

Cellular Chemistry

Notes 7.1

Objectives

1. List the elements of life and explain how they are used.
2. List and state the properties the different macromolecules.
3. State the function(s) of the macromolecules.

A chemistry review

As we learned in our last unit, the microscope allowed people to observe cells that make up all organisms. However, even smaller were the parts that make up the cell. We are not talking about organelles; we're talking about the matter that the cell and its parts are made of! All matter in the universe—living and non-living—can be broken down into basic substances. Let's take a quick review of what these substances are.

1. **Atoms.** Atoms are the smallest part of matter that keep the properties of an element.
2. **Elements.** Elements are substances that contain only one type of atom.
3. **Molecules.** Two or more atoms held together by a bond.
4. **Compounds.** Two or more different elements bonded together.

It is difficult for students to understand the difference between an atom and an element and a molecule and a compound. Elements are anything that contain one type of atom (ex: gold, iron, oxygen, carbon, etc.) Atoms are the smallest part an element can be divided into while still being that element. Compounds and molecules also sound similar, but they are different. All compounds are molecules. However, not molecules are compounds. This is because all compounds must be made of two or more different elements. Molecules can be (but don't have to be) made of the same element.

All cells are made of the same elements.

Of the over 90 naturally occurring elements on our planet, only 25 are essential for life. Just six elements make up about 99% of the mass of the human body. These six elements are oxygen, carbon, hydrogen, nitrogen, calcium, and phosphorus. As we will see, these elements are commonly found in large molecules, called macromolecules, that are found in all cells.

Most activities in the cell involve atoms and molecules interacting. In this process, called a chemical reaction, bonds between atoms are broken and new bonds form to make different molecules. Energy is needed to break bonds between atoms, and energy is released when new bonds form. Cells use this chemical energy for life activities.

Large molecules support cell function.

It may sound unbelievable, but your entire body is made of molecules. Different molecules take on different forms and have different properties. In your body are large molecules,

called macromolecules. There are four types of macromolecules found in organisms: carbohydrates, lipids, proteins, and nucleic acids. Together, the macromolecules ensure the survival of the cell. As different as they are, they each have similar characteristics. For example, all four macromolecules are made of carbon. Each macromolecule is also made of smaller parts, called subunits, which we shall explore.

1. **Carbohydrates.** Carbohydrates provide the cell with energy. Simple carbohydrates are sugars. Sugars are made from carbon, oxygen, and hydrogen. Inside cells, sugar molecules are broken down. This process provides energy for the cell. Simple sugar molecules can also be linked together to form more complex carbohydrates such as starch, cellulose, and glycogen (used to store energy in animals).

Starch and cellulose are complex carbohydrates made by plant cells. When a plant cell makes more sugar than it can use, the extra sugar molecules are stored in long chains called starch. Plants also make cellulose, which is the material that makes up the cell wall.

2. **Lipids.** Lipids are the fats, oils, and waxes found in living things. Like carbohydrates, simple lipids are made of atoms of carbon, oxygen, and hydrogen. Lipids can be used by an organism for energy and for making cell structures, like the cell membrane. Even though lipids and carbohydrates can have similar chemical makeups, their atoms are arranged differently. This results in different properties.

One noticeable difference is that lipids feel very slippery. Another important property is that lipids do not mix with water. This is the result of the arrangement of their atoms. Many common lipids consist of a molecule called glycerol bonded to long chains of carbon and hydrogen called fatty acids.

3. **Proteins.** Proteins are macromolecules that are made of amino acids. Amino acids contain the elements carbon, oxygen, hydrogen, nitrogen, and sometimes sulfur. Because of their importance in building proteins, amino acids are called the building blocks of life. Without amino acids, life would not exist!

In proteins, amino acids are linked together into long chains that fold in three-dimensional shapes. The structure and function of a protein is determined by the number, order, and type of amino acids in it.

Some amino acids can be made by the body, but others must be taken from an outside food source. Your body gets the amino acids it needs from proteins in food, such as eggs and cheese. Your body breaks down these proteins into the amino acids and uses them to build the proteins it needs.

There are many types of proteins that each have an important job. For example, enzymes are proteins that control chemical reactions in the cells. Other proteins support the growth and repair of living matter. The action of proteins allows you to move. Some of the protein in your blood fights infection. Another protein, called

hemoglobin, carries oxygen to the cells in your body. Proteins are also an important part of cell membranes. These proteins transport materials into and out of the cell.

- 4. Nucleic Acid.** Nucleic acids are macromolecules that hold the information for the maintenance, growth, and reproduction of a cell. There are two types of nucleic acid: RNA and DNA. Both are made from carbon, oxygen, hydrogen, nitrogen, and phosphorus. The subunits of nucleic acid are called nucleotides. There are four nucleotides in DNA, which you will learn about at a later time.

DNA provides the information used by the cell for making proteins a cell needs. This information takes the form of a code contained in the specific order of different nucleotides in the DNA. The pattern of nucleotides in DNA is then coded into RNA, which is delivered to the cytoplasm. Here, ribosomes “read” the RNA and produce the proteins.

Macromolecule	Function	Subunit	Elements
Carbohydrates	Energy, building cell structures	sugar	C, H, O
Lipids	Energy, building cell structures	glycerol, fatty acids	C, H, O
Proteins	Growth, repair, movement, etc.	amino acid	C, H, O, N, (S)
Nucleic Acids	Store information	nucleotide	C, H, O, N, P

Most of the cell is made of water

About two thirds of every cell is water. As we learned in our last unit, water is a necessity for all organisms for many reasons. Recall, for example, that water is needed to carry out chemical reactions in the cell. Water is also important to the environment outside the cell. Water found inside the cells makes up about 46% of your body’s mass. Water found outside the cells makes up about 23% of your body’s mass.

Water has a very important property: it is able to dissolve substances. However, this is not true of all substances. Imagine if your cell membranes were made of a substance that could dissolve in water: you’d be a big puddle! However, our cell membranes are made of lipids. Lipids do not dissolve in water.

Lipids do not dissolve in water because of their structure. Yet, how do they form our cell membrane and keep our cells together? The lipids in the cell membrane are made of two special parts: a hydrophilic head and a hydrophobic tail. The head of the lipid is the glycerol and it loves water (that’s why it’s called hydrophilic). It will point itself towards water. Its tail is the fatty acid and it hates water (that’s why it’s called hydrophobic). It will point itself away from water.

As a result, our cell membrane is made of two layers of lipids. The tails point toward each other and the heads point outward. This creates the protective boundary that is our cell membrane.

Practice Questions

Answer the following questions for review.

1. What is the difference between an atom and an element?
2. What is the difference between a molecule and a compound?
3. How many elements are essential to life?
4. What are the six elements that make up most of the mass of the human body?
5. What is a macromolecule?
6. What are the four macromolecules found in organisms?
7. What is the function of carbohydrates?
8. What elements are carbohydrates made of?
9. What is the function of lipids?
10. What is the subunit of a lipid?
11. Which part of a lipid is hydrophobic? Which part is hydrophilic?
12. What is a protein?
13. What is the subunit of an amino acid?
14. What are two sources of amino acids for the body?
15. What are two examples of nucleic acid?
16. What is the function of nucleic acid?
17. Why is our cell membrane made of lipids?

Extension Questions

The following questions are optional. They may extend your understanding of the topics in these notes.

1. What are the 25 elements essential to life? What is the role of these elements (how do they support life)?
2. Proteins are created by ribosomes. To learn more about this, search for protein synthesis online. It's fascinating to see what your cells are constantly doing!
3. Do all cells have the same type of cell membrane? Are they all made of lipids?