can only enhance the performance of a particular trait but an individual needs a set of beneficial mutation to increase its overall survival and reproduction. Natural selection acts at the level of the individual within a population; it selects for individuals with greater contributions to the gene pool of the next generation, known as an organism's evolutionary fitness (or Darwinian fitness).

Adaptive evolution in finches: Through natural selection, a population of finches evolved into three separate species by adapting to several different selection pressures. Each of the three modern finches has a beak adapted to its life history and diet

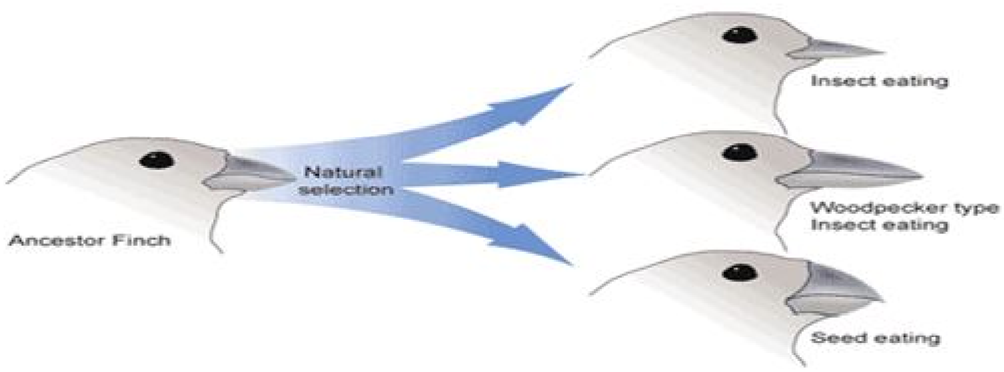


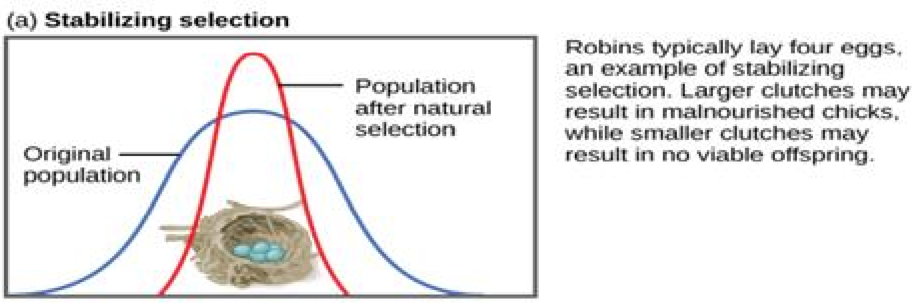
***Fig 4.1.** Adaptive radiation in Darwin finches*

There are several ways selection can affect population variation:

1. stabilizing selection
2. directional selection
3. diversifying selection
4. frequency-dependent selection
5. sexual selection

(a) Stabilizing selection: a type of natural selection in which genetic diversity decreases as the population stabilizes on a particular trait value

- If natural selection favours an average phenotype by selecting against extreme variation, the population will undergo stabilizing selection. For example Robin typically laid four eggs because a larger clutch size may result in malnourished chicks, while smaller clutches may result in no viable offspring. As a result of this stabilizing selection, the population's genetic variance will decrease.



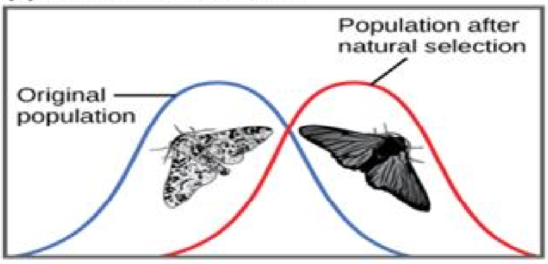
(b)Directional Selection

Directional selection: a mode of natural selection in which a single phenotype is favoured, causing the allele frequency to continuously shift in one direction

- When the environment changes, populations will often undergo directional selection, which selects for phenotypes at one end of the spectrum of existing variation.

- A classic example of this type of selection is the evolution of the peppered moth in eighteenth- and nineteenth-century England. Prior to the Industrial Revolution, the moths were predominately light in colour, which allowed them to blend in with the light-colored trees and lichens in their environment. As soot began spewing from factories, the trees darkened and the light-colored moths became easier for predatory birds to spot.
- Over time, the frequency of the melanic form of the moth increased because their darker coloration provided camouflage against the sooty tree; they had a higher survival rate in habitats affected by air pollution. Similarly, the hypothetical mouse population may evolve to take on a different coloration if their forest floor habitat changed. The result of this type of selection is a shift in the population's genetic variance toward the new, fit phenotype.

(b) Directional selection



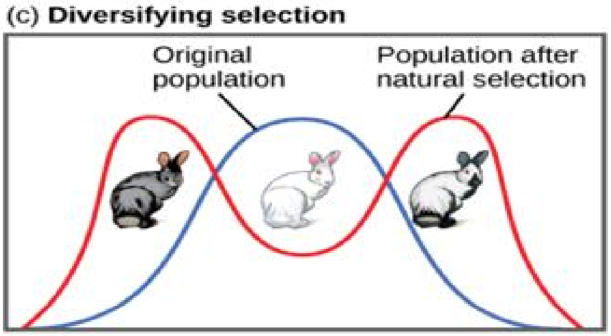
Light-colored peppered moths are better camouflaged against a pristine environment; likewise, dark-colored peppered moths are better camouflaged against a sooty environment. Thus, as the Industrial Revolution progressed in nineteenth-century England, the color of the moth population shifted from light to dark, an example of directional selection.

(c)Diversifying (or Disruptive) Selection

Disruptive selection: A mode of natural selection in which extreme values for a trait are favoured over intermediate values.

- Sometimes natural selection can select for two or more distinct phenotypes that each have their advantages. In these cases, the intermediate phenotypes are often less fit than their extreme counterparts. Known as diversifying or disruptive selection, this is seen in many populations of animals that have multiple male mating strategies, such as lobsters. Large, dominant alpha males obtain mates by brute force, while small males can sneak in for furtive copulations with the females in an alpha male's territory. In this case, both the alpha males and the "sneaking" males will be selected for, but medium-sized males, which cannot overtake the alpha males and are too big to sneak in for copulations, are selected against.
- Diversifying selection can also occur when environmental changes favour individuals on either end of the phenotypic spectrum. Let's take an example of population of gray and Himalayan rabbits (grey and white), Himalayan rabbits are better able to blend with the rocky environment than white rabbits, resulting in **diversifying selection**. The result of this type of selection is increased genetic variance as the population becomes more diverse.

(c) Diversifying selection



In a hyphothetical population, gray and Himalayan (gray and white) rabbits are better able to blend with a rocky environment than white rabbits, resulting in diversifying selection.

The Lederberg experiment

In 1952, **Esther** and **Joshua Lederberg** performed an experiment that helped to show that many mutations are random, not directed.

Here is the experimental set-up for the Lederberg experiment. All you really need to know in terms of background information is that bacteria grow into isolated colonies on plates, and that you can reproduce the colonies from an original plate to new plates by “stamping” the original plate with a cloth and then stamping empty plates with the same cloth. Bacteria from each colony are picked up on the cloth and then deposited on the new plates by the cloth.

The hypothesis for the experiment is that antibiotic resistant strains of bacteria surviving an application of antibiotics had the resistance before their exposure to the antibiotics, not as a result of the exposure.

1. Bacteria are spread out on a plate, called the “original plate.”
2. They are allowed to grow into several different colonies.
3. This layout of colonies is stamped from the original plate onto a new plate that contains the antibiotic penicillin.
4. Colonies X and Y on the stamped plate survive. They must carry a mutation for penicillin resistance.
5. The Lederberg’s set out to answer the question; did the colonies on the new plate evolve antibiotic resistance because they were exposed to penicillin? The answer is no:When the original plate is washed with penicillin, the same colonies (those in position X and Y) live — even though these colonies on the original plate have never encountered penicillin before.

   So the penicillin-resistant bacteria were there in the population before they encountered penicillin. They did not evolve resistance in response to exposure to the antibiotic.

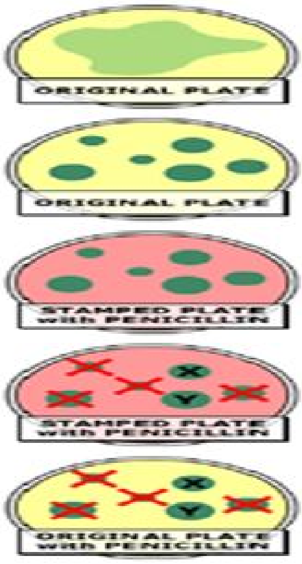


Fig. 4.2. *Esther and Joshua Lederberg experiment*

Thus, different mutations exist in population and are selected for expression when the environment is appropriate.

Genetic drift or Sewall-Wright effect

In each generation, some individuals may, just by chance, leave behind a few more descendents (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the “lucky” individuals, not necessarily the healthier or “better” individuals. That, in a nutshell, is **genetic drift.** It happens to all populations — there’s no avoiding the vagaries of chance.

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.

Bottlenecks and founder effects

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

Population bottlenecks occur when a population's size is reduced for at least one generation. Because genetic drift acts more quickly to reduce genetic variation in small populations, undergoing a bottleneck 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.

Reduced genetic variation means that the population may not be able to adapt to new selection pressures, such as climatic change or a shift in available resources, because the genetic variation that selection would act on may have already drifted out of the population.

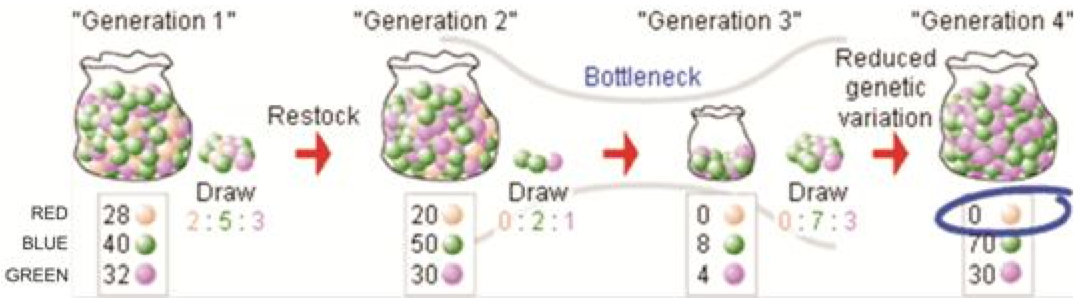


Fig 4.2. Population bottlenecks occur when a population's size is reduced for at least one generation. Because genetic drift acts more quickly to reduce genetic variation in small populations, undergoing a bottleneck can reduce a population's genetic variation by a lot, even if the bottleneck doesn't last for many generations. This is illustrated by the bags of marbles shown above here red marbles completely lost from the sample in the final generation.

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 genes 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.

Founder effect

A founder effect occurs when a new colony is started by a few members of the original population. This small population size means that the colony may have:

- Reduced genetic variation from the original population.
- A non-random sample of the genes in the original population.

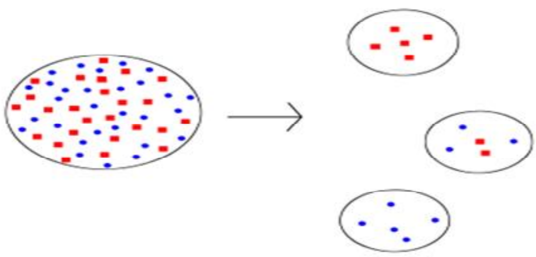


Fig. 4.3. Founders effect occurs when a new colony is started by a few members of the original population.

For example, the African population of Dutch settlers in South Africa is descended mainly from a few colonists. Today, the Afrikaner population has an unusually high frequency of the gene that causes Huntington's disease, because those original Dutch colonists just happened to carry that gene with unusually high frequency. This effect is easy to recognize in genetic diseases, but of course, the frequencies of all sorts of genes are affected by founder events.

Another example; when humans take a few individuals of some organism and try to establish a population of them in some other country where they do not exist (founder effect) or when humans kill a lot of individual of some population (ex. Tigers and leopards in India) so that only few individuals remain (bottleneck effect).

Example-1: Genetic variability in the natural populations is generated by **[B.H.U.-2015]**

(a) Genetic drift (b) Sewall-Wright effect

(c) Mutation (d) Selection

Ans. (c) Mutations

Soln. It is a permanent alternation of the nucleotide sequence of the Genome of an organism and it causes the genetic variability in natural population.

Example-2: Due to founder effect in a population, the degree of genetic variability:

(a) Is similar to original population (b) Remains constant **[B.H.U.-2016]**

(c) Is increased (d) is reduced

Soln. In founder effect, only few individual seek & adapt in new place. And upcoming generations of this species at this place show genetic composition of this group of individual. But, this group is not representing the actual or original gene pool of their parent population. So, their genetic diversity of this founder's population is somewhat less then original population.