Cellulose consists of a long unbranched chain of b-glucose subunits. The subunits are joined by a 1, 4 glycosidic bond. The chain of B-glucose subunits forms a straight chain.

The hydroxyl groups on carbon 2 of each subunit are exposed, allowing hydrogen bonds to form between adjacent cellulose molecules. Some 60-70 molecules bind together to form a cellulose microfibril & many microfibrils join together to form macrofibrils.

Cellulose is strong & completely insoluble. It is used in plant cell walls & provides enough strength to support the whole plant.

Amylose	Cellulose
• Made up of a-glucose • Straight chain • Tends to coil up • Plant storage polysaccharide	• Made up of b-glucose (in a chain, alternate glucose subunits are inverted) • Forms straight chains • The b-glycosidic bond can only be broken down by a cellulose enzyme, which herbivores have, but humans do not • Forms plant cell walls

Glucose + fructose → sucrose

Glucose +glucose → maltose

Glucose +galactose → lactose

Disaccharides can be converted back to monosaccharides by hydrolysis.

List the reasons why amylose is a good storage product.

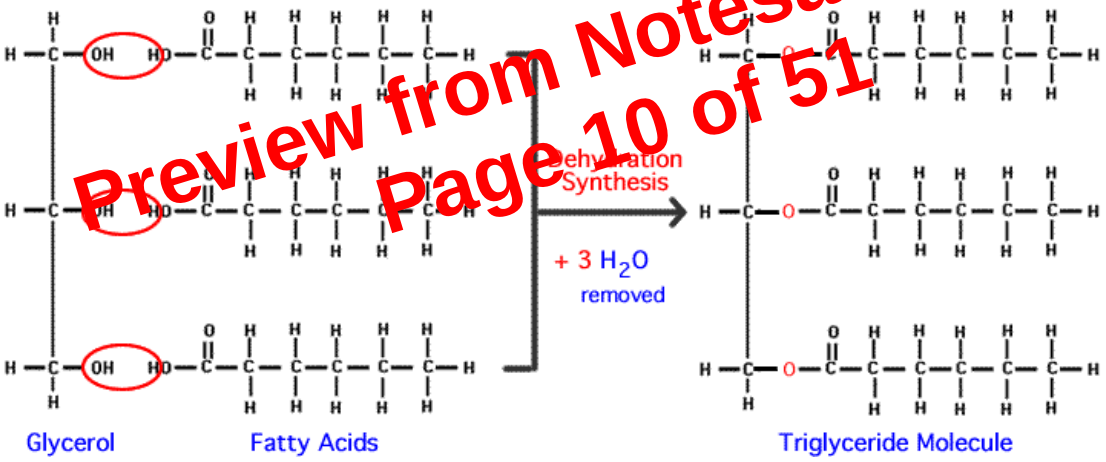
Explain why cellulose is insoluble.

(g) How the structure and properties of glucose, starch, glycogen and cellulose molecules relate to their function in living organisms

Glucose	Starch (Amylose)	Glycogen	Cellulose
Simplest sugar, used in respiration.	Insoluble in water so does not affect the water potential of the cell	Because it is so highly branched it can be broken down to glucose very quickly	Hundreds of the polypeptide chains lie side by side forming hydrogen bonds with each other- very strong. The arrangement of macrofibrils in cell wells: • allows water to move in and out easily • determines how a cell can grow or change shape Cell walls can be reinforced with other substances to provide extra support, or make the walls waterproof (p) compare, with the aid of diagrams,

(h) The structure of a triglyceride and a phospholipid as examples of macromolecules

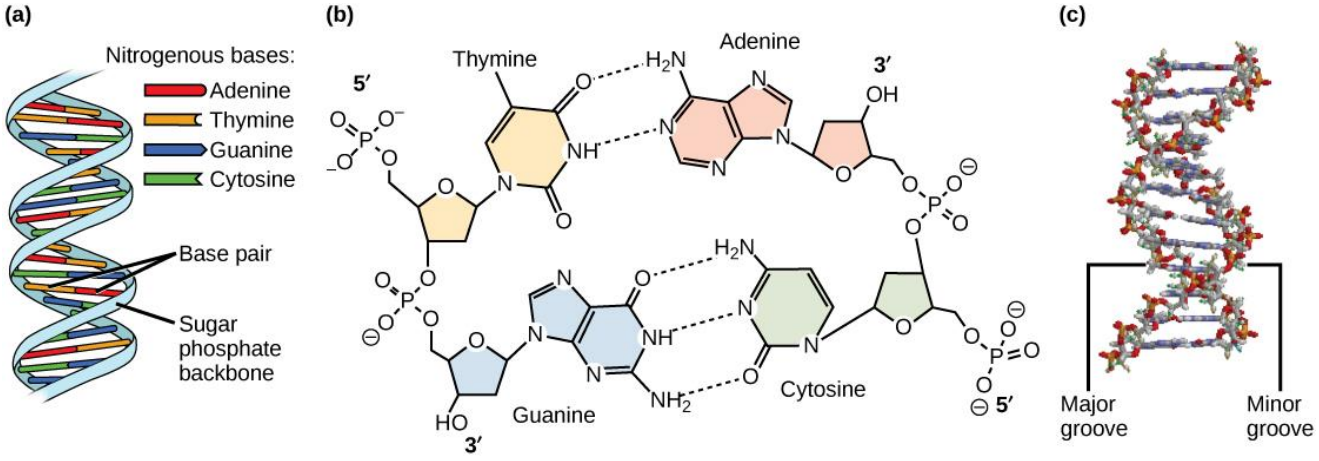
Triglyceride - Glycerol plus three fatty acids



- 3 fatty acids combine with 1 glycerol to produce a triglyceride. The elimination of 1 water molecule is shown. 3 water molecules are released.

The structure of DNA

DNA is also a polynucleotide. The organic bases can pair up one purine with one pyrimidine. They pair according to their complementary shapes. Adenine always pairs to thymine (or uracil in RNA) using 2 hydrogen bonds. The 2 polynucleotide strands lie in opposite directions, which are known an antiparallel. The 2 single polynucleotide strands are joined together to make a double strand. The whole molecule twists to form a helix, hence the name 'double helix'.

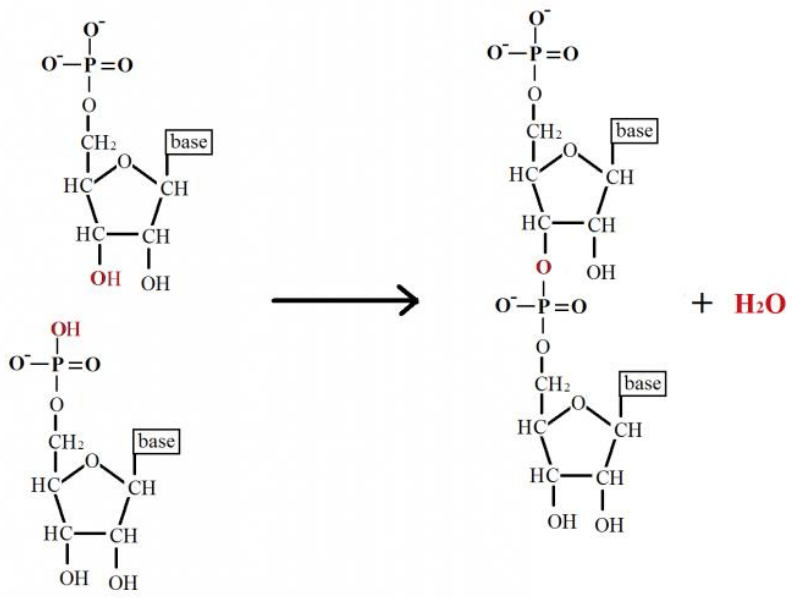


A binds to T with 2 hydrogen bonds whereas C binds to G with 3. This is why A cannot bind to C & T and why T cannot bind to G.

(b) <u>The synthesis and breakdown of polynucleotides by the formation and breakage of phosphodiester bonds</u>

Polynucleotides

A polynucleotide is formed when nucleotides bind together in a long chain. The bonds are formed by condensation & are called phosphodiester bonds. They can be broken by hydrolysis. These bonds form between the sugar of 1 nucleotide & the other phosphate group of another, making a sugar-phosphate 'backbone'. This leaves the organic base of each nucleotide sticking out to the side of the chain.

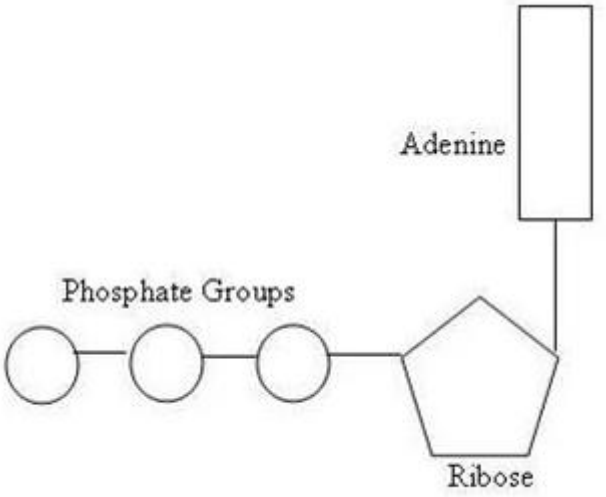


(c) The structure of ADP and ATP as phosphorylated nucleotides.

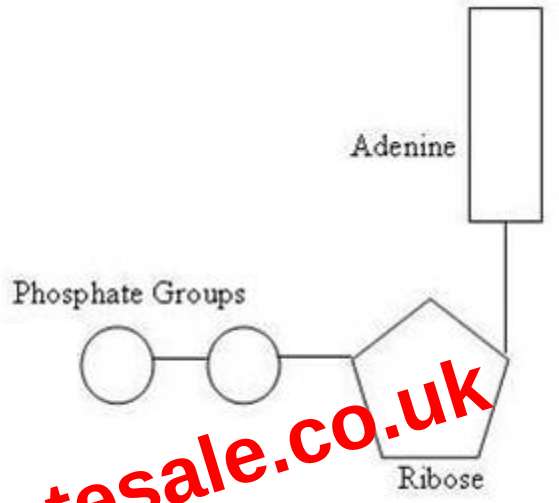
Comprising a pentose sugar (ribose), a nitrogenous base (adenine) and inorganic phosphates.

ADP and ATP are phosphorylated nucleotides. They contain a pentose sugar (ribose), a nitrogenous base (adenine) & 2 or 3 inorganic phosphates.

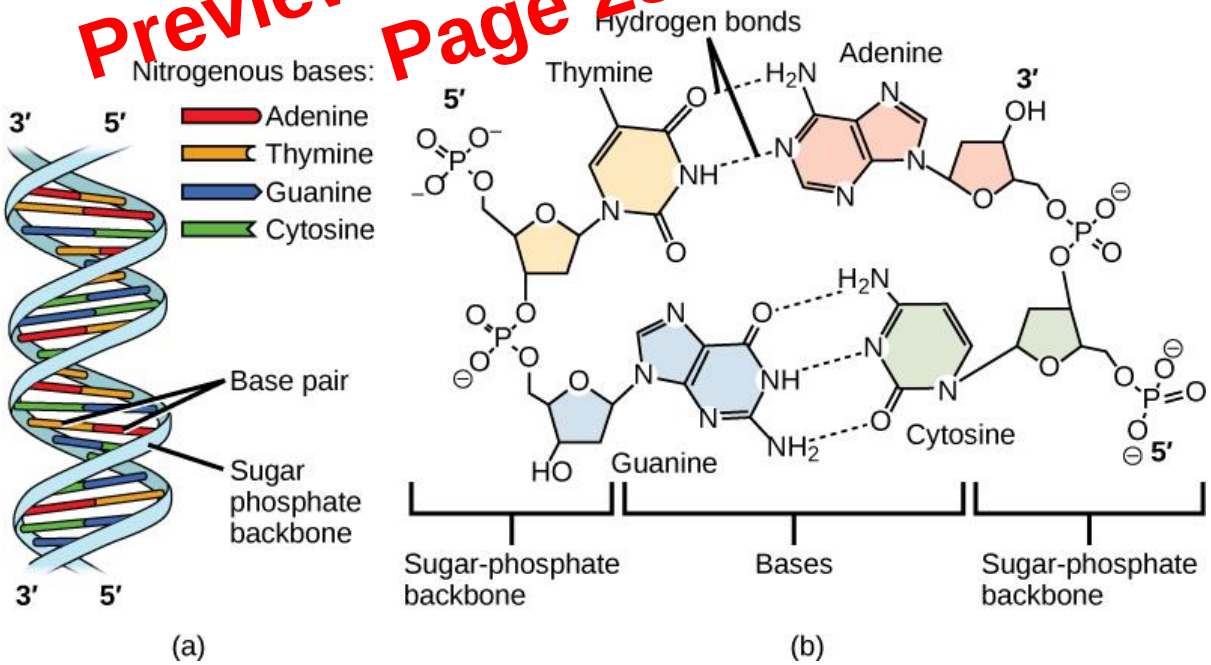
Structure of ATP:



Structure of ADP:



d) (i) the structure of DNA (deoxyribonucleic acid)



Enzymes are called globular biological catalysts because they speed up metabolic reactions in living organisms. Their action affects both their structure and function within cells, tissues and organs.

- Catalysts speed up chemical reactions & remain unchanged at the end of the reaction, able to be used again
- A small amount of catalyst can catalyse the conversion of a large number of substrate molecules into product molecules
- The number of reactions that an enzyme molecule can catalyse per second is known as its turnover number

(b) The role of enzymes in catalysing both intracellular and extracellular reactions

To include catalase as an example of an enzyme that catalyses intracellular reactions and amylase and trypsin as examples of enzymes that catalyse extracellular reactions.

Enzymes may be intracellular (working inside cells), such as catalase, which converts hydrogen peroxide to oxygen and water. Alternatively, enzymes may be extracellular (working outside cells), such as the digestive enzymes **amylase** and **trypsin**, which are released into the digestive system.

(c) The mechanism of enzyme action

To include the tertiary structure, specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex, product formation and lowering of activation energy.

Specificity,

The active site of an enzyme is a specific shape, depending on the reaction that it catalyses, meaning that other molecules won't fit into the active site

Active site:

The area on an enzyme to which the substrate binds

Lock and key hypothesis:

The theory of enzyme action in which the enzyme active site is complementary to the substrate molecule, like a lock and key

Induced-fit hypothesis:

The theory of enzyme action in which the enzyme molecule changes shape to fit the substrate molecule more closely as it binds to it

Enzyme-substrate complex:

The intermediary formed when a substrate molecule binds to an enzyme molecule

Enzyme-product complex:

The intermediate structure in which product molecules are bound to an enzyme molecule

Lowering of activation energy:

Enzymes reduce the activation enthalpy so the reaction can proceed at a much lower temperature

(d) (i) The effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity

pH:

- Low pH = lots of H+ ions
- H+ ions have a positive charge
- Either extreme of H+ ion concentration can interfere with the hydrogen and ionic bonds holding the tertiary structure together.
- The pH affects the charge of the amino acids at the active site, so the properties of the active site change and the substrate can no longer bind
- At high pH values, a –COOH group will dissociate to become a charged –COO- group

Temperature:

- Up to a certain point, increasing temperature will increase the rate of reaction, as there will be more collisions between enzymes and the substrate, and more of these collisions will have the required activation enthalpy for the reaction to proceed.
- But heat also makes the molecules vibrate. This puts strain on the inter-molecular bonds, and some of the weaker bonds (hydrogen bond and ionic bonds) may break.
- In enzymes there are large numbers of these bonds holding the tertiary structure, and especially the active site, in place.
- As the heat increases, more and more of these bonds are broken
- The tertiary structure disintegrates further and further
- The rate of reaction decreases
- If enough of these bonds are broken, the entire tertiary structure will unravel and the enzyme will stop working
- This is not reversible and is known as denaturation

Enzyme concentration

As enzyme concentration increases, the rate of reaction increases linearly as there are more active sites are available, until the substrate concentration becomes a limiting factor and the rate stops increasing

Substrate concentration

As the substrate concentration rises, the rate of reaction rises because there are more substrate molecules to react. At higher concentrations, all of the active sites become filled, so the rate of reaction remains the same

(d) (ii) practical investigations into the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity

pH:

A starch-agar plate is made up by mixing starch with agar. The mixture is poured into a petri dish and left to set. It forms a semi-rigid gel in the plate. Cut wells into each plate using a cork borer. Into each well place the same volume of a different pH buffer solution. Into each well except one, place an identical volume of stock amylase solution. Into the well without the amylase, add an equal volume of distilled water as a control. Incubate for 24h in a dry oven at 35˚C. Flood the plate with an iodine solution and rise with water. Measure the diameter of the cleared zone- this gives an indication of how much substrate has been turned into product

Temperature:

Take samples of potato tissue (containing catalase) using a cork borer then stick into discs of equal thickness. Place an equal number of discs in each of seven tissues and place one in each of a range of water baths from 20-80˚C. Place an equal volume of pH 7 buffer and hydrogen peroxide into each of sever separate test tubes and place one in each water bath. Allow to equilibrate. Taking each in turn, add peroxide/buffer mixture to the potato discs, and then fit a stopper and a side arm into the tube. Close the clip. As oxygen gas is produced in the reaction it pushes the water bubble along the side arm. Time how long it takes for the bubble to move 5cm.

Enzyme concentration:

Use the reaction as before, but keeping the temperature constant, and instead having a different number of potato discs in each test tube

Substrate concentration:

As before, but keeping the temperature and the number of potato discs the same and changing the volume of hydrogen peroxide in each test tube.

(e) The need for coenzymes, cofactors and prosthetic groups in some enzyme-controlled reactions

To include Cl – as a cofactor for amylase, Zn2+ as a prosthetic group for carbonic anhydrase and vitamins as a source of coenzymes.

Cofactors: Ions that increase the rate of enzyme-controlled reactions. Their presence allows enzyme substrate complexes to form more easily.

Coenzymes: Small, organic, non-protein molecules that bind for a short period of time to the active site. They may bind just before, or at the same time, as the substrate binds. In many reactions,

long tubes with wide lumen. They are suited to transporting water and minerals up the plant, and also support the plant.

In the phloem, the cells also elongate, but their ends do not break down completely, but form sieve plates between the cells. Next to each sieve plate is a companion cell which is very metabolically active and used in moving the products of photosynthesis up and down the plant.

Palisade cells

Palisade cells within leaves are well adapted for photosynthesis because:

- Contain many chloroplasts (to absorb as much light as possible)
- Elongate (to fit many chloroplasts into the space)
- Thin walls so that Carbon dioxide can diffuse in
- Show cytoplasmic streaming (to move the chloroplasts around)
- Contain starch grains (to store products of photosynthesis)

- They are long and cylindrical, so that they pack together quite closely but with a little space between them for air to circulate; carbon dioxide in these air spaces diffuses into the cells
- They have a large vacuole so that the chloroplasts are positioned nearer to the periphery of the cell, reducing the diffusion distance for carbon dioxide
- They contain many chloroplasts – the organelles that carry out photosynthesis
- They contain cytoskeleton threats and motor proteins to move the chloroplasts – nearer to the upper surface of the leaf when sunlight intensity is low, but further down when it is high.

Erythrocytes (red blood cells) carry oxygen in the blood:

- Biconcave disc shape (to provide a large surface area to take up oxygen quickly)
- No nucleus = more room for haemoglobin (to bind to the oxygen)
- Small and flexible (to fit through tiny capillaries)

Neutrophils (engulf and digest foreign matter or old cells):

- Flexible shape (to enable movement through tissues)
- Lobed nucleus (to help movement through membranes)
- Many ribosomes (to manufacture digestive enzymes)
- Many lysosomes (to hold digestive enzymes and to break down the engulfed particles)
- Many mitochondria (to release the energy needed for activity)
- Well-developed cytoskeleton (to enable movement)
- Membrane-bound receptors (to recognise materials that need to be destroyed