

*Natural Sciences 360*

*Legacy of Life*

*Lecture 3*

*Dr. Stuart S. Sumida*

# Phylogeny (and Its Rules)

## Biogeography

So, what is all the fuss about  
“phylogeny?”

PHYLOGENETIC SYSTEMATICS allows us both define groups and their relationships.

However, those definitions MUST be careful, rigorous, and testable. (If they aren’t testable, they aren’t science.)

Biologically valid groups must be defined on the basis of SHARED, DERIVED characteristics.

In other words: a biologically valid group is defined on the basis of features that are found in ALL members of the group, and ONLY in members of that group.

These SHARED, DERIVED characters are known as “SYNAPOMORPHIES.”\*

\*Singular: Synapomorphy

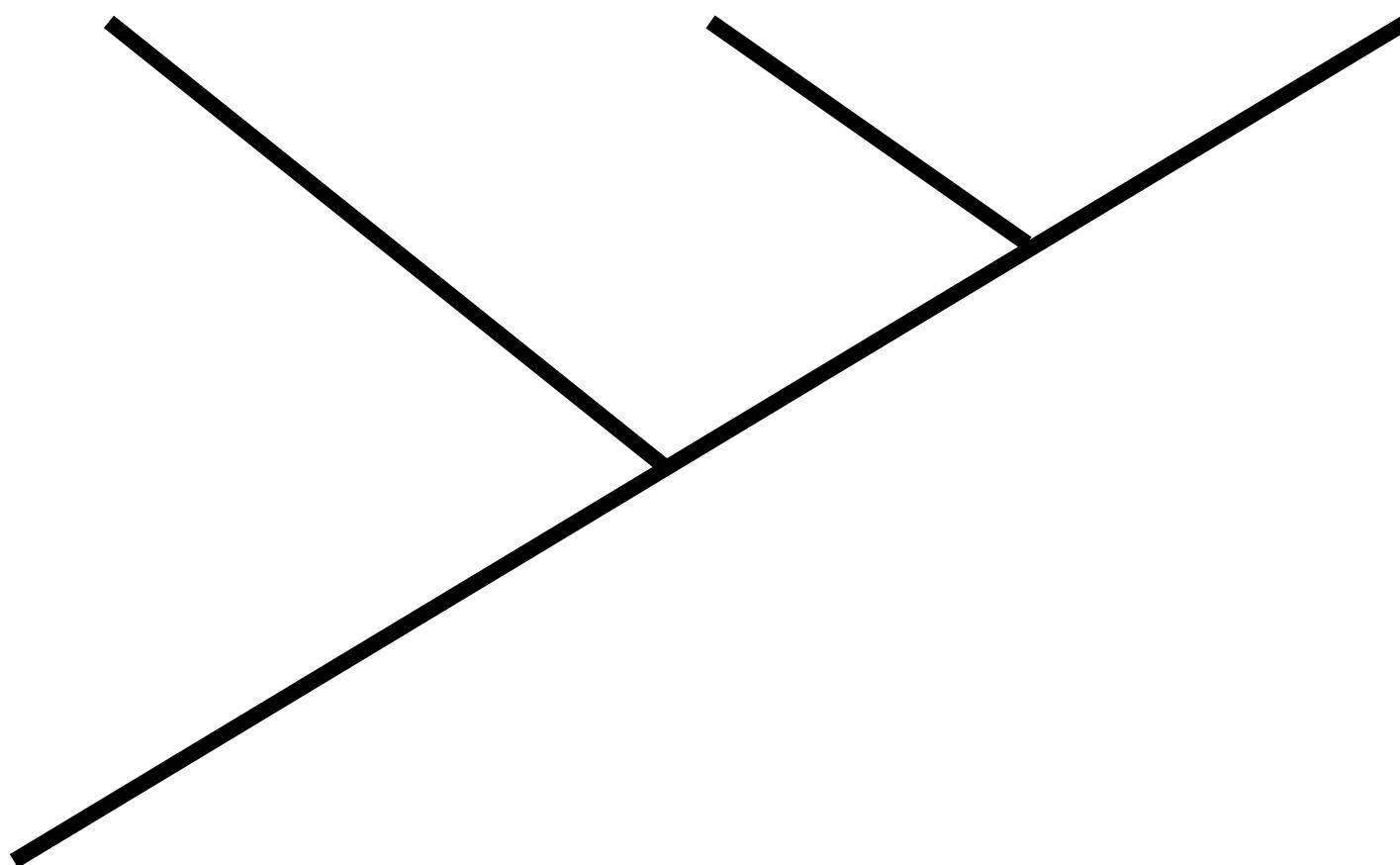
The degree of relatedness of groups is dependant on WHAT synapomorphies are shared, and at what level...

What is a shared, derived character at one level, will NOT be a shared derived character at another level.

Bacteria

Archaea

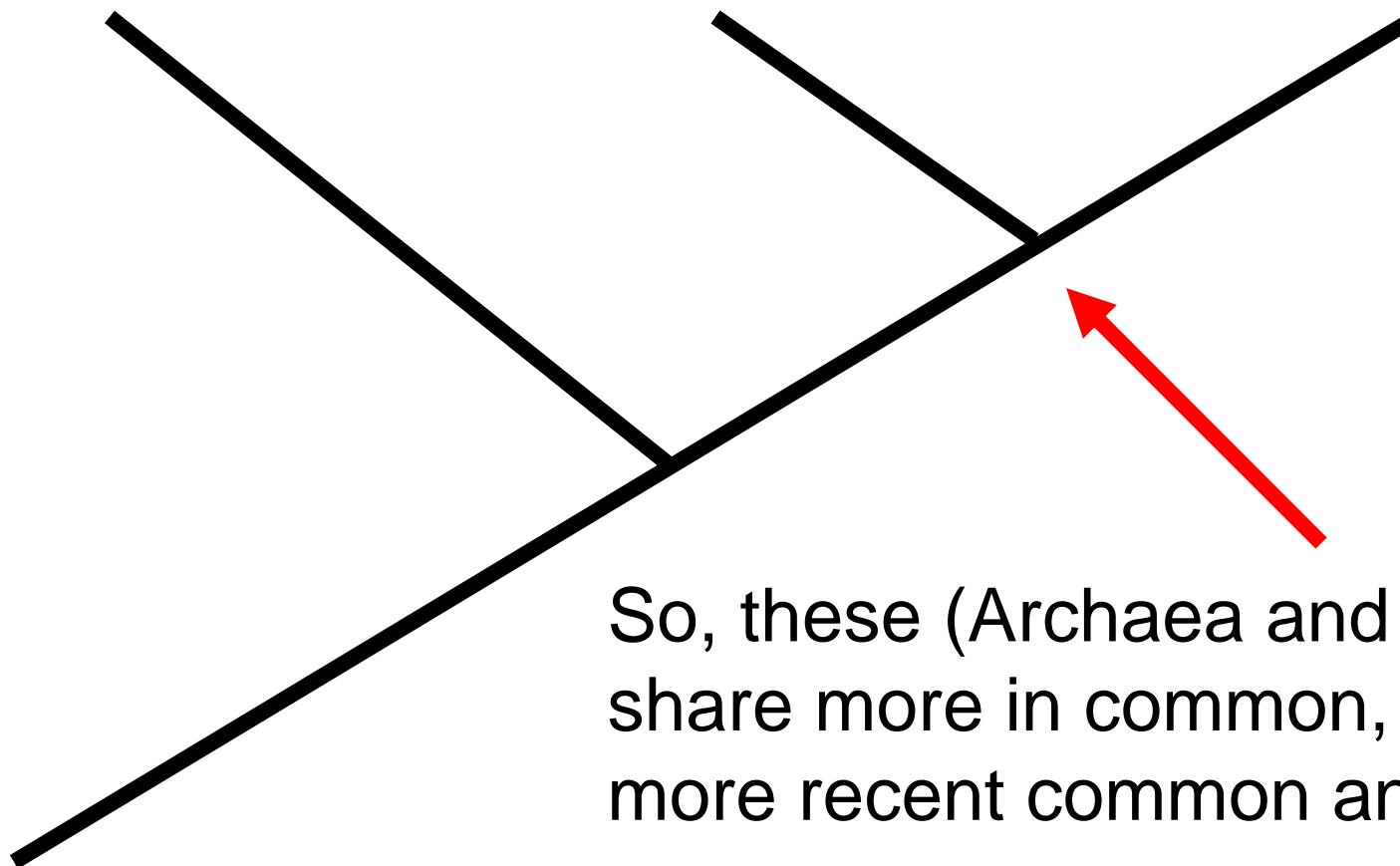
Eucarya



Bacteria

Archaea

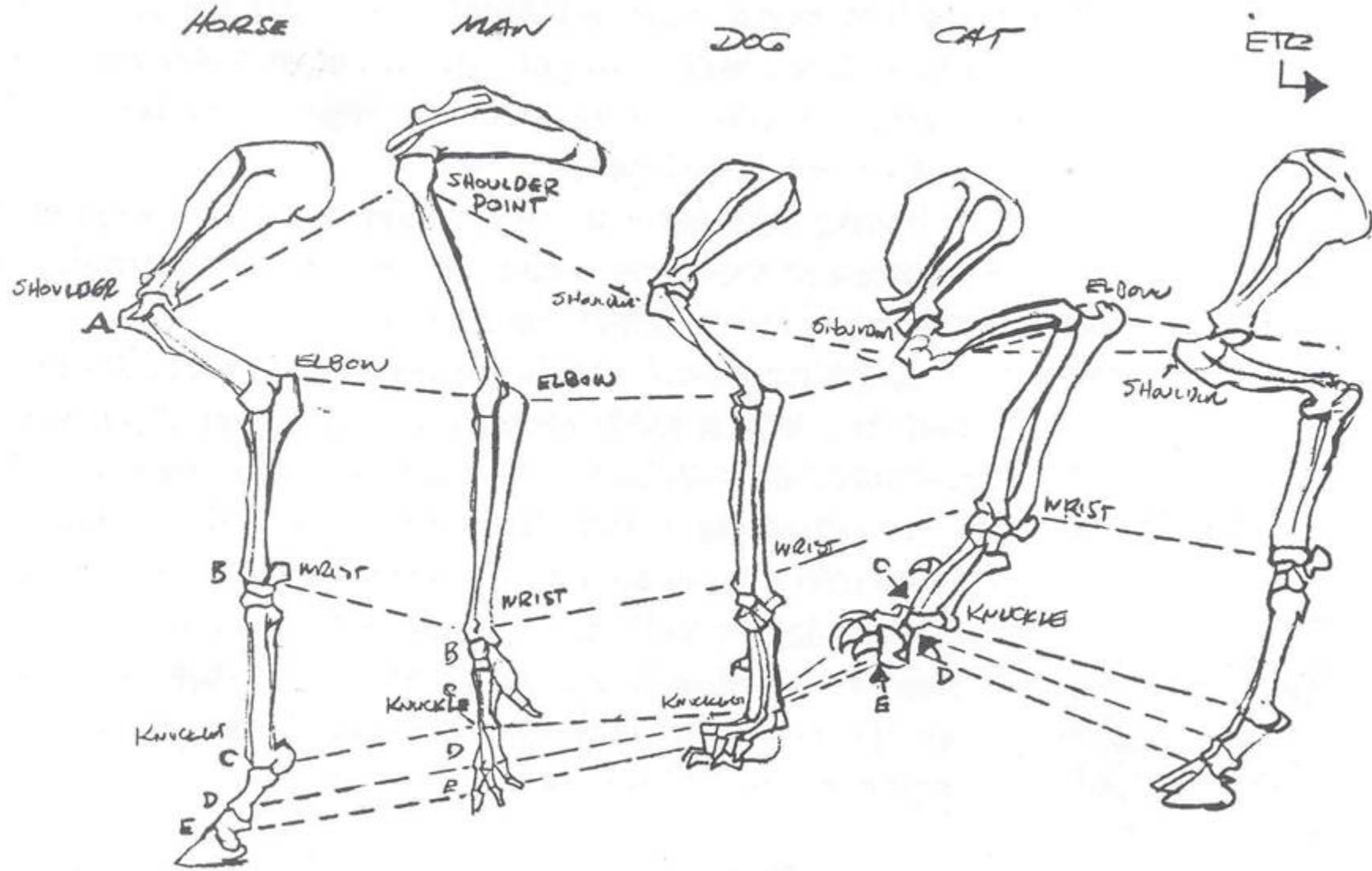
Eucarya



So, these (Archaea and Eucarya) share more in common, and a more recent common ancestor.

What kind of features can be used to generate phylogenetic trees?

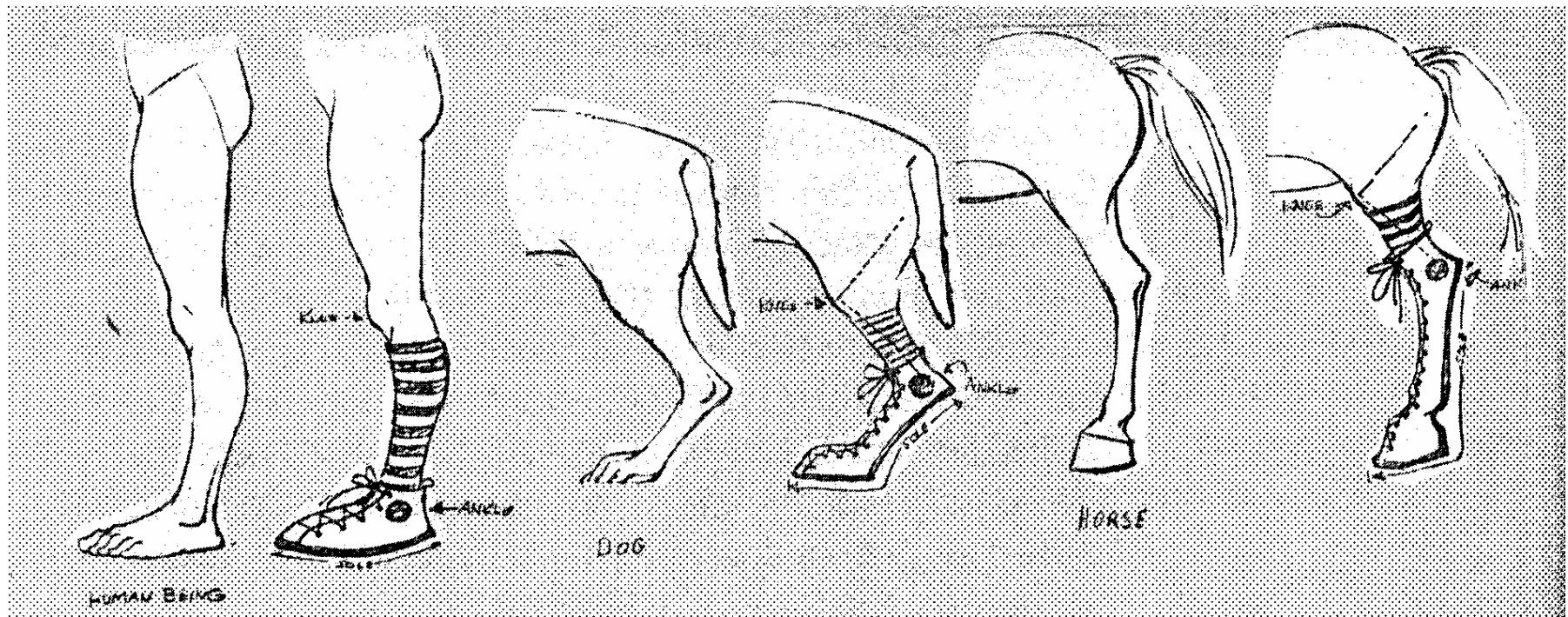
They must be **HOMOLOGOUS CHARACTERS**. That is, they must be structures or features inherited from a common structure in a common ancestor.



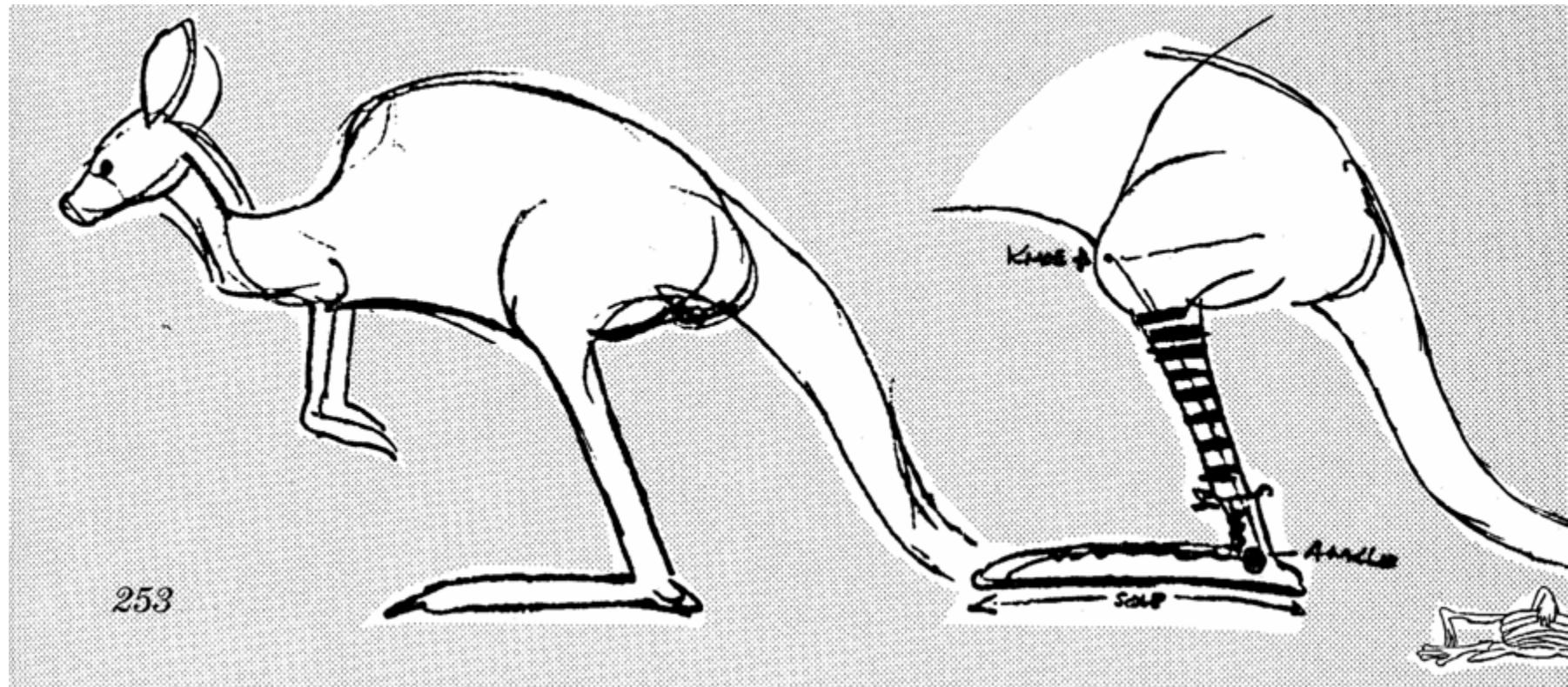
# Criteria for Anatomical Homology:

- Same Anatomical Position
- Same Embryological Material
- Supplied by Same Nerve

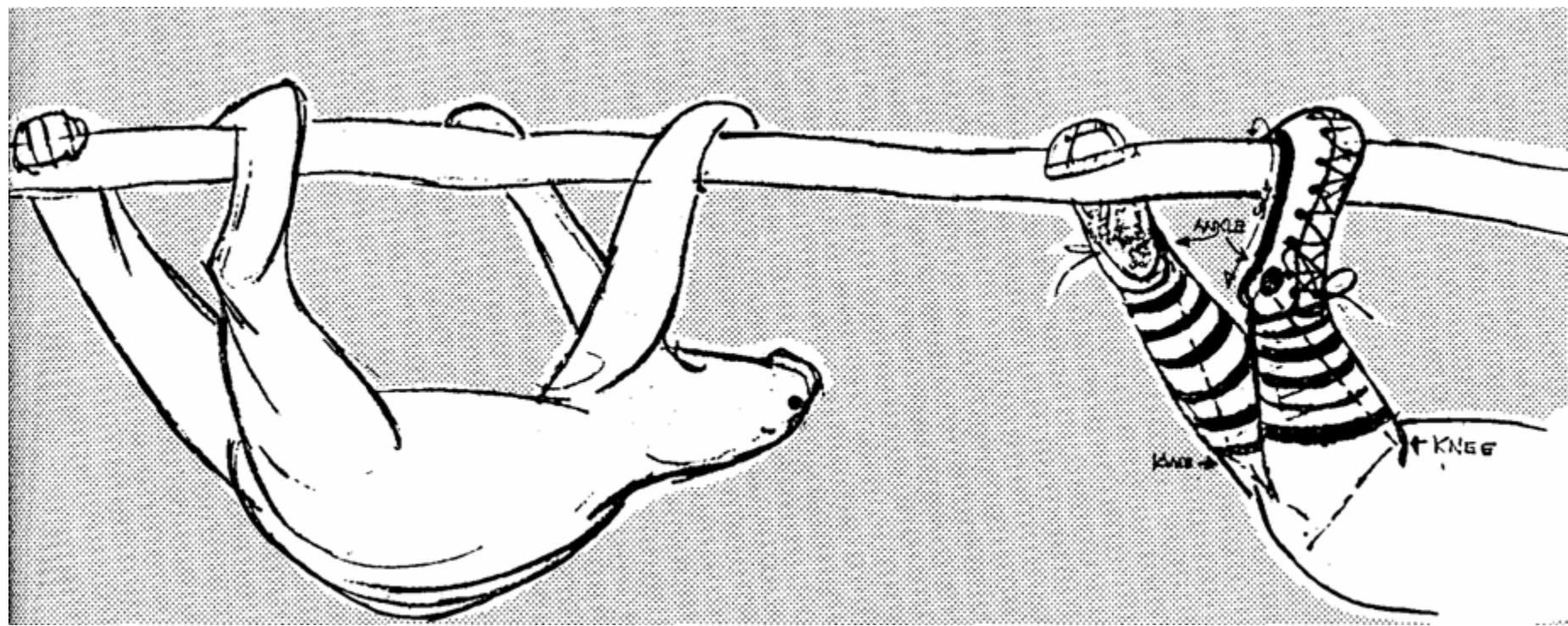
Function is NOT a good criterion  
(because functions can change over time...)



From: *Chuck Amuck* by Chuck Jones, Farrar Straus  
Giroux Publishers, New York, 1989.



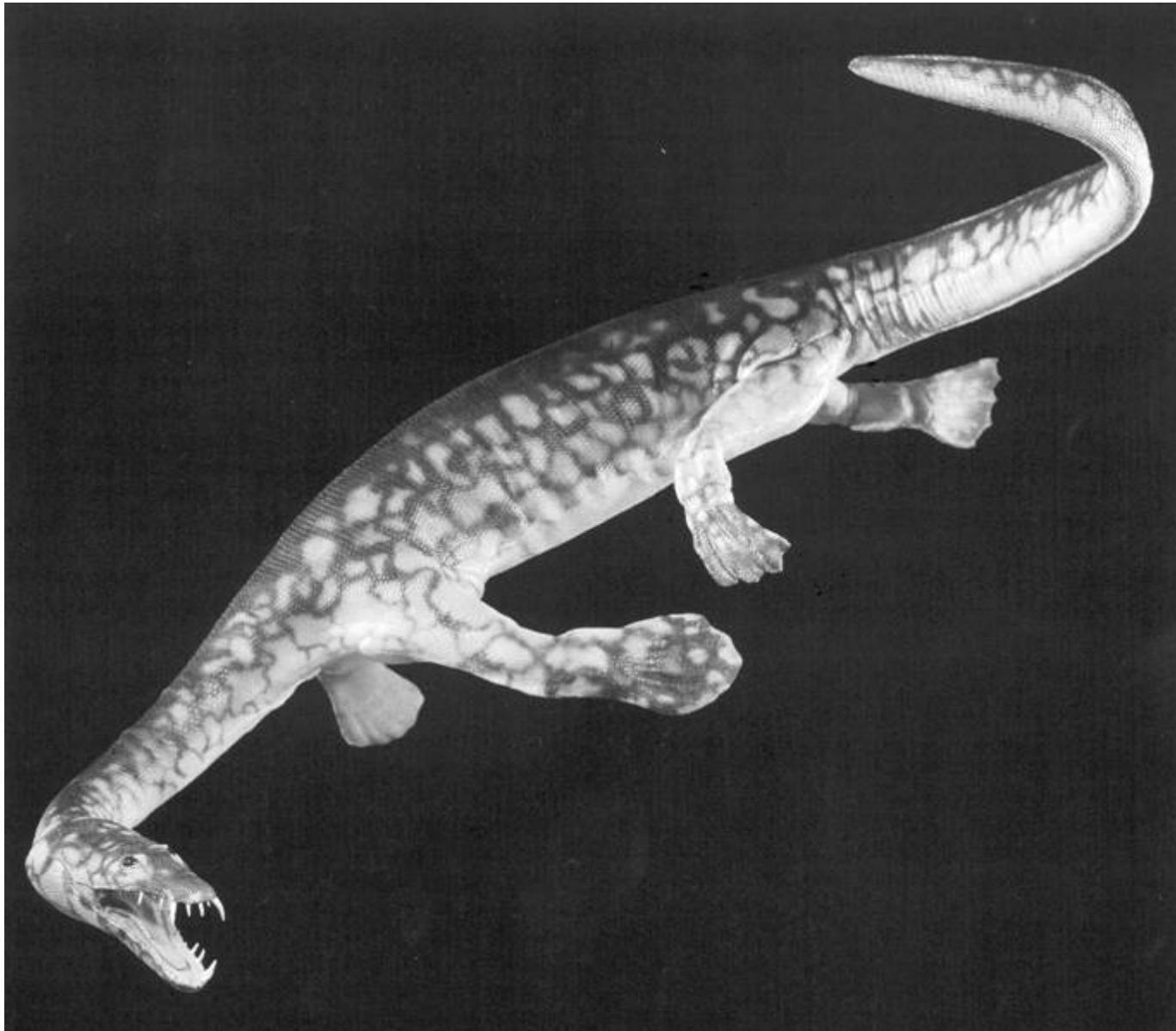
253



Knowing the relationships of organisms allows us to consider certain other concepts:

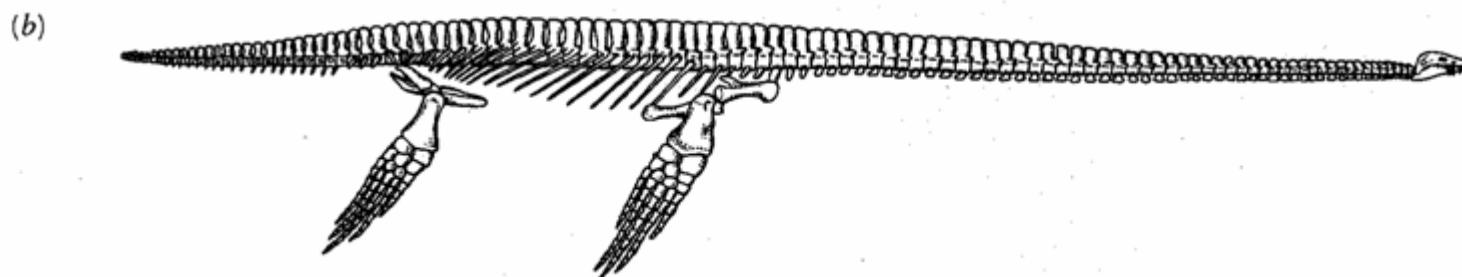
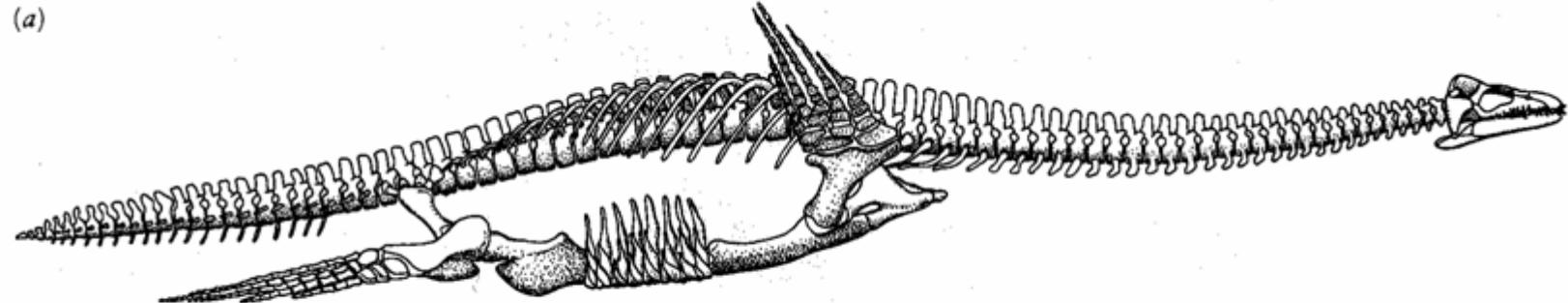
**CONVERGENT EVOLUTION** – the acquisition of similar features due to similar environmental pressures.

**PARALLEL EVOLUTION** – (a special case of convergence) when convergent evolution takes place between very closely related lineages.

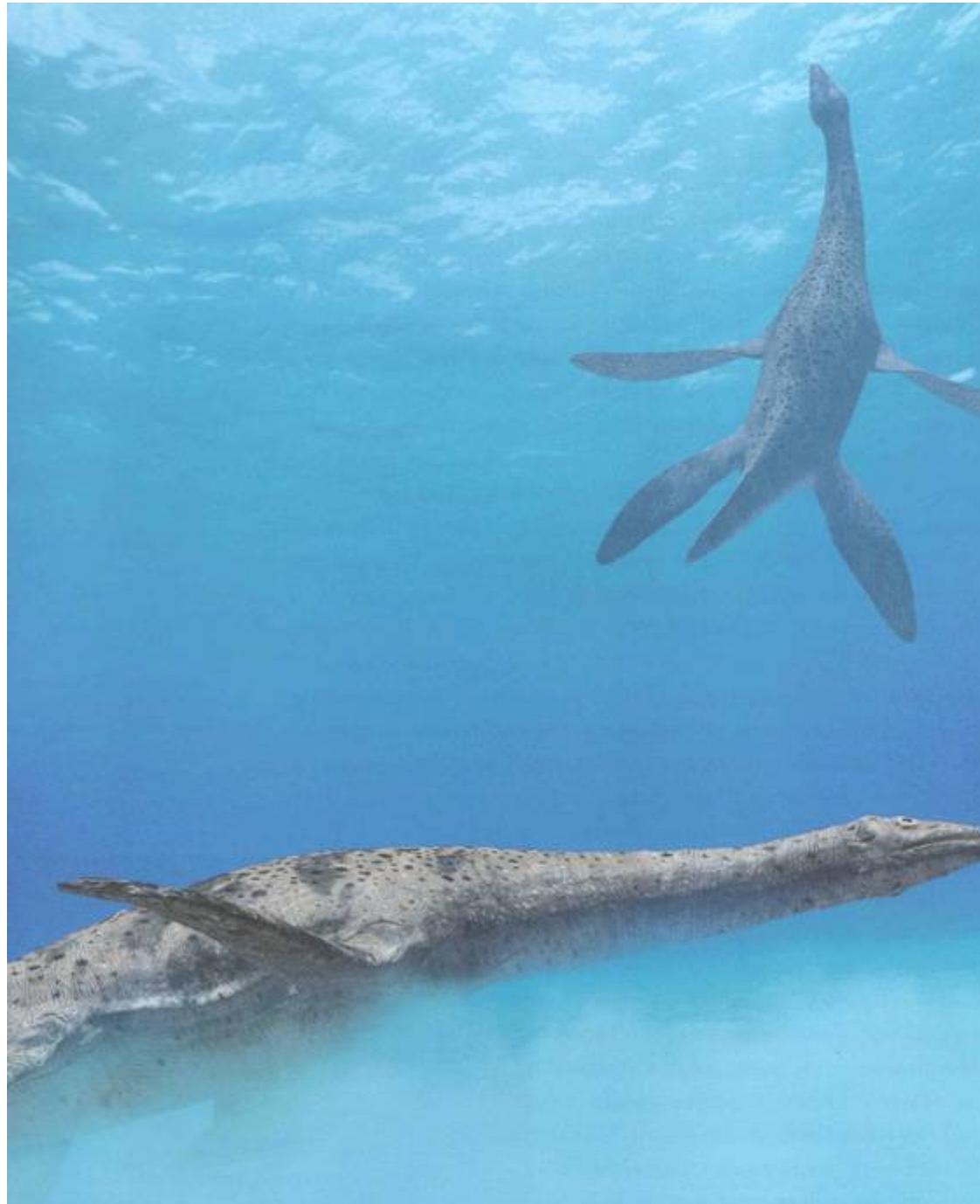


*Nothosaurus*: reconstruction

# *Cryptoclidus* (plesiosaurid)



*Hydrothecosaurus*  
(elasmosaurid)



*Cryptocleidus*  
(about 30  
meters long)



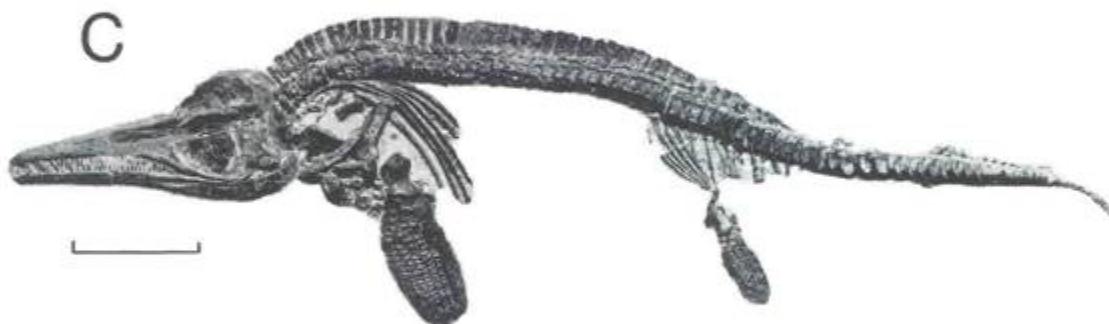
*Liopleurodon*

(about 80 feet  
long)

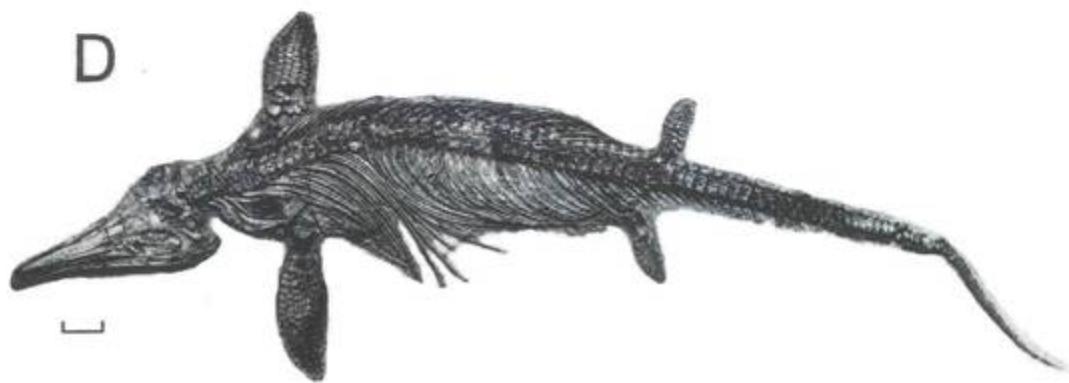
B



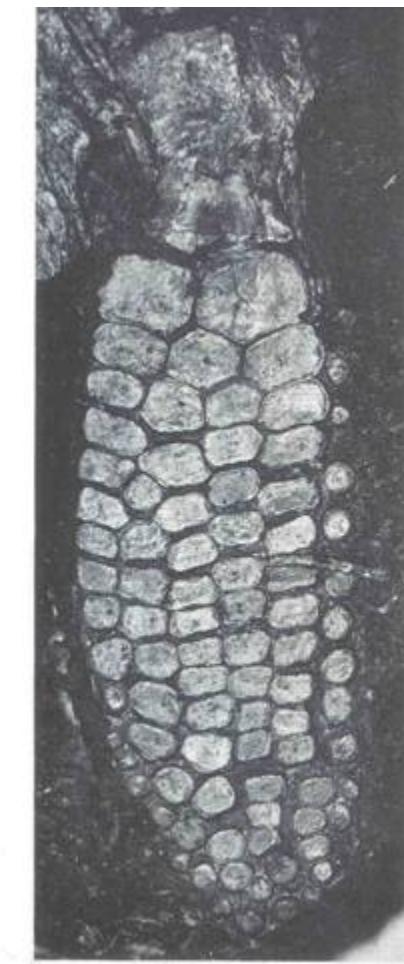
C



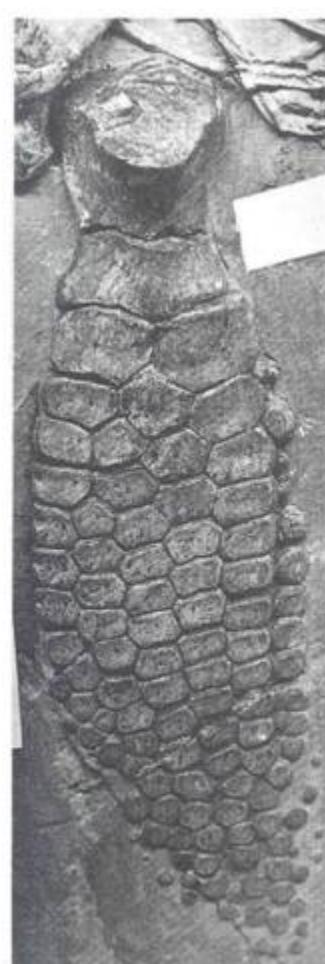
D



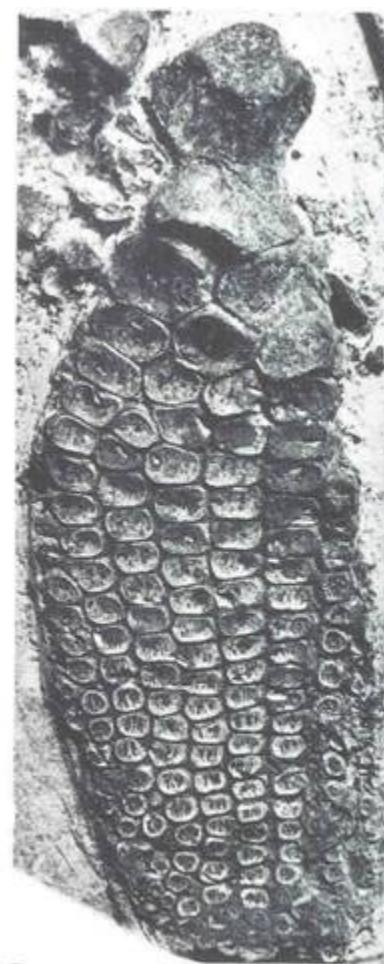
*Ichthyosaurus*



A



B



C



D

Limbs modified into flippers



Juvenile *Ophthalmosaurus*

Cetaceans are fusiform marine mammals

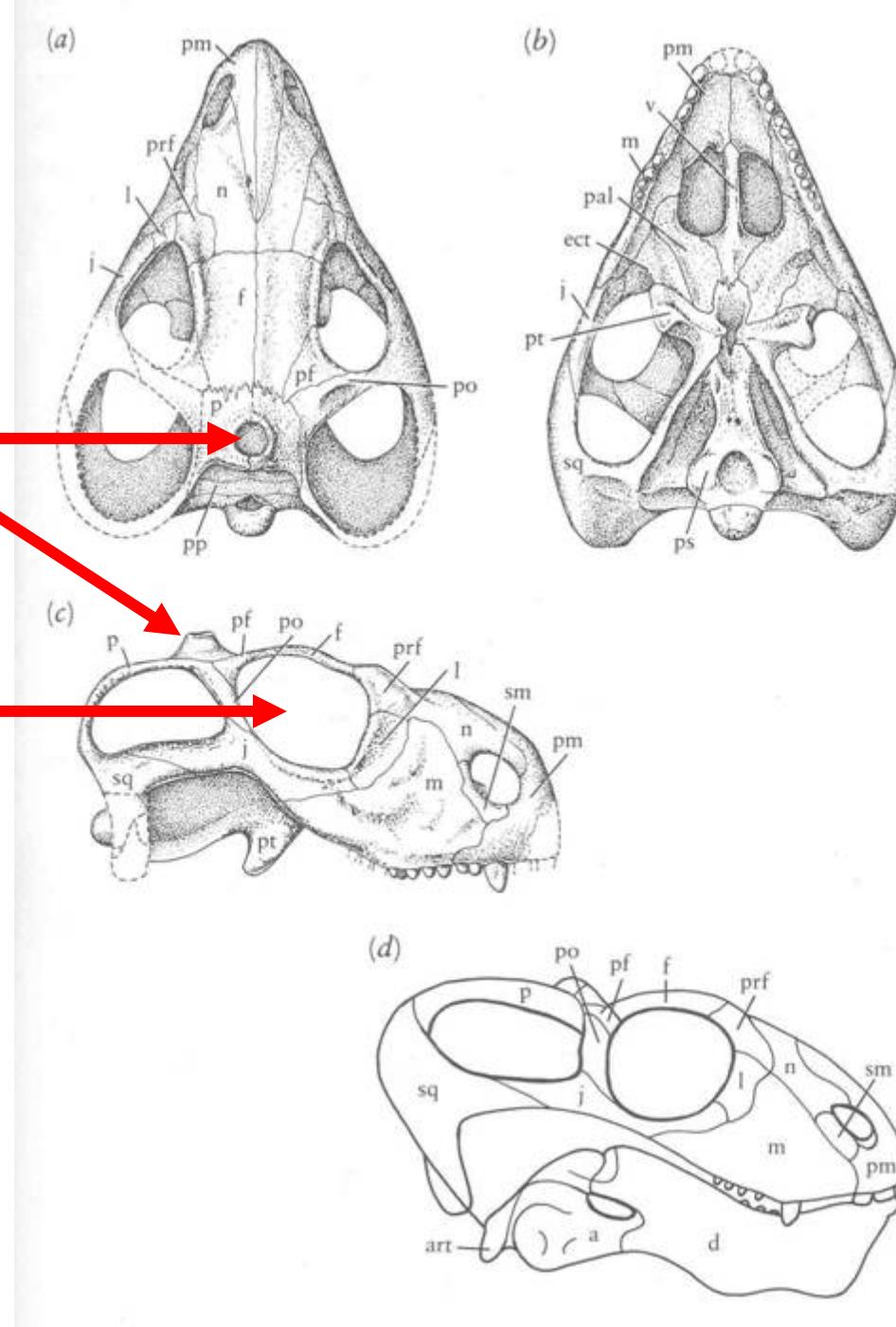


A primitive relative  
of mammals:

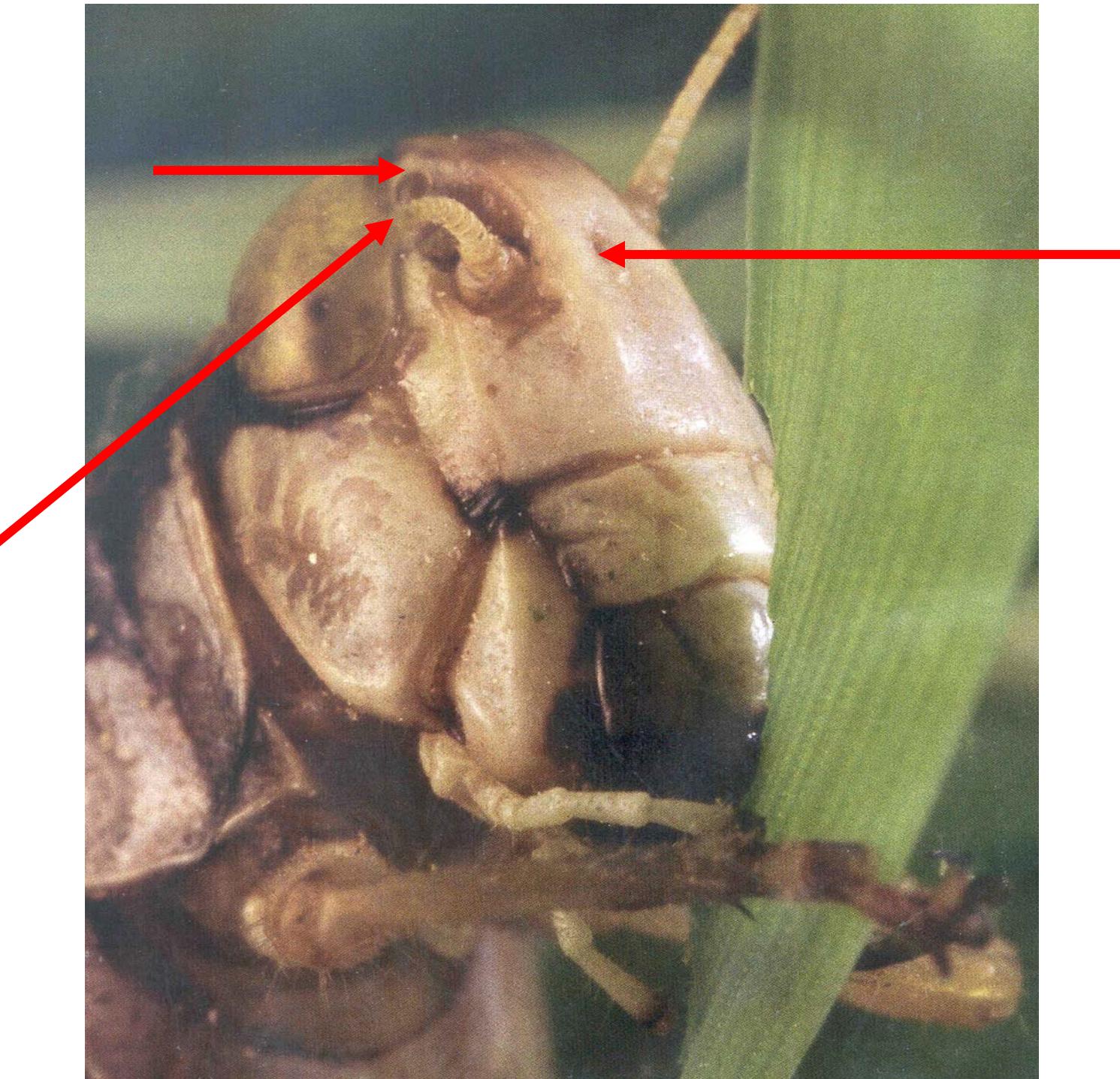
Parietal Eye



Position of image-  
forming eye.





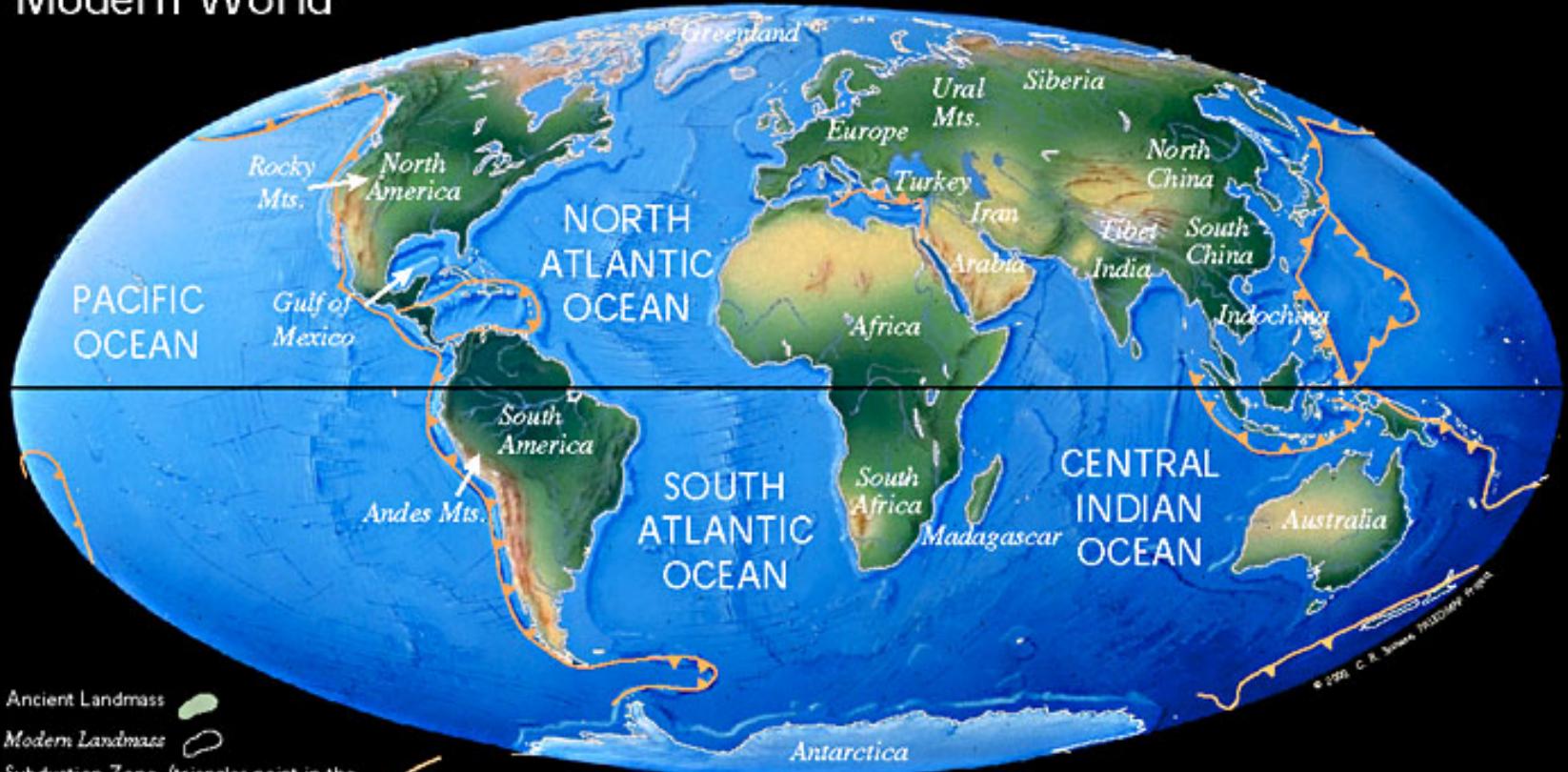


Biogeography  
&  
Paleobiogeography  
(Or, Why You Can't Walk  
from Utah to Germany --  
Anymore)

Global reconstructions shown in  
today's lecture may be seen at the  
Paleomap Project:

<http://www.scotese.com>

## Modern World



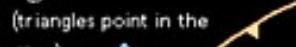
Ancient Landmass



Modern Landmass



Subduction Zone (triangles point in the direction of subduction)

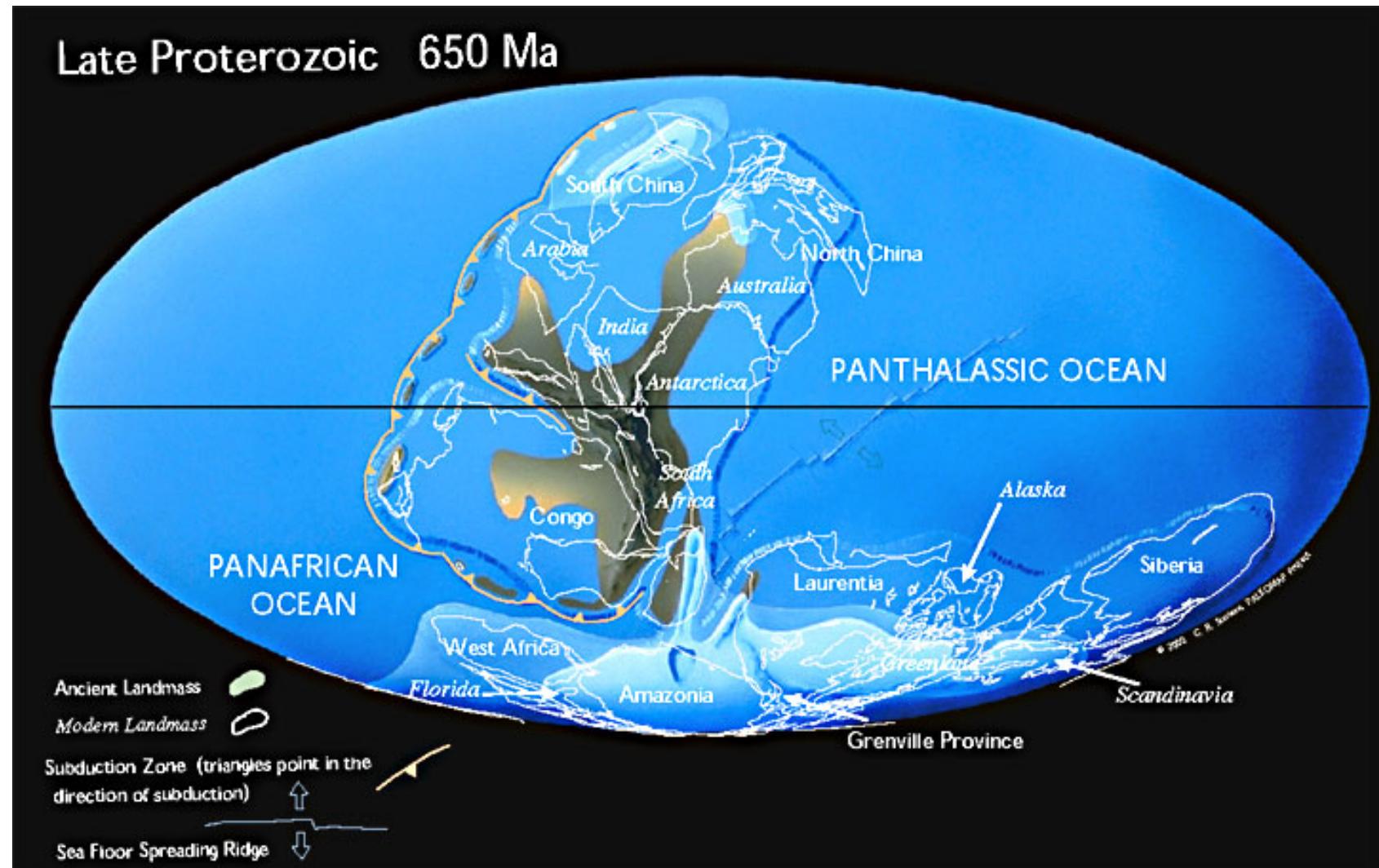


Sea Floor Spreading Ridge

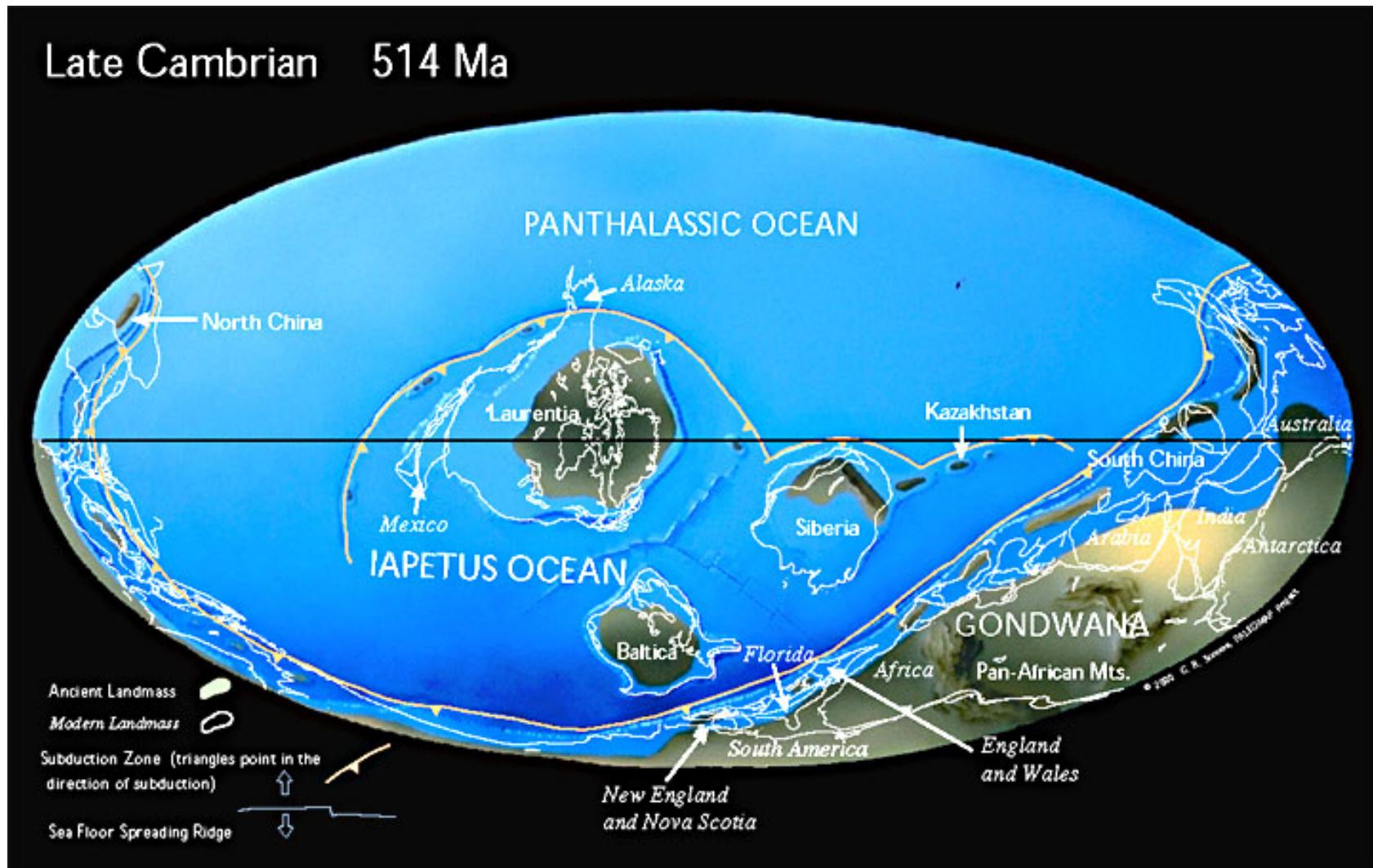


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# Late Precambrian Supercontinent and Ice House World

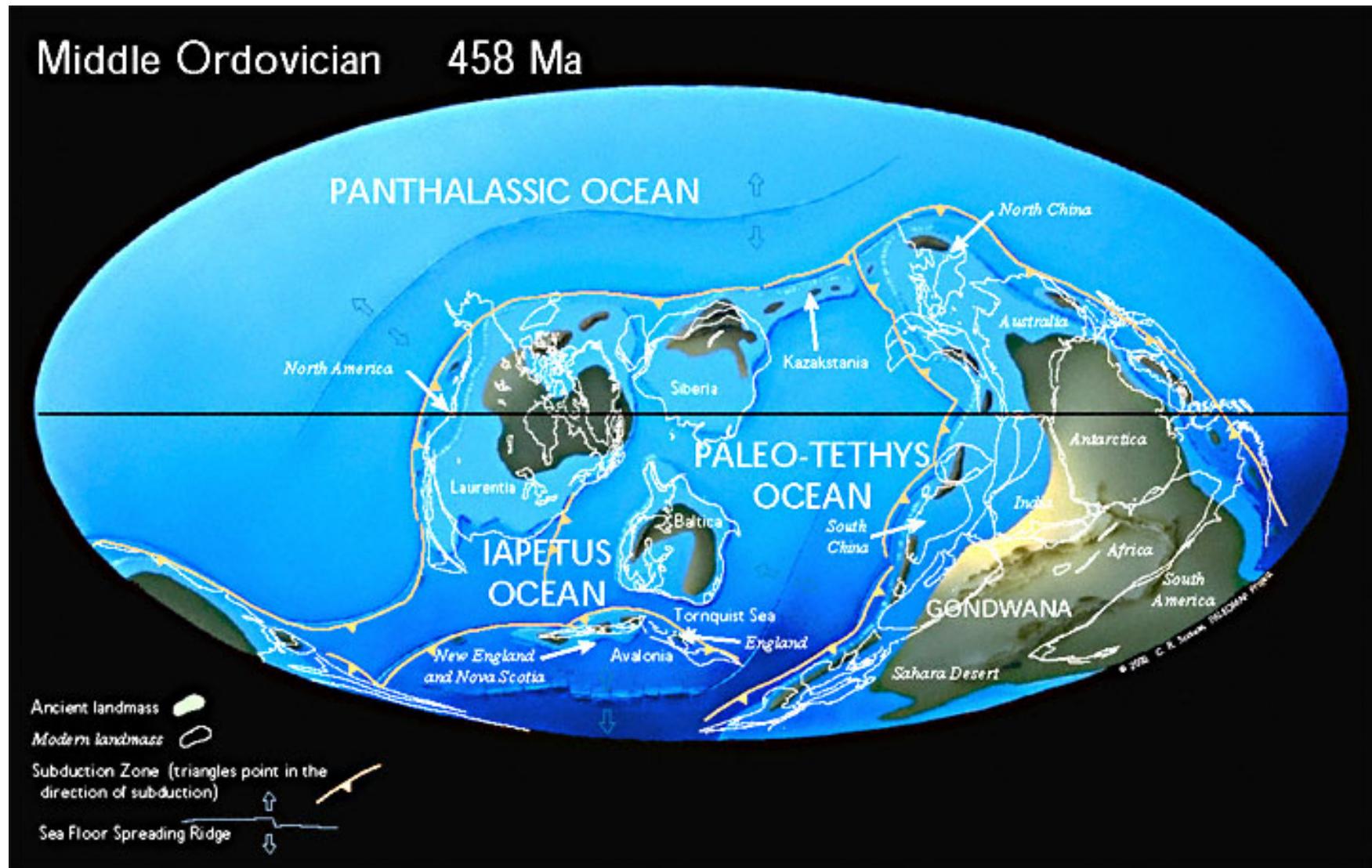


# Cambrian: the beginning of the Paleozoic Era

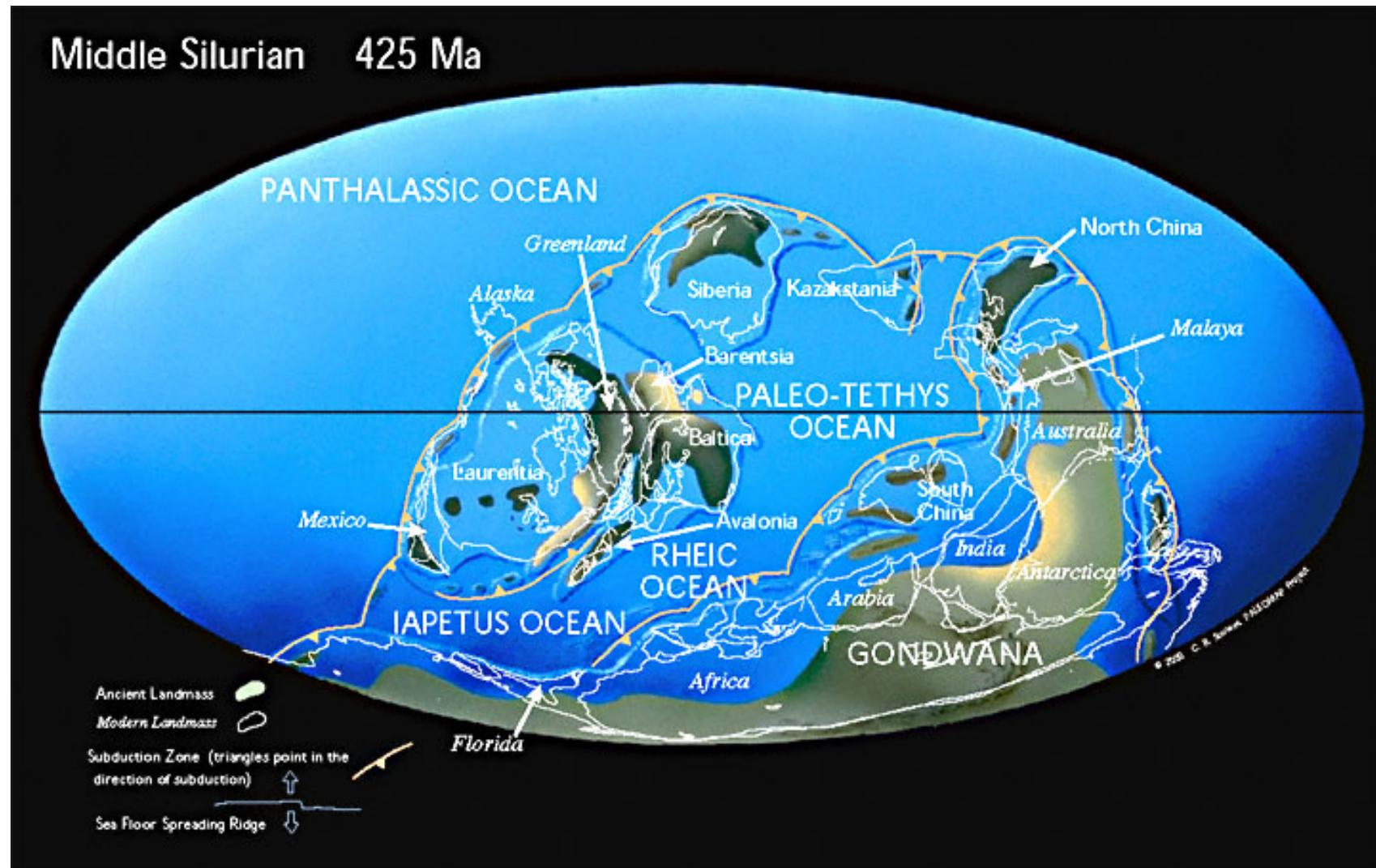


Combined southern continents: **GONDWANA**

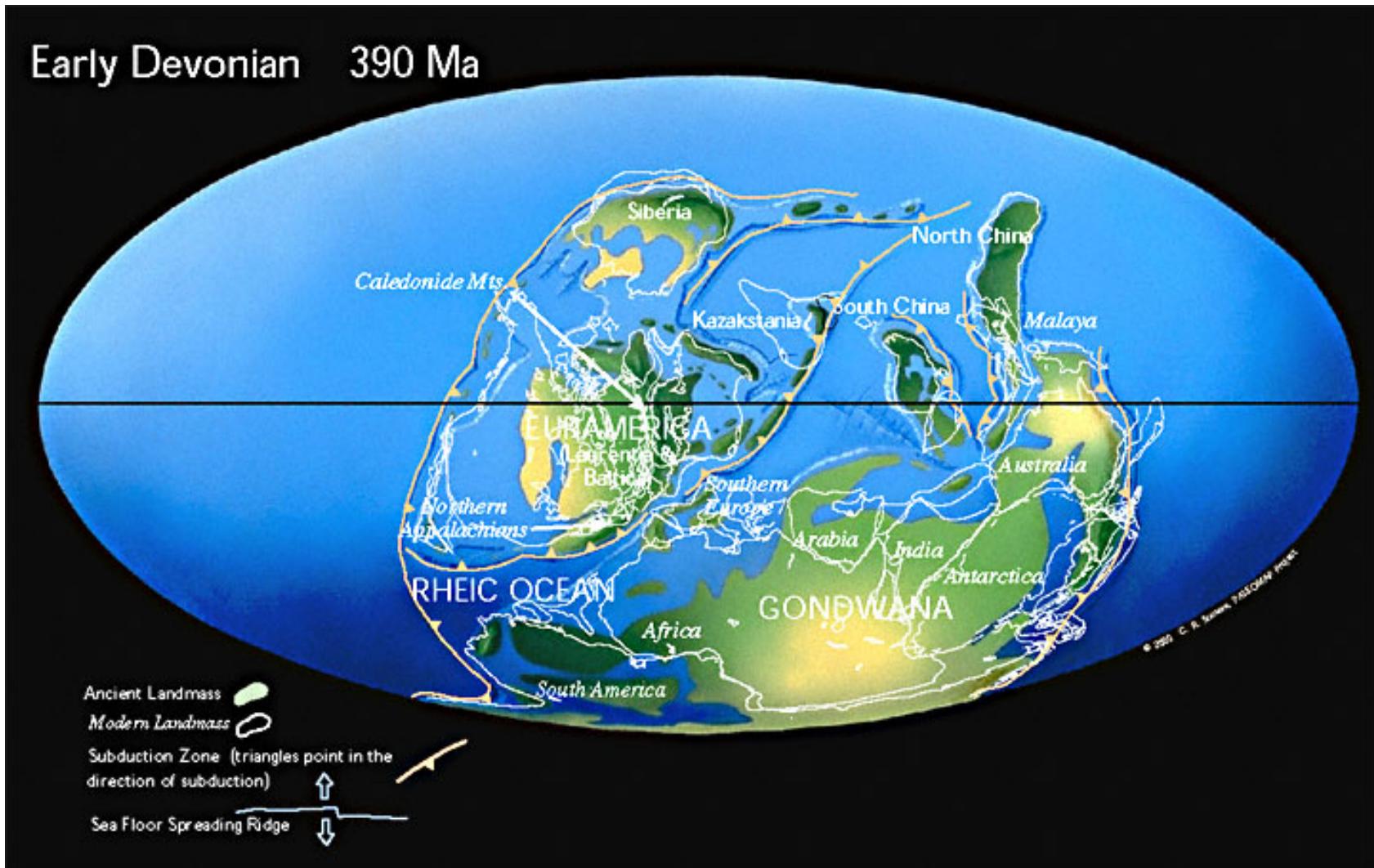
# Ancient Oceans Separate the Continents



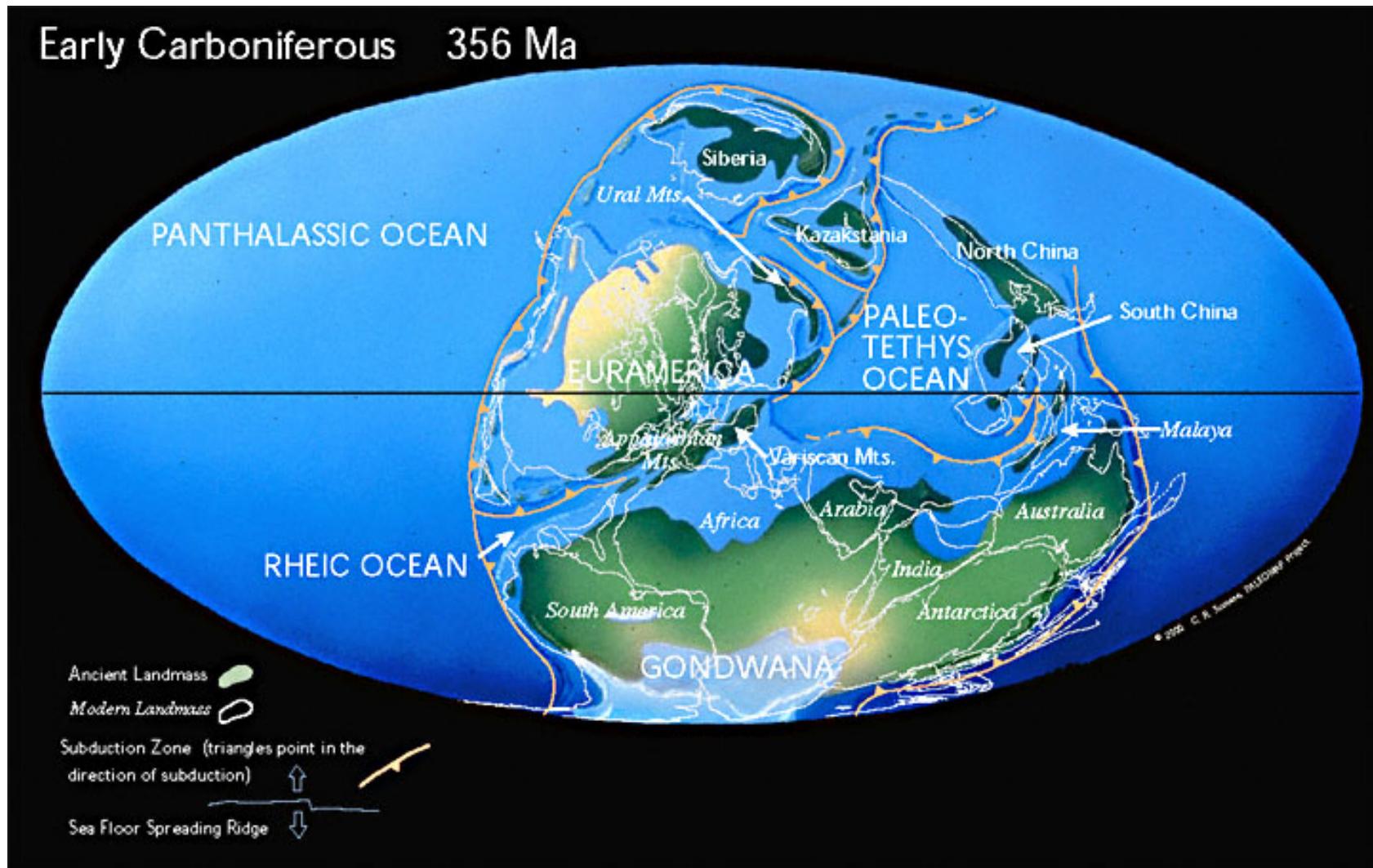
# Continents Begin to Collide as Paleozoic Oceans Close



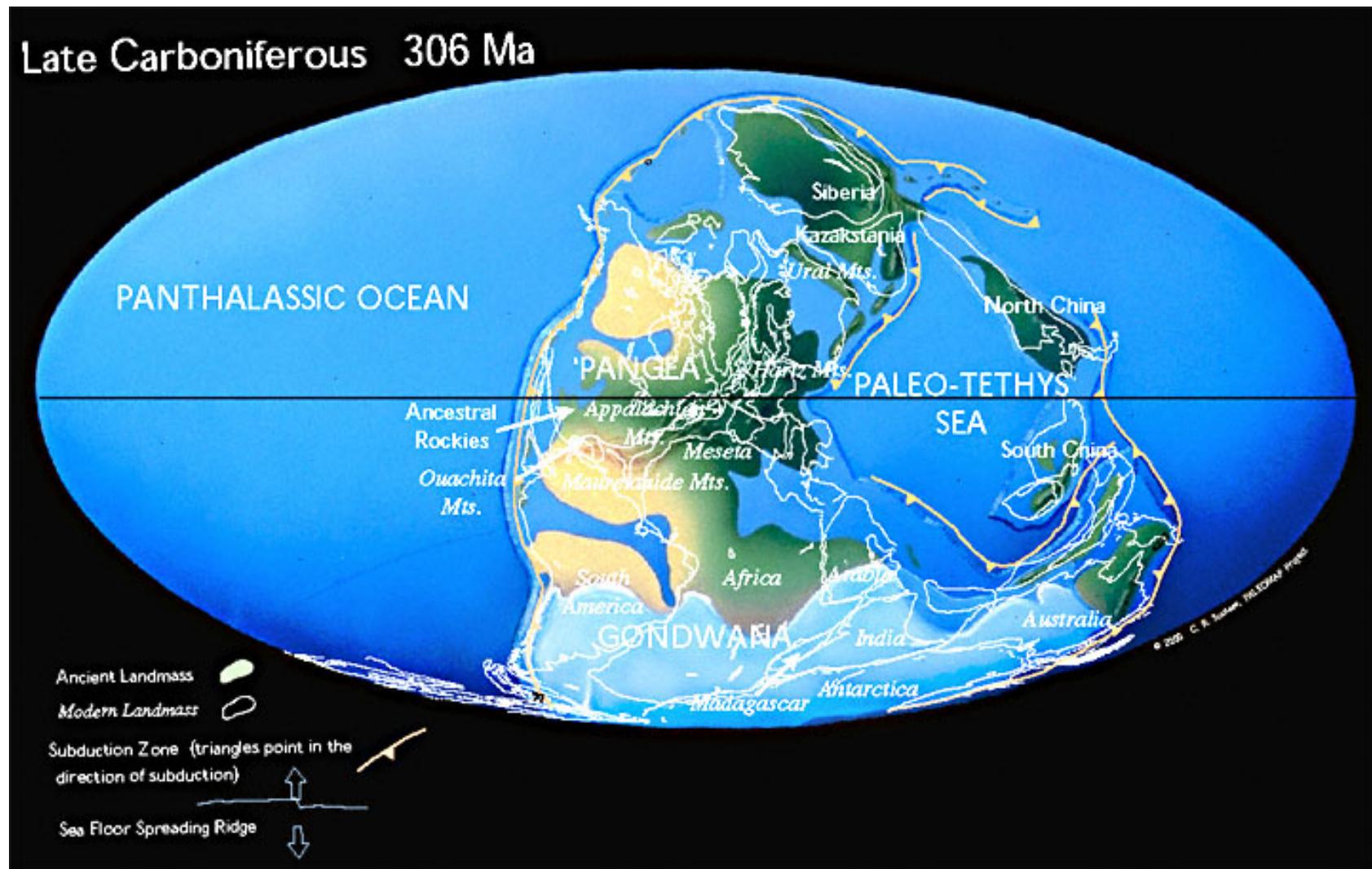
# The Devonian Was the Age of Fish!



# During the Early Carboniferous Pangea Begins to Form.

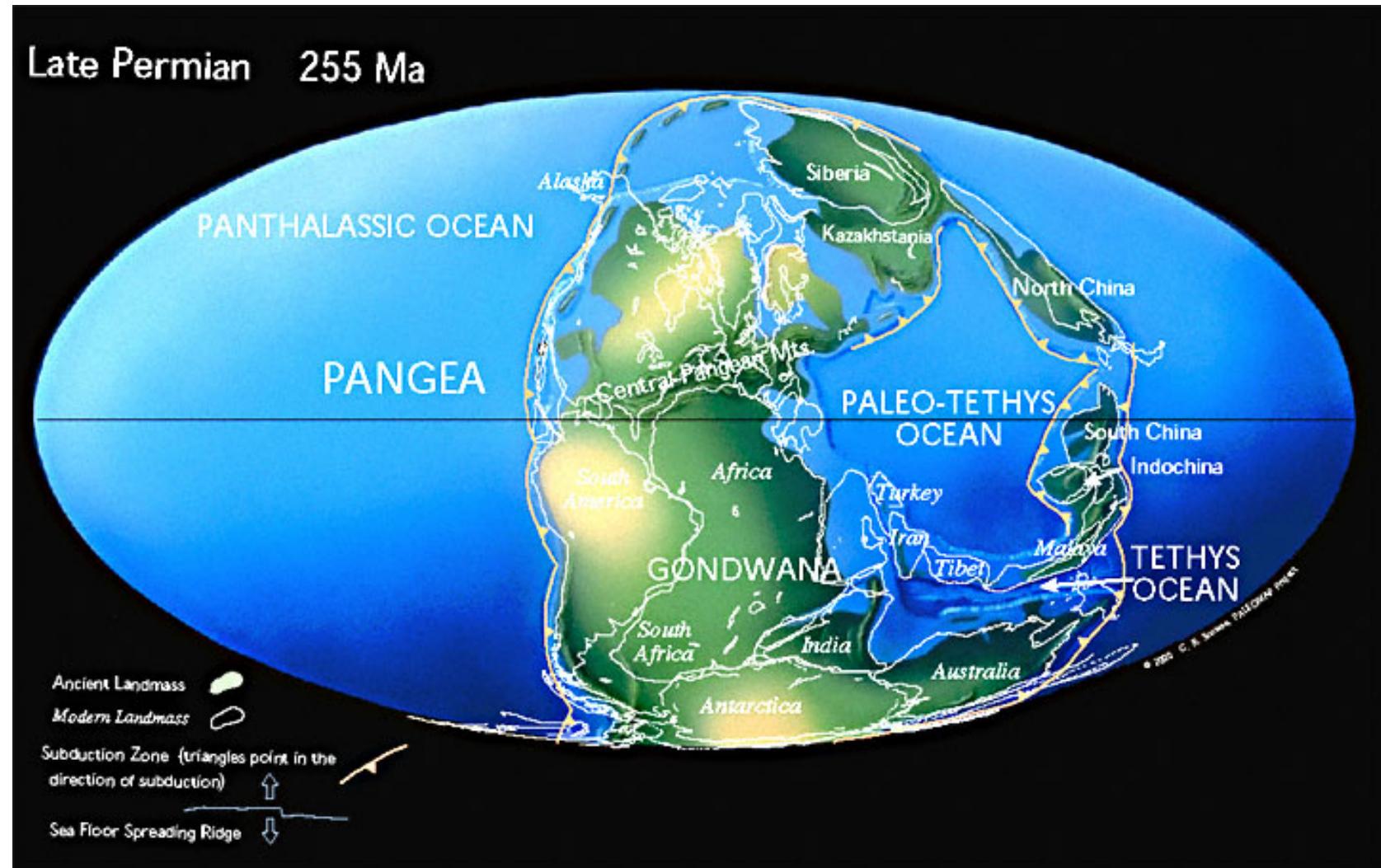


# The Late Carboniferous a Time of Great Coal Swamps



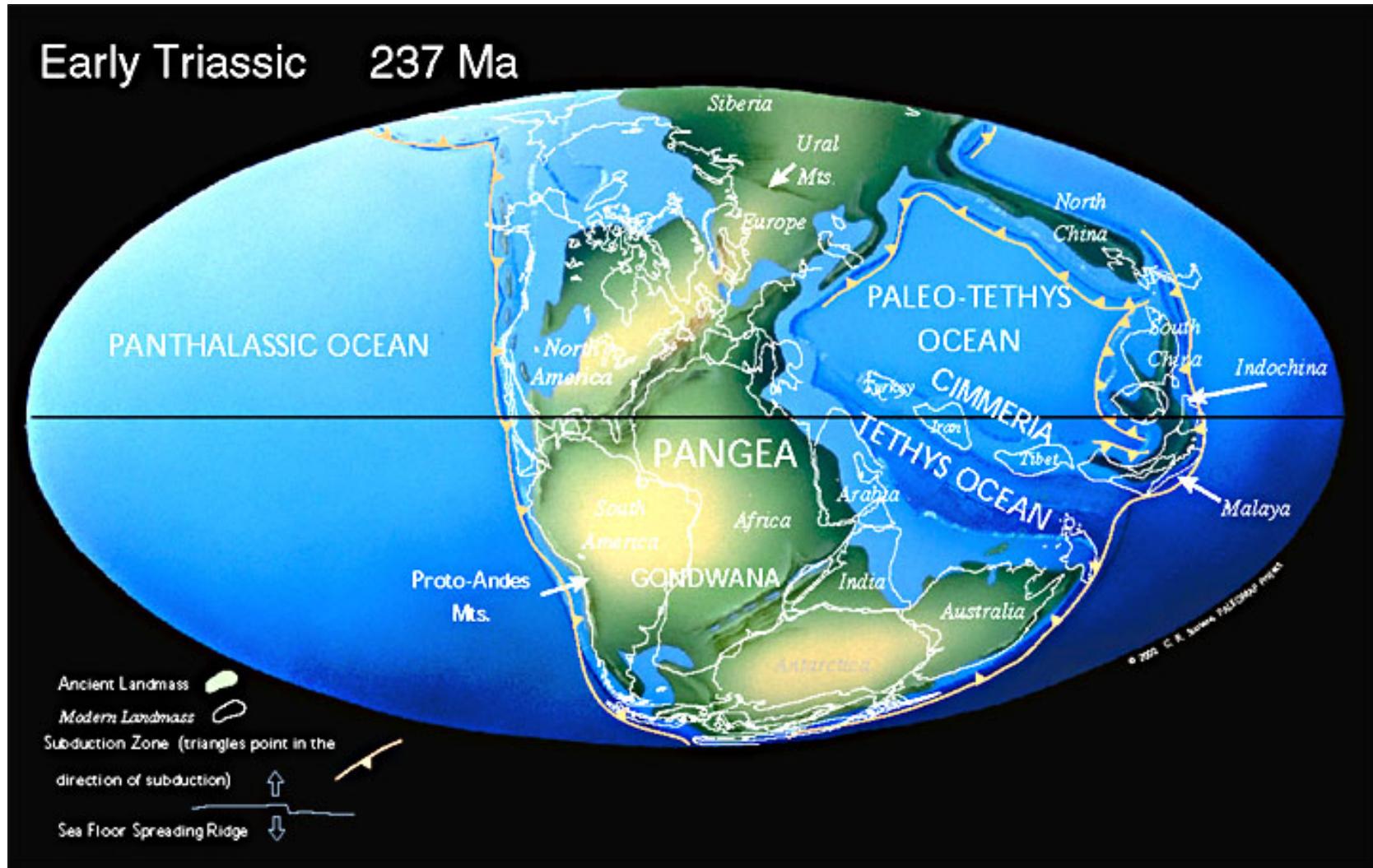
**PANGEA:** “Supercontinent” combining northern and southern continents

At the end of the Permian was Greatest Extinction of All Time



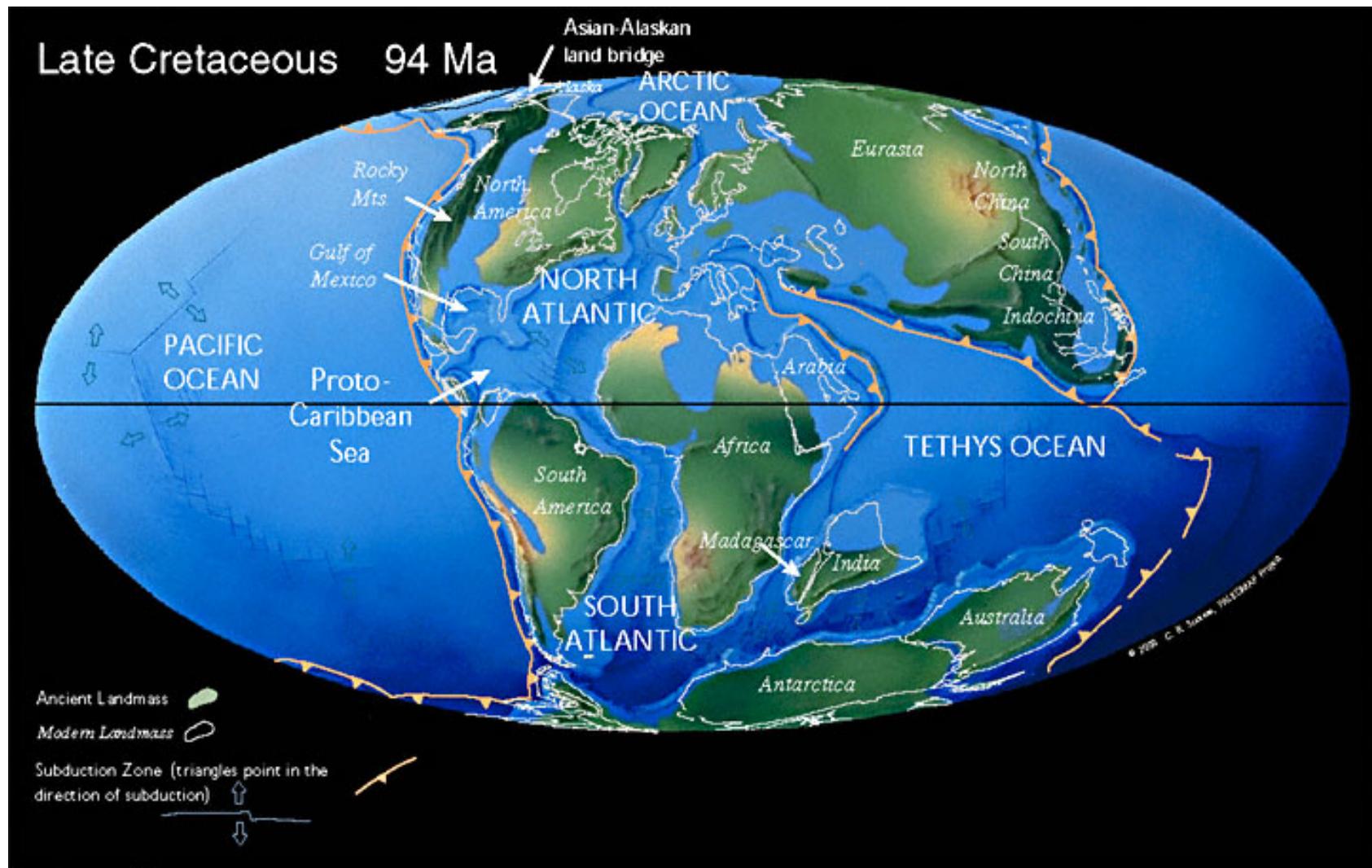
**PANGEA = LAURASIA** (northern) + **GONDWANA** (southern)

At the end of the Triassic, Pangea began to rift apart.

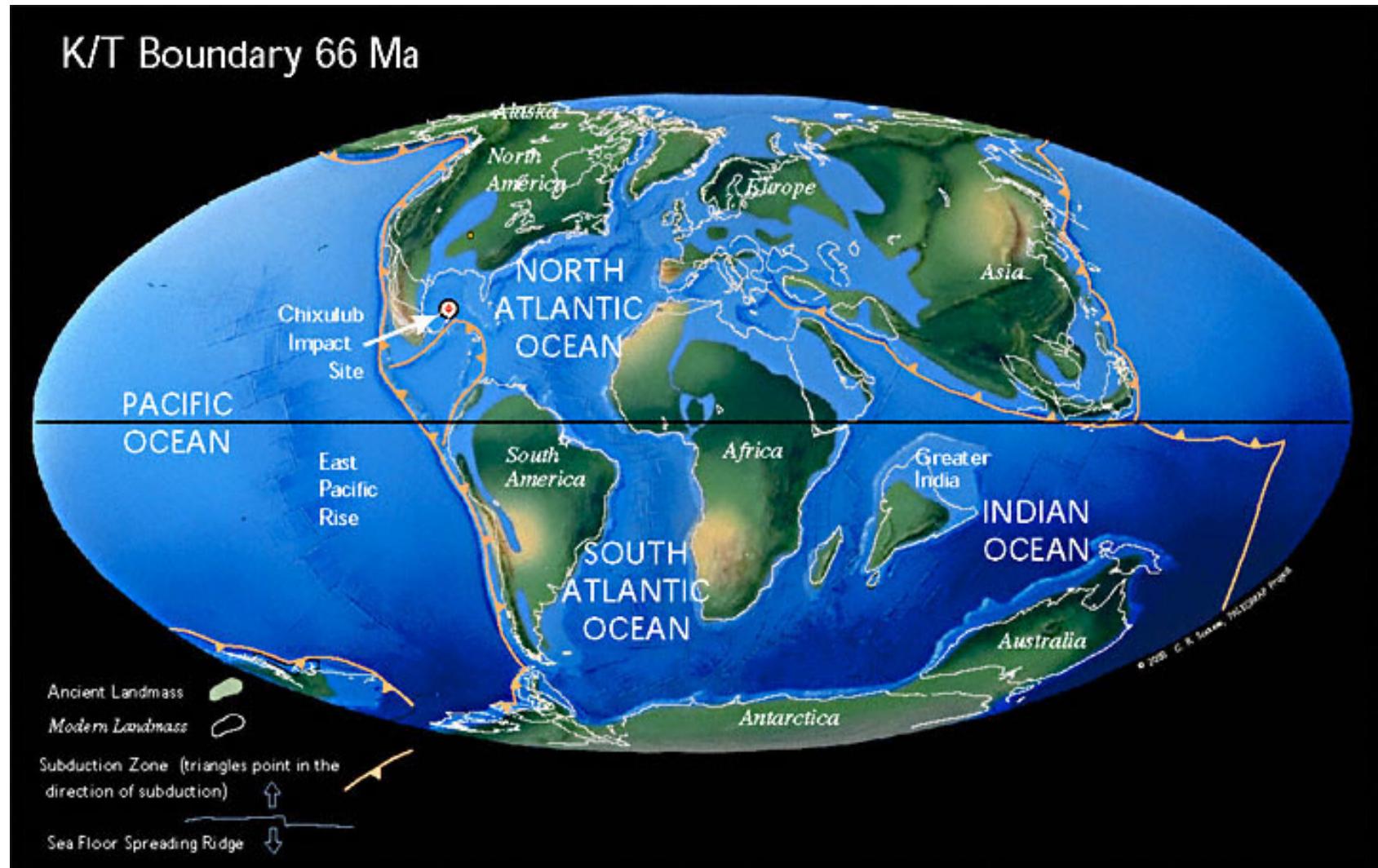


Through most of age of dinosaurs, California is under water.

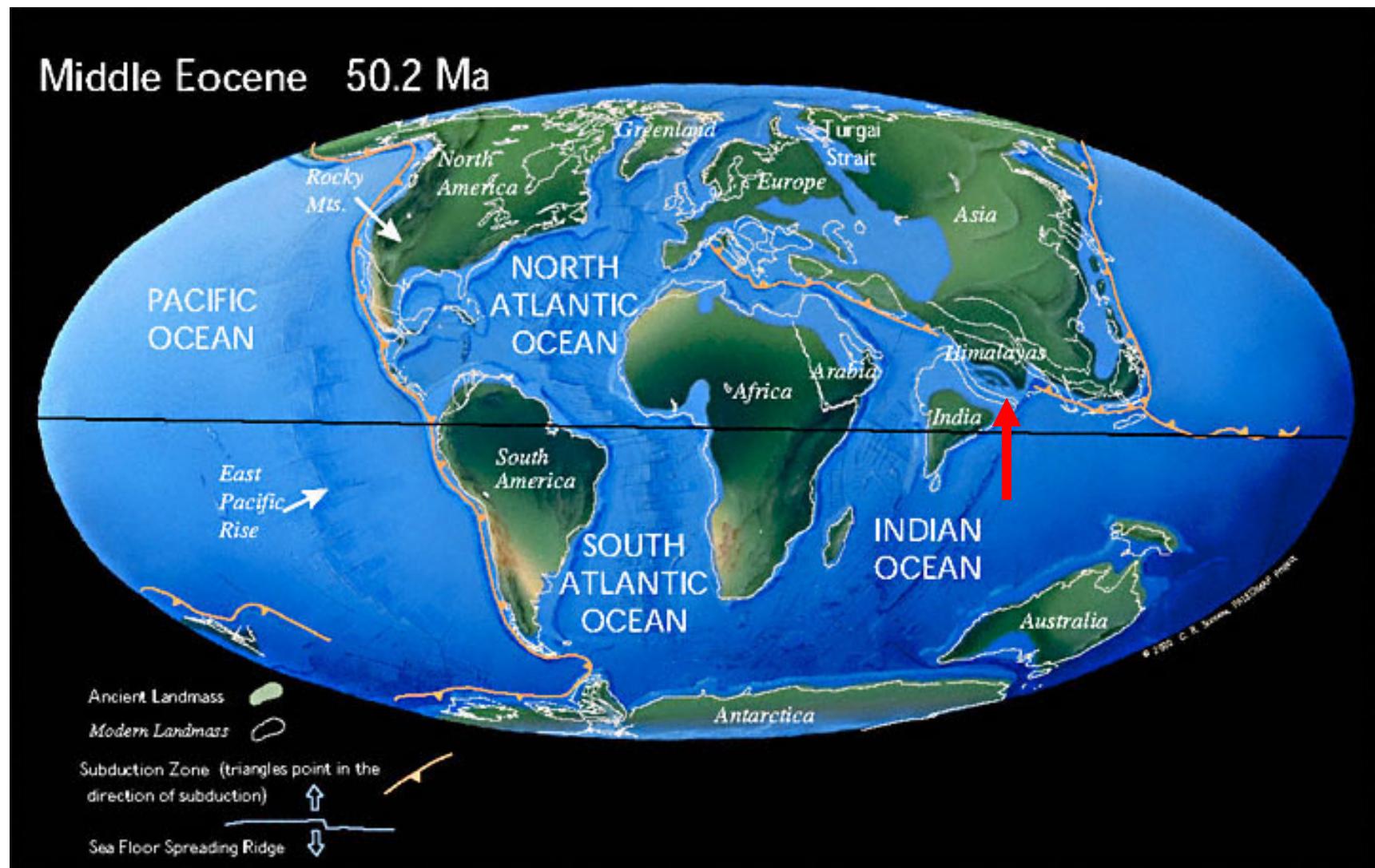
# New Oceans Begin to Open



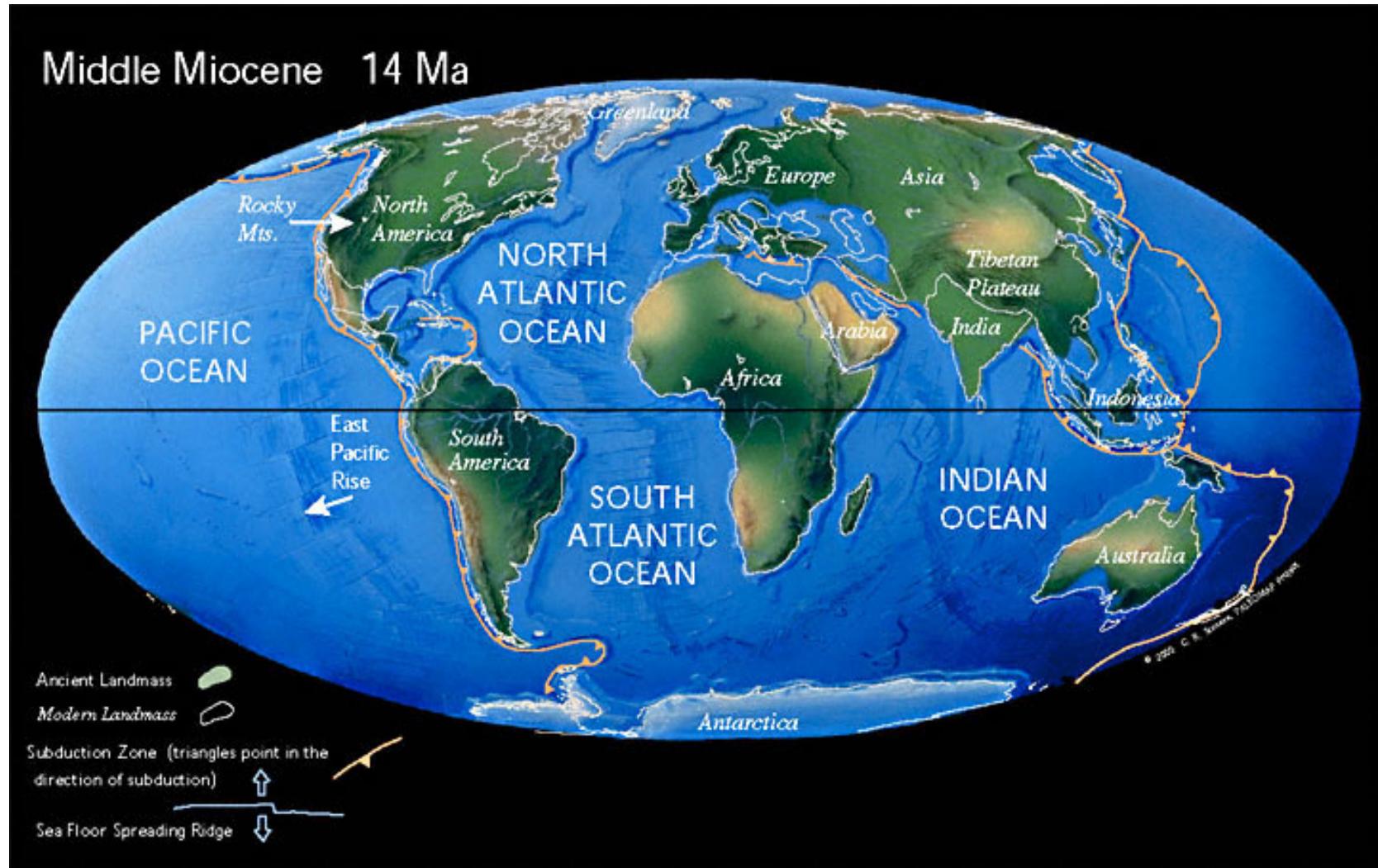
# The End of the Dinosaurs



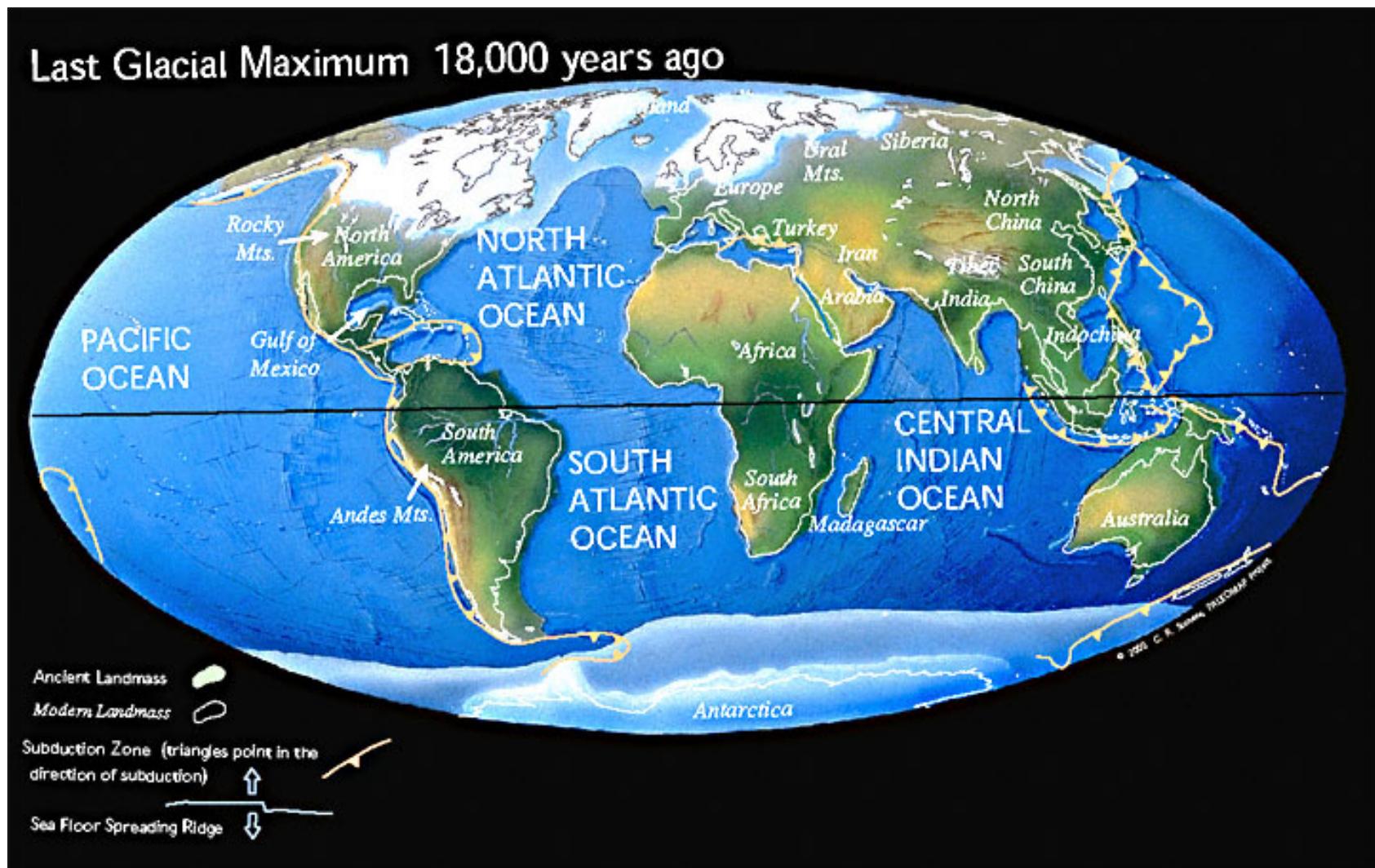
During the Early Cenozoic India began to Collide with Asia.



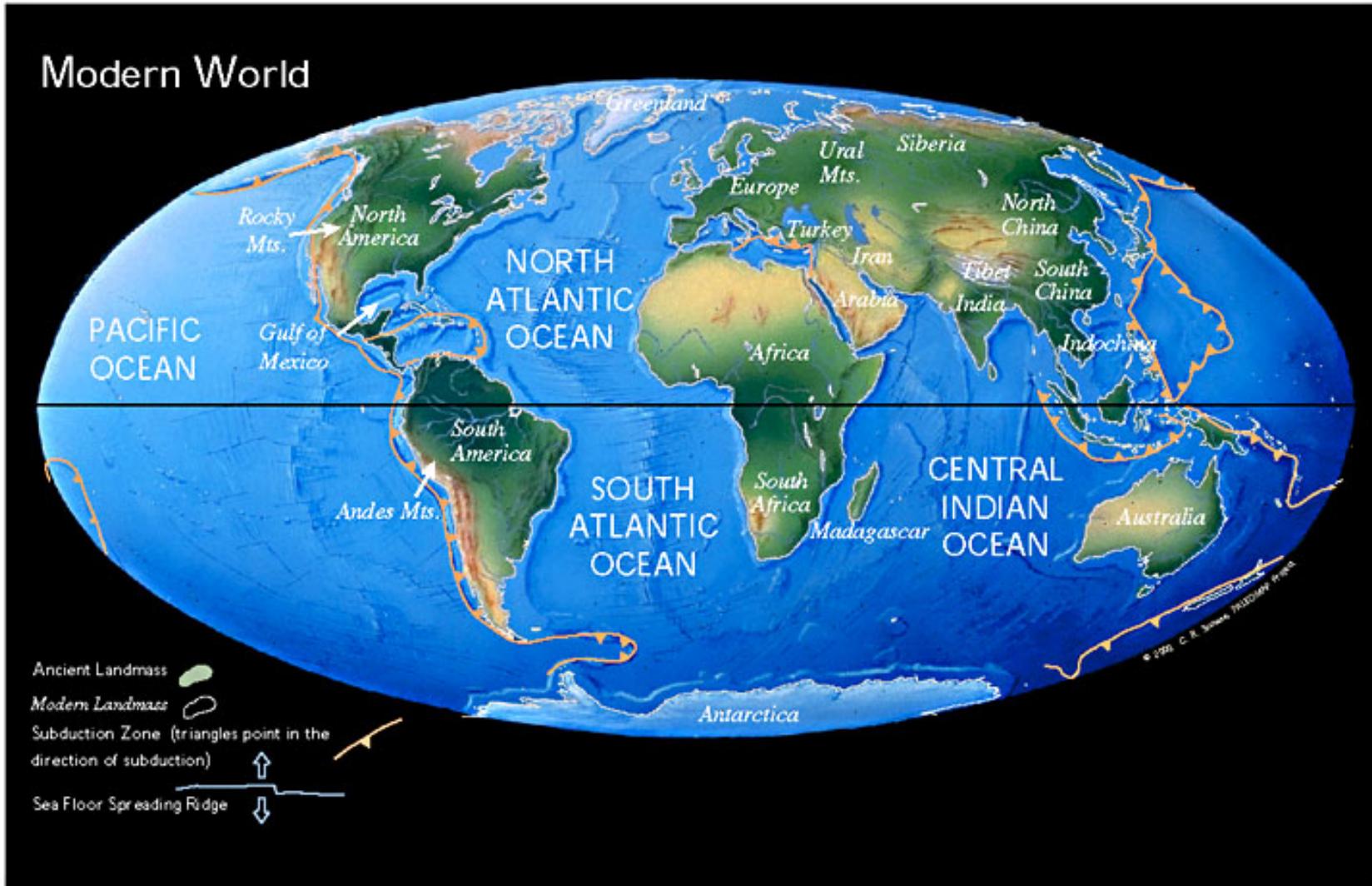
# The World Assumes a Modern Configuration



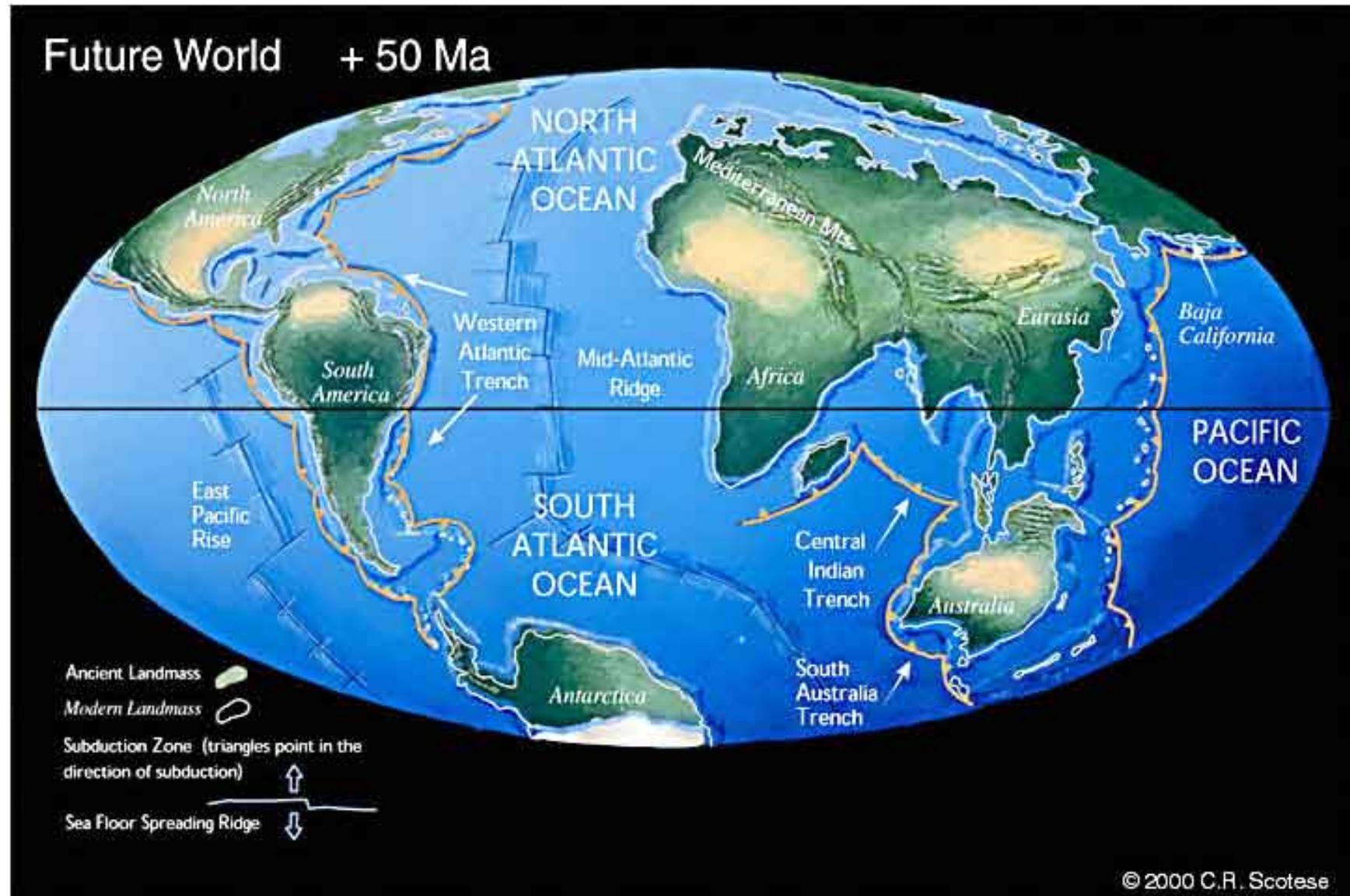
The Earth has been in an Ice House Climate for the last 30 million years.



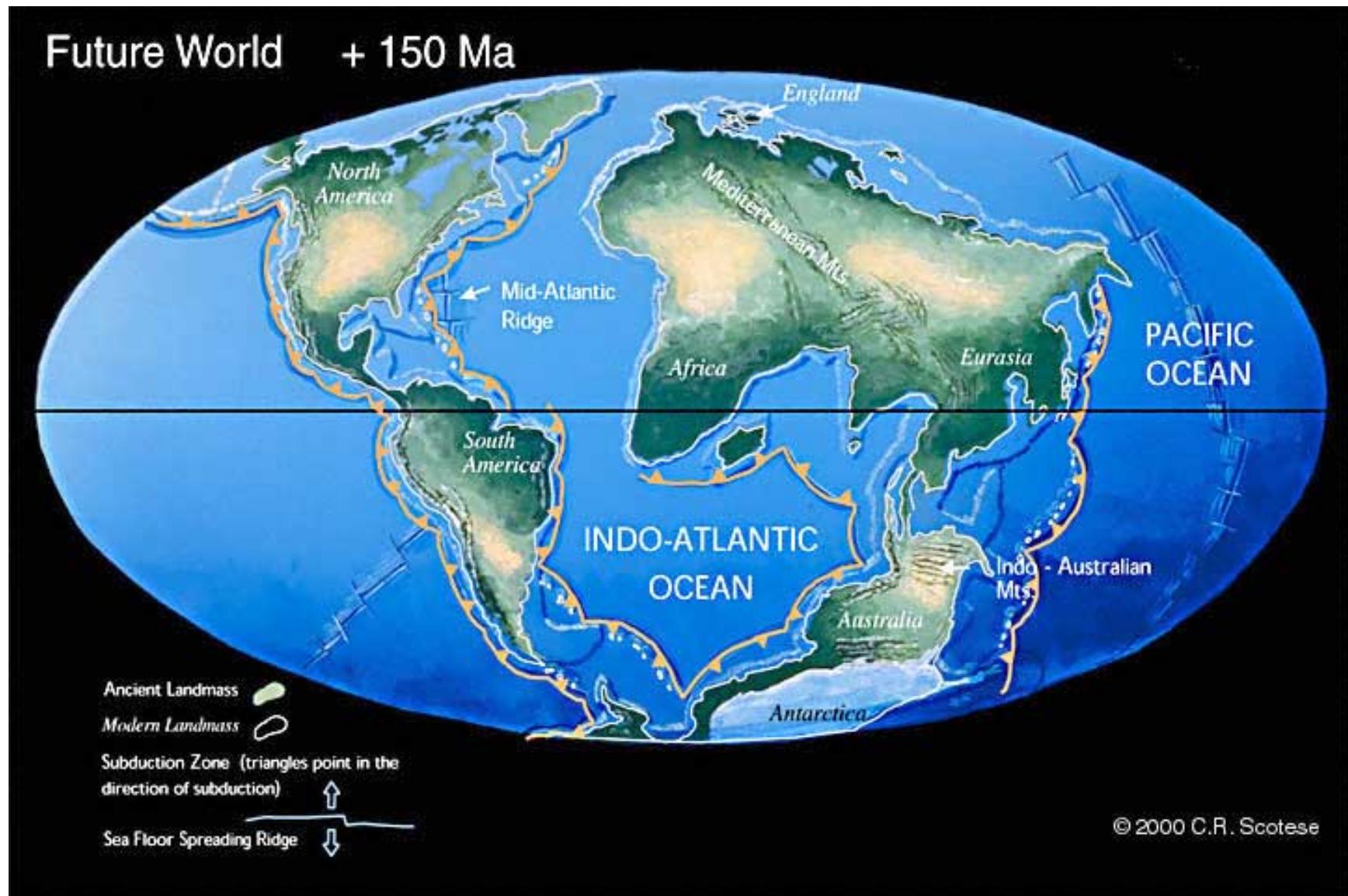
Modern World



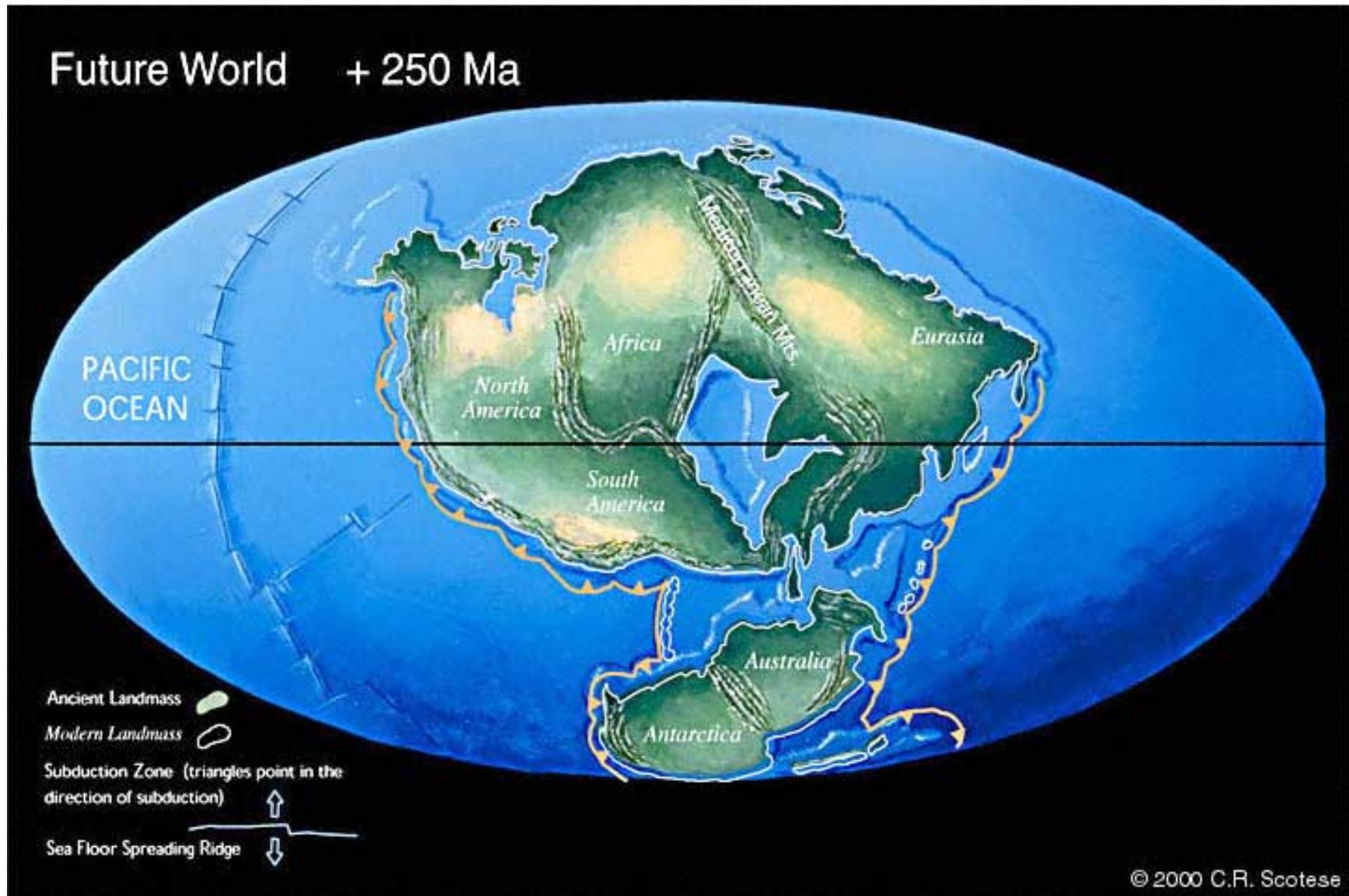
This is the way the World may look like 50 million years from now.



# The Atlantic Ocean begins to Close



*"Pangea Ultima"* will form 250 million years in the Future.



# Continental Drift:

- One of the most important scientific understandings of the last century.
- We accept it today, but it wasn't actually accepted until the 1960s.

# Continental Drift:

- Paleontological discoveries drove this: work of A.S. Romer comparing fossil animals from South America and Africa. Very similar animals came from continents far apart in the present day.
- (Note how the coastlines of South American and Africa compliment one another.)

# Continental Drift:

At about the speed that your fingernails grow.

If this is the case, it must take a very long time. (More evidence that the earth is very ancient.)

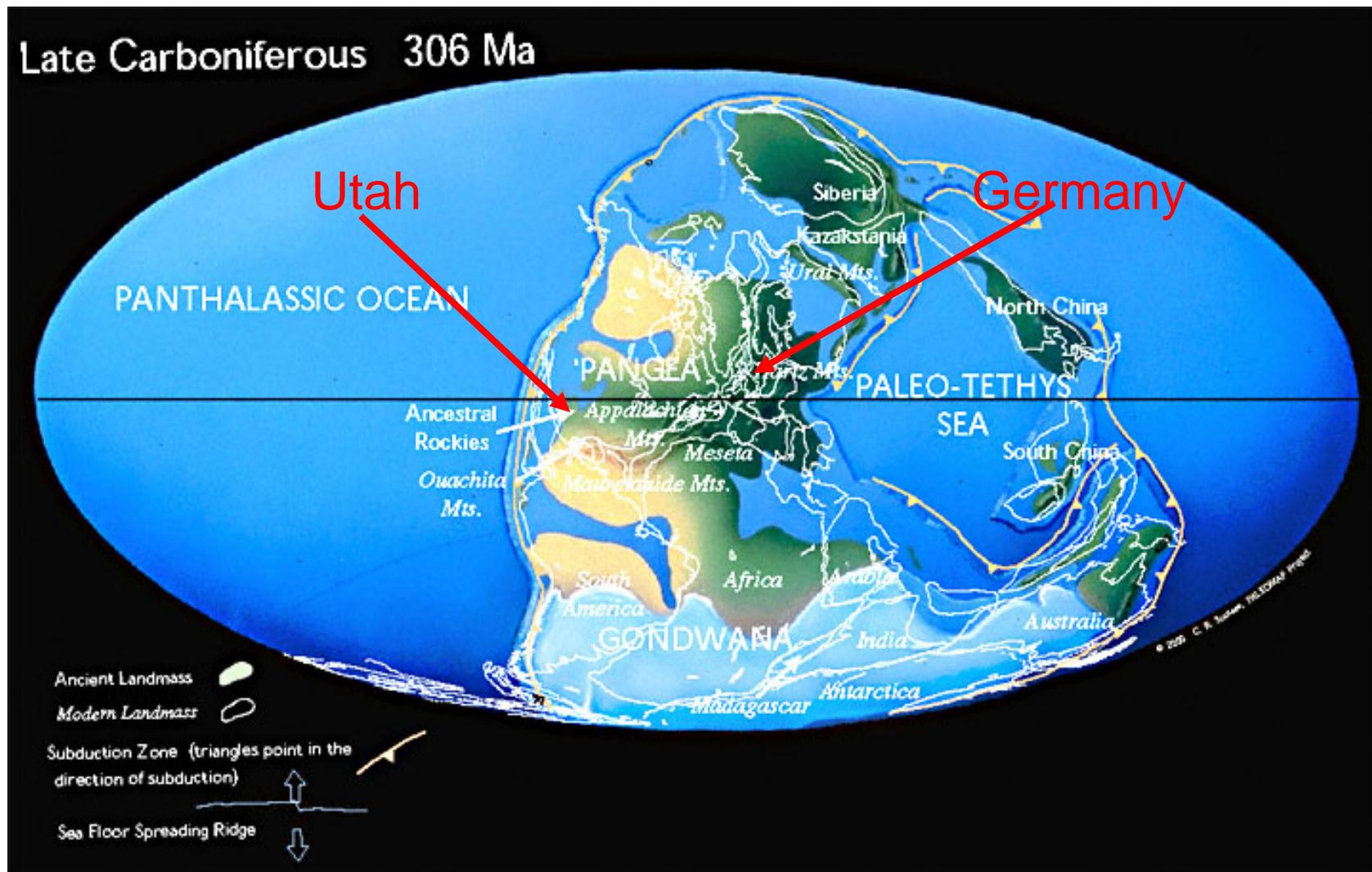
So . . .

You can't walk from Utah to  
Germany TODAY.

But what about approximately  
300 million years ago?

What is the evidence for this?

# The Late Carboniferous a Time of Great Coal Swamps



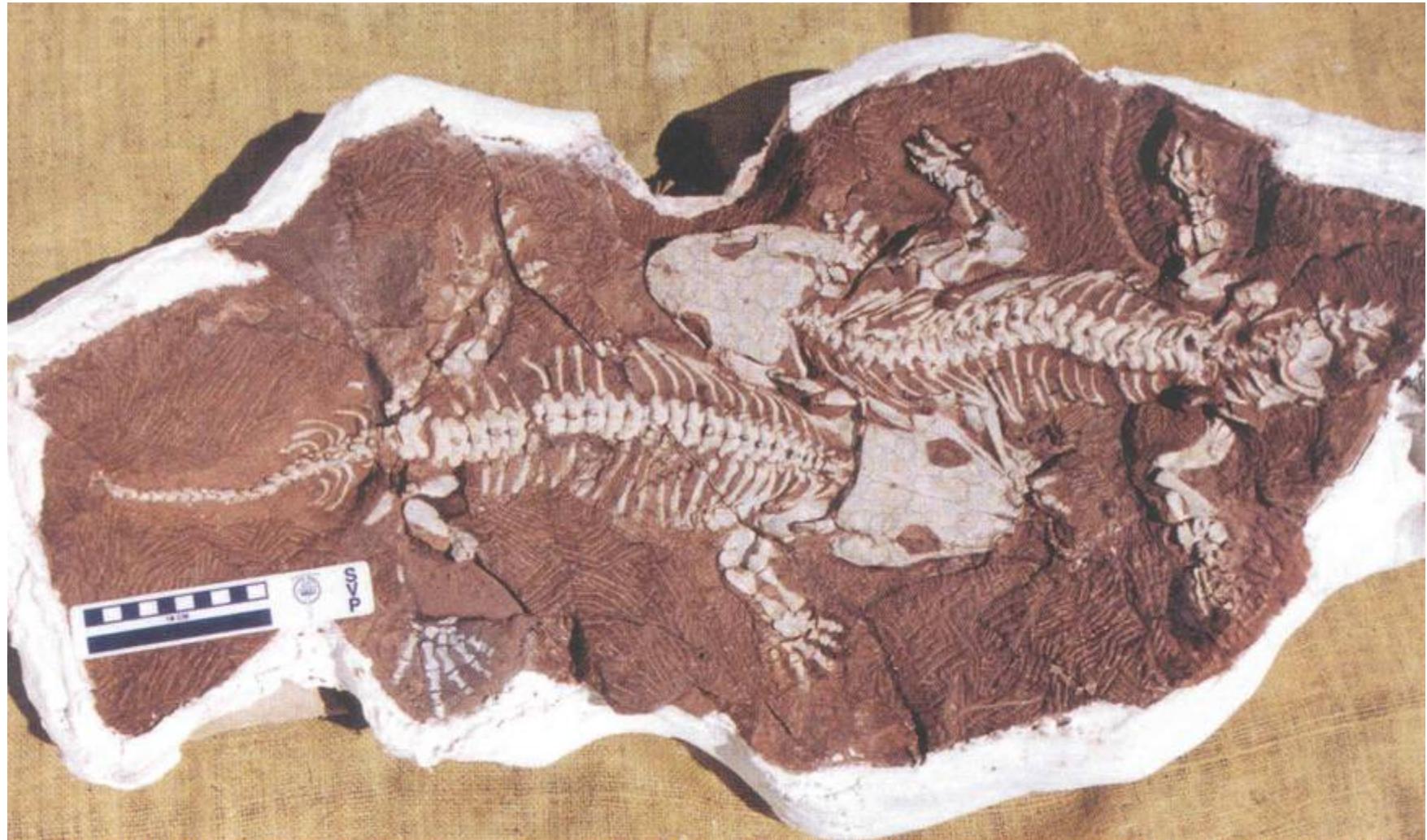












Advanced Amphibian: e.g. Seymouriamorpha  
*Seymouria sanjuanensis* – exact same species found  
in Utah, Texas, Oklahoma, and central Germany

*Orobates*, New genus of Diadectid – found in both North America and central Germany



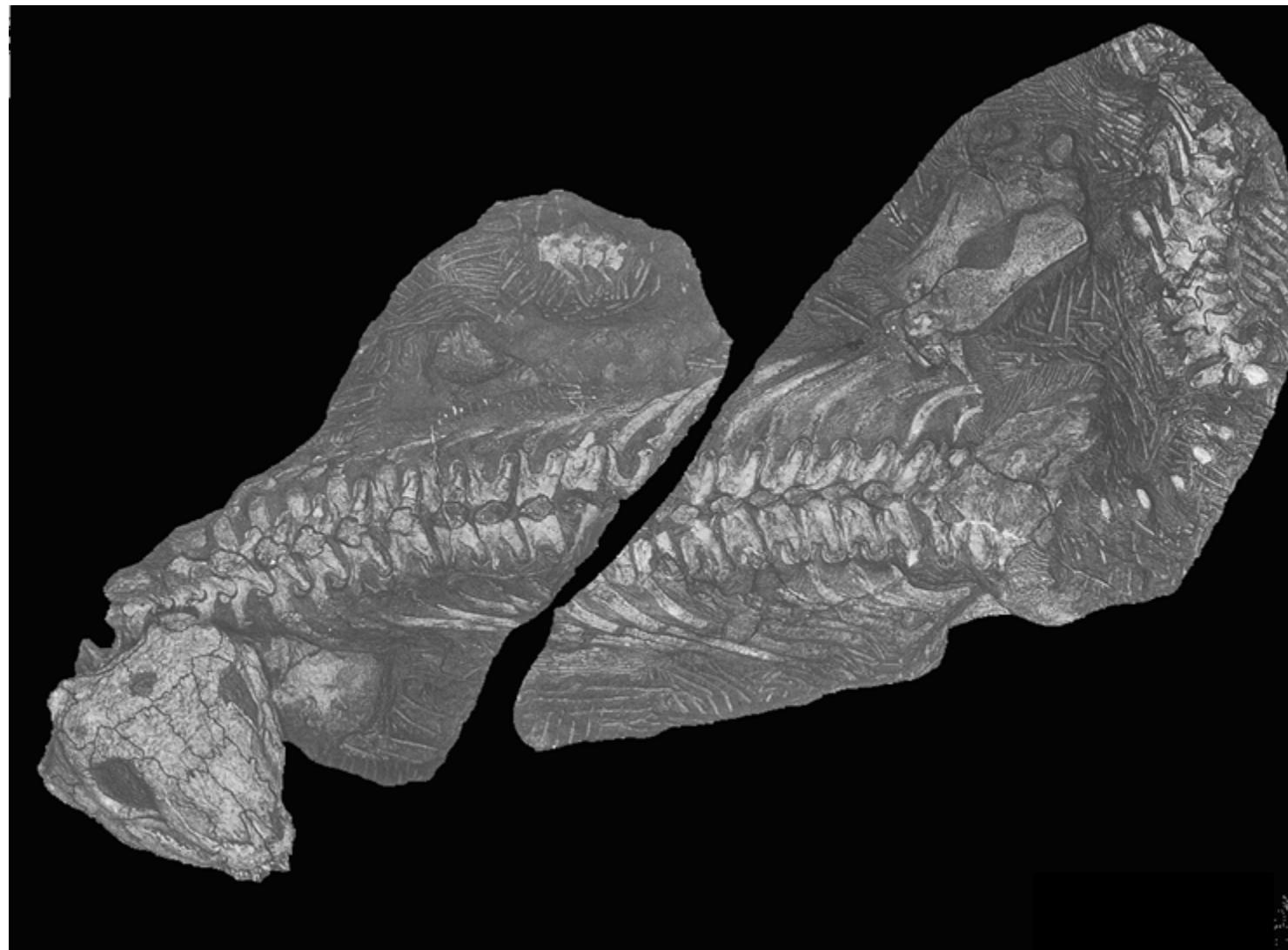
*Orobates*, New Diadectid (same taxon as previous slide)



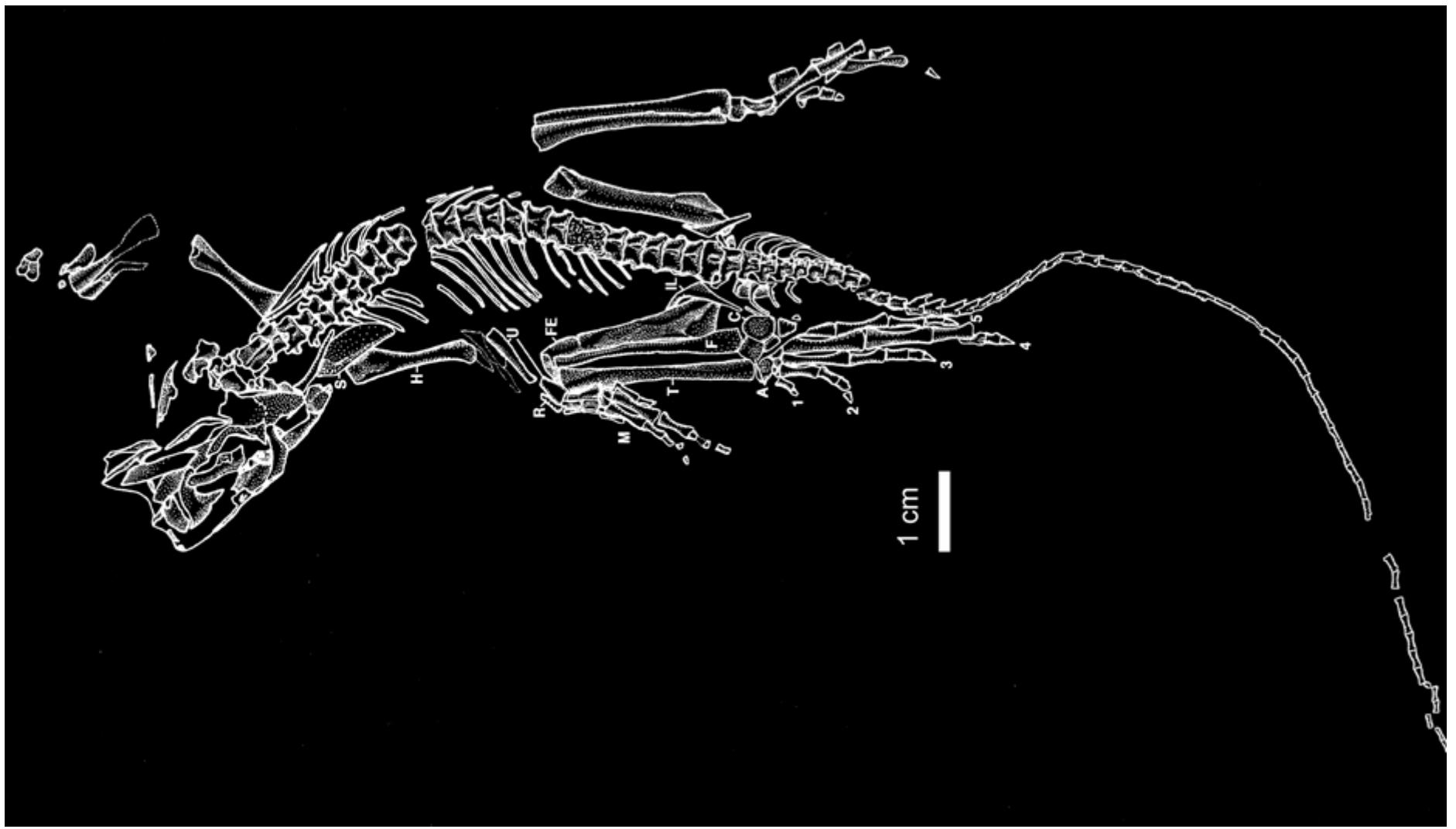
*Orobates*



*Diadectes* – this genus found in Utah, New Mexico, Texas, Oklahoma, and central Germany

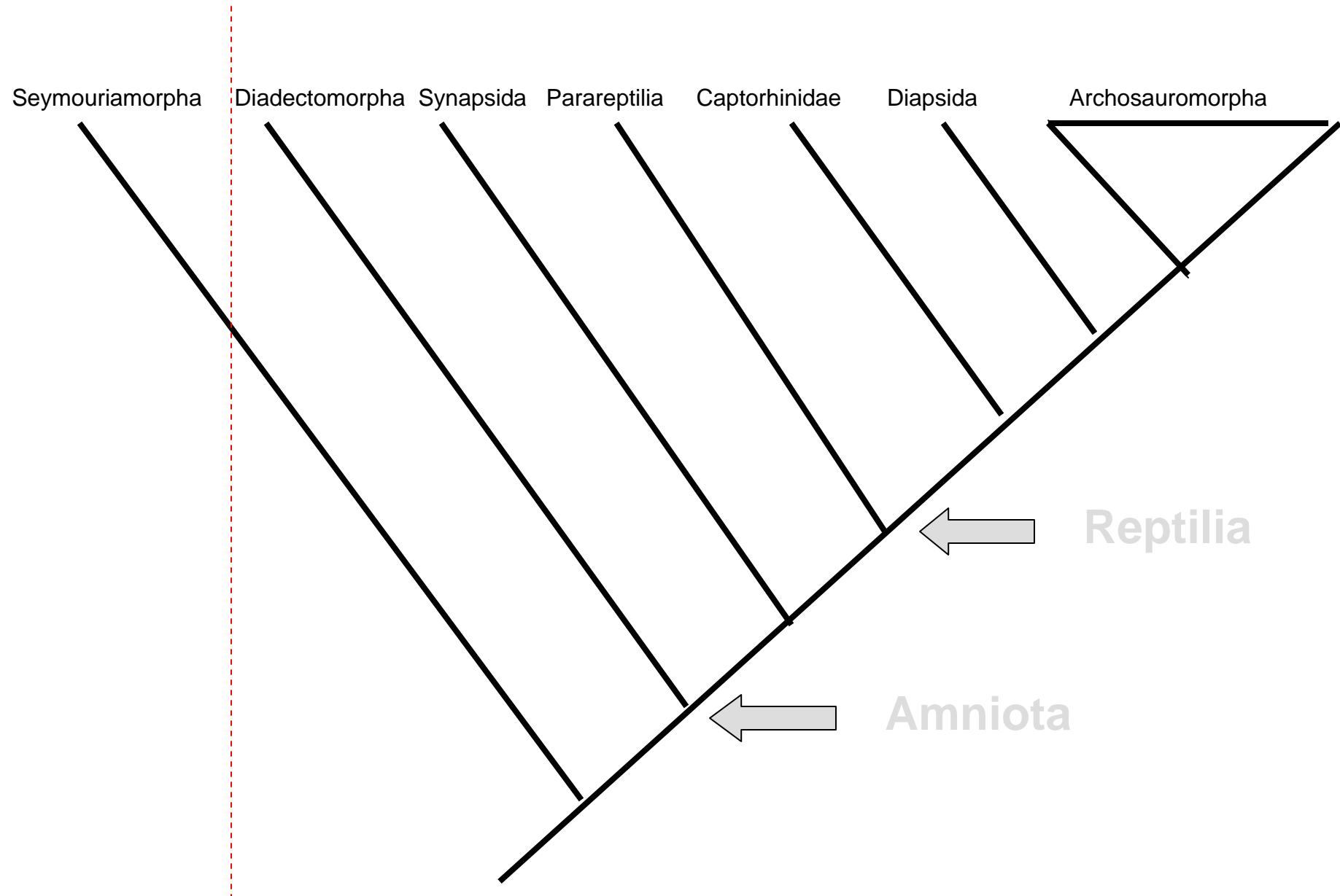








## “Amphibia” Amniota



**BIOSTRATIGRAPHY:**  
Determination of age of sediments based on the occurrence of similar to fossils in sediments of known age.