WJEC Biology A-level

Topic 4.4: Variation and evolution

Notes

Phenotype – the **characteristics of an organism**, which result from the **interaction of the genes of the organism with the environment** in which it lives.
There are two types of variation in phenotype – **continuous and discontinuous**. Continuous variation is variation within a range and it includes mass and height whereas discontinuous variation can only take particular values – such as gender or shoe size.
Variation in genotype has an effect on variation in phenotype. Some characteristics are influenced by one gene only and are known as **monogenic**. Such characteristics show **discontinuous variation**. Sometimes times several genes at different loci are involved in determining a characteristic – this is known as **polygenic inheritance and often gives rise to continuous variation.**

Some characteristics are influenced by both genotype and the environment. Examples include:

- **Height** is a polygenic characteristic. However, an organism might not reach its maximum height due to **poor nutrition** which is an environmental factor.
- Some people can be genetically predisposed to **lung cancer** due to the presence of **proto-oncogenes** which regulate the cell cycle. Smoking exposes them to chemicals which convert these genes into active oncogenes in lung cells thus leading to **uncontrolled cell division** in the lungs which can result in lung cancer.
- **Animal hair colour**, for example Siamese cat hair colour is determined by both genotype and environment. Siamese cats have a gene coding for enzyme **tyrosinase** which darkens the fur which is active only below 31 degrees therefore only **body extremities** of Siamese cats are dark.

Natural selection and evolution

The **niche** of a species is **its role within the environment**. Species which share the same niche compete with each other and a better adapted species survive. The idea that better adapted species survive is the basis of **natural selection.**

Organisms are adapted to their environment in various ways:

- **Anatomical adaptations** are **physical adaptations**, either external or internal e.g. presence of loops of Henlé which allow desert mammals to produce concentrated urine and minimise water loss
- **Behavioural adaptations** are **changes in behaviour** which improve the organism's chance of survival e.g. mating calls
- **Physiological adaptations** are **processes inside an organism's body** that increase its chance of survival e.g. regulation of blood flow through the skin

Natural selection is the process in which **fitter individuals** who are betted adapted to the environment **survive and pass on the advantageous genes to future generations.** Evolution is the process by which the **frequency of alleles in a gene pool changes over time as a result of natural selection.**

Evolution via natural selection:

- There's a **variety of phenotypes** within a population
- An **environmental change occurs** and as a result of that the **selection pressure changes**
- Some individuals possess **advantageous alleles which give them a selective advantage and allow them to survive and reproduce**
- The **advantageous alleles are passed on to their offspring**
- Over time, **the frequency of alleles in a population changes** and this leads to evolution

Factors that can affect the evolution of a species:

- **Genetic drift** is a phenomenon where there is a small change in allele frequency which occurs as a result of the fact that not all the individuals in a population reproduce. This effect is amplified in very small groups, isolated from the rest of the population.
- **Genetic bottleneck** – rapid reduction in population size which has an effect on the population size and genetic variation in future generations.
- **Founder effect** – decrease in genetic diversity which occurs when the population descends from a small number of ancestors.

Speciation is the process by which new species arise after a **population becomes separated** and **cannot interbreed**. For instance, **allopatric speciation** is caused by a **physical barrier**. As the two groups become separated and reproductively isolated as a result, the **gene flow is reduced**. Each group experiences a different selection pressure as the environment they live in is different. Over time, the frequency of alleles changes through **natural selection** and the two parts of the population **can no longer interbreed and become separate species.** Another type of speciation is **sympatric speciation** where new species evolve from a **single ancestral species** when **inhabiting the same geographic region**, for example as a result of a **chromosomal error during cell division** which leads to **reproductive isolation.**

The **Hardy-Weinberg Equation** can be used to **estimate the frequency of alleles in a population** and to see whether a **change in allele frequency is occurring in a population over time.**
p = the frequency of the **dominant** allele (represented by A)
q = the frequency of the **recessive** allele (represented by a)
For a population in genetic equilibrium:
p + q = 1.0 (The sum of the frequencies of both alleles is 100%.)
$(p + q)^2 = 1$ so $p^2 + 2pq + q^2 = 1$
The three terms of this binomial expansion indicate the frequencies of the three genotypes:
p^2 = frequency of AA (**homozygous dominant**)
2pq = frequency of Aa (**heterozygous**)
q^2 = frequency of aa (**homozygous recessive)**