The Mesozoic World

A quick review of Dinosaurian animals

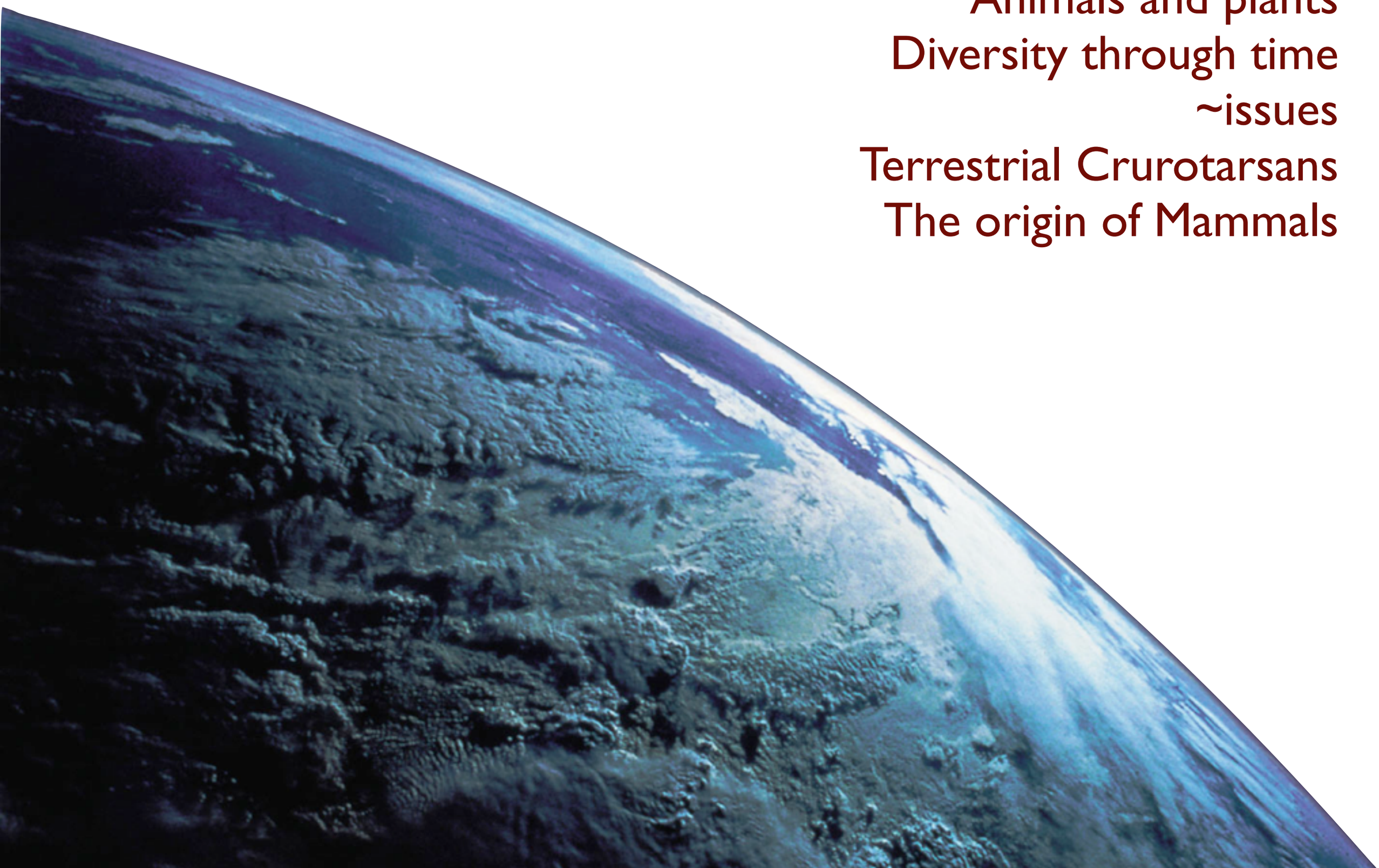
Animals and plants

Diversity through time

~issues

Terrestrial Crurotarsans

The origin of Mammals



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

Some early terrestrial archosaurs in the Triassic...

remember these guys?

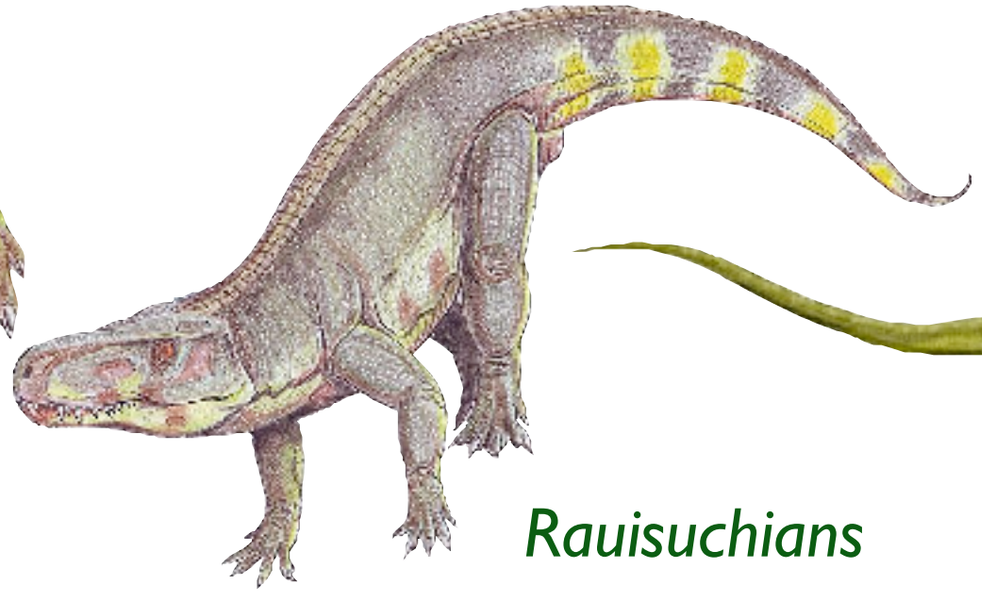
Rhyncosaurs

early Triassic

VERY abundant

Herbivorous

Terrestrisuchus



Rauisuchians

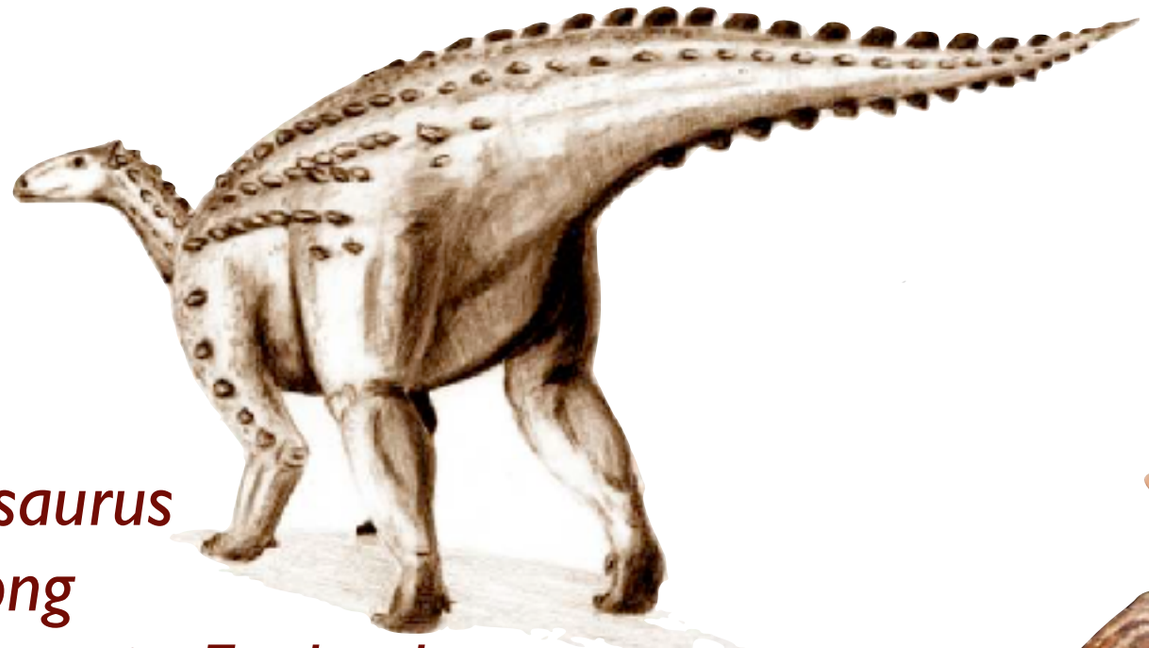
Saltoposuchus

Proterosuchus

Basal Archosaur

Ornithischians!

Thyreophorans: Stegosaurs & Ankylosaurs



Scelidosaurus
13 ft long
Early Jurassic, England

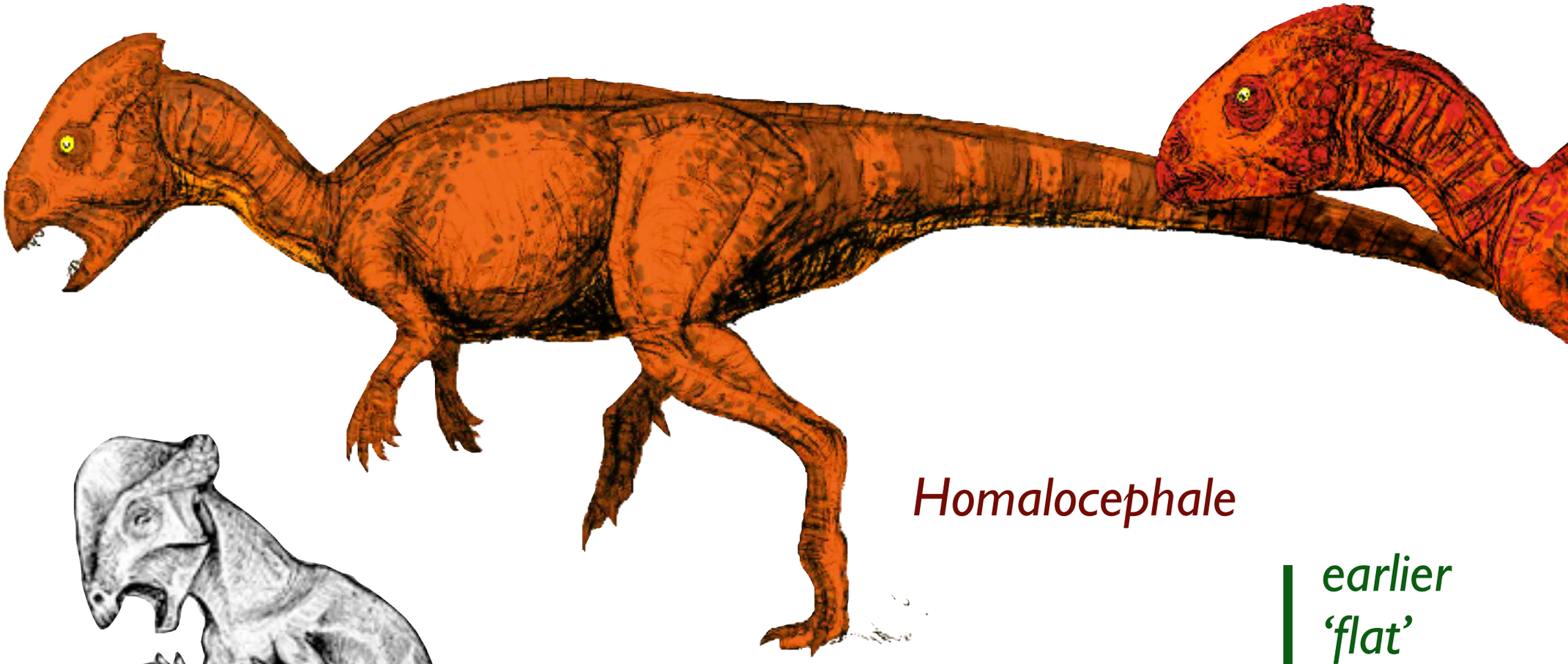
Gastonia

Stegosaurus

Clever girl...

Kanyesaurus westicus

Ceropoda: Marginocephalia: Pachycephalosaurs



Homalocephale

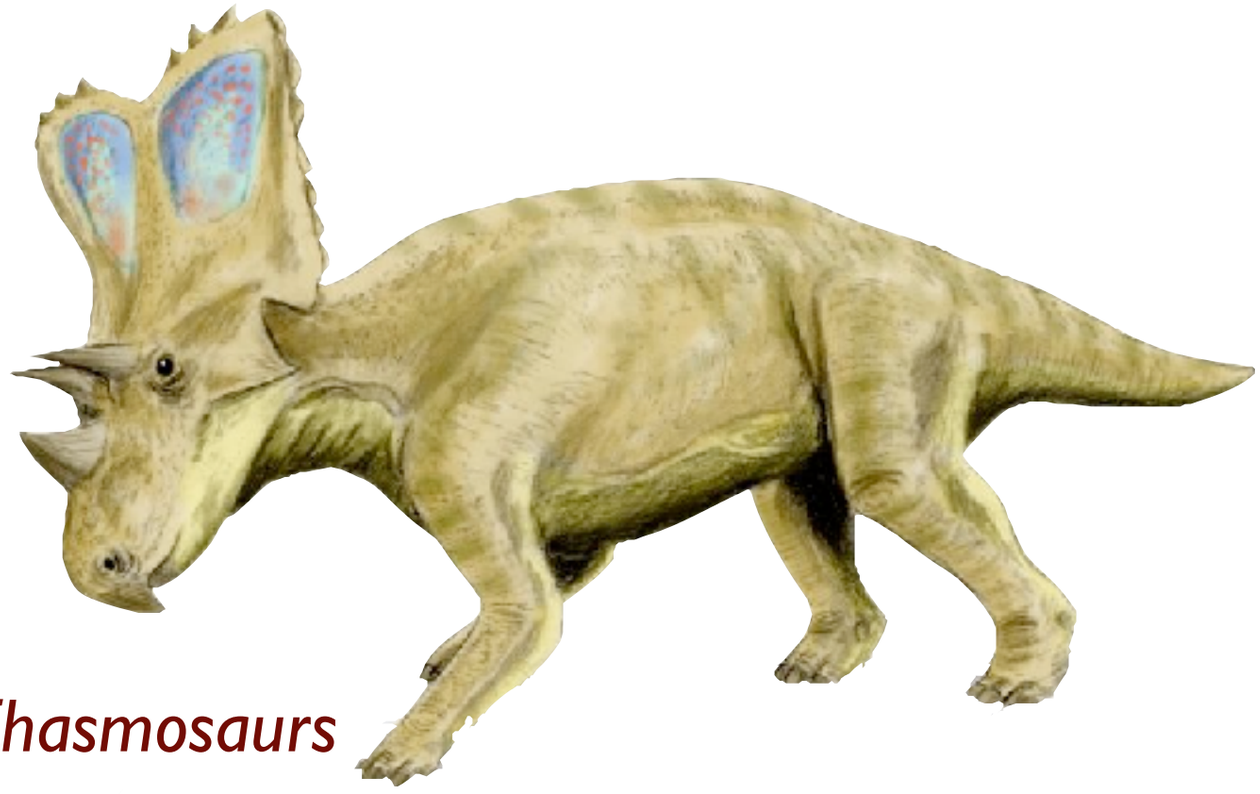
Stegoceras

earlier
'flat'

derived
'round'

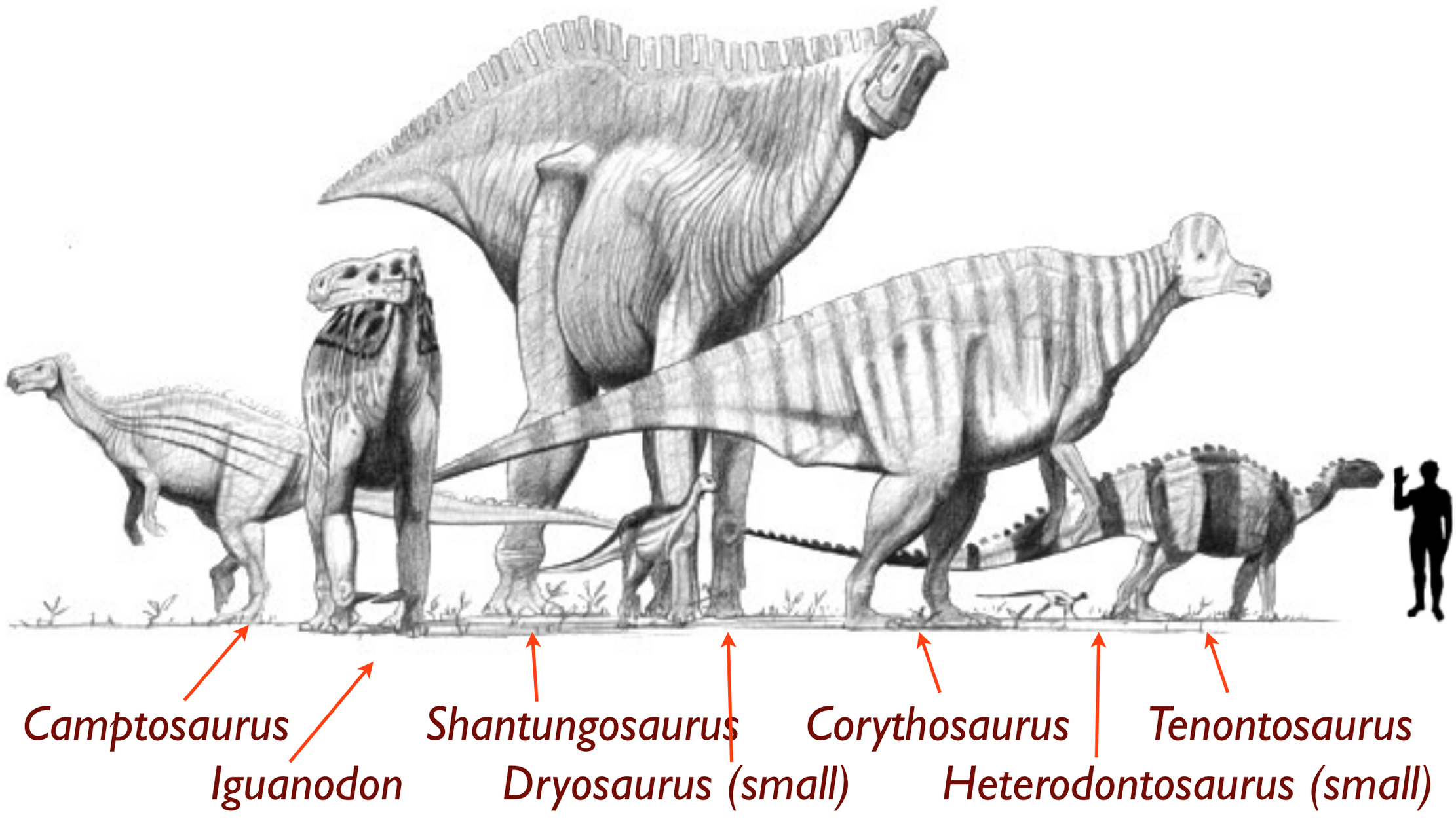
Ceropoda: Marginocephalia: Ceratopsia

Centrosaurs

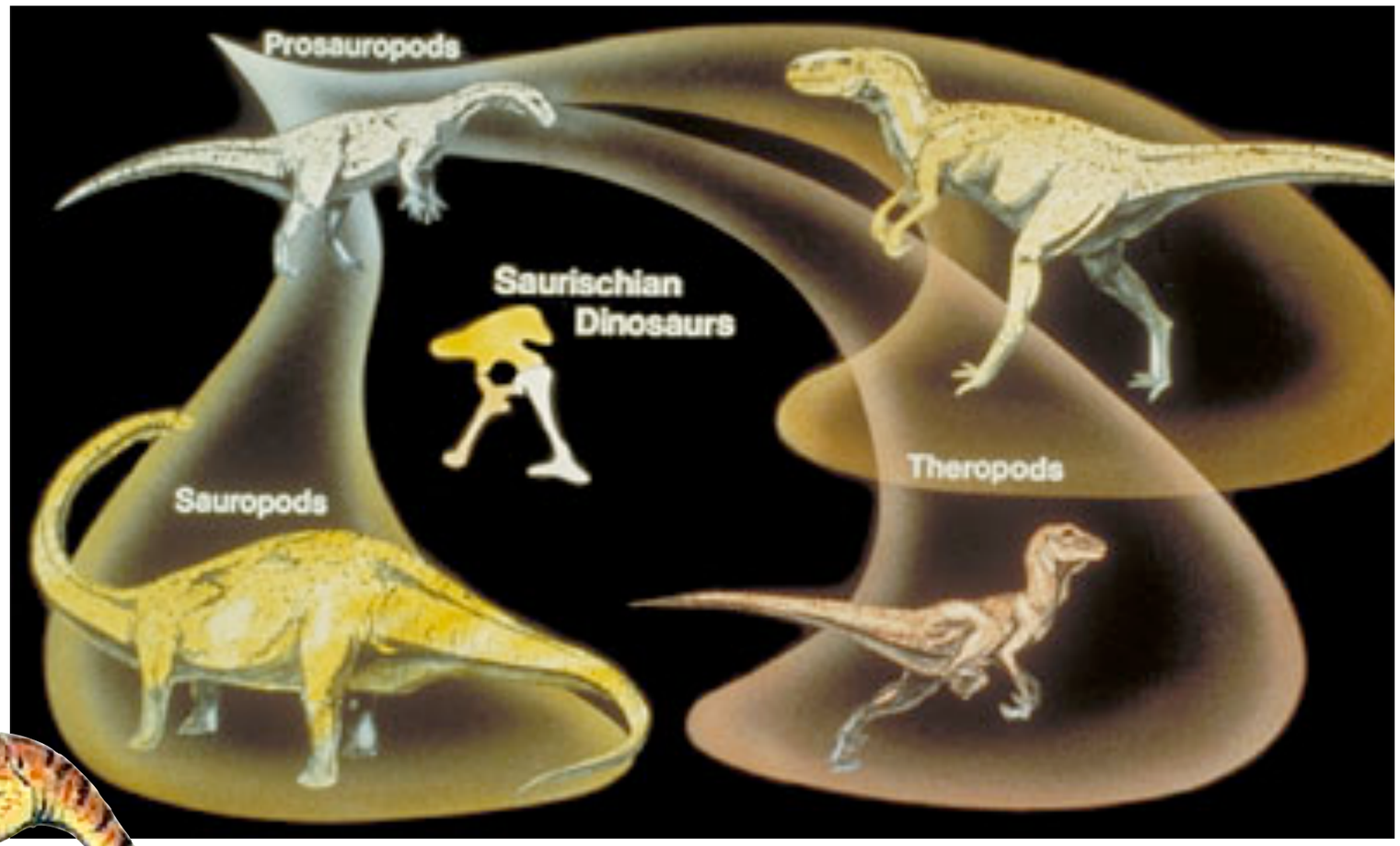


Chasmosaurs

Ceropoda: Ornithopoda



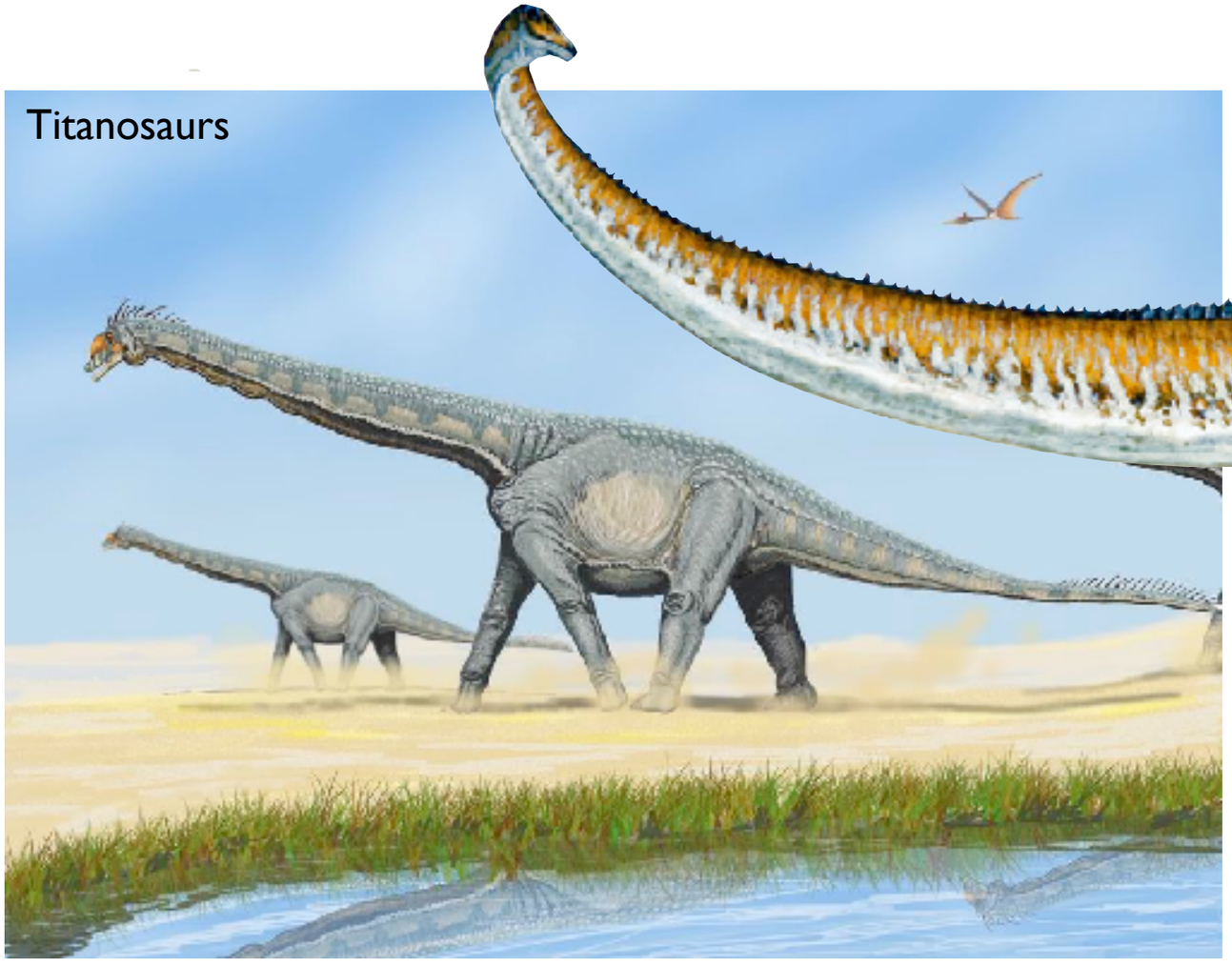
Saurischians!

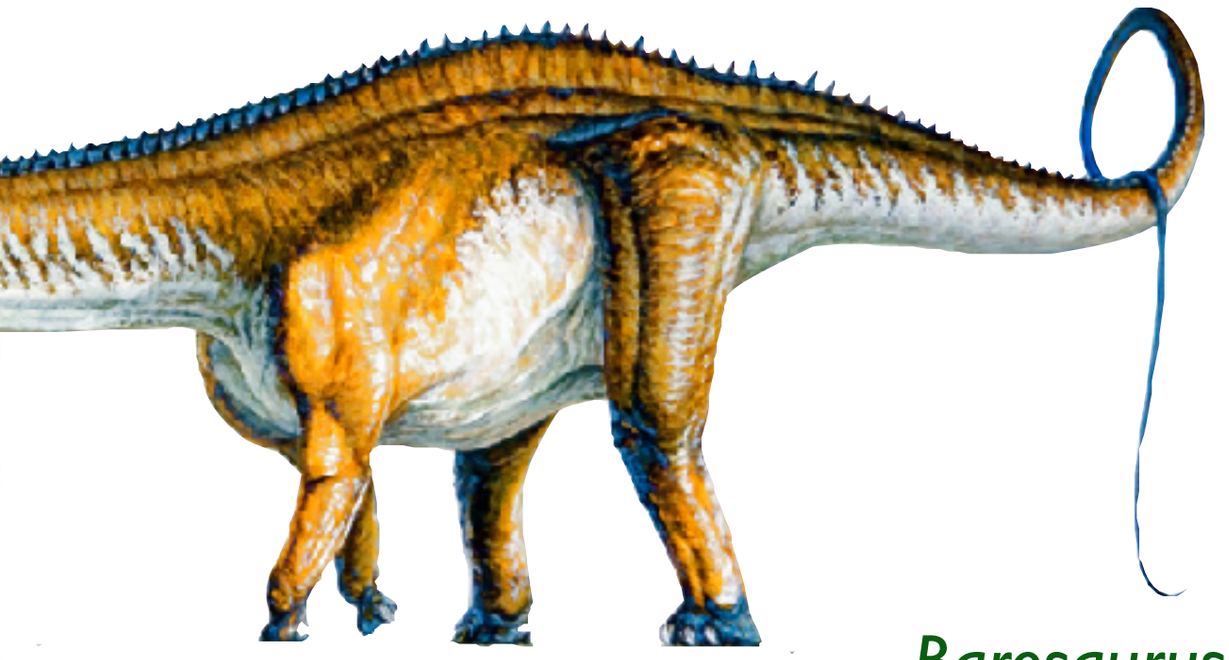


Sauropodamorpha

Coloradisaurus
Prosauropod

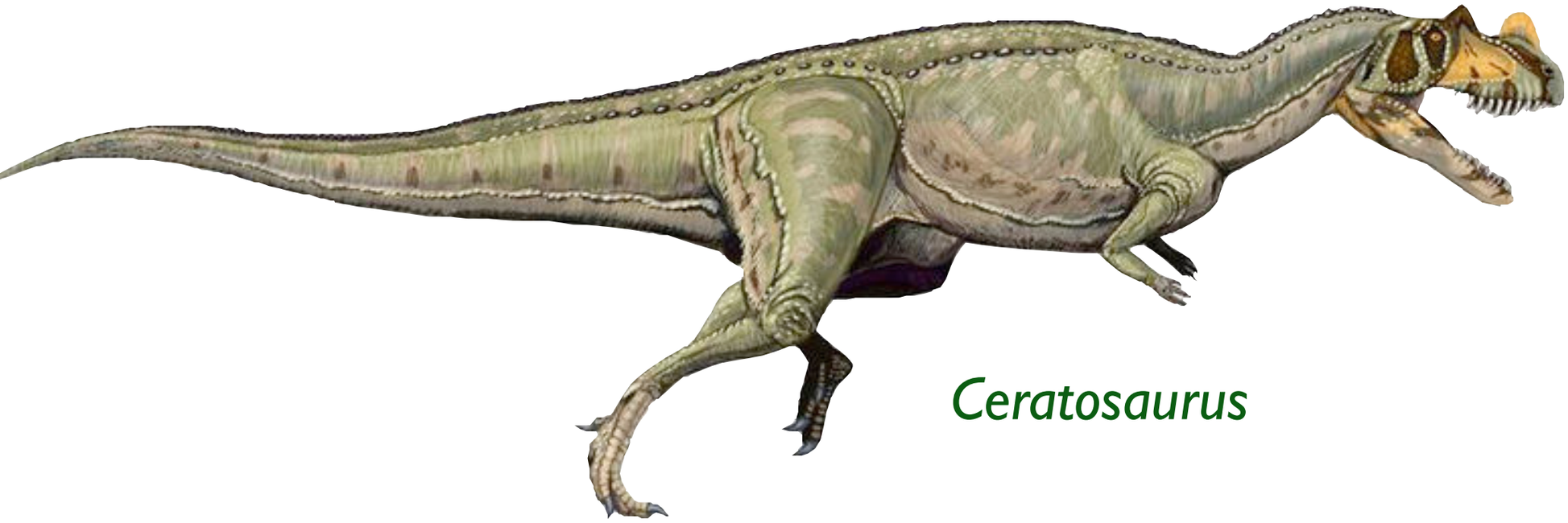
Brachiosaurus





Barosaurus
Diplodocid

Non-avian Theropods



Ceratosaurus

Sinvenator

Giganotosaurus; Late Cretaceous South America
16 meters (52 ft) long

Struthiomimus; Late Cretaceous
N. America 4.3 meters (14 ft) long

Bird-like non-avian Theropods

Microraptor

Mahakala

Avian Theropods

Archaeopteryx

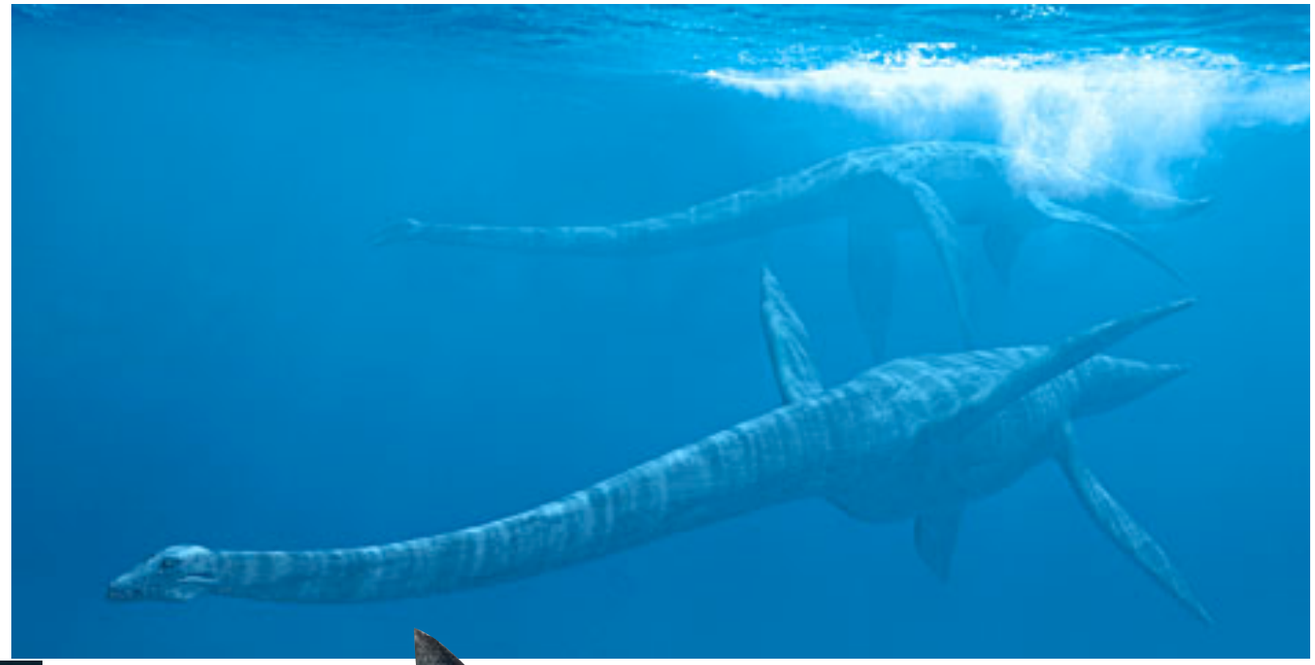
Frigate Bird

Raven

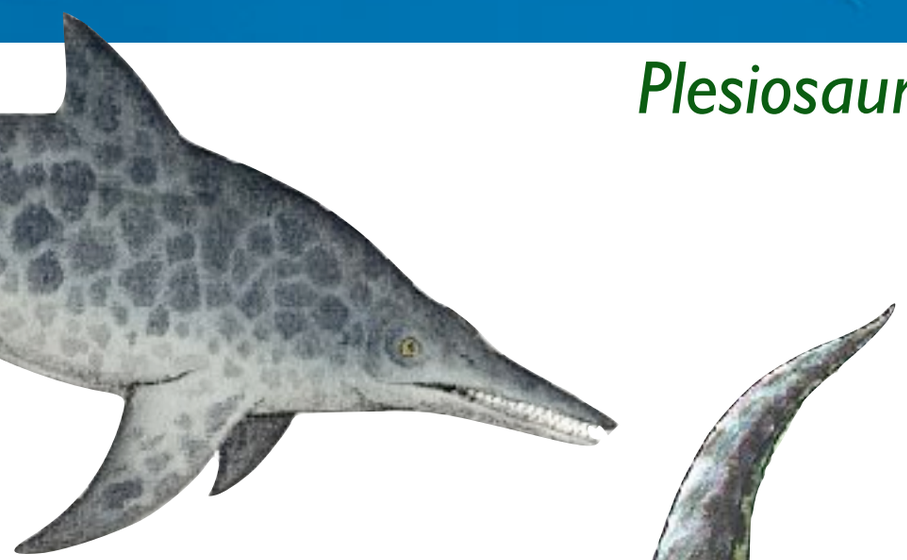
Pterosaurs!

Marine reptiles!

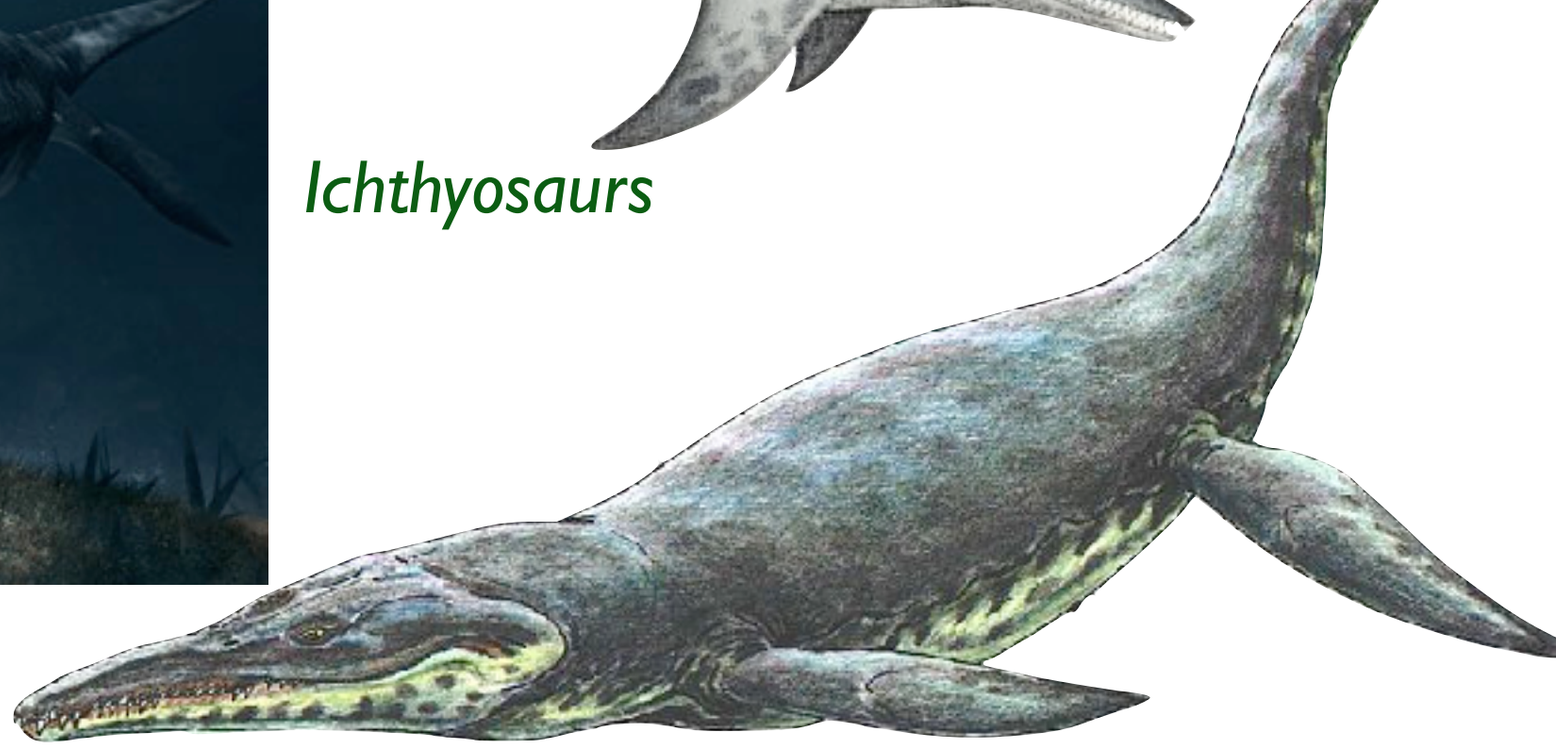
Mosasaurs



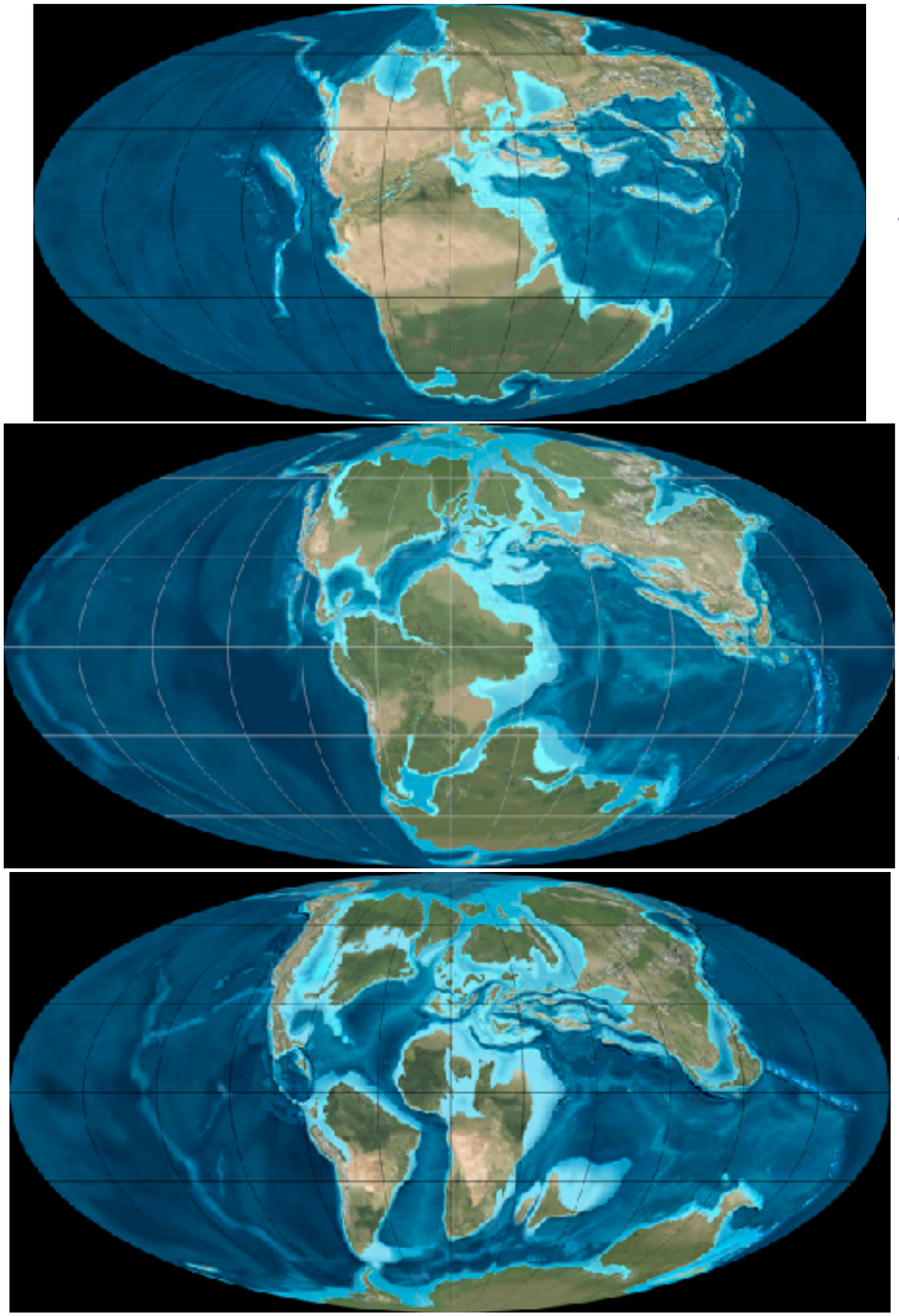
Plesiosaurs



Ichthyosaurs



Pliosaurs



Big scale questions:

Biogeography

When/How did dinosaurs originate?

How does diversity change through time?

Are there spatial patterns among dinosaur groups?

Are there temporal patterns among dinosaur groups?

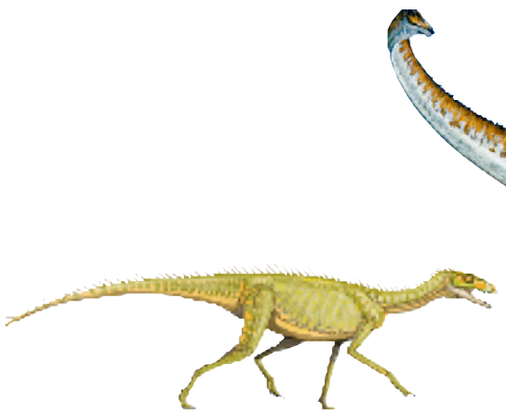
Ecology

Are there correlations between groups?

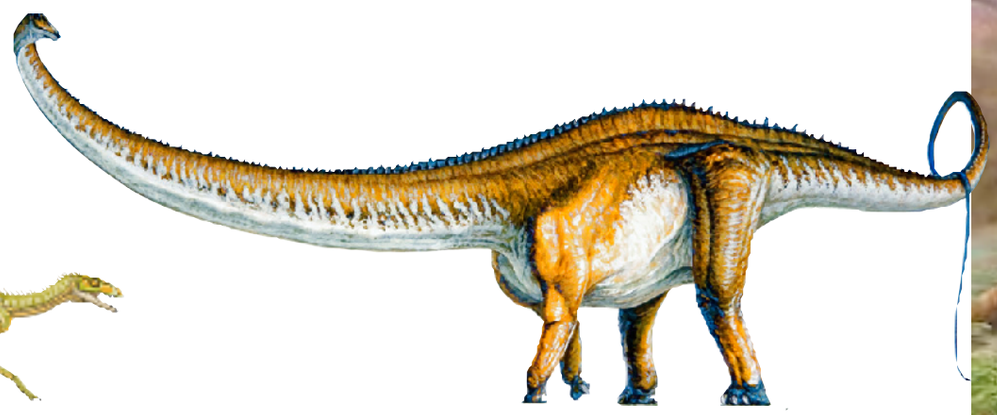
Dinosaurs + plants?

When/How did dinosaurs originate?

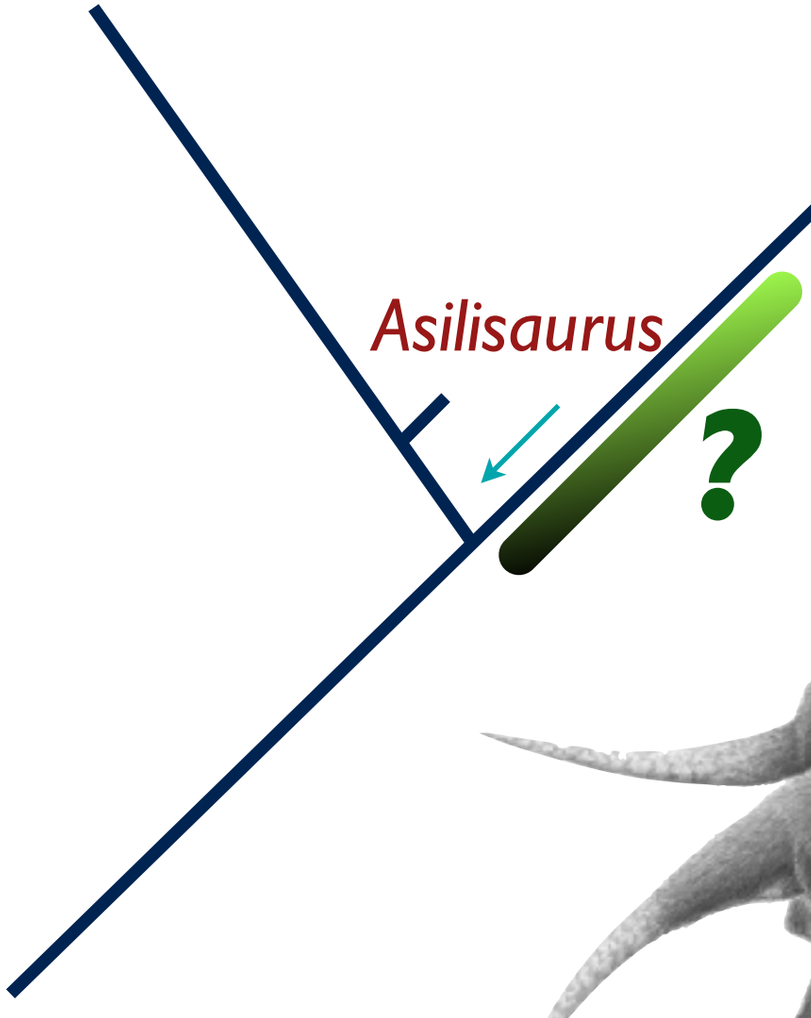
245 to 230 Ma



Silesauridae



Dinosauria



Asilisaurus

Morganucodon

nature COMMUNICATIONS

ARTICLE

DOI: 10.1038/s41467-018-03996-1 OPEN

Dinosaur diversification linked with the Carnian Pluvial Episode

Massimo Bernardi[1,2], Piero Gianolla[3], Fabio Massimo Petti[1,4], Paolo Mietto[5] & Michael J. Benton[2]

Dinosaurs diversified in two steps during the Triassic. They originated about 245 Ma, during the recovery from the Permian-Triassic mass extinction, and then remained insignificant until they exploded in diversity and ecological importance during the Late Triassic. Hitherto, this Late Triassic explosion was poorly constrained and poorly dated. Here we provide evidence that it followed the Carnian Pluvial Episode (CPE), dated to 234–232 Ma, a time when climates switched from arid to humid and back to arid again. Our evidence comes from a combined analysis of skeletal evidence and footprint occurrences, and especially from the exquisitely dated ichnofaunas of the Italian Dolomites. These provide evidence of tetrapod faunal compositions through the Carnian and Norian, and show that dinosaur footprints appear exactly at the time of the CPE. We argue then that dinosaurs diversified explosively in the mid Carnian, at a time of major climate and floral change and the extinction of key herbivores, which the dinosaurs opportunistically replaced.

Continental / marginal marine

Carbonate ramps: Outer; Inner to middle

Carbonate platforms: Microbial slope / mounds; Tidal flat / lagoon

Basins

Ma GTS2012* | Period / Epoch | Age / Stage | Substage | Ammonoid Zone/Subzone

Triassic

Upper

Norian

Lacian

G. paulckei

Guembelites jandianus

Carnian

Tuvalian

Anatropites spinosus

Tropites subbullatus

Tropites dilleri

Julian

Austrotrachyceras austriacum

Trachyceras aonoides

Trachyceras aon

Daxatina canadensis

Middle

Ladinian

Longobardian

Fassanian

Protrachyceras

"F." regoledanus

A. neumayri

P. longobardicum

"E." gredleri

P. margaritosum

Eoprotrachyceras

"A." recubariense

E. curionii

Anisian

Illyrian

Nevadites

Hungarites

A. avisianum

R. reitzi

Paraceratites

P. trinodosus

S. abichi

Pelsonian

Balatonites

S. binodosus

B. balatonicus

C. cucense

Bithynian

Kocaelia

Subzone 2

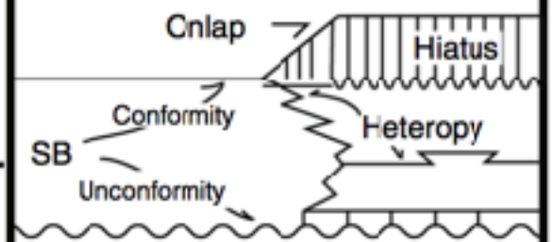
A. ismidicus

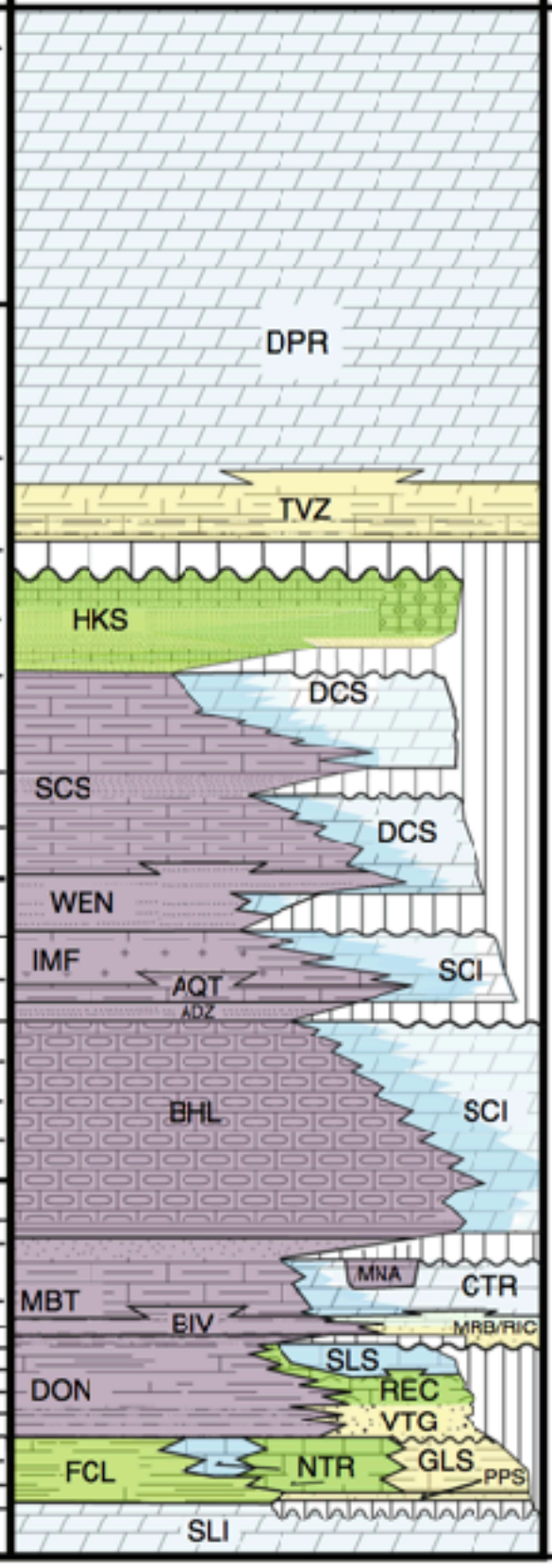
Subzone 1

N. osmani

Aegean

Paracrochordiceras

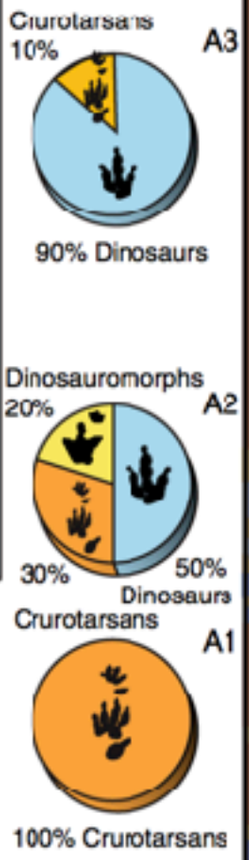




ICHNOTAXA: *Chirotheridae*; *Atreipus*; *Erazoum*; *Grallator*; *Eubrontes*

TRACKMAKER: Crurotarsans; Dinosauromorphs; Dinosaurs

ASSEMBLAGES



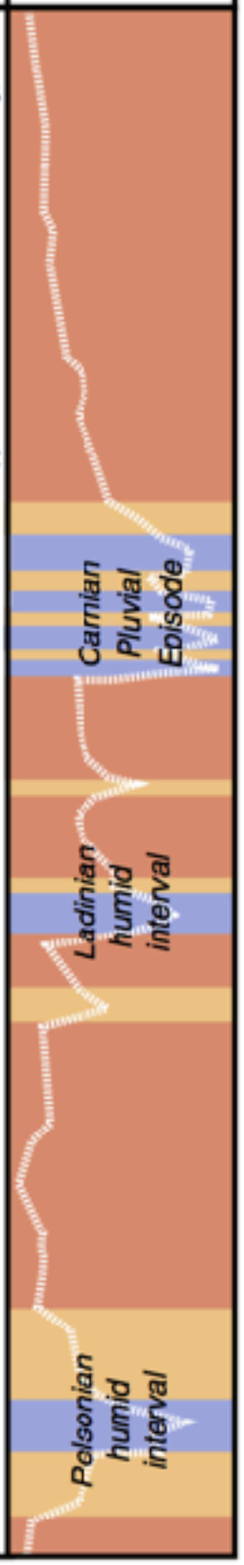
CLIMATE (After Stefani et al., 2010)

Arid

Semi-arid

Humid

ARID HUMID



When/How did dinosaurs originate?

This is something that we've talked about a lot!

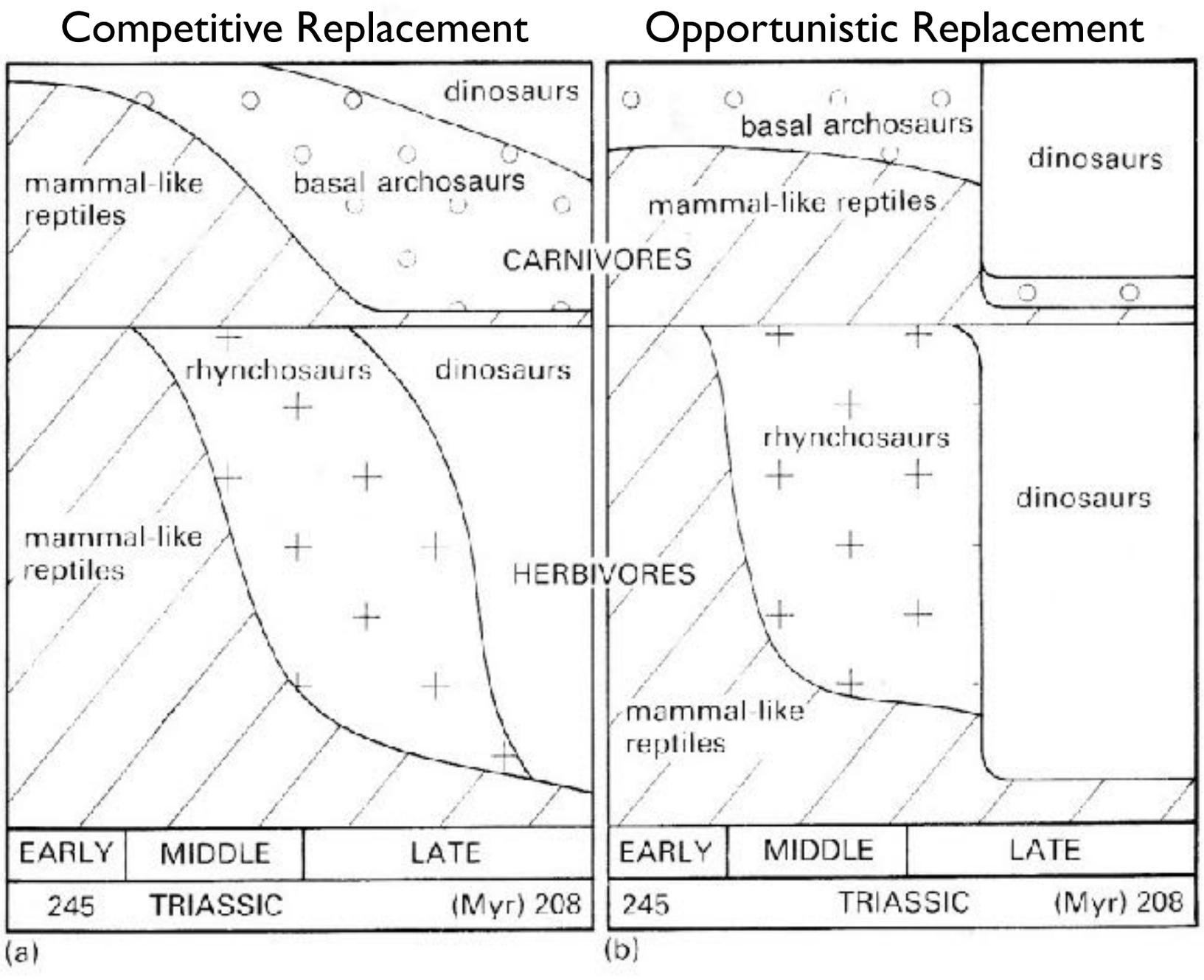


Fig. 6.10 Two models for the replacement of mammal-like reptiles, basal archosaurs, and rhynchosaurs by dinosaurs: (a) a competitive replacement scenario; (b) an opportunistic mass extinction replacement model.

Late Triassic: 228-200 Ma

<u>Climate-Tectonics:</u>

Supercontinent at start of Triassic

Warm Climate

Ice Caps gone

Uniform Temperature gradients

Red bed and evaporites suggest continued drying

<u>Plants</u>:

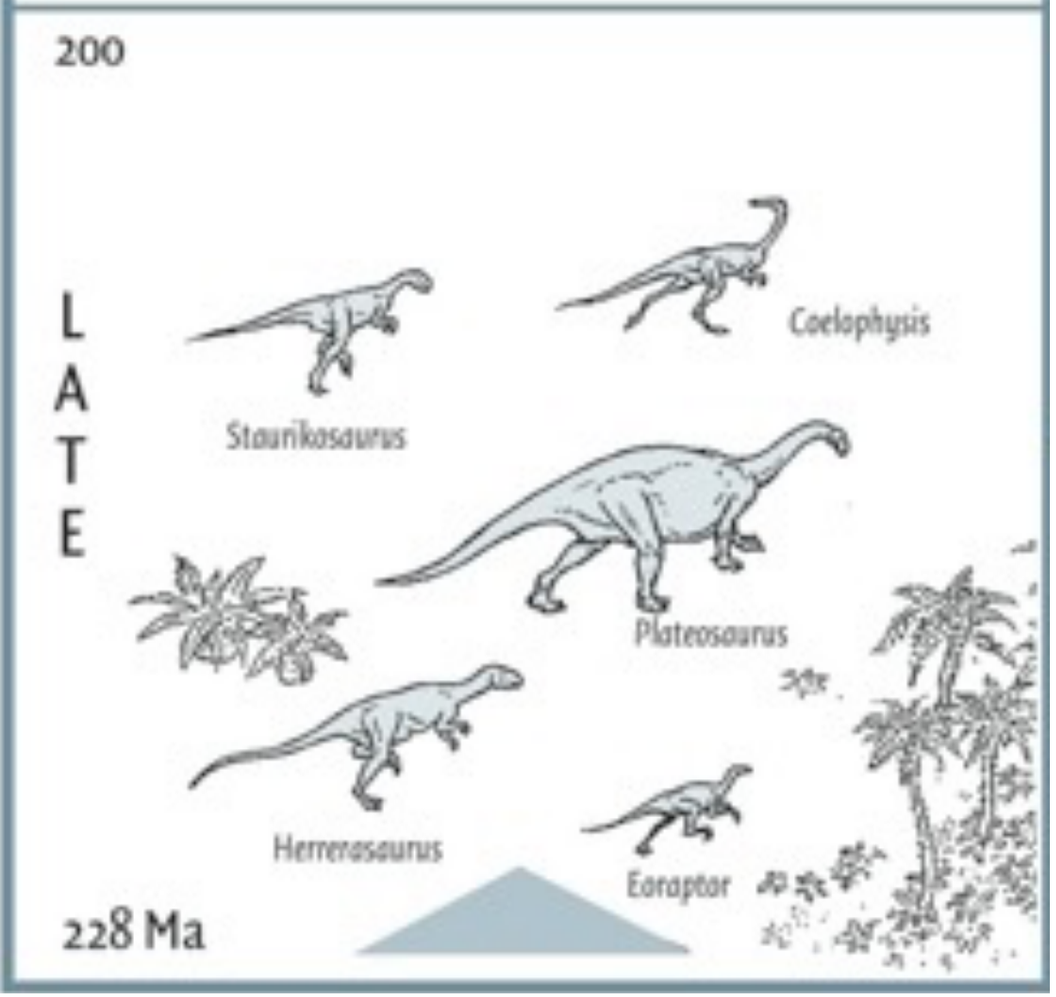
Lycophytes (oldest living vascular plants)

Fern ground cover

Conifers and Tree Ferns dominated forests

Cycads and Ginkgoes appear

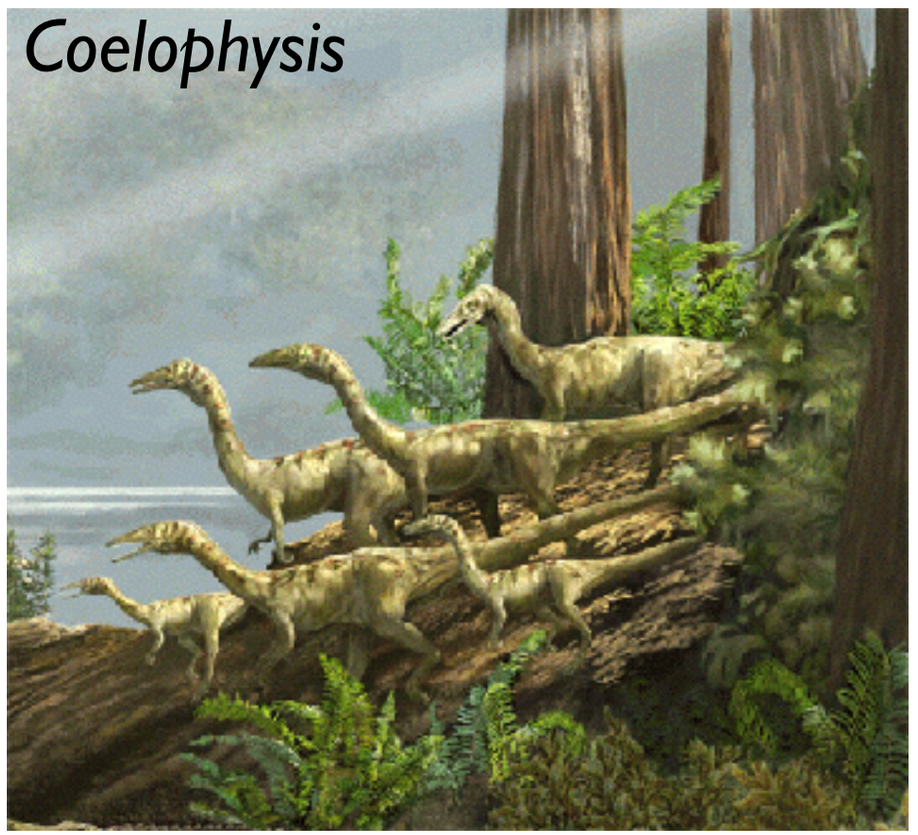
Late Triassic: 228-200 Ma



In addition: archaic archosaurs and therapsids remain important + first mammals, turtles, ichthyosaurs (long), pterosaurs (small), nothosaurs, placodonts

Plateosaurus
Sauropodamorpha

Pisanosaurus

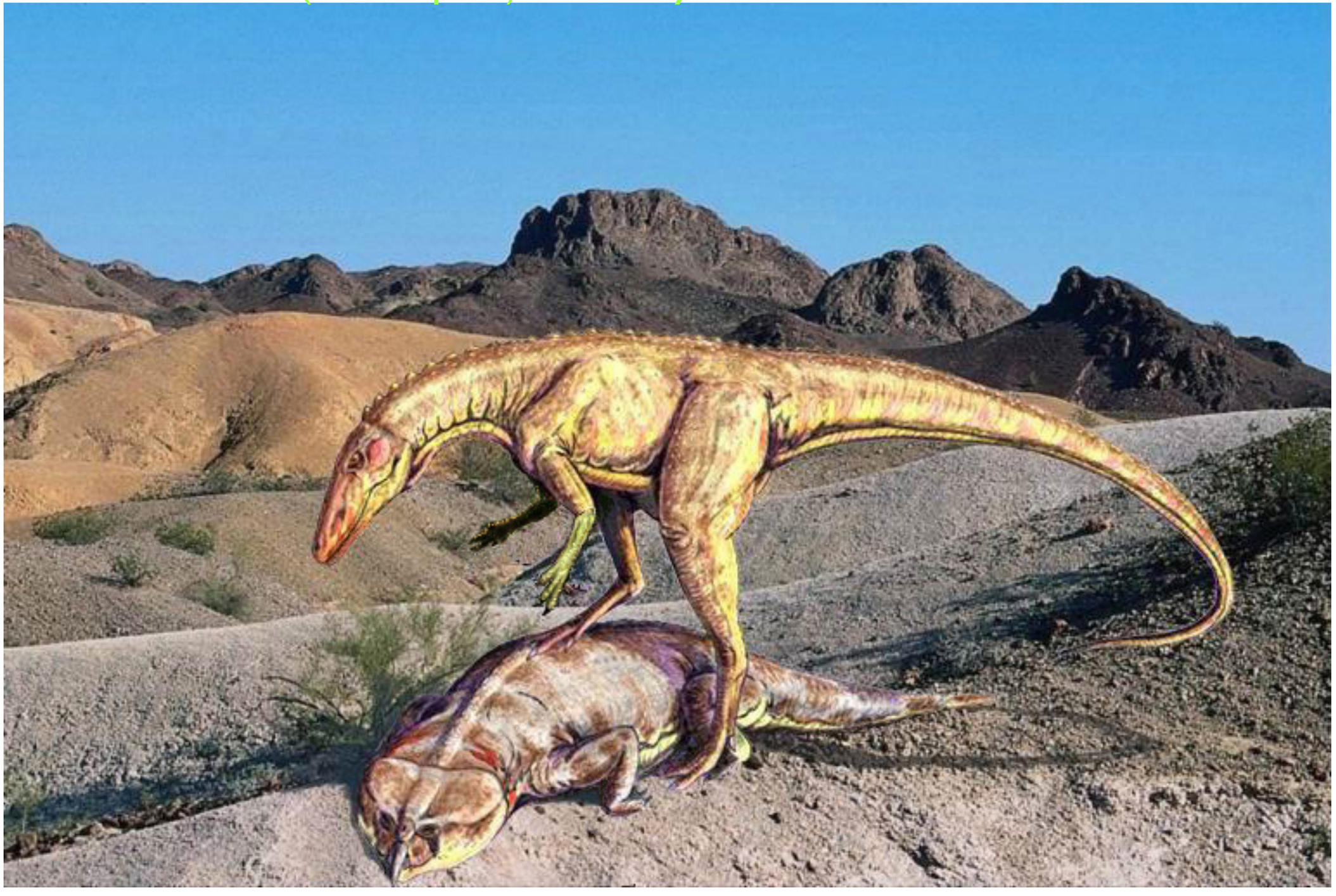


Late Triassic: 228-200 Ma

- The Triassic is remarkable because there is very little Endemism among flora and fauna: The Pangaea Effect
- Endemism: when faunas are restricted to a certain geographic range
- Increases in diversity typically follow increases in endemism. Why?

Late Triassic: 228-200 Ma

Staurikosaurus (Theropod) *vs.* a Rhyncosaur in the late Triassic



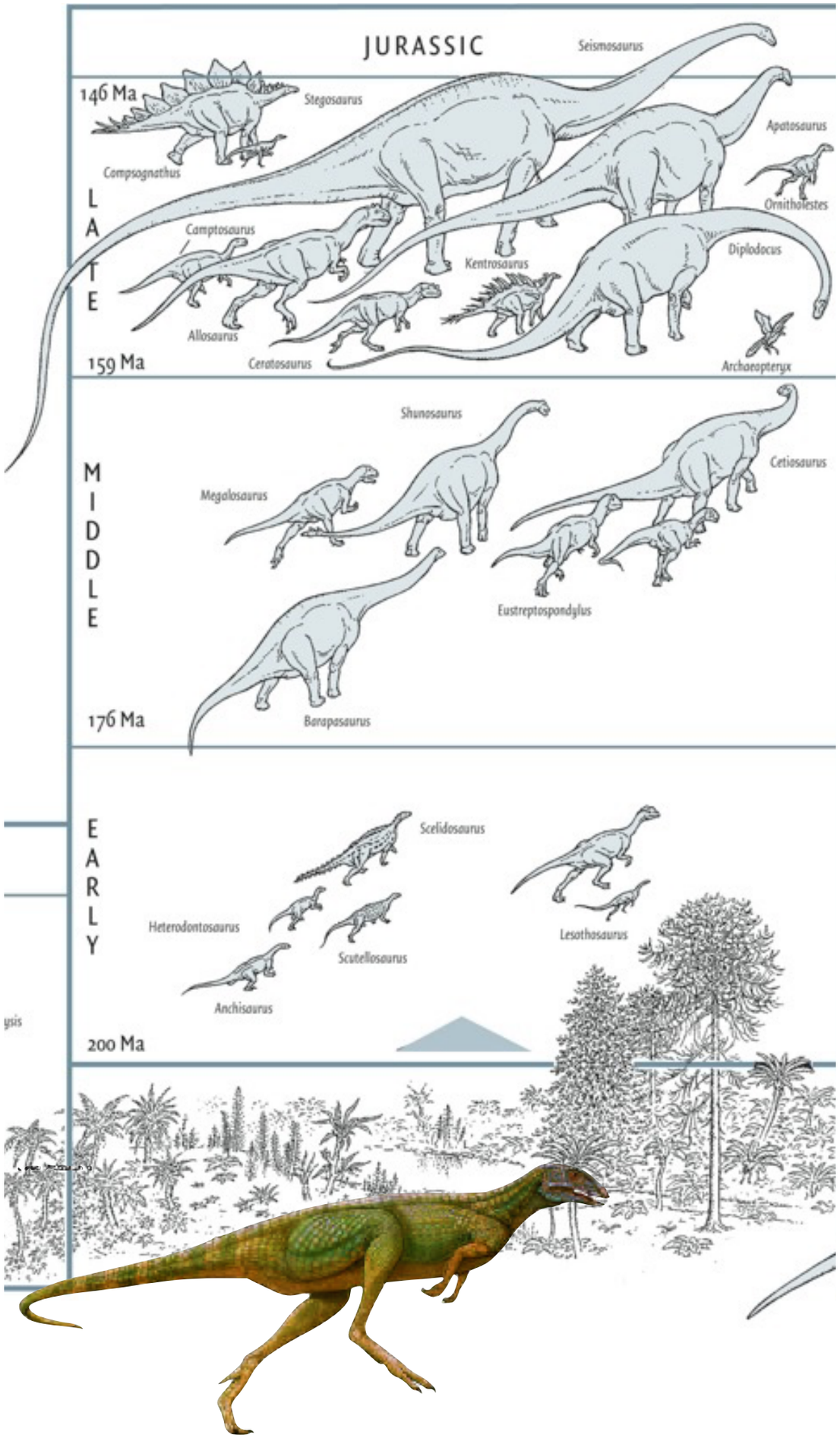
Jurassic: 200-146 Ma

<u>Climate-Tectonics:</u>

Warm, equable climate (fewer temp. swings as oceans form)
Continents routinely flooded
Extensive rifting and volcanism
North Atlantic opens
Sea levels higher (little, if any, permanent ice)

<u>Plants</u>:

Lush jungles covered the planet
Confers were the primary tall trees
Cycads, Ginkgoes (northern hemisphere)
Ferns were the dominant undergrowth



In addition: mammals (nocturnal insectivores), lizards & amphibians (daytime insectivores, ichthyosaurs (long), pterosaurs (small), plesiosaurs, first birds

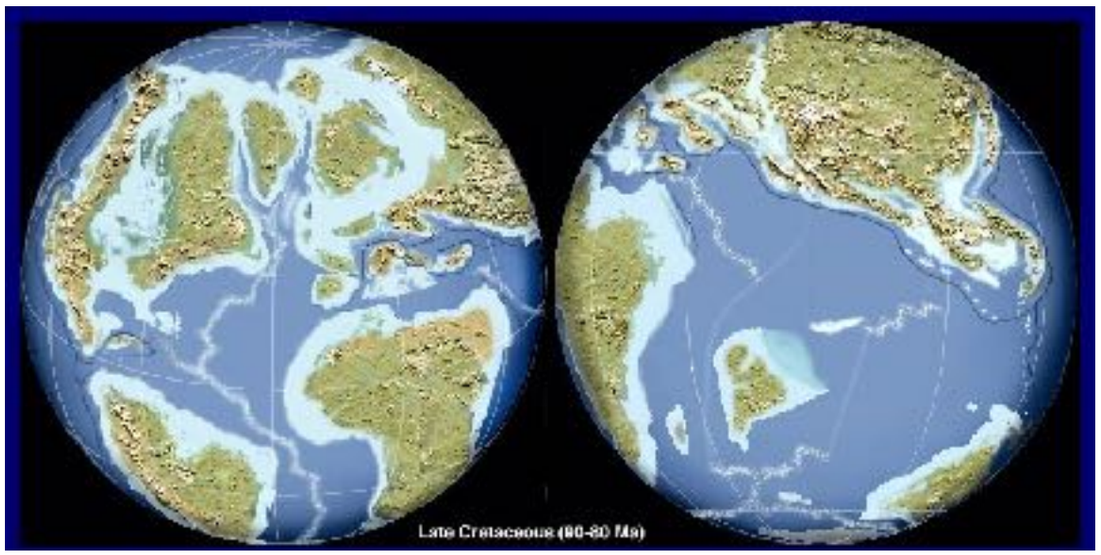
Jurassic: 200-146 Ma

- Dinosaurs are the dominant terrestrial vertebrates
- Small mammals, pterosaurs, and newly evolved crocodilians share the landscape
- Pangaea had not 'unzipped'. Therefore, there was little endemism represented in terrestrial biota

Jurassic: 200-146 Ma

- The middle Jurassic is not well known
- This is primarily the result of bias in the fossil record (few sediments formed)... not because there were no Dinos!
- End Jurassic characterized by ecosystems becoming isolated: DIVERSITY and ENDEMISM increase!
- Sauropods and Stegosaurs are the dominant herbivores

Cretaceous: 146-65.5 Ma



<u>Climate-Tectonics:</u>

Equable climate, but some emerging seasonality

Continued rifting, volcanism, inland seas

Increased CO_2, increased greenhouse environment

Development of the Southern Atlantic

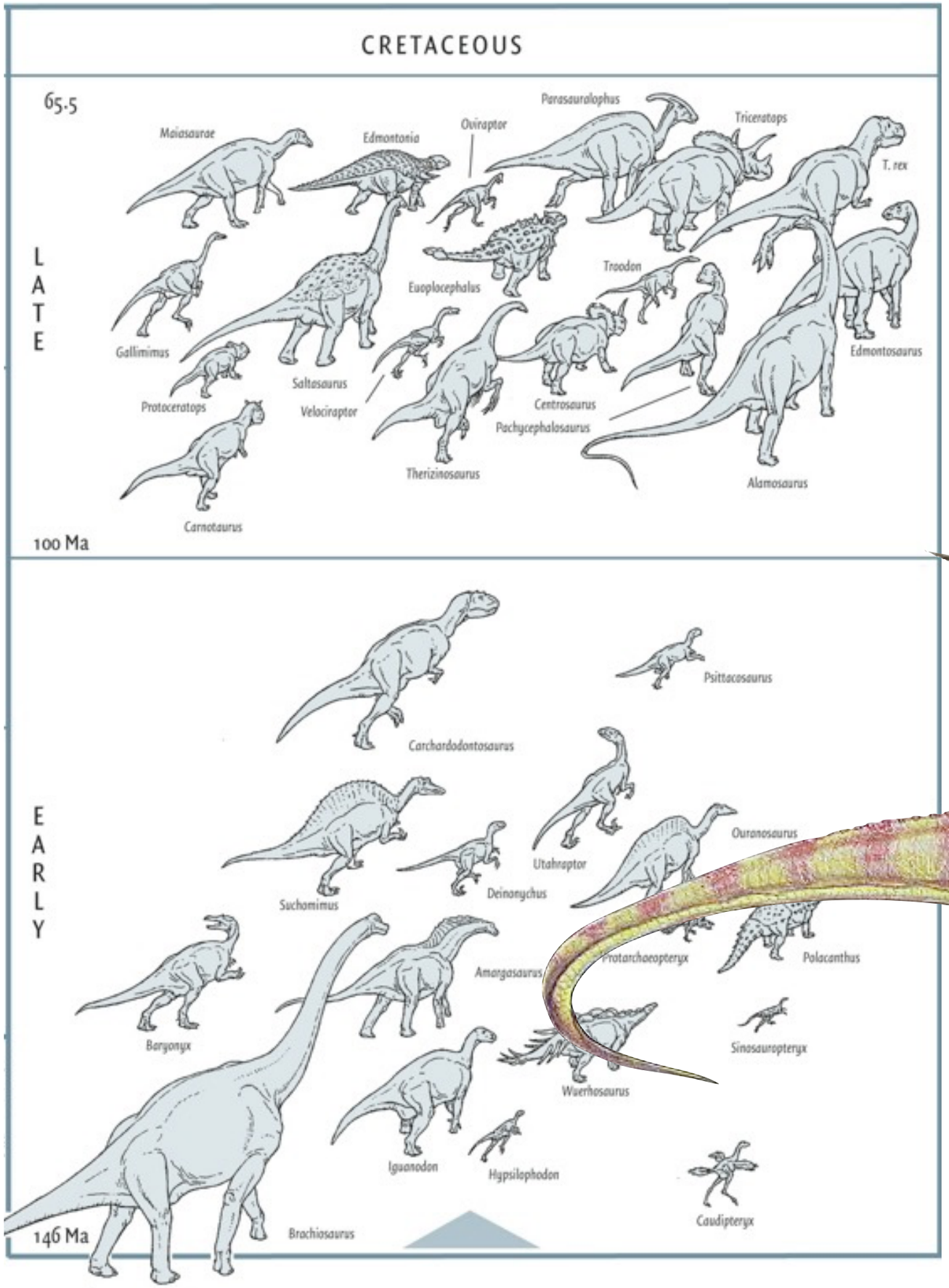
Complete unzipping of Pangaea

<u>Plants</u>:

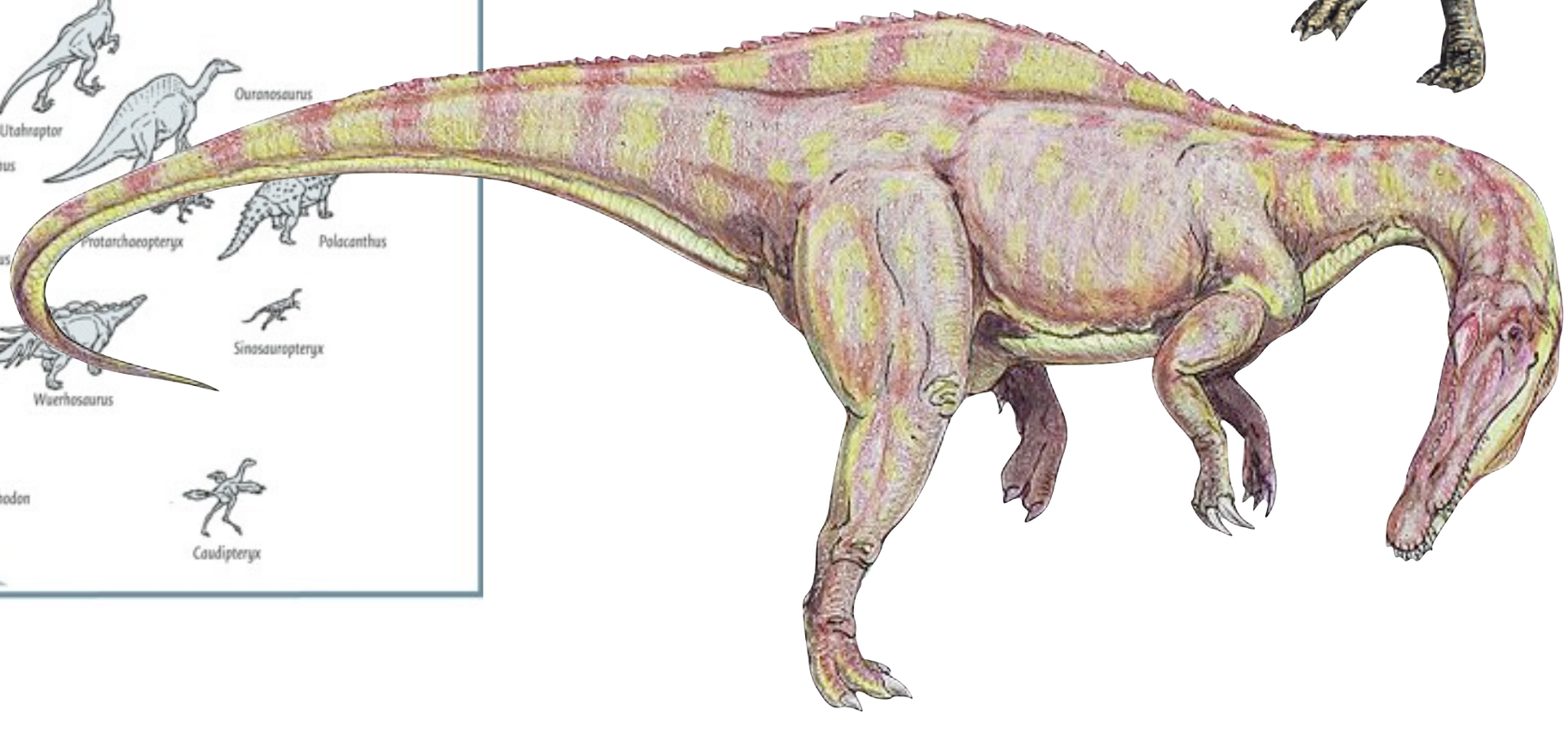
Cycads, ginkgoes and ferns in <u>decline</u>

Angiosperms take over the understory

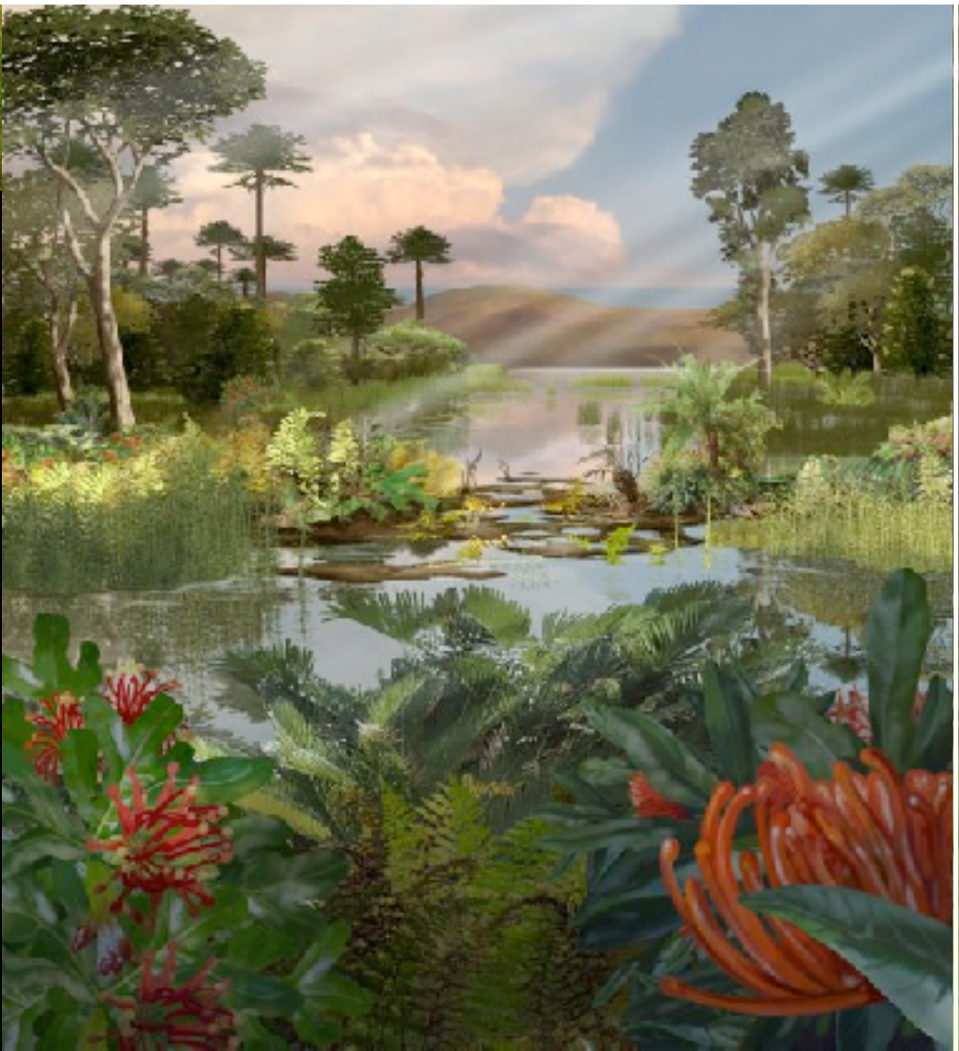
Conifers remain dominant, but their ranges become more restricted as angiosperms continue to flourish



In addition: mammals (nocturnal insectivores), lizards & amphibians (daytime insectivores, ichthyosaurs (fish-like), pterosaurs (large), plesiosaurs, small diversity of birds

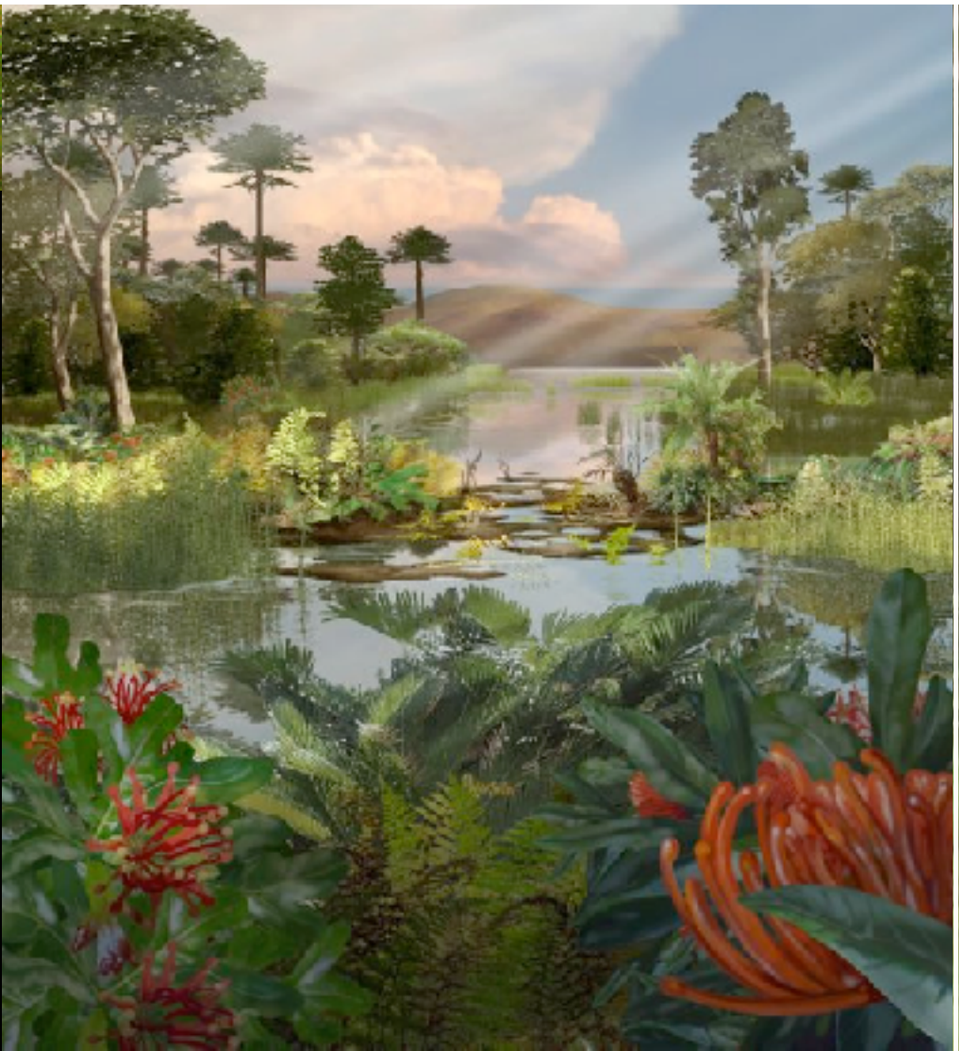


Cretaceous: 146-65.5 Ma



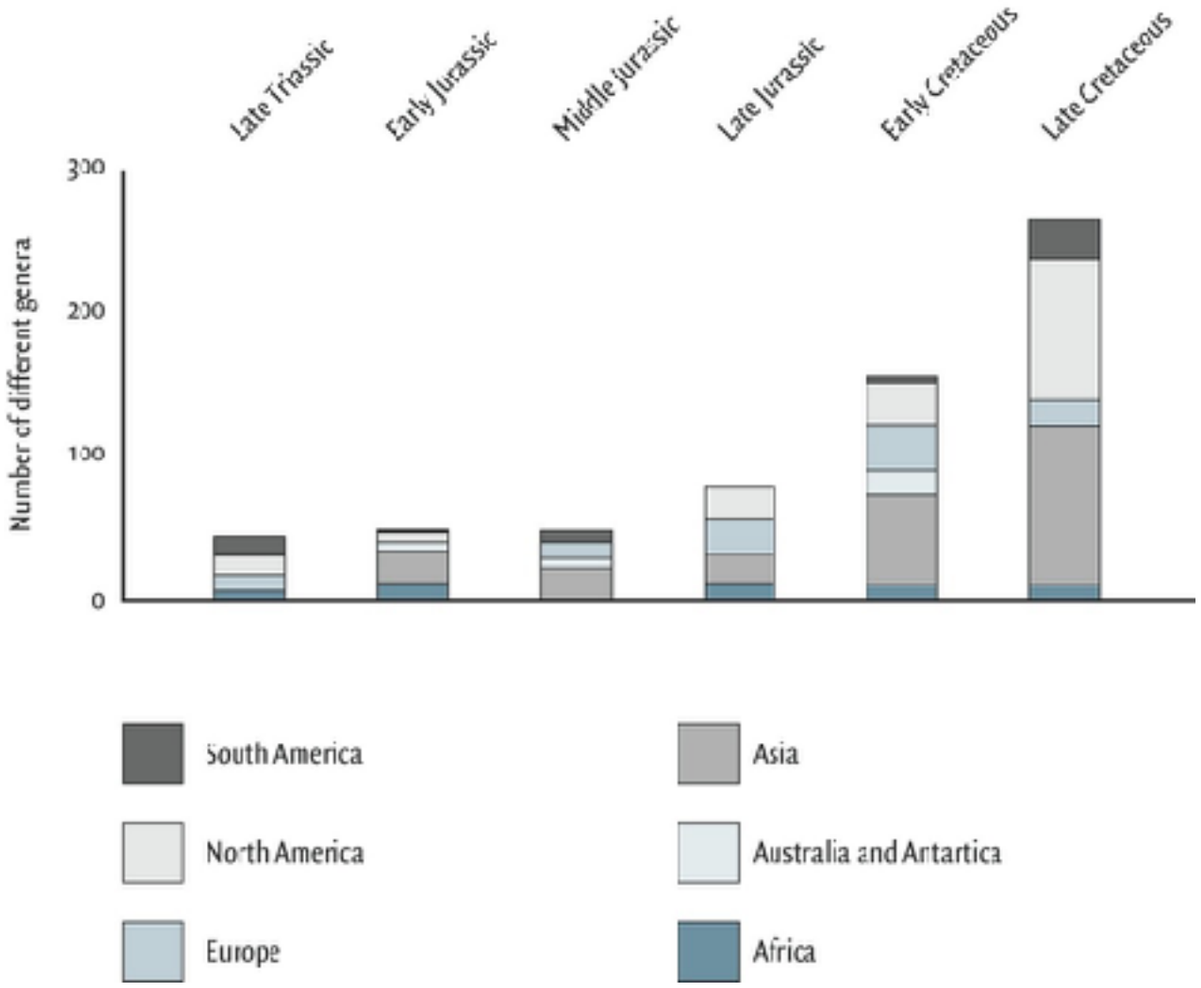
- Continued increase in Endemism as Pangaea separates
- Early Cretaceous: rise of Ornithopods
- Ankylosaurs and Ceratopsians become dominant herbivores
  - ~ note the success of the ‘chewers’...
- Troodontids and Dromaeosaurs explode in diversity

Cretaceous: 146-65.5 Ma

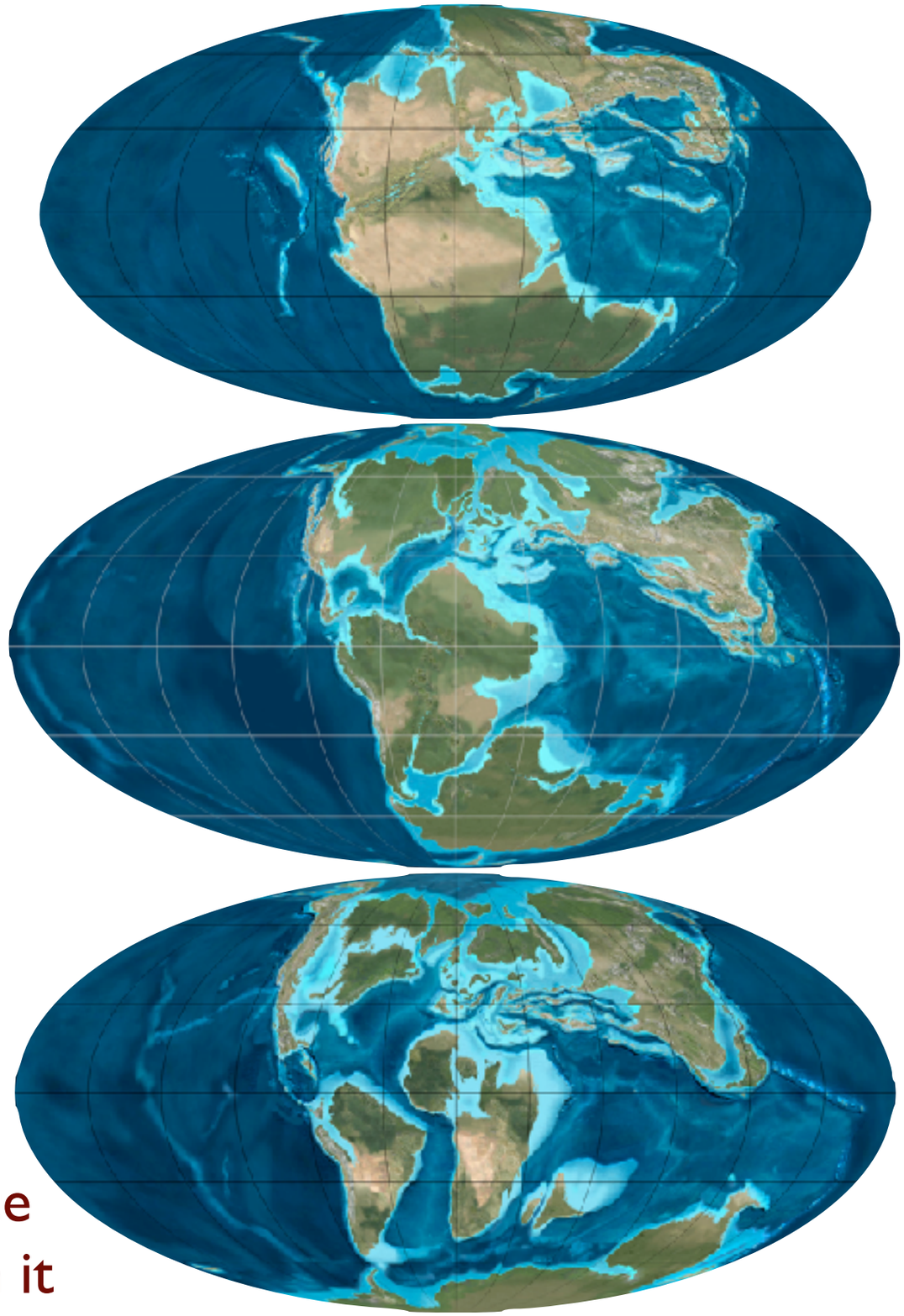


- Late Cretaceous: the most diverse time for dinosaurs
  - Tyrannosaurs
  - Pachycephalosaur explosion
- This diversity does not seem to be the result of climate... no severe or sudden climate changes during this time (endemism)
  - Southern continents: sauropods, ornithopods, ankylosaurs, & Ceratosaur theropods (Jurassic-Style)
  - Northern continents: Pachycephalosaurs, Ceratopsians & Hadrosaurids

Diversity through time...



Changes in dinosaur diversity by continent



Count species? genera? families? through time

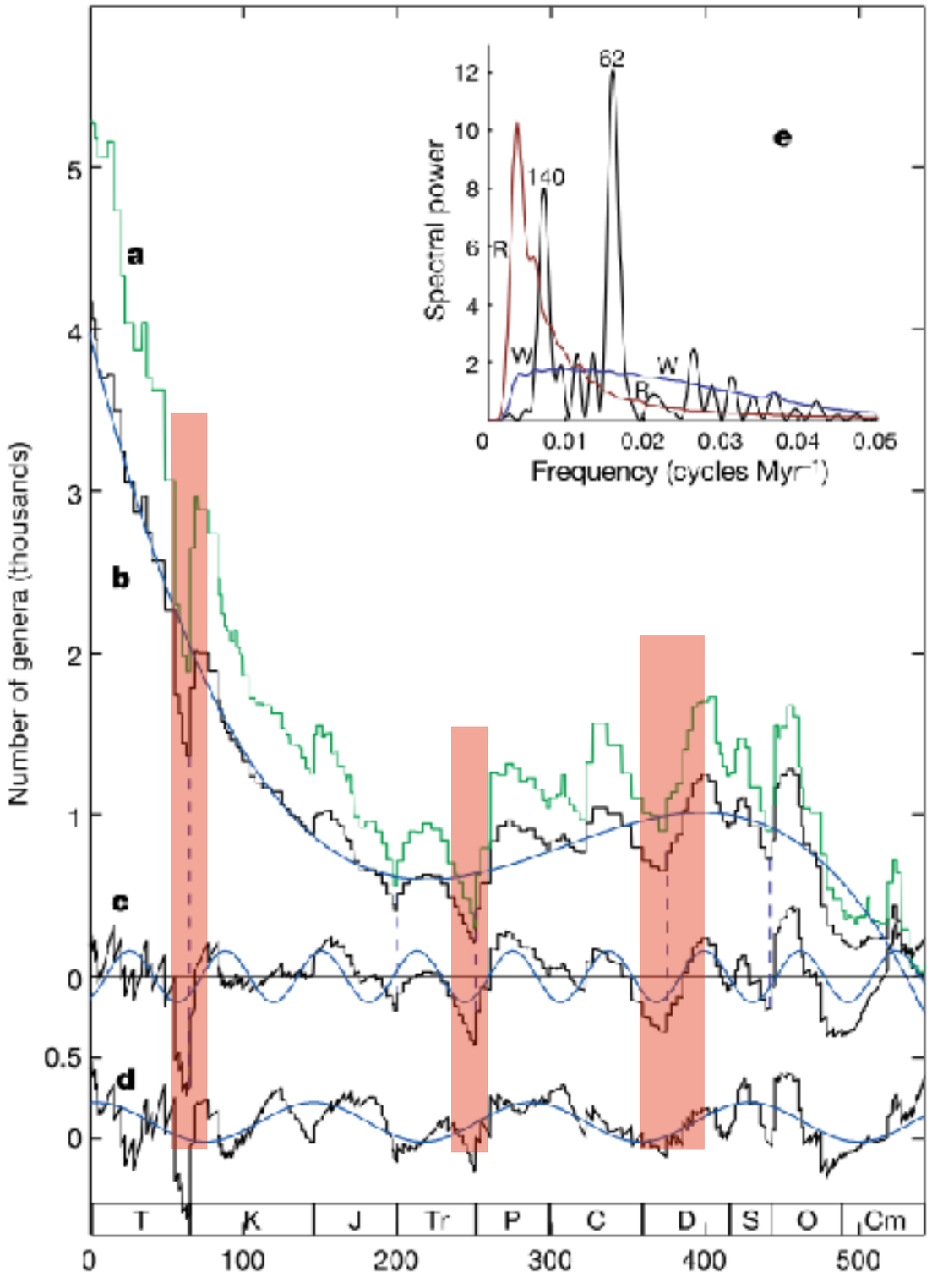
1) steady increase in diversity through time

2) Compare changes in diversity within each place through time... if the changes are consistent, then it is likely not a bias of rock availability

3) Compare changes across taxa...

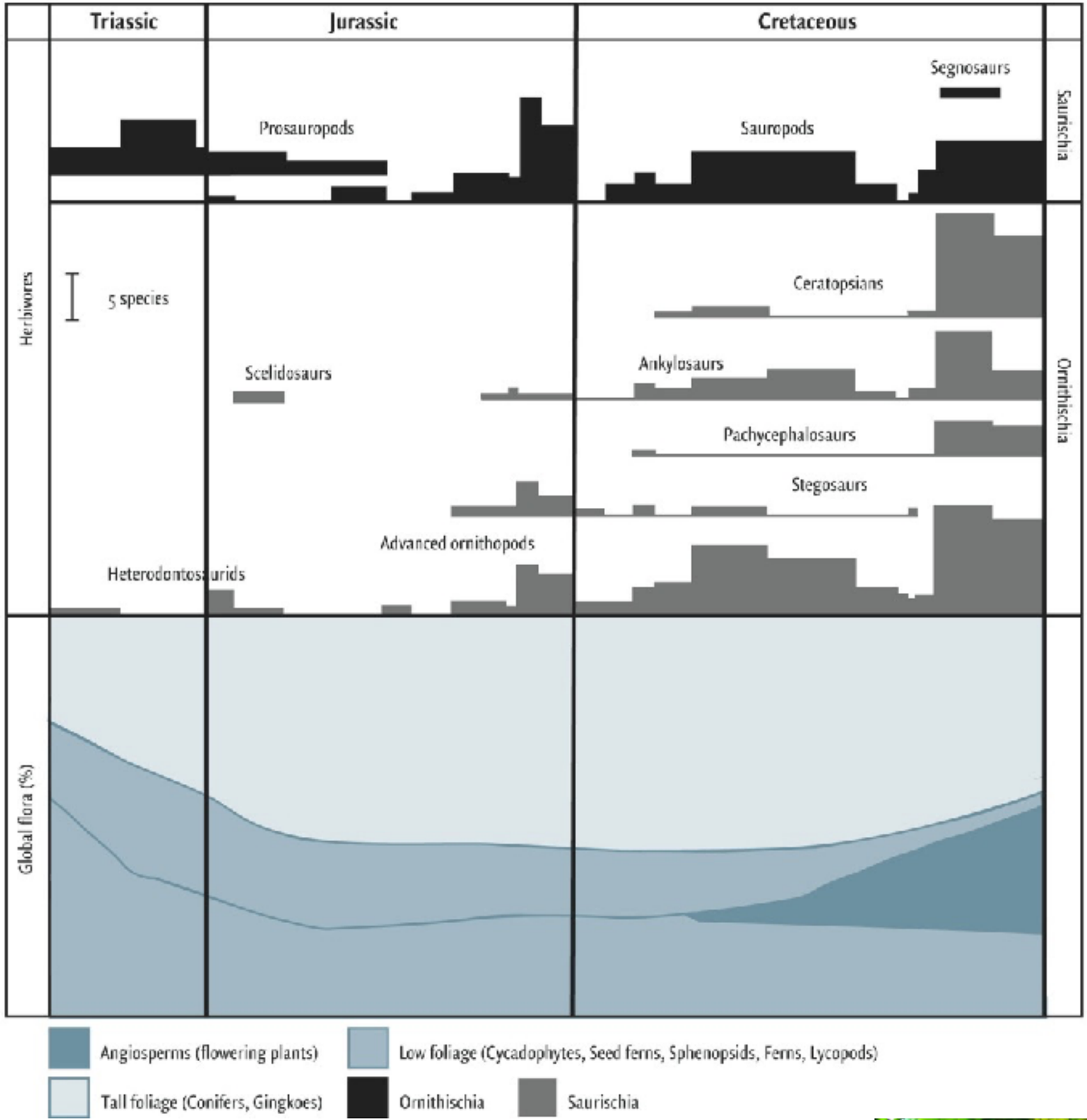
The Pull of the Recent: as we get closer to the recent, fossil biota become better known

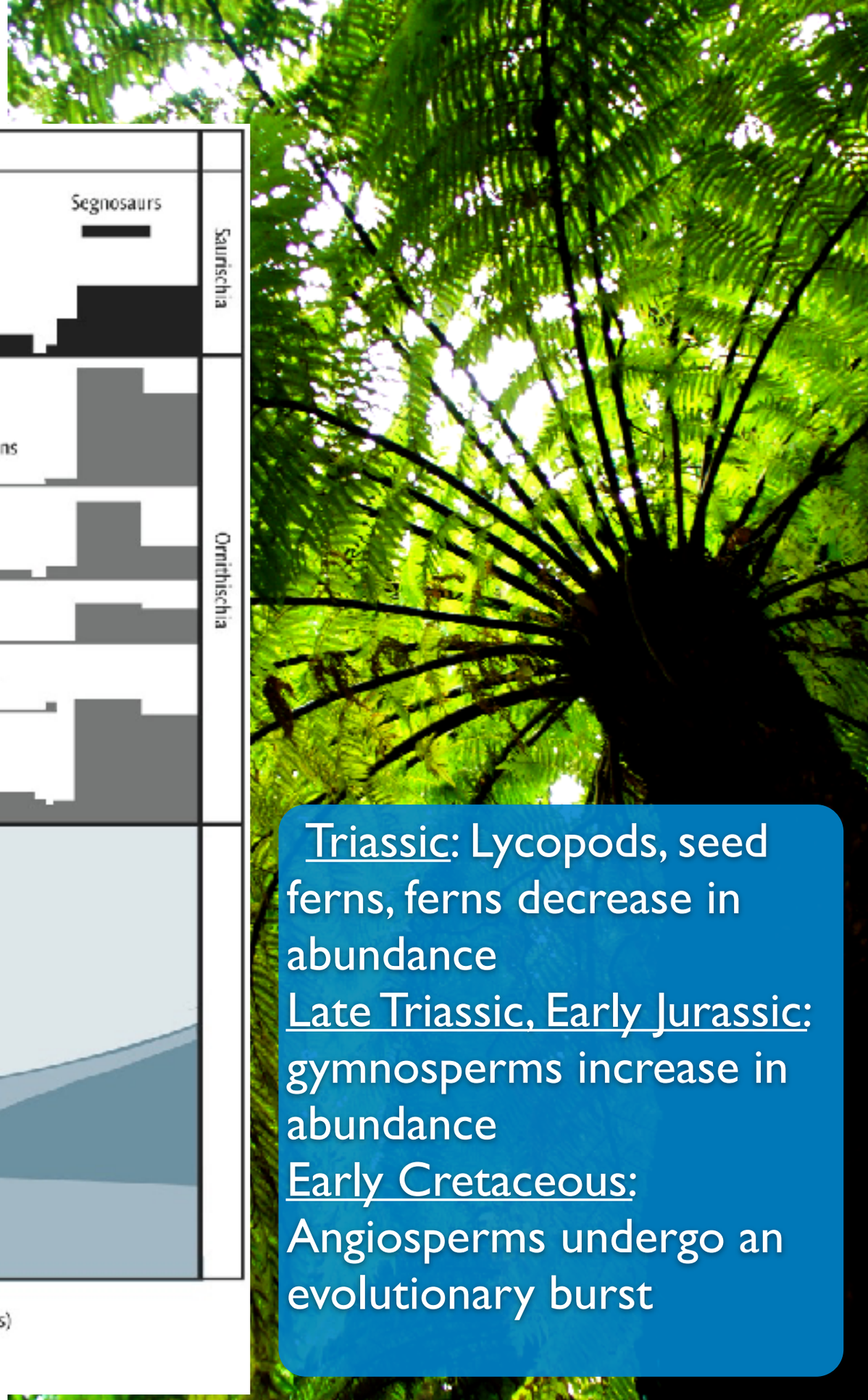
Diversity through time...



The Sepkoski Curve

Plant and animal coevolution?

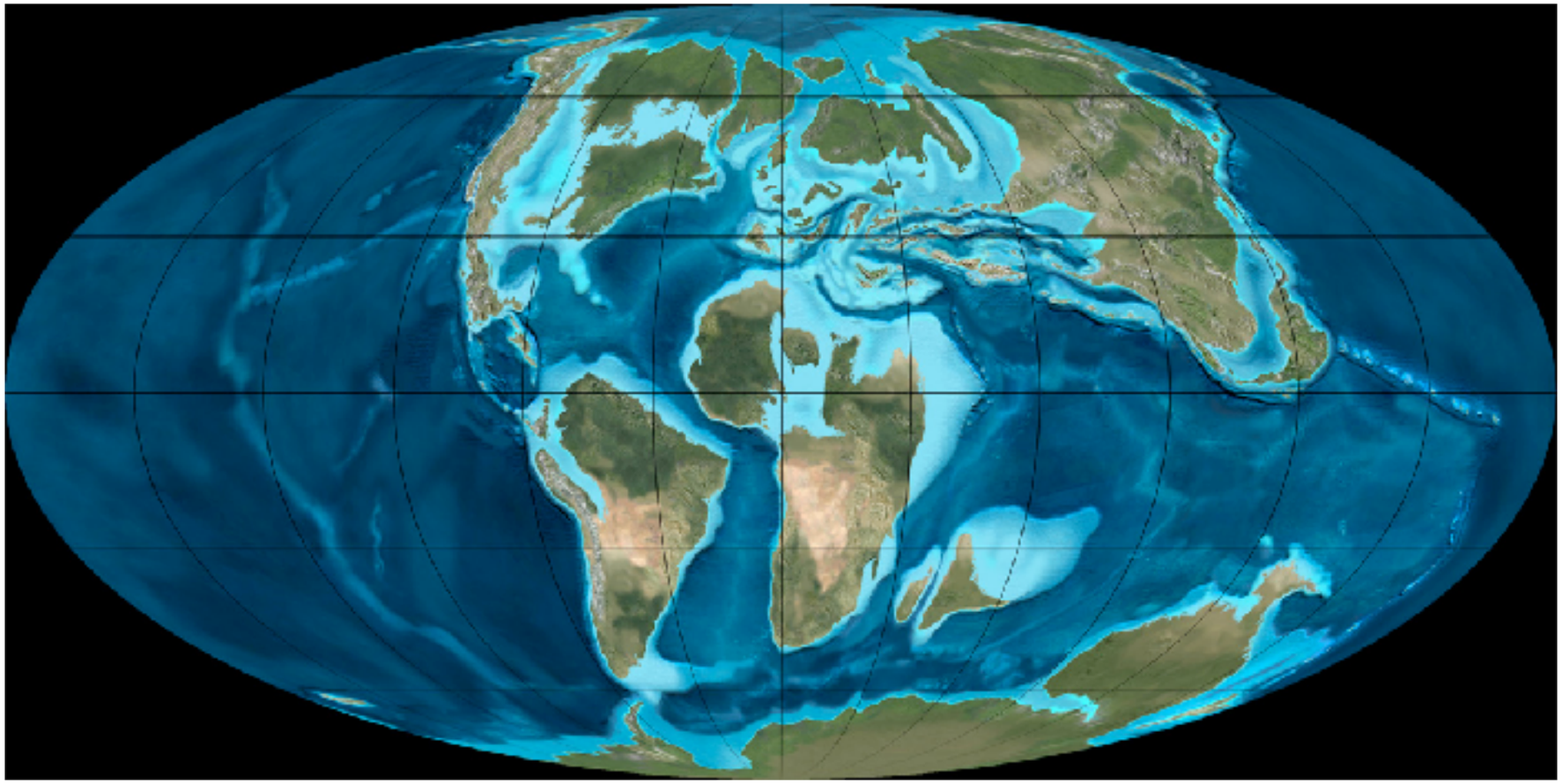




Triassic: Lycopods, seed ferns, ferns decrease in abundance

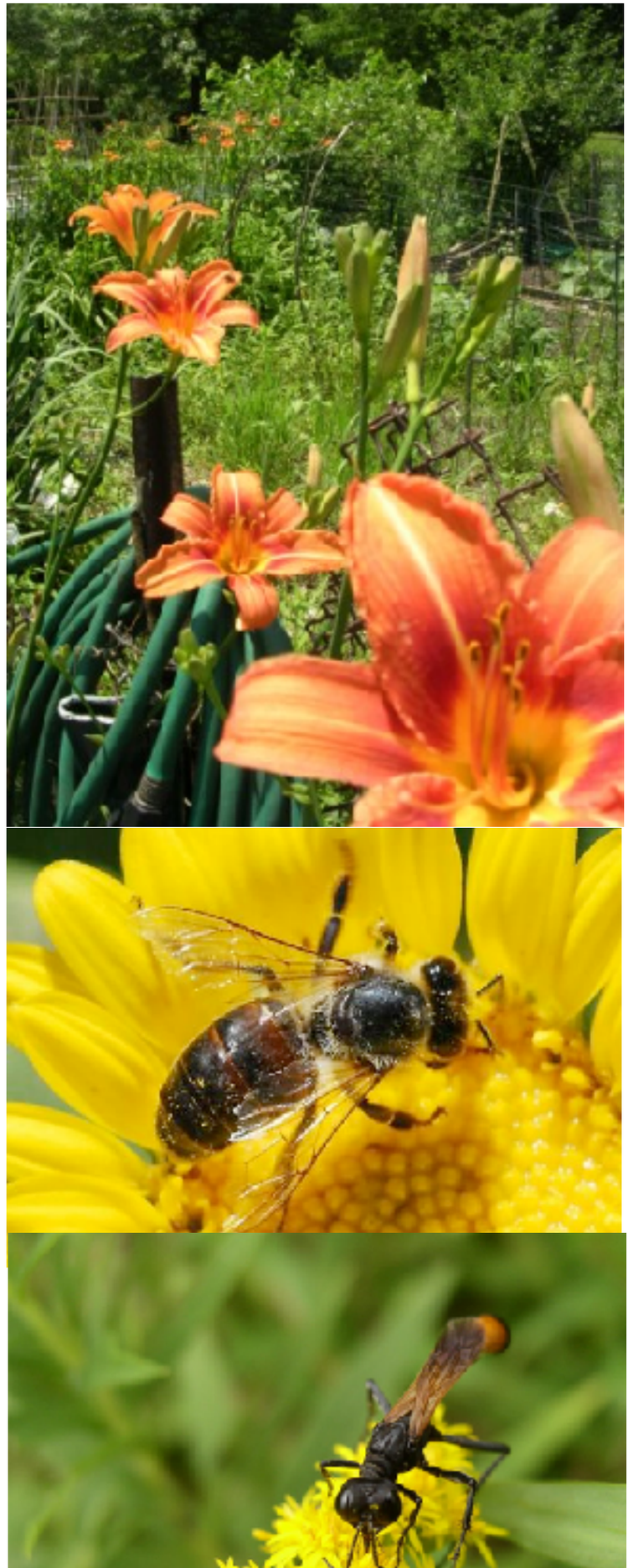
Late Triassic, Early Jurassic: gymnosperms increase in abundance

Early Cretaceous: Angiosperms undergo an evolutionary burst



We can TEST whether or not Dinosaur herbivores had an exclusive impact on plants evolution...

1) Advanced herbivores (hadrosaurs, pachycephalosaurs, ceratopsians) were Northern Hemisphere animals.
2) The Southern Hemisphere herbivores were mainly sauropods & early ornthipods (unspecialized)
3) Therefore, if derived Dinosaurian herbivore evolution was linked to angiosperm evolution, the evolution of angiosperms should be very different in the Northern Hemisphere.



It isn't.

So, although angiosperm evolution certainly had a large effect on Dinosaur evolution, it is doubtful that Dinosaurs had a global effect on angiosperm evolution