Classification and biodiversity

Classification and the species concept, the three-domain system, biodiversity and endemism, measuring species richness, heterozygosity and the index of diversity, and niches and adaptations.

Classification

Classification organises the variety of life into groups based on **relationships** between organisms, using the **similarities and differences** in their **phenotypes** (structure) and **genotypes** (DNA and protein sequences). It is built around the **species** concept.

- A **species** is a group of organisms with similar characteristics that can **interbreed** to produce **fertile offspring**. The definition has limits: it does not apply to asexual organisms or fossils, and hybrids exist.
- The hierarchy: **domain, kingdom, phylum, class, order, family, genus, species** (each group within the next).
- The **binomial system** names an organism with its **genus** (capital letter) and **species** (lower case), in italics, e.g. *Homo sapiens*.

Evidence changes classification

Traditional classification used **morphology** (anatomy). New evidence, particularly **molecular** evidence such as DNA base sequences and the amino acid sequences of proteins, shows how closely organisms are related. The more similar the sequences, the more **recently** two species shared a common ancestor.

New data is critically evaluated by the **scientific community** (by peer review and by repeating the work), which leads to new groupings.

The three-domain system

Carl Woese's comparison of **ribosomal RNA** sequences led to the **three-domain system**, replacing the five kingdoms with:

Domain	Characteristics
Archaea	Prokaryotes; unusual membrane lipids; many live in extreme environments; RNA polymerase and ribosomes more like those of eukaryotes
Bacteria	Prokaryotes with peptidoglycan cell walls
Eukarya	Eukaryotic cells with a nucleus: protists, fungi, plants, animals

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Biodiversity

Biodiversity is the variety of living organisms. It includes **species diversity**, **genetic diversity** within a species, and **ecosystem diversity**. Over time the variety of life has become extensive, but it is now being **threatened by human activity**: habitat destruction, pollution, overexploitation, climate change and the introduction of invasive species.

Endemism: an **endemic** species is found only in a particular area (e.g. lemurs in Madagascar). Endemic species are especially vulnerable to extinction.

Measuring biodiversity

- **Species richness**: the **number of different species** in a habitat. It can be counted by sampling with **quadrats and transects** or pitfall traps. It does not show how many individuals there are of each.
- **Genetic diversity** within a species is measured by the **heterozygosity index**:

$$\text{heterozygosity index} = \frac{\text{number of heterozygotes}}{\text{number of individuals in the population}}$$

- **Index of diversity (D)** compares the biodiversity of habitats, taking the **abundance** of each species into account:

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

where N is the **total number of organisms of all species** and n is the **number of individuals of each species**.

> **TRY IT**
>
> A sample has 3 species with 10, 5 and 5 individuals. Calculate D.

$N = 20$. $N(N-1) = 380$. $\sum n(n-1) = 90 + 20 + 20 = 130$. $D = 380/130 = 2.9$. A higher D means greater diversity; a low D shows that a few species dominate.

A **low** index suggests an environment under stress (pollution) or one with few niches, while a **high** index suggests a stable, complex habitat.

Niche and adaptation

A **niche** is the **role** of a species in its habitat: its **habitat**, **food** and its interactions with other organisms and the environment. Two species cannot occupy exactly the same niche for long (competition).

Adaptations fit an organism to its environment:

- **Behavioural** (migration, hibernation, burrowing, courtship),
- **Anatomical** (structural: thick fur, a long beak, waxy cuticle, small leaves),

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- **Physiological** (processes: antifreeze proteins, production of concentrated urine, tolerance of salt).

Example: a camel has anatomical adaptations (humps for fat, broad feet), behavioural (resting in shade) and physiological (concentrated urine, tolerating a body temperature rise).

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