Heredity and Evolution

Heredity refers to the passing of characteristics from one generation to the next, while **Evolution** is the gradual process by which simple life forms develop into complex organisms over time through several generations.

Accumulation of Variations During Reproduction

Variation and Its Causes

- **Variation** means differences in characters or traits among individuals of a species
- Occurs during reproduction due to:
    - Errors in DNA copying
    - Sexual reproduction (fusion of different gametes)
    - Different combinations of genetic material
    - Gene mutations
    - Interaction of genes with environmental changes

Importance of Variations

- Forms the basis of heredity
- Enables organisms to adapt to changing environments
- Accumulation of variations leads to evolution
- Essential for species survival
- **Example:** Bacteria that can tolerate higher temperatures survive heat waves

Types of Reproduction and Variation

- **Asexual reproduction:** Produces subtle variations (hardly noticeable)
- **Sexual reproduction:** Produces greater variations and diversity

Heredity and Inherited Traits

Basic Concepts

- **Heredity:** Biological process that maintains or passes characteristics from parents to offspring
- **Inherited traits:** Characteristics passed from parents to children (eye color, skin color, height)
- **Characters:** Recognizable heritable features

- **Traits:** Alternative forms of a character

Genetic Terminology

- **Genes:** Specific parts of chromosomes that determine hereditary characteristics
- **Alleles:** Alternative forms of a gene for the same character
- **Genotype:** Genetic constitution of an organism
- **Phenotype:** Physical appearance resulting from genotype expression

Mendel's Experiments and Laws

Why Mendel Chose Garden Pea (Pisum sativum)?

Advantages:

- Short life cycle (quick results)
- Could be grown throughout the year
- Choice of cross or self-fertilization
- 7 pairs of contrasting characters
- Large number of offspring for statistical analysis

Seven Contrasting Characters in Pea Plants

1. **Height:** Tall vs Dwarf
2. **Seed color:** Yellow vs Green
3. **Pod color:** Green vs Yellow
4. **Flower color:** Violet vs White
5. **Seed shape:** Round vs Wrinkled
6. **Pod shape:** Inflated vs Constricted
7. **Flower position:** Axial vs Terminal

Mendel's Laws

1. Law of Dominance

- In a pair of contrasting traits, one is dominant and the other is recessive
- Dominant trait is expressed in heterozygous condition
- **Example:** In pea plants, tallness (T) is dominant over dwarfness (t)

2. Law of Segregation

- Each parent contributes one factor (allele) for each trait
- Factors separate during gamete formation
- Each gamete receives only one allele for each trait

3. Law of Independent Assortment

- Different traits are inherited independently
- Applies when genes are located on different chromosomes

Monohybrid Cross

- Cross between two parents differing in one character
- **F1 generation:** All offspring show dominant trait
- **F2 generation:** 3:1 ratio (dominant:recessive)

Dihybrid Cross

- Cross between parents differing in two characters
- **F2 ratio:** 9:3:3:1

Sex Determination

In Humans

- **Males:** XY chromosomes (heterogametic)
- **Females:** XX chromosomes (homogametic)
- Sex is determined by male parent
- **Ratio:** 1:1 (male:female)

Sex Determination Process

1. Male produces two types of sperm (X and Y)
2. Female produces only X-containing eggs
3. X sperm + X egg = Female (XX)
4. Y sperm + X egg = Male (XY)

Evolution

Definition

Evolution is the gradual change in species over time due to accumulation of variations that provide survival advantages.

Mechanisms of Evolution

1. Natural Selection

- Process by which organisms with favorable traits survive and reproduce
- "Survival of the fittest"
- Organisms better adapted to environment have higher survival rates
- **Example:** Darwin's finches with different beak shapes for different food sources

2. Genetic Drift

- Random changes in gene frequency in small populations
- Can lead to loss of genetic variation
- **Example:** If green beetles are eliminated by forest fire, only red beetles remain

3. Artificial Selection

- Human practice of selectively breeding organisms for specific traits
- **Examples:** Dog breeding, crop improvement

Speciation

Definition

Process by which new species are formed from pre-existing species due to various factors.

Factors Leading to Speciation

1. Geographic Isolation

- Populations separated by physical barriers (mountains, rivers)
- Reduces gene flow between populations
- Each population adapts to local environment

2. Genetic Drift

- Random genetic changes in isolated populations
- Can lead to reproductive isolation

3. Natural Selection

- Different environmental pressures in different locations
- Populations develop different adaptations

Process of Speciation

1. Single species splits into separate populations
2. Geographic or reproductive isolation occurs
3. Different evolutionary pressures act on each population
4. Genetic differences accumulate over time
5. Populations become unable to interbreed
6. New species formed

Evolution and Classification

Basis of Classification

- Organisms grouped based on similarities in characteristics
- More similar characteristics = more closely related
- Closely related species have recent common ancestors

Hierarchical Classification

- Kingdom → Phylum → Class → Order → Family → Genus → Species
- Each level represents different degrees of relationship

Tracing Evolutionary Relationships

1. Homologous Characteristics

- **Definition:** Similar basic structure with different functions
- Indicate common ancestry
- **Examples:**
    - Forelimbs of mammals, birds, reptiles (same bone structure, different functions)
    - Wings of birds and bats (different evolutionary origin)

2. Analogous Characteristics

- **Definition:** Similar functions with different basic structures
- Result of convergent evolution
- Do not indicate common ancestry
- **Example:** Wings of insects and birds

Evidence of Evolution

1. Fossils

- Preserved remains of ancient organisms
- Show gradual changes over time
- Provide direct evidence of evolution
- **Dating methods:** Carbon dating, relative dating

2. Embryological Evidence

- Similarities in embryonic development
- Indicates common ancestry
- **Example:** All vertebrate embryos have gill slits

3. Comparative Anatomy

- Homologous and analogous structures
- Vestigial organs (organs that have lost their function)
- **Examples:** Appendix in humans, tail bones

4. Molecular Evidence

- DNA and protein similarities
- More similar molecules = closer relationship
- Most direct evidence of evolutionary relationships

Human Evolution

Early Human Ancestors

- **Australopithecus:** Walked upright, small brain
- **Homo habilis:** Tool maker, larger brain
- **Homo erectus:** Used fire, migrated from Africa
- **Homo sapiens:** Modern humans, largest brain

Key Evolutionary Changes

1. **Bipedalism:** Walking on two legs
2. **Brain development:** Increased intelligence
3. **Tool use:** Enhanced survival ability
4. **Language development:** Communication skills

Important Points for Exams

1. **Heredity** ensures characteristics pass from parents to offspring
2. **Variations** are essential for evolution and species survival
3. **Mendel's laws** explain patterns of inheritance
4. **Sex determination** in humans depends on X and Y chromosomes
5. **Natural selection** drives evolutionary changes
6. **Speciation** creates new species through isolation and adaptation
7. **Classification** reflects evolutionary relationships
8. **Multiple evidence** supports theory of evolution

Summary

Heredity and evolution are interconnected processes that explain how traits are passed between generations and how species change over time. Mendel's experiments revealed the basic principles of inheritance, while Darwin's theory of natural selection explains how favorable variations accumulate to drive evolution. The study of these processes helps us understand biodiversity, classify organisms, and trace evolutionary relationships among all living things.