Interactive Learning Objects

Biology
Biochemical Compounds
Lesson Plan

TVOntario
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Biochemical Compounds

Learning object description

The carbohydrates, lipids, and peptides are three very important biological molecules. Carbohydrates act as fuel for cellular metabolism and serve in storage and structural roles. Carbohydrates are found as polymers of the simplest carbohydrate subunit, the monosaccharide. There are three monosaccharides (glucose, fructose, and galactose), all with the molecular formula of $C_6H_{12}O_6$, making them isomers. The ratio of hydrogen to oxygen atoms in a monosaccharide is 2:1, as it is in water, leading to the name carbo (containing carbon) hydrate (of water). Monosaccharides can bond together in pairs to form disaccharides. Examples of disaccharides include sucrose (table sugar), lactose (found in milk), and maltose (or malt sugar used in brewing beer). Long polymers of carbohydrates can also form. These structures are called polysaccharides and are useful for storage and as structural components. Examples of polysaccharides include starch and glycogen.

The lipids, or fats, are found as triglycerides formed from the bonding of one glycerol molecule to three fatty acids. Fatty acids have long hydrocarbon chains, and because of this structure are insoluble in water and serve as excellent fuels. Fatty acids are found as either saturated or unsaturated, referring to the bonding found in the carbon backbone of the structure. When only single bonding is found, there are more hydrogen atoms bonded to each carbon and this structure is called saturated. When double bonds occur between carbon atoms in the chain, fewer hydrogen atoms will be found, and this structure is known as unsaturated. Saturated and unsaturated fatty acids have different physical properties, most notably their state at room temperature: saturated fatty acids tend to be solids while unsaturated fatty acids tend to be liquids.

The amino acids are the building blocks of pepetides. Long chains of amino acids bonded together are called polypeptides. These polypeptides are the components of proteins. While carbohydrates and lipids contain only carbon, hydrogen, and oxygen atoms, amino acids also contain a nitrogen atom.

In this learning object, students will examine models of glucose (a monosaccharide), maltose (a disaccharide composed of two glucose molecules), a typical saturated fatty acid, and a dipeptide. They will examine the bonding arrangements within these molecules to find relationships among them and between their structure and behaviour.

Learning objective

The students will be able to:

- Construct models of monosaccharides, disaccharides, fatty acids and dipeptides
- explain the relationship between a molecule's structure and its chemical behaviour
- Predict, using an atom's valence, the correct position of carbon, oxygen, nitrogen, and hydrogen atoms in biochemical molecules
- Identify functional groups within biochemical molecules

Correlation to the Ontario Curriculum

Grade 11 Biology – SBI3U Academic:

- Identify and describe the structure and function of important biochemical compounds, including carbohydrates,

proteins, lipids, and nucleic acids
- View and manipulate computer-generated, three-dimensional molecular models of important biochemical compounds, including carbohydrates, proteins, lipids, and nucleic acids

Grade 12 Biology – SBI4U Academic:
- Describe the structure and function of the macromolecules necessary for the normal metabolic functions of all living things, and the role of enzymes in maintaining normal metabolic functions
- Identify the functional groups within biological molecules (e.g., hydroxyl, carbonyl, carboxyl, amino, phosphate) and explain how they contribute to the function of each molecule (e.g., use molecular models to determine whether a molecule is polar or non-polar, and relate this property to diffusion through a plasma membrane)
- Investigate the structures of biological molecules and functional groups using computer-generated, three-dimensional images and/or by building molecular models (e.g., simple carbohydrates, amino acids, simple polypeptides)

Vocabulary

- fatty acid
- dipeptide
- glucose
- maltose
- monosaccharide
- disaccharide
- functional group

Pre-viewing

- Introduce students to biochemical molecules by having them first conduct some hands-on investigations using samples of different carbohydrates:

Carbohydrates:
- Have students construct a data table in which they will record their findings of the molecular formula (which they can look up in their textbooks), and descriptions of texture, taste, and solubility in water of each type of carbohydrate based on their own observations. Include in the samples glucose (a monosaccharide), maltose (a disaccharide), starch (a polysaccharide) and any other carbohydrates you may have on hand.
  SAFETY NOTE: It is very important that students learn never to taste materials in a science lab unless specifically advised to by their teacher. Students may be given the option to taste or not. Be certain that samples are fresh, and pure if you are going to encourage students to taste them.

Lipids:
- Have students construct a data table in which they will record their findings of the molecular formula (which they will find in their textbooks) of oleic acid and stearic acid (or any fatty acids you have on hand). Their data tables should also include their observations of each fatty acid's physical properties (colour, state and solubility in water and lighter fluid [mostly butane] or other hydrocarbon).
  SAFETY NOTE: hydrocarbons are flammable and must be stored and handled with caution; students must wear safety goggles while testing the solubility of the fatty acids in lighter fluid. Alternately, you may wish to perform this step as a demonstration.
- Tell the class that they will return to these observations after viewing the models and doing the interactive activities of the Structure of Biochemical Molecules learning object.

While viewing

Have the class work either individually or in pairs, depending on your and their preference and access to computers.

View models:

1) Glucose and maltose

Tell students to carefully observe the structures of glucose and maltose presented in the model. Have them compare the models to the molecular formulae they found from their textbooks. Ask them to work out the ratio of hydrogen atoms to oxygen atoms in the glucose model.

Have students compare the two molecules:

In what ways are they similar and different?

What is the relationship between maltose and glucose?

2) Fatty acid

Tell students to note the positions of each type of atom in a typical fatty acid. They should note that the oxygen atoms are both bonded to the terminal carbon atom of the chain in a functional group with one oxygen atom double bonded and the other single bonded as an –OH group (hydroxyl group). Tell them that this type of functional group is called a carboxyl group.

Ask them to observe the composition of the remaining part of the fatty acid. They should note that it is a hydrocarbon: in other words, it is composed of only carbon and hydrogen atoms.

3) Dipeptide

Have students note which atoms are present in a dipeptide.

Ask students to view the dipeptide model, and ask them to locate the carboxyl group. Tell them that a dipeptide is composed of two smaller subunits, called amino acids. Amino acids possess two characteristic functional groups: the carboxyl group and an amino group (--NH2). Have students look for the amino group in the dipeptide model.

Students will notice that there is a nitrogen atom in the middle of the didpeptide's structure. Tell them that this is the place where the two amino acids bonded together and ask them to work out how that process might have occurred, given that each amino acid had to initially have one carboxyl and one amino group. This challenge may lead to a discussion of condensation (dehydration synthesis) reactions, an appropriate extension for Grade 12 (SBI4U).

4) Quiz

Have students construct the models in the quiz portion of the learning object individually.

Make a list of valences of each type of atom on the board and remind the class that they can use these to help them, predict which atom needs to bonded in each position: Carbon = 4, Oxygen = 2, Hydrogen = 1, Nitrogen = 3.

Post viewing

Have students use their observations from the pre-viewing and while viewing activities to complete the following analysis questions:

1. Based on the structures of the examples given, and observation of the ratio between hydrogen and oxygen atoms in this type of molecule, why are carbohydrates given that name?
2. Glucose is a monosaccharide and maltose is a disaccharide. Define these terms and explain the relationship between the two examples.

3. Suggest an explanation for difference in solubility of fatty acids in water and butane.

Assessment

- Assess students' answers to the analysis questions for Knowledge and Understanding: understanding of concepts, principles, laws, and theories (e.g., identifying assumptions; eliminating misconceptions; providing explanations); knowledge of facts and terms.
- Assess their data tables for Inquiry: collecting, organizing, and presenting data.