Human Biology

Lecture 1

Dr. Abbas Hussein Mugheer

Biology

Biology is a branch of natural science that deals with the study of living things, including their origin, structure, function, maturation, evolution and classification. Study of living things and their vital processes the field deals with all the physicochemical aspects of life. The modern tendency toward cross-disciplinary research and the unification of scientific knowledge and investigation from different fields has resulted in significant overlap of the field of biology with other scientific disciplines. Modern principles of other fields chemistry, medicine, and physics, for example are integrated with those of biology in areas such as biochemistry, biomedicine, and biophysics.

Biology is subdivided into separate branches for convenience of study, though all the subdivisions are interrelated by basic principles. Thus, while it is custom to separate the study of plants (botany) from that of animals (zoology), and the study of the structure of organisms (morphology) from that of function (physiology), all living things share in common certain biological phenomena—for example, various means of reproduction, cell division, and the transmission of genetic material. Biology is often approached on the basis of levels that deal with fundamental units of life.

At the level of molecular biology, for example, life is regarded as a manifestation of chemical and energy transformations that occur among the many chemical constituents that compose an organism. As a result of the development of increasingly powerful and precise laboratory instruments and techniques, it is possible to understand and define with high precision and accuracy not only the ultimate physiochemical organization (ultrastructure) of the molecules in living matter but also the way living matter reproduces at the molecular level. Especially crucial to those advances was the rise of genomics in the late 20th and early 21st centuries.

Importance of Biology

There are numerous indications of the importance of biology. Biology is primarily concerned with studying life. In addition, it offers a thorough scientific explanation of how all living and nonliving things interact with one another. It provides information about various life forms. Additionally, biology includes various areas of study concerned with the sustainability of life, such as the study of the human body and the environment, the ecosystem, the quality of food, the causes of disease, and the discovery of new medications.

Cell theory

A theory in biology that includes one or both of the statements that the cell is the fundamental structural and functional unit of living matter and that the organism is composed of autonomous cells with its properties being the sum of those of its cells.

Schleiden (1804–1881) Schwann (1810–1882) Credit for developing cell theory is usually given to two scientists: Theodor Schwann and Matthias Jacob Schleiden. While Rudolf Virchow contributed to the theory, he is not as credited for his attributions toward it. In 1839, Schleiden suggested that every structural part of a plant was made up of cells or the result of cells. He also suggested that cells were made by a crystallization process either within other cells or from the outside. However, this was not an original idea of Schleiden. He claimed this theory as his own, though Barthelemy Dumortier had stated it years before him. This crystallization process is no longer accepted with modern cell theory. In 1839, Theodor Schwann states that along with plants, animals are composed of cells or the product of cells in their structures. This was a major advance in the field of biology since little was known about animal structure up to this point compared to plants. From these conclusions about plants and animals, two of the three tenets of cell theory were postulated:

1. All living organisms are composed of one or more cells
2. The cell is the most basic unit of life

Schleiden's theory of free cell formation through crystallization was refuted in the 1850s by Robert Remak, Rudolf Virchow, and Albert Kolliker. In 1855, Rudolf Virchow added the third tenet to cell theory. In Latin, this tenet states Omnis cellula e cellula.

3. All cells arise only from pre-existing cells

However, the idea that all cells come from pre-existing cells had already been proposed by Robert Remak; it has been suggested that Virchow plagiarized Remak. Remak published observations in 1852 on cell division, claiming Schleiden and Schwann were incorrect about generation schemes. He instead said that binary fission, which was first introduced by Dumortier, was how reproduction of new animal cells was made. Once this tenet was added, classical cell theory was complete.

Modern interpretation

The generally accepted parts of modern cell theory include:

1. All known living things are made up of one or more cells.
2. All living cells arise from pre-existing cells by division.
3. The cell is the fundamental unit of structure and function in all living organisms.
4. The activity of an organism depends on the total activity of independent cells.
5. Energy flow (metabolism and biochemistry) occurs within cells.
6. Cells contain DNA which is found specifically in the chromosome and RNA found in the cell nucleus and cytoplasm.
7. All cells are basically the same in chemical composition in organisms of similar species.

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Lecture 2

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Classification of organisms

Living organisms are classified mainly to avoid confusion, to make study of organisms easy and learn how various organisms are related to each other. Scientists classified living organisms into different kingdoms, phylum, class, etc. and are based on different criteria.

Our planet is a home for millions to billions of living species from small microbes to huge animals and humans. In our surroundings, we can see different types of plants, insects, birds and animals. Based on certain specialized features, these living species have been classified into their respective categories.

There are several different species of animals, birds, insects and plants, which vary in their mode of nutrition, their habitat, life cycle. Their names also differ from place to place, even within a country. To avoid this kind of confusion, scientists have classified and named them according to their characters.

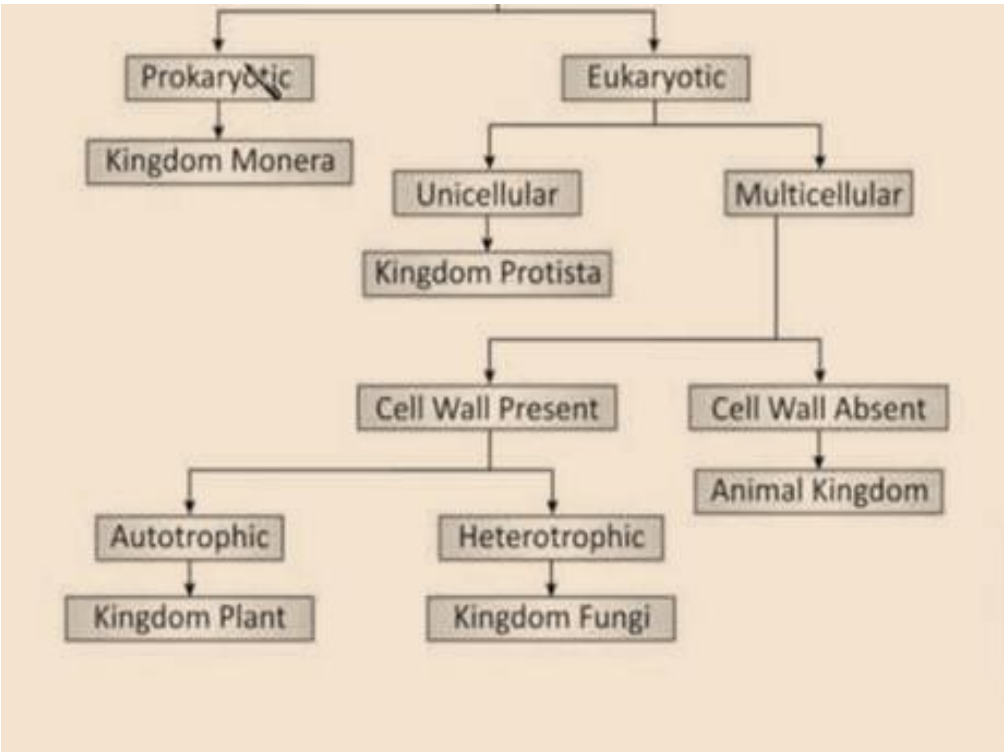
On the basis of their similarities and differences, living organisms are arranged into different groups and sub groups, which is termed classification of living organisms. This scientific process of classification is termed Biological classification. Science that deals with the classification and nomenclature of all living organisms are termed as Taxonomy. Here, the classification is mainly based on general, physical, genetic and biochemical variations.

The biological classifications have a number of advantages. Following are the advantages of classifying organisms:

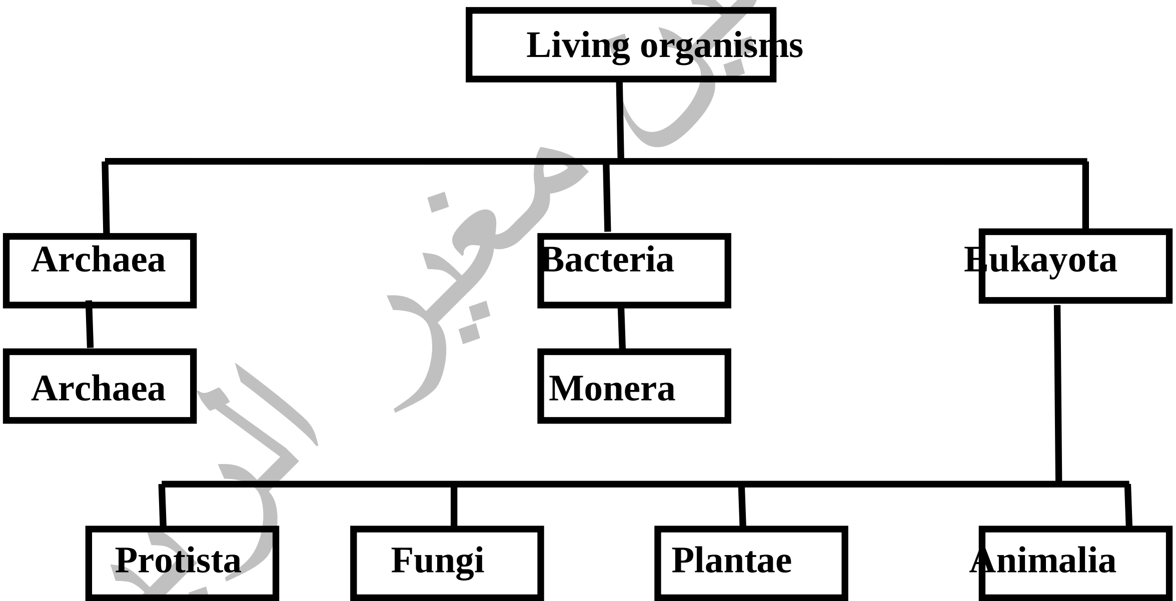
1. Understand the evolution of organisms.
2. Classify organisms based on their features.
3. Study different kinds of organisms both present and extinct.
4. Describes the inter-relationship among the various organisms.
5. Discover how animals, plants and other living species are related and are useful for human welfare.

Categories of classification of organisms

1. Domain
2. Kingdom
3. Phylum
4. Class
5. Order
6. Family
7. Genus
8. Species



The Five Kingdoms Scheme of classification



The Modern classification of living organisms

Human Biology

Lecture 3

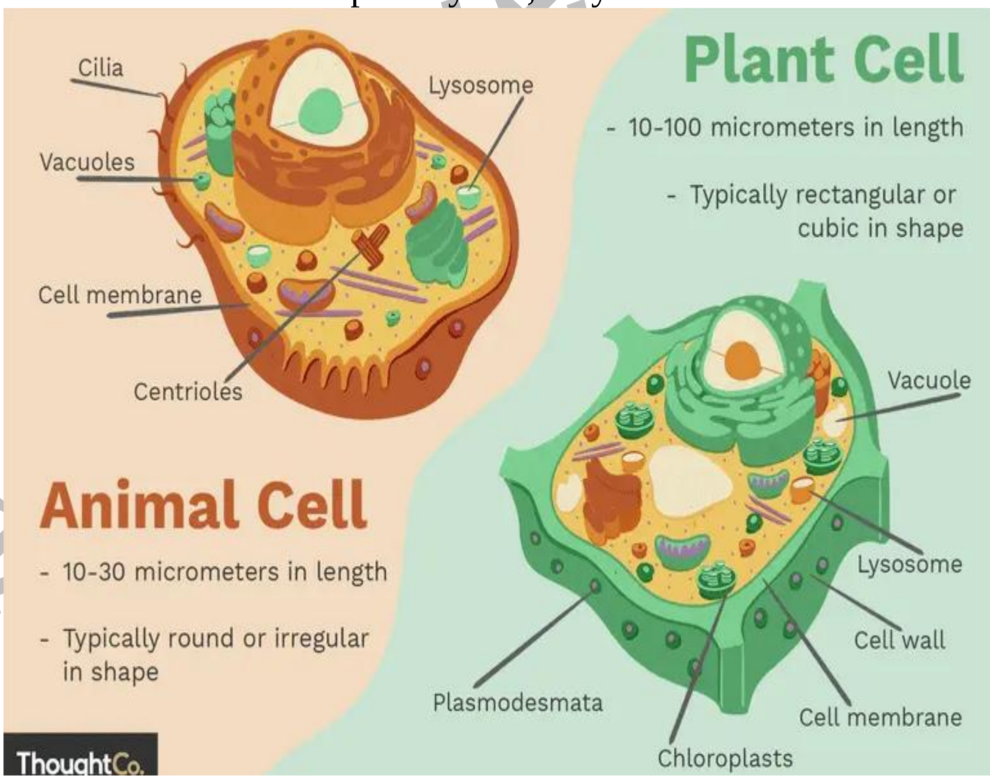
Dr. Abbas Hussein Mugheer

Cell Structures

Cells were discovered in 1665 by British scientist Robert Hooke who first observed them in his crude (by today's standards) seventeenth century optical microscope. In fact, Hooke coined the term "cell", in a biological context, when he described the microscopic structure of cork like a tiny, bare room or monk's cell. The nuclei are stained with a red probe, while the Golgi apparatus and microfilament actin network are stained green and blue, respectively. The microscope has been a fundamental tool in the field of cell biology and is often used to observe living cells in culture.

1. **Centrioles** : Centrioles are self-replicating organelles made up of nine bundles of microtubules and are found only in animal cells. They appear to help in organizing cell division, but aren't essential to the process.
2. **Cilia and Flagella**: For single-celled eukaryotes, cilia and flagella are essential for the locomotion of individual organisms. In multicellular organisms, cilia function to move fluid or materials past an immobile cell as well as moving a cell or group of cells.
3. **Endoplasmic Reticulum**: The endoplasmic reticulum is a network of sacs that manufactures, processes, and transports chemical compounds for use inside and outside of the cell. It is connected to the double-layered nuclear envelope, providing a pipeline between the nucleus and the cytoplasm.
4. **Endosomes and Endocytosis**: Endosomes are membrane-bound vesicles, formed via a complex family of processes collectively known as **endocytosis**, and found in the cytoplasm of virtually every animal cell. The basic mechanism of endocytosis is the reverse of what occurs during exocytosis or cellular secretion. It involves the invagination (folding inward) of a cell's plasma membrane to surround macromolecules or other matter diffusing through the extracellular fluid.
5. **Golgi Apparatus**: The Golgi apparatus is the distribution and shipping department for the cell's chemical products. It modifies proteins and fats built in the endoplasmic reticulum and prepare them for export to the outside of the cell.
6. **Intermediate Filaments**: Intermediate filaments are a very broad class of fibrous proteins that play an important role as both structural and functional elements of the cytoskeleton. Ranging in size from 8 to 12 nanometers, intermediate filaments function as tension-bearing elements to help maintain cell shape and rigidity.
7. **Lysosomes**: The main function of these microbodies is digestion. Lysosomes break down cellular waste products and debris from outside the cell into simple compounds, which are transferred to the cytoplasm as new cell-building materials.
8. **Microfilaments**: Microfilaments are solid rods made of globular proteins called actin. These filaments are primarily structural in function and are an important component of the cytoskeleton.

9. **Microtubules**: These straight, hollow cylinders are found throughout the cytoplasm of all eukaryotic cells (prokaryotes don't have them) and carry out a variety of functions, ranging from transport to structural support.
10. **Mitochondria**: Mitochondria are oblong shaped organelles that are found in the cytoplasm of every eukaryotic cell. In the animal cell, they are the main power generators, converting oxygen and nutrients into energy.
11. **Nucleus**: The nucleus is a highly specialized organelle that serves as the information processing and administrative center of the cell. This organelle has two major functions: it stores the cell's hereditary material, or DNA, and it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).
12. **Peroxisomes**: Microbodies are a diverse group of organelles that are found in the cytoplasm, roughly spherical and bound by a single membrane. There are several types of microbodies but peroxisomes are the most common.
13. **Plasma Membrane**: All living cells have a plasma membrane that encloses their contents. In prokaryotes, the membrane is the inner layer of protection surrounded by a rigid cell wall. Eukaryotic animal cells have only the membrane to contain and protect their contents. These membranes also regulate the passage of molecules in and out of the cells.
14. **Ribosomes**: All living cells contain ribosomes, tiny organelles composed of approximately 60 percent RNA and 40 percent protein. In eukaryotes, ribosomes are made of four strands of RNA. In prokaryotes, they consist of three strands of RNA.



Physical properties of cells

Cells are incredibly complex structures that are composed of many different components, and their complexity arises from several physical properties. Some of these properties include:

1. **Size:** Cells are extremely small, measuring on the scale of micrometers. Despite their small size, cells are able to carry out an incredibly wide range of functions, including growth, reproduction, and response to the environment.
2. **Organization:** Cells are highly organized, with different structures and organelles performing specific functions. For example, the cell membrane separates the inside of the cell from the outside, while the nucleus contains the genetic material.
3. **Membranes:** Cells are encased in a semi-permeable membrane that controls what enters and exits the cell. This allows the cell to maintain a specific environment, called the intracellular milieu, which enables the cell to carry out its specific functions.
4. **Movement:** Cells are able to move, either through their own means (such as muscle cells) or by being transported by other means (such as blood cells). Movement allows cells to change position in response to changes in the environment, and allows cells to interact with other cells.
5. **Metabolism:** Cells are able to carry out a wide range of metabolic reactions, using energy and nutrients from the environment to support growth and replication.
6. **Responding to the environment:** Cells are able to sense and respond to changes in their environment through various receptors and signaling pathways.
7. **Structure and regulation:** the complexity of cells can be also attributed to their complex network of protein and chemical interactions that are regulated by the cell's DNA, which plays a crucial role in defining the cell's function and behavior.

All these physical properties combined give the cells the complexity that allows them to carry out a wide range of functions and adapt to changing environmental conditions.

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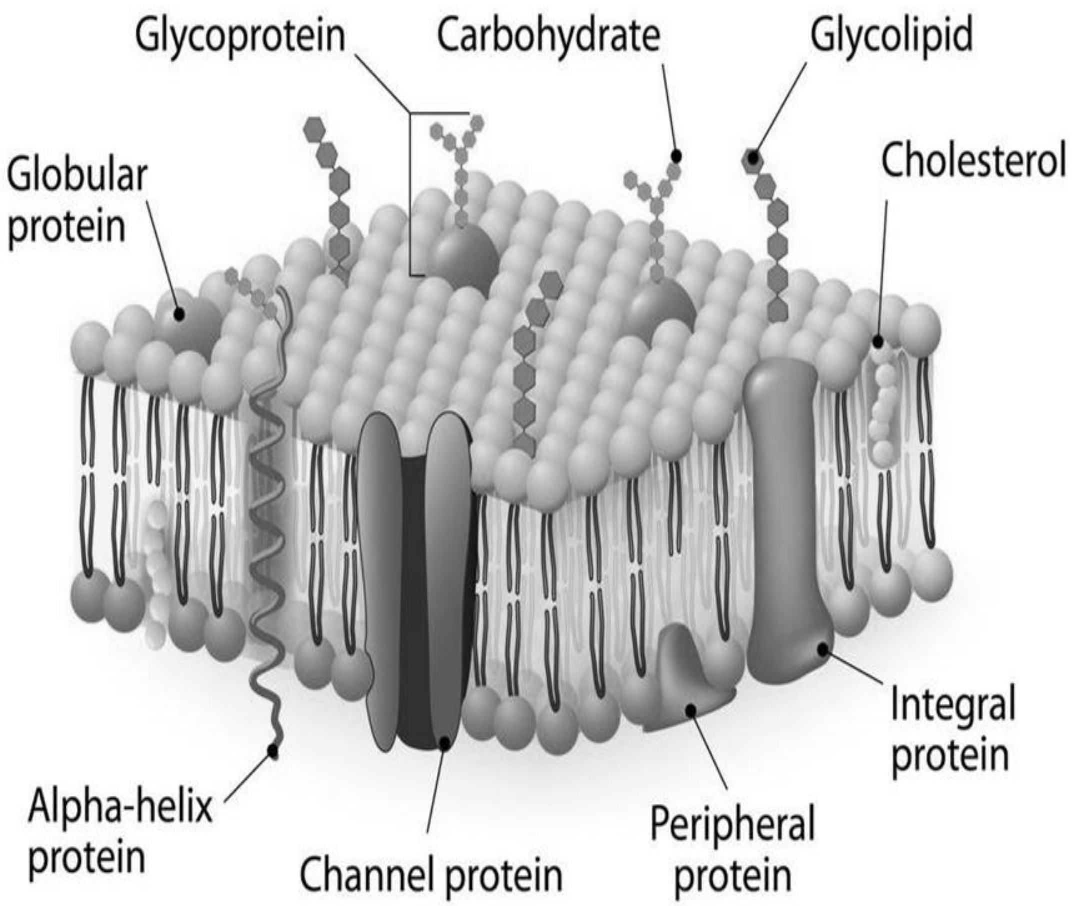
Cell Membrane

The cell membrane (plasma membrane) is a thin semi-permeable membrane that surrounds the cytoplasm of a cell. Its function is to protect the integrity of the interior of the cell by allowing certain substances into the cell while keeping other substances out. It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others. Thus the cell membrane also serves to help support the cell and help maintain its shape.

Cell Membrane Structure

The cell membrane is primarily composed of a mix of proteins and lipids. Depending on the membrane's location and role in the body, lipids can make up anywhere from 20 to 80 percent of the membrane, with the remainder being proteins. While lipids help to give membranes their flexibility, proteins monitor and maintain the cell's chemical climate and assist in the transfer of molecules across the membrane.



Cell Membrane Lipids

Phospholipids are a major component of cell membranes. Phospholipids form a lipid bilayer in which their hydrophilic (attracted to water) head areas spontaneously arrange to face the aqueous cytosol and the extracellular fluid, while their hydrophobic (repelled by water) tail areas face away from the cytosol and extracellular fluid. The lipid bilayer is semi-permeable, allowing only certain molecules to diffuse across the membrane.

Cholesterol is another lipid component of animal cell membranes. Cholesterol molecules are selectively dispersed between membrane phospholipids. This helps to keep cell membranes from becoming stiff by preventing phospholipids from being too closely packed together. Cholesterol is not found in the membranes of plant cells. Glycolipids are located on cell membrane surfaces and have a carbohydrate sugar chain attached to them. They help the cell to recognize other cells of the body.

Cell Membrane Proteins

The cell membrane contains two types of associated proteins. **Peripheral membrane proteins** are exterior to and connected to the membrane by interactions with other proteins. **Integral membrane proteins** are inserted into the membrane and most pass through the membrane. Portions of these transmembrane proteins are exposed on both sides of the membrane. Cell membrane proteins have a number of different functions.

Structural proteins help to give the cell support and shape. Cell membrane **receptor proteins** help cells communicate with their external environment through the use of hormones, neurotransmitters, and other signaling molecules.

Transport proteins, such as globular proteins, transport molecules across cell membranes through facilitated diffusion. **Glycoproteins** have a carbohydrate chain attached to them. They are embedded in the cell membrane and help in cell to cell communications and molecule transport across the membrane.

Function

The cell membrane surrounds the cytoplasm of living cells, physically separating the intracellular components from the extracellular environment. The cell membrane also plays a role in anchoring the cytoskeleton to provide shape to the cell, and in attaching to the extracellular matrix and other cells to hold them together to form tissues. Fungi, bacteria, most archaea, and plants also have a cell wall, which provides a mechanical support to the cell and precludes the passage of larger molecules.

The cell membrane is selectively permeable and able to regulate what enters and exits the cell, thus facilitating the transport of materials needed for survival. The movement of substances across the membrane can be achieved by either passive transport, occurring without the input of cellular energy, or by active transport, requiring the cell to expend energy in transporting it. The membrane also maintains the cell potential. The cell membrane thus works as a selective filter that allows only certain things to come inside or go outside the cell. The cell employs a number of transport mechanisms that involve biological membranes:

Endocytosis: Endocytosis is the process in which cells absorb molecules by engulfing them. The plasma membrane creates a small deformation inward, called an invagination, in which the substance to be transported is captured. This invagination is caused by proteins on the outside on the cell membrane, acting as receptors and clustering into depressions that eventually promote accumulation of more proteins and lipids on the cytosolic side of the membrane. The deformation then pinches off from the membrane on the inside of the cell, creating a vesicle containing the captured substance. Endocytosis is a pathway for internalizing solid particles ("cell eating" or **phagocytosis**), small molecules and ions ("cell drinking" or **pinocytosis**), and macromolecules. Endocytosis requires energy and is thus a form of active transport.

Exocytosis: Just as material can be brought into the cell by invagination and formation of a vesicle, the membrane of a vesicle can be fused with the plasma membrane, extruding its contents to the surrounding medium. This is the process of exocytosis. Exocytosis occurs in various cells to remove undigested residues of substances brought in by endocytosis, to secrete substances such as hormones and enzymes, and to transport a substance completely across a cellular barrier. In the process of exocytosis, the undigested waste-containing food vacuole or the secretory vesicle budded from Golgi apparatus, is first moved by cytoskeleton from the interior of the cell to the surface. The vesicle membrane comes in contact with the plasma membrane. The lipid molecules of the two bilayers rearrange themselves and the two membranes are, thus, fused. A passage is formed in the fused membrane and the vesicles discharge its contents outside the cell.

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Lecture 5

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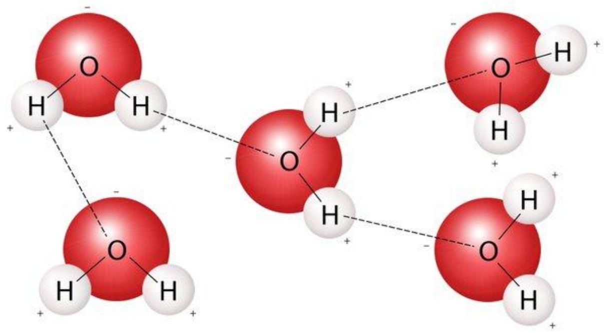
The Chemistry of cell

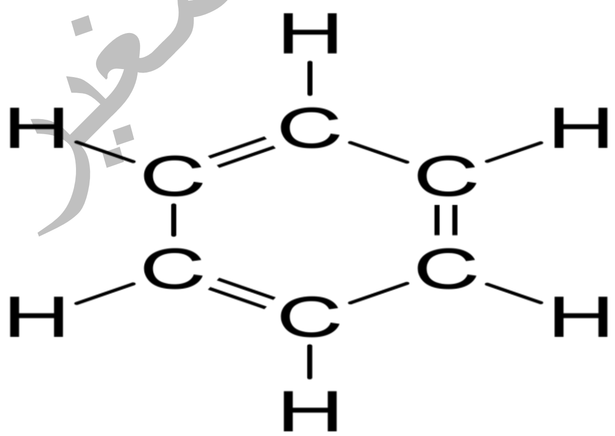
Water:

There is no life without water; water will be used to review some very basic ideas in chemistry, particularly as applies to cell and molecular biology.



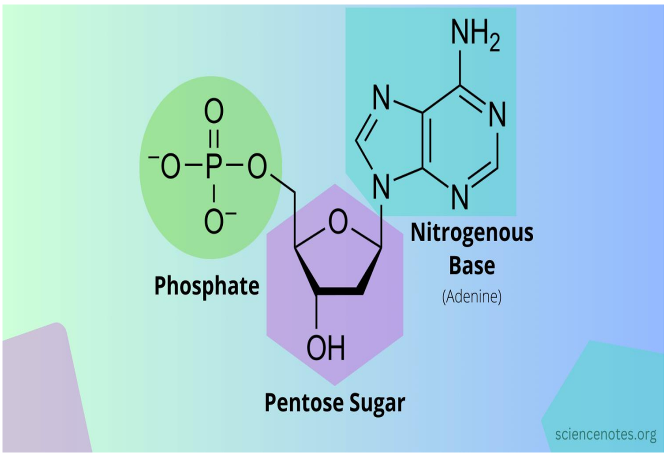
Carbon:

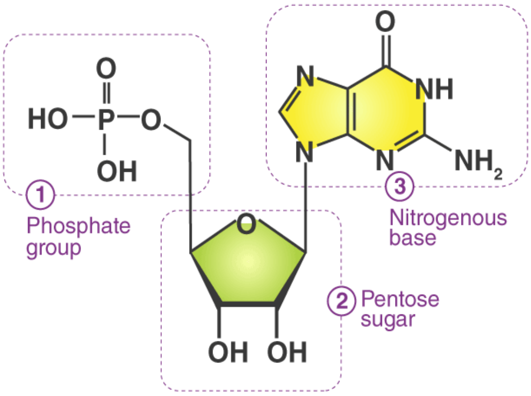
The major constituent molecules in all living organisms are based on carbon. Carbon has versatility stemming from its four outer shell electrons, allowing the possibility of four covalent bonds with a variety of partners, including very stable carbon-carbon covalent bonds. Because of this, long carbon chains can form the backbone of more complex molecules and makes possible the great diversity of macromolecules found in the cell.



Nucleotides:

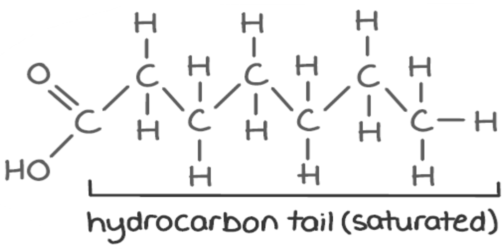
The building blocks of RNA and DNA, are themselves composed of a pentose sugar attached to a nitrogenous base on one side and a phosphate group on another. The sugar is either the 5-carbon sugar ribose or its close cousin, deoxyribose (the “deoxy” refers to a “missing” hydroxyl group on the 2-carbon, which has an H instead). The attached nitrogenous base can be a purine, which is a 6-member ring fused to a 5-member ring, or a pyrimidine, which is a single 6-membered ring.

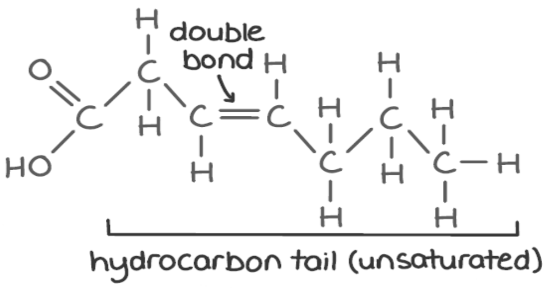




Fatty Acids

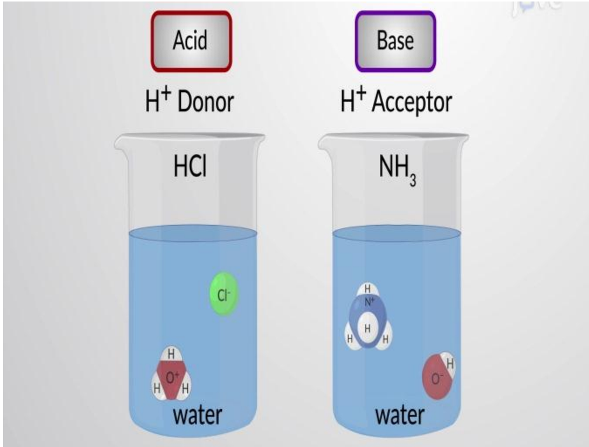
Unlike monosaccharides, nucleotides, and amino acids, fatty acids are not monomers that are linked together to form much larger molecules. Although fatty acids can be linked together, for example, into triacylglycerols or phospholipids, they are not linked directly to one another, and generally no more than three in a given molecule. The fatty acids themselves are long chains of carbon atoms topped off with a carboxyl group. The lengths of the chain vary, but most are between 14 and 20 carbons.





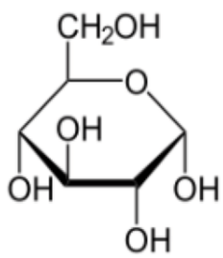
Acids and Bases

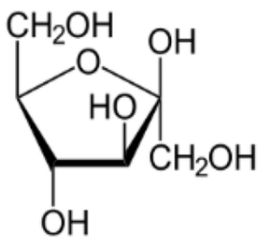
The release of H+ and OH— are not limited to water molecules, and many compounds do so in aqueous solutions. These compounds can be classified as acids (raising the free H+ concentration) or bases (increasing the free hydroxyl concentration]. The extent to which acids and bases donate or remove protons is measured on the pH scale, which is a logarithmic scale of relative H+ concentration.

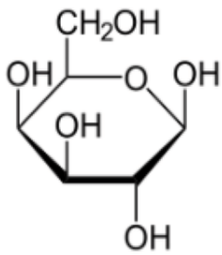


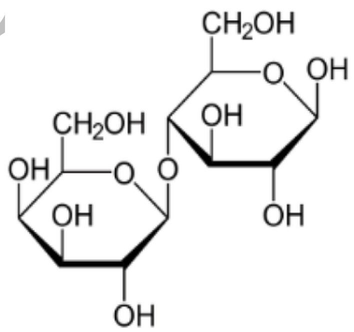
Sugars

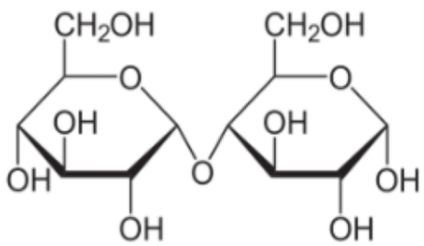
Sugars and glucose in particular, are important molecules for cells because they are the primary energy source. Sugars have the general chemical formula CH_2O and can be joined together almost infinitely for storage. However, because they are hydrophilic, they allow water molecules to intercalate between them, and cannot pack as efficiently as fats, which are hydrophobic and thus exclude water. On the other hand, the sugars can be mobilized for use more quickly.


Glucose


Fructose

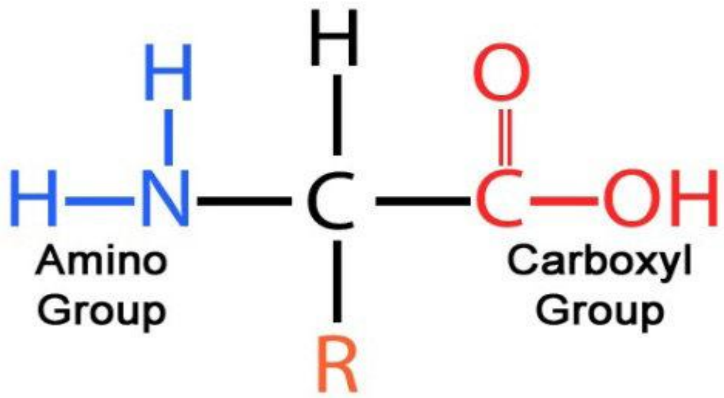

Galactose

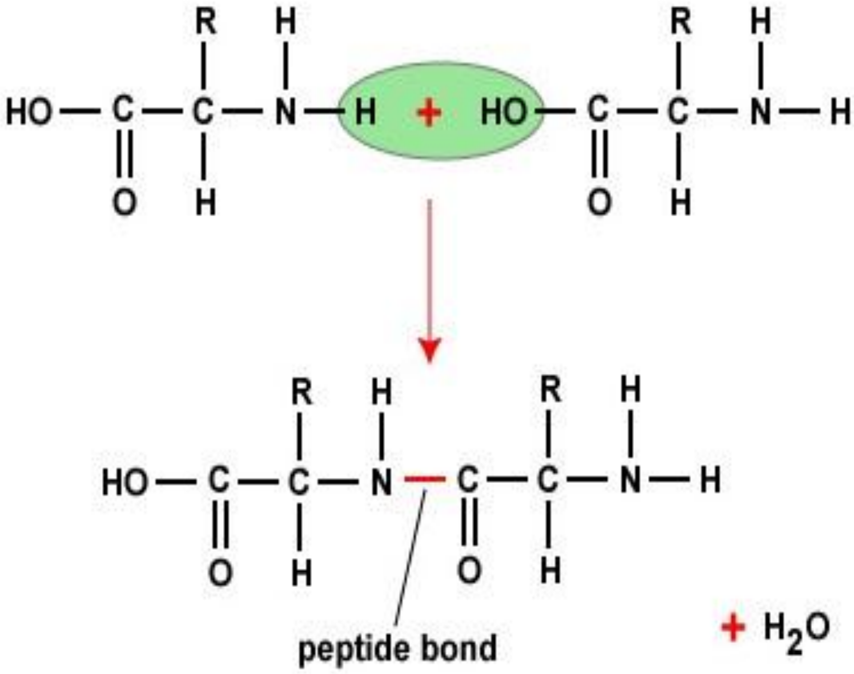

Lactose


Maltose

Amino Acids

Most of the major molecules of the cell - whether structural, like cellular equivalents of a building's girders and beams, or mechanical, like enzymes that take apart or put together other molecules, are proteins. Proteins interact with a wide variety of other molecules, though any given interaction is usually quite specific. The specificity is determined in part by electrical attraction between the molecules.





Human Biology

Lecture 6

Dr. Abbas Hussein Mugheer

Types of cells

Cells are broadly categorized into two types: eukaryotic cells, which possesses a nucleus, and prokaryotic cells, which lack a nucleus but still has a nucleoid region. Prokaryotes are single-celled organisms, whereas eukaryotes can be either single-celled or multicellular.

Prokaryotic cells

Structure of a typical prokaryotic cell

Prokaryotes include bacteria and archaea, two of the three domains of life. Prokaryotic cells were the first form of life on Earth, characterized by having vital biological processes including cell signaling. They are simpler and smaller than eukaryotic cells, and lack a nucleus, and other membrane-bound organelles. The DNA of a prokaryotic cell consists of a single circular chromosome that is in direct contact with the cytoplasm. The nuclear region in the cytoplasm is called the nucleoid. Most prokaryotes are the smallest of all organisms ranging from 0.5 to 2.0 µm in diameter.

A prokaryotic cell has three regions:

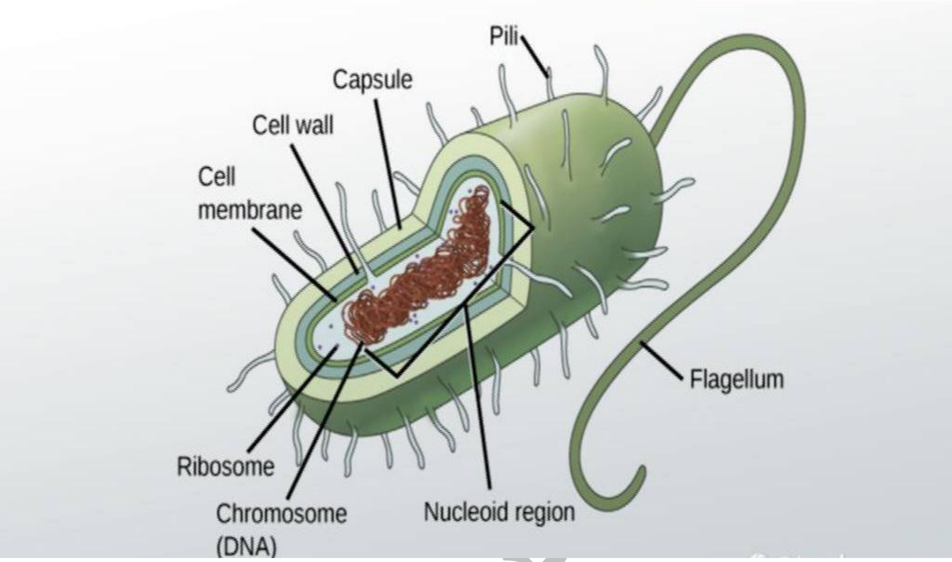
Enclosing the cell is the cell envelope, generally consisting of a plasma membrane covered by a cell wall which, for some bacteria, may be further covered by a third layer called a capsule. Though most prokaryotes have both a cell membrane and a cell wall, there are exceptions such as *Mycoplasma* and *Thermoplasma* (archaea) which only possess the cell membrane layer. The envelope gives rigidity to the cell and separates the interior of the cell from its environment, serving as a protective filter. The cell wall consists of peptidoglycan in bacteria and acts as an additional barrier against exterior forces. It also prevents the cell from expanding and bursting (cytolysis) from osmotic pressure due to a hypotonic environment. Some eukaryotic cells (plant cells and fungal cells) also have a cell wall.

Inside the cell is the cytoplasmic region that contains the genome (DNA), ribosomes and various sorts of inclusions. The genetic material is freely found in the cytoplasm. Prokaryotes can carry extrachromosomal DNA elements called plasmids, which are usually circular. Linear bacterial plasmids have been identified in several species of spirochete bacteria, including members of the genus Borrelia notably Borrelia burgdorferi, which causes Lyme disease. Though not forming a nucleus, the DNA is condensed in a nucleoid. Plasmids encode additional genes, such as antibiotic resistance genes.

On the outside, some prokaryotes have flagella and pili that project from the cell's surface. These are structures made of proteins that facilitate movement and communication between cells.

Bacterial shapes

Cell shape, also called cell morphology, has been hypothesized to form from the arrangement and movement of the cytoskeleton. Many advancement in the study of cell morphology come from studying simple bacteria such as *Staphylococcus aureus*, *E. coli*, and *B. subtilis*. Different cell shapes have been found and described, but how and why cells form different shapes is still widely unknown. Some cell shapes that have been identified include rods, cocci and spirochetes. Cocci are circular, bacilli are elongated rods, and spirochetes are spiral in form.

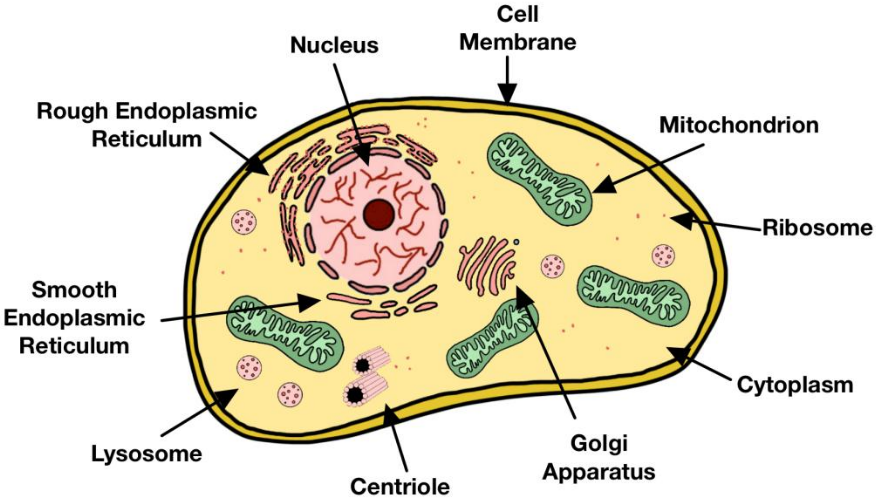


Eukaryotic cells

Plants, animals, fungi, slime moulds, protozoa, and algae are all eukaryotic. These cells are about fifteen times wider than a typical prokaryote and can be as much as a thousand times greater in volume. The main distinguishing feature of eukaryotes as compared to prokaryotes is compartmentalization: the presence of membrane-bound organelles (compartments) in which specific activities take place. Most important among these is a cell nucleus, an organelle that houses the cell's DNA. This nucleus gives the eukaryote its name, which means "true kernel (nucleus)". Some of the other differences are: The plasma membrane resembles that of prokaryotes in function, with minor differences in the setup. Cell walls may or may not be present.

The eukaryotic DNA is organized in one or more linear molecules, called chromosomes, which are associated with histone proteins. All chromosomal DNA is stored in the cell nucleus, separated from the cytoplasm by a membrane. Some eukaryotic organelles such as mitochondria also contain some DNA.

Many eukaryotic cells are ciliated with primary cilia. Primary cilia play important roles in chemosensation, mechanosensation, and thermosensation. Each cilium may thus be viewed as a sensory cellular antennae that coordinates a large number of cellular signaling pathways, sometimes coupling the signaling to ciliary motility or alternatively to cell division and differentiation. Motile eukaryotes can move using motile cilia or flagella. Motile cells are absent in conifers and flowering plants. Eukaryotic flagella are more complex than those of prokaryotes.



Comparison of features of prokaryotic and eukaryotic cells		
	Prokaryotes	**Eukaryotes**
Typical organisms	bacteria, archaea	protists, fungi, plants, animals
Typical size	~ 1–5 µm	~ 10–100 µm
Type of nucleus	nucleoid region; no true nucleus	true nucleus with double membrane
DNA	circular (usually)	linear molecules (chromosomes) with histone proteins
RNA/protein synthesis	coupled in the cytoplasm	RNA synthesis in the nucleus protein synthesis in the cytoplasm
Ribosomes	50S and 30S	60S and 40S
Cytoplasmic structure	very few structures	highly structured by endomembranes and a cytoskeleton
Cell movement	flagella made of flagellin	flagella and cilia containing microtubule s; lamellipodia and filopodia co ntaining actin
Mitochondria	None	one to several thousand
Chloroplasts	None	in algae and plants
Organization	usually single cells	single cells, colonies, higher multicellular organisms with

		specialized cells
Cell division	binary fission (simple division)	mitosis (fission or budding) meiosis
Chromosomes	single chromosome	more than one chromosome
Membranes	cell membrane	Cell membrane and membrane-bound organelles

Human Biology

Lecture 7

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Characteristics of Living Things

Defining a living thing is a difficult proposition, as is defining "life" that property possessed by living things. However, a living thing possesses certain properties that help define what life is.

Complex organization

Living things have a level of complexity and organization not found in lifeless objects. At its most fundamental level, a living thing is composed of one or more cells. These units, generally too small to be seen with the naked eye, are organized into tissues. A tissue is a series of cells that accomplish a shared function. Tissues, in turn, form organs, such as the stomach and kidney. A number of organs working together compose an organ system. An organism is a complex series of various organ systems.

Metabolism

Living things exhibit a rapid turnover of chemical materials, which is referred to as metabolism. 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. Nonliving things do not display metabolism.

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

To respond effectively to changes in the environment, an organism must coordinate its responses. A system of nerves and a number of chemical regulators called hormones coordinate activities within an organism. The organism responds to the stimuli by means of a number of effectors, such as muscles and glands. Energy is generally used in the process.

Organisms change their behavior in response to changes in the surrounding environment. For example, an organism may move in response to its environment. Responses such as this occur in definite patterns and make up the behavior of an organism. The behavior is active, not passive; an animal responding to a stimulus is different from a stone rolling down a hill. Living things display responsiveness; nonliving things do not.

Growth

Growth requires an organism to take in material from the environment and organize the material into its own structures. To accomplish growth, an organism expends some of the energy it acquires during metabolism. An organism has a pattern for accomplishing the building of growth structures.

During growth, a living organism transforms material that is unlike itself into materials that are like it. A person, for example, digests a meal of meat and vegetables and transforms the chemical material into more of himself or herself. A nonliving organism does not display this characteristic.

Reproduction

A living thing has the ability to produce copies of itself by the process known as reproduction. These copies are made while the organism is still living. Among plants and simple animals, reproduction is often an extension of the growth process. 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.

A sexual 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.

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. They develop abilities to cope with their environment that their ancestors did not have.

Evolution also results in a greater variety of organisms than existed in previous eras. This proliferation of populations of organisms is unique to living things.

Ecology

The environment influences the living things that it surrounds. Ecology is the study of relationships between organisms and their relationships with their environment. Both biotic factors (living things) and abiotic factors (nonliving things) can alter the environment. Rain and sunlight are non-living components, for example, that greatly influence the environment. Living things may migrate or hibernate if the environment becomes difficult to live in.

Human Biology

Lecture 8

Dr. Abbas Hussein Mugheer

Cell division

Cell division can be defined as a crucial biological process wherein a single parent cell divides resulting in the formation of two or more daughter cells. This process is integral for various biological functions like:

1. Growth
2. Development
3. Tissue repair
4. Reproduction

Cell division is a fundamental process that enables multicellular living organisms to develop from a single cell into complex organisms, while it is the typical mode of reproduction for unicellular organisms. It also plays a crucial role in maintaining tissue integrity. In the life of typical rapidly dividing human or animal cells with a total cycle time of 24 hours .

There are two forms of cell division:

(1) **direct cell division** .

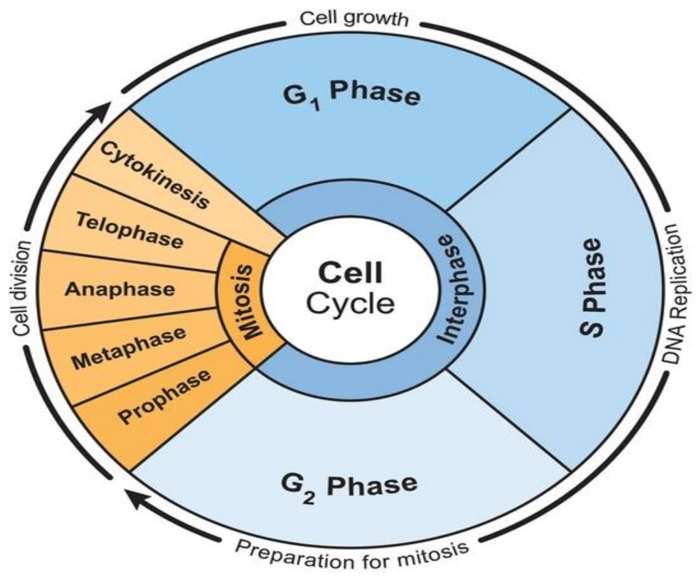
(2) **indirect cell division**.

Direct cell division is one in which the nucleus and the cytoplasm of the cell divide directly into two parts. This form of cell division is also referred to as amitosis. In contrast, indirect cell division involves complicated changes within the cell, e.g. formation of chromosomes, before the parent cell divides and produces daughter cells. Mitosis is a cell division that involves an indirect method of producing daughter cells.

Cell division is commonly used interchangeably with mitosis, a process comprised of karyokinesis and cytokinesis resulting in two genetically identical cells. Nevertheless, cell division is not exclusive to mitosis; it is also happening in meiosis, which, in comparison, is a process giving rise to cells with non-identical genetic material. Thus, cell division is a biological process involved in the growth and reproduction of various organisms. It is part of the organism's cell cycle.

The initial phase, the G1 phase, spans approximately 11 hours… This is followed by the **S-phase** lasting approximately 8 hours and subsequently,

The G2 phase occurs over approximately 4 hours, this culminates in the M phase which lasts for approximately 1 hour. What is astounding here is that cell division lasts only 1 hour in the 24-hour-long cell cycle. Even though cell division constitutes such a minuscule part (5%) of a larger cell cycle, it manifests some of the most intricate steps of cell cycle control like ensuring duplication of the genetic material of the cell, overseeing the proper assembly of genetic material into precise genetic configurations, and also its subsequent separation into 2 new daughter cells or progeny cells wherein each cell receives a complete set of genetic instructions.



Types of cell division.

Cell division encompasses different types of division which are :

1-Mitosis
2- Meiosis
3- Amitosis

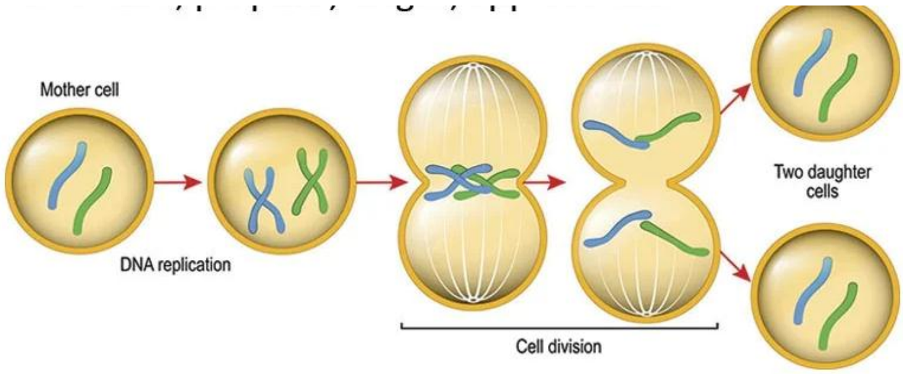
Mitosis

Mitosis is a unique type of cell division that can be observed in both somatic (non-reproductive cells) as well as germinal cells (egg cells and sperms). It involves a series of tightly regulated and organized steps that lead to the formation of two daughter cells. These genetically identical daughter cells (genetically identical to the parent cell) contain an equal number of chromosomes. Mitosis is known to aid several processes like tissue growth, maintenance, and asexual reproduction.

In eukaryotes, mitotic cell division occurs after the interphase (G1, S, G2 phases). Interphase is marked by the DNA synthesis and duplication of organelles and always precedes cell division

Mitosis comprises 4 main phases:

1- Prophase (where chromosomes condense and the nuclear envelope disintegrates)
2- Metaphase (where the chromosomes line up at the metaphase plate)
3- Anaphase (separation of sister chromatids)
4- Telophase (formation of two daughter cells with distinct cytoplasmic and genetic material)



Meiosis:

Meiosis is a specialized form of cell division that occurs in only germinal cells (egg and sperm cells) and not in somatic cells. This type of cell division is specifically designated for sexual reproduction in reproductive cells. It consists of two successive divisions that eventually result in the production of 4 daughter cells (or 4 gametes). These daughter cells are "genetically different" from the parent cell. Also, gametes don't contain an equal number of chromosomes as the parent cell. Each daughter cell is composed of "half the number of chromosomes" when compared to the parent cell. Meiosis is primarily responsible for genetic variation through processes such as genetic recombination.

Also called reduction division. The process by which the meiotic type of eukaryotic cell division occurs is relatively more complex than both prokaryotic binary division/budding and eukaryotic mitotic type of cell division.

This type of eukaryotic cell division process is an essential means of reproduction. It ensures that gamete formation occurs properly and genetic diversity is maintained in the species. Amongst the 2 types of cell divisions in eukaryotic organisms, meiosis is the second type.

This type of cell division occurs in sexually reproducing organisms. Just like mitosis, DNA, and organelles are replicated in the interphase before meiotic cell division.

Meiosis comprises 2 sets of divisions:

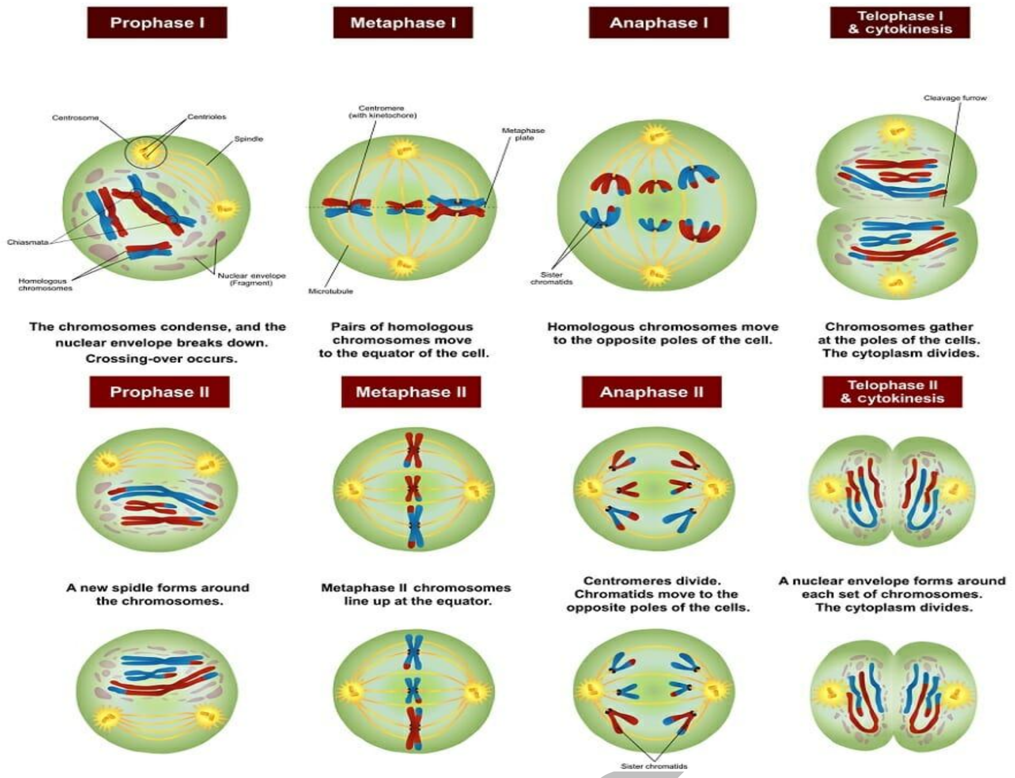
A-Meiosis I (marked by the separation of homologous chromosomes)

B-Meiosis II (marked by separation of sister chromatids; this is similar to mitosis)

At the end of meiotic cell division, four daughter cells (gametes) are formed, unlike 2 daughter cells in mitotic cell division. All daughter cells, i.e., gametes produced after meiosis have just 1 one copy of the genome, making them haploid (four haploid daughter cells). Only after one gamete fuses with the gamete of the opposite sex during fertilization, the ploidy level is restored.

The cell division stages vary among organisms, the different stages of meiosis are:

1-Prophase I 2- Metaphase I 3-Anaphase I 4-Telophase I --Cytokinesis
5-Prophase II 6- Metaphase II 7- Anaphase II 8-Telophase II



Amitosis:

Amitosis is a less common type of cell division that's usually observed in some specific single-celled organisms or specific cells within multicellular organisms. It differs from mitosis and meiosis as it does not involve the characteristic formation of a mitotic spindle apparatus or the precise separation of chromosomes.

Amitosis is a type of cell division observed in only certain categories of organisms. It is special because of its simplicity and directness. Unlike other forms of cell division that involve complex steps and precise chromosome separation, amitosis occurs through a relatively straightforward process. The parent cell simply divides directly into two or more daughter cells "without the involvement of elaborate machinery or intricate genetic reorganization". So, what does that mean to us?

This simplicity in amitosis can be fascinating as it highlights an alternative mechanism for cell division that 'bypasses the intricate processes' like:

1. Chromosome duplication
2. Spindle formation
3. Precise chromosome segregation

Amitosis thus serves as a remarkable example of the diversity and adaptability of cell division mechanisms in the natural world, shedding light on the wide range of strategies employed by living organisms to perpetuate their existence.

Human Biology

Lecture 9

Dr. Abbas Hussein Mugheer

Genetic Principles

Heredity is a process of transmission of heritable traits from parents to their offspring. Genetics is the branch of biology dealing with the principles and mechanism of inheritance and variation.

Inheritance is the basis of heredity and by this process; traits are passed on from the parents to the offspring. Continuity of the gene pool is maintained by the process of inheritance. Genes are the basic unit of inheritance and located on chromosomes.

Variation exists among individuals of one species. Variation is due to crossing over, recombination, mutation and environmental effects on the expression of genes present on chromosomes.

Mendel's Laws of Inheritance

Gregor Johann Mendel is called "Father of genetics". Mendel performed experiments on Garden pea. He took 14 true-breeding plants of pea having seven distinguishable characters, which have two opposite traits.

He called genes as "factors", which are passed from parents to offspring. Genes, that code for a pair of opposite traits are called "alleles". He gave three laws of inheritance based on his observation:

Law of Dominance

This is also called Mendel's first law of inheritance. According to the law of dominance, hybrid offspring will only inherit the dominant trait in the phenotype. The alleles that are suppressed are called the recessive traits while the alleles that determine the trait are known as the dominant traits.

Law of Segregation

The law of segregation states that during the production of gametes, two copies of each hereditary factor segregate so that offspring acquire one factor from each parent. In other words, allele (alternative form of the gene) pairs segregate during the formation of gamete and re-unite randomly during fertilization. This is also known as Mendel's third law of inheritance.

Law of Independent Assortment

Also known as Mendel's second law of inheritance, the law of independent assortment states that a pair of traits segregates independently of another pair during gamete formation. As the individual heredity factors assort independently, different traits get equal opportunity to occur together

A certain species is made up of individuals who have common features of appearance (hair color, eye shape and color, height, weight, etc.), behavior (aggressiveness, intelligence, sexual patterns), physiology (presence of certain enzymes and hormones, etc.), etc. Information about these characters is found in the DNA of the nucleus, and is passed down from parent to child. Each piece of DNA that contains information to express a certain character is called a gene, and a chromosome contains several of these genes.

The genes contained in DNA provide information about the different characteristics of the individual. Each character, determined by a gene, can have several different alternatives or alleles. The genotype is the set of genes of the individual. The expression of this genotype, depending on a certain environment, constitutes the phenotype of the individual. That is, the phenotype is what we see of that individual, if they have light or dark eyes, if they have straight or curly hair, etc. The phenotype is influenced by the environment, since it can modify it. The genotype, on the other hand, is not influenced by the environment.

Genetics concepts

In diploid beings, DNA is grouped into pairs of chromosomes. In each of these pairs, one chromosome comes from the father and one from the mother (homologous chromosomes). Each gene appears on the two chromosomes of each pair, so a certain character is determined by these two genes, which can be the same or different. The alleles are the different types of possible genes that may be for that character. For example, having light eyes is due to the action of one allele, and having dark eyes is due to the action of another allele. An individual can have the same two alleles, on the same pair of chromosomes, or different.

If the two alleles of the pair are equal, the individual is said to be homozygous or purebred for that trait. If the two alleles of the pair are different, the individual is said to be heterozygous or hybrid for that trait. The homologous chromosomes are a pair of chromosomes, one from the father and one from the mother, which contain the same genes, but may have different alleles.

As we have seen, the genotype is the set of genes of an individual. But not all the alleles that we have are manifested, since each character is determined by two alleles, and one of them may not appear. That is why there are characters that remain hidden, without manifesting themselves, but they are expressed in the phenotypes of grandparents and grandchildren.

Some of the genetic concepts that we have to be clear about are the following:

1-Gene: it is a fragment of chromosome responsible for the appearance of a hereditary character. The molecular genetic defines a gene as a DNA fragment (nucleotide sequence) responsible for the synthesis of a protein. Genes are segments of DNA made up of hundreds or thousands of nucleotides.

2-Locus. It is the place on the chromosome where the gene is located. In the plural, it is called loci.

3-Homologous genes. The homologous chromosomes have equivalent loci. That is, they both have the gene with the information for the same character in the same position. Therefore, in diploid cells, each character is regulated by two genes.

4-Alleles. They are each of the different possible genes that can be located at a certain locus. Two alleles of homologous chromosomes may or may not contain the same information.

5-Homozygous individual or pure race (for one character). When the two genes on homologous chromosomes contain the same information, that is, they have the same allele.

6-Heterozygous or hybrid individual (for one character). When the two genes on homologous chromosomes contain different information, that is, they have two different alleles.

7-The genotype is the set of genes that an individual has. The phenotype of an individual is the set of characters that it manifests.

8-The phenotype is determined by the genotype and influenced by the environment.

Human Biology

Lecture 10

Dr. Abbas Hussein Mugheer

Gene expression

A process by which information from a gene is used in the synthesis of a functional gene product that enables it to produce end products, proteins or non-coding RNA, and ultimately affect a phenotype. These products are often proteins, but in non-protein-coding genes such as transfer RNA (tRNA) and small nuclear RNA (snRNA), the product is a functional non-coding RNA. Gene expression is summarized in the central dogma of molecular biology first formulated by Francis Crick in 1958, further developed in his 1970 article, and expanded by the subsequent discoveries of reverse transcription and RNA replication. The process of gene expression is used by all known life eukaryotes (including multicellular organisms), prokaryotes (bacteria and archaea), and utilized by viruses to generate the macromolecular machinery for life.

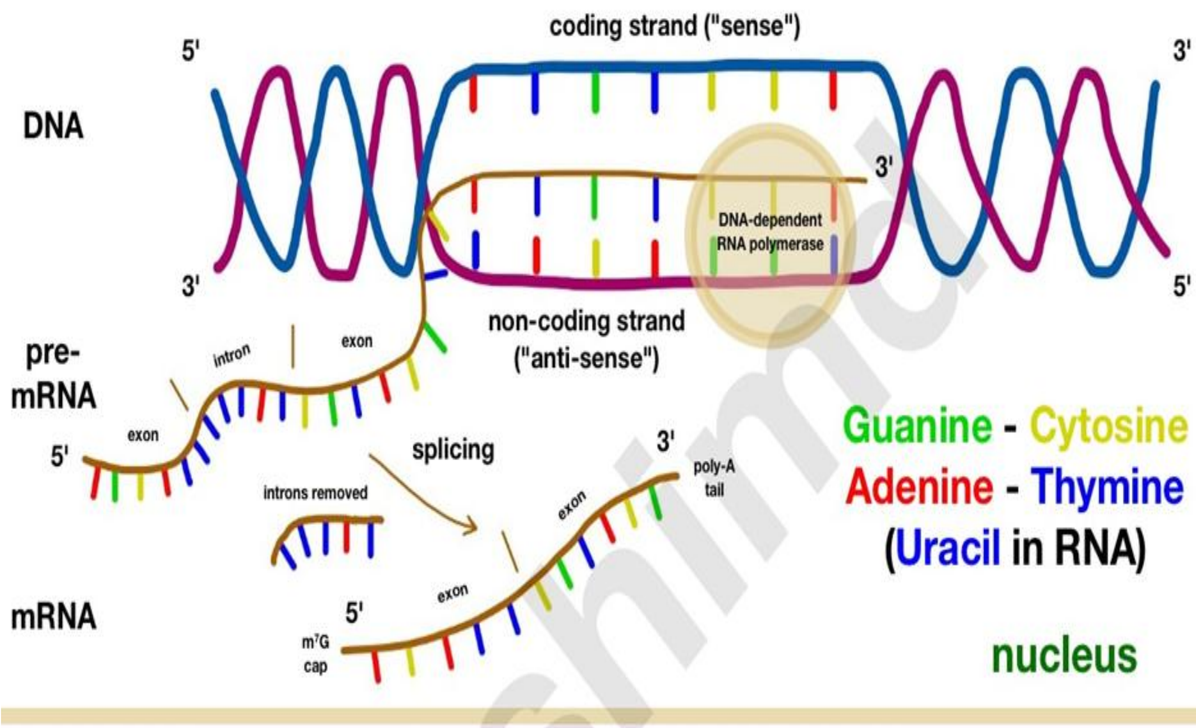
In genetics, gene expression is the most fundamental level at which the genotype gives rise to the phenotype, i.e. observable trait. The genetic information stored in DNA represents the genotype, whereas the phenotype results from the "interpretation" of that information. Such phenotypes are often displayed by the synthesis of proteins that control the organism's structure and development, or that act as enzymes catalyzing specific metabolic pathways.

All steps in the gene expression process may be modulated (regulated), including the transcription, RNA splicing, translation, and post-translational modification of a protein. Regulation of gene expression gives control over the timing, location, and amount of a given gene product (protein or ncRNA) present in a cell and can have a profound effect on the cellular structure and function. Regulation of gene expression is the basis for cellular differentiation, development, morphogenesis and the versatility and adaptability of any organism. Gene regulation may therefore serve as a substrate for evolutionary change.

The production of a RNA copy from a DNA strand is called transcription, and is performed by RNA polymerases, which add one ribonucleotide at a time to a growing RNA strand as per the complementarity law of the nucleotide bases. This RNA is complementary to the template $3' \rightarrow 5'$ DNA strand, with the exception that thymines (T) are replaced with uracils (U) in the RNA and possible errors.

Transcription

Transcription is when the DNA in a gene is copied to produce an RNA transcript called messenger RNA (mRNA). This is carried out by an enzyme called RNA polymerase which uses available bases from the nucleus of the cell to form the mRNA. RNA is a chemical similar in structure and properties to DNA, but it only has a single strand of bases and instead of the base thymine (T), RNA has a base called uracil (U).



Translation

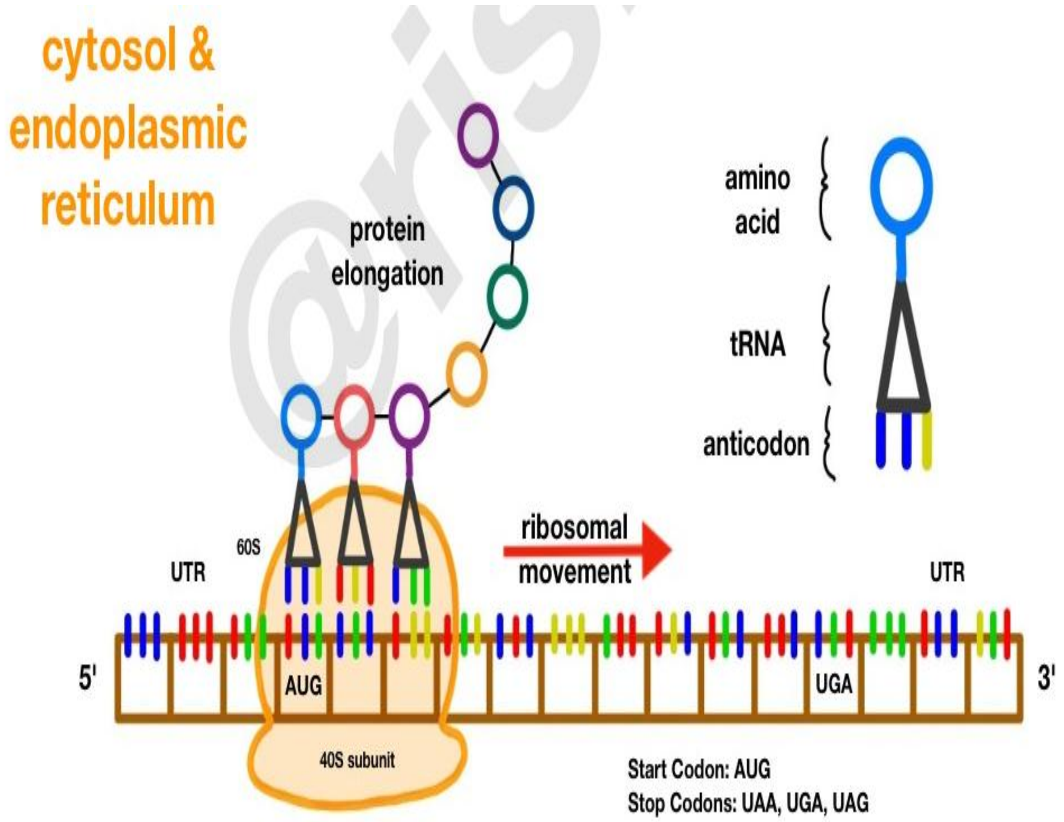
Translation occurs after the messenger RNA (mRNA) has carried the transcribed ‘message’ from the DNA to protein-making factories in the cell, called ribosomes. The message carried by the mRNA is read by a carrier molecule called transfer RNA (tRNA). The mRNA is read three letters (a codon) at a time. Each codon specifies a particular amino acid. For example, the three bases ‘GGU’ code for an amino acid called glycine.

As there are only 20 amino acids but 64 potential combinations of codon, more than one codon can code for the same amino acid. For example, the codons ‘GGU’ and ‘GGC’ both code for glycine. Each amino acid is attached specifically to its own tRNA molecule. When the mRNA sequence is read, each tRNA molecule delivers its amino acid to the ribosome and binds temporarily to the corresponding codon on the mRNA molecule.

Once the tRNA is bound, it releases its amino acid and the adjacent amino acids all join together into a long chain called a polypeptide.

This process continues until a protein is formed. Proteins carry out most of the active functions of a cell. During the translation, tRNA charged with amino acid enters the ribosome and aligns with the correct mRNA triplet. Ribosome then adds amino acid to growing protein chain.

Every mRNA consists of three parts: a 5′ untranslated region (5′UTR), a protein-coding region or open reading frame (ORF), and a 3′ untranslated region (3′UTR). The coding region carries information for protein synthesis encoded by the genetic code to form triplets. Each triplet of nucleotides of the coding region is called a codon and corresponds to a binding site complementary to an anticodon triplet in transfer RNA. Transfer RNAs with the same anticodon sequence always carry an identical type of amino acid. Amino acids are then chained together by the ribosome according to the order of triplets in the coding region. The ribosome helps transfer RNA to bind to messenger RNA and takes the amino acid from each transfer RNA and makes a structure-less protein out of it. Each mRNA molecule is translated into many protein molecules, on average ~2800 in mammals.



Human Biology
Lecture 11
Dr. Abbas Hussein Mugheer

Organ systems

An organ system is a group of organs that work together in the body to perform a complex function, such as pumping blood or processing and utilizing nutrients. There are 11 major organ systems in the human body: The immune system, The circulatory system, The lymphatic system, The respiratory system, The integumentary system, The endocrine system, The digestive system, The urinary system, The musculoskeletal system, The nervous system, The reproductive system.

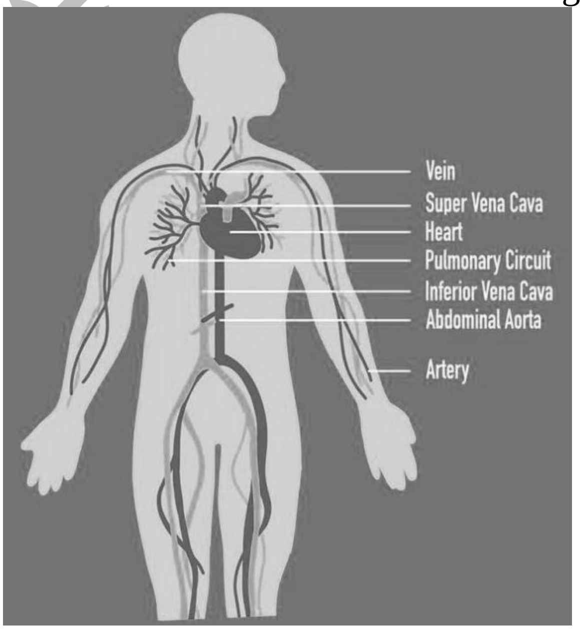
Organ systems work together with other organ systems to keep the body in good health for example, the circulatory and digestive systems work together to deliver nutrients throughout the body with the exception of the reproductive system, each is necessary for survival.

Circulatory System

The circulatory system transports oxygen and nutrients to all corners of the body. It also carries away carbon dioxide and other waste products. When people talk about this organ system, they're usually talking about the cardiovascular system at large, which includes the:

1- Heart
2- Blood vessels (arteries and veins)
3- The blood itself

In order for blood to make it everywhere it needs to go, the circulatory system maintains the blood flow within a certain pressure range. Blood pressure that's too high puts extra stress on other organs and tissues. Low blood pressure means the blood—and its nutrients—won't make it to where it needs to go.

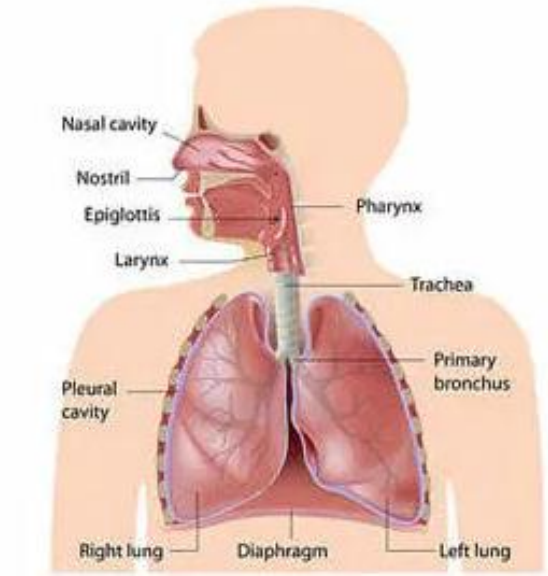


Respiratory System

The respiratory system is responsible for breathing, which is the controlled movement of air in and out of the body (ventilation). It also moves oxygen and carbon dioxide into and out of the bloodstream (respiration). This organ system contains the:

1- Lungs
2- Trachea (windpipe)
3- Airways of the respiratory tree

One of the least understood responsibilities of the respiratory system is to help regulate the body's pH balance, or the body's balance of acids and bases. Carbon dioxide is made into carbonic acid, which affects the pH balance. The respiratory system regulates this pH level when it releases carbon dioxide from the body. Breathing issues may indicate a condition that affects the body's acidity.



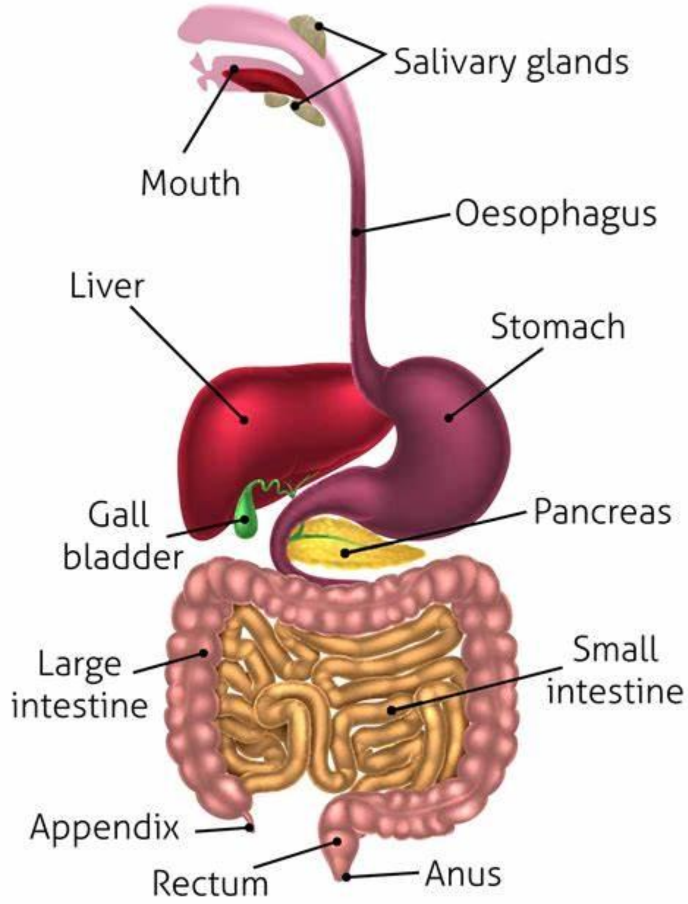
Digestive System

The gastrointestinal (GI) system is sometimes referred to as the gut or the digestive system. It is responsible for breaking down foods into nutrients, which the body needs for energy, growth, and cell repair. This system includes all the organs that carry food from where it enters the body to where it exits, including the:

1- Mouth
2- Esophagus
3- Stomach
4- Small intestine
5- Large intestine
6- Rectum
7- Anus
8- The pancreas, gallbladder, and liver are also part of this organ system.

The GI tract and the endocrine system have a lot of interaction. The endocrine system produces the hormones that regulate digestion and the absorption of nutrients. The GI system also owes a lot to the vagus nerve, the main contributor to the parasympathetic nervous system, which regulates bodily functions. The vagus nerve is involved in slowing metabolism, lowering heart rate and blood pressure, and stimulating the mechanics of digestion.

Some organs belong to more than one organ system. The pancreas, for example, can be considered a part of the digestive system because it secretes enzymes that help the body break down fat, protein, and starch. It is also part of the endocrine system because it produces hormones that help regulate blood sugar.

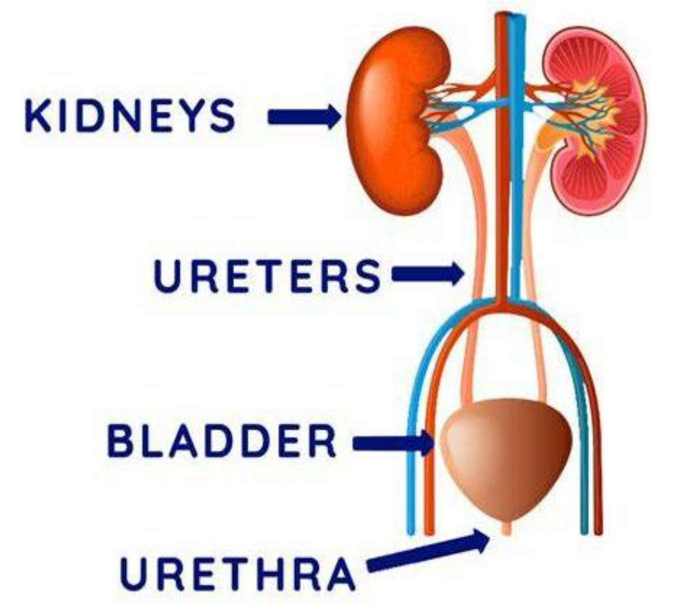


Urinary System

The urinary system is made up of the:

1- Kidneys
2- Ureters
3- Bladder
4- Urethra

These organs work together to filter blood and remove toxins and waste from body tissues. The removal of excess fluid through this organ system also helps regulate blood pressure.



Musculoskeletal System

The musculoskeletal system provides the framework and the engine for our movement, posture, and physical abilities.

This organ system includes the:

1- Skeleton

2- All the muscles, tendons, and ligaments attached to the skeleton

The three types of muscles in the body are:

a- Skeletal (voluntary)

b- Smooth (visceral or involuntary), which are inside walls of organs like the intestines

c- Cardiac (heart muscle)

Only skeletal muscle is considered part of the musculoskeletal system.

Nervous System

The nervous system is a network that makes it possible for different parts of the body to communicate with one another. Think of it as your body's command station. All body processes, reactions, thoughts, and movements stem from this organ system. The nervous system is incredibly detailed and includes the:

1- Brain
2- Spinal cord
3- All the nerves connected to both of these organs

It contains the only tissue that isn't fed directly through contact with blood.