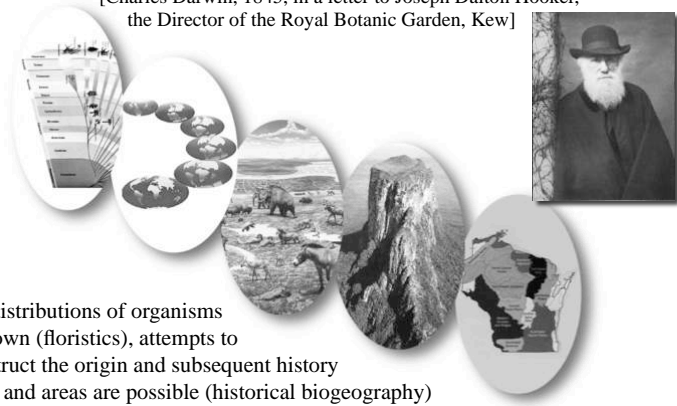


Historical Biogeography

" . . . that grand subject, that almost keystone of the laws of creation,
Geographical Distribution"

[Charles Darwin, 1845, in a letter to Joseph Dalton Hooker,
the Director of the Royal Botanic Garden, Kew]

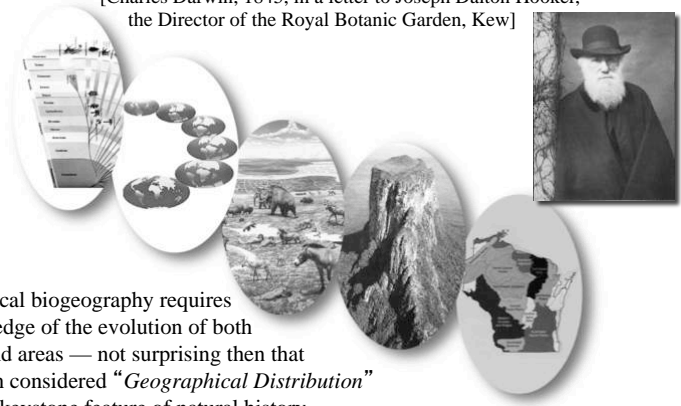


Once distributions of organisms are known (floristics), attempts to reconstruct the origin and subsequent history of taxa and areas are possible (historical biogeography)

Historical Biogeography

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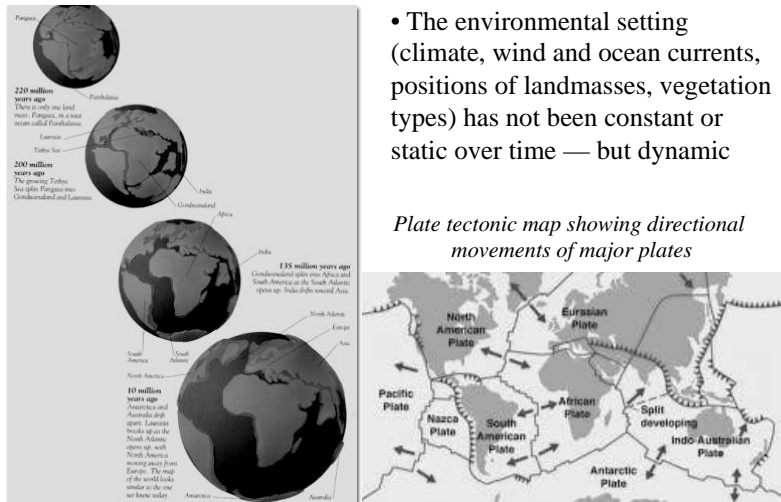


Historical biogeography requires knowledge of the evolution of both taxa and areas — not surprising then that Darwin considered "*Geographical Distribution*" such a keystone feature of natural history

Historical Biogeography

- The environmental setting (climate, wind and ocean currents, positions of landmasses, vegetation types) has not been constant or static over time — but dynamic

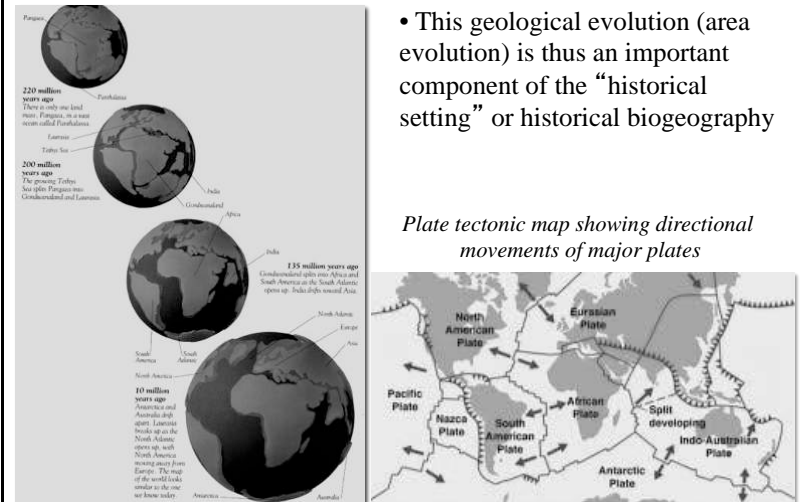
Plate tectonic map showing directional movements of major plates



Historical Biogeography

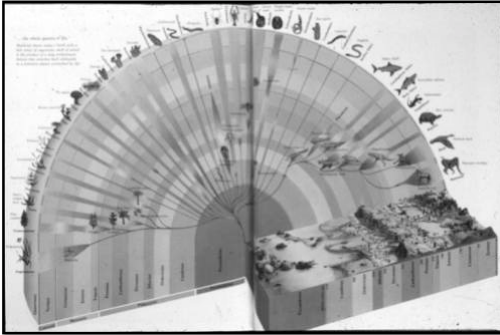
- This geological evolution (area evolution) is thus an important component of the "historical setting" or historical biogeography

Plate tectonic map showing directional movements of major plates



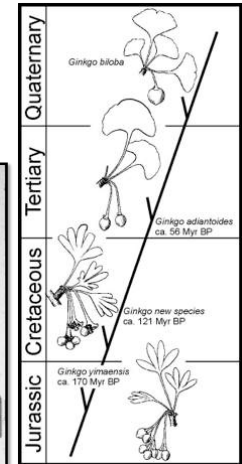
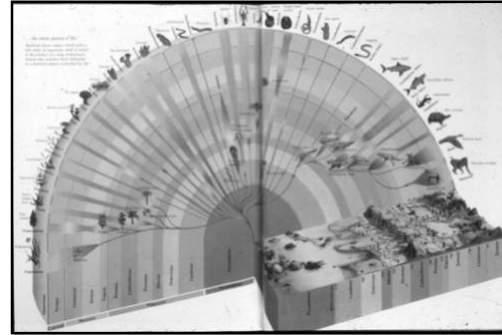
Historical Biogeography

- plants and animals inhabiting the changing environmental setting are not constant either
- flora and fauna comprising the vegetation biomes change over time, often in response to the “geological evolution”



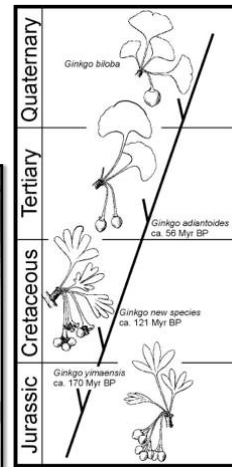
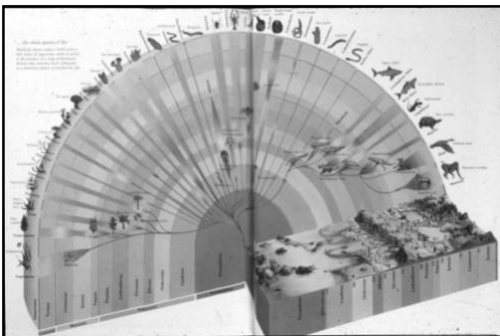
Historical Biogeography

- New species arise in a given area by immigration or from pre-existing species
- species accumulate variation, adapt, and further diversify



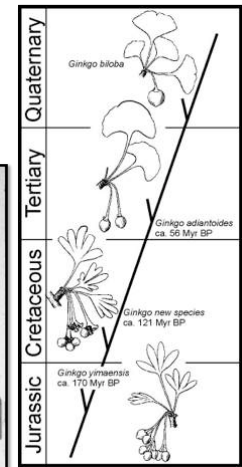
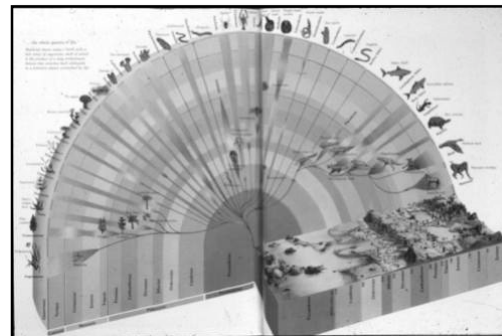
Historical Biogeography

- species go extinct and are replaced by other perhaps more adapted species
- the same holds true for larger lineages (genera, families) — or taxa or clades



Historical Biogeography

- This biological evolution (taxa or clade evolution) is thus a second important component of the “historical setting” or historical biogeography

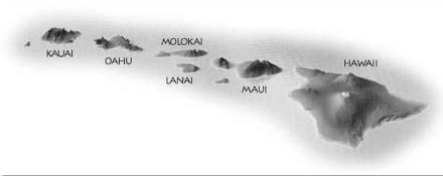


Historical Biogeography



Example: *Argyroxiphium sandwicense*

- interplay of geological and biological evolution is critical in understanding why the Haleakala silversword is found in Maui
- when and where it or its ancestors came from
- why it is has its morphology, chromosomes, and physiology.



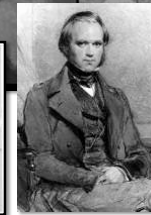
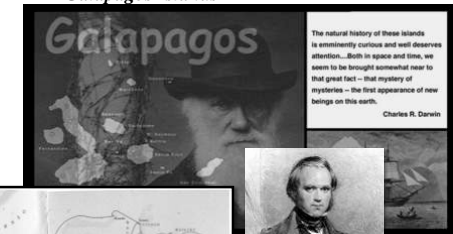
Evolution & Biogeography

Biogeography is central to the development of evolutionary theory. The extensive travels of Darwin and Wallace gave important examples of biogeographical distributions, associated variation, and evidence of evolutionary change

Charles Darwin and his travels in the Galapagos Islands



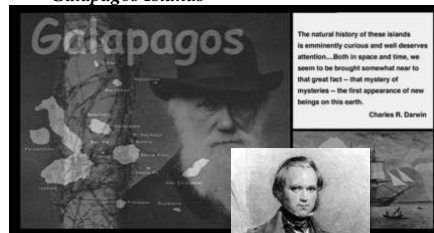
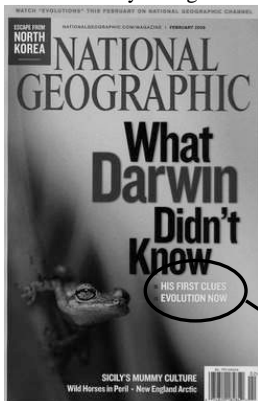
Alfred Wallace and his travels in the Malay archipelago



Evolution & Biogeography

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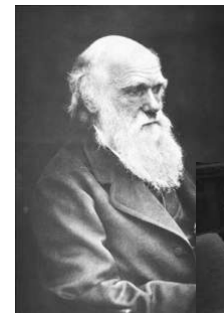
Charles Darwin and his travels in the Galapagos Islands



... were biogeographical!

Evolution & Biogeography

These biogeographical based examples played a pivotal role in the formulation of both Darwin's and Wallace's evolutionary theories jointly presented in 1858 in London and culminating in the publication of the *Origin of Species* in 1859.



Charles Darwin

Two points about this book

Darwin himself never uses the word "evolution" in *Origin of Species*.

He calls the process

"descent with modification".



Darwin devoted two chapters to biogeography in the *Origin of Species*: Chapter 11 - Geographical Distribution; Chapter 12 - Geographical Distribution *continued*

Origin of Species

Evolution

What is it? a definition:

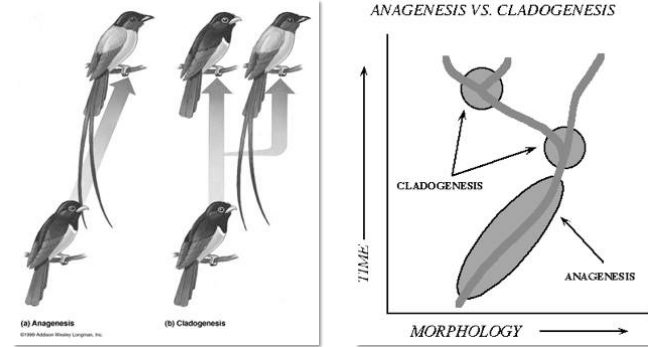
The change of genetic materials (DNA, genes, chromosomes = Genotype), and thus also of the physical appearance (morphology, physiology = Phenotype), within and among populations and species through time.

Evolution

What is it? Evolution is often separated into:

anagenesis - evolution within a species lineage — modification (Darwin's term)

cladogenesis - evolution to form new species lineages or **speciation** — descent



Evolution

What does it predict? A tree of life!

The affinities of all the beings of the same class have sometimes been represented by a **great tree** . . . As **buds** give rise by growth to fresh buds, and these if vigorous, **branch** out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great **Tree of Life**, which fills with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications.

Charles Darwin, 1859



Evidence for Evolution

Biogeography and Comparative Biology — homology vs. analogy

Our discussion of *Vegetation vs. Flora* has already provided numerous examples of unrelated organisms showing **convergent (analogous)** features as responses to similar environmental pressures

Similar body shapes and structures have evolved in the North American desert cacti . . .

and separately in the euphorbias in southern African deserts

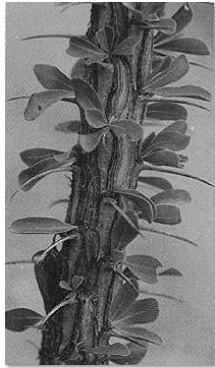


Evidence for Evolution

Biogeography and Comparative Biology — homology vs. analogy

Convergent structures in the ocotillo (left) from the North American deserts . . .

and in the allaudia (right) from Madagascar.



Fouquieria - Fouquieriaceae

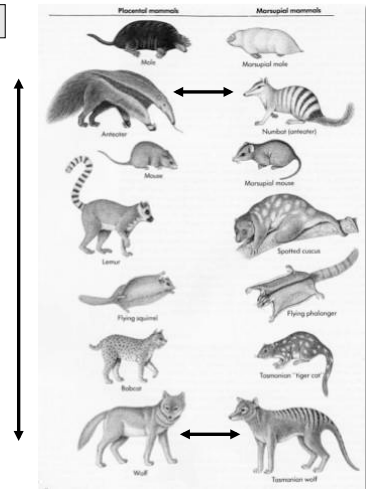


Allaudia - Didieriaceae

Evidence for Evolution

Biogeography and Comparative Biology

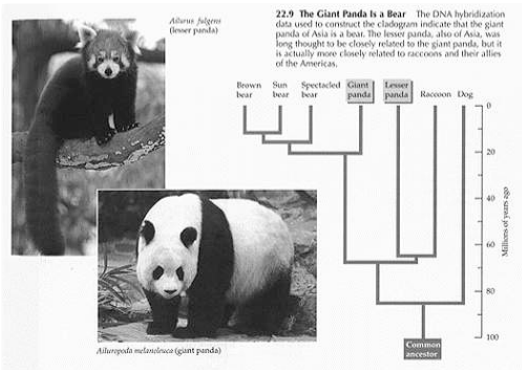
The convergence of mammals (marsupials) in Australia vs. the placental mammals elsewhere in the world is one of the most spectacular examples of biogeographical based **convergences** in animals as well as **divergences** within each lineage



Evidence for Evolution

Molecular "fossil" record — phylogenetic trees

The use of DNA to produce (estimate) phylogenetic relationships among organisms has revolutionized our understanding of character evolution

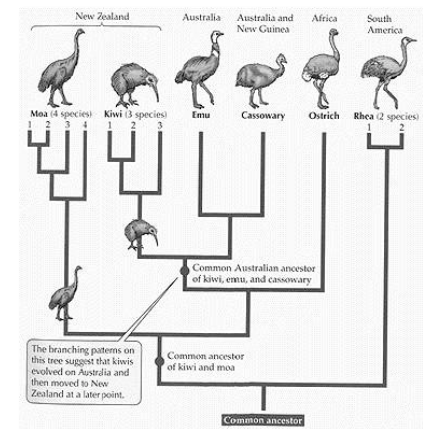


Evidence for Evolution

Molecular "fossil" record — phylogenetic trees

The use of DNA to estimate phylogenetic relationships among organisms has also revolutionized biogeography

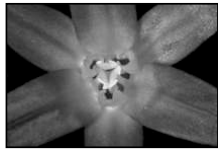
Phylogenetic trees not only provide strong hypotheses of biological relationships but they can also give estimates of relationships of the areas which the taxa occupy



Evidence for Evolution

Molecular "fossil" record — phylogenetic trees

The *Brodiaea* complex (Themidaceae) in California and Madrean Region of SW N. Amer.



Brodiaea terrestris



Bessera elegans

(Pires and Sytsma 2002)



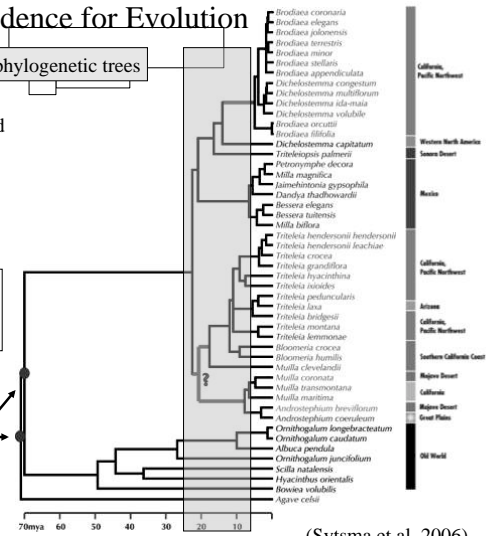
Evidence for Evolution

Molecular "fossil" record — phylogenetic trees

Chronogram of Themidaceae and Hyacinthaceae

• origins of California Floristic Province lineages (2 or 3) are Miocene

Fossil fixed ages of 71.5 and 70.5 mya



(Sytsma et al. 2006)