

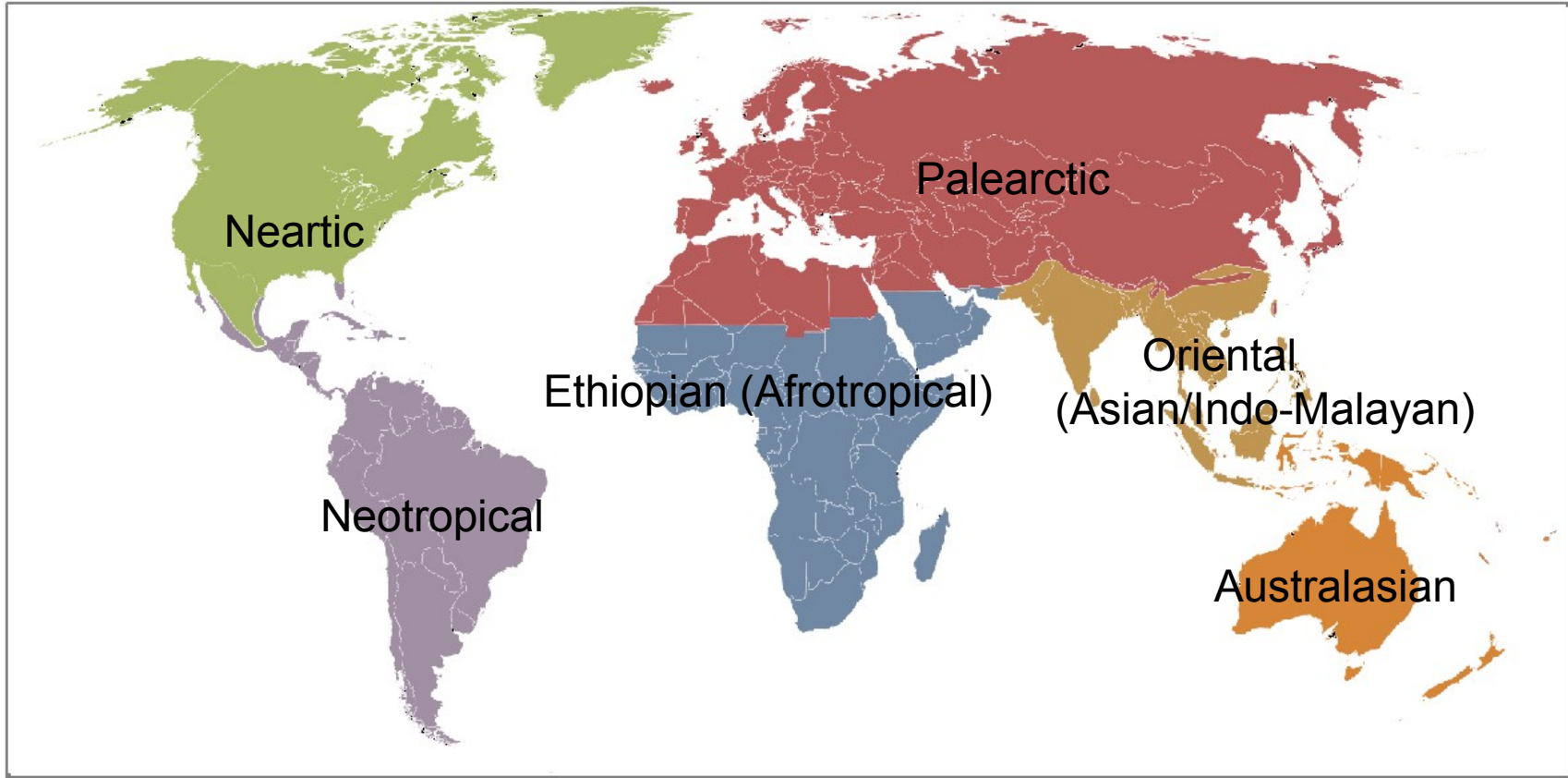
BIO4102/BIO6102/MSB315

**Evolutionary Ecology
(Varsha 2023)**

Ullasa Kodandaramaiah

MODULE: HISTORICAL BIOGEOGRAPHY

Zoogeographic regions



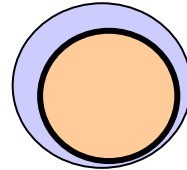
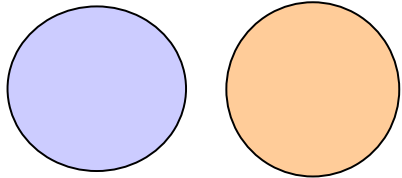
Australasian + Oriental + Afrotropical = Old World Tropics
Nearctic + Neotropical = New World

Historical biogeography – how did species come to be distributed the way they are?

Related to place of origin, i.e., *speciation*

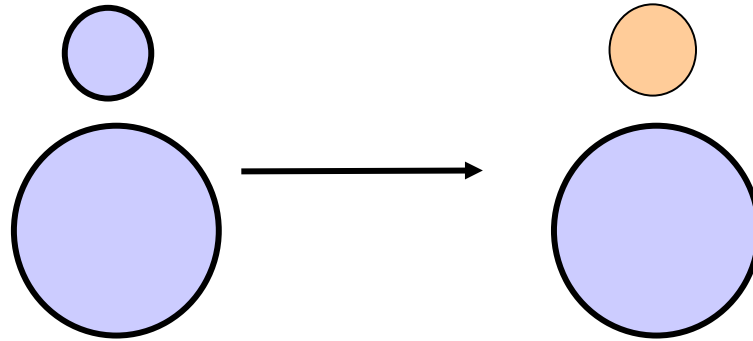
Allopatric - newly formed species occupy different geographic areas

Sympatric – newly formed species occupy the same geographic areas

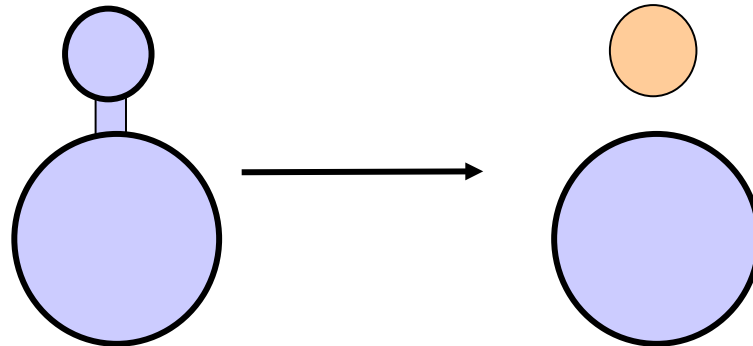


disjunct distributions

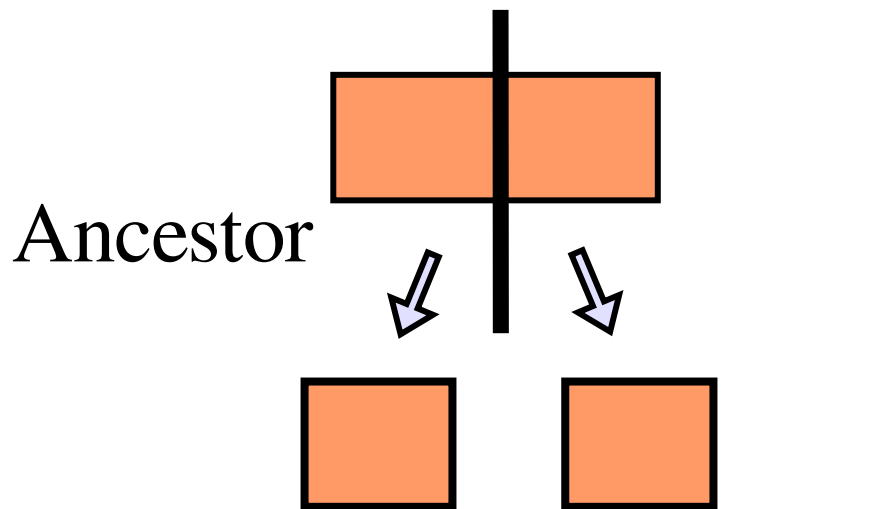
Peripatric: Small peripheral, isolated population.
founder effect, genetic drift, etc (e.g island colonization)



Parapatric: Speciation with limited gene flow



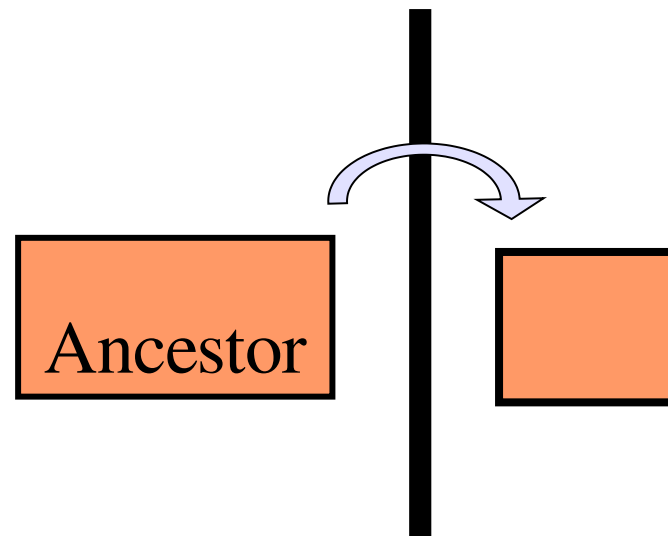
Historical biogeography perspective -
allopatric, peripatric & parapatric: *disjunct distributions*



Species 1

Species 2

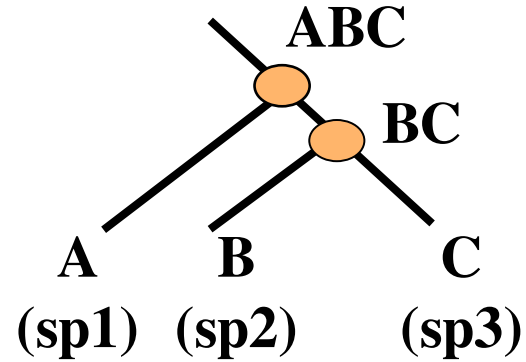
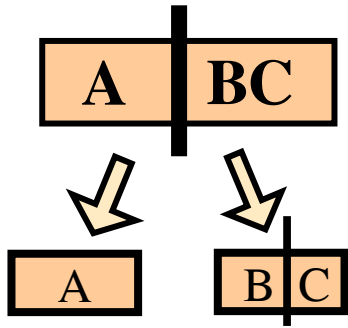
Vicariant speciation



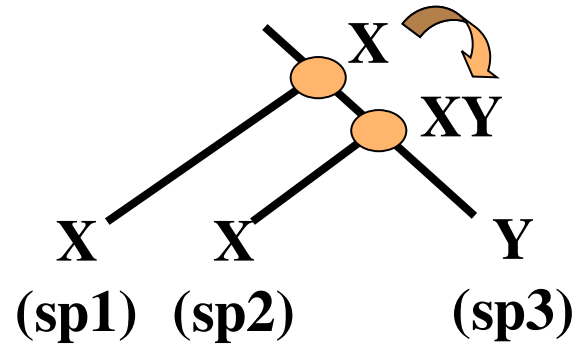
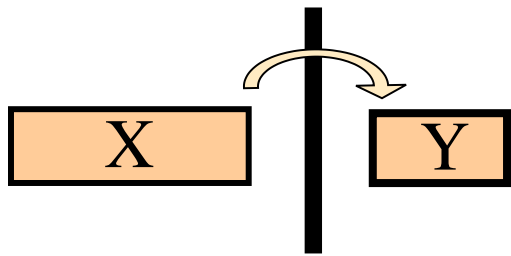
Speciation
by dispersal

Colonization *before* v/s *after*

Ancestral areas



Vicariant speciation between areas A+BC and B+C



Speciation by dispersal from area X to Y

How do we explain *disjunct distributions*

pre-1960's era

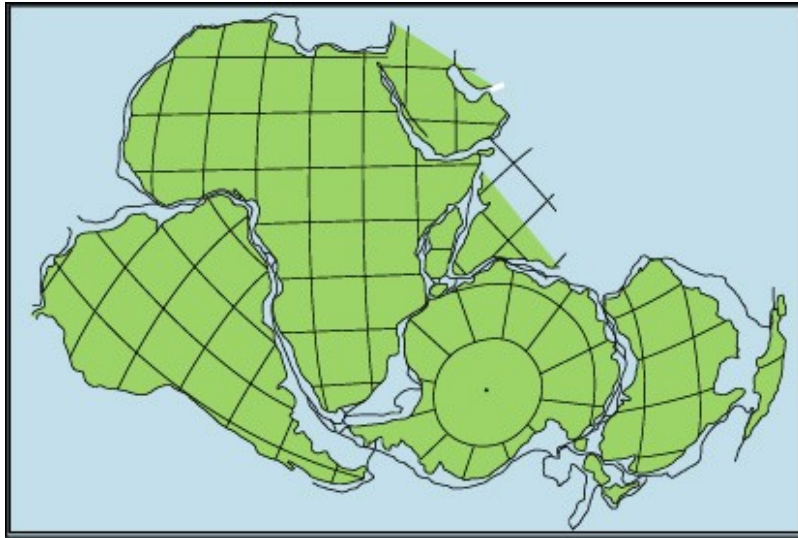
- belief in a stable earth
- *maximum-dispersal model* – 'dispersalism', identification of centres-of-origin

1960's

- Acceptance of plate tectonic theory (continental drift)
 - phylogenetics

Plate tectonics

Was noted for several centuries that the outlines of some continents appeared as though they could fit together like a jigsaw



best when the outlines are edges continental shelves.

Alfred Wegener – '*Theory of Continental Drift*' (proposed in early 1900s; accepted in 1960s)

Evidence – shape, fossils, mountain belts, etc

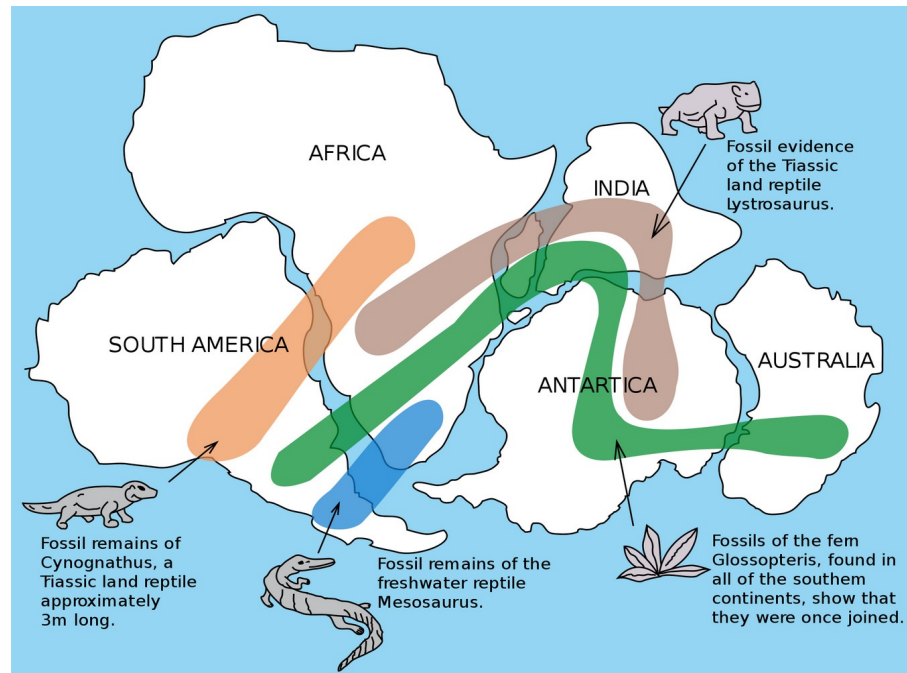


Illustration by Osvaldocangaspadilla,
Wikimedia

Soil & rock samples from mountain ranges



Plate Tectonics: theory that the earth's crust, including the continents and ocean floors, is made up of a series of plates, as plates collide volcanoes occur, and may result in oceanic islands, mountain ranges etc.

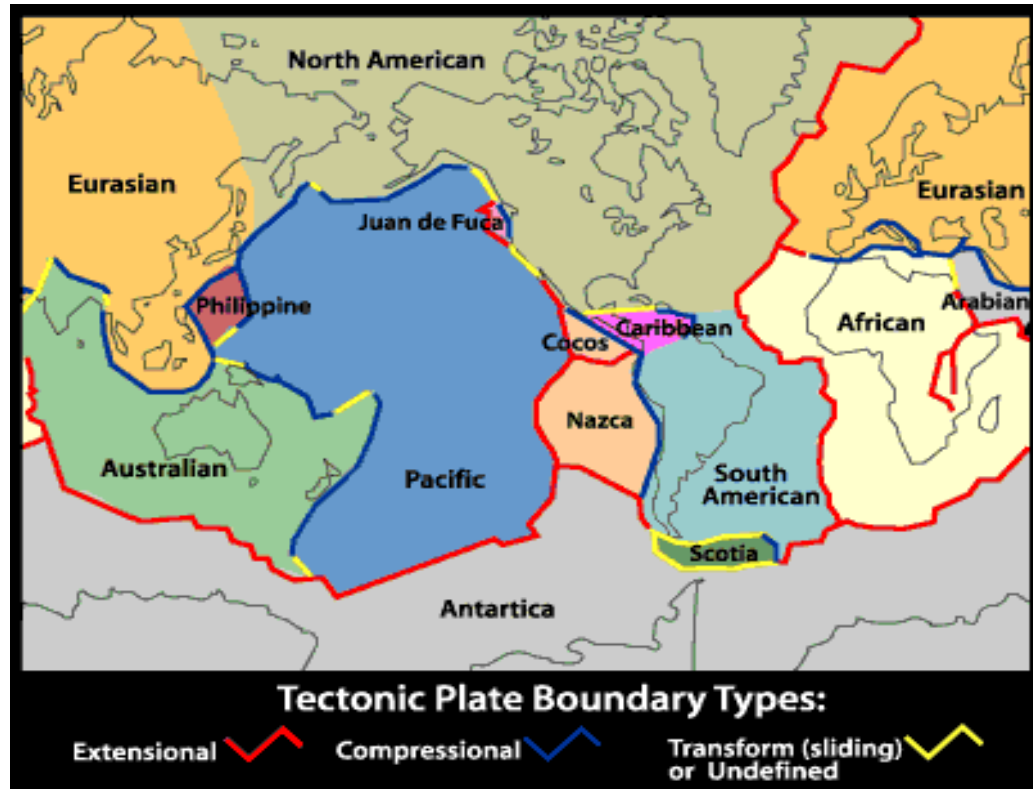


Image: Rick Cheel

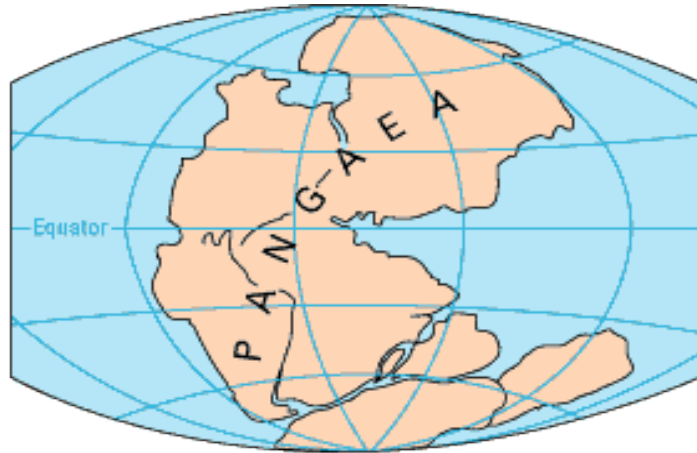
Continental Drift -
movement over geological time of the earth's large land masses as a result of plate tectonics

Pangea



Wikimedia

225 MYA - Pangea



PERMIAN
225 million years ago

200 MYA – Laurasia begins to separate from Gondwanaland

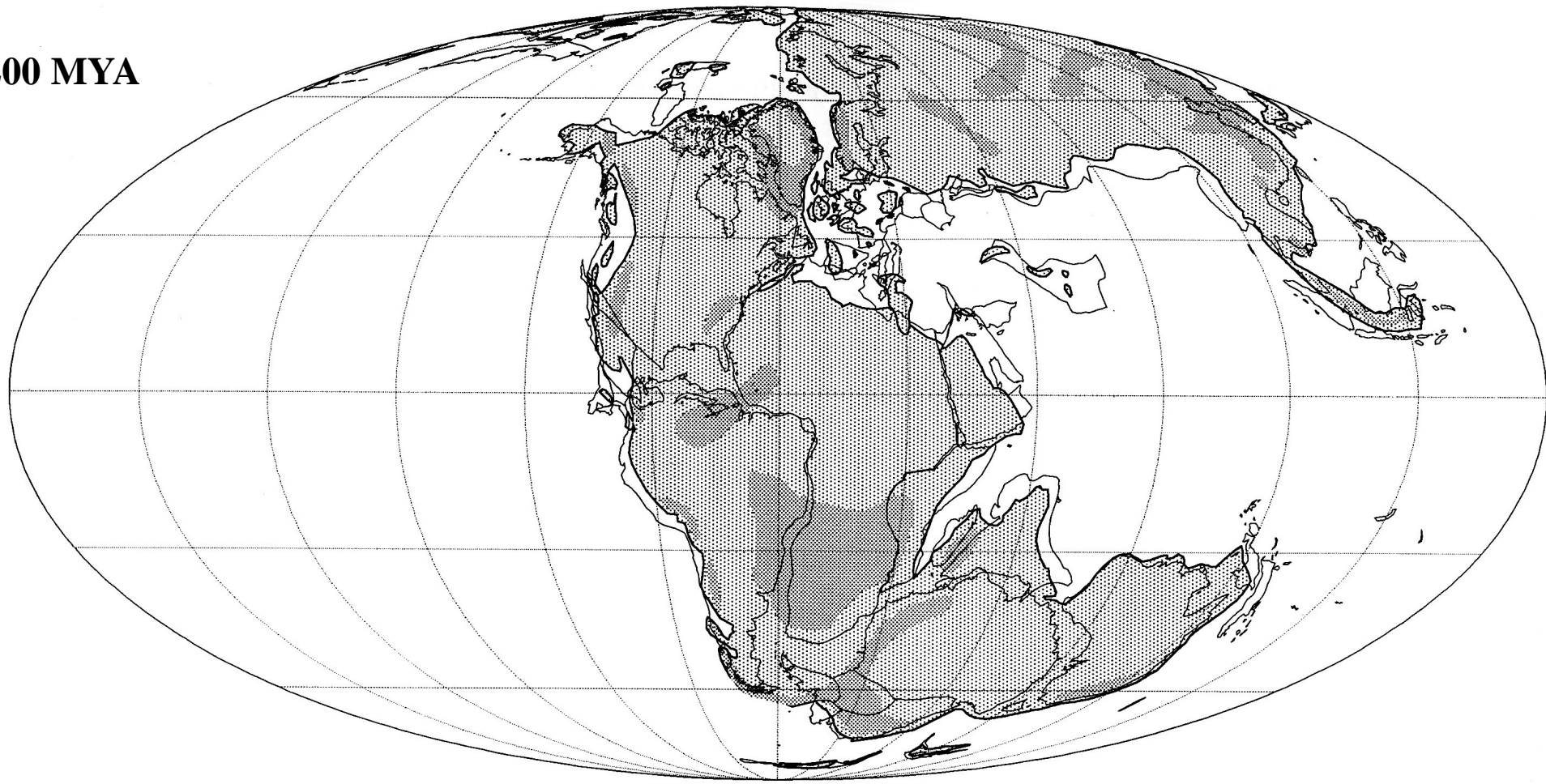


TRIASSIC
200 million years ago



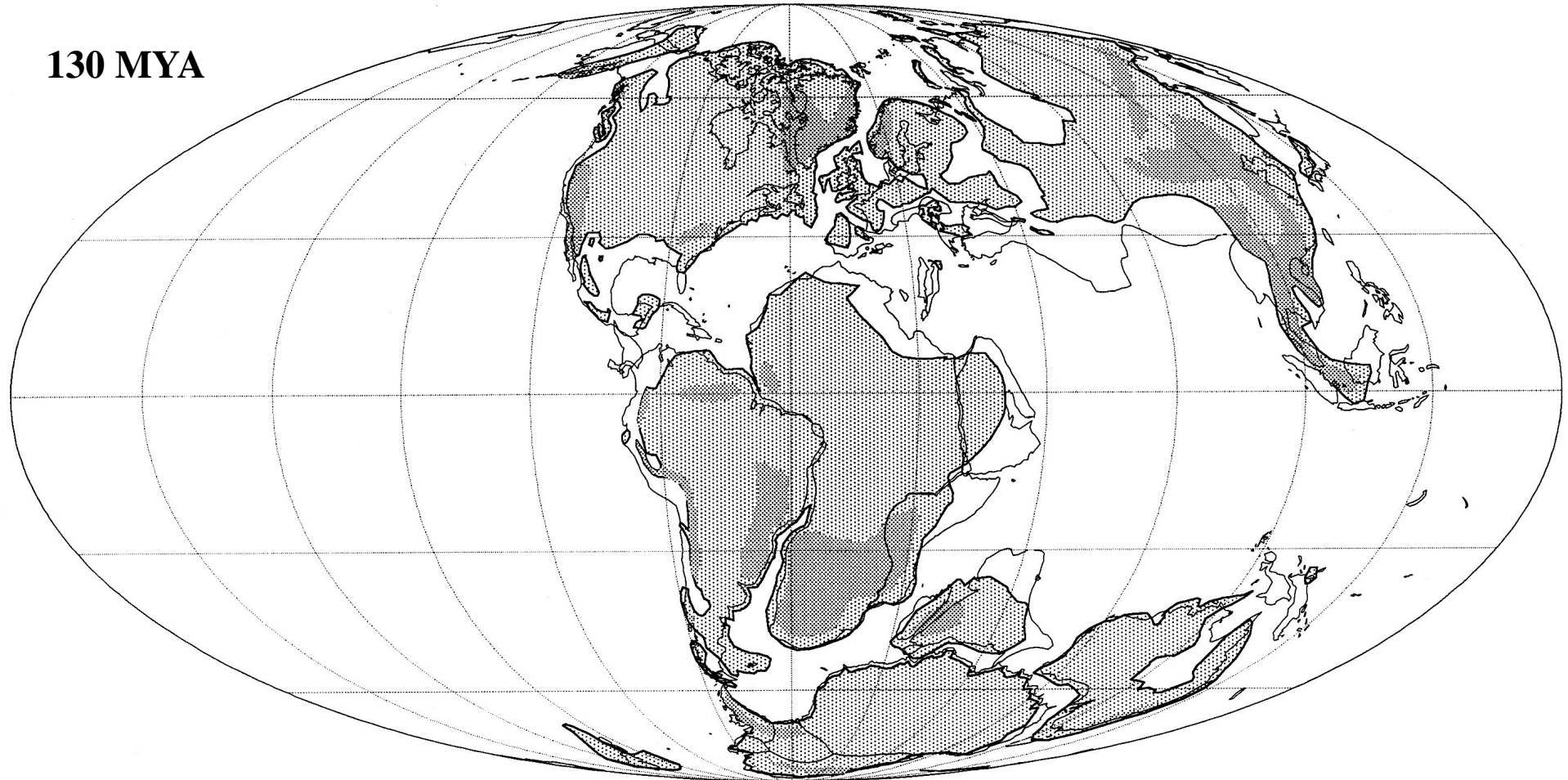
Breakup of Pangaea/Gondwana

200 MYA

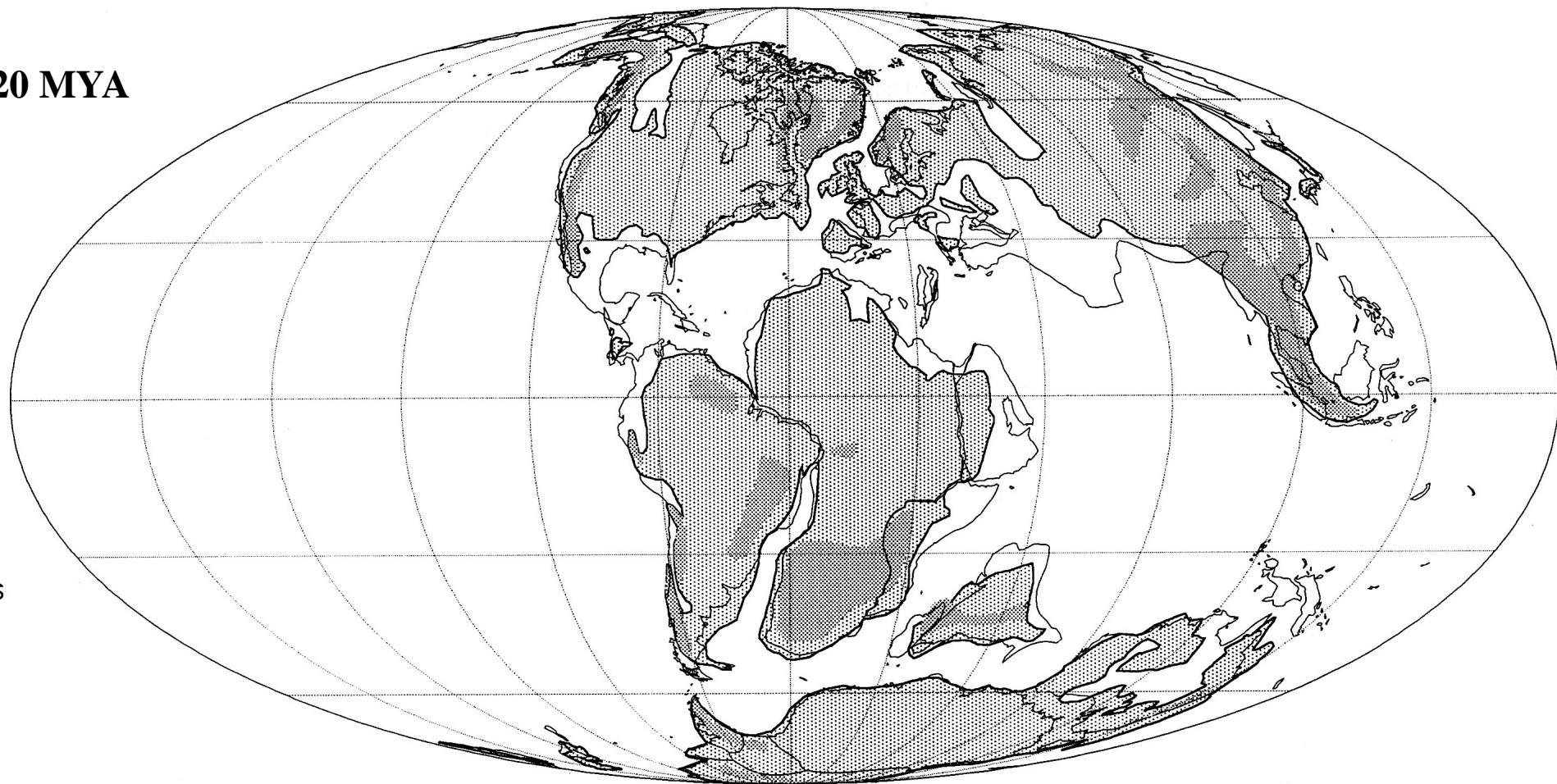


India+Madagascar+Seychelles beginning rifting

130 MYA

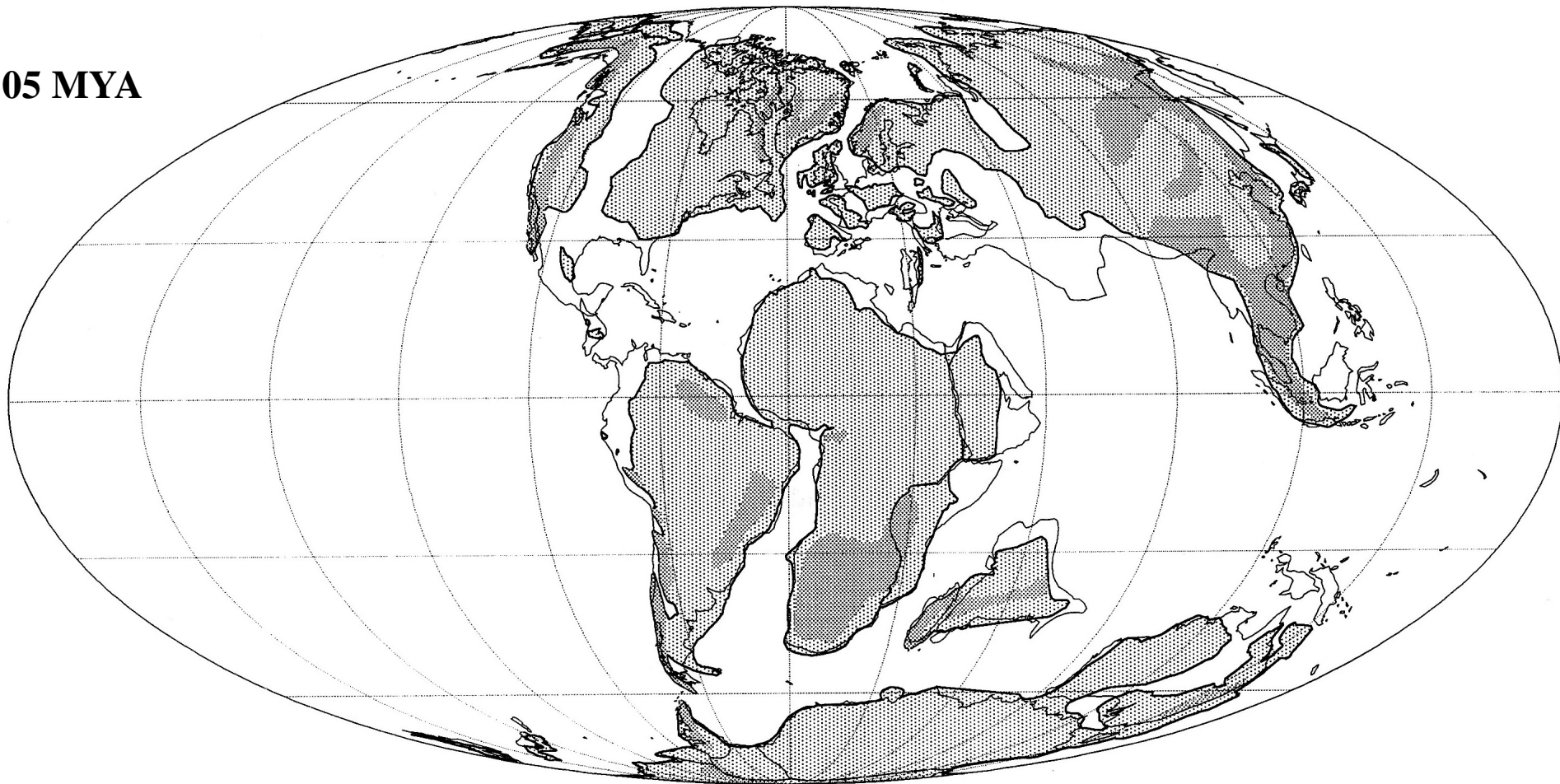


120 MYA

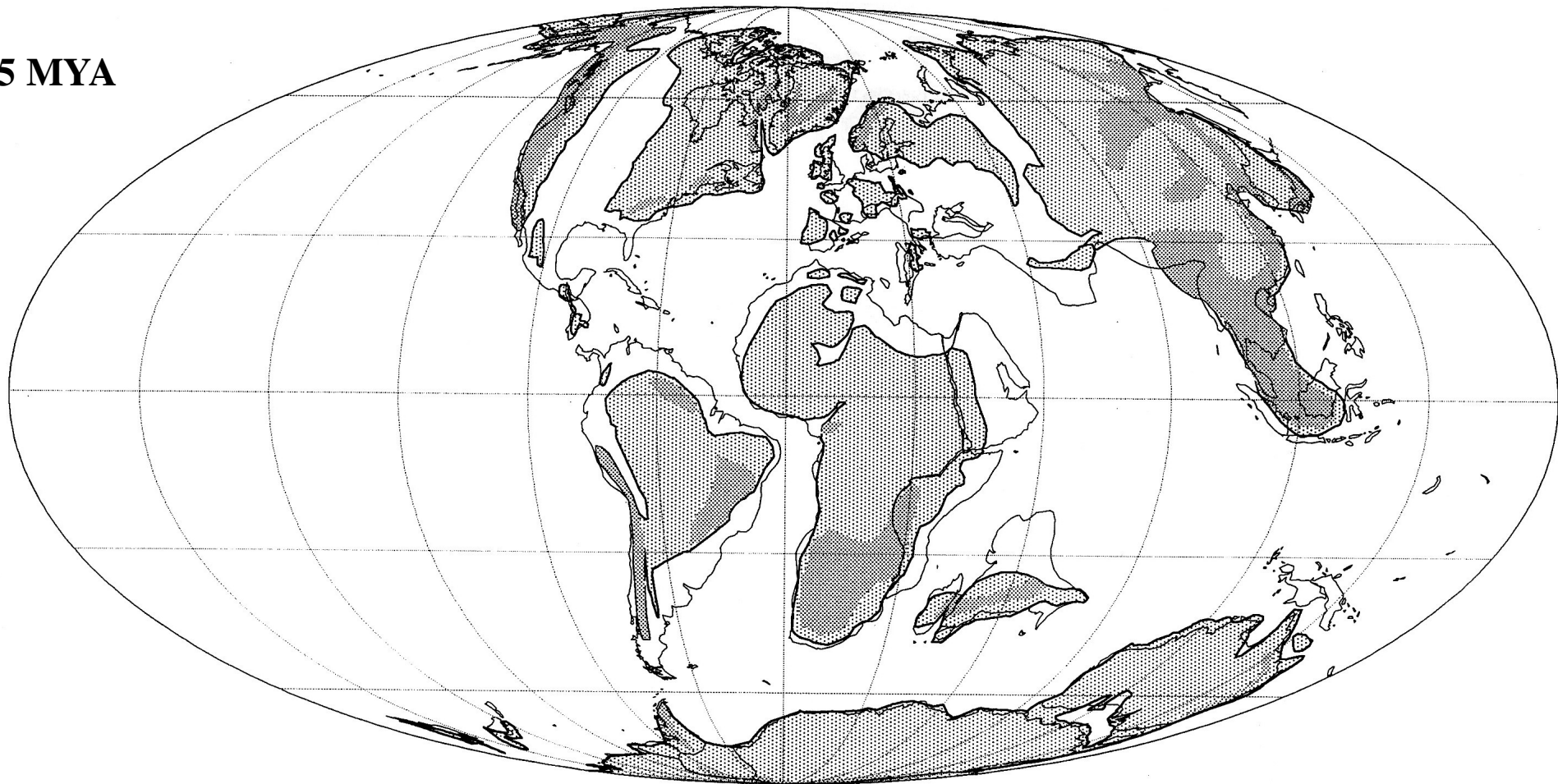


Africa breaks away

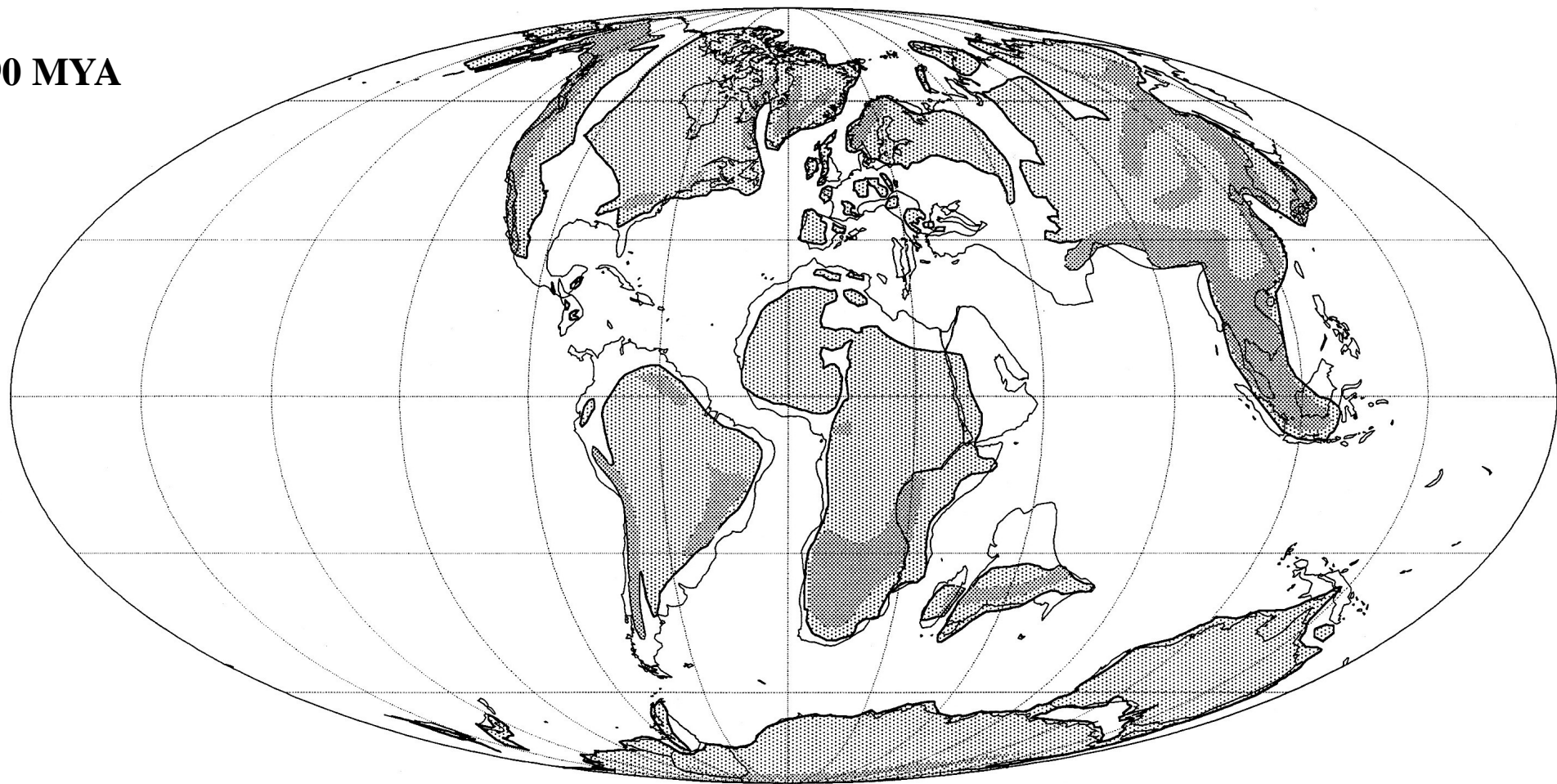
105 MYA



95 MYA

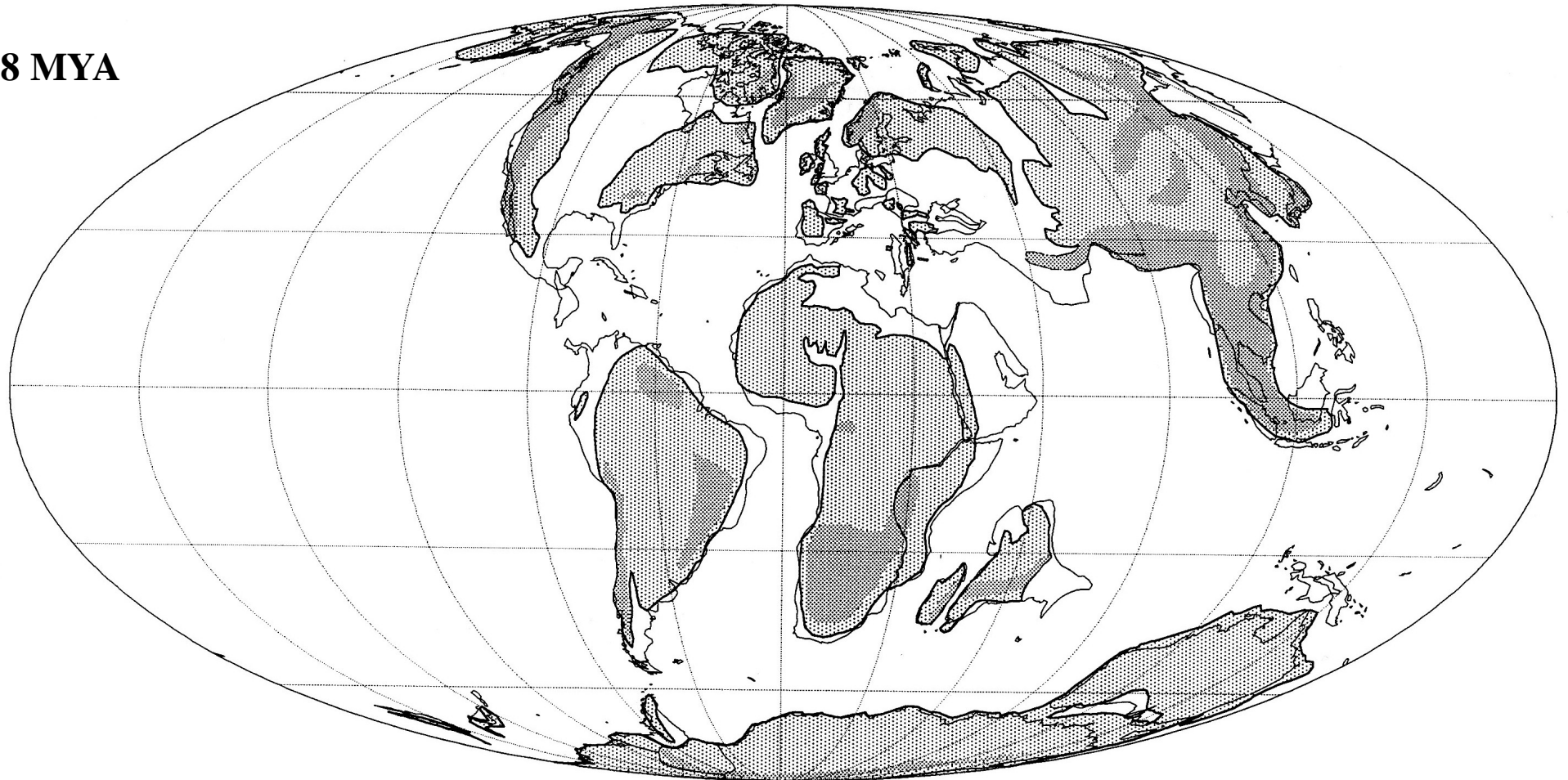


90 MYA



India-Seychelles separated from Madagascar

88 MYA



Nasikabatrachus sahyadrensis (Pig-nosed frog/Purple frog)

Biju and Bossuyt 2003, Nature 425, 711-714

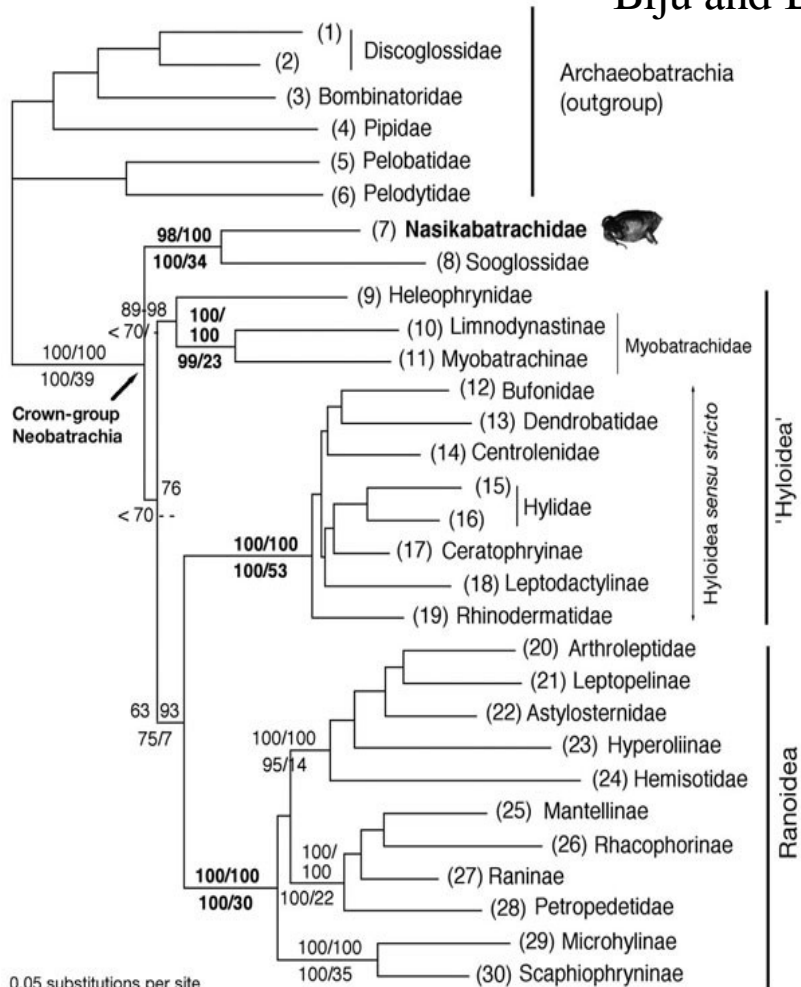


Photo: Karthick Bala, Wikimedia

Sooglossidae (Seychelles)
Nasikabatrachidae (Western Ghats)

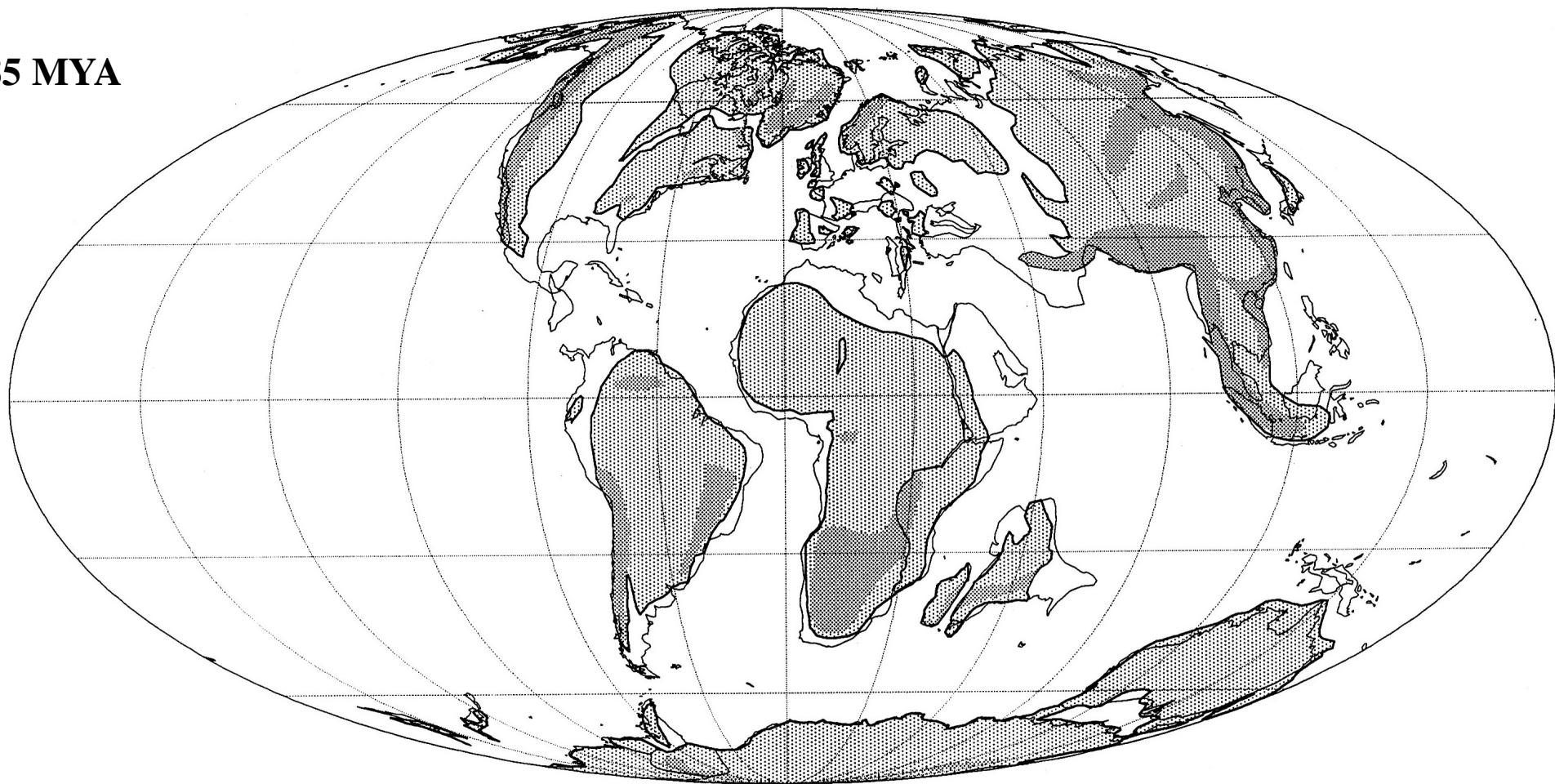
Divergence – ca 130 mya

Reflection

- Can the origin of Nasikabatrachidae be attributed to vicariant speciation?

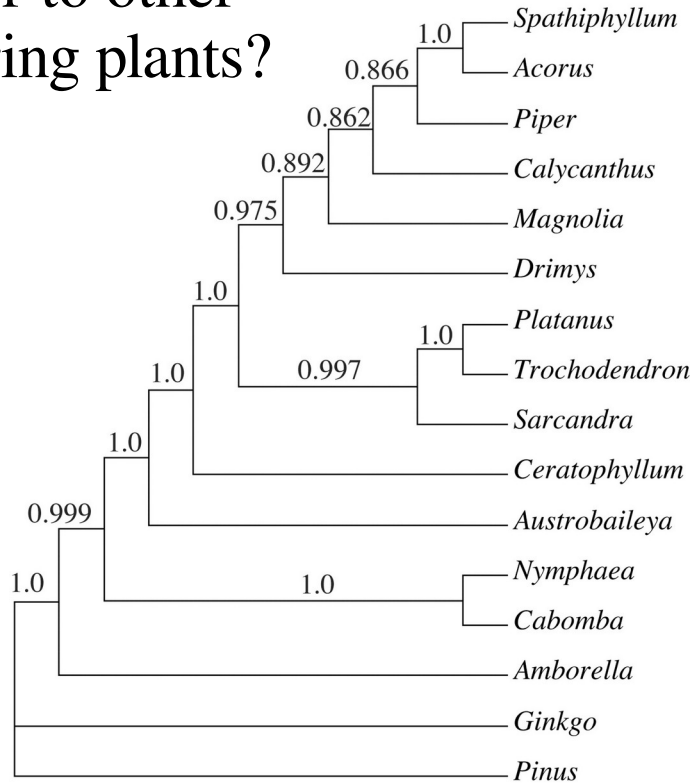
(New Zealand+New Caledonia) from Australia+Antarctica

85 MYA



Amborella trichopoda: New Caledonia

Sister to other
flowering plants?



©2002 by National Academy of Sciences

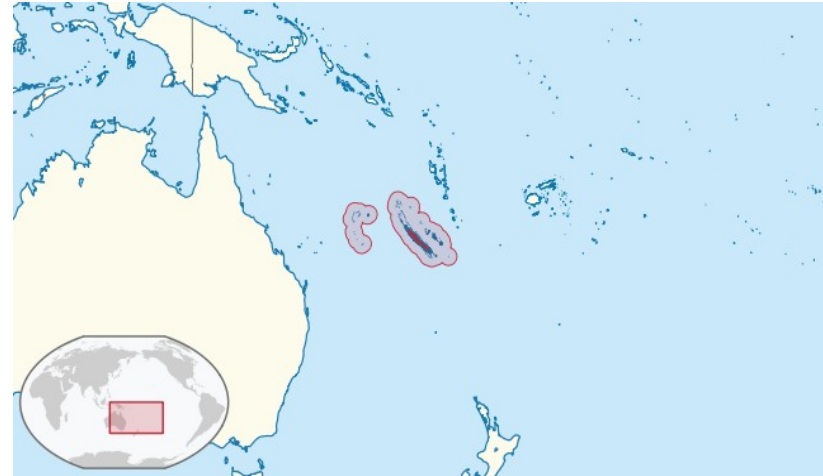


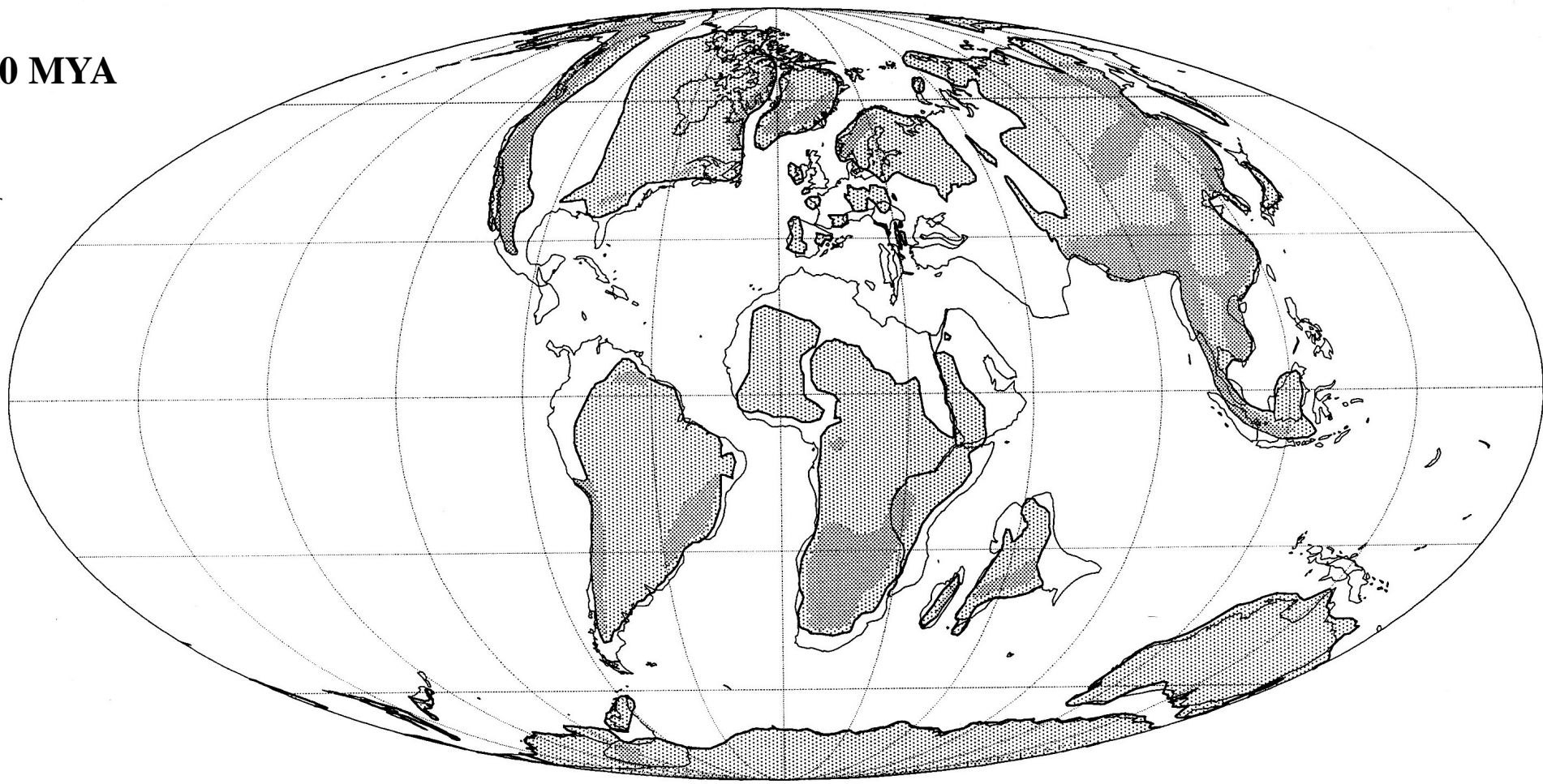
Image: Wikimedia

Photo: Thomas
J. Lemieux



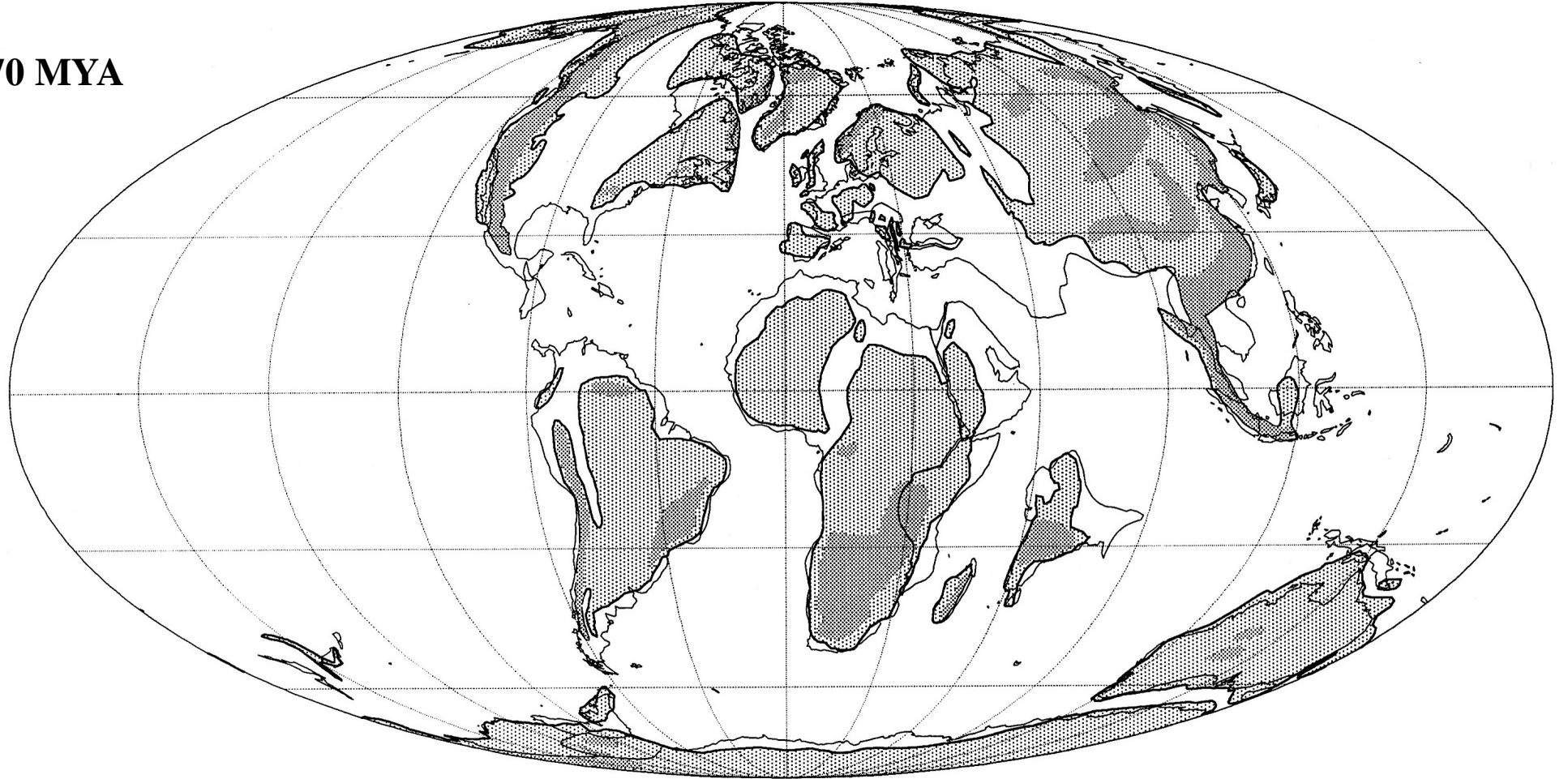
Bayesian phylogeny with posterior probabilities indicated above the branches (note: this is not depicted as ultrametric tree). Zanis et al. (2002) PNAS

80 MYA

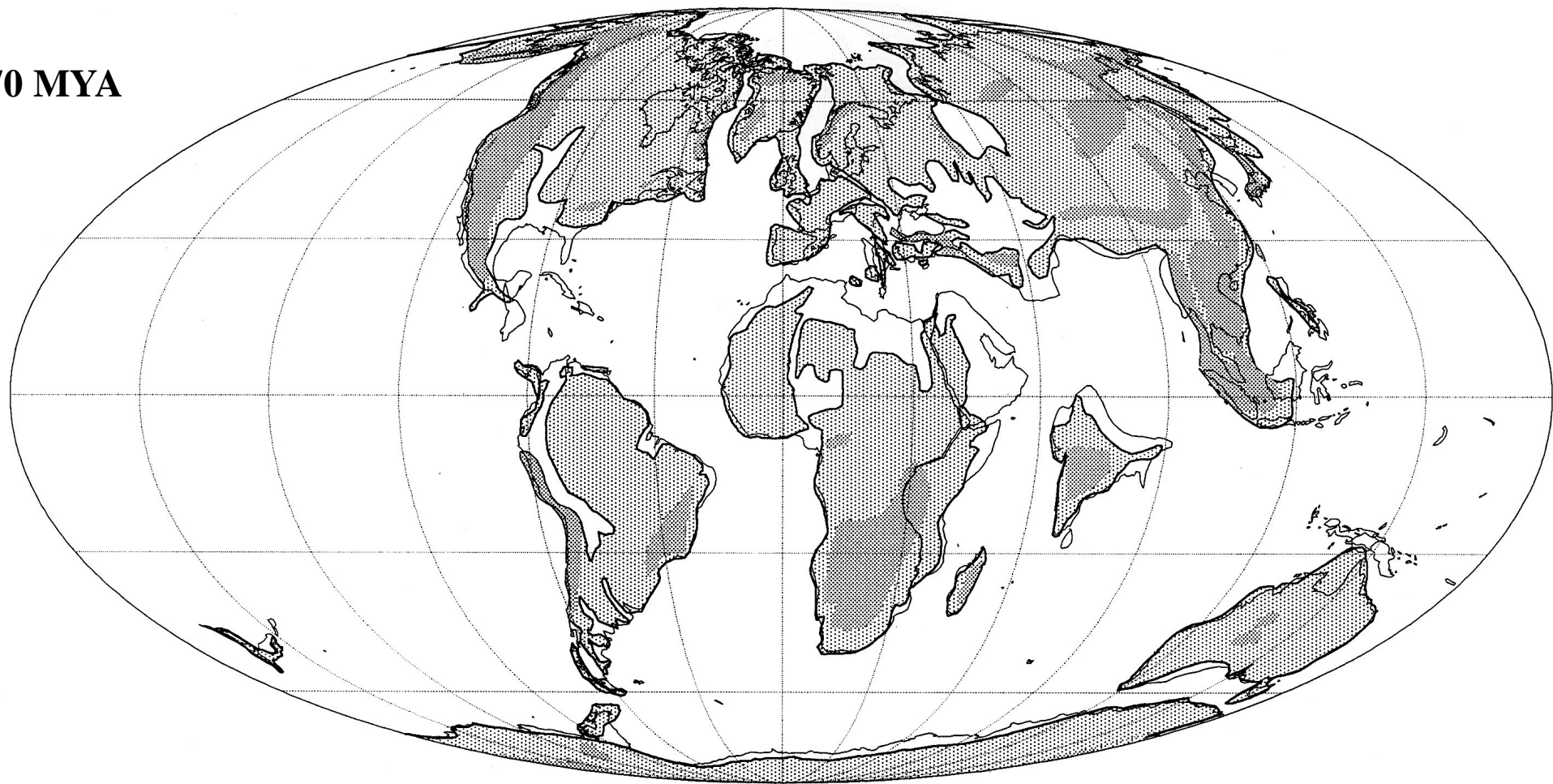


India seperated from Seychelles ca. 65 mya

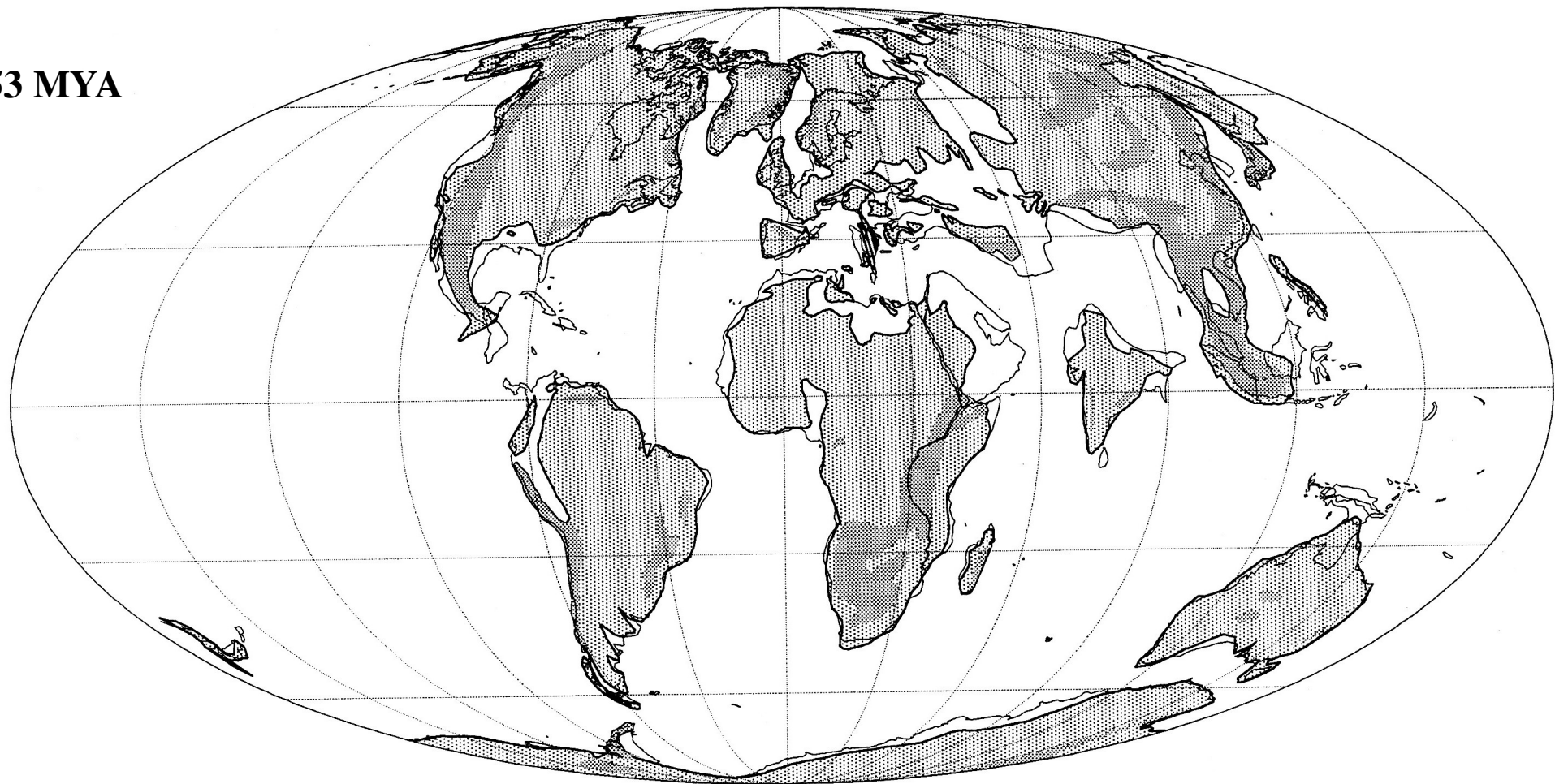
70 MYA



70 MYA

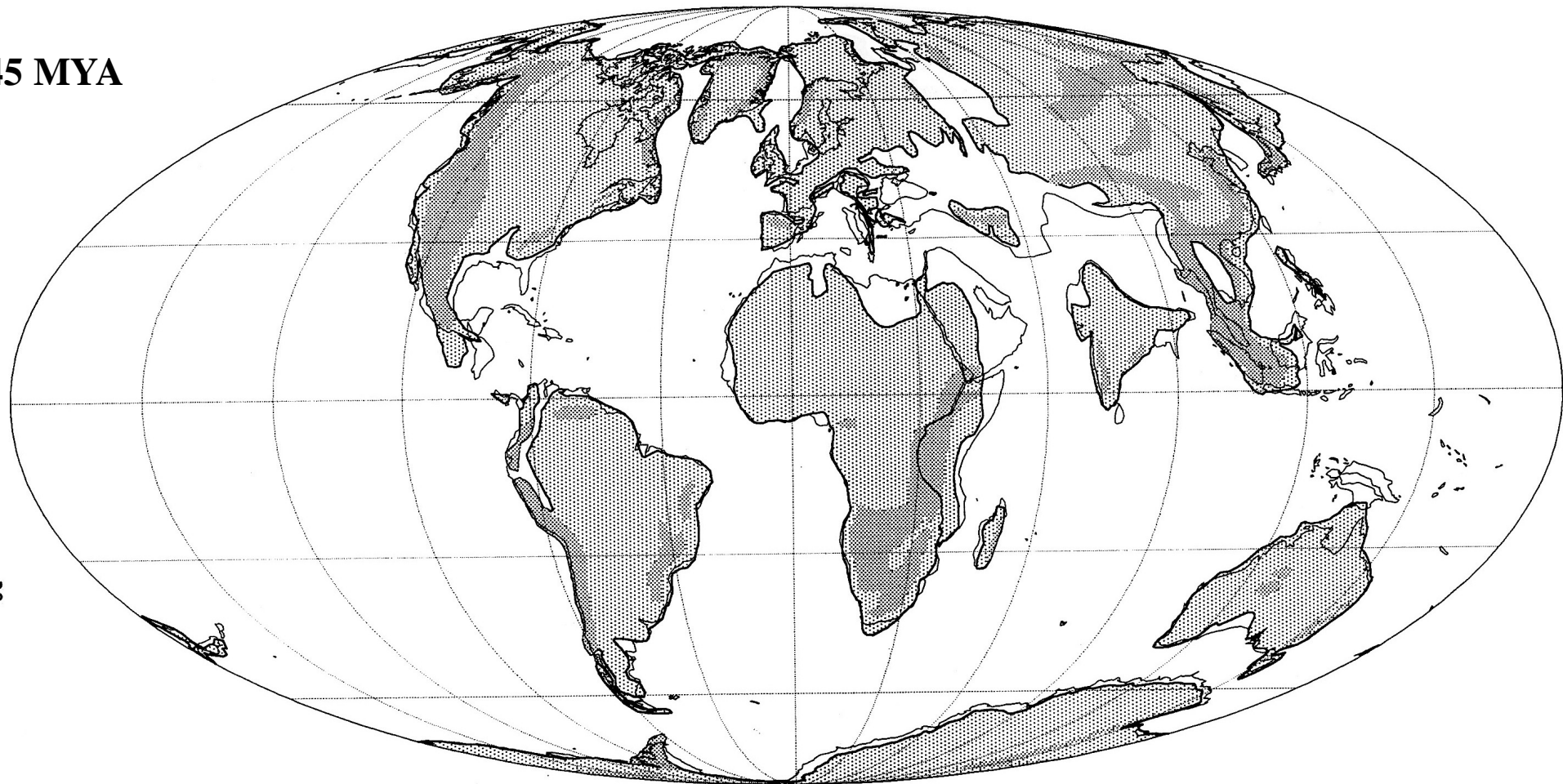


53 MYA



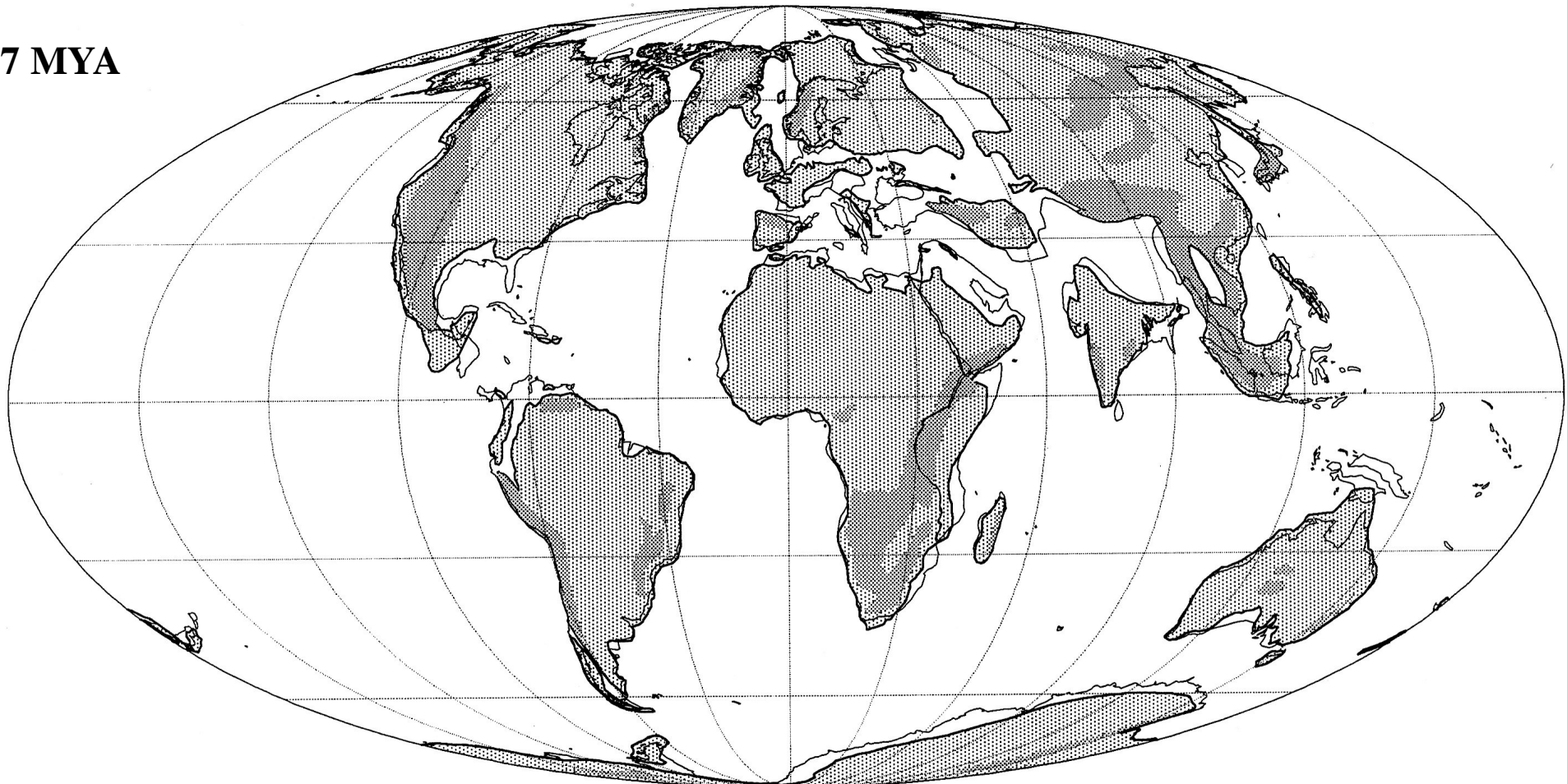
Australia starts drifting northwards, split completely by 40 mya

45 MYA

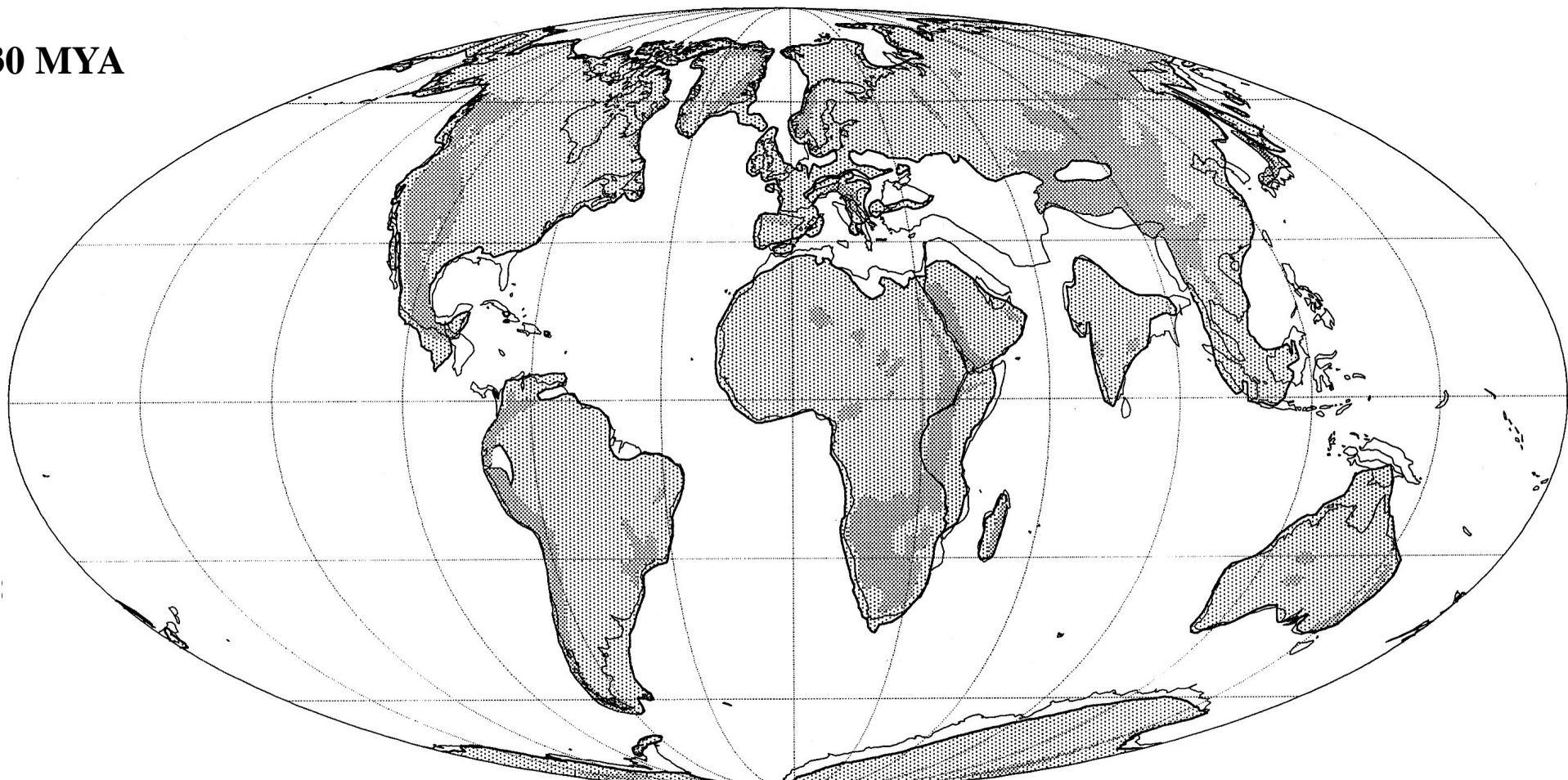


**SA starts drifting northwards, split completely by 35 mya,
circumpolar current**

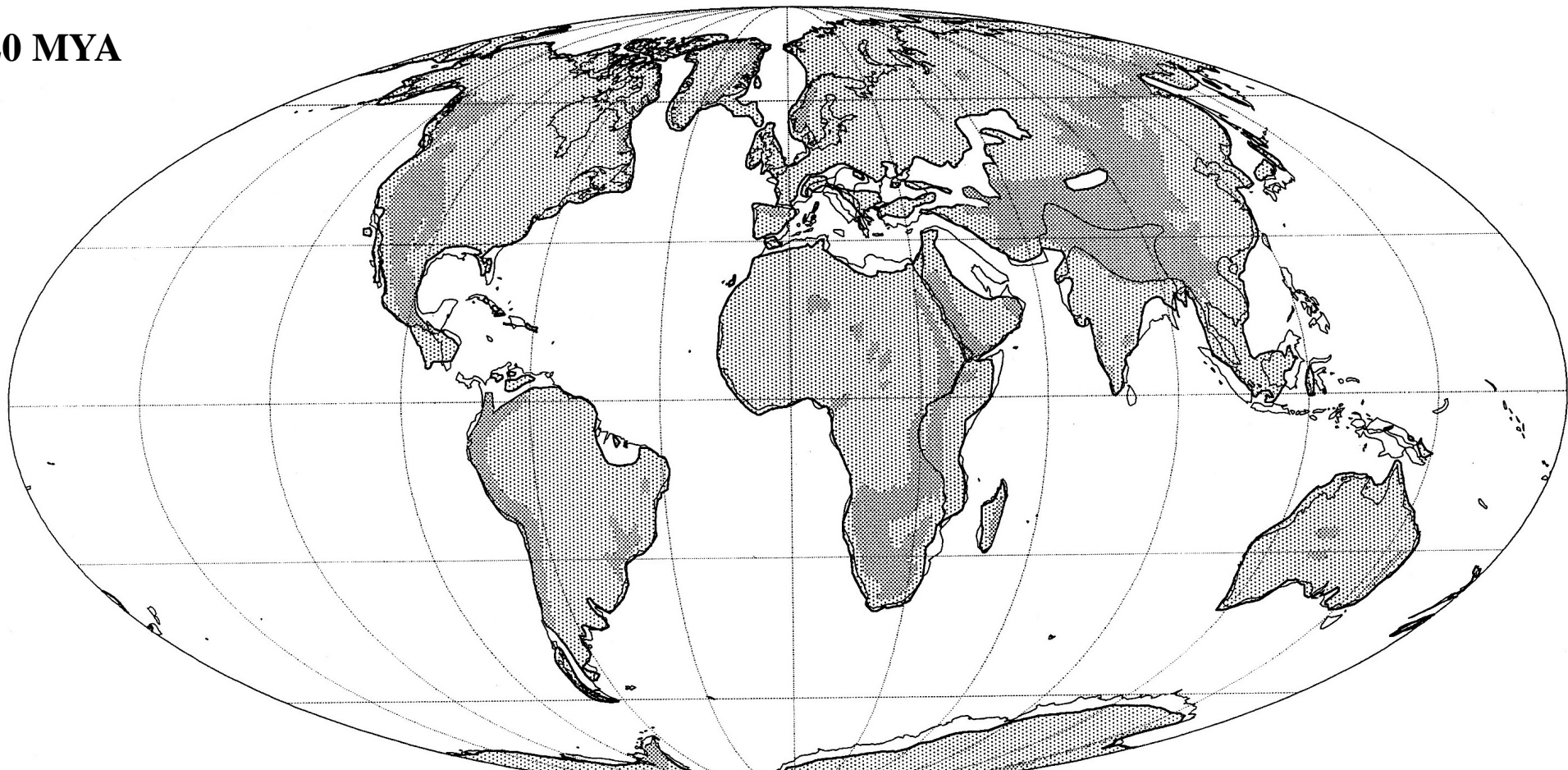
37 MYA



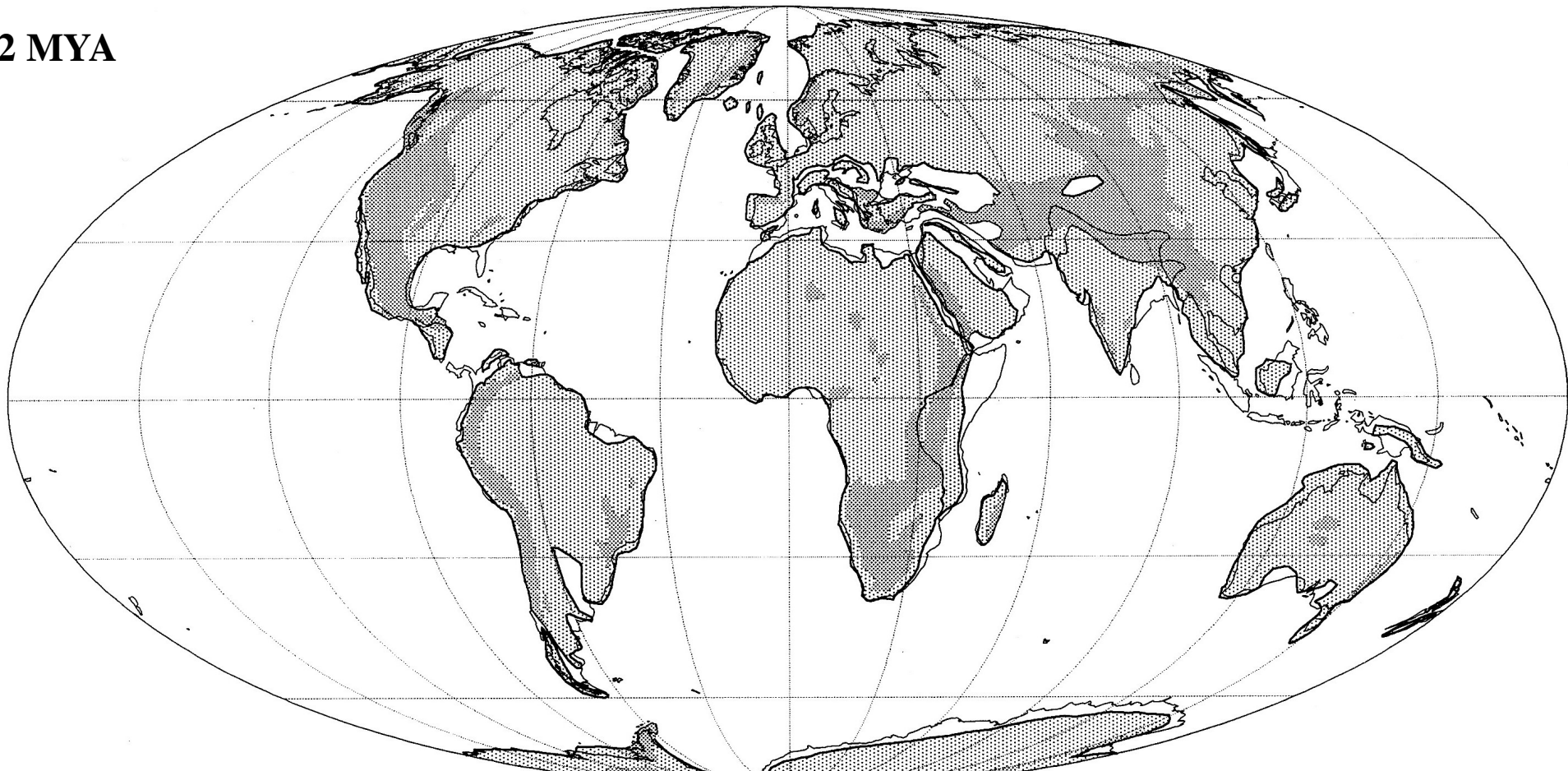
30 MYA



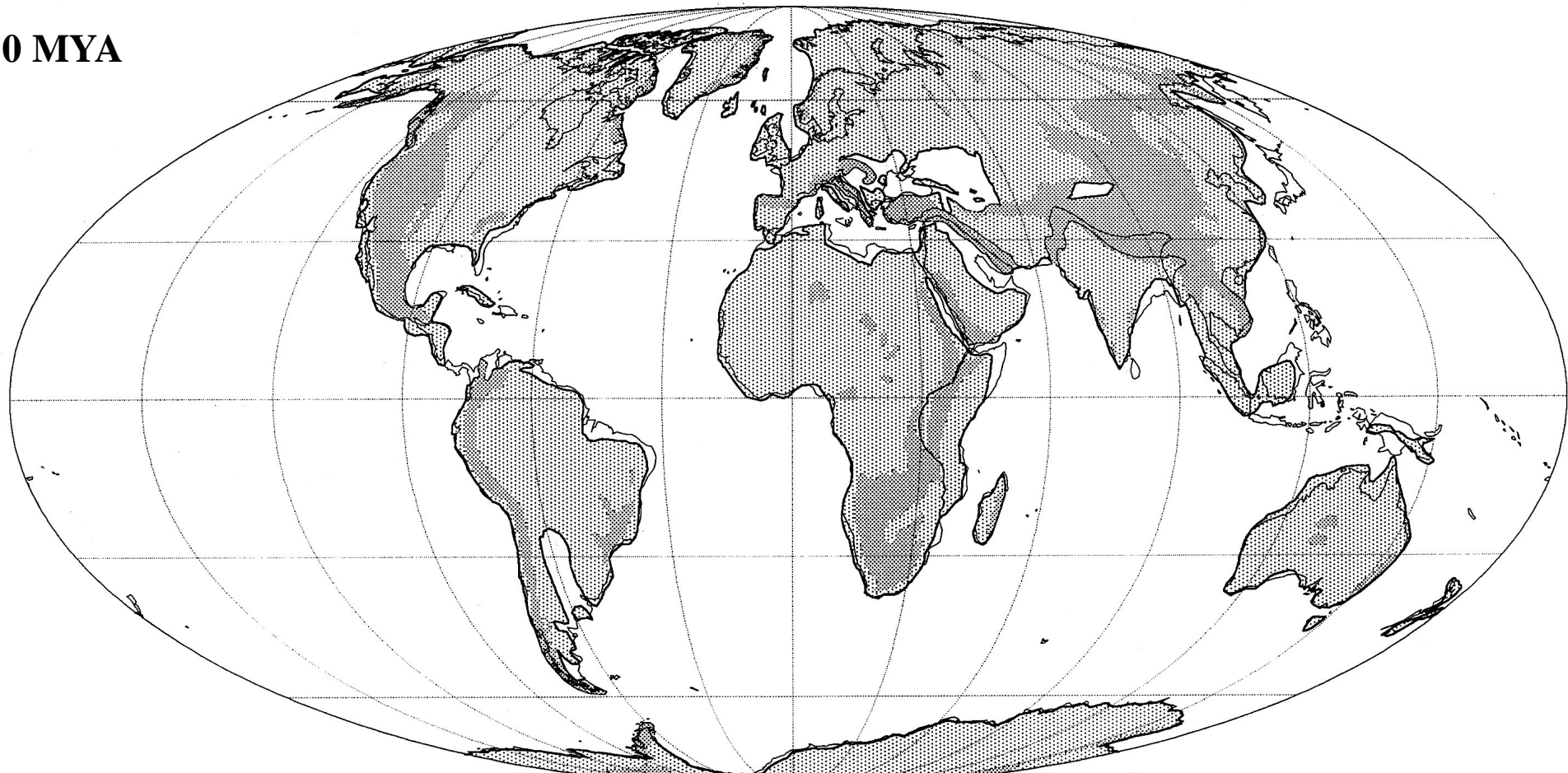
20 MYA



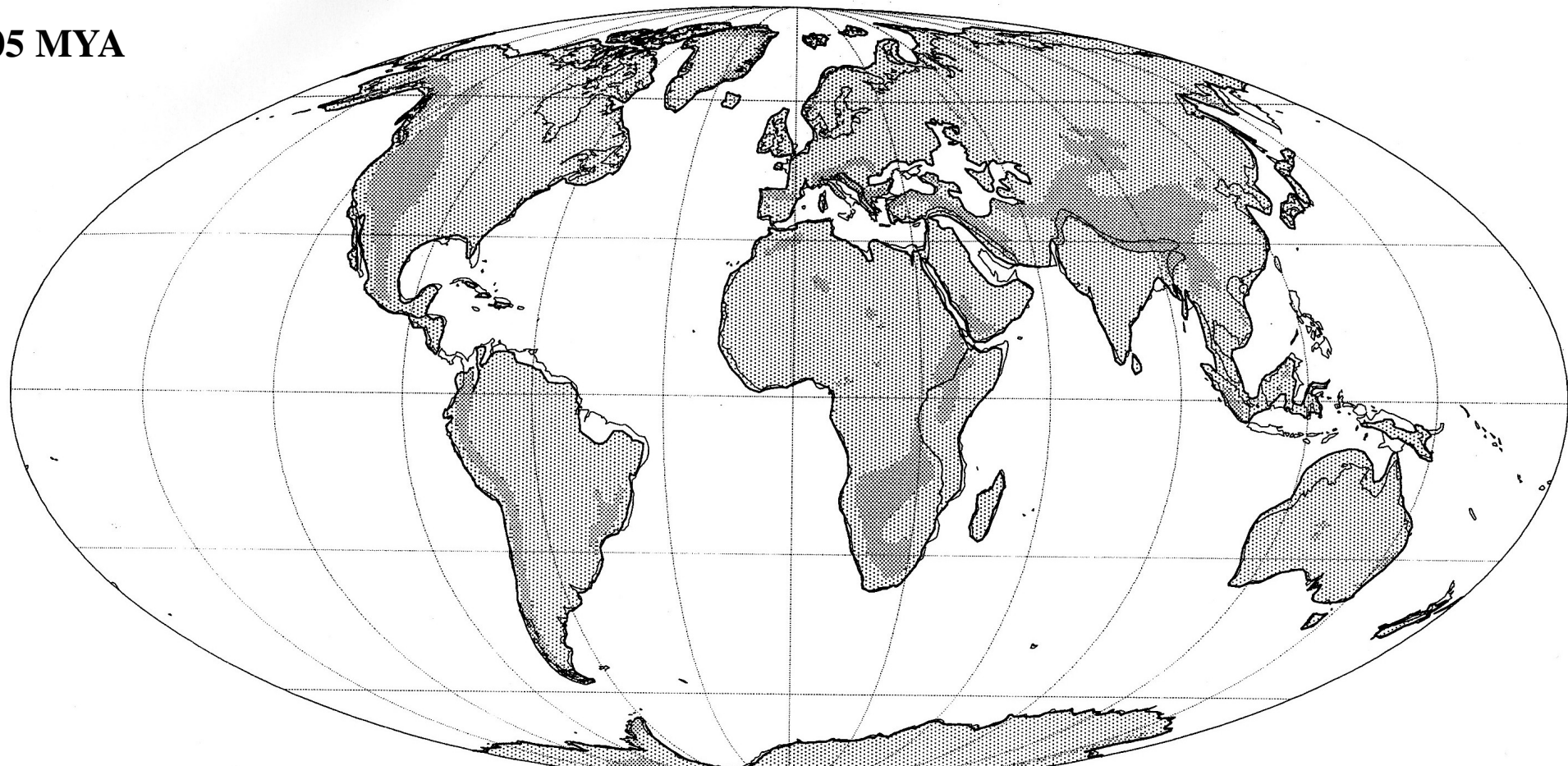
12 MYA



10 MYA



05 MYA



Laurasia

Eastern and Western Palaearctic (i.e, Europe+Northern Asia),
Eastern and Western Nearctic (i.e., North America)

Connected, disconnected and reconnected in different combinations

- Transatlantic bridges
- Beringian bridges

Breakup of Gondwana: Summary

- India+Madagascar+Seychelles break off 130-80 mya
- Africa splits off 105 mya, collision with Eurasia ca 20 mya
- New Zealand isolated ca. 85 mya
- India separated from Madagascar ca 88 mya
(collision with Asia ca 40 mya, Himalayas)
- India from Seychelles ca 65
- Australia from Antarctica ca.40 mya
- SA from Antarctica ca 35 mya
(Antarctic circumpolar current & glaciation)



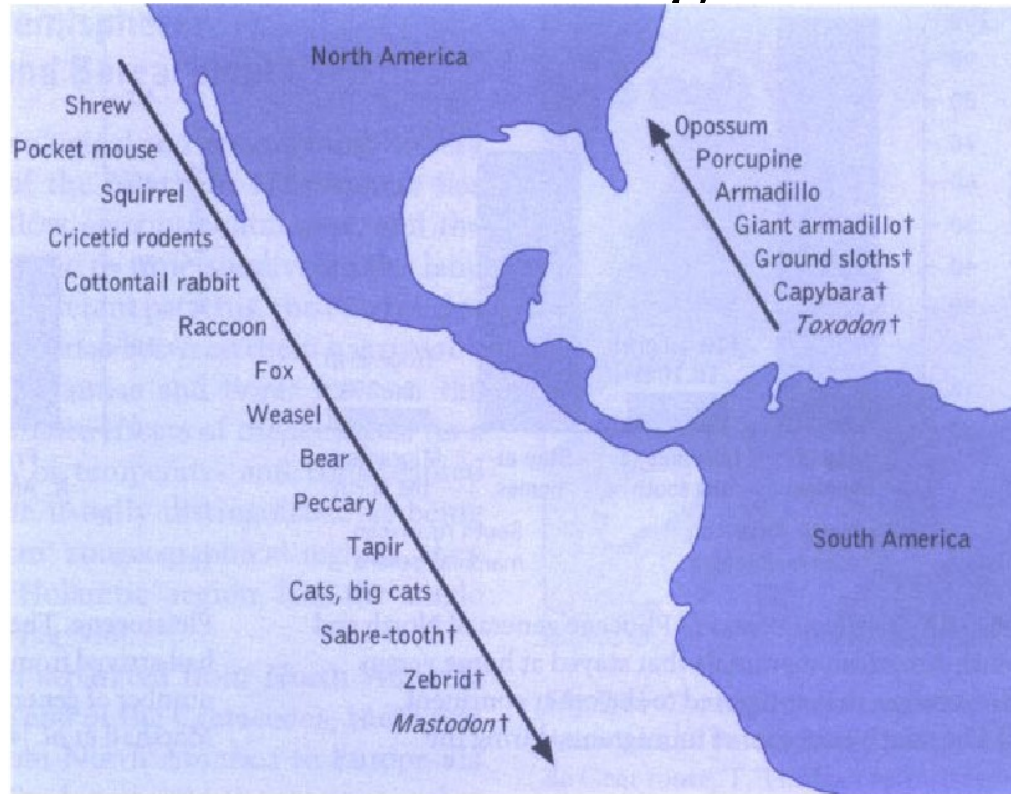
South and North America

- isolated since separation of Laurasia from Gondwana
- Reconnected 3 mya
- Isthmus of Panama

Great American Interchange

50% of extant land mammal genera in South America descend from North American immigrants.

Corresponding figure for North America: 29%



Great American Interchange migrants. Those with a cross by their name became extinct in their new continent.

- Fauna exchanged adapted to savannas
- Isthmus >> savanna?

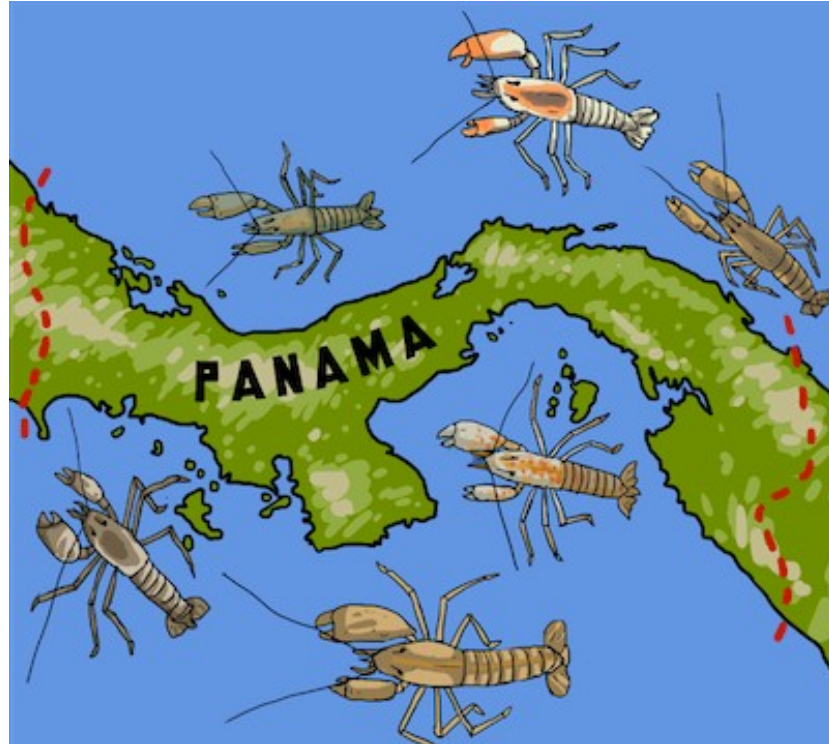


Modified from slide by John McCall

Panamanian Isthmus : Vicariance

Altheus (snapping shrimp)

Hurt *et al* (2008) *Evolution* 63-2: 514–530

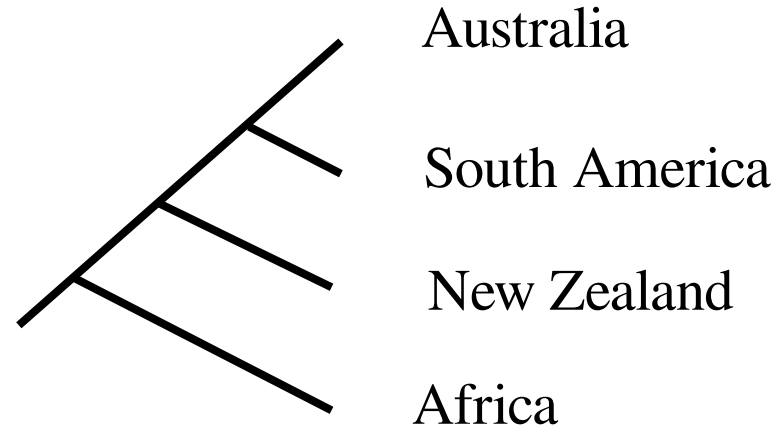
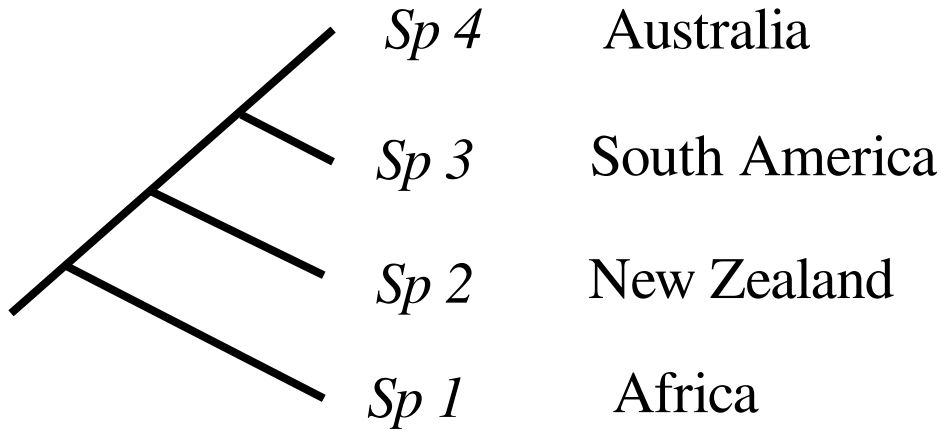


Reflection

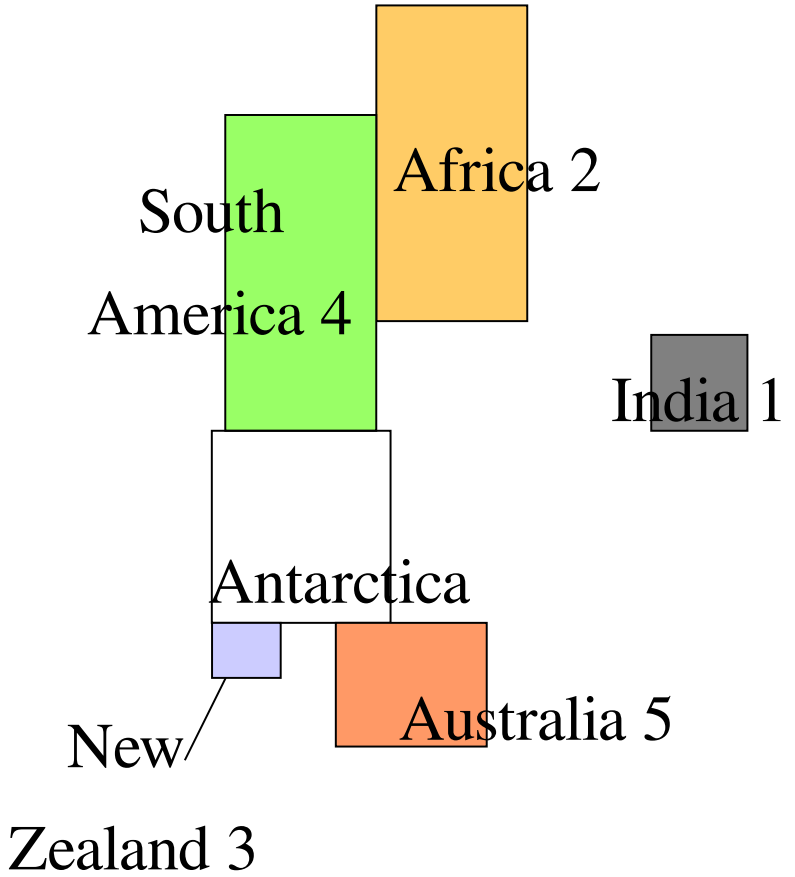
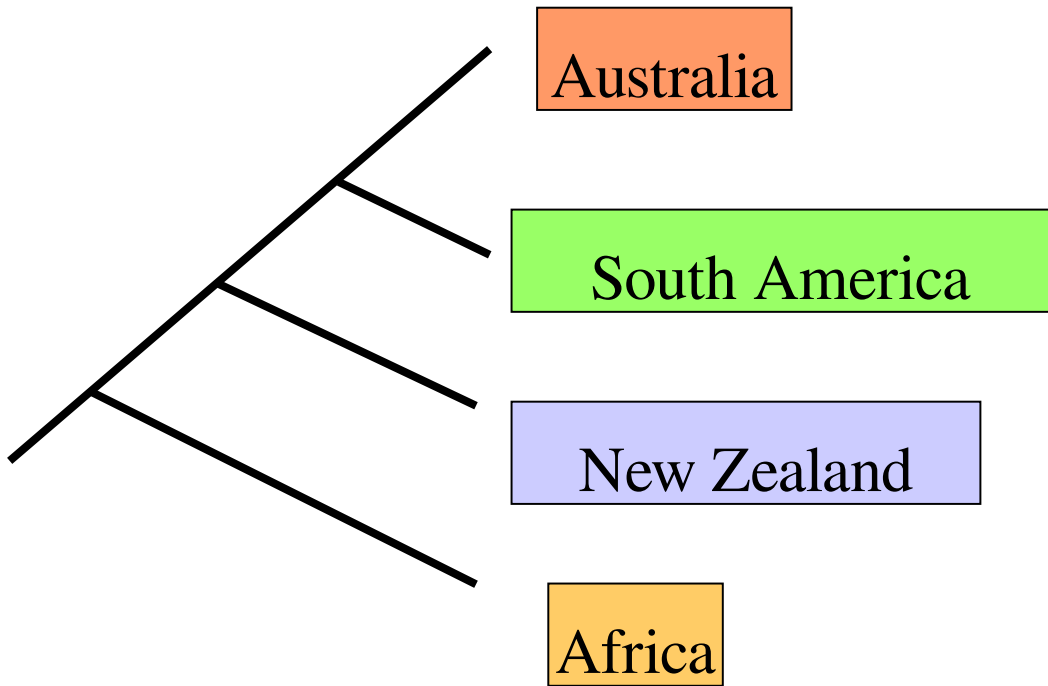
- Assume that the formation of the Isthmus of Panama led to multiple vicariance speciation events within a fish genus. How would the patterns of speciation look on a phylogeny? Depict this with a phylogeny, along with ancestral areas for each node and terminal

Chironomid midges and break-up of Gondwana.

'Phylogeny reflects vicariance' - phylogenetic biogeography



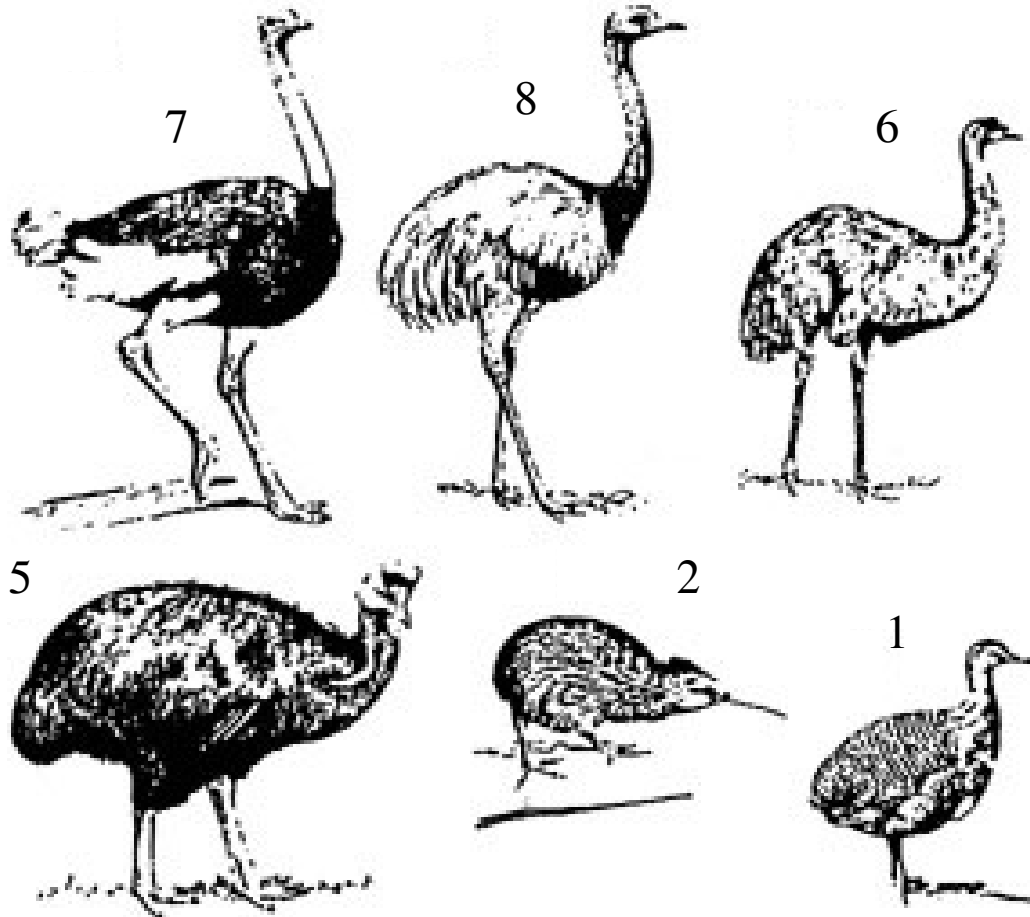
Note: Simplified version



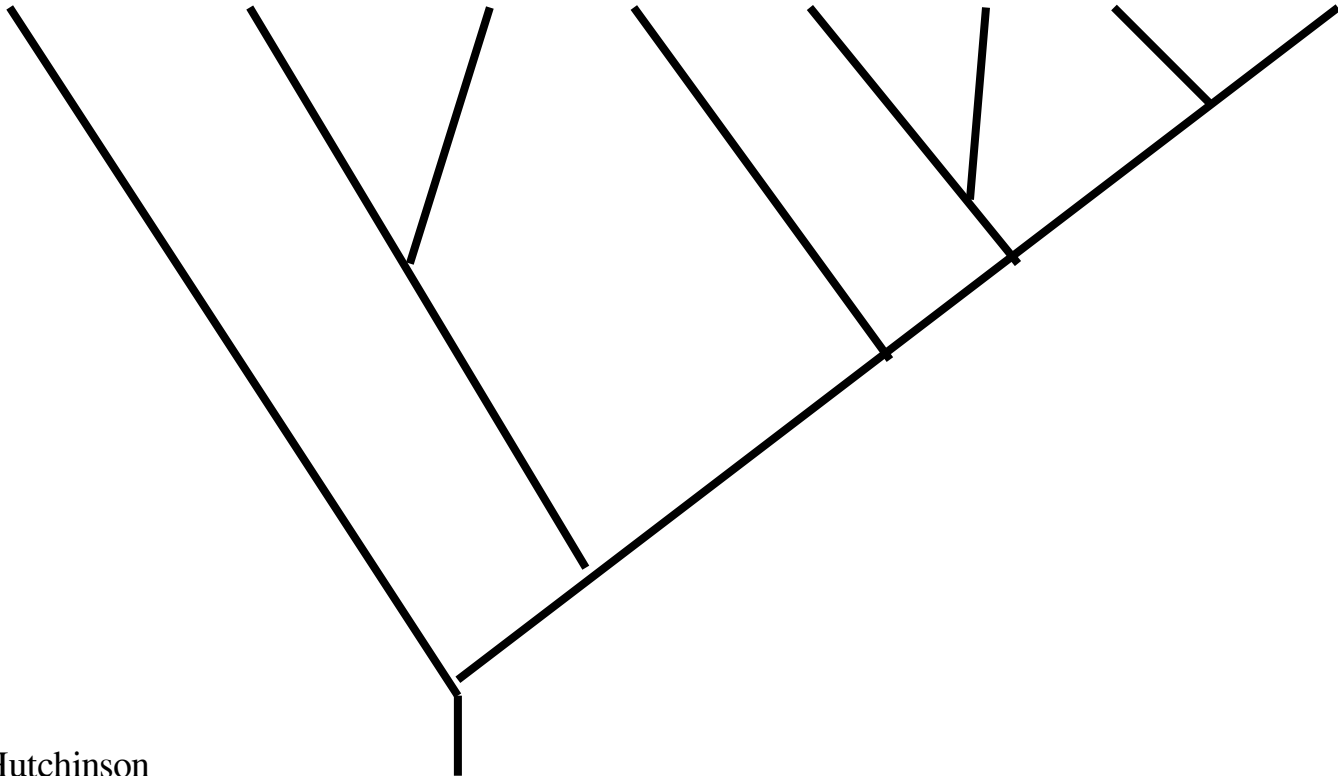
Palaeognathae: Living ratites and tinamous (large, mainly flightless birds)

1. Tinamous: SAm
2. Kiwis: NZ
3. (Moas: NZ)
4. (Elephant birds: Africa)
5. Cassowaries: Aus-NG
6. Emus: Aus
7. Ostrich: Afr-EurA
8. Rheas: SAm

(extinct groups)



Taxon: 1 2 3 4 5 6 7 8
Area: S.Am NZ NZ Ma Au,NG Au Af S.Am



Cooper et al 2001. *Nature* 409 (6821): 704–70

(a) Gondwana was the original home of ratites.



Gondwana was a "supercontinent" made up of many plates

The ancestral ratite lived throughout Gondwana

(b) Gondwana began to break up into separate continents.



(c) Ratites speciated as the continents moved apart.

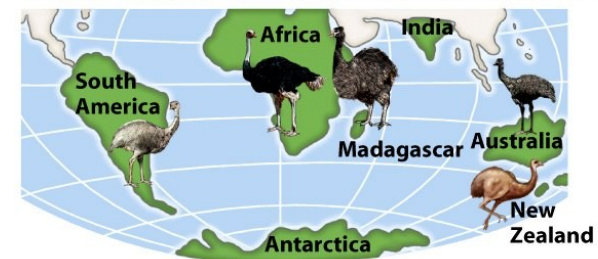


Figure 25-6 Biological Science, 2/e
© 2005 Pearson Prentice Hall, Inc.

Fig: Pearson Prentice Hall Inc

K/T Boundary 66 Ma

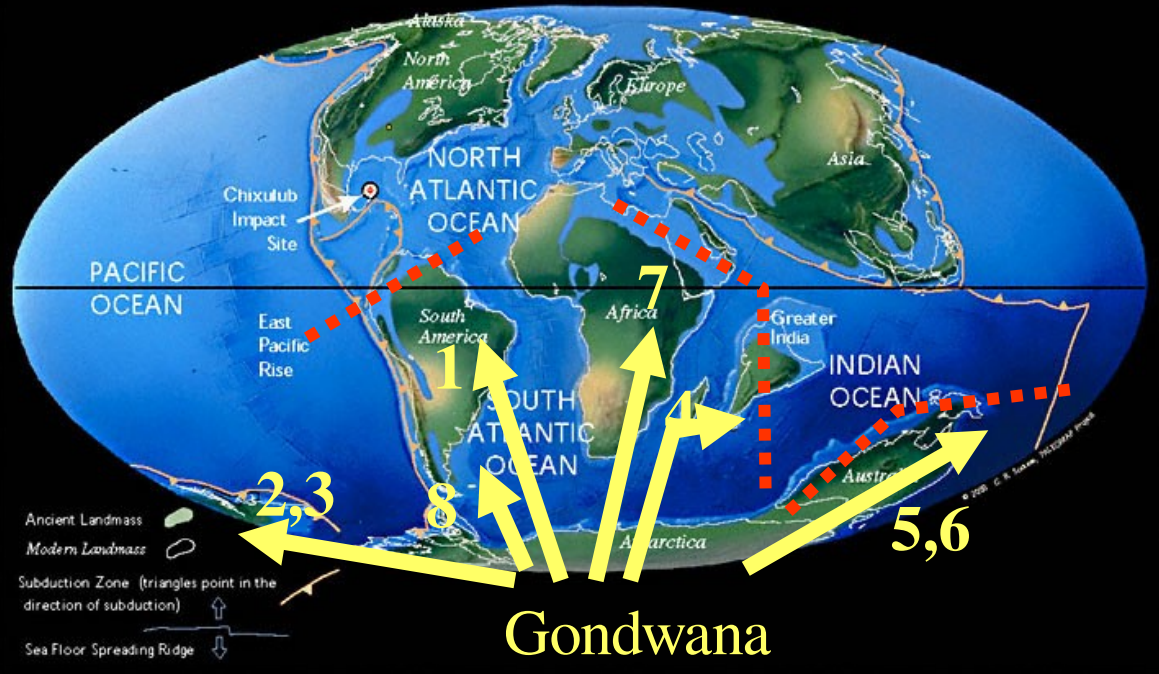


Illustration by Ian Hutchinson

Speciation by 'Dispersal'

pre 1960's: dominant view

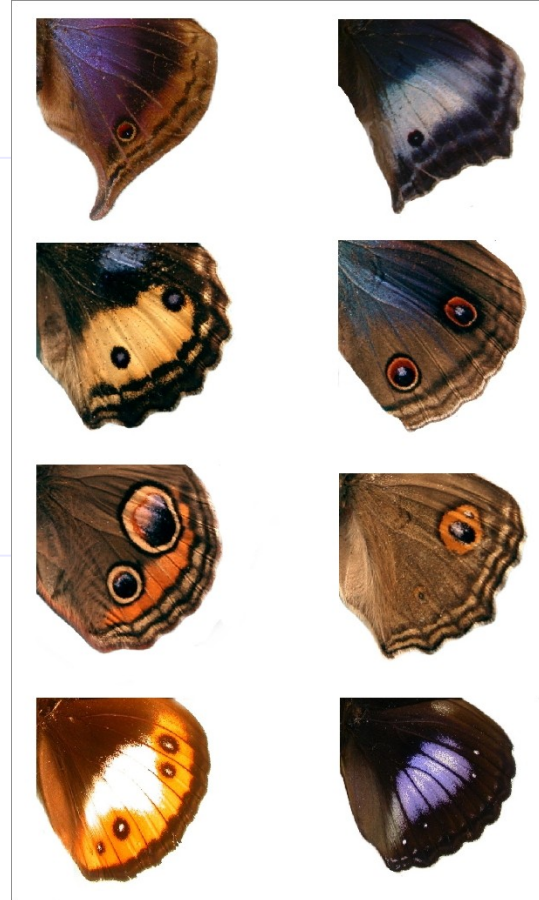
1960's: 'the science of the improbable, the rare, the
mysterious and the miraculous'

,

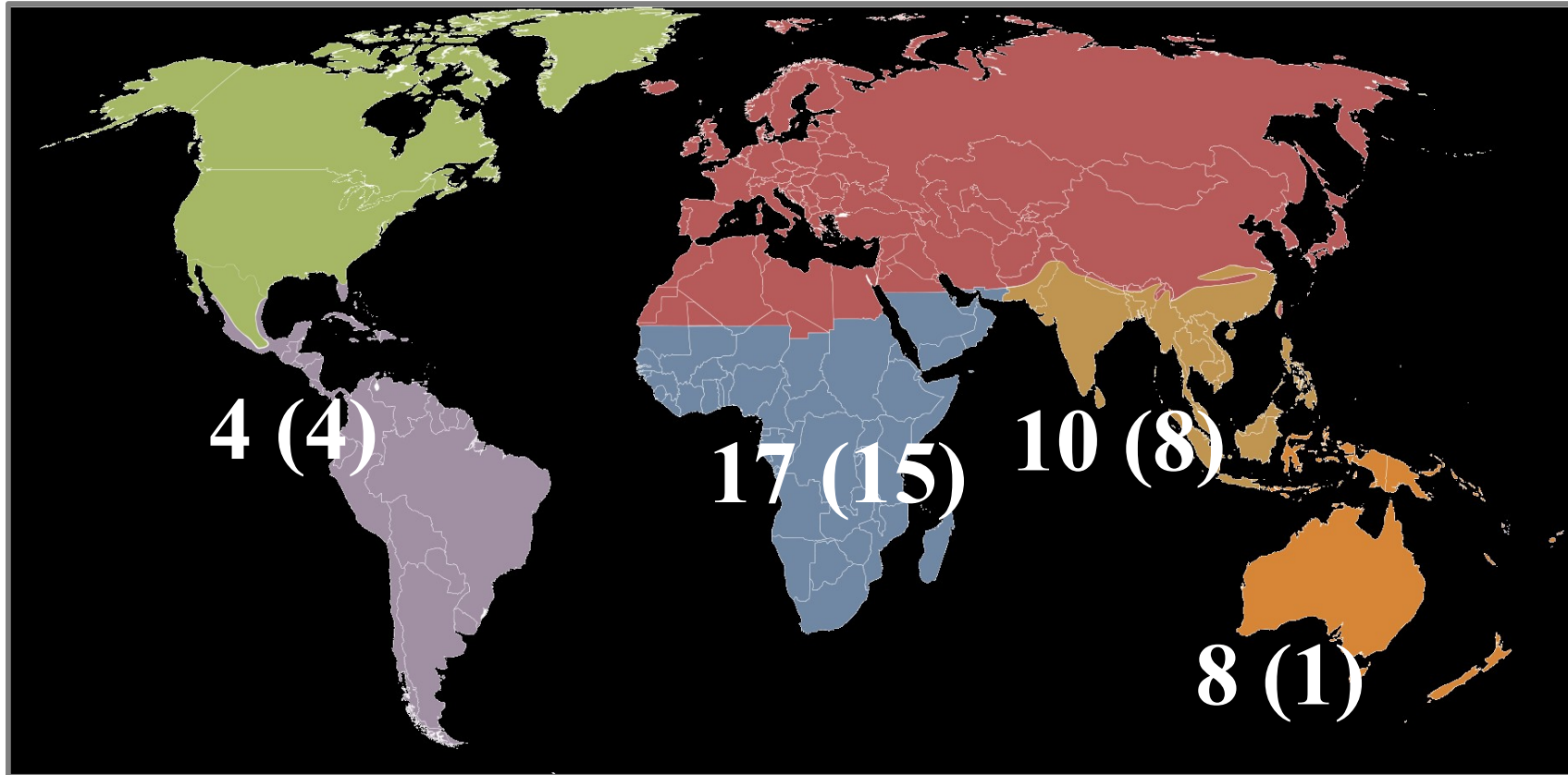
Historical biogeography of *Junonia*: Testing hypotheses of vicariance and dispersal

31 spp.

pansies,
buckeyes.



Extant distribution



simple **VICARIANCE** scenario



simple **DISPERSAL** Scenario



Phylogeny: predictions

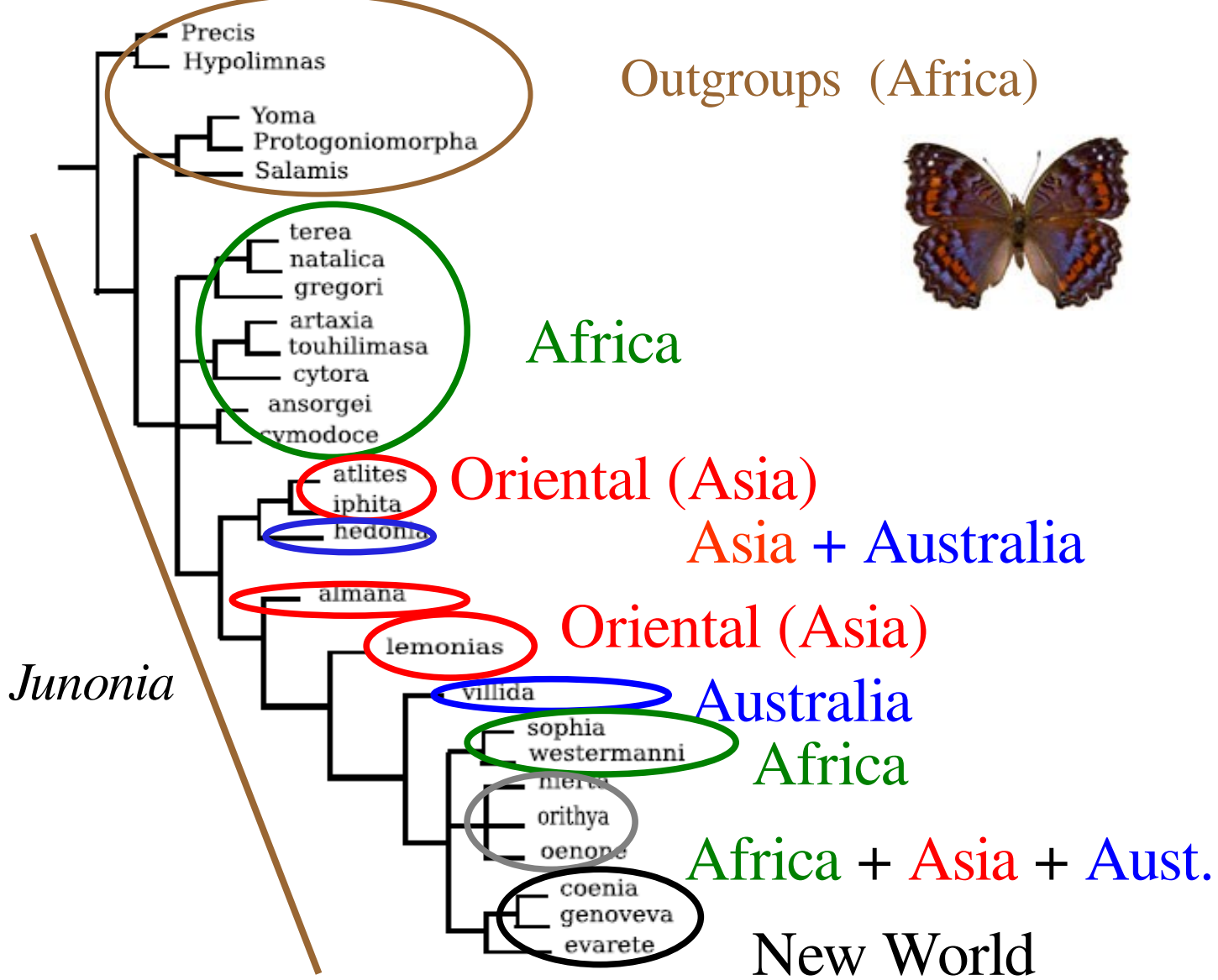
- simple **VICARIANCE** scenario:
 - species within different regions form monophyletic groups.
- simple **DISPERSAL** scenario:
 - Asian spp. nested within African
 - Australian spp nested within Asian
 - New World spp nested within African

Molecular phylogeny

3 genes

- 1 mitochondrial - COI
- 2 nuclear - EF1-alpha & wingless

> 3000 bp : 22 spp.

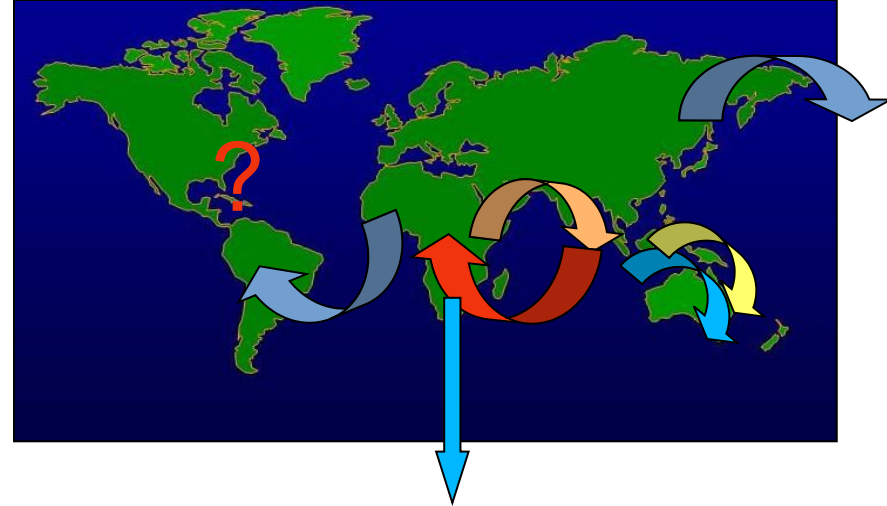
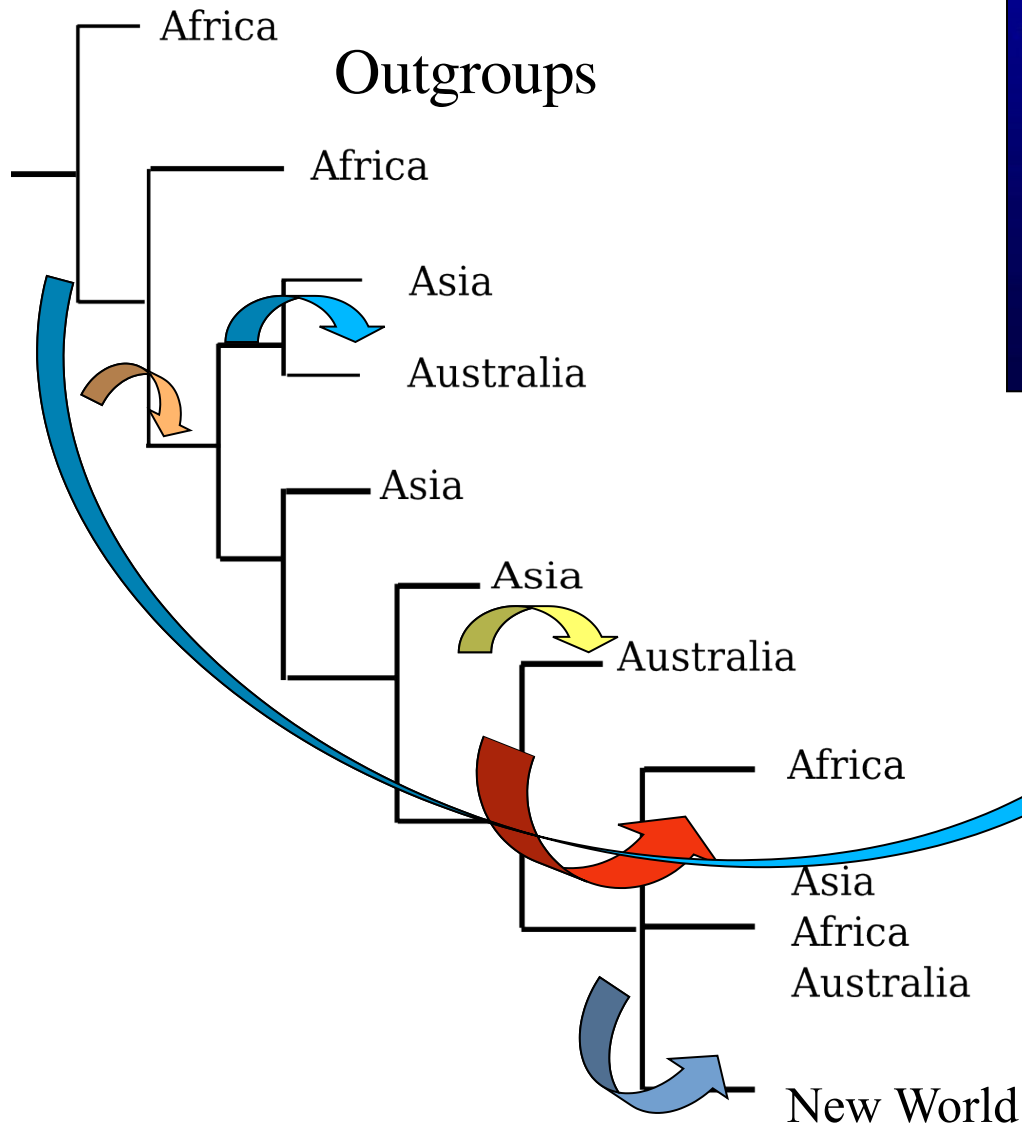


Predictions:

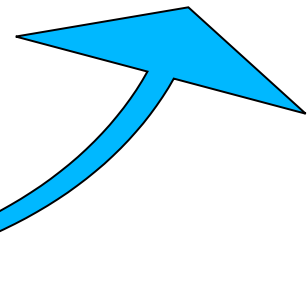
- simple **VICARIANCE** scenario:

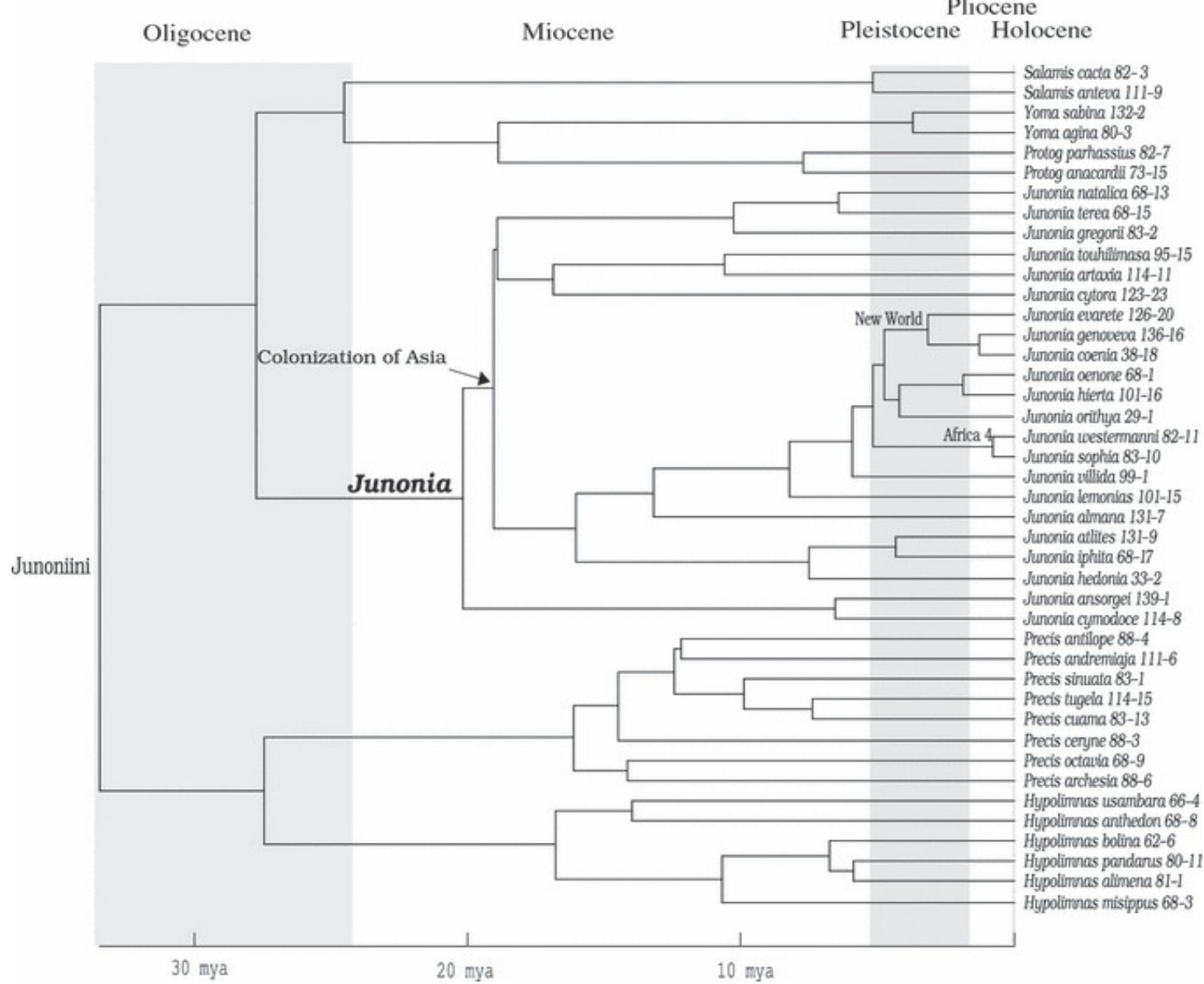
Species within different regions form
monophyletic groups.

- simple **DISPERSAL** scenario ?



The beginning of things





Molecular dating

20 mya
Collision of
Africa+Arabia with
Eurasia

Over the last 20 years, many studies based on molecular phylogenetic data and molecular dating analyses have shown that dispersal is very common, while few studies have supported vicariance as the dominant driver of speciation

Nevertheless, both have been important in the evolution of life forms

One of the major goals of historical biogeography is to understand the role of dispersal and vicariance in the evolution of different taxa, and to understand dispersal routes