CIE Biology GCSE

18: Variation and selection

Notes

Variation

Variation refers to the **differences** between each organism in a species. Variation is beneficial to a species as it **allows natural selection** to occur and **reduces the risk of extinction** from **disease**. There are two types of variation: **genetic variation** and **phenotypic variation**.

- **Genetic variation** - each organism in a species has a different set of DNA, which is due to genetic variation. Genetic variation is increased during meiosis, which produces gametes. Each gamete has a different set of alleles, which means that when the two gametes fuse an entirely new set of genes are produced.

- **Phenotypic variation** - The phenotype of an organism refers to its observable characteristics, such as height or hair colour. Phenotypical variation can be caused by both **genetic and environmental factors**. For example, the potential height of an organism is decided in genes which come from the parents, although some organisms will never reach this height as they do not receive enough nutrients from their environment.

Variation can be **continuous** and **discontinuous**. Continuous variation results in a **range of phenotypes between two extremes**, for example height or weight. Discontinuous variation, however, is limited to a **discrete number of categories**, such as blood group, which is limited to A, B, AB, or O in humans. Discontinuous variation is mainly **caused by genes alone**.

Mutations:
Mutations are **genetic changes** which result in a **change in the sequence of DNA bases**. These changes can occur due to a variety of factors, including exposure to some **chemicals** and **ionising radiation**. If the mutation occurs at a particular allele, this allele may be altered, changing how it functions. This is how **new alleles are formed**.

An example of this is **sickle-cell anemia**: sickle-cell anemia is a condition where **red blood cells become sickle shaped**. Sickle cells **carry less oxygen** and can **block blood vessels**. This condition is caused by a **mutation** in the beta-haemoglobin gene, which alters the allele which produces haemoglobin (protein). This allele is **recessive**; thus, it is only present in the phenotype if two copies of this allele are present (homozygous). The mutation can also have positive effects; people who are homozygous or heterozygous, i.e. have one sickle-cell allele and one un-mutated allele, are **immune to malaria**, as the malaria parasite **cannot infect the sickle-shaped cells**. Sickle-cell anemia is therefore commonly found in areas where malaria is common. This shows that **natural selection** for this gene is occurring in these areas, as those with the gene do not catch the disease and are **more likely to survive**. This allows this allele to be preserved.

Adaptations

Adaptive features are **inherited functional features** that help the organism by increasing its **fitness**, which is the ability of the organism to **survive and reproduce** in its environment.

Xerophytes are plants that are adapted to live in **very dry climates**, such as cacti. They have a number of adaptive features that help to increase survival by **reducing water loss**:

- **Fewer stomata** - water vapour diffuses out of the plant via the stomata, thus less water is lost if there are fewer stomata. Stomata are also sunken in pits in the leaf, which allows bubbles of moist air to be trapped around them. This lowers the water potential gradient, so less water is lost from the leaf.
- **Small, rolled leaves or spines** - this reduces the surface area of the leaf and traps moisture to lower the water potential gradient, reducing water loss.
- **Deep roots** - this allows plants to absorb water from the soil. Roots are also adapted to absorb lots of water when it rains for storage, e.g. in monsoon seasons.
- **Thick waxy cuticle** - this provides a waterproof barrier around the leaf to prevent water loss.

Hydrophytes, in contrast, are plants which are adapted to live in **very wet conditions** and includes species such as the water lily and the lotus. These plants are adapted differently to xerophytes as they **do not need to minimize water loss**:

- **Leaf shape** - leaves are usually large and flat to have a large surface area which promotes water loss.
- **Stomata** - positioned on the top of the leaf where the sun hits. There is also a large number of stomata, which are usually open to allow water vapour to diffuse out of the leaf.
- **Thin/no waxy cuticle** - water loss does not need to be restricted by this layer in hydrophytes.
- **Small root system** - as there is a large amount of water reliably available, root systems can be shallow, and water can diffuse directly into the stem.

Selection

Natural selection is where organisms with **favourable alleles** and **advantageous characteristics** have a **higher probability of surviving and reproducing**. This is due to **competition** within a population for resources and mates. As there is **variation** in the alleles of each species, each organism within a species has different traits, some positive and some negative. Those with more positive traits can **adapt** to the environment more effectively and are thus is more likely to survive and produce many offspring, which inherit these alleles. **Over time, negative characteristics are lost** from the species as organisms with those characteristics are not able reproduce to pass on their alleles. This is known as **evolution**. Evolution allows a population to become **more adapted** to its environment over time, as a result of natural selection.

Antibiotic resistance:

Some bacterial strains become **resistant** to antibiotics as a result of **natural selection**:

1. A **mutation** occurs in a bacterial cell allele which makes it resistant to an antibiotic.
2. When that antibiotic is administered, this **cell is not killed,** whereas cells which have not become resistant are killed.
3. The resistant cell can therefore survive and **reproduce**, passing on the resistant allele to produce more resistant bacteria.

Selective breeding:

Selective breeding is where humans select animals or plants with **desirable features** and breed these together to make more offspring with these desirable features. This process is repeated over many generations. As this breeding is controlled by humans, it is known as **artificial selection**.

An example of selective breeding of animals is the German Shepherd. These dogs were originally bred as working dogs to herd sheep as they are known for their intelligence and agility. Humans selectively breed these dogs to **exaggerate desirable qualities**, such as their sloping backs and large ears. This involves crossing dogs which show these traits so that the **alleles are passed on to their offspring**. Farmers also selectively breed crops. For example, bananas are selectively bred for their size, shape and easiness to peel. This means that plants which express these characteristics are bred to produce more offspring with desirable characteristics.