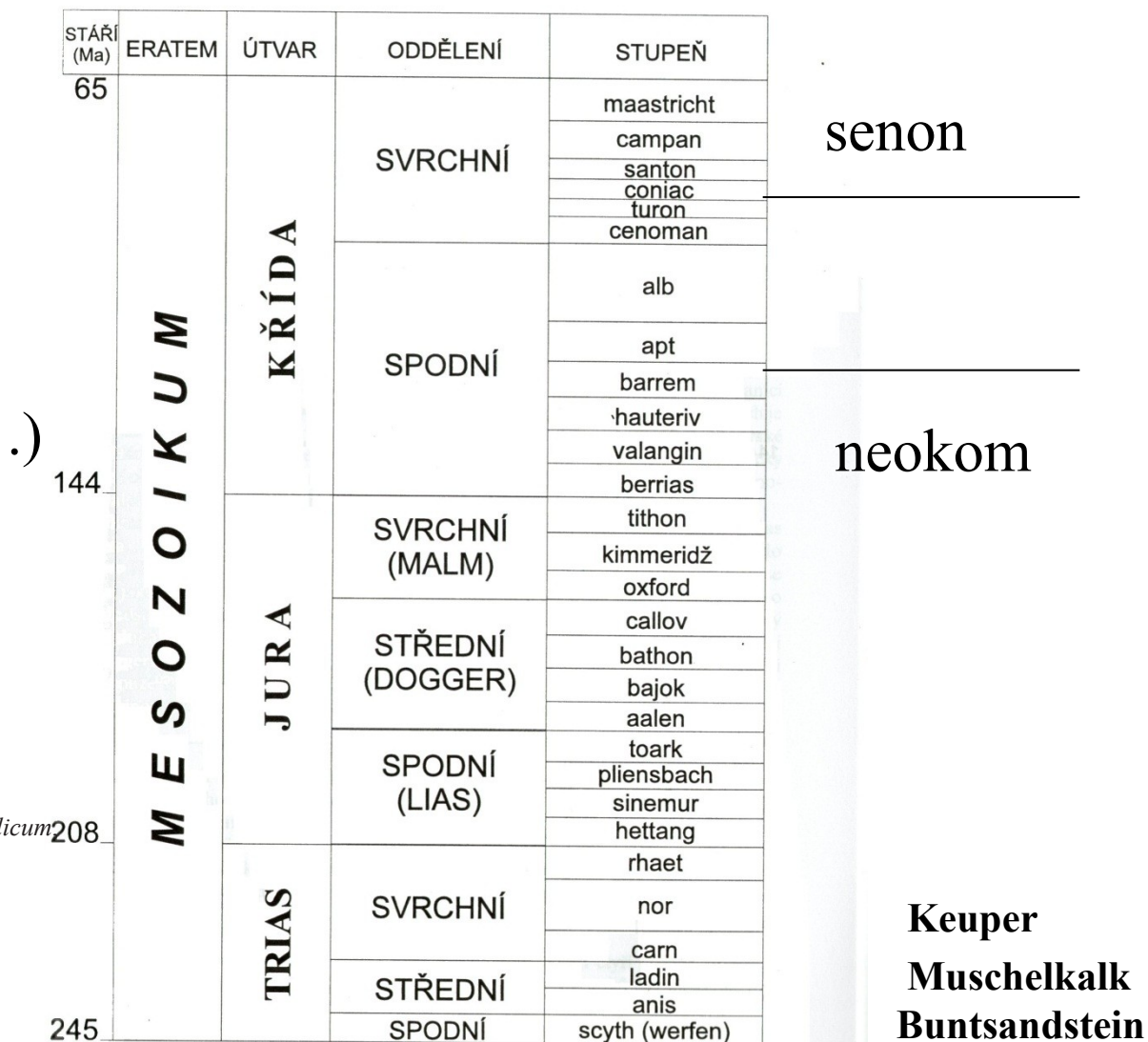
- Developed from latest Late Triassic synapsids
 - remained mouse-sized
 - did not compete with dinosaurs in their niches
 - developed mammary glands
 - endothermic and homothermic--required high food intake
 - jaw muscles and teeth well adapted for catching prey
 - soft palate to separate breathing 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
 - » opossum, 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
 - Ankylosaurs
 - Stegosaurs
 - Hadrosaurs, Pachycephalosaurs
 - Iguanodonts
 - Ceratopsids



Iridium geochemical anomaly.
Associated with a major extinction
horizon (dinosaurs, ammonites,
foraminifers, etc



FO of ammonite *Psiloceras sp. pelagicum*
FO of palynomorph *Cerebropollenites thiergartii*

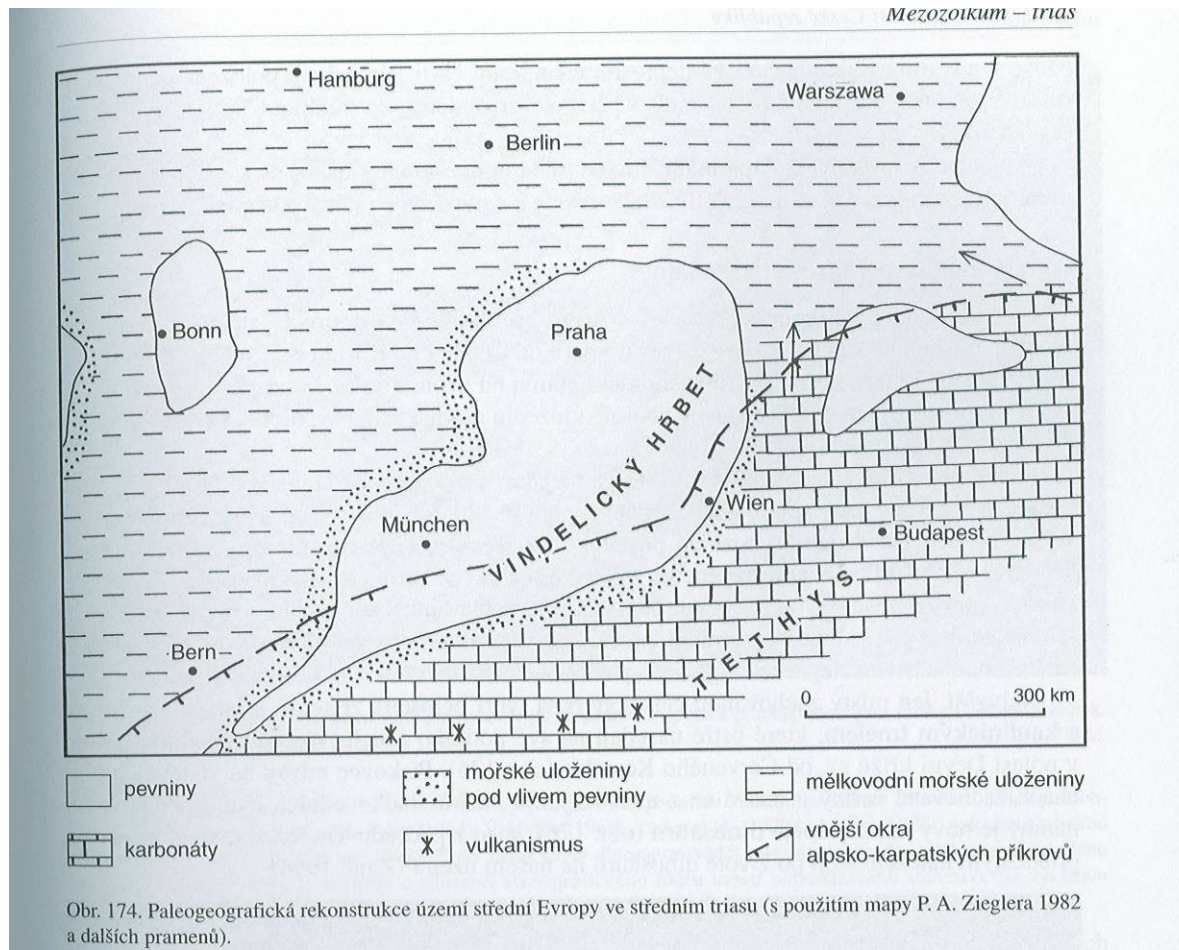
Conodont FAD *Chiosella timorensis*

Tab. 62. Základní členění mesozoika.

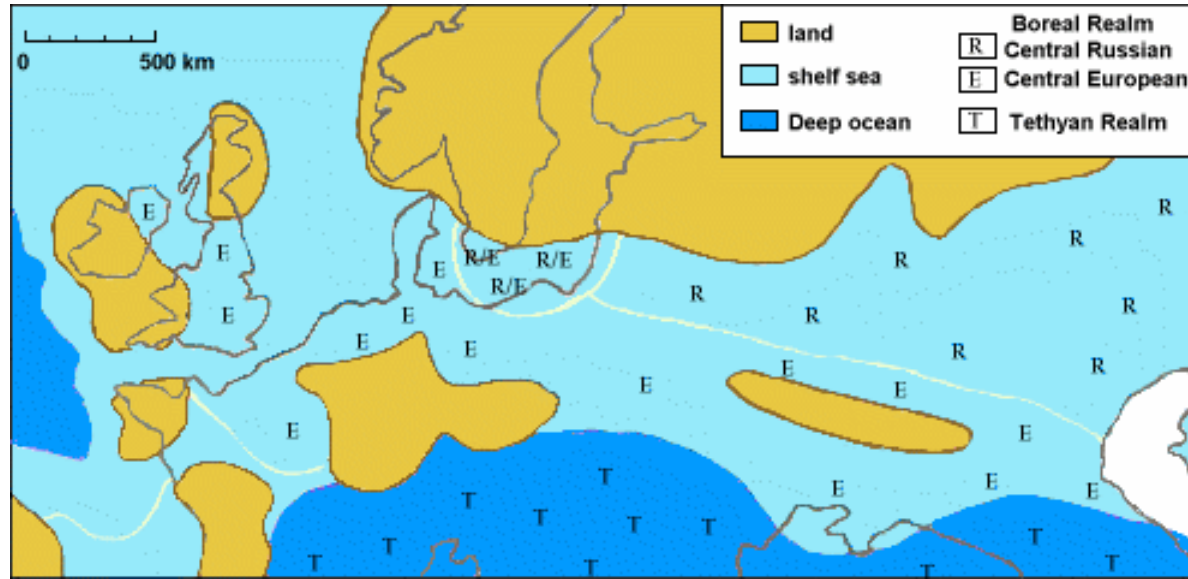
Triassic – Buntsandstein, Muschelkalk, Keuper, German development. Alpine development – Vindelic land,. Communication – Burgund and Moravian gate.

Jurassic –Jura Mountains. Black, brown and white Jurassic.
70 ammonite zones

Cretaceous – chalk. Extinction. Neokomian, Senonian.



Tethyan Realm – *Diceras*, other rudists, *Nerinea* and *Globotruncana* in Cretaceous. Widespread carbonates



Boreal Realm – clastic sediments, *Virgatites*, *Cylindroteuthis*, *Bositra* in Jurassic, *Globigerina* in Cretaceous.

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

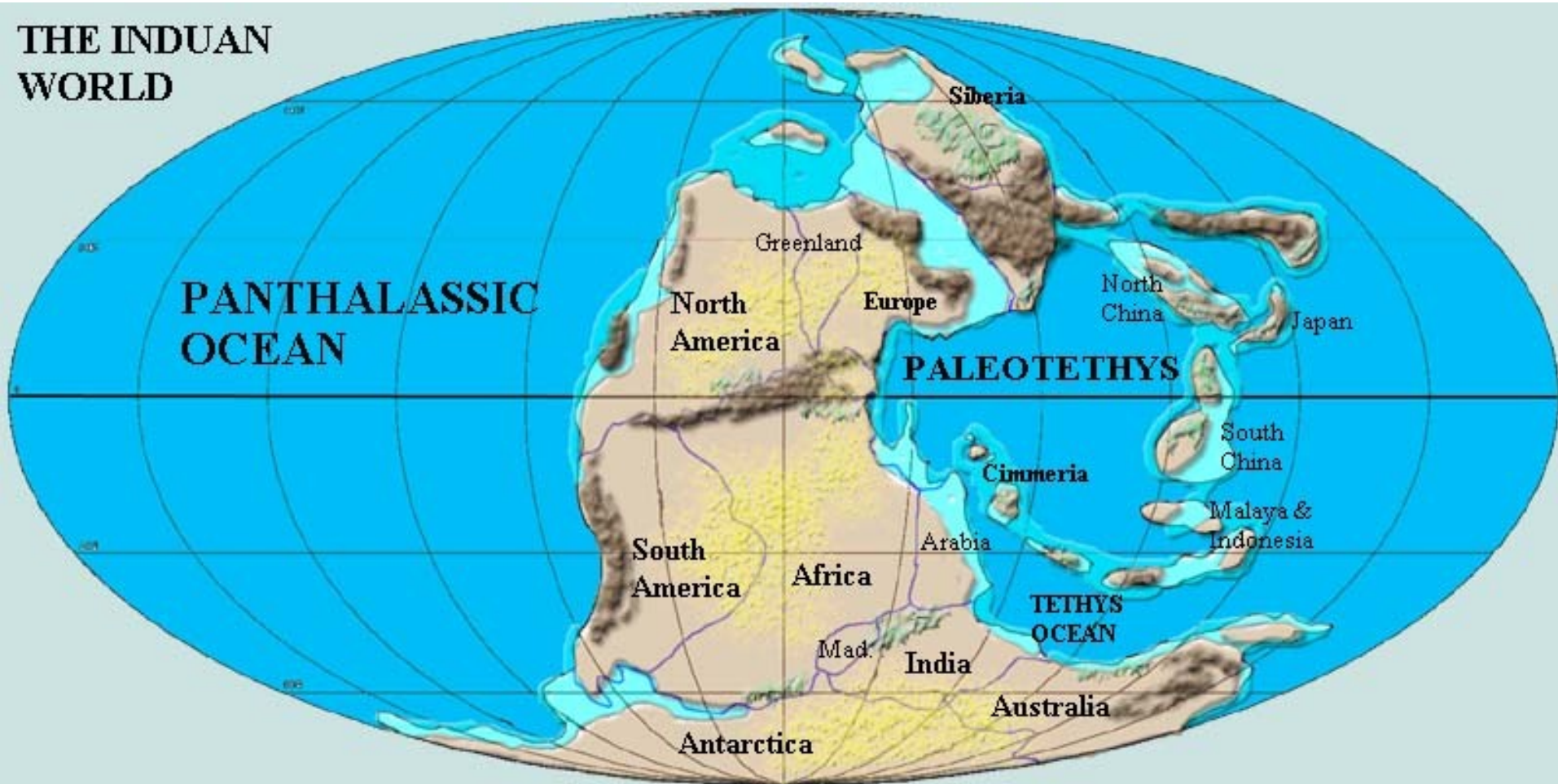
Base of Jurassic - Guide event is undecided

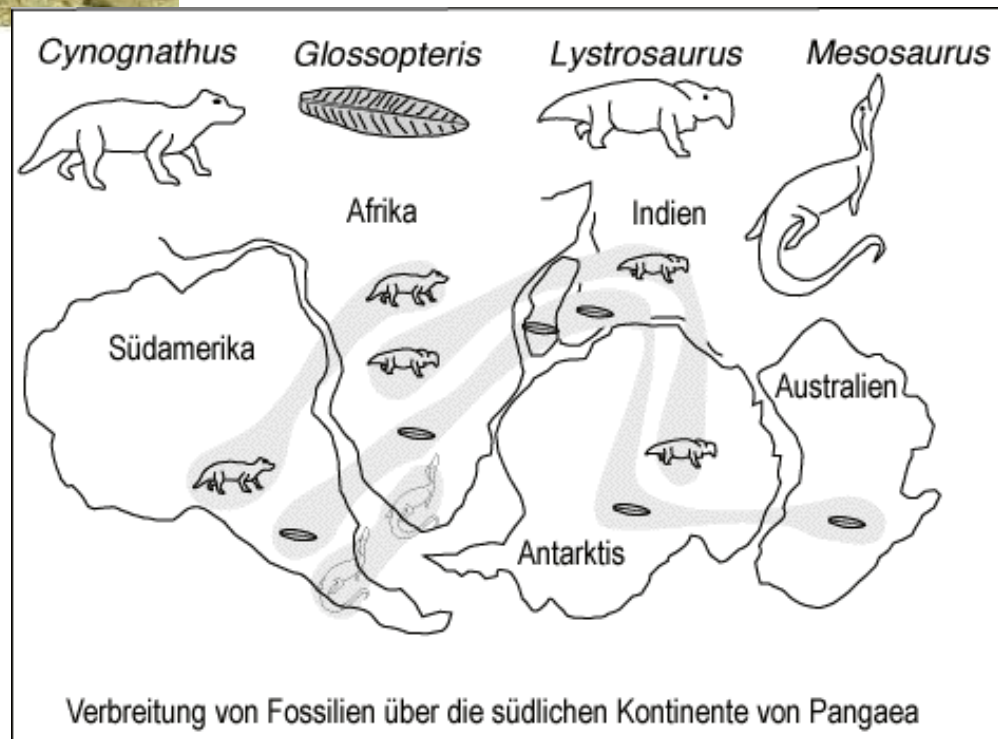
Base of Cretaceous - Guide event is undecided

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

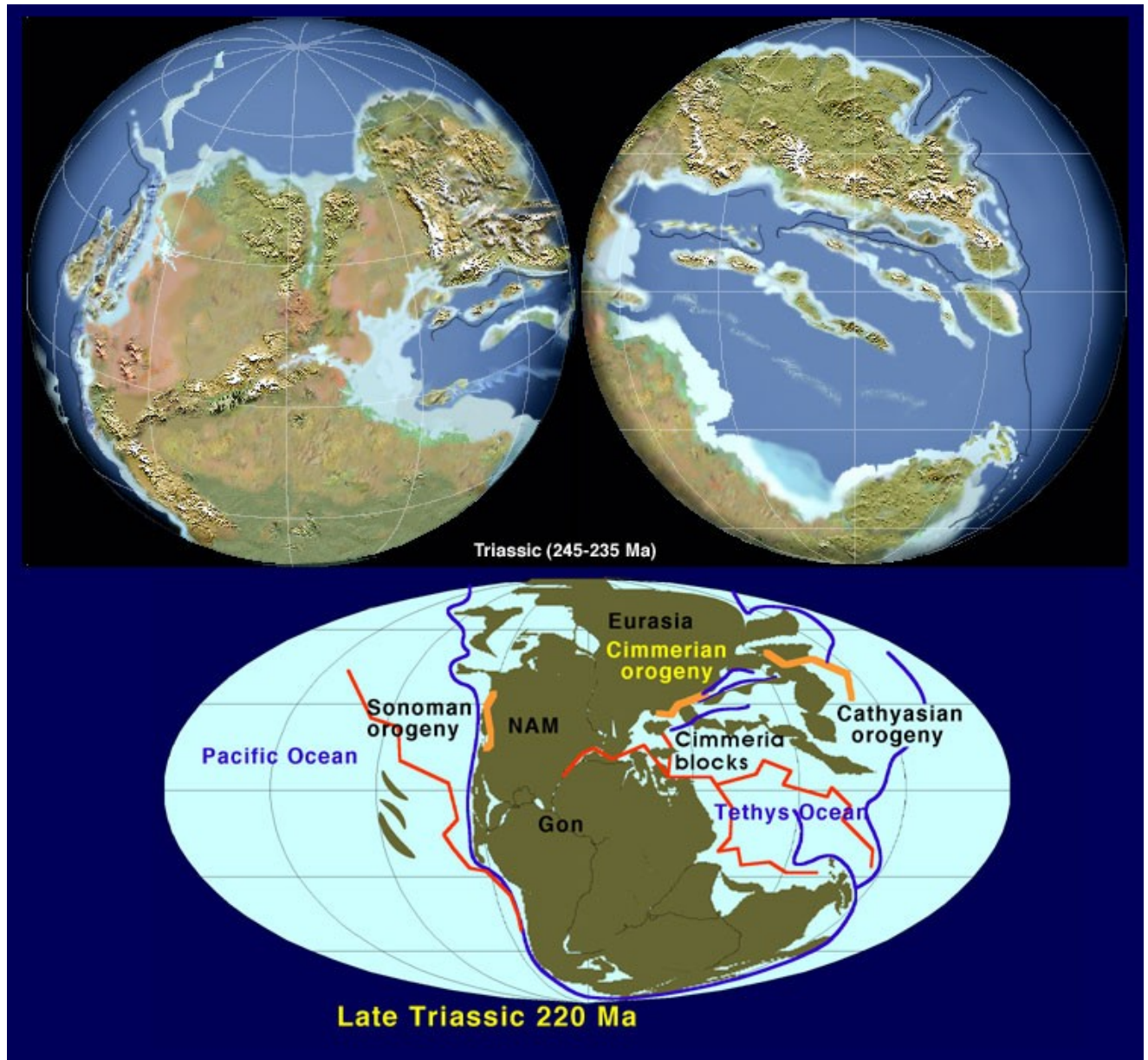
Paleogeography and tectonic processes

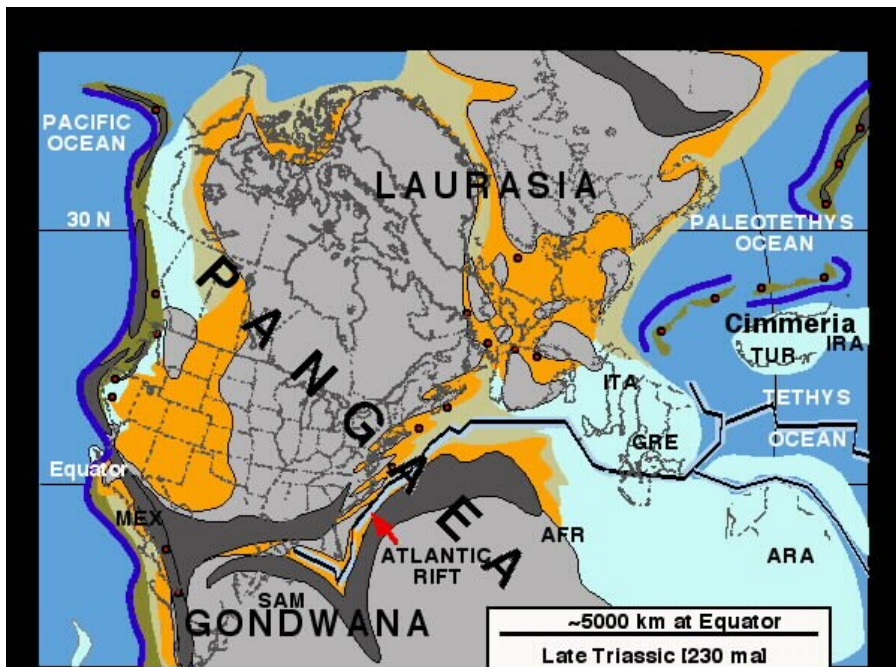
Pangea – Lystrosaurus, aride climate.



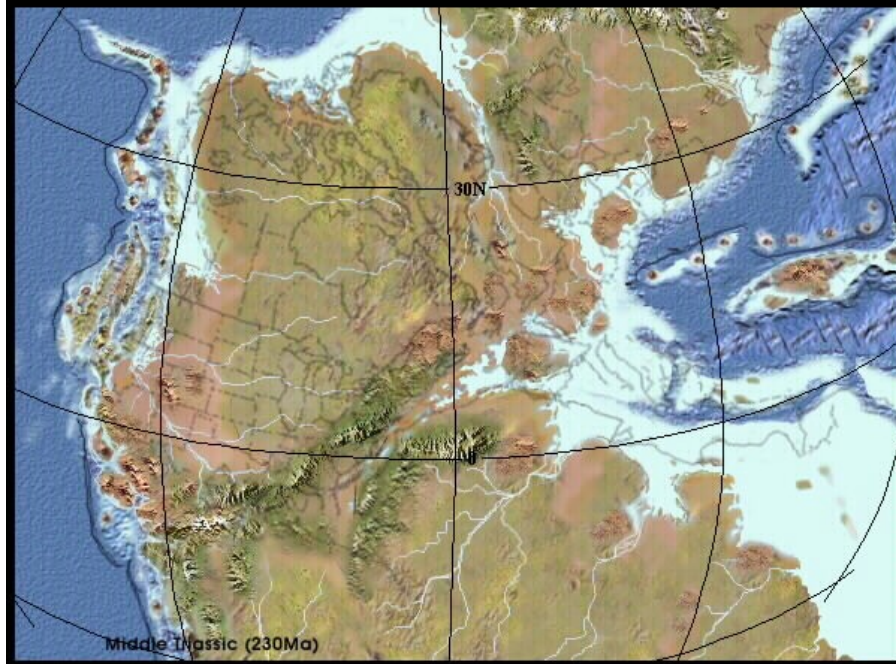


**Otevírání Atlantiku
začalo vytvářením
příkopů a halfgrabenů
již v permu a triasu.**

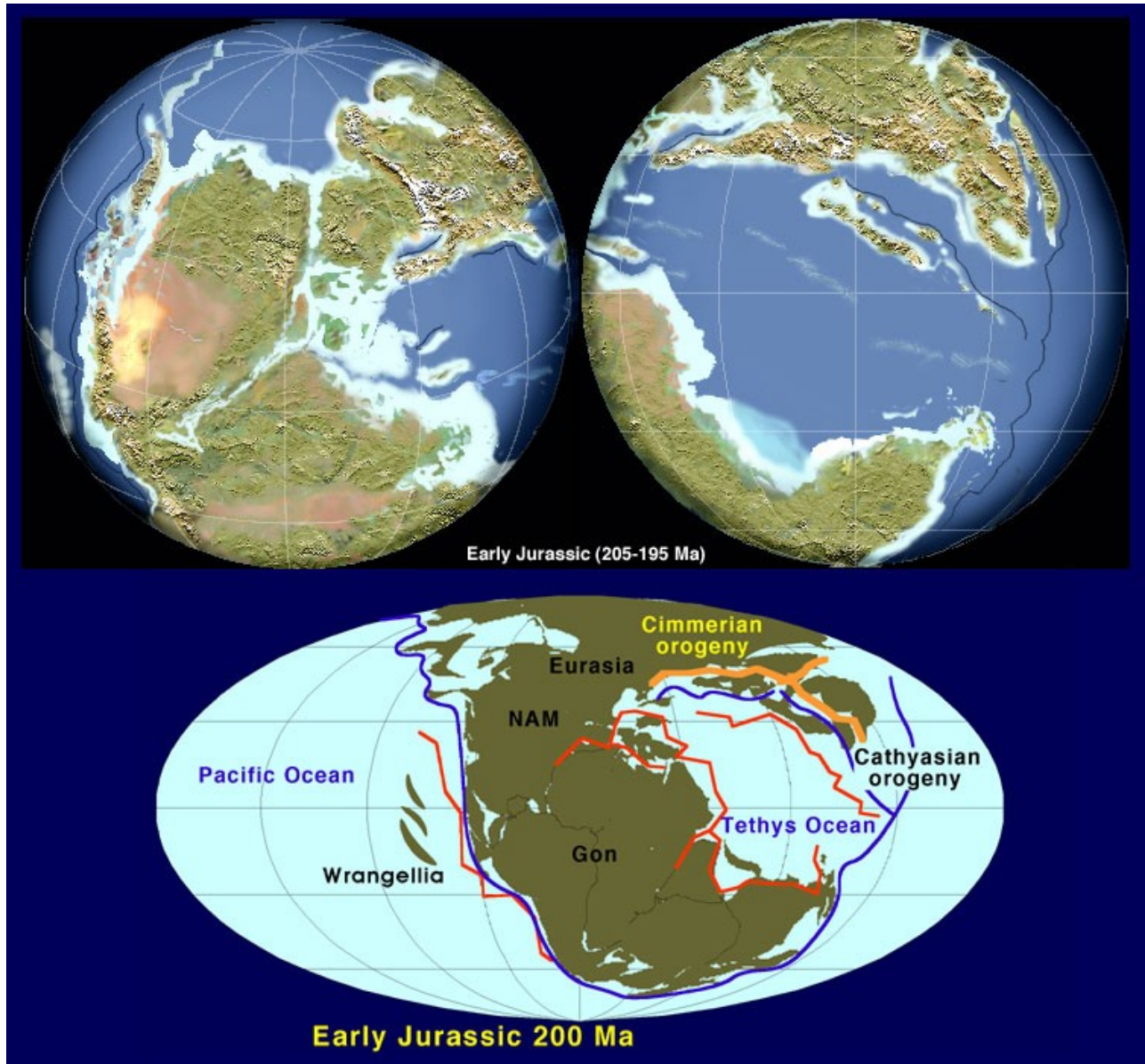


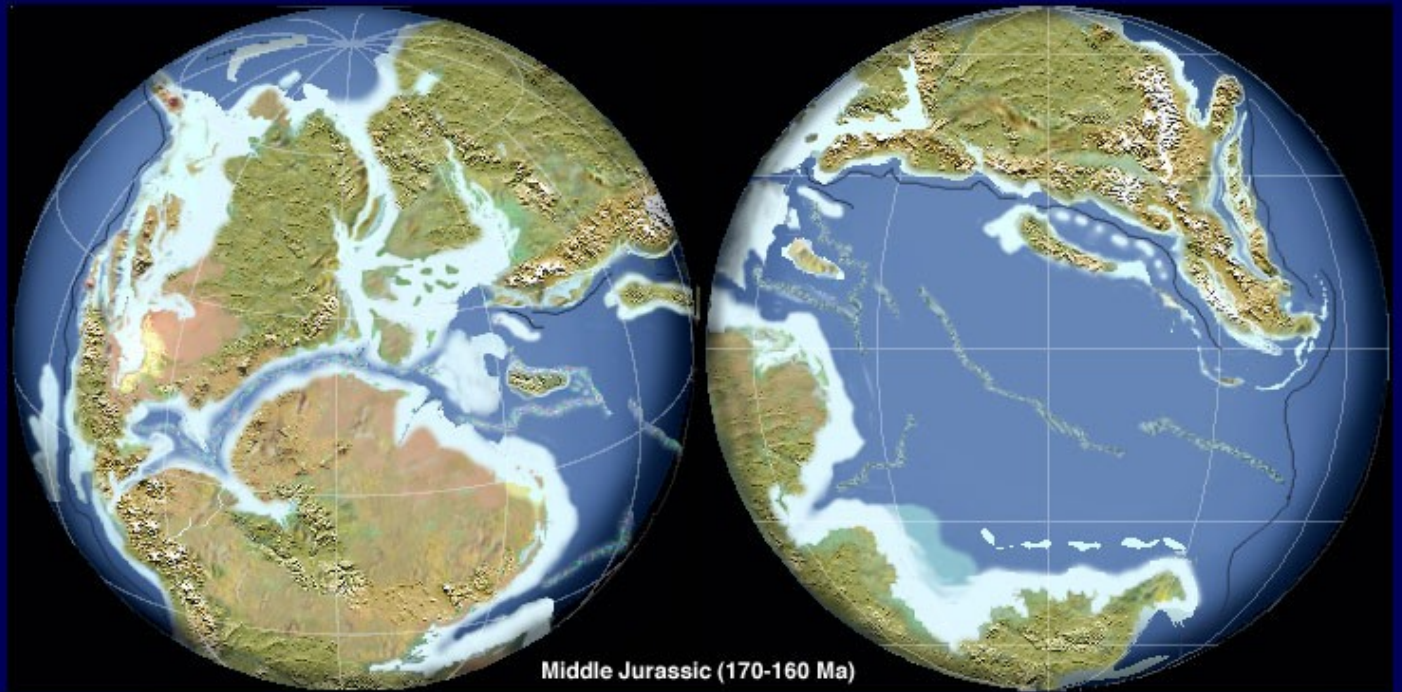


During latest Triassic: **rifting** in **mid-Pangaea** (between North America + Europe and Africa).



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





Middle Jurassic (170-160 Ma)



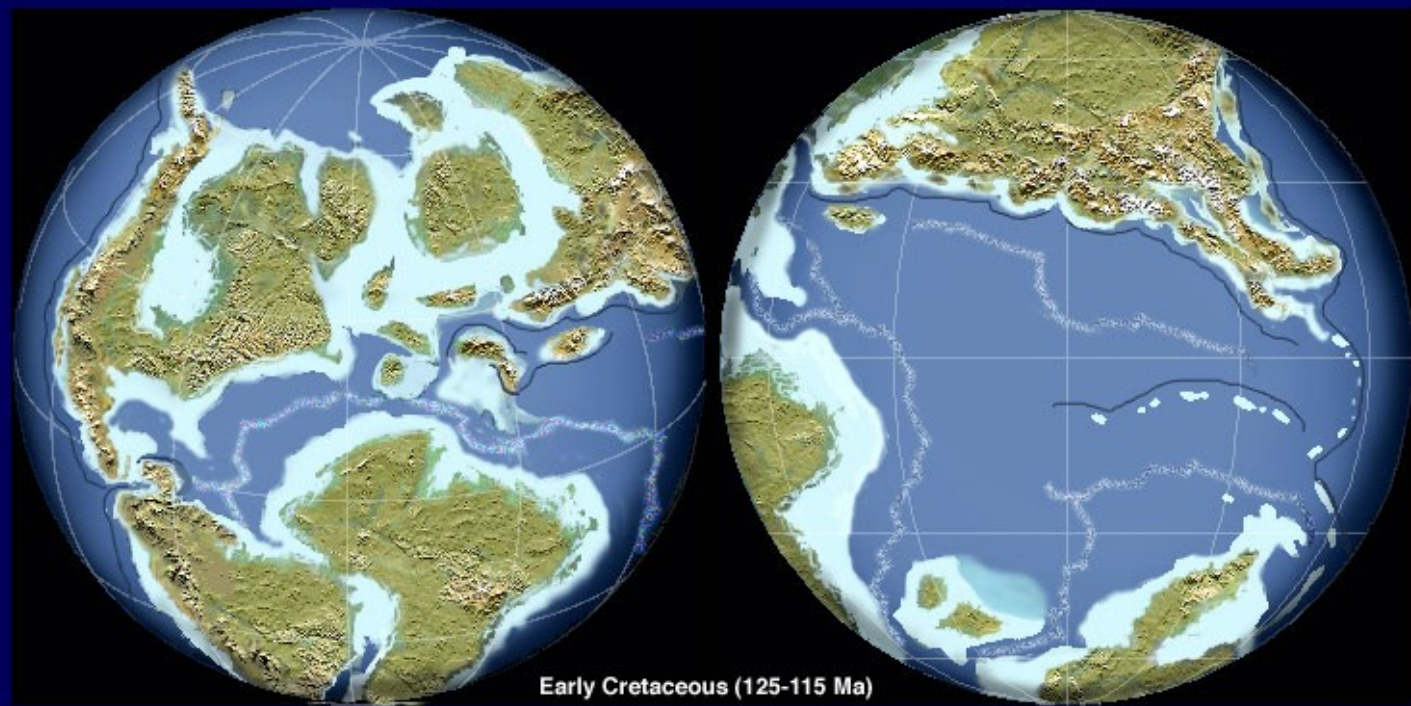
Middle Jurassic 160 Ma

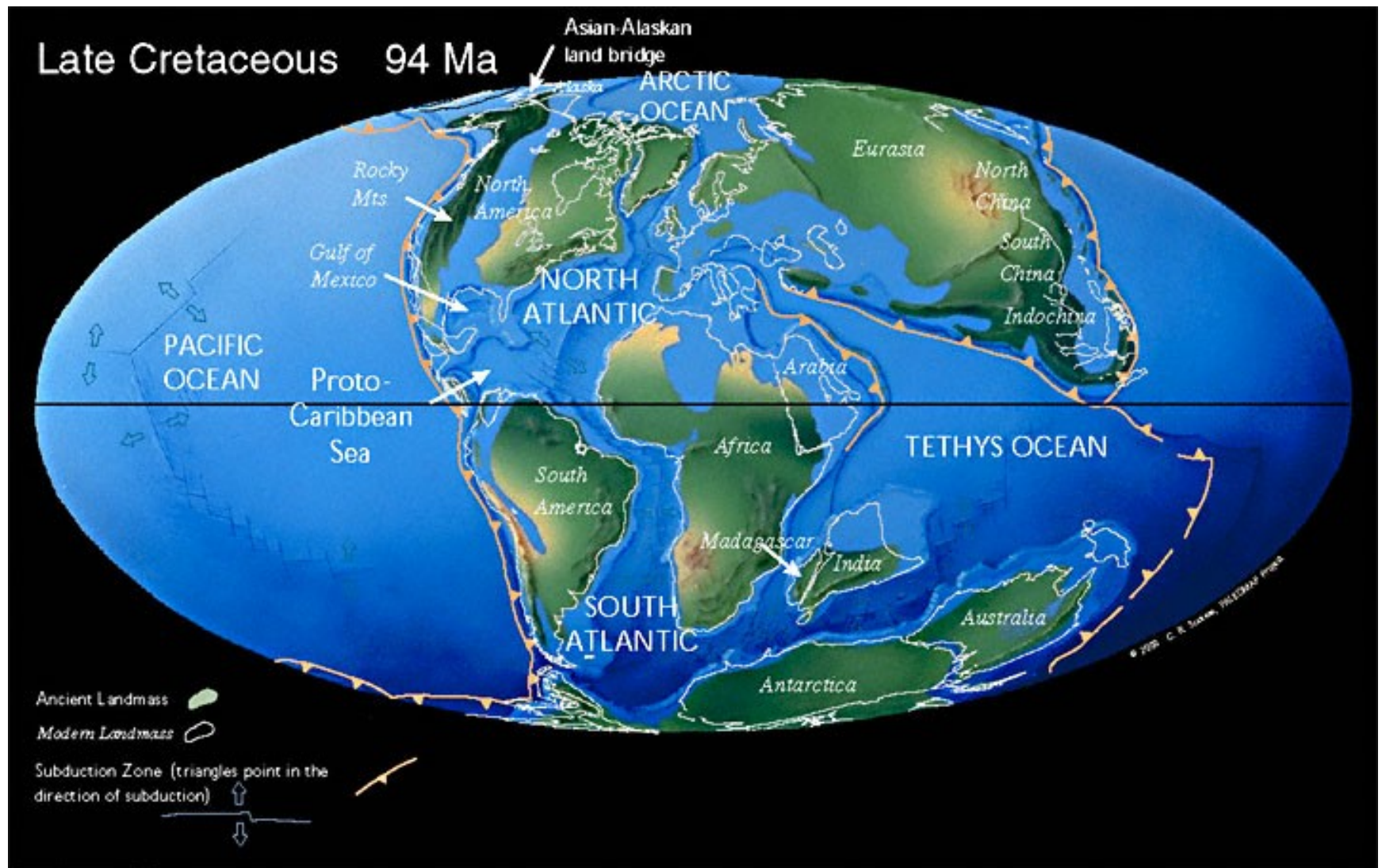
Late Jurassic 152 Ma



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

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





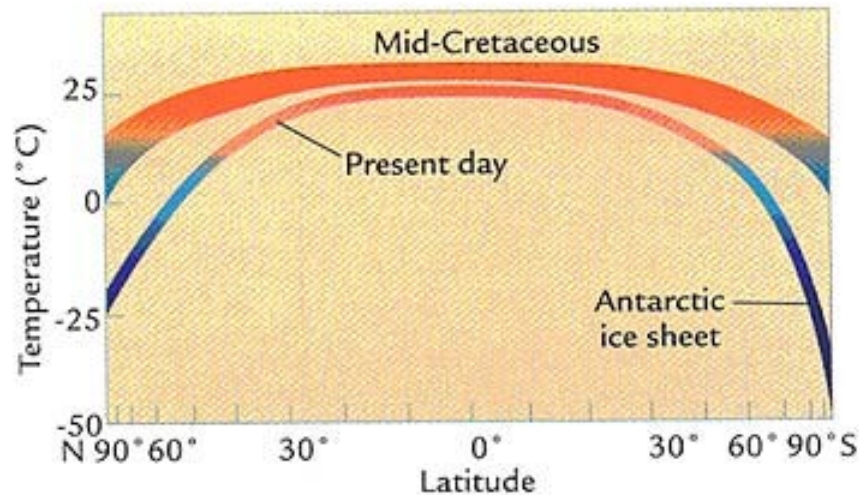
During the Cretaceous the South Atlantic Ocean opened. India separated from Madagascar and raced northward on a collision course with Eurasia. Notice that North America was connected to Europe, and that Australia was still joined to Antarctica.

Climate

Triassic – aride, similar to Permian

Jurassic - 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/Tertiary

Cimmerian orogeny – eastern Tethys

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

Mesozoic flora

Algae

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

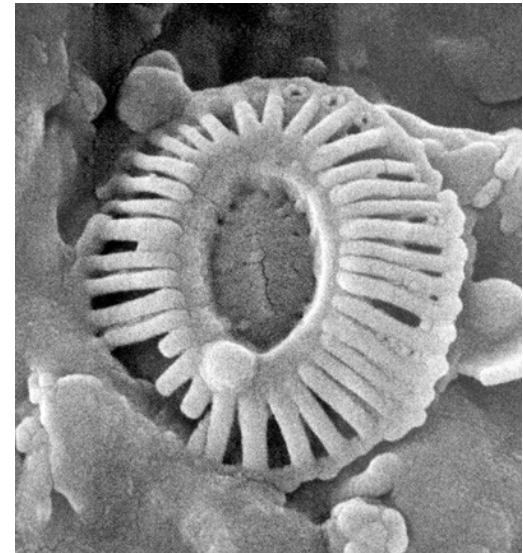
The **Wetterstein mountains** are a chain of mountains which is part of the Northern Limestone Alps, located in the Eastern Alps, between Bavaria and Austria. The Zugspitze, which is the highest peak in Germany is located here



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

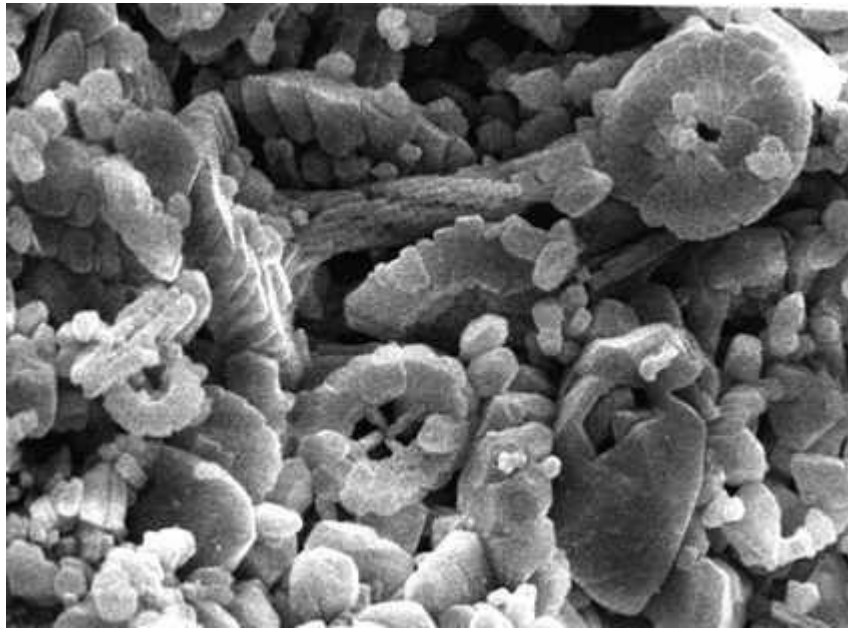
In Jurassic and especially Cretaceous diversification of marine microflora. In Jurassic – explosive evolution of **Dinoflagellates**, another explosive phase in Cretaceous. Cretaceous last expansion of acritarchs. Growing role of **calcareous nanoplankton** in Jurassic and especially Cretaceous.

Chalk – epicontinental seas, 200-300m depth





Upper Cretaceous chalk exposures along the English Channel, East Sussex, England



This scanning electron micrograph (SEM) shows how important organisms can be in forming sediment. The high resolution image shows a fractured surface of a fragment of Upper Cretaceous chalk. The chalk is composed mainly of small elliptical 'scales' or platelets or fragments of these, each fragment or platelet element being a single calcite crystal. The platelets (coccoliths, average 7 microns in diameter) once overlapped to form an external skeleton (coccosphere) which surrounded the spherical cells of tiny plankton (diameters 15-100microns) which lived in the surface waters of the ancient chalk sea

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

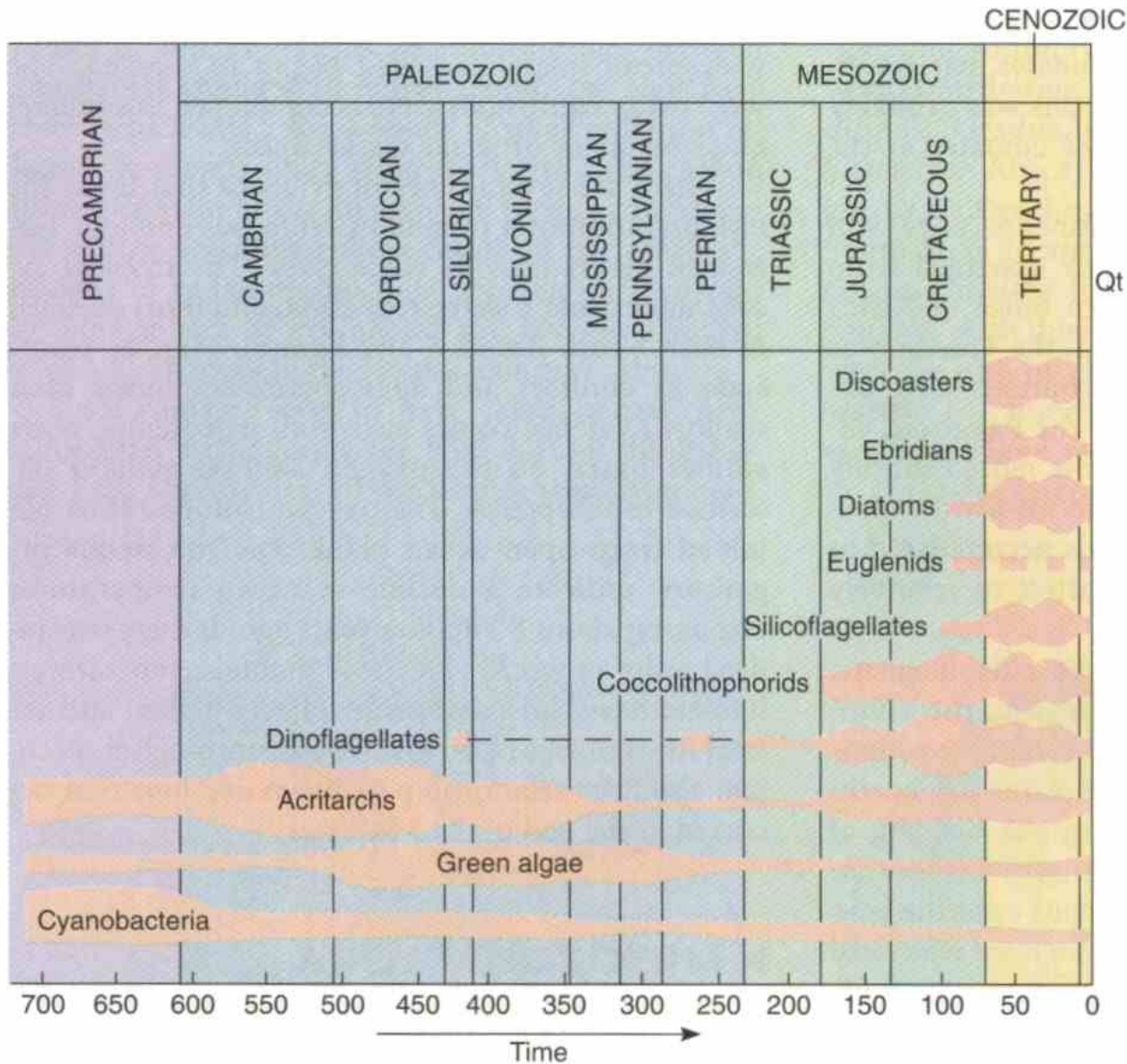
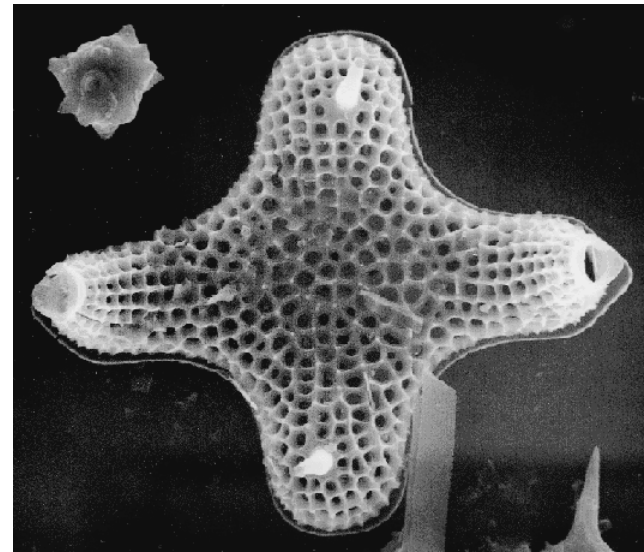
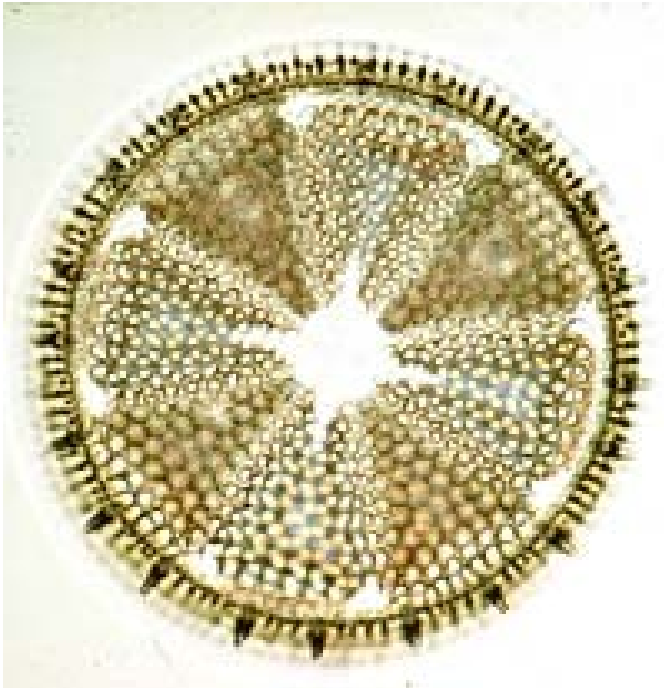


FIGURE 12-2 Geologic distribution and abundances of phytoplankton. (From Tappan, H., and Leoblich, A. R., Jr. 1970. Geol. Soc. Am. Special Paper 127:257.)

Bacillariophyta (The Diatoms)



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 Jurassic-early Cretaceous. Today only Ginkgo biloba.

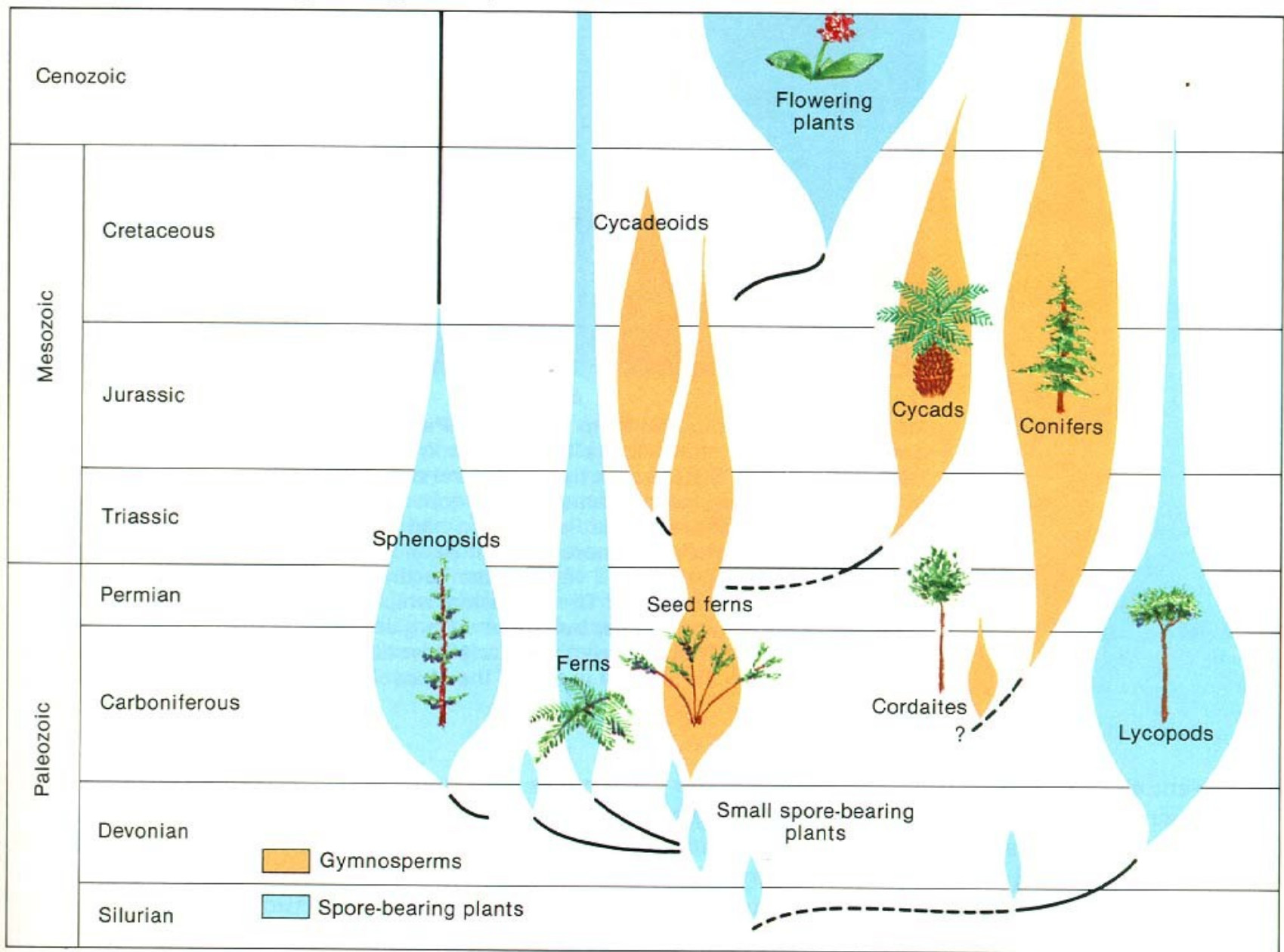
In Triassic still abundant ferns and lycopods.

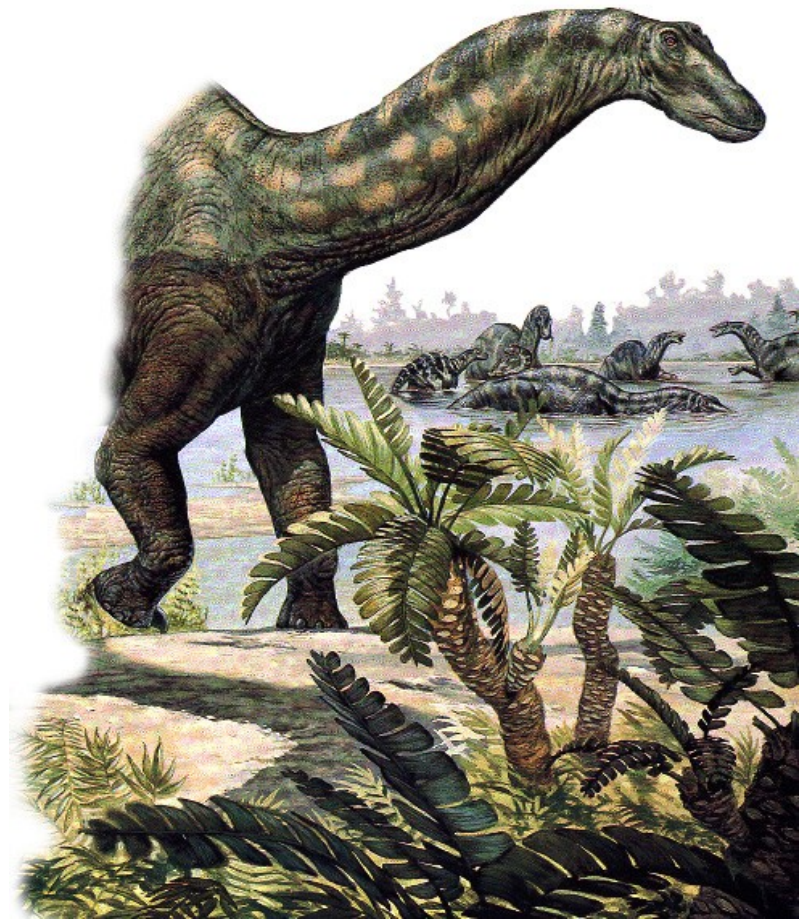
First angiosperms – latest Jurassic., in early Cretaceous quick diversification, since middle Cretaceous dominant flora - **Cenophytikum(Neophytikum)**.

Great advantages – short reproduction cycle, polination by insects

Absence of grasses and savana, prairie and meadow biotopes.

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





Voltzia



Oldest flowering plant fossil



Archaeofructus 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 – *Claraia claraia*

Early Triassic – *Claraia 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

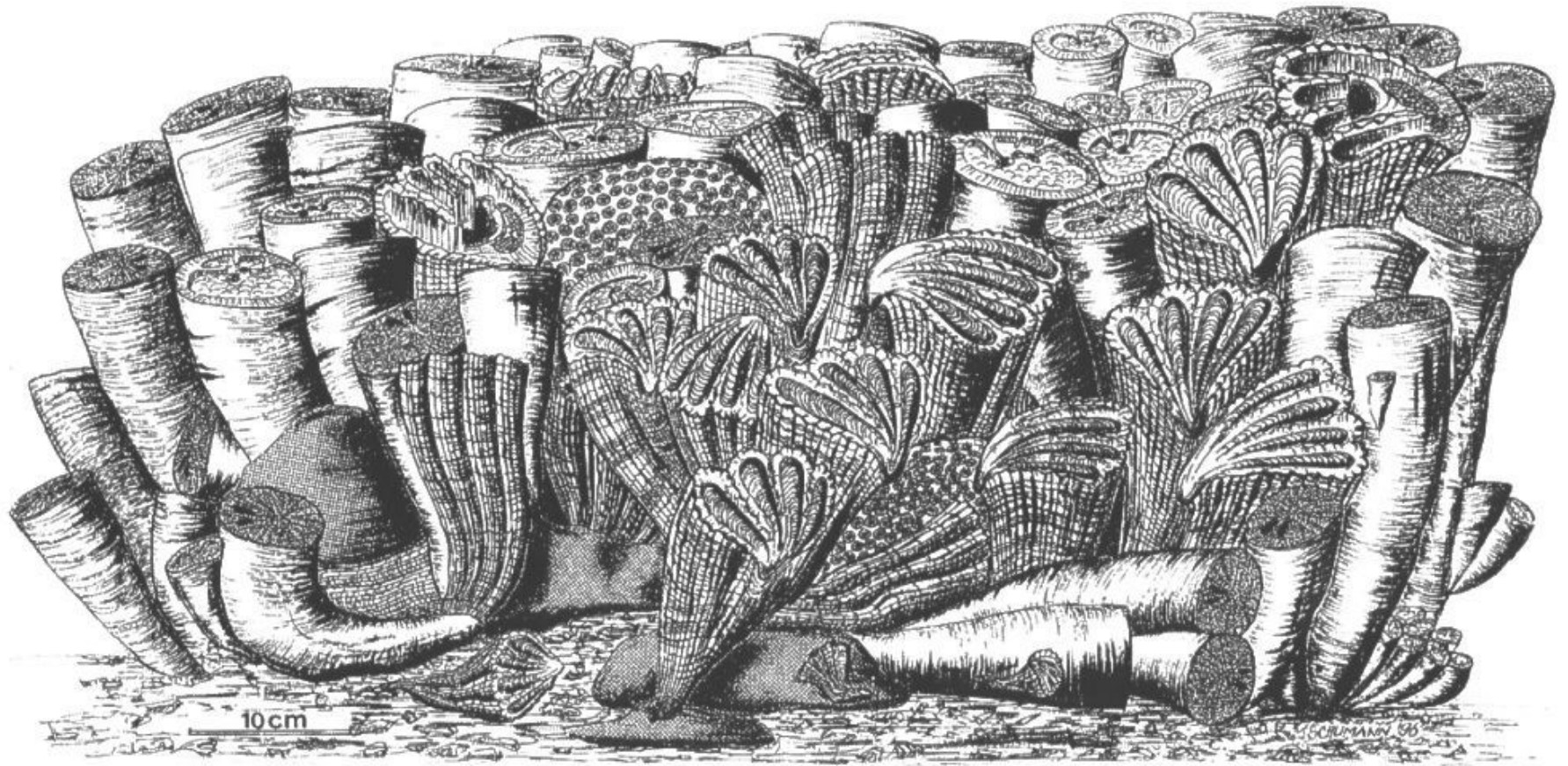


Diceras





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

Black Jurrasic of Germany

Inoceramus sp.



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

Na snímku je jeden z našich nejslavnějších kamenů – **opuka**. Čerstvá má krásnou žlutavou až zlatou barvu, jako stavební kámen se dá krásně opracovávat, a proto z ní byla postavena **skoro celá románská Praha**, kousek Loun i kostely v jiných městech. **Opuka je tvořena** několika součástmi, jejichž poměry kolísají: **drobnými zrnky křemene, jilem, uhličitanem vápenatým a oxidem křemičitým**. Pod mikroskopem v ní objevíme **mnoho jehlic hub**. Česká opuka je kolem 100 milionů let stará a usadila se v křídovém moři. Jak vznikl název *opuka*? Převzali jsme ho údajně ze staré ruštiny, kde *opoka* znamenala křemitou, střípkovitě se rozpadající sedimentární horninu. Každopádně je základem sloveso *pukat* (přesněji slovanské *pukać* – klepat, praskat), neboť opuka snadno puká

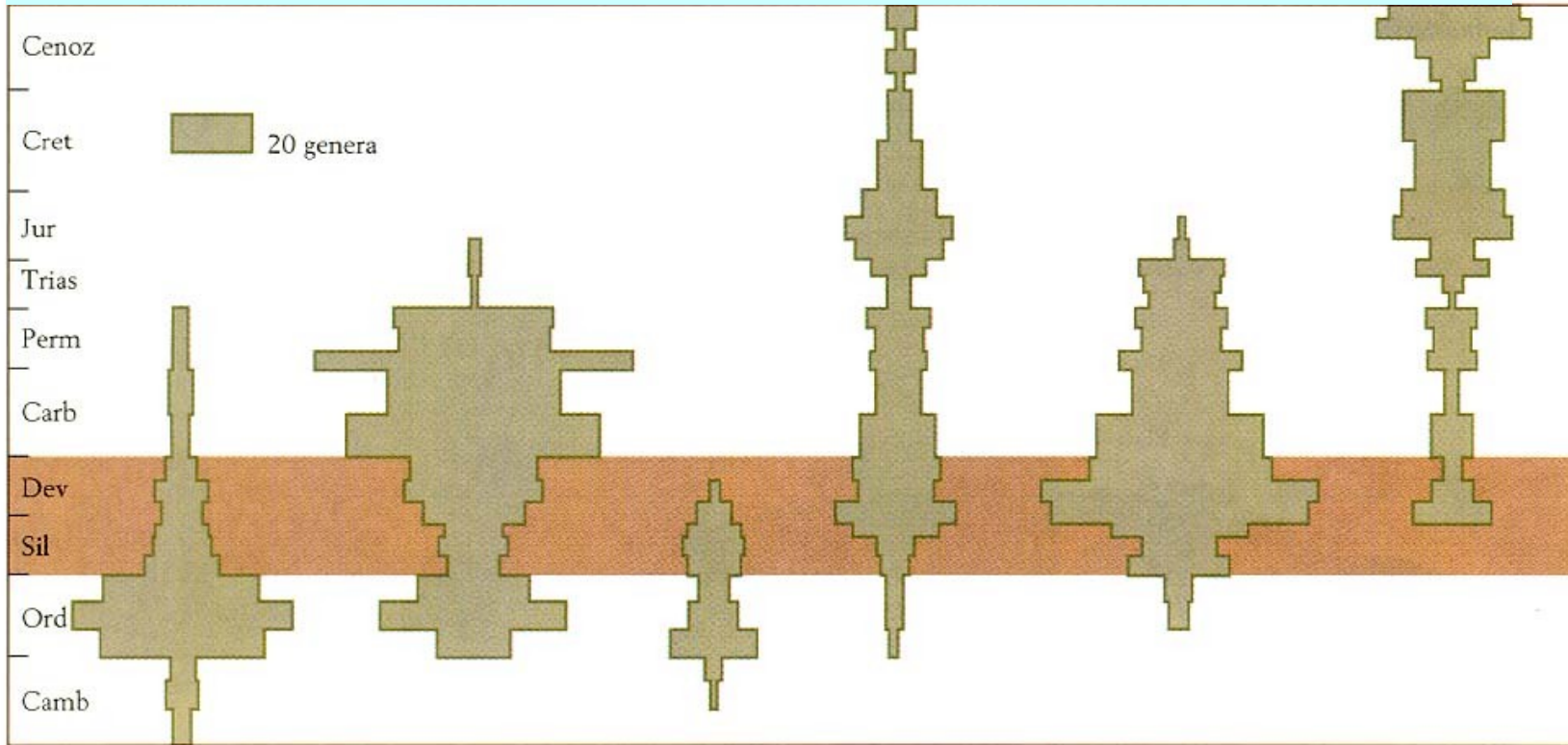


Opuková rotunda sv. Jiří na Řípu

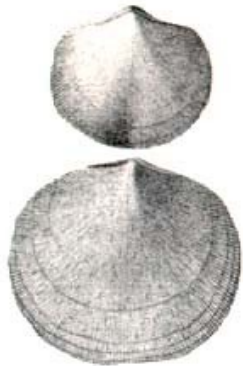
Gastropods – typical genus for Tethyan Realm **Nerinea**. In Cretaceous gastropods associations obtain **Caenozoic character**.

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 rock-forming role. In Cretaceous retreat.

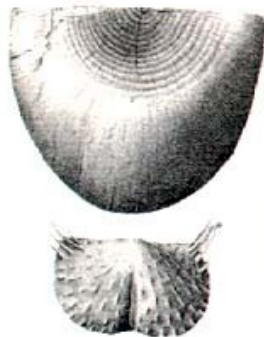
Brachiopods – Triassic small diversification, especially rynchonellids and terebratulids. Since Triassic retreat.



Orthida



Strophomenida



Pentamerida



Rynchonellida

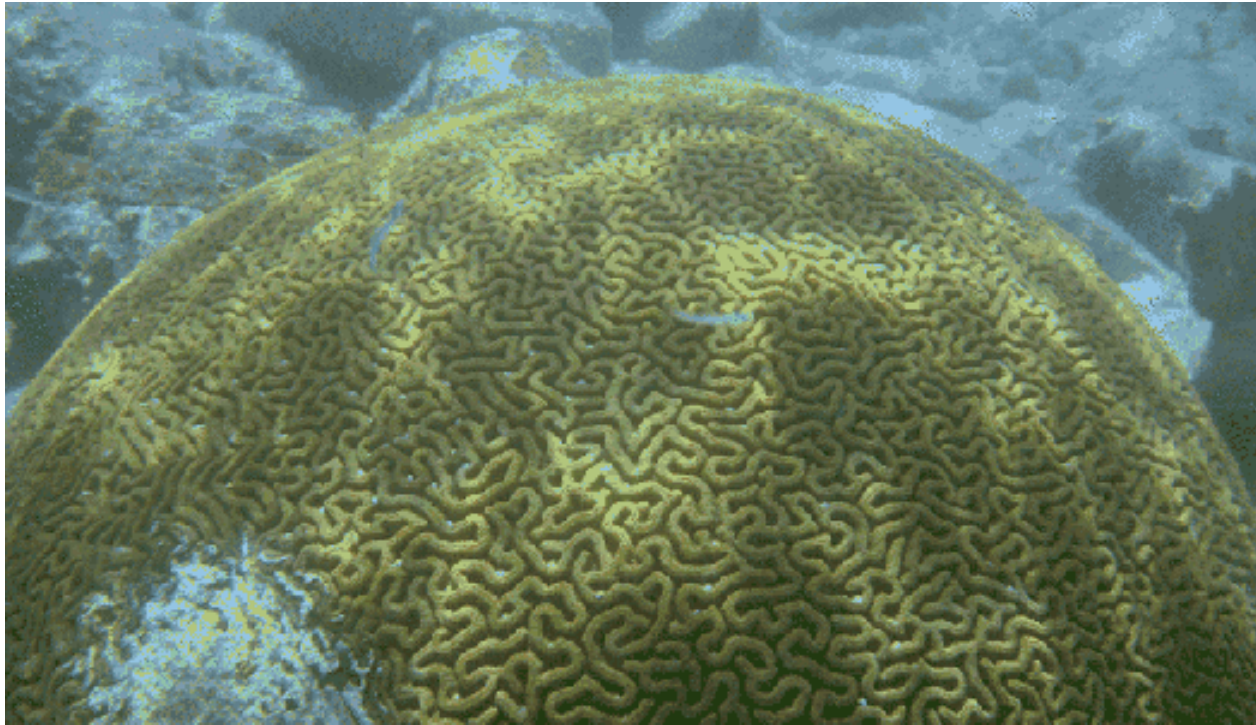


Spiriferida



Terebratulida

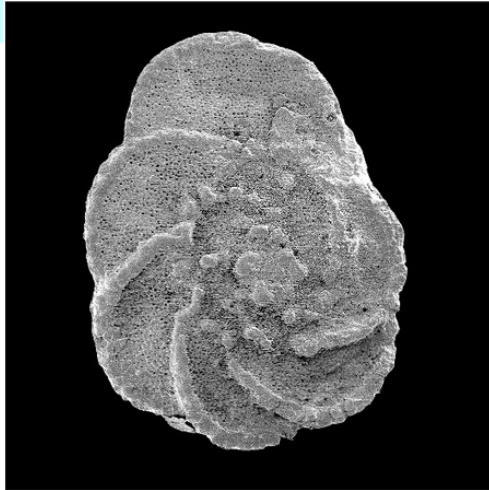




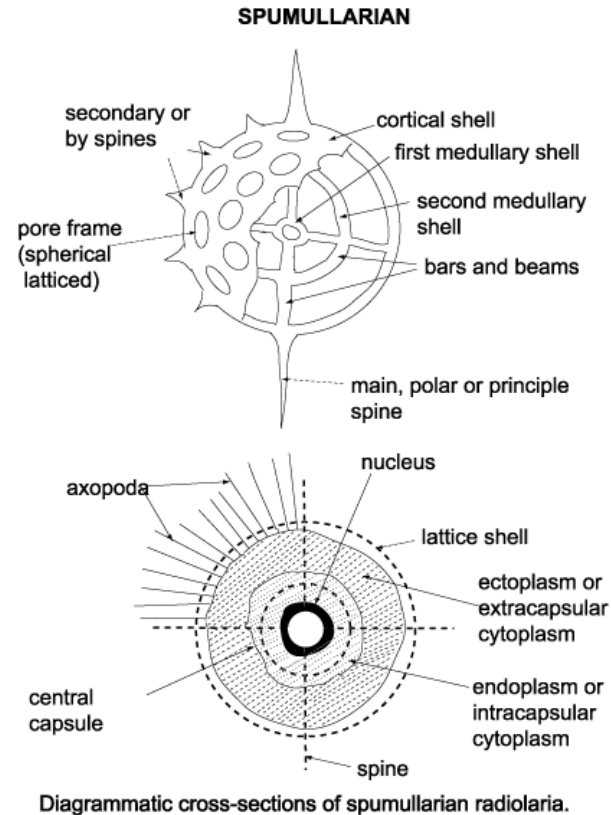
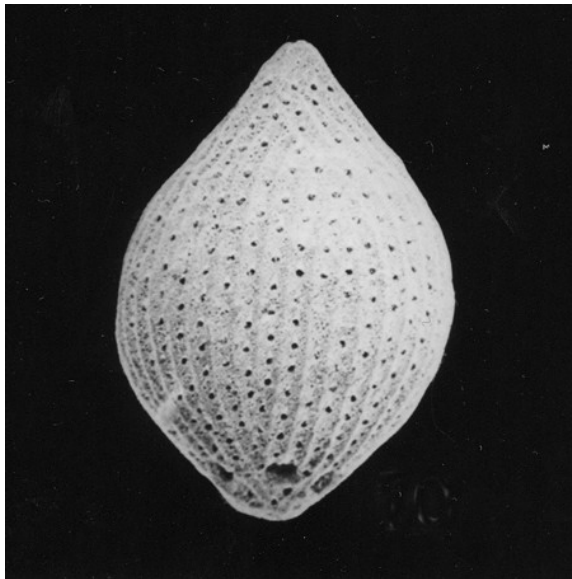
Scleractinian ("hard-rayed") corals first appeared in the **Middle Triassic** and refilled the ecological niche once held by tabulate and rugose corals. They are probably not closely related to the extinct tabulate or rugose corals, and probably arose independently from a sea anemone-like ancestor. Their 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.

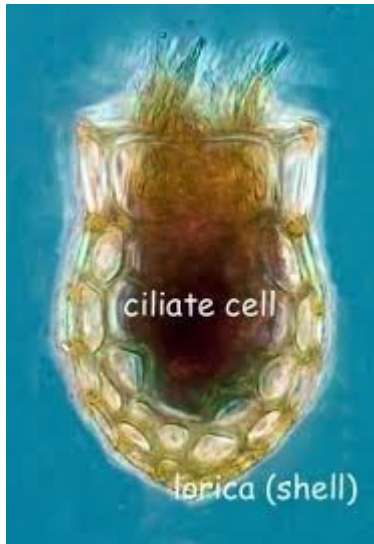
Globotruncana



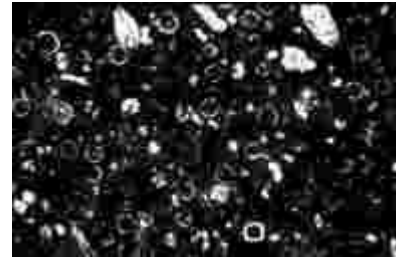
Radiolaria – expansion in Jurassic, Spumellaria.



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



Calpionella alpina



Calcari a Calpionelle in Val Graveglia

Arthropods

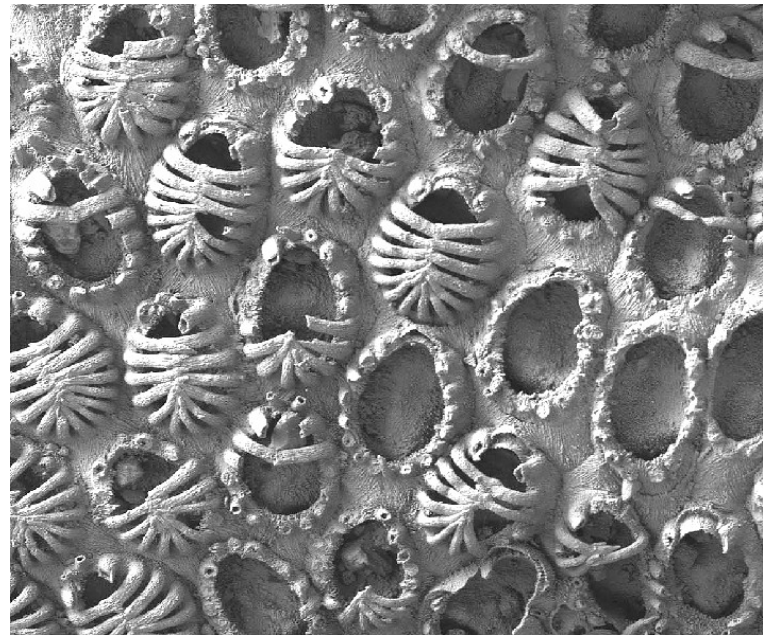
Malacostraca(rakovci) - Crabs, shrimps, lobsters, etc

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

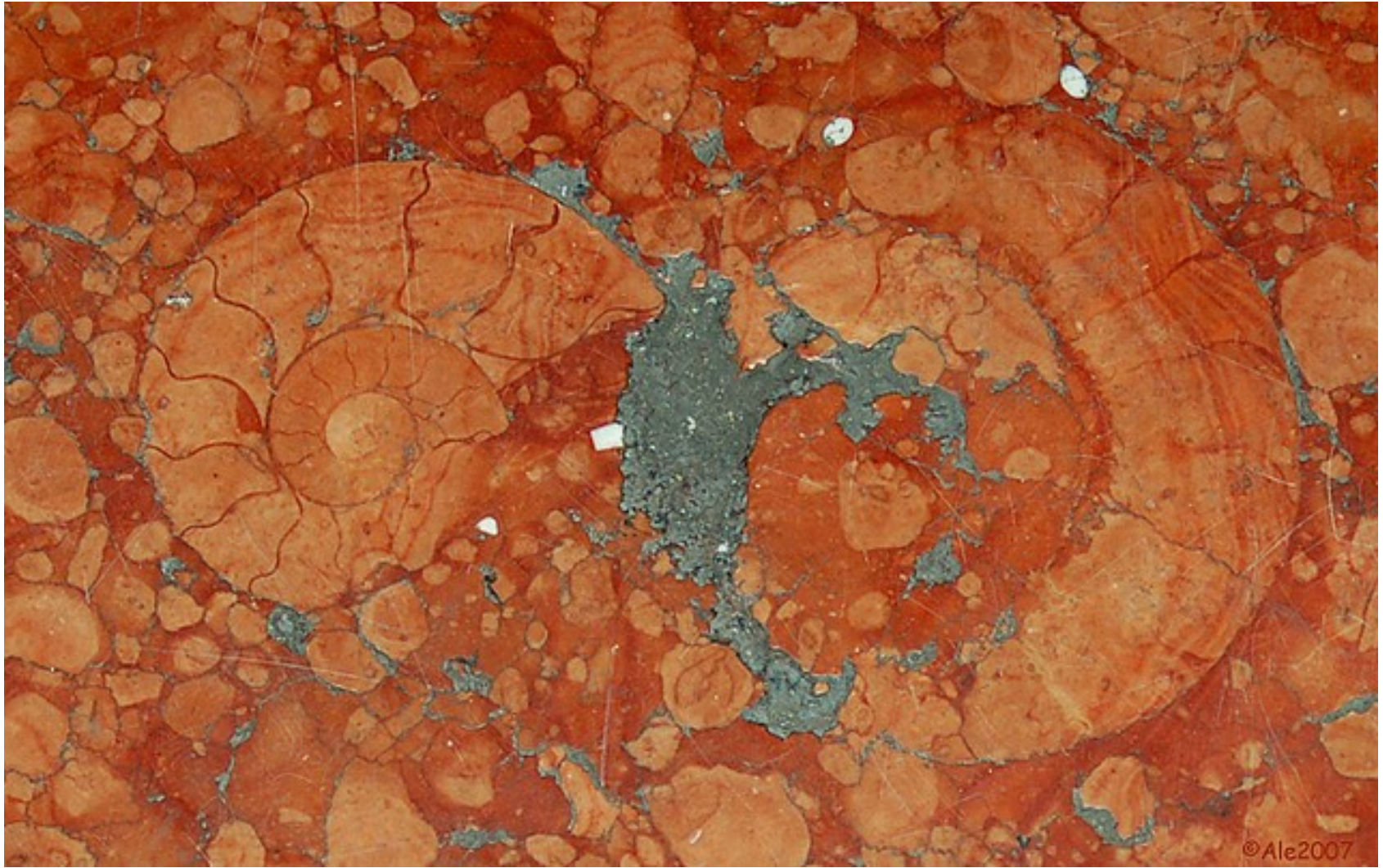


Ammonites

Nearly extinct 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

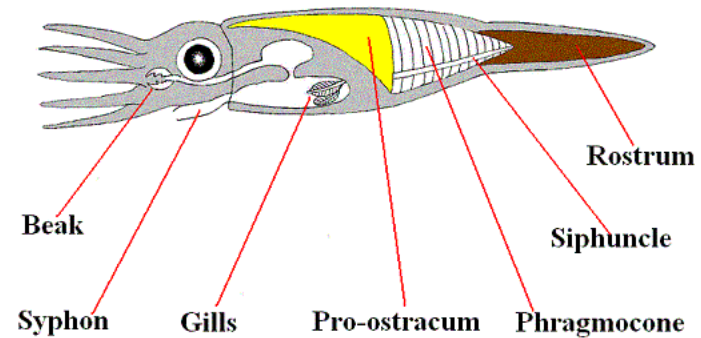
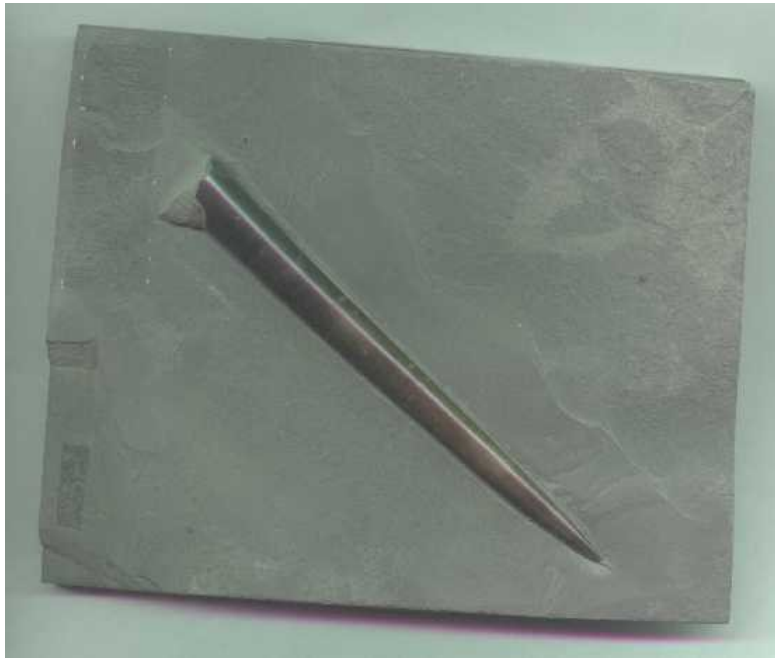




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Nautiloid cephalopods – retreat. End Triassic extinction of orthocers.

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



Belemnite Anatomy

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

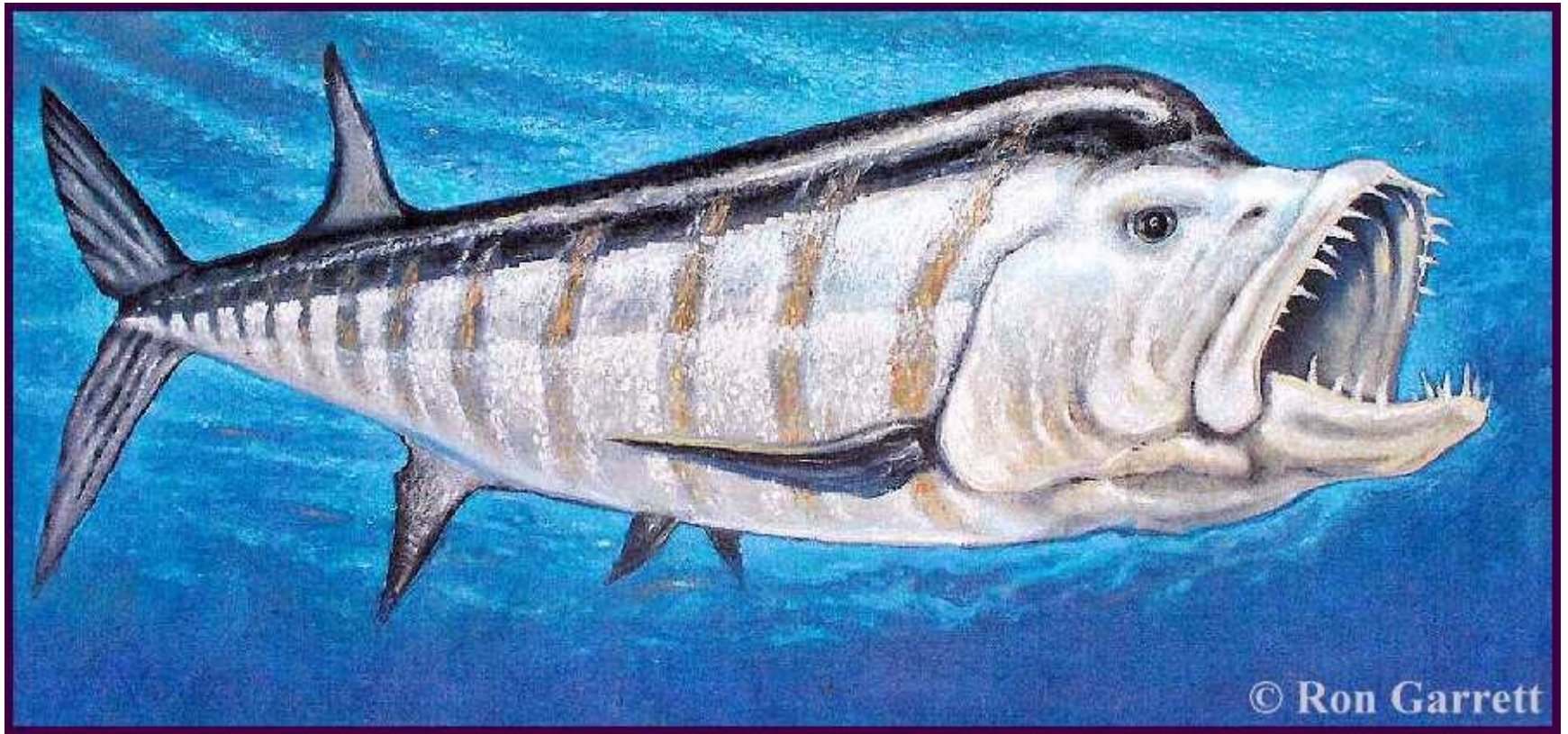
Chondrostei — dominant late Paleozoic fish group

Holostei- dominant in Triassic

Teleostei- dominant since Jurassic

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 (1 foot=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

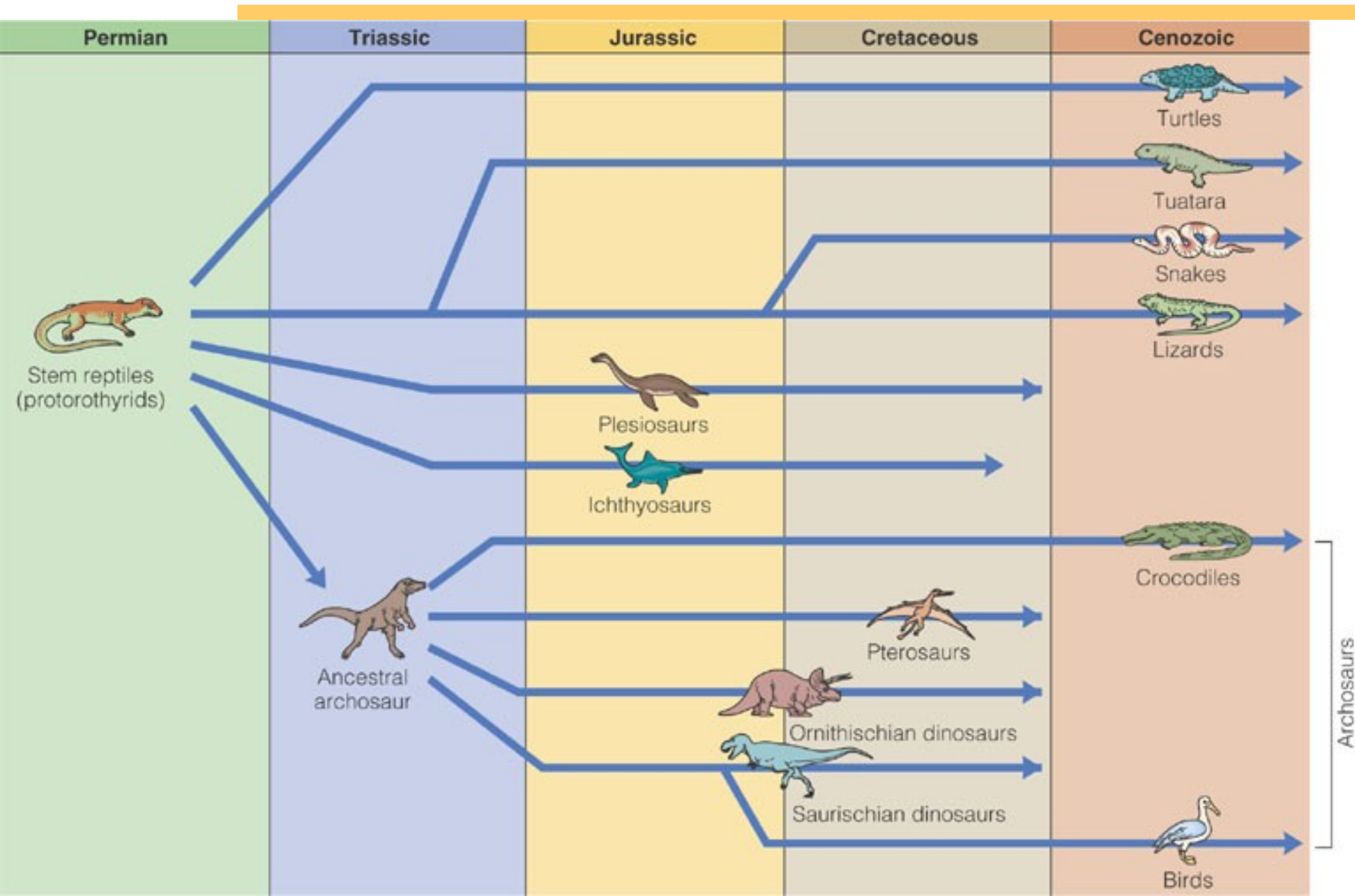
O. **Ornithischia**

O. **Crocodylia**

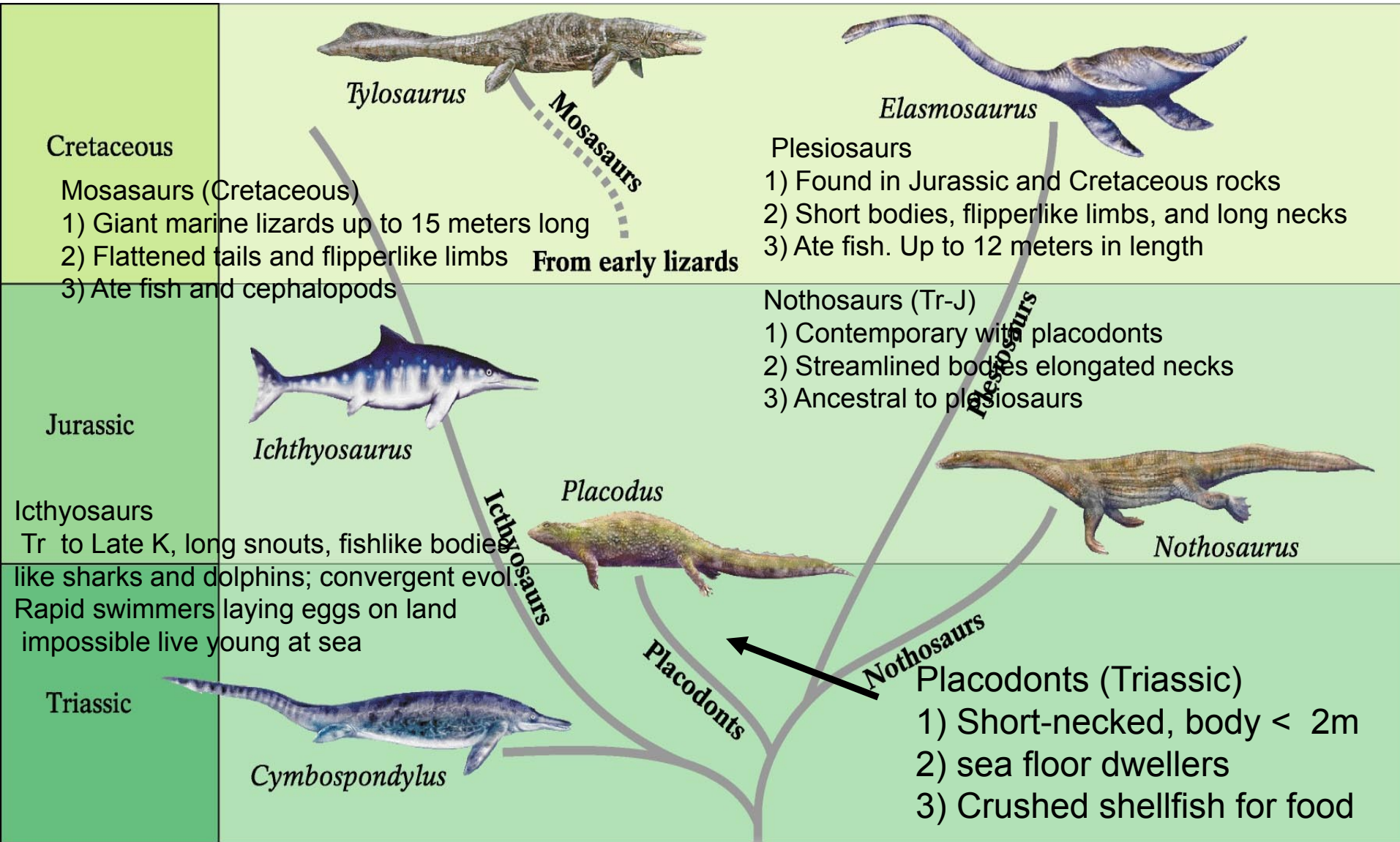
4 - **Euryapsida** - marine reptiles, includes the plesiosaurs & ichthyosaurs

Dinosauria

Reptiles and Birds

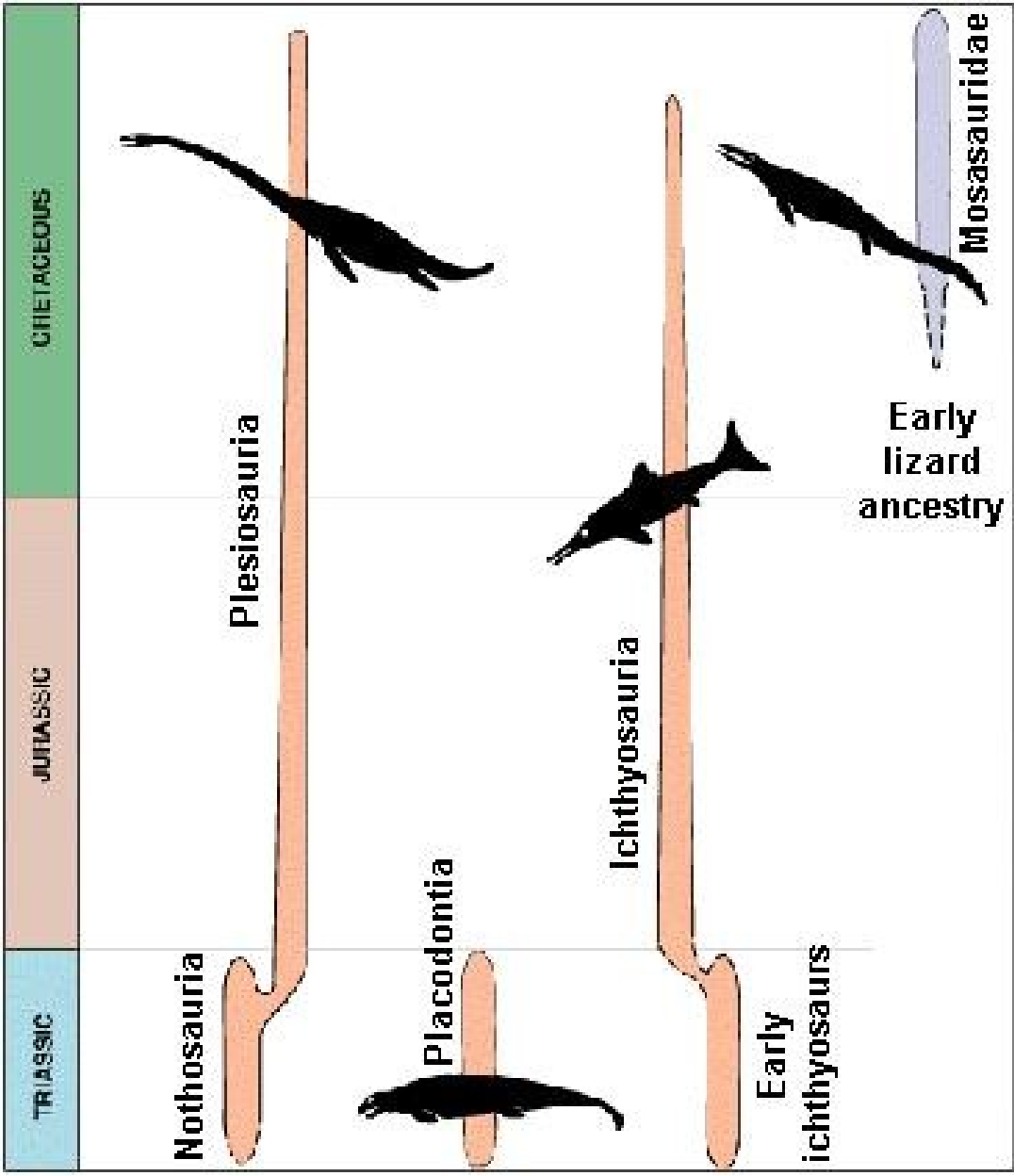


Euryapsid Marine reptiles



Plus Marine Crocodiles

From early diapsids

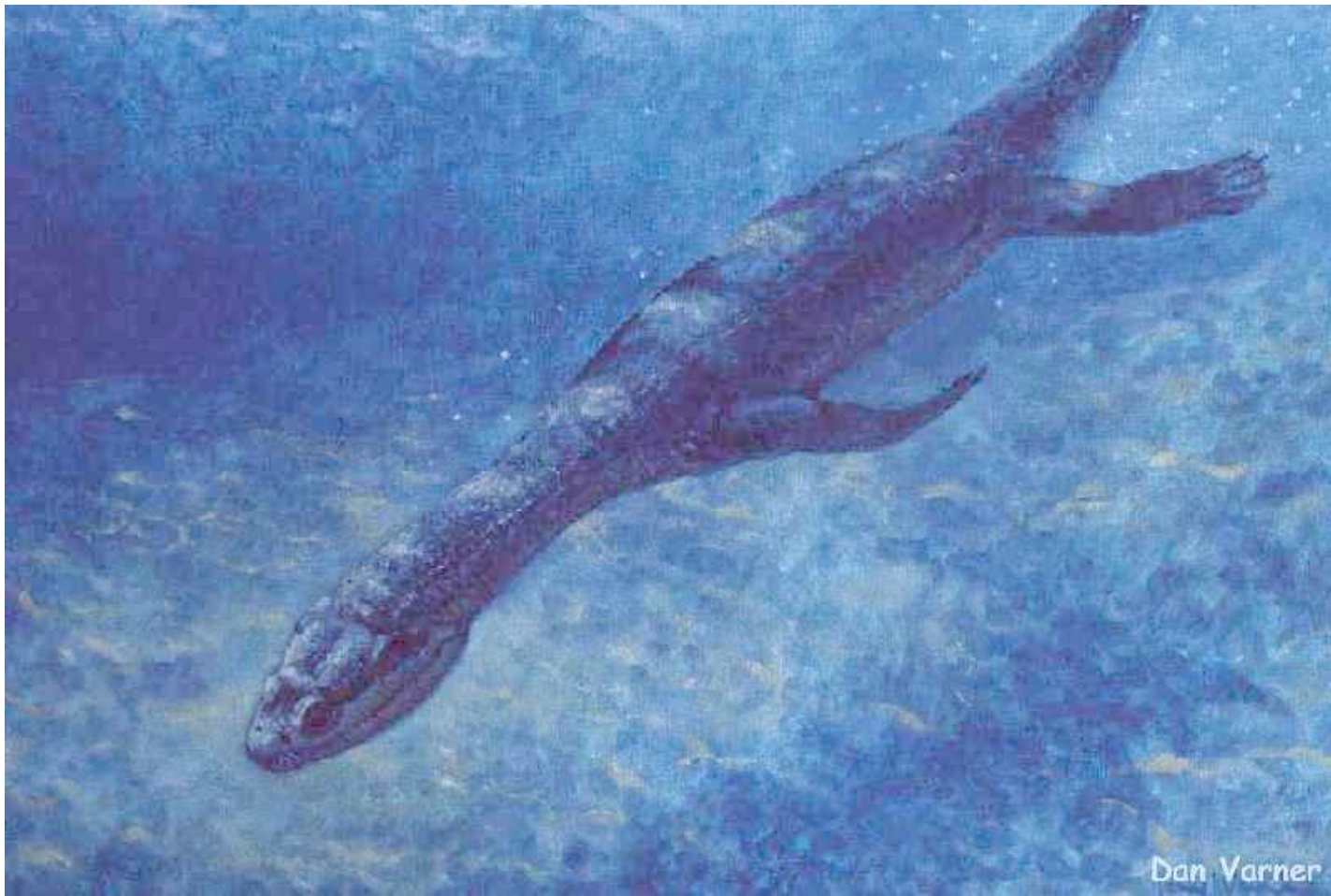


Euryapsids

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

Sauropterygia – Placodontia
Notosauria
Plesiosauria
Ichtyosauria

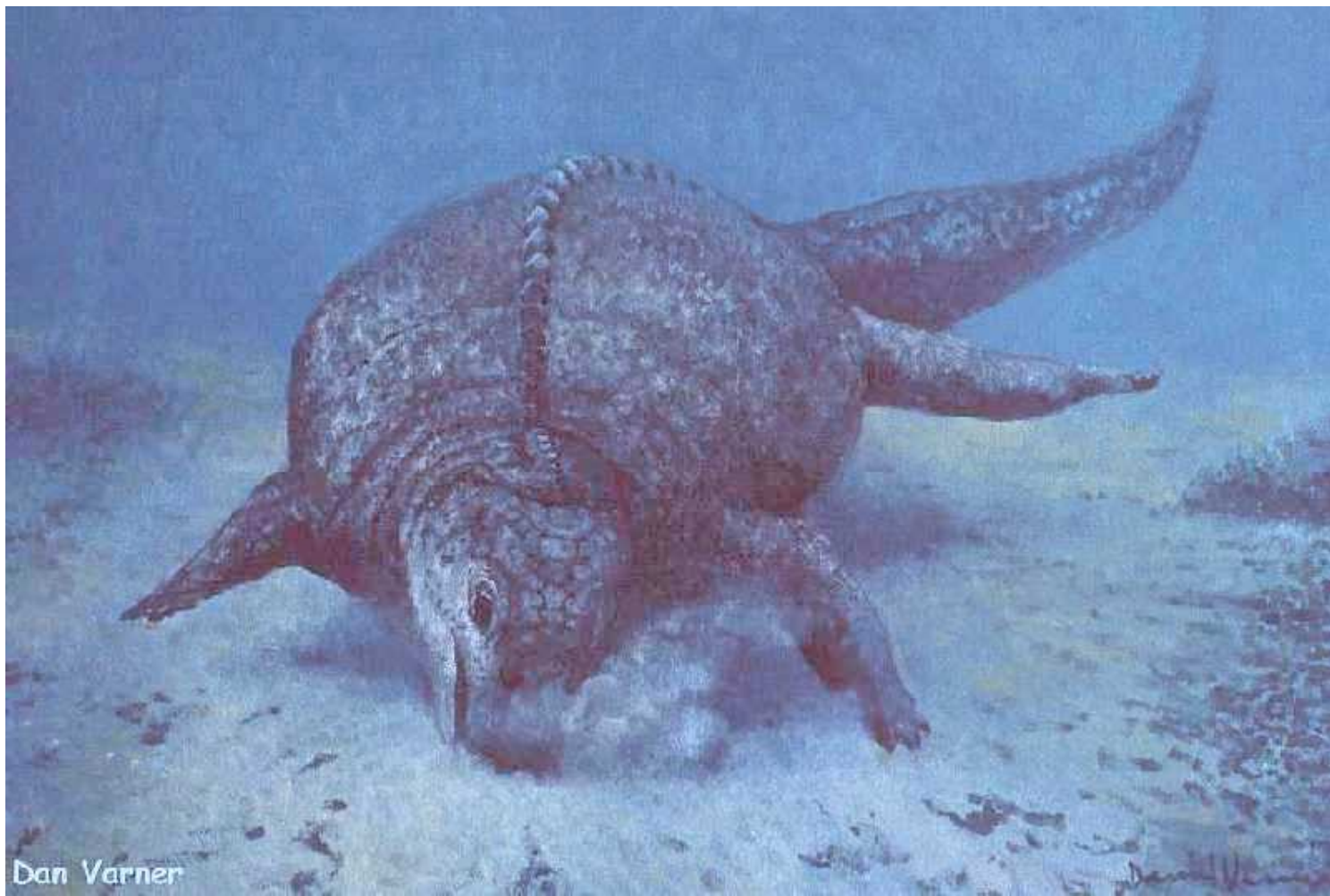
Ichthyosaurs and plesiosaurs had inhabited the oceans since the **Triassic**, evolving into many diverse forms and surviving several major extinction events. For unknown reasons, ichthyosaurs declined significantly in early Cretaceous and are thought to have been extinct by the time that the earliest **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* (10m). 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.



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



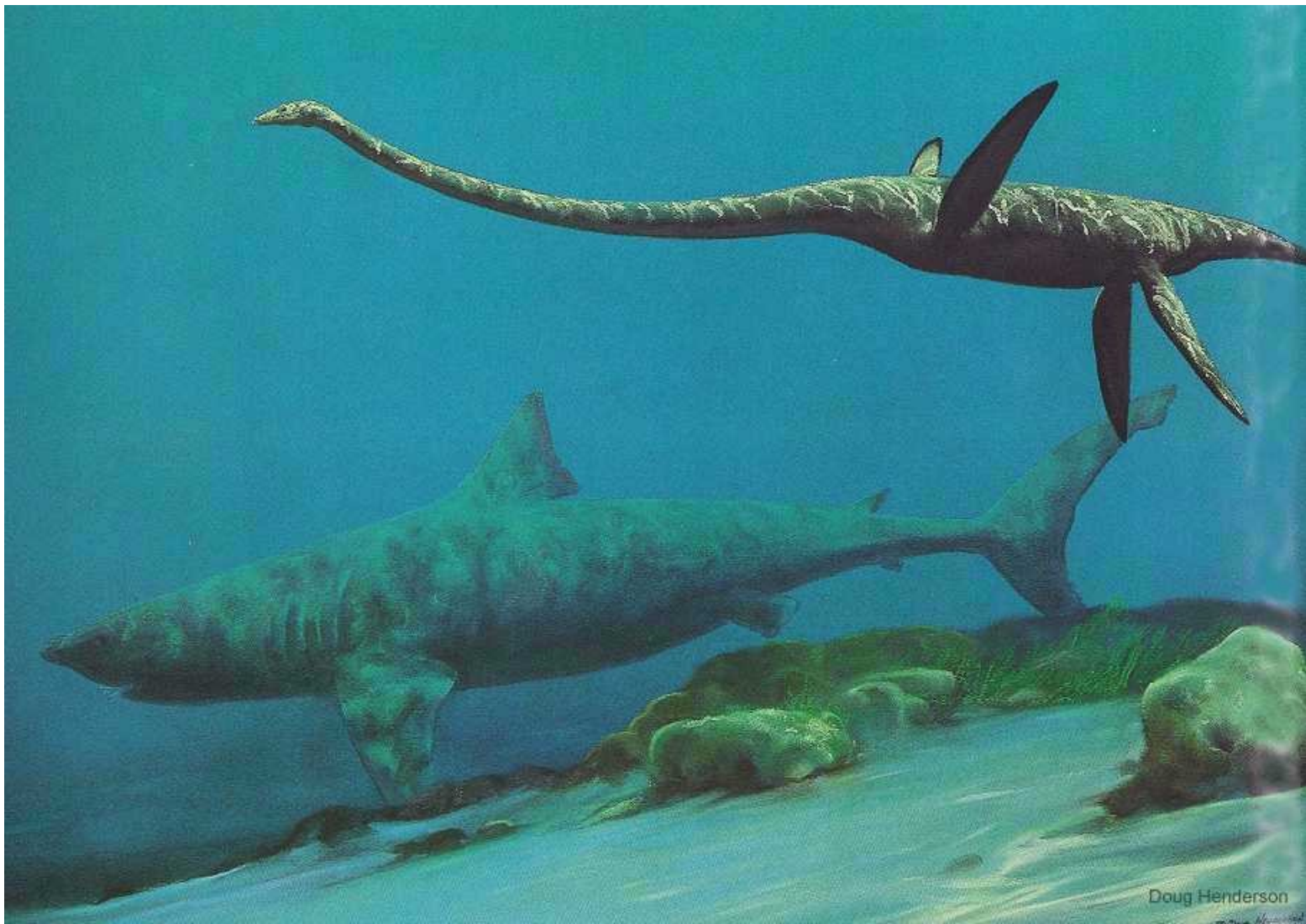
Triassic – notosaur and placodont



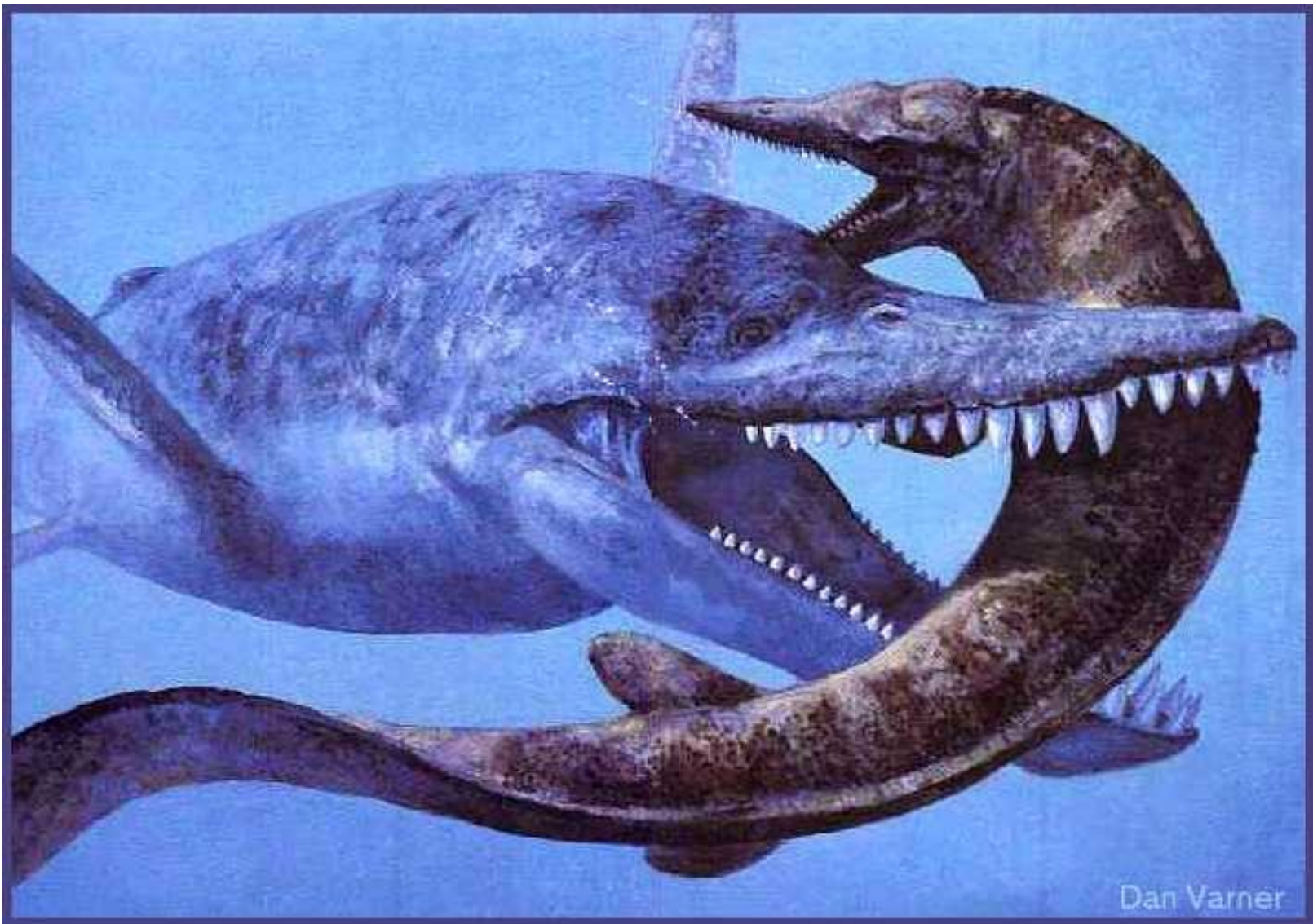
***Placodus*, a placodont from the early to middle Triassic of Europe grubs for clams and other shellfish in the mud of a near-shore sea bottom. While placodonts fed in the ocean, they probably spent a large portion of their lives on land**

- **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.

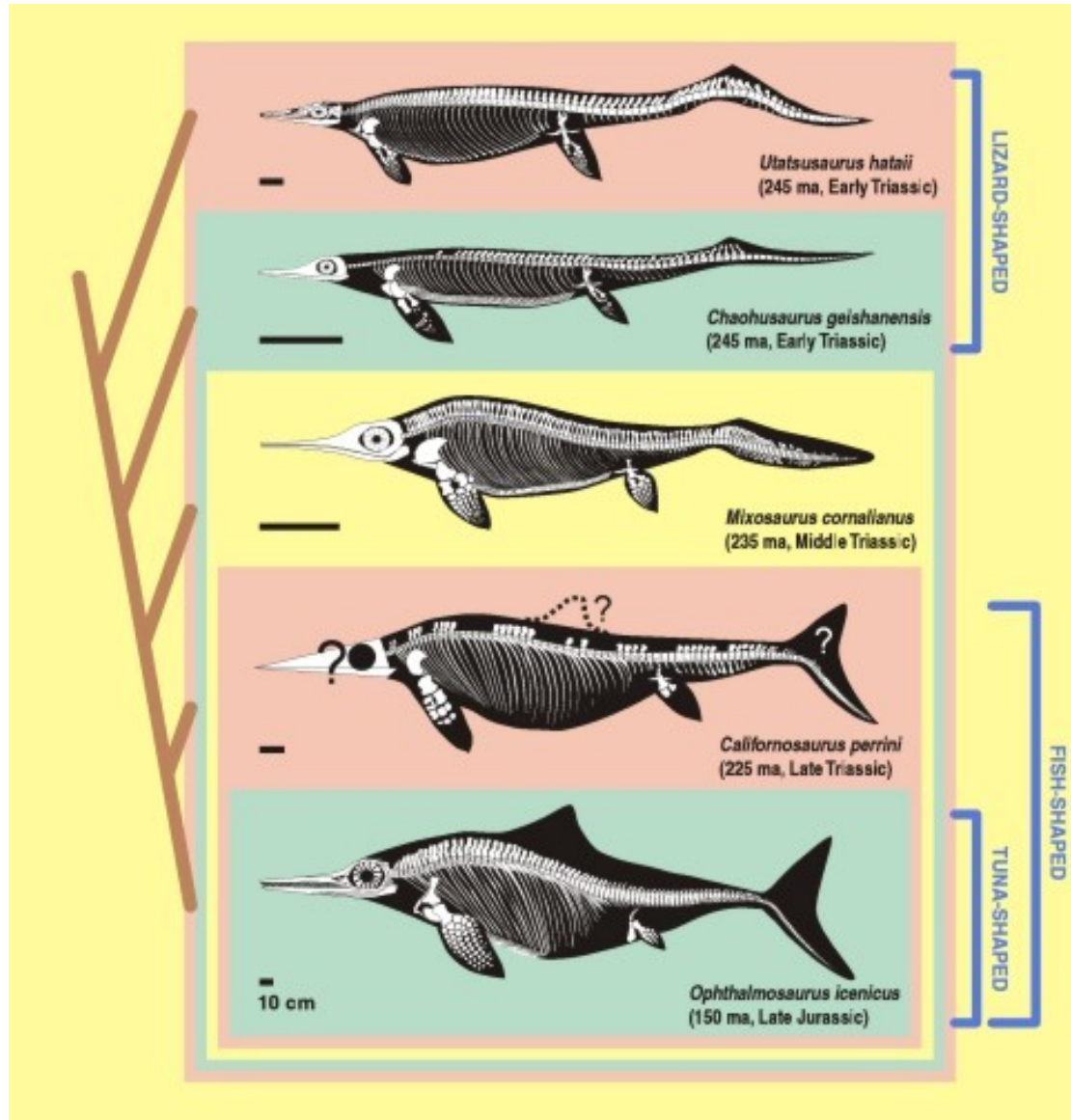


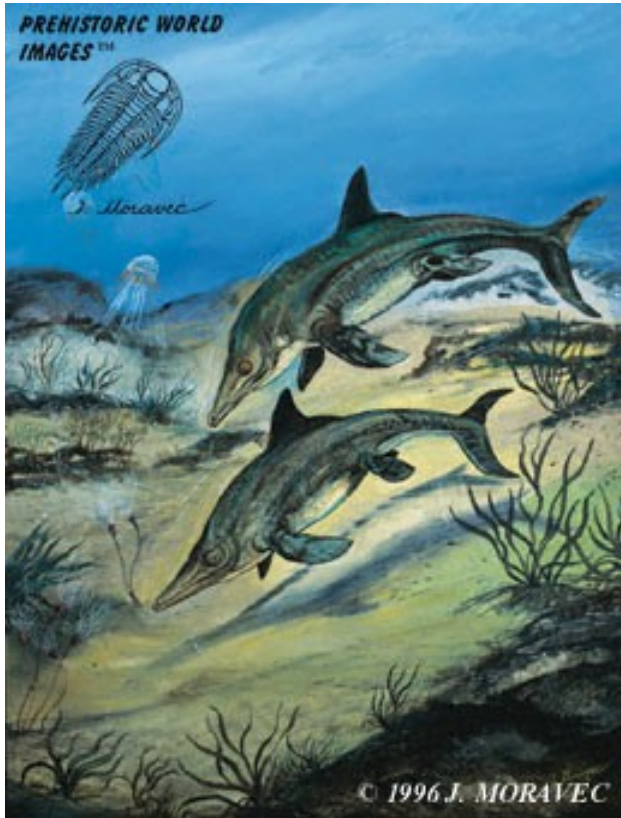
This picture shows what happens when the hunter becomes the hunted; a giant pliosaur Kronosaurus attacks a juvenile mosasaur. Even though mosasaurs were top predators, their young were often preyed upon by sharks, large fish, pliosaurs and even other species of mosasaurs. Life could be short for the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

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



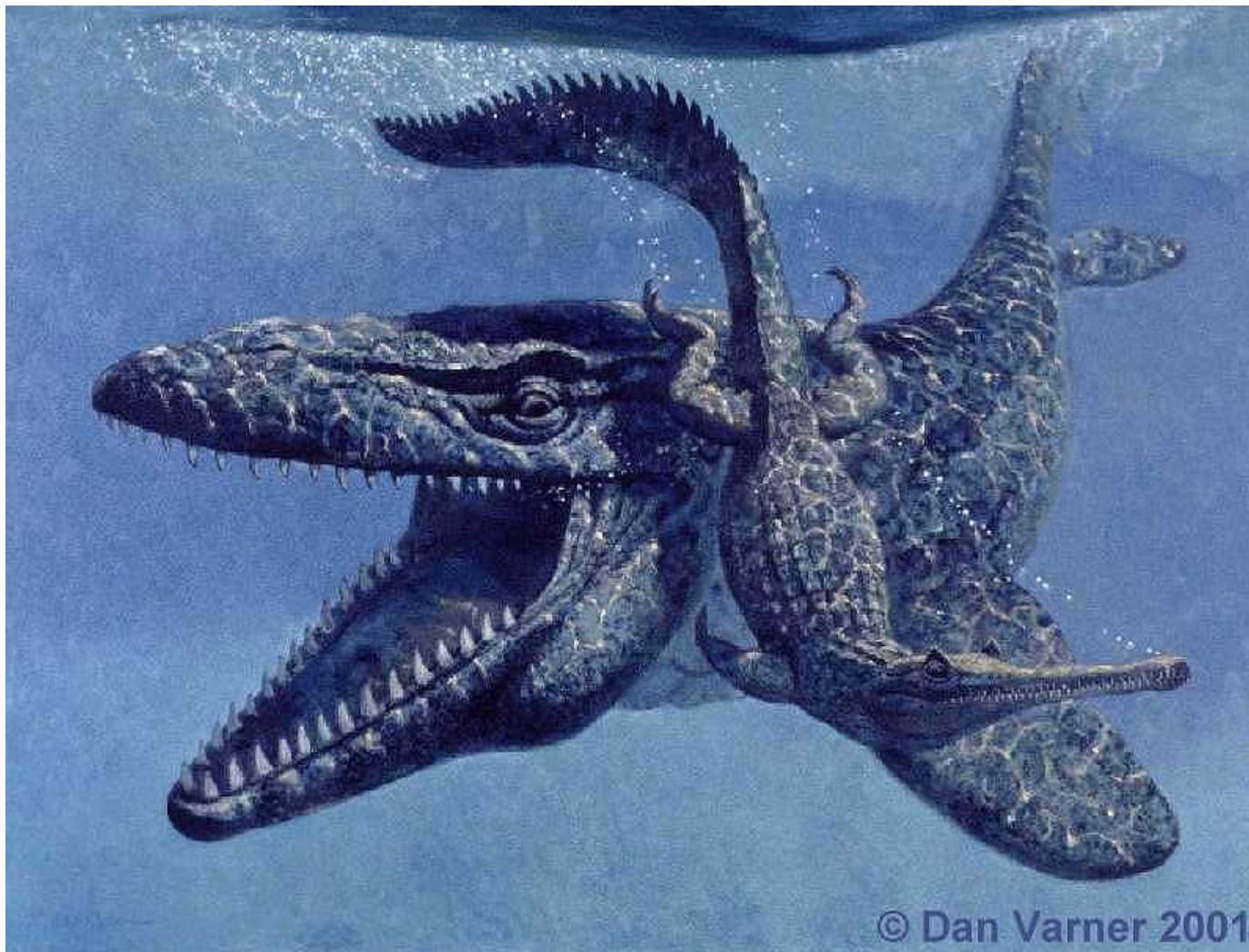
Ichthyosaurs diversified very quickly once they appeared. Several different body plans emerged in the Early and Middle **Triassic**. But, if you simplify the matter, you can see that there was a general transition from lizard-shaped body plan to fish-shaped one through the evolution of ichthyosaurs,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



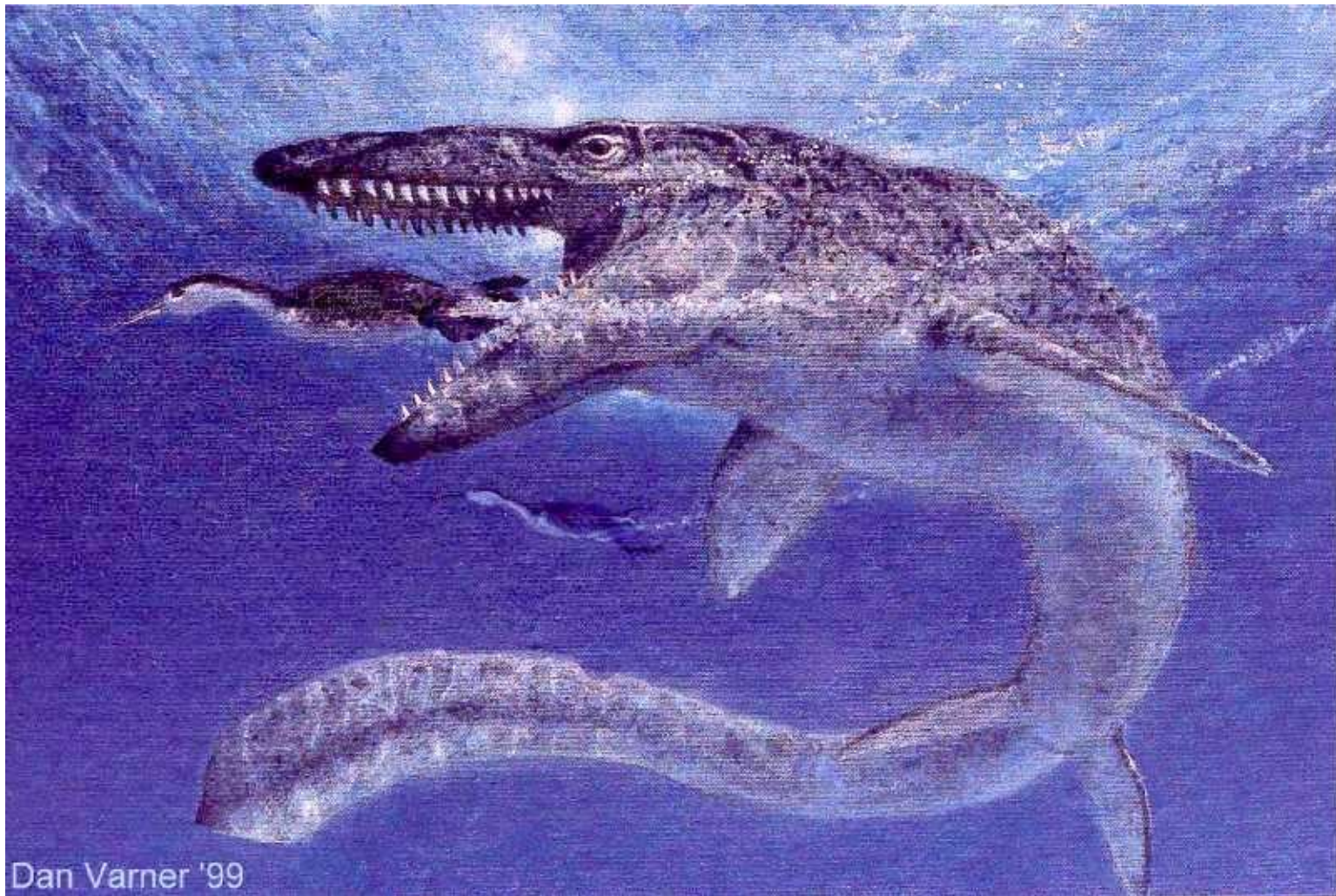


Mosasaur - Cretaceous

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.**



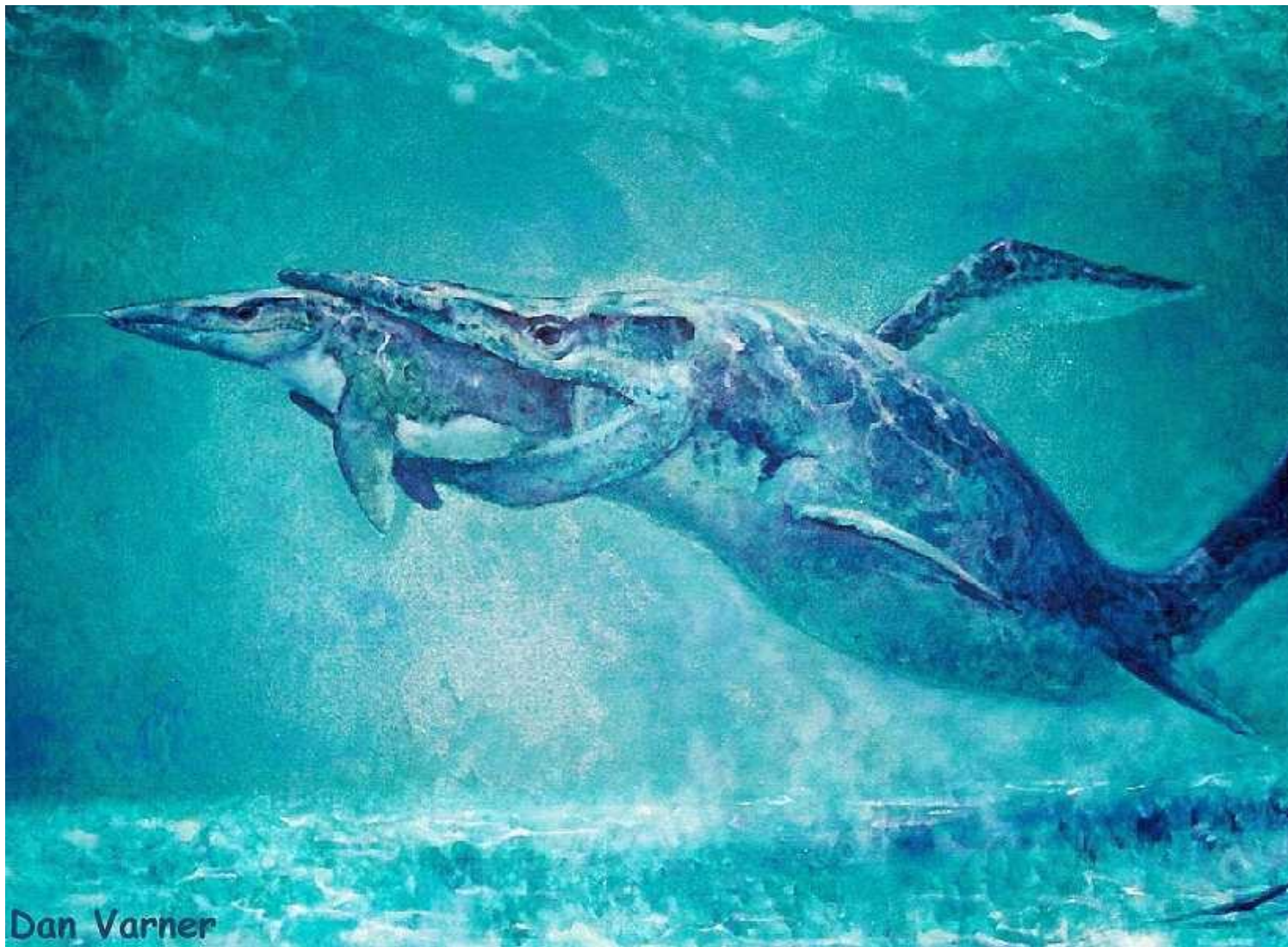
Here a *Mosasaurus hoffmanni* just misses the mark in an attack on the marine crocodile, *Thoracosaurus*,



the little swimming birds (*Hesperornis*) are about 5 feet long and the *Tylosaurus* ... well, it's huge. Modeled after the largest specimen on exhibit (The Bunker Tylosaur), 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.

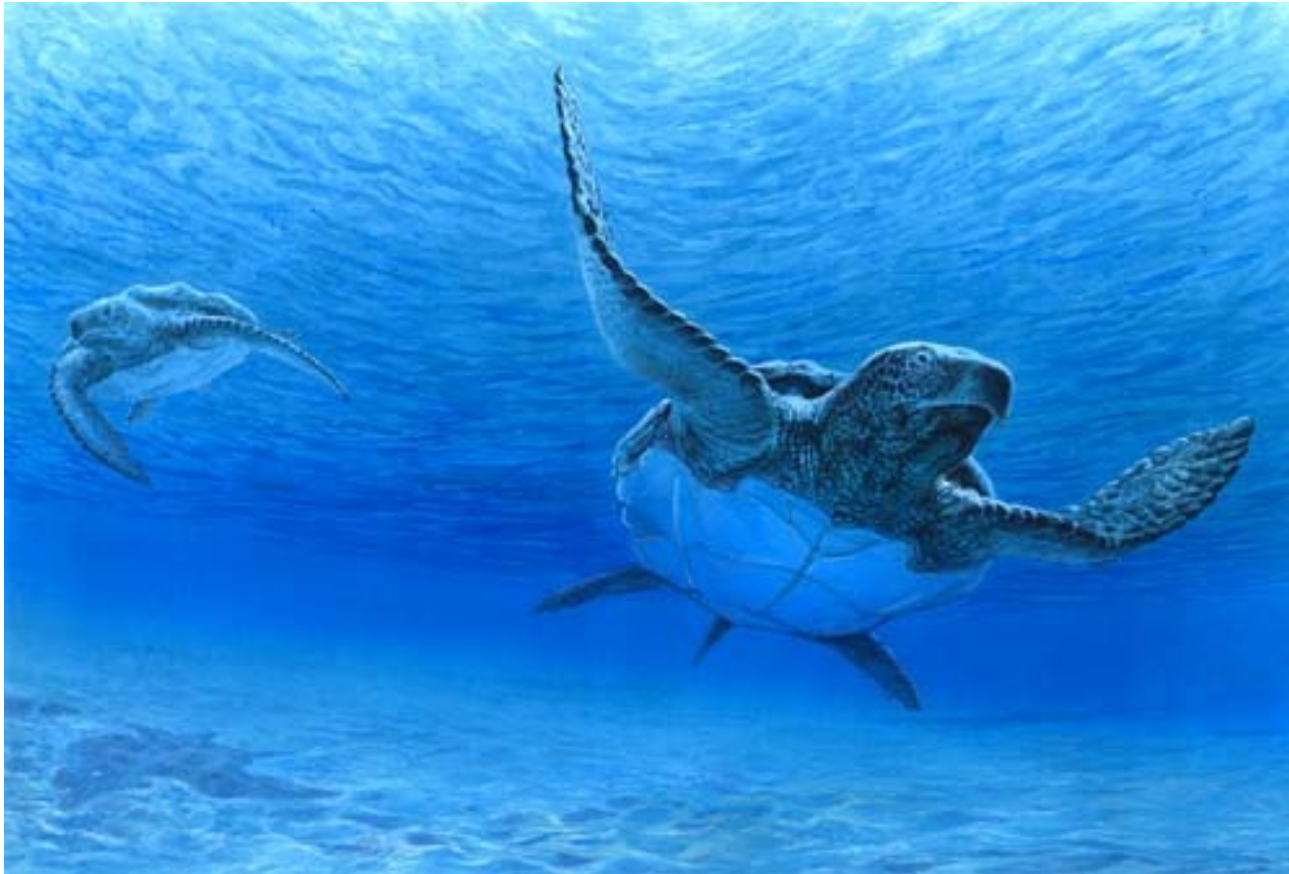


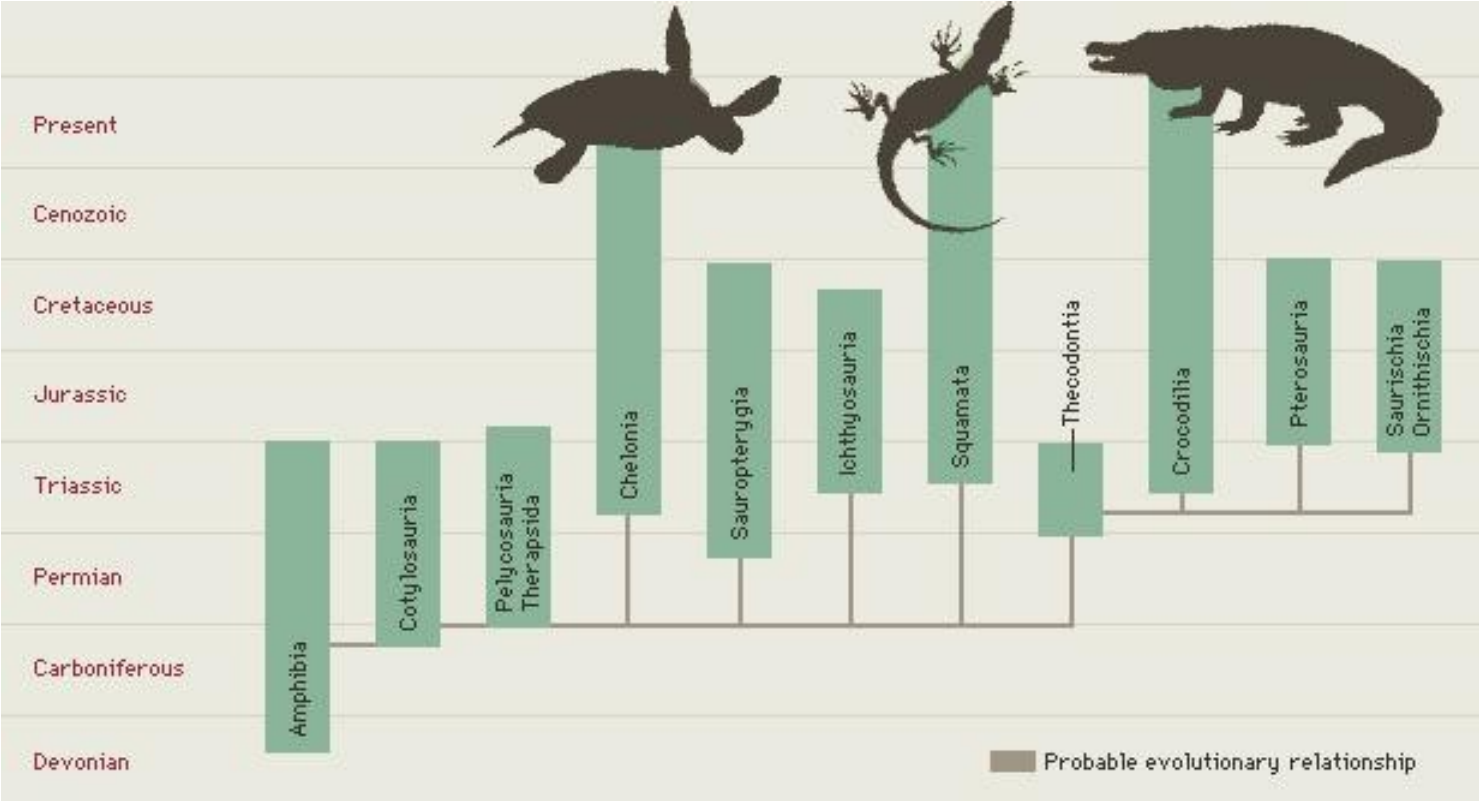
Here a large *Tylosaurus* is about to make lunch of a smaller mosasaur called *Halisaurus sternbergi*. Like their modern relatives, the snakes, mosasaurs were capable of swallowing large prey whole because of the unique design of their skull and very flexible lower jaws.

Land Reptiles

Cotylosaurs – end Triassic extinction

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





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. **Crocodylia**

4 - Euryapsida - marine reptiles, includes the plesiosaurs & ichthyosaurs

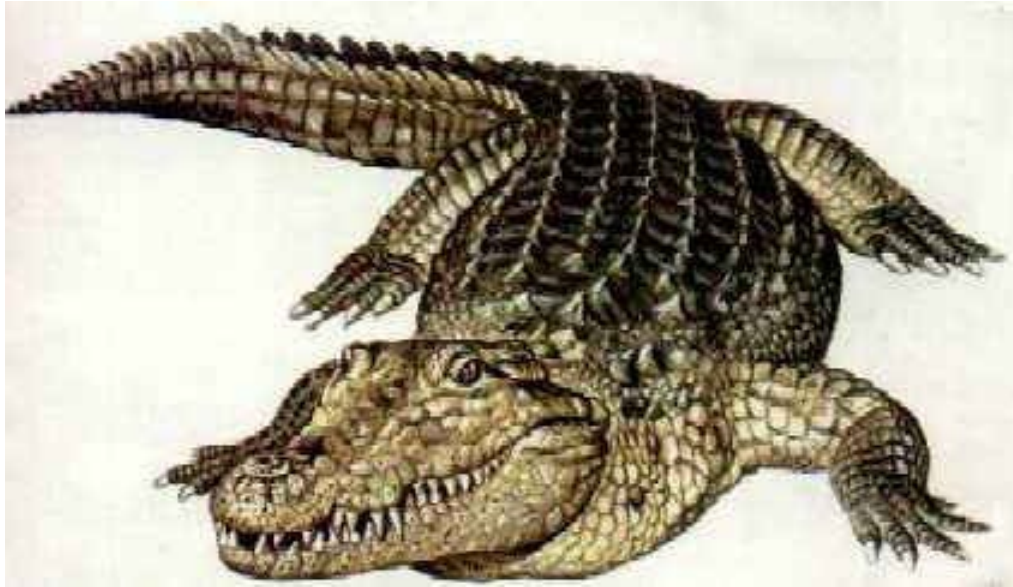
Lepidosaurs – radiation at the beginning of Triassic, Small lizard-like reptiles. Predecessors of thecodonts (Permian) and **Squamata** (Triassic)

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

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

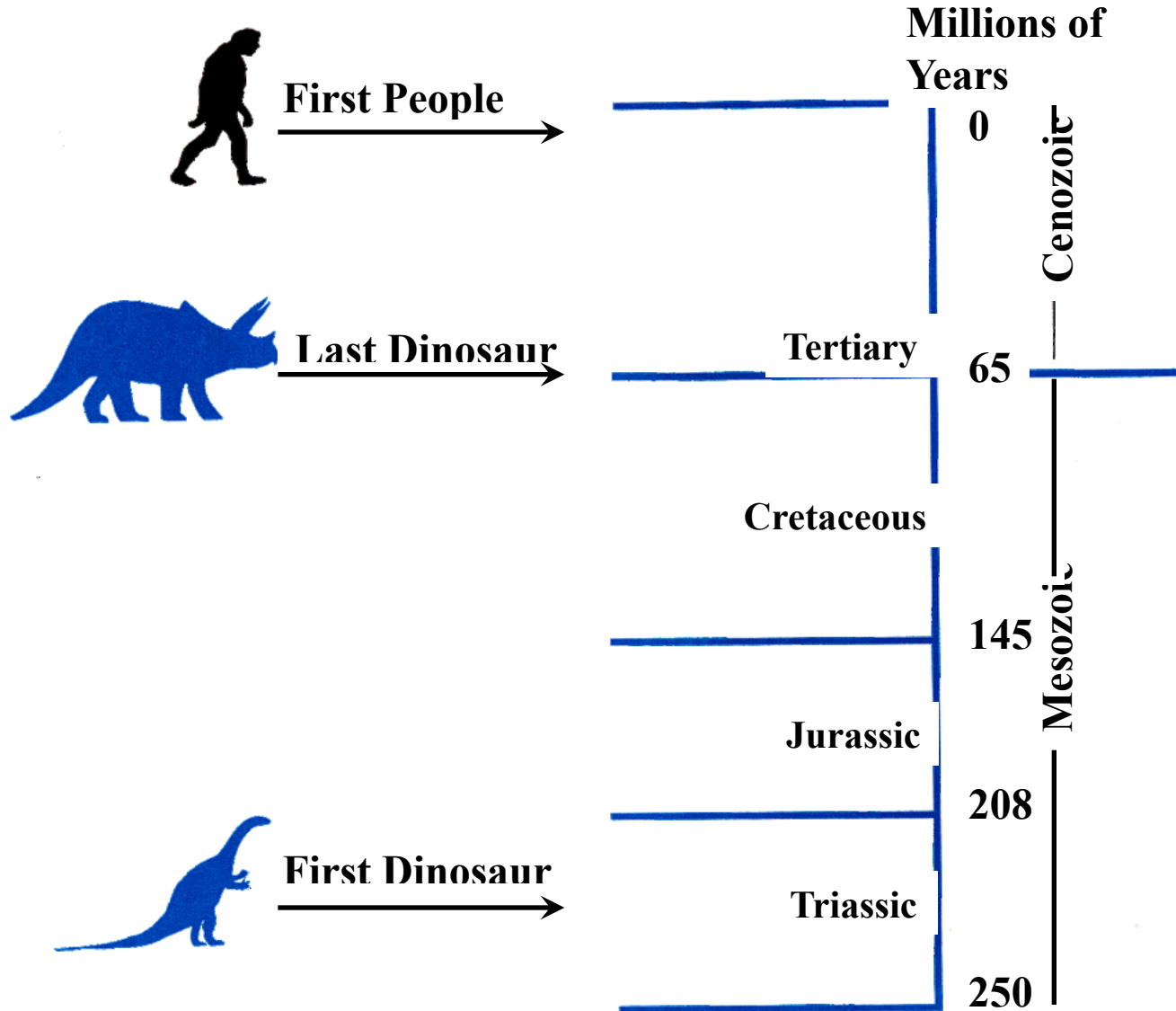


An early and very 'fish-like' crocodile (*Geosaurus*) swims in the shallow seas covering Germany in the Middle to Late **Jurassic**. Although not closely related to the ichthyosaurs, the tails of member of the Metriorhynch family were adapted for swimming in the same way, even to the noticeable down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



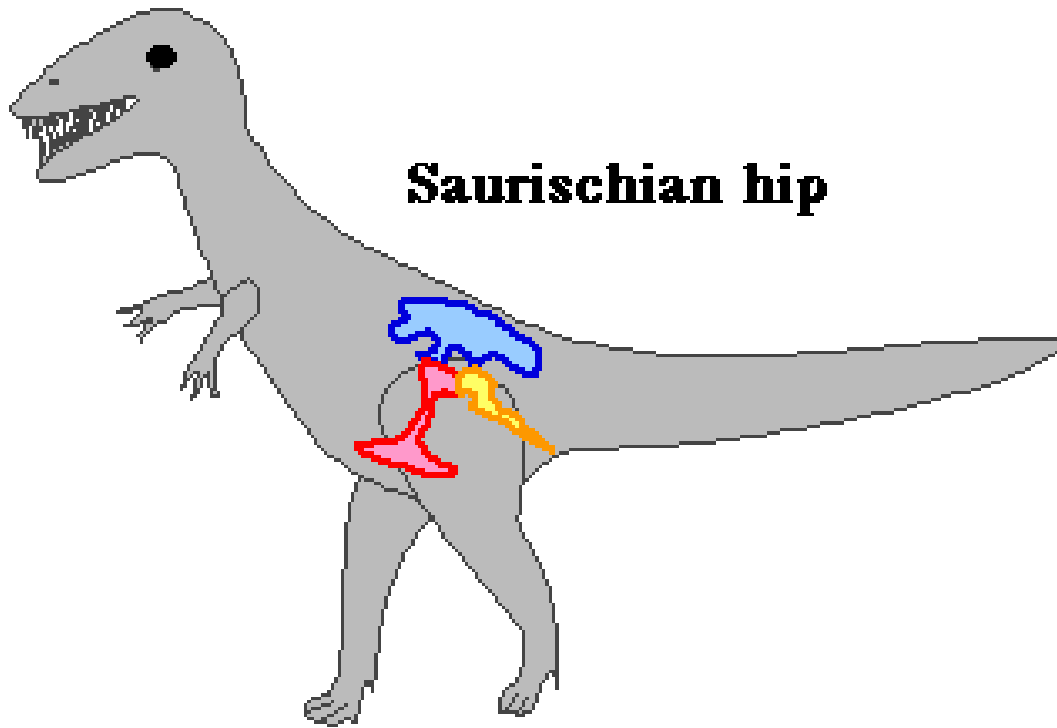
Phobosuchus

When did dinosaurs live?

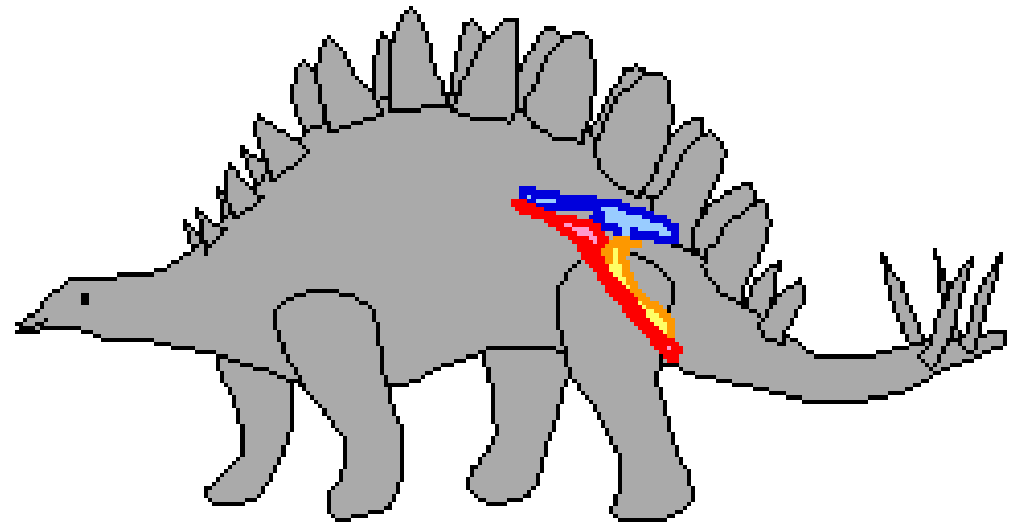


What are dinosaurs?

- Suborders
 - Saurischia – lizard hips
 - Ornithischia – bird hips

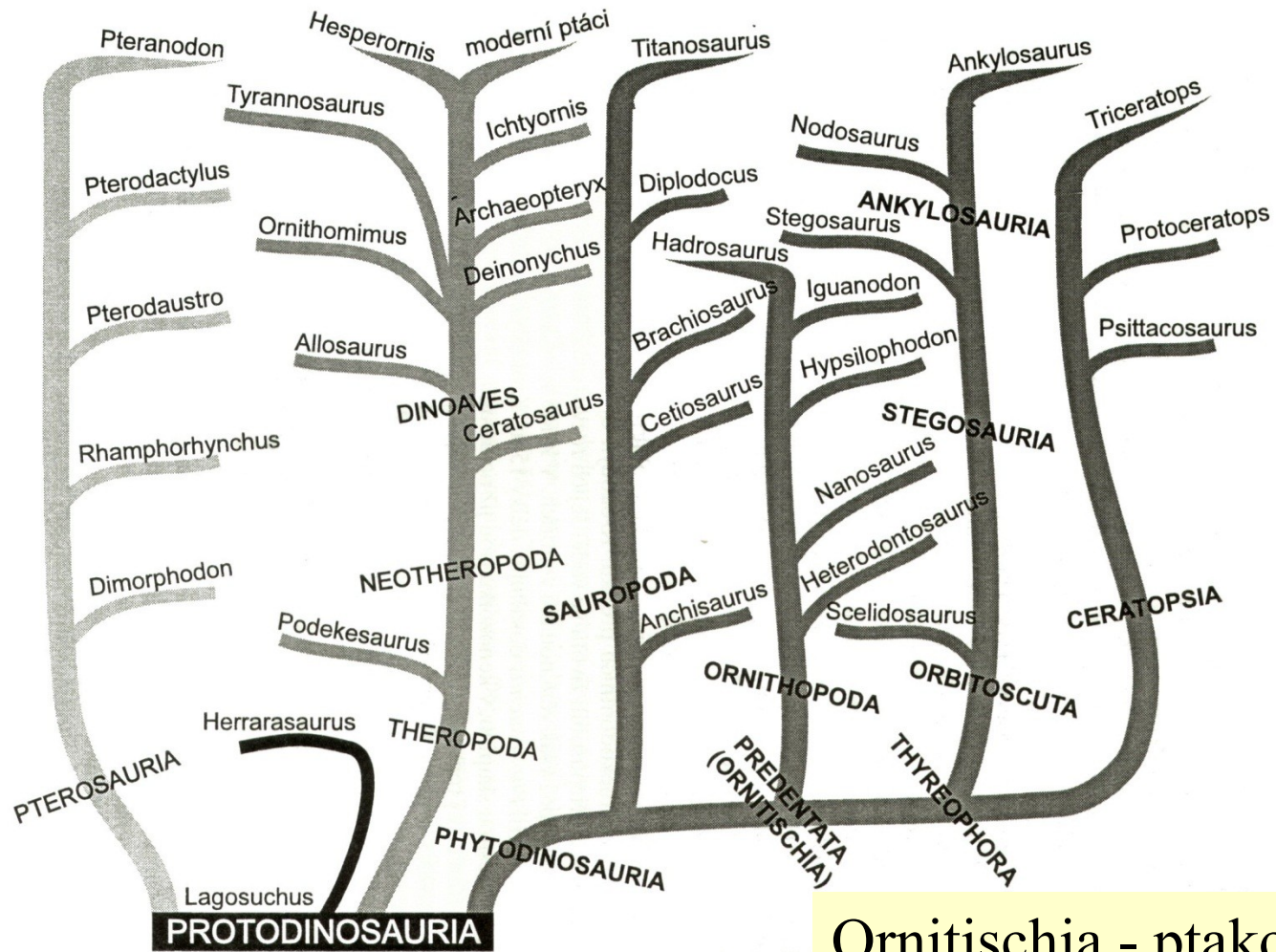


Saurischian hip



Ornithischian hip

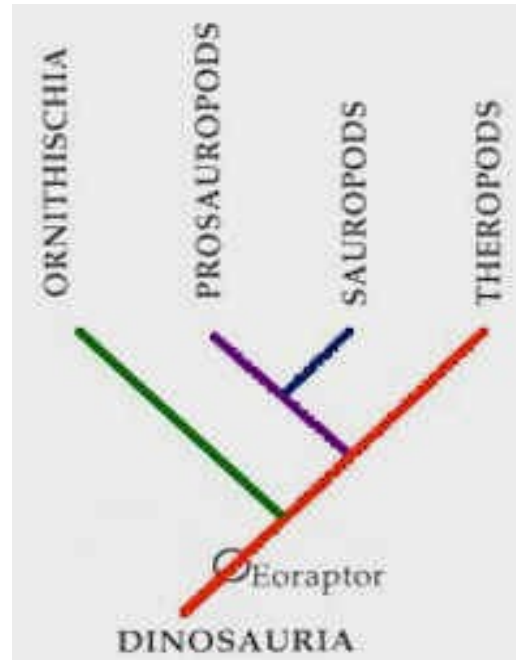
Saurischia-plazopánví



Ornithischia - ptakopánví

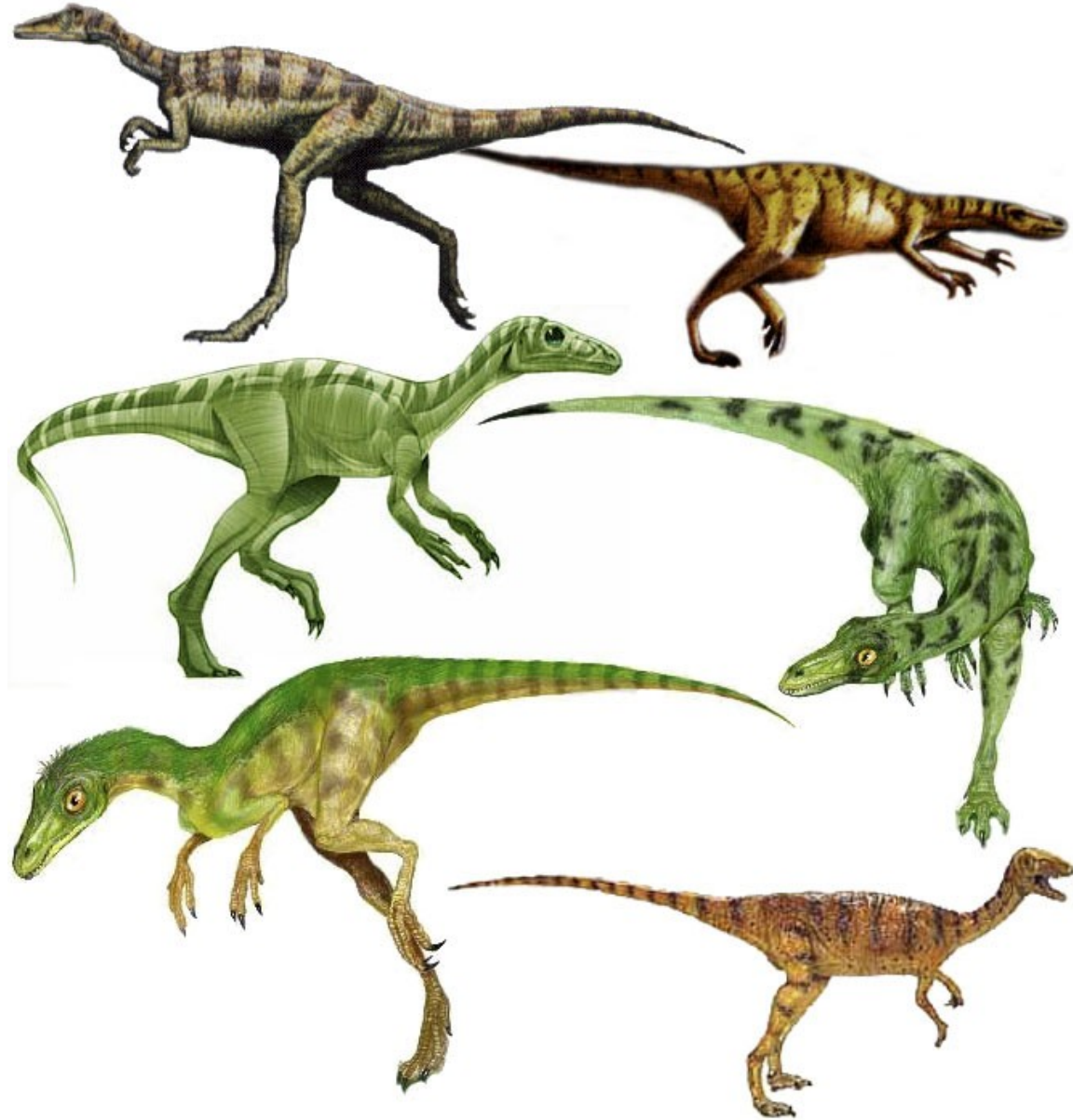
Obr. 71. Schematické znázornění evoluce dinosaurů (zjednodušeno podle Bakker, 1986).

Saurischia



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



Velociraptor (Jurassic Park)



Scientific Name: *Velociraptor*
Phylum: Chordata
Class: Dinosauria
Theropoda



Deinonychus



Both
Sides
Shown



Troodon



Archaeopteryx



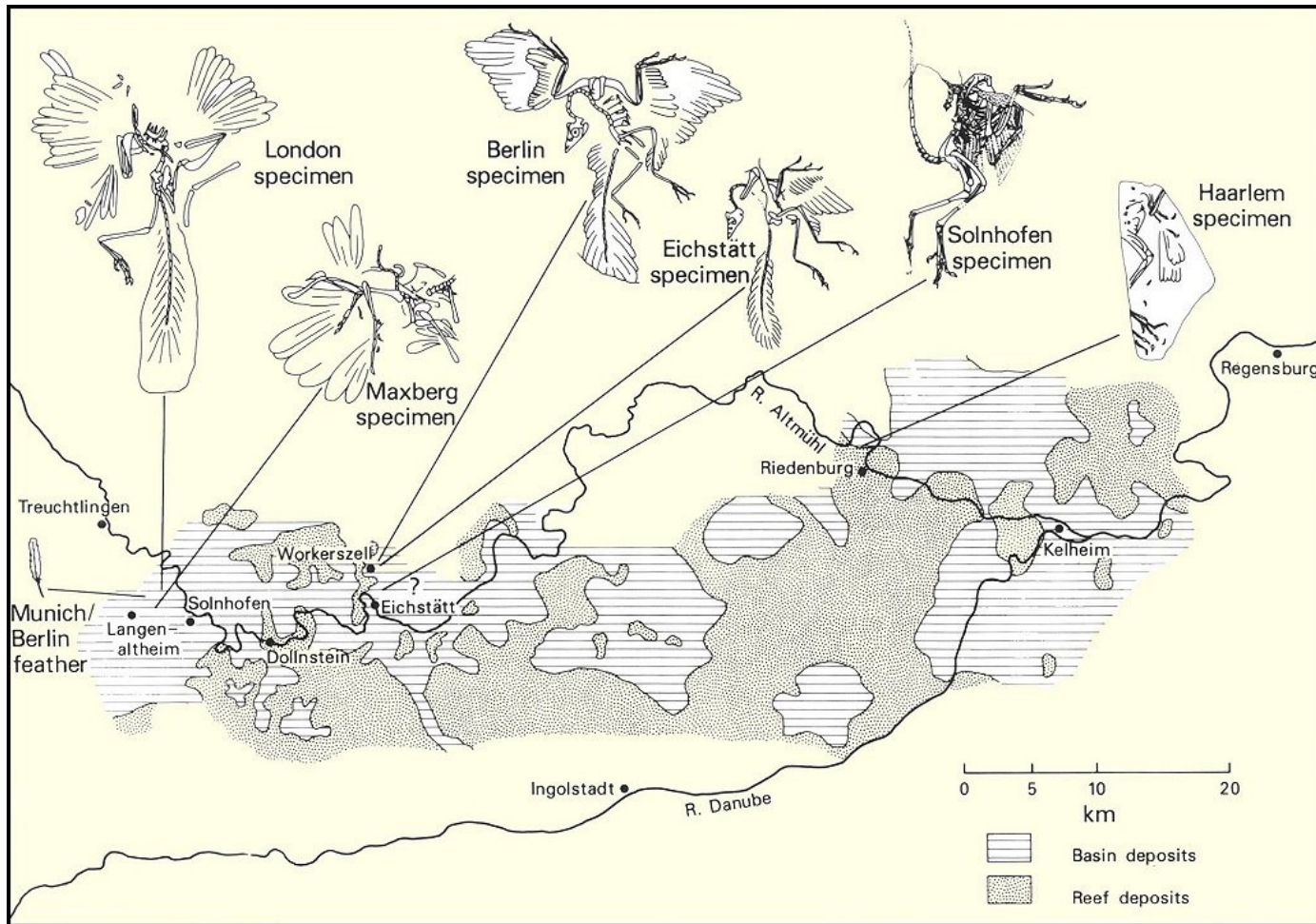
Fossil



Maybe...?

Where are Archaeopteryx found?

Mostly in Germany



Carnosauria



Allosaurus

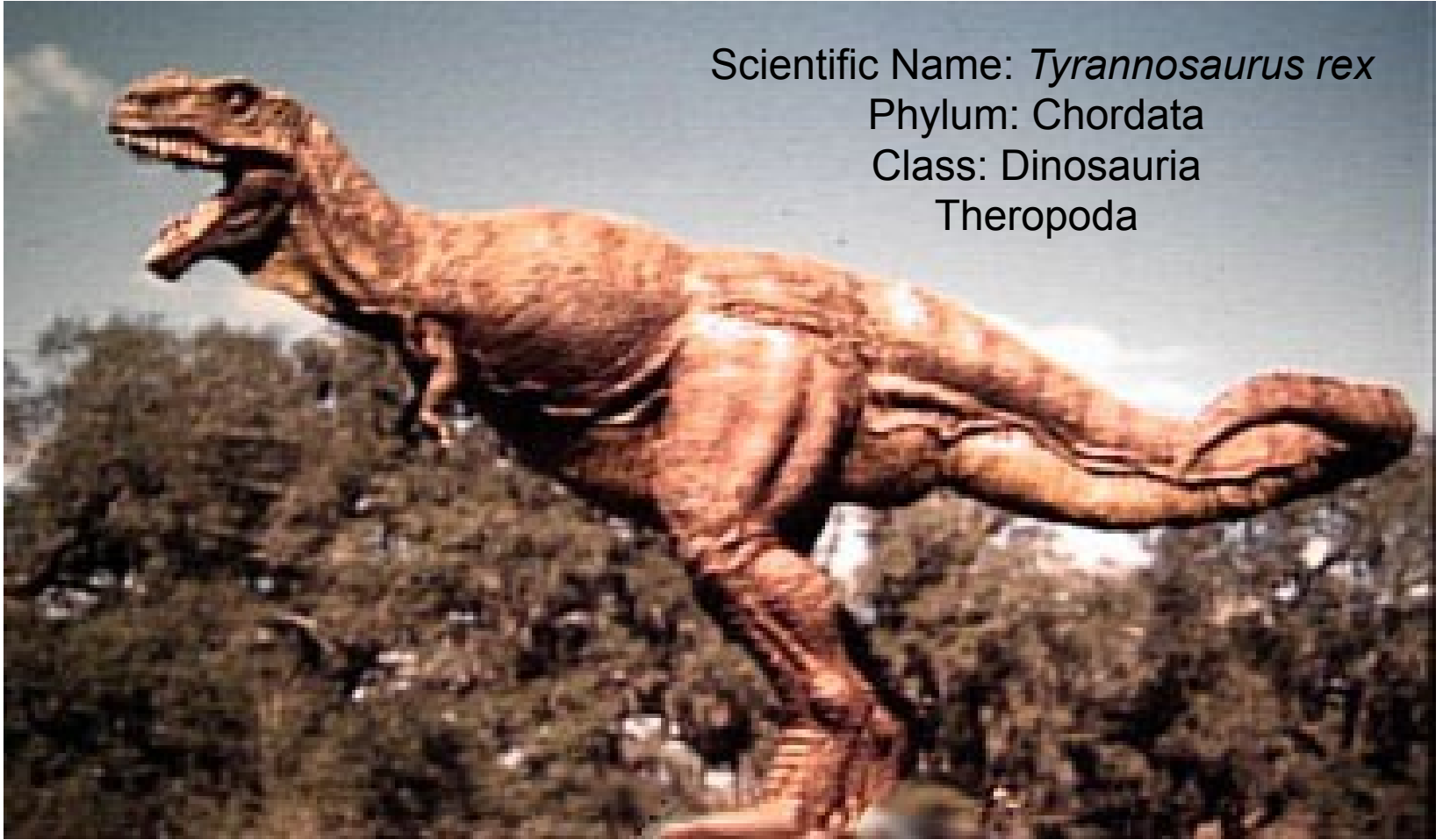
And T-Rex

Scientific Name: *Tyrannosaurus rex*

Phylum: Chordata

Class: Dinosauria

Theropoda



Tyrannosaurides (T-Rex)



Největší opeřenec žil v Číně

Peking - Skoro půldruhé tuny v dospělosti vážil opeřený dinosaur, jehož tři zkameněné pozůstatky našli vědci na severovýchodě Číny.

Nedávno popsáný opeřený masožravý tvor byl starším příbuzným *Tyranosaurus rex*. Žil před asi 125 miliony let, v dospělosti vážil 1400 kilogramů a je podle zpravodajského serveru BBC největším známým opeřeným živočichem, který kdy žil na Zemi.

Poznatky vědců, které otiskl časopis *Nature*, zpochybňují dosavadní teorie o vývoji tyranosaura rexe i jeho příbuzných. Ti žili před asi 65 miliony let. O většině jejich předků se usuzovalo, že byli mnohem menší.

Nově popsaný opeřený dinosaur patřil do čeledi tyranosauroidů a je jedním z dřívějšího příbuzných obávaného tyranosaura. Odborníci nový druh pojmenovali **Yutyranus huali**, což lze přeložit jako "krásný opeřený vladař". Tři fosilie popsali Sing Sü s kolegy z čínské akademie věd v Pekingu. Zkameněliny jsou mimořádně dobře zachovalé a představují dospělého jedince a dvě asi půltunová mláďata.

Yutyranus se v některých rysech shodoval s jeho pozdějšími příbuznými. Na rozdíl od tyranosaura měl ale peří a tři funkční prsty, zatímco tyranosaurus měl funkční prsty jen dva.

Vědci se domnívají, že **dlouhá nitkovitá pera sloužila jako izolace**. Živočich žil v období druhohor nazývaném **spodní křída**. Teploty prý byly tehdy nižší než ve zbytku této vývojové etapy Země a pohybovaly se kolem deseti stupňů Celsia, o osm méně než teplotní průměr. Odborníci ale nevyklučují, že peří hrálo roli při námluvách nebo v bojích. **Podle studie je dokonce možné se domnívat, že pera měli na části těla i tyranosauři.**

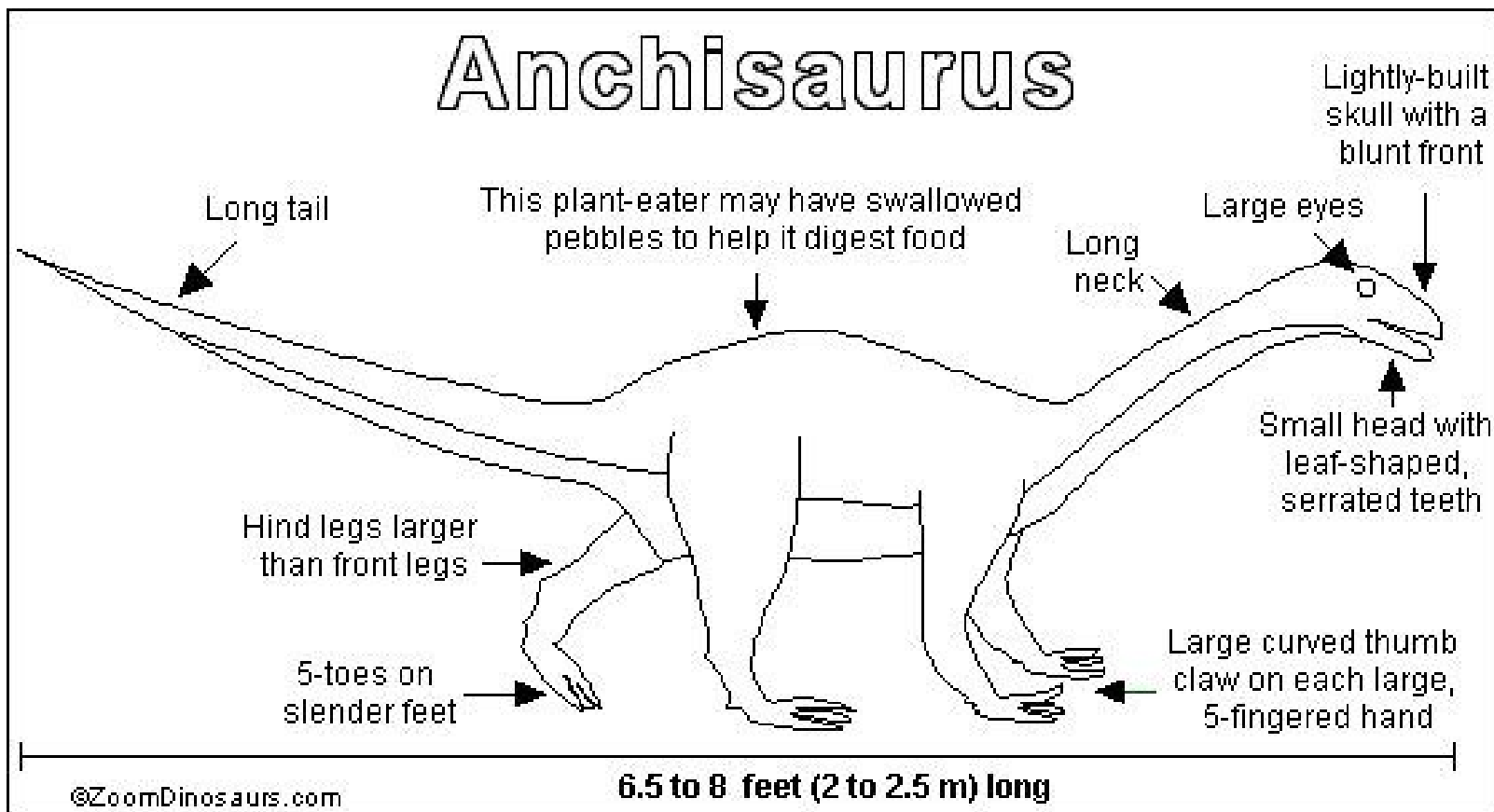
Ze největšího dosud známého opeřeného dinosaura byl podle agentury AFP dosud pokládán beipiaosaurus. Yutyranus ale ve srovnání s ním vážil 40 krát víc.

PHYTODINOSAURIA

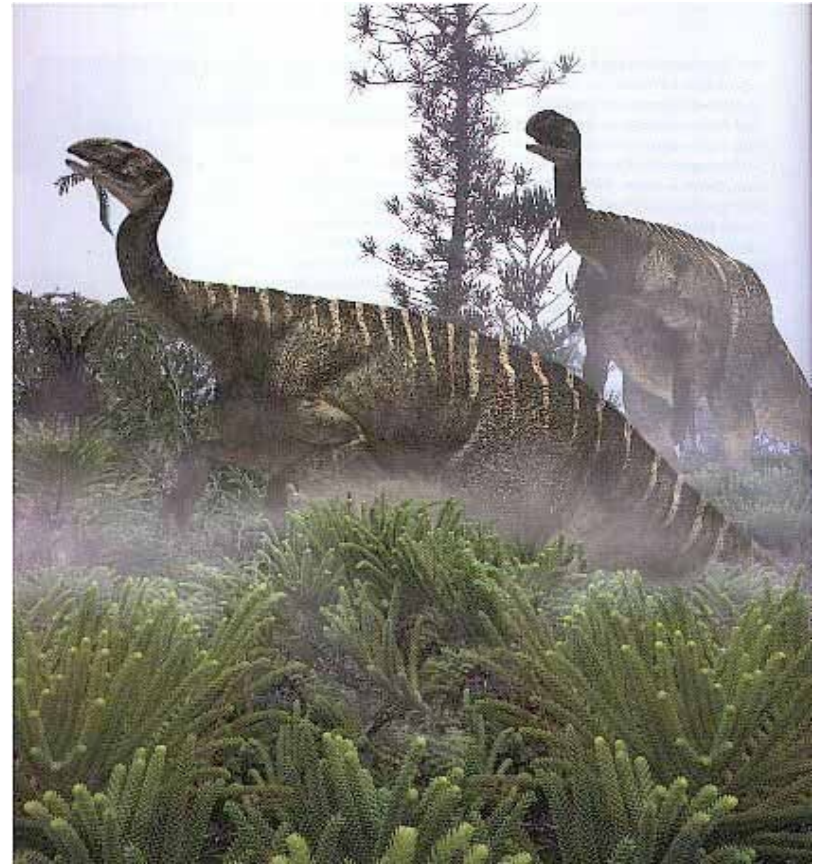
Prosauropoda



Plateosaurus (flat-lizard)



Prosauropoda (Plateosaurus)



Plateosaurus (small head)



Sauropods

Who were the Sauropods?

Mainly Jurassic



„Brontosaurus“



Apatosaurus - Jurassic
Brontosaurus is younger synonym

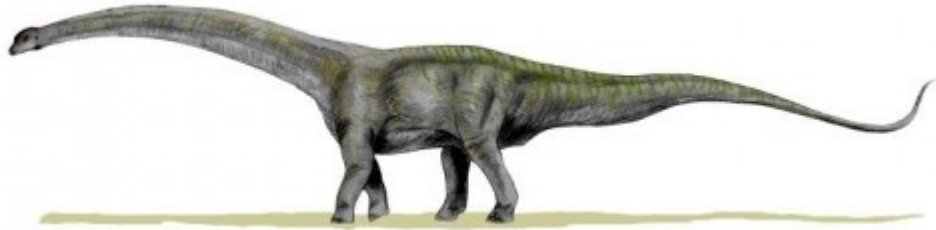


Z 55 na 33 metrů se zmenšil „nejdelší“ známý dinosaur poté, co vědci přehodnotili svůj původní nález.

45 m

100 tun

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.



Bruhathkayosaurus



Estimated length 44m



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

Ultrasaurus – 130 tun



The Ornithischians (bird-hip structure) - Phytodinosauria



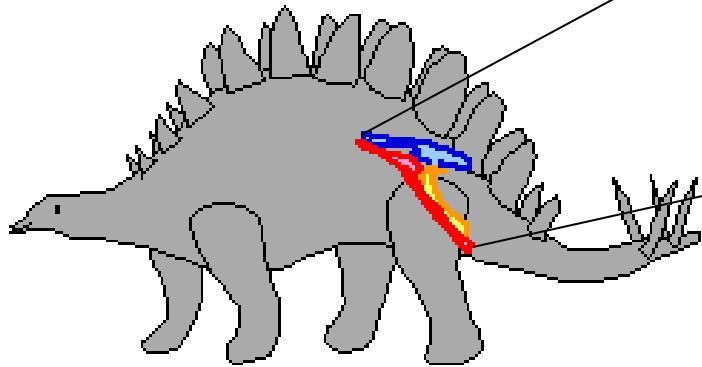
There were five basic kinds of ornithischians

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

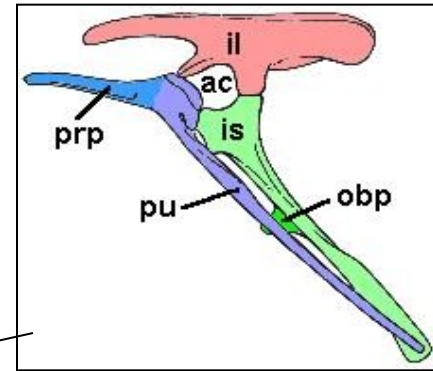
Entirely vegetarians

- Exploited vegetation low to the ground

Pelvis characteristics



Ornithischian hip



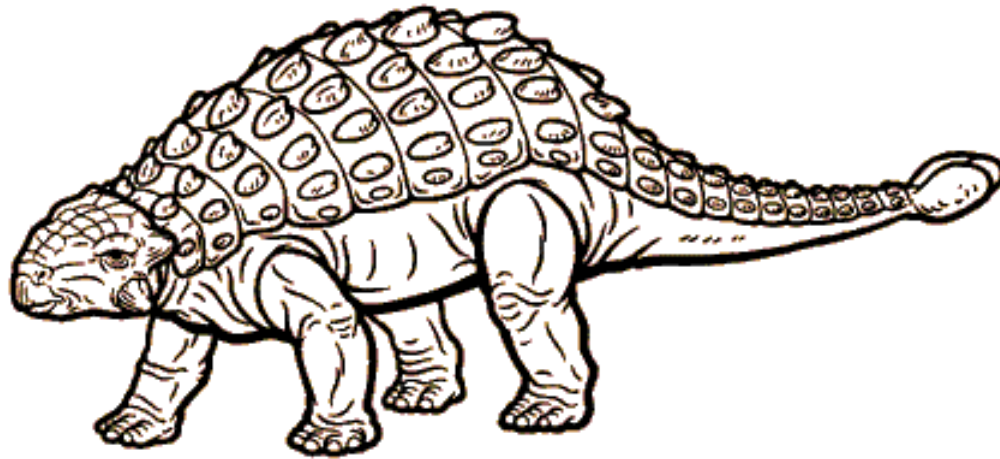
Stegosauria



Stegosaurus

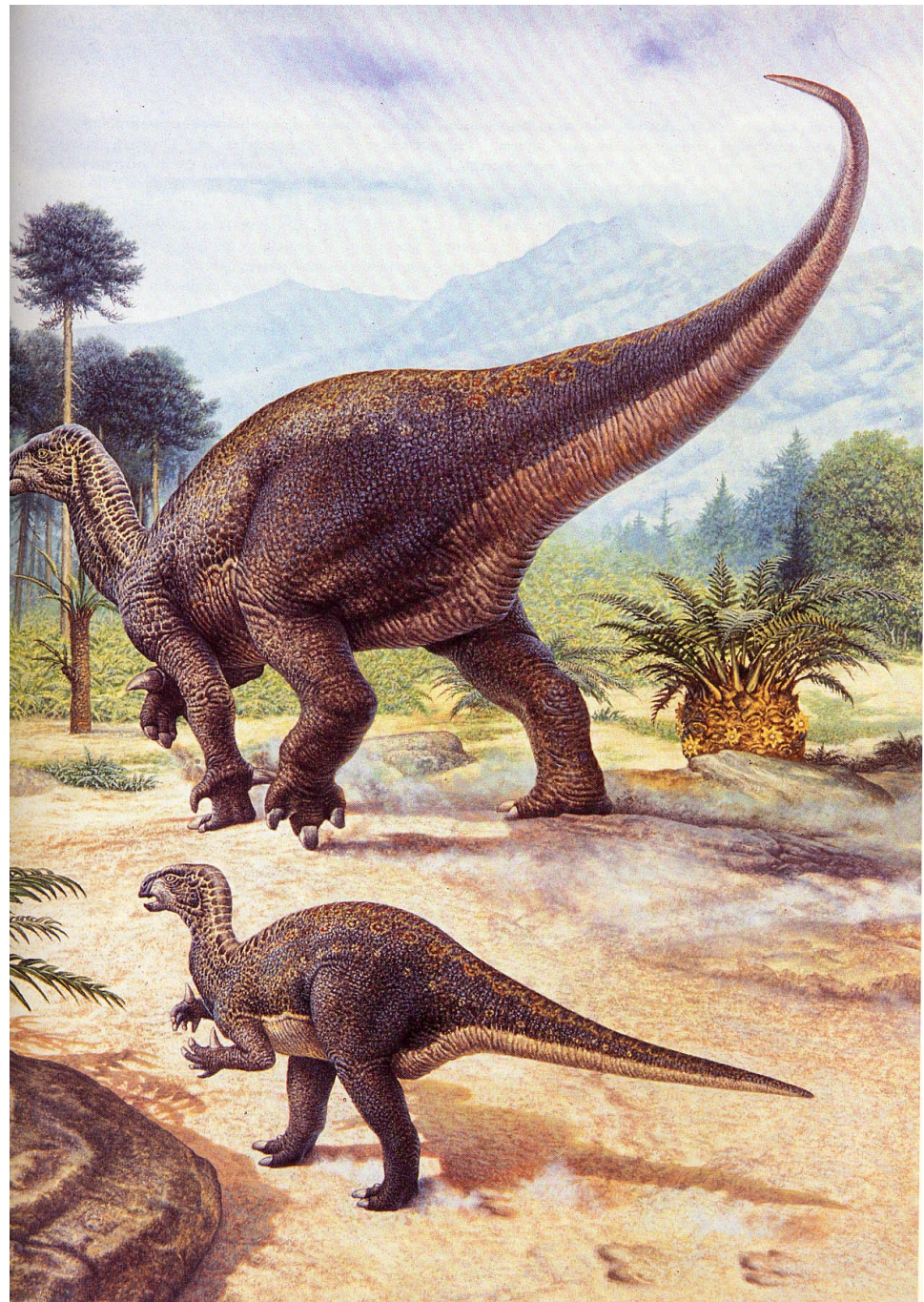


ANKYLOSAURS

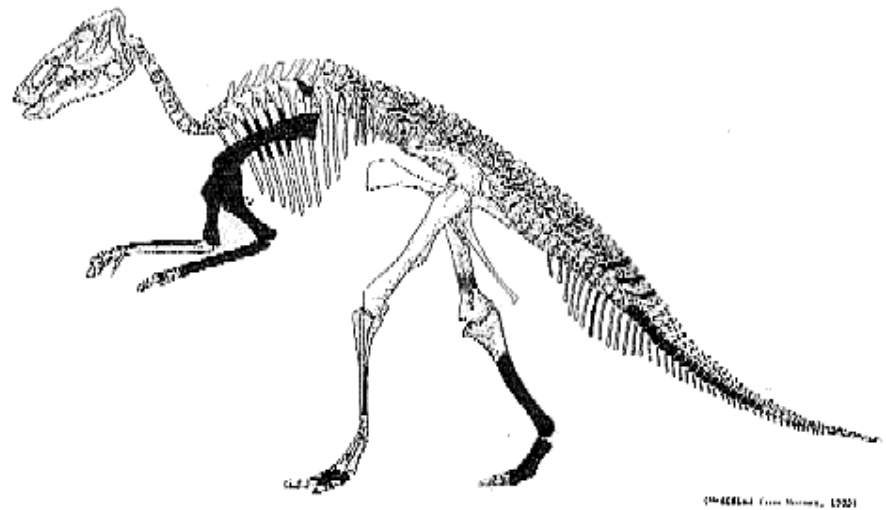


Ornithopoda

Iguanodonts



Hadrosaurs



Duck Bill Idea – Sometimes called Duck-billed dinosaur

Types of Hadrosaurs

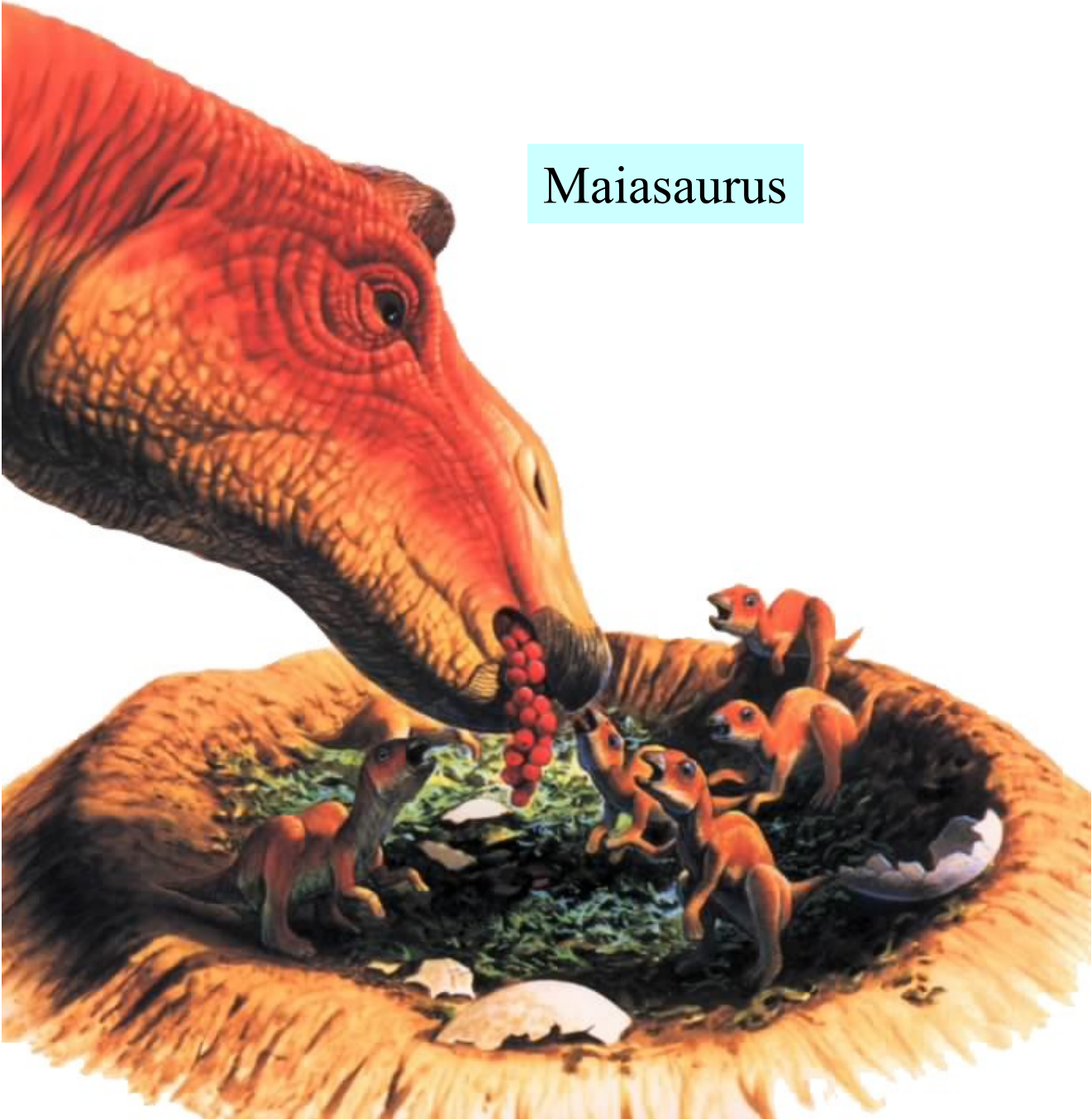


Anatosaurus

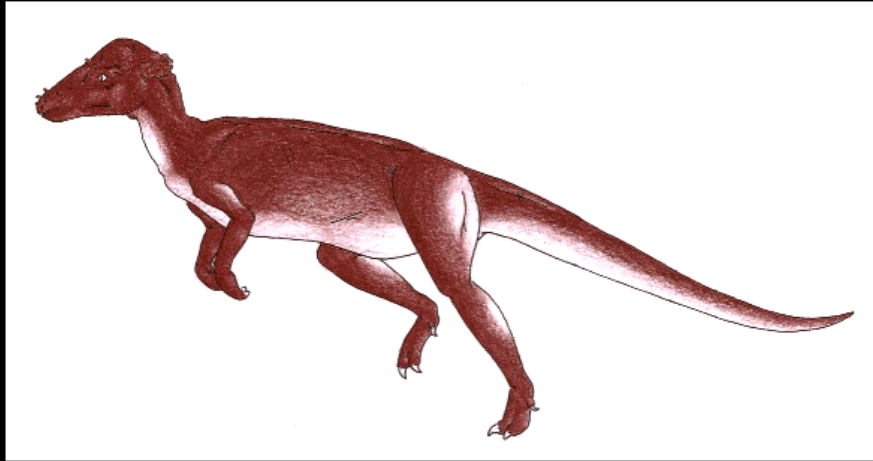


Parasauro

Maiasaurus



Pachycephalosaurs



CLASH OF THE BONEHEADS

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



Ceratopsia

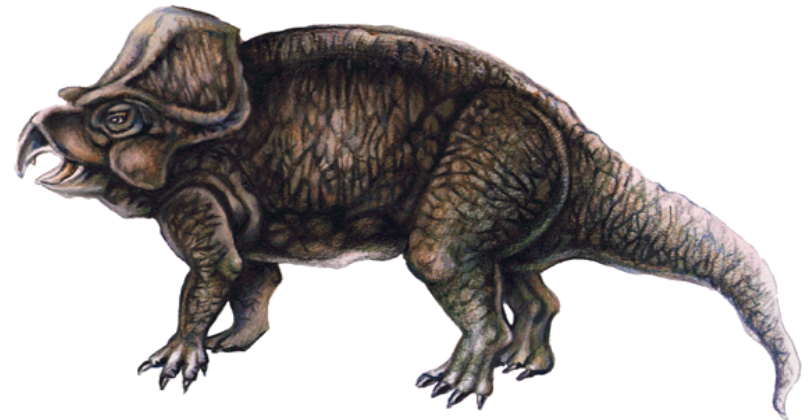
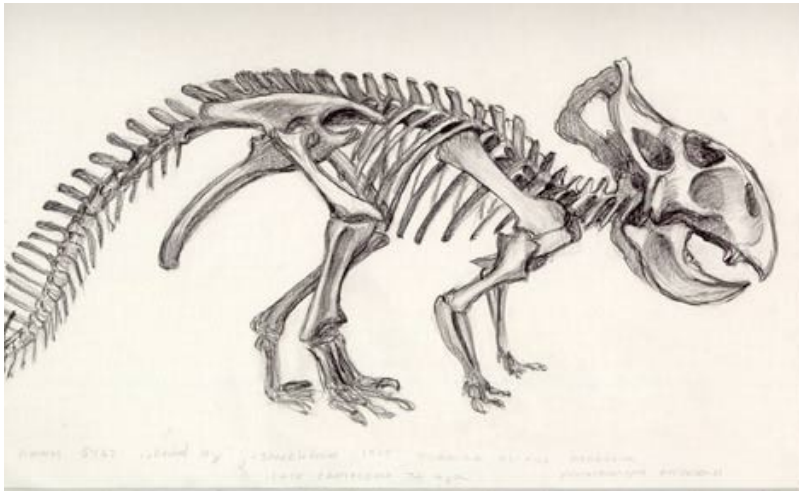
Ceratopsia



M. Shiraiishi
©1999

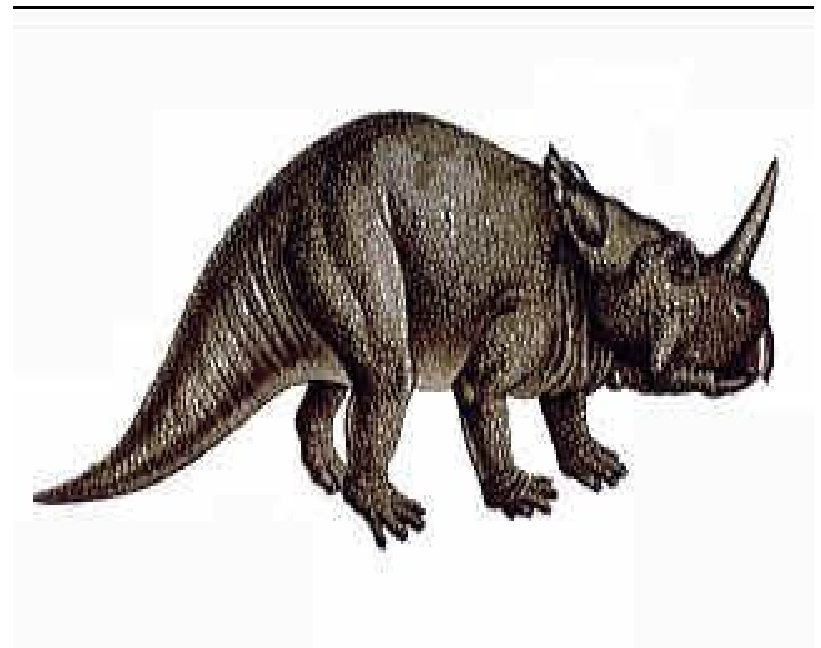
(c)1999 M. Shiraiishi---All Rights Reserved

Types of Ceratopsia



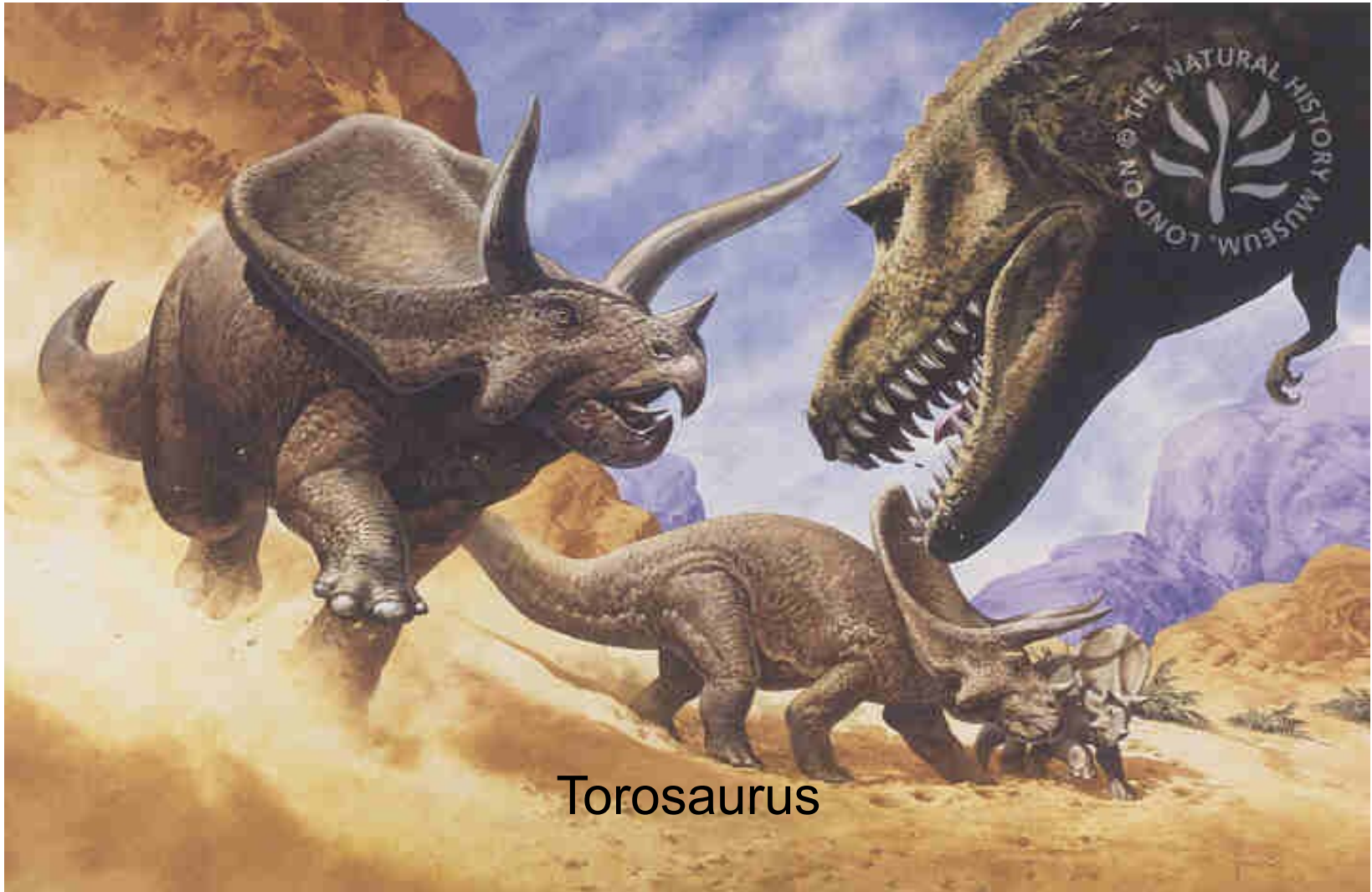
Protoceratops

Types of Ceratopsia



Monoclonius

Types of Ceratopsia



Torosaurus



Types of Ceratopsia



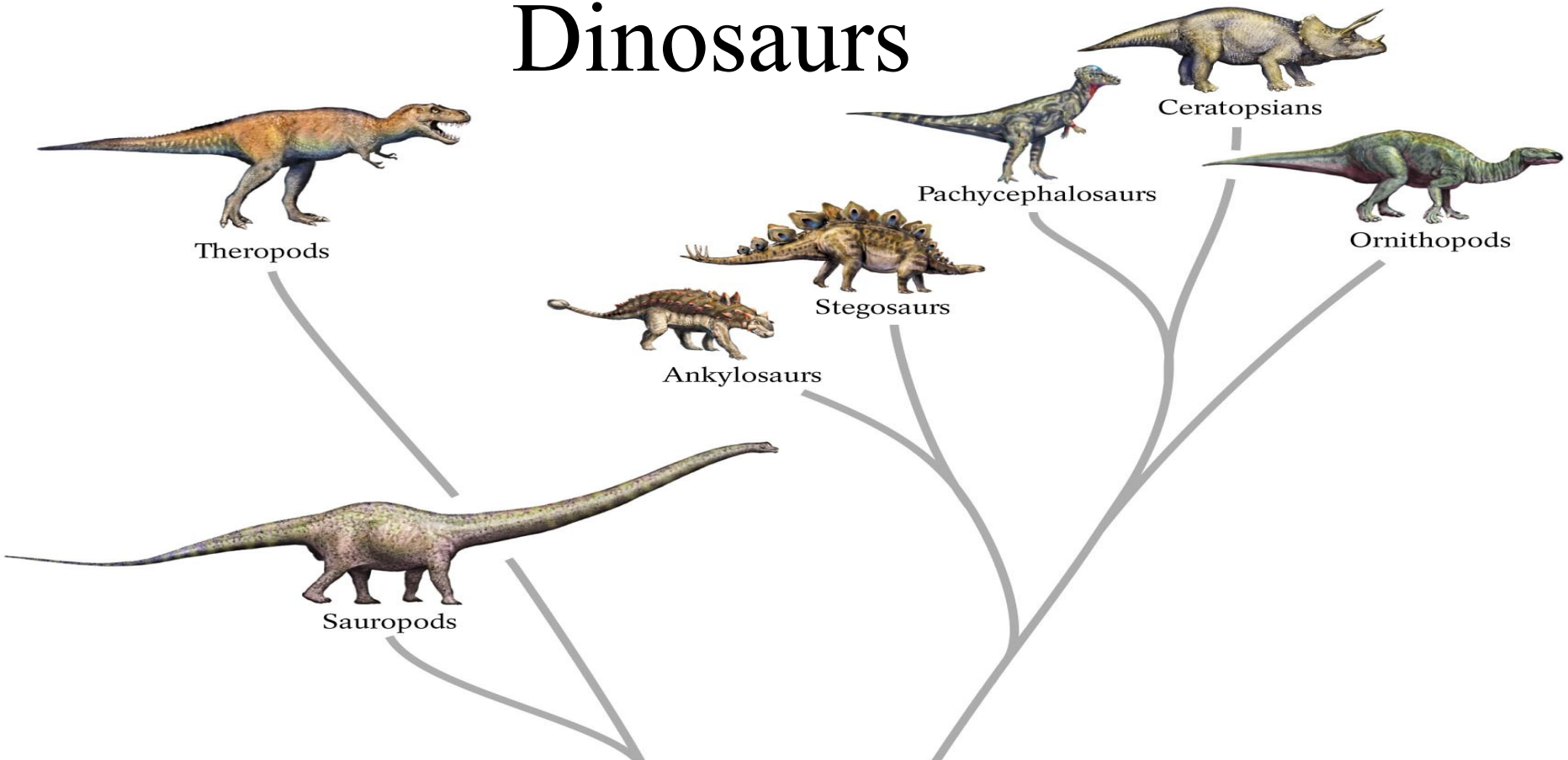
Triceratops



Saurischians

Ornithischians

Dinosaurs



Theropods

Ceratopsians

Pachycephalosaurs

Ornithopods

Stegosaurus

Ankylosaurs

Sauropods

“Lizard hip”

“Bird hip”

Back of hip this side

Front of hip this side

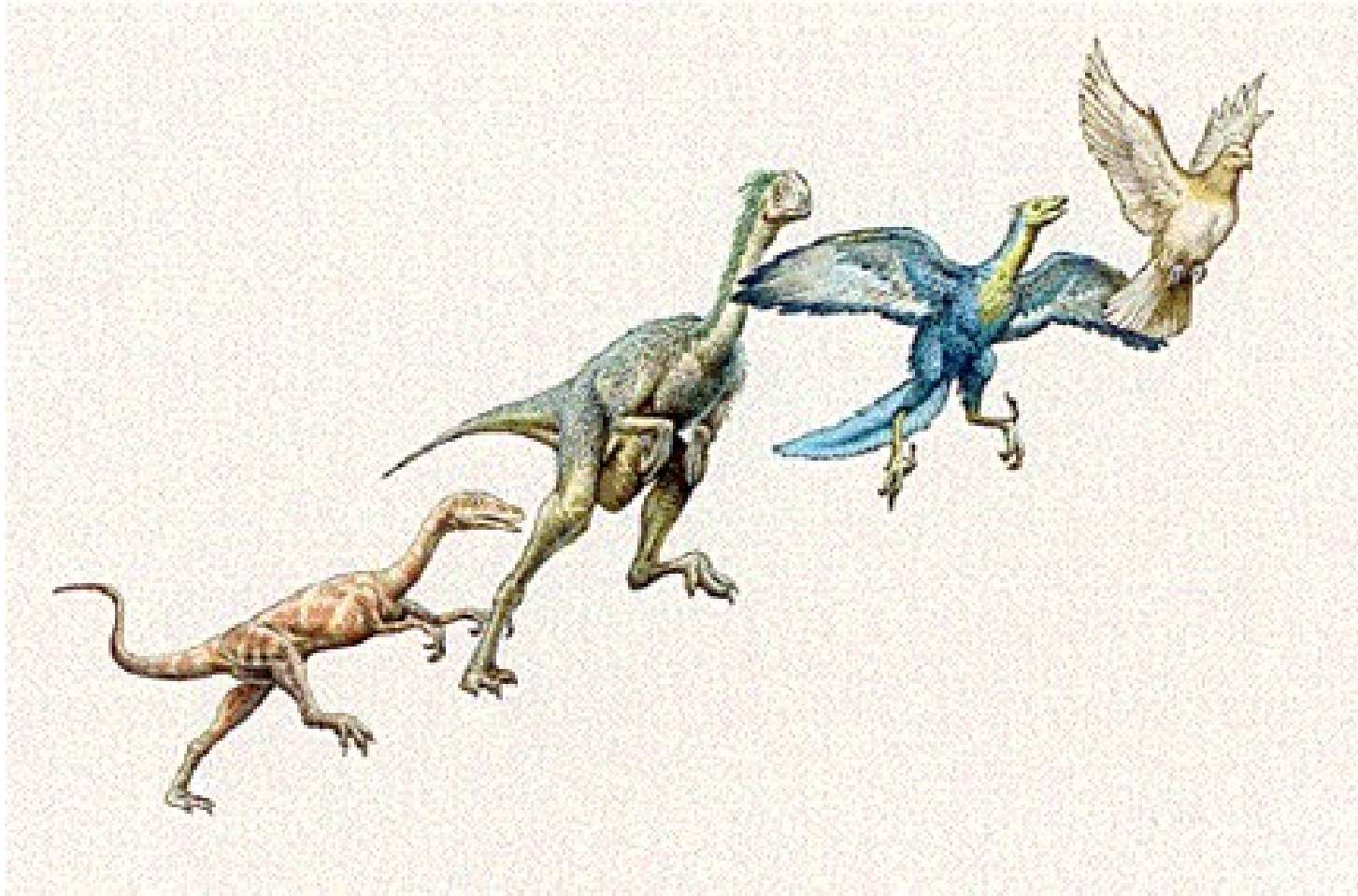
- Ischium
- Pubis
- Ilium

Common ancestor

Geographic Distribution



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

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



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

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

Xiaotingia byl rod malého opeřeného teropodního dinosaura z čeledi Archaeopterygidae. Tento drobný, ptákům podobný dinosaur žil v období rané pozdní jury (asi před 160 miliony let) na území dnešní Číny (souvřství Tiaojishan, západní Liao-ning). Byl blízce příbuzný "srpodrápým" deinonychosaurům, jako byly rody Velociraptor nebo Deinonychus. Velmi blízce příbuzný byl také "bavorskému praptákovi" rodu Archaeopteryx. Zajímavé je, že objevem čínského příbuzného by mohl zmíněný archeopteryx ztratit postavení "prvního praptáka" a začít být klasifikován jako deinonychosaurní (neptačí) dinosaur.



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 (opposite birds) - ? Archeopteryx(Jurassic),Confuciusornis
(Jurassic-Cretaceous)

Ornithurae (modern birds) — Hesperornis, Ichthyornis (Cretaceous)



Hesperornis



Dan Varner

Pterosauria

Triassic-Cretaceous

Jurassic with tail

Rhamphorhynchus

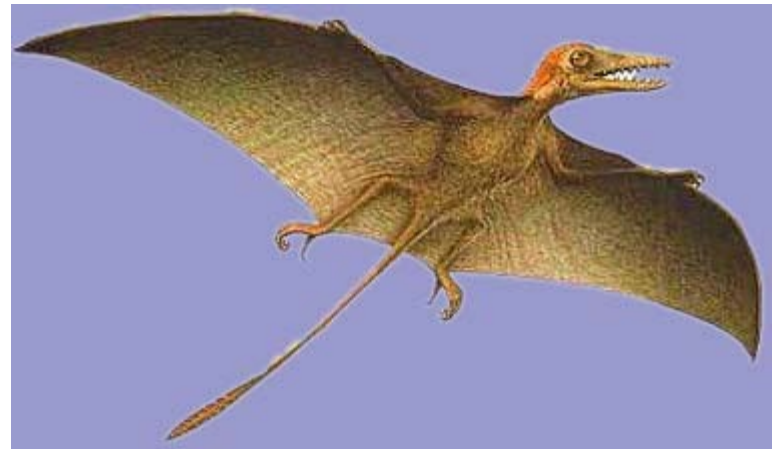


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Shiraishi
D. Shiraishi



Sordes pilosus



Quetzalcoatlus



Czech Republic

First Cenomanian dinosaur from Central Europe (Czech Republic)

OLDŘICH FEJFAR, MARTINKOŠŤÁK,
JIŘÍ KVAČEK, MARTIN MAZUCH, and MICHAL MOUČKA

Fejfar, O., Košťák, M., Kvaček, J., Mazuch, M., and Moučka, M. 2005. First Cenomanian dinosaur from Central Europe

(Czech Republic). *Acta Palaeontologica Polonica* 50 (2): 295–300.

We describe the first dinosaur skeletal remains found in the Czech Republic, consisting of one complete femur and inde-

terminable bone fragments. They were recovered from the upper Cenomanian near-shore marine sediments deposited on

the slopes of an ancient archipelago, several kilometres north of the larger Rhenish-Bohemian Island that was situated in

what is now the middle of Europe. Sediments yielding dinosaur remains are of late Cenomanian age, *Inoceramus*

pictus–*I. pictus bohemicus* inoceramid zone of the local lithostratigraphic unit, the Peruc-Korycany Formation. These are

the first uncontested dinosaurian fossils reported from this formation and also the first Cenomanian dinosaur record in

Central Europe. They document a small **ornithopod** belonging to an **iguanodontid** species comparable with similar Late

Cretaceous European forms. The herbivorous dinosaur lived among a vegetation transitional between salt marsh flora,

with abundant halophytic conifer *Frenelopsis alata*; and an alluvial plain assemblage dominated by lauroid angiosperms.

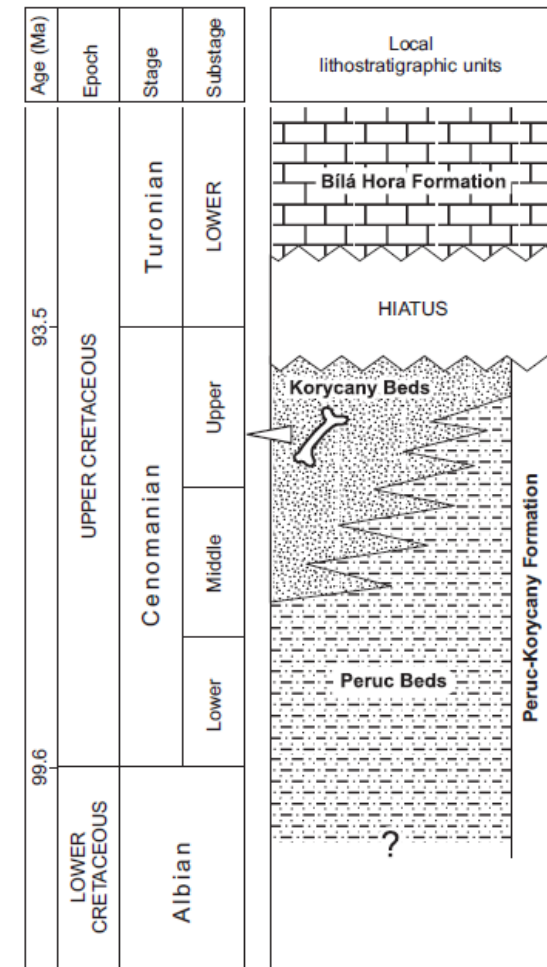
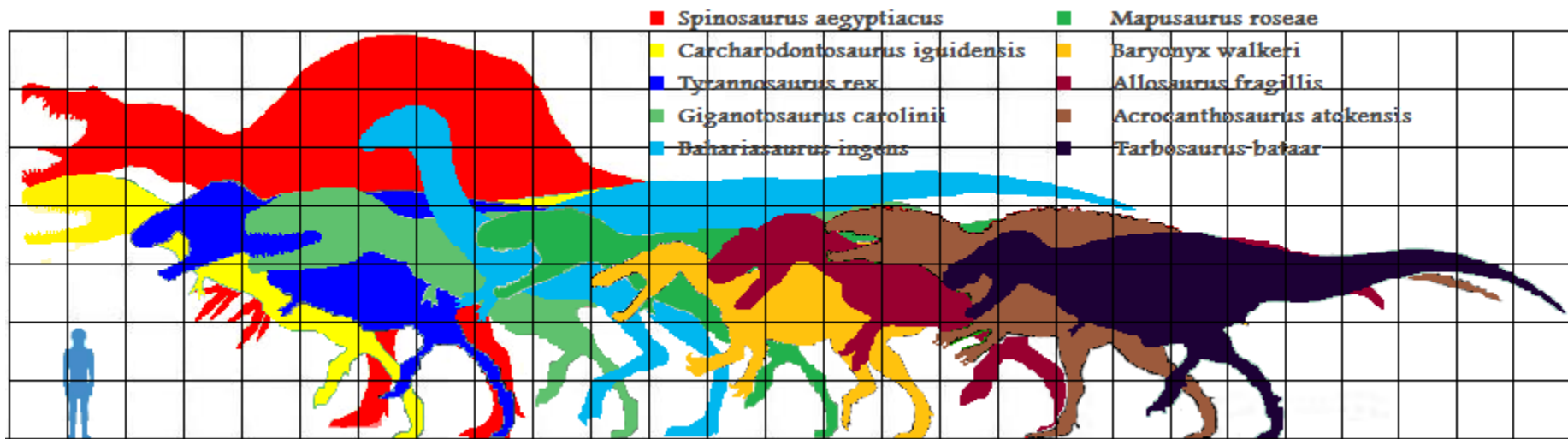


Fig. 2. The stratigraphic position of the dinosaur remains in the Bohemian Cretaceous Basin. Time scale after Gradstein and Ogg (2004).

http://en.wikipedia.org/wiki/Dinosaur_size#Longest_theropods



Synapsids

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

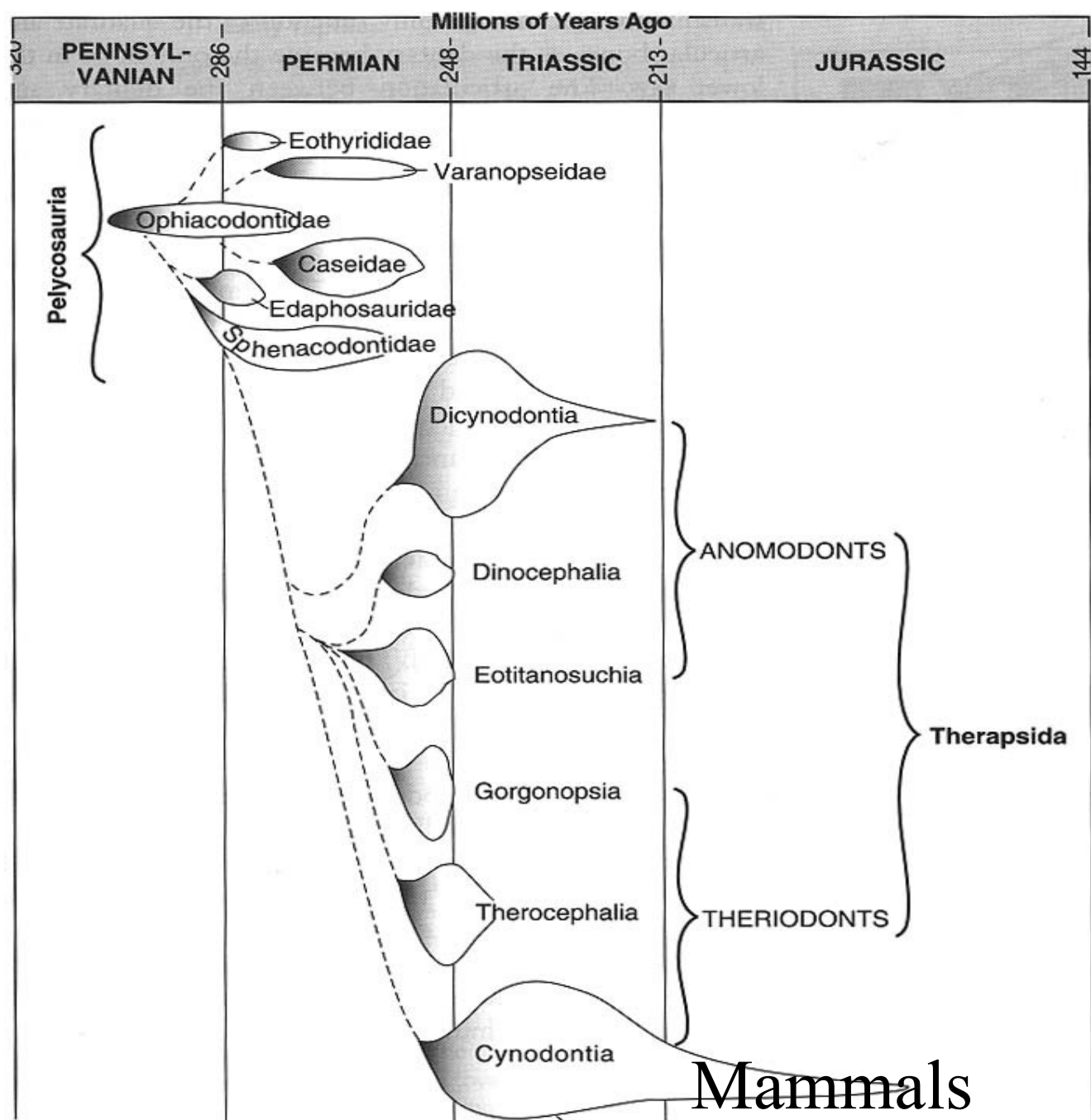


Fig 4.2, Feldhamer

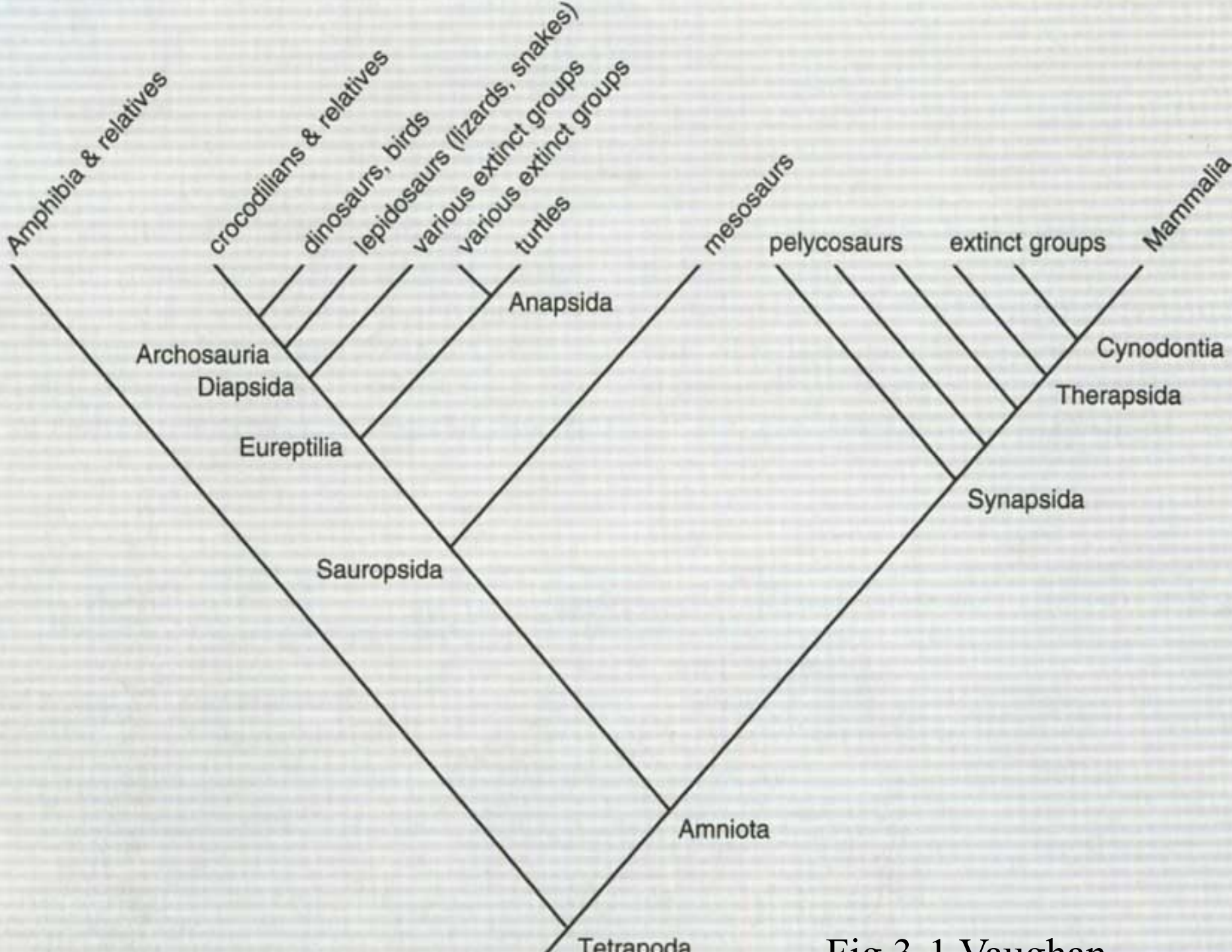


Fig 3.1 Vaughan

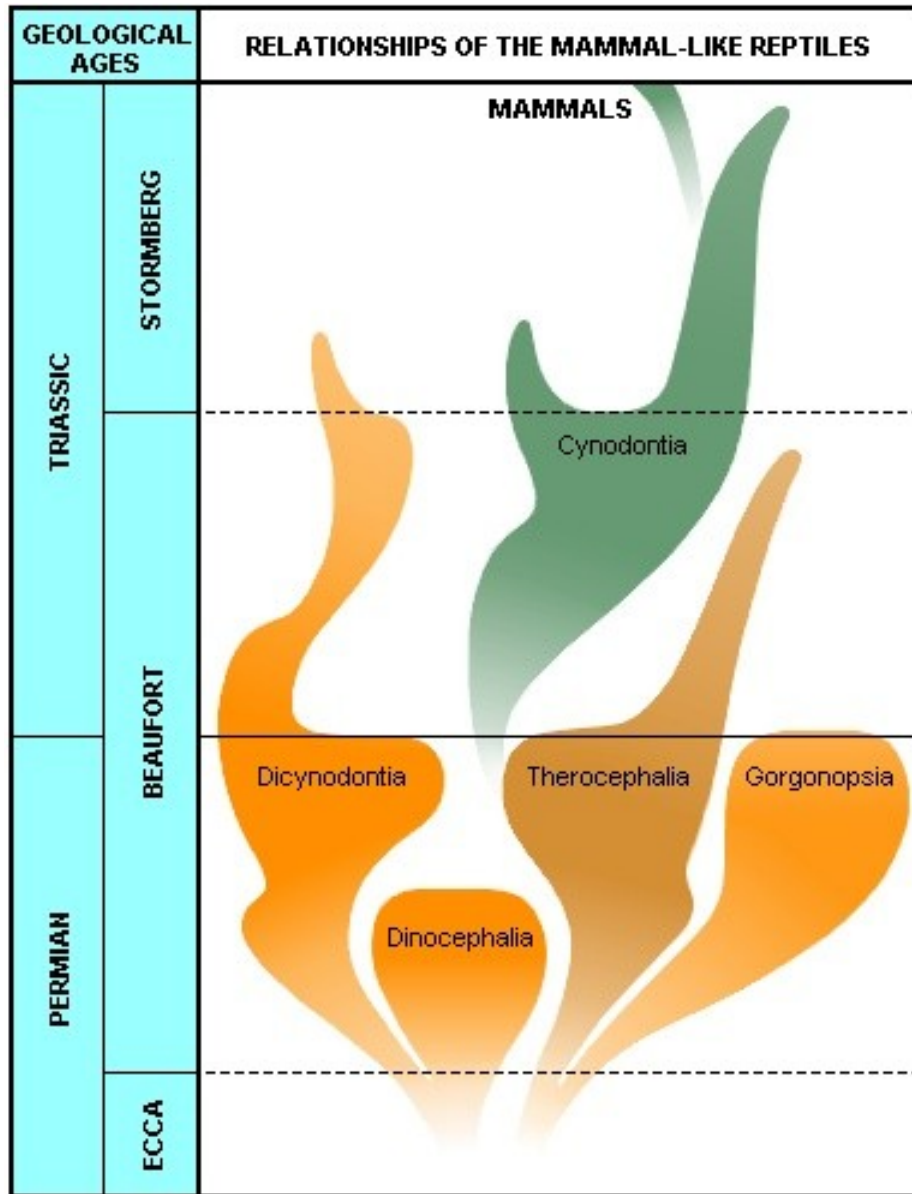
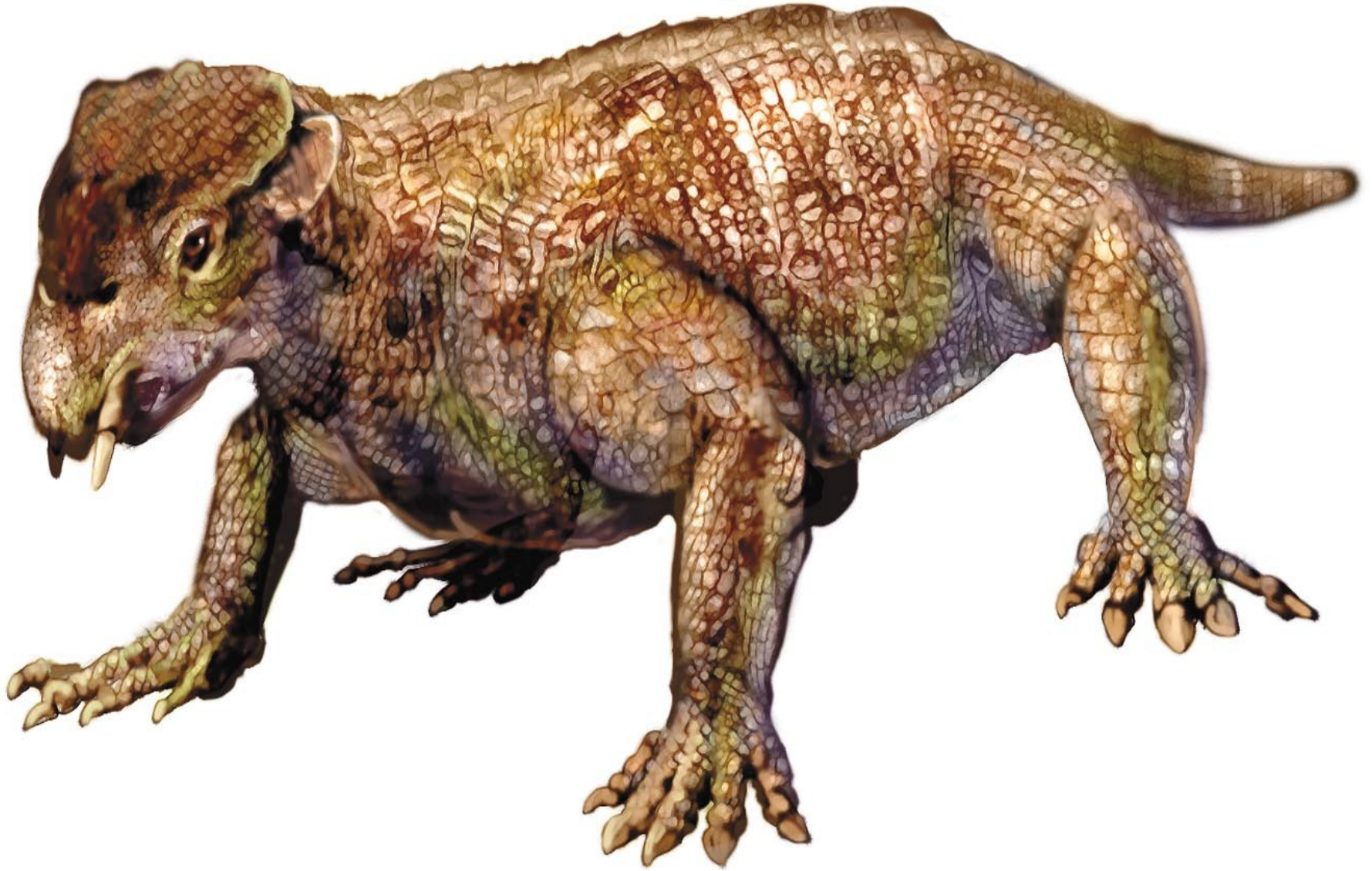


Diagram showing the relationships between the various mammal-like reptiles. Mammal-like reptiles did not survive beyond the end of the Triassic period, but one group, the Cynodontia, gave rise to the first mammals at the end of the Triassic, about 200 million years ago

Mesozoic Therapsids



Lystrosaurus

Evolution

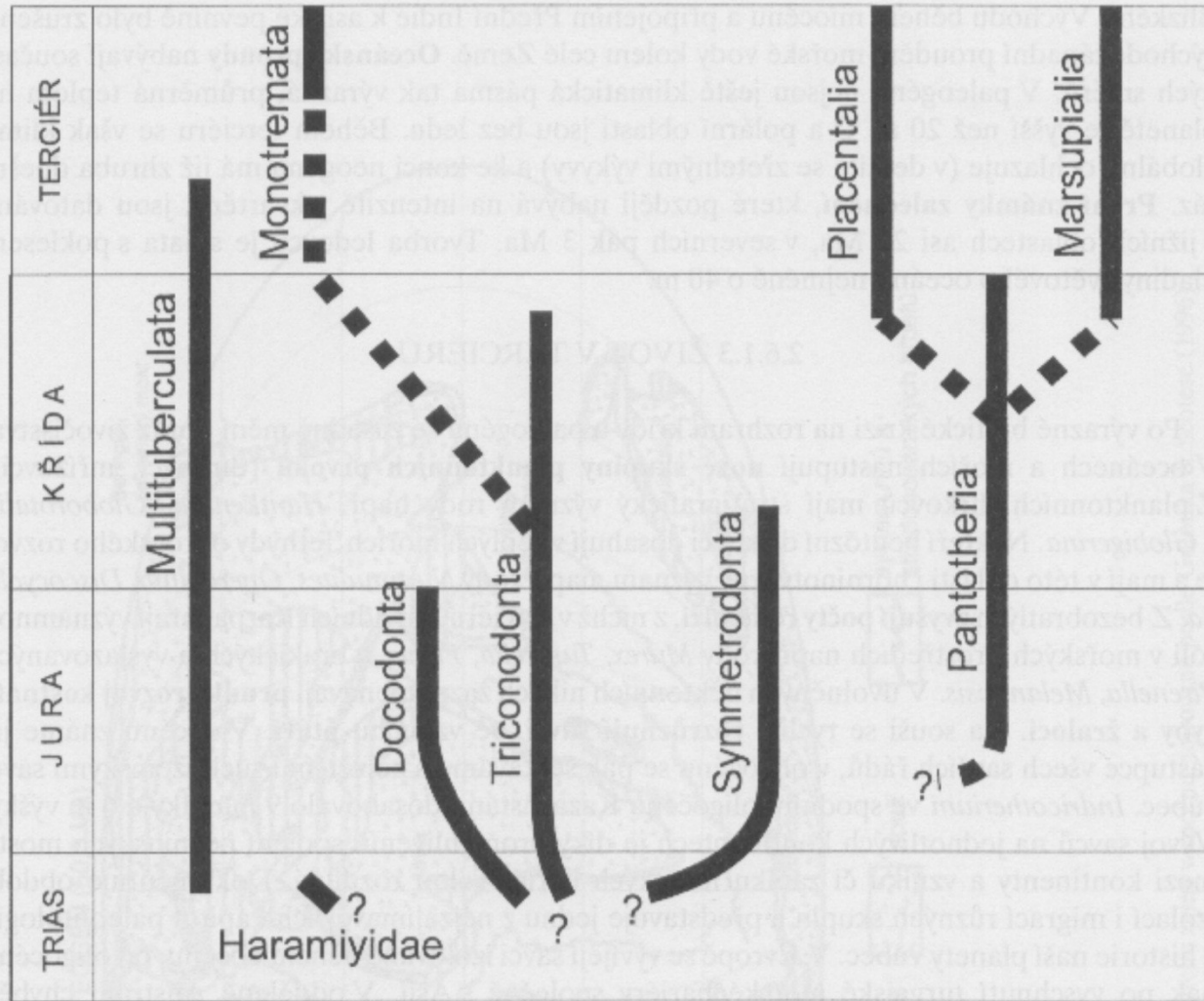
- Animals evolved from the group of reptiles called Therapids.
- Therapids have both reptilian and mammalian characteristics.
- Therapids have a jaw bone composed of 5 bones rather than a simple jaw bone.



Mammals

Prototheria

Theria



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

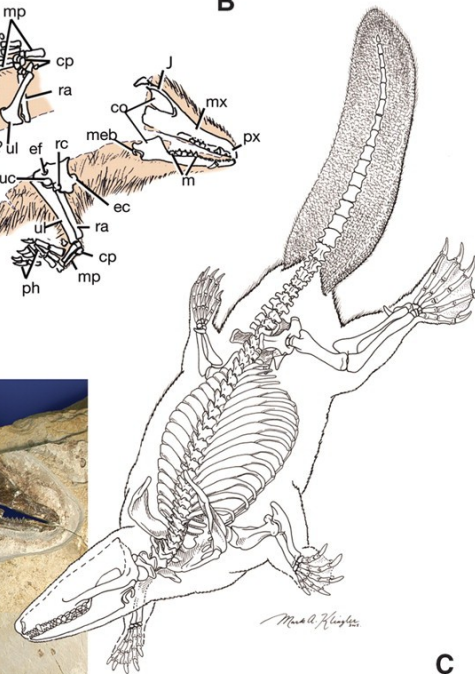
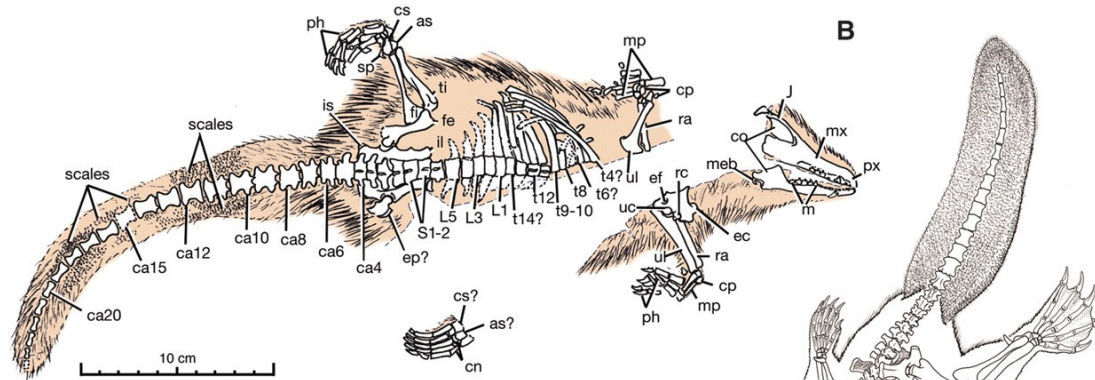
SUBCLASS: PROTOTHERIA

- **NO PLACENTA**
- **Egg laying mammals**

A Swimming Mammaliaform from the Middle Jurassic and Ecomorphological Diversification of Early Mammals

Qiang Ji, Zhe-Xi Luo, Chong-Xi Yuan, Alan R. Tabrum

Mammals of the Mesozoic era (248 to 65 million years ago) generally are considered to be primitive, shrew-like creatures living in the shadow of the dinosaurs. Pushing back the mammalian conquest of the waters by more than 100 million years, Ji *et al.* report a Middle Jurassic, **164-million-year-old** skeleton with a beaverlike tail and seal-like teeth perfectly adapted for an aquatic lifestyle.



The new Middle Jurassic docodont **Castorocauda** from Inner Mongolia possesses striking features for an aquatic life-style and combines skeletal, dental, and softpart characters of modern aquatic placentals such as beavers (*Castor*), river otters (*Lutra*), and seals (*Phoca*)

C

Science 24 February 2006:
Vol. 311, no. 5764, pp. 1123 - 1127

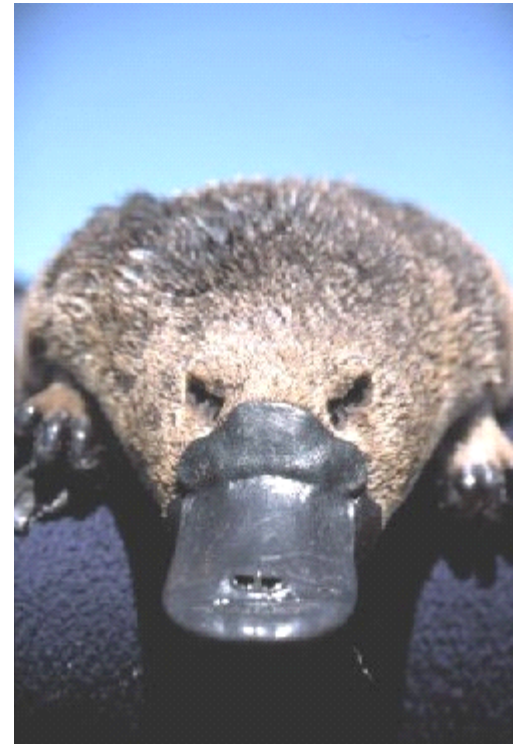
Monotremata

- Oviparous egg laying mammals
- **Only 3 in existence**
- Duck-billed platypus and two species of spiny anteaters called echidna.
- Not completely endothermic (their body temperature is lower and fluctuates more than other mammals)

Ježura



Monotremata
Ornithorhynchidae
(*Ornithorhynchus anatinus*)



Marsupials

- Marsupials give birth to tiny immature young that crawl to a pouch on the mothers belly immediately after they are born.



250 species of marsupial species exist in Australia, New Guinea, Tasmania, And the Americas



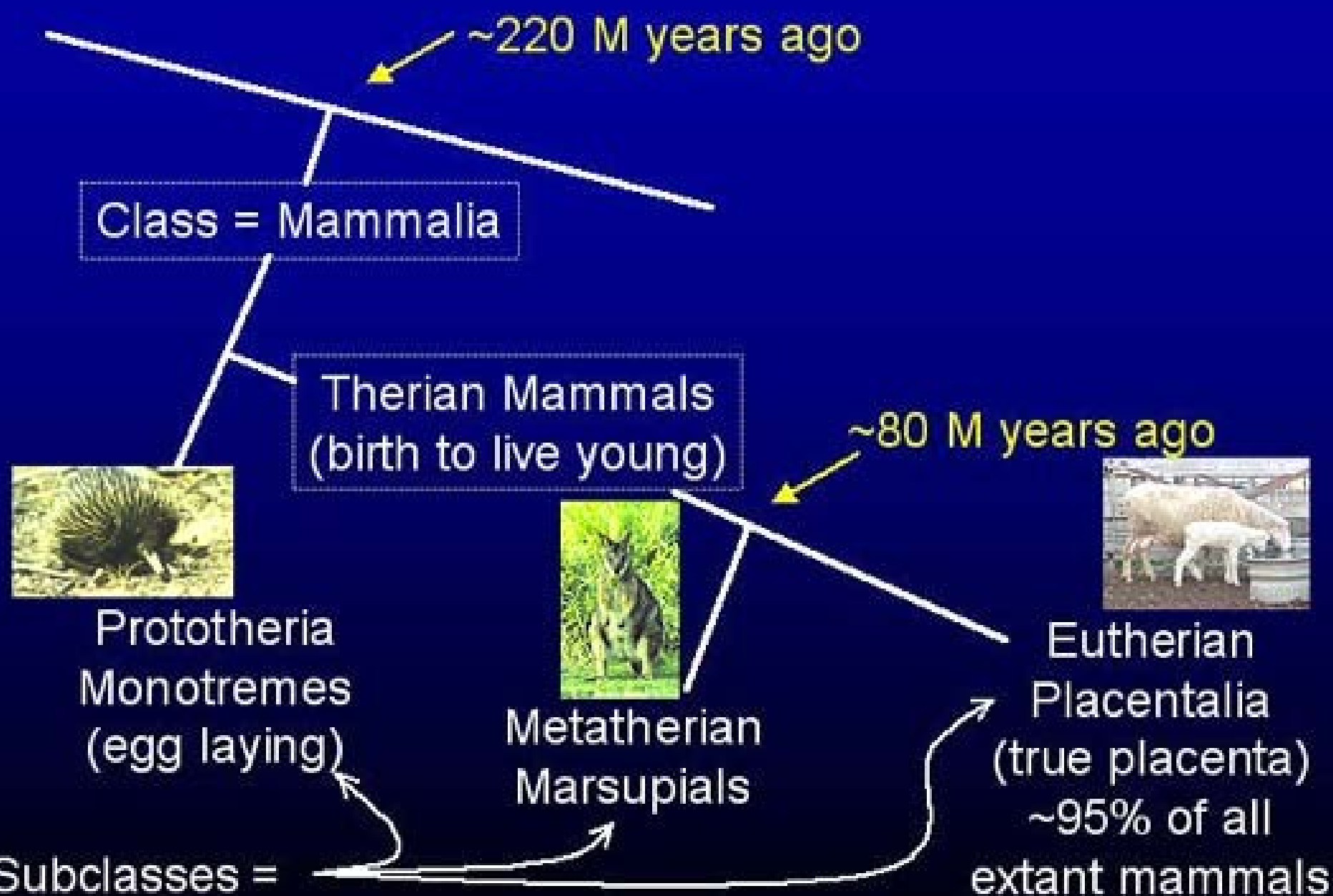
**Tasmanian
Devil
Ďábel
medvědovitý**

Characteristics of Placentals

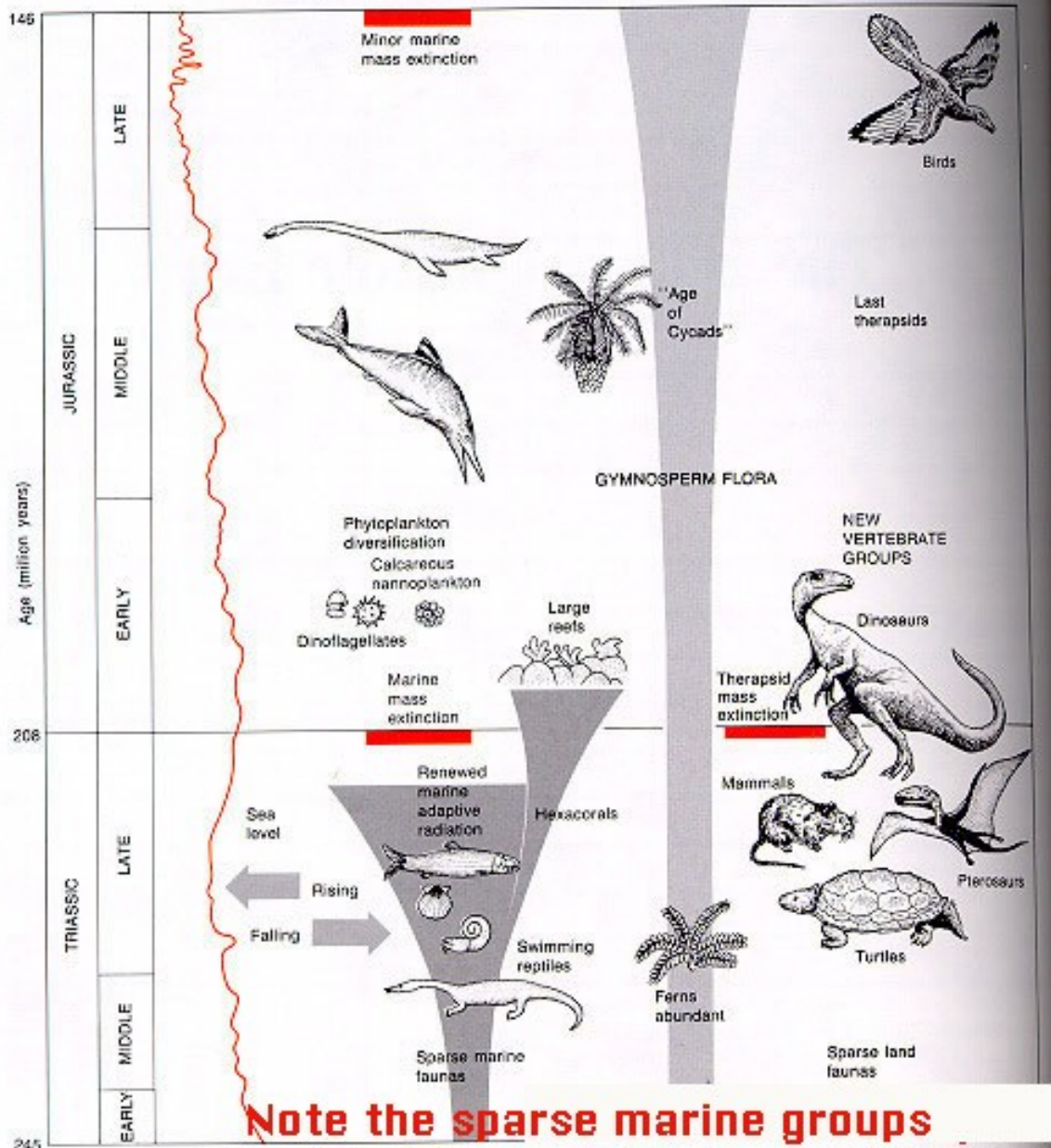
- Placental mammals carry unborn young in the uterus until young can survive in the wild.
- Oxygen and nutrients are transferred from mother's blood to baby's blood



Origin of Mammalian Species



MAJOR EVENTS OF EARLY MESOZOIC TIME



Sea level rises gradually during early Mesozoic time.

mals, including dinosaurs, occupied Late Triassic terres-

End Triassic extinction

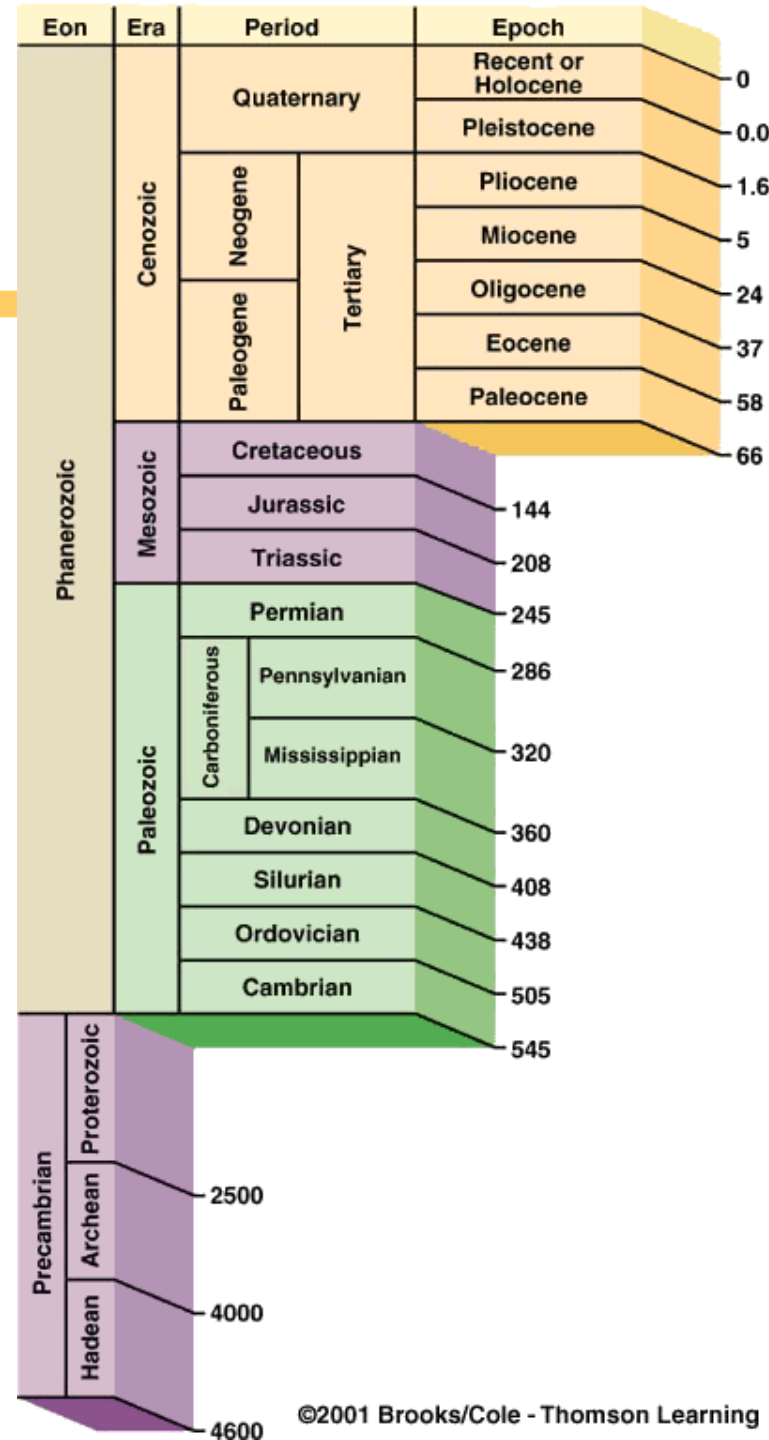
The Triassic period ended with a mass extinction, which was particularly severe in the oceans; the **conodonts** disappeared, some marine reptiles except ichthyosaurs and plesiosaurs. Invertebrates like brachiopods, gastropods, and molluscs were severely affected. In the oceans, **22% of marine families** and possibly about half of marine genera went missing

Though the end-Triassic extinction event was not equally devastating everywhere in terrestrial ecosystems. **Thecodonts and therapsids** disappeared, as did most of the large **labyrinthodont amphibians** (dominant in Paleozoic), groups of small reptiles.

Volcanic eruptions - Massive volcanic eruptions, specifically the flood basalts of the Central Atlantic Magmatic Province (CAMP), would release carbon dioxide or sulfur dioxide and aerosols, which would cause either intense global warming (from the former) or cooling (from the latter).

volcanic **CO₂ outgassing** - **warming** and catastrophic dissociation of **gas hydrates** may have exacerbated greenhouse conditions

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)

The **Cretaceous-Tertiary extinction event** was a period of massive extinction of species that occurred about 65.5 million years ago. It corresponds to the end of the Cretaceous period and the beginning of the Tertiary period.

T. Many forms of life perished, encompassing approximately **50 percent of all plant and animal families**, including the non-avian dinosaurs.

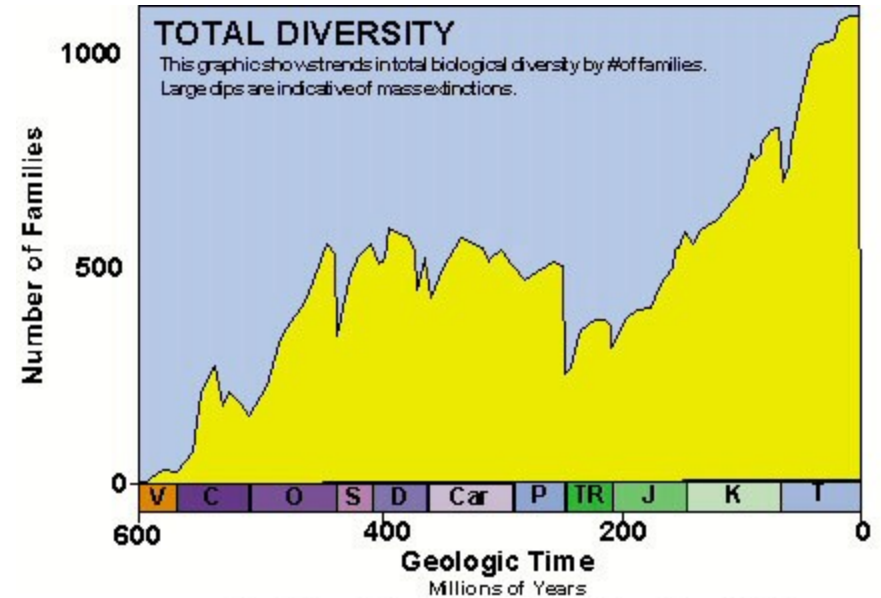
A broad range of organisms became extinct at the end of the Cretaceous, the most conspicuous being the **dinosaurs**. While **Birds** were the sole survivors among Dinosauria, but they also suffered heavy losses.

The last of the **pterosaurs** (flying reptiles that occurred in a great range of sizes) also vanished. **Mammals** suffered as well, with marsupials and multituberculates (rodent-like, tree-dwelling mammals) experiencing heavy losses; placentals were less affected. The great **sea reptiles** of the Cretaceous, the mosasaurs and plesiosaurs, also fell victim to extinction. Among mollusks, the **ammonites**, a diverse group of coiled cephalopods, were exterminated, belemnites nearly extinct, extinct the specialized **rudist** and inoceramid clams. As much as 57 percent of the **plant species** in North America may have become extinct as well.

K/T extinction has attracted more attention because it affected dinosaurs

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



Adapted from Sepkoski, Jr J.J. *Paleobiology* 19, no.1 (1993)

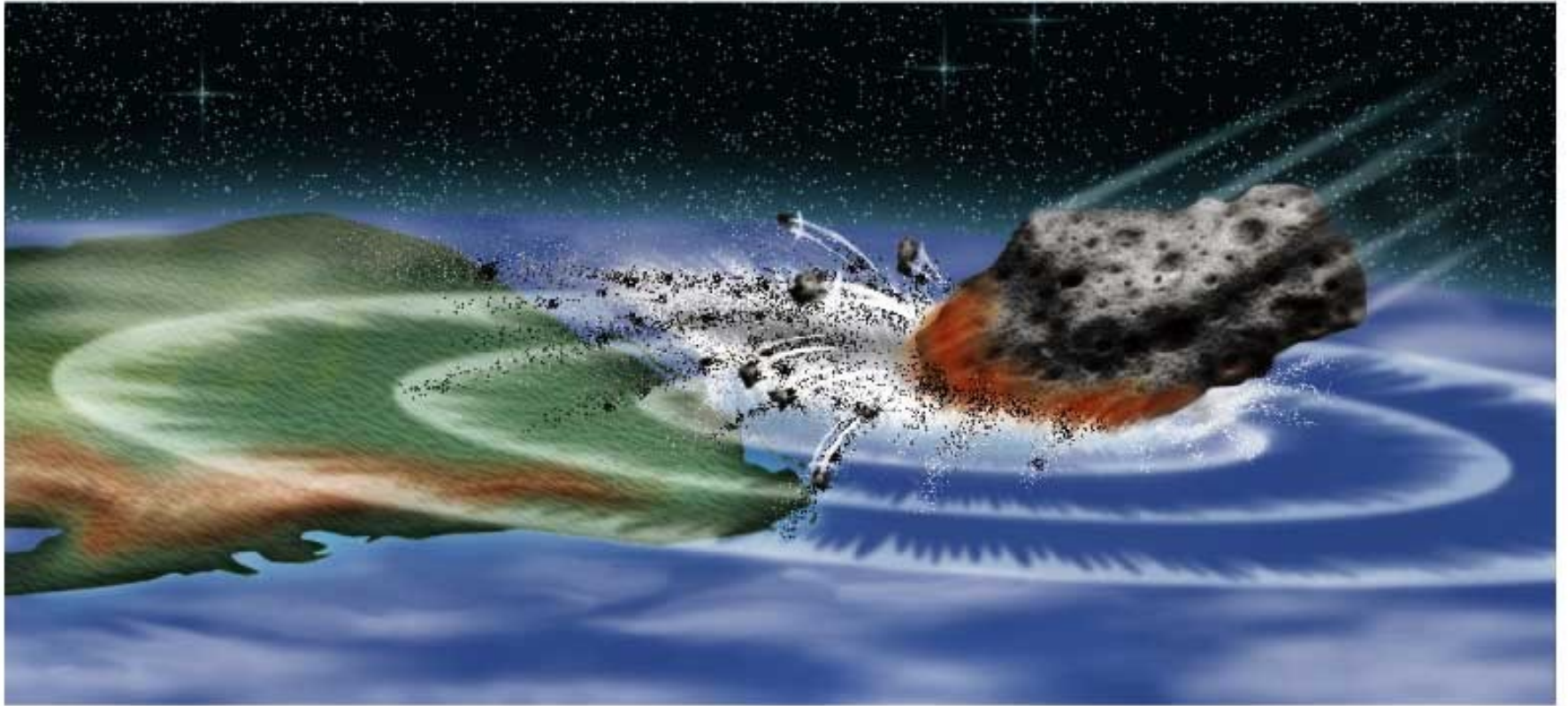
http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/totaldiversity.jpg

Meteorite Impact Crater

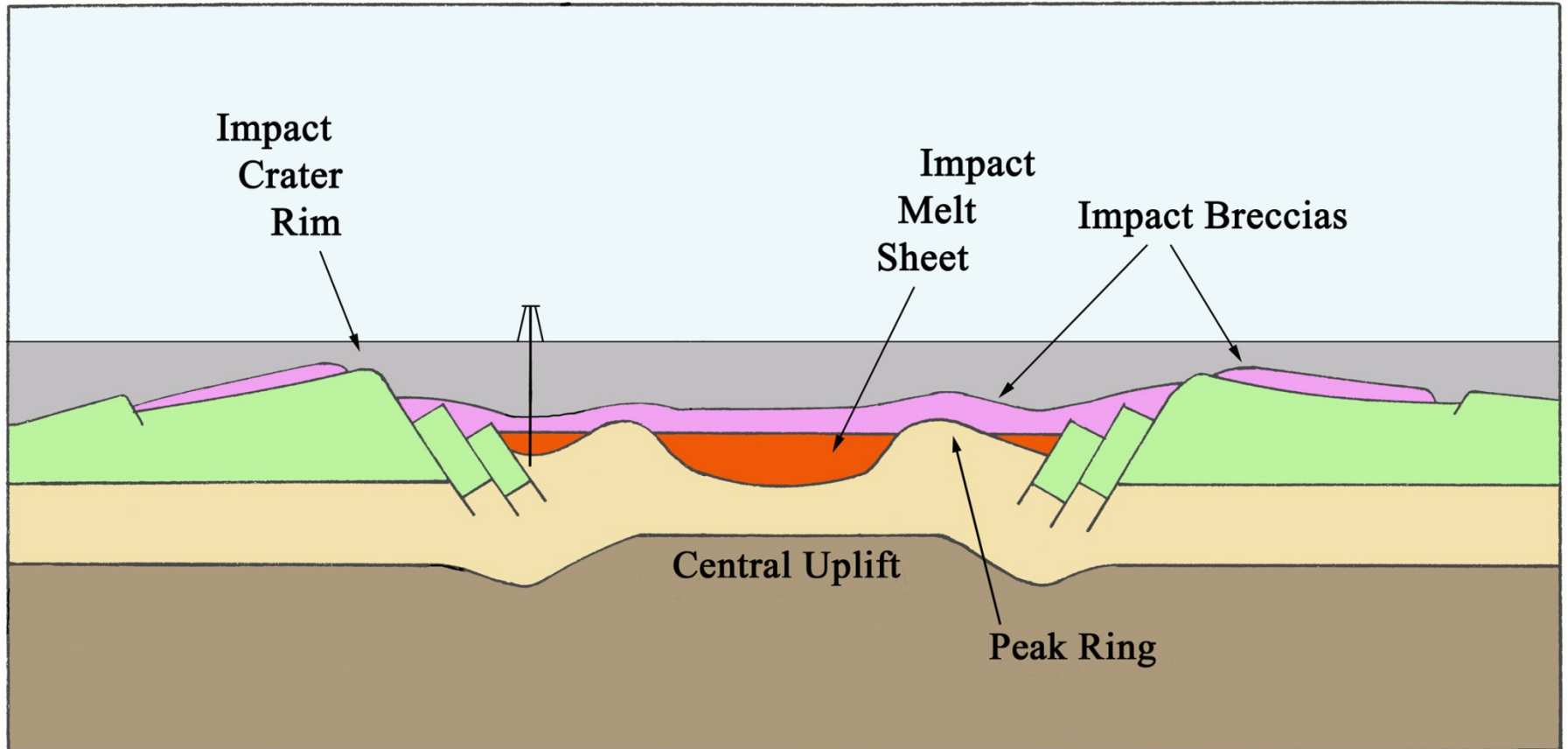
- Proposed meteorite impact crater
- Centered on Chicxulub on the Yucatán Peninsula of Mexico
- Discovered in 1950's, interpreted to be volcanic



Figure 24.14



Chicxulub Crater



David A. Kring, NASA/Univ. Arizona Space Imagery Center

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.

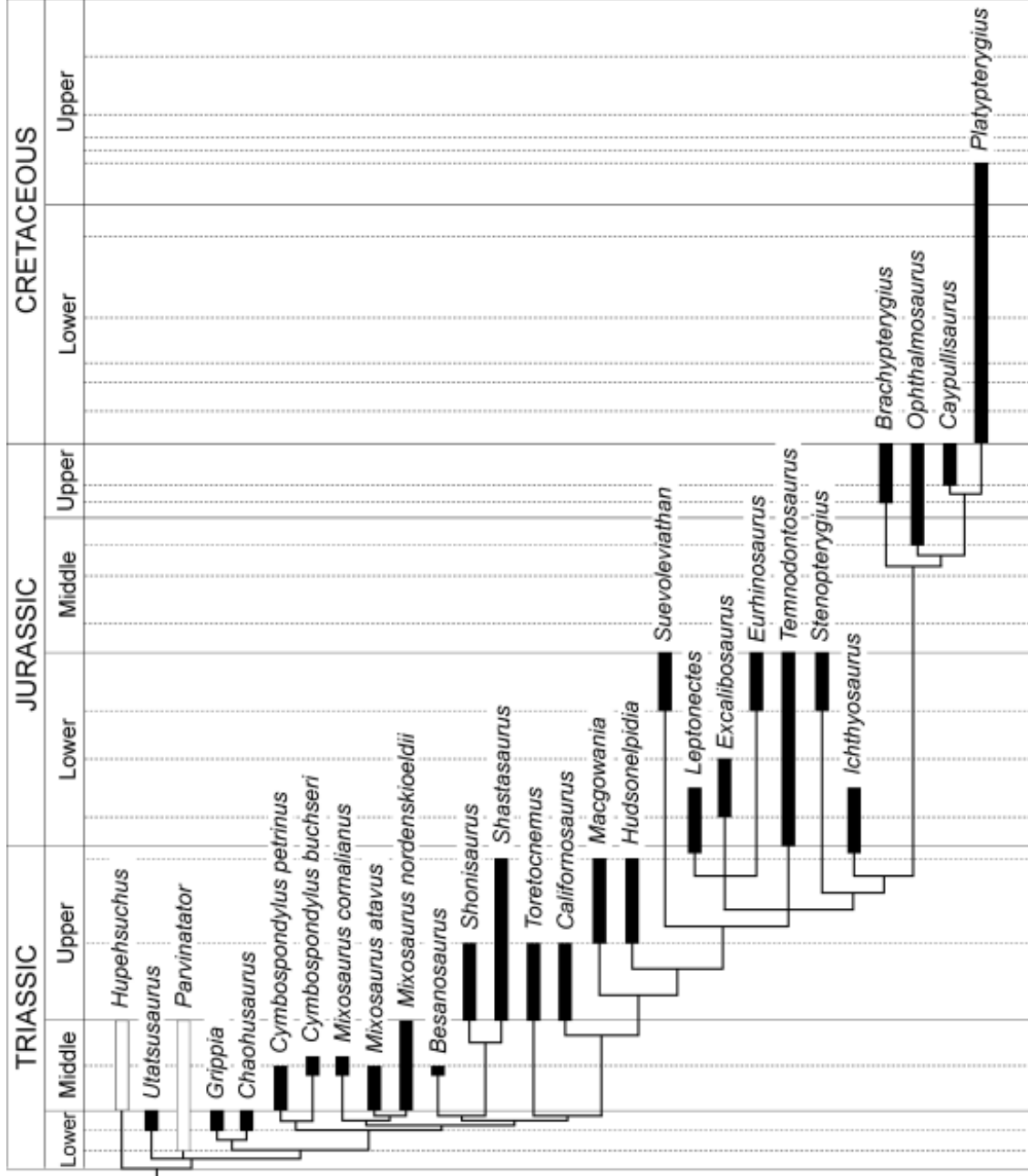
According to the impact hypothesis

- 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

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

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.



DIVERSIFICATION - DOMINANCE OF FISH-SHAPED BODY PLAN



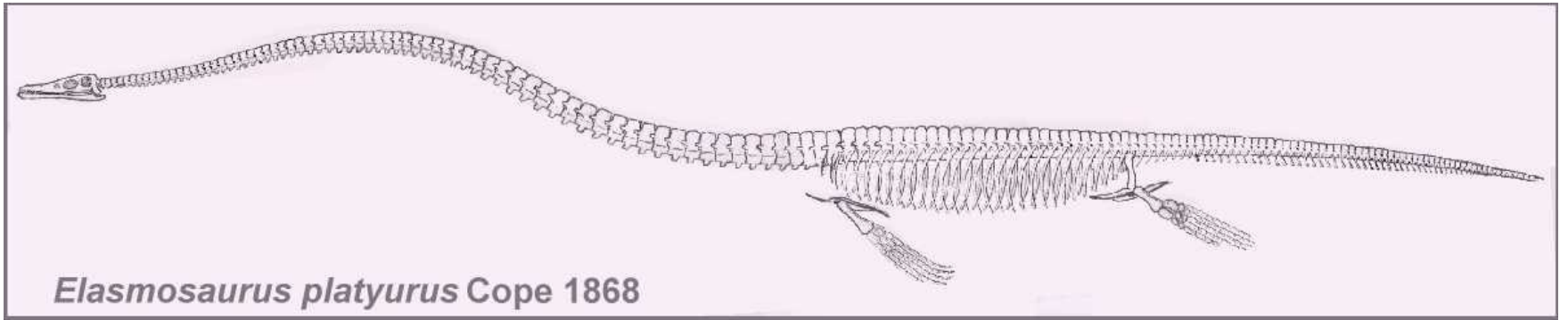
Liopleurodon ferox
There is an unofficial 'Premier League' in vertebrate palaeontology which consists of the animals which attract a lot of public attention. Its members include *T.rex*, *Seismosaurus*, *Argentinosaurus*, *Giganotosaurus* and so on - the biggest and fiercest extinct animals. When the 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.



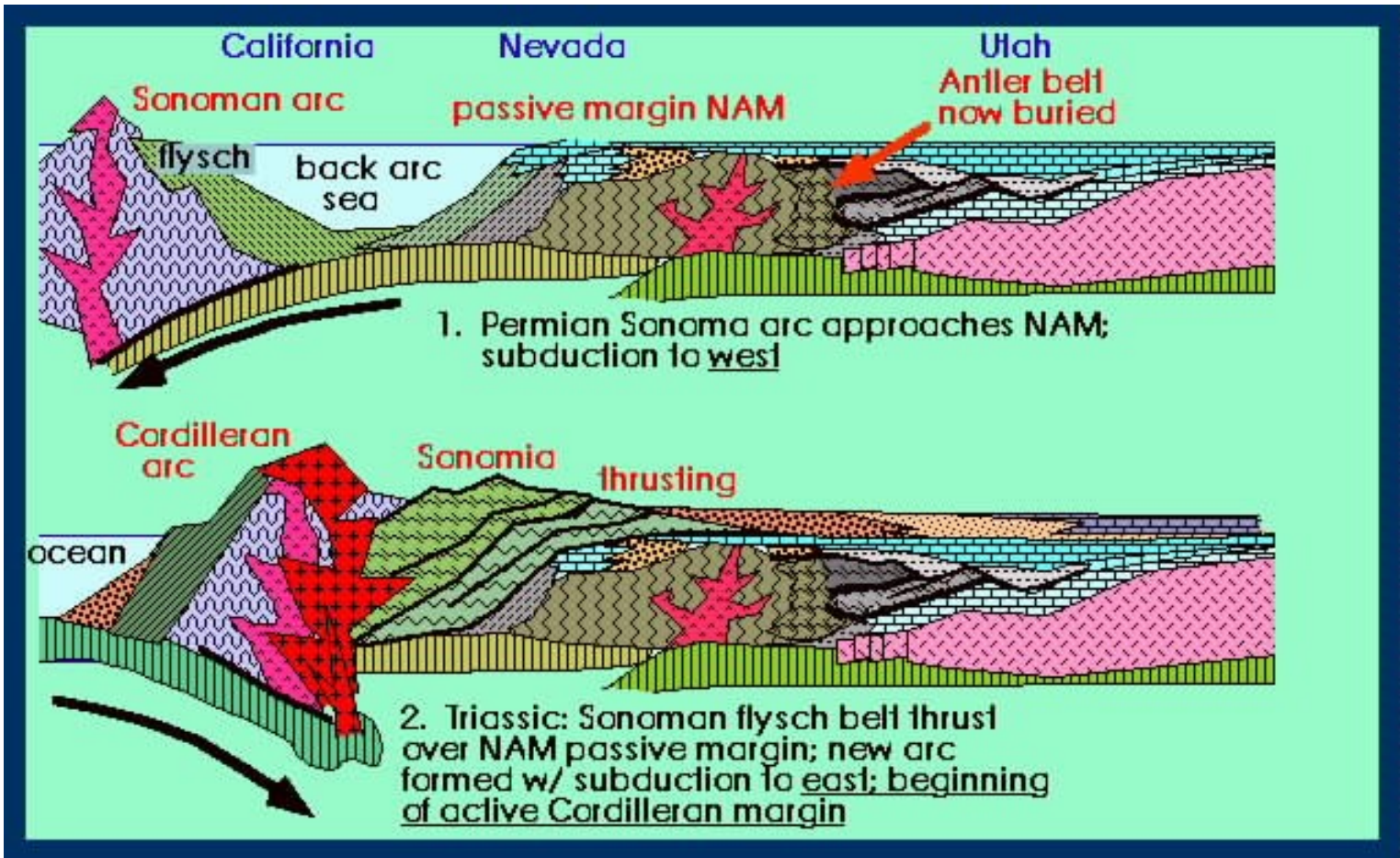
What was *Liopleurodon*?

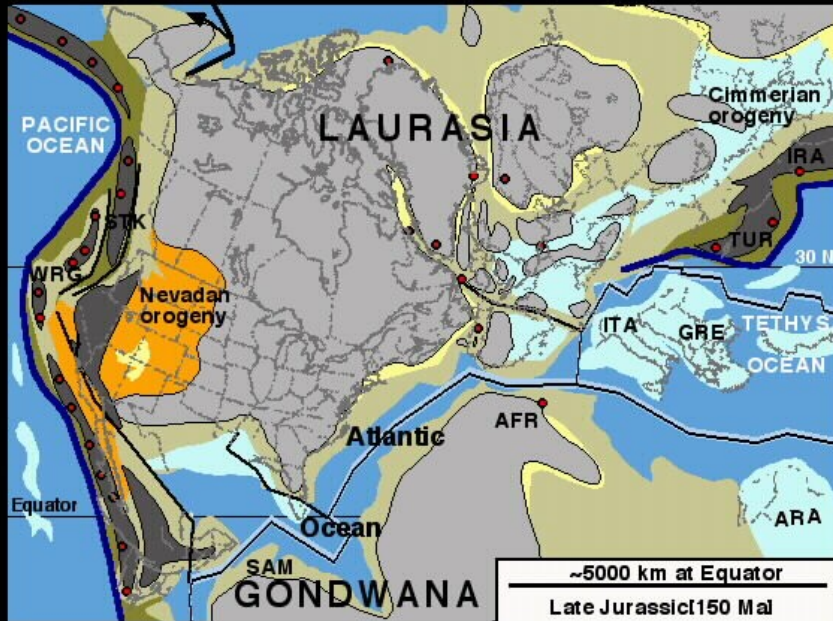
Liopleurodon was a large predatory marine reptile. Its remains are found in the Callovian Oxford Clay of Eastern England and Northern France, and date from about 160 million years ago.



Elasmosaurus platyurus Cope 1868

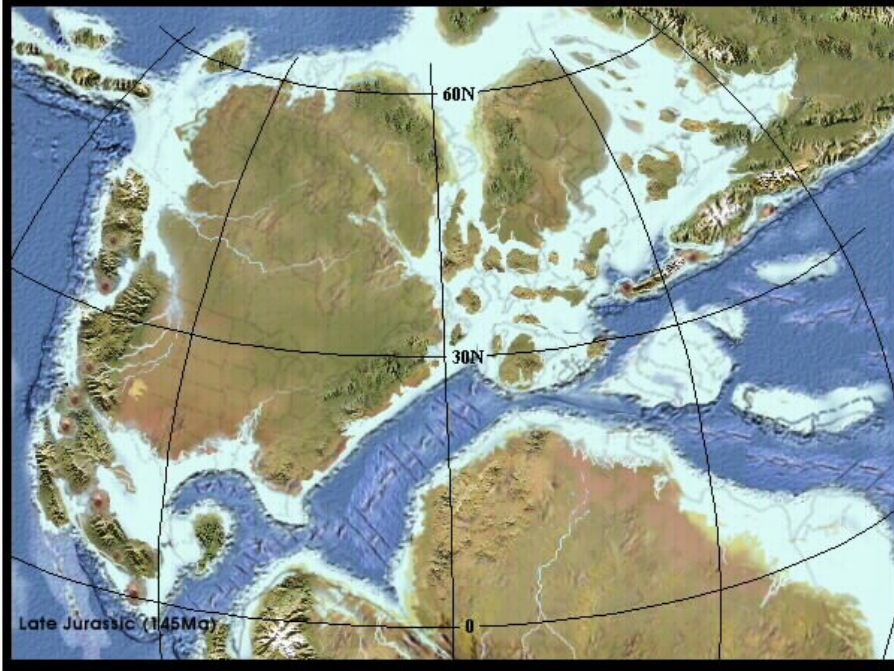
Marine crocodylians appear in Early Jurassic. Heyday of the ichthyosaurs; high diversity of plesiosaurs (including forms over 14 m long!!).

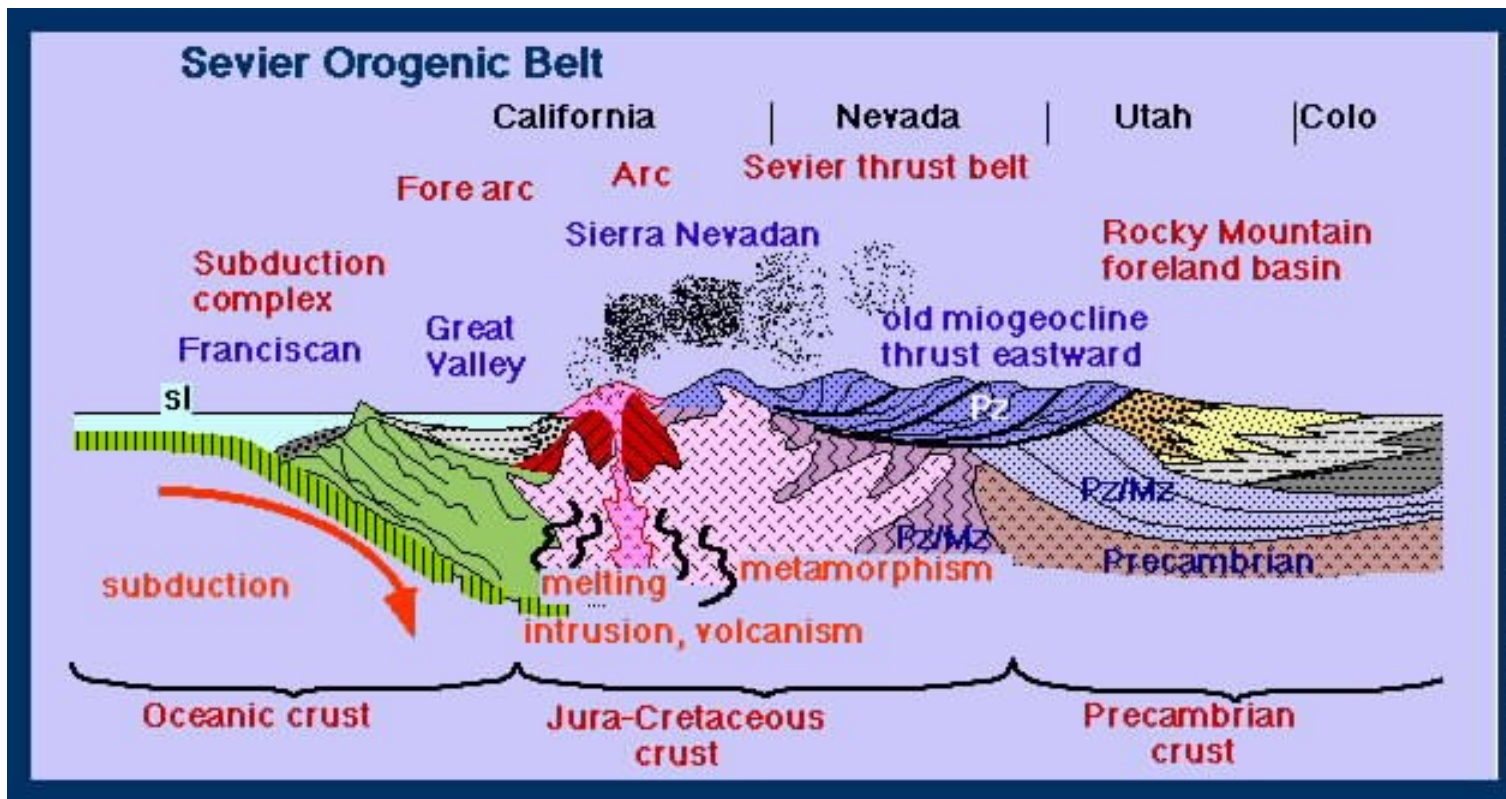




During Late Jurassic, Nevadan Orogeny:

- 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 **Morrison Formation**

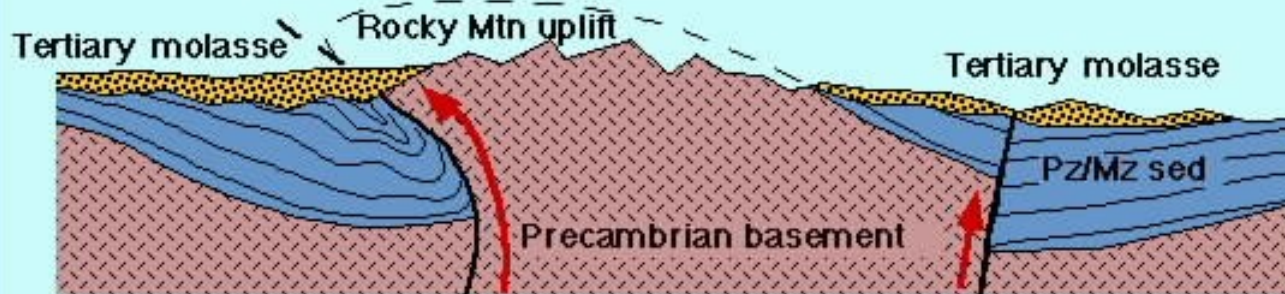




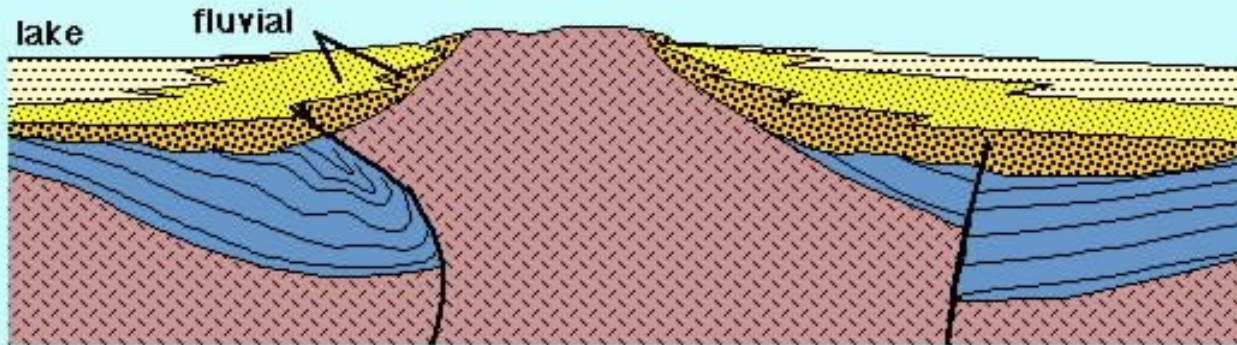
During the mid-Cretaceous:

- 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 in regions further eastward
- Eastward migration of mountain range from Washington/Oregon to Idaho
- This new style is called **Sevier Orogeny**: lasts until near the end of the Late Cretaceous
- Within forearc basin, many regional transgression-regression events

Laramide Style Uplifts



1. Paleocene - Eocene



2. Late Eocene

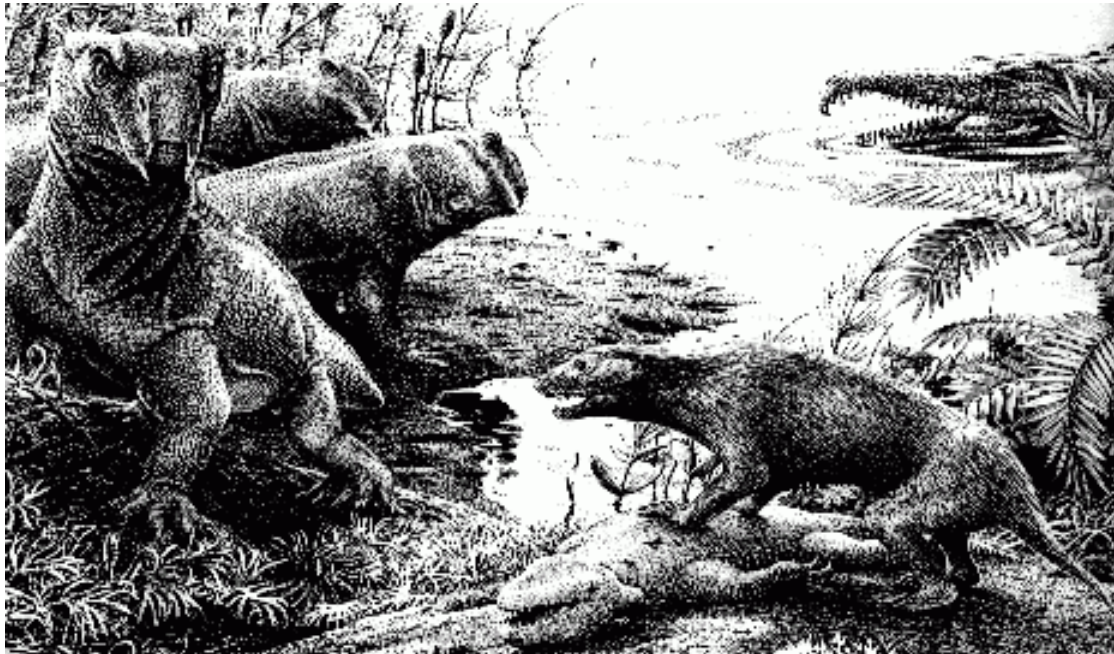
During Maastrichtian:

- Beginning of **Laramide Orogeny** 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 *Lystrosaurus* 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:

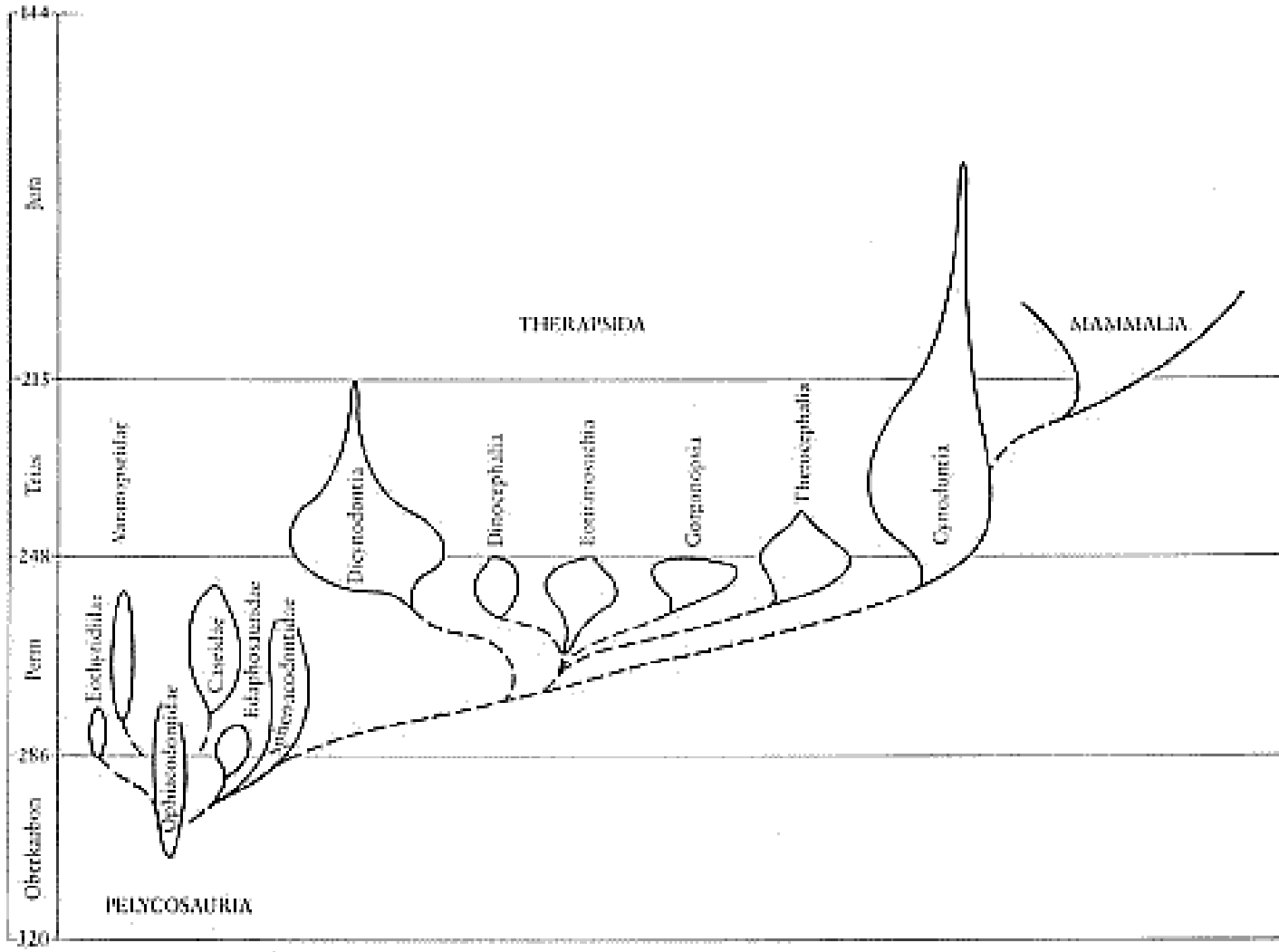
Continued insect diversification throughout the Mesozoic, including:

- 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



Prototheria (monotremes 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 (triconodonts)

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







CERATOSAURUS *nasicornis*
& ***STEGOSAURUS*** *armatus*

CAMARASAUR
US supremus
& ***ALLOSAUR***
RUS fragilis

***RHAMPHO
RHYNCHUS***





COELOPHYSIS



Figure 10.9: (A) Reconstruction of *Williamsonia seawardiana* 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

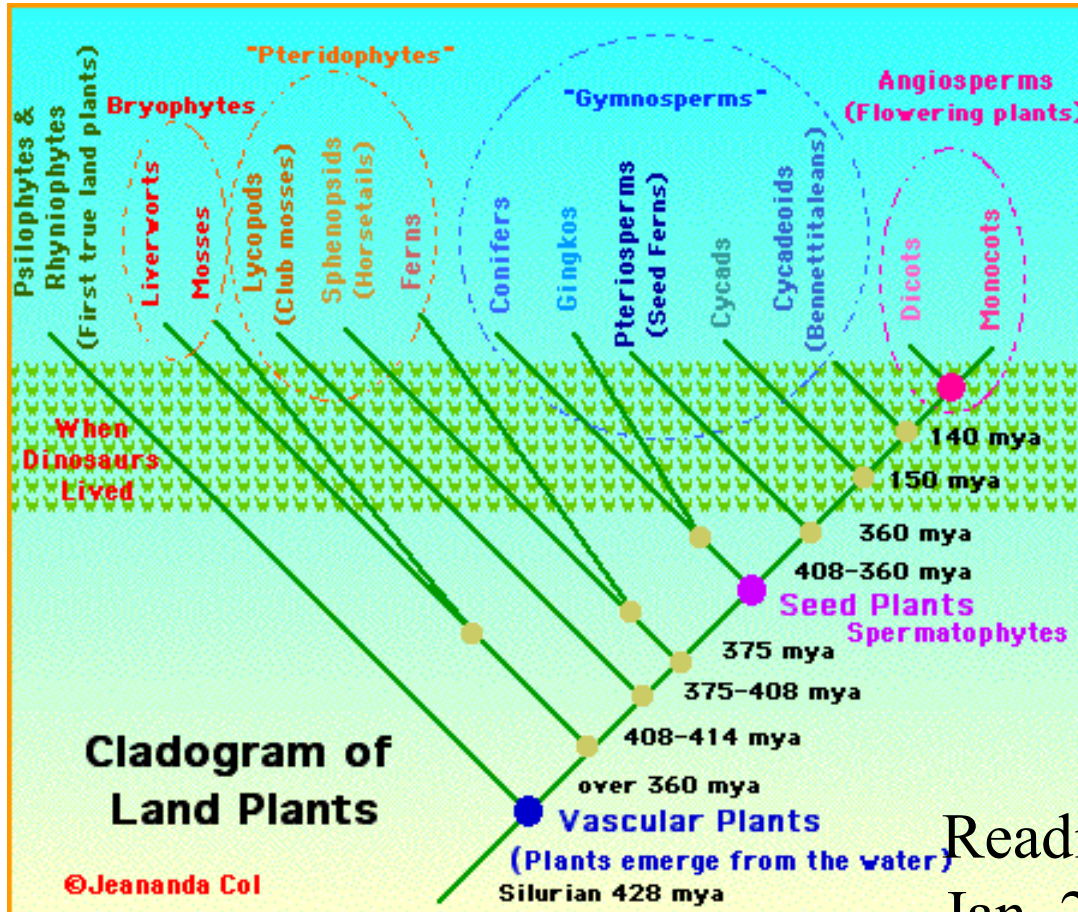


Archaeofructus liaoningensis

* 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).



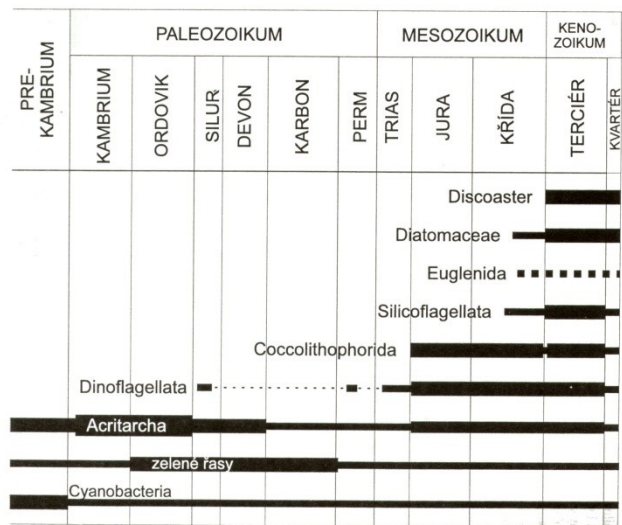
Reading: Chap. 1
 Jan. 28 Every Rock is
Lithology

Reading: Chap. 2
 LAB: Description and

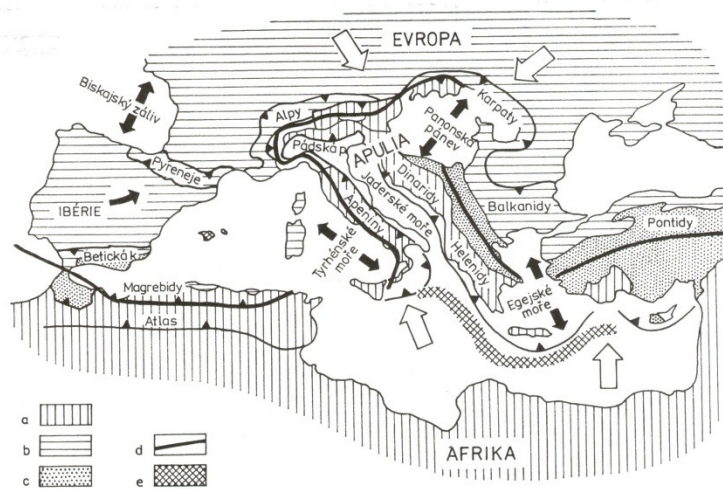
- Cordilleran Highlands
 - Triassic - Sonoma - CA, Nev, ID
 - Jurassic - Nevadan - CA, Nev, ID
 - Jurassic/Cretaceous - Sevier - Nev,Ut
 - Cretaceous/Tertiary - Laramide

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

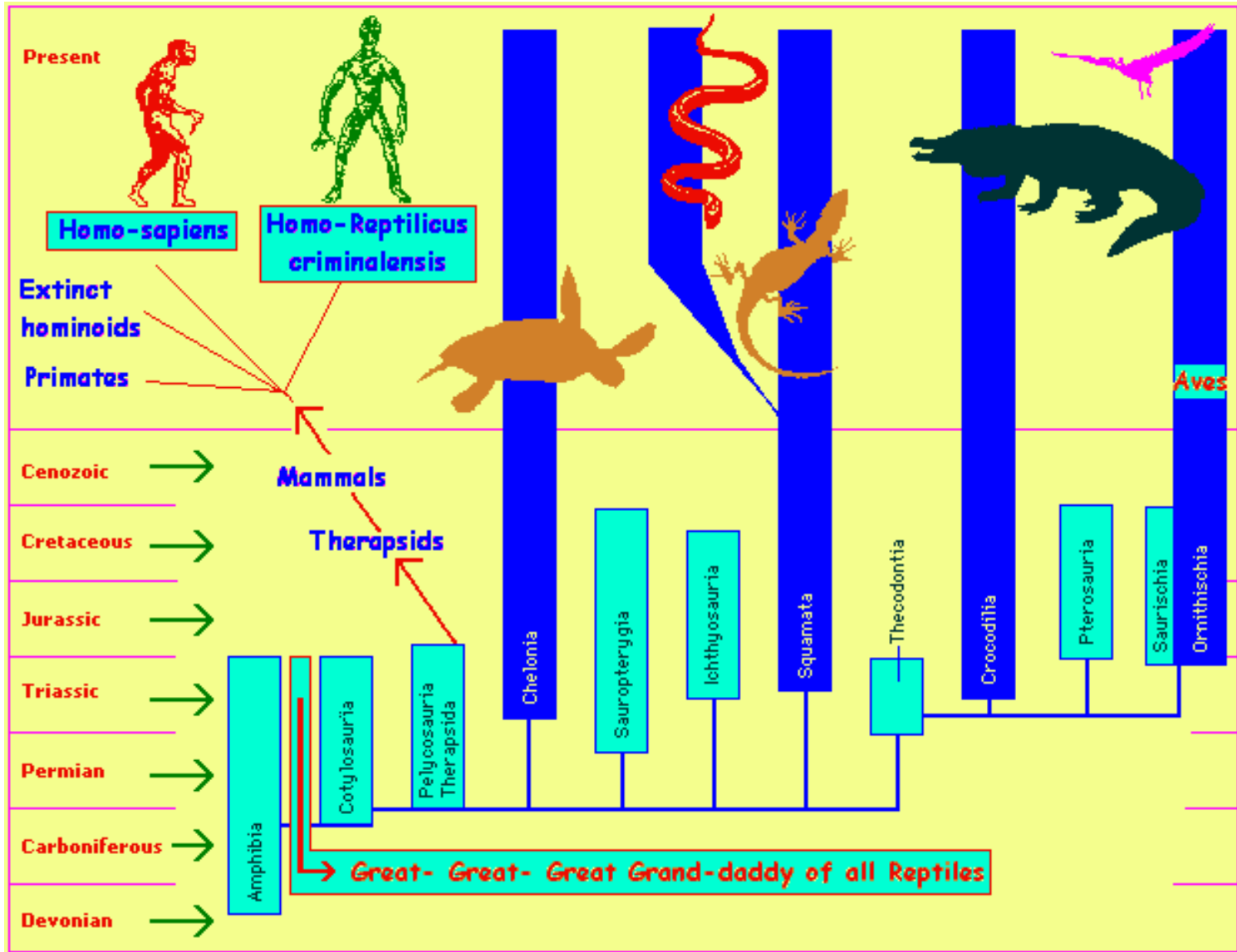
Tab. 62. Základní členění mesozoika.



100

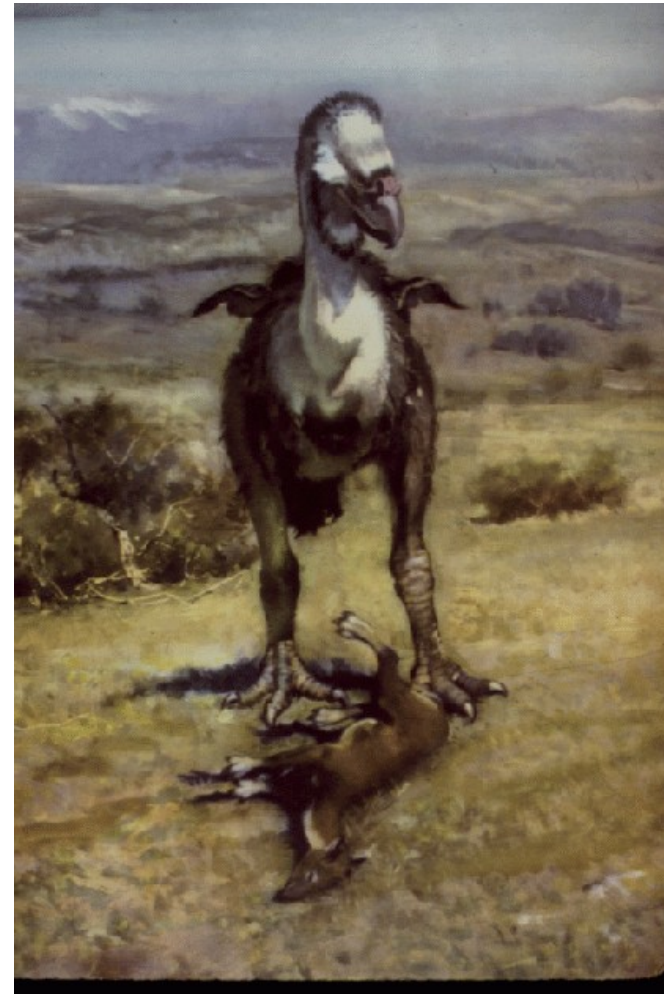


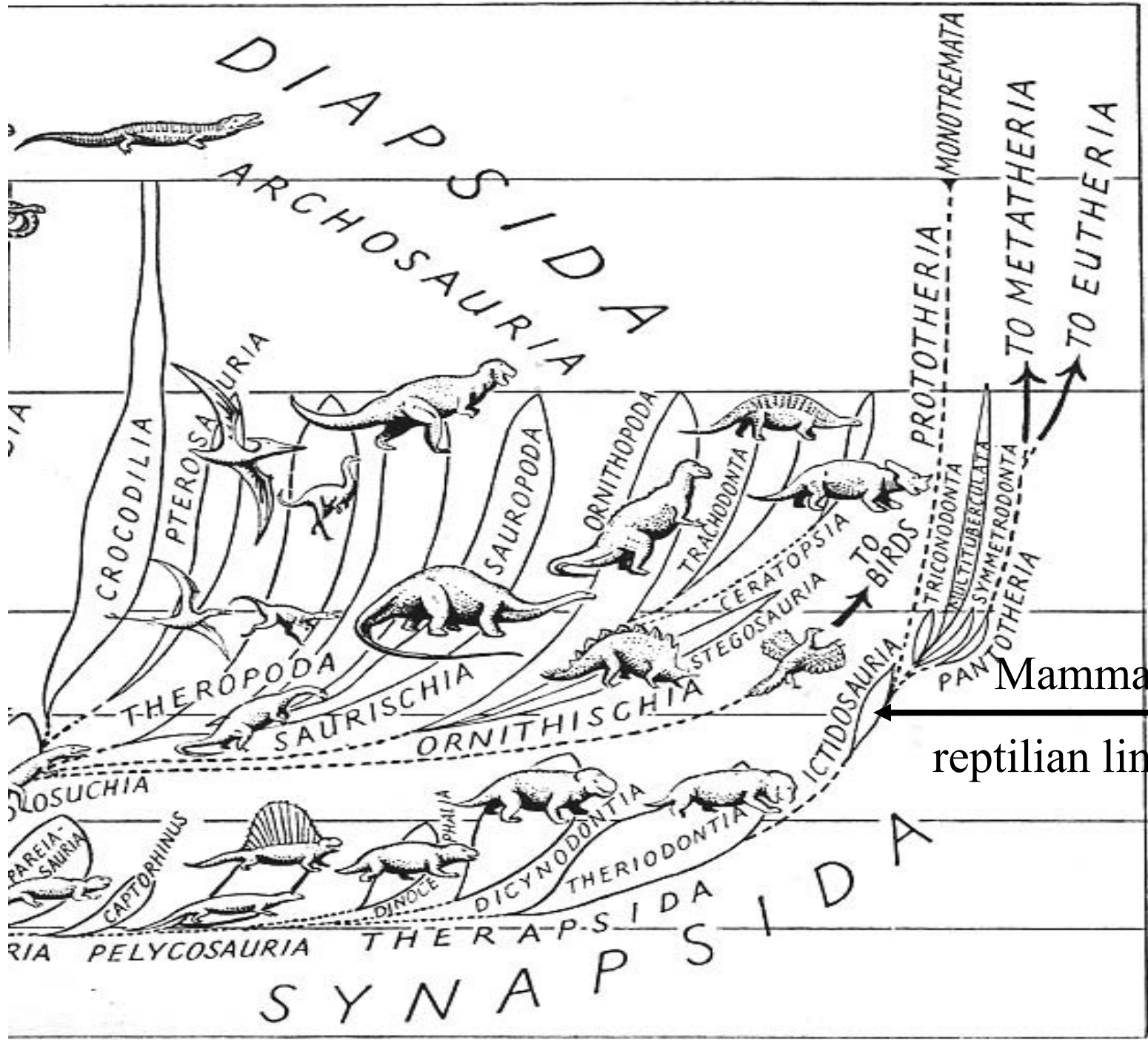
Obr. 72. Alpínský orogén v Evropě a Malé Asii. Legenda: a – africká platforma a deformované horniny afrického okraje, b – evropská platforma a deformované horniny evropského okraje, c – tetýdní oceánské horniny, d – okraje desek, e – středomořský hřbet, prázdňé šípky – hlavní směry konvergence, píné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



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

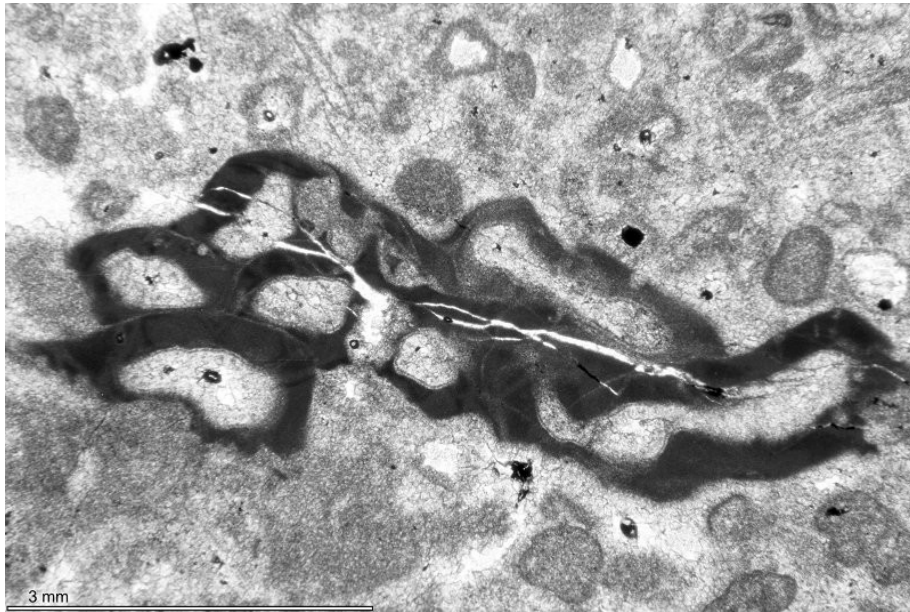




Mammalian-reptilian line

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

Tubiphytes





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.

Archaic Mammals of the Jurassic

Mammalian radiation of the early Jurassic

- Triconodontia (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 tribosphenic molar)
& ancestor of therian mammals (Eutheria & Metatheria)