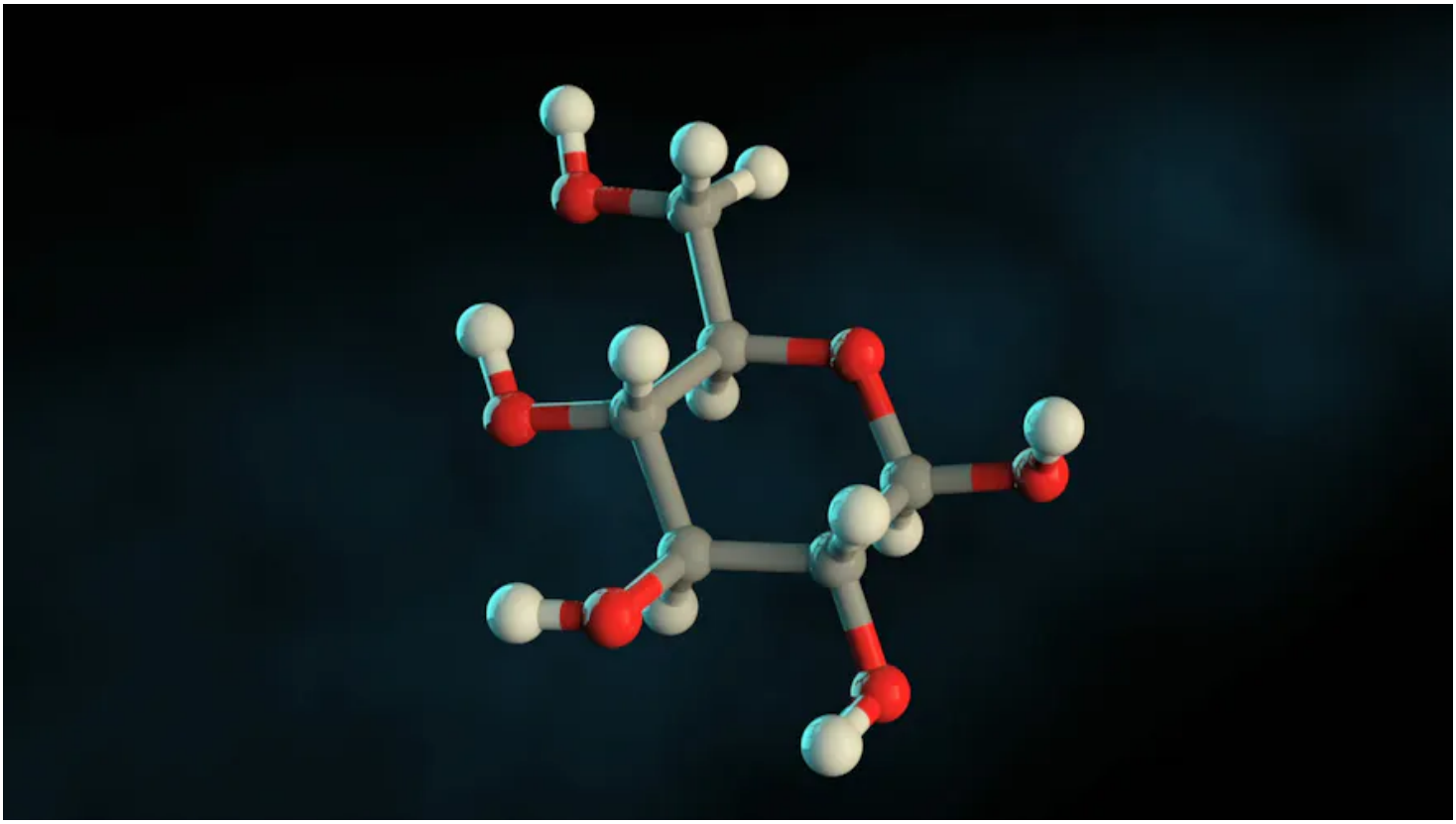
Biological polymers: Proteins, carbohydrates, lipids

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A model of glucose, a common sugar molecule that is a form of carbohydrate. Carbohydrates are one of the four kinds of macromolecules, or polymers. Image: INTELECOM/Science Source

Biological polymers are large molecules composed of many similar smaller molecules linked together in a chainlike fashion. The individual smaller molecules are called monomers. When small organic molecules are joined together, they can form giant molecules or polymers. These giant molecules are also called macromolecules.

In chemistry and biology, a macromolecule is defined as a molecule with a very large number of atoms. Macromolecules typically have more than 100 component atoms. Macromolecules exhibit very different properties from smaller molecules, including their subunits, when applicable. (In contrast, a micromolecule is a molecule which has a small size and molecular weight.)

The term macromolecule was coined by Nobel laureate Hermann Staudinger in the 1920s. At the time, the term "polymer" had a different meaning than it does today, or else it might have become the preferred word. Most polymers are macromolecules and many biochemical molecules are macromolecules. Polymers consist of subunits, called monomers, that are covalently linked to

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form larger structures. Natural polymers are used to build tissue and other components in living organisms.

Proteins, DNA, RNA and plastics are all macromolecules. Many carbohydrates and lipids are macromolecules. Carbon nanotubes are an example of a macromolecule that is not a biological material.

Generally speaking, all macromolecules are produced from a small set of about 50 monomers. Different macromolecules vary because of the arrangement of these monomers. By varying the sequence, an incredibly large variety of macromolecules can be produced. While polymers are responsible for the molecular "uniqueness" of an organism, the common monomers mentioned above are nearly universal.

The variation in the form of macromolecules is largely responsible for molecular diversity. Much of the variation that occurs both within an organism and among organisms can ultimately be traced to differences in macromolecules. Macromolecules can vary from cell to cell in the same organism, as well as from one species to the next.

Biomolecules

There are four basic kinds of biological macromolecules. They are carbohydrates, lipids, proteins and nucleic acids. These polymers are composed of different monomers and serve different functions.

Carbohydrates are molecules composed of sugar monomers. They are necessary for energy storage. Carbohydrates are also called saccharides and their monomers are called monosaccharides. Glucose is an important monosaccharide that is broken down during cellular respiration to be used as an energy source. Starch is an example of a polysaccharide (many saccharides linked together) and is a form of stored glucose in plants.

Lipids are water-insoluble molecules that can be classified as fats, phospholipids, waxes and steroids. Fatty acids are lipid monomers that consist of a hydrocarbon chain with a carboxyl group attached at the end. Fatty acids form complex polymers such as triglycerides, phospholipids and waxes. Steroids are not considered true lipid polymers because their molecules do not form a fatty acid chain. Instead, steroids are composed of four fused carbon ringlike structures. Lipids help to store energy, cushion and protect organs, insulate the body and form cell membranes.

Proteins are biomolecules capable of forming complex structures. Proteins are composed of amino acid monomers and have a wide variety of functions including transportation of molecules and muscle movement. Collagen, hemoglobin, antibodies and enzymes are examples of proteins.

Nucleic acids are molecules consisting of nucleotide monomers linked together to form polynucleotide chains. DNA and RNA are examples of nucleic acids. These molecules contain instructions for protein synthesis and allow organisms to transfer genetic information from one generation to the next.

Assembling And Disassembling Polymers

While there is variation among the types of biological polymers found in different organisms, the chemical mechanisms for assembling and disassembling them are largely the same across

organisms. Monomers are generally linked together through a process called dehydration synthesis, while polymers are disassembled through a process called hydrolysis. Both of these chemical reactions involve water. In dehydration synthesis, bonds are formed linking monomers together while losing water molecules. In hydrolysis, the water interacts with a polymer causing bonds that link monomers to each other to be broken.

Synthetic Polymers

Unlike natural polymers, which are found in nature, synthetic polymers are man-made. They are derived from petroleum oil and include products such as nylon, synthetic rubbers, polyester, Teflon, polyethylene and epoxy. Synthetic polymers have a number of uses and are widely used in household products. These products include bottles, pipes, plastic containers, insulated wires, clothing, toys and nonstick pans.

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Write Prompt

Write a short paragraph that explains the central idea of the article. Use at least two details from the article to support your response.

Write Prompt

Why are macromolecules important to human survival?

Make a claim. Support your claim with evidence from the article. Then, explain why the evidence supports your claim.

Quiz

1 Read the paragraph from the section "Synthetic Polymers."

> *Unlike natural polymers, which are found in nature, synthetic polymers are man-made. They are derived from petroleum oil and include products such as nylon, synthetic rubbers, polyester, Teflon, polyethylene and epoxy. Synthetic polymers have a number of uses and are widely used in household products. These products include bottles, pipes, plastic containers, insulated wires, clothing, toys and nonstick pans.*

Which word from the paragraph helps you understand that synthetic polymers come from oil products?

(A) natural

(B) derived

(C) widely

(D) insulated

2 Read the selection from the introduction [paragraphs 1-6].

> *By varying the sequence, an incredibly large variety of macromolecules can be produced. While polymers are responsible for the molecular "uniqueness" of an organism, the common monomers mentioned above are nearly universal.*

Why did the author use the phrase "nearly universal"?

(A) to illustrate that very few organisms can produce macromolecules

(B) to illustrate that very few organisms are able to create a wide variety of macromolecules

(C) to demonstrate that almost all organisms share common monomers

(D) to demonstrate that almost all organisms create their own unique monomers

3 Which section from the article BEST explains why polymers are so vital for organisms?

(A) Introduction [paragraphs 1-6]

(B) "Biomolecules"

(C) "Assembling And Disassembling Polymers"

(D) "Synthetic Polymers"

4 Read the following statement.

> *Some of the polymers, or macromolecules that are in existence are synthetic.*

Which sentence from the article provides the BEST support for the above statement?

(A) Most polymers are macromolecules and many biochemical molecules are macromolecules.

(B) Macromolecules exhibit very different properties from smaller molecules, including their subunits, when applicable.

(C) Natural polymers are used to build tissue and other components in living organisms.

(D) Carbon nanotubes are an example of a macromolecule that is not a biological material.