BIL 161 - Mechanisms of Evolution

Natural Selection: Introduction

Organic evolution is defined as the process by which populations of living organisms change and diversify as they descend from an ancestral form. There are five factors/mechanisms by which this can occur:

1. **Mutation**, a change in the DNA code that builds and operates an organism
2. **Genetic Drift** due to small population size
3. **Non-random mating** among population members
4. **Immigration and Emigration** (gene flow) among populations
5. **Natural Selection** (Darwin's theory)

Natural selection is the most familiar of these evolutionary forces.

In *On the Origin of Species by Means of Natural Selection,* Charles Darwin proposed that evolution proceeded by means of a four-step process he called **natural selection**:

1. **Overproduction**: Organisms have the capacity to produce large numbers of offspring.
2. **Heritable Variation**: These offspring exhibit variable heritable traits.
3. **Competition**: These offspring must compete for limited resources in the environment.
4. **Differential Reproduction**: Individuals whose traits enable them to best exploit resources in the environment will leave more genes to the next generation than those less well adapted.

Of the five factors that can drive populations to evolve, *only natural selection results in a population better adapted for survival in its particular environment*.

The results of natural selection are everywhere around you.

- the warning (**aposematic**) coloration of a stinging bee
- a woodpecker's bill, perfectly shaped to excavate wood
- the camouflaging (**cryptic**) color of a grasshopper on a leafy branch
- all the characteristics that make you human

...are all products of this process.

The raw material of evolution is **mutation**. Without genetic variation, a population cannot evolve. A population that is **polymorphic** for a particular trait exhibits more than one form of that trait.

A mutation (and the trait(s) it influences) can be

- **adaptive** – increases the individuals likelihood of survival/reproduction
- **maladaptive** – decreases the individuals likelihood of survival/reproduction
- **neutral** – does not affect the individuals likelihood of survival/reproduction

An individual's **Darwinian fitness** is the relative proportion of offspring it leaves to the next generation, compared to its **conspecifics** (members of its own species).

By definition, the individuals with the highest Darwinian fitness leave more genes to the next generation than their conspecifics do. Thus, in the contest of evolution, ***whoever has the most babies wins.***

A polymorphic population is usually made up of individuals expressing traits along a continuum. This can be expressed as a **Gaussian (bell-shaped) curve** (Figure 1).

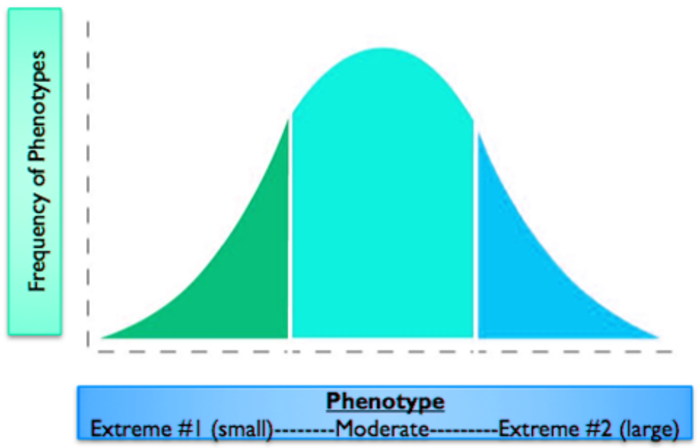

Figure 1. An example of a bell-shaped curve representing frequency of individuals of varying sizes in a population

Natural selection can act on individuals in any region of this curve. If a particular phenotype is more adaptive than others, then the phenotypic (and genotypic) composition of the population can change over generations, typically in one of three ways (Figure 2).

- **stabilizing selection**
  - the average phenotype is most adaptive.
  - mode is stable
  - curve may become more narrow

- **directional selection**
  - phenotype at one extreme of the range or the other is the most adaptive.
  - mode shifts right or left, depending on selective pressure

- **diversifying (= disruptive) selection**
  - phenotypes at either extreme are more adaptive than the average phenotype.
  - curve becomes bimodal
  - original average phenotype becomes rare or extinct

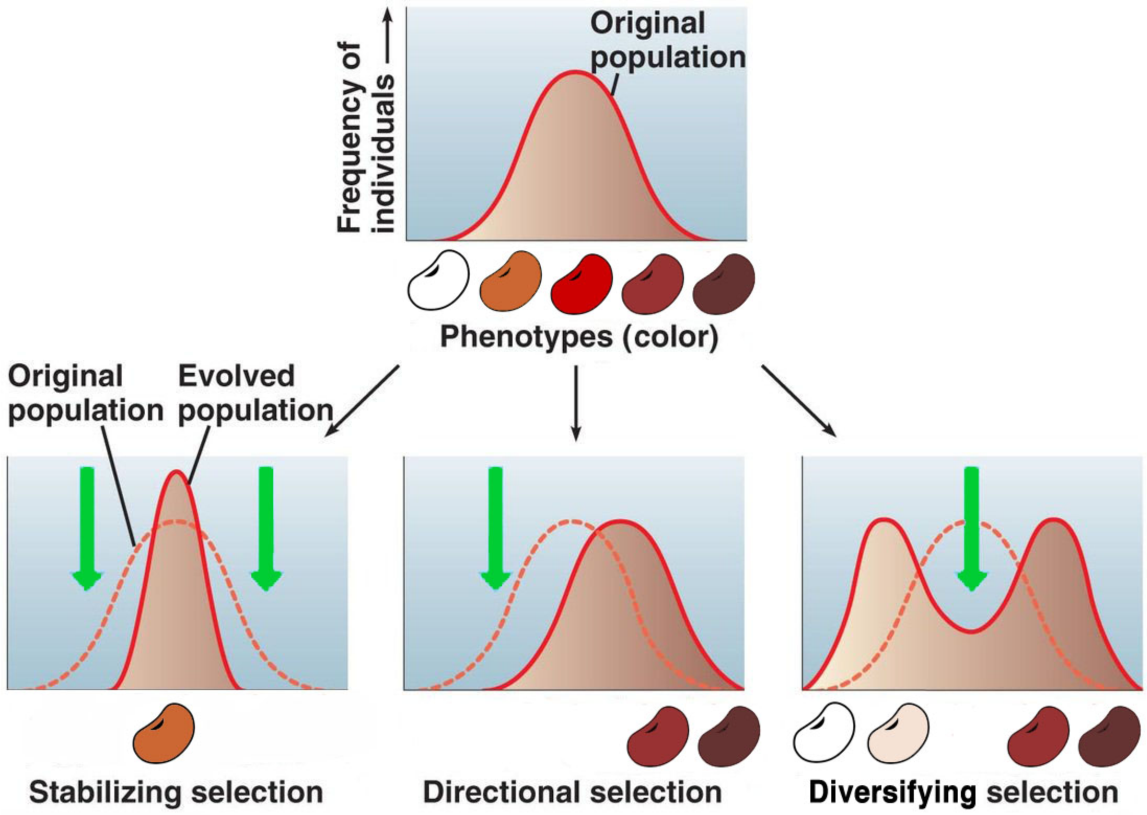

Figure 2. Natural selection can shift phenotypic ratios of a population in three general ways: stabilizing selection, directional selection, and diversifying (disruptive) selection.

Notes on Our Model Species

In today's lab, we will simulate natural selection in a simplified ecosystem consisting of two interacting populations of organisms, **predators** and **prey**, and their grassy habitat (lawn). After several generations of predator foraging, we will analyze changes in relative phenotype frequencies in both (1) predator and (2) prey populations.

In our simulated ecosystem, the role of **prey species** will be played by the common bean, *Phaseolus vulgaris*. But since they will be role-playing, they will take on a new scientific name, ***Beanus gooberensis***.

This prey population is polymorphic for **color** (and, to a lesser degree, for size and shape). To keep things simple, we will focus only on the **color** phenotype. Because many predators rely on **visual cues** to detect prey, less conspicuous prey individuals may have a **selective advantage** over their more visible conspecifics.

The role of **predator species** will be played by (drumroll, please) YOU and your classmates, *Homo sapiens*. But again, we're role-playing and taking on new characteristics. So your new predator species' scientific name will be ***Homo imperitus***.

Like the prey population, the predators are polymorphic. Individuals differ in the both **heritable** and **acquired** characteristics relevant to foraging for prey, such as

- visual acuity
- speed
- dexterity
- cunning
- experience
- etc.

Because you are human predators, we cannot easily control for most of these traits. However, the playing field will be leveled by our focus on a single characteristic that we will supply: **mouthparts**. There will be four different types of mouthparts in our predator population.

- Fork
- Spoon
- Knife
- Tongs

Because mouthpart shape affects handling time and ability to capture prey, certain individual predators may have a selective advantage over their conspecifics.

Depending on the number of predators in your lab section, you might not use all four types of mouthparts, since the simulation will work only if there are equal numbers of each type of predator at the start of the simulation. **The number of each type of predator will be determined by your instructor.**

Equipped with this background knowledge, you are now ready to read the instructions for our foraging adventure.