Edexcel

AS level

Biology

CODE: (4BI1)

Topic 1A

Molecules, transport and health

1A.1-The chemistry of life

Ionic and covalent bonding

In **fig A**, the dragonfly and plant, along with the cow in fig **C**, are made of chemicals. Understanding basic principles of chemistry helps develop a better understanding of biological systems. Chemical bonds within molecules affect the properties of compounds, affecting their functions within cells and organisms. For instance, understanding the chemistry of water requires understanding chemical bonds and how dipoles are created within molecules.

fig A All life depends on some very fundamental chemistry.

An atom is the basic unit of all elements, consisting of a nucleus with positive protons and neutral neutrons and surrounded by negative electrons. A full outer shell is stable, but most atoms do not, as electrons change in chemical reactions.

There are two ways they can achieve this.

1. **Ionic bonding**: The reaction involves atoms giving or receiving electrons, with one atom becoming an anion (negative) and the other becoming a cation (positive). Ionic bonds, strong forces of attraction, hold the oppositely charged ions together. (see fig B).

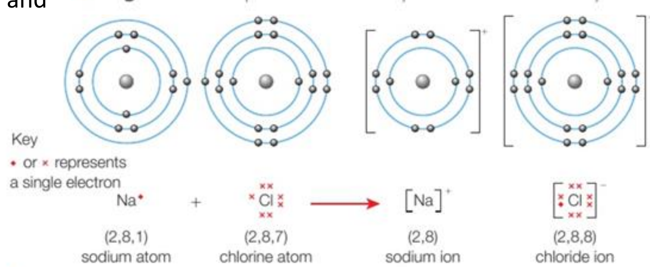


fig B The formation of sodium chloride (salt), an inorganic substance that is very important in living organisms, is an example of ionic bonding.

2. **Covalent bonding:** the atoms involved in the reaction share electrons (see fig **D**). **Covalent bonds** are very strong and the molecules formed are usually neutral. Consequently, the molecule has a part that is slightly negative and a part that is slightly positive. This separation of charge is called a **dipole**, and the tiny charges are represented as 8+ and 8- (see fig **F**). The molecule is described as a **polar molecule.** This polarity is particularly common if the bond involves one or more hydrogen atoms.

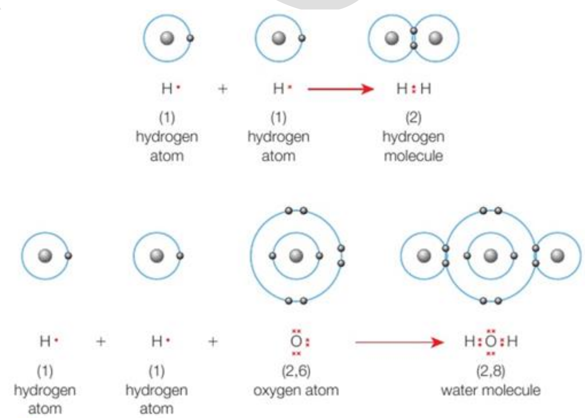


fig D The formation of hydrogen molecules and water molecules are examples of covalent bonding.

THE IMPORTANCE OF INORGANIC IONS

When ionic substances dissolve in water, the ions separate in a process called dissociation. Here are some of the inorganic ions (and their roles) you will meet as you study biology.

IMPORTANT ANIONS

- Nitrate ions (NO_3) - these are needed in plants to make DNA and also amino acids and, therefore, proteins from the products of photosynthesis
- Phosphate ions (PO,3-)- these are needed in all living organisms to make ATP and ADP as well as DNA and RNA
- Chloride ions (Cl) - these are needed in nerve impulses, sweating and many secretory systems in animals
- Hydrogencarbonate ions (HCO_3)- these are needed to buffer blood pH to prevent it becoming too acidic

IMPORTANT CATIONS

- Sodium ions (Na^+) - these are needed in nerve impulses, sweating and many secretory systems in animals
- Calcium ions (Ca^{2+}) - these are needed for the formation of calcium pectate for the middle lamella between two cell walls in plants, and for bone formation and muscle contraction in animals

• Hydrogen ions (H+) - these are needed in cellular respiration and photosynthesis, and in numerous pumps and systems as well as pH balance
• Magnesium ions (Mg2+)- these are needed for production of chlorophyll in plants

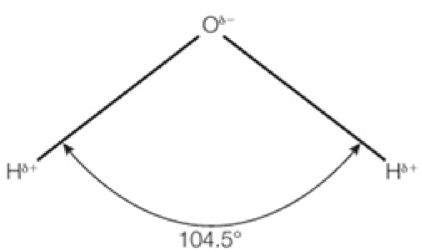
▲ **fig E** Water is vital for life on Earth in many different ways – in a desert, the smallest amount of water allows plants to grow.

The chemistry of water

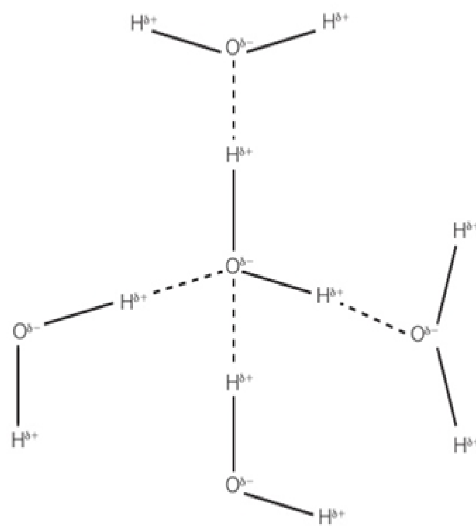
Fig E illustrates that water is a crucial reactant in photosynthesis, a process that relies on living cells for all reactions. Understanding water's properties aids in comprehending key systems in organisms and serves as a major habitat, supporting more life than any other part of the planet.

Water's chemical formula is H2O, consisting of two hydrogen and one oxygen atoms. It is a polar molecule due to electrons being held closer to the oxygen atom. (see **fig F)**

Hydrogen bonds are a crucial aspect of water molecules, forming a weak electrostatic attraction between water molecules. These bonds, as shown in **fig G,** are more common than expected due to the high melting and boiling points of water. These bonds are essential for protein structure and DNA function, as they require a significant amount of energy to break.



▲ **fig F** A model of a water molecule showing dipoles.



▲ **fig G** Hydrogen bonding in water molecules, based on attraction between positive and negative dipoles.

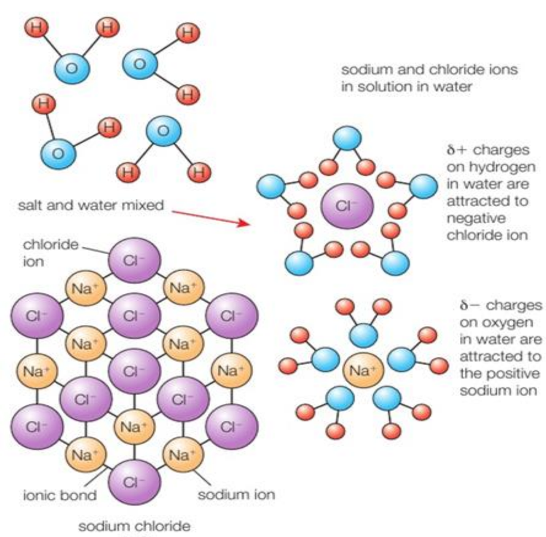
The properties of water

make it very important in biological systems for many reasons.
• Water is a polar solvent. Because it is a polar molecule, many ionic substances like sodium chloride will dissolve in it (see fig H).

• Water is an excellent transport medium because the dipole nature of water enables many different substances to dissolve in it .

• As water cools to 4°C, its density increases, forming ice. Ice is less dense than water, forming an insulating layer and preventing freezing. It melts quickly due to its exposure to the sun. This unusual property allows organisms to live in water, even in colder countries, despite freezing winters.

• Water is slow to absorb and release heat - it has a high specific heat capacity. The hydrogen bonds between the molecules need a lot of energy to separate them.



▲ **fig H** A model of sodium chloride dissolving in water as a result of the interactions between the charges on sodium and chloride ions and the dipoles of the water molecules.

• Water is a liquid - it cannot be compressed. This is an important factor in many hydraulic mechanisms in living organisms.

• Water molecules are cohesive - the forces between the molecules mean they stick together. This is very important for the movement of water from the roots to the leaves of plants

• Water molecules are adhesive - they are attracted to other different molecules. This is also important in plant transport systems and in surface tension.

• Water's high surface tension is due to the greater attraction between water molecules, including hydrogen bonds, and air, forming a thin'skin' of tension. This tension is crucial in plant transport systems and affects life at water masses like ponds and lakes. (see fig I)

fig I Without surface tension, a raft spider like this could not move across the water and hunt.

SUBJECT VOCABULARY

anion a negative ion
cation a positive ion
ionic bonds bonds formed when atoms give or receive electrons; they result in charged particles called ions
covalent bonds bonds formed when atoms share electrons; covalent molecules may be polar if the electrons are not shared equally
dipole the separation of charge in a molecule when the electrons in covalent bonds are not evenly shared
polar molecule a molecule containing a dipole
dissociation splitting of a molecule into smaller molecules, atoms, or ions, especially by a reversible process
hydrogen bonds weak electrostatic intermolecular bonds formed between polar molecules containing at least one hydrogen atom

1A.2 – Carbohydrates 1: monosaccharides and disaccharides

What are organic compounds?

Biological molecules, often organic compounds, are crucial for the structure and function of living things. These organic molecules contain carbon atoms, hydrogen, oxygen, nitrogen, sulfur, and phosphorus. They make up most of the body's non-water material. Understanding the chemistry of organic molecules helps understand carbohydrates, lipids, and proteins. Carbon atoms can bond four times, creating long chains and forming tetrahedral shapes. Carbon compounds can be rings, branched chains, or three-dimensional (3D) shapes. (See fig A) Some carbon compounds form large **polymers,** demonstrating the ability of carbon to combine and form **macromolecules.**

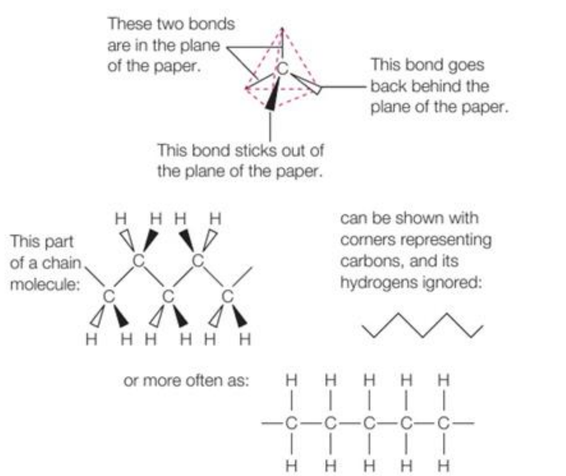


fig A The bonds in a carbon atom have a complicated 3D shape. This is difficult to represent, so in most molecular diagrams we use one of several different ways to draw them.

Carbohydrates

Carbohydrates are important in cells as a usable energy source and important in human foods around the world (see fig B). They are also important for storing energy and they form an important part of the cell wall in plants, fungi and bacteria. Sugars and **starch** are the best-known carbohydrates. **Sucrose** is the familiar white crystalline table sugar; **glucose** is used as a fuel by the cells of our bodies.

The basic structure of all carbohydrates is the same. They consist of carbon, hydrogen and oxygen. There are three main groups of carbohydrates: **monosaccharides**, **disaccharides** and **polysaccharides**. Some have more complex molecules than others.

MONOSACCHARIDES: THE SIMPLE SUGARS

Monosaccharides are simple sugars in which there is one oxygen atom and two hydrogen atoms for each carbon atom in the molecule. A general formula for this can be written (CH_2O),. Here n can be any number, but it is usually low.

• **Triose sugars** (n = 3) have three carbon atoms and the general formula $C_3H_6O_3$. They are important in mitochondria, where the respiration process breaks down glucose into triose sugars

• **Pentose sugars** (n = 5) have five carbon atoms and the general formula $C_5H_{10}O_5$. Ribose and deoxyribose are important in the nucleic acids deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), which make up the genetic material (see Section 2B.3).

• **Hexose sugars** (n = 6) have six carbon atoms and the general formula $C_6H_{12}O_6$. They are the best-known monosaccharides, often taste sweet and include glucose, galactose and fructose. General formulae show you how many atoms there are in the molecule, and what type they are, but they do not tell you what the molecule looks like and why it behaves as it does.

Glucose has two **isomers** (different forms): α-glucose and β-glucose. The two isomers have different arrangements of the atoms on the side chains of the molecule.

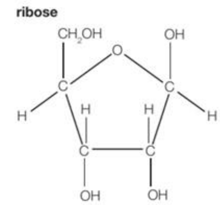
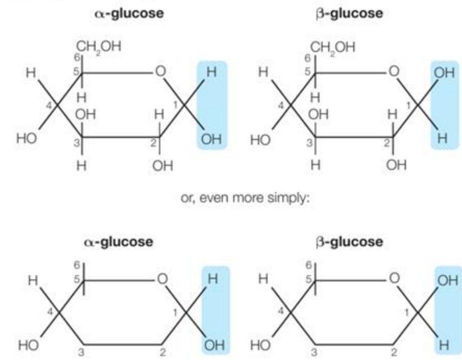


fig C Pentose sugars such as ribose have 5 carbon atoms.



Disaccharides: the double sugars

Disaccharides, like sucrose, are formed by two monosaccharides joining together in a **condensation reaction.** This results in a glycosidic bond, which is a covalent bond between the two monosaccharides. The number of carbon atoms involved in the bond is determined by the number of carbon atoms in the bond, such as 1,4-**glycosidic bonds** between carbon 1 and carbon 4, and 1,6-glycosidic bonds between carbon 1 and carbon 6.

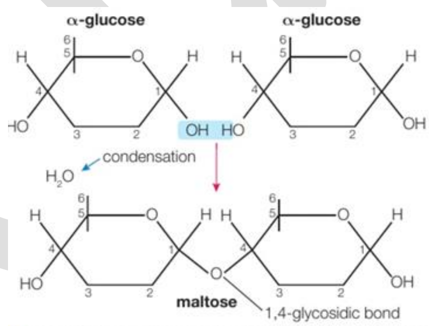


fig E The formation of a glycosidic bond. The condensation reaction between two monosaccharides results in a disaccharide and a molecule of water.

When different monosaccharides join together, different disaccharides are made, and these have different properties. Many disaccharides taste sweet. Table A shows some of the more common ones.

DISACCHARIDE	SOURCE	MONOSACCHARIDE
sucrose	stored in plants such as sugar cane	glucose + fructose
lactose	milk sugar – this is the main carbohydrate found in milk	glucose + galactose
maltose	malt sugar – found in germinating seed such as barley	glucose + glucose

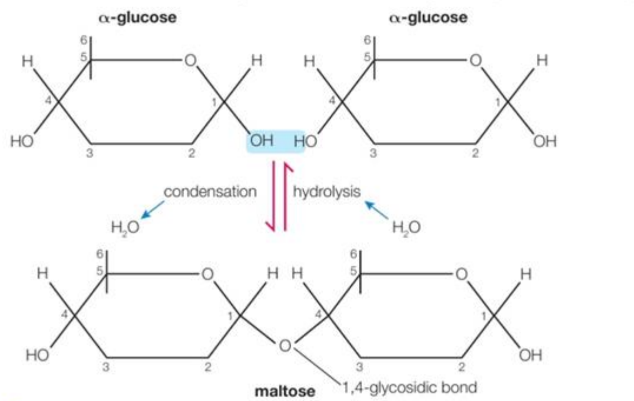
table A Three common disaccharides

SUBJECT VOCABULARY

monomer a small molecule that is a single unit of a larger molecule called a polymer
polymer a long-chain molecule made up of many smaller, repeating monomer units joined together by chemical bonds
macromolecule a very large molecule often formed by polymerisation
starch a long-chain polymer formed of glucose monomers
sucrose a sweet-tasting disaccharide formed by the joining of glucose and fructose by a 1,4-glycosidic bond
glucose a hexose sugar
monosaccharide a single sugar monomer
disaccharide a sugar made up of two monosaccharide units joined by a glycosidic bond, formed in a condensation reaction
polysaccharide a polymer consisting of long chains of monosaccharide units joined by glycosidic bonds
triose sugar a sugar with three carbon atoms
pentose sugar a sugar with five carbon atoms
ribose a pentose sugar that is part of the structure of RNA
deoxyribose a pentose sugar that is part of the structure of DNA
deoxyribonucleic acid (DNA) a nucleic acid that is the genetic material in many organisms
ribonucleic acid (RNA) a nucleic acid which is the genetic material in some organisms and is involved in protein synthesis
hexose sugar sugar with six carbon atoms
isomers molecules that have the same chemical formula, but different molecular structures
condensation reaction a reaction in which a molecule of water is removed from the reacting molecules as a bond is formed between them
glycosidic bond a covalent bond formed between two monosaccharides in a condensation reaction, which can be broken down by a hydrolysis reaction to release the monosaccharide units
reducing sugars sugars that react with blue Benedict's solution and reduce the copper(II) ions to copper(I) ions giving an orangey-red precipitate
non-reducing sugars sugars that do not react with Benedict's solution

1A.3 – Carbohydrates 2: polysaccharides

Molecules with between 3 and 10 sugar units are known as **oligosaccharides,** while molecules containing 11 or more monosaccharides are known as true polysaccharides. The glycosidic bonds in the polysaccharide can be broken to release monosaccharide units for cellular respiration. The glycosidic bond between two glucose units is split by a process known as **hydrolysis** (see fig A).



▲ **fig A** Glycosidic bonds are made by condensation reactions and broken down by hydrolysis.

Carbohydrates and energy

Monosaccharides and disaccredits

Every chemical reaction taking place in a cell needs energy. This energy is supplied by a substance called adenosine triphosphate, **ATP**.

The compounds that are produced, called the **end products,** are waste carbon dioxide and water, and lots of ATP. This supplies the energy needed for all the reactions in the cell.

POLYSACCHARIDES

The structure of polysaccharides makes them ideal as energy storage molecules within a cell.

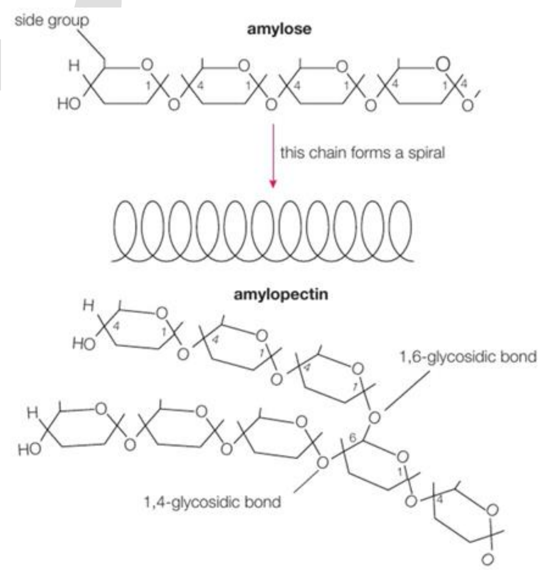
- They can form very compact molecules, which take up little space.
- They are physically and chemically inactive, so they do not interfere with the other functions of the cell.
- They are not very soluble in water, so have almost no effect on water potential within a cell and cause no osmotic water movements.

STARCH

Starch is particularly important as an energy store in plants. The sugars produced by photosynthesis are rapidly converted into starch, which is insoluble and compact but can be broken down rapidly to release glucose when it is needed.

Starch consists of long chains of a-glucose. But if you look at it more closely you will see that it is a mixture of two compounds:

- **Amylose:** an unbranched polymer of between 200 and 5000 glucose units. As the chain lengthens the molecule spirals, which makes it more compact for storage.
- **Amylopectin**: a branched polymer of glucose units. The branching chains have many terminal glucose units that can be broken off rapidly when energy is needed.



▲ **fig D** Amylose and amylopectin – a small difference in the position of the glycosidic bonds in the molecule makes a big difference to the properties of the compounds.

GLYCOGEN

Glycogen is sometimes referred to as 'animal starch' because it is the only carbohydrate energy store found in animals. It is also an important storage carbohydrate in fungi. Chemically, glycogen is very similar to the amylopectin molecules in starch, and it also has many a-glucose units.

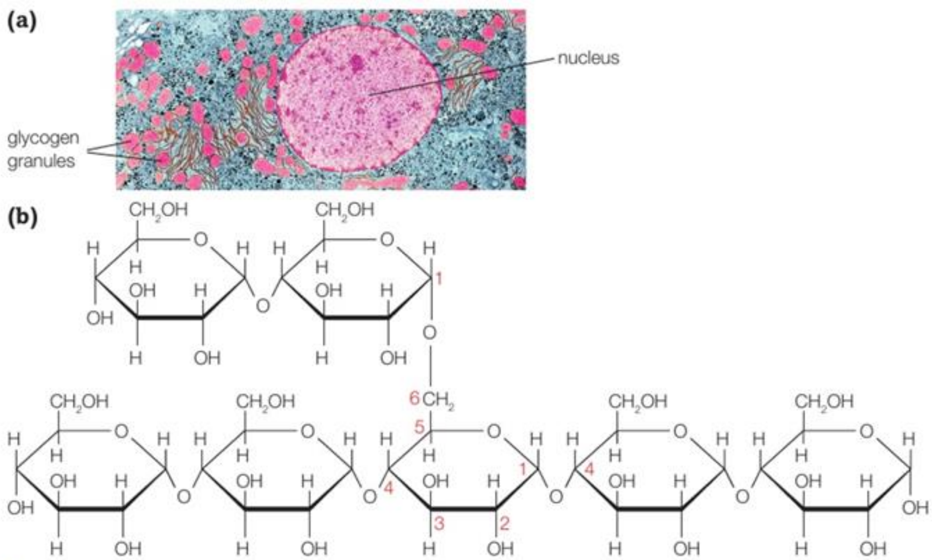


fig E In **(a)** you can see liver cells full of small glycogen granules, stained pink in this micrograph. If your blood glucose levels are low, this glycogen store in your liver can be broken down to provide the glucose you need for cellular respiration. In **(b)** you can see the structure of glycogen with 1,4 and 1,6-glycosidic bonds.

The chemical structure of glycogen shown in **fig E (b)** looks very similar to that of amylopectin. However, when you look at bigger sections of the molecules in **fig F** you can see that glycogen has many more branches than amylopectin.

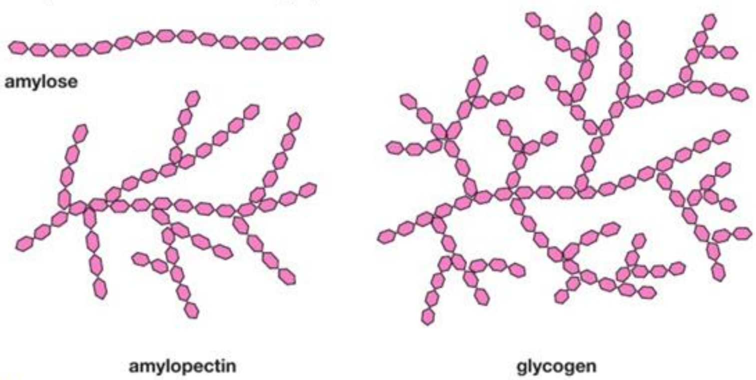


fig F You can clearly see the many side branches which allow glycogen to be broken down so quickly when you compare amylose, amylopectin and glycogen.

SUBJECT VOCABULARY

oligosaccharides molecules with between 3 and 10 monosaccharide units

hydrolysis a reaction in which bonds are broken by the addition of a molecule of water

ATP adenosine triphosphate, the molecule that acts as a universal energy supply molecule in all cells

end products the final products of a chemical reaction

amylose a complex carbohydrate containing only α-glucose monomers joined together by 1,4-glycosidic bonds so the molecules form long unbranched chains

amylopectin a complex carbohydrate made up of α-glucose monomers joined by 1,4-glycosidic bonds with some 1,6-glycosidic bonds so the molecules branch repeatedly

glycogen a complex carbohydrate with many α-glucose units joined by 1,4-glycosidic bonds with many 1,6-glycosidic bonds, giving it many side branches

1A.4 - lipids

Triglycerides are formed when glycerol and three fatty acids combine, creating an ester bond through esterification. The lipid's nature depends on the fatty acids joined, with saturated lipids being more solid at room temperature and longer chain fatty acids producing solid fats.

Fats and oil

fatty acids and glycerol (propane-1,2,3-triol). These are combined using **ester bonds.** Glycerol has the chemical formula C_3H_8O3 (see fig B).

Glycerol has the chemical formula C3H8O3 (see fig B). All fatty acids have a long hydrocarbon chain - a folded backbone of carbon atoms with hydrogen atoms attached, and a carboxyl group (-COOH) at one end. Living tissues contain more than 70 different types of fatty acid. Fatty acids vary in two ways:

- **T**he length of the carbon chain can differ (but is often 15-17 carbon atoms long)
- **T**he fatty acid may be a saturated fatty acid or an unsaturated fatty acid.

In a saturated fatty acid, each carbon atom is joined to the one next to it by a single covalent bond. A common example is stearic acid (see fig **C**). In an unsaturated fatty acid, the carbon chains have one or more double covalent bonds between carbon atoms in them. A **monounsaturated fatty** acid has one carbon-carbon double bond and a **polyunsaturated fatty** acid has more than one carbon-carbon double bond (see fig **D**).

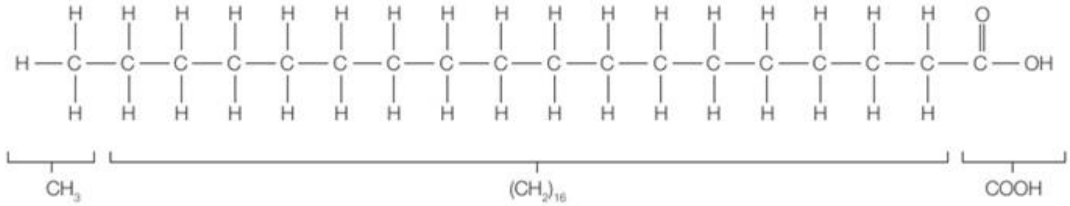


fig C Displayed formula of stearic acid, a saturated fatty acid found in both plant and animal fats

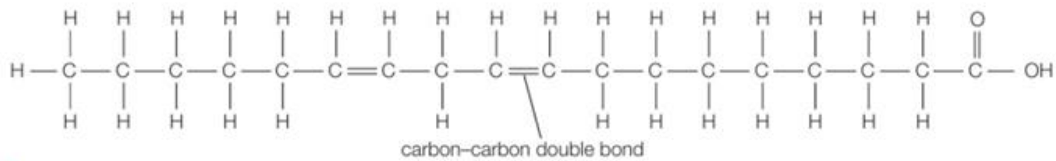


fig D Displayed formula of linoleic acid, a polyunsaturated fatty acid

Forming ester bonds

Triglycerides are formed when glycerol and three fatty acids combine, creating an ester bond through esterification. The lipid's nature depends on the fatty acids joined, with saturated lipids being more solid at room temperature and longer chain fatty acids producing solid fats.

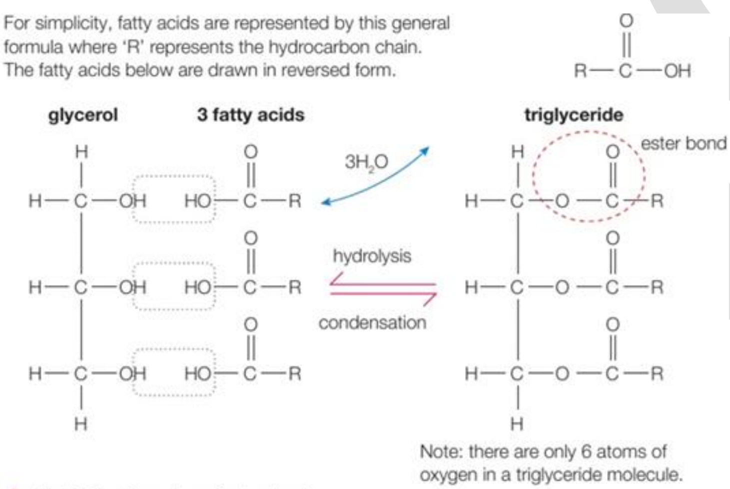


fig E The formation of ester bonds

SUBJECT VOCABULARY

lipids a large family of organic molecules that are important in cell membranes and as an energy store in many organisms; they include triglycerides, phospholipids and steroids
fatty acids organic acids with a long hydrocarbon chain
glycerol propane-1,2,3-triol, an important component of triglycerides
ester bonds bonds formed in a condensation reaction between the carboxyl group (-COOH) of a fatty acid and one of the hydroxyl groups (-OH) of glycerol
saturated fatty acid a fatty acid in which each carbon atom is joined to the one next to it in the hydrocarbon chain by a single covalent bond
unsaturated fatty acid a fatty acid in which the carbon atoms in the hydrocarbon chain have one or more double covalent bonds in them
monounsaturated fatty acid a fatty acid with only one double covalent bond between carbon atoms in the hydrocarbon chain
polyunsaturated fatty acid a fatty acid with two or more double covalent bonds between carbon atoms in the hydrocarbon chain
esterification the process by which ester bonds are made

1A.5 Proteins

About 18% of your body is made up of protein. Proteins make hair, skin and nails, the enzymes needed for metabolism and digestion, and many of the hormones that control the different body systems. They enable muscle fibres to contract, make antibodies that protect you from disease, help clot your blood and transport oxygen in the form of **haemoglobin**.

Proteins are a group of macromolecules made up of many small monomer units called amino acids joined together by condensation reactions. **Amino acids** combine in long chains to produce proteins. There are about 20 different naturally occurring amino acids that can combine in different ways to produce a wide range of different proteins.

Amino acids

All amino acids have a basic structure with an amino group and carboxyl group attached to a carbon atom. The R group, which may contain sulfur or selenium, affects amino acid interactions with others within the protein molecule, affecting the tertiary structure of the protein.

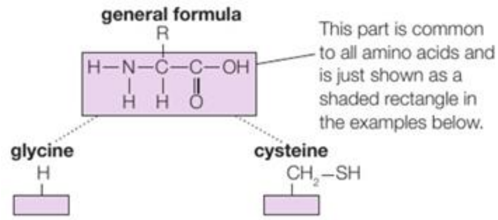


fig A Some different amino acids. In the simplest amino acid, glycine, R is a single hydrogen atom. In a larger amino acid such as cysteine, R is much more complex.

Forming proteins from amino acids

Amino acids join by a reaction between the amino group of one amino acid, and the carboxyl group of another. They join in a condensation reaction and a molecule of water is released. A **peptide bond** is formed when two amino acids join, and a **dipeptide** is the result (see fig B). The R group is not involved in this reaction. More and more amino acids join to form **polypeptide** chains, which contain from about 100 to many thousands of amino acids.

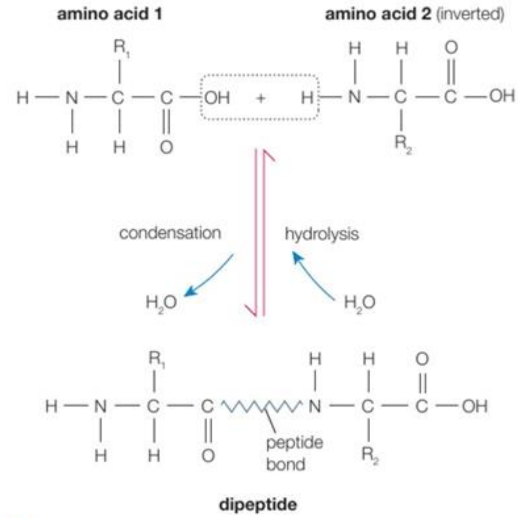


fig B Amino acids are the building blocks of proteins, joined together by peptide bonds.

Bonds in protein

The peptide bond between amino acids is a strong bond. Other bonds are also made between the amino acids in a chain, to create the 3D structures of the protein. They depend on the atoms in the R group and include hydrogen bonds, disulfide bonds and ionic bonds.

Hydrogen bonds

Hydrogen bonds are crucial in protein structures, formed by tiny negative and positive charges on carboxyl and hydrogen atoms in amino acids. These bonds are weak but can be formed between any amino acid in the correct position, holding proteins together firmly. They can break easily under changing pH or temperature conditions.

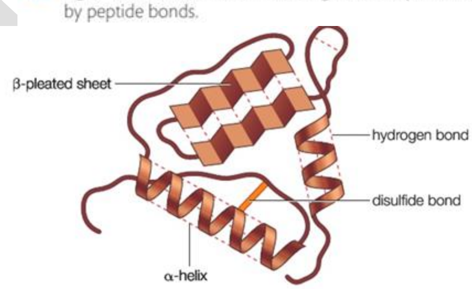


fig C Hydrogen bonds and disulfide bonds maintain the shape of protein molecules and this determines their function.

Disulfide bonds

Disulfide bonds form when two cysteine molecules are close together in the structure of a polypeptide (see fig C). An oxidation reaction occurs between the two sulfur-containing groups, resulting in a strong covalent bond known as a disulfide bond. These disulfide bonds are much stronger than hydrogen bonds, but they happen much less often. They are important for holding the folded polypeptide chains in place.

Ionic bonds

Ionic bonds are strong bonds between amino acid side chains in protein molecules. Hair is made of keratin, and styling methods like blow drying or straightening can temporarily reform hydrogen bonds, while perming is a chemical treatment used in hair salons to permanently change hair appearance, breaking disulfide bonds between polypeptide chains.

Protein structure

Proteins can be described by their primary, secondary, tertiary and quaternary structure (see fig D).

• The primary structure of a protein is the sequence of amino acids that make up the polypeptide chain, held together by peptide bonds.

• The secondary structure of a protein is the arrangement of the polypeptide chain into a regular, repeating three-dimensional (3D) structure, held together by hydrogen bonds. Most **fibrous proteins** have this type of structure.

•The tertiary structure is another level of 3D organisation in addition to the secondary structure in many proteins. The amino acid chain, including any a-helices and 3-pleated sheets, is folded further into complicated shapes.

• The quaternary structure of a protein is only found in proteins consisting of two or more polypeptide chains. The quaternary structure describes the way these separate polypeptide chains fit together in three dimensions.

Changes in conditions such as temperature or pH affect the bonds that keep the 3D shapes of proteins in place. Even small changes can cause the bonds to break, resulting in the loss of the 3D shape of the protein. This is called **denaturation**.

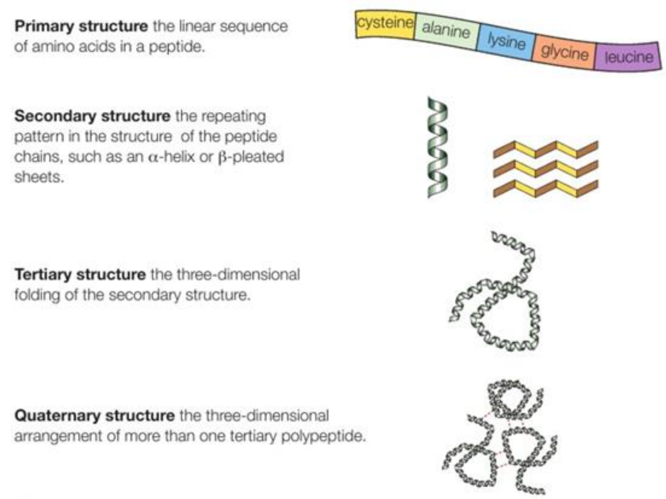


fig D The 3D structure of proteins

Fibrous and globular proteins

Fibrous proteins

Fibrous proteins, with little or no tertiary structure, are long, parallel polypeptide chains with occasional cross-linkages that form fibres. They are insoluble in water and are tough, making them ideal for their structural functions in organisms. **Collagen**, the most common structural protein found in animals, gives strength to tendons, ligaments, bones, and skin. Its unusual structure consists of three polypeptide chains, each up to 1000 amino acids long, arranged in a unique triple helix held together by hydrogen bonds.

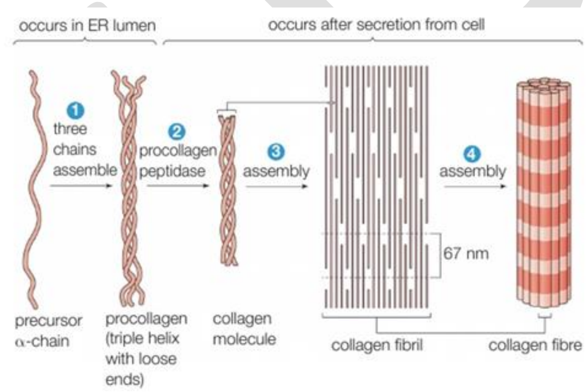


fig E Collagen is a fibrous protein with an unusual triple helix structure and immense strength.

Globular proteins

Globular proteins have complex tertiary and sometimes quaternary structures. They fold into spherical (globular) shapes. Some R groups are **hydrophobic**. They repel water and will not mix or dissolve in it. They are usually found on the inside of globular proteins. Some R groups are **hydrophilic** - they have an affinity for water.

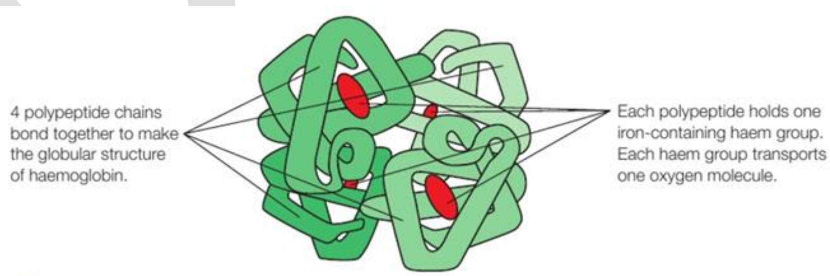


fig F The complex quaternary structure of haemoglobin produces a globular protein containing four haem groups which can carry oxygen to the tissues of the body.

The carboxyl and amino ends give them ionic properties, so you might expect them to dissolve in water and form a solution. Instead, the molecules are so big that they form a **colloid**.

Conjugated proteins

The shape of a protein molecule is usually very important in its function. Some protein molecules are joined with (conjugated to) another molecule called a **prosthetic group** (see fig F). This structural feature usually affects the performance and functions of the molecules. These molecules are called **conjugated proteins. Lipoproteins** are formed when proteins are conjugated with lipids - you will find out more about these important biological molecules when you look at factors affecting the health of your heart .

Glycoproteins are proteins with a carbohydrate prosthetic group. The carbohydrate part of the molecule helps them to hold a lot of water and also makes it harder for protein-digesting enzymes (**proteases**) to break them down. Lots of lubricants used by the human body - such as mucus and the synovial fluid in the joints - are glycoproteins.

SUBJECT VOCABULARY

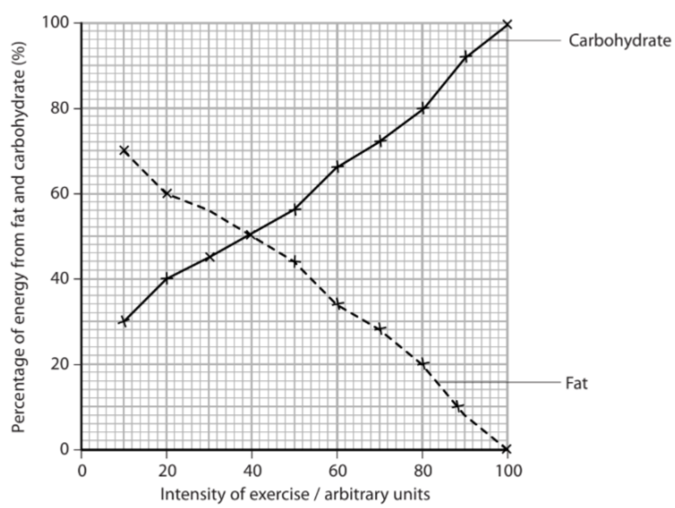
haemoglobin a red pigment that carries oxygen and gives the erythrocytes their colour
amino acids the building blocks of proteins consisting of an amino group ($-NH_2$) and a carboxyl group ($-COOH$) attached to a carbon atom and an R group that varies between amino acids
peptide bond the bond formed by condensation reactions between amino acids
dipeptide two amino acids joined by a peptide bond
polypeptide a long chain of amino acids joined by peptide bonds
disulfide bond a strong covalent bond produced by an oxidation reaction between sulfur groups in cysteine or methionine molecules, which are close together in the structure of a polypeptide
fibrous proteins proteins that have long, parallel polypeptide chains with occasional cross-linkages that produce fibres; they have little tertiary structure
denaturation the loss of the 3D shape of a protein (e.g. caused by changes in temperature or pH)
collagen a strong fibrous protein with a triple helix structure
globular proteins large proteins with complex tertiary and sometimes quaternary structures, folded into spherical (globular) shapes
hydrophobic a substance that tends to repel water and that will not mix with or dissolve in water
hydrophilic a substance with an affinity for water that will readily dissolve in or mix with water
colloid a suspension of molecules that are not fully dissolved
prosthetic group the molecule incorporated in a conjugated protein
conjugated proteins protein molecules joined with or conjugated to another molecule called a prosthetic group
lipoproteins conjugated proteins with a lipid prosthetic group
glycoproteins conjugated proteins with a carbohydrate prosthetic group
proteases protein-digesting enzymes

Revision questions

(1) (a) Amylose and glycogen are polysaccharides.
(i) Name the type of chemical reaction that joins monosaccharides together to form an amylose molecule.
(ii) Name the chemical bond that is formed between the monosaccharides in an amylose molecule.
(iii) D escribe one structural difference between amylose and glycogen.
(iv) Explain two ways in which the structures of amylose and glycogen make them suitable for energy storage.

(2) Carbohydrates are important components of our diets.
(a) Distinguish between the structures of each of the following pairs of carbohydrate molecules.
(i) Monosaccharides and disaccharides
(ii) Amylose and amylopectin
(b) Explain why a diet consisting of a high proportion of carbohydrates could lead to obesity.

(3) Fats and carbohydrates such as glycogen are important energy storage molecules. These are broken down during exercise.
(a) Describe the structure of glycogen and explain why it is a suitable molecule for storing energy.
(b) The graph below shows how the percentage of energy obtained from fat and carbohydrate varies according to the intensity of exercise being carried out.



(i) Using the information in the graph, describe how the source of energy used depends on the intensity of exercise.
(ii) A carbohydrate-loading diet is used by athletes in preparation for some athletic events. This diet involves increasing carbohydrate intake and decreasing activity, several days before the event.

Carbohydrate-loading is not a suitable method of preparation for all athletic events.

Using the information in the graph and your knowledge of glycogen, explain what type of athletic event could be prepared for using a carbohydrate-loading diet.

(4) Plants produce a variety of material useful to humans, such as starch, cellulose and fibres.
(a) Starch can be used to form packaging. Explain why it may be better to make packaging from starch rather than from oil-based products.
(b) The stem of a plant contains xylem vessels and sclerenchyma fibres. Compare the functions of xylem vessels with the functions of sclerenchyma fibres.

(5) Histamine and the proteins interferon and lysozyme are involved in the non-specific responses to infection.
(a) (i) Describe how the production and action of interferon differs from the production and action of lysozyme.

(6) Histamine and the proteins interferon and lysozyme are involved in the non-specific responses to infection.
(a) (i) Describe how the production and action of interferon differs from the production and action of lysozyme.
(ii) Suggest why the protein structure of lysozyme is important to the way in which it acts against pathogens.
(b) Following a bite by an insect, the area around the bite may show signs of inflammation as histamine is released.
(i) Explain why an insect bite, which breaks the surface of the skin, may lead to inflammation around the injury.
(ii) In order to reduce inflammation, a cream containing antihistamines might be applied to the skin, around an insect bite.
Suggest why applying this cream might be better than taking tablets containing antihistamines.

(7) Amylose and glycogen are polysaccharides.
(i) Name the type of chemical reaction that joins monosaccharides together to form an amylose molecule.
(ii) Name the chemical bond that is formed between the monosaccharides in an amylose molecule.
(iii) D escribe one structural difference between amylose and glycogen.
(iv) Explain two ways in which the structures of amylose and glycogen make them suitable for energy storage.

(8) All mammals, such as harp seals, feed their young on milk produced by mammary glands. This continues until the young are old enough to eat the same diet as their parents.

The photograph below shows a female harp seal feeding her pup.


magnification ×0.002

(a) The table below shows the composition of human milk and harp seal milk.
(i) Suggest two substances (other than protein, lipid and lactose) that milk should contain for the development of the harp seal pups.
(ii) Harp seal pups are born in the Arctic where it is extremely cold and there is little shelter. After nine days of feeding, the mass of a harp seal pup can increase by about 300%.
Using information from the table, suggest why a harp seal pup increases in mass more quickly than a human baby.

Milk	Protein (%)	Lipid (%)	Lactose (%)
Human	1.4	3.8	7.0
Harp seal	13.8	36.5	0.0