

CAIE Biology A-level

Topic 18: Biodiversity and classification

Notes

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

- **Species richness** - the **number of different species in a community**. This can be measured by simply counting the number of species present via methods such as **random sampling**. Random sampling is important to determine the **biodiversity** of an area to **avoid bias**.
- **Genetic diversity** - a measure of the **genetic variation** found in a particular species. In other words, it is the **number of alleles in a gene pool**. It can be determined by calculating **the heterozygosity index (H)**. The higher the heterozygosity index (H), the more genetically diverse the species.

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

Biodiversity can also be measured using the **index of diversity (D)** which can be calculated as follows:

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

Key to symbols:

- n = number of individuals of each type present in the sample (types may be species and/or higher taxa such as genera, families, etc.)
- N = the total number of all individuals of all types present in the sample

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

A **species** is a group of organisms with similar **morphological and physiological features** that are able to **interbreed** to produce **fertile offspring**.

In conclusion, biodiversity can be assessed at different levels, including:

- the number and range of different ecosystems and habitats
- the number of species and their relative abundance
- the genetic variation within each species



Methods of measuring the distribution or abundance of organisms within an area:

Frame quadrat

A sampling technique using a square frame which is divided into equal sections like a grid. To measure species abundance, you can count the abundance of each species in each section of the frame. This quadrat can be used along a transect.

Line transect

A sampling technique which consists of making a line on the ground between 2 points within the sampled area. Species touching the line at regular intervals are recorded to determine the abundance and distribution of organisms in an ecosystem.

Belt transect

A sampling technique which consists of making **2 parallel lines** on the ground between 2 points within the sampled area. Quadrats are placed at intervals, and the species within/touching the quadrat are recorded to determine the abundance and distribution of organisms in an ecosystem.

Mark release and recapture

A method of **estimating the population size of** motile organisms. It involves capturing a sample of the population, marking them and releasing them. At a later date, another sample is captured and the number of marked individuals recorded. This method assumes a closed population, with no significant migration, births, or deaths between samples.

The population size can be estimated using the Lincoln index:

$$N = \frac{n_1 \times n_2}{m_2}$$

- N = estimated population size.
- n₁ = number of captured individuals in the first sample.
- n₂ = total number of individuals in the second sample (unmarked & marked individuals).
- m₂ = number of marked individuals in second sample.



Species and taxonomy

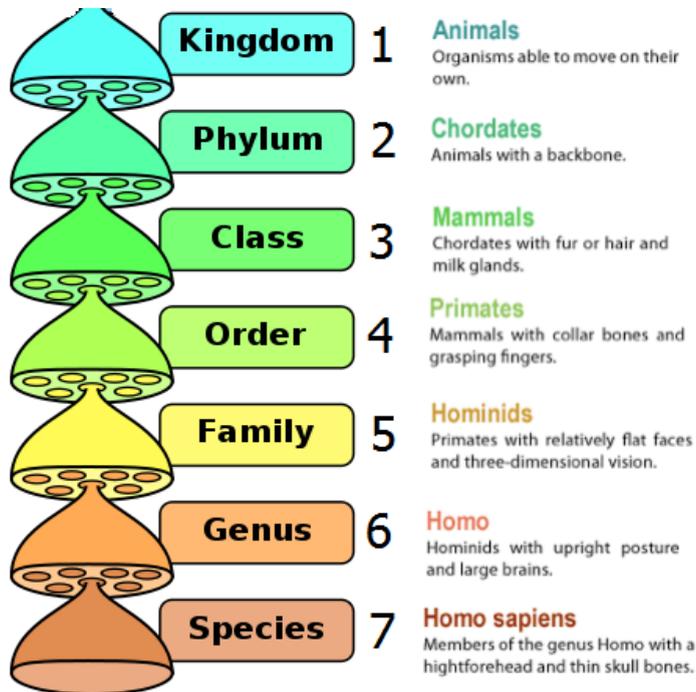


Figure SEQ Figure * ARABIC 1 Wikipedia

Classification is the process of **naming and organising organisms into groups based on their characteristics**. Organisms can be grouped into one of the **three domains: Bacteria, Archaea, and Eukarya**. Organisms can also be grouped into one of the four kingdoms: **Protocista, Fungi, Plantae and Animalia**.

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.



The three domains

Organisms are classified into **three domains** based on **molecular evidence**, particularly **DNA and RNA**, as well as **cell structure** and **biochemistry**. The analysis of molecular differences in different organisms to determine the extent of their evolutionary relatedness is known as **molecular phylogeny**.

Viruses are not included in the three domains as they are **non-living** and are not classed as cells. In taxonomy, they are instead classified by their type of nucleic acid (RNA or DNA) and whether they are single-stranded or double-stranded.

1. Bacteria

- **Prokaryotic** organisms - no nucleus or membrane-bound organelles.
- Circular DNA not associated with histone proteins.
- Cell walls contain **peptidoglycan**.
- Lipids in membranes consist of **ester bonds** linking fatty acids to glycerol.
- Ribosomes are **70S**.
- Many are pathogenic, but most are harmless or beneficial.

2. Archaea

- **Prokaryotic** organisms - no nucleus or membrane-bound organelles.
- Circular DNA associated with **histone-like proteins**.
- Cell walls **do not contain peptidoglycan**.
- Lipids in membranes consist of **ether bonds** linking fatty acids to glycerol.
- Ribosomes are **70S**.
- Many live in **extreme environments** (e.g. high temperature, high salinity).
- Genetically more similar to **Eukarya** than to bacteria as they share features such as histone-like proteins and similar ribosomal RNA

3. Eukarya

- **Eukaryotic** organisms - cells contain a **nucleus** and membrane-bound organelles.
- Linear DNA associated with **histone proteins**.
- Ribosomes are **80S**.
- Includes **animals, plants, fungi, and protocists**.



The four kingdoms

1. Animalia

- Multicellular.
- Presence of a nucleus and other membrane bound organelles.
- No cell wall.
- No chloroplasts.
- Able to move using **contractile proteins, flagella, or cilia**.
- They are **heterotrophic feeders** hence nutrients are acquired by ingestion.
- They store food in the form of glycogen.

2. Plantae

- Multicellular.
- Presence of a nucleus and other membrane bound organelles.
- Contain a **cellulose cell wall**.
- Contain chloroplasts as well as chlorophyll.
- Mostly unable to move.
- **Autotrophic feeders** - acquire food via photosynthesis.
- Store food in the form of starch.

3. Protocista

- Mostly **unicellular**.
- Presence of a nucleus and other membrane bound organelles.
- Some contain chloroplasts.
- Some can move due to the presence of cilia or flagella.
- Some are **autotrophic** (can make their own food), some are **heterotrophic**, and some can be **both**.
- Some may be **parasitic**.

4. Fungi

- Can be **multicellular** or **unicellular**.
- Presence of a nucleus and other membrane bound organelles.
- Contain a **chitin** cell wall.
- Contain no chloroplasts or chlorophyll.
- Cannot move.
- Most of them have a body or a **mycelium** composed of thread-like hyphae.
- **Saprophytic feeders** - acquire nutrients from dead or decaying matter.
- Some can be **parasitic**.
- Mostly store food in the form of **glycogen**.

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**.
- Scientists start **collecting evidence** to either **support or reject the suggestion**.



Conservation

- There are many threats to biodiversity in **aquatic** and **terrestrial** ecosystems. The threats include **loss of habitat** and **environmental degradation**, **climate change**, excessive use of **fertilisers** which leads to **pollution**, **overexploitation** and **unsustainable use of resources** as well as invasion of **alien species**. **Alien species** might outcompete the native organisms or introduce diseases therefore they need to be controlled.
- There are many **ecological, aesthetic, social and commercial** reasons to maintain biodiversity. For instance, microorganisms are a source of useful products such as antibiotics.
- **Zoos** use various methods to **conserve endangered species and their genetic diversity**, some of the methods used include: **captive breeding programmes** in which endangered species are carefully bred to increase genetic diversity and population size and **reintroduction programmes** which 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 is 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**.
- Other means of conserving endangered mammals include **assisted reproduction** in the form of **IVF, embryo transfer and surrogacy**.
- **Culling and contraceptive methods** are used to prevent overpopulation of protected and non-protected species.
- Non-governmental organisations such as **World Wide Fund for Nature (WWF)** and **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** play an important role in local and global conservation. For instance, WWF funds conservation projects and publicises environmental issues whereas CITES controls the trade of endangered species and their products.
- The **International Union for Conservation of Nature (IUCN)** an international organisation that helps coordinate conservation efforts between nations. They work together to conserve endangered animals. They play an important role in global conservation.



- **Degraded habitats** can be restored on a small scale by **planting new trees** on land that is no longer needed for food production and on a large scale by **replanting forests**.

Spearman's Rank Correlation and Pearson's Linear Correlation

Spearman's rank correlation and Pearson's linear correlation are statistical tests used to analyse the **relationship between two variables**, particularly when investigating how **biotic and abiotic factors affect the distribution and abundance of species**. In ecological studies, these tests help determine whether a change in one variable is associated with a change in another.

Spearman's rank correlation is used when data is **not normally distributed**, when the relationship is **not linear**, or when the data is given as **ranks rather than raw values**. The data for each variable is ranked, and the correlation coefficient (r_s) indicates the **strength and direction** of the relationship. A value close to **+1** indicates a strong positive correlation, a value close to **-1** indicates a strong negative correlation, and a value close to **0** indicates no correlation. Spearman's rank is commonly used in ecology, for example to analyse the relationship between **species abundance** and an **abiotic factor** such as soil moisture or light intensity.

Pearson's linear correlation is used when the data is **continuous, normally distributed**, and shows a **linear relationship**. It measures how closely the data points fit a straight line. The correlation coefficient (r) also ranges from **-1 to +1**, with values closer to the extremes indicating stronger correlations. Pearson's correlation may be used when analysing variables such as **population size** against **temperature** or **nutrient concentration**, provided the assumptions of the test are met.

In both tests, correlation does **not imply causation**. A significant correlation suggests a relationship between variables, but further investigation is required to determine whether one variable directly affects the other. In ecological contexts, correlations help identify how **biotic factors** (such as competition, predation, or disease) and **abiotic factors** (such as pH, temperature, or oxygen concentration) may influence where organisms are found and how abundant they are.

