

### Relationships of Floras (& Faunas)

Knowledge of earth and organism histories now permit closer examination of relationships of disjunct floras and faunas

- Southern Hemisphere temperate
- Southern Hemisphere tropics
- the Wallace Line
- Eastern Asian - Eastern North American temperate



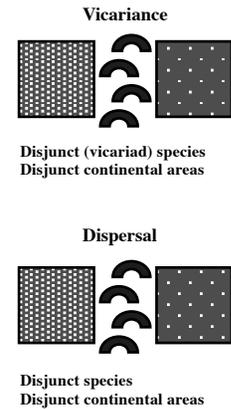
### Vicariance vs. Dispersal how do you decide?

Biogeography has relied on two sources of information

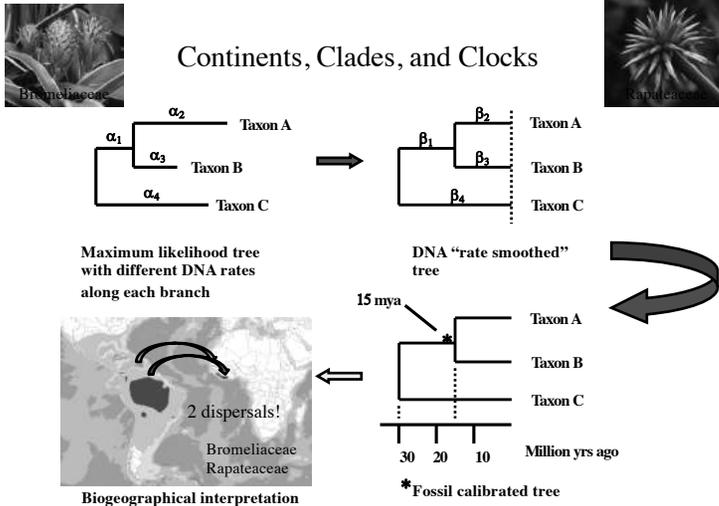
1. Phylogenetic trees - clades
2. Knowledge of splitting events of areas - continents, mountain erection, etc.

What is missing?

3. Times for branching events of clades relative to geological event – clocks!



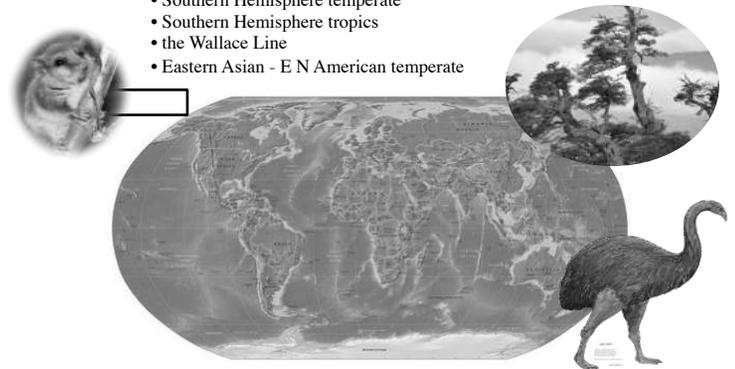
### Continents, Clades, and Clocks



### Relationships of Floras & Faunas

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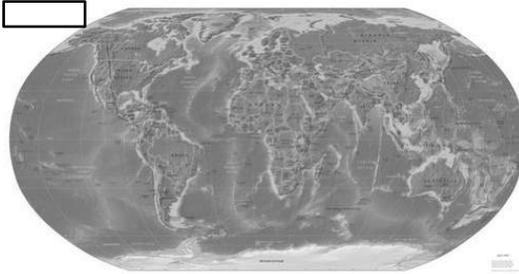
- Southern Hemisphere temperate
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## Southern Hemisphere Temperate Flora

Interesting contrast between the floras of the southern hemisphere temperate and tropical floras.

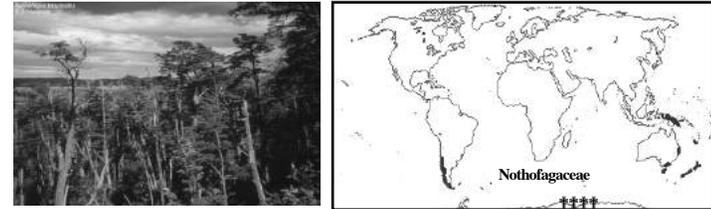
[The northern hemisphere continents are far more affected by recent glaciation events, so their distribution patterns are far more complex].



## Southern Hemisphere Temperate Flora

35 species of trees and shrubs, evergreen and deciduous, restricted to South America, New Zealand, Australia, Tasmania, New Caledonia, New Guinea, and fossilized in Antarctica

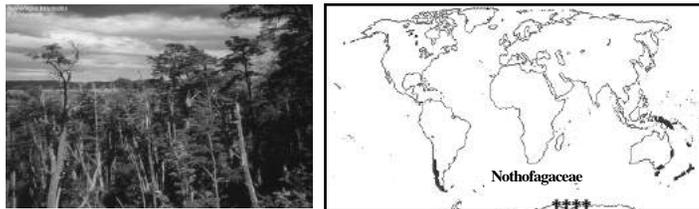
Absent from Africa! — “odd continent out”



## Southern Hemisphere Temperate Flora

Connections between South America and Australasia pronounced:

- Subg. *Nothofagus* — South America
- Subg. *Fuscopora* — S. Am., N. Zeal., Tasmania
- Subg. *Lophozonia* — S. Am., N. Zeal., Tasmania, Austr.
- Subg. *Brassospora* — New Caledonia, New Guinea

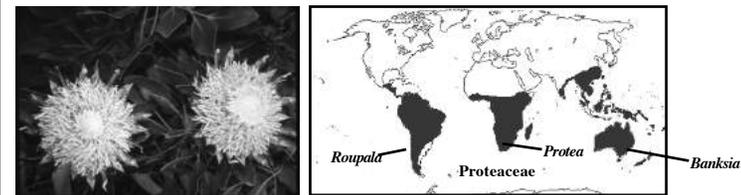


## Southern Hemisphere Temperate Flora

Proteaceae comprise 1700 species of woody plants placed in 79 genera predominantly of the southern hemisphere. The family, unlike Nothofagaceae, occurs in south Africa and Madagascar, and extends into southern China.

The 16 genera from Africa are endemic and comprise only 3 lineages. In comparison, South America and Australasia share roughly half of the genera in common. All tribes within the latter two areas are shared.

Africa — “odd continent out”!



### Southern Hemisphere Temperate Flora

Restionaceae comprise 520 species of grass-like plants placed in 58 genera predominantly of the southern hemisphere.



*Askidiosperma* — Restionaceae  
Cape Region



### Southern Hemisphere Temperate Flora

Restionaceae comprise 520 species of grass-like plants placed in 58 genera predominantly of the southern hemisphere.

The 350 species from Africa are unique and belong only to 11 genera of the *Restio* group. In contrast, South America and Australasia share many genera including some species. Africa — “odd continent out”!



Fynbos, S. Africa  
— Restionaceae



### Southern Hemisphere Temperate Flora

Why is Africa the “odd continent out” when it comes to the *temperate* southern hemisphere flora?

Three reasons:



**Proteaceae**



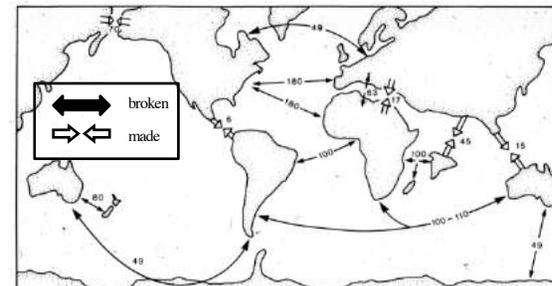
**Restionaceae**



**Nothofagaceae**

### Southern Hemisphere Temperate Flora

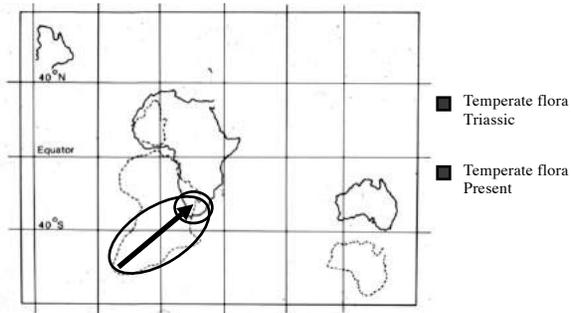
1. All three continents separated from Gondwana at about 100-110 mya in the early Cretaceous, but South America and Australia linked with temperate Antarctica until about 50 mya (and via small water passages until 27 mya)



Estimates in millions of years BP when migration routes between land masses were broken or made.

### Southern Hemisphere Temperate Flora

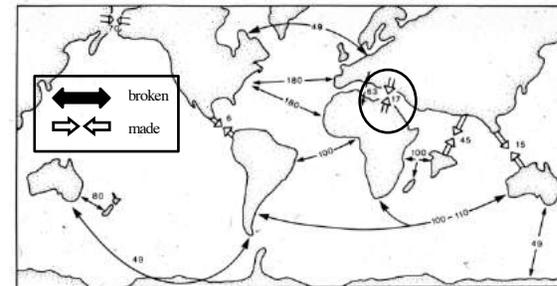
2. Africa drifted further north and experienced greater climatic change through this latitudinal journey. Greater extinction of temperate biota; which is now restricted to small area of south Africa.



Positions of Labrador, Africa, and Australia in the Triassic (200 mya) and at the present

### Southern Hemisphere Temperate Flora

3. Africa made secondary contact with temperate Eurasia around 17 mya; long contact further differentiated the temperate flora of Africa relative to South America and Australia

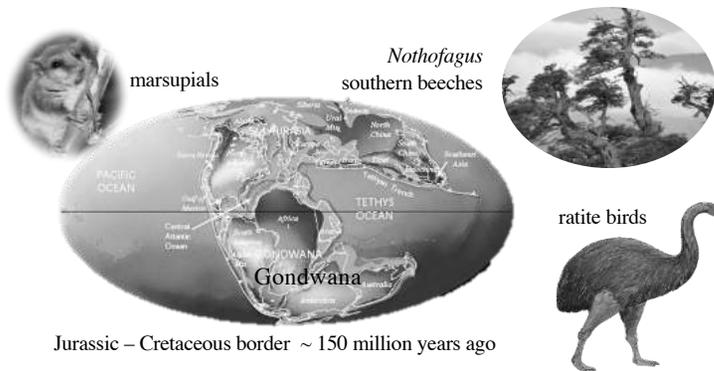


Estimates in millions of years BP when migration routes between land masses were broken or made.

### Vicariance vs. Dispersal?

Temperate Gondwanan disjuncts – vicariance and/or dispersal ?

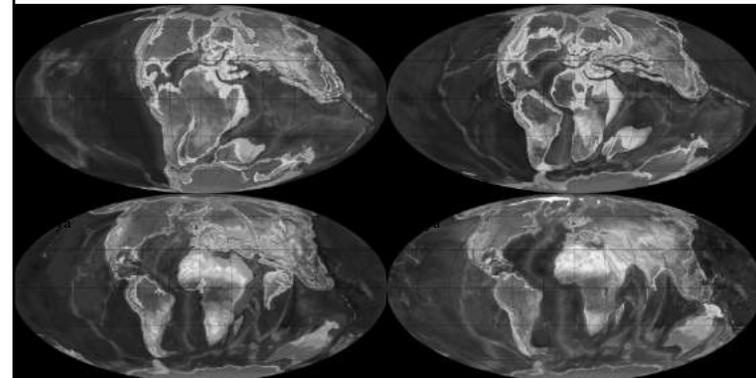
Timing of organism divergence vs. timing of geological divergence critical



### Vicariance vs. Dispersal?

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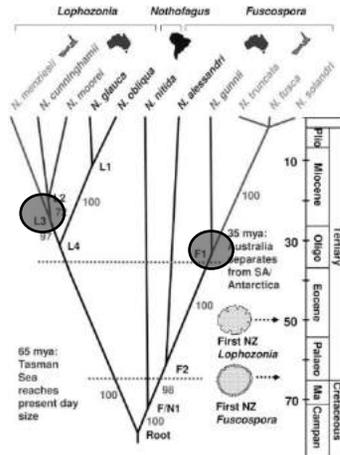


### Southern Hemisphere Temperate Flora

southern beeches? –

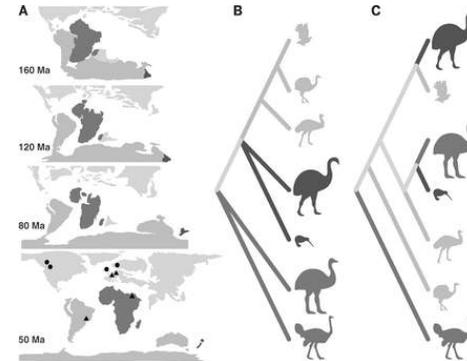
vicariance and a lot of dispersals

Australia <-> New Zealand dispersals



### Southern Hemisphere Temperate Fauna

ratites – flightless birds? vicariance and a lot of dispersals



A. Geological connections  
B. Geological story  
C. Mitochondrial story (different story)

Science 2014 Mitchell et al.

### Southern Hemisphere Temperate Fauna

ratites – flightless birds

## Ancient DNA reveals elephant birds and kiwi are sister taxa and clarifies ratite bird evolution

Kieren J. Mitchell,<sup>1</sup> Bastien Llamas,<sup>1</sup> Julien Soubrier,<sup>1</sup> Nicolas J. Rawlence,<sup>1\*</sup> Trevor H. Worthy,<sup>2</sup> Jamie Wood,<sup>3</sup> Michael S. Y. Lee,<sup>1,4</sup> Alan Cooper<sup>1†</sup>

The evolution of the ratite birds has been widely attributed to vicariant speciation, driven by the Cretaceous breakup of the supercontinent Gondwana. The early isolation of Africa and Madagascar implies that the ostrich and extinct Madagascan elephant birds (Aepyornithidae) should be the oldest ratite lineages. We sequenced the mitochondrial genomes of two elephant birds and performed phylogenetic analyses, which revealed that these birds are the closest relatives of the New Zealand kiwi and are distant from the basal ratite lineage of ostriches. This unexpected result strongly contradicts continental vicariance and instead supports flighted dispersal in all major ratite lineages. We suggest that convergence toward gigantism and flightlessness was facilitated by early Tertiary expansion into the diurnal herbivory niche after the extinction of the dinosaurs.

### Southern Hemisphere Temperate Fauna

ratites – flightless birds

Yonezawa et al. (2017) Phylogenomics and morphology of extinct paleognaths reveal the origin and evolution of the ratites. *Current Biology*

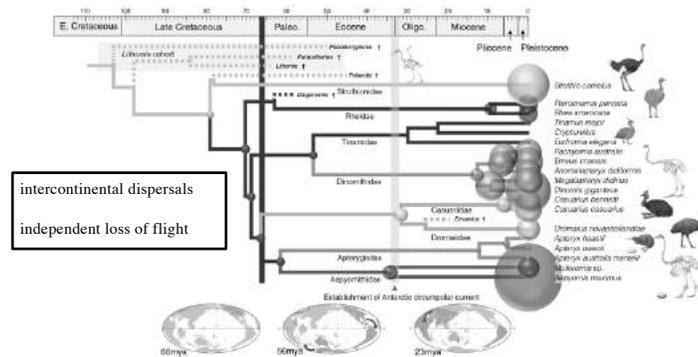
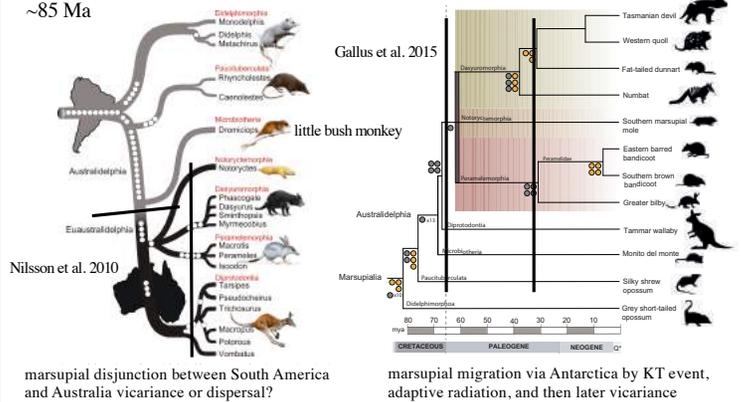


Figure 4. Palaeognathae Genomic Time Tree and Body Size

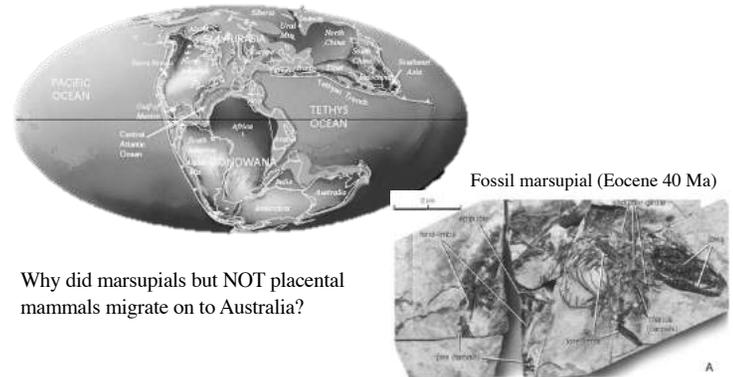
### Southern Hemisphere Temperate Fauna

Tracking marsupial evolution using genomic data - marsupial and placental mammals diverged in the Late Cretaceous ~85 Ma



### Vicariance vs. Dispersal?

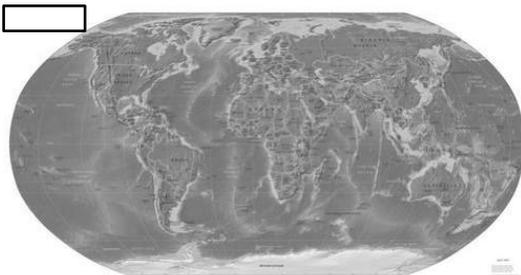
Fossils of both marsupials and placental mammals found in Antarctica



### Relationships of Floras (& Faunas)

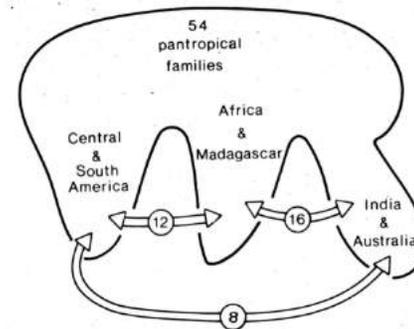
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### Southern Hemisphere Tropical Flora

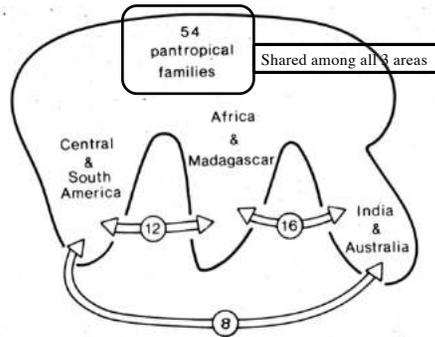
The floristic relationships among the three southern hemisphere continents are quite different when one examines the tropical floras.



Numbers of shared families between the three tropical floristic regions

### Southern Hemisphere Tropical Flora

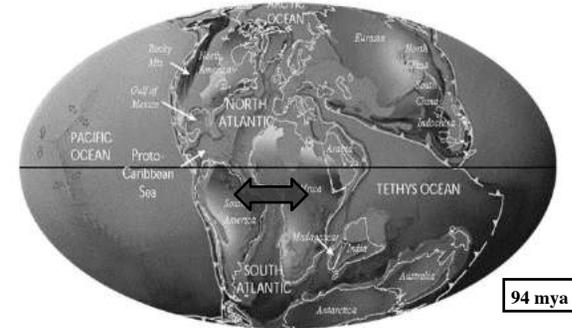
First point is that there are a large number of pantropical families — indicating tropical connections throughout the Cretaceous



Numbers of shared families between the three tropical floristic regions

### Southern Hemisphere Tropical Flora

Gondwanan separation began near the early Cretaceous (135 mya), but there was still considerable tropical connections for another 40 my



### Southern Hemisphere Tropical Flora

For example, tropical America and Africa were still close at around 84 mya (late-Cretaceous) even though temperate regions had separated 30+ my earlier



### Southern Hemisphere Tropical Flora



Flowering plants are first seen at the earliest Cretaceous (~130Mya), and many major lineages are already seen at 90 mya

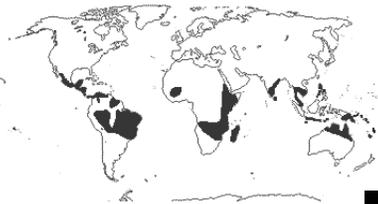
Thus, early ("primitive") families are often pantropical in distribution

Distribution of Monimiaceae – an early-diverging angiosperm family

*Siparuna*



### Southern Hemisphere Tropical Flora



Distribution of *Gyrocarpus* - a genus from the early-diverging angiosperm family Hernandiaceae

*Gyrocarpus jacquini*  
Asian tropics

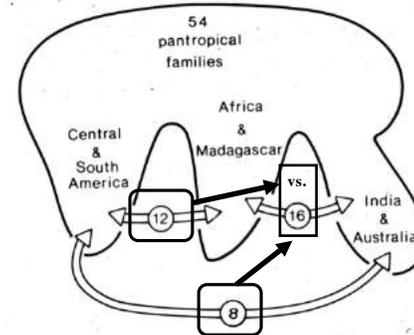


Flowering plants are first seen at the earliest Cretaceous (~130Mya), and many major lineages are already seen at 90 mya

Thus, early ("primitive") families are often pantropical in distribution . . . or even genera of these families!

### Southern Hemisphere Tropical Flora

**Second**, Africa is not the "odd continent out" — in fact, it appears that South America seems less related in its tropical flora to either Africa or AustralAsia.

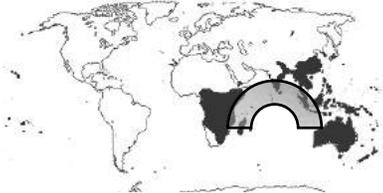


Numbers of shared families between the three tropical floristic regions

### African - Australasian Distributions

Many families show the African - Australasian distribution pattern. Why?

1. A relatively continuous tropical land arc exists across the northern Indian Ocean and through the Malay Archipelago - assists migration



Distribution of Pittosporaceae



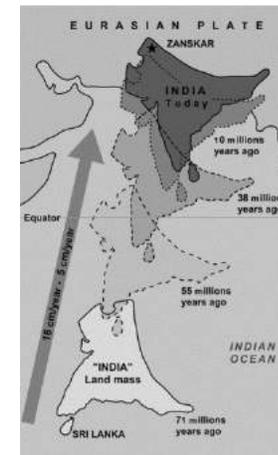
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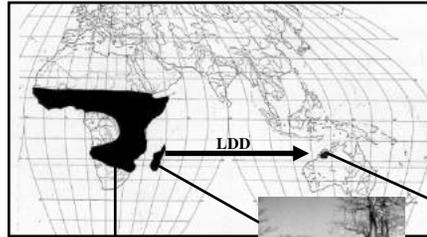
1. A relatively continuous tropical land arc exists across the northern Indian Ocean and through the Malay Archipelago - assists migration

2. India, Africa, and Australia all rafted up to make contact with the Eurasian plate at different times - facilitates mixing

3. These factors appear to have set the conditions for Long Distance Dispersal



### African - Australasian Distributions



The baobab (*Adansonia* - Malvaceae) disjunct pattern has been shown to be due to long distance dispersal



*Adansonia digitata*



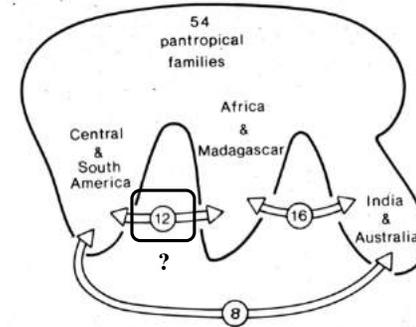
*Adansonia grandidieri*



*Adansonia gregorii*

### Southern Hemisphere Tropical Flora

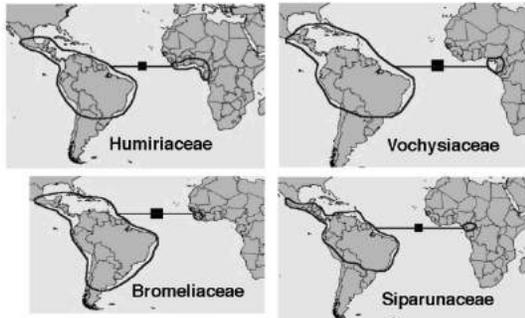
Third, 12 families shared only between South America and Africa *may not indicate shared biota* . . .



Numbers of shared families between the three tropical floristic regions

### Southern Hemisphere Tropical Flora

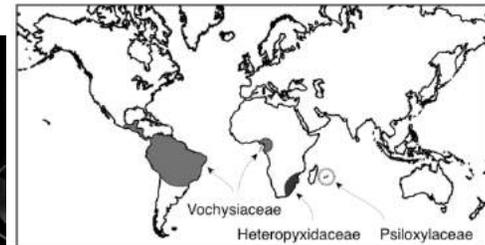
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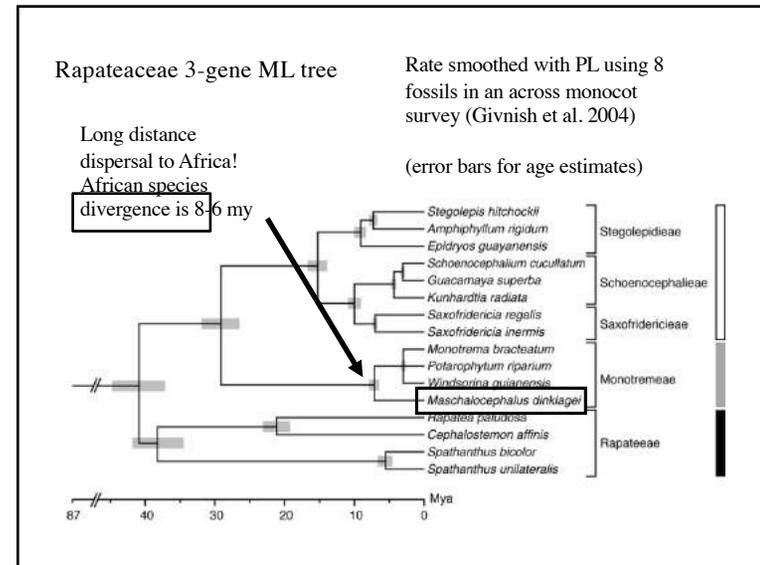
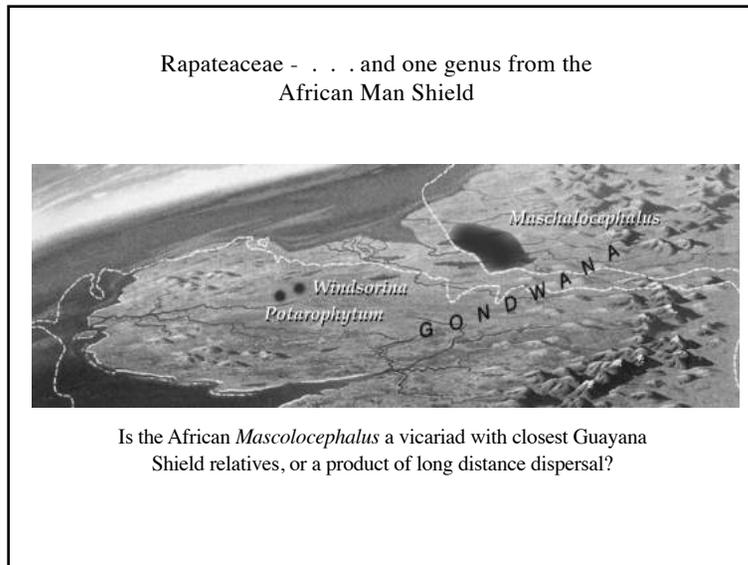
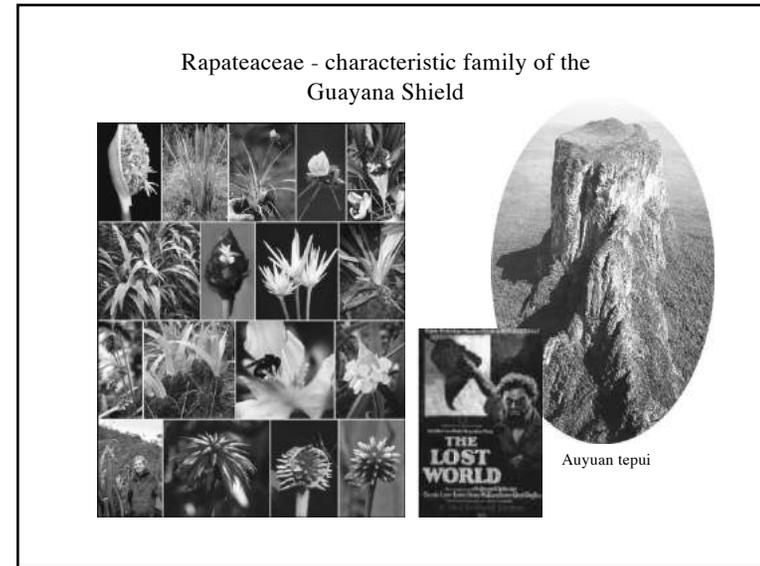
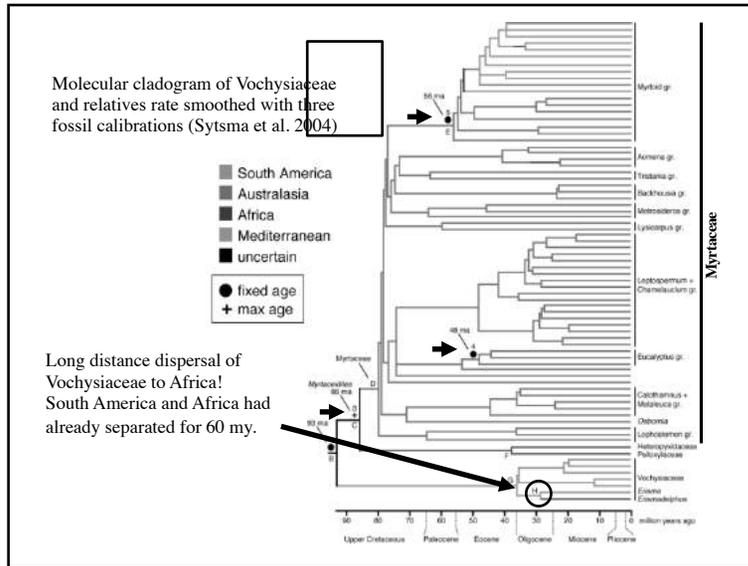


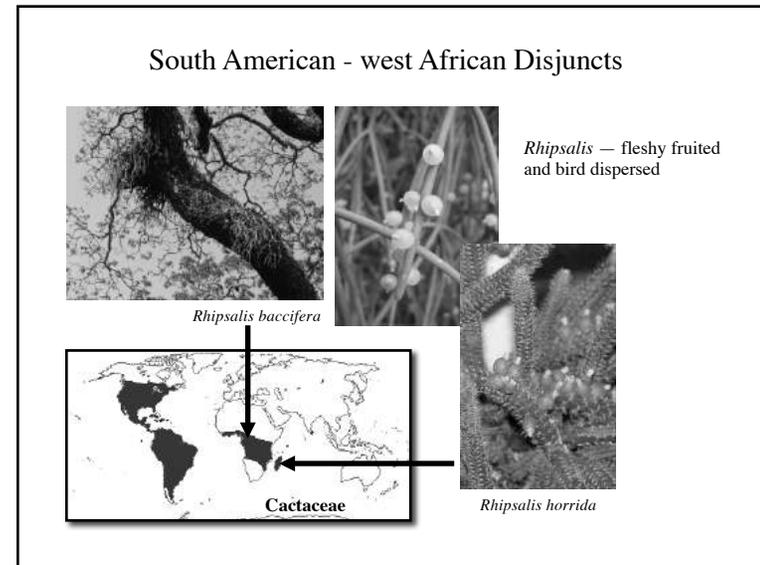
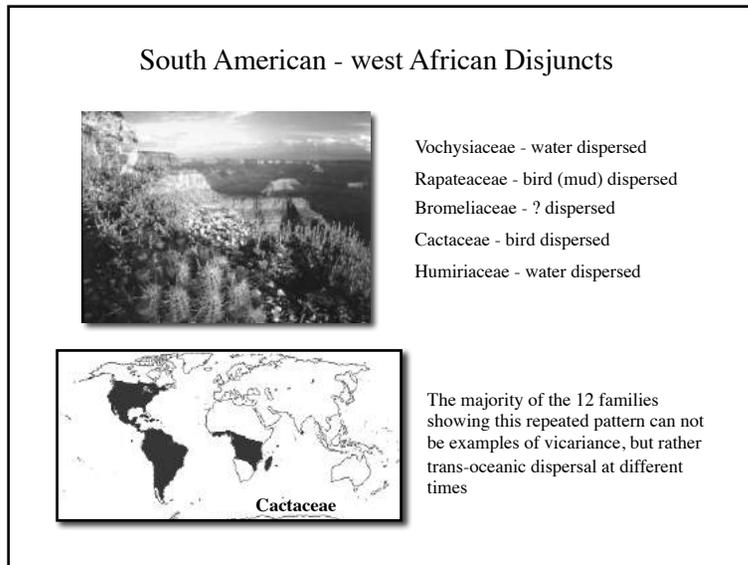
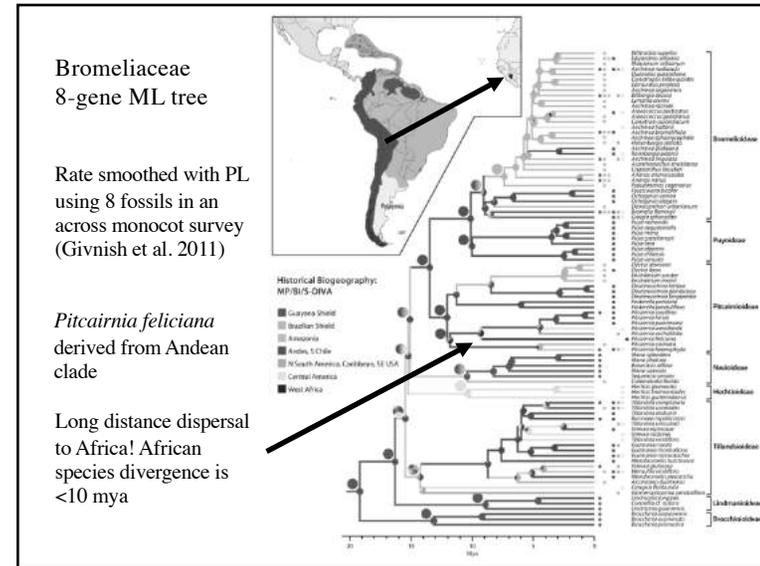
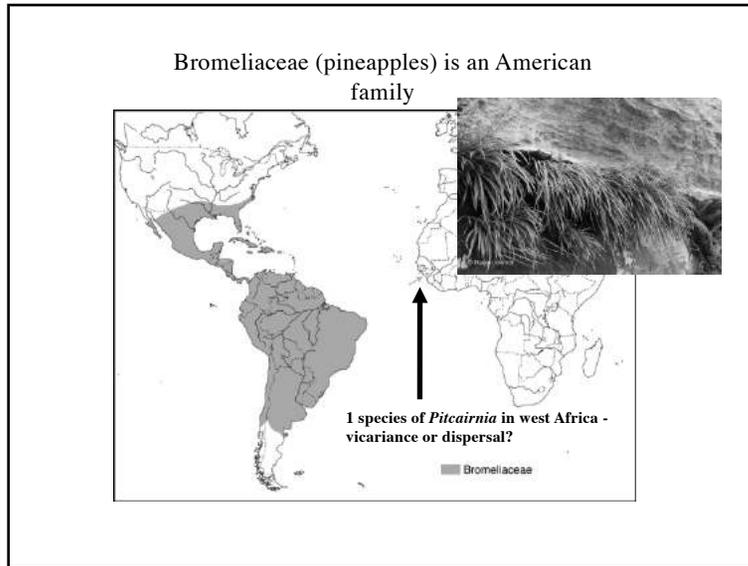
although vicariant biogeographers argue for an *ancestral biota*

Vochysiaceae: 8 genera, 210 spp.  
all American except 3 spp.

Gondwanan vicariance or dispersal?







### South American - west African Disjuncts



Humiriaceae  
8 / 50spp

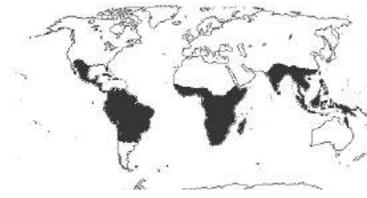
*Sacoglottis* with 7 species in neotropics;  
1 species (*S. gabonensis*) in W. Africa

*S. amazonica* - water dispersed fruit





### Boreotropics Hypothesis



An alternative to Gondwanan vicariance or transoceanic dispersal has been proposed for several families that are largely tropical but also have northern temperate lineages

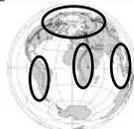
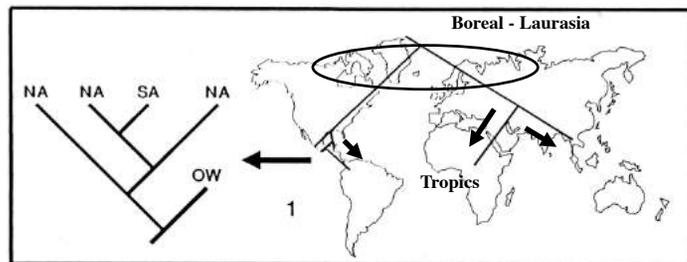
Pantropical distribution of Malpighiaceae

Phylogenetic analysis of these families indicate that the northern lineages are basal or primitive and not derived as previously suspected – Boreotropical hypothesis



### Boreotropics Hypothesis

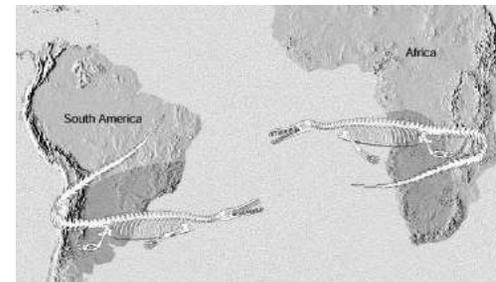
- these families likely originated in Laurasia (not Gondwana)
- and migrated to the tropics in two or three separate lineages



Comte de Buffon (1707–1788)

### Southern Hemisphere Faunal Relationships

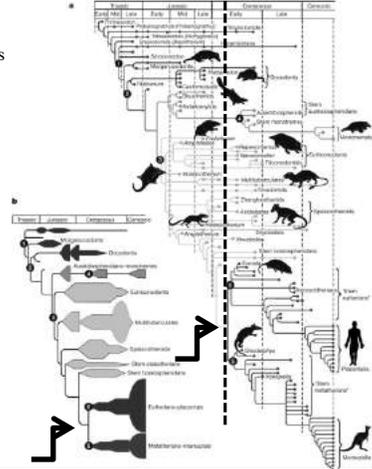
Does vicariance explain patterns of animal distributions? Certainly for old lineages such as Reptilia



Mesosaurus - Permian freshwater reptile

### Southern Hemisphere Faunal Relationships

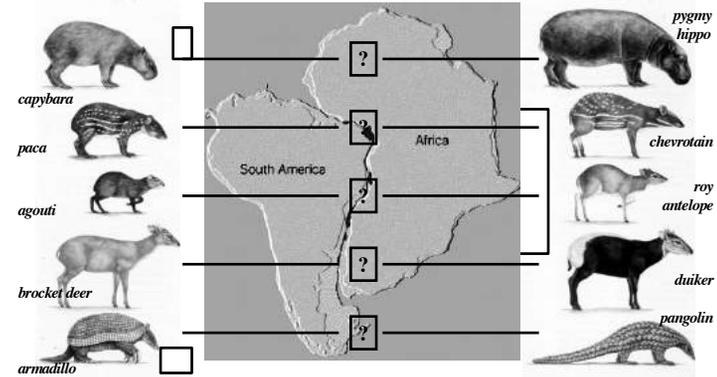
Does vicariance explain patterns of animal distributions? Certainly for old lineages such as Reptilia and mammals



Placental vs. marsupial separation in earliest Cretaceous

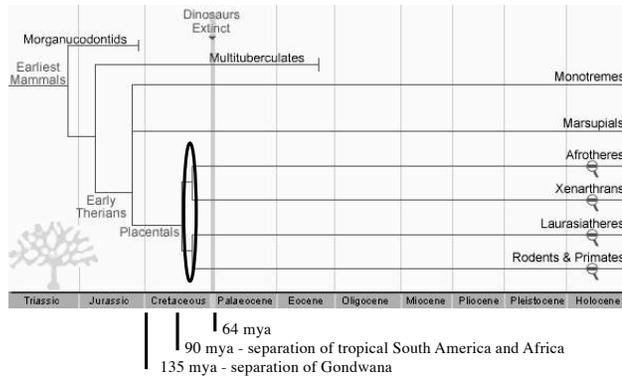
### Southern Hemisphere Faunal Relationships

Does vicariance explain patterns of placental mammal distributions? Long controversy on how South American and African placentals are related.



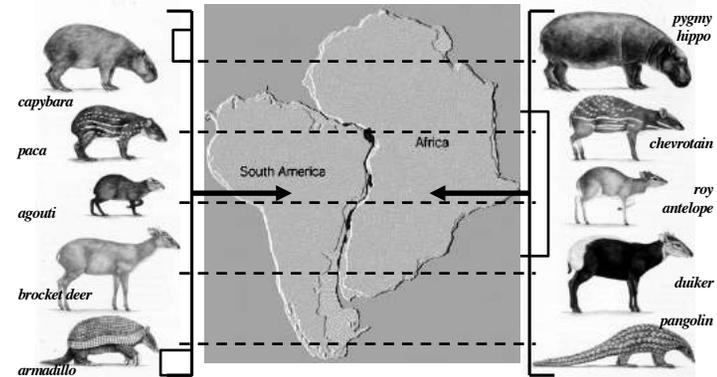
### Southern Hemisphere Faunal Relationships

Major radiations of placental mammals occurred after Gondwanan separation and split of tropical South America and Africa



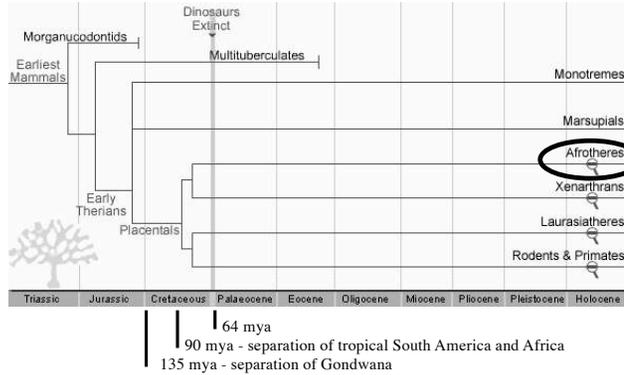
### Southern Hemisphere Faunal Relationships

Relationships in placental mammals exist only within a continent and similarities between South America and Africa are a striking case of **convergence**.



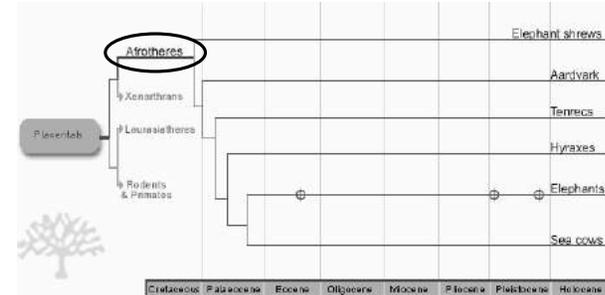
### Southern Hemisphere Faunal Relationships

A major surprise in the last few years using DNA sequences has been the recognition of a biogeographically defined lineage of African mammals with no (at least initially) defining morphological features — **Afrotheria**



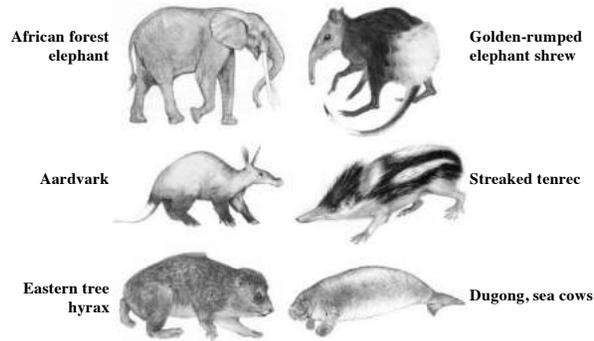
### Southern Hemisphere Faunal Relationships

The lineage **Afrotheria** has been evolving in isolation for 85-90 my and includes quite divergent and once considered totally unrelated mammals



### Southern Hemisphere Faunal Relationships

Representatives of the six orders comprising the Superorder Afrotheria — a striking case of **divergence** within a lineage

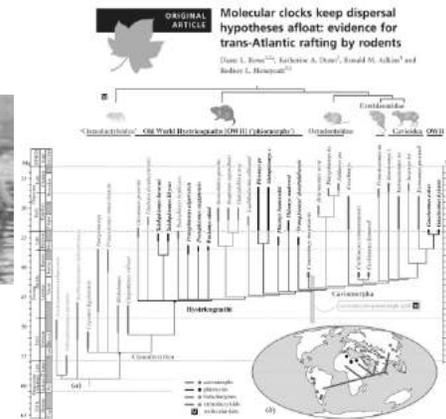


### Southern Hemisphere Faunal Relationships

Despite isolation of South American and African mammal lineages — still recent trans-Atlantic dispersal

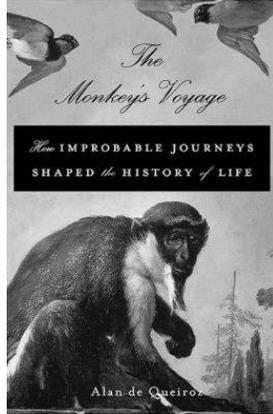


Capybara (*Hydrochoerus hydrochaeris*)



## Southern Hemisphere Faunal Relationships

Despite isolation of South American and African mammal lineages – still recent trans-Atlantic dispersal



36 mya fossil  
monkey teeth - Peru

Eocene primates of South America and the African origins of New World monkeys –  
*Bond et al. (2015) Nature*