Natural Selection and Adaptation

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Biol 417: Evolutionary Ecology

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Review

Tinbergen's 4 questions

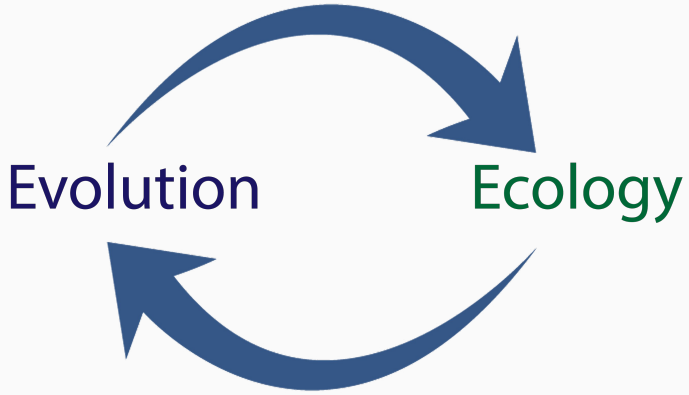
Last lecture we learned how Tinbergen argued that we only truly understand a biological phenomenon if it can be describe it in terms of:

	Dynamic	**Static**
Proximate (How)	Ontogeny (development)	Mechanism (causation)
Ultimate (Why)	Phylogeny (evolution)	Function (adaptation)

— Tinbergen (1963)

Evolutionary ecology

We then covered how **Evolutionary Ecology** lies at the intersection of ecology and evolutionary biology and is focused on providing comprehensive answers to "Why?" questions.



Today's lecture

Our goal in this course is to understand how ecological conditions drive evolutionary processes through natural selection.

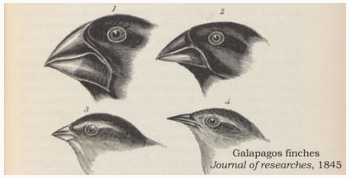
Before we can do that we need to clarify why **Natural Selection** and **Evolution** are not synonymous, what levels selection occurs at, and what evolutionary ecologists mean by the terms **adaptation** and **fitness**.

Evolution vs. Natural Selection

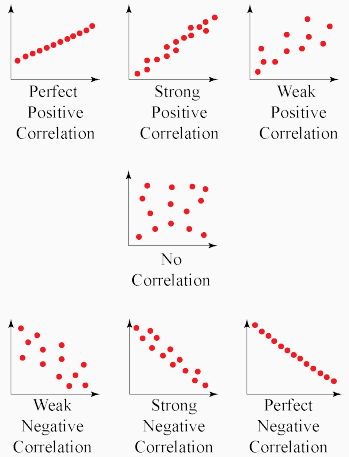
Natural selection

Natural selection occurs in a population which has:

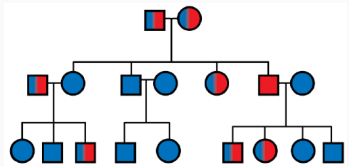
- **Variation** in a trait between individuals (body size, leaf diameter, beak shape, etc.).



- **Correlation** between the value of a trait and lifetime reproductive success.



- **Inheritability** of that trait between parents and their offspring.



Natural selection cont.

If these 3 criteria are satisfied then:

- There will be **intra-generational** predictability in fitness and survival.
- There will be **inter-generation** predictability in how offspring differ from their parents (assuming the population is not at equilibrium).

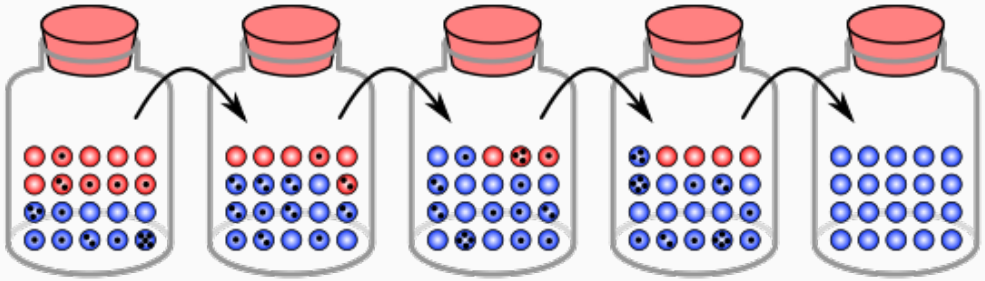
This predictable shift in a trait, governed by inheritable variance tied directly to fitness, is what we refer to when we use the term natural selection.

Natural selection causes evolution to occur (i.e., a change through time).

Natural selection vs. evolution

Evolution describes a change through time. Natural selection causes evolution to occur, but it is not the only mechanism for evolution.

For example genetic drift caused by stochasticity in allele frequencies can cause evolution without any selective benefits.

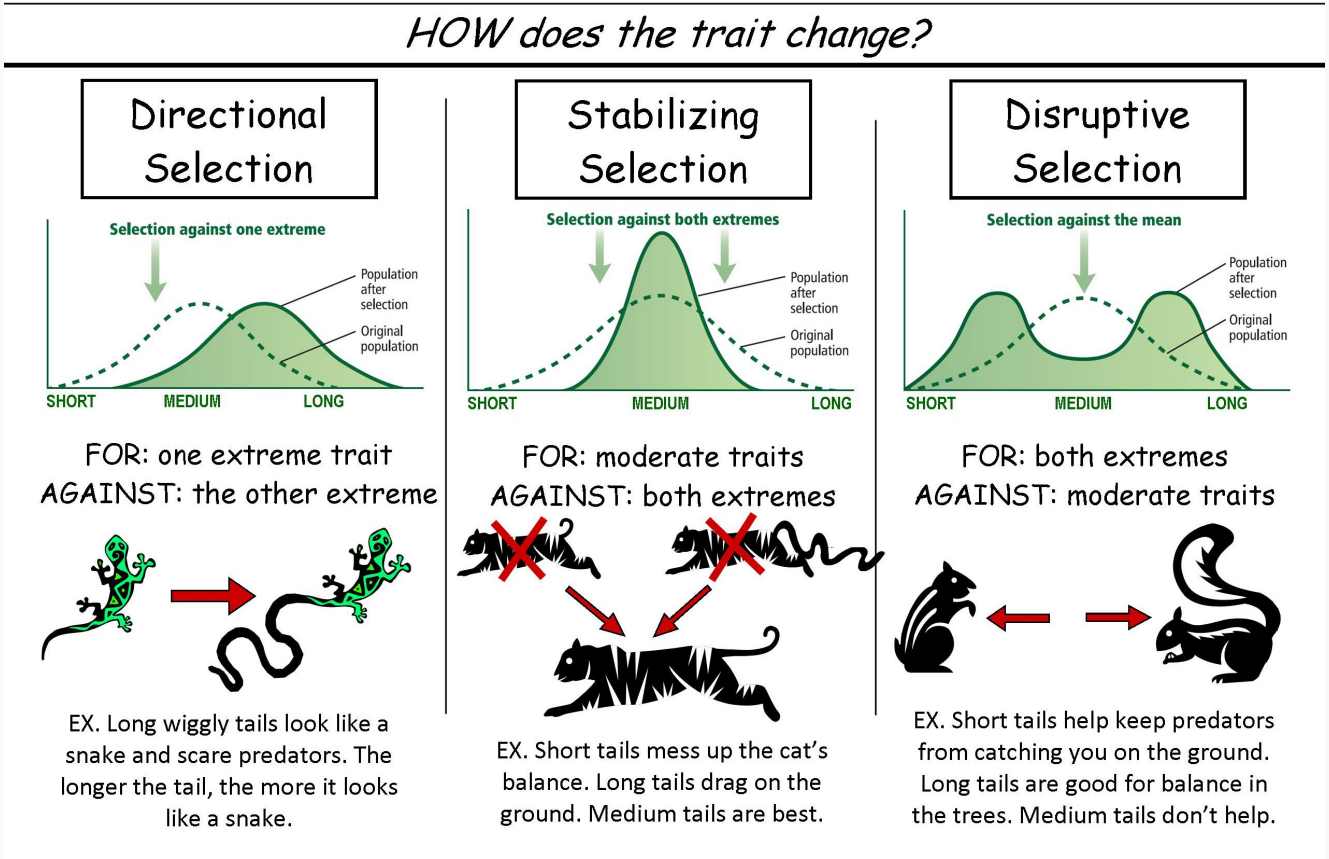


Source: dnareplicationsystem

What sets these apart is the **predictability of evolution by natural selection**.

Types of Selection

Selection on means and variances



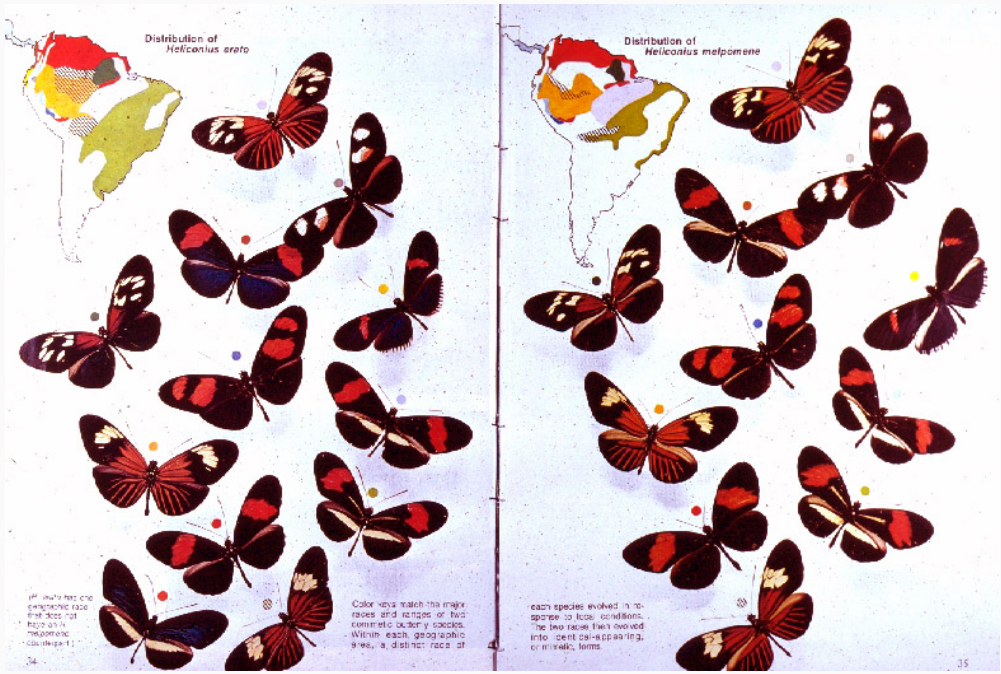
Source: Socratic Q&A

- **Directional**: change in μ and maybe σ^2
- **Stabilising**: change in σ^2 and maybe μ
- **Disruptive**: change in σ^2

Frequency dependent selection

Frequency dependent selection occurs when the fitness of an individual (or phenotype) depends on its frequency in the pop.

E.g., at any location in South America *Heliconius melpomene* will look more similar to the sympatric *H. erato* morph than to *H. melpomene* in another part of their range (any guesses why?).



Adapted from Turner (1981)

Density (in)dependent selection

Density **dependent** selection only occurs when a population surpasses some critical population density (e.g., constraints imposed by limited resources and environmental carrying capacities).

Density **independent** selection occurs at any population density (e.g., extreme weather events, tolerance to local conditions, etc.).

Hard vs. soft selection

Soft selection

Soft selection occurs when only a proportion of the population can survive and reproduce (e.g., competition for limited resources).

Some individuals will always survive soft selection.

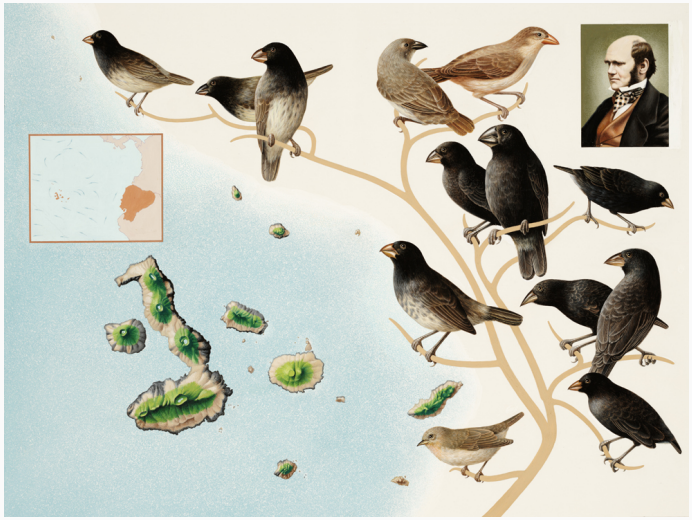
Hard selection

Hard selection occurs when conditions impede survival/reproduction (e.g., extreme weather events).

The ability to survive hard selection is independent of density and competitive abilities.

Natural vs. artificial selection

Natural selection



Source: Happy Gringo

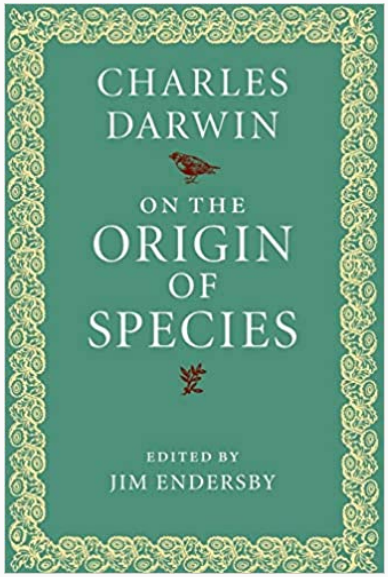
Artificial selection

Source: Business Insider

Natural selection has no 'end goal' but artificial selection has a goal that is not necessarily tied to fitness.

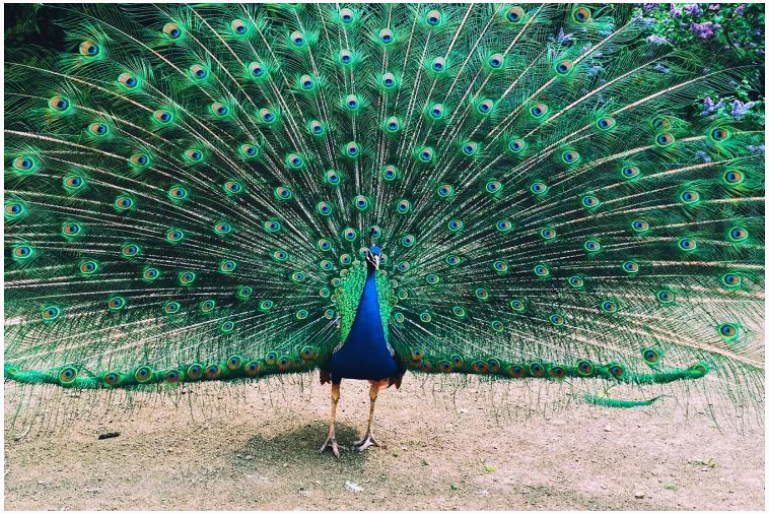
Natural vs. sexual selection

Natural selection



In the Origin of Species Darwin focused on traits that improved survival.

Sexual selection



How does this help survival?

Sexual selection can favour traits that reduce survival as long as fitness is maintained.

Adaptation

The cumulative effect of natural selection is adaptedness (i.e., the ability to survive and reproduce in an environment).

The process through which adaptedness is acquired is called adaptation.

Adaptedness has a strict environmental context (can be high in one environment, but low in another), and can even be dependent on community structure (can be high when certain species are present, but low when they are absent).

Evolution by natural selection is therefore deeply rooted in ecology.

Take home message

There are a lot of mechanisms by which selection can act to drive evolution and adaptation (most of which are tied to ecological factors).

None of these mechanisms are likely to be acting in isolation, nor will they have the same magnitude of importance in each case.

This makes evolution by selection a highly dynamic process that can generate a large array of outcomes.

Only by studying evolution through an ecological lens can we fully appreciate a species' evolutionary history.

References

Tinbergen, N. (1963). On aims and methods of Ethology. *Ethology*, 20, 410–433.

Turner, J.R. (1981). Adaptation and evolution in heliconius: a defense of neodarwinism. *Annual Review of Ecology and Systematics*, 12, 99–121.