



Biology

Biological Macromolecules



Assis. Prof. Dr. Labeed Al - Saad

The objectives

- Overview.
- Carbohydrates.
- Proteins.
- Lipids.
- Nucleic acids.

BIOMOLECULES



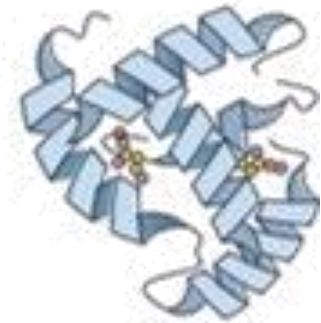
LIPIDS



NUCLEIC ACIDS



CARBOHYDRATES



PROTEINS

Overview

- Biological macromolecules are large molecules that are essential for life and are built from smaller organic molecules. There are four major classes of biological macromolecules: carbohydrates, lipids, proteins, and nucleic acids.
- Each of these classes plays a crucial role in living organisms, with carbohydrates and lipids serving as energy storage molecules, proteins as versatile macromolecules performing various functions, and nucleic acids as the carriers of genetic information.

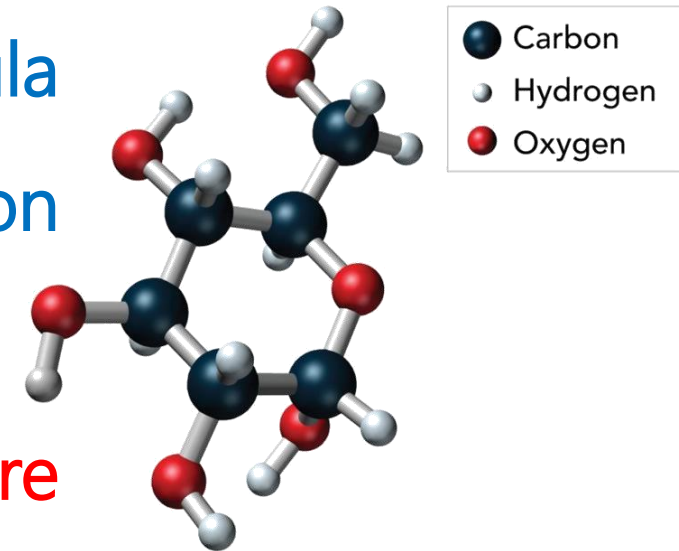
Overview

- Macromolecules are fundamental to comprehending the mechanisms of life and the development of new medical treatments and technologies. Their study is essential in fields such as biochemistry, molecular biology, and biotechnology.

Carbohydrates

Chemical Composition:

- Carbohydrates are composed of carbon, hydrogen, and oxygen atoms, with the general empirical formula $(CH_2O)_n$, where "n" represents the number of carbon atoms.
- They are classified based on their chemical structure into three main groups: monosaccharides, disaccharides, and polysaccharides



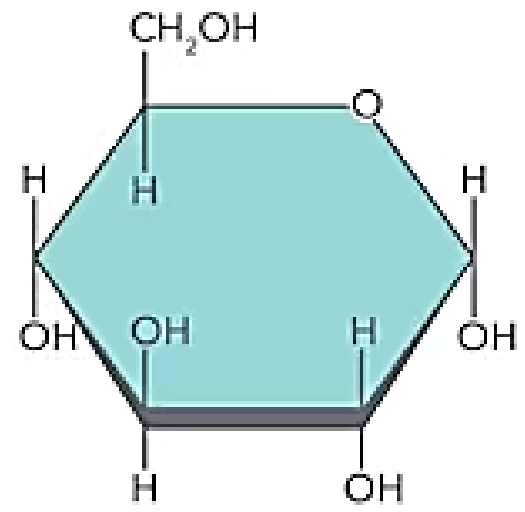
Carbohydrates

Monosaccharides:

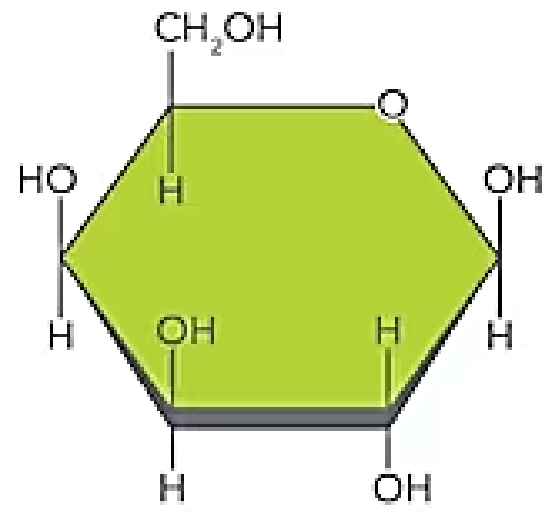
- Monosaccharides are the simplest form of carbohydrates, consisting of a single sugar unit. Common examples include glucose, fructose, and galactose.
- They are the basic building blocks of more complex carbohydrates and are the primary source of energy for cellular respiration.

Carbohydrates

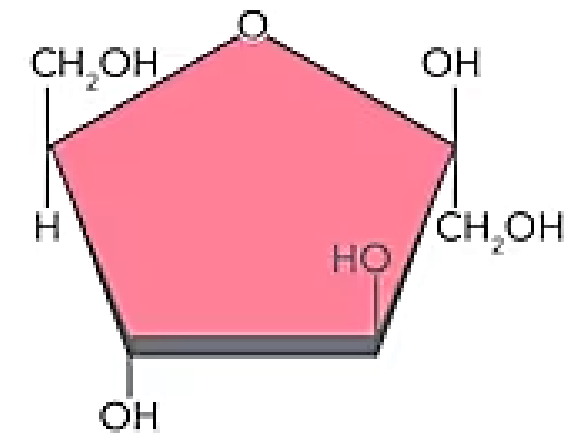
Monosaccharides: 6-Carbon Isomers $C_6H_{12}O_6$



Glucose



Galactose



Fructose

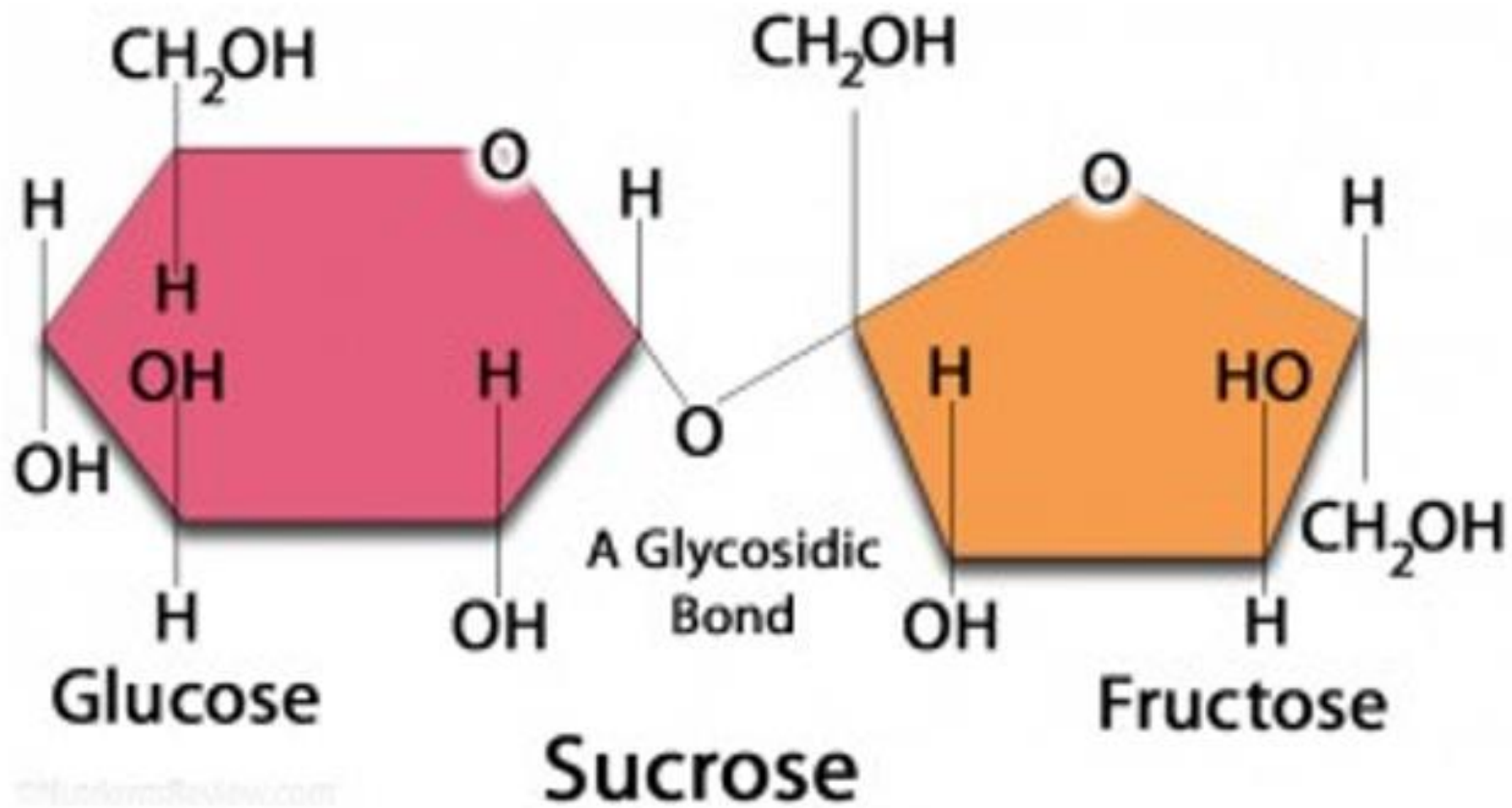
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Carbohydrates

Disaccharides:

- Disaccharides are formed by the condensation of two monosaccharide units through a glycosidic bond. Examples include sucrose (glucose + fructose), lactose (glucose + galactose), and maltose (glucose + glucose).
- They serve as transport forms of sugars and are broken down into monosaccharides during digestion for energy utilization.

Carbohydrates

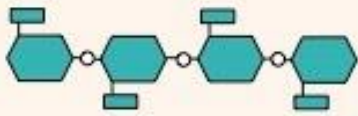
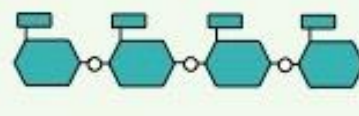
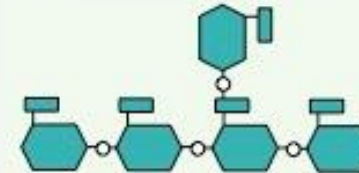
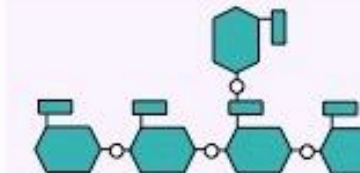
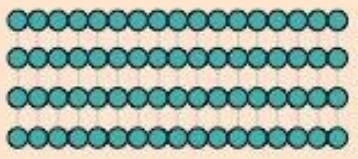

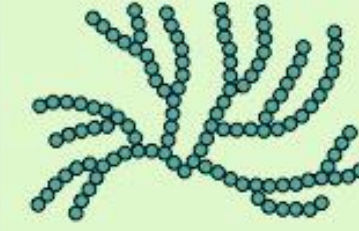
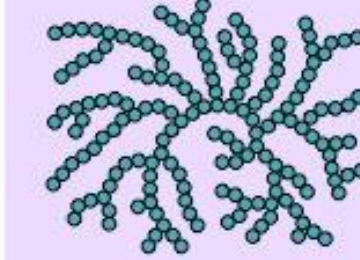


<https://www.nutrientsreview.com/wp-content/uploads/2014/08/disaccharide-example-300x194.jpg>

Carbohydrates

Polysaccharides:

- Polysaccharides are complex carbohydrates composed of long chains of monosaccharide units. Examples include starch, glycogen, and cellulose.
- They function as energy storage molecules (starch in plants and glycogen in animals) and structural components (cellulose in plant cell walls and chitin in the exoskeleton of arthropods).

	Cellulose	Starch		Glycogen
		Amylose	Amylopectin	
Source	Plant	Plant	Plant	Animal
Subunit	β -glucose	α -glucose	α -glucose	α -glucose
Bonds	1-4	1-4	1-4 and 1-6	1-4 and 1-6
Branches	No	No	Yes (~per 20 subunits)	Yes (~per 10 subunits)
Diagram				
Shape				

<https://www.creative-proteomics.com/images/7-Polysaccharide-Analysis.jpg>

Carbohydrates

Functions of Carbohydrates in Living Organisms:

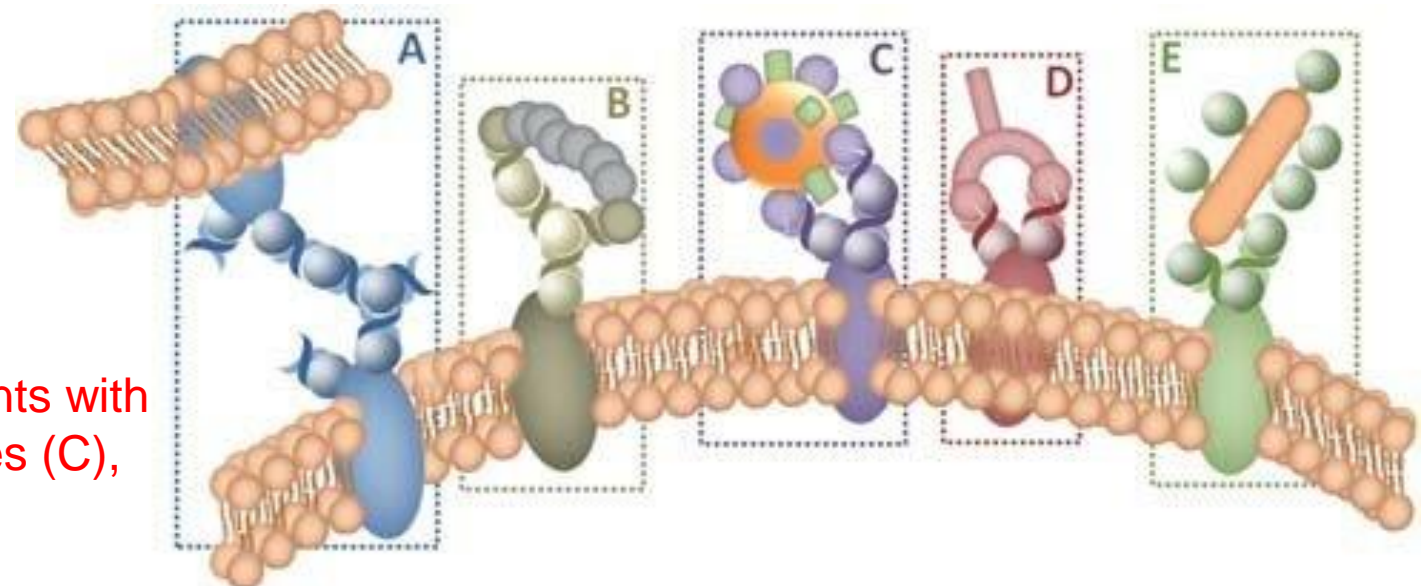
- **Energy Source:** Carbohydrates are the primary source of energy for cellular processes, providing fuel for metabolism, physical activity, and vital organ functions.
- **Structural Support:** Certain carbohydrates, such as cellulose and chitin, contribute to the structural integrity of plant cell walls and the exoskeletons of arthropods, respectively.

Carbohydrates

Functions of Carbohydrates in Living Organisms:

- Cellular Signaling: Carbohydrates are involved in cell-cell recognition, immune response, and molecular signaling through glycoproteins and glycolipids on cell surfaces.

Participation of cell surface carbohydrates in recognition events with another cell (A), toxins (B), viruses (C), antibodies (D) and bacteria (E).



DOI: [10.1039/C0JM01605E](https://doi.org/10.1039/C0JM01605E)

Carbohydrates

Dietary Importance:

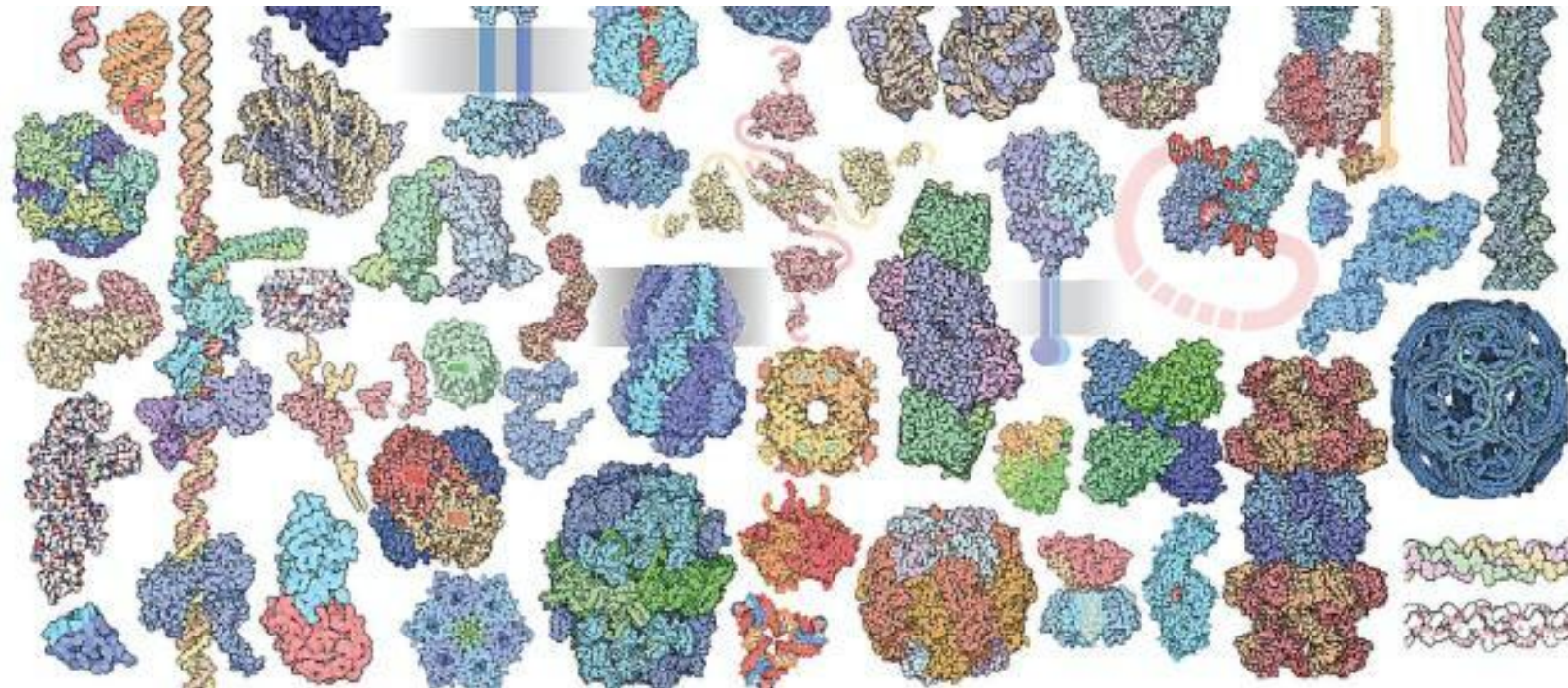
- Carbohydrates are a crucial component of the human diet, providing a readily available source of energy. Whole grains, fruits, vegetables, and legumes are rich sources of complex carbohydrates, fiber, and essential nutrients.
- The balance of simple and complex carbohydrates in the diet is important for maintaining blood sugar levels, energy metabolism, and overall health.

Carbohydrates

In conclusion, carbohydrates are vital biomolecules with diverse functions in living organisms, serving as a fundamental source of energy and contributing to structural and signaling roles. Understanding the chemistry and biological significance of carbohydrates is essential for appreciating their impact on human nutrition, metabolism, and overall well-being.

Proteins

- Proteins are fundamental macromolecules that play crucial roles in the structure, function, and regulation of living organisms. They are composed of amino acids and are involved in a wide range of biological processes.



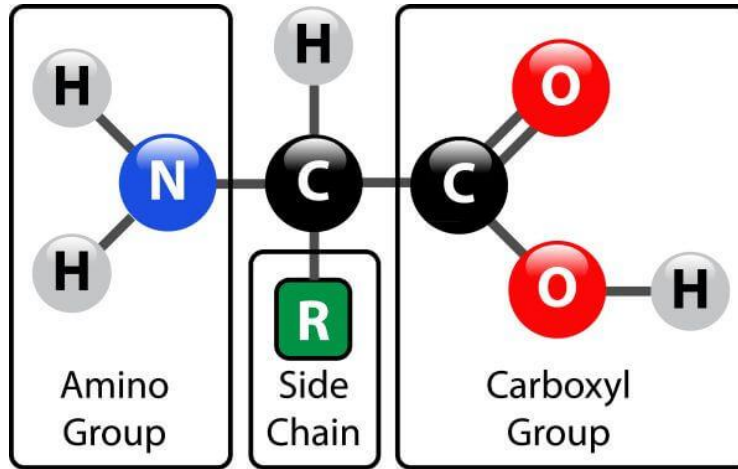
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Proteins

Amino Acid Composition:

- Proteins are composed of long chains of amino acids, which are organic compounds containing an amino group ($-NH_2$) and a carboxyl group ($-COOH$) attached to a central carbon atom.
- There are 20 standard amino acids that serve as the building blocks of proteins, each characterized by a unique side chain (R group) that confers specific chemical properties.

Proteins



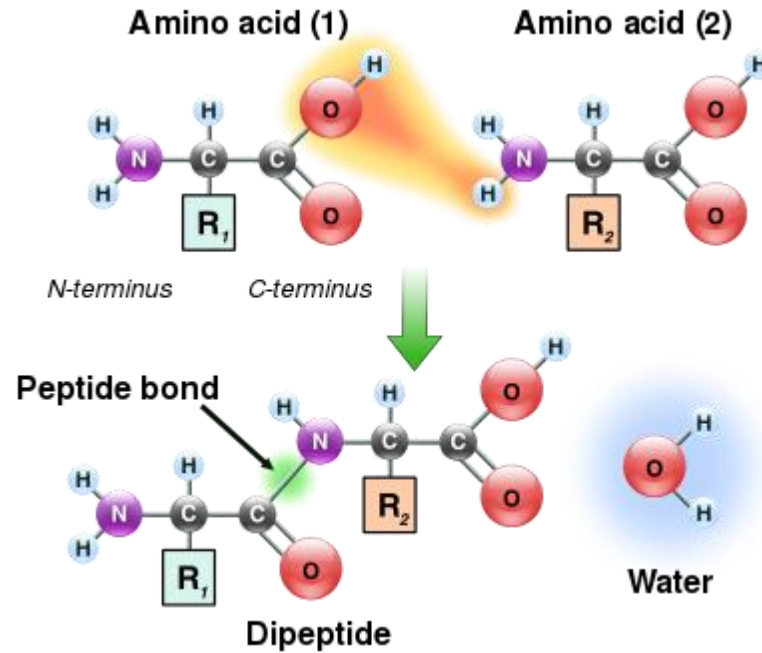
<https://biologydictionary.net/wp-content/uploads/2021/01/amino-acid.jpg>

Positively charged					Negatively charged		12.1 or 6.0: pKa of side chain ● Sulfur or Selenium
 Arginine Arg R	 Histidine His H	 Lysine Lys K	 Aspartic Acid Asp D	 Glutamic Acid Glu E			
Polar uncharged					Special cases		
 Serine Ser S	 Threonine Thr T	 Asparagine Asn N	 Glutamine Gln Q	 Glycine Gly G	 Proline Pro P	 Cysteine Cys C	 Selenocysteine Sec U
Hydrophobic					Hydrophobic		
 Alanine Ala A	 Valine Val V	 Isoleucine Ile I	 Leucine Leu L	 Methionine Met M	 Phenylalanine Phe F	 Tyrosine Tyr Y	 Tryptophan Trp W

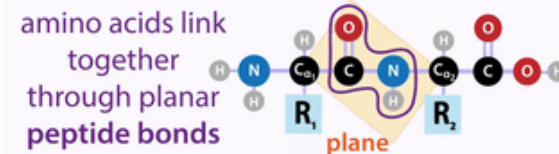
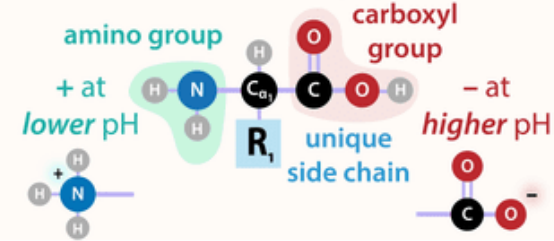
https://upload.wikimedia.org/wikipedia/commons/4/4e/Proteinogenic_Amino_Acid_Table.png

Proteins

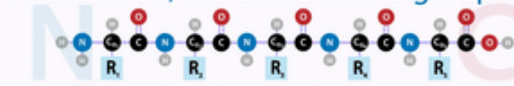
Polypeptides are polymers composed of many amino acids linked together by **peptide bonds**. Peptide bond forms between carboxyl group of one amino acid and amino group of another, and it is a dehydration reaction.



amino acids are like protein letters
central carbon (C_α)



we now call these amino acid leftovers **residues**
link a lot of amino acids to get a **polypeptide**
N-terminus) has a free **amino group**
C-terminus) has a free **carboxyl group**



R is one of 20 different unique side chains

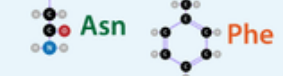
R groups range from **small & flexible** to big & bulky



negative to positive

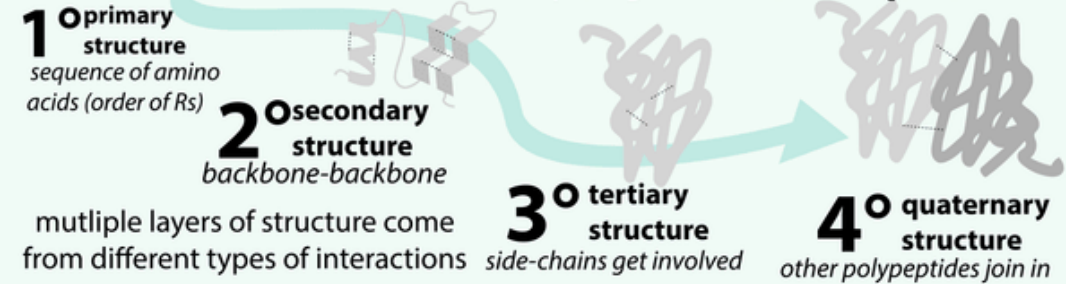


water-loved to water-excluded
hydrophilic **hydrophobic**



these groups stick off from the peptide backbone like charms and influence how the protein folds and functions

fold it up to get a functional **protein**



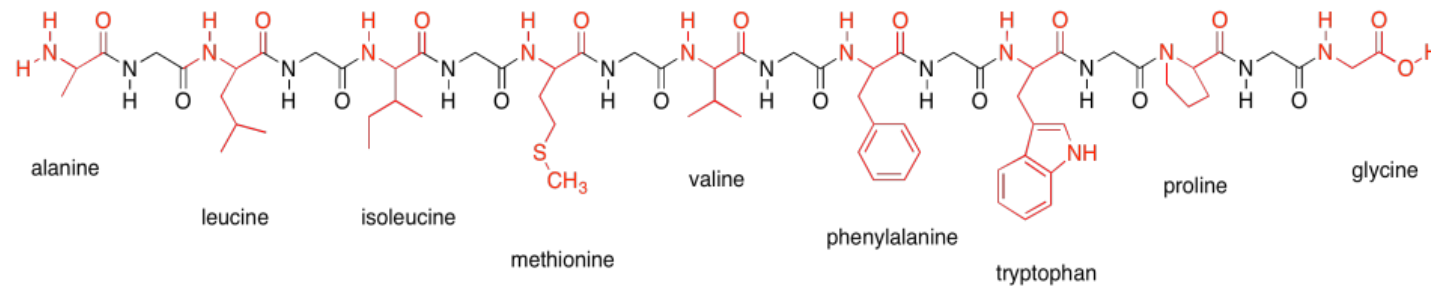
multiple layers of structure come from different types of interactions

<https://www.biologyonline.com/dictionary/polypeptide>

Useful video

<https://www.youtube.com/watch?v=S6aIS2aoy9Q>

<https://upload.wikimedia.org/wikipedia/commons/thumb/6/6d/Peptidformationball.svg/400px-Peptidformationball.svg.png>



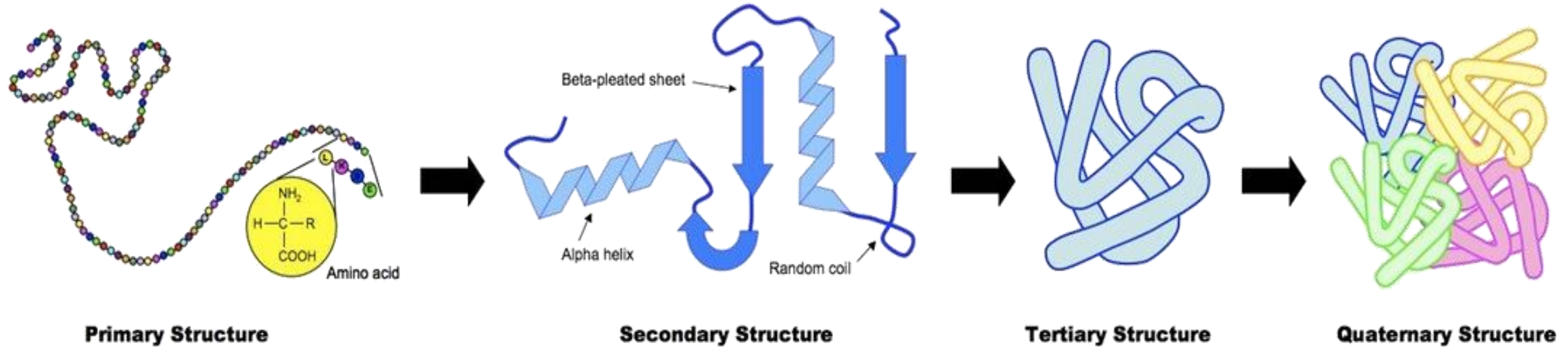
<https://employees.csbsju.edu/cschaller/Principles%20Chem/imf/AAhydrophobic.png>

Proteins

Protein Structure:

- Proteins exhibit a hierarchical structure, including primary, secondary, tertiary, and quaternary levels of organization.
- The primary structure refers to the linear sequence of amino acids in a protein, while the secondary structure involves local folding patterns such as alpha helices and beta sheets. The tertiary structure represents the overall three-dimensional conformation of the protein, and the quaternary structure applies to proteins composed of multiple subunits.

Proteins



Amino acid sequence determines primary protein structure. Polypeptide develops **disulphide bonds** and thus secondary structure of protein is generated. Further 3D arrangement of polypeptide (by folding) is essential to make a protein functional.

<https://upload.wikimedia.org/wikipedia/commons/thumb/6/6d/Peptidformationball.svg/400px-Peptidformationball.svg.png>

Useful videos

<https://www.youtube.com/watch?v=PPJ7C3hcnPw>

<https://www.youtube.com/watch?v=-Qymfiempms>

Proteins

Functions of Proteins:

- **Enzymes:** Many proteins act as enzymes, catalyzing biochemical reactions by facilitating the conversion of substrates into products.
- **Structural Support:** Proteins such as collagen, actin, and tubulin provide structural support for cells, tissues, and organelles.
- **Transport and Storage:** Certain proteins, like hemoglobin and ferritin, are involved in the transport and storage of essential molecules, such as oxygen and iron, within the body.

Proteins

Functions of Proteins:

- **Hormones and Signaling:** Proteins such as insulin and growth factors function as signaling molecules that regulate various physiological processes.
- **Immune Response:** Antibodies and other immune system proteins play a critical role in recognizing and neutralizing foreign substances, pathogens, and toxins.

Proteins

Functions of Proteins:

- **Contractile Proteins:** Proteins like myosin and actin are essential for muscle contraction and movement.
- **Gene Expression and Regulation:** Transcription factors and RNA polymerases are proteins involved in the regulation of gene expression.

Proteins

Contractile: The purpose of the contractile protein is to regulate the movements of your heart and muscles.

Defensive: This type of protein keeps your immune system strong and helps defend against diseases and infections.

Enzymatic: Enzymatic protein aids your digestive system by accelerating the metabolic processes occurring within your cells.

Hormonal: Hormonal protein enables the cells in your body to communicate with each other. An example of a hormonal protein is insulin—the hormone produced in the pancreas that regulates your body's blood sugar levels.

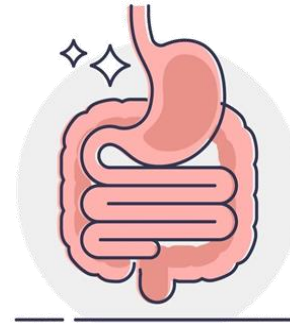
Receptor: Think of receptor proteins as your cells' security guards; these proteins control all the substances that enter and exit your cells.

Storage: The storage protein is responsible for storing mineral ions. One example of a mineral ion is iron, which forms hemoglobin—a necessary component in your red blood cells.

Structural: This type of protein is fibrous in that it creates the framework necessary for healthy bones, muscles, tendons, skin, and cartilage. Collagen, elastin, and keratin are examples of structural proteins.

Transport: Rounding out the list is the transport protein—the protein that delivers important materials (such as hemoglobin) to your cells.

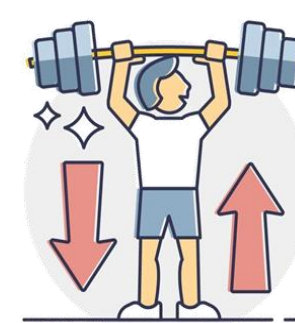
FUNCTIONS OF PROTEINS



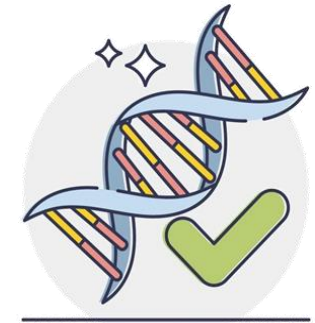
Digestive enzymes help facilitate chemical reactions



Antibodies support immune function



Support muscle contraction and movement



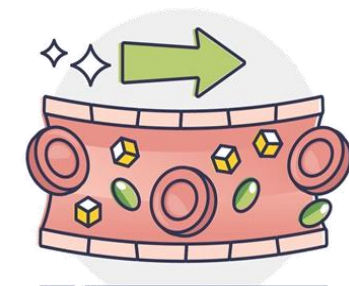
Support the regulation and expression of DNA and RNA



Provide support to the body



Hormones help coordinate bodily function



Move essential molecules around the body

<https://www.firelands.com/empower/health-clinics/types-protein-your-diet/>

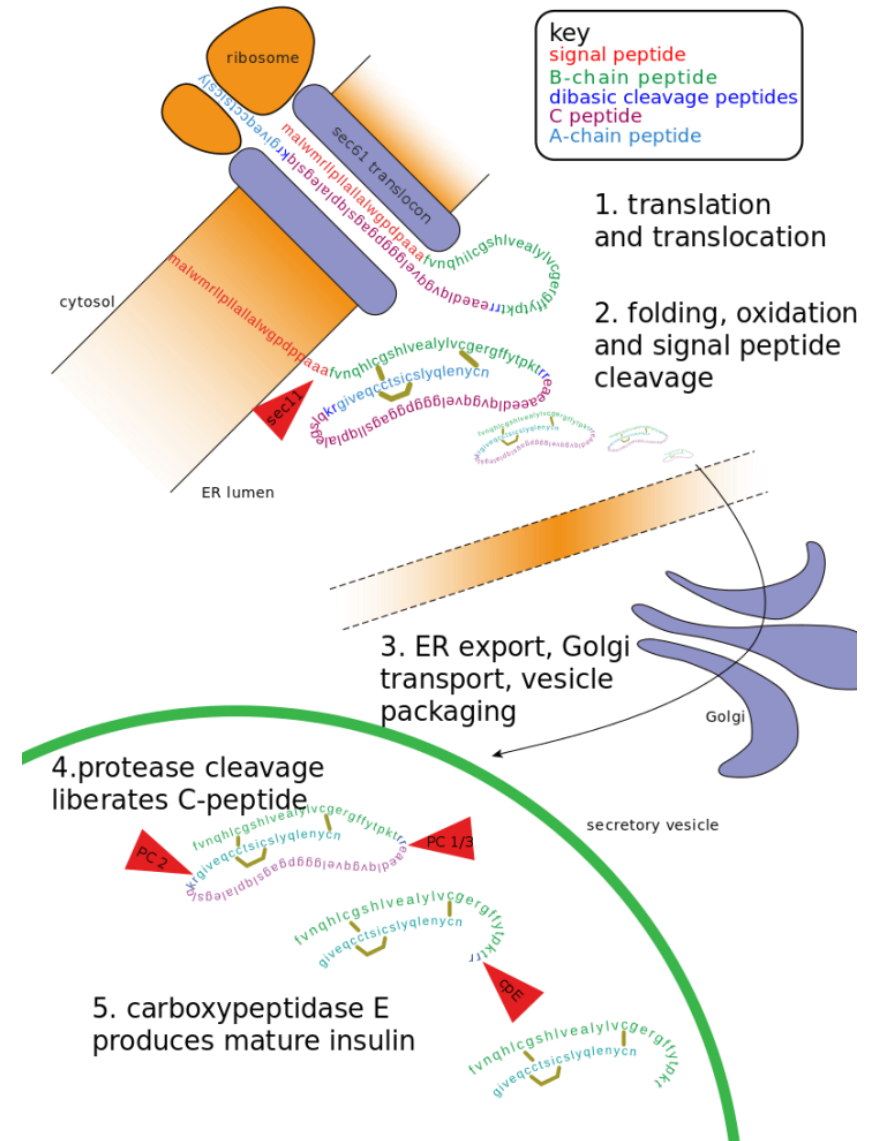
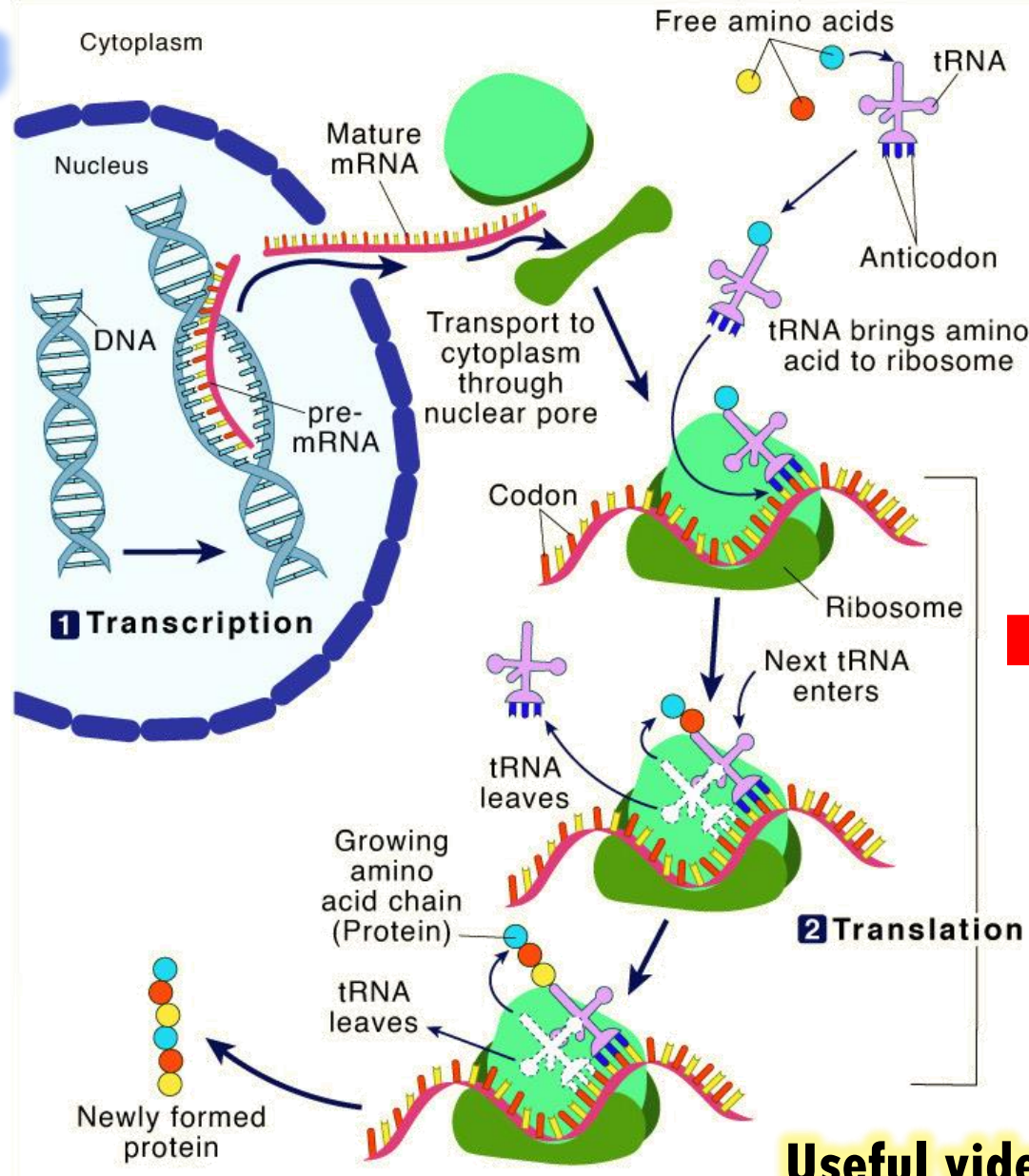
Useful video <https://www.youtube.com/watch?v=eZ7rZWZkWqY>

Proteins

Protein Synthesis:

- Protein synthesis occurs through the process of translation, where the genetic information encoded in messenger RNA (mRNA) is used to assemble a specific sequence of amino acids into a polypeptide chain.
- Ribosomes, transfer RNA (tRNA), and aminoacyl-tRNA synthetases are key components involved in the translation process.

Proteins



Useful video <https://www.youtube.com/watch?v=gG7uCskUOrA&t=57s>

Proteins

Dietary Importance:

- Proteins are essential components of the human diet, providing amino acids necessary for the synthesis of new proteins, enzymes, and other vital molecules.
- Dietary sources of protein include meat, fish, eggs, dairy products, legumes, nuts, and certain grains.



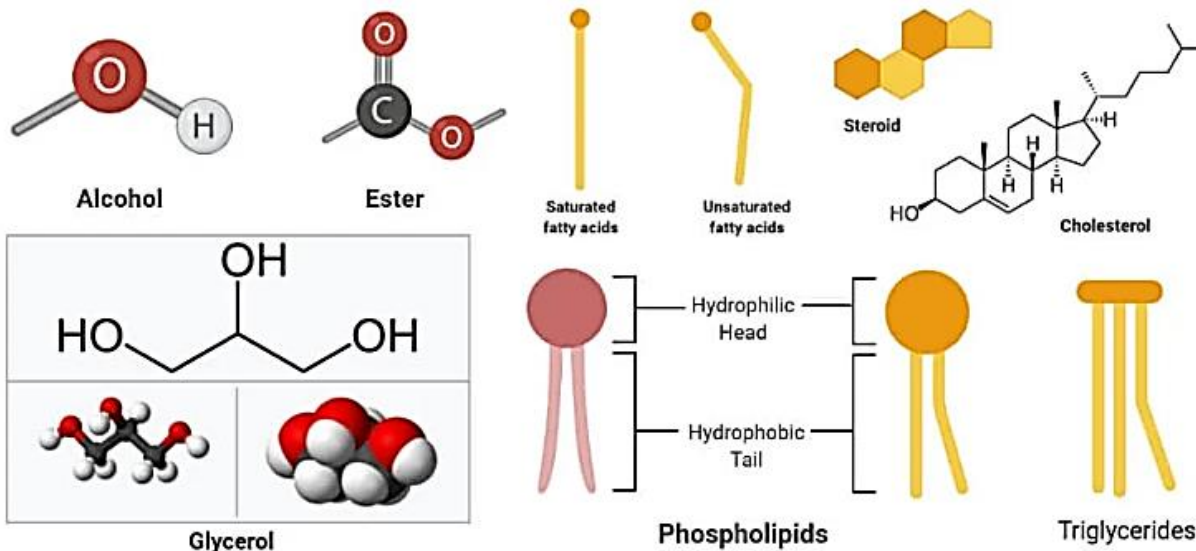
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Proteins

In conclusion, proteins are indispensable biomolecules with diverse functions in living organisms, encompassing enzymatic catalysis, structural support, signaling, and regulatory roles. Understanding the structure, function, and synthesis of proteins is vital for comprehending their impact on human health, nutrition, and various biological processes.

Lipids

Lipids are a diverse group of biomolecules that play essential roles in the structure, function, and regulation of living organisms. They are characterized by their hydrophobic nature and include a wide range of compounds such as fats, oils, phospholipids, steroids, and waxes.



<https://microbenotes.com/wp-content/uploads/2020/12/Lipids-and-Fatty-Acids.jpeg>

Lipids

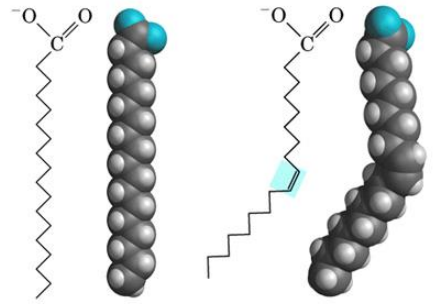
Classification of Lipids:

- **Fatty Acids:** These are the building blocks of many lipids, consisting of a long hydrocarbon chain with a carboxylic acid group at one end.
- **Triglycerides:** Triglycerides, commonly known as fats and oils, are composed of three fatty acid molecules esterified to a glycerol molecule. They serve as a major form of energy storage in organisms.

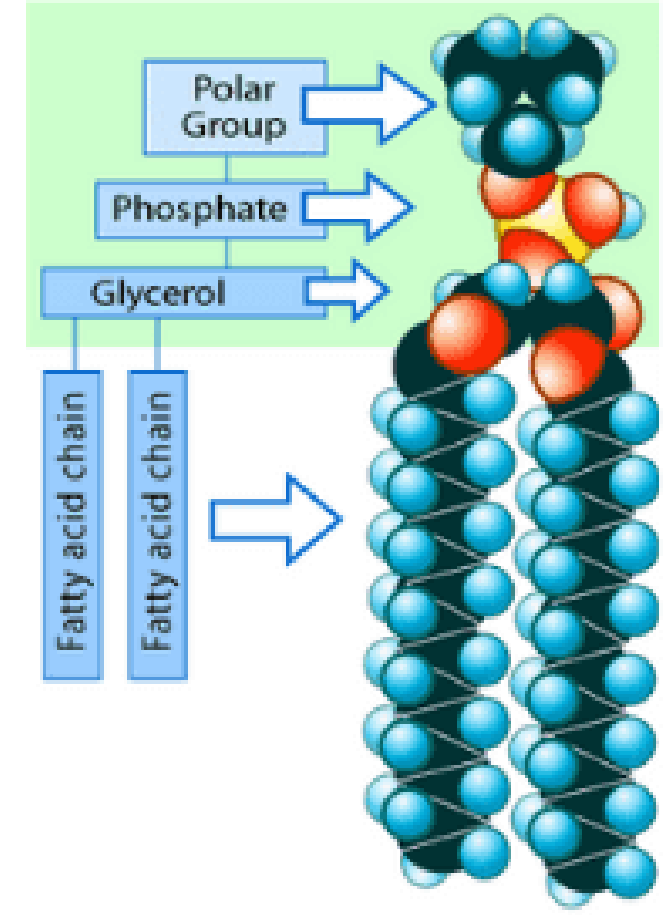
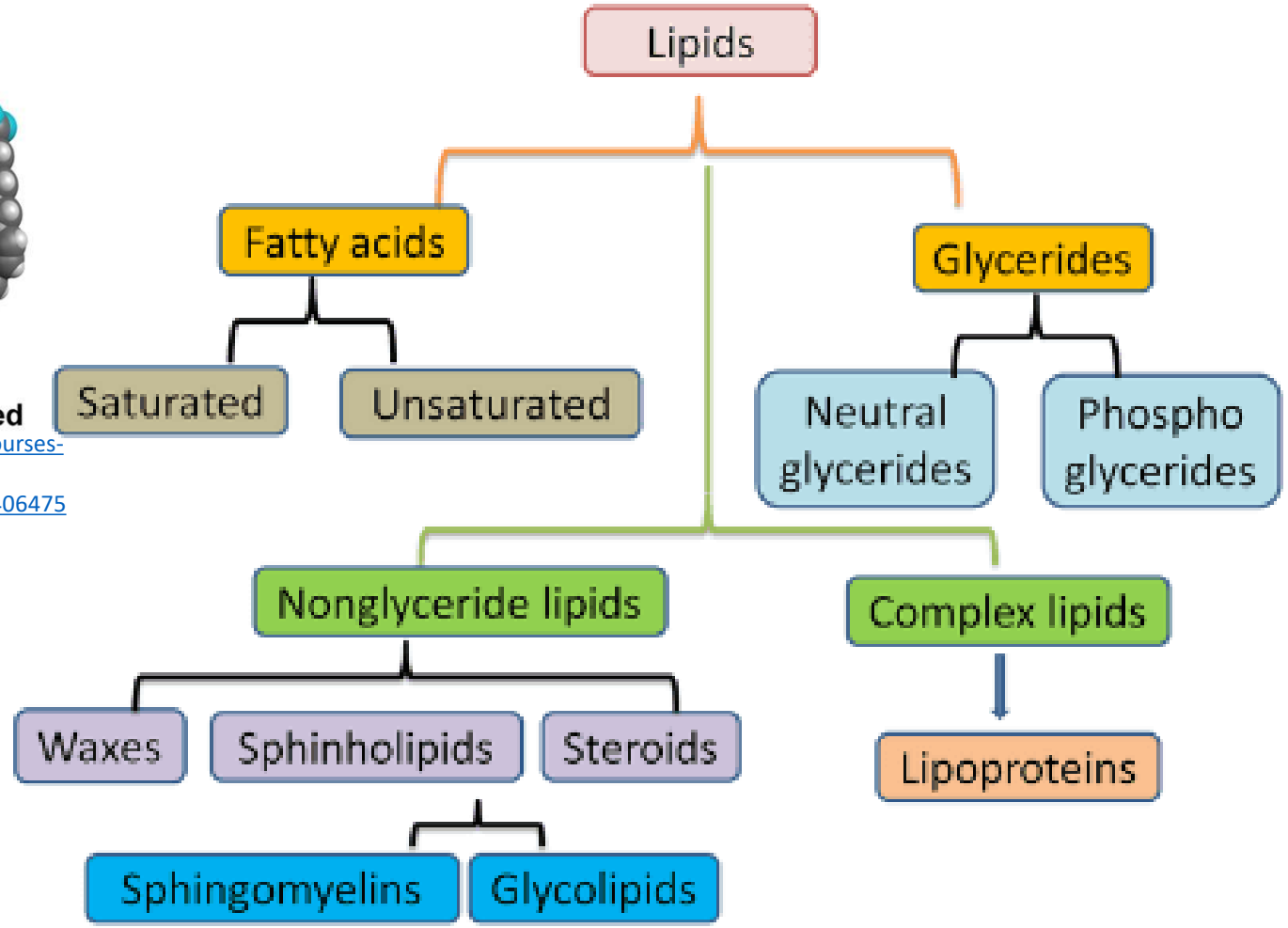
Lipids

- **Phospholipids:** Phospholipids are a key component of cell membranes, featuring a hydrophilic head (phosphate group) and two hydrophobic tails (fatty acids).
- **Steroids:** Steroids are a class of lipids with a characteristic four-ring structure, including cholesterol, hormones (e.g., estrogen, testosterone), and bile acids.
- **Waxes:** Waxes are long-chain fatty acids esterified to long-chain alcohols, providing waterproofing and protective functions in plants and animals.

Lipids



<https://s3-us-west-2.amazonaws.com/courses-images-archive-read-only/wp-content/uploads/sites/1470/2015/12/04064755/Mono-n-Poly.jpg>



<https://www.phdnest.com/lipids/>

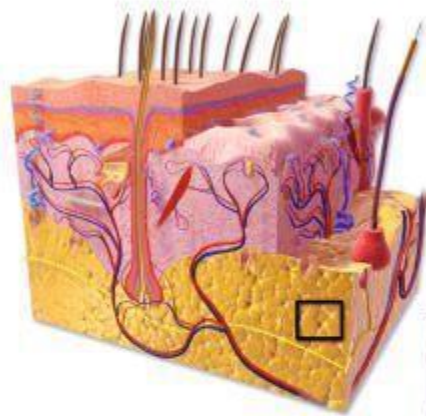
Lipids

Functions of Lipids:

- **Energy Storage:** Triglycerides serve as an efficient form of energy storage, with adipose tissue in animals and seeds in plants serving as major reservoirs.
- **Structural Components:** Phospholipids form the lipid bilayer of cell membranes, providing a barrier that separates the interior of cells from their external environment.

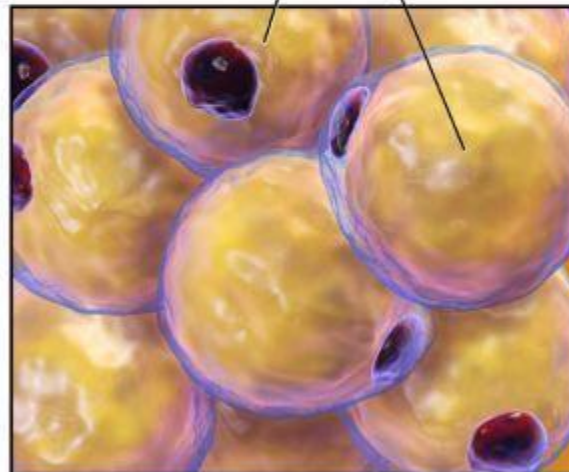
Lipids

Functions of Lipids

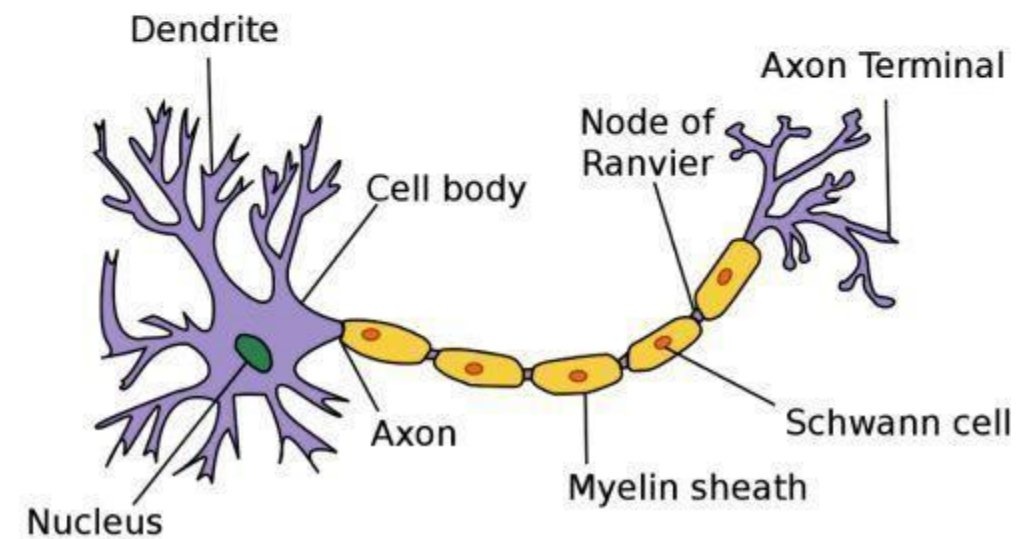
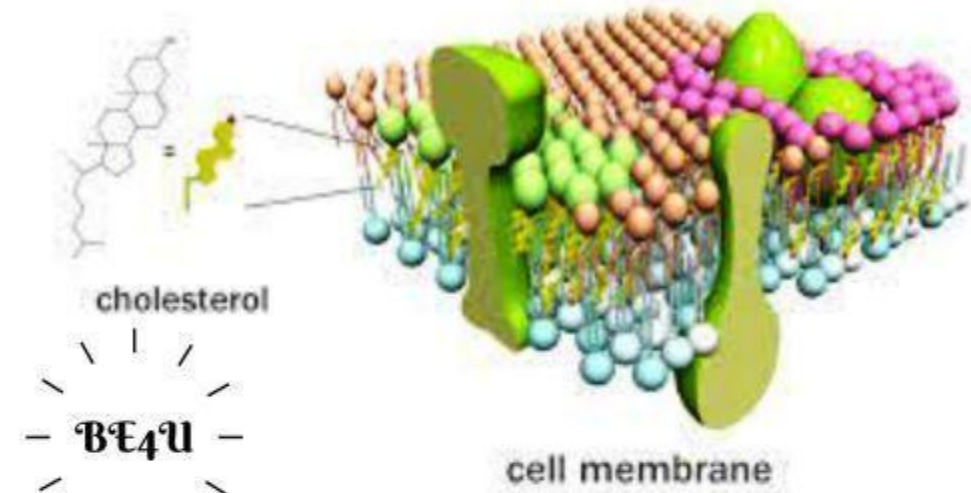


Adipose Tissue

Adipocytes
(white adipose cells)



www.biologyexams4u.com



Lipids

- **Insulation and Protection:** Adipose tissue acts as insulation and cushioning in animals, while waxes provide waterproofing and protection for leaves, fruits, and animal integument.
- **Signaling and Cell Communication:** Lipids such as steroids act as signaling molecules that regulate various physiological processes, including growth, development, and metabolism.
- **Absorption of Fat-Soluble Nutrients:** Lipids facilitate the absorption and transport of fat-soluble vitamins (A, D, E, and K) in the body.

Lipids

Dietary Importance:

- Dietary lipids are a crucial component of the human diet, providing essential fatty acids (e.g., omega-3 and omega-6 fatty acids) and fat-soluble vitamins.
- Sources of dietary lipids include oils, butter, nuts, seeds, avocados, fatty fish, and animal products.

Lipids

Lipid Metabolism:

- Lipid metabolism involves processes such as lipolysis (breakdown of triglycerides into fatty acids and glycerol), fatty acid oxidation, and lipogenesis (synthesis of fatty acids and triglycerides).
- Lipoproteins, such as LDL (low-density lipoprotein) and HDL (high-density lipoprotein), play a crucial role in the transport of lipids in the bloodstream.

Lipids

In conclusion, lipids are vital biomolecules with diverse functions in living organisms, serving as energy stores, structural components, signaling molecules, and essential dietary components. Understanding the chemistry, metabolism, and biological significance of lipids is critical for comprehending their impact on human health, nutrition, and various physiological processes.

Nucleic acid

Nucleic acids are essential biomolecules that play a central role in the storage, transmission, and expression of genetic information in living organisms. They are composed of long chains of nucleotides and are crucial for the inheritance of genetic traits, as well as the synthesis of proteins.

Nucleic acid

Types of Nucleic Acids:

- Deoxyribonucleic Acid (DNA): DNA is the hereditary material in most organisms, storing genetic information that determines an organism's traits. It is found in the nucleus of eukaryotic cells and in the cytoplasm of prokaryotic cells.
- Ribonucleic Acid (RNA): RNA is involved in various cellular processes, including gene expression, protein synthesis, and regulation of gene activity. It is found in the nucleus and cytoplasm of cells.

Nucleic acid

Structure of Nucleic Acids:

- Nucleotides: Nucleic acids are composed of monomeric units called nucleotides, which consist of three components:
 - ❖ A nitrogenous base (adenine, guanine, cytosine, thymine in DNA, and uracil in RNA)
 - ❖ A five-carbon sugar (deoxyribose in DNA and ribose in RNA)
 - ❖ A phosphate group

Nucleic acid

Structure of Nucleic Acids:

- DNA Structure: DNA is a double-stranded molecule with a double helix structure, consisting of two complementary strands of nucleotides held together by hydrogen bonds between the nitrogenous bases (adenine pairs with thymine, and guanine pairs with cytosine).
- RNA Structure: RNA is typically single-stranded and can fold into complex three-dimensional structures due to base pairing interactions and other molecular forces.

Nucleic acid

Functions of Nucleic Acids:

- Genetic Information Storage: DNA stores the genetic information that is passed from one generation to the next, carrying the instructions for the synthesis of proteins and the regulation of cellular processes.
- Protein Synthesis: RNA plays a key role in protein synthesis by carrying genetic information from DNA to the ribosomes, where it is translated into specific amino acid sequences to form proteins.

Nucleic acid

Functions of Nucleic Acids:

- Regulation of Gene Expression: Nucleic acids are involved in the regulation of gene expression, controlling when and to what extent specific genes are activated or repressed.

Nucleic acid

Nucleic Acid Metabolism:

- DNA Replication: The process by which DNA is duplicated before cell division, ensuring that genetic information is faithfully passed on to daughter cells.
- Transcription: The synthesis of RNA from a DNA template, a key step in gene expression.
- Translation: The process by which the genetic information in RNA is used to direct the synthesis of specific proteins.

Nucleic acid

In conclusion, nucleic acids are fundamental to life, serving as the blueprint for an organism's structure and function. Understanding their structure, functions, and metabolism is crucial for unraveling the complexities of genetics, molecular biology, and the inheritance of traits.

THANK YOU!