SNS COLLEGE OF TECHNOLOGY

COIMBATORE

UNIT – I

INTRODUCTION TO LIFE

CHARACTERISTICS OF LIVING ORGANISMS

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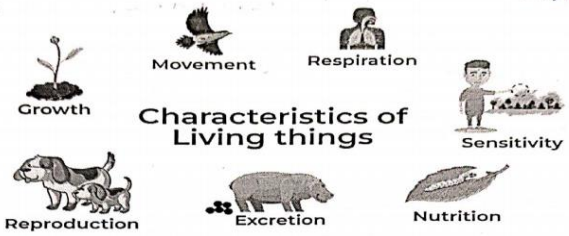

Living organisms share several fundamental characteristics that distinguish them from non-living things. These characteristics include:

1. **Cellular Organization**: All living organisms are composed of one or more cells, which are considered the basic units of life. Cells can be prokaryotic (without a nucleus) or eukaryotic (with a nucleus).
2. **Metabolism**: Living organisms exhibit metabolism, which includes all the chemical reactions that occur within their bodies to maintain life. This includes processes for converting energy from food into usable forms (e.g., respiration and photosynthesis).
3. **Homeostasis**: Living organisms maintain a stable internal environment despite changes in their external environment. This regulation involves processes such as temperature control, pH balance, and the regulation of water and ion concentrations.
4. **Growth and Development**: Living organisms undergo growth and development. Growth is an increase in size and number of cells, while development is the process by which organisms undergo changes in shape and function during their life cycle.
5. **Reproduction**: Living organisms have the ability to reproduce, either sexually (involving the combination of genetic material from two parents) or asexually (without the combination of genetic material, resulting in offspring genetically identical to the parent).
6. **Response to Stimuli**: Living organisms can respond to environmental stimuli such as light, temperature, and touch. This responsiveness is critical for survival and adaptation.
7. **Adaptation through Evolution**: Populations of living organisms undergo changes over generations through the process of evolution. This adaptation to the environment is driven by natural selection, resulting in the survival of organisms best suited to their environment.

8. **Heredity**: Living organisms possess genetic material (DNA or RNA) that they pass on to their offspring. This genetic information determines the traits and characteristics of the organism.

DNA – Deoxyribonucleic acid
RNA – Ribonucleic Acid

CELL THEORY

The cell theory is a fundamental principle in biology that describes the properties of cells. It is one of the foundational concepts for understanding life and consists of three main tenets:

1. **All living organisms are composed of one or more cells**: This means that the cell is the basic unit of life. Whether an organism is unicellular (composed of a single cell) or multicellular (composed of multiple cells), the cell is the fundamental building block.
2. **The cell is the basic unit of structure and organization in organisms**: This tenet emphasizes that all the functions of an organism occur within cells. Cells are the smallest units that perform all vital physiological processes, including metabolism, energy conversion, and reproduction.
3. **All cells arise from pre-existing cells**: This principle states that cells are not spontaneously generated but come from the division of existing cells. This concept was crucial in understanding growth, development, and the continuity of life.

Historical Background

- **Robert Hooke (1665)**: Hooke was the first to observe cells under a microscope and coined the term "cell" after observing the cell walls in cork tissue.
- **Anton van Leeuwenhoek (1674)**: Leeuwenhoek improved the microscope and was the first to observe living cells, including bacteria and protozoa, which he called "animalcules."
- **Matthias Schleiden (1838)**: Schleiden, a botanist, concluded that all plant tissues are composed of cells.
- **Theodor Schwann (1839)**: Schwann, a zoologist, extended Schleiden's conclusion to animals, stating that all animal tissues are also composed of cells.
- **Rudolf Virchow (1855)**: Virchow proposed that "Omnis cellula e cellula," meaning "all cells come from cells," which solidified the idea that cell division is the means by which new cells are produced.

Cell Theory

Cell theory is one of the fundamental principles of biology. It was developed in the 19th century and has three main tenets:

1. **All living organisms are composed of one or more cells**: This means that the cell is the basic unit of life in all living things.
2. **The cell is the basic unit of structure and function in living organisms**: Cells are the smallest unit that can carry out the processes that define life.
3. **All cells arise from pre-existing cells**: This principle states that new cells are formed only by the division of existing cells, highlighting the continuity of life.

These principles were established by scientists such as Matthias Schleiden, Theodor Schwann, and Rudolf Virchow.

Classification of Cells

Cells can be classified into two main categories based on their structure and complexity:

1. Prokaryotic Cells

- **Characteristics**:
  - Lack a true nucleus; instead, they have a nucleoid region where the DNA is located.
  - Do not have membrane-bound organelles.
  - Generally smaller and simpler than eukaryotic cells.
  - Examples include bacteria and archaea.
- **Components**:
  - **Cell membrane**: A lipid bilayer that encloses the cell.
  - **Cell wall**: Provides structure and protection; in bacteria, it contains peptidoglycan.
  - **Cytoplasm**: Gel-like substance where cellular processes occur.
  - **Ribosomes**: Structures responsible for protein synthesis.
  - **Nucleoid**: Region where the cell's DNA is located.

2. Eukaryotic Cells

- **Characteristics:**
  - Have a true nucleus enclosed by a nuclear membrane.
  - Contain membrane-bound organelles, each with specific functions.
  - Generally larger and more complex than prokaryotic cells.
  - Examples include cells of animals, plants, fungi, and protists.
- **Components:**
  - **Cell membrane:** A lipid bilayer that encloses the cell.
  - **Nucleus:** Contains the cell's DNA and controls its activities.
  - **Mitochondria:** Powerhouses of the cell, responsible for energy production.
  - **Endoplasmic Reticulum (ER):** Network of membranes involved in protein and lipid synthesis; can be rough (with ribosomes) or smooth (without ribosomes).
  - **Golgi apparatus:** Modifies, sorts, and packages proteins and lipids for transport.
  - **Lysosomes:** Contain enzymes for digestion of cellular waste.
  - **Cytoskeleton:** Provides structural support and aids in cell movement.
  - **Chloroplasts** (in plant cells): Sites of photosynthesis, converting solar energy into chemical energy.

Differences between Prokaryotic and Eukaryotic Cells

Feature	Prokaryotic Cells	Eukaryotic Cells
Nucleus	No true nucleus	True nucleus present
Size	Smaller (1-10 μm)	Larger (10-100 μm)
Organelles	No membrane-bound organelles	Membrane-bound organelles
DNA Structure	Circular DNA	Linear DNA
Examples	Bacteria, Archaea	Animals, Plants, Fungi, Protists

Understanding cell theory and the classification of cells provides the foundation for studying the structure and function of all living organisms.

Biomolecules, also known as biological molecules, are any molecules that are produced by living organisms. They are essential to the structure and function of cells and are involved in various biological processes.

Definition

Biomolecules: Organic molecules that are present in living organisms and are essential to their structure and function. These molecules include carbohydrates, lipids, proteins, and nucleic acids.

Classification

Biomolecules can be classified into four major types:

1. **Carbohydrates**:
    - **Definition**: Organic compounds composed of carbon, hydrogen, and oxygen, typically with a hydrogen

      atom ratio of 2:1.

    - **Function**: Serve as a primary source of energy (e.g., glucose), provide structural support in plants (e.g., cellulose), and act as signaling molecules.
    - **Examples**: Monosaccharides (glucose, fructose), disaccharides (sucrose, lactose), polysaccharides (starch, glycogen, cellulose).
2. **Lipids**:
    - **Definition**: A diverse group of hydrophobic molecules composed mainly of carbon and hydrogen.
    - **Function**: Store energy, form cellular membranes, and act as signaling molecules.
    - **Examples**: Fats (triglycerides), phospholipids, steroids (cholesterol), waxes.

3. **Proteins**:
    - **Definition**: Large, complex molecules made up of amino acids linked by peptide bonds.
    - **Function**: Catalyze biochemical reactions (enzymes), provide structural support (collagen), transport molecules (hemoglobin), and regulate processes (hormones).
    - **Examples**: Enzymes (amylase), structural proteins (keratin), transport proteins (albumin), antibodies.
4. **Nucleic Acids**:
    - **Definition**: Polymers composed of nucleotides, which consist of a sugar, a phosphate group, and a nitrogenous base.
    - **Function**: Store and transmit genetic information and facilitate the synthesis of proteins.
    - **Examples**: DNA (deoxyribonucleic acid), RNA (ribonucleic acid).

Other Important Biomolecules

- **Vitamins**: Organic molecules that are necessary in small quantities for normal metabolism and cannot be synthesized by the body in sufficient amounts.
- **Minerals**: Inorganic elements that play crucial roles in various physiological functions.

Genes and chromosomes are fundamental components of the genetic material in living organisms, responsible for inheritance and the functioning of all biological processes.

Genes

Definition: Genes are segments of DNA (deoxyribonucleic acid) that contain the instructions for building and maintaining the cells of an organism. They are the basic units of heredity.

Key Points:

- **Structure**: A gene is composed of a sequence of nucleotides in the DNA. These sequences are arranged in a specific order, which determines the genetic information carried by the gene.

- **Function**: Genes encode for proteins or functional RNA molecules. The process of gene expression involves transcription (copying DNA into RNA) and translation (using RNA to synthesize proteins).
- **Regulation**: Gene expression is tightly regulated to ensure that genes are turned on or off at the right times, in the right cells, and in the appropriate amounts.
- **Inheritance**: Genes are inherited from parents to offspring, and they determine inherited traits. They can exist in different forms called alleles, which contribute to genetic diversity.

Examples:

- **BRCA1**: A gene associated with breast cancer susceptibility.
- **HBB**: The gene that codes for the beta-globin subunit of hemoglobin, mutations of which can cause sickle cell anemia.

Chromosomes: Chromosomes are long, thread-like structures composed of DNA and proteins (histones) that package and organize genetic material in the cell nucleus.

Key Points:

- **Structure**: Chromosomes consist of tightly coiled DNA wrapped around histone proteins. Each chromosome contains many genes.
- **Number**: The number of chromosomes varies between species. Humans have 46 chromosomes, arranged in 23 pairs.
    - **Autosomes**: 22 pairs of non-sex chromosomes.
    - **Sex Chromosomes**: 1 pair of sex chromosomes (XX in females, XY in males).
- **Function**: Chromosomes ensure accurate replication and distribution of genetic material during cell division (mitosis and meiosis).
- **Types**:
    - **Eukaryotic Chromosomes**: Linear chromosomes found in the nucleus of eukaryotic cells.
    - **Prokaryotic Chromosomes**: Typically circular chromosomes found in prokaryotic cells (e.g., bacteria).

Key Processes:

- **Replication**: Chromosomes duplicate during cell division to ensure each daughter cell receives a complete set of genetic information.
- **Segregation**: Chromosomes are segregated into daughter cells during mitosis (somatic cell division) and meiosis (reproductive cell division).

Examples:

- **Human Chromosome 1**: The largest human chromosome, containing about 2,000 to 2,100 genes.
- **Human Chromosome Y**: The sex chromosome responsible for male sex determination.

Interrelationship

- **DNA**: The molecule that carries genetic information in both genes and chromosomes.
- **Genes on Chromosomes**: Genes are located on chromosomes. Each chromosome carries many genes that code for various proteins and RNA molecules.

Importance

Understanding genes and chromosomes is crucial for fields like genetics, medicine, and biotechnology. They provide insights into hereditary diseases, genetic variation, and the mechanisms of life at a molecular level.