Biology

Biology is a natural science concerned with the study of life and living organisms and their environments. The word "biology" is derived from the Greek words "bios" (meaning life) and "logos" (meaning "study"). Modern biology is a wide and selective field composed of many specialized that study the structure, function, growth, distribution, evolution, or other features of living organisms. However, despite the broad scope of biology, there are certain general and unifying concepts that govern all study and research:

1. the cell is the basic unit of life
2. genes (consisting of DNA or RNA) are the basic unit of heredity
3. evolution accounts for the unity and diversity seen among living organisms
4. all organisms survive by consuming and transforming energy
5. all organisms maintain a stable internal environment

Biology is important because it helps us understand how living things work and how they function and interact on multiple levels. Advances in biology have helped scientists do things such as develop better medicines and treatments for diseases, understand how a changing environment might affect plants and animals, produce enough food for a growing human population.

Branches of Biology

Some of the branches of biology are briefly discussed below:

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1. **Zoology**: is one of the main branches of biology that deals with animals and animal life, including the study of the structure, physiology, development, and classification of animals. Aristotle is regarded as the father of zoology.
2. **Botany**: is a branch of biology that deals with the study of plants, including their structure, properties, and biochemical processes. Also included are plant classification and the study of plant diseases and of interactions with the environment. Theophrastus is known as the father of Botany.
3. **Microbiology**: is one of the main branches of biology that study microorganisms, or microbes, a diverse group of generally minute simple life-forms that include bacteria, archaea, algae, fungi, protozoa, and viruses. The field is concerned with the structure, function, and classification of such organisms and with ways of both exploiting and controlling their activities. Leeuwenhoek is known as the father of Microbiology.
4. **Taxonomy**: It is one of the most important branches of Biology that deals with categorizing and naming different organisms based on their characteristics.
5. **Morphology**: It is the study of external form, size, color, structure, and relative position of the various living organs of living organisms.
6. **Anatomy**: is one of the main branches of biology that allows an individual to understand the structure and the parts of organisms including animals, humans, and living organisms. Moreover, it investigates how a living body adapts and maintains balance with the physical environment and human health.
7. **Histology**: It is the study of tissue organization and structure as observed through the light microscope.
8. **Cytology**: It is the study of the form and structure of cells including the behavior of the nucleus and other organelles.

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9. **Cell Biology**: It is the study of morphological, organizational, biochemical, physiological, genetic, developmental, pathological, and evolutionary of a cell and its components.
10. **Molecular Biology**: It is the study of the nature, physicochemical organization, and interaction of bio-molecules that bring about and control various activities of the protoplasm.
11. **Physiology**: It is the study of different types of body functions and processes.
12. **Embryology**: It is the study of fertilization, growth, division, and differentiation of the zygote into an embryo or early development of living beings before the attainment of structure and size of the offspring.
13. **Ecology**: It is the study of living organisms in relation to another organism and their environment.
14. **Genetics**: It is the study of the inheritance of characters or heredity and variations. **Heredity** is the study of the expression and transmission of traits from parents to offspring.
15. **Virology**: It is the study of viruses in all their aspects.
16. **Biochemistry**: is the branch of biology concerned with the chemical and physiochemical processes that occur within living organisms.
17. **Biotechnology**: is the exploitation of biological processes such as genetic manipulation of micro-organisms for the production of antibiotics, hormones, etc.
18. **Mycology**: is a branch of Biology which is primarily concerned with fungi and explores their genetic and biochemical properties. it also examines its taxonomy and how it can be used by human beings as a source for traditional medicine, food.

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Characteristics of living organisms

All living organisms share common characteristics, including:

1. Organization

The structural arrangement of living things in an orderly manner. Cell theory argues that all living things are made of cells. Some living organisms consist of one cell (unicellular) e.g., bacteria and amoeba, others multicellular e.g., humans. All organisms carry out their activities in cells. This gives a structured plan to improve efficiency and increases the probability of survival.

2. Nutrition

Living things take in materials from their surroundings that they use for growth or to provide energy. Nutrition is the process by which organisms obtain energy and raw materials from nutrients such as proteins, carbohydrates, and fats. Plants and some bacteria are autotrophic which means they make their own food. Animals, fungi, and most bacteria are heterotrophic. Which means they need to consume food that is made by plants.

3. Respiration

Respiration is a chemical reaction that releases energy from food substances in all living cells. Living things break down food within their cells to release energy for carrying out the processes.

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4. Metabolism

Metabolism represents all the chemical reactions that occur in cells of a living organism and that provide energy for vital processes and for synthesizing new organic material. Metabolism involves exchanges of chemical matter with the external environment and extensive transformations of organic matter within the cells of a living organism. Metabolism generally involves the release or use of chemical energy. A metabolic pathway is a series of reactions, each of which has its own enzyme. The materials entering these reactions are called reactants, and the materials leaving the pathway are called products. It is divided into two primary categories:

A. **Catabolism** is the set of metabolic processes that break down large molecules. These include breaking down and oxidizing food molecules. The purpose of the catabolic reactions is to provide the energy and components needed by anabolic reactions which build molecules.
B. **Anabolism** is the set of constructive metabolic processes where the energy released by catabolism is used to synthesize complex molecules. In general, the complex molecules that make up cellular structures are constructed step-by-step from smaller and simpler precursors. Numerous metabolic reactions occur simultaneously in any living thing.

5. **Movement**:

Some organisms move in a very obvious way, such as a running animal. Other living things move in a way that is more difficult to detect. Technological devices, such as a microscope to be able to observe movement.

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6. **Excretion**:

All living things excrete. As a result of the many chemical reactions occurring in cells, they have to get rid of waste products that might poison the cells. Excretion is the removal of toxic materials, the waste products of metabolism (e.g., urea and carbon dioxide), and substances in excess from the body. These waste products can become toxic to the cell if allowed to accumulate. The organism tries to maintain a stable internal environment (homeostasis). Advanced animals transfer waste internally from cells to blood to excretory organs e.g., lungs, skin, urinary system, whilst the liver breaks down toxic material.

7. Growth

Growth is seen in all living things. It involves using food to produce new cells. The permanent increase in cell number and size is called growth.

8. Reproduction

All living organisms have the ability to produce offspring. formation of new individuals/organisms. More complex organisms engage in a type of reproduction called sexual reproduction, in which two parents contribute to the formation of a new individual. During this process, a new combination of traits can be produced. Asexual reproduction involves only one parent, and the resulting cells are generally identical to the parent cell. For example, bacteria grow and quickly reach maturity, after which they split into two organisms by a process of asexual reproduction called binary fission.

9. Responsiveness

All living things are able to respond to stimuli in the external environment. For example, living things respond to changes in light, heat, sound, and chemical.

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To detect stimuli, organisms have means for receiving information, such as eyes, ears, and taste buds.

10.Homeostasis

For the metabolic pathways within a cell to function correctly, the environmental conditions (such as proper temperature, pH, and appropriate concentration of diverse chemicals) of the cell must be kept within strict operating limits. The ability of a cell or an organism to maintain an internal environment that operates under specific conditions is called homeostasis.

11.Adaptation

adaptation, in biology, is the process by which a species becomes fitted to its environment; it is the result of natural selection's acting upon heritable variation over several generations. Organisms are adapted to their environments in a great variety of ways: in their structure, physiology, and genetics, in their locomotion or dispersal, in their means of defense and attack, in their reproduction and development, and in other respects.

12.Evolution

Living organisms have the ability to adapt to their environment through the process of evolution. During evolution, changes occur in populations, and the organisms in the population become better able to metabolize, respond, and reproduce.

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Classification of Organisms

The system of biological kingdoms is the way in which science classifies living things according to their ancestry, therefore, sharing some of their genes and belonging to the same family tree. As well as the kingdoms of living things there are other taxonomic categories within the same classification system such as domain, phylum, class, order, family, genus, and species. They all follow a hierarchical order and are dependent on each other.

The Classification of living things into five kingdoms:

I. Animal kingdom

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The kingdom Animalia is the most evolved and is divided into two large groups vertebrates and invertebrates. These animals are multi-celled, their cells lack cell walls, heterotrophic eukaryotes with aerobic respiration, sexual reproduction, and the ability to move. This kingdom is one of the most diverse and comprises mammals, fish, birds, reptiles, amphibians, insects, and mollusks.

II. Plant kingdom

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Trees, plants, and other species of vegetation make up part of the Plantae kingdom - one of the oldest and characterized by its immobile, multicellular, and eukaryotic nature. These autotrophic organisms, whose cells contain cellulose and chlorophyll are essential for life on Earth since they release oxygen through photosynthesis. As regards their method of reproduction, this may be either sexual or asexual.

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III. Monera kingdom

This is the kingdom of microscopic living things and groups together the prokaryotes (archaea and bacteria). This group is present in all habitats such as in soil. They also live in extreme habitats such as hot springs, deserts, snow, and deep oceans where very few other life forms can survive. Many of them live in or on other organisms as parasites. Bacteria are grouped under four categories based on their shape: the spherical Coccus (cocci), the rod-shaped Bacillus (bacilli), the comma-shaped Vibrium (vibrio), and the spiral Spirillum (spirilla) (Figure 3.1).

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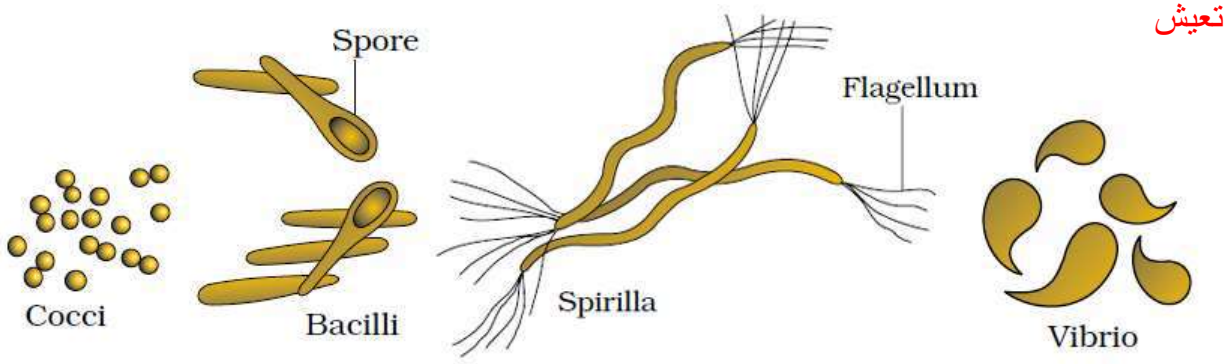

Characteristics of Monera

The important characteristics of Monera are mentioned below:

1. The Monerans are unicellular organisms with no defined nucleus.
2. They contain 70S ribosomes.
3. The DNA is naked and is not bound by a nuclear membrane.
4. It lacks organelles like mitochondria, lysosomes, plastids, Golgi bodies, endoplasmic reticulum, centrosome, etc.
5. They reproduce asexually by binary fission or budding.
6. The cell wall is rigid and made up of peptidoglycan.

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7. Flagellum serves as the locomotory organ.
8. These are environmental decomposers.
9. They show different modes of nutrition such as autotrophic, parasitic, heterotrophic, or saprophytic.

Classification of Monera

Kingdom Monera is classified into three sub-kingdoms- Archaebacteria, Eubacteria, and Cyanobacteria.

A. Archaebacteria

1. These are the most ancient bacteria found in the most extreme habitats such as salty areas.
2. The structure of the cell wall is different from that of the other bacteria which helps them survive in extreme conditions.
3. The mode of nutrition is autotrophic.
4. The nucleotide sequences of its t-RNA and r-RNA are unique.

B. Eubacteria

Eubacteria are also known as "true bacteria".

1. The cell wall is rigid and made up of peptidoglycans.
2. It moves with the help of flagella.
3. A few bacteria contain short appendages on the cell surface, known as pili which help the bacteria during sexual reproduction. Pili also helps a pathogen to attach to the host.
4. They are divided into two categories; gram-positive and gram-negative, depending upon the nature of the cell wall and the stain they take.

C. Cyanobacteria

These are also known as blue-green algae.

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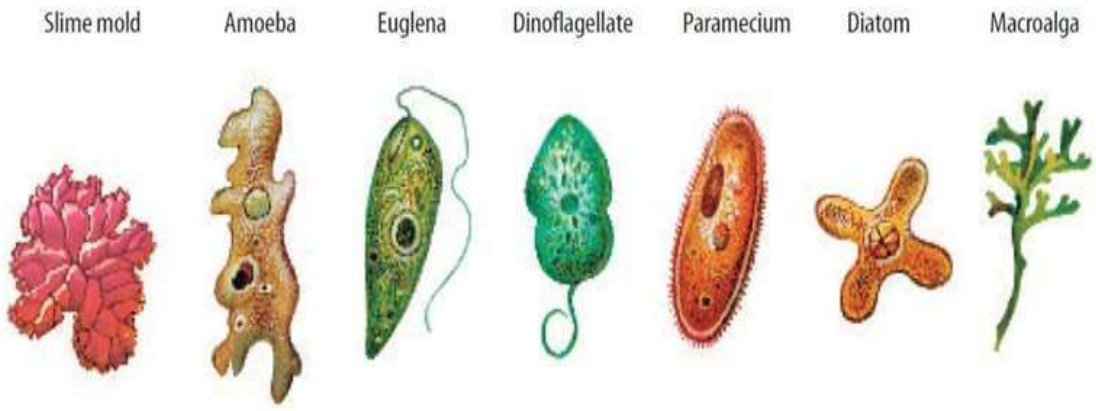
1. have chlorophyll a similar to green plants and are photosynthetic autotrophs.
2. The cyanobacteria are unicellular, colonial, or filamentous.
3. They are found in the aquatic region.
4. Some of these organisms can fix atmospheric nitrogen in specialized cells called heterocysts, e.g., Nostoc and Anabaena.

IV. Protista Kingdom

The protists are eukaryotes; their cells have a nucleus and all of the various organelles. Unicellular organisms are predominant in kingdom Protista, and even the multicellular forms lack the tissue differentiation that is seen in more complex organisms. Being eukaryotes, the protistan cell body contains a well-defined nucleus and other membrane-bound organelles. Some have flagella or cilia. Protists reproduce asexually and sexually by a process involving cell fusion and zygote formation.



V. Fungi Kingdom

Fungi are multicellular eukaryotes that are heterotrophic by absorption. They send out digestive enzymes into the immediate environment, and then, when

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organic matter is broken down, they absorb nutrient molecules. Like bacteria, most fungi are saprotrophic decomposers that break down the waste products and dead remain of plants and animals. Some fungi parasitize on both plants and animals. Although yeast is unicellular fungi, the body of a fungus is usually a multicellular structure known as a mycelium. A mycelium is a network of filaments called hyphae. Fungal cells are different from plant cells not only by lacking chloroplasts but also by having a cell wall that contains chitin and not cellulose. Chitin is a polymer of glucose, but each glucose molecule has an amino group attached to it. Fungi produce non flagellate spores during both sexual and asexual reproduction, which are dispersed by the wind.

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The Cell

All organisms, including humans, are composed of cells. From single-celled bacteria to plants and complex animals such as ourselves, the cell represents the fundamental unit of life. Despite their importance, most cells are small and can be seen only under a microscope. Most human cells are about 100 μm in diameter.

The Cell Theory

1. **A cell is the basic unit of life**. According to the cell theory, nothing smaller than a cell is considered to be alive. There is no smaller unit of life that is able to reproduce and grow, respond to stimuli, remain homeostatic, take in and use materials from the environment, and become adapted to the environment. In short, life has a cellular nature.
2. **All living organisms are made up of cells**. While many organisms, such as bacteria, are single-celled, other organisms, including humans and plants, are multicellular. In multicellular organisms, cells are often organized as tissues, such as nervous tissue and connective tissue. Even bone consists of cells surrounded by the material that they have deposited.
3. **New cells arise only from preexisting cells**. When mice or humans reproduce, a sperm cell joins with an egg cell to form a zygote. This is the first cell of a new multicellular organism. By reproducing, parents pass a copy of their genes to their offspring. The genes contain the instructions that allow the zygote to grow and develop into a complete organism.

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Cell Components

I. Plasma Membrane

The plasma membrane is a phospholipid bilayer with attached or embedded proteins. A phospholipid molecule has a polar head and nonpolar tails. When phospholipids are placed in water, they naturally form a spherical bilayer. The polar heads, being charged, are hydrophilic (attracted to water). They position themselves to face the watery environment outside and inside the cell. The nonpolar tails are hydrophobic (not attracted to water). They turn inward toward one another, where there is no water. The proteins are able to change their position by moving laterally. The fluid mosaic model is a working description of membrane structure. It states that the protein molecules form a shifting pattern within the fluid phospholipid bilayer. Cholesterol lends support to the membrane. Short chains of sugars are attached to the outer surface of some protein and lipid molecules. These are called glycoproteins and glycolipids, respectively. Some plasma membrane proteins form channels through which certain substances can enter cells (Figure 4.1).

Plasma Membrane Functions

The plasma membrane isolates the interior of the cell from the external environment. In doing so, it allows only certain molecules and ions to enter and exit the cytoplasm freely. Therefore, the plasma membrane is said to be selectively permeable. Small, lipid-soluble molecules, such as oxygen and carbon dioxide, can pass through the membrane easily. The small size of water molecules allows them to freely cross the membrane by using protein channels

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called aquaporins. Ions and large molecules cannot cross the membrane without more direct assistance.

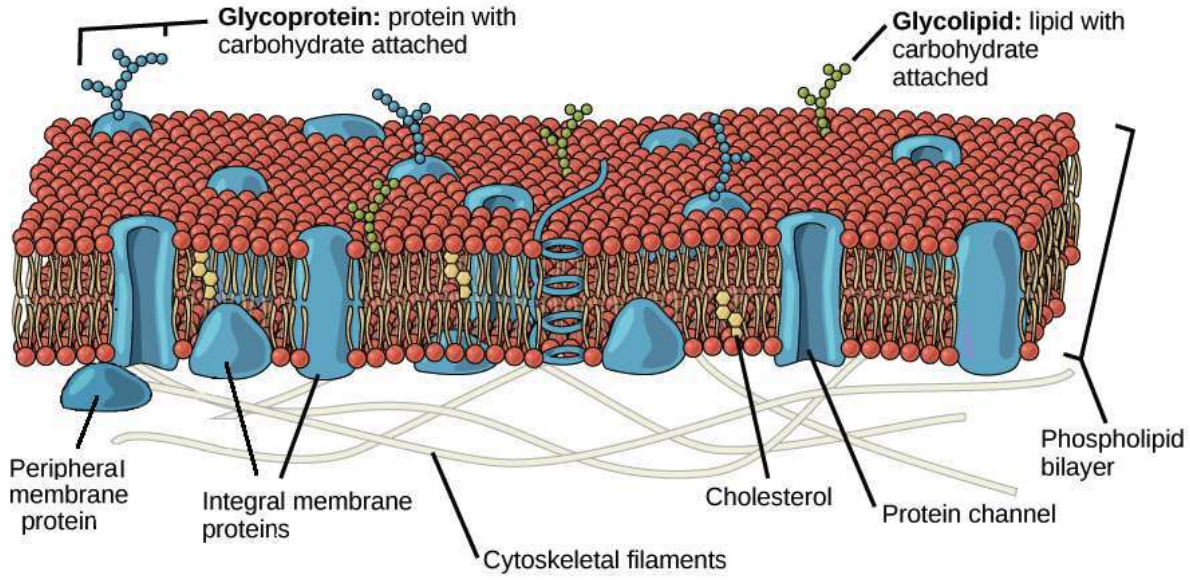

Fig. 4.1 plasma membrane structure

II. Cytoplasm

The cytoplasm is a thick solution that fills each cell and is enclosed by the cell membrane. It is mainly composed of water, salts, and proteins. In eukaryotic cells, the cytoplasm includes all of the material inside the cell and outside of the nucleus. All of the organelles in eukaryotic cells, such as the nucleus, endoplasmic reticulum, and mitochondria, are located in the cytoplasm. The portion of the cytoplasm that is not contained in the organelles is called the cytosol, where most metabolic reactions take place. (Figure 4.2).

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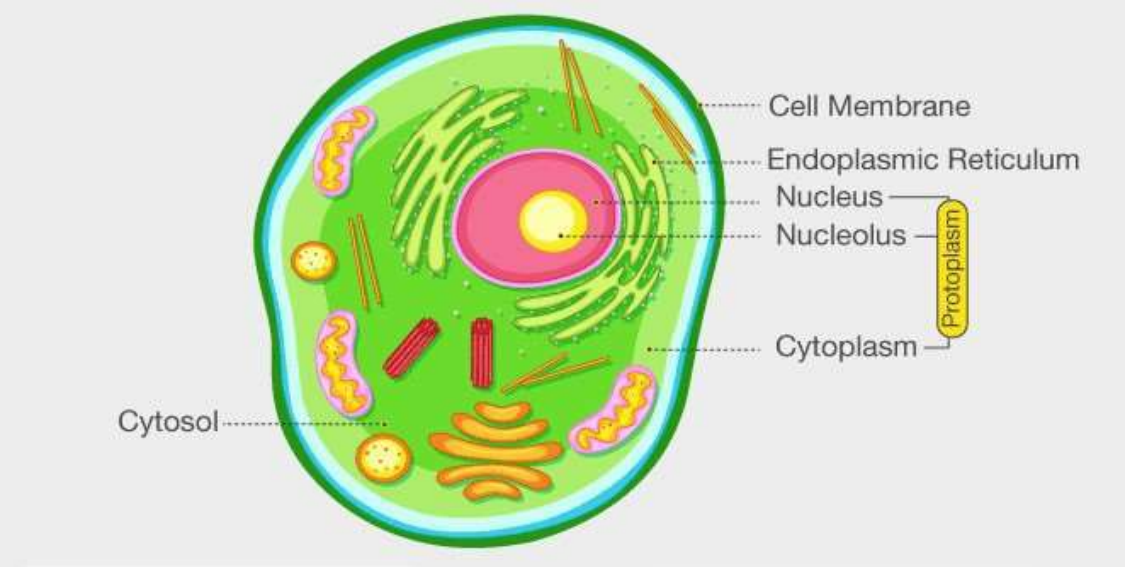

Fig. 4.2 Cytoplasm and Cytosol

III. Nucleus

The nucleus, a prominent structure in eukaryotic cells, stores genetic information (Figure 4.3). Every cell in the body contains the same genes. Genes are segments of DNA that contain information for the production of specific proteins. DNA, with RNA acting as an intermediary, specifies the proteins in a cell. Proteins have many functions in cells, and they help determine a cell's specificity. Chromatin is the combination of DNA molecules and proteins that make up the chromosomes, the structures that transmit genetic information from one generation to the next. Chromatin can coil tightly to form visible chromosomes during cell division. Chromatin is surrounded by a semifluid medium called the nucleoplasm. A difference in pH suggests that nucleoplasm has a different composition than the cytoplasm. The nucleus is separated from the cytoplasm by a double membrane known as the nuclear envelope. This is continuous with the endoplasmic reticulum (ER), a membranous system of saccules and channels. The nuclear envelope has nuclear pores of sufficient size

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to permit the passage of ribosomal subunits out of the nucleus and proteins into the nucleus.

Nuclear membrane: The membrane that encloses the nucleus is called the nuclear membrane. It is a double-layered membrane and is composed of lipids and proteins. In this membrane, there are some pores called nucleopores. The nuclear membrane controls the transport system from the nucleoplasm to the cytoplasm. The membrane separates the contents of the nucleus from the cytoplasm.

Nucleoplasm: The jelly-like fluid enveloped by the nuclear membrane is called the nucleoplasm. It is similar to the cytoplasm of a cell. It is a viscous fluid that contains nucleic acids, proteins, enzymes, and some other substances dissolved in and mixed with it.

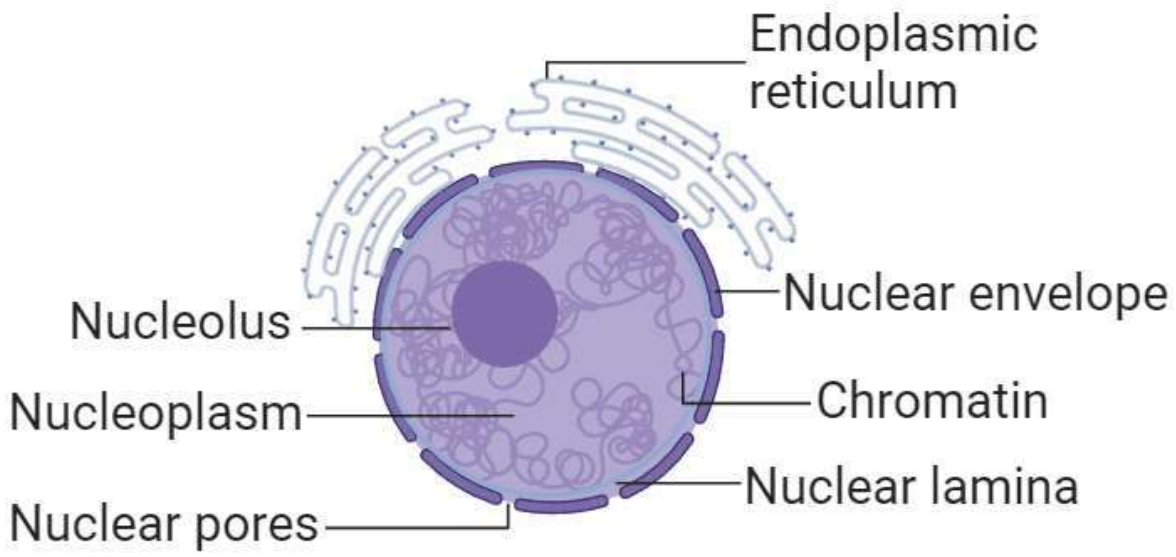

Fig. 4.3 Nucleus structure

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Cell Components

IV. Ribosomes

Ribosomes are organelles composed of proteins and rRNA. Protein synthesis occurs at the ribosomes. Ribosomes are often attached to the endoplasmic reticulum, but they also may occur free within the cytoplasm, either singly or in groups called polyribosomes. Proteins synthesized at ribosomes attached to the endoplasmic reticulum have a different destination from that of proteins manufactured at ribosomes free in the cytoplasm.

Each ribosome is composed of two subunits, a larger one and a smaller one, each of which has a characteristic shape. These ribosomes units are denoted by Svedberg (S) values depending on the rate of the sedimentation in the centrifugation (Figure 5.1).

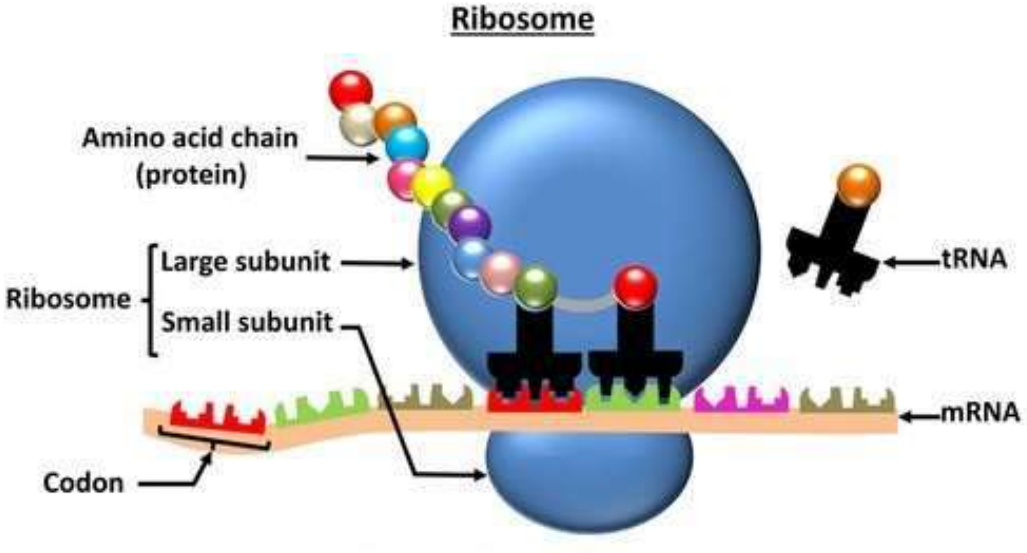

Fig. 5.1 Ribosome structure

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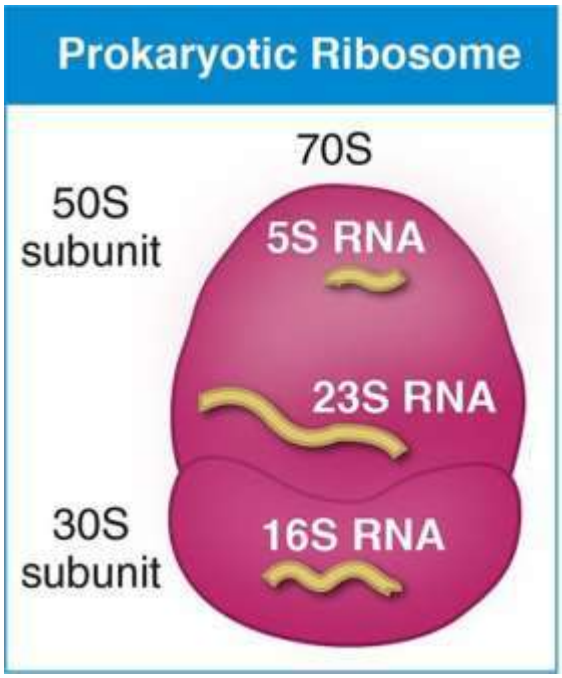
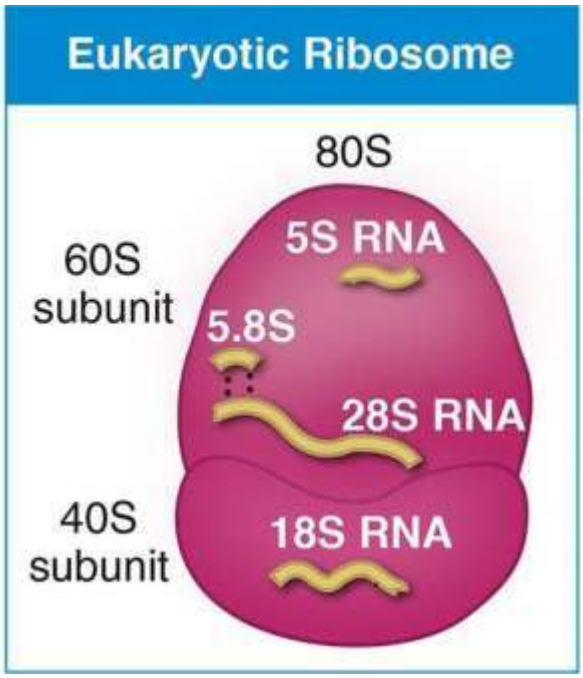
Prokaryotic ribosomes are 70S ribosomes, which are smaller than eukaryotic ribosomes. They consist of two subunits; a small subunit and a large subunit. The small subunit of prokaryotic ribosomes is 30S while the large subunit is 50S. Moreover, in prokaryotes, rRNA is organized into three strands in ribosomes. Three strands are 16 S RNA, 5S RNA, and 23S RNA. Unlike eukaryotic ribosomes, prokaryotic ribosomes do not attach to the membranes of the nucleus or endoplasmic reticulum. They are present freely in the cytoplasm.

Eukaryotic ribosomes are 80S particles that are larger than prokaryotic ribosomes. They consist of 40S small subunit and 60S large subunit. Furthermore, eukaryotic ribosomes contain more ribosomal proteins than prokaryotic ribosomes. There are four strands of RNA in eukaryotic ribosomes. They are 18S, 5S, 5.8S, and 28S RNAs. Unlike prokaryotic ribosomes, eukaryotic ribosomes are found freely in the cytoplasm and are also attached to ER membranes.





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V. The Endoplasmic Reticulum

The endoplasmic reticulum (ER) has two portions (Figure 5.2). Rough ER is studded with ribosomes on the side of the membrane that faces the cytoplasm. Here, proteins are synthesized and enter the ER interior, where processing and modification begin. Some of these proteins are incorporated into the membrane, and some are for export. Smooth ER, continuous with rough ER, does not have attached ribosomes. Smooth ER synthesizes the phospholipids that occur in membranes and has various other functions, depending on the particular cell. In the liver, it helps detoxify drugs.

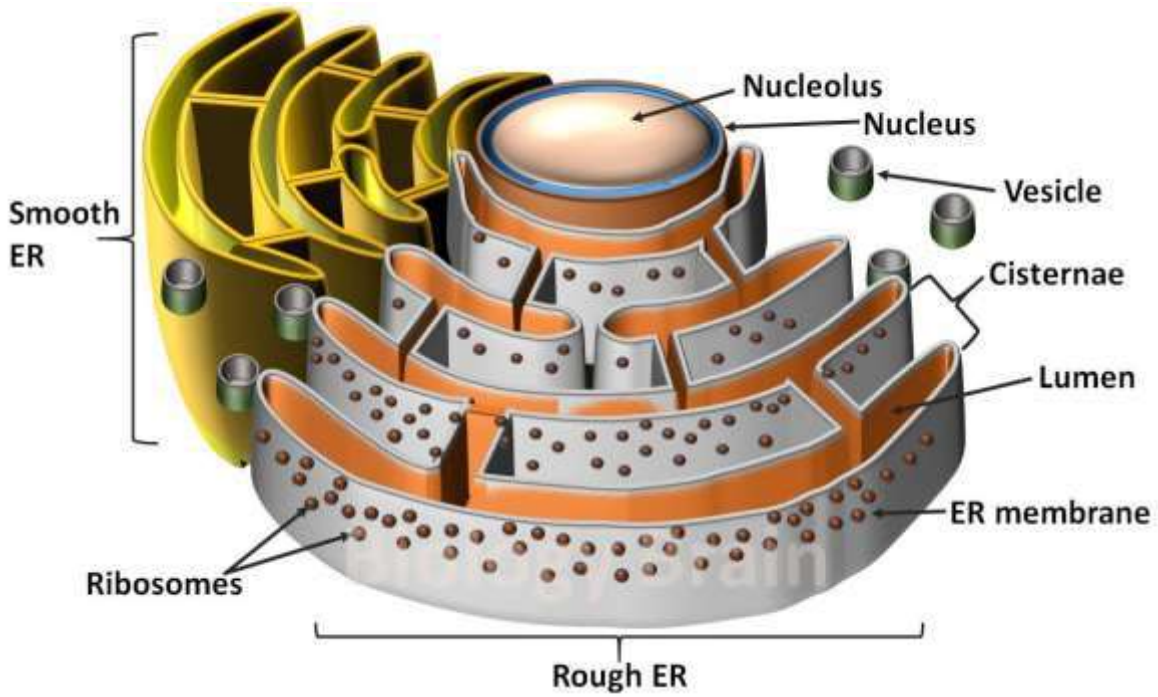

Fig. 5.2 Endoplasmic Reticulum

VI. The Golgi Apparatus

The Golgi apparatus consists of a stack of slightly curved saccules, where proteins and lipids received from the ER are modified. For example, a chain of sugars may be added to them. This makes them glycoproteins and glycolipids,

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molecules often found in the plasma membrane. The vesicles that leave the Golgi apparatus move to other parts of the cell. Some vesicles proceed to the plasma membrane, where they discharge their contents. In all, the Golgi apparatus is involved in processing, packaging, and secretion.

VII. Lysosomes

Lysosomes, membranous sacs produced by the Golgi apparatus, contain hydrolytic enzymes. Lysosomes are found in all cells of the body but are particularly numerous in white blood cells that engulf disease-causing microbes. When a lysosome fuses with such an endocytic vesicle, its contents are digested by lysosomal enzymes into simpler subunits, which then enter the cytoplasm. In a process called autodigestion, parts of a cell may be broken down by the lysosomes. Some human diseases are caused by the lack of a particular lysosome enzyme such as Fabry disease, Mucopolysaccharidoses (MPS) diseases, and Pompe disease.

VIII. Cilia and Flagella

Both prokaryotic and eukaryotic cells contain structures known as cilia and flagella. Cilia and flagella are formed from specialized groupings of microtubules called basal bodies. If the protrusions are short and numerous they are termed cilia. If they are longer and less numerous (usually only one or two) they are termed flagella. The primary function of cilia and flagella is movement. such as the ciliated cells that line our respiratory tract sweep debris trapped within mucus back up the throat. This helps keep the lungs clean. Similarly, ciliated cells move an egg along the uterine tube, where it will be fertilized by a flagellated sperm cell. They also help to move substances around cells.

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IX. Mitochondria

Mitochondria (sing., mitochondrion) are often called the powerhouses of the cell. the mitochondria convert the chemical energy of glucose products into the chemical energy of ATP (Adenosine triphosphate) molecules. In the process, mitochondria use up oxygen and give off carbon dioxide. Therefore, the process of producing ATP is called cellular respiration. The structure of mitochondria is appropriate to the task. The inner membrane is folded to form little shelves called cristae. These project into the matrix, an inner space filled with a gel-like fluid. The matrix of a mitochondrion contains enzymes for breaking down glucose products. ATP production then occurs at the cristae.

Difference between Eukaryotic and Prokaryotic cells:

Prokaryotic Cell	**Eukaryotic cell**
Size is 0.1- 5.0 um	Size is 5-100 um
Nucleus is absent	Nucleus is present
Membrane-bound nucleus absent.	Membrane-bound Nucleus is present.
One chromosome is present, but not true chromosome plastids	More than one number of chromosomes is present.
Unicellular	Unicellular or Multicellular
Lysosomes and Peroxisomes absent	Lysosomes and Peroxisomes present
Microtubules absent	Microtubules present
Endoplasmic reticulum absent	Endoplasmic reticulum present

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Mitochondria absent	Mitochondria present
Cytoskeleton absent	Cytoskeleton present
Ribosomes smaller	Ribosomes larger
Vesicles present	Vesicles present
Golgi apparatus absent	Golgi apparatus present
Cell wall chemically complexed	Cell wall is present in plants and fungi and chemically simpler
Vacuoles absent	Vacuoles present
Permeability of Nuclear membrane is not present	Permeability of Nuclear membrane is selective
Sexual reproduction is absent	Sexual reproduction is present
Endocytosis and exocytosis are absent.	Endocytosis and exocytosis occurred
It may have pili and fimbriae.	Pili and fimbriae are absent
Transcription occurs in the cytoplasm	Transcription occurs inside the nucleus.
Examples: Bacteria and Archaea	Examples: Protists, Fungi, Plants, and Animals

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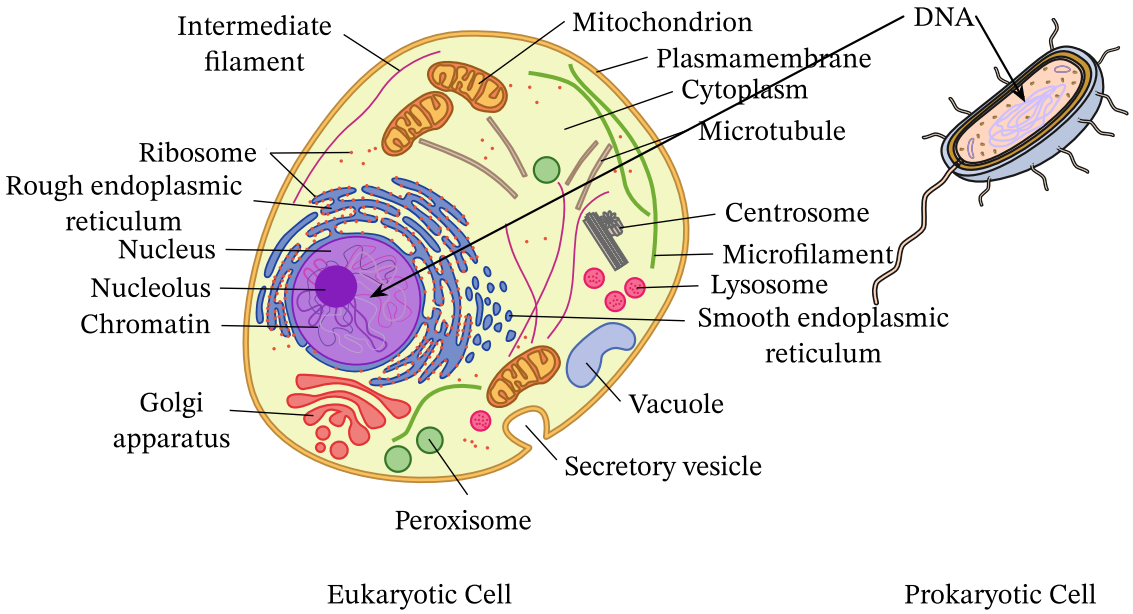

Fig. 5.3 Cell structure

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