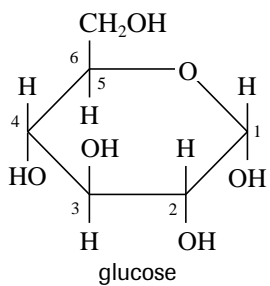


2.5 STARCH AND CELLULOSE—POLYMERS OF SUGARS

PRACTICE

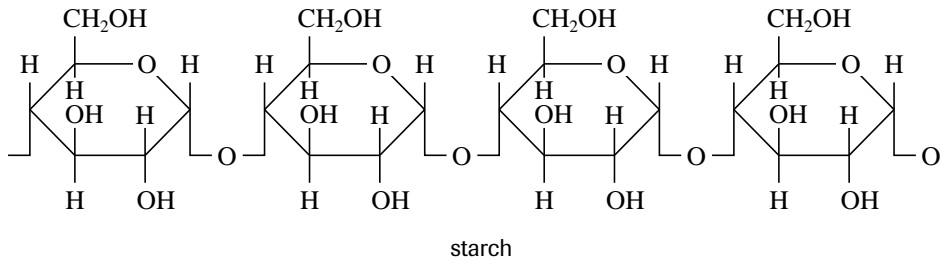
(Page 128)

Understanding Concepts

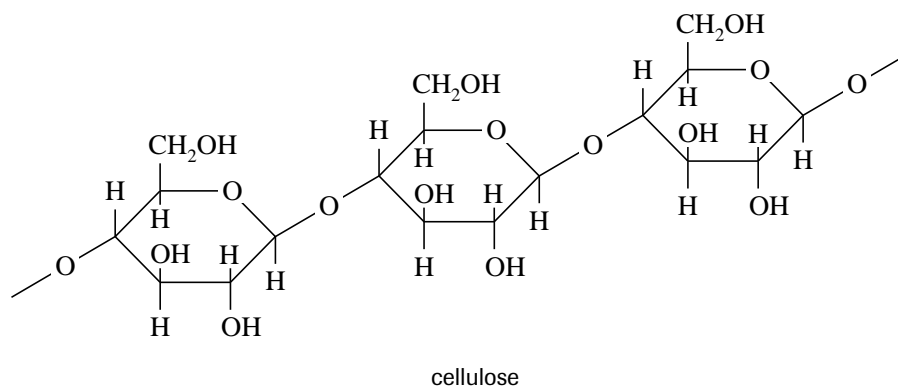
- Both contain carbonyl and hydroxyl groups. In glucose, the carbonyl group forms an aldehyde and in fructose, the carbonyl group forms a ketone.
- In animals, starch is used for energy and glycogen is used for energy storage. The orientation of the glucose–glucose linkages favours intrachain hydrogen bonds between hydroxyl groups and results in a helical structure. These chains are sufficiently small to make these polysaccharides soluble in water, and easily transported in the organism. Enzymes are present to break down starch and glycogen into glucose.
 - In plants, starch is used for energy storage and cellulose is used for cell structure and strength in plants. Starch: same answer as (a). The orientation of the glucose–glucose linkages favours interchain hydrogen bonds between hydroxyl groups, which results in a linear structure. These interchain links produce a strong and inflexible structure of layered sheets of cellulose, insoluble in water, ideal for its function.
- Sugars: monosaccharides or disaccharides, readily soluble in water. Starch: polymers of glucose, soluble in water, requires specific enzymes to be broken down into glucose.
 - Starch: helical polymer chains of glucose, soluble in water, flexible structure allows ready transport throughout organism. Cellulose: linear polymer chains with interchain hydrogen bonding, rigid and insoluble in water, requires specific enzymes to be broken down into glucose.
- 

glucose

 - When the ring structure of a glucose molecule is formed, the OH groups can be fixed either above the ring or below the ring.

- Molecules of sugars have many hydroxyl groups that are capable of hydrogen bonding with other molecules, resulting in high melting points. The intermolecular attractions in hydrocarbons are mainly the weaker van der Waals forces.
- 

starch



The orientation of the attached groups in a glucose ring are fixed, and when glucose molecules form a polymer chain, the monomers added in one orientation produce helical chains (starch), and the monomers added in another orientation produce linear chains (cellulose).

SECTION 2.5 QUESTIONS

(Page 128)

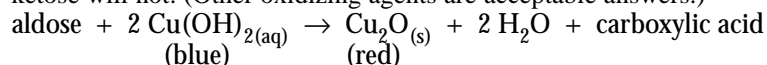
Understanding Concepts

- glucose
 - fructose
 - glucose
 - sucrose
- Polysaccharides are condensation polymers. The linkages between monosaccharides in a polysaccharide chain are formed by condensation reactions with the elimination of a water molecule.
- $\text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O} \rightarrow 2 \text{C}_6\text{H}_{12}\text{O}_6$
 - $\text{C}_{12}\text{H}_{22}\text{O}_{11} + 12 \text{O}_2 \rightarrow 12 \text{CO}_2 + 11 \text{H}_2\text{O}$
- Glucose has an aldehyde functional group and fructose has a ketone functional group. Since aldehydes can undergo controlled oxidation to acids, and ketones cannot, the glucose is the reducing sugar (because it reduces the oxidizing agent as it itself is oxidized).
- Propane: hydrocarbon with weak intermolecular attractions (van der Waals forces); low boiling point; gas at room temperature. Rubbing alcohol (2-propanol): an alcohol with some hydrogen bonding between molecules due to presence of a hydroxyl group; higher boiling point than propane; liquid at room temperature. Paint remover (acetone): a ketone with some polar attractions between molecules due to presence of carbonyl group; higher boiling point than propane; volatile liquid at room temperature. Table sugar (sucrose): many hydroxyl groups present, multiple hydrogen bonds between molecules; higher boiling and melting points than propane, 2-propanol, and acetone; solid at room temperature.
- Potatoes contain starch and our saliva contains an enzyme that is able to break down the starch into its monomers, glucose. The glucose tastes sweet to us.
 - We do not produce the enzyme required to break down cellulose into glucose, so no glucose is produced in the mouth and grass would not taste sweet to us.
 - Cows rely on other organisms such as bacteria in their digestive tracts to help digest the cellulose in grass. Cows do not themselves produce the required enzymes in their mouths, and thus the grass would not likely taste sweet when they first chew it.
- Starch and cellulose are both polymers of glucose and, when burned, both produce carbon dioxide and water, with the same amount of energy released. Humans can only break down starch and lack the enzyme to break down cellulose. Thus, cellulose remains unchanged in humans, with no release of energy. Starch can be broken down in humans, with the release of energy.
- Sugars are small molecules with many hydroxyl groups, making them readily soluble in the aqueous sap. Tree trunks are mainly cellulose, which are long linear polymer chains of glucose, packed tightly together by interchain hydrogen bonds, making them rigid and insoluble in water.

Applying Inquiry Skills

9. Experimental Design

Sugars that contain an aldehyde group can be oxidized by oxidizing agents; ketoses cannot. The sugars can be allowed to react with a weak oxidizing agent (e.g., $\text{Cu}(\text{OH})_2$) and the aldose will cause a change in the oxidizing agent; the ketose will not. (Other oxidizing agents are acceptable answers.)



Materials

An oxidizing agent (commonly Benedict's reagent, solution of $\text{Cu}(\text{OH})_2$), sugars to be tested, test tubes, pipets, hot-water bath.

Procedure

To separate labelled test tubes, add 5 mL Benedict's reagent and 10 drops 1% sugar solution. Place the test tubes in a boiling-water bath and heat for 5 min.

Observations

The aldose sugars such as glucose would produce a red solid with the Benedict's reagent, the ketose sugars such as fructose would not.

Making Connections

10. (Sample answer) Paper or Plastic Bags

Paper:

Advantages—made from renewable resources, e.g., wood fibres; biodegradable and is decomposed in a short time, releasing the atoms and molecules to be recycled; strong; can be reused in many applications, e.g., wrapping parcels, book covers. Disadvantages—can rip easily; becomes soggy when wet; not waterproof.

Plastic:

Advantages—strong and flexible; waterproof; can be reused in many applications, e.g., as garbage bags; less bulky than paper bags when folded for storage; low cost. Disadvantages—made using nonreusable resources; not readily decomposed; takes up landfill sites.

11. (a) The acetylated amino group contains a polar carbonyl group that is capable of forming strong hydrogen bonds with the hydroxyl groups in the polymer. Chitin molecules, being similar to cellulose, are linear and the inter-chain hydrogen bonds pack the polymer chains tightly together, giving the molecule strength and rigidity.
- (b) Strong and rigid, insoluble in water (large size) or nonpolar solvents (abundance of polar groups).
- (c) Highly suitable as protective covering because of its structural strength and its insolubility in water and nonpolar solvents.

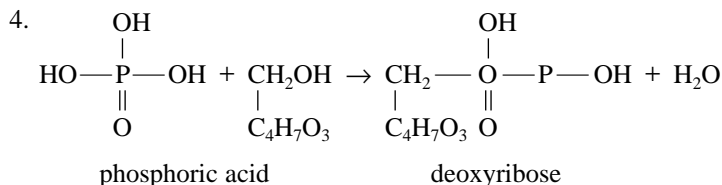
2.6 NUCLEIC ACIDS

PRACTICE

(Page 131)

Understanding Concepts

1. Deoxyribonucleic acid. It carries the genetic information codes for the sequence of amino acids in protein synthesis.
2. A phosphate group, a five-carbon sugar called ribose, and a nitrogenous base which contains an amino group.
3. (a) Covalent bonds: formed from condensation reactions between the hydroxyl groups of the phosphate on one nucleotide and the ribose of another nucleotide, forming a ribose-phosphate backbone.
- (b) Hydrogen bonds: formed between the NH groups and the C=O groups of the nitrogenous bases from adjacent strands.



5. Its structure allows it to be flexible and coiled into tertiary structures to be stored in the nucleus of the cell. The nucleotides are paired specifically (AT and CG), requiring that one strand in the double helix is an exact opposite copy of the other strand. When each strand is replicated, a new opposite strand identical to its original partner is produced. This mechanism allows the genetic information to be copied and distributed to other cells.
6. (a) Heat, change in pH, and high-energy radiation (e.g., gamma rays, beta rays, X rays, and UV light).
- (b) Any change in the DNA sequence causes a change in the sequence of amino acids synthesized in its designated protein. The change in amino sequence results in the synthesis of a different protein or no protein at all; the faulty or absent protein causes a faulty or absent cell function.

SECTION 2.6 QUESTIONS

(Page 132)

Understanding Concepts

1. (a) adenine, guanine, thymine, cytosine
- (b) Similarities: They all contain a phosphate group, a ribose, and a nitrogenous base. All four bases are ring structures of carbon and nitrogen, and contain NH groups. They differ in the nitrogenous bases, with A and G having two rings joined together and C and T having a single ring.
2. RNA is ribonucleic acid. It is similar to DNA and is also involved in protein synthesis. The ribose unit in RNA contains an extra OH group in place of one of the H atoms.