Chapter 2: Biological molecules

AS Biology

General learning outcomes:

- **Describe** how large biological molecules are made from smaller molecules
- **Describe** the structure and function of carbohydrates, lipids and proteins

Biological molecules intro

- The study of biological molecules forms an important branch of biology known as **molecular biology**
  - Molecular biology is closely linked with **biochemistry**, which looks at the chemical reactions of biological molecules
  - The sum total of all the biochemical reactions in the body is known as **metabolism**
  - The structure of molecules are closely related to

Building blocks of life

- 4 most common elements in living organisms are, in order of abundance, hydrogen, carbon, oxygen and nitrogen
  - They account for more than 99% of the atoms found in all living things
  - Carbon atoms can join together to form long chains or ring structures
    - Can be thought of as the basic skeletons of *organic molecules* to which groups of other atoms are attached
      - *Organic molecules* <u>always</u> contain carbon and hydrogen

Figure 2.3, page 30

Monomers, polymers and macromolecules

- **Macromolecule** means giant molecule
  - 3 types of macromolecules in living organisms: polysaccharides, proteins (polypeptides) and nucleic acids (polynucleotides)
    - ‘poly’ means many; the above molecules are **polymers**, meaning that they are made of many repeating subunits that are similar or identical to each other

Monomers, polymers and macromolecules

- The subunits are referred to as **monomers**
  - They’re joined together like beads on a string
- Making polymers is relatively simple because the same reaction is repeated many times
- Natural examples of polymers are cellulose and rubber
- Industrially produced polymers include: polyester, polythene, PVC and nylon
  - These are all made up of carbon-based monomers and contain thousands of carbon atoms joined end to end

Carbohydrates

- All carbohydrates contain the elements carbon, hydrogen and oxygen.
- ‘hydrate’ refers to water
  - Hydrogen and oxygen atoms are present in the ratio of 2:1 in carbohydrates, as they are in water
- The **general formula** for a carbohydrate: $C_x(H_2O)_y$.
- Three main groups of carbohydrates: monosaccharides, disaccharides and polysaccharides
  - ‘saccharide” refers to a sugar or sweet substance

Monosaccharides

- Monosaccharides are **sugars**
  - Sugars dissolve easily in water to form sweet-tasting solutions
  - General formula: $(CH_2O)_n$
  - Consist of a **single** sugar molecule; ‘mono’ means one

Monosaccharides

- Main types of monosaccharides classified according to the number of carbon atoms in each molecule:
  - **Trioses** (3C)
  - **Pentoses** (5C)
    - Common examples: ribose and deoxyribose
  - **Hexoses** (6C)
    - Common examples: glucose, fructose and galactose
- Names of all sugars end with **-ose**

Monosaccharides

- Molecular and structural formula
  - Formula (aka **molecular formula**) for a hexose: $C_6H_{12}O_6$
  - **Structural formula** shows the arrangements of the atoms in a molecule

QUESTION

The formula for a hexose is $C_6H_{12}O_6$, or $(CH_2O)_6$. What would be the formula of:

a. a triose?

b. a pentose?

Figure 2.3, page 30

Ring structures

- Pentoses and hexoses have long enough chains of carbon atoms that they can close up on themselves and form more stable ring structures

Figure 2.4, page 30

Roles of monosaccharides in living organisms

- 2 Major functions:
  - Commonly used as a source of energy in respiration due to the larger number of carbon-hydrogen bonds
    - C-H bonds are broken to release energy which is transferred to help make ATP (adenosine triphosphate) from ADP (adenosine diphosphate) and phosphate
    - Most important in energy metabolism is glucose

Roles of monosaccharides in living organisms

- Important as building blocks for larger molecules
  - Example: glucose is used to make the polysaccharides starch, glycogen and cellulose
  - Example: ribose (5C) is one of the molecules used to make RNA (ribonucleic acid) and ATP
  - Example: Deoxyribose (5C) is one of the molecules used to make DNA

Disaccharides

- Disaccharides are sugars
- Three most common disaccharides
  - Maltose (glucose + glucose)
  - Sucrose (glucose + fructose)
    - Transport sugar in plants and commonly bought in stores
  - Lactose (glucose + galactose)
    - Sugar found in milk and important in young mammals diets

Forming disaccharides

- Formed when two monosaccharides are joined together
  - process name is **condensation**
  - *See Figure 2.5
    - For each condensation reaction, two hydroxyl (-OH) groups line up alongside each other
    - One combines with a hydrogen atom from the other to form a water molecule
    - An oxygen ‘bridge’ forms between the two molecules, holding them together and forming a disaccharide
      - ‘di’ means two
      - The ‘bridge’ is called a **glycosidic bond**

Disaccharides

- since monosaccharides have many -OH groups, there are a large number of possible disaccharides
- the shape of the enzyme controlling the reaction determines which -OH groups come alongside each other
  - Few of the possible disaccharides are common in nature

Breaking disaccharides

- The reverse of condensation is the *addition* of water, which is known as **hydrolysis**
  - Occurs during the digestion of disaccharides and polysaccharides when they are broken down to monosaccharides