Gene Pools & Allele Frequency

Gene Pool: the total of all the genes / alleles present in a population
Species: a group of organisms that can interbreed and produce fertile offspring.
Population: a group of organisms belonging to the same species in a particular area. All members of a population have the potential to interact and breed with each other. Individuals that are isolated from one another are members of different populations.

Allele Frequency: the proportion of each allele (different versions of a gene) within a population. The allele frequency can be seen by converting the number of each allele to a percentage.

Genetic Variation: the number of different alleles (or allelic combinations) within a population.

Mutations
Mutations are any permanent changes to the sequence of bases in an individual’s genome. Mutations are the source of new alleles (and thus ultimately the source of all variation).

Entering the gene pool
Not all mutations introduce new alleles into a population. Mutations may not enter the gene pool because:
- They are somatic.
- Most gametes go unfertilised (gamete redundancy).
- They are lethal.

Becoming established within the gene pool
If the mutant allele is disadvantageous in some way (reduces fitness), then the allele may simply be lost from the population. However, if the new allele conveys some adaptive / competitive advantage (it increases fitness), the frequency of the new allele will increase. This occurs as a result of natural selection.

Gene Flow
Gene flow is the movement of genes into or out of a population. This may involve:
- Immigration - when new individuals enter the population
- Emigration - when individuals leave the population

Gaining & losing alleles through gene flow
Gene flow tends to reduce the differences between populations because members of each population can interbreed and genes are essentially shared or transferred between the two populations. This makes the two gene pools become more similar. Gene flow can have a greater effect on smaller populations. In a small population some individuals might be the only ones to carry a particular allele. If they leave the population that allele might be lost entirely. In a larger population it is likely that some other individuals will still possess the same allele. When an individual immigrates into a population they might introduce a new allele. Therefore gene flow can result in the loss or introduction of new alleles.

If two populations become isolated from one another and there is no gene flow between them, they may develop into two distinct species. This process is known as speciation. As the two populations evolve under slightly different selection pressures they can become so different that they can no longer interbreed or produce fertile offspring.

Two populations don't have to be geographically isolated from one another for speciation to occur. Speciation occurs when there is little or no inter-breeding (gene flow) between the two groups. Speciation is the result of reproductive isolation.

Genetic Drift
Genetic drift is any random change to the allele frequency of a population due to chance events. Chance has a role in determining whether a given individual survives and reproduces. Some individuals might produce more offspring and others might die and produce no offspring, not because of any selection pressure, but by pure chance.

Genetic drift has a much greater impact on the allele frequency of smaller populations. In a small population, if an individual dies due to a chance event, they may be the only one that carries a particular allele. Thus, genetic drift can result in the loss of alleles and reduce genetic variation. Genetic drift has a much smaller impact on larger populations where random increases / decreases in allele frequencies are more likely to offset each other (e.g. some individuals with blond hair will have less of it, but others will have more). This is why the allele frequencies are more stable in larger populations.

Selection
Biological Fitness: Populations of sexually reproducing organisms consist of varied individuals. The fittest individuals are those that are best adapted to their environment.

Selection Pressures: The factors that determine which characteristics are most favourable are known as selection pressures. These can include environmental factors, predators, food sources, etc.

Natural Selection: The fittest individuals (the best adapted) have greater reproductive success; they pass on their genes to a larger number of offspring. As a result the frequency of the alleles that code for their adaptations will increase over subsequent generations.

The range of variation within a population for a particular trait can generally be fitted to a bell curve with the majority of individuals clustered somewhere in the middle. Fewer individuals possess the phenotypic extremes at each end of the range.

Types of Natural Selection
Stabilising Selection - favours the most common phenotype as the best adapted. This reduces variation by selecting against alleles that produce more extreme phenotypes at either end of the phenotypic range. The resulting bell shaped curve is narrower.

Directional Selection - favours alleles that produce phenotypes at one extreme of a phenotypic range. Selection reduces variation at one extreme of the range while allowing variants at the other end. The resulting bell shaped curve shifts in the direction of the selection.

Disruptive Selection - favours alleles that code for phenotypes at both extremes of a phenotypic range. The bell shaped curve acquires two peaks. Disruptive occurs when environmental conditions are varied or when the population covers a large area.

Artificial Selection
Involves breeding individuals with the most desirable phenotypes (selective breeding). While this works in the same way as natural selection, selection imposed by humans is often more rapid and intense than that occurring in nature.

Sexual Selection
Individuals usually carefully select a mate that has desirable traits (adaptations). By selecting a mate that is well adapted to the environment (greater biological fitness) there is a greater chance the offspring will inherit these traits too.

Population Bottleneck
A population bottleneck occurs when a population is reduced to a small number of survivors. This can occur because of natural seasonal climate change, heavy predation, disease or catastrophic events (e.g. floods, volcanic eruptions, landslides). The small number of individuals that survive will not be representative of the original, larger gene pool. Some alleles will be over-represented, some will be under-represented and some alleles will have been lost entirely. Even once the population has recovered the allele frequencies won't be the same as they were in the original population.

Population bottlenecks reduce the genetic diversity of populations because they result in the loss of alleles.

Following a bottleneck, the small surviving population will be impacted more severely by genetic drift and inbreeding.

Founder Effect
If a small number of individuals emigrate or become isolated from their original population the colonising or founded population may not be a representative sample of the alleles in the parent population’s gene pool. Some alleles will be over-represented, some will be under-represented and some alleles will have been lost entirely. The newly founded population may be successful and eventually grow in numbers, even beyond that of the original ancestral population. However, the allele frequencies of these populations will still be markedly different. Some alleles would not have been present in the small group of founders and will therefore also be absent in their offspring. As a result some alleles will be missing in the new population.

The underlying principles of founder effect and population bottlenecks are the same. A population is founded by, or reduced to a small number of survivors resulting in a loss of genetic diversity.

Inbreeding occurs when closely related individuals produce offspring together. When related individuals reproduce there is an increased chance that their offspring will inherit a genetic disorder because related individuals are more likely to carry recessive alleles for the same gene. Inbreeding reduces the number of new alleles combination (genetic diversity) and is often a problem in small populations.