Darwin's Finches and the Origin of *Sub*species

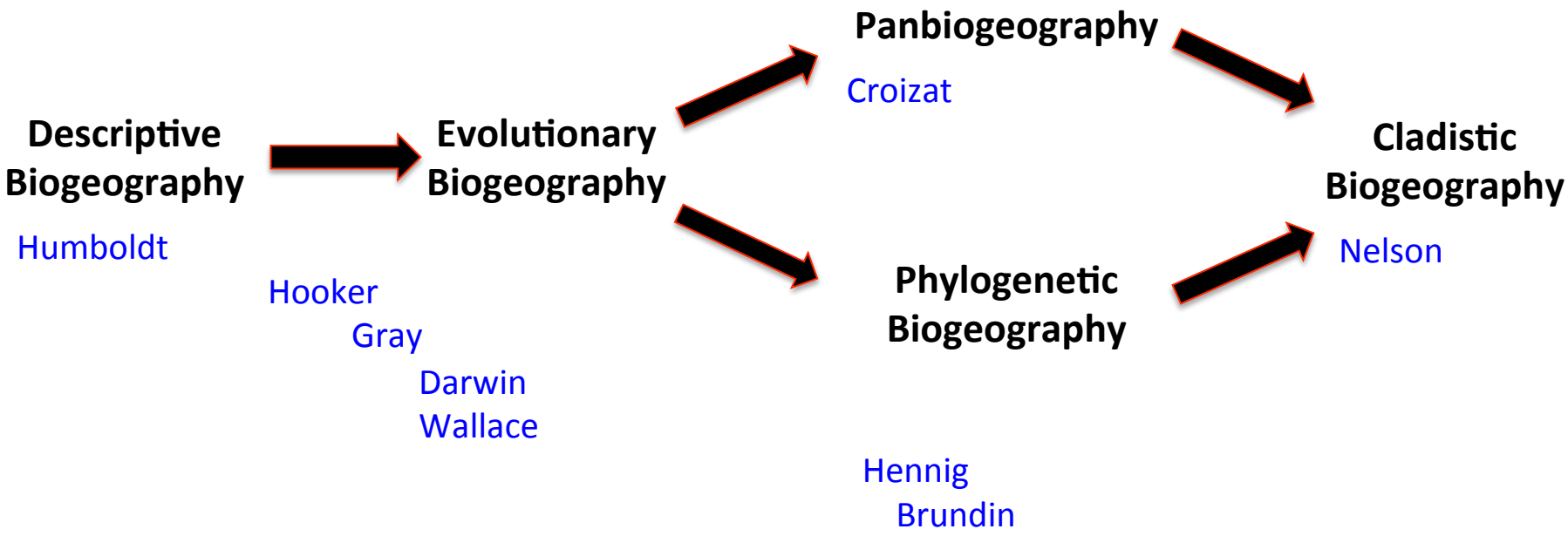
Reading: David Lack

A Revolution in Biogeographical Methods

Lecture 14 Recap

Gareth Nelson

A Revolution in Biogeographical Methods



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A Revolution in Biogeographical Methods

- **Dispersal vs. vicariance models**

- *Dispersal* models explain disjunctions by dispersal across pre-existing barriers

- *Vicariance* models explain disjunctions by the appearance of barriers fragmenting the ranges of ancestral species

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A Revolution in Biogeographical Methods

- **Popper's Criterion**

- Scientific explanations differ from non-scientific ones only be virtue of their falsifiability

- We must be able to test and potentially reject any explanation that is to be considered scientific

William of Ockham

A Revolution in Biogeographical Methods

- **Ockham's (Occam) Razor**

- *Among competing hypotheses, the one with the fewest assumptions should be selected.*

- This leads us to the idea of parsimony

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- *Parsimony*

- Methodological rule that requires us to minimize the number of parallel dispersals

- For examples that require much parallel dispersal, we must abandon the dispersal hypothesis in favor of a vicariance hypothesis

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A Revolution in Biogeographical Methods

- The cladistic method of biogeography is the most rigorous, but this model of dispersal followed by a model of vicariance cannot explain all distributions

- …but, we have a better chance of understanding biogeographical patterns when we have a phylogeny because it allows us to select a method that works best for the group

Diversification – *or* – Why are there so many species?

- One of the most fundamental questions in biology…

Why are there so many species?

Diversification – *or* – Why are there so many species?

- One of the most fundamental questions in biology…

How, when, and under what circumstances does species proliferation take place?

Alexander von Humboldt

Diversification – *or* – Why are there so many species?

Plant Associations

High → **Low**

Boreal Forest — **Tropical Forest**

Diversification – *or* – Why are there so many species?

- *"The diversity of organisms which live in a given territory is a function of the variety of available habitats. The richer and more diversified the environment becomes, the greater should be the multiformity of the inhabitants. And vice versa: diversity of the inhabitants signifies that the environment is rich in adaptive opportunities."*

-Dobzhansky

Diversification – *or* – Why are there so many species?

- Much of the diversification literature documents patterns of diversity across space

- Treats geography as playing an integral role in the evolution in biological diversity

- Even in cases where speciation occurs in the same area, highly localized geographic circumstances are often said to play a role

Diversification – *or* – Why are there so many species?

- What is *diversification*?

- Increase in species richness within biological lineages through time

Diversification – *or* – Why are there so many species?

- Early biogeographers documented the distributions of organisms, and began to assess diversity be the assigning of ‘types’, or variation due to error

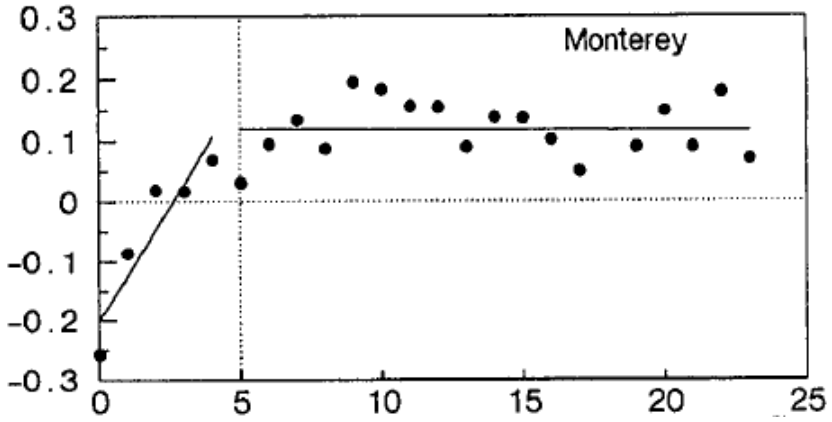
- By the turn of the 20th century the prevailing view of diversification had begun to change with the idea of what constitutes a species

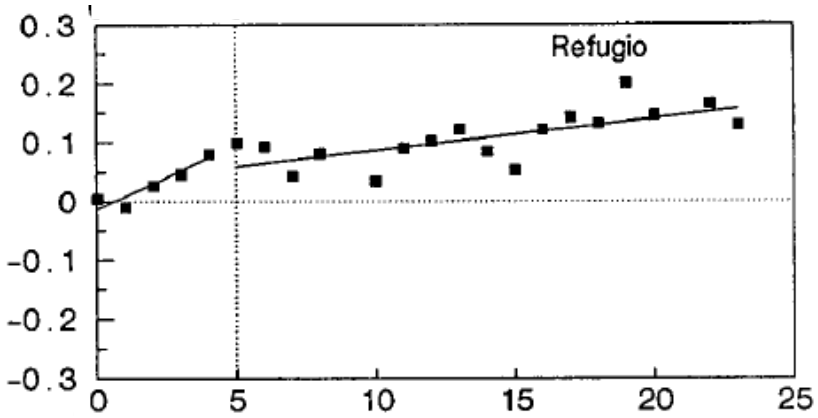
Diversification – *or* – Why are there so many species?

- There was a gradual acceptance of geographical variants of a species as different *subspecies*

- or *ecotypes* – adapted to living in different ecological stations due to changes in environment

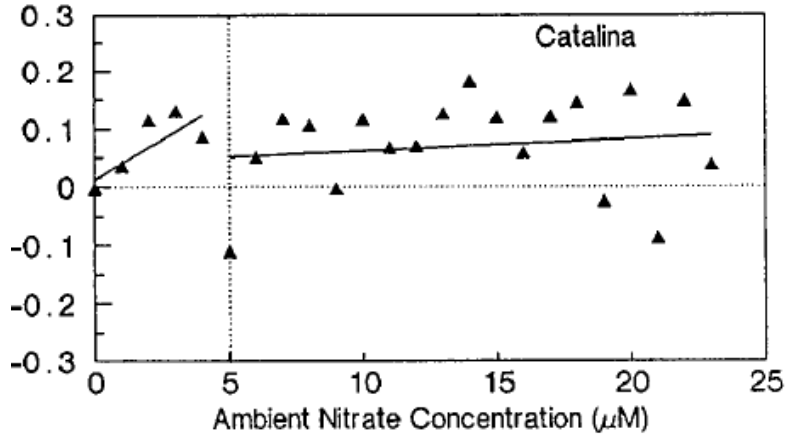
Diversification – *or* – Why are there so many species?





Growth rate for 3 populations of giant kelp across external nitrate concentrations

(Kopczak et al. 1991)



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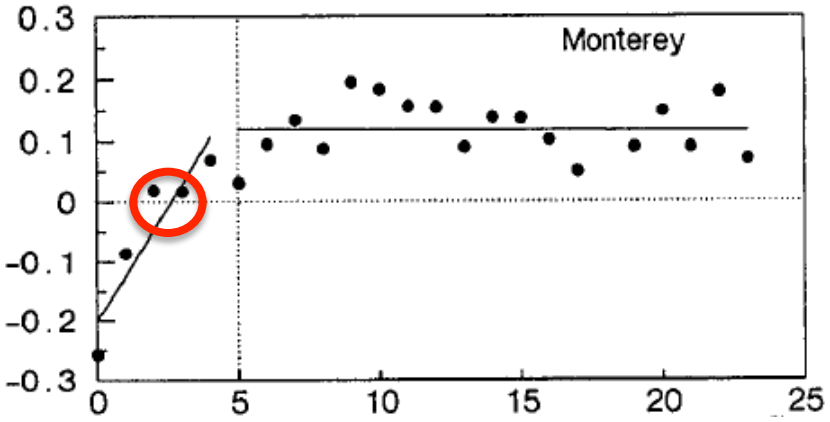

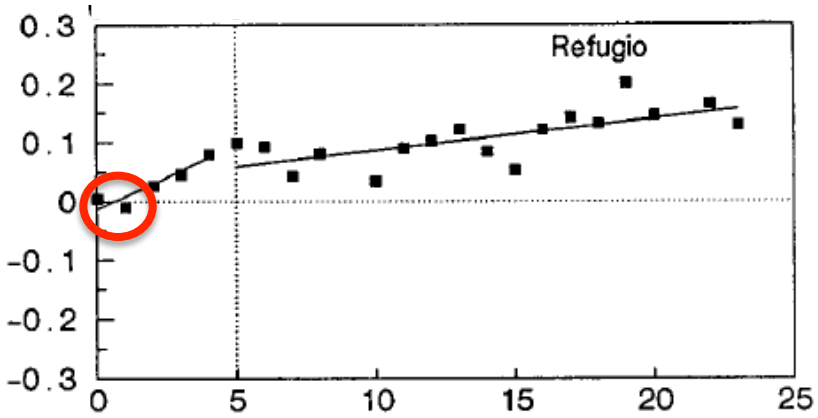

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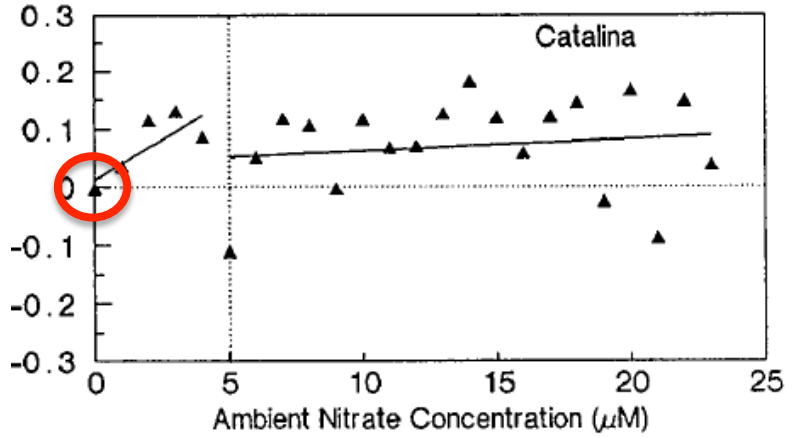

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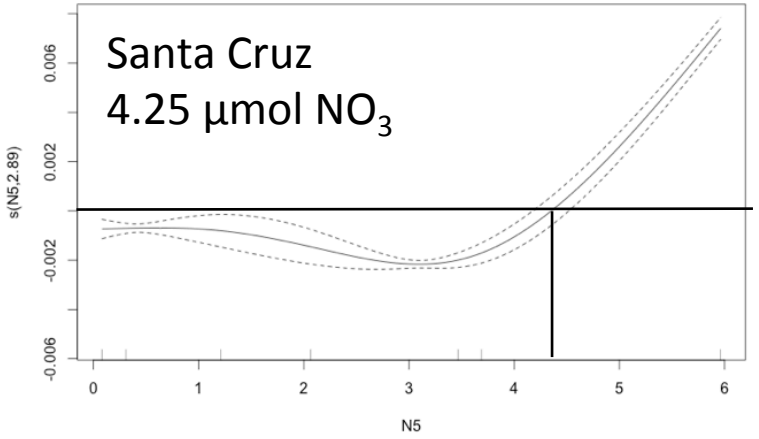
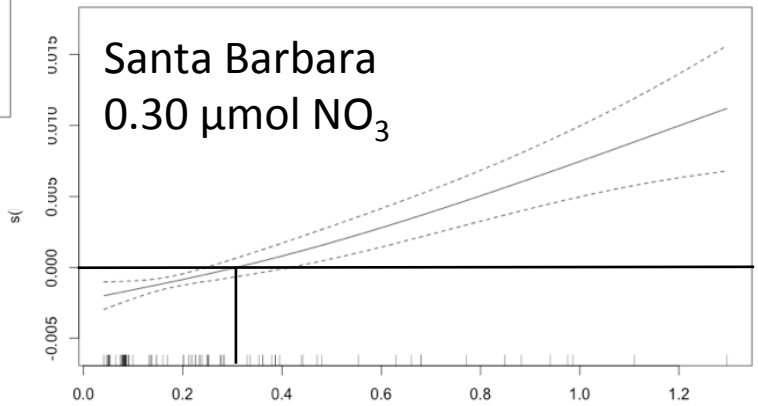
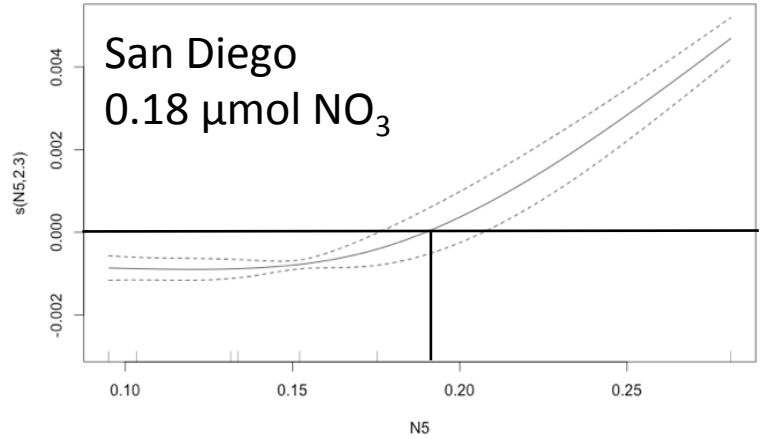




Growth compensation quota for 3 populations of giant kelp



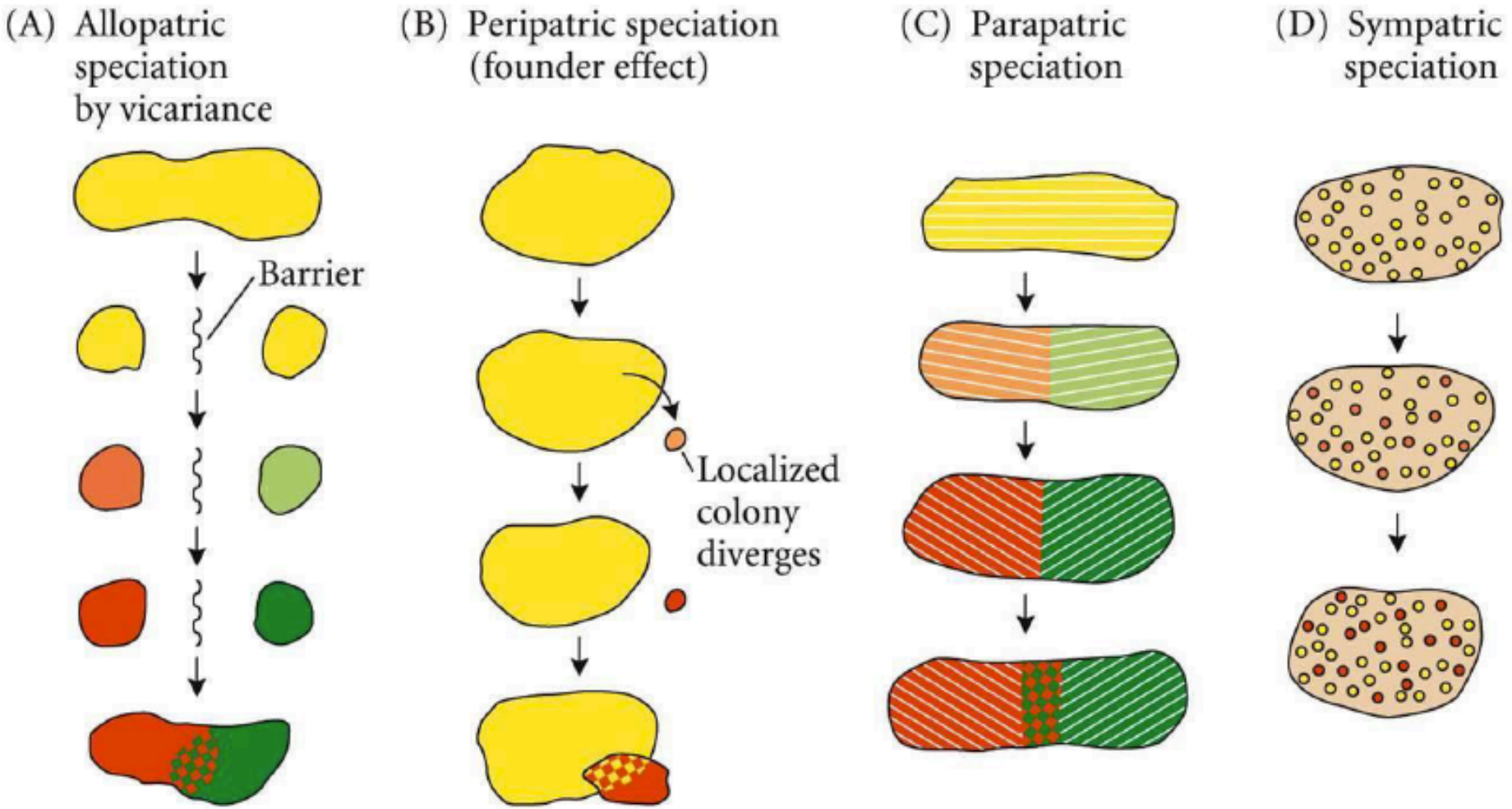
Diversification – *or* – Why are there so many species?

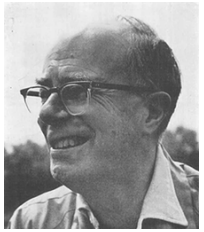
- **Biological species concept**

- *"(Populations) …have risen to species rank (that) have become so different from each other physiologically that they… can come together again without interbreeding."*

-Ernst Mayr

Diversification – *or* – Why are there so many species?





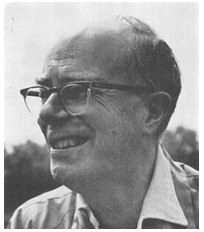
David Lack

Diversification – *or* – Why are there so many species?

- *Darwin's Finches*

- First to focus on the evolution of diversity in a limited group of organisms that combined systematic, behavioral, and ecological perspectives

- *"forms differentiated in geographical isolation have later met and kept distinct."*



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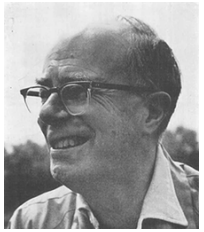
Diversification – *or* – Why are there so many species?

- During the war of 1812, Captain Porter of the U.S. frigate *Essex* was resupplying his food supply with Galapagos tortoises and noticed that tortoises from different islands had difference appearances

- This observation was mentioned to Darwin 20 years later when Darwin visited the islands as the naturalist on the *Beagle* (these forms extended to mockingbirds, plants, and of course finches).



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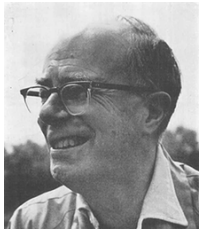
Diversification – *or* – Why are there so many species?

- *"How has it happened in the several islands situated within sight of each other, having the same geological nature, the same height, climate, etc., that many of the immigrants should have been differently modified, though only in a small degree. This long appeared to me a great difficulty: but it arises in chief part from the deeply-seated error of considering the physical conditions of a country as the most important for its inhabitants; whereas it cannot be disputed that the nature of the other inhabitants with which each has to compete, is at least as important, and generally a far more important element of success…"*

  - Charles Darwin



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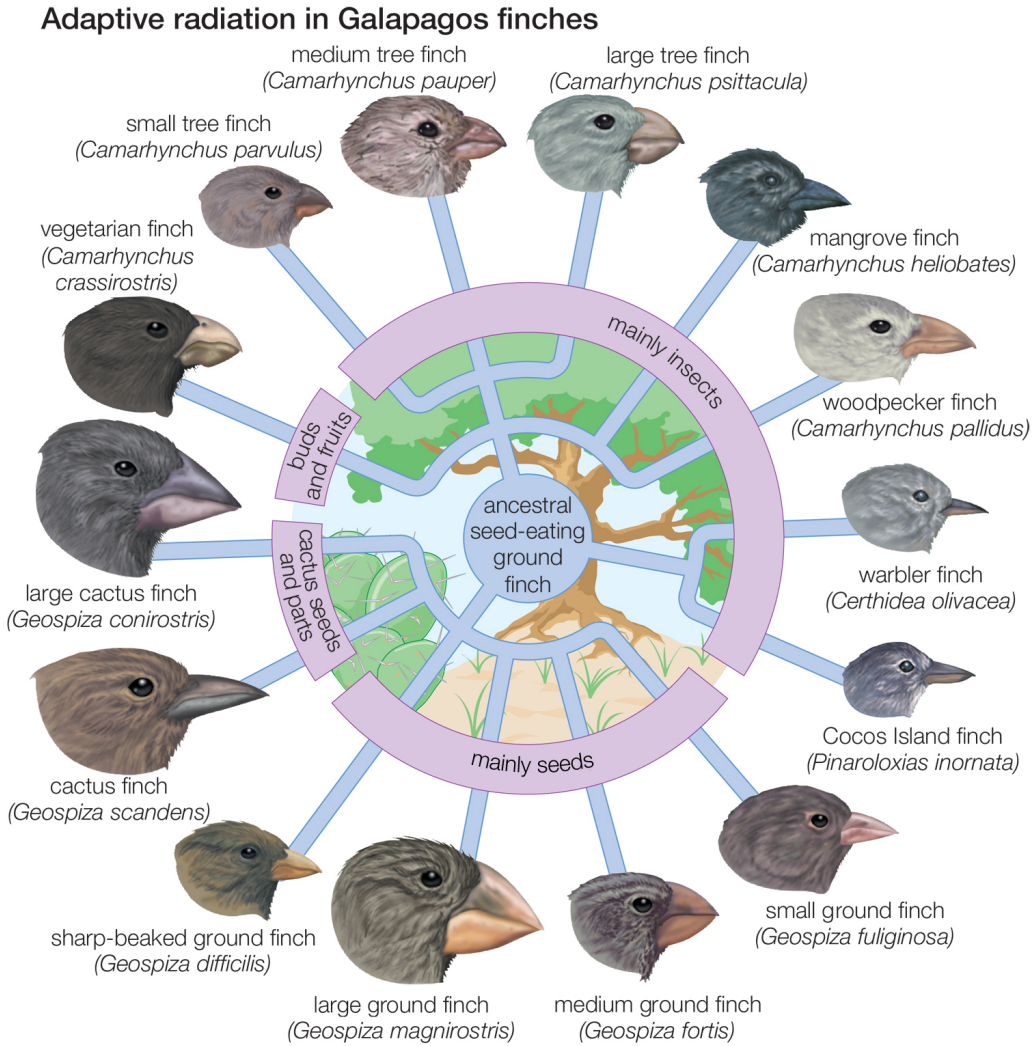
Diversification – *or* – Why are there so many species?



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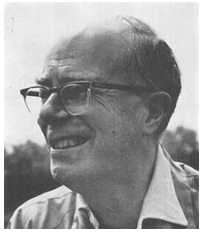

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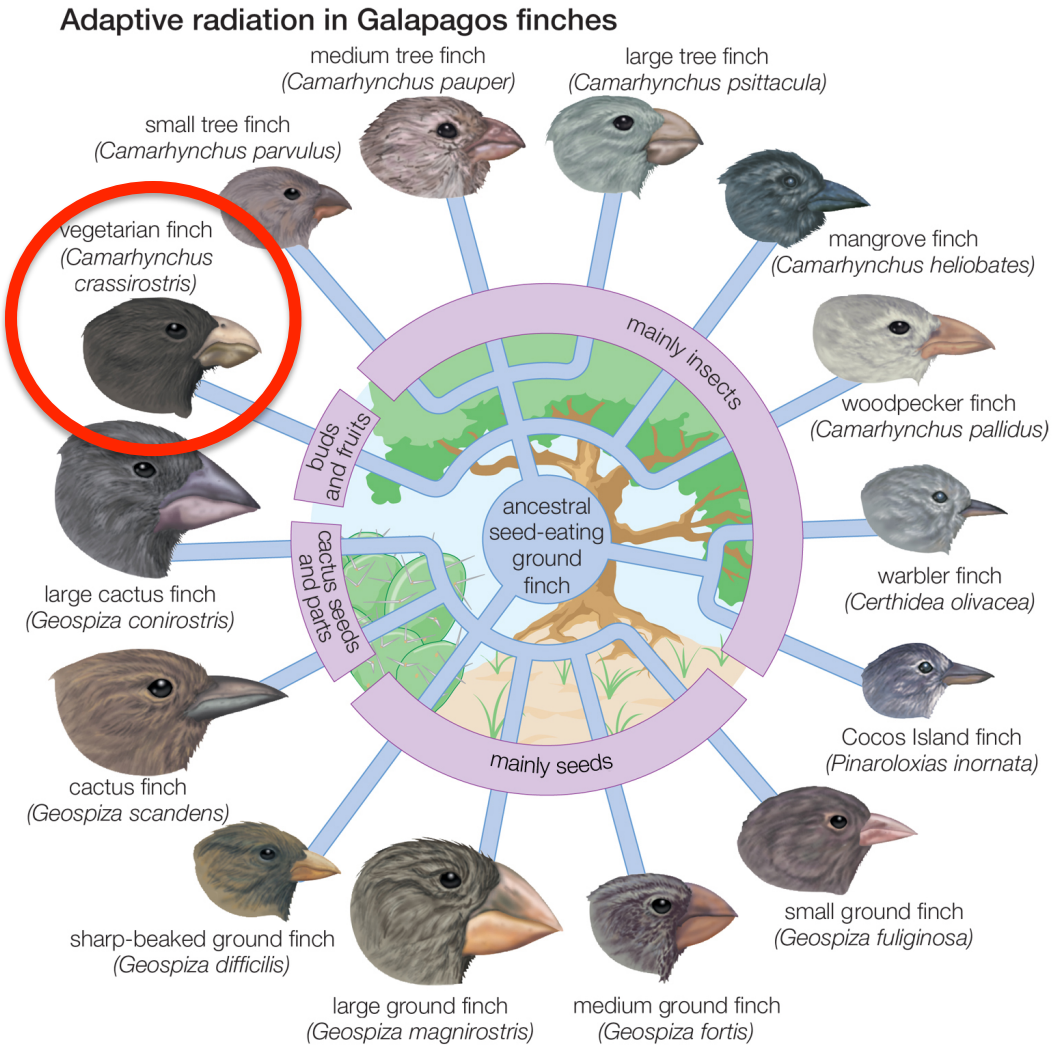
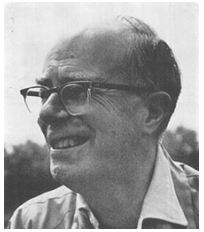
Diversification – *or* – Why are there so many species?

"Thus in the vegetarian tree finch …the birds from different islands show few, if any, differences in either plumage, beak, or size."





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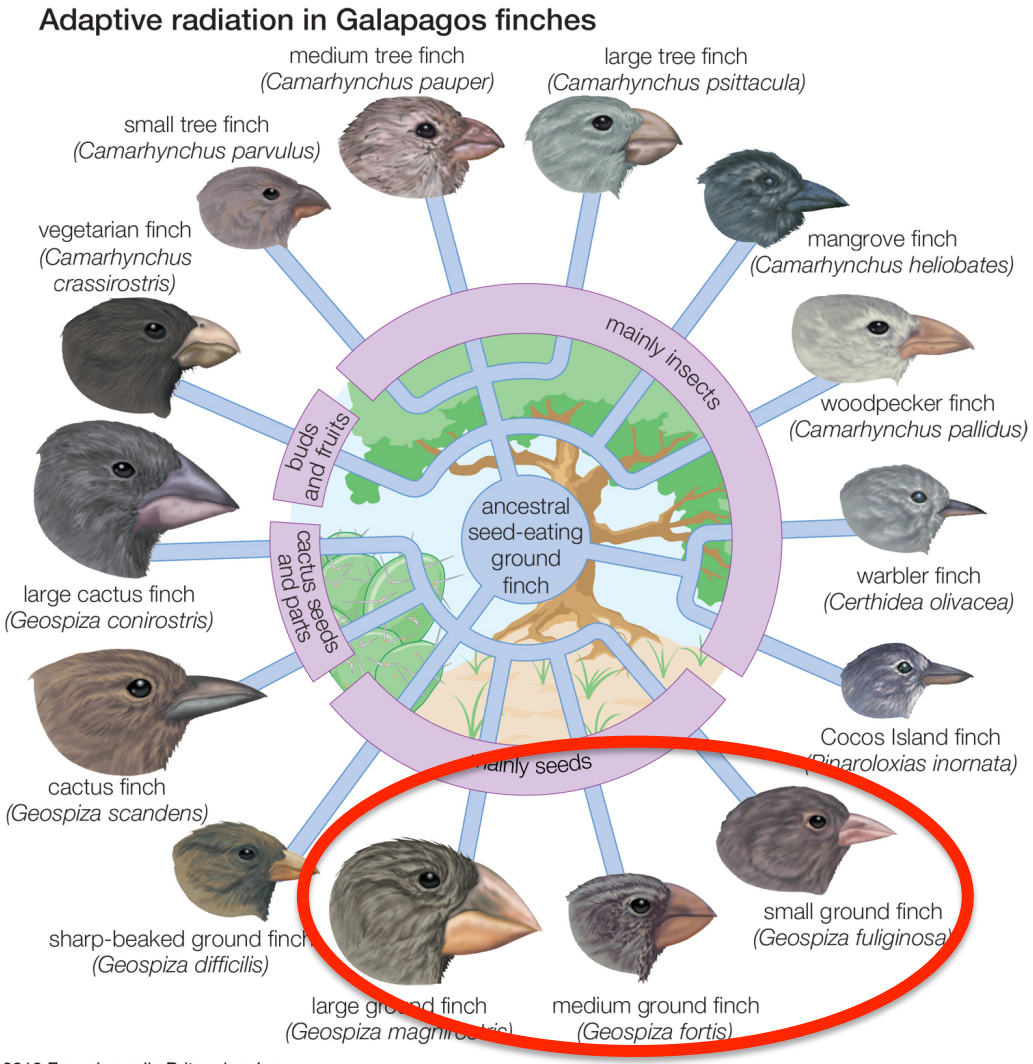
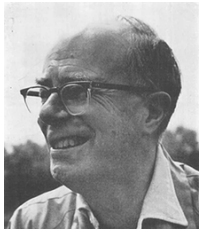
Diversification – *or* – Why are there so many species?

"…the three ground finches… show no differences in plumage on different islands; but they differ fairly markedly in the average size of beak and wing."





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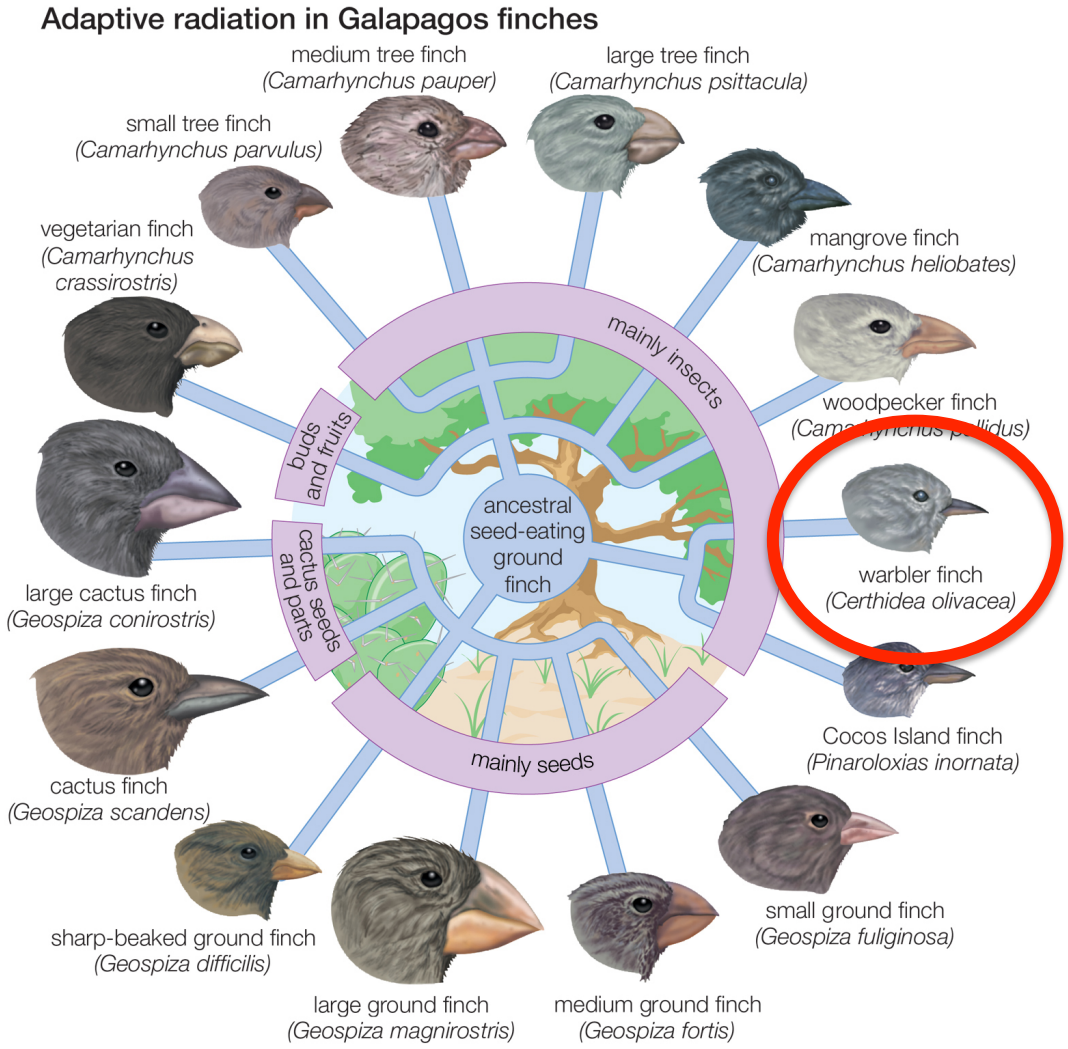
Diversification – *or* – Why are there so many species?

"…the warbler finch… in which the island forms differ markedly in color of plumage, but less obviously in size of beak and wing."



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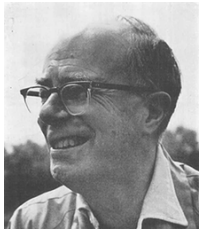

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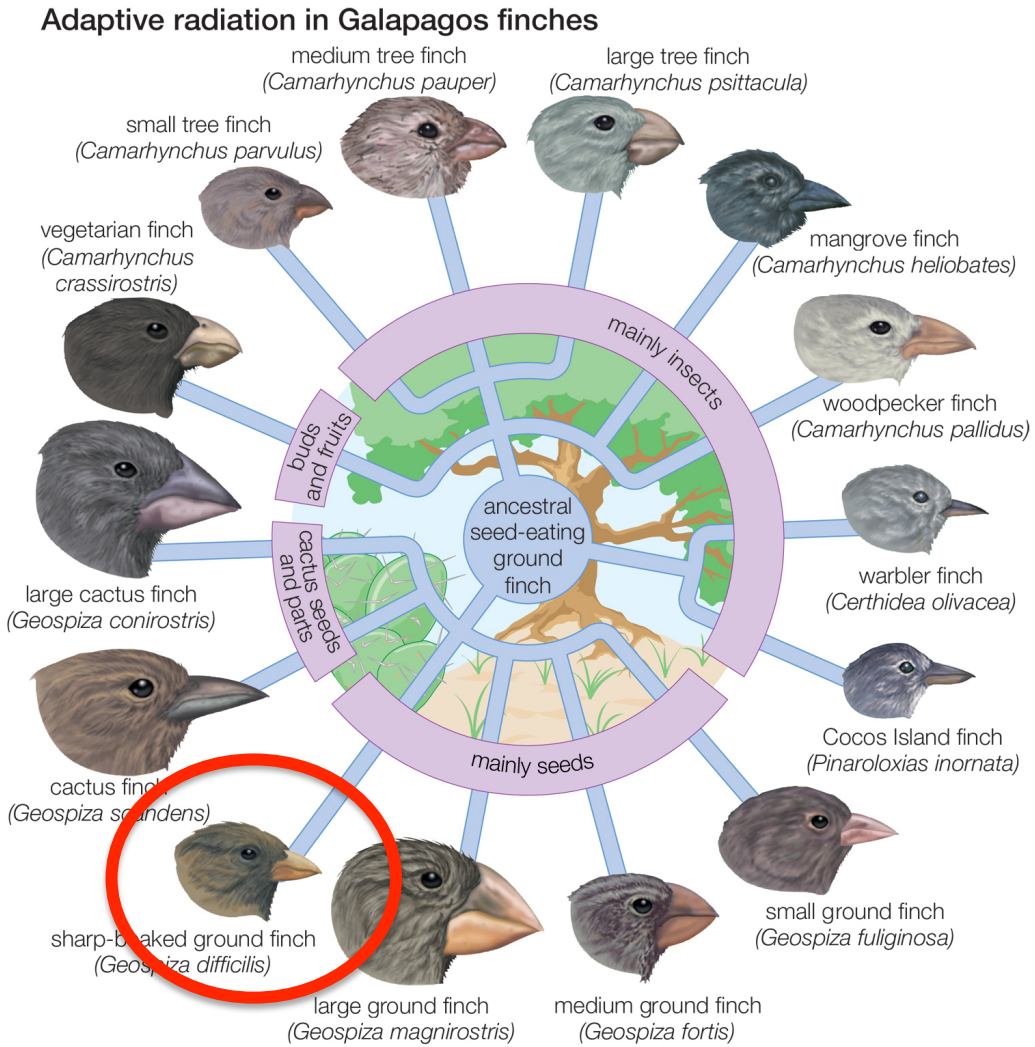
Diversification – *or* – Why are there so many species?

"…the sharp-beaked ground finch… in which there are three clearly defined subspecies differing from each other in plumage, beak, wing-length and ecological niche."



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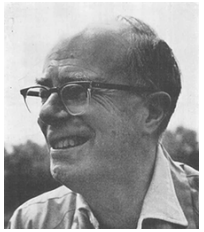

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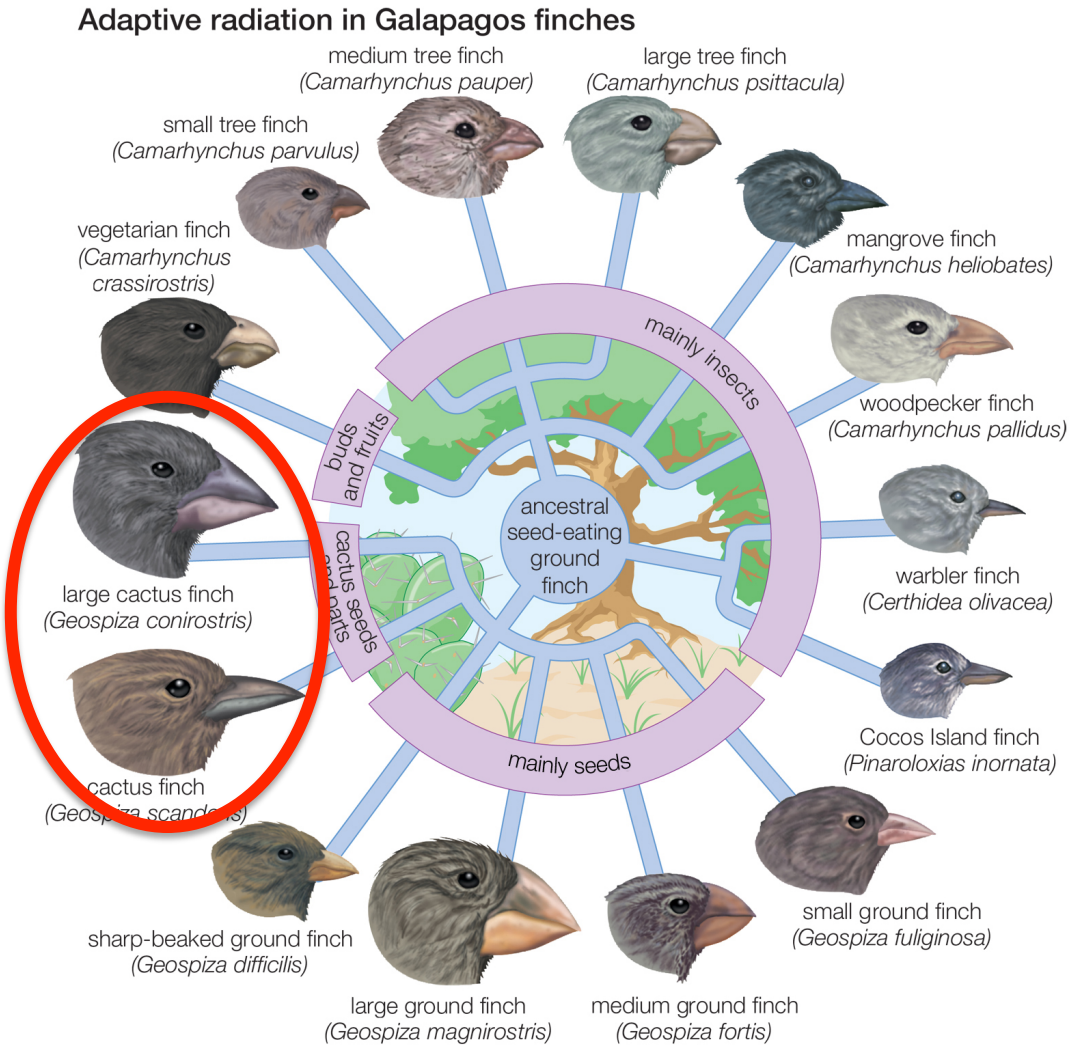
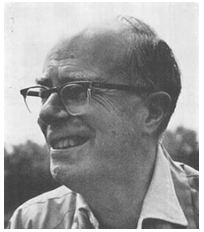
Diversification – *or* – Why are there so many species?

"…the large cactus ground finch differs so markedly from (the cactus finch) that, though the two forms replace each other geographically, it is doubtful whether they represent pronounced geographical forms of the same original species..."





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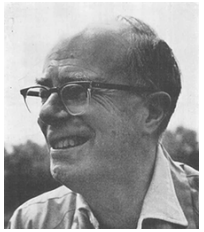
Diversification – *or* – Why are there so many species?

- How did so many finch species come to be on this small, isolated archipelago?



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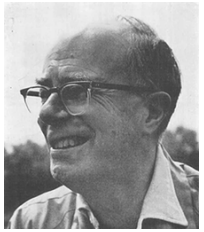
Diversification – *or* – Why are there so many species?

- *"…the most isolated islands, namely Cocos, Culpepper, Wenman, Tower and Hood, have a much higher proportion of peculiar forms than have the central Galapagos islands, while on moderately isolated islands, …, there is an intermediate condition, with proportionately fewer endemic forms than on the remote islands, but proportionally more than on the central islands."*



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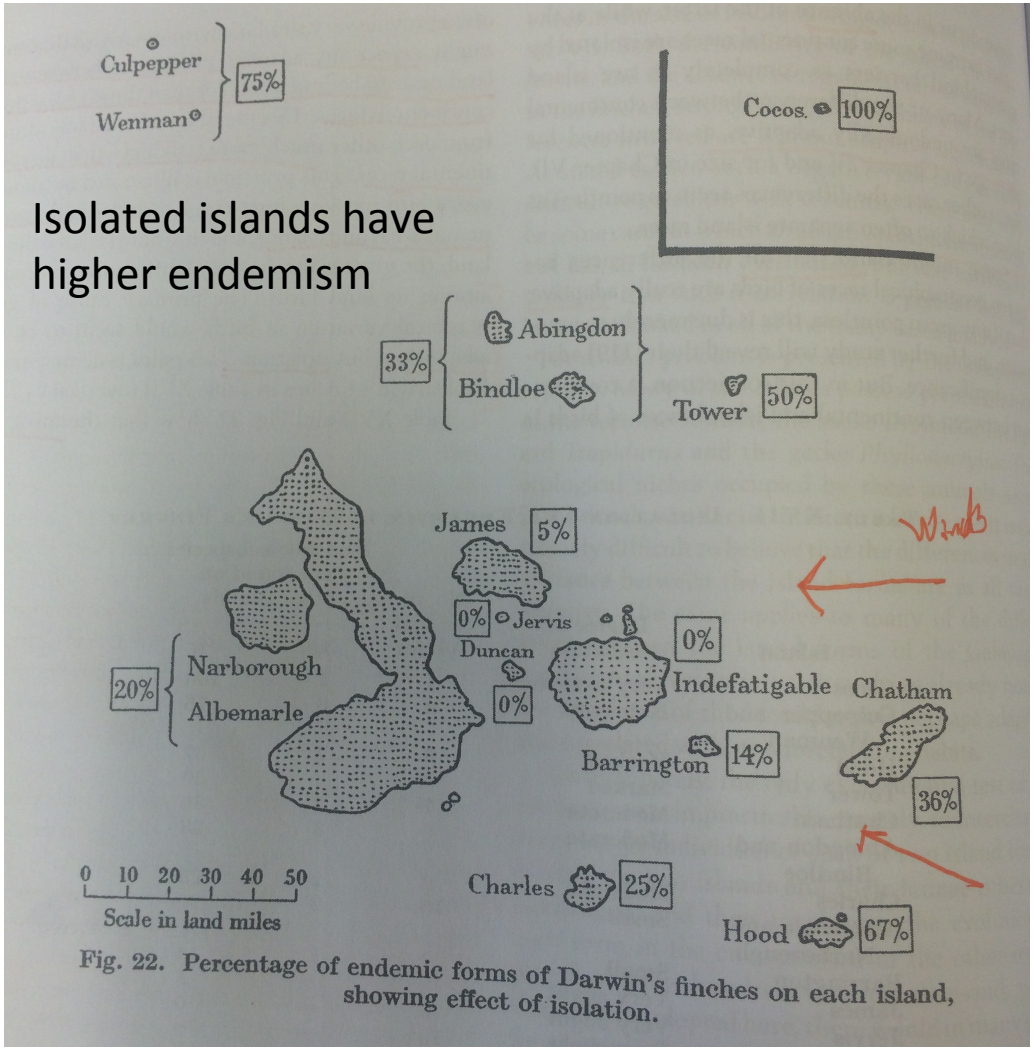
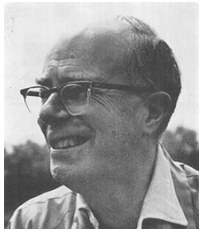


Fig. 22. Percentage of endemic forms of Darwin's finches on each island, showing effect of isolation.



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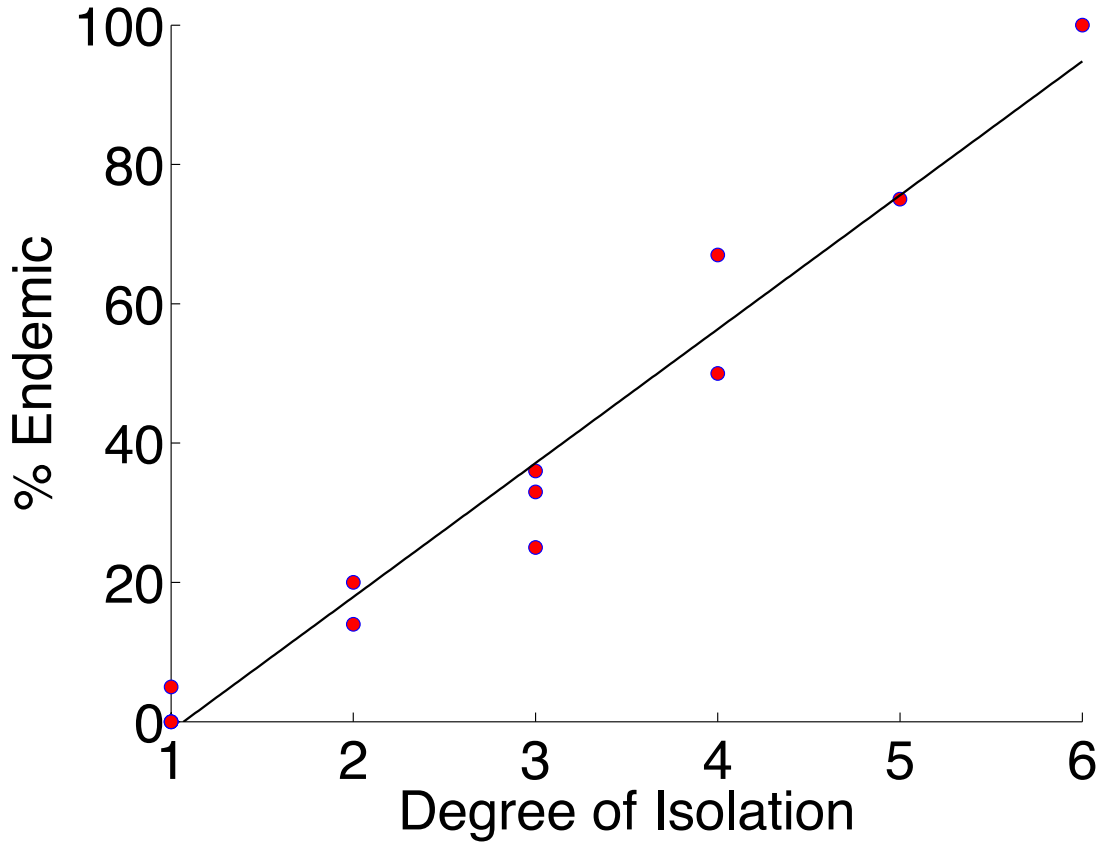

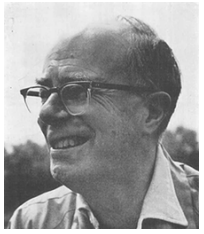

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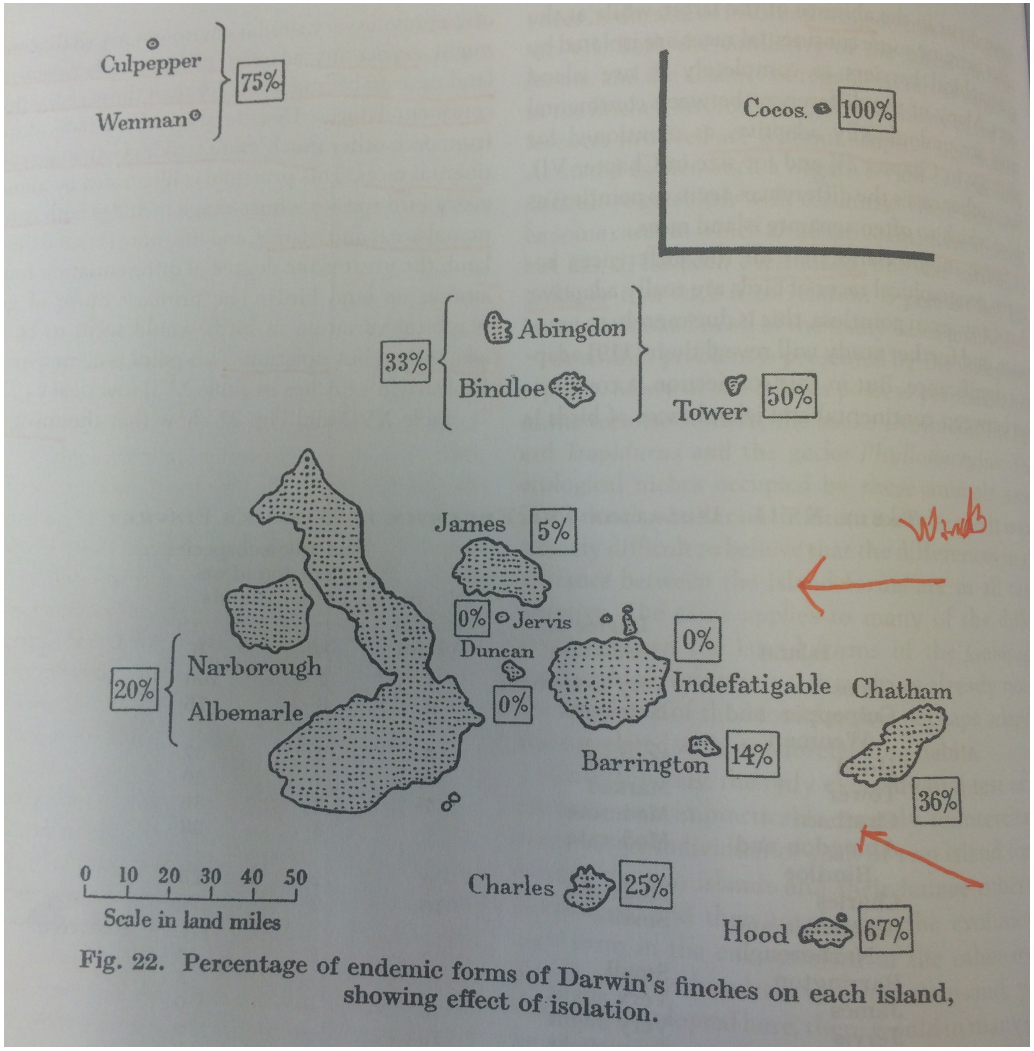
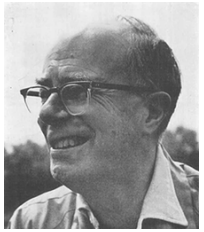


Fig. 22. Percentage of endemic forms of Darwin's finches on each island, showing effect of isolation.

Trade winds blow from east to west and islands to the east have higher proportional endemism, as it would inhibit migration.



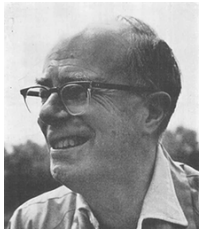
David Lack

Diversification – *or* – Why are there so many species?

- *"Big evolutionary changes are normally achieved in a series of small steps…"*

- Example of the insectivorous tree finch (*Camarhynchus)* on Charles

- The island has 2 species of tree finch, *C. psittacula* and *C. pauper*



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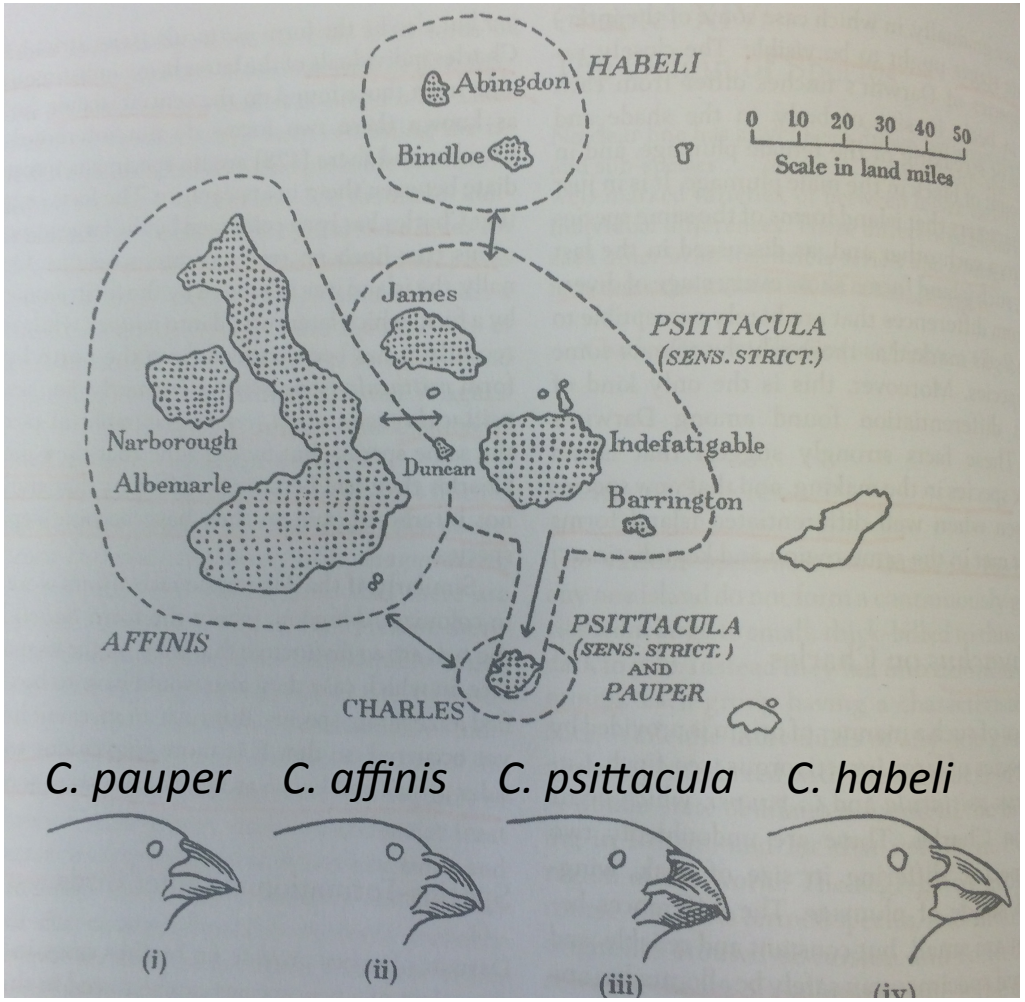
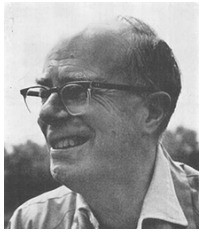




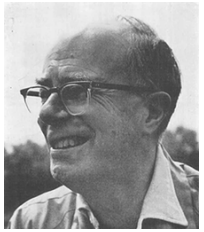
David Lack

Diversification – *or* – Why are there so many species?

- If *C. psittacula* did not occur on Charles, than all of the tree finches could be included in one species

- *C. pauper* appears to be the most primitive, streaked and with a finch-like beak

- *C. affinis* shows a close resemblance to *C. pauper* in both plumage and beak



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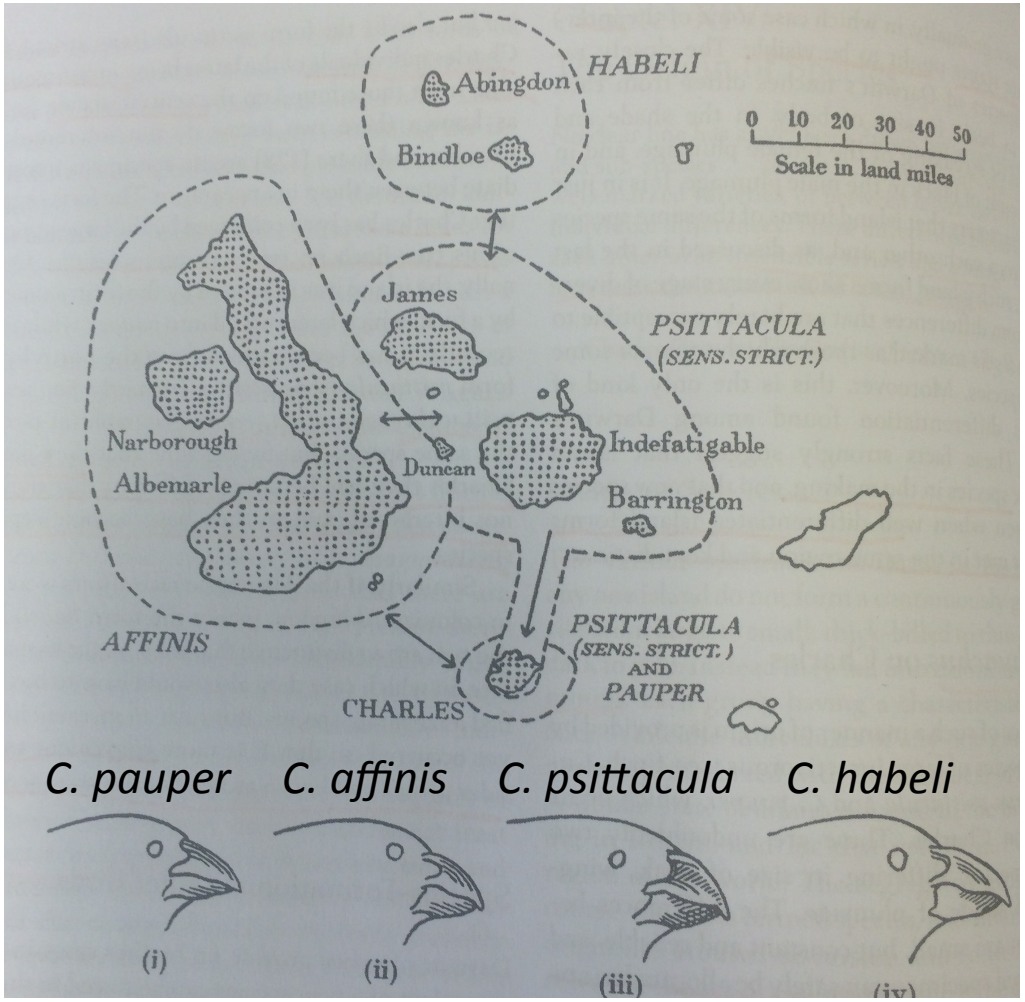

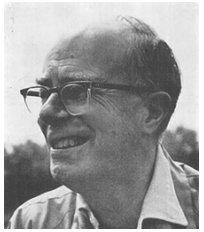

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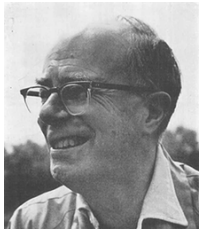
Diversification – *or* – Why are there so many species?

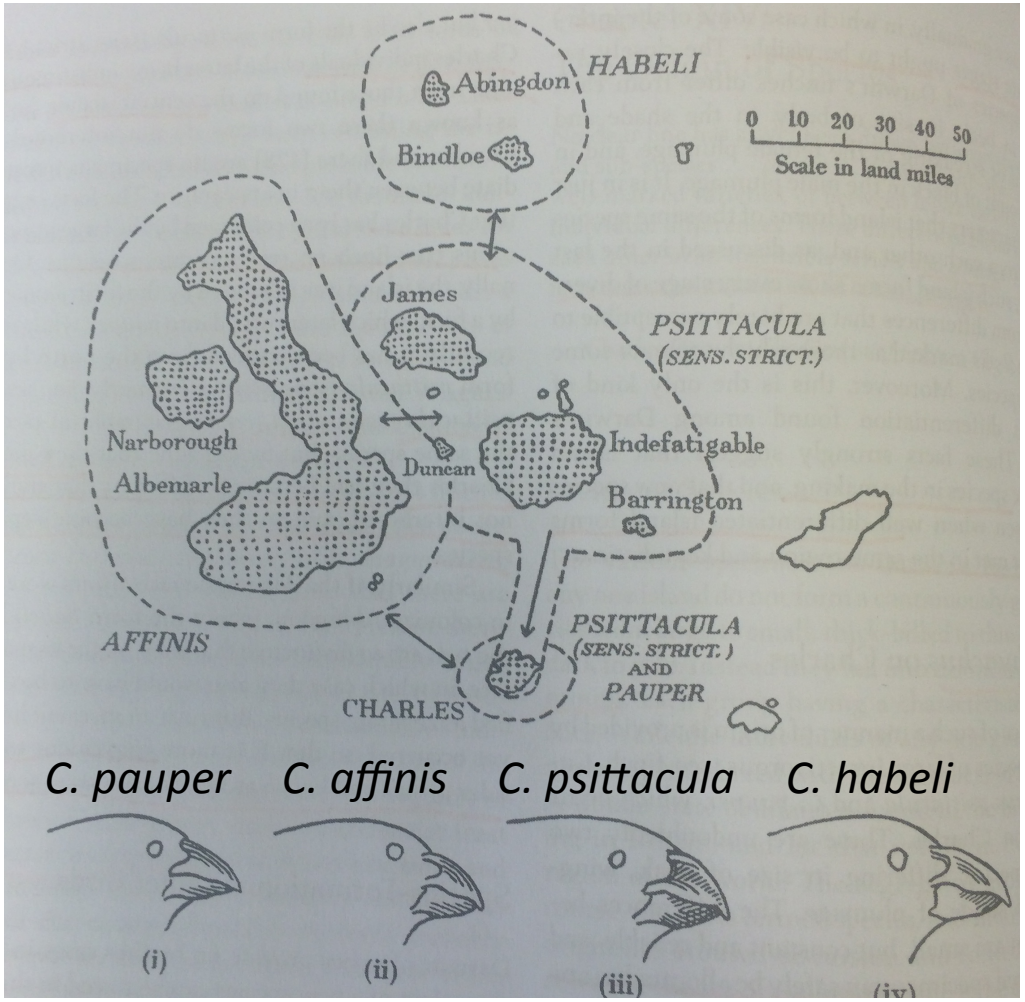
- *C. psittacula* is less streaked, larger and with a more parrot-shaped beak, but links with *C. affinis* through an intermediate population on the island Duncan

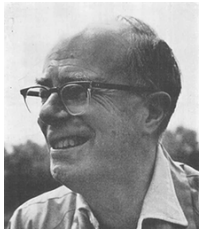
- The northern form *C. habeli* shows the most resemblance to *C. psittacula*



David Lack

Diversification – *or* – Why are there so many species?

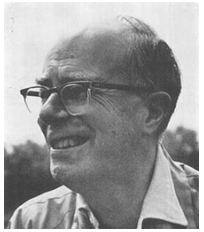




David Lack

Diversification – *or* – Why are there so many species?

- *The only type of incipient differentiation found in Darwin's finches is that shown by geographical races, and there is nothing to suggest that geographic isolation is not the essential preliminary to species-formation in this group."*



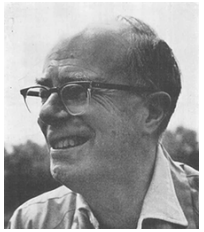
David Lack

Diversification – *or* – Why are there so many species?

Main Points

- Diversification is the increase in species richness within biological lineages through time
- *Biological species concept* and *types of speciation*
- Increasing endemism with increasing isolation
- Repeated geographic isolation and adaptation leading to differentiation in the finches
- *"forms differentiated in geographical isolation have later met and kept distinct."*

Questions on the reading?



David Lack

Discussion Point

- *"Natural selection will always act according to the nature of the places which are either unoccupied or not perfectly occupied by other beings; and this will depend on infinitely complex relations. But as a general rule, the more diversified in structure the descendants from any one species can be rendered, the more places they will be enabled to seize on, and the more their modified progeny will be increased."*

  - Charles Darwin