OE22204 - Basics of Bio-Nanotechnology

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Biotechnology

- **Basics of Biology**
- **Cell and Organelles**
- **Nucleic Acids as Genetic Material**
- **Bio-Macromolecules**
- **Carbohydrates**
- **Lipids**
- **Proteins**
- **Nucleic Acids**

Basics of Biology

- Biology is the science that studies life, but what exactly is life?

- All living organisms share several key characteristics or functions: order, sensitivity or response to the environment, reproduction, adaptation, growth and development, regulation, homeostasis, energy processing, and evolution.

- When viewed together, these nine characteristics serve to define life.

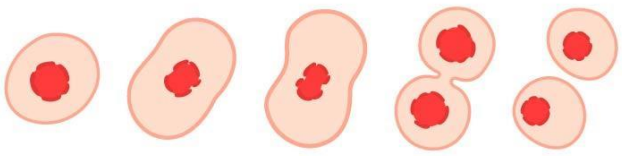
Order of arrangement of cells

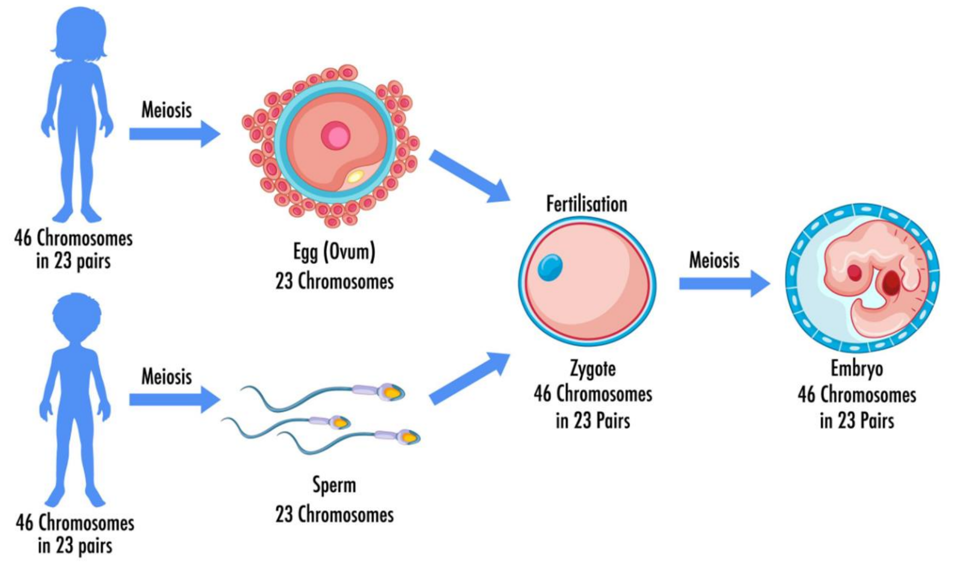
Every cells form tissues. Tissues, in turn, collaborate to create organs (body structures with a distinct function). Organs work together to form organ systems.

Sensitivity or Response to Stimuli

Organisms respond to diverse stimuli. For example, plants can bend toward a source of light, climb on fences and walls, or respond to touch. Even tiny bacteria can move toward or away from chemicals (a process called chemotaxis) or light (phototaxis). Movement toward a stimulus is considered a positive response, while movement away from a stimulus is considered a negative response.

Reproduction





Single-celled organisms reproduce by first duplicating their DNA, and then dividing it equally as the cell prepares to divide to form two new cells.

Multicellular organisms often produce specialized reproductive germline cells that will form new individuals.

Growth and Development

Organisms grow and develop following specific instructions coded for by their genes. These genes provide instructions that will direct cellular growth and development, ensuring that a species' young will grow up to exhibit many of the same characteristics as its parents.

Adaptation

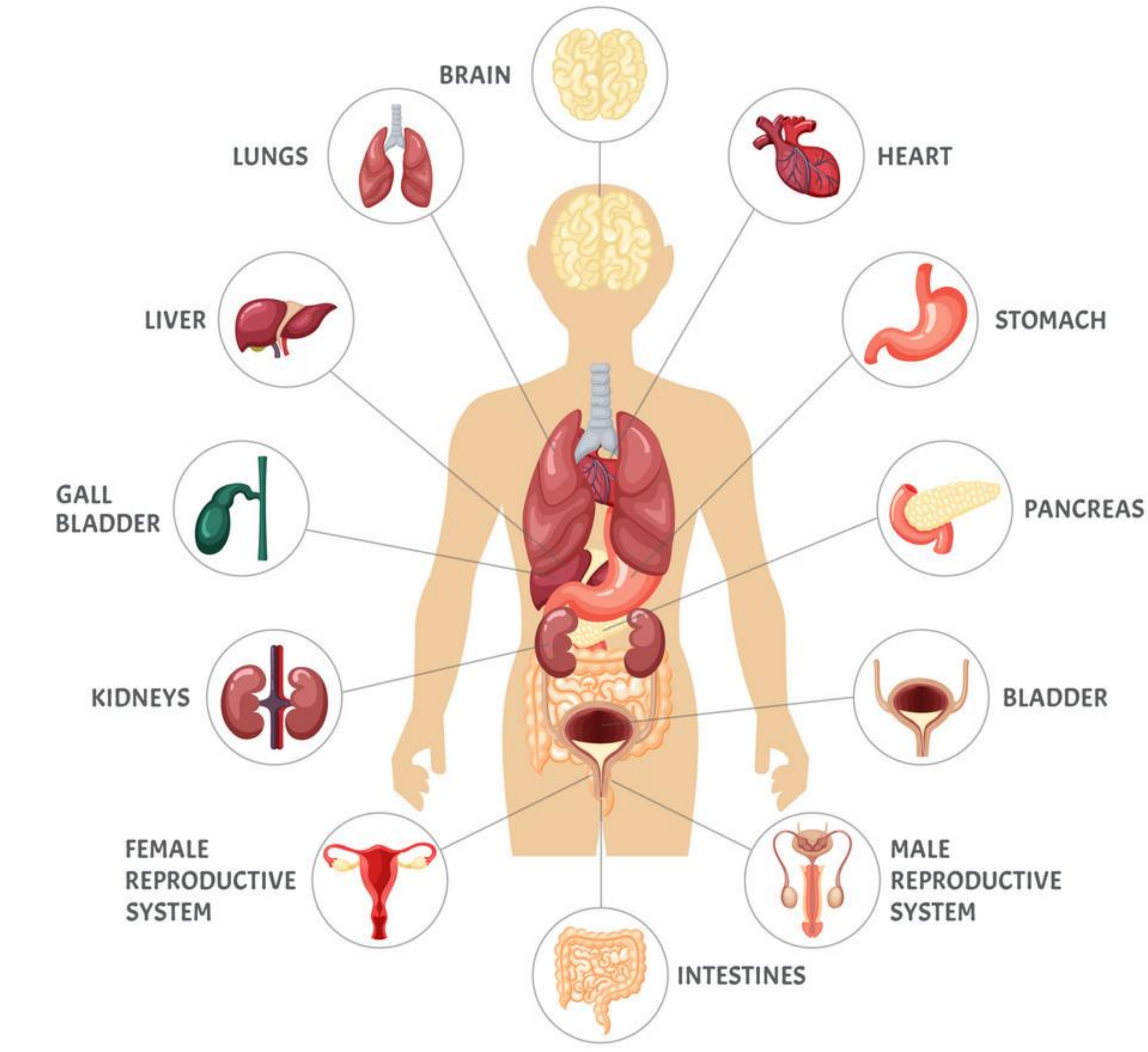
Long neck for reaching the leaves on tall trees

Black and white stripes to blend in with each other and confuse predator

Long ears to tackle African heat

Organisms grow and adapt themselves to the surroundings.

Regulation



Organisms have multiple regulatory mechanisms to coordinate internal functions, respond to stimuli, and cope with environmental stresses. Cells perform specific functions, such as carrying oxygen throughout the body, removing wastes, delivering nutrients to every cell, and cooling the body.

Homeostasis

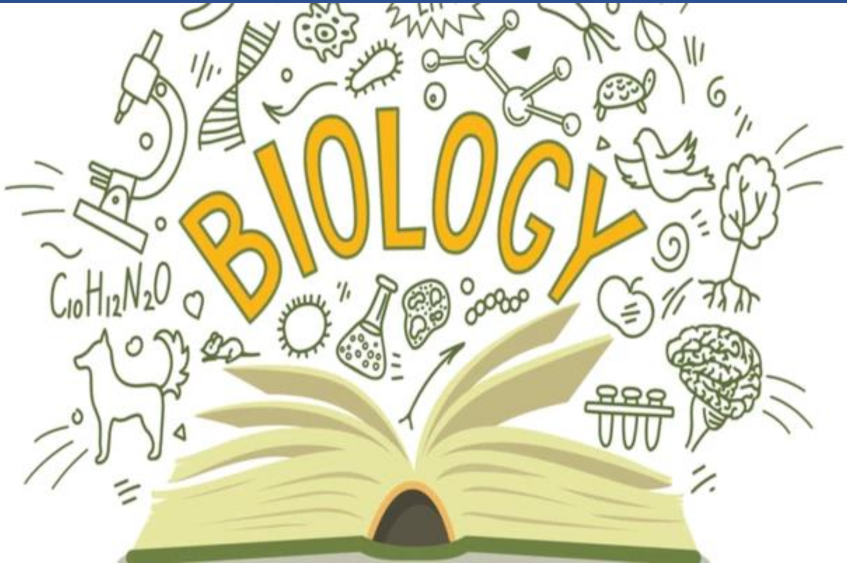
Homeostasis - Ability of an organism to maintain constant internal conditions (E.g. Internal Body Temperature)

Organisms that live in cold climates, such as the polar bear have body structures that help them withstand low temperatures and conserve body heat. Structures that aid in this type of insulation include fur, feathers, blubber, and fat.

Energy Processing

All organisms use a source of energy for their metabolic activities. Some organisms capture energy from the sun and convert it into chemical energy in food; others use chemical energy in molecules they take in as food

Definition of Biology



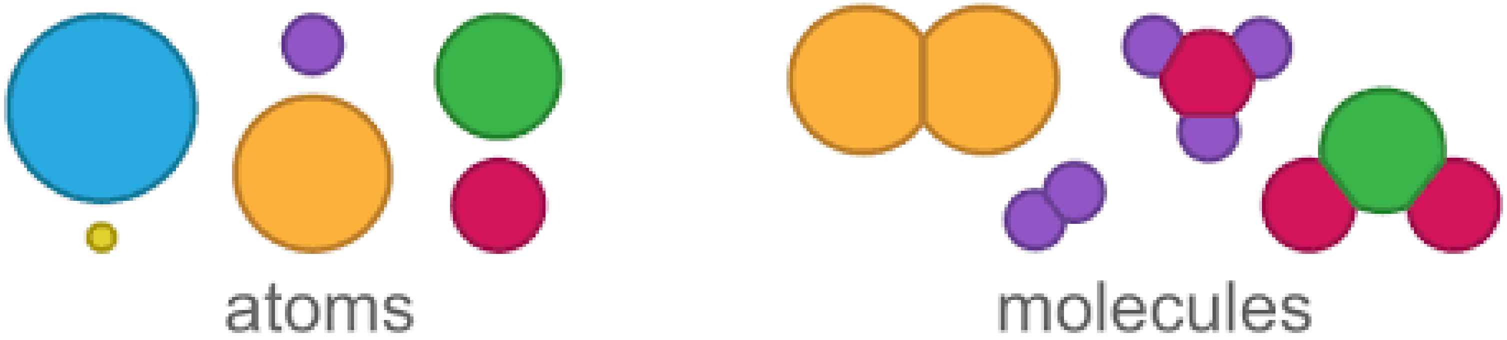
- The study of living things and their vital processes.

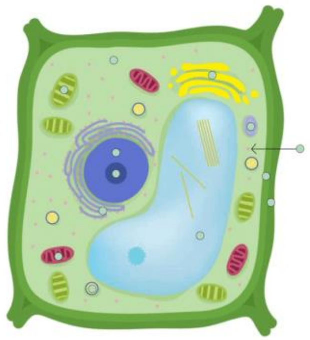
- Biology is subdivided into separate branches such as the study of plants (botany) from that of animals (zoology), and the study of the structure of organisms (morphology) from that of function (physiology), all living things share in common certain biological phenomena for example, various means of reproduction, cell division, and the transmission of genetic material.

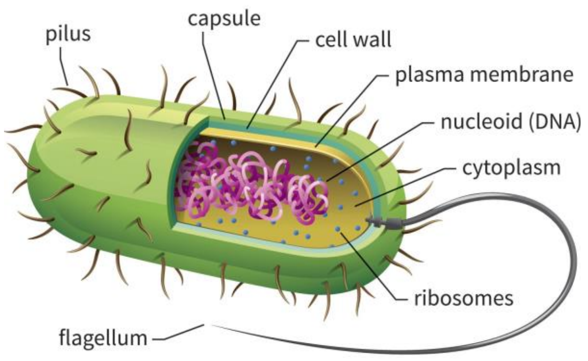
Levels of Organization of Living Things

Living things are highly organized and structured. The atom is the smallest and most fundamental unit of matter. It consists of a nucleus surrounded by electrons. Atoms form molecules. A molecule is a chemical structure consisting of at least two atoms held together by one or more chemical bonds.

Many molecules that are biologically important are macromolecules, large molecules that are typically formed by polymerization. An example of a macromolecule is deoxyribonucleic acid (DNA), which contains the instructions for the structure and functioning of all living organisms.







- All living things are made of cells; the cell itself is the smallest fundamental unit of structure and function in living organisms.

- Cells are classified as prokaryotic or eukaryotic.

- Prokaryotes are single-celled or colonial organisms that do not have membrane-bound nuclei; in contrast, the cells of eukaryotes have membrane-bound organelles and a membrane-bound nucleus.

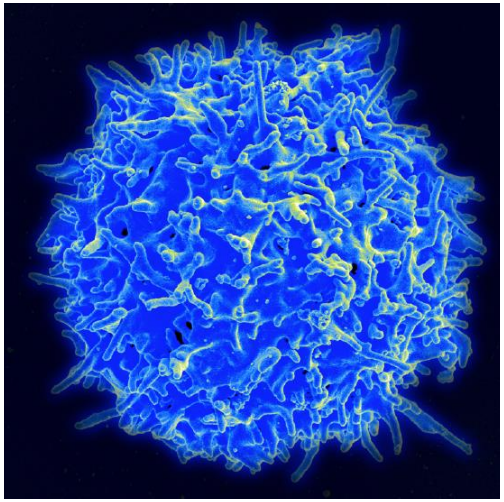
Cells

- Cells are the basic units of the structure and function of living things.

- They are the smallest units that can carry out the processes of life.

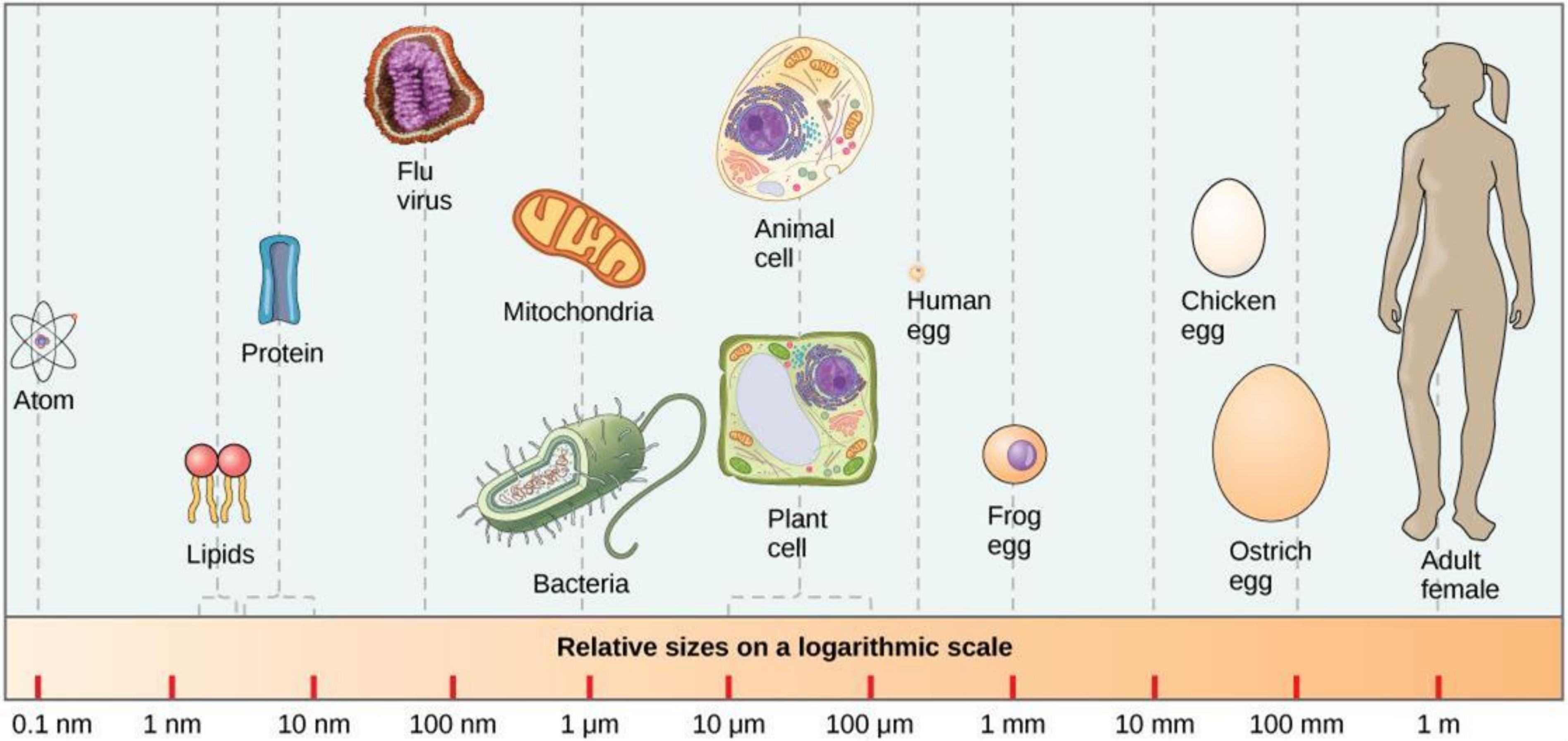
- All organisms are made up of one or more cells, and all cells have many of the same structures and carry out the same basic life processes.

- Several cells of one kind that interconnect with each other and perform a shared function form tissues, several tissues combine to form an organ (your stomach, heart, or brain), and several organs make up an organ system (such as the digestive system, circulatory system, or nervous system). Several systems that function together form an organism (like a human being).



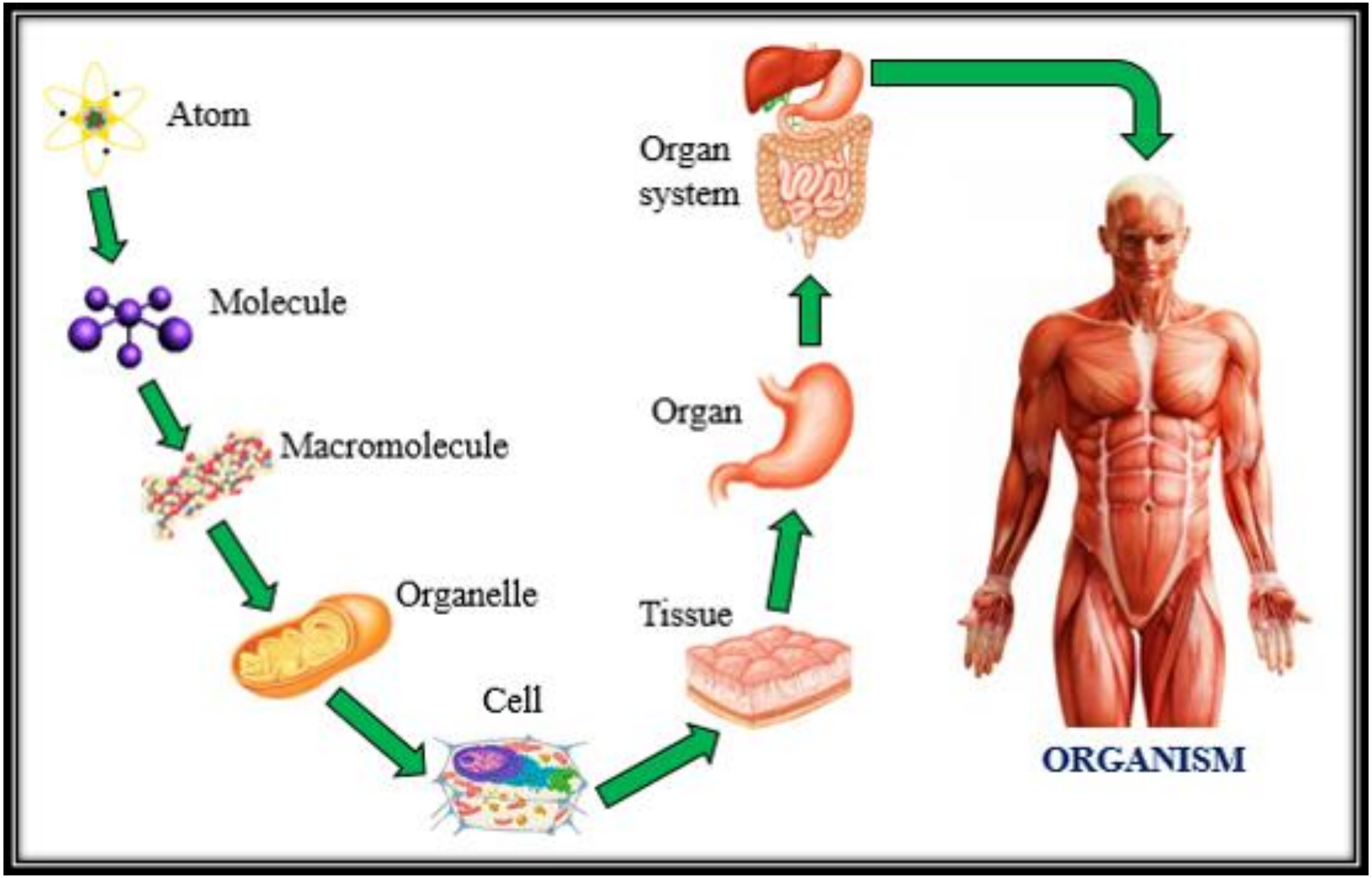
Immune cell

Cell Size

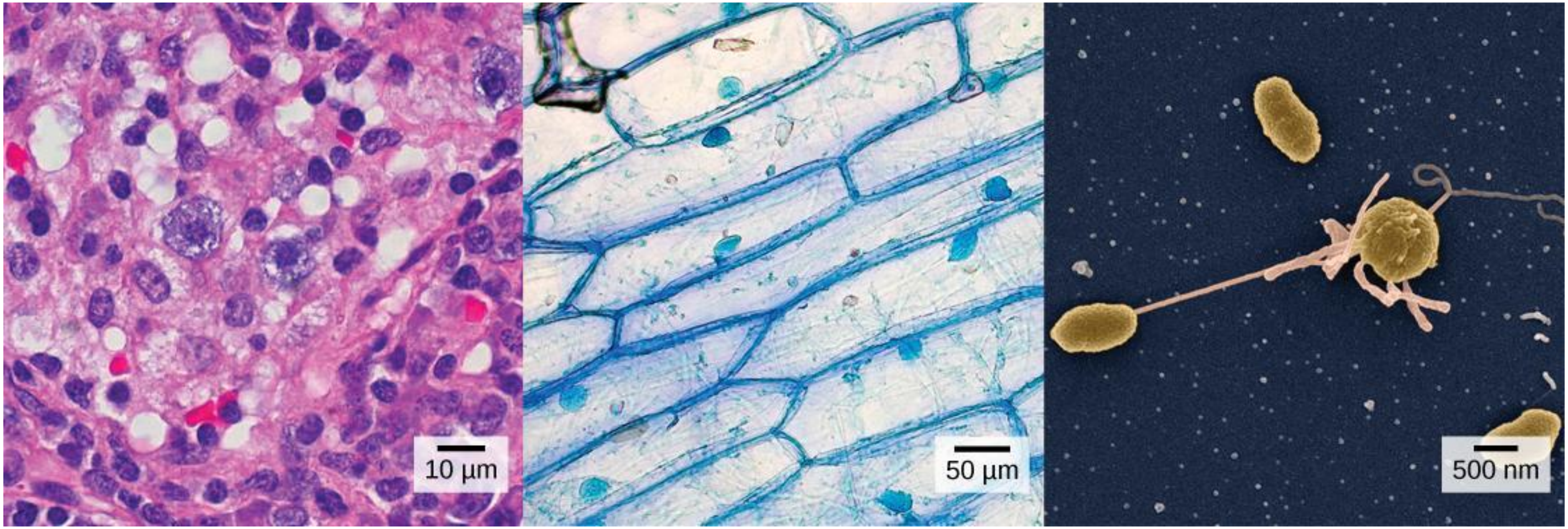


Atom
Lipids
Protein
Flu virus
Mitochondria
Bacteria
Animal cell
Plant cell
Human egg
Frog egg
Chicken egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m

Cell Size


Atom
Molecule
Macromolecule
Organelle
Cell
Tissue
Organ
Organ system
ORGANISM

Cells



Nasal Sinus Cells | Onion Cells | Bacterial Cells

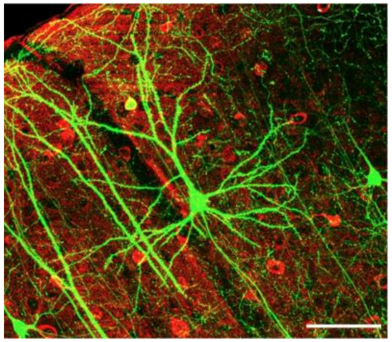
Your body has many kinds of cells, each specialized for a specific purpose. For example, epithelial cells protect the surface of the body. Bone cells help to support and protect the body. Cells of the immune system fight invading bacteria. Additionally, blood and blood cells carry nutrients and oxygen throughout the body while removing carbon dioxide.

Different forms of Human Cells

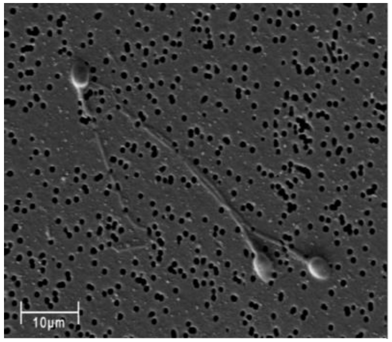
- Cells with different functions often have different shapes. For example, the job of the nerve cell is to carry messages to other cells. The nerve cell has many long extensions that reach out in all directions, allowing it to pass messages to many other cells at once.

- The sperm cells have tails. The tail helps a sperm cell "swim" through fluids in the female reproductive tract in order to reach an egg cell.

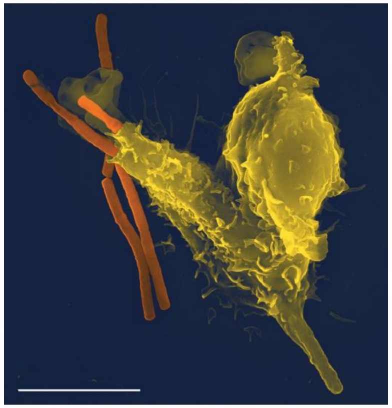
- The white blood cell has the job of destroying bacteria and other pathogens. Figure shows the large white blood cell (in yellow) engulfing and destroying bacteria (in orange)



Nerve cell



Sperm cell

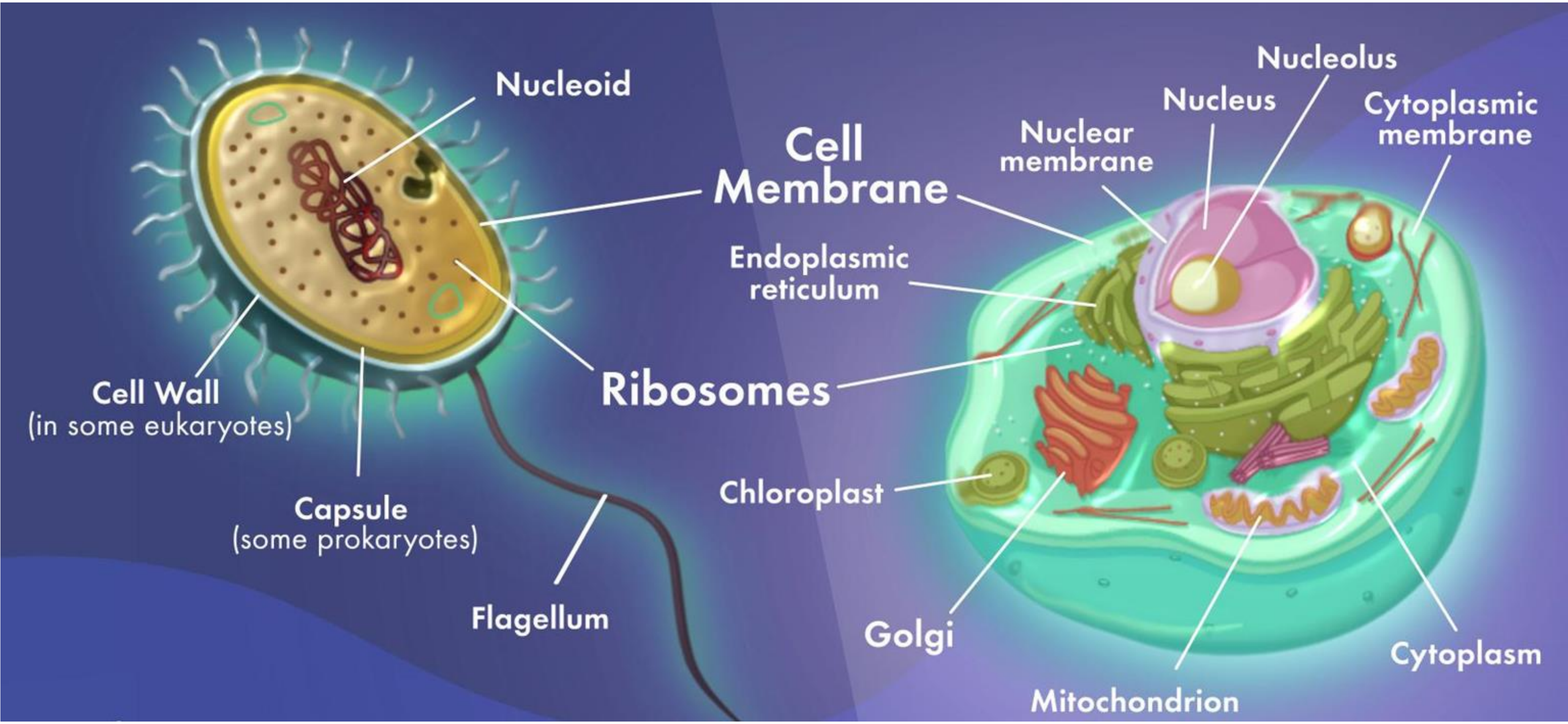


White Blood cell

Cells With and Without a Nucleus

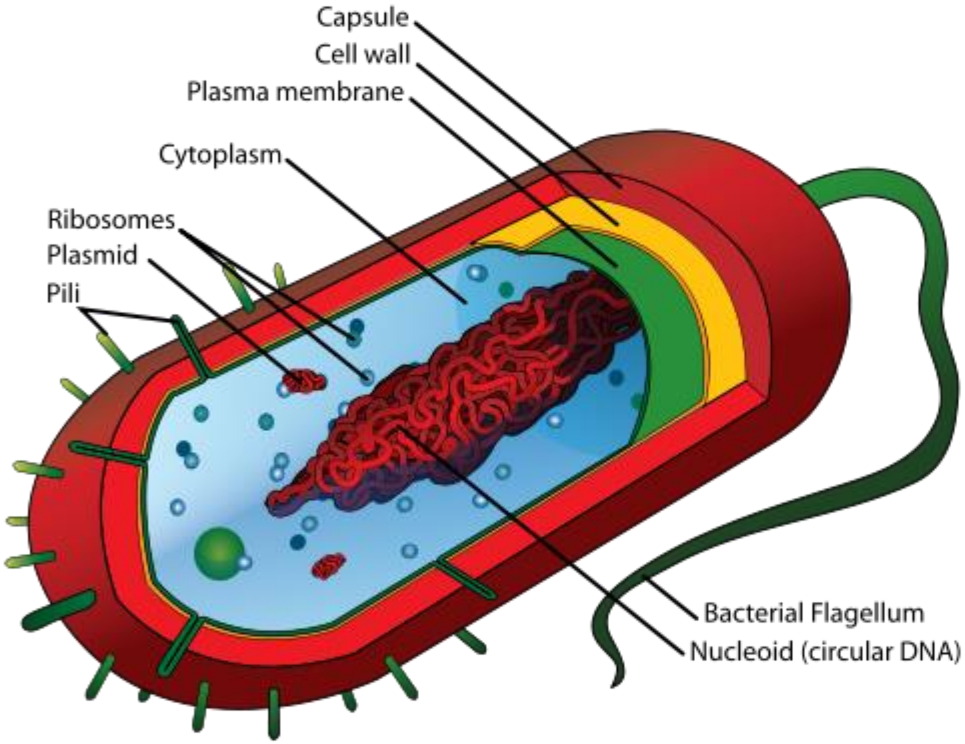
- There is a basic cell structure that is present in many but not all living cells: the nucleus.
- The nucleus of a cell is a structure in the cytoplasm that is surrounded by a membrane (the nuclear membrane) and contains DNA.
- Based on whether or not they have a nucleus, there are two basic types of cells: prokaryotic cells and eukaryotic cells.

Prokaryotic Vs. Eukaryotic



Prokaryotic Cells

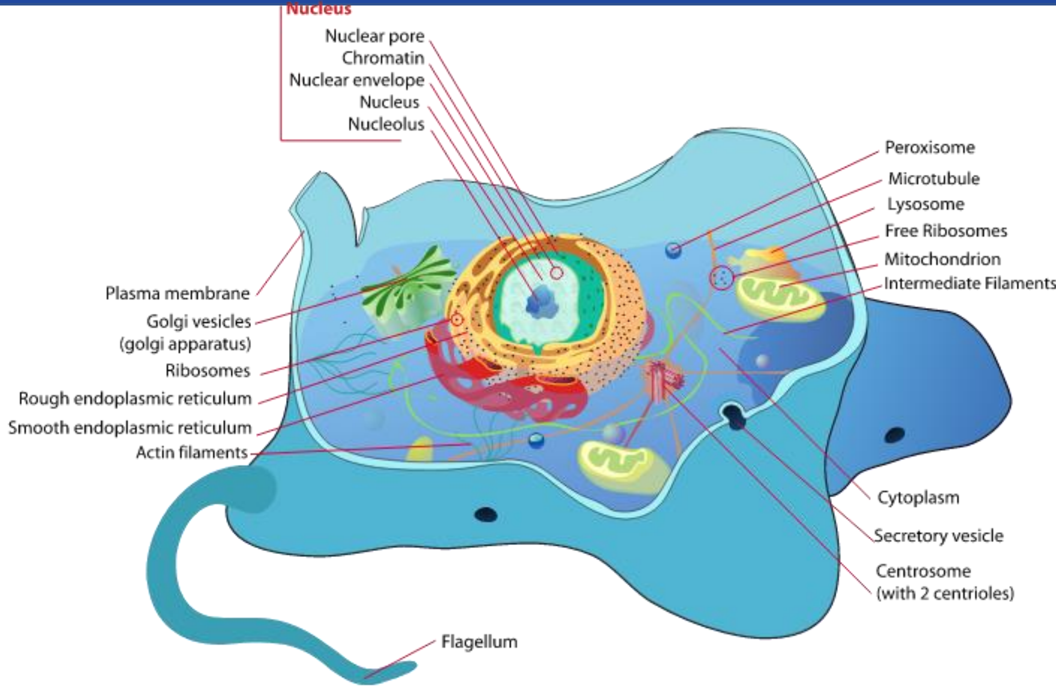
- Prokaryotic cells are cells without a nucleus. The DNA in prokaryotic cells is in the cytoplasm rather than enclosed within a nuclear membrane.
- Prokaryotic cells are found in single-celled organisms, such as the bacterium.
- Organisms with prokaryotic cells are called prokaryotes.
- They were the first type of organisms to evolve and are still the most common organisms today.



Prokaryotic Cells (contd.)

Cell Structure	Description
Flagellum	Long projection(s) outside of the cell in some bacteria; aids in the motility
Pili	Small projections outside of the cell; aid in attachment
Capsule	A thick protective layer outside the cell wall of some bacteria
Cell wall	Outer layer of bacterial cells; more chemically complex than eukaryotic cell walls
Plasma Membrane	Phospholipid bilayer marking the outside of the cytoplasm
Cytoplasm	The fluid portion of the cell
Ribosome	Involved in protein synthesis
Nucleoid	Circular DNA found in the cytoplasm
Plasmid	Small loops of DNA found in some bacteria

Eukaryotic Cell



- Eukaryotic cells are cells that contain a nucleus. Eukaryotic cells are usually larger than prokaryotic cells.

- They are found in some single-celled and all multicellular organisms. Organisms with eukaryotic cells are called eukaryotes, and they range from fungi to people.

Eukaryotic Cell (contd.)

Structure	Location	Description
Flagellum	Outside the cell	A projection used for locomotion in some eukaryotic cells
Plasma Membrane	Outer layer of cell	Phospholipid bilayer enclosing the cytoplasm
Cytoplasm	Bound by the plasma membrane	Entire region between the plasma membrane and the nuclear envelope, consisting of organelles suspended in the gel-like cytosol, the cytoskeleton, and various chemicals
Golgi Vesicles (Golgi Apparatus)	Cytoplasm	A series of stacked membranes that sorts, tags, and packages lipids and proteins for distribution
Ribosomes	free-floating or on rough ER	Involved in protein synthesis
Rough Endoplasmic Reticulum	Cytoplasm	Interconnected membranous structures that are studded with ribosomes and engage in protein modification and phospholipid synthesis
Smooth Endoplasmic Reticulum	Cytoplasm	Interconnected membranous structures that have few or no ribosomes on its cytoplasmic surface and synthesize carbohydrates, lipids, and steroid hormones; detoxifies certain chemicals (like pesticides, preservatives, medications, and environmental pollutants), and stores calcium ions
Mitochondria	Cytoplasm	(singular = mitochondrion) cellular organelles responsible for carrying out cellular respiration, resulting in producing ATP, the cell's main energy-carrying molecule
Peroxisome	Cytoplasm	The small, round organelle that contains hydrogen peroxide, and detoxifies many poisons
Lysosome	Cytoplasm	Organelle in an animal cell that functions as the cell's digestive component; it breaks down proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles
Secretory Vesicle	Cytoplasm	Small, membrane-bound sac that functions in cellular storage and transport; its membrane is capable of fusing with the plasma membrane and the membranes of the endoplasmic reticulum and Golgi apparatus

Organelles of Cell

- This simple, cut-away model of an animal cell shows that a cell resembles a plastic bag full of Jell-O. Its basic structure is a plasma membrane filled with cytoplasm. Like Jell-O containing mixed fruit, the cytoplasm of the cell also contains various structures, such as a nucleus and other organelles.

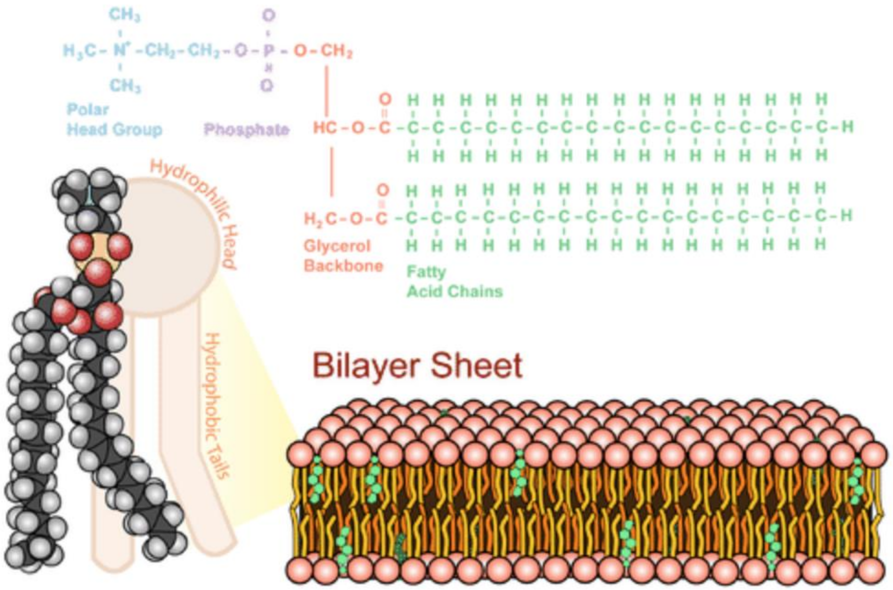
- Our body is made up of trillions of cells, but all of them perform the same basic life functions. They all obtain and use energy, respond to the environment, and reproduce.

Plasma Membrane

- The plasma membrane is a structure that forms a barrier between the cytoplasm inside the cell and the environment outside the cell.

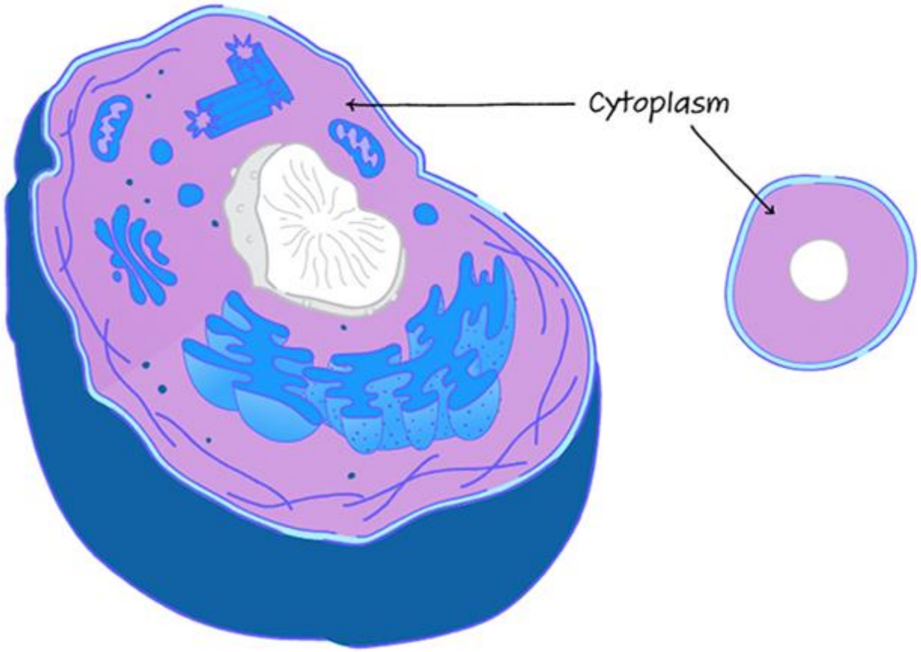
- Without the plasma membrane, there would be no cell. The membrane also protects and supports the cell and controls everything that enters and leaves it.

- It allows only certain substances to pass through while keeping others in or out.



- The plasma membrane is composed mainly of phospholipids, which consist of fatty acids and alcohol. The phospholipids in the plasma membrane are arranged in two layers, called a phospholipid bilayer, with a hydrophobic, or water-hating, interior and a hydrophilic, or water-loving, exterior.

Cytoplasm

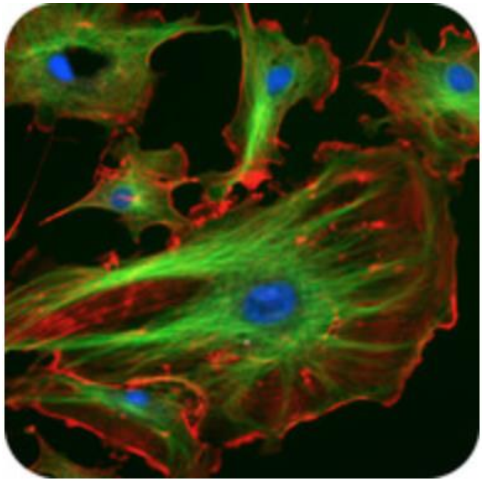


- The cytoplasm is a thick, usually colorless solution that fills each cell and is enclosed by the cell membrane. Cytoplasm presses against the cell membrane, filling out the cell and giving it its shape. Sometimes cytoplasm acts like a watery solution and sometimes it takes on a more gel-like consistency.

- It is composed of about 80 percent water and also contains dissolved salts, fatty acids, sugars, amino acids, and proteins such as enzymes. These dissolved substances are needed to keep the cell alive and carry out metabolic processes.

- The cytoplasm helps to keep organelles in place. It is also the site of most metabolic activities in the cell, and it allows materials to pass easily throughout the cell.

Cytoskeleton



- Although cytoplasm may appear to have no form or structure, it is actually highly organized. A framework of protein scaffolds called the cytoskeleton provides the cytoplasm and the cell with structure. The cytoskeleton consists of thread-like filaments and tubules that crisscross the cytoplasm.

- As its name suggests, the cytoskeleton is like a cellular “skeleton.” It helps the cell maintain its shape and also helps to hold cell structures such as organelles in place within the cytoplasm.

- The eukaryotic cytoskeleton is made up of a network of long, thin protein fibers. These threadlike proteins continually rebuild to adapt to the cell's constantly changing needs. Three main kinds of cytoskeleton fibers are microtubules, intermediate filaments, and microfilaments.

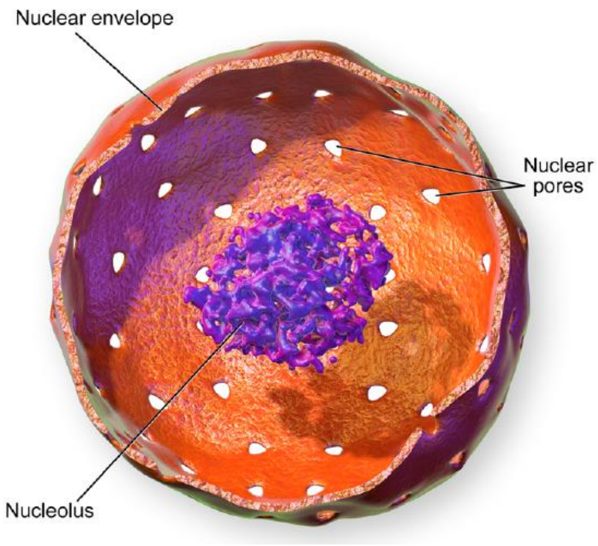
Cell Organelles

- An organelle is a structure within the cytoplasm of a eukaryotic cell that is enclosed within a membrane and performs a specific job.
- Organelles are involved in many vital cell functions.
- Organelles in animal cells include the following
    - Nucleus
    - Mitochondria
    - endoplasmic reticulum
    - Golgi apparatus
    - Vesicles
    - Vacuoles.

Cell Organelles (Analogy to a factory)

Organelle	Function	Factory part
Nucleus	DNA Storage	Room where the blueprints are kept
Mitochondrion	Energy production	Powerplant
Smooth Endoplasmic Reticulum (SER)	Lipid production; Detoxification	Accessory production - makes decorations for the toy, etc.
Rough Endoplasmic Reticulum (RER)	Protein production; in particular for export out of the cell	Primary production line - makes the toys
Golgi apparatus	Protein modification and export	Shipping department
Peroxisome	Lipid Destruction; contains oxidative enzymes	Security and waste removal
Lysosome	Protein destruction	Recycling and security

Nucleus



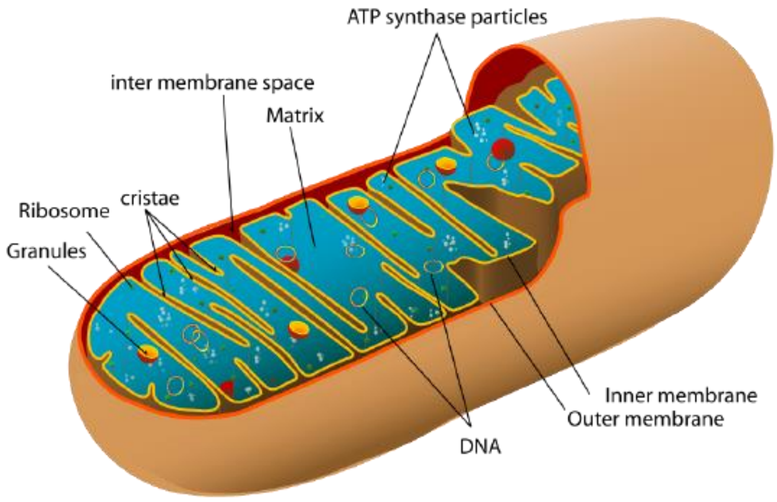
- The nucleus is the largest organelle in a eukaryotic cell and is considered to be the cell's control center. It contains most of the cell's DNA, which makes up chromosomes and is encoded with the genetic instructions for making proteins.

- The function of the nucleus is to regulate gene expression, including controlling which proteins the cell makes.

- Most eukaryotic cells contain just a single nucleus, but some types of cells, such as red blood cells, contain no nucleus.

- A few other types of cells, such as muscle cells, contain multiple nuclei.

Mitochondria



The mitochondrion is an organelle that makes energy available to the cell. This is why mitochondria are sometimes referred to as the power plants of the cell.

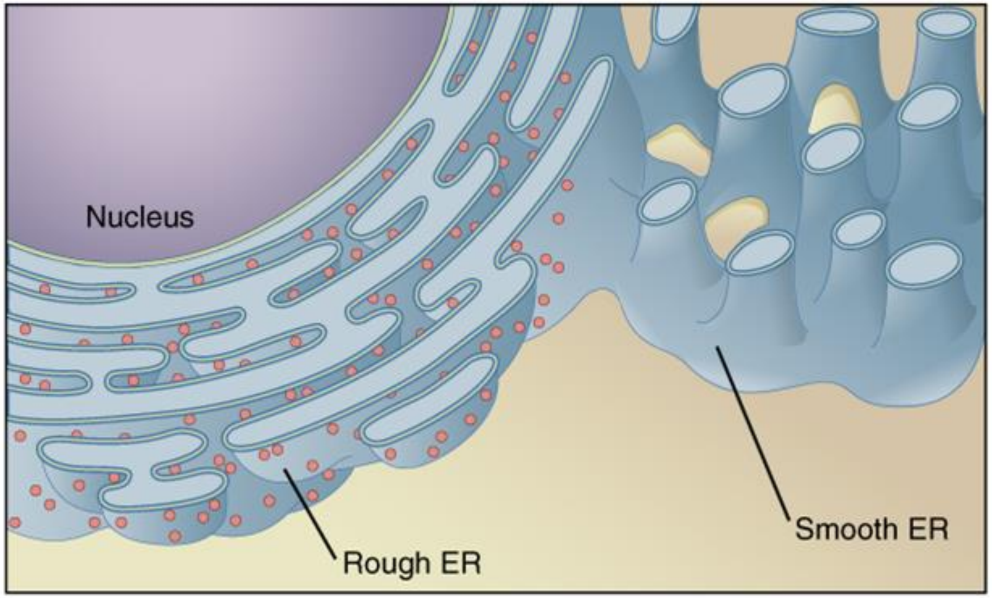
They use energy from organic compounds such as glucose to make molecules of ATP (adenosine triphosphate), an energy-carrying molecule that is used almost universally inside cells for energy.

Mitochondrial Compartments

The double membrane nature of the mitochondria results in five distinct compartments, each with an important role in cellular respiration. These compartments are:

- the outer mitochondrial membrane,
- the intermembrane space (the space between the outer and inner membranes),
- the inner mitochondrial membrane,
- the cristae (formed by infoldings of the inner membrane), and
- the matrix (space within the inner membrane).

Endoplasmic Reticulum (contd.)



- The endoplasmic reticulum (ER) is a network of phospholipid membranes that form hollow tubes, flattened sheets, and round sacs.
- These flattened, hollow folds and sacs are called cisternae.

The ER has two major functions:

Transport: Molecules, such as proteins, can move from place to place inside the ER, much like on an intracellular highway.

Synthesis: Ribosomes that are attached to the ER, similar to unattached ribosomes, make proteins. Lipids are also produced in the ER.

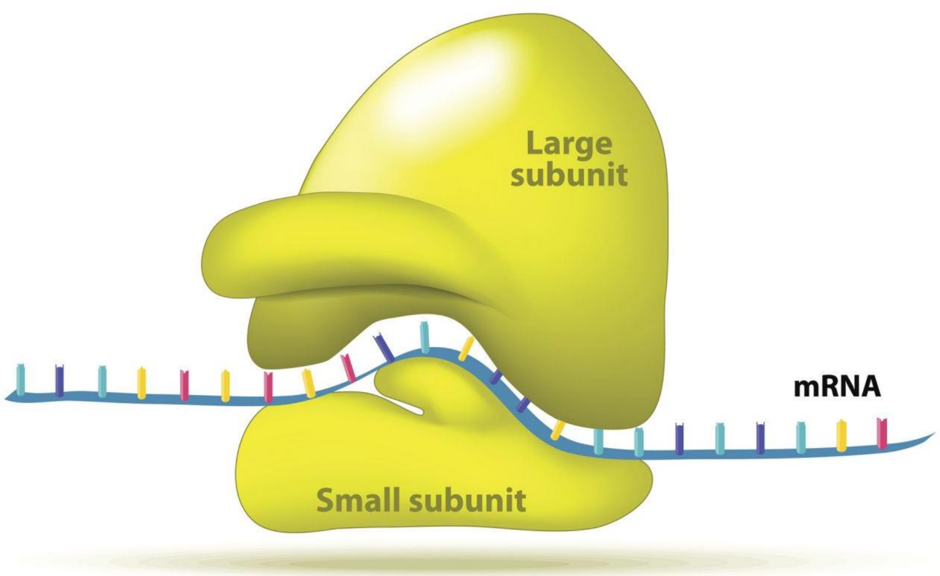
Endoplasmic Reticulum

There are two types of endoplasmic reticulum, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER):

- Rough endoplasmic reticulum is studded with ribosomes, which gives it a “rough” appearance. These ribosomes make proteins that are then transported from the ER in small sacs called transport vesicles. The transport vesicles pinch off the ends of the ER. The rough endoplasmic reticulum works with the Golgi apparatus to move new proteins to their proper destinations in the cell. The membrane of the RER is continuous with the outer layer of the nuclear envelope.

- Smooth endoplasmic reticulum does not have any ribosomes attached to it, and so it has a smooth appearance. SER has many different functions, some of which include lipid synthesis, calcium ion storage, and drug detoxification. The smooth endoplasmic reticulum is found in both animal and plant cells and it serves different functions in each. The SER is made up of tubules and vesicles that branch out to form a network. In some cells, there are dilated areas like the sacs of RER. Smooth endoplasmic reticulum and RER form an interconnected network.

Ribosomes

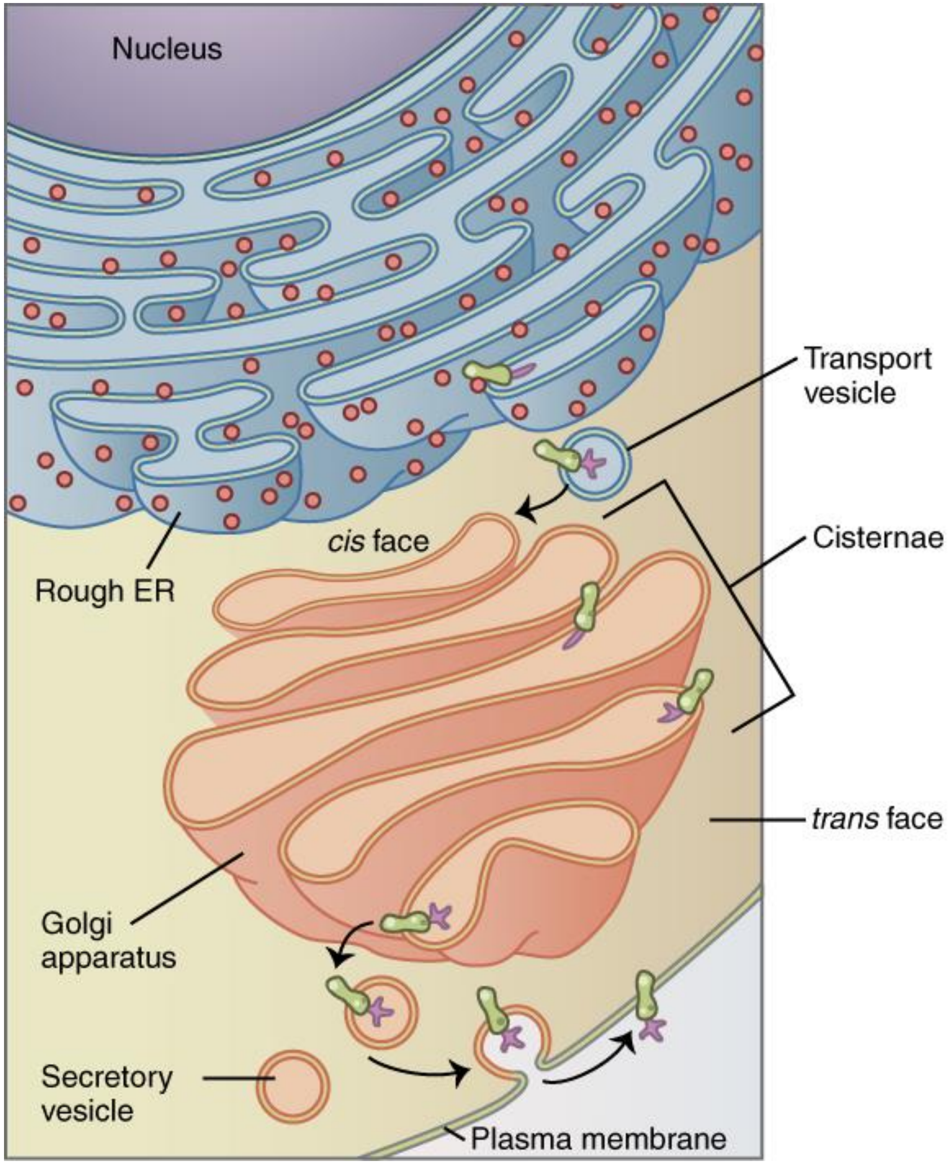


- Ribosomes are small structures where proteins are made. Although they are not enclosed within a membrane, they are frequently considered organelles.

- Each ribosome is formed of two subunits. Both subunits consist of proteins and RNA. RNA from the nucleus carries the genetic code, copied from DNA, which remains in the nucleus.

- At the ribosome, the genetic code in RNA is used to assemble and join together amino acids to make proteins. Ribosomes can be found alone or in groups within the cytoplasm as well as on the RER.

Golgi Apparatus



- The Golgi apparatus is a large organelle that processes proteins and prepares them for use both inside and outside the cell.

- The Golgi apparatus modifies, sorts, and packages different substances for secretion out of the cell, or for use within the cell.

- The Golgi apparatus is found close to the nucleus of the cell where it modifies proteins that have been delivered in transport vesicles from the Rough Endoplasmic Reticulum. It is also involved in the transport of lipids around the cell.

Vesicles and Vacuoles

- Both vesicles and vacuoles are sac-like organelles that store and transport materials in the cell. Vesicles are much smaller than vacuoles and have a variety of functions.

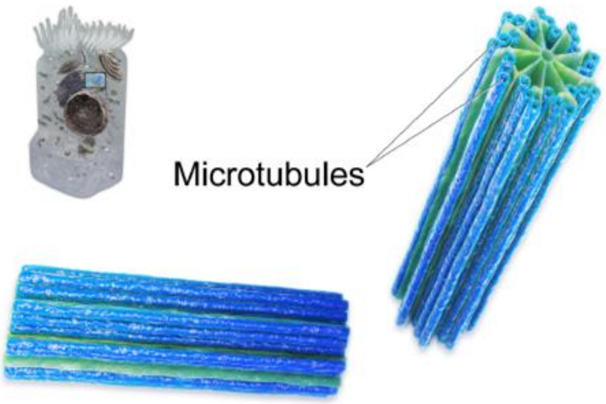
- Some vesicles are used as chambers for biochemical reactions. Other vesicles include:

  - Lysosomes, which use enzymes to break down foreign matter and dead cells.

  - Peroxisomes, which use oxygen to break down poisons.

  - Transport vesicles, transport contents between organelle as well as between cell exterior and interior.

Centrioles



- Centrioles are organelles involved in cell division.
- The function of centrioles is to help organize the chromosomes before cell division occurs so that each daughter cell has the correct number of chromosomes after the cell divides.
- Centrioles are found only in animal cells and are located near the nucleus.
- Each centriole is made mainly of a protein named tubulin.

Biological Macromolecules

- Biological macromolecules are large cellular components abundantly obtained naturally and are responsible for varieties of essential functions for the growth and survival of living organisms.

- There are four important classes of biological macromolecules, viz.,

- Carbohydrates
- Lipids
- Proteins
- Nucleic Acids

Carbohydrates

- The origin of the term "carbohydrate" is based on its components: carbon ("carbo") and water ("hydrate").

- Carbohydrates can be represented by the stoichiometric formula $(CH_2O)n$, where n is the number of carbons in the molecule. Therefore, the ratio of carbon to hydrogen to oxygen is 1:2:1 in carbohydrate molecules.

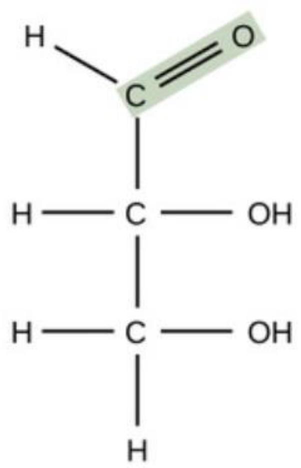
- Carbohydrates are classified into three subtypes: monosaccharides, disaccharides, and polysaccharides.

Monosaccharides

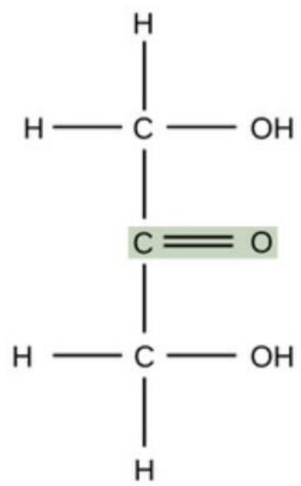
- Monosaccharides (mono- = “one”; sacchar- = “sweet”) are simple sugars. In monosaccharides, the number of carbons usually ranges from three to seven.

- If the sugar has an aldehyde group (the functional group with the structure R-CHO), it is known as an aldose.

- If it has a ketone group (the functional group with the structure RC(=O)R’), it is known as a ketose.



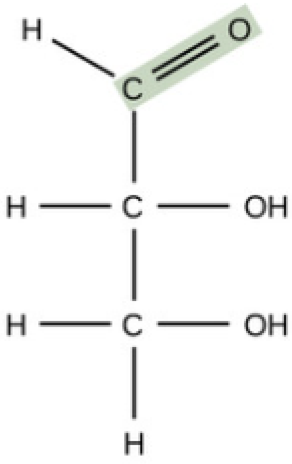
Aldose



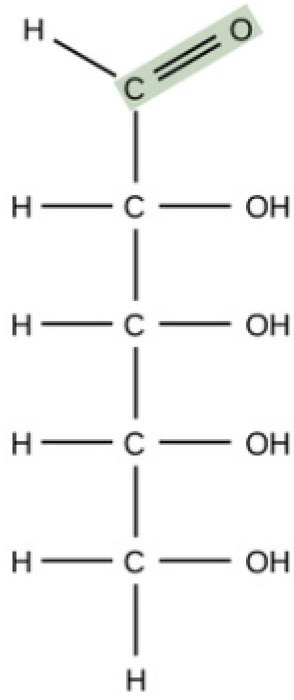
Ketose

Monosaccharides

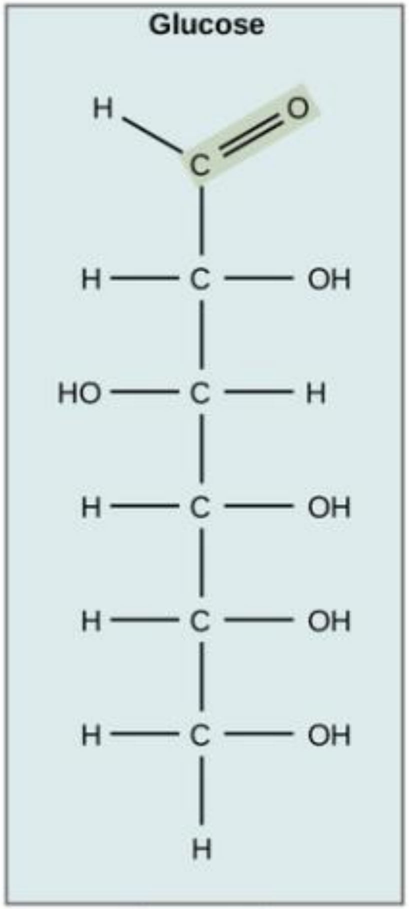
- Depending on the number of carbons in the sugar, they also may be known as trioses (three carbons), pentoses (five carbons), and or hexoses (six carbons).



Triose



Pentose

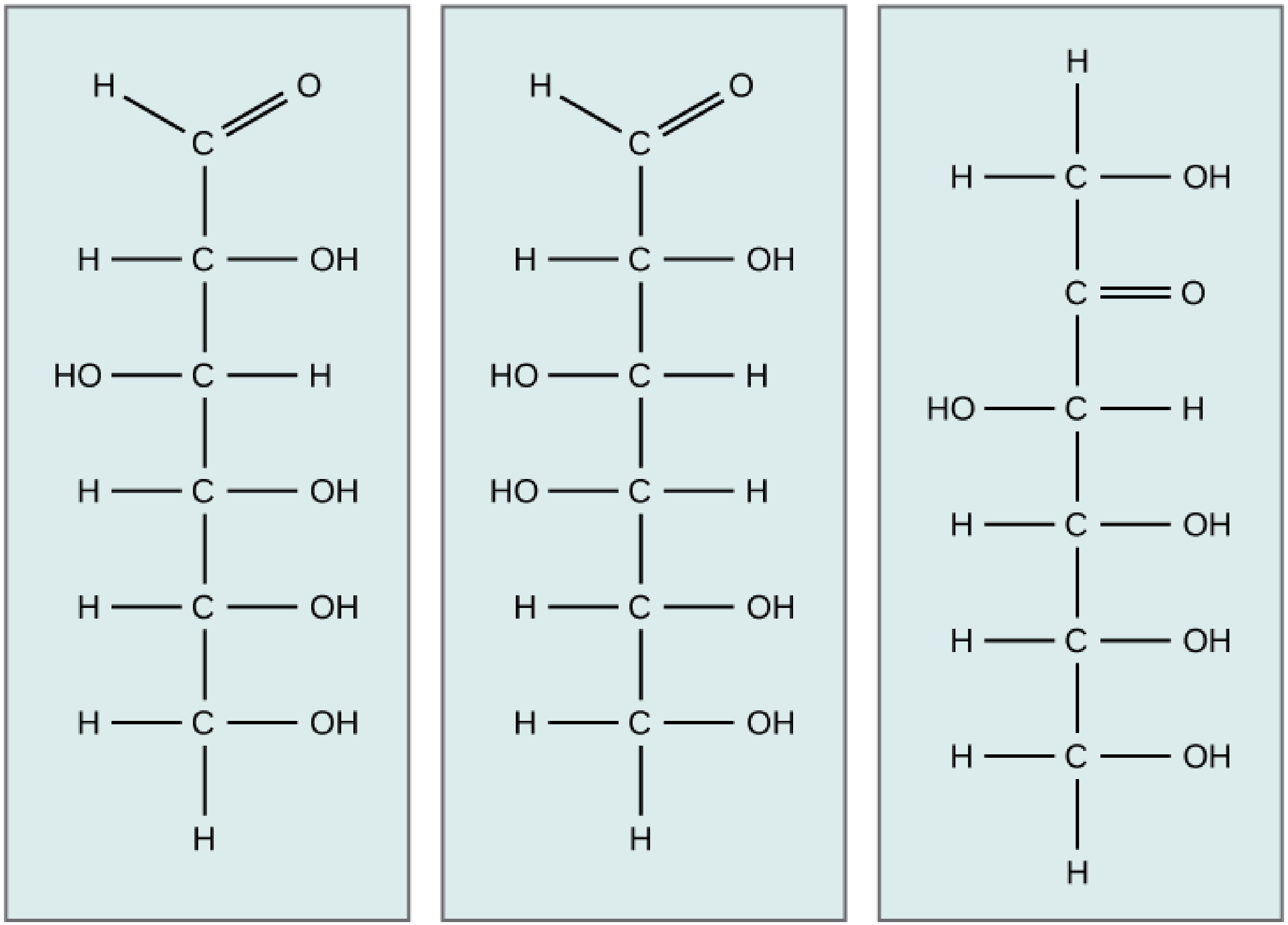


Hexose

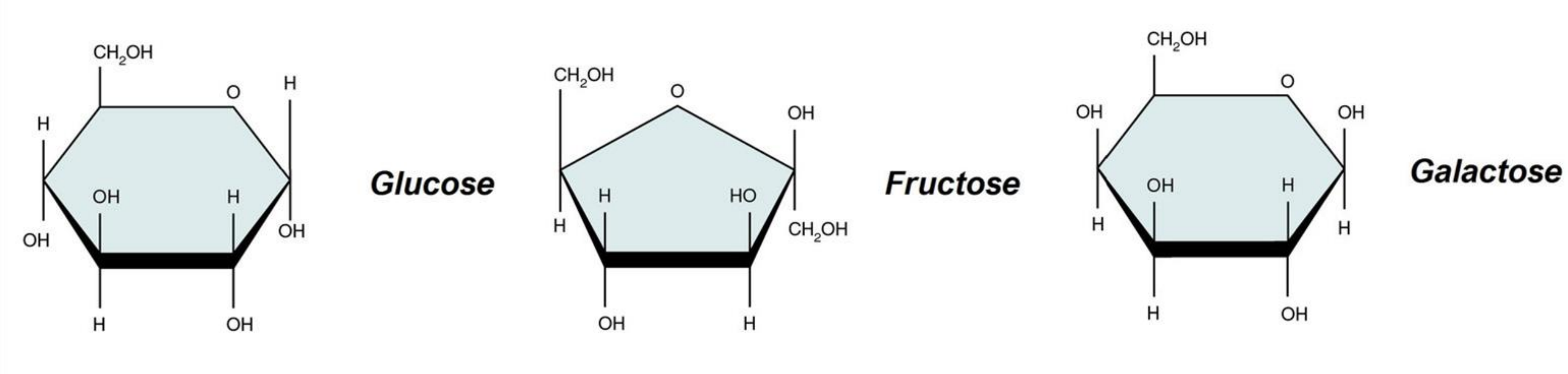
Common Monosaccharides

- Glucose, Galactose and Fructose are the common monosaccharides

Glucose Galactose Fructose



- Although glucose, galactose, and fructose all have the same chemical formula ($C_6H_{12}O_6$), they differ structurally and stereo-chemically.



Grape Sugar

Fruit Sugar

Milk Sugar

Common Monosaccharides

- Glucose ($C_6H_{12}O_6$) is a common monosaccharide and an important source of energy.

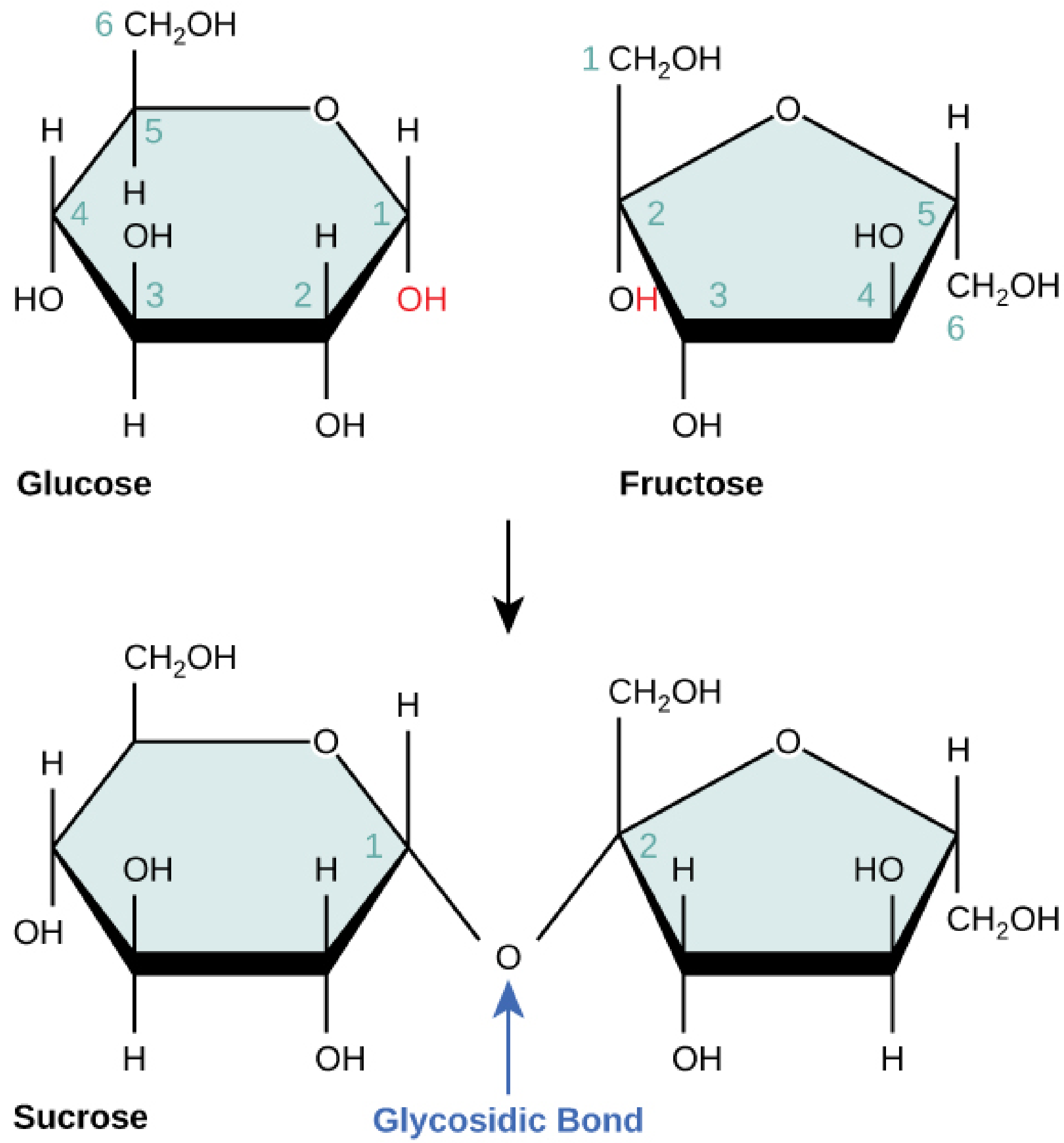
- During cellular respiration, energy is released from glucose and that energy is used to help make adenosine triphosphate (ATP).

- Plants synthesize glucose using carbon dioxide and water, and glucose, in turn, is used for energy requirements for the plant.

Disaccharides

- Disaccharides (di- = “two”) form when two monosaccharides undergo a dehydration reaction (also known as a condensation reaction or dehydration synthesis).

- A covalent bond formed between a carbohydrate molecule and another molecule (in this case, between two monosaccharides) is known as a glycosidic bond.



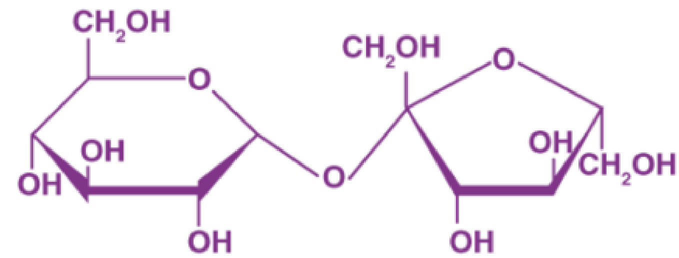
Disaccharides

Sucrose = Glucose + Fructose
(Table Sugar)

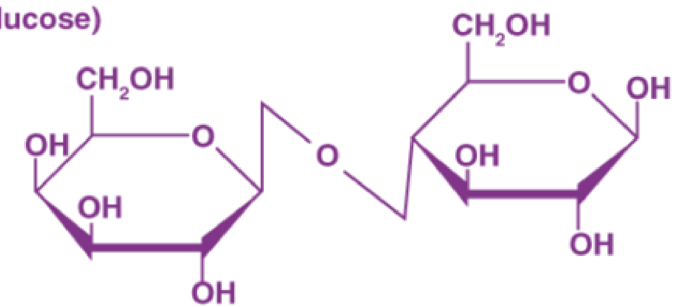
Lactose = Glucose + Galactose
(Milk Sugar)

Maltose = Glucose + Glucose
(Malt Sugar)

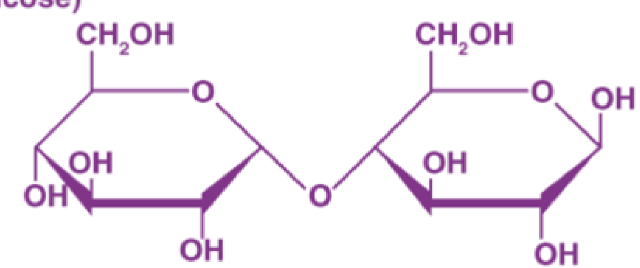
Sucrose
(Glucose-fructose)



Lactose
(Galactose-glucose)



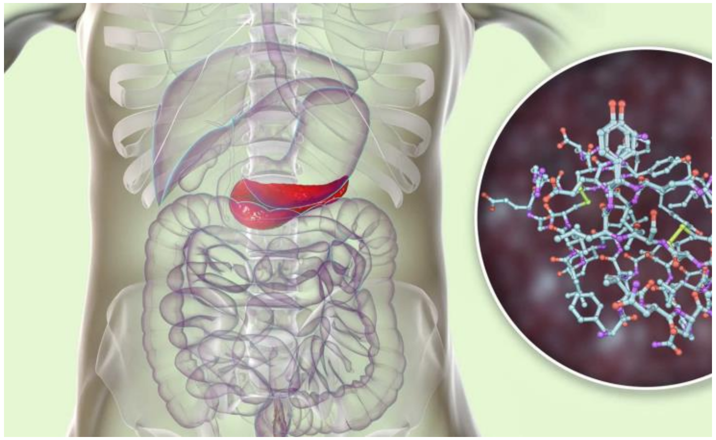
Maltose
(Glucose-glucose)



Polysaccharides

- A long chain of monosaccharides linked by glycosidic bonds is known as a polysaccharide (poly- = “many”).
- The chain may be branched or unbranched, and it may contain different types of monosaccharides.
- Starch, glycogen, cellulose, and chitin are primary examples of polysaccharides.

Starch (Energy storage in plants)



Glycogen (Energy storage in humans)

Polysaccharides

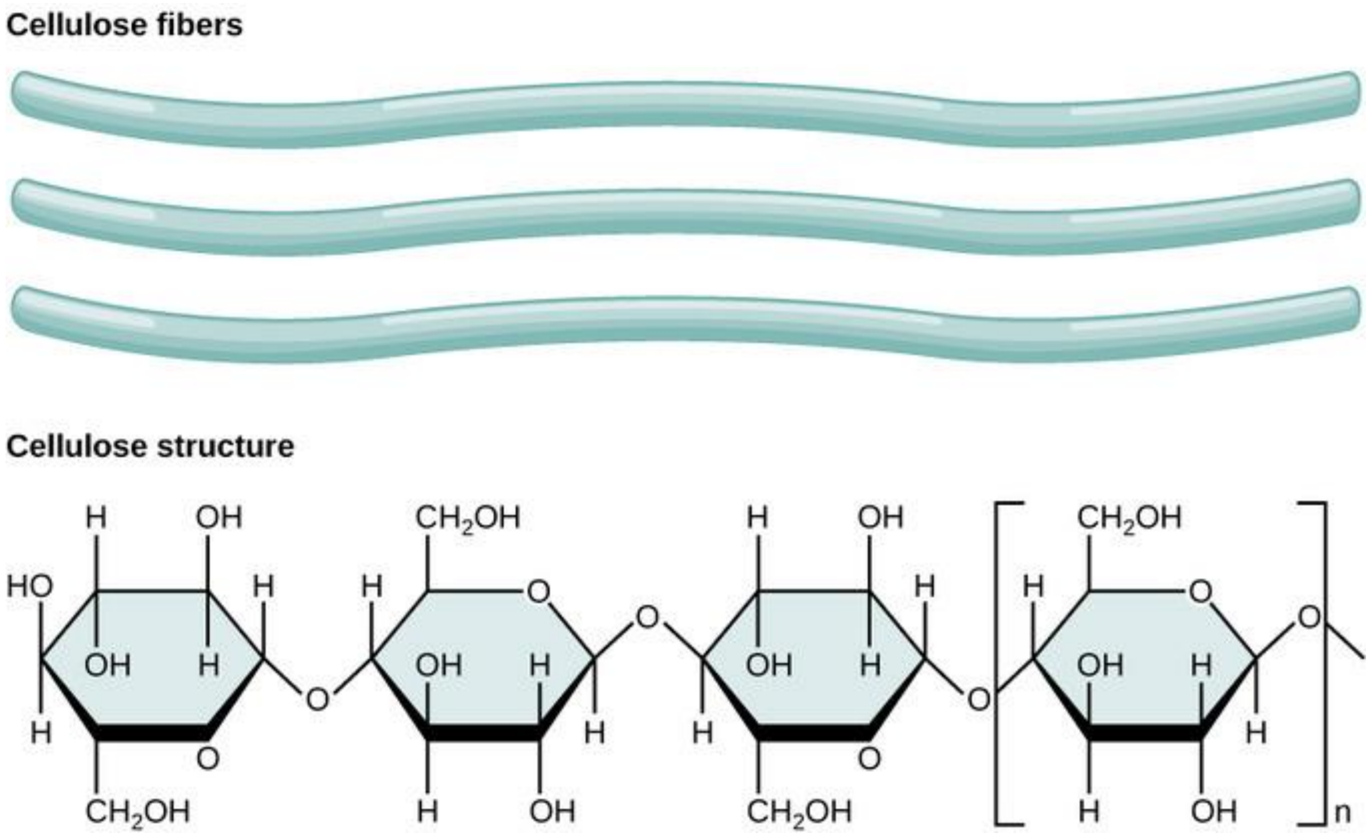
- Glycogen is the storage form of glucose in humans and other vertebrates.

- It is made up of monomers of glucose.

- Glycogen is the animal equivalent of starch and is a highly branched molecule usually stored in liver and muscle cells.

- Whenever blood glucose levels decrease, glycogen is broken down to release glucose in a process known as glycogenolysis.

Polysaccharides



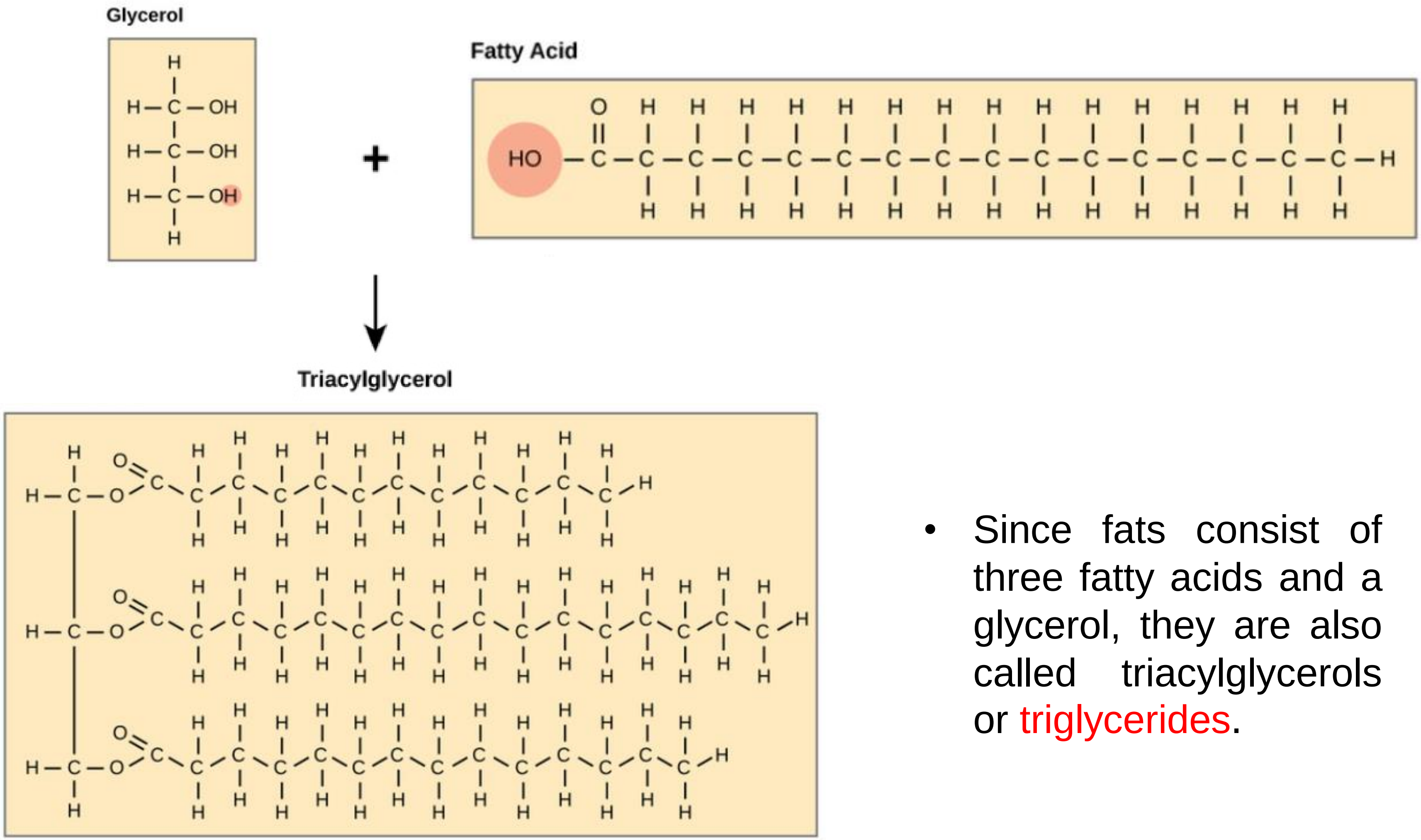
- Cellulose is the most abundant natural biopolymer. The cell wall of plants is mostly made of cellulose and provides structural support to the cell. Cellulose is made up of glucose monomers.

Carbohydrates - Key Points

- Monosaccharides are simple sugars made up of three to seven carbons, and they can exist as a linear chain or as ring-shaped molecules.
- Glucose, galactose, and fructose are monosaccharide isomers, which means they all have the same chemical formula but differ structurally and chemically.
- Disaccharides form when two monosaccharides undergo a dehydration reaction (a condensation reaction); they are held together by a covalent bond.
- Sucrose (table sugar) is the most common disaccharide, which is composed of the monomers glucose and fructose.
- A polysaccharide is a long chain of monosaccharides linked by glycosidic bonds; the chain may be branched or unbranched and can contain many types of monosaccharides.

Lipids

- A fat molecule consists of two main components: glycerol and fatty acids.



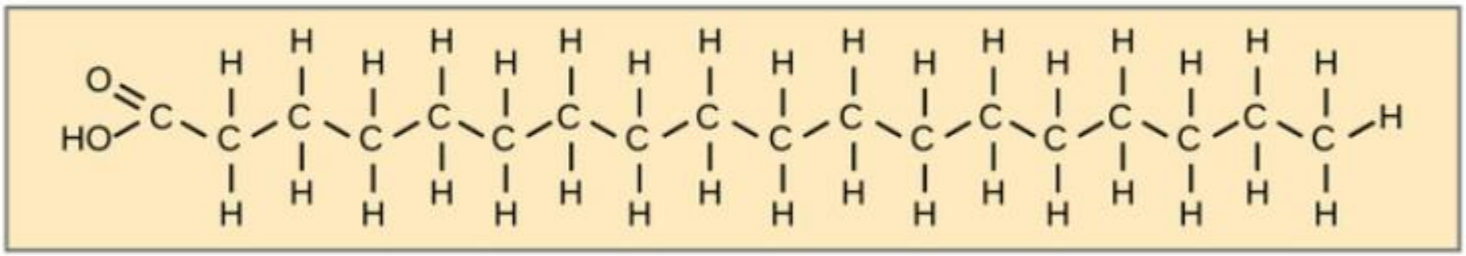
- Since fats consist of three fatty acids and a glycerol, they are also called triacylglycerols or triglycerides.

Saturated vs. Unsaturated Fatty Acids

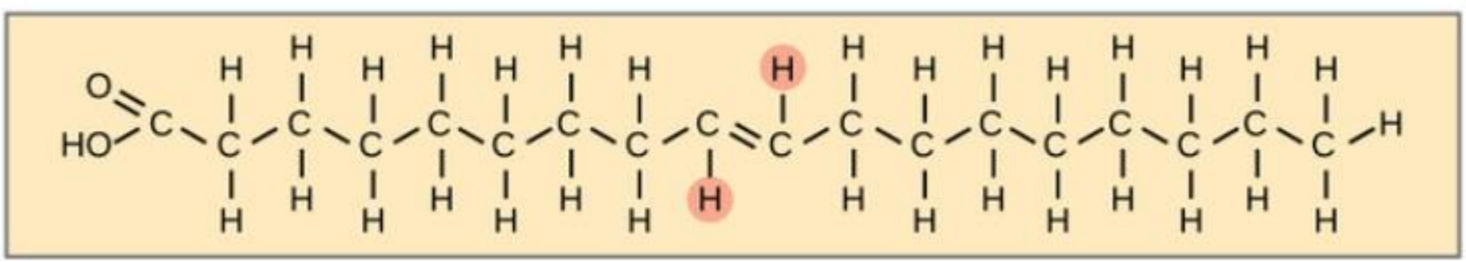
- In a fatty acid chain, if there are only single bonds between neighboring carbons in the hydrocarbon chain, the fatty acid is said to be saturated.

Saturated fatty acid

Stearic acid



- When the hydrocarbon chain contains a double bond, the fatty acid is said to be unsaturated.



Essential Fatty Acids

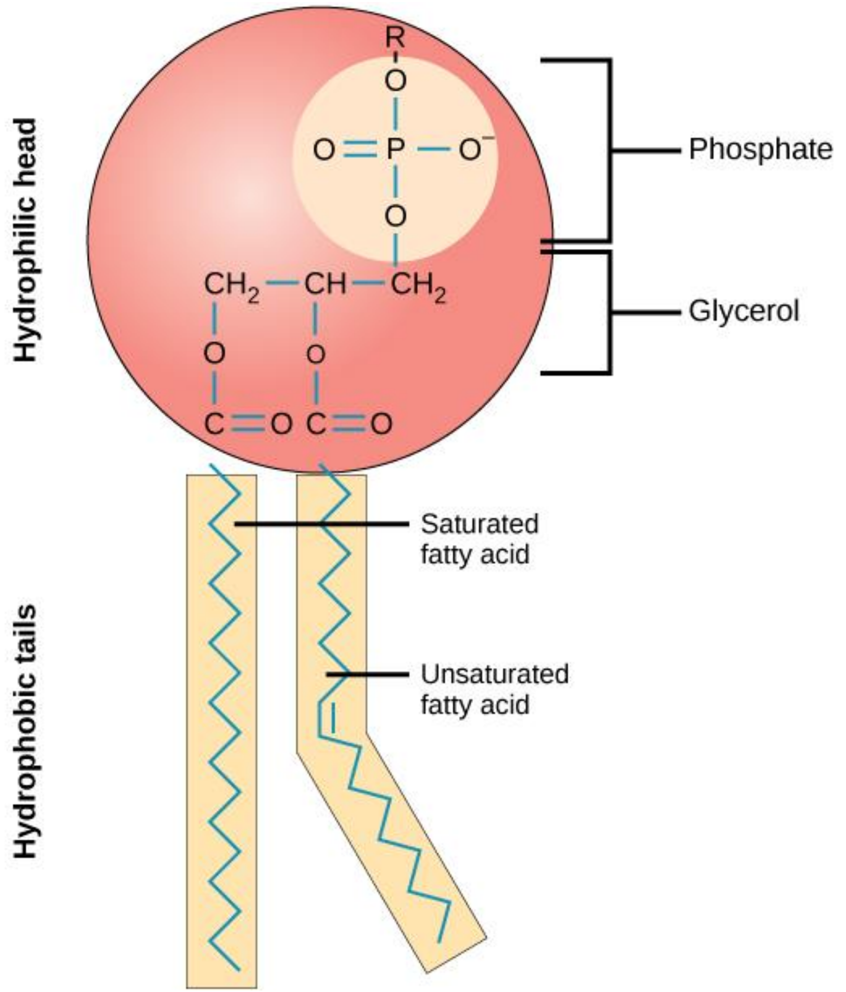
- Essential fatty acids are fatty acids required for biological processes, but not synthesized by the human body.

- Consequently, they have to be supplemented through ingestion via the diet and are nutritionally very important.

- Omega-3 fatty acid
- Omega-6 fatty acid

Phospholipids

- Phospholipids are major components of the plasma membrane, the outermost layer of animal cells.



Phospholipids

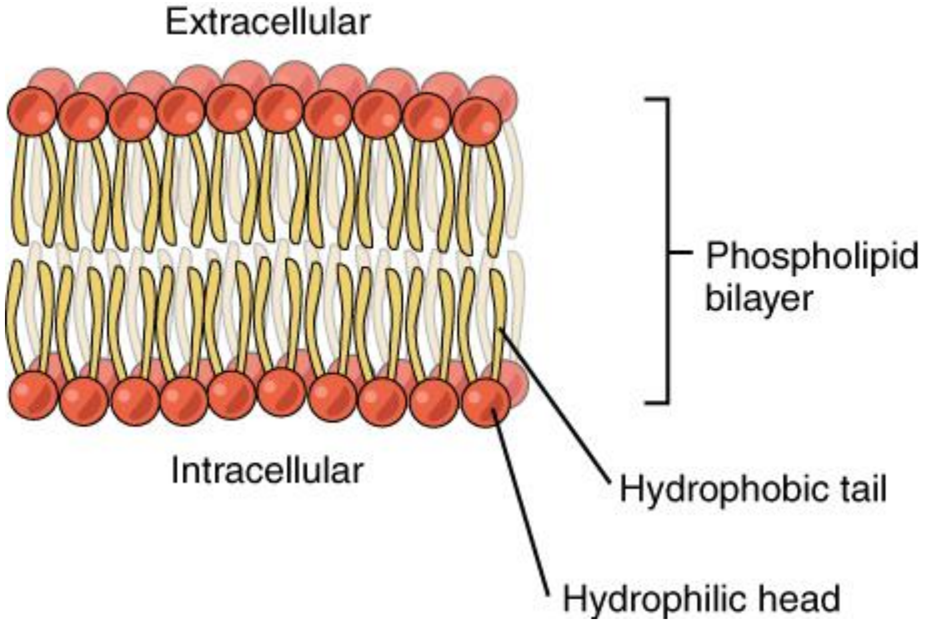
- A phospholipid is an amphipathic molecule which means it has both a hydrophobic and a hydrophilic component.

- A single phospholipid molecule has a phosphate group on one end, called the "head," and two side-by-side chains of fatty acids that make up the lipid "tails. "

- The phosphate group is negatively charged, making the head polar and hydrophilic, or "water loving." The phosphate heads are thus attracted to the water molecules in their environment.

- The lipid tails, on the other hand, are uncharged, nonpolar, and hydrophobic, or "water fearing." A hydrophobic molecule repels and is repelled by water. Some lipid tails consist of saturated fatty acids and some contain unsaturated fatty acids. This combination adds to the fluidity of the tails that are constantly in motion.

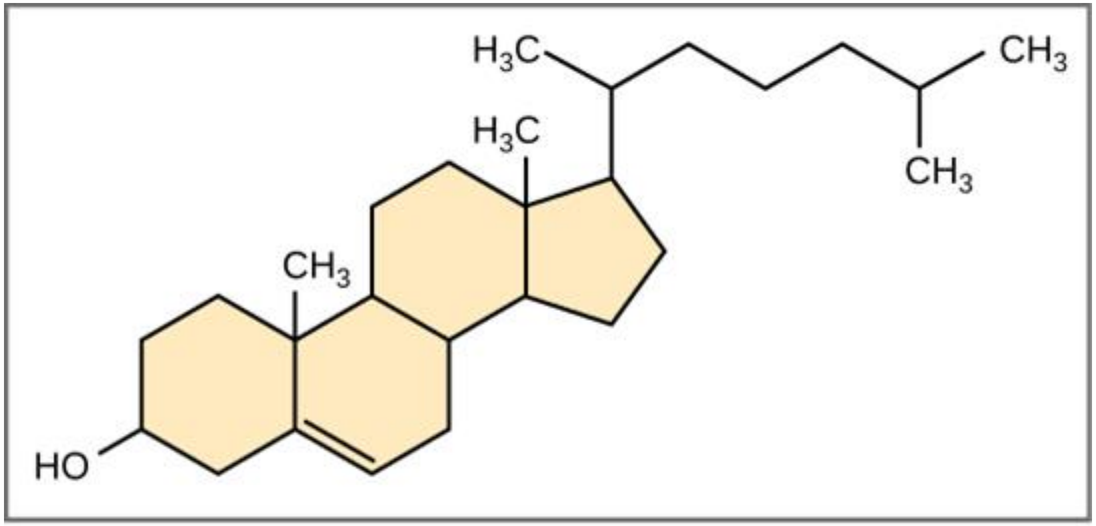
Phospholipids and Biological Membranes



- The cell membrane consists of two adjacent layers of phospholipids, which form a bilayer.

- As a result, there are two distinct aqueous compartments on each side of the membrane. This separation is essential for many biological functions, including cell communication and metabolism.

Lipid Molecules - Steroids



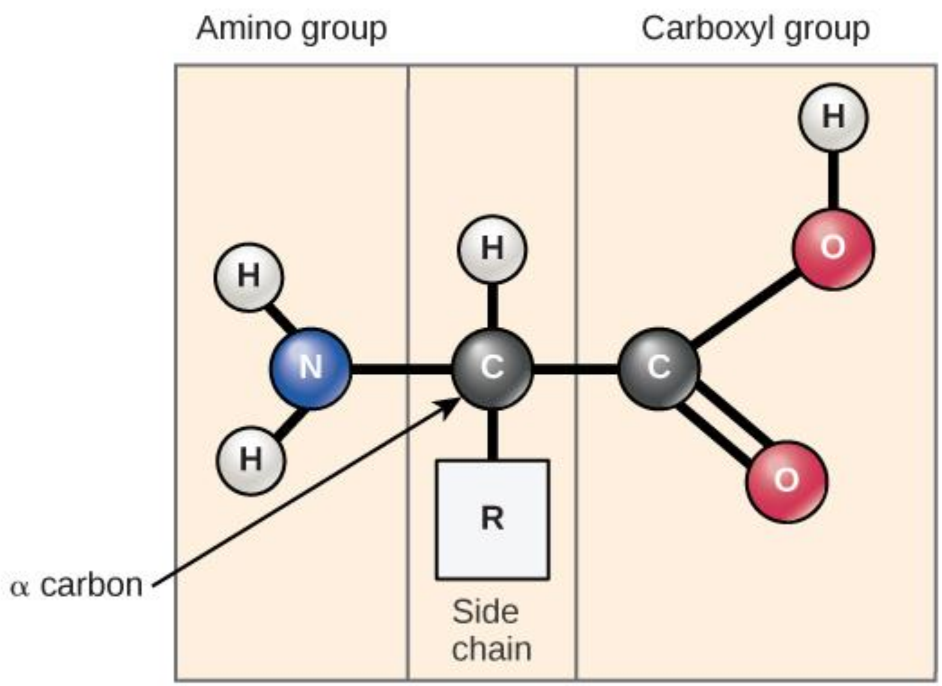
Cholesterol

- Steroids have a fused ring structure. E.g. Cholesterol.
- Cholesterol is the most common steroid and is mainly synthesized in the liver; it is the precursor to vitamin D. Cholesterol is also a precursor to many important steroid hormones like estrogen, testosterone, and progesterone.

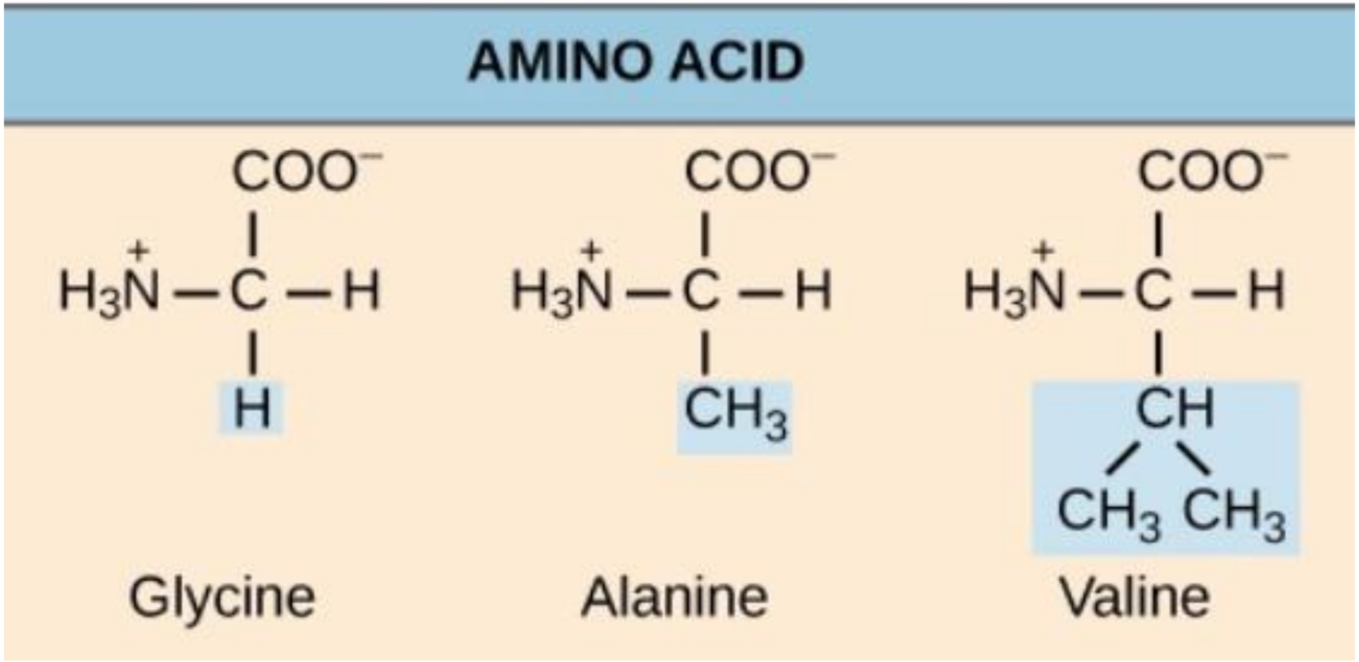
Proteins

- Proteins (a polymer) are macromolecules composed of amino acid subunits (the monomers).

- Each amino acid has the same fundamental structure, which consists of a central carbon atom, also known as the alpha (α) carbon, bonded to an amino group (NH2), a carboxyl group (COOH), and to a hydrogen atom.

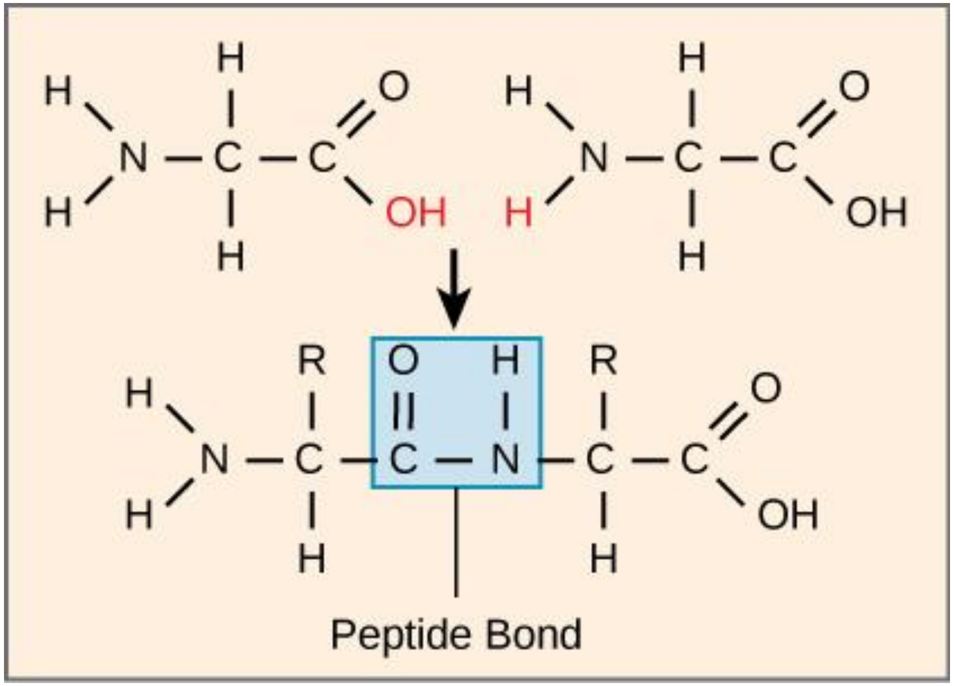


- There are 21 amino acids present in proteins, each with a specific R group or side chain.
- Ten of these are considered essential amino acids in humans because the human body cannot produce them and they must be obtained from the diet.



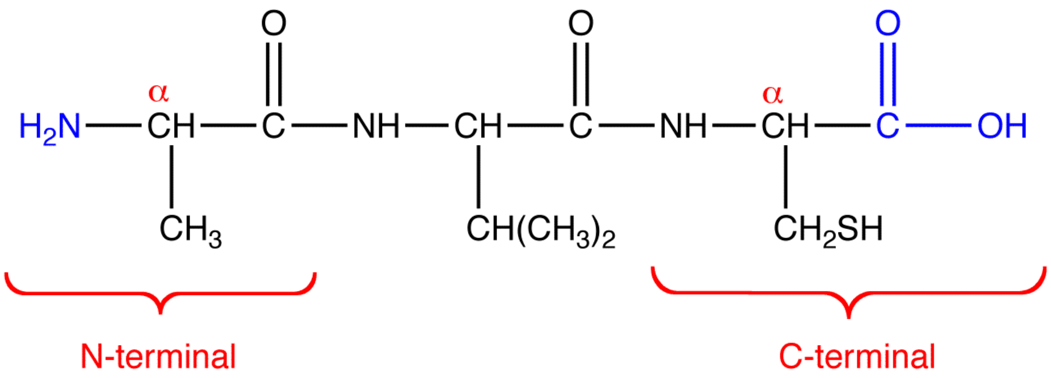
Proteins

- The sequence and the number of amino acids ultimately determine the protein's shape, size, and function.
- Each amino acid is attached to another amino acid by a covalent bond, known as a peptide bond.



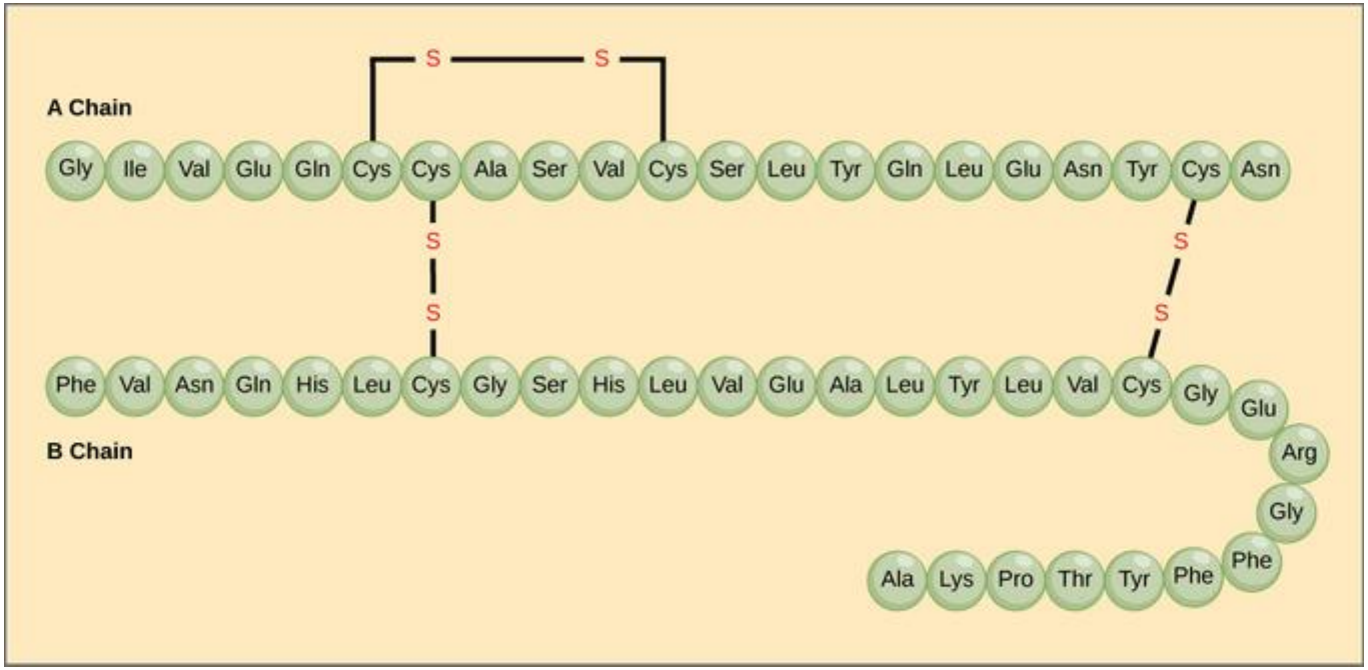
- The resulting chain of amino acids is called a polypeptide chain. Each polypeptide has a free amino group at one end.

- This end is called the N terminal, or the amino terminal, and the other end has a free carboxyl group, also known as the C or carboxyl terminal.

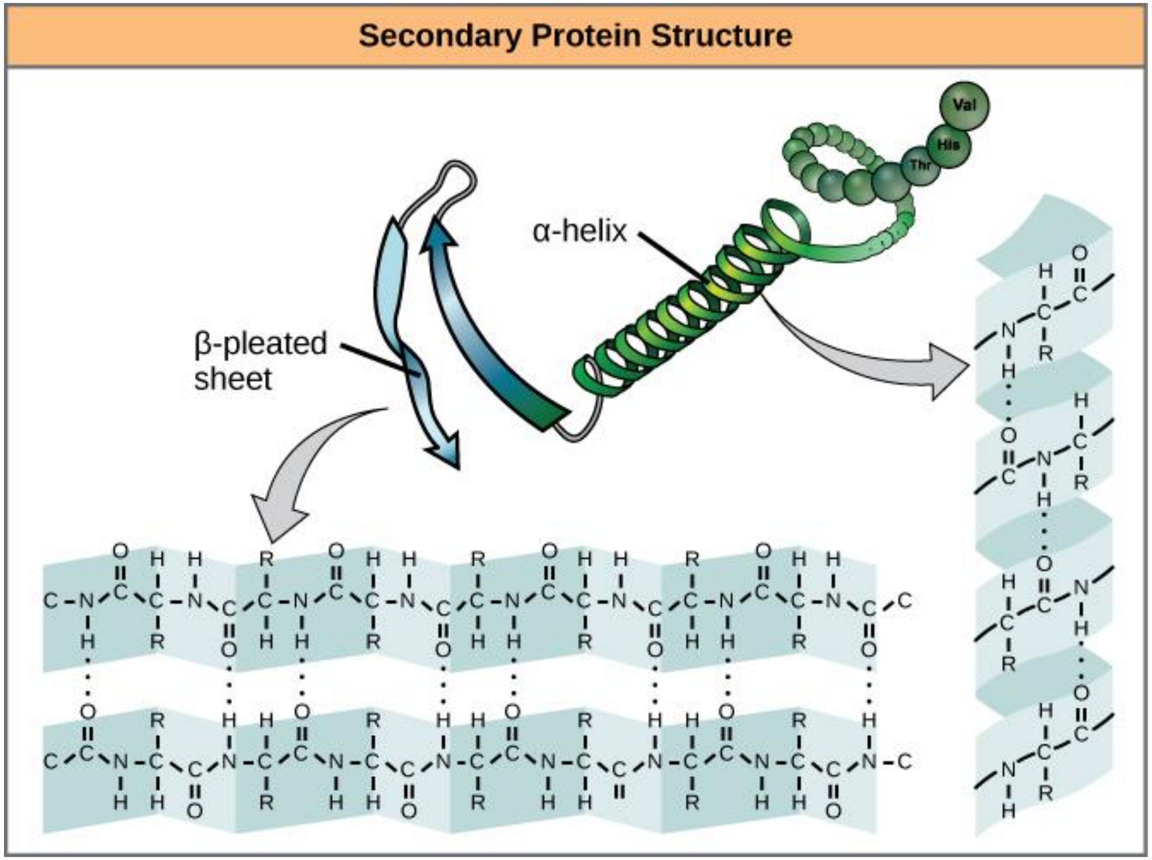


Protein Structure

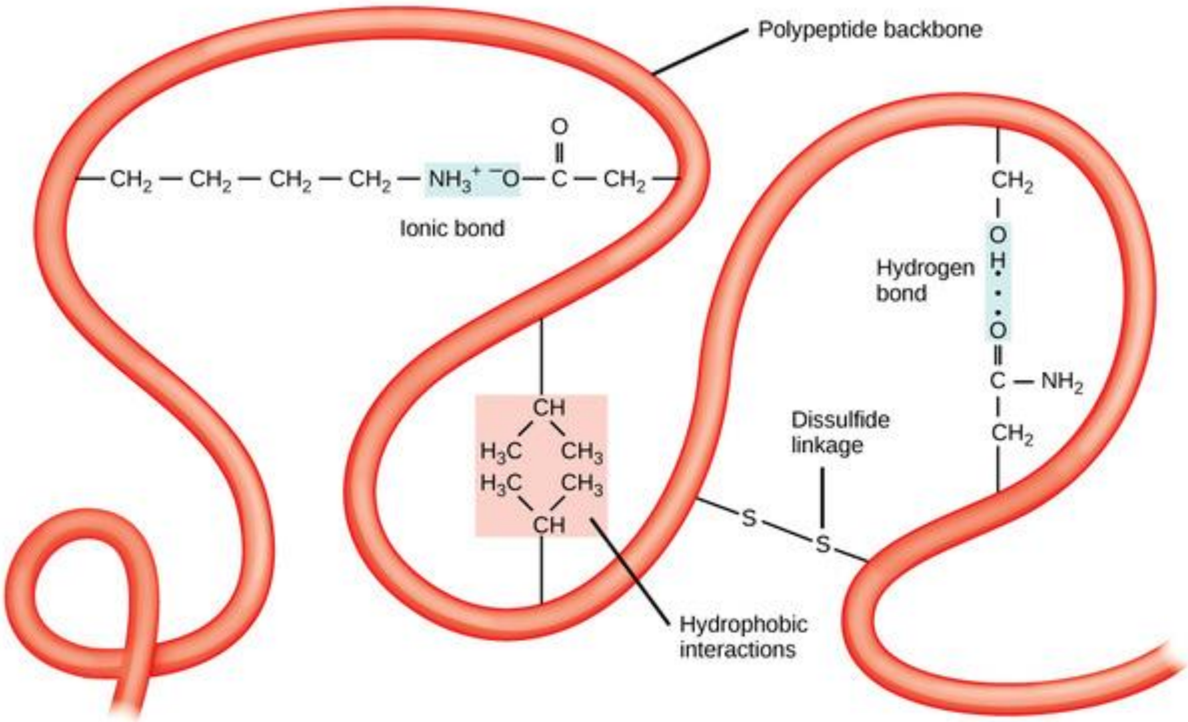
- Primary Structure: A protein's primary structure is the unique sequence of amino acids in each polypeptide chain that makes up the protein.



- Secondary Structure: A protein's secondary structure is whatever regular structures arise from interactions between neighboring or near-by amino acids as the polypeptide starts to fold into its functional three-dimensional form.



- Tertiary Structure: The tertiary structure of a polypeptide chain is its overall three-dimensional shape, once all the secondary structure elements have folded together among each other. Interactions between polar, nonpolar, acidic, and basic R group within the polypeptide chain create the complex three-dimensional tertiary structure of a protein.



Protein Structure

- Quaternary Structure: The quaternary structure of a protein is how its subunits are oriented and arranged with respect to one another. As a result, quaternary structure only applies to multi-subunit proteins; that is, proteins made from more than one polypeptide chain.

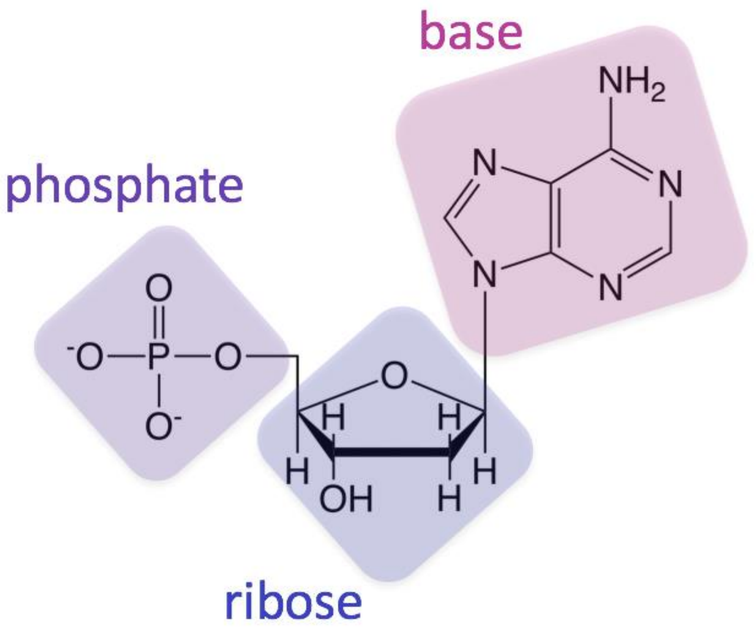
Quaternary protein structure
protein consisting of more than one amino acid chain

- The two main types of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA is the genetic material found in all living organisms, ranging from single-celled bacteria to multicellular mammals.

- Nucleic acids are giant biomolecules made of monomers called nucleotides.

- Each nucleotide is made up of three components:

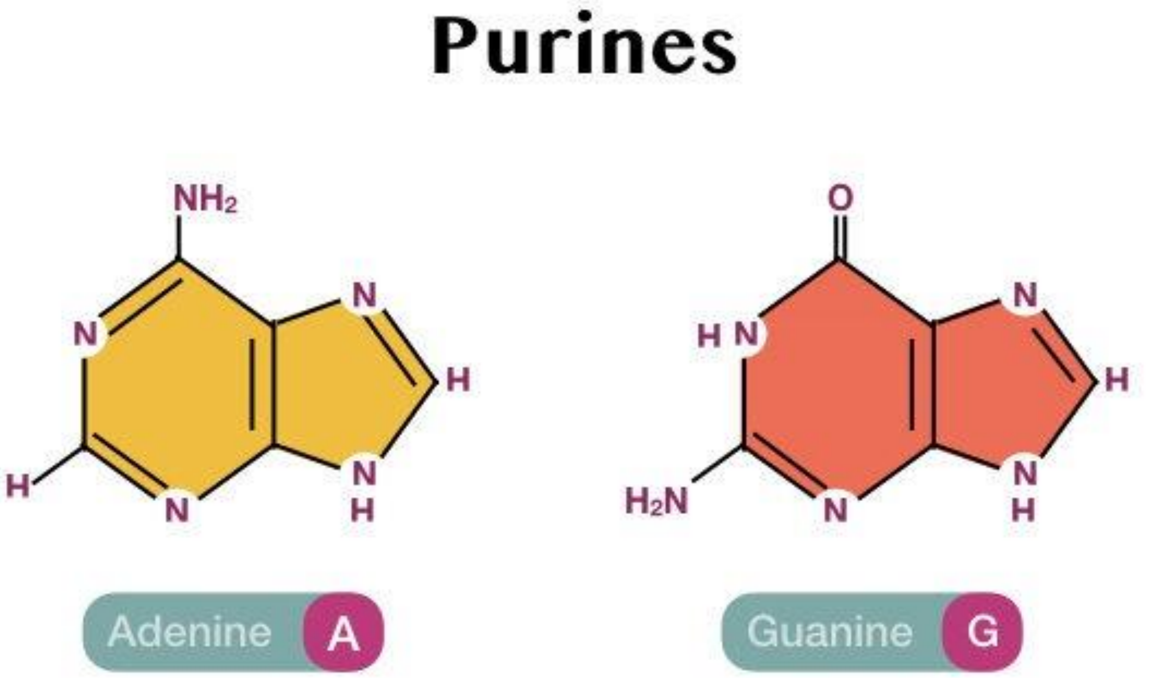
1. a nitrogenous base
2. a pentose (five-carbon) sugar
3. a phosphate group



Nitrogenous Base

- Each nucleotide in DNA contains one of four possible nitrogenous bases: adenine (A), guanine (G) cytosine (C), and thymine (T).

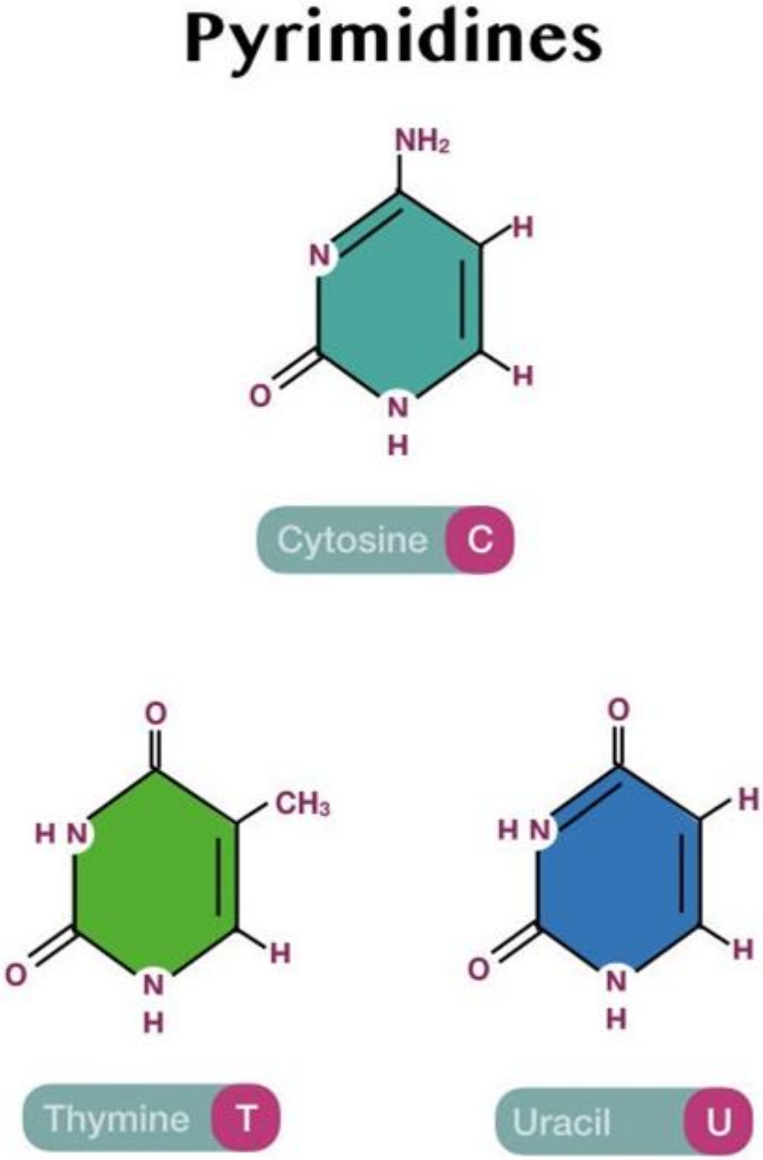
- Adenine and guanine are classified as purines. The primary structure of a purine consists of two carbon-nitrogen rings.



- Cytosine, thymine, and uracil are classified as pyrimidines which have a single carbon-nitrogen ring as their primary structure.

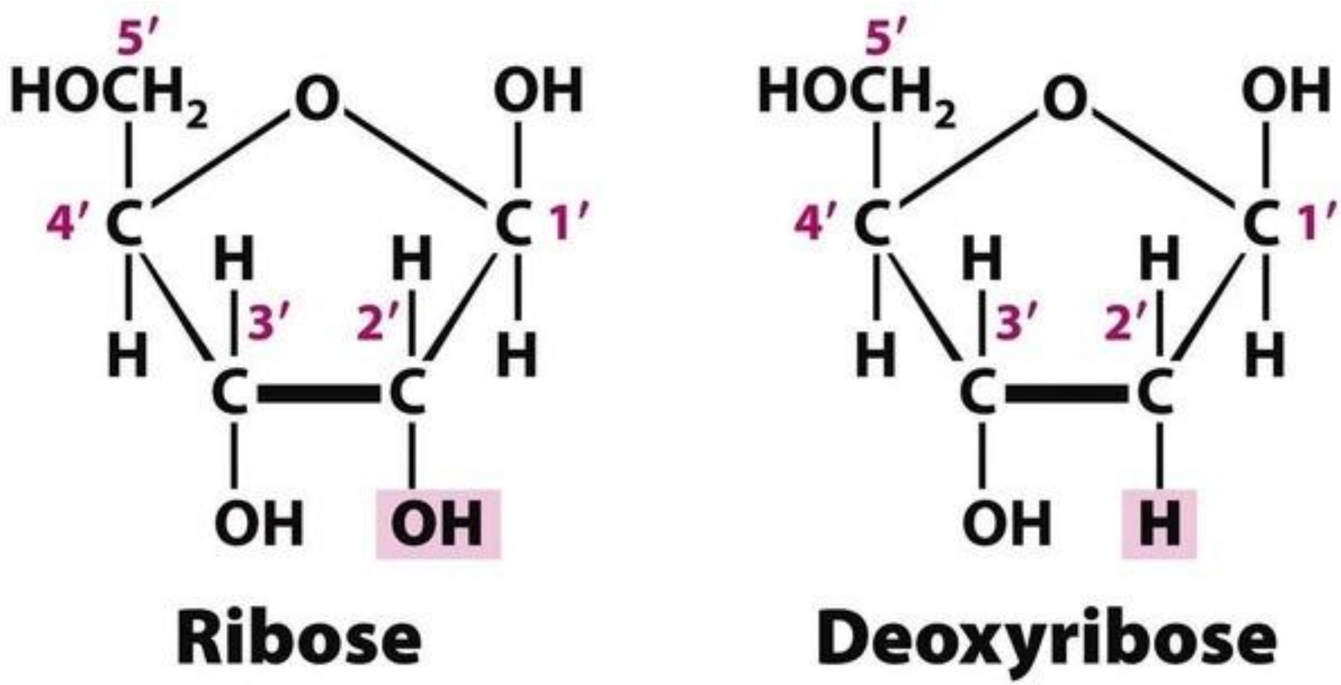
- The nitrogenous bases are simply known by their symbols A, T, G, C, and U.

- DNA contains A, T, G, and C whereas RNA contains A, U, G, and C.

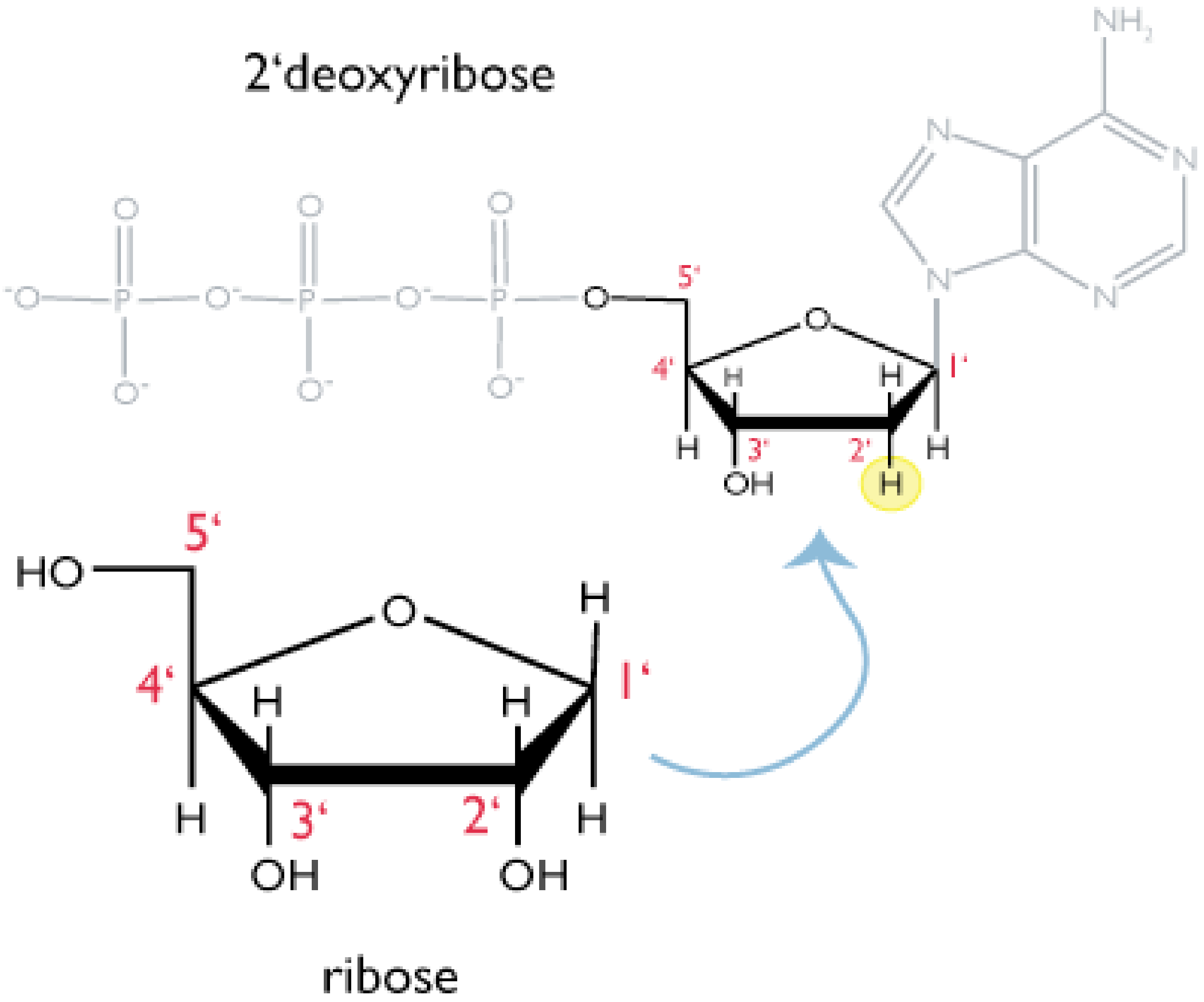


Five-Carbon Sugar

- The pentose sugar in DNA is deoxyribose and in RNA it is ribose.
- The difference between the sugars is the presence of the hydroxyl group on the second carbon of the ribose and hydrogen on the second carbon of the deoxyribose.



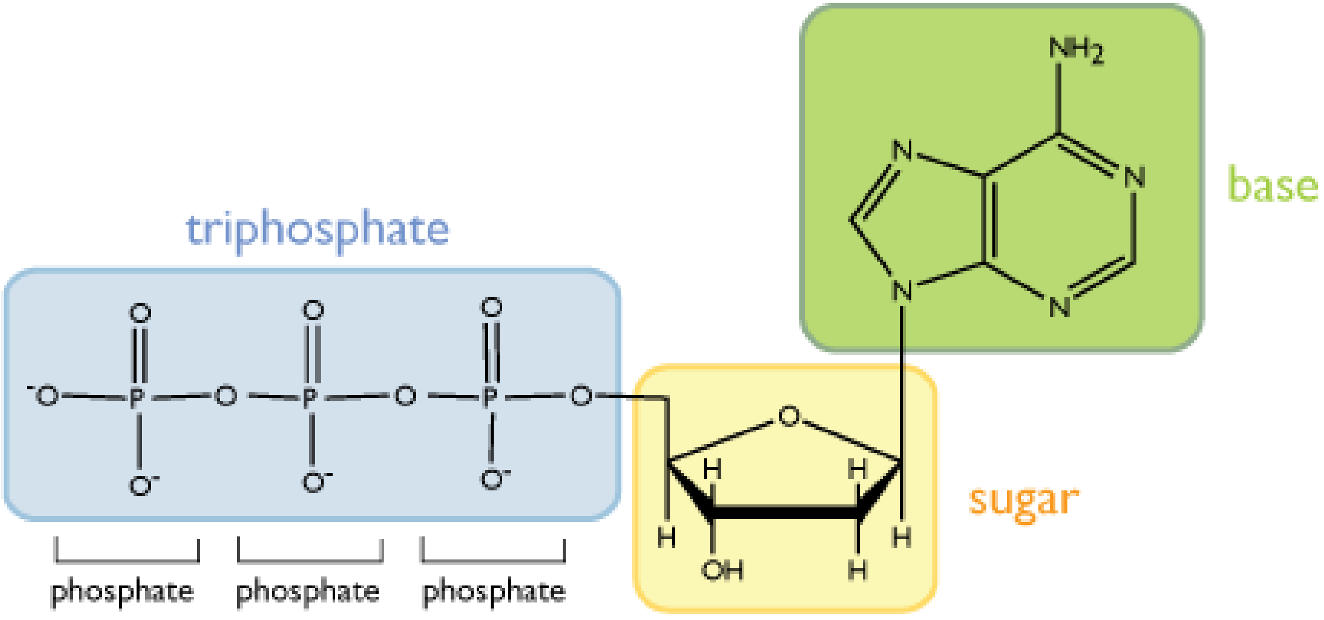
Five-Carbon Sugar

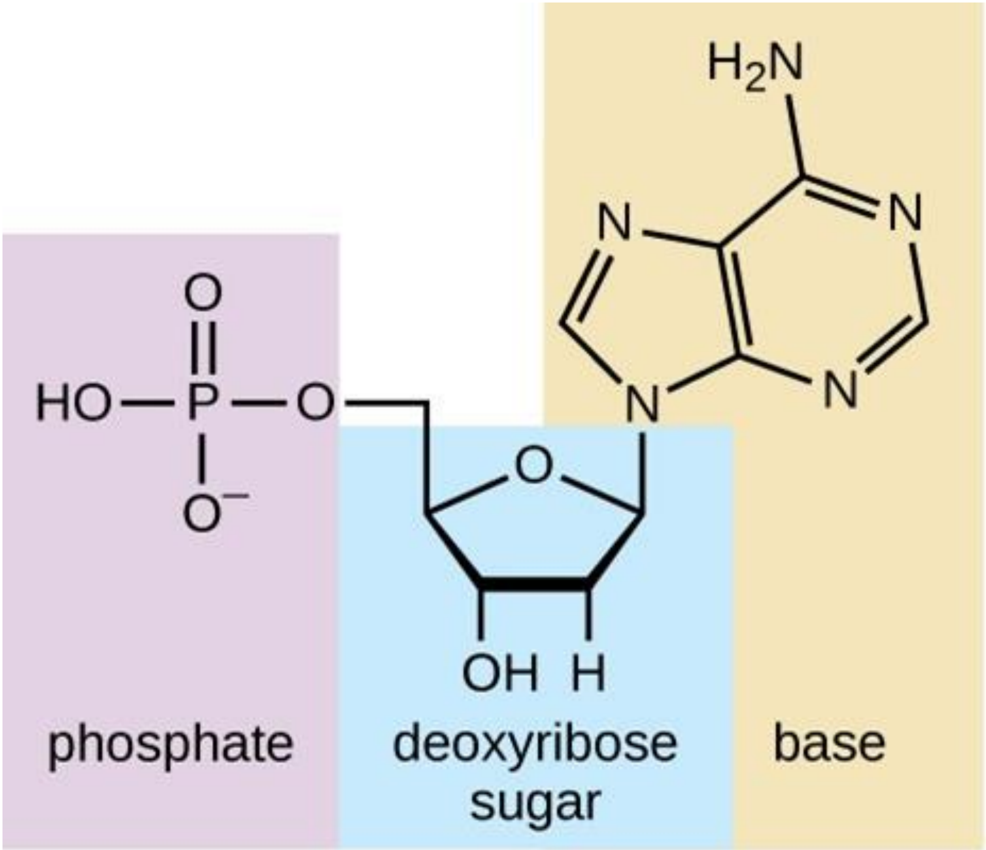


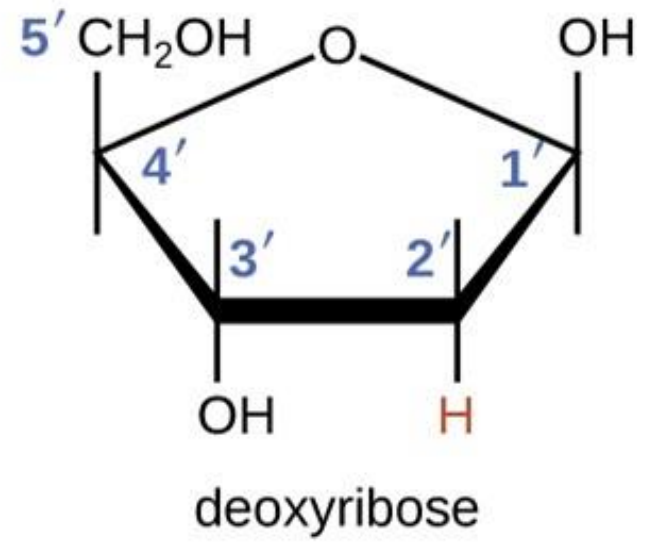
Phosphate Group

- The phosphate residue is attached to the hydroxyl group of the 5′ carbon of one sugar and the hydroxyl group of the 3′ carbon of the sugar of the next nucleotide, which forms a 5′3′ phosphodiester linkage.

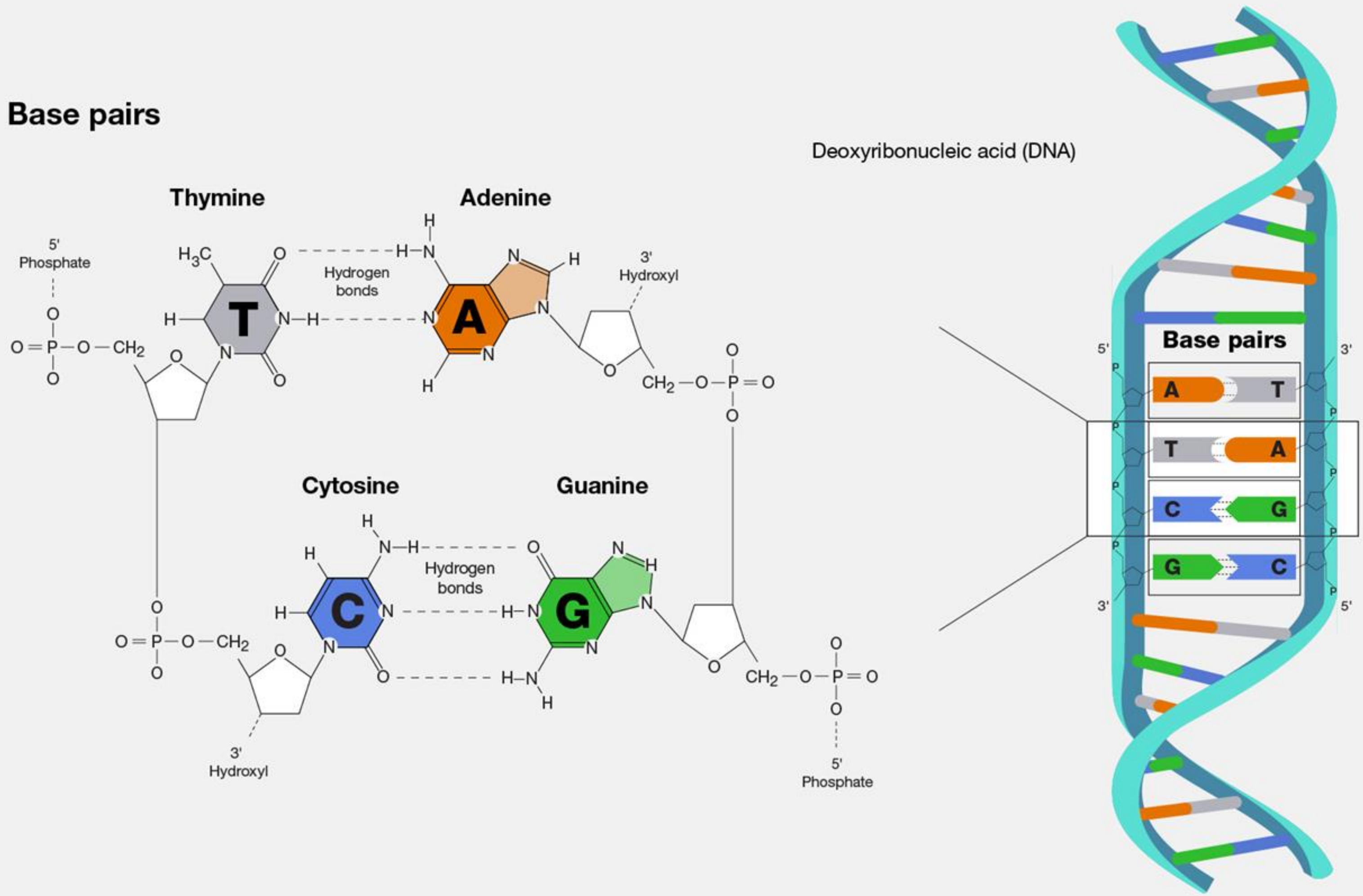
- Its formation involves the removal of two phosphate groups.



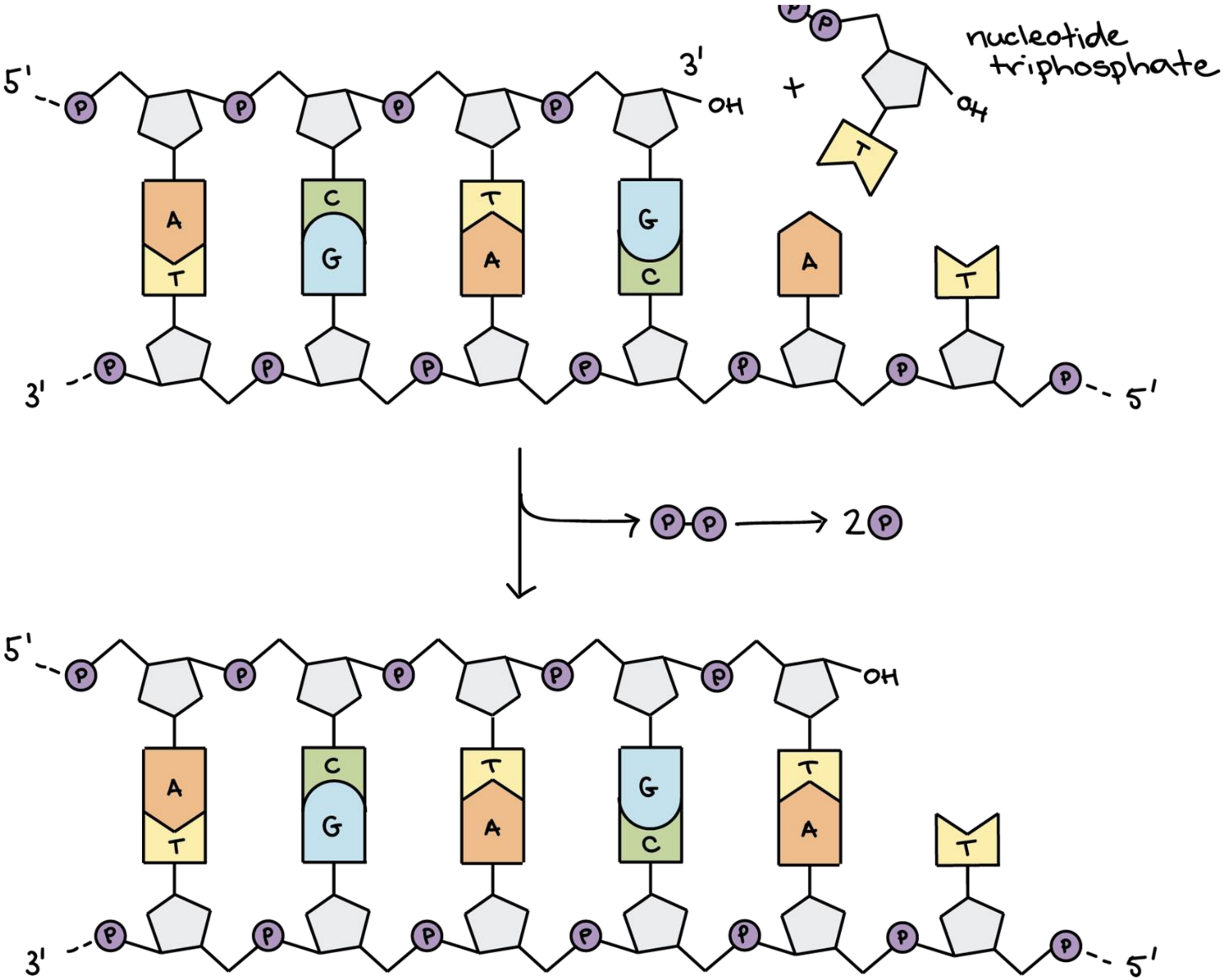

O
HO—P—O
O⁻
O
N
N
N
N
H2N
OH H
phosphate
deoxyribose sugar
base


5′ CH2OH
O
OH
4′
1′
3′
2′
OH
H
deoxyribose

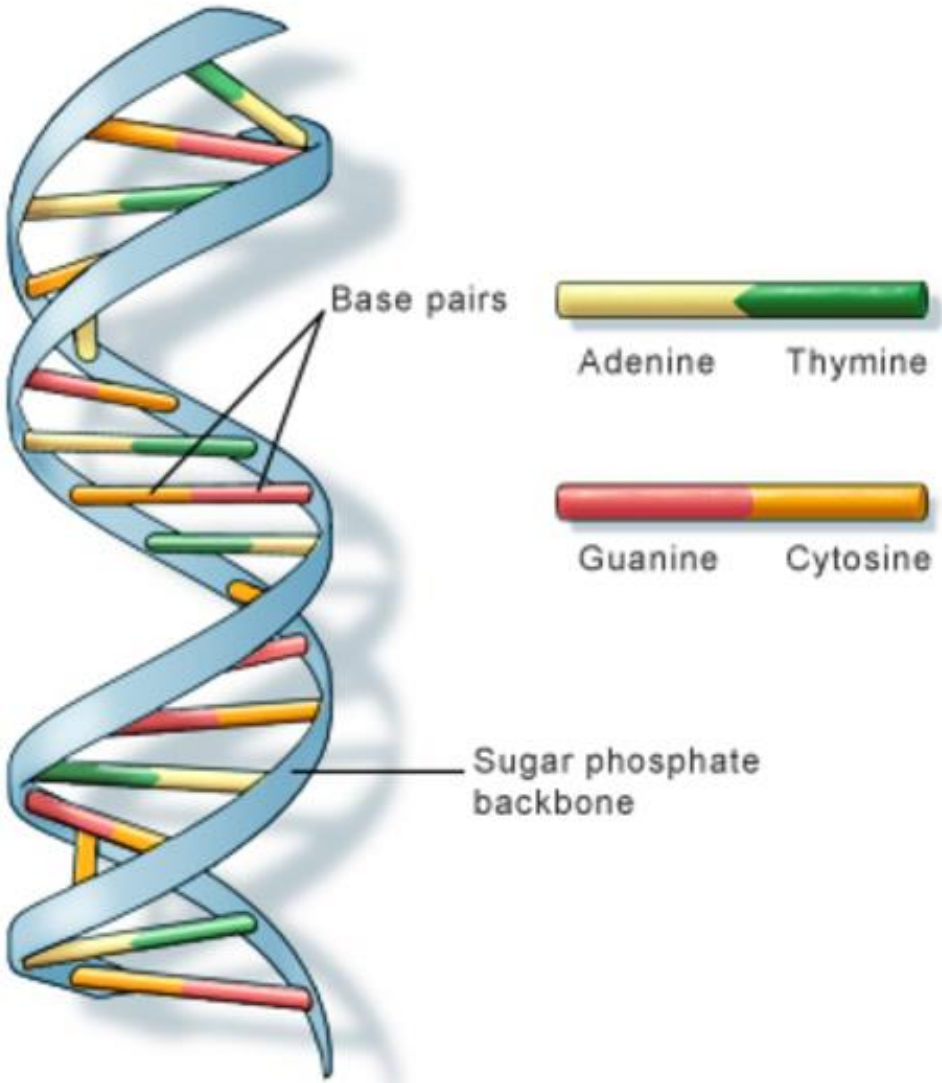
Nucleic Acids as Genetic Material



Nucleic Acids as Genetic Material



Nucleic Acids as Genetic Material

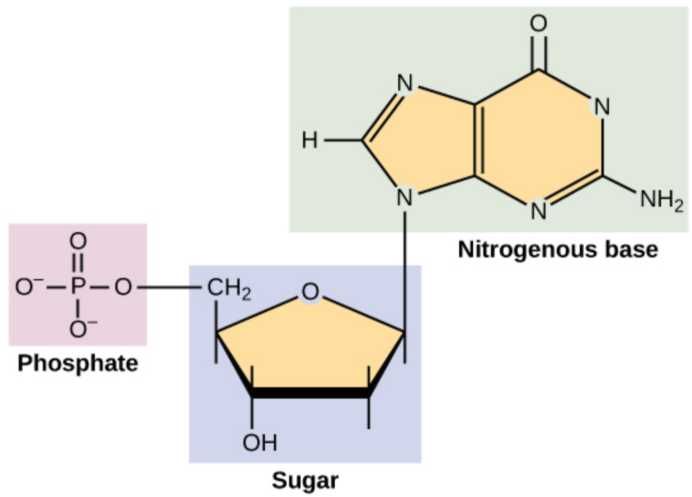


Nucleic Acids as Genetic Material

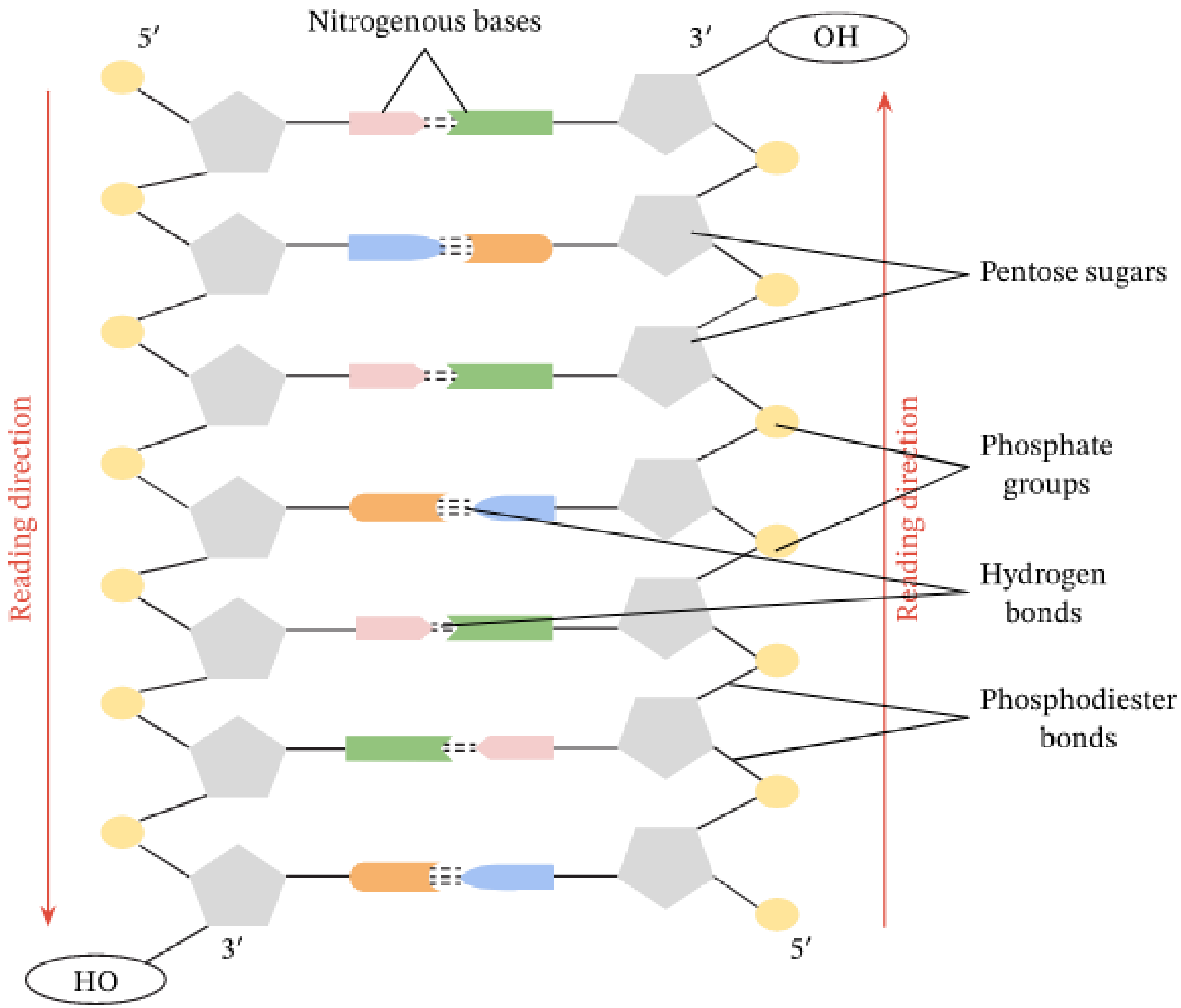
- DNA, or deoxyribonucleic acid, is the heritable material found in all cells. DNA provides the instructions to build, maintain, and regulate cells and organisms and is passed on when cells divide and when organisms reproduce.

- Each chain of the double helix is made up of repeating units called nucleotides.

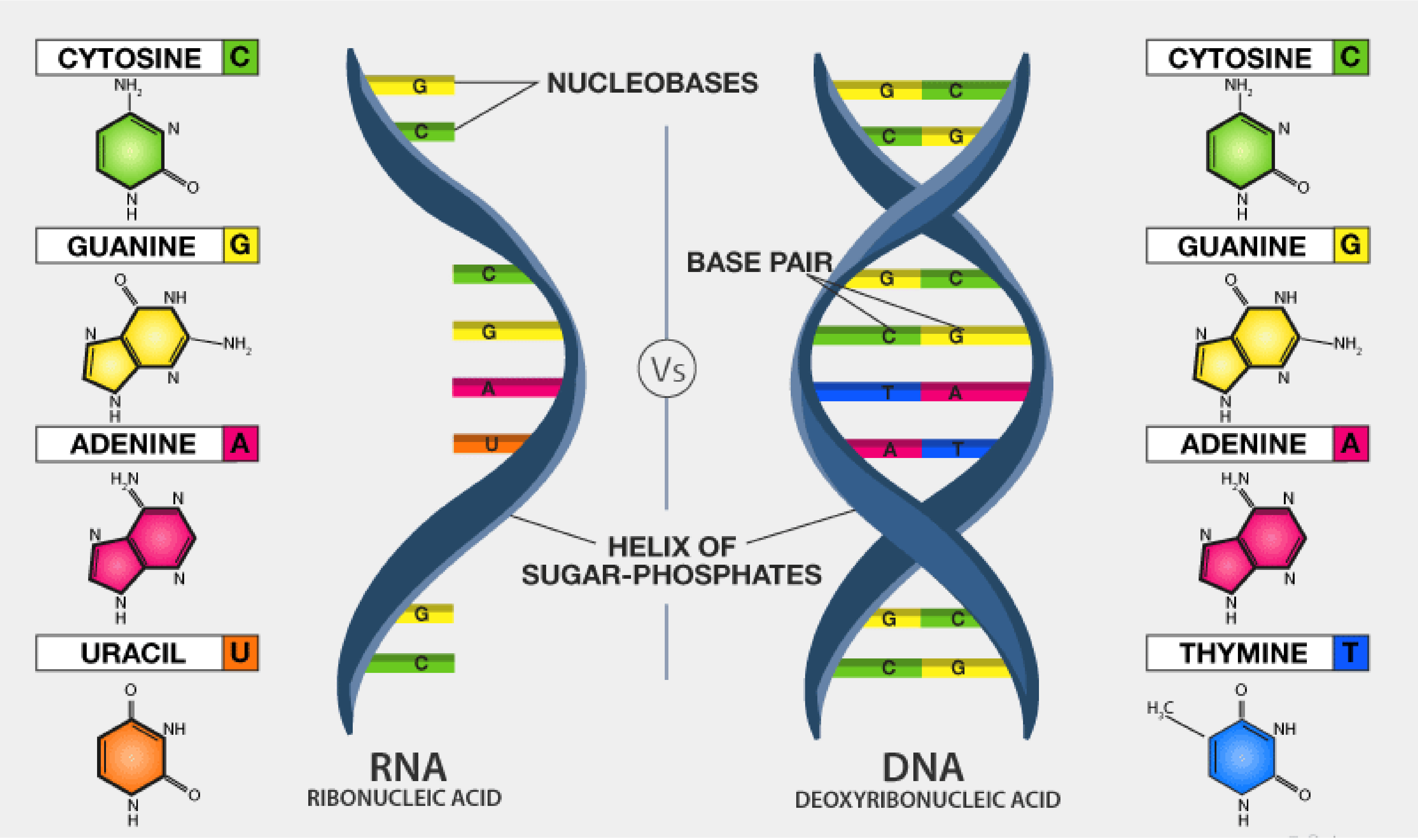
- A single nucleotide is composed of three functional groups: a sugar, a triphosphate, and a nitrogenous (nitrogen-containing) base,



Nucleic Acids as Genetic Material



DNA vs RNA


CYTOSINE C
GUANINE G
ADENINE A
URACIL U
NUCLEOBASES
BASE PAIR
Vs
HELIX OF
SUGAR-PHOSPHATES
RNA
RIBONUCLEIC ACID
DNA
DEOXYRIBONUCLEIC ACID
CYTOSINE C
GUANINE G
ADENINE A
THYMINE T

Genetic Material Function

- The genetic material is extremely important since it keeps all information about the organism.
- The variety of genetic composition between individuals is a result of differences in the sequence and order of the bases forming DNA.
- DNA strands of genetic material are highly condensed and organized in the cell to keep the genetic material safe.
- However, it should be available to the cell to be used as a template for various biochemical reactions such as protein synthesis.

Characteristics of Genetic Material

- The genetic material is found in every cell. It stores all information about the organism. It varies among different organisms.

- It controls different functions in the cell, controls the replication of its cell, and the formation of new cells. It also accounts for the variation of organisms.

- The hereditary material present in all cells is DNA.

- Individual characteristics such as hair and skin color are carried on genes.

- Some genetic changes (mutations) might affect the genetic material of an individual and may well be passed on to the next generation. Other changes might not affect the genetic material and consequently do not pass to their offspring.