Cambridge AS level Biology

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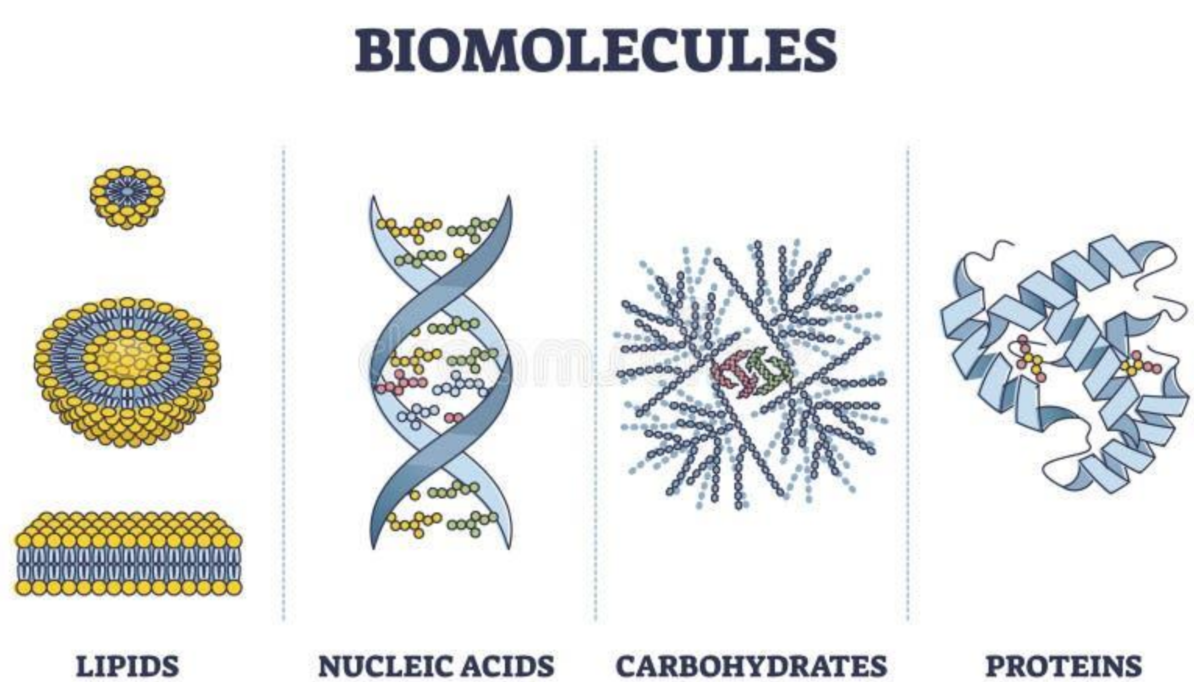
Chapter 02



The building blocks of life

Carbon is particularly important because carbon atoms can join to form long chains or ring structures. They can be thought of as the basic skeletons of organic molecules to which groups of other atoms are attached. **Organic molecules** always contain carbon and hydrogen.

It is believed that, before **life** evolved, there was a period of **chemical** evolution in which thousands of carbon-based molecules evolved from the simpler ones.

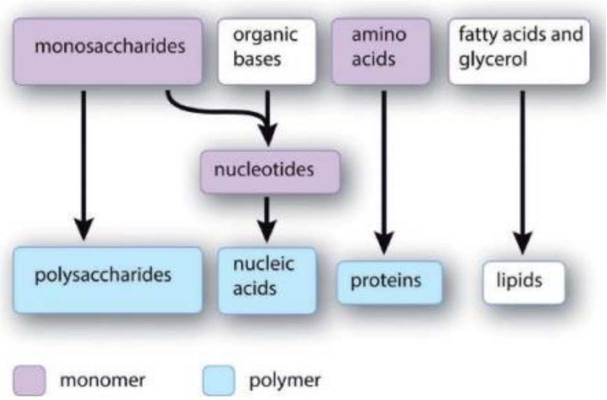


Figure 2.2 The building blocks of life.

Monomers, polymers and macromolecules

The term **macromolecule** means giant molecule. The prefix 'poly' means many, and these molecules are **polymers,** meaning that they are made up of many repeating subunits that are similar or identical to each other. These subunits are referred to as **monomers.**

The monomers from which polysaccharides, proteins and nucleic acids are made are monosaccharides, amino acids and nucleotides respectively, as shown in Figure 2.2 also shows two types of molecules which, although not polymers, are made up of simpler biochemicals. These are lipids and **nucleotides.**

A **macromolecule** is a large biological molecule such as a protein, polysaccharide or nucleic acid.

A **monomer** is a relatively simple molecule which is used as a basic building block for the synthesis of a polymer; many monomers are joined together to make the polymer, usually by condensation reactions; common examples of molecules used as monomers are monosaccharides, amino acids and nucleotides.

A **polymer** is a giant molecule made from many similar repeating subunits joined together in a chain; the subunits are much smaller and simpler molecules known as monomers; examples of biological polymers are polysaccharides, proteins and nucleic acids.

Carbohydrates

All carbohydrates contain the elements carbon, hydrogen and oxygen. The 'hydrate' part of the name comes from the fact that hydrogen and oxygen atoms are present in the ratio of 2: 1, as they are in water ('hydrate' refers to water). The **general formula** for a carbohydrate can therefore be written as $C_x(H_2O)_y$

Monosaccharides

Monosaccharides are **sugars**. Sugars dissolve easily in water to form sweet-tasting solutions. Monosaccharides have the general formula $(CH_2O)_n$ and consist of a **single** sugar molecule ('mono' means one).

The main types of monosaccharides, if they are classified according to the number of carbon atoms in each molecule, are **trioses** (3C), **pentoses** (5C) and **hexoses** (6C). The names of all sugars end with -**ose.**

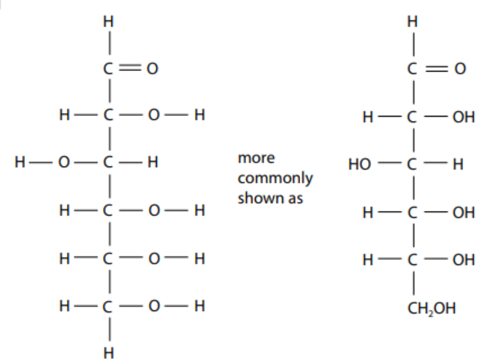


Figure 2.3 Structural formula of glucose. –OH is known as a hydroxyl group. There are five in glucose.

Molecular and structural formulae

The formula for a hexose can be written as $C_6H_{12}O_6$. This is known as the **molecular formula**. It is also useful to show the arrangements of the atoms, which can be done using a diagram known as the **structural formula.**

Ring structures

You will see from Figure 2.4 that the hydroxyl group, –OH, on carbon atom **1** may be **above** or **below** the plane of the ring. The form of glucose below the ring is known as **α-glucose** (alpha-glucose) and the form above the ring is **β-glucose** (beta-glucose). The same molecule can switch between the two forms. Two forms of the same chemical are known as **isomers,**

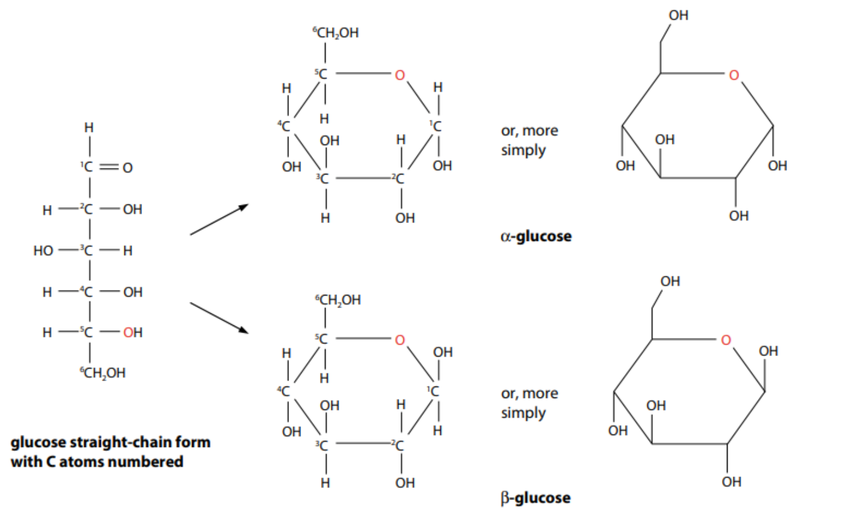


Figure 2.4 Structural formulae for the straight-chain and ring forms of glucose. Chemists often leave out the C and H atoms from the structural formula for simplicity.

Roles of monosaccharides in living organisms

Monosaccharides, particularly glucose, are crucial in energy metabolism due to their large carbon-hydrogen bonds, which release energy for ATP production from ADP and phosphate.

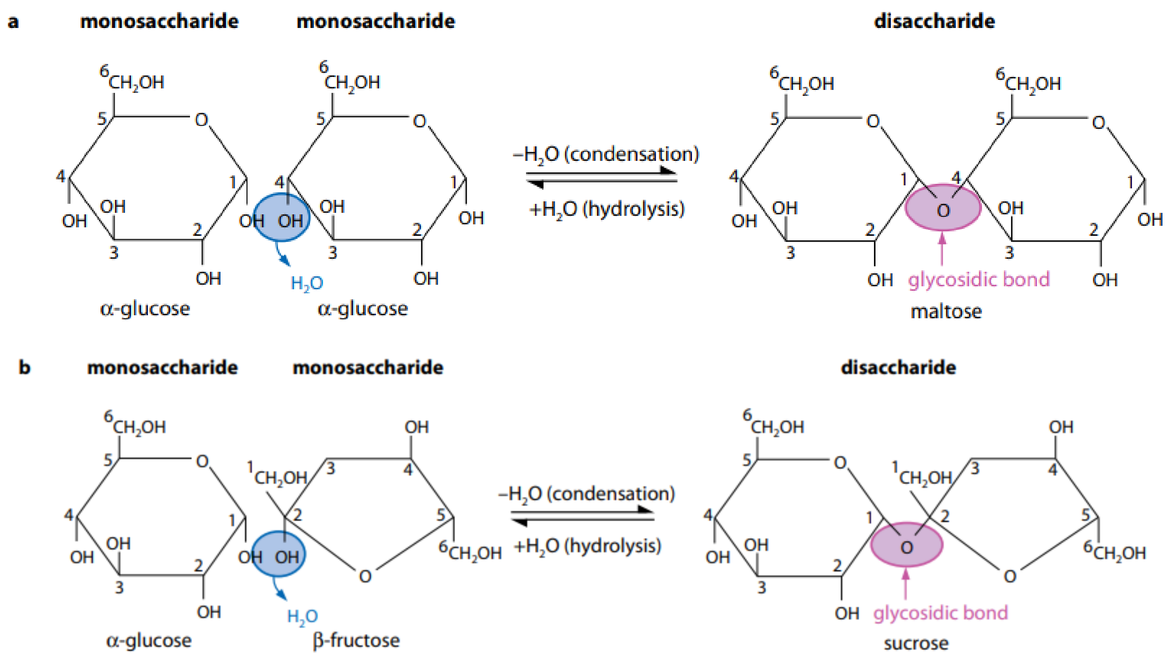


Figure 2.5 Formation of a disaccharide from two monosaccharides by condensation. **a** Maltose is formed from two α-glucose molecules. This can be repeated many times to form a polysaccharide. Note that in this example the glycosidic bond is formed between carbon atoms **1** and **4** of neighbouring glucose molecules. **b** Sucrose is made from an α-glucose and a β-fructose molecule.

A **monosaccharide** is a molecule consisting of a single sugar unit with the general formula $(CH_2O)_n$.

A **disaccharide** is a sugar molecule consisting of two monosaccharides joined together by a glycosidic bond.

A **polysaccharide** is a polymer whose subunits are monosaccharides joined together by glycosidic bonds.

For each condensation reaction, two hydroxyls (–OH) groups line up. One combines with a hydrogen atom from the other to form a water molecule. This allows an oxygen 'bridge' between the two molecules, holding them together and forming a **disaccharide** ('di' means two). The bridge is called a **glycosidic bond.**

The reverse of condensation is the **addition** of water, which is known as **hydrolysis** (Figure 2.5). This takes place during the digestion of disaccharides and polysaccharides when they are broken down into monosaccharides.

Polysaccharides

Glucose is crucial for cells' energy storage, as accumulation can cause cell concentration issues and interfere with normal chemistry. Condensation reactions convert glucose into storage polysaccharides like starch in plants and glycogen in animals, which can be quickly made available through enzyme-controlled reactions.

Starch and glycogen

Starch is a mixture of two substances – **amylose** and **amylopectin.** Amylose is made by condensations between α-glucose molecules, as shown in Figure 2.5a. Starch grains, formed from amylose and amylopectin molecules, are found in chloroplasts, and storage organs like potato tubers and cereal seeds. They can be easily seen with a light microscope.

Starch is never found in animal cells. Instead, a substance with molecules very like those of amylopectin is used as the storage carbohydrate. This is called **glycogen.**

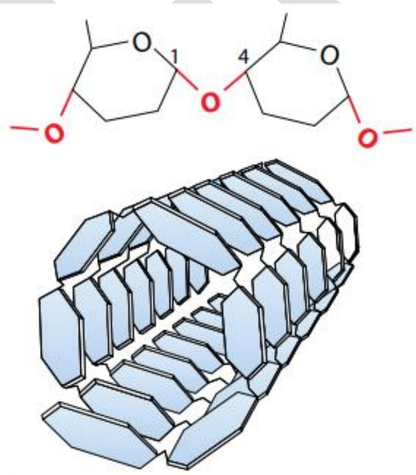


Figure 2.6 Arrangement of α-glucose units in amylose. The 1,4 linkages cause the chain to turn and coil. The glycosidic bonds are shown in red and the hydroxyl groups are omitted.

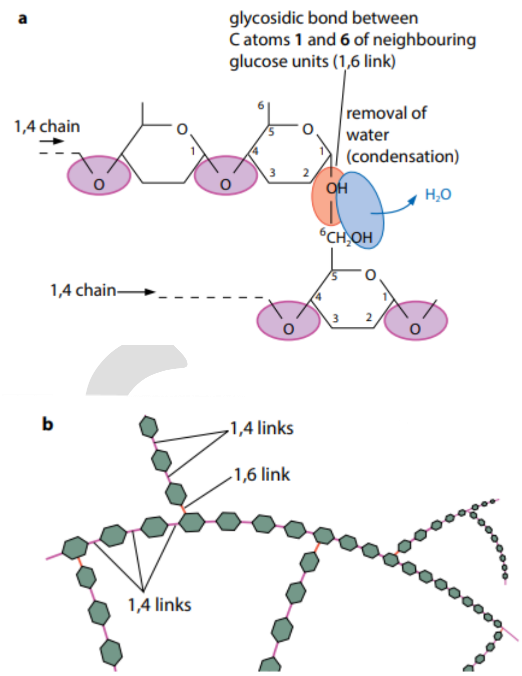


Figure 2.7 Branching structure of amylopectin and glycogen. **a** Formation of a 1,6 link, a branchpoint, **b** Overall structure of an amylopectin or glycogen molecule. Amylopectin and glycogen only differ in the amount of branching of their glucose chains.

BOX 2.2: Testing for the presence of starch

Background information

Starch molecules tend to curl up into long spirals. The hole that runs down the middle of this spiral is just the right size for iodine molecules to fit into. To test for starch, you use something called 'iodine solution'. (In fact, iodine won't dissolve in water, so the 'iodine solution' is actually iodine in potassium iodide solution.) The starch–iodine complex that forms has a strong blue-black colour.

Procedure

Iodine solution is orange-brown. Add a drop of iodine solution to the solid or liquid substance to be tested. A blue-black colour is quickly produced if starch is present.

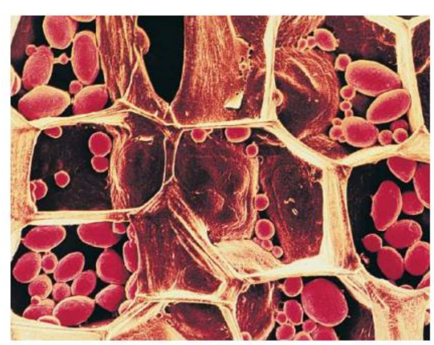


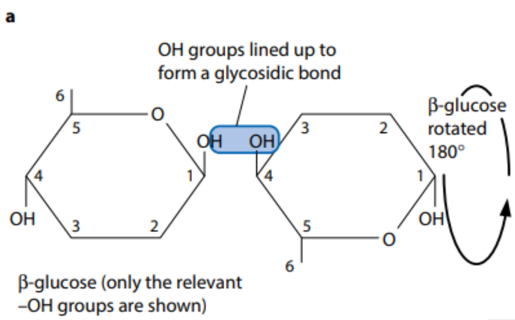
Figure 2.8 False-colour scanning electron micrograph of a slice through a raw potato showing cells containing starch grains or starch-containing organelles (coloured red) (×260).

Cellulose

Starch grains, formed from amylose and amylopectin molecules, are found in chloroplasts, and storage organs like potato tubers and cereal seeds. They can be easily seen with a light microscope.

Remember that in the β-isomer, the –OH group on carbon atom 1 projects **above** the ring (Figure 2.4). To form a glycosidic bond with carbon atom 4, where the –OH group is **below** the ring, one glucose molecule must be upside down (rotated 180°) relative to the other.

These **hydrogen bonds** are individually weak, but so many can form, due to the large number of –OH groups, that collectively they provide enormous strength. Between 60 and 70 cellulose molecules become tightly cross-linked to form bundles called microfibrils. **Microfibrils** are in turn held together in bundles called **fibres** by hydrogen bonding.



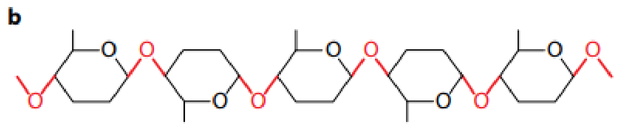
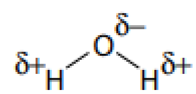


Figure 2.9 **a** Two β-glucose molecules lined up to form a 1,4 link. Note that one glucose molecule must be rotated 180° relative to the other, **b** Arrangement of β-glucose units in cellulose: glycosidic bonds are shown in red and hydroxyl groups are omitted.

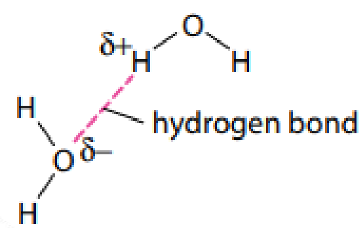
Dipoles and hydrogen bonds



When atoms in molecules are held together by covalent bonds, they share electrons. Each shared pair of electrons forms one **covalent bond.**

However, the electrons are not shared equally. In water, the oxygen atom gets slightly more than its fair share, and so has a small negative charge, written δ– (delta minus). The hydrogen atoms get slightly less than their fair share, and so have a small positive charge, written δ+ (delta plus).

This unequal distribution of charge is called **a dipole.**



In water, the negatively charged oxygen of one molecule is attracted to a positively charged hydrogen of another, and this attraction is called a **hydrogen bond.**

Dipoles occur in many different molecules, particularly wherever there is an –OH, –CO or –NH group. Hydrogen bonds can form **between these groups** because the negatively charged part of one group is attracted to the positively charged part of another.

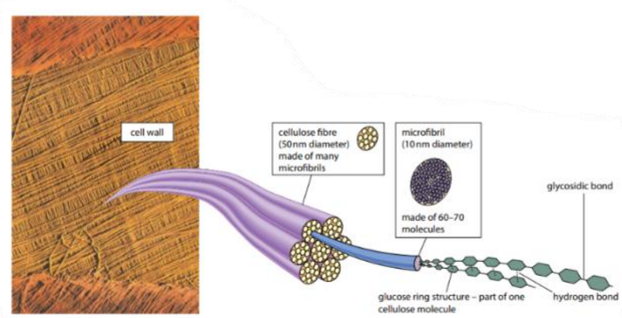


Figure 2.10 Structure of cellulose.

Molecules which have groups with dipoles, such as sugars, are said to be **polar.** They are attracted to water molecules because the water molecules also have dipoles. Such molecules are said to be **hydrophilic** (water-loving), and they tend to be soluble in water. Molecules which do not have dipoles are said to be **non-polar.** They are not attracted to water, and they are **hydrophobic** (water-hating). Such properties make possible the formation of cell membranes.

Lipids

Lipids are organic molecules insoluble in water, including fats and oils. They are solid at room temperature and liquid at room temperature, with true lipids being esters formed from fatty acids and alcohols.

Fatty acids

Fatty acids are a series of acids found in fats, containing a carboxyl group and long hydrocarbon tails attached to the acid head, consisting of a chain of carbon atoms and hydrogen.

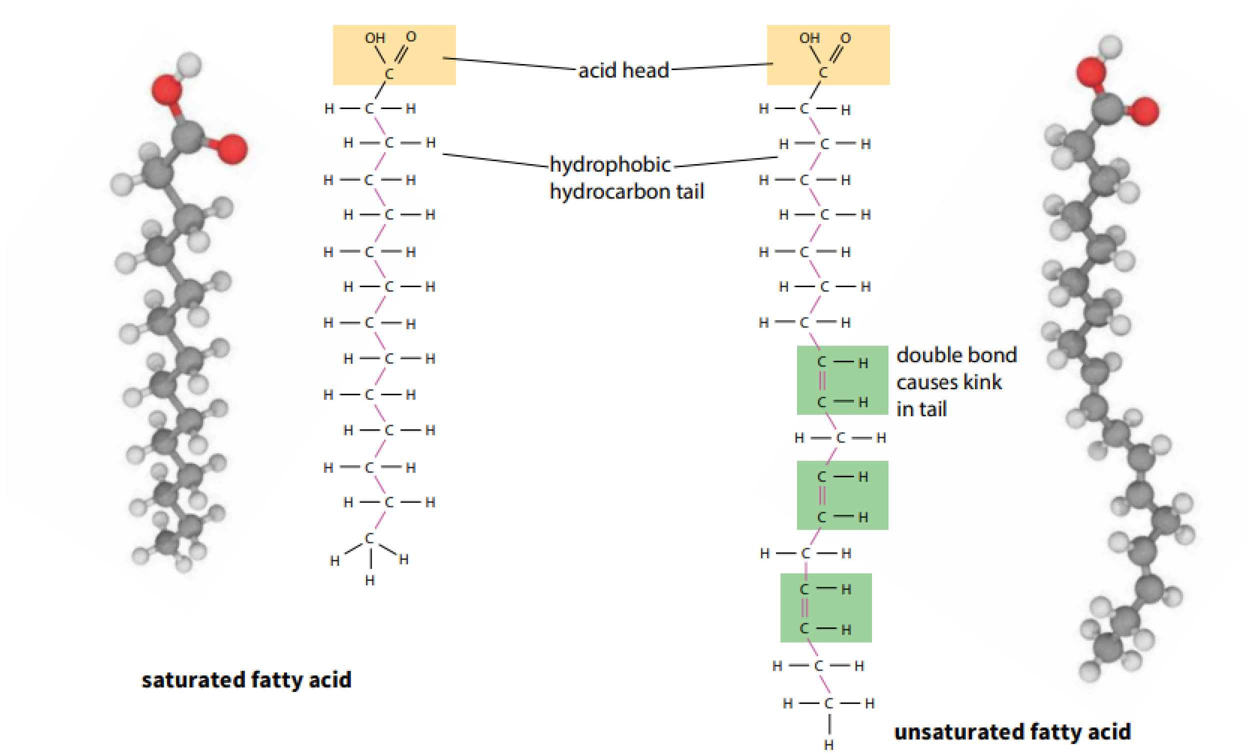


Figure 2.11 Structure of a saturated and an unsaturated fatty acid. Photographs of models are shown to the sides of the structures. In the models, hydrogen is white, carbon is grey and oxygen is red.

The tails of some fatty acids have double bonds between neighbouring carbon atoms, like this: –C C–. Such fatty acids are described as **unsaturated**

They form **unsaturated lipids**. Double bonds make fatty acids and lipids melt more easily, the fatty acid or lipid is described as **polyunsaturated**; if there is only one it is **monounsaturated.**

Alcohols and esters

The reaction between an acid and an alcohol produces a chemical known as an **ester**. The chemical link between the acid and the alcohol is known as an **ester bond** or an ester linkage.

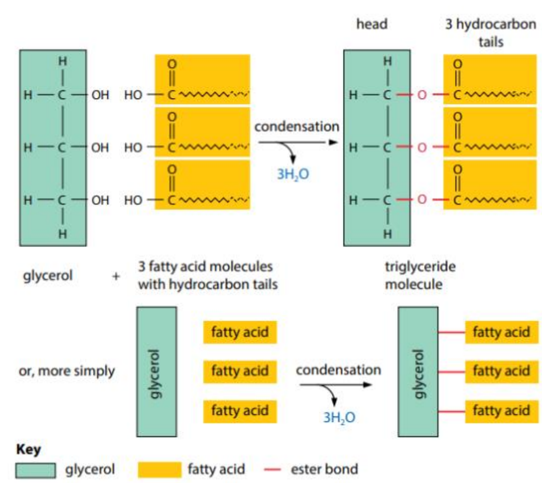


Figure 2.12 Formation of a triglyceride from glycerol and three fatty acid molecules.

Triglycerides

The most common lipids are **triglycerides** (Figure 2.13). These are fats and oils. A glyceride is an ester formed by a fatty acid combined with the alcohol glycerol. As we have seen, glycerol has three hydroxyl groups.

Triglycerides are hydrophobic, insoluble in water but soluble in organic solvents like ether, chloroform, and ethanol due to their non-polar hydrocarbon tails.

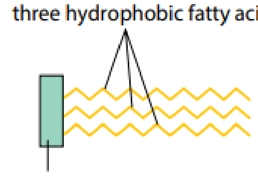


Figure 2.13 Diagrammatic representation of a triglyceride molecule.

Roles of triglycerides

Lipids make excellent **energy reserves** because they are even richer in carbon-hydrogen bonds than carbohydrates. Fat is stored in several places in the human body, particularly just below the dermis of the skin and around the kidneys. Below the skin, it also acts as an **insulator** against loss of heat.

An unusual role for lipids is as a **metabolic source of water.**

Figure 2.14 The desert kangaroo rat uses metabolism of food to provide most of the water it needs.

Phospholipids

Phospholipids are a special type of lipid. Each molecule has the unusual property of having one end which is soluble in water. This is because one of the three fatty acid molecules is replaced by a phosphate group, which is polar (page 35) and can therefore dissolve in water. The phosphate group is hydrophilic (water-loving) and makes the head of a phospholipid molecule **hydrophilic**, although the two remaining tails are still hydrophobic (Figure 2.15).

Figure 2.15 Diagrammatic representation of a phospholipid molecule. Compare with Figure 2.13.

Proteins

Proteins are an extremely important class of macromolecule in living organisms. More than 50% of the dry mass of most cells is protein. Proteins have many important functions.

Amino acids

Figure 2.16 shows the general structure of all amino acids and glycine, the simplest amino acid. They all have a central carbon atom which is bonded to an **amine** group, –NH2, and a **carboxylic acid** group, –COOH. It is these two groups which give amino acids their name

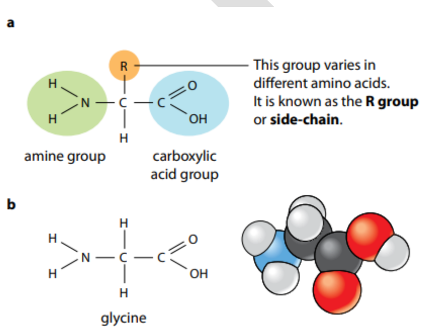


Figure 2.16 **a** The general structure of an amino acid. **b** Structure of the simplest amino acid, glycine, in which the R group is H, hydrogen. R groups for the 20 naturally occurring amino acids are shown in Appendix 1.

BOX 2.3: Testing for the presence of lipids

Background information

Lipids are insoluble in water, but soluble in ethanol (alcohol). This fact is made use of in the **emulsion test** for lipids.

Procedure

The substance that is thought to contain lipids is shaken vigorously with some absolute ethanol (ethanol with little or no water in it). This allows any lipids in the substance to dissolve in the ethanol. The ethanol is then poured into a tube containing water. If lipid is present, a cloudy white suspension is formed.

Further information

If there is no lipid present, the ethanol just mixes into the water. Light can pass straight through this mixture, so it looks completely transparent. But if there is lipid dissolved in the ethanol, it cannot remain dissolved when mixed with the water. The lipid molecules form tiny droplets throughout the liquid. This kind of mixture is called an **emulsion**. The droplets reflect and scatter light, making the liquid look white and cloudy.

peptide bond

Figure 2.17 shows how two amino acids can join. One loses a hydroxyl (–OH) group from its carboxylic acid group, while the other loses a hydrogen atom from its amine group. This leaves a carbon atom of the first amino acid-free to bond with the nitrogen atom of the second. The link is called a **peptide bond**

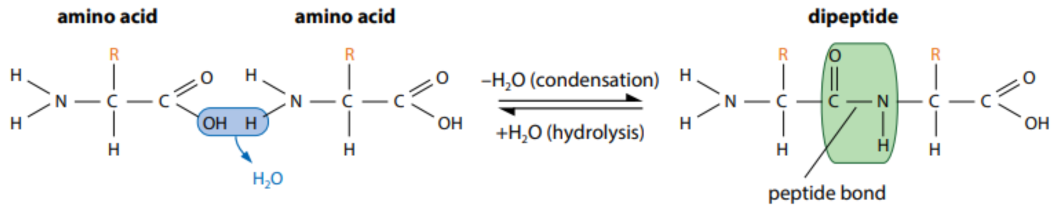


Figure 2.17 Amino acids link together by the loss of a molecule of water to form a peptide bond.

The new molecule which has been formed, made up of two linked amino acids, is called a **dipeptide.** A molecule made up of many amino acids linked together by peptide bonds is called a **polypeptide.**
A complete **protein** molecule may contain just one polypeptide chain, or it may have two or more chains which interact with each other. In living cells, **ribosomes** are the sites where amino acids are joined together to form polypeptides. The reaction is controlled by enzymes.

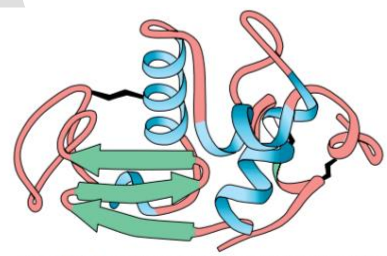


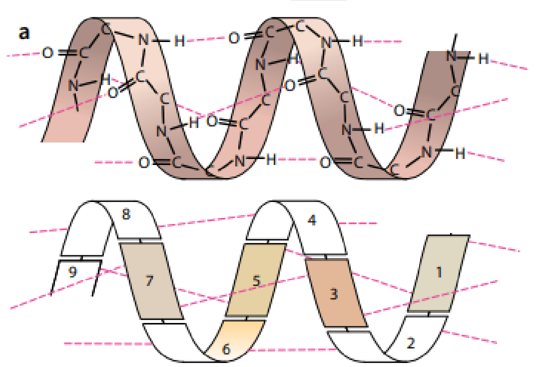
Figure 2.20 Secondary and tertiary structure of lysozyme. α-helices are shown as blue coils, β-sheets as green arrows, and random coils as red ribbons. The black zig-zags are disulfide bonds.

A polypeptide or protein molecule may contain several hundred amino acids linked into a long chain. The amino acids contained in the chain, and the sequence in which they are joined, is called the **primary structure** of the protein.

Secondary structure

The amino acids in a polypeptide chain influence each other even if they are not directly next to each other. A polypeptide chain, or part of it, often coils into a corkscrew shape called an **α-helix**. This **secondary structure** is due to hydrogen bonding between the oxygen of the –CO– group of one amino acid and the hydrogen of the –NH– group of the amino acid four places ahead of it.

β-pleated sheet, Hydrogen bonds, although strong enough to hold the α-helix and β-pleated sheet structures in shape, are easily broken by high temperatures and pH changes.



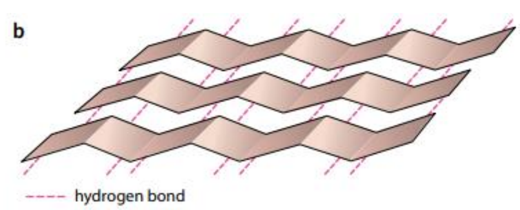


Figure 2.19 Protein secondary structure. **a** Structure of the α-helix. The R groups are not shown. **b** Another common arrangement is the β-pleated sheet. Both of these structures are held in shape by hydrogen bonds between the amino acids.

Tertiary structure

Proteins often have a coiled secondary structure, as shown in Figure 2.20. Lysozyme molecules fold into coils, while myoglobin's α-helices are cylinders. Despite appearing disorganized, these molecules are precise, and held in place by amino acid bonds. How a protein coils up to form a precise three-dimensional shape is known as its **tertiary structure.**

Hydrogen bonds can form between a wide variety of R groups. **Disulfide bonds** form between two cysteine molecules, which contain sulfur atoms

the four disulfide bonds in ribonuclease in Figure 2.18?) **Ionic bonds** form between R groups containing amine and carboxyl groups. (Which amino acids have these?) **Hydrophobic interactions** occur between R groups which are non-polar, or **hydrophobic.**

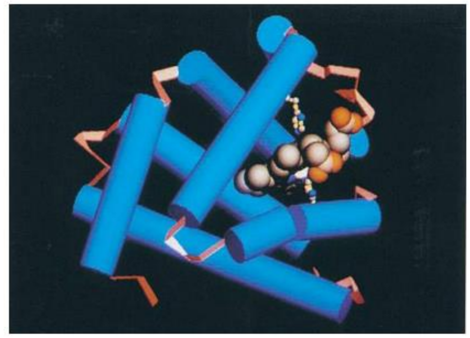
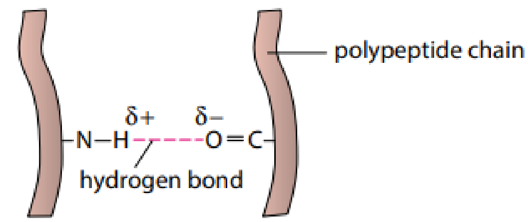
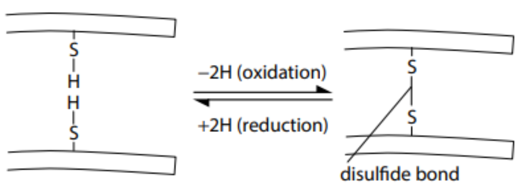


Figure 2.21 A computer graphic showing the secondary and tertiary structures of a myoglobin molecule. Myoglobin is the substance which makes meat look red. It is found in muscle, where it acts as an oxygen-storing molecule. The blue sections are α-helices and are linked by sections of polypeptide chain which are more stretched out – these are shown in red. At the top right is an iron-containing haem group (page 43).

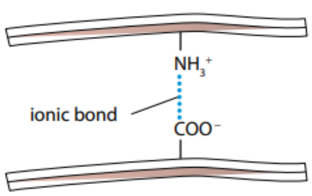
a Hydrogen bonds form between strongly polar groups for example, –NH–, –CO– and –OH groups.



b Disulfide bonds form between cysteine molecules. They are strong covalent bonds. They can be broken by reducing agents.



c Ionic bonds form between ionised amine (NH_3^+) groups and ionised carboxylic acid (COO^-) groups. They can be broken by pH changes.



Primary structure is the sequence of amino acids in a polypeptide or protein.

Secondary structure is the structure of a protein molecule resulting from the regular coiling or folding of the chain of amino acids, e.g. an α-helix or β-pleated sheet.

Tertiary structure is the compact structure of a protein molecule resulting from the three-dimensional coiling of the already-folded chain of amino acids.

d Weak hydrophobic interactions occur between non-polar R groups. Although the interactions are weak, the groups tend to stay together because they are repelled by the watery environment around them.

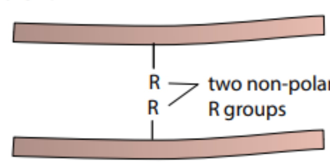
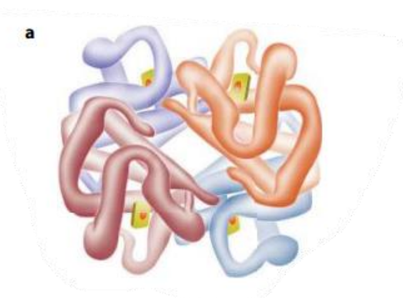
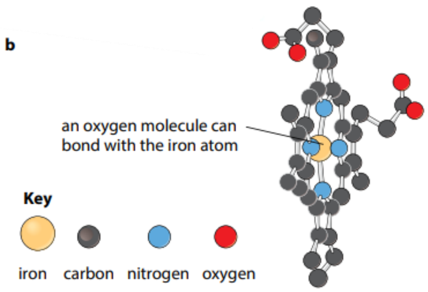


Figure 2.22 The four types of bond which are important in protein tertiary structure: **a** hydrogen bonds, which are also important in secondary structure, **b** disulfide bonds, **c** ionic bonds and **d** hydrophobic interactions.

Quaternary structure

Many protein molecules are made up of two or more polypeptide chains. Hemoglobin is an example of this, having four polypeptide chains in each molecule (Figure 2.23). The association of different polypeptide chains is called the **quaternary structure** of the protein.





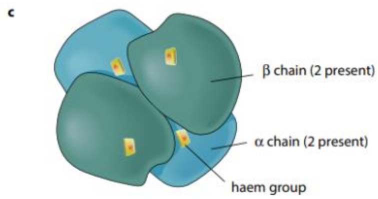


Figure 2.23 Haemoglobin. **a** Each haemoglobin molecule contains four polypeptide chains. The two α chains are shown in purple and blue, and the two β chains in brown and orange. Each polypeptide chain contains a haem group, shown in yellow and red. **b** The haem group contains an iron atom, which can bond reversibly with an oxygen molecule. **c** The complete haemoglobin molecule is nearly spherical.

Quaternary structure is the three-dimensional arrangement of two or more polypeptides, or of a polypeptide and a non-protein component such as haem, in a protein molecule.

Globular and fibrous proteins

A protein whose molecules curl up into a 'ball' shape, such as myoglobin or haemoglobin, is known as a **globular protein.**
Proteins are found in living organisms and aqueous environments like blood, tissue fluid, and plant phloem. Globular proteins curl up, with non-polar, hydrophobic R groups pointing into the centre, making them soluble due to water molecules clustering around them.

Many other protein molecules do not curl up into a ball but form long strands. These are known as **fibrous proteins.** Fibrous proteins are not usually soluble in water and most have structural roles.

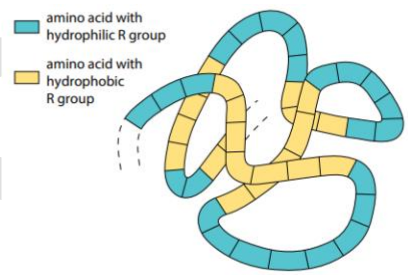


Figure 2.24 A section through part of a globular protein molecule. The polypeptide chain coils up with hydrophilic R groups outside and hydrophobic ones inside, which makes the molecule soluble.

Hemoglobin – a globular protein

Hemoglobin is an oxygen-carrying pigment found in red blood cells and is a globular protein. We have seen that it is made up of four polypeptide chains, so it has a quaternary structure. Each chain is itself a protein known as globin.

In the genetic condition known as **sickle cell anemia**, one amino acid which occurs in the **surface** of the β chain is replaced with a different amino acid.

Each polypeptide chain of haemoglobin contains a **haem group**, shown in Figure 2.23b. A group like this, which is an important, permanent, part of a protein molecule but is not made of amino acids, is called a **prosthetic group**

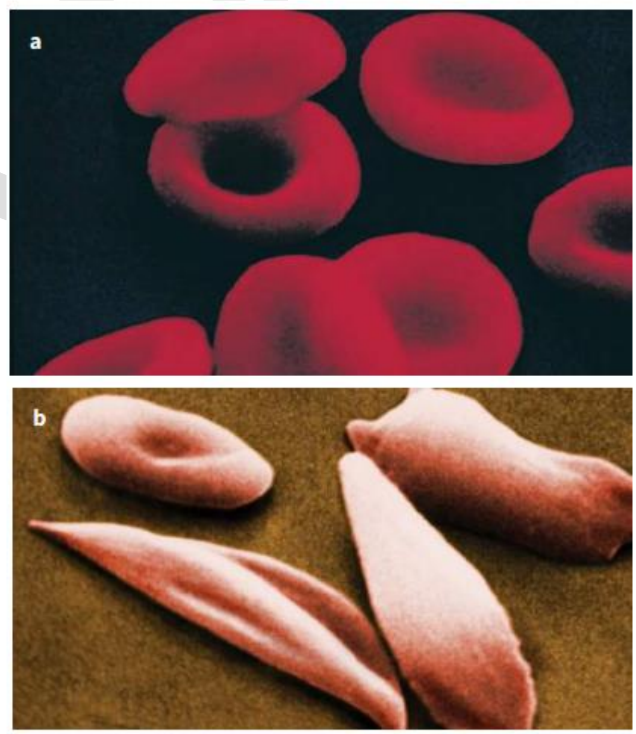


Figure 2.25 **a** Scanning electron micrograph of human red blood cells (× 3300). Each cell contains about 250 million haemoglobin molecules. **b** Scanning electron micrograph of red blood cells from a person with sickle cell anaemia. You can see a normal cell and three or four sickled cells (×3300).

BOX 2.4: Testing for the presence of proteins

Background information
All proteins have peptide bonds, containing nitrogen atoms. These form a purple complex with copper(II) ions and this forms the basis of the biuret test.

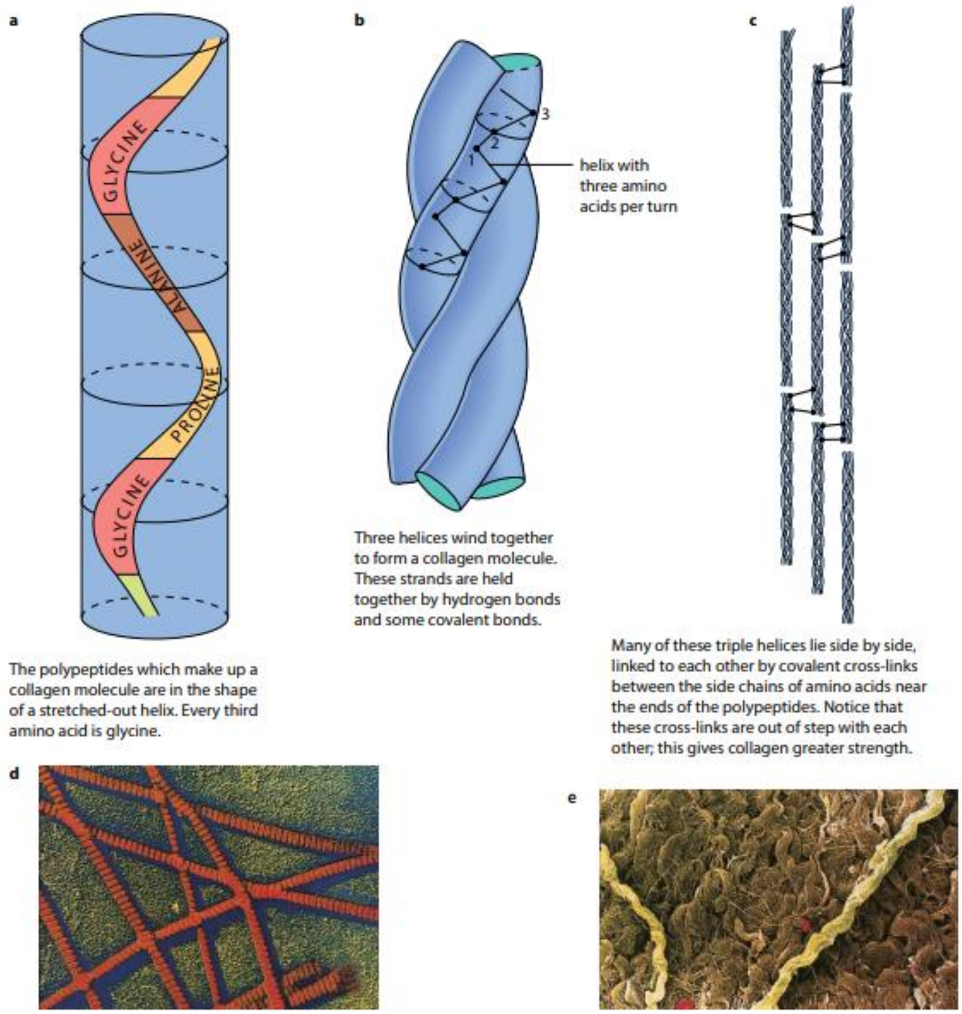
The reagent used for this test is called **biuret reagent**. You can use it as two separate solutions: a dilute solution of potassium hydroxide or sodium hydroxide, and a dilute solution of copper(II) sulfate. Alternatively, you can use a ready-made biuret reagent that contains both the copper(II) sulfate solution and the hydroxide ready mixed. To stop the copper ions reacting with the hydroxide ions and forming a precipitate, this ready-mixed reagent also contains sodium potassium tartrate or sodium citrate.

Procedure
The biuret reagent is added to the solution to be tested. No heating is required. A purple colour indicates that protein is present. The colour develops slowly over several minutes.

Collagen – a fibrous protein

Collagen, a common protein in animals, is found in various parts of the body, including skin, tendons, cartilage, bones, teeth, and blood vessel walls. It is an important **structural protein**, not only in humans but in almost all animals, and is found in structures ranging from the body walls of sea anemones to the egg cases of dogfish.

Fibriils are formed by the interaction of three-stranded collagen molecules, with covalent bonds between amino acid R groups. Staggered ends prevent weak spots across fibrils, and many fibrils form strong bundles called **fibres.**



a: The polypeptides which make up a collagen molecule are in the shape of a stretched-out helix. Every third amino acid is glycine.

b: Three helices wind together to form a collagen molecule. These strands are held together by hydrogen bonds and some covalent bonds.

c: Many of these triple helices lie side by side, linked to each other by covalent cross-links between the side chains of amino acids near the ends of the polypeptides. Notice that these cross-links are out of step with each other; this gives collagen greater strength.

d: A scanning electron micrograph of collagen fibrils (×17000). Each fibril is made up of many triple helices lying parallel with one another. The banded appearance is caused by the regular way in which these helices are arranged, with the staggered gaps between the molecules (shown in **c**) appearing darker.

e: A scanning electron micrograph of human collagen fibres (×2000). Each fibre is made up of many fibrils lying side by side. These fibres are large enough to be seen with an ordinary light microscope.

Figure 2.26 Collagen. The diagrams and photographs begin with the very small and work up to the not-so-small. Thus three polypeptide chains like the one shown in **a** make up a collagen molecule, shown in **b**; many collagen molecules make up a fibril, shown in **c** and **d**; many fibrils make up a fibre, shown in **e**.

Water

Water is a crucial biochemical, forming 70%-95% of cell mass and providing an environment for organisms. It covers three-quarters of the planet and has surprising properties like hydrogen bonding, making it difficult to separate and affecting its physical properties. Water's unique properties make it a medium for molecules and ions to mix, allowing life to evolve. This makes it more difficult to convert water from a liquid to a gas.

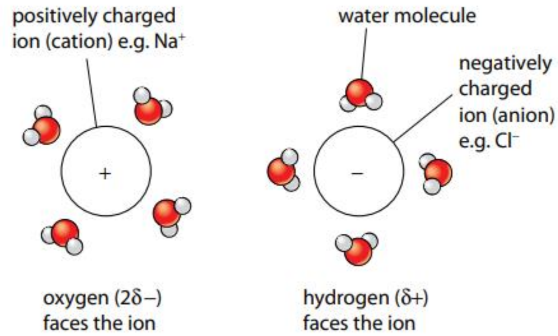


Figure 2.27 Distribution of water molecules around ions in a solution.

Water as a solvent

Water **separates** ions and polar molecules with uneven charge distribution, as water molecules attract them and collect around them, facilitating their dissolution.

By contrast, non-polar molecules such as lipids are insoluble in water and, if surrounded by water, tend to be **pushed together** by the water, since the water molecules are **attracted to each other.**

Water as a transport medium

Water is the transport medium in the blood, in the lymphatic, excretory and digestive systems of animals, and in the vascular tissues of plants. Here again its solvent properties are essential.

High specific heat capacity

The heat capacity of a substance is the amount of heat needed to raise its temperature. Water has a high specific heat capacity, as its hydrogen bonds make it difficult for molecules to move freely. This high heat capacity makes water more resistant to temperature changes, allowing biochemical reactions to operate at constant rates. Large bodies of water, like lakes and oceans, provide more stable habitats for aquatic organisms, as they are slow to change as environmental temperature changes.

High latent heat of vapourisation

The latent heat of vapourisation measures the heat energy required to change a liquid from liquid to gas. Water has a high latent heat due to its high heat capacity and hydrogen bonding. This energy loss causes water molecules to cool down, which is biologically important as it reduces dehydration risk and helps cool leaves during transpiration. Conversely, when water changes from liquid to solid ice, it loses more energy, making it less likely to freeze, benefiting aquatic organisms.

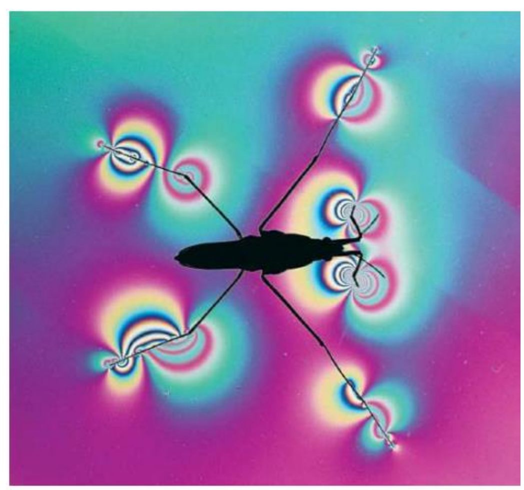


Figure 2.28 A pond skater standing on the surface of pond water. This was photographed through an interferometer, which shows interference patterns made by the pond skater as it walks on the water's surface. The surface tension of the water means the pond skater never breaks through the surface.

Density and freezing properties

Water's density decreases below 4°C, allowing ice to float on liquid water and insulate it, reducing freezing risk and increasing life survival in cold conditions. Temperature-related changes maintain ocean nutrient circulation.

High surface tension and cohesion

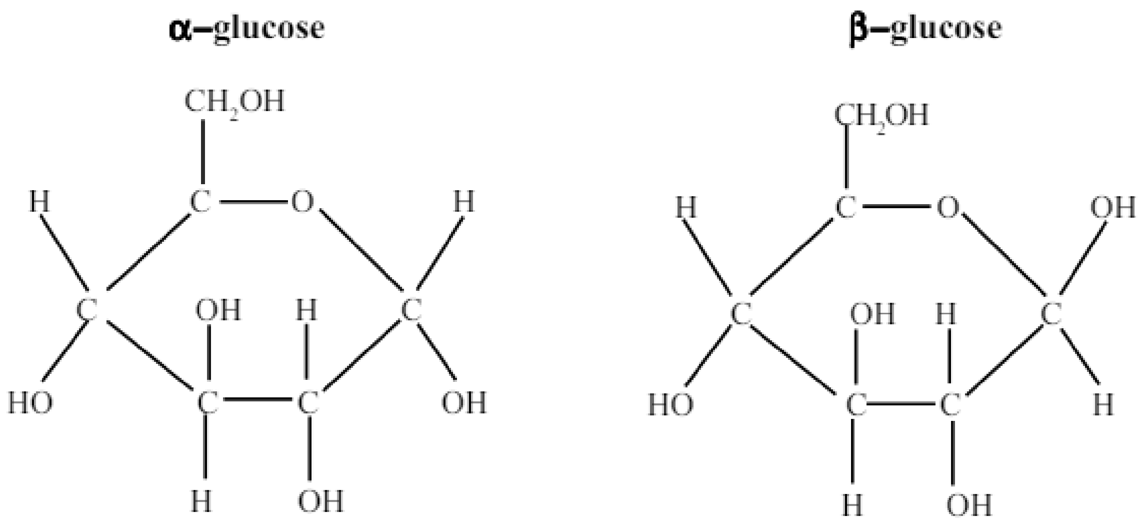
Water molecules have very high cohesion – in other words, they tend to stick to each other. This explains why water can move in long, unbroken columns through the vascular tissue in plants and is an important property in cells. High cohesion also results in high surface tension at the surface of water. This allows certain small organisms, such as pond skaters, to exploit the surface of water as a habitat, allowing them to settle on or skate over its surface (Figure 2.28).

Water as a reagent

Water plays a crucial role in chemical reactions within cells, such as photosynthesis, where sunlight separates hydrogen from oxygen in water molecules, providing energy for plants. Waste oxygen from photosynthesis supplies oxygen for respiration and is essential for hydrolysis reactions, breaking down large molecules for digestion.

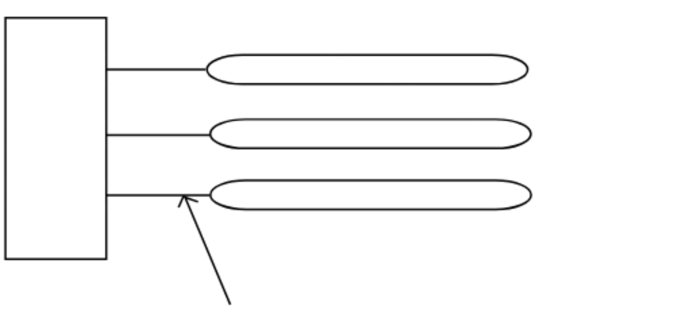
Revision questions

1) The diagrams below show two different forms of glucose



(a) What term is used to describe these two forms?
(b) How do the two forms of glucose differ from one another?
(c) Why is it important to have these two differing forms?
(d) What kinds of bonds occur in carbohydrates?

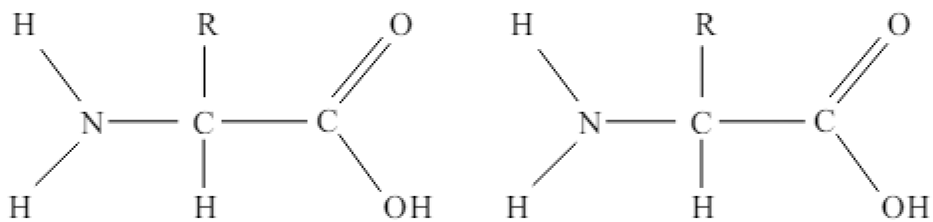
2) Stearic acid is a saturated fatty acid with the formula $C_{17}H_{35}COOH$. Oleic acid is an unsaturated fatty acid with the formula $C_{17}H_{33}COOH$. (a) (i) What do the terms saturated and unsaturated mean?
(ii) In what ways do the properties of saturated and unsaturated fats differ?
(b) Why are lipids useful as storage molecules?
(c) (i) Name the parts of the triglyceride shown below by writing in the boxes and completing the label.



(ii) In what way would the structure of a phospholipid differ from this triglyceride?

3) (a) Describe the structure of a phospholipid
(b) (i) Show, using a labelled diagram, how phospholipids are arranged in a biological membrane
(ii) Explain why the molecules arrange themselves in this way
(c) Give two uses of lipids, other than storage.
(d) Describe a test you would carry out to determine the presence of fat in a sample solution.

4) The diagram below shows the general structure of two molecules of amino acid.



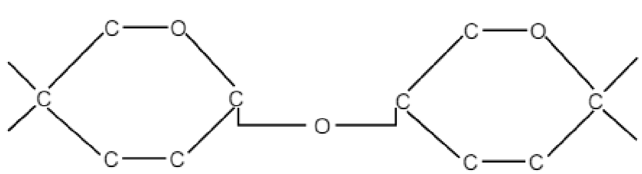
(a) Using the diagram above show how the two amino acids join to make a dipeptide.
(b) (i) What does the “R” represent?
(ii) Give an example of an “R” group.
(iii) What is the name of the bond that links two adjacent amino acids?
(c) “Amino acids are amphoteric”. What does this mean?
(d) Name two types of bonds which hold tertiary protein structure together.
(e) Name one common protein which has a quaternary protein structure.
(f) Describe how you would carry out a test to detect the presence of protein in an unknown sample solution.

5)(a) The table below refers to various carbohydrates and their molecular structure. If a feature is correct place a tick in the box, and if it is incorrect place a cross in the box.

	monosaccharide	disaccharide	polysaccharide
ribose			
glucose			
maltose			
starch			
lactose			
glycogen			
cellulose			

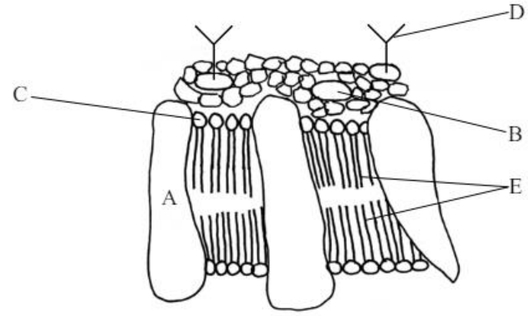
(b) State two structural differences between starch and cellulose.

6) The carbohydrate below has been formed from two glucose molecules.



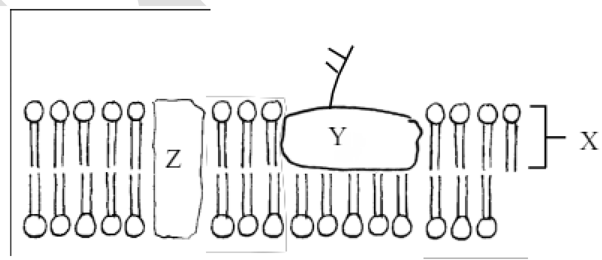
(a) What is this type of carbohydrate called?
(b) What is the name of the chemical bond which joins these two hexose units together?
(c) What is the chemical reaction in which one or more hexose units are joined together?
(d) State one function of the carbohydrate shown above in living cells.
(e) (i) Draw a diagram to show how the two glucose molecules would have been bonded when forming part of a cellulose fibril.
(ii) Name the type of bond involved.

7) The diagram below shows part of the cell membrane
(a) Which two structures would release amino acids on hydrolysis?
(b) Identify components E.
(c) (i) Identify structure D.
(ii) Describe the composition of structure D.
(iii) State two functions of structure D.



8) The diagram below shows a part of a cell membrane.
(a) Label X, Y and Z.
(b) State one function of:
(c) The following table refers to the functions of some of the molecules involved in the cell surface membrane. If a function is correct place a tick in the appropriate box if it is incorrect place a cross in the appropriate box

	Phospholipid	Protein	Carbohydrate
Act as enzymes			
Allows passage of water soluble substances			
Involved in cell recognition			



9) Read through the following account of DNA and then write in the spaces the most appropriate word or words to complete the account. A DNA molecule is composed of .... sugars, phosphate groups and four types of .... base. Within the DNA molecule bases are held together in pairs by .... bonds. For example, guanine is always paired with .... and thymine is always paired with .... Bases in these pairs are said to be .... to each other. Adenine and guanine are examples of .... bases, whereas .... is an example of a pyrimidine base. The two strands of nucleotides are twisted around one another to form a .... and in each turn of the spiral, there are .... base pairs.