TOPIC 2.6

ADAPTATIONS

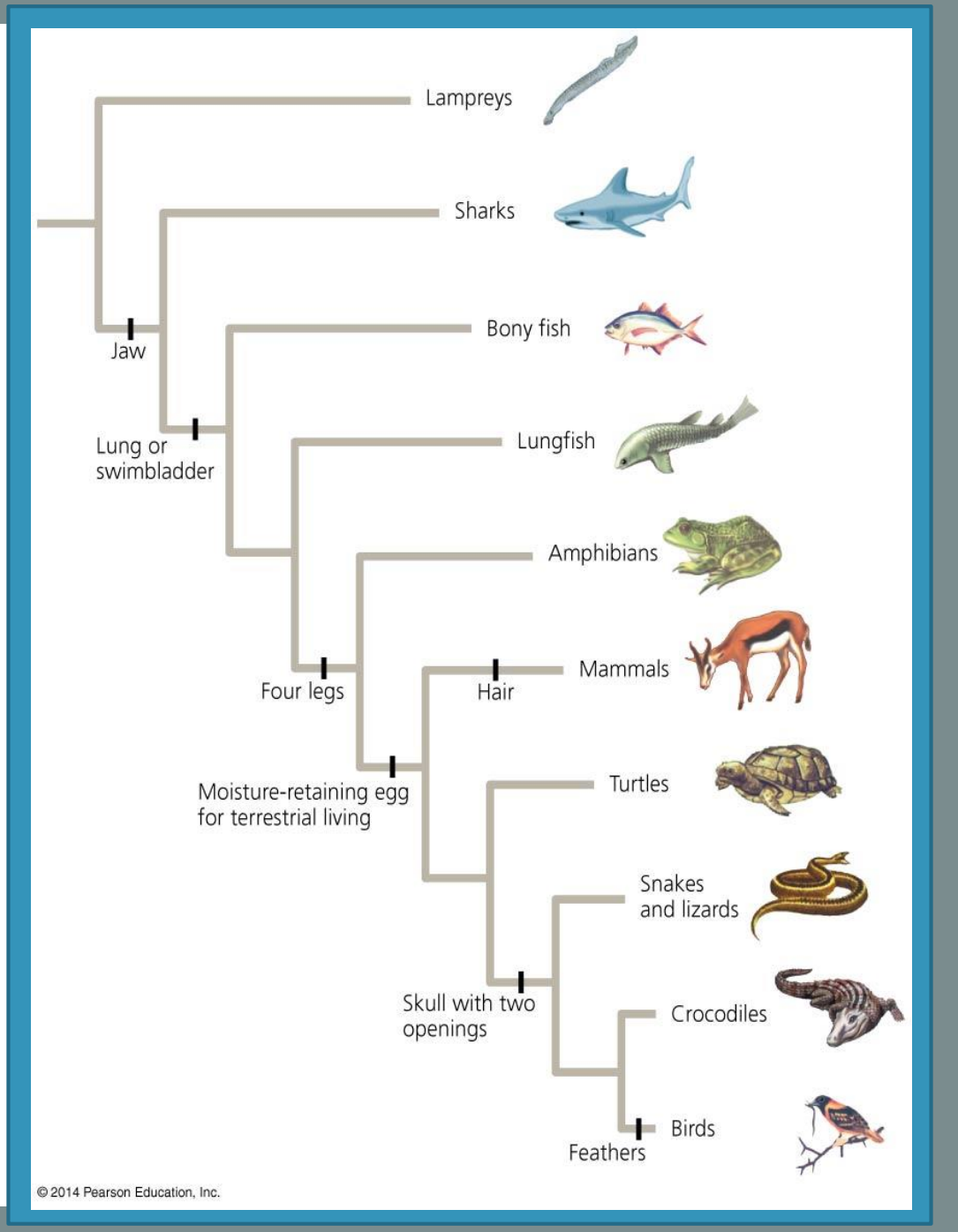
Enduring Understanding: Ecosystems have structure and diversity that change over time.

Learning Objectives: Describe how organisms adapt to their environment.

Related Readings: pg 47 - 60, "Environment; The Science Behind the Stories" 4th Edition, Withgott, Jay and Laposata, Matthew.

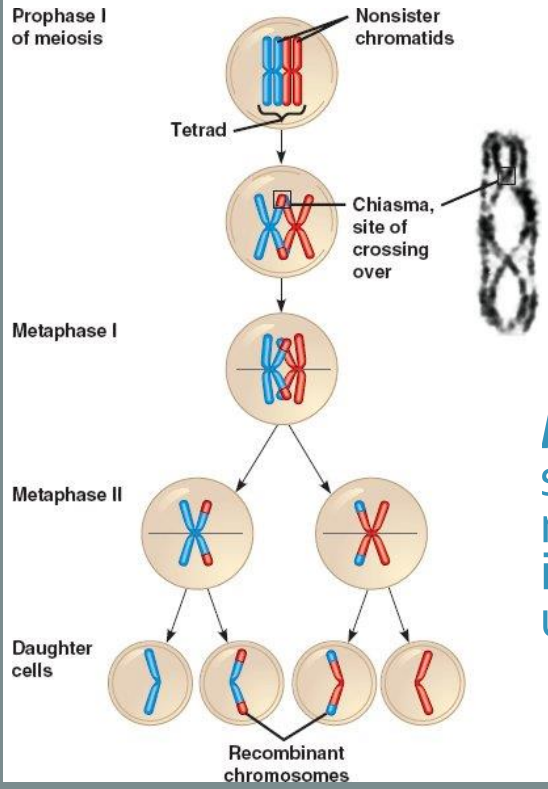
Evolution: The Source of Earth's Biodiversity

- **Evolution**
  - ***Evolution*** is the change in the inheritable traits of *populations* over generations in response to selective pressures caused by changes/disturbances in their environment
  - Genetic mutations alter the genetic code in random ways
  - Meiosis and random fertilization create unique combinations of traits
  - Natural selection acts on these mutations and new genetic combinations, possibly resulting in the adaptive evolution of populations
  - The evolution of species is also affected by random events (genetic drift)
  - When parts of a population become isolated from one another and evolve separately, speciation may occur



Sources of Genetic Variation

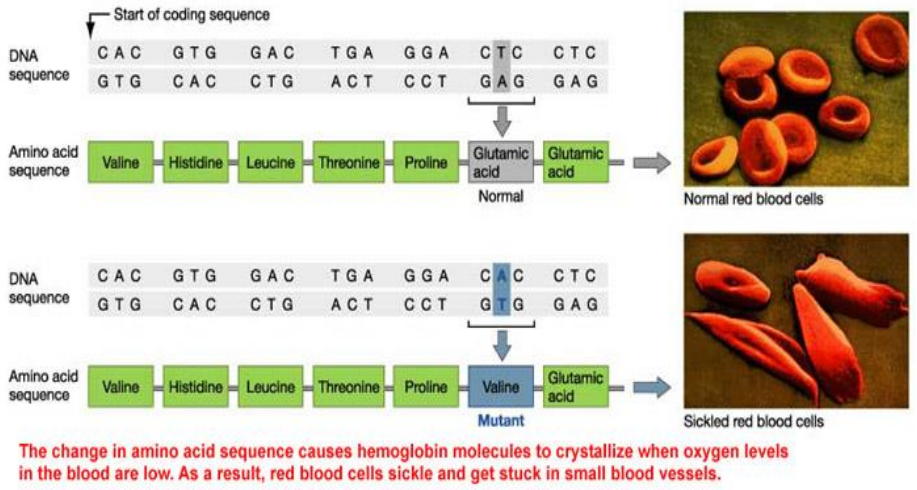
Meiosis and Sexual Recombination



- Most sexually reproducing organisms receive two copies of every gene, one from each parent.
- During ***Meiosis***, these two sets genes are shuffled together and then divided into separate gametes (sex cells, sperm/eggs)
  - Meiosis creates new combinations of maternal and paternal genes in the gametes each individual produces.
  - ***Crossing Over and Independent Assortment*** are processes during meiosis that are responsible for creating these new combinations.
  - All of the gametes produced by a single individual are genetically unique from one another

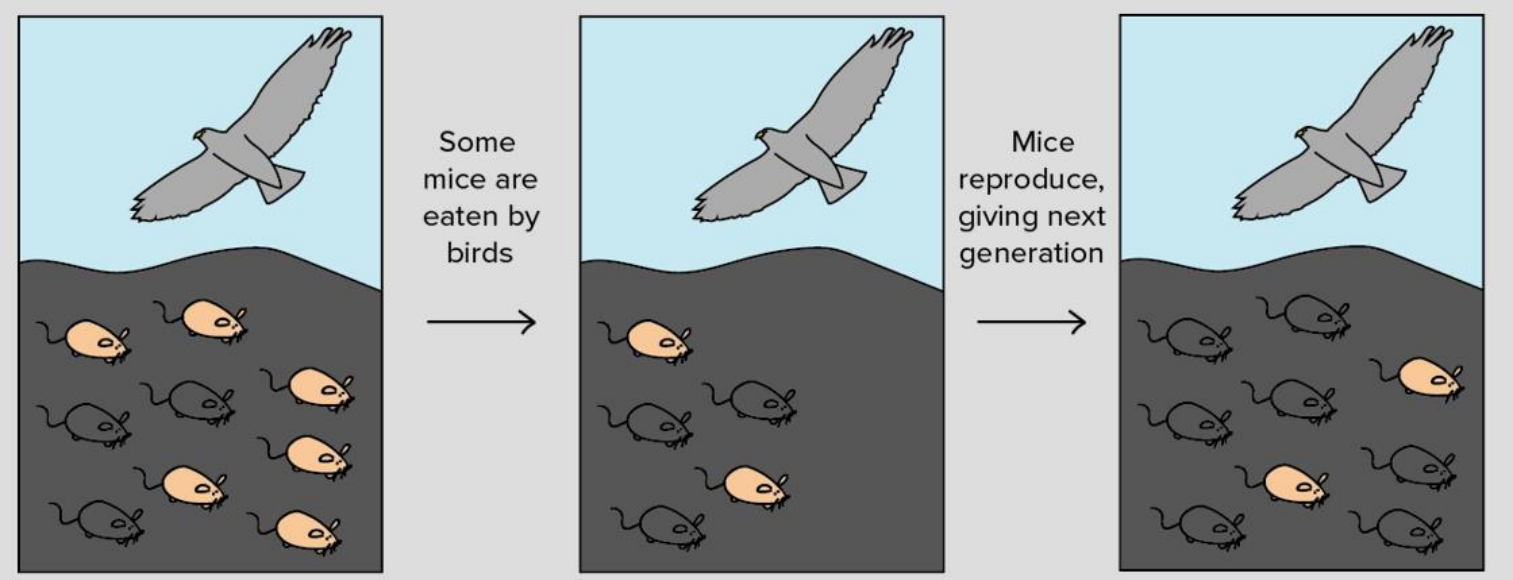
Random Fertilization pairs one randomly selected gamete from one individual with a randomly selected gamete from another individual, resulting in offspring with a unique combination of genes.

- **Mutations**
  - Inheritable traits are coded for by the sequence of nucleotides in DNA
  - Sometimes mutagens or mistakes in replication alter the sequence of nucleotides in random ways, resulting in a ***mutation***
  - Mutations create genetic variation within populations
    - Most are detrimental, but others create new traits not previously seen in the population



Natural selection and Adaptation

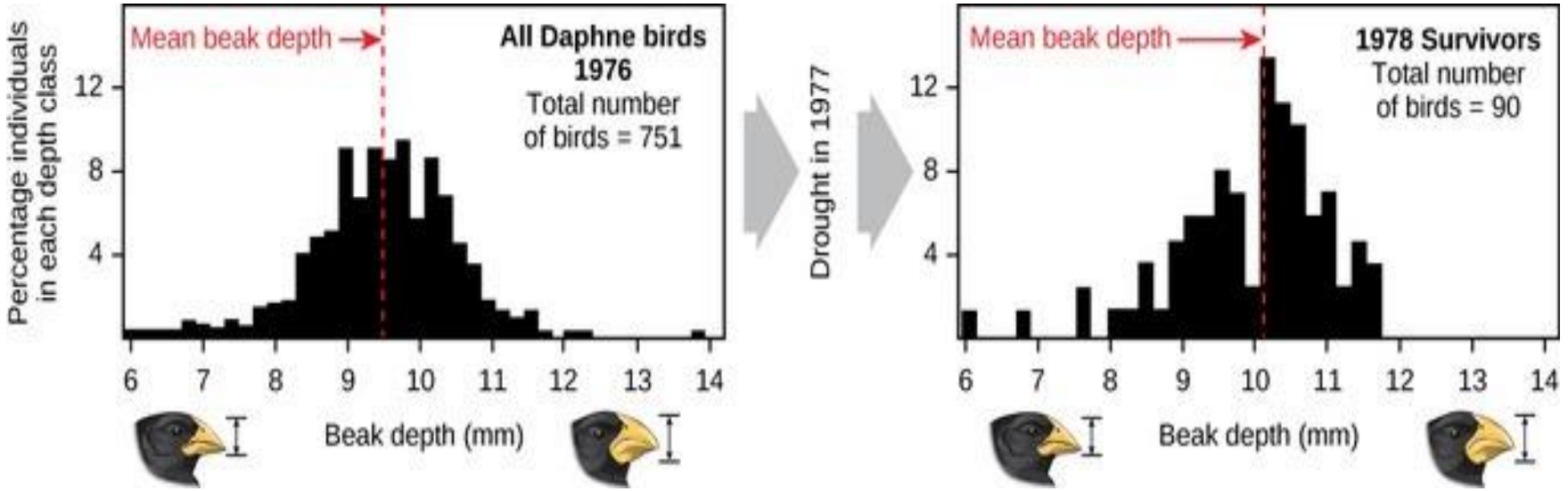
- ***Natural selection***
- Populations produce more offspring than can survive leading to a struggle to survive and reproduce.
- Mutations and sexual recombination create genetic difference between individuals within a population
- Some individuals have genetic variations that make the better suited to the ***selection pressures*** of their environment
- Generally, those with these beneficial variations live longer and/or reproduce more effectively leaving behind more offspring
- The traits that allowed for better survival and reproduction in one generation (***adaptations***), will be passed down to the next generation at a higher rate.



The Environment Determines Which genetic variations are Adaptive

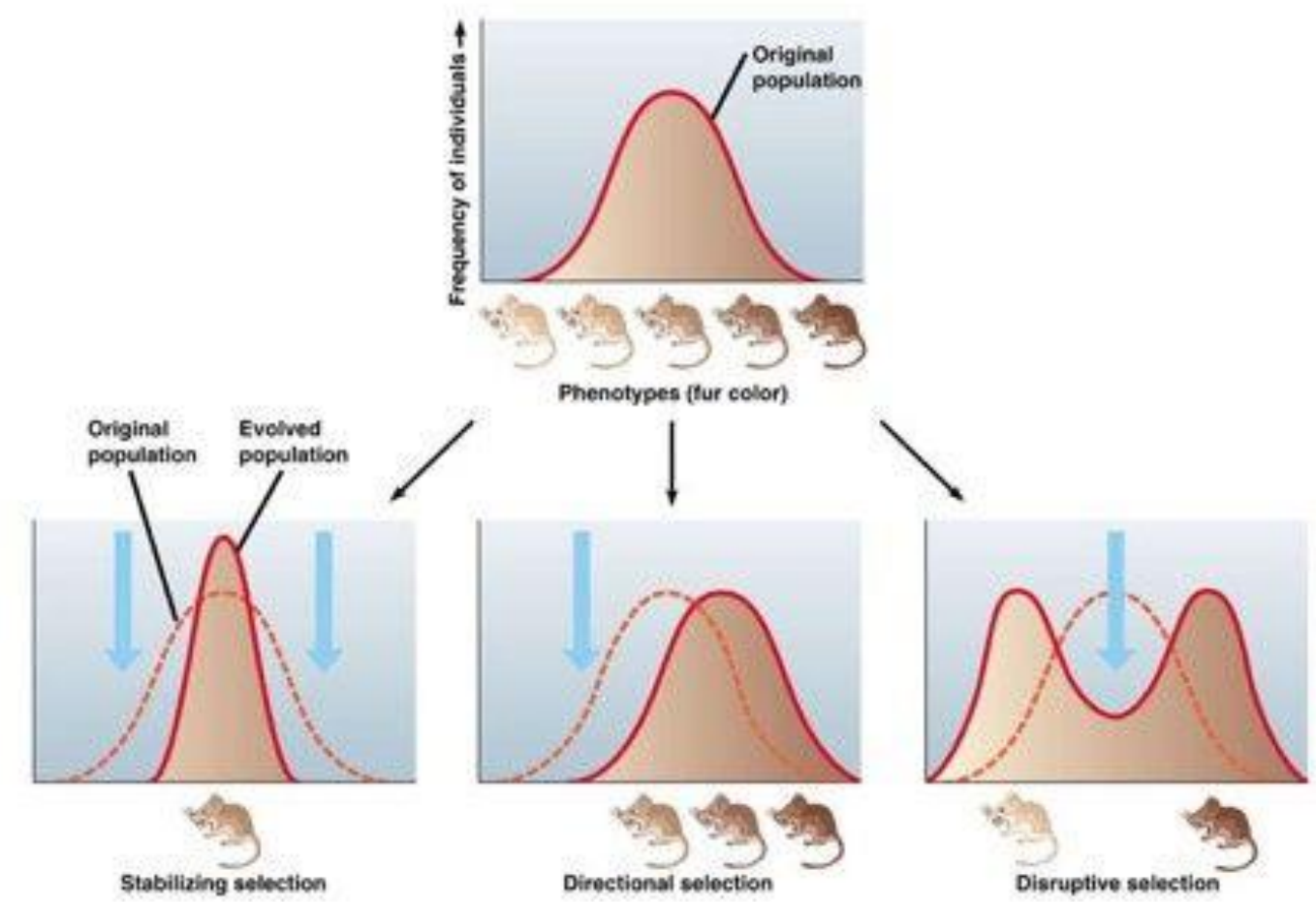
- Different environments will have different selective pressures that act on the genetic differences within a population in different ways.
- Adaptations are specific to the environment an organism lives in.
- Changes in the environment, change the selection pressures shaping the evolution of species living in those environment.
  - Old adaptations may become a liability and old liabilities may become adaptive.

Periods of drought kill of finches with smaller beaks, making larger beaks for seed cracking an adaptation.
In wet years, insect populations may be larger, and the environment may favor smaller beaks adapted to catching insects.



Natural selection shapes organisms and diversity

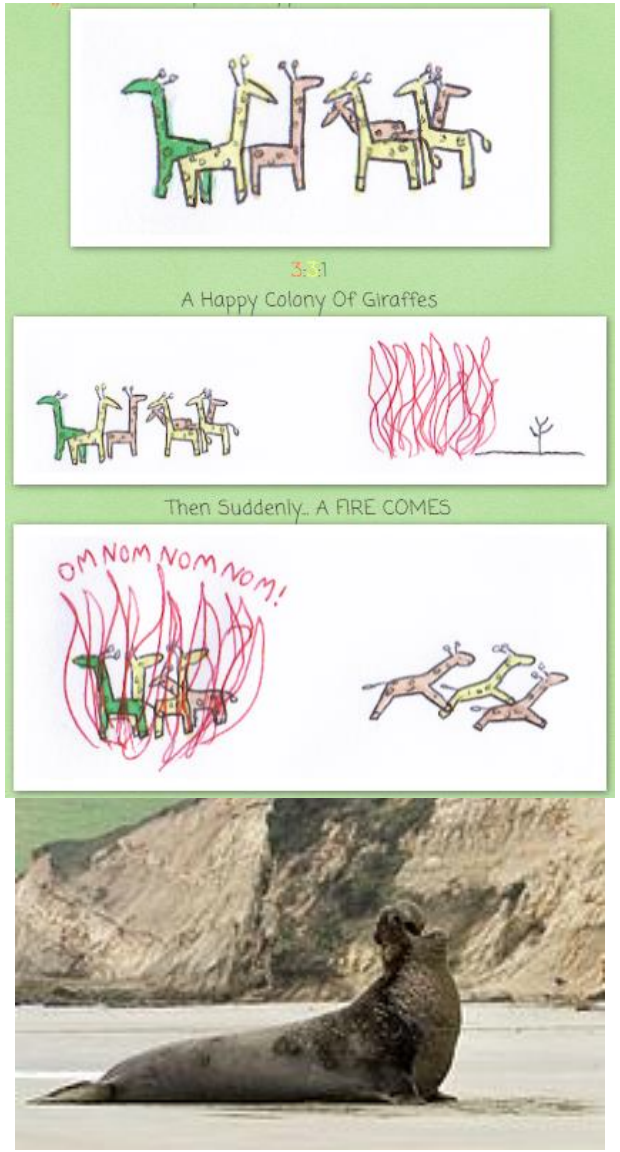
- **Directional Selection**
  - drives a feature in one direction
  - Favors one of the extremes of a trait
- **Stabilizing Selection**
  - Favors the more moderate, intermediate versions of a trait
  - Reduces diversity within a population for a given trait
- **Diversifying Selection**
  - Favors both extremes of a trait within a population
  - Increases the diversity of a population for a given trait



Not all evolution is adaptive

- Characteristics that help an organism survive and / or reproduce in a particular environment are ***adaptations.***
  - Natural selection promotes adaptive change in populations

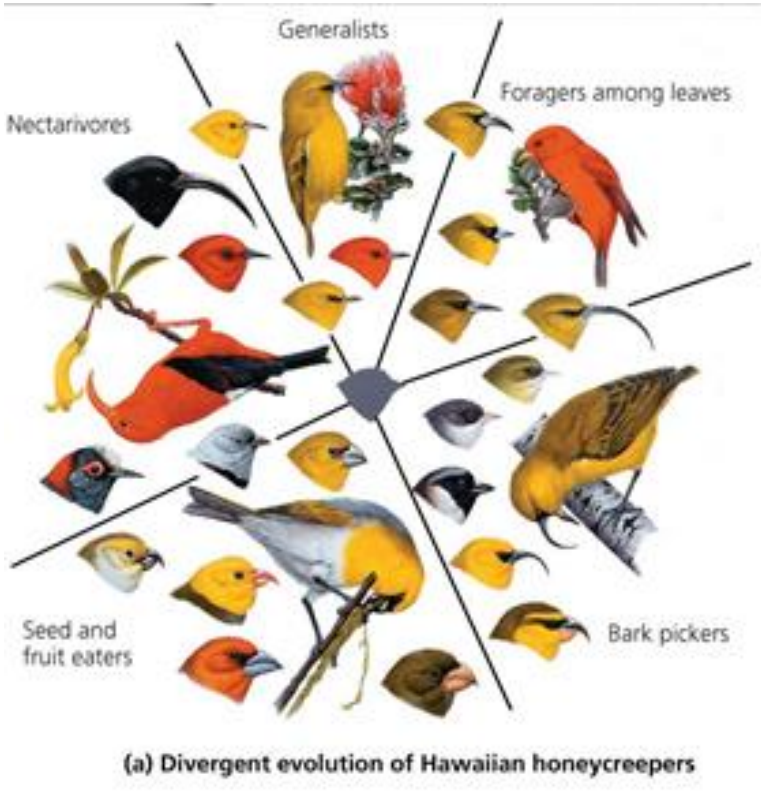
- Not all evolutionary change is adaptive
  - ***Genetic drift*** is a random change in the gene pool of a population. It is not adaptive
    - ***Bottleneck effect:*** A once large population is drastically reduced in size by a sudden and dramatic disturbance to its environment. A few individuals survive due to chance, not because of a genetic variation that increased their chance of survival. (e.g. California's Northern Elephant Seal population)
    - ***Founders effect:*** A few individuals are randomly cut off from the rest of the population and become the founders of a new population. By chance, some genes in the new gene pool will be over represented, and others will be underrepresented. Some previously existing traits may be missing altogether. (e.g. Polydactyly in Old Order Amish of Pennsylvania)



Bottleneck Effect

Founder Effect

Selective pressures from the environment influence adaptation



(a) Divergent evolution of Hawaiian honeycreepers

The many species of Honeycreepers in Hawaii result from divergent evolution from an early colonist species.

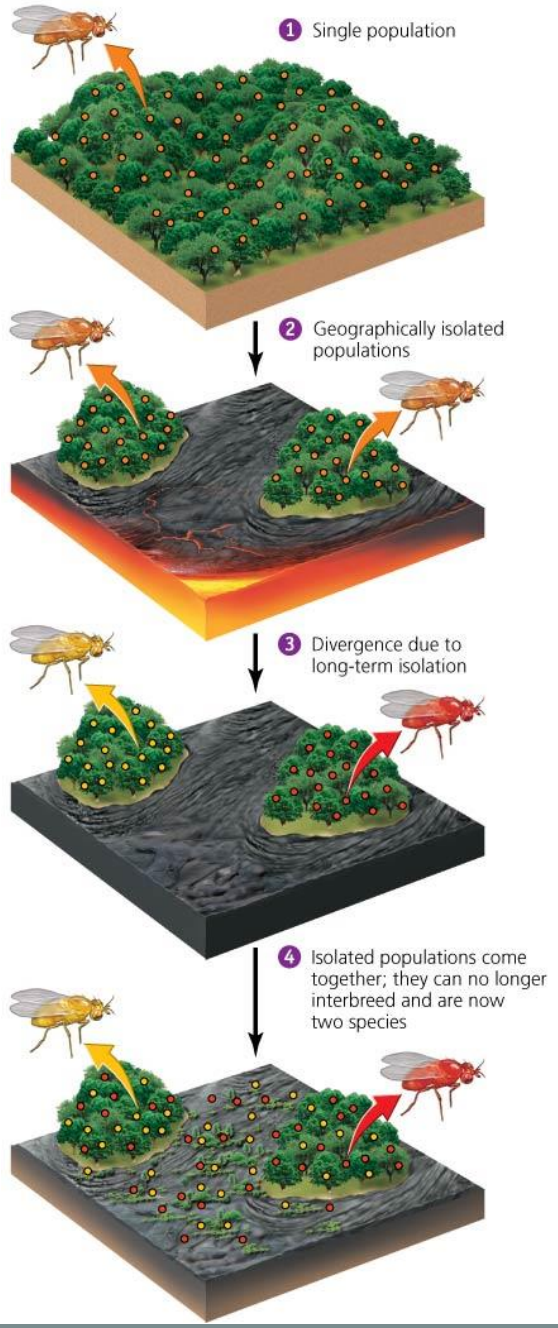
Divergent Evolution

- Related species with different environments experience different pressures and adapt differently to their respective environments
- E.g. honeycreepers in Hawaii
- **Convergent evolution** unrelated species may acquire similar traits because they live in similar environments.
  - Although similar in appearance, the genetic basis for physical traits remains different
  - Cactus in the Americas and euphorbia in Africa

Although genetically very different, cacti and euphorbia have evolved similar adaptations in response to their desert environments through convergent evolution.

Speciation produces new types of organisms

- **Speciation**
  - The process of generating new species from a single species
- ***Allopatric speciation***
  - species formation due to physical isolation of populations from one another
  - Populations can be separated by glaciers, rivers, mountains and other geographic barriers
  - Each population accumulates its own set of mutations which are acted on by natural selection and genetic drift in unique ways
  - The main mode of speciation for most taxa
- **Sympatric Speciation**
  - Mutation and nondisjunction events create genetically isolated, self fertilizing populations.
  - Common among plants and other self fertile or asexually reproducing populations



We can infer the history of life's diversification by comparing organisms

- **Scientists can trace the evolution of traits**
  - Some traits evolved and were passed on with subsequent speciation events creating further diversity within a group of similar species (e.g. diversity among vertebrates)
  - Other traits evolved more than once (e.g., the ability to fly)

- **Phylogenetic trees**
  - diagrams that show relationships among species, groups of species, populations, etc.
  - Based on patterns of similarity in genes or external traits