Evolution

Sources of Variation From Gene to Organism

- Without genetic variation, some of the basic mechanisms of evolutionary change cannot operate.

There are three primary sources:

- **1. <u>Mutations</u>** are changes in the DNA. A single mutation can have a large effect, but in many cases, evolutionary change is based on the accumulation of many mutations.

- **2. <u>Gene flow</u>** is any movement of genes from one population to another and is an important source of genetic variation.

- **3. <u>Sexual Reproduction</u>** can introduce new gene combinations into a population. This genetic shuffling is another important source of genetic variation.

1. Mutation

- Recall that your genetic code, <u>DNA</u>, can **mutate**.

- Mutation can be **<u>single-gene mutations</u>** (addition, deletion or substitution) and may be harmful, neutral or advantageous (rare).

- Mutation can be **chromosomal mutations** during meiosis (gamete egg or sperm production) when chromosomes are rearranged and chromosome numbers are halved.

- Mutations are usually harmful, but *can* be beneficial.

EX. Sickle Cell is a mutation of red blood cells that amongst many other complications can block blood vessels. A beneficial side effect is that it can offer resistance to Malaria.
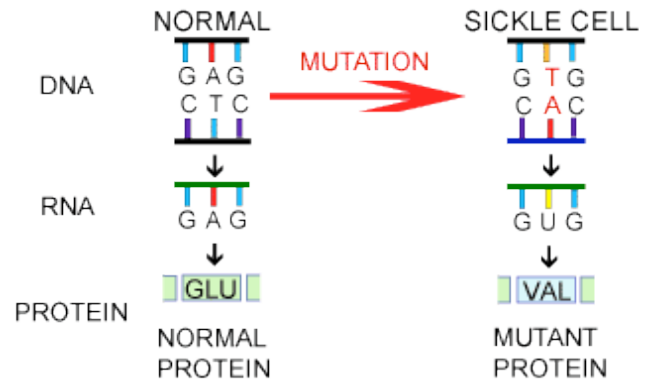
2. **Gene flow**

- Gene flow, also called migration,is any movement of genes from one population to another.

- Gene flow includes lots of different kinds of events, such as pollen being blown to a new destination or people moving to new cities or countries.

- If genes are carried to a population where those genes previously did not exist, gene flow can be a very important source of genetic variation. In the graphic below, the gene for brown coloration moves from one population to another.

- In the graphic below, the gene for brown coloration moves from one population to another.
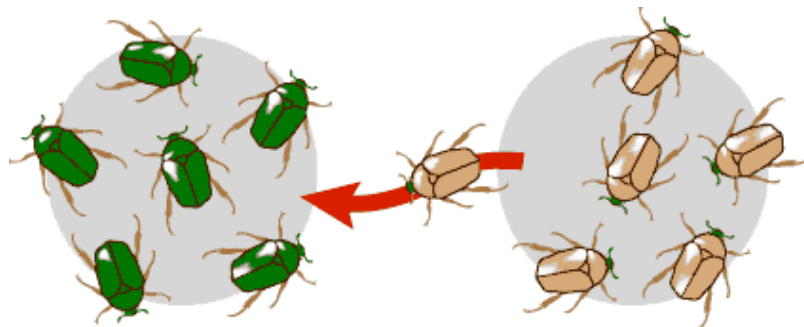

3. Sexual Reproduction

- <u>Independent Assortment</u> is the random shuffling of pairs of chromatids during meiosis (production of egg or sperm cells) will produce a variety of different gametes.
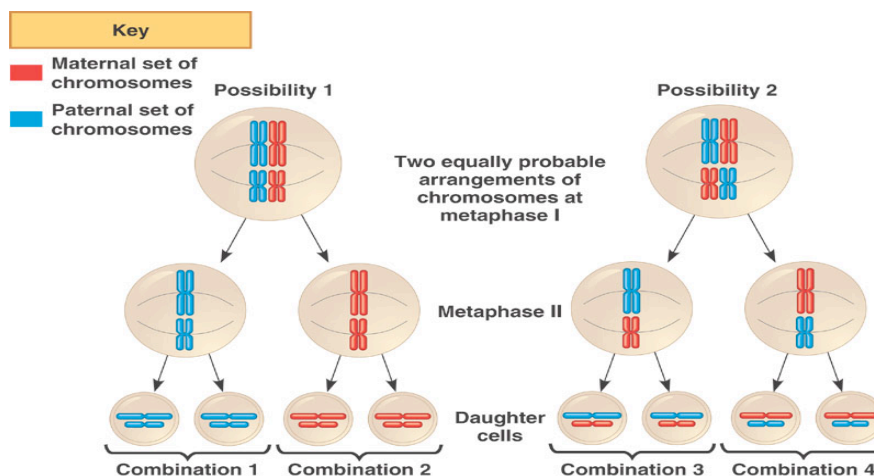
- <u>Recombination</u> or Crossing over is when pieces of homologous chromosomes shuffle genetic information while lined up during metaphase in meiosis (gamete production).

Synapsis   Crossing over   Recombination complete   Chromatid
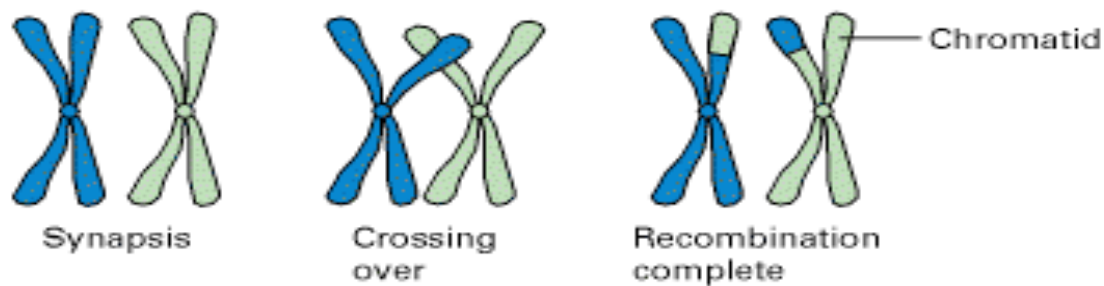
- <u>Mate selection</u> - variation comes from your choice of mate. You are a genetic combination of your biological parents.

Father has big nose
Mother has bushy eyebrows
Son gets big nose and bushy eyebrows
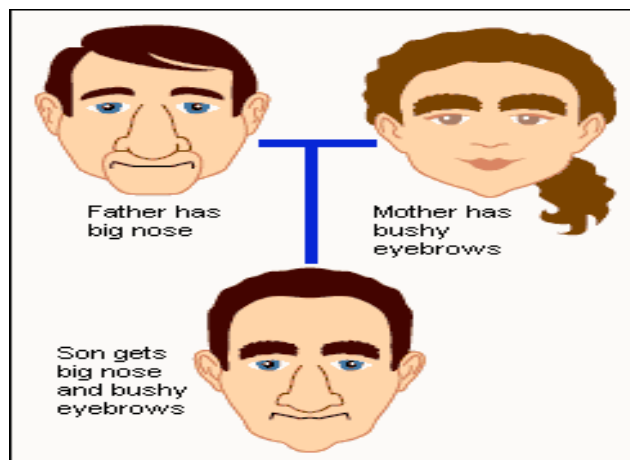
Other Reasons that the Gene Pool changes

- **Genetic Drift::** An allele may become more frequent in a population due to <u>chance!</u>

- -**Environmental catastrophe**: survivor's alleles increase in frequency (bottleneck effect).

- -**Isolation from population**: inbreeding increases certain allele frequencies (seen in founder populations...when a small group of individuals with a particular phenotype is isolated from the original population).

- -Usually involves **small populations**.

Genetic Drift - Environmental Catastrophe

- Earlier we used this hypothetical cartoon. Genetic drift affects the genetic makeup of the population but, unlike natural selection, through an entirely random process. So although genetic drift is a mechanism of evolution, it doesn't work to produce adaptations.
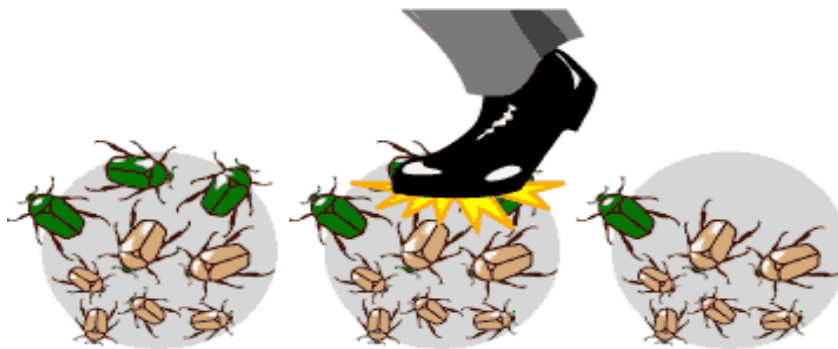
Genetic Drift - Bottle Neck

• **Genetic drift** can cause big losses of genetic variation for **small populations**.

•Population bottleneck occur when a population's size is reduced for at least one generation. Because <u>genetic drift</u> acts more quickly to reduce <u>genetic variation</u> in small populations, undergoing a <u>bottleneck</u> can reduce a population's genetic variation by a lot, even if the bottleneck doesn't last for very many generations. This is illustrated by the bags of marbles shown below, where, in generation 2, an unusually small draw creates a bottleneck.
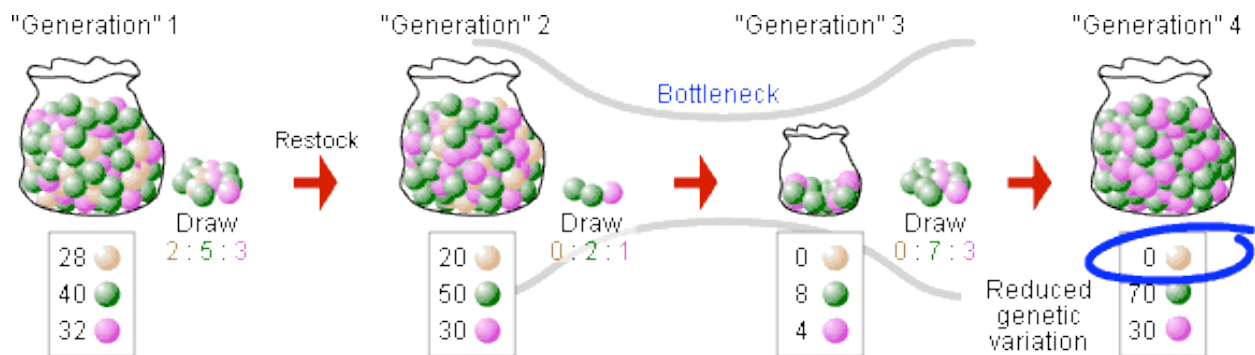

An example of a bottleneck:

Northern elephant seals have reduced genetic variation probably because of a population bottleneck humans inflicted on them in the 1890s. Hunting reduced their population size to as few as 20 individuals at the end of the 19th century. Their population has since rebounded to over 30,000—but their <u>genes</u> still carry the marks of this bottleneck: they have much less genetic variation than a

population of southern elephant seals that was not so intensely hunted.

Genetic Drift - Population Isolation

- <u>Geographical Isolation</u> such as a population on an island or separated by mountains or even simple distance can cause genetic drift.

Continuous Population Divided into Two or More Smaller Populations
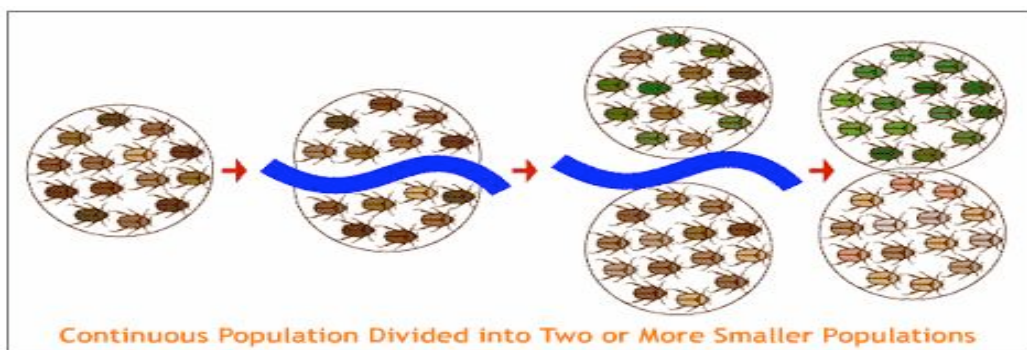
The Pace of Evolution

Does evolution occur in rapid bursts or gradually? This question is difficult to answer because we can't replay the past with a stopwatch in hand. However, we can try to figure out what patterns we'd expect to observe in the fossil record if evolution did happen in bursts, or if evolution happened gradually. Then we can check these predictions against what we observe.

Gradualisms is when species descended from a common ancestor gradually diverge more and more in their morphology as they acquire unique adaptations, where **punctuated equilibrium** changes mostly as it buds from a parent species and then changes little for the rest of its existence. As the species diverge through the evolution sequence it is possible that a parent species could diverge and enter a stage of gradualism. No, one does not have to exclude the other.

Time

Morphological change

(a) Gradualism model

Morphological change

(b) Punctuated equilibrium model