

Natural selection and adaptation (population thinking I)

On the Galápagos Islands, Darwin found *closely related species occupying very different ecological niches* - for example, the birds we now call "Darwin's finches". Later, while trying to make sense of such cases, he came up with the idea of evolution by natural selection.

The map shows the Galápagos Islands in the Pacific Ocean, west of South America. The phylogenetic tree illustrates the relationships between various finch species, including: Small ground finch, Medium ground finch, Large ground finch, Cactus ground finch, Large cactus ground finch, Sharp-shinned ground finch, Small insectivorous tree finch, Large insectivorous tree finch, Large insectivorous tree finch on Isla Fernandina, Woodpecker finch, Vegetarian tree finch, Gray warbler finch, and Olive warbler finch.

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Darwin's argument

A pregnant finch from mainland South America gets blown to the bird-free Galápagos by a storm.

Populations on different islands and in different habitats learn to eat different available (and largely underutilized) foods.

Selection adapts the populations to these niches, and they speciate.

The process:

1. Individuals vary in traits that affect their abilities to use different foods.
2. Some of this variation is heritable (i.e., offspring tend to resemble their parents) ...
3. ... and this variation affects survival and reproduction.
4. As a consequence, populations evolve to become better adapted to their local situations, diverge, and become different species.

Note that each of these steps in the process is independently testable!

Darwin's model in action: *G. fortis* on Isla Daphne Major

Geospiza fortis, the medium ground finch.

For nearly 40 years, the Grants and their colleagues have studied the population on Isla Daphne Major.

Peter Grant Rosemary Grant (when they were young)

The population averages about 1000 birds.

Most of them are known individually (i.e., banded).

Some live up to 16 years.

The map of Isla Daphne Major shows the Outer slope, Inner slope, Camp, and Boat landing.

Medium Ground Finches (*Geospiza fortis*)

male

female

Individuals vary in beak depth (and other aspects of size)

N = 751

all birds on Daphne Major in 1976

Number of finches

Beak depth (mm)

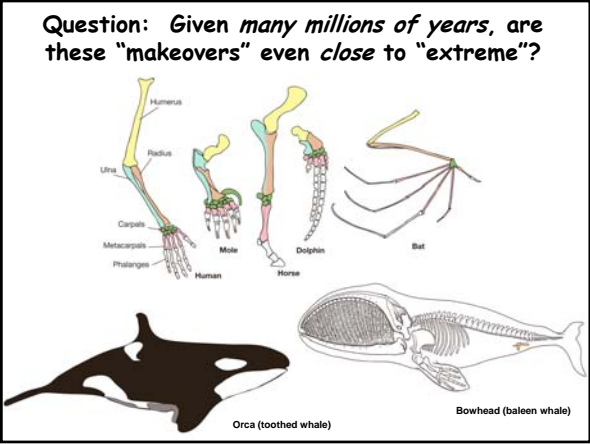
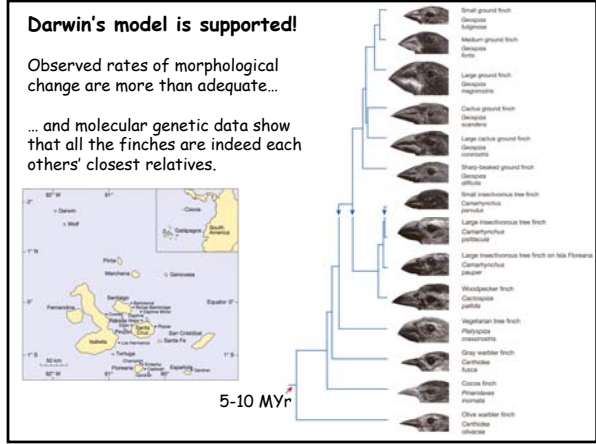
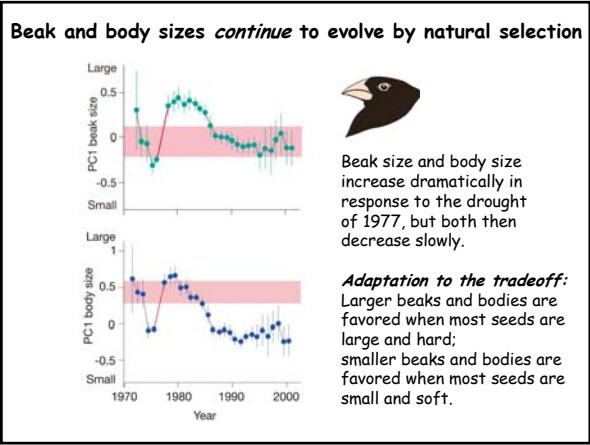
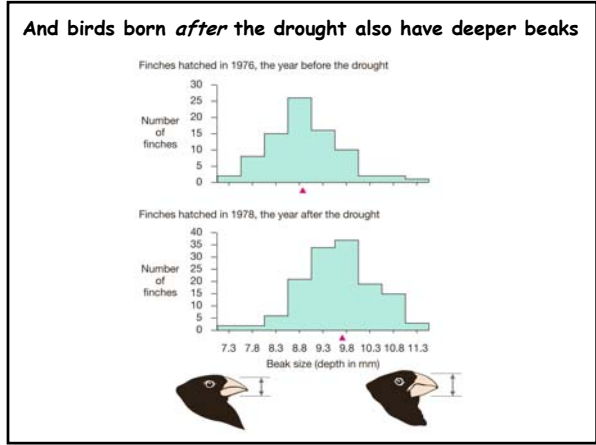
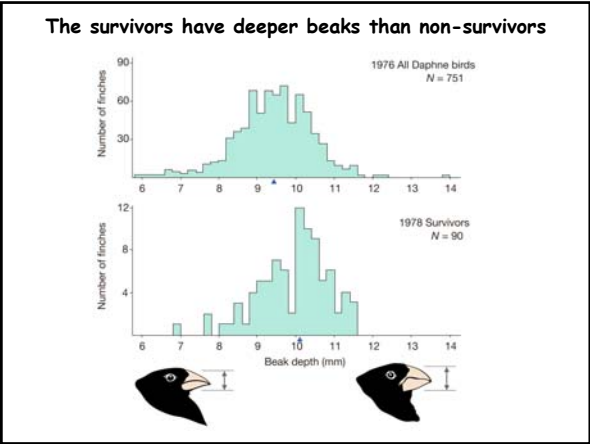
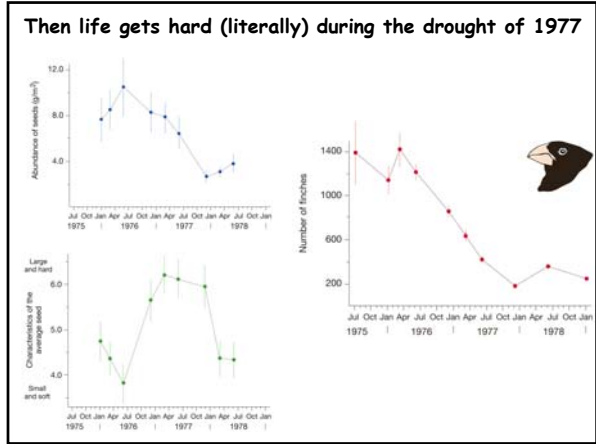
An ecologically mediated tradeoff:
Birds with thicker beaks can crack and eat larger, harder seeds, but birds with *thinner* beaks handle *smaller, softer* seeds more efficiently.

Much of this variation is heritable (offspring resemble parents)

Offspring beak depth (mm)

Midparent beak depth (mm)

• 1978
• 1976



Natural selection is widely misunderstood!

"Survival of the fittest" is a definition of fitness (and not a very good one).

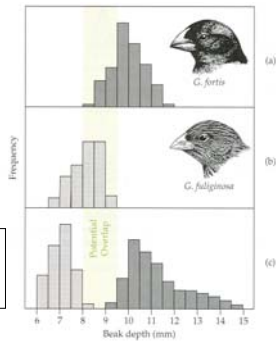
Yes it's tautological - it's a definition!

The substantive, non-circular claim is that *selection of heritable variation causes evolutionary adaptation.*

Selection favors individual fitness, not the good of the species.

And it is blindly "situational", not forward looking, and *not* progressive!

- (a) *G. fortis* on Daphne Major
- (b) *G. fuliginosa* on Los Hermanos
- (c) Both species on Santa Cruz



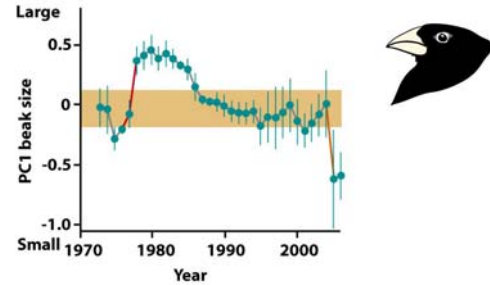
In the next big drought (2004), beaks evolve *downward* in size!

Why?

Now there are *large* ground finches (*Geospiza magnirostris*) on Daphne Major.

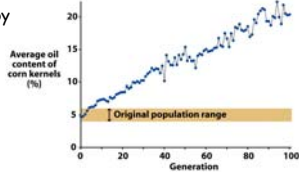
They dominate the large-seeded plants that *G. fortis* relied on in 1977.

So *G. fortis* individuals now do best (under the circumstances) if they specialize on small seeds, even though such seeds are rare.



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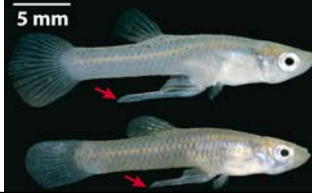
It acts only on existing traits, but by doing so can give rise to new ones.



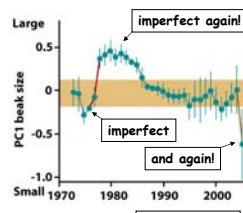
Male mosquito fish (*Gambusia affinis*)



And for **MANY** reasons it does **NOT** lead to perfection!



Reactive adaptation to current conditions *inevitably* causes imperfection



Larger beaks and bodies are favored when most available seeds are large and hard.

Smaller beaks and bodies are favored when most *available* seeds are small and soft (for *whatever* reason, including competition from other species).

So most species are probably "adapting to recover from past adaptation", most of the time!

