Edexcel (A) Biology A-level

Topic 4: Biodiversity and Natural Resources

Notes

Biodiversity

Biodiversity is the **variety of living organisms.** Over time the variety of life on Earth has become extensive but is now being **threatened by human activity** such as deforestation. Biodiversity can be measured in terms of:

- **Species richness** - the **number of different species in a habitat.**
- **Genetic diversity** - a measure of the **genetic variation** found in a particular species, in other words the **number of alleles in a gene pool**.

Biodiversity within a species can be measured by calculating the heterozygosity index:

H= number of heterozygotes / number of individuals in the population

Biodiversity can also be measured, and therefore compared between different habitats, using the **index of diversity (D)**:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

D = Diversity index

N = total number of organisms

n = total number of organisms of each species

Σ = the sum of

Endemism is the state of a species being **unique to a particular geographic location,** such as an island, and not found anywhere else.

Natural Selection and Evolution

The ecological **niche** of a species is **its role within the community**. Species which share the same niche compete with each other; the better-adapted species will outcompete the other forcing it to alter the niche it occupies or it could die. 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 long 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** that increase an organism's chance of survival e.g. regulation of blood flow through the skin.

Natural selection is the process in which **fitter individuals** who are better adapted to the environment **survive and pass on the advantageous alleles 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:

- A **variety of phenotypes** exist within a population due to mutation.
- 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**.

The **Hardy-Weinberg Equation** can be used to **estimate the frequency of alleles in a population** and to **monitor changes in allele frequency.**

p = the frequency of the dominant allele (represented by A)
q = the frequency of the recessive allele (represented by a)
p^2 = frequency of AA (homozygous dominant)
2pq = frequency of Aa (heterozygous)
q^2 = frequency of aa (homozygous recessive)

For a population in genetic equilibrium:

$p + q = 1.0$

$(p + q)^2 = 1$ hence
$p^2 + 2pq + q^2 = 1$

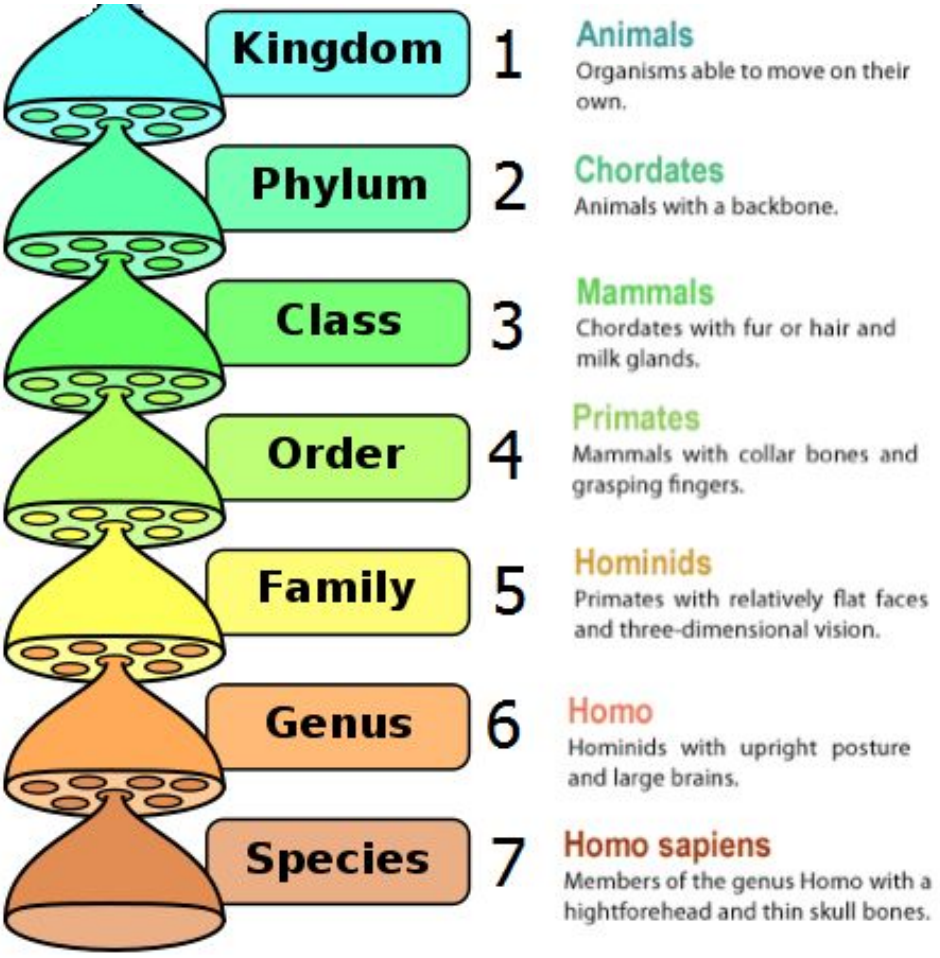
Conditions of the Hardy-Weinberg Equation:
- No mutations
- Random mating
- Large population
- Isolated population
- No selection pressure

If two populations become **reproductively isolated**, new species will be formed due to accumulation of different genetic information in populations over time due to different environments and selection pressures. This is speciation and may be either **allopatric** (in which groups of organisms are geographically isolated) or **sympatric** (in which they are isolated by other means, within the same area) .

Classification

Classification is a means of organising the variety of life based on relationships between organisms using differences and similarities in phenotypes and genotypes. In the five-kingdom model for classification, organisms can be grouped into one of the five kingdoms: **animals, plants, fungi, protists and monera**. Within each kingdom they can then be grouped further into **phylum, class, order, family, genus and species**.

Each species is named according to the **binomial system**, the first part of the name is the genus and the second part of the name is the species e.g. *Homo sapiens*.

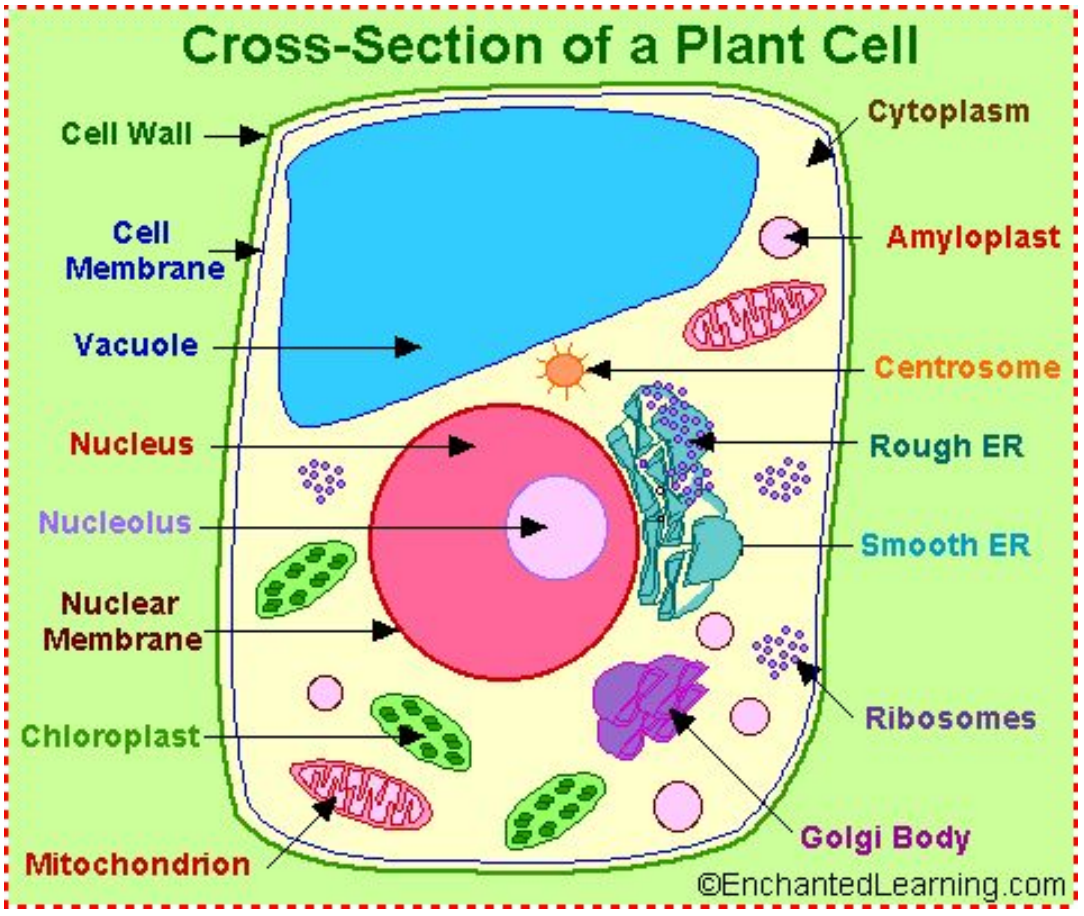


The analysis of molecular differences in different organisms to determine the extent of their evolutionary relationship is known as **molecular phylogeny**. The data obtained by molecular phylogeny has been accepted by scientists and this gave rise to new taxonomic groupings – the Three-Domain model of classification. In this (more recent) model, the five kingdoms are sorted into one of the **three domains: Bacteria, Archaea and Eukaryota.** The monera are split between the bacteria (eubacteria) and archaebacteria.

The scientific community evaluates the data in the following ways:

- The findings are published in **scientific journals** and presented at **scientific conferences**.
- Scientists then study the evidence in a process called **peer review.**

Plant Cells



Plant cells, like animal cells, are eukaryotic cells, meaning they have a nucleus and membrane-bound organelles. However, they also possess several structures which aren't present in animal cells:

- **Cell wall** - made of **cellulose**. The cell wall is made up of the **middle lamella,** which is made of calcium pectate and holds adjacent cells together and cellulose microfibrils and microfibres.
- **Plasmodesmata** - an extension of cytoplasm between the cell wall of adjacent cells involved in the transport of substances between them.
- **Pits** - thin sections of the cell wall which also allow communication between adjacent cells.

- **Chloroplasts** - the site of photosynthesis. They contain stacks of **thylakoid** membranes called **grana** containing **chlorophyll.** The grana are connected by extensions of thylakoid membranes called **lamellae.** Grana are surrounded by a colourless fluid called **stroma** which contains all the enzymes required for photosynthesis. Chloroplasts are bound by a double membrane called the **envelope**.
- **Amyloplasts** - organelles, surrounded by a double membrane, which contain **amylopectin (starch)**.
- **Vacuole** - contains **cell sap** and is surrounded by a **tonoplast** (single membrane). Provides the cell with strength and support.

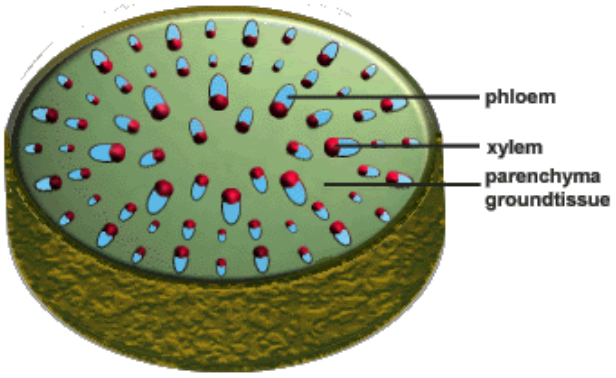
Transport in Plants

Carbohydrates are molecules which consist only of carbon, hydrogen and oxygen. They are long chains of sugar units called saccharides. There are three types of saccharides: **monosaccharides, disaccharides and polysaccharides**. Monosaccharides can join together to form disaccharides and polysaccharides by **glycosidic bonds** which are formed in **condensation reactions**.

Cellulose is a component of cell wells in plants and is composed of long, unbranched chains of **beta glucose** which are joined by glycosidic bonds. **Microfibres formed of microfibrils** are strong threads which are made of long cellulose chains joined together by **hydrogen bonds** and they provide **structural support** in plant cells.

Plants have a vascular bundle, containing various components for transport and support:

- **Xylem vessels** transport **water and minerals,** as well as provide **structural support**. They are long cylinders made of dead tissue with open ends. Xylem vessels are thickened with a tough substance called lignin.
- **Phloem vessels** are tubes made of living cells which are involved in translocation, which is the movement of food substances and nutrients from leaves to storage organs.
- Cambium cells between xylem and phloem are undifferentiated and able to specialise as the plant grows
- **Sclerenchyma fibres** provide **structural support**. They are short structures made of dead cells with a hollow lumen and end walls. They're also thickened with lignin.
- **Parenchyma cells** (pith) act as packing between other cells and vessels



Plants fibres are very useful to humans, for instance:

- They are a **sustainable and renewable resource,** as the plants they are extracted from can be regrown.
- Plant fibre products are **biodegradable,** as they can be broken down by microbes, as opposed to materials made from non-renewable resources such as oil based plastics.
- Plant fibres are **very strong** and therefore can be used to make materials such as ropes and fabrics.
- Production of plant fibre products is **cheaper** than oil-based ones.
- Starch can be used to make **bioplastics and bioethanol,** which is a fuel.

Water and Inorganic Ions

- Water is required in plants for **photosynthesis**, maintaining **structural rigidity**, **transport of substances,** and **thermoregulation**.
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- **Magnesium ions** are important as they are involved in **chlorophyll production**. They also activate some of the plant enzymes.
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- **Nitrate ions** supply nitrogen for making **DNA, RNA, proteins,** and **chlorophyll**.
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- **Calcium ions** are a component of the **plant cell wall** – they form **calcium pectate**. They're also **essential for plant growth**.

Drug Testing

William Withering's digitalis soup experiment, in which he isolated the active ingredient from foxglove and then tested different doses on patients and recorded the findings, led to the development of contemporary drug testing protocols.

There are 3 stages of contemporary drug testing:

- **Phase 1,** during which a range of doses of the drug is tested on a **very small group of people** to see if it is **safe to use**.
- **Phase 2,** during which the drug is tested on **a small group of patients with the condition** to see if it has any **effect on the condition**.
- **Phase 3** is the last phase, in which a **large group of patients** is given the drug to assess the effectiveness of the drug, as well as record type and frequency of side effects. This phase involves a **double blind trial,** meaning neither the doctors nor the patients know who is given the actual drug and who is given a **placebo** (a chemically inactive substance that resembles the drug being tested to determine psychological impact or the strength of the **placebo effect**).

Conservation

Conservation can be in-situ (in an organism's habitat) or ex-situ (outside of an organism's habitat). Both methods of conservation have risks and benefits.

Ex-Situ:

- **Captive breeding programmes** e.g. in zoos, in which endangered species are carefully bred to increase genetic diversity and population size. Genetic diversity is maintained via exchange of organisms and gametes, keeping stud books, preventing inbreeding and use of techniques such as IVF AI. **Reintroduction programmes** aim to release animals bred in captivity into their natural habitat as well as to restore lost habitats.
- **Seed banks** store a large number of seeds in order to **conserve genetic diversity** and prevent plant species from going **extinct**. Storing seeds instead of plants means that a **large variety of species can be conserved**, it's also cheaper than storing whole plants as it takes up **less space**. The seeds are stored in **cool, dry conditions** as this maximises the amount of time they can be stored for and they are **periodically tested for viability**.

In-Situ:

- **Education programmes** which aim to educate people about the importance of maintaining biodiversity, captive breeding programmes as well as illegal trade of animal products.

- Initiatives such as **National Parks** and **Sites of Specific Scientific Interest** aim to conserve habitats and biodiversity.