

Question 3: **What factors affect allele frequencies?**

Population genetics is a branch of genetics that involves the study of the frequency of particular alleles or traits in a population. Among its many crucial components, population genetics involves the principle of the Hardy-Weinberg theory or equilibrium as other authors may ascribe to the theory. The Hardy-Weinberg equilibrium states that the allele frequencies in a population remain constant from one generation to the next. This principle helps predict the probability of off-springs to inherit particular traits in a population.

The Hardy-Weinberg equilibrium also has what is called the Hardy-Weinberg equation. This equation simply illustrates the above stated theory, the Hardy-Weinberg theory. The equation is as below;

$$p + q = 1$$

$$p^2 + 2pq + q^2 = 1$$

Where p is the frequency of the "A" allele and q is the frequency of the "a" allele in the population. In the equation, p^2 represents the frequency of the homozygous genotype AA, q^2 represents the frequency of the homozygous genotype aa, and $2pq$ represents the frequency of the heterozygous genotype Aa.

However, the Hardy-Weinberg theory does not apply to our real life that is subject to changes. As a result, the Hardy-Weinberg Equilibrium only applies to ideal situations. This is to say situations that are not affected by the changes that affect populations. Some among the many factors that bring about changes include; natural selection, non-random mating, gene flow (migration), genetic drift, Artificial selection, and mutations.

The factors affecting changes in allele frequency can be divided into two categories: systematic processes, which are predicable in both magnitude and direction and dispersive processes, which are predictable in magnitude but not direction. The three systematic processes are migration, mutation, and selection (both artificial and natural). Dispersive processes are a result of sampling in small populations.

This assignment addresses these factors and how they affect allele frequencies in a population.

1. Migration (Gene Flow)

When talking about population genetics, migration also refers to gene flow. The two words are often used interchangeably. The term migration means the movement of individuals between populations, whereas gene flow is the movement of genes between populations. New genes would be established in the population if the immigrant successfully reproduces in its new environment, but if it doesn't reproduce migration would still have occurred while gene flow would have not.

Migration or gene flow can introduce new alleles into a population at a rate and at more loci than expected from mutation. It can also alter allele frequencies if the populations involved have the same alleles but not in the same proportions. Thus the effect of migration on changes in allele frequency depends on differences in allele frequencies (migrants vs. residents) and proportion of migrants in the population.

2. Mutations

Mutation is the spontaneous change in a change in a gene or chromosome number. These changes can be beneficial or harmful to the organism and species. As such, mutations cause many changes in allele frequencies.

Mutations include changes as small as the substitution of a single DNA building block, or nucleotide base, with another nucleotide base. Meanwhile, larger mutations can affect many genes on a chromosome. Along with substitutions, mutations can also be caused by insertions, deletions, or duplications of DNA sequences. Some mutation can be transferred from parent to offspring while others cannot.

Mutations can be introduced due to mistakes made during DNA replication or due to exposure to mutagens, which are chemical and environmental agents that can introduce mutations in the DNA sequence, such as ultraviolet light. Some mutations do not result in changes in the amino acid sequence of the encoded protein and can be described as silent mutations. Other mutations result in abnormal protein products. Mutations can introduce new alleles into a population of organisms and increase the population's genetic variation.

3. Natural Selection

The process by which comparatively better adapted individuals out of a heterogeneous population are favored by Nature over the less adapted individuals is called natural selection. There are about three types of natural selection. These are; stabilizing or balancing selection, progressive selection and disruptive selection. Stabilizing selection leads to the elimination of organisms having overspecialized characters and maintains homogenous population which is genetically constant. In progressive or directional selection, the population changes towards one particular direction along with change in environment. And for disruptive selection, it favours extreme expressions of certain traits to increase variance in a population. It breaks a homogeneous population into many adaptive forms and results in balanced polymorphism.

The process of natural selection operates through differential reproduction. It means that those individuals, which are best adapted to the environment, survive longer and reproduce at a higher rate and produce more offsprings than those which are less adapted. If differential reproduction continues for a number of generations, and then the genes of those individuals which produce more offsprings will become predominant in the gene pool of the population

Due to sexual communication, there is free flow of genes so that the genetic variability which appears in certain individuals, gradually spreads from one population to population and then on neighboring sister populations and finally on most of the members of a species. So natural selection causes progressive changes in gene frequencies, i.e. the frequency of adaptive genes increases while the frequency of less adaptive genes decreases.

4. Non-random mating

When a population interbreeds, nonrandom mating can sometimes occur because one organism chooses to mate with another based on certain traits. In this case, individuals in the population make specific behavioral choices, and these choices shape the genetic combinations that appear in successive generations. When this happens, the mating patterns of that population are no longer random.

Nonrandom mating can occur in two forms, with different consequences. One form of nonrandom mating is inbreeding, which occurs when individuals with similar genotypes are more likely to mate with each other rather than with individuals with different genotypes. The second form of nonrandom mating is called outbreeding, wherein there is an increased probability that individuals with a particular genotype will mate with individuals of another particular genotype. Whereas inbreeding can lead to a reduction in genetic variation, outbreeding can lead to an increase.

5. Genetic drift

Genetic drift occurs in small populations, where infrequently-occurring alleles face a greater chance of being lost. Once it begins, genetic drift will continue until the involved allele is either lost by a population or is the only allele present at a particular gene locus within a population. Both possibilities decrease the genetic diversity of a population.

Genetic drift is common after a population experiences a population bottleneck. A population bottleneck arises when a significant number of individuals in a population die or are otherwise prevented from breeding, resulting in a drastic decrease in the size of the population. Genetic drift can result in the loss of rare alleles, and can decrease the size of the gene pool. Genetic drift can also cause a new population to be genetically distinct from its original population, which has led to the hypothesis that genetic drift plays a role in the evolution of new species.

6. Distribution

Distribution basically refers to the physical assortment of a population in a particular location. A species with a broad distribution rarely has the same genetic makeup over its entire range. For example, individuals in a population living at one end of the range may live at a higher altitude and encounter different climatic conditions than others living at the opposite end at a lower altitude. In such a setup with the same population being in different locations, the relative allele frequencies differs almost hugely. As such, Distribution is one way that genetic variation can be preserved in large populations over wide physical ranges, as different forces will shift relative allele frequencies in different ways at either end.

If the individuals at either end of the range reconnect and continue mating, the resulting genetic intermixing can contribute to more genetic variation overall. However, if the range becomes wide enough that interbreeding between opposite ends becomes less and less likely, and the different forces acting at either end become more and more pronounced, and the individuals at each end of the population range may eventually become genetically distinct from one another.

Conclusion

The change in allele frequencies can be beneficial or disadvantageous to the population or species of the organism. It can be beneficial if it helps the organism survive in extreme condition and can be harmful if they make a population die easily when environmental changes occur.

It is also important to note that change in allele frequencies will lead to change in genotypes of organisms and populations. And the new genotypes will be transferred to the offsprings. This as the result brings about new breeds of organism in populations. But again, this can either be advantageous or disadvantageous to populations.