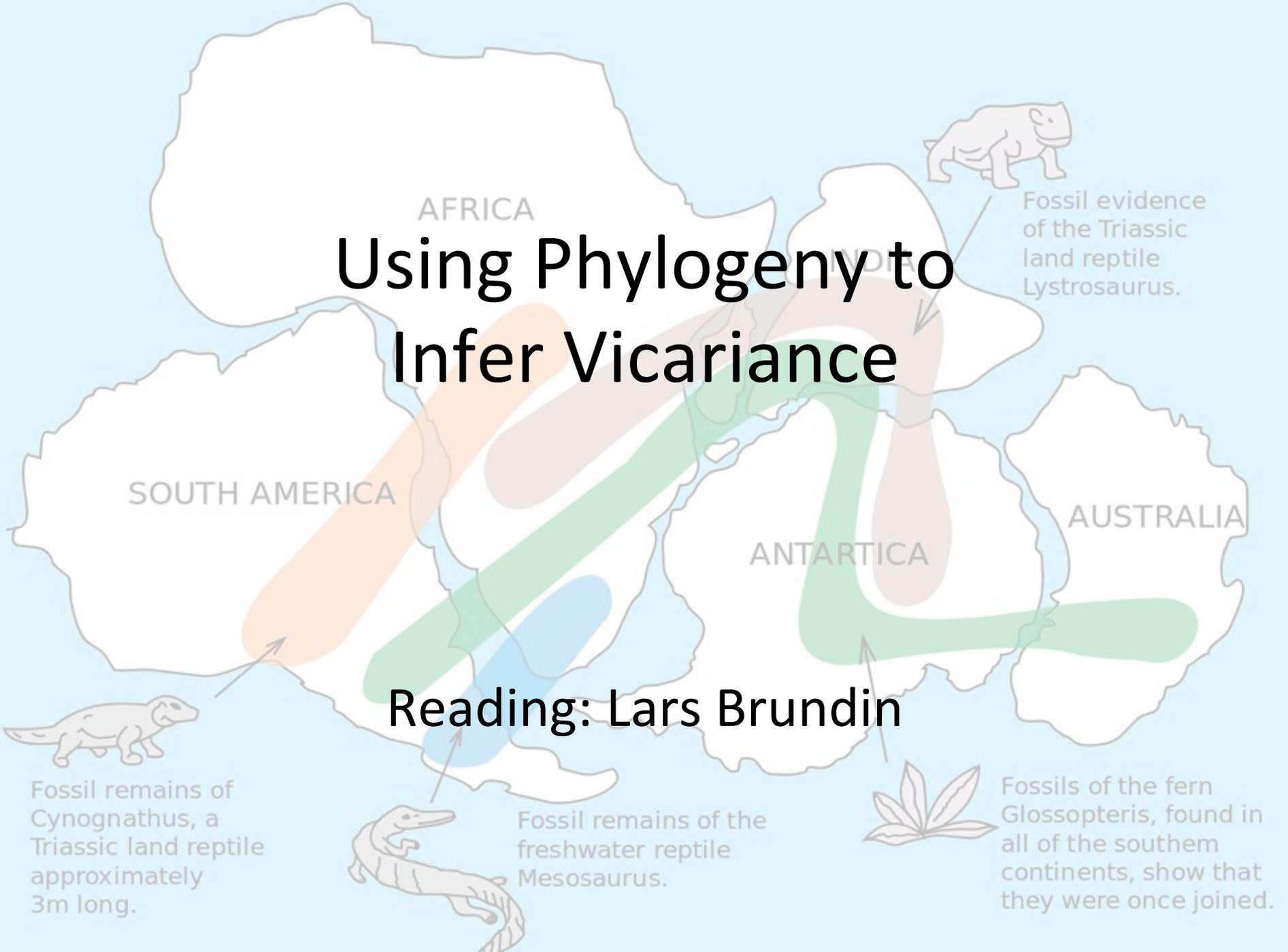


Using Phylogeny to Infer Vicariance



AFRICA

INDIA

SOUTH AMERICA

ANTARTICA

AUSTRALIA



Fossil evidence of the Triassic land reptile Lystrosaurus.

Reading: Lars Brundin



Fossil remains of Cynognathus, a Triassic land reptile approximately 3m long.



Fossil remains of the freshwater reptile Mesosaurus.



Fossils of the fern Glossopteris, found in all of the southern continents, show that they were once joined.

Earth History, Vicariance, and Dispersal

Lecture 5 Recap



Alfred
Wegener



Alfred
Wegener

Earth History, Vicariance, and Dispersal

- In his book, Wegener described how **the continents of SA and Africa fit together** (not the first to describe this)
- First to compare the continents with **fossil evidence** as evidence for being joined
- Also looked at **rock strata at the margins of continents** which suggested that these continents were formed in the same manner



Alfred
Wegener

Earth History, Vicariance, and Dispersal

- However, there was no mechanism described and so the idea had to wait for advances in technology and other discoveries
- **Sea floor spreading and magnetism**
- **Differences in rock density between continents and seafloor**
- **Seismic concentrations, or hotspots**



Alfred
Wegener

Earth History, Vicariance, and Dispersal

- **Subduction Zones**
- Takes place at convergent boundaries of tectonic plates
- Process where heavy, dense oceanic plate is moved underneath a lighter, less dense plate (usually a continental plate)
- Without this process plate tectonics could not occur as new seafloor at spreading sites needs older crust to be returned to the mantle



Joseph Dalton
Hooker

Earth History, Vicariance, and Dispersal

- *“... the botanical relationship [of the three great areas of land in the southern latitudes] is as strong as that which prevails throughout the lands within the Arctic and Northern Temperature zones, and which is not to be accounted for by any theory of transport or variation, but which is agreeable to the hypothesis of all being members of a once more extensive flora, which has been broken up by geological and climatic causes.”*



Sven Ekman

Earth History, Vicariance, and Dispersal

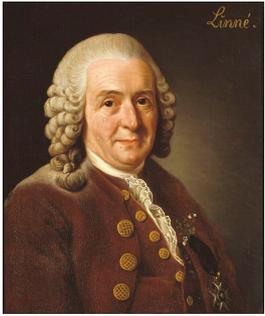
- *“Time, which in reality nothing more than a succession of events, that is historical happenings, is a factor of profound importance for all manifestations of life.”*
- *“...biogeography cannot confine itself simply to describing the occurrence of living forms, arranging them regionally, investigating the ecological causes of distribution. It must also proceed historically.”*



Sven Ekman

Earth History, Vicariance, and Dispersal

- We cannot understand the present day biogeographical distributions of animals and plants without an understanding of the history of the planet
- Historical biogeography attempts to reconstruct the origin of taxa; sequences of their dispersal, isolation, and extinction; and to explain how geological events have shaped present day patterns of distribution
- Addresses the *how*, *when*, and *why* of species distributions



Carl Linnaeus

Earth History, Vicariance, and Dispersal

- Two schools of thought:
 - 1. **Dispersal biogeography** follows from the premise that species spread outward from a *center of origin* so that present day biota results from the accumulated dispersal of the various descendant lineages
 - 2. **Vicariance biogeography** follows that an unstable earth is involved in the splitting of biota into isolated populations by emerging barriers (*TECO events*)



Alfred
Wegener

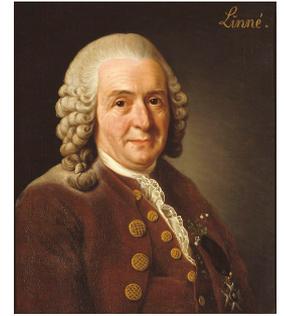
Earth History, Vicariance, and Dispersal

- **TECO events**
- Tectonic – plate movements and orogeny
- Eustatic – changing sea levels
- Climatic – shifting climate belts, ice ages
- Oceanographic – oceanographic circulation changes



Alfred
Wegener

Earth History, Vicariance, and Dispersal



Carl Linnaeus

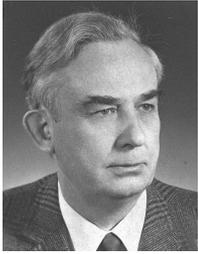
- In reality, large-scale disjunct distribution patterns can result from *dispersal* or *vicariance* or *both*, and distributional patterns are clearly modified over time by evolutionary and ecological processes



Lars Brundin

Earth History, Vicariance, and Dispersal

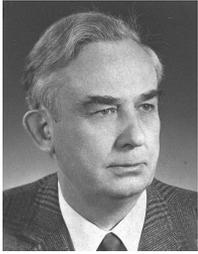
- Now that there was knowledge that continents are not fixed through time, it facilitated the development of analytical techniques
- The field was no longer based on narrative approaches
- A classic study was one by Lars Brundin that employed *phylogenetic models* to demonstrate concordance between animal distributions and plate tectonics



Willi Hennig

Earth History, Vicariance, and Dispersal

- We first have to understand the phylogenetic approach
- *Cladistic biogeography*
- German scientist who is considered the father of phylogenetic systematics
- Sent to Italy during WWII to fight malaria, captured by the British forces and during his time as a POW drafted *Basic Outline of a Theory of Phylogenetic Systematics* (1950)
- We will revisit Hennig in Week 4

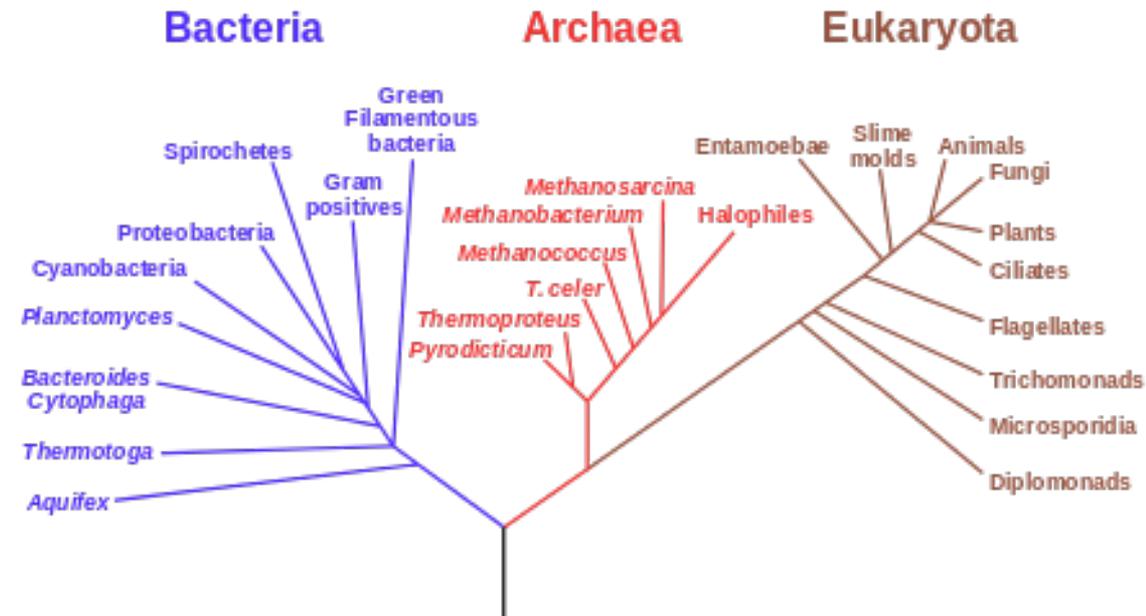


Willi Hennig

Earth History, Vicariance, and Dispersal

- Nodes represent most recent common ancestor
- Further back on the tree the farther back in relative time
- Extinct clades are usually represented by abrupt, short branches, or one that fades away

Phylogenetic Tree of Life





Lars Brundin

Earth History, Vicariance, and Dispersal

- *Transantarctic Relationships and Their Significance, as Evidenced by Chironomid Midges*
- One must understand vicariant patterns in biogeography before attempting to decipher 'chance dispersal' patterns



Lars Brundin

Earth History, Vicariance, and Dispersal

- *“What about the general suitability of chironomid midges as indicators in biogeography?”*
- *“In the possession of a developmental cycle comprising larva, pupa, and imago these orders offer **three quite different types of organization and adaptation** within the limits of a species. We thus have the great advantage of being able to **cross-check the phylogenetic conclusions** drawn from one stage with the others, thus attaining a **high degree of reliability** by the establishment of **monophyletic sister groups.**”*



Lars Brundin

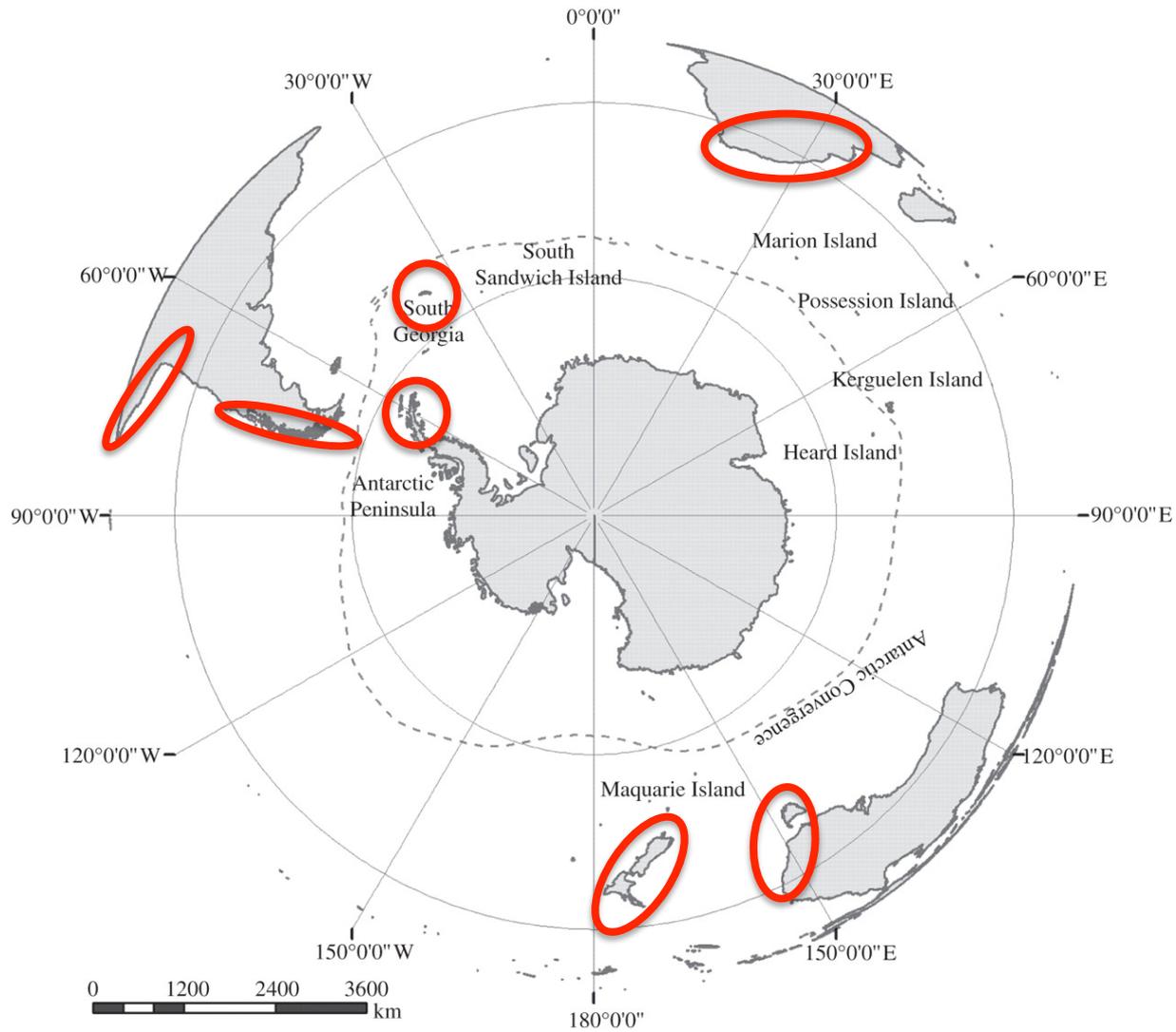
Earth History, Vicariance, and Dispersal

- **Advantages to using midges as a model organism**
- Accessibility to samples – many and easy to collect
- Extremely cold-resistant – less affected by glaciation
- Very small – easier to maintain a population during stress
- Feed on diatoms – almost always abundant
- Habitat unchangeable – always will be mountain streams
- Old enough –traced back to the Jurassic at least (200mya)
- Patterns results of processes beyond the action of man



Lars Brundin

Earth History, Vicariance, and Dispersal

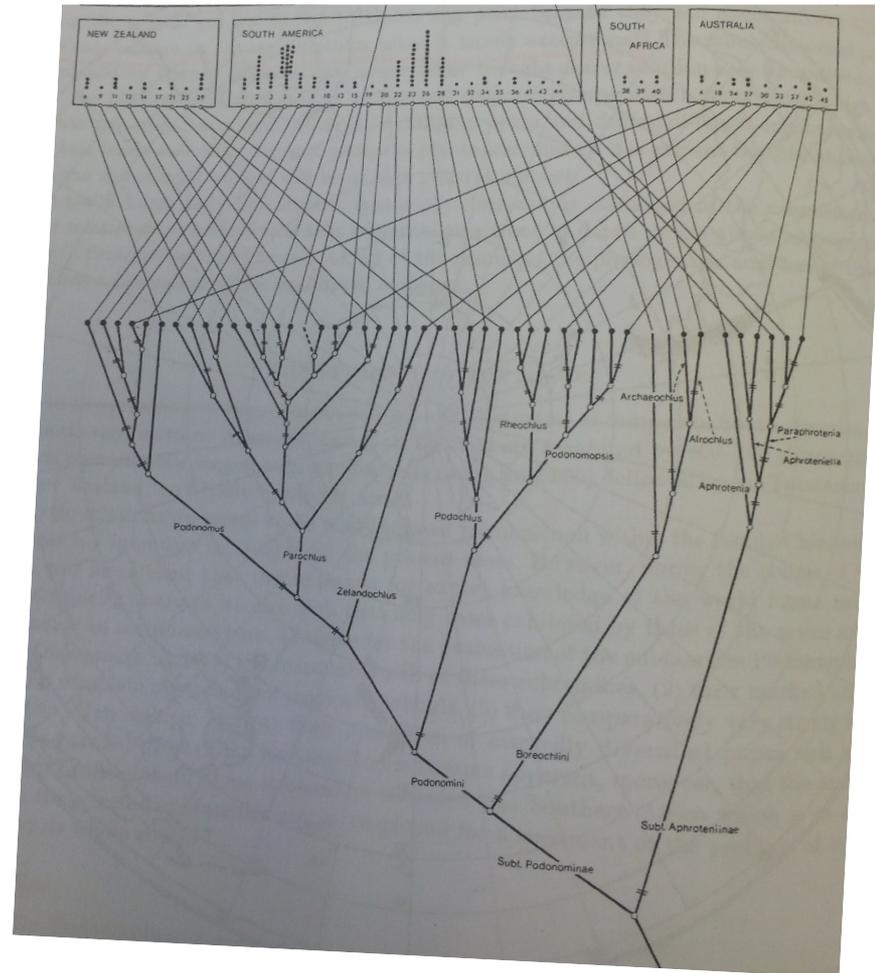




Lars Brundin

Earth History, Vicariance, and Dispersal

NZ S. America S. Af Aus





Lars Brundin

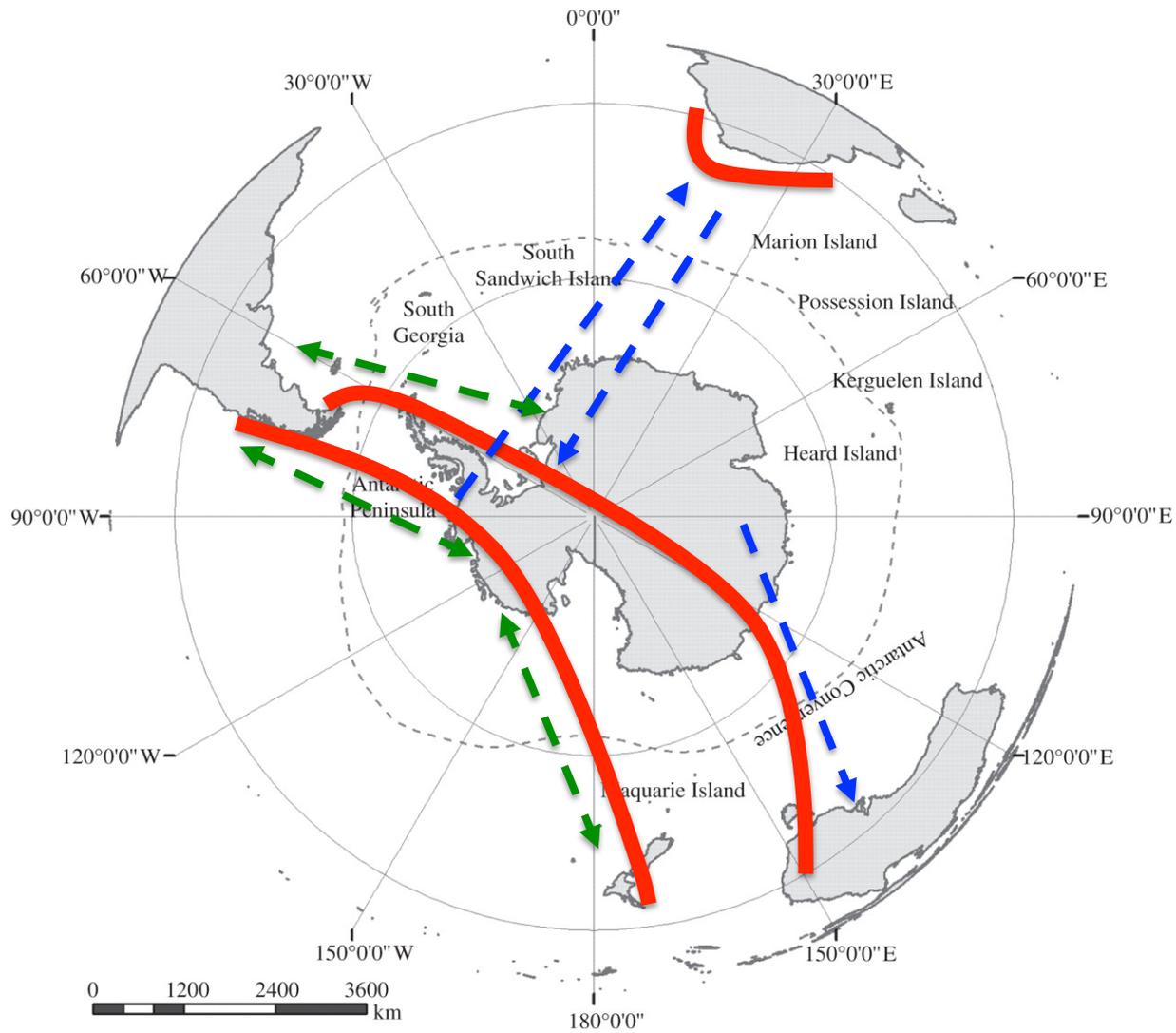
Earth History, Vicariance, and Dispersal

- **Major observations from phylogeny**
- The sister group of a NZ group lives always in S. America, or in S. America *and* Tasmania-Aus.
- There are no direct connections between a group of Tasmania-Aus. and group of NZ
- A group of Tasmania-Aus. Is always an apomorph (*morphological advance*) offshoot of the S. American fauna.



Lars Brundin

Earth History, Vicariance, and Dispersal



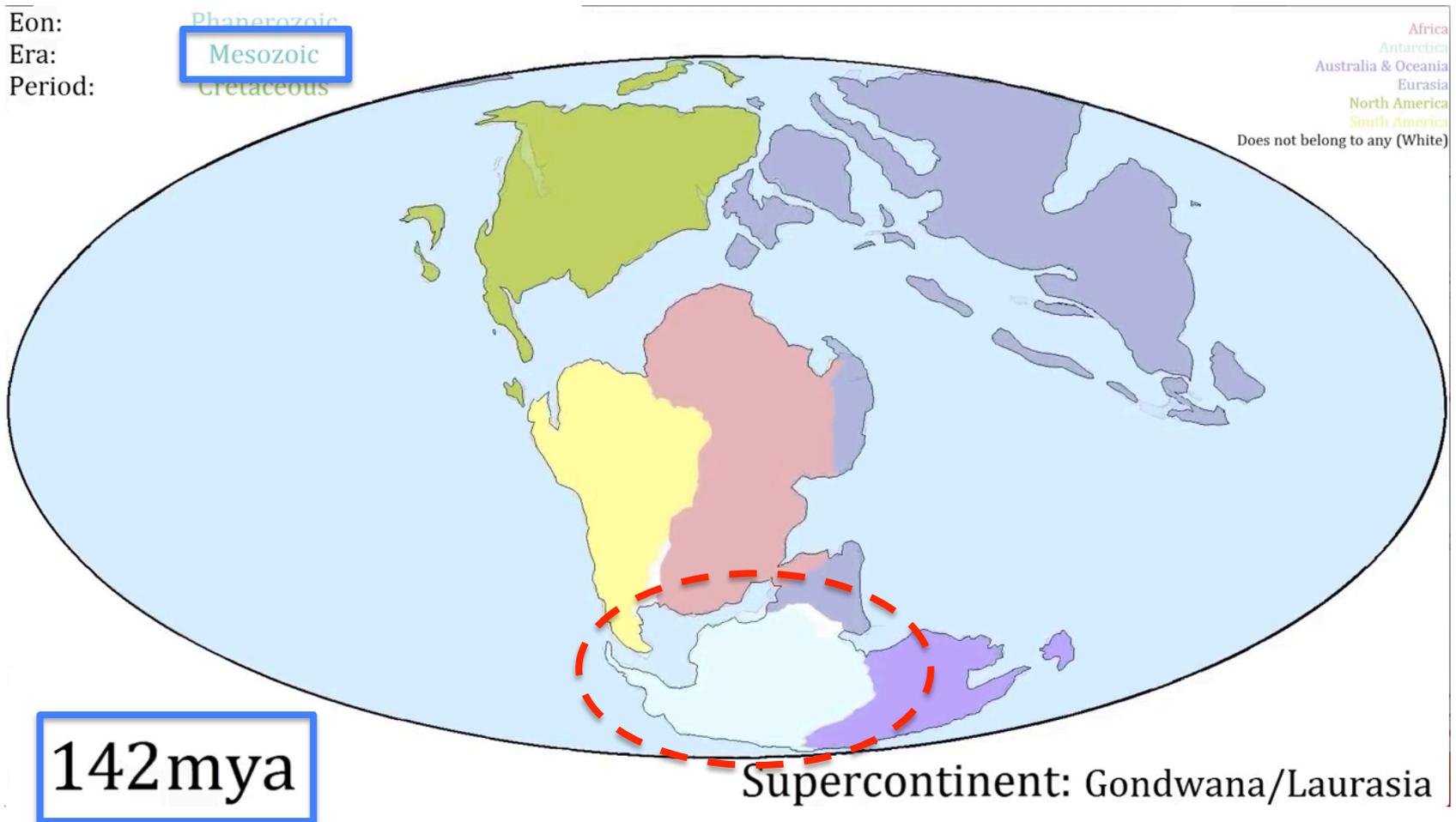


Lars Brundin

Earth History, Vicariance, and Dispersal

Eon:
Era:
Period:

Phanerozoic
Mesozoic
Cretaceous





Lars Brundin

Earth History, Vicariance, and Dispersal

- *“The cases of 25 transantarctic phyletic connections and their amphitropical ramifications analyzed in the present paper tell a story of orderly dispersal which goes back to the middle Mesozoic. There is not the slightest evidence of chance dispersal over wide stretches of ocean or of any sort of hopping of ancestral forms from island to islands between the southern continents.”*

Earth History, Vicariance, and Dispersal



Joseph Dalton
Hooker

- *“... the botanical relationship [of the three great areas of land in the southern latitudes] is as strong as that which prevails throughout the lands within the Arctic and Northern Temperature zones, and which is not to be accounted for by any theory of transport or variation, but which is agreeable to the hypothesis of all being members of a once more extensive flora, which has been broken up by geological and climatic causes.”*



Lars Brundin

Earth History, Vicariance, and Dispersal

Main Points

- The advent of plate tectonics led to the field of biogeography becoming analytical rather than narrative
- Brundin used Hennig's phylogenetics and a model order to demonstrate vicariant patterns of speciation
- Brundin showed that by finding general rules in phylogenetic trees, one can trace back vicariant events to hundreds of millions of years ago
- This work verified observations by Hooker and others about the relatedness of the southern flora and fauna

Questions on the reading?



Lars Brundin

Discussion Point 1

- *“What belongs to main pattern, what is barely exceptional?”*
- What did Brundin mean by this statement in the relation to the midges?
- How do we separate regular pattern from exceptional occurrences? How do we judge what is important?



Lars Brundin

Discussion Point 2

- *“...all scientists studying phylogenies are potential biogeographers in a truly progressive sense.”*
- How is this statement meaningful in relation to Hennig and Ekman?