2. Biological Molecules

2.2 Carbohydrates and Lipids

Paper 2

Question Paper

1 In the mesophyll tissue of leaves, products of photosynthesis can be used to synthesise organic compounds, such as the polysaccharide cellulose and some amino acids.

A source of nitrogen for amino acid synthesis can be provided by nitrate ions that have been taken up in the roots and transported to the leaves.

(a) Describe the structure of a cellulose molecule.

.....

.....

.....

.....

.....

.....

.....

..... [3]

2 The olive plant, *Olea europaea*, is grown in many parts of the world. The fruits of the plant (olives) and the oil that can be obtained from the fruits (olive oil), provide food for humans.

Triglycerides are the main type of lipid in olive oil. They are synthesised in the olive plant from glycerol and fatty acids.

Scientists can analyse samples of different olive oils to identify:

- the fatty acids used to synthesise triglycerides
- the composition of the different triglycerides present.

(a) Table 1.1 shows some details of the five most common fatty acids found in samples of olive oil produced by olive plants grown in different regions in Portugal.

Table 1.1

Key
C : D = number of carbon atoms : number of double bonds in the hydrocarbon chain
X = missing detail

fatty acid	percentage of total fatty acid content	C : D	chemical structure
oleic acid	55.0–83.0	18 : 1	$CH_3(CH_2)_7CH{=}CH(CH_2)_7\mathbf{X}$
palmitic acid	7.5–20.0	16 :	$CH_3(CH_2)_{14}\mathbf{X}$
linoleic acid	3.5–21.0	18 :	$CH_3(CH_2)_4(CH{=}CH)CH_2(CH{=}CH)(CH_2)_7\mathbf{X}$
stearic acid	0.5–5.0	18 :	$CH_3(CH_2)_{16}\mathbf{X}$
palmitoleic acid	0.3–3.5	16 :	$CH_3(CH_2)_5CH{=}CH(CH_2)_7\mathbf{X}$

(i) Table 1.1 shows the **C : D** values for oleic acid.

In Table 1.1, write the values for **D** for each of the four other fatty acids listed. [1]

(ii) In the first column of Table 1.1, draw a circle around each of the fatty acids that can be described as saturated. [1]

(iii) State the detail of chemical structure, represented by **X**, which is missing from Table 1.1.

..... [1]

(iv) The analysis of the triglycerides present in the different samples of olive oil showed that:

- there are many different triglycerides present in olive oil
- each olive oil is different in its composition, but the same few triglycerides are present in all olive oils.

With reference to Table 1.1 and to the structure of triglycerides, suggest explanations for these observations.

.....

.....

.....

.....

.....

..... [2]

3 **(a)** Fig. 4.1 shows the structure of sucrose, a disaccharide produced by plant cells.

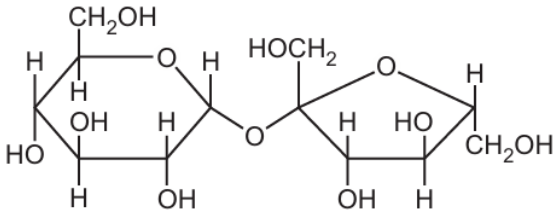


Fig. 4.1

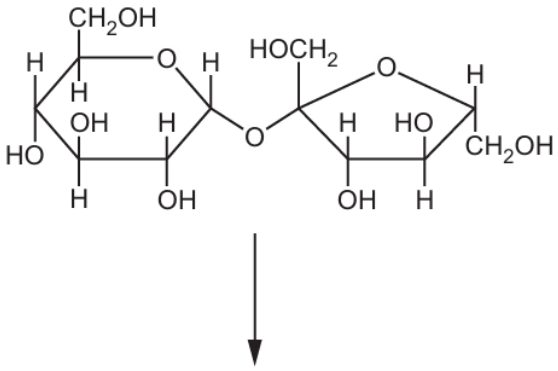
(i) Name the covalent bond that joins the two monomers in sucrose.

..... [1]

(ii) Sucrose is hydrolysed by the enzyme sucrase in the human digestive system.

The products of this hydrolysis reaction are the monosaccharides α-glucose and fructose.

Complete the diagram to show the hydrolysis of sucrose to form α-glucose and fructose.



[3]

4 Fig. 2.1 is a photomicrograph of a longitudinal section (LS) through a root tip. Two different regions are visible:

- the root apical meristem
- the root cap.

Cells in the root cap synthesise a gel-like, sticky secretion known as mucilage, which is important in reducing friction between soil and the growing root. It is composed mainly of polysaccharides and also contains some amino acids and enzymes.

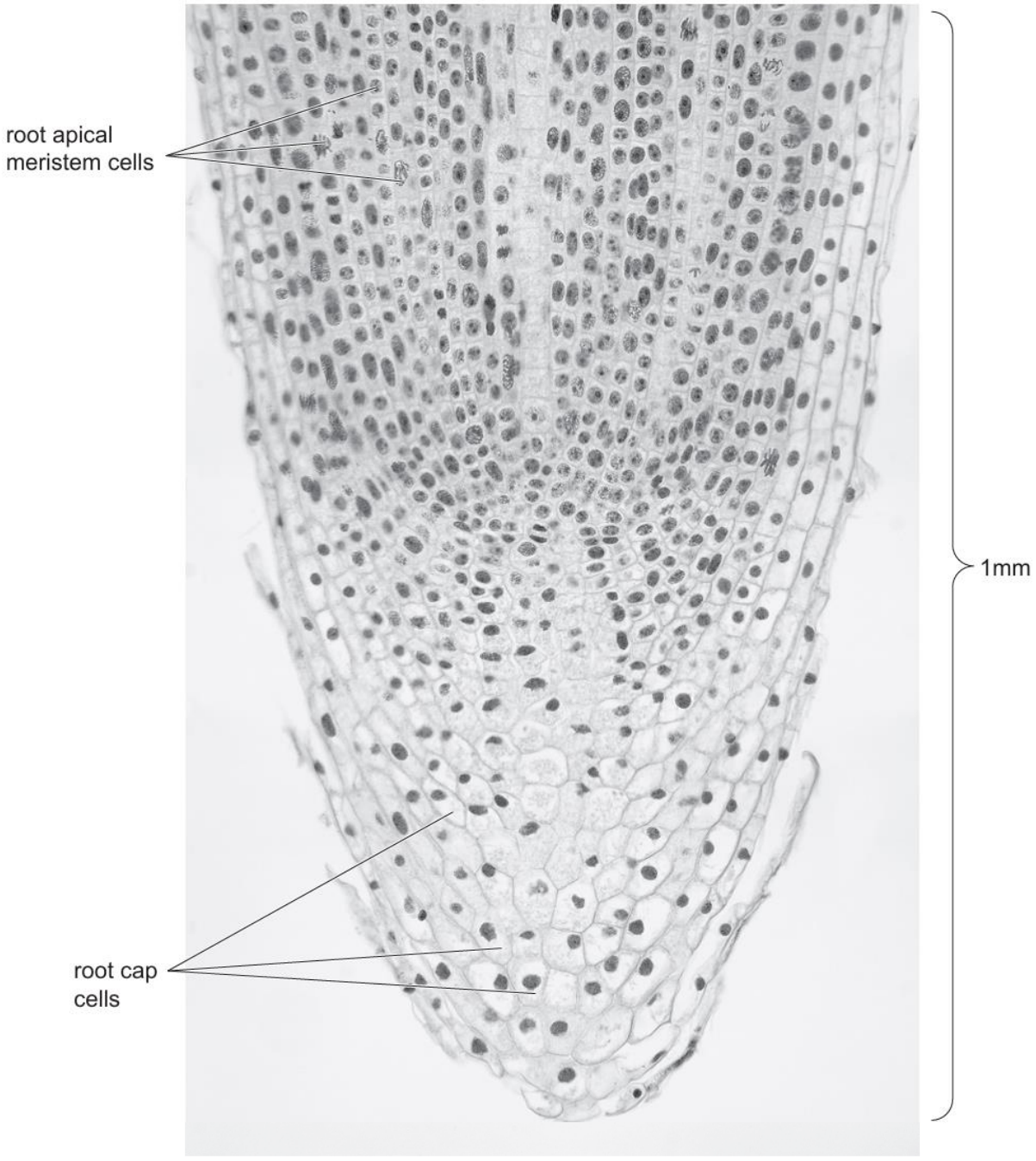


Fig. 2.1

(d) The polysaccharides and amino acids present in the mucilage are a source of nutrients for soil microorganisms that live in the area surrounding the root. Some of these microorganisms can break down soil compounds to release mineral ions.

(i) Explain what is meant by a polysaccharide.

.....

.....

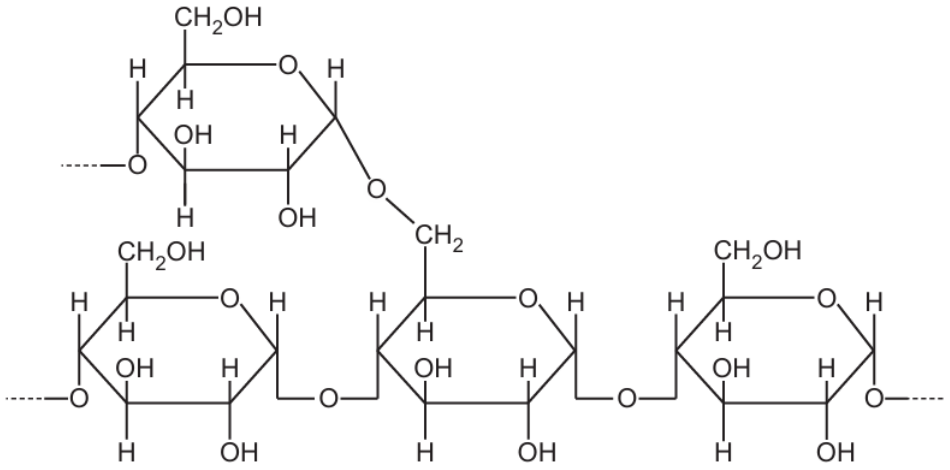
.....

.....

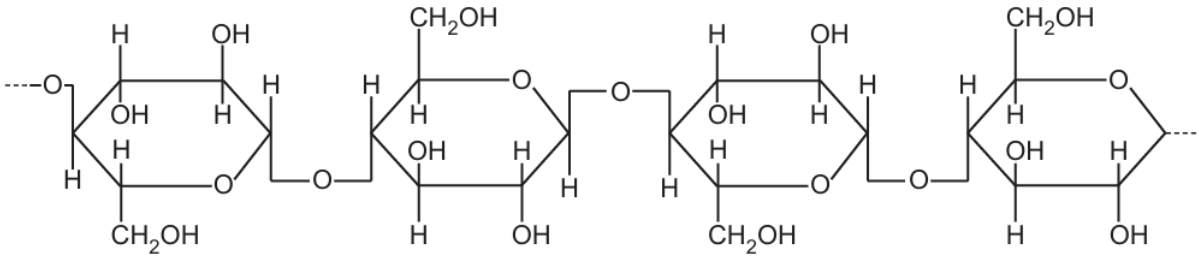
..... [2]

5 Glycogen and cellulose are polymers.

Fig. 2.1 shows small, representative regions of a glycogen molecule and a cellulose molecule.



glycogen



cellulose

Fig. 2.1

(a) Describe **three** ways, **visible in Fig. 2.1**, in which the molecule of glycogen differs from the molecule of cellulose.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(b) Glycogen is found in the form of granules in mammalian liver and muscle cells. Fig. 2.2 is a diagram of part of a molecule of glycogen isolated from a glycogen granule.

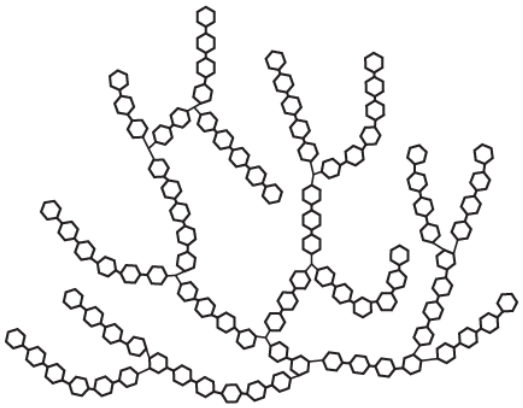


Fig. 2.2

Explain how the structure of glycogen is related to its function in cells.

.....

.....

.....

.....

.....

.....

..... [3]

(c) Explain how the arrangement of cellulose molecules in plant cell walls is related to their function.

.....

.....

.....

.....

.....

.....

..... [3]

6 Plants have specialised cells for the efficient transport of assimilates.

(b) The polysaccharide callose is found in the cell walls of cells close to plasmodesmata.

Fig. 3.1 is a simplified diagram showing the structure of callose. Not all hydrogen atoms are shown.

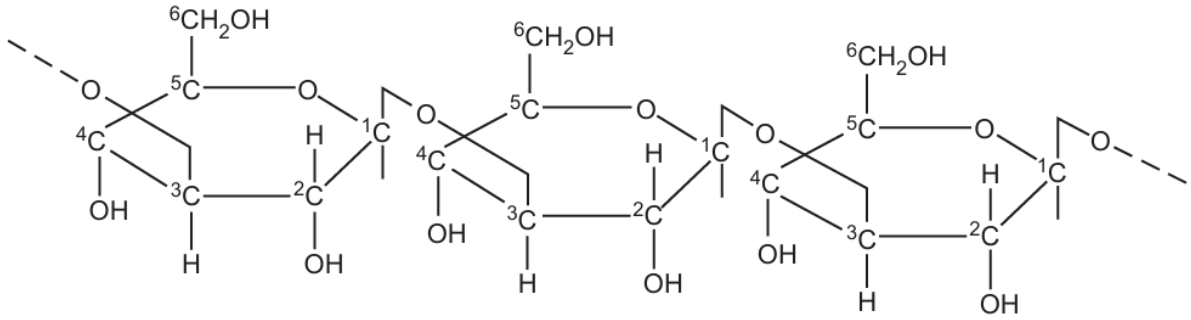


Fig. 3.1

Complete Table 3.2 to compare the structure of a callose molecule with a cellulose molecule.

Table 3.2

feature of polysaccharide	callose molecule	cellulose molecule
monosaccharide used to synthesise the polysaccharide	β-glucose	
bond connecting the monomers		1,4 glycosidic bond
shape of molecule	helix	
orientation of monosaccharides in the molecule		alternate glucose molecules are rotated by 180 °

[4]

7 Hummingbirds are the smallest of birds and are found in the Americas. Some species migrate hundreds of kilometres between warmer overwintering areas and summer breeding grounds. Like mammals, birds maintain a constant body temperature.

Hummingbirds have a high requirement for sugars because they have a very high metabolic rate. Fig. 3.1 shows a hummingbird feeding on nectar, one of their main food sources.



Fig. 3.1

(a) Nectar is a sugary liquid containing mainly sucrose, fructose and glucose.
Sucrose has the molecular formula $C_{12}H_{22}O_{11}$. Fructose and glucose each have the molecular formula $C_6H_{12}O_6$.

State **two** differences between sucrose and fructose, other than the number of carbon, hydrogen and oxygen atoms present.

.....

.....

.....

.....

..... [2]

(b) In preparation for migration, sugars need to be converted to triglycerides to function as energy reserves. Hummingbirds can double their body mass during this time.

(i) Fig. 3.2 shows the structural formula of one type of storage triglyceride. The triglyceride has two types of fatty acid residue, palmitate and oleate.

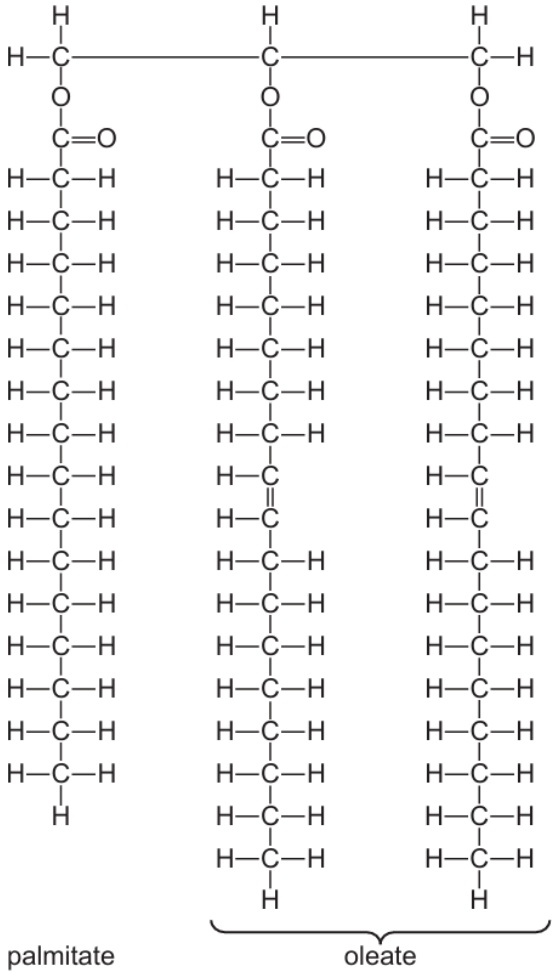


Fig. 3.2

Outline the features of the molecular structure of the triglyceride shown in Fig. 3.2.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) In hummingbirds, glycogen is the long-term carbohydrate energy store.

Suggest **one** reason why hummingbirds build up a greater energy store in the form of triglyceride, rather than a greater energy store of glycogen, in preparation for migration.

.....

.....

..... [1]

8 Adipocytes are cells found in adipose tissue in mammals. These cells absorb glycerol and fatty acids to make triglycerides for long-term storage.

Fig. 4.1a shows a glycerol molecule and three fatty acids. Fig. 4.1b shows the triglyceride molecule formed from these components.

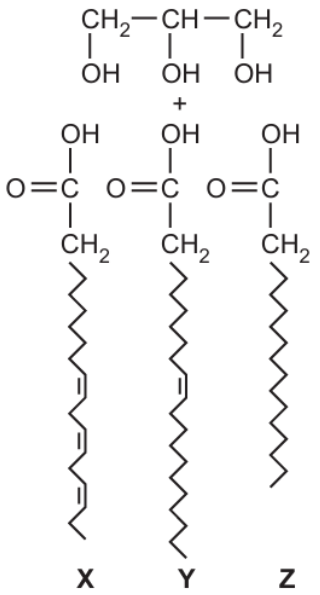


Fig. 4.1a

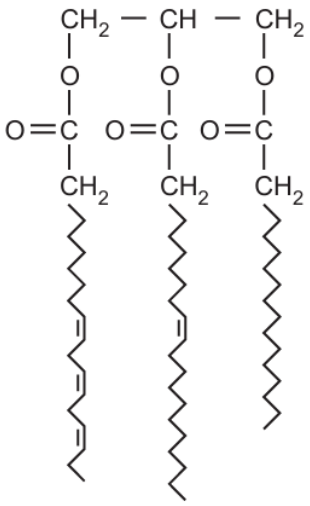


Fig. 4.1b

(a) (i) State the name of the bonds that form between glycerol and fatty acids.

..... [1]

(ii) When a bond forms between glycerol and a fatty acid, water is a product of the reaction.

State the name given to this type of reaction.

..... [1]

(iii) Describe the differences between the fatty acids, **X**, **Y** and **Z**, shown in Fig. 4.1a.

.....

.....

.....

.....

.....

.....

..... [3]

(b) (i) State reasons why triglycerides are described as hydrophobic.

.....

.....

.....

.....

..... [2]

9 **(b) (ii)** Starch granules contain amylose and amylopectin.

Describe the similarities **and** differences between the structure of amylose and the structure of amylopectin.

.....

.....

.....

.....

.....

.....

.....

..... [4]

10 In most plants, sucrose is the main sugar that is transported from sources to sinks.

(b) Fig. 5.1 shows part of one pathway that is used in plant cells to synthesise sucrose. The enzyme sucrose synthase catalyses the transfer of glucose from UDPG (uridine diphosphate glucose) to fructose.

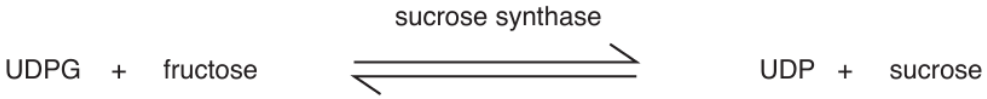


Fig. 5.1

The structure of UDPG is shown in Fig. 5.2.

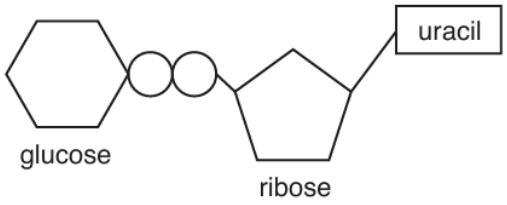


Fig. 5.2

(i) Name the type of bond formed when sucrose is synthesised.

..... [1]

(c) UDPG is used in some algae (photosynthetic protoctists) to synthesise a storage compound known as floridean starch.

The molecular structure of floridean starch has been described as an intermediate between amylopectin and glycogen, with little or no amylose.

Describe the molecular structure of floridean starch by completing the passage.

Floridean starch is a polysaccharide composed of ..... monomers.

The monomers are joined by ..... and ..... linkages,

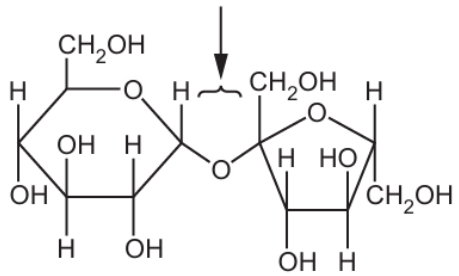
to give a branching structure that is less highly branched than

..... .

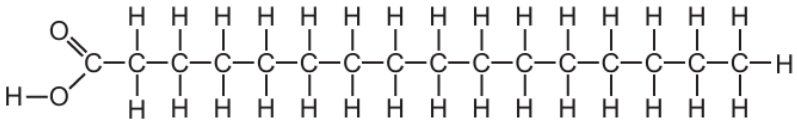
[4]

11 Fig. 1.1 shows five biological molecules.

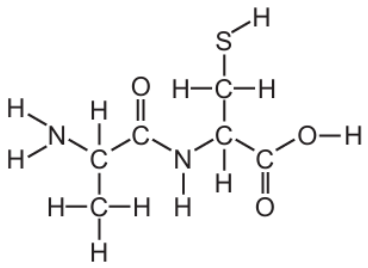
A



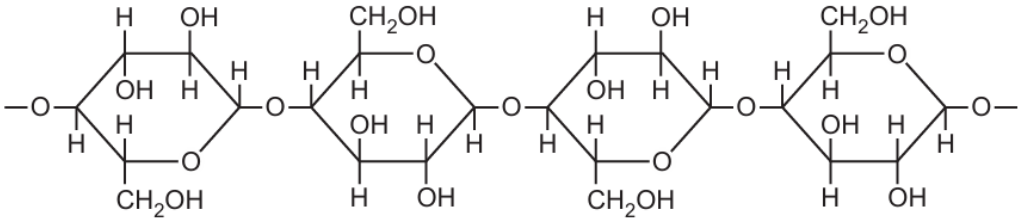
B



C



D



E

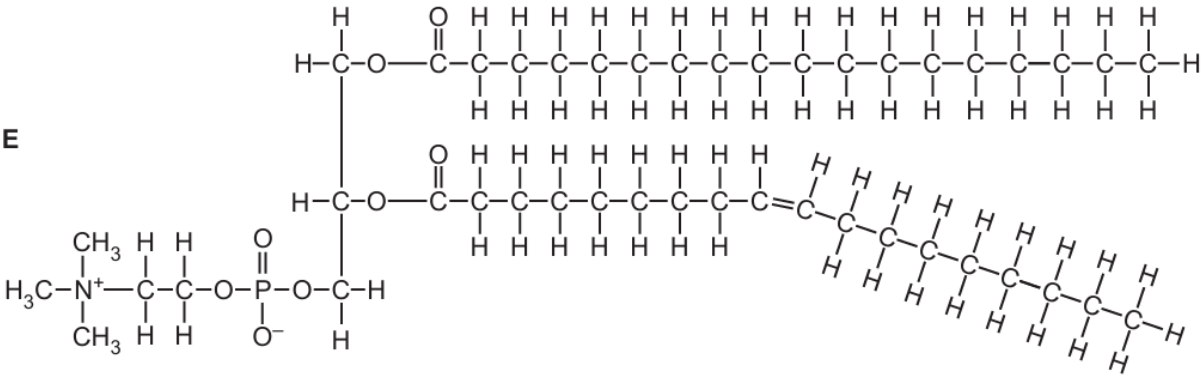


Fig. 1.1

(a) State the name of the bond in molecule **A** indicated by the arrow.

..... [1]

(b) Molecule **B** is described as a saturated fatty acid.

State why molecule **B** is described as a saturated fatty acid.

.....

..... [1]

(c) Molecule **D** is a polymer.

State the name of the monomer that is used to synthesise this polymer.

..... [1]

(e) State the letter of the molecule that forms part of the cell surface membranes of eukaryotic cells.

..... [1]

12 **(a)** Fig. 2.1 shows the molecular structure of a triglyceride molecule.

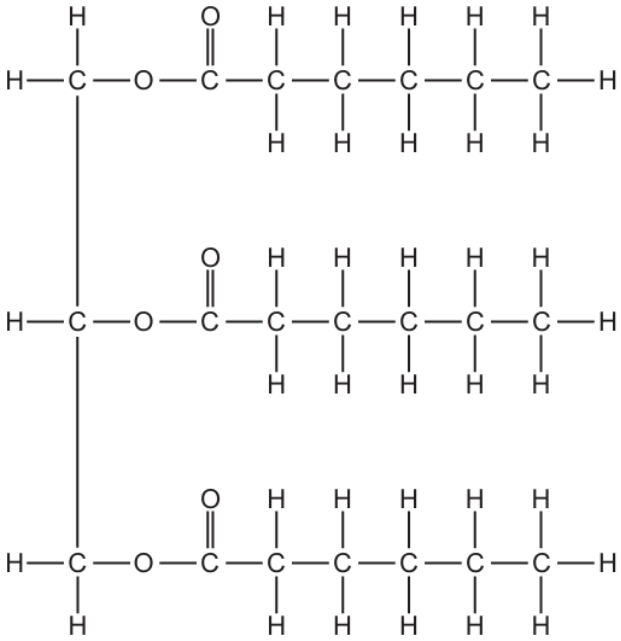


Fig. 2.1

(i) Draw a circle around an ester bond shown in Fig. 2.1. [1]

(ii) Name the type of reaction used to produce a triglyceride from its components.

State the number of water molecules produced during this reaction.

type of reaction .....

number of water molecules produced .....

[2]

13 Sucrose phosphorylase is an enzyme found in some species of bacteria. One function of this enzyme is for the production of compounds that help to protect the cell from harmful osmotic changes in the external environment.

Fig. 5.1 shows the reversible reaction that takes place within the bacterial cell.

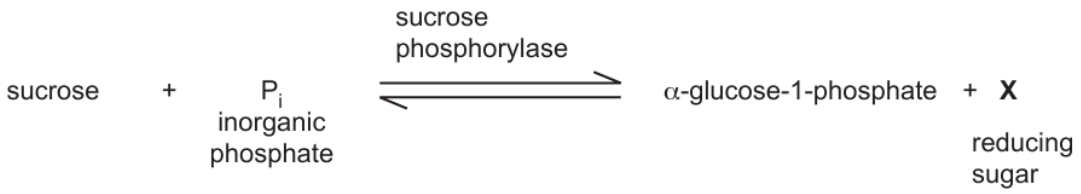


Fig. 5.1

(a) Name reducing sugar **X** in Fig. 5.1.

.....

[1]

14 Carbohydrates, proteins and nucleic acids are types of biological molecule. Within each type, there are examples of molecules that can be described as polymers.

(a) A polymer is a large molecule composed of smaller repeating molecules known as monomers.

Complete Table 4.1 to produce a summary of some named biological polymers.

Table 4.1

polymer	constituent monomer	type of bond between monomers
amylose	glucose	
cellulose	glucose	
collagen		peptide
DNA	DNA nucleotide	
glycogen		glycosidic

[4]

(b) Explain why an amylose molecule and a cellulose molecule have very different structures, even though they both have glucose as the constituent monomer.

.....

.....

.....

.....

.....

.....

..... [2]

15 Linoleic acid is an unsaturated fatty acid that is found in some triglycerides and some phospholipids.

Phospholipids are components of cell membranes.

Fig. 2.1 shows a molecule of linoleic acid.

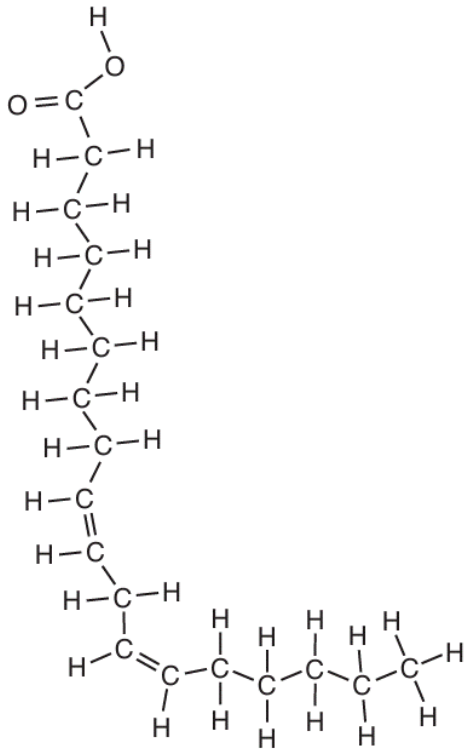


Fig. 2.1

(b) (i) State why triglycerides and phospholipids **cannot** be described as polymers.

.....

.....

..... [1]

(ii) State two **differences** in the **structure** of triglycerides and phospholipids.

1 .....

.....

2 .....

.....

[2]

16 Cells contain carbohydrates, proteins, lipids and nucleic acids.

(a) Fig. 5.1 is a list of biological molecules, some of which are components of larger molecules.

cellulose
thymine nucleotide
α-glucose
β-glucose
messenger RNA
glycogen
glycine
α-globin

Fig. 5.1

Complete Table 5.1 by using **only** the molecules listed in Fig. 5.1.

- Each example can be written under **one or more** correct headings.
- **All** the examples in Fig. 5.1 should appear at least **once** in Table 5.1.

Table 5.1

examples			
monomers	polymers	monosaccharides	polysaccharides

[5]

17 Bacteria may be classified according to differences in cell wall structure. The differences are shown by using the Gram stain.

- A Gram-positive bacterium has a cell wall mainly composed of a thick layer of peptidoglycan (murein).
- A Gram-negative bacterium has a more complex cell wall. This wall is composed of a much thinner layer of peptidoglycan and an outer layer known as the outer membrane.

Escherichia coli is a Gram-negative bacterium.

Fig. 3.1 is a diagram through the cell surface membrane **and** the cell wall of *E. coli*.

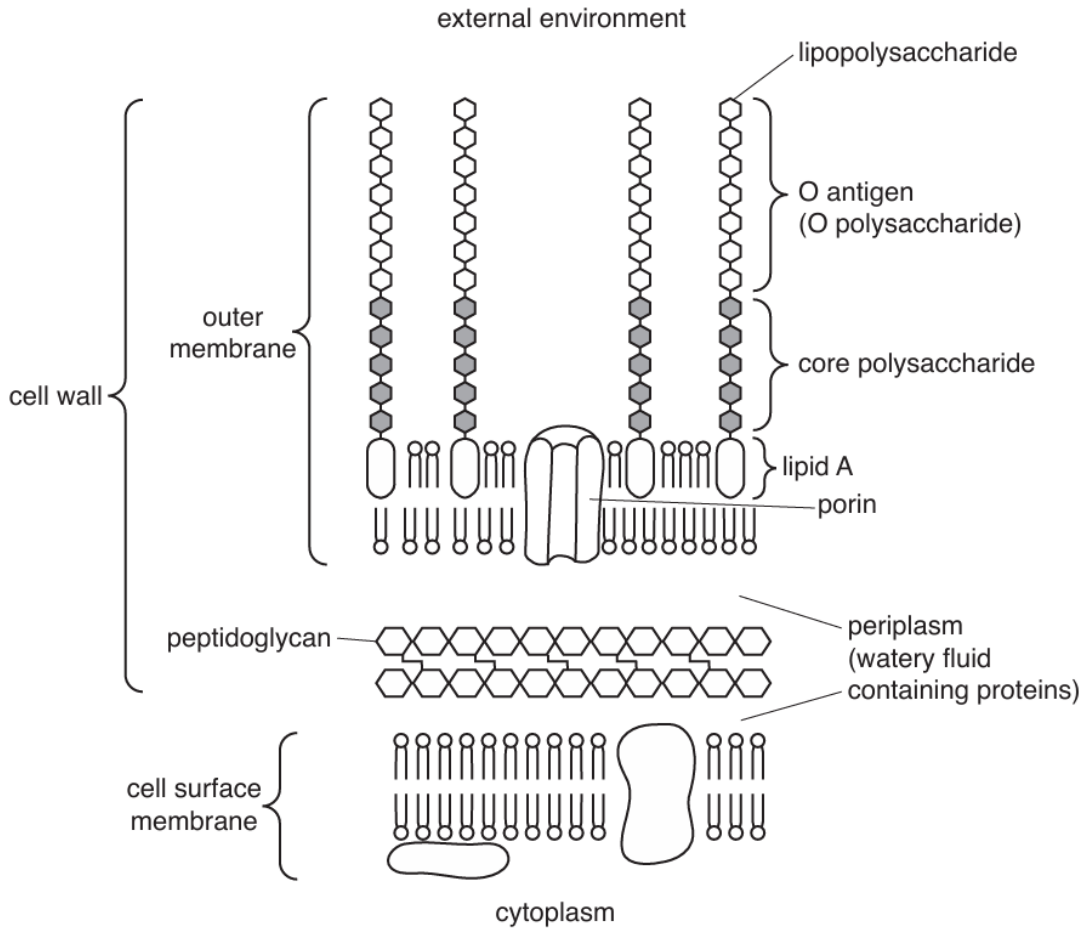


Fig. 3.1

(c) Fig. 3.1 shows that the outer membrane of the cell wall of *E. coli* contains lipopolysaccharides. These are not present in the cell surface membrane. Each lipopolysaccharide (LPS) consists of a lipid and a polysaccharide portion.

The O antigen is the outer part of the polysaccharide portion of the LPS. It faces the aqueous external environment.

(i) Define the term *polysaccharide*.

.....

.....

.....

.....

.....[2]

18 **(a)** Sucrose is a disaccharide.

Fig. 2.1 shows how sucrose is broken down in a reaction with hydrochloric acid.

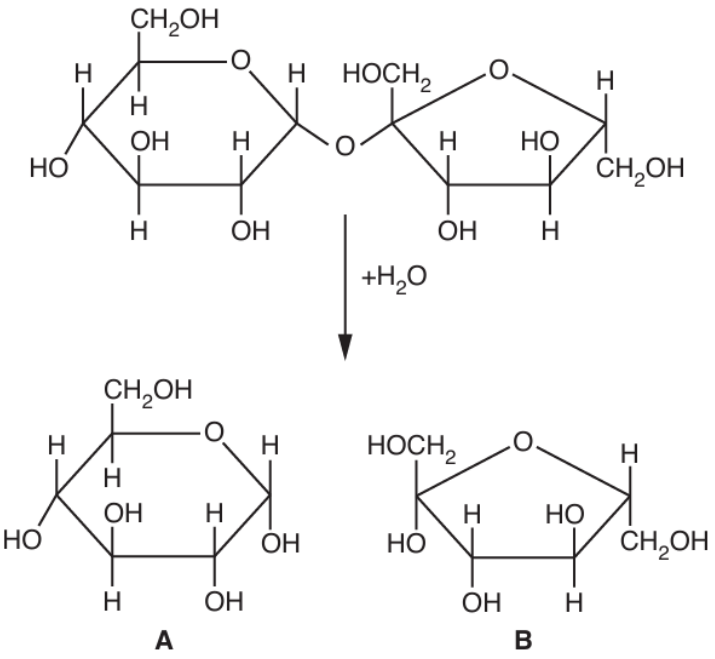


Fig. 2.1

(i) Name the products, **A** and **B**, of the reaction shown in Fig. 2.1.

A .....

B .....
[2]

(ii) Name the type of bond that is broken in the reaction shown in Fig. 2.1.

.....[1]

(iii) State the type of reaction shown in Fig. 2.1.

.....[1]

(b) When Benedict's solution is added to a sucrose solution and put into a boiling water-bath, no change in colour is observed.

State why no colour change is observed.

.....

.....

.....

.....

.....[2]

19 DNA and RNA are nucleic acids.

(a) Explain why RNA can be described as a polymer **and** as a macromolecule.

.....

.....

.....

.....

.....

.....

..... [2]

20 Fig. 2.1 shows the disaccharide lactose, which is found in milk.

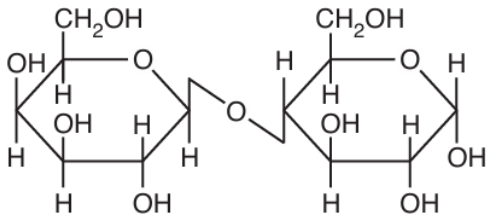


Fig. 2.1

(a) Name the type of bond that joins the two monosaccharides in lactose.

..... [1]

(b) The enzyme lactase catalyses the breakage of the bond between the two monosaccharides in lactose.

(i) Name the type of reaction that breaks this bond.

..... [1]

21 **(a)** Fig. 3.1 is a transmission electron micrograph showing two adjacent cells in a leaf.

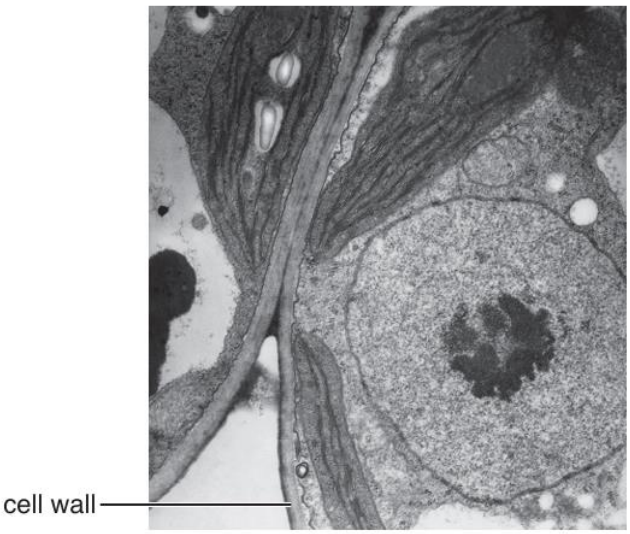


Fig. 3.1

(i) Cellulose is the main polysaccharide in cell walls of plants.

Describe the structure of cellulose.

.....

.....

.....

.....

.....

.....

.....

..... [3]