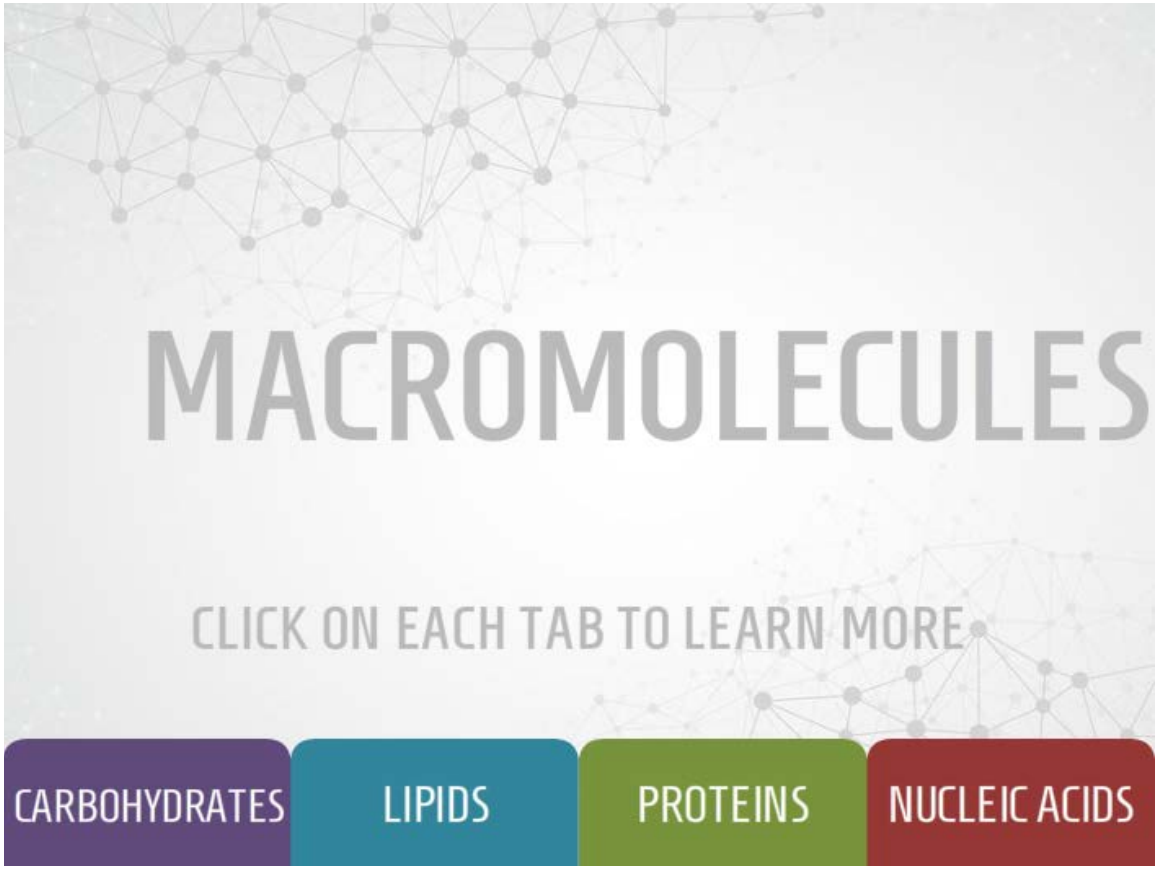
Module 2: Biochemistry
Topic 3 Content: Macromolecules Notes



There are four main groups of organic compounds: carbohydrates, lipids, proteins, and nucleic acids. These groups are called macromolecules, or polymers, because they are formed by joining smaller molecules, or monomers. These macromolecules perform specific essential functions in the cell.

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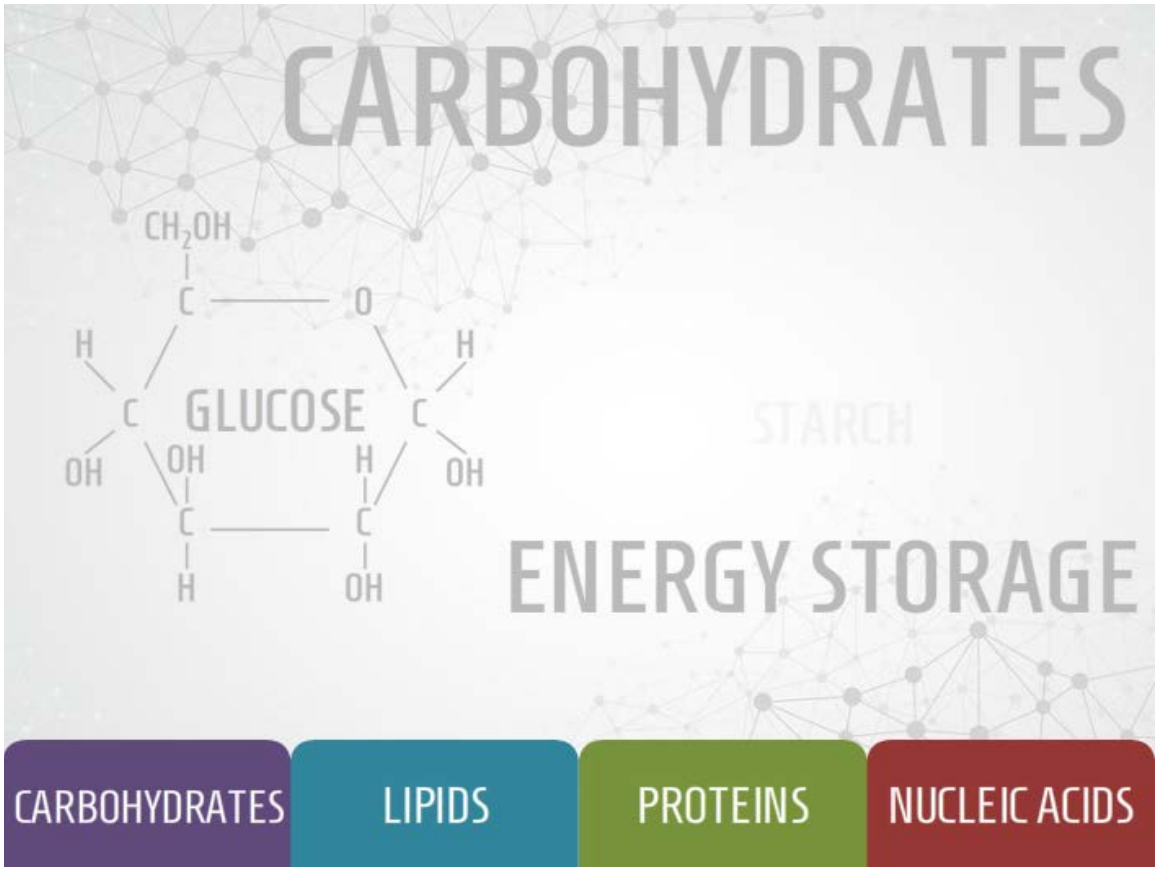

Carbohydrates are organic macromolecules composed of carbon, hydrogen, and oxygen in a ratio of 1:2:1. The building blocks, or monomers, of carbohydrates are simple sugars, and the numbers of simple sugars in the molecule are how carbohydrates are classified. Monosaccharides, like glucose, fructose, and ribose have only one sugar molecule. Sucrose, lactose, and maltose are all types of disaccharides which are formed by linking two simple sugars together. For example, sucrose is formed when glucose and fructose are combined. Polysaccharides are formed when many monosaccharides are joined together. Two examples of polysaccharides are glycogen, which is found in liver and muscle cells, and starch, which is found in plant cells.

Carbohydrates function as energy storage molecules in the cell. Glucose stores energy for immediate use, while glycogen and starch store a large amount of energy until it is needed. Glycogen is then metabolized, or broken down, into glucose. Carbohydrates are also used for structural support in the cell. Chains of glucose form cellulose, which is a tough fibrous molecule in plant cell walls. The cell walls of fungi contain the polysaccharide chitin, which is also found in the exoskeleton of arthropods like lobster and shrimp.

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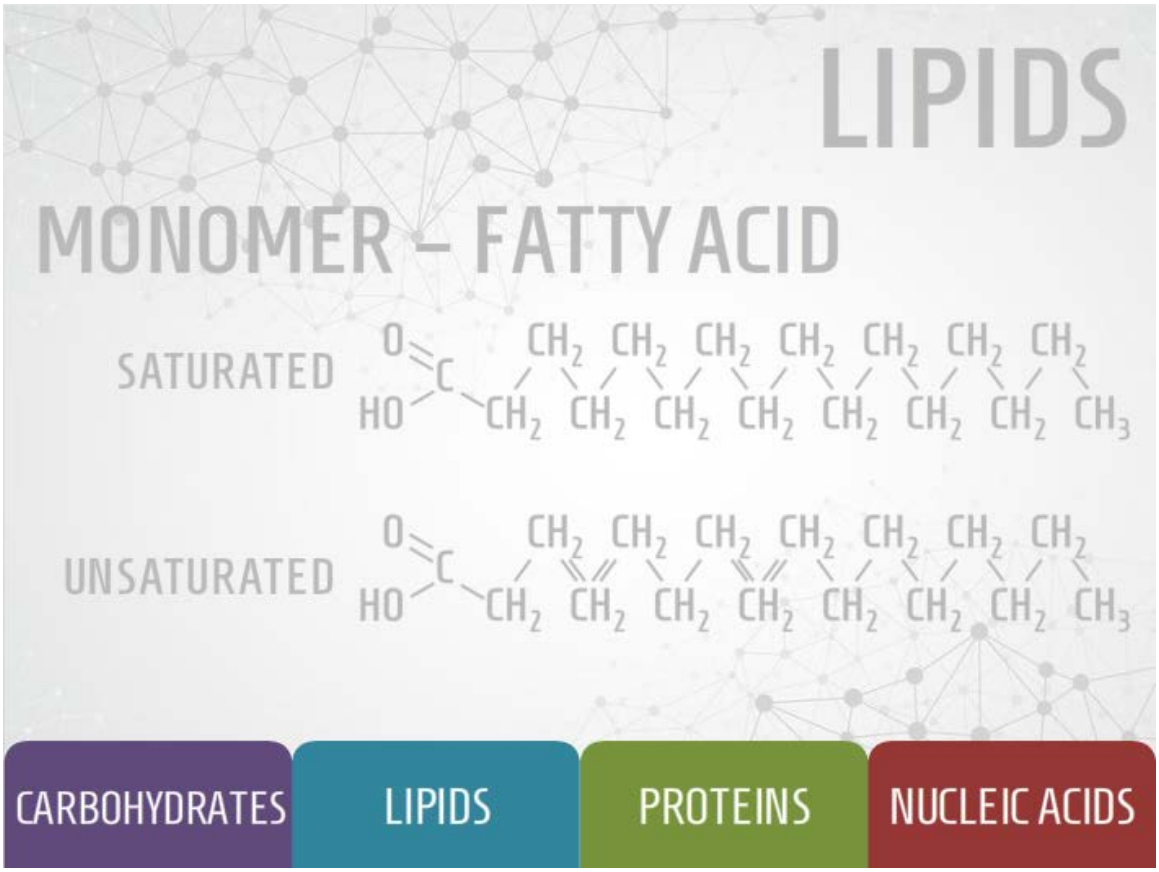

Lipids include fats, oils, waxes, steroids and phospholipids. Fatty acids, which are long chains of carbon and hydrogen atoms attached to a carboxyl group on one end, are the monomers of lipids. Fatty acids can be unsaturated, which means they have at least one double bond between carbon atoms, or saturated, which means there are no double bonds.

Recall what happens when you try to mix oil and water. They will not stay mixed and almost immediately separate into two layers. This is because lipids are hydrophobic, which means that they will not dissolve in water. This property allows lipids to act as water barriers. Waxes form the coating on the surface of many plants and animals, protecting them from excess water loss. Phospholipids are the main component of cell membranes and function to keep the inside of the cell protected and separate from its external environment.

The hydrophobic nature of fat molecules also allows them to function as reserve energy storage. Because lipids will not react or dissolve in water, the energy stored in fat can be stored for a long time. When extra energy is required, fat molecules can be broken down, and the energy is available for use.

Lipids also function as insulating molecules and signaling molecules. Steroids are a group of lipids that are able to dissolve in water and in other lipids, enabling them to move through and around in cells. Signaling molecules such as these include hormones and cholesterol. Blubber is a layer under the skin of many marine mammals, composed of fatty acids. These fat-filled cells not only store energy for the animal, they also provide a layer of insulation to help the animal conserve heat in cold water. Lipids function as insulating molecules in other animals as well.

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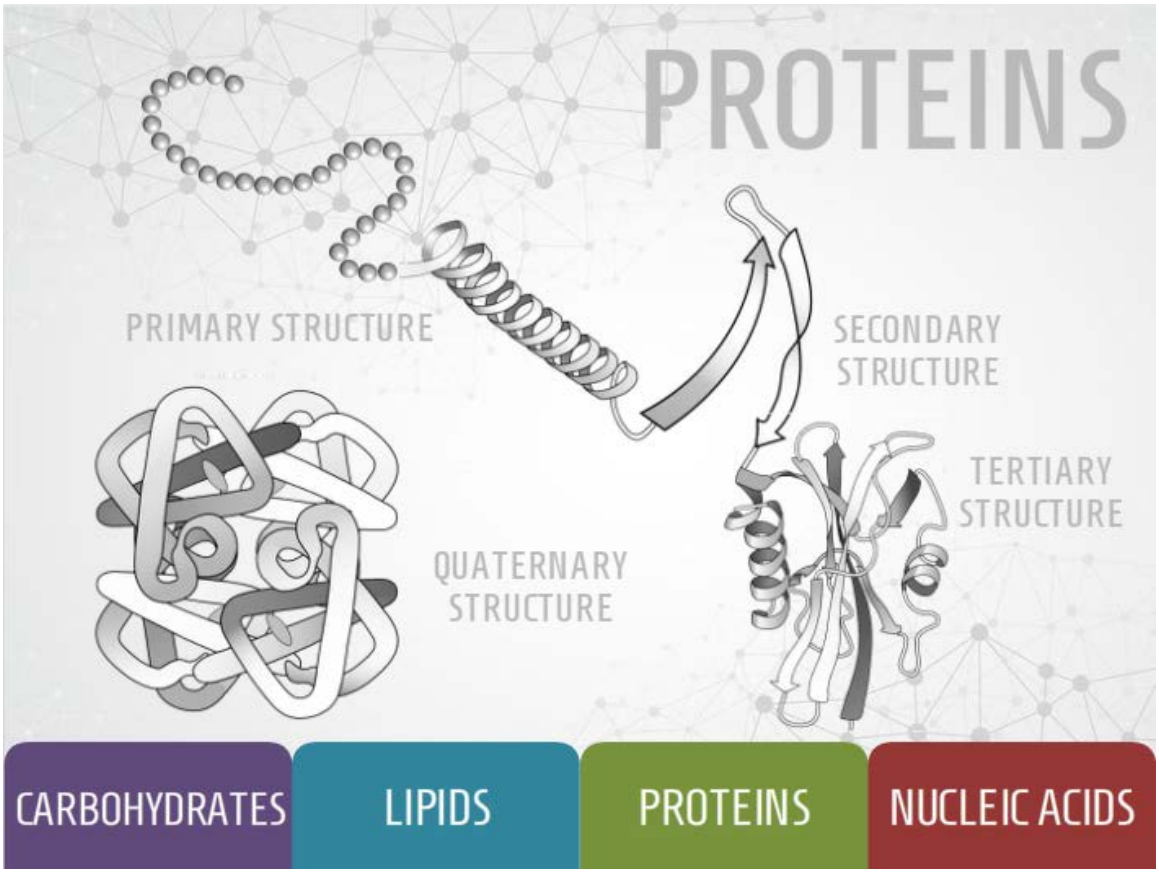

Proteins are large molecules composed of the elements carbon, hydrogen, oxygen, nitrogen, and sometimes sulfur. Amino acids are the building blocks, or monomers, of proteins. There are twenty amino acids that are joined by peptide bonds in varying sequences to form polypeptide chains. Proteins are made from one or more polypeptides.

Amino acids in proteins interact with each other in a variety of ways, causing a protein to have up to four tiers of structure. The primary structure is the linear sequence of amino acids in each polypeptide. The secondary structure is defined by the three-dimensional shape formed when amino acids fold over and connect with each other at a specific region. The tertiary structure occurs when the entire molecule folds into a specific shape, which for most proteins is a globular shape. A quaternary structure is sometimes formed when one protein joins with other proteins.

Proteins are important to all living organisms. Just about every function in your body involves the activity of a protein. Transport proteins carry substances inside the cell and from cell to cell. In a red blood cell, hemoglobin is a transport protein that carries oxygen throughout the body. Proteins in the cell membrane help provide structure and a channel through which large molecules are able to enter and exit the cell. Contractile proteins in muscle cells are responsible for movement, and antibodies are proteins that are responsible for protecting the body against pathogens like viruses and bacteria. Many hormones are proteins. Enzymes, which are important catalysts in every chemical reaction, are also proteins.

The ability of a protein to perform its function is tied to the structure of the protein. If the shape of the protein is changed, the ability of the protein to function may decrease or cease altogether. When a protein's shape is altered, the protein is said to be denatured. A protein can become denatured when the temperature or the pH of the environment changes. The risk of denaturing proteins is why you should seek medical attention if you are running an extremely high body temperature when you are sick.

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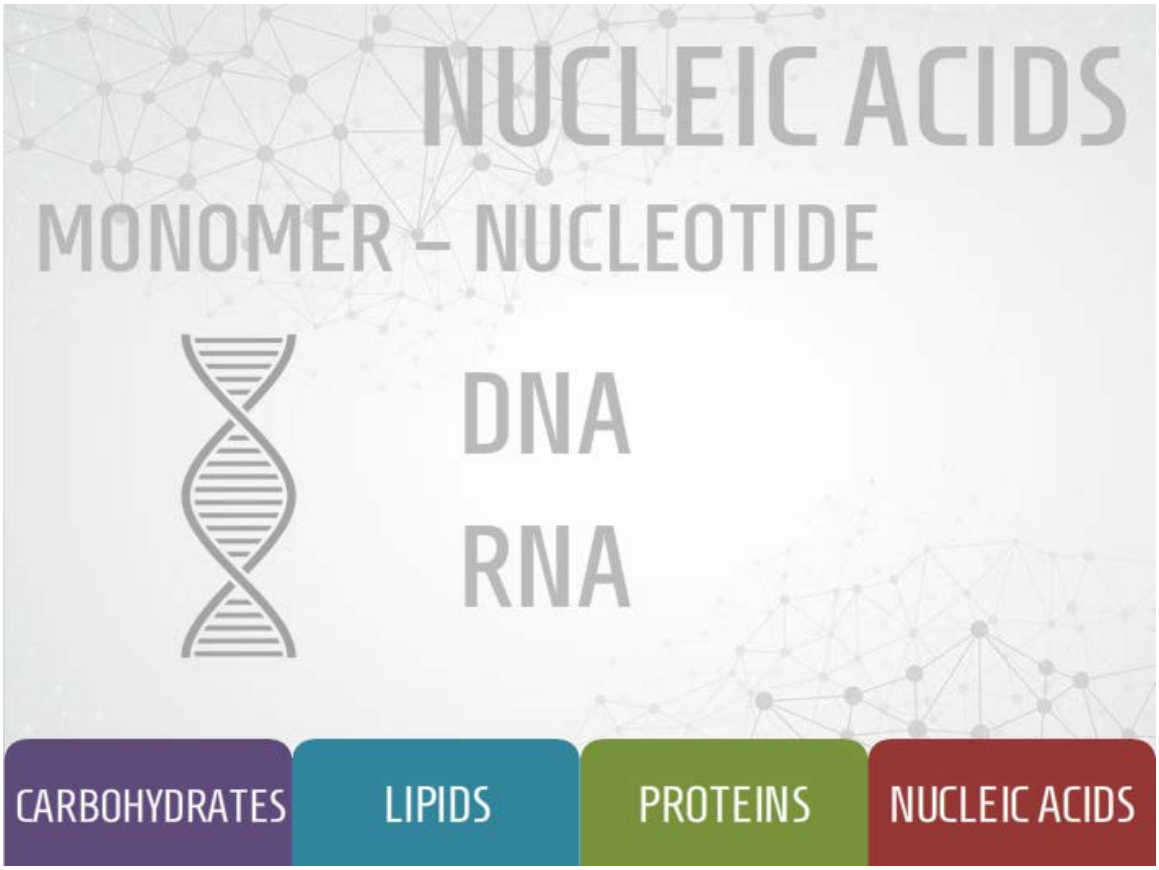

Nucleic acids are huge polymers made of long chains of nucleotides. Nucleotides are composed of the elements carbon, hydrogen, oxygen, nitrogen, and phosphorous, and have a basic three-part structure - a phosphate, a nitrogenous base, and a five-carbon sugar.

Two types of nucleic acids found in all living organisms are DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA and RNA carry genetic information and are essential to all life because they contain the information needed to make proteins. Another nucleic acid is adenosine triphosphate, or ATP. The nucleotide that makes ATP is made of three phosphates, and functions as the energy molecule in the cell. Energy is released and used in important cellular processes when the bond between the second and third phosphates is broken.