

Lecture 1: Foundations of Biology

1.1 Evolution through Natural Selection (Charles Darwin)

- All life evolved from **pre-existing life**.
- Evolution explains both:
 - the **diversity** of organisms
 - their **adaptation** to specific environments
- Evolution occurs at the level of **populations over generations**, not individuals within a lifetime.

Natural selection is the primary mechanism by which evolution occurs.

1.2 Darwin's Three Observations

Darwin's theory is based on three fundamental observations about populations.

- **Variation**
 - Individuals in a population vary in their ability to survive and reproduce.
 - This ability is referred to as **fitness**.
 - Variation exists even within the same species living in the same environment.
- **Heredity**
 - Traits associated with fitness can be **passed on to offspring**.
 - This means advantageous traits can persist across generations.
- **Competition**
 - There are **never enough resources** (e.g. food, space, mates).
 - As a result, not all individuals survive or reproduce.
 - This creates competition for **survival and reproduction**.

Together, these observations explain why some traits become more common over time.

1.3 Evolution as a Two-Step Process

Evolution can be summarised as a **two-step process**:

- **Variability**
 - Individuals within a population differ in traits.
- **Ordering of variability by natural selection**

- Individuals with traits that increase fitness are more likely to survive and reproduce.
- These traits become **more frequent in the population over generations.**

Natural selection does not create new traits — it **acts on existing variation.**

1.4 Evidence of Natural Selection

Several lines of evidence support evolution by natural selection.

- **Homology**
 - Similarity between features due to **inheritance from a common ancestor.**
 - Homologous structures may perform **different functions** but share the same basic structure.
 - Example: **pentadactyl limb** in vertebrates.
- Homology reflects **shared evolutionary history**, not similarity of function.
- **Biogeography**
 - The geographic distribution of organisms provides evidence for evolution.
 - Australia's **unique flora and fauna** evolved due to long-term isolation of the continent.
 - Isolation limits gene flow and allows populations to evolve independently.
- **Fossils**
 - Fossil records show **increasing complexity over time.**
 - Older fossils tend to be simpler than more recent ones.
 - Supports the idea that life has changed gradually over long periods.

Historical concept:

- **Haeckel's theory:** *Ontogeny recapitulates phylogeny*
 - Development is a fast-action replay of evolutionary ancestry.
 - Example: human embryos briefly have tails, reflecting ancestral forms.
 - This idea is **not accepted literally today**, but is historically important.

1.5 Unity of Biochemical Processes

- All organisms share the same **fundamental biochemical processes.**
- This unity suggests a **common evolutionary origin** of life.

Examples:

- All organisms possess **DNA**:
 - Contains the instructions for growth, development, and function.
- All organisms possess **proteins**:
 - Act as enzymes and structural components that carry out genetic instructions.
- **Central dogma of biology** (Francis Crick):
 - Genetic information flows from **DNA** → **RNA** → **Protein**
 - This process underlies all cellular function.

1.6 Cell Theory (Schleiden & Schwann)

Cell theory states that:

- All living things are composed of **one or more cells**.
- All living cells arise from **pre-existing cells by division**.
- The cell is the **fundamental unit of structure and function** in living organisms.
- Cells contain **hereditary information (DNA)** that is passed on during cell division.

Cell theory links **cell biology, genetics, and evolution**.

1.7 Studying the Evolution (Relatedness) of Life

- All organisms have **genes (DNA)**.
- DNA contains a **record of evolutionary history**.
- By comparing genes, scientists can:
 - infer relatedness
 - construct evolutionary relationships

Study of cell morphology originally identified two major cell types:

- **Prokaryotes**
- **Eukaryotes**

Further molecular analysis revealed two domains of prokaryotes:

- **Bacteria**
- **Archaea**, which are **more closely related to eukaryotes**.

Exam tips

- Darwin's **three observations** are extremely high-yield.
- Be able to explain **why** competition is essential for natural selection.
- "Natural selection acts on populations, not individuals" is a common MCQ trap.
- Homology questions often test **structure vs function**.
- Expect short-answer questions linking **DNA, evolution, and classification**.

Memory tips

- **VHC** → Variation, Heredity, Competition.
- **Homology** = same structure, different function.
- **One arrow rule:** DNA → RNA → Protein (never backwards).