Edexcel International AS Biology

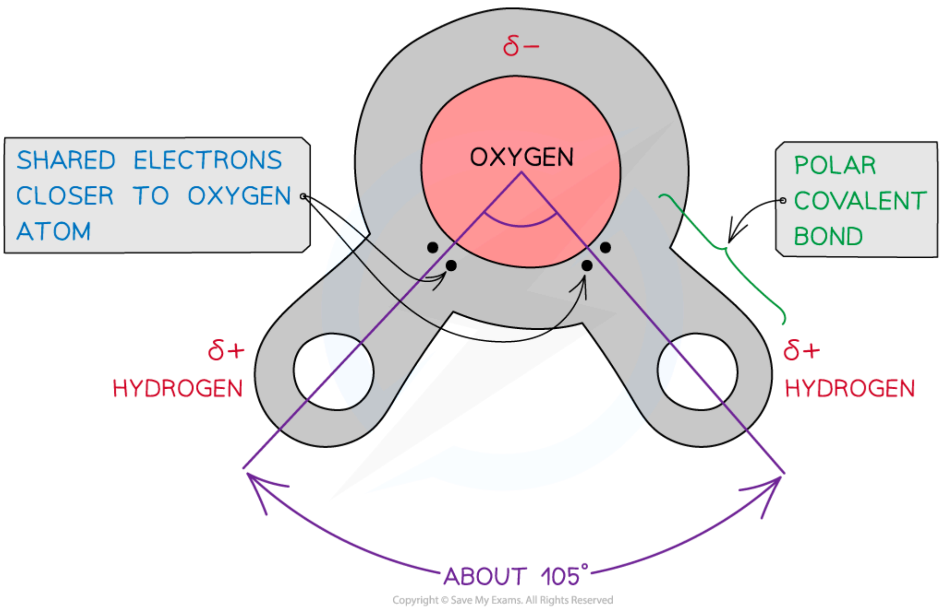
Your notes

Biological Molecules

Contents

The Importance of Water

- Water is the medium in which all metabolic reactions take place in cells and in which all substances are transported around the body
- Water is composed of atoms of **hydrogen and oxygen**
  - One atom of oxygen combines with two atoms of hydrogen by sharing electrons; this is **covalent bonding**
- The **sharing** of the **electrons** is **uneven** between the oxygen and hydrogen atoms
  - The oxygen atom attracts the electrons more strongly than the hydrogen atoms, resulting in a **weak negatively charged region** on the oxygen atom (δ^-) and a **weak positively charged region** on the hydrogen atoms (δ^+)
- This separation of charge due to the electrons in the covalent bonds being unevenly shared is called a **dipole**
- When a molecule has **one** end that is negatively charged and **one** end that is positively charged it is said to be a **polar molecule**
  - Water is a **polar** molecule

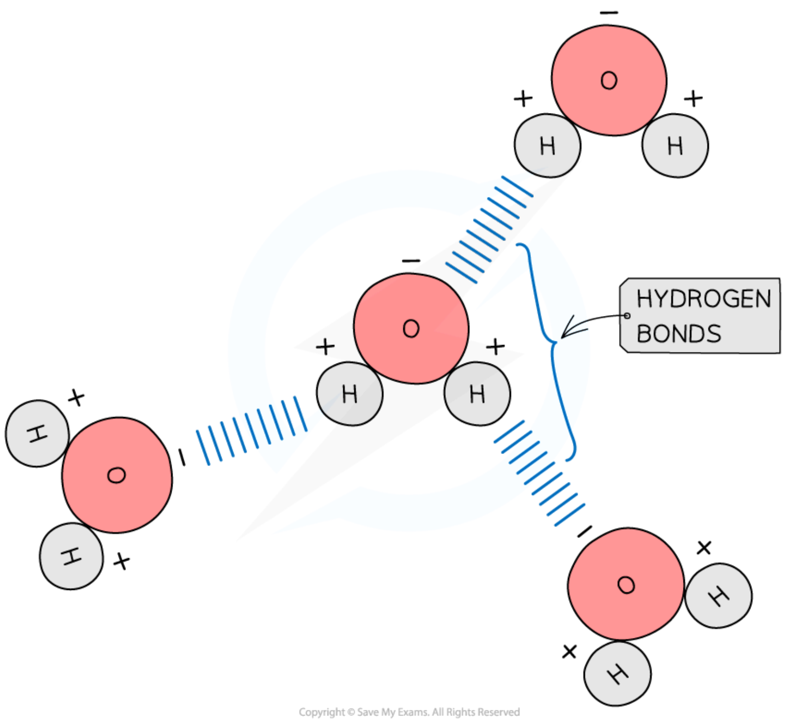


The covalent bonds of water make it a polar molecule

- **Hydrogen bonds** form between the positive and negatively charged regions of nearby water molecules as a result of the polar nature of water
  - Hydrogen bonds are weak when they are few in number, so they are constantly breaking and reforming; this means that water molecules flow past each other in a

liquid state

- Hydrogen bonds contribute to the many properties water molecules have that make them so important to living organisms



The polarity of water molecules allows hydrogen bonds to form between adjacent water molecules

Water's dipole nature makes it good at transporting substances

- The polar nature of water gives water properties that make it good at transporting substances
  - Water is **cohesive**
  - Water is a **solvent**

Cohesion and adhesion

- Hydrogen bonds between water molecules allow for strong **cohesion between water molecules**
  - **Cohesion** is the attraction of water molecules to each other
- Water is also able to form hydrogen bonds with **other molecules**; this is known as **adhesion**
- The forces of cohesion and adhesion within a body of water and between water and its surroundings mean that water **flows easily**
  - Water molecules pull other water molecules along due to cohesion

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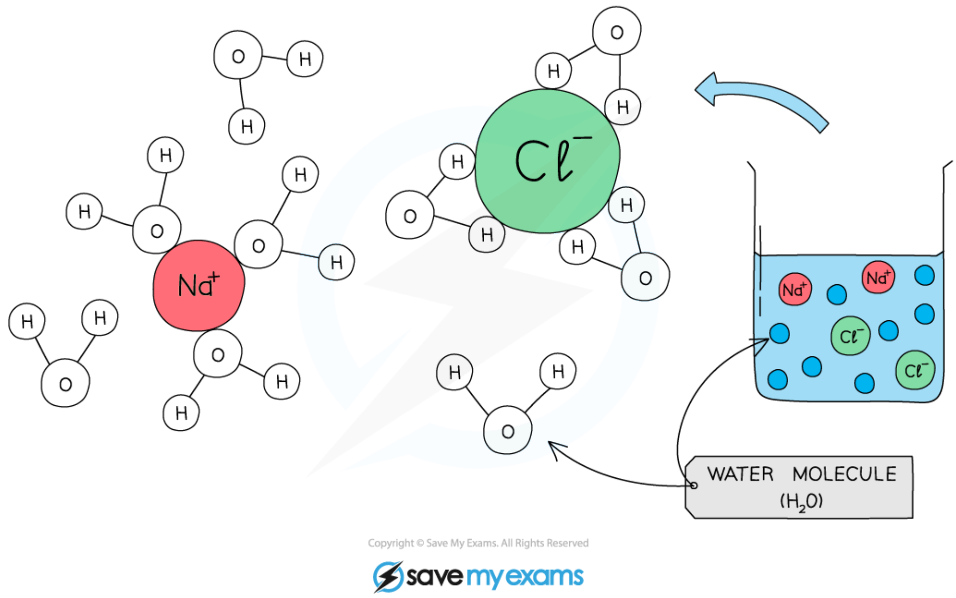
- Water adheres to the sides of a vessel due to adhesion

Solvent

- As water is a **polar molecule** many ions, e.g. sodium and chloride ions, and covalently bonded polar substances, e.g. glucose, will dissolve in it
    - Water molecules **surround charged particles**; the positive parts of water are attracted to negatively charged particles and the negative parts of water are attracted to positively charged particles
    - The surrounded molecules break apart e.g. sodium chloride molecules break into sodium ions and chloride ions
    - The ions surrounded by water molecules have **dissolved**
- This allows chemical reactions to occur within cells as the dissolved solutes are more chemically reactive when they are free to move about
- Metabolites can be transported efficiently in a dissolved state



Water molecules surround charged particles due to forces of attraction between polar water and the charged particles. The surrounded particles are said to have dissolved

Examiner Tips and Tricks

Examiners will often assess how structure relates to function so it is important you know the structure of water and how its properties help it carry out its role, specifically with regards to transport.

Your notes

Types of Saccharide

- **Carbohydrates** are one of the main carbon-based compounds in living organisms
- All molecules in this group contain **C**, **H** and **O**
  - Carbon atoms are key to the structure of organic compounds because
    - Each carbon atom can form **covalent bonds**; this makes the compounds very stable
      - Covalent bonds are so strong they require a large input of energy to break them
    - Carbon atoms can form covalent bonds with oxygen, nitrogen and sulfur
    - Carbon atoms can bond to form straight chains, branched chains, or rings
- Carbon compounds can form small, single subunits, or **monomers,** that bond with many repeating subunits to form large molecules, or **polymers**
  - This is a process called polymerisation
- The three types of carbohydrates are:
  - **monosaccharides**
    - The **monomers** of carbohydrates; they can join together to make carbohydrate polymers
    - Monosaccharides are simple carbohydrates
    - Monosaccharides are **sugars**, e.g. **triose** (3C) sugars, **pentose** (5C) sugars and **hexose** (6C) sugars
  - **disaccharides**
    - **Two monosaccharides** can join together via condensation reactions to form **disaccharides**
    - Examples include lactose and maltose
  - **polysaccharides**
    - Polysaccharides are carbohydrate polymers; **repeated chains of many monosaccharides**
    - Starch (including amylose and amylopectin), glycogen, and cellulose are examples of polysaccharides

Examiner Tips and Tricks

> Although cellulose is an important polysaccharide you do not need to know about it in this topic.

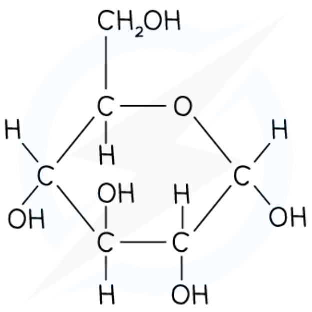
Your notes

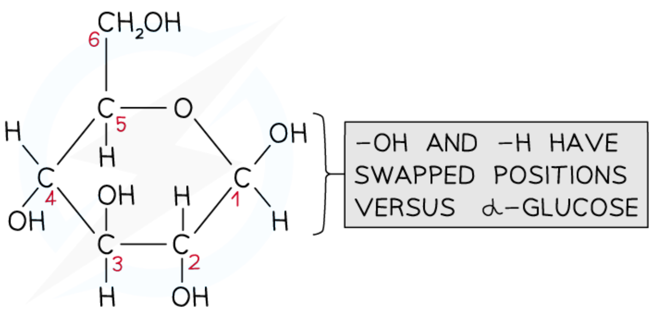
Saccharide Structure & Function

Monosaccharides

Monosaccharide structure

- **Glucose** is a well known example of a monosaccharide
  - Glucose is a **hexose sugar**
  - The six carbons that make up glucose form a **ring structure**
    - Carbons 1–5 form a ring, while carbon 6 sticks out above the ring
- Glucose comes in two forms; **alpha** (α) and **beta** (β)
  - The forms of glucose are almost identical; they differ only in the **location of the H and OH groups attached to carbon 1**
    - Alpha glucose has the H above carbon 1 and the OH group below
      - Remember = **a**lpha has the H **a**bove
    - Beta glucose has the H below carbon 1 and the OH group above
      - Remember = **b**eta has the H **b**elow





Alpha glucose (top) has the hydrogen above carbon 1 and the OH group below, while beta glucose (bottom) has the hydrogen below carbon 1 and the OH group above

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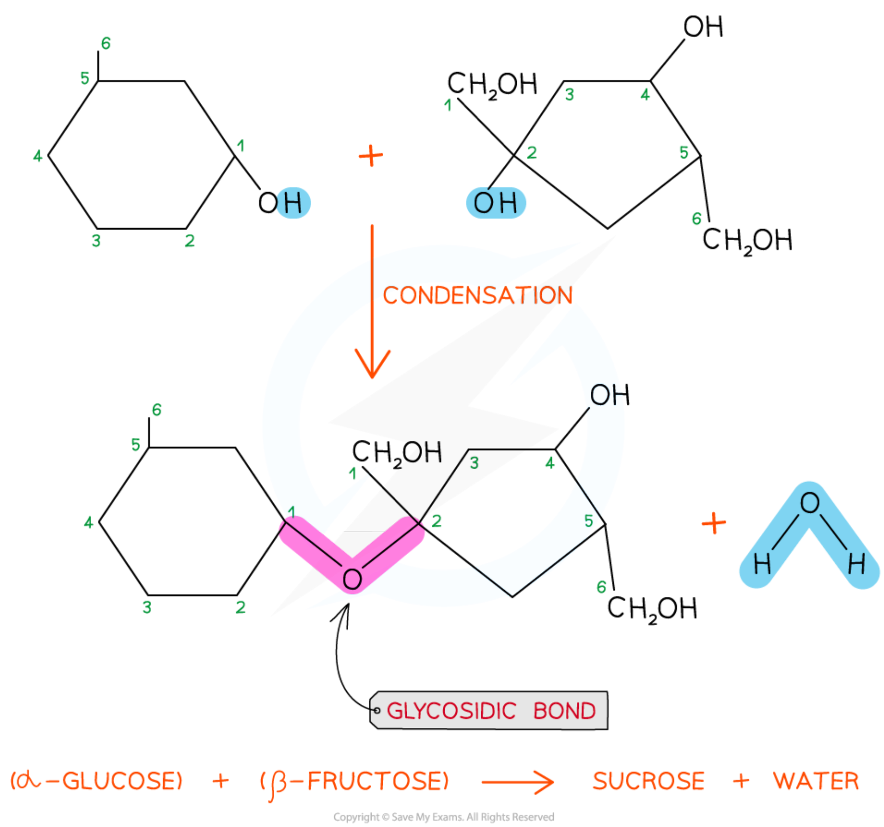
Monosaccharide function

- The main function of monosaccharides is **to store energy** within their bonds
  - When the bonds are broken during respiration, energy is released
- The structure of glucose is related to its function as the main energy store for animals and plants
  - It is **soluble** so can be transported easily
  - It has many **covalent bonds which store energy**
- Monosaccharides can combine through condensation reactions to form larger carbohydrates
- Some monosaccharides are used to **form long, structural fibres,** which can function as cellular support in some cell types

Disaccharides

Disaccharide structure

- Common examples of disaccharides include
  - **Maltose**
    - Contains two molecules of glucose linked by a 1,4 glycosidic bond
    - This means that the glycosidic bond is located between carbon 1 of one monosaccharide and carbon 4 of the other
  - **Sucrose**
    - Contains a molecule of glucose and a molecule of fructose linked by a 1,2 glycosidic bond
    - This means that the glycosidic bond is located between carbon 1 of one monosaccharide and carbon 2 of the other
  - **Lactose**
    - Contains a molecule of glucose and a molecule of galactose linked by a 1,4 glycosidic bond



Sucrose is a disaccharide formed from a molecule of glucose (left) and a molecule of fructose (right) joined together by a 1,2 glycosidic bond

Disaccharide function

- The function of disaccharides is to **provide the body with a quick-release source of energy**
  - Disaccharides are made up of two sugar molecules so they're easily broken down by enzymes in the digestive system into their respective monosaccharides and then absorbed into the bloodstream
- Due to the presence of a large number of hydroxyl groups, **disaccharides are easily soluble in water**
  - These hydroxyl groups form hydrogen bonds with the water molecules when dissolved in aqueous solutions
- Just like monosaccharides they are **sweet in taste**
  - Sucrose, also known as table sugar, is an example

Polysaccharides

Starch: structure

- Starch is constructed from **two different polysaccharides**
  - **Amylose**

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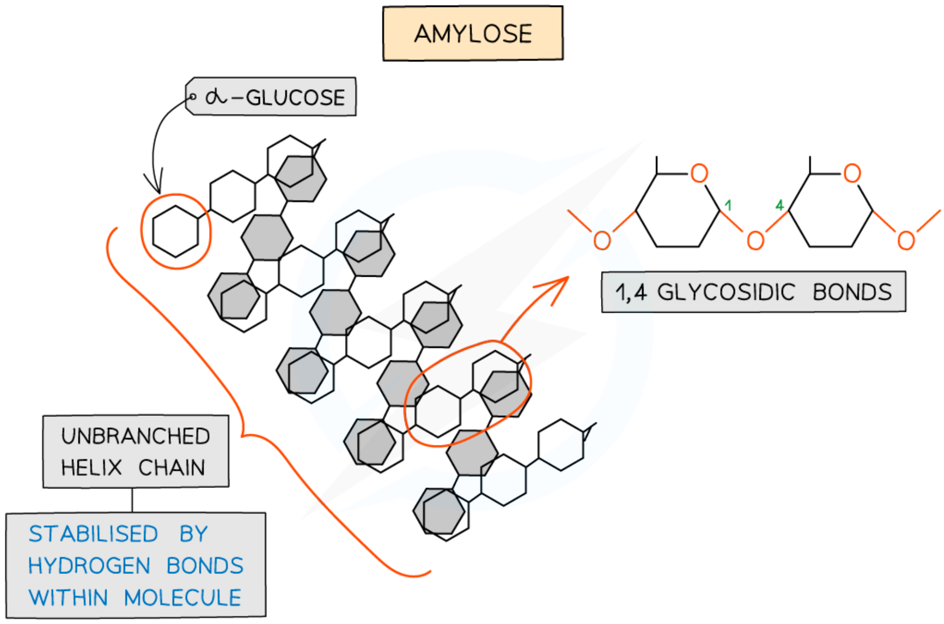
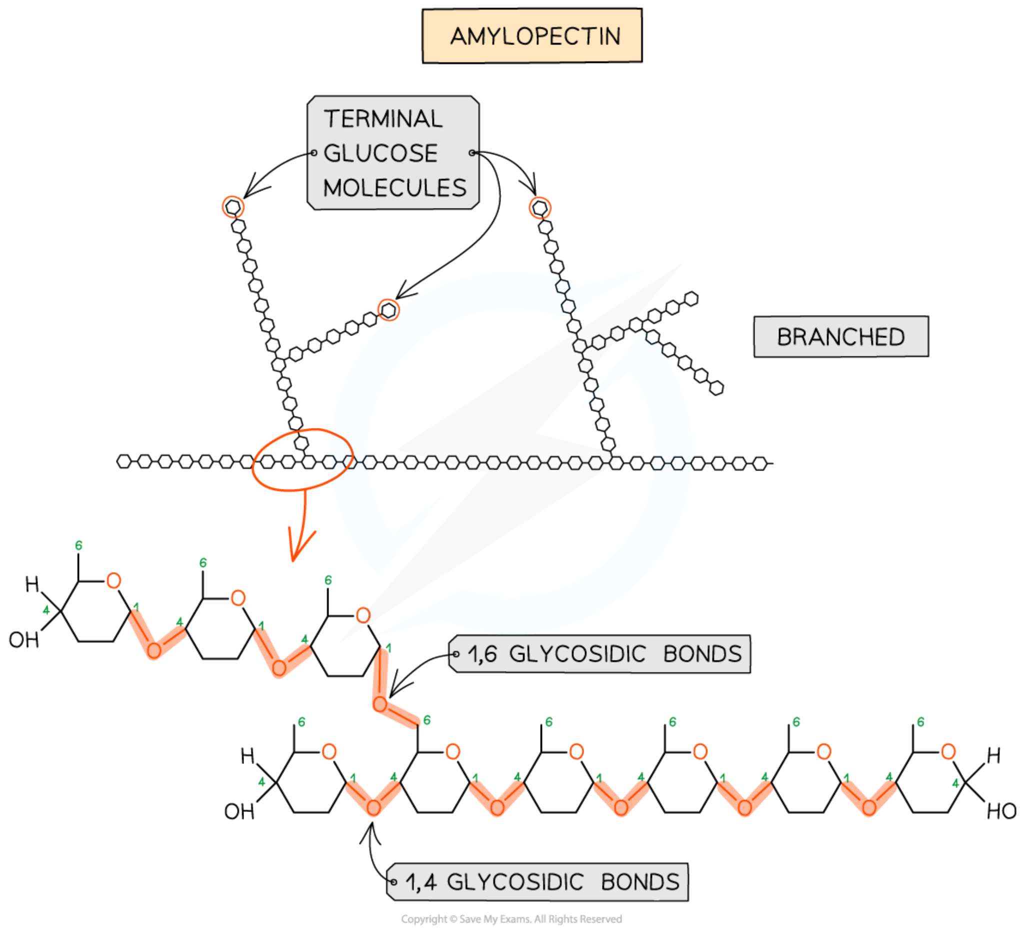
- Unbranched **helix-shaped** chain with 1,4 glycosidic bonds between α-glucose molecules
  - A helix is a spiral shape
- The helix shape enables it to be more **compact** and thus more can be stored
- **Amylopectin**
  - A **branched molecule** containing 1,4 glycosidic bonds between α-glucose molecules **and** 1,6 glycosidic bonds
  - The branches result in many terminal glucose molecules that can be **easily hydrolysed** for use during cellular respiration or added to for storage
- Both forms of starch are **insoluble**, so they do not dissolve and **won't alter the water potential** of cells



Amylose is a helix-shaped polysaccharide found in starch, the storage polysaccharide in plants



Amylopectin is a branched polysaccharide found in starch

Starch: function

- Starch is the **storage** polysaccharide of **plants;** it is stored as granules in **plastids**
  - Plastids are **membrane-bound organelles** that can be found in plant cells
    - They have a specialised function, e.g. amyloplasts store starch grains and chloroplasts carry out photosynthesis
- The **amylose** in starch has a helical structure which makes it very compact, meaning that much can be stored in a small space
- The **amylopectin** in starch has branches that provide many terminal glucose molecules that can be **easily hydrolysed** for use during cellular respiration or added for storage

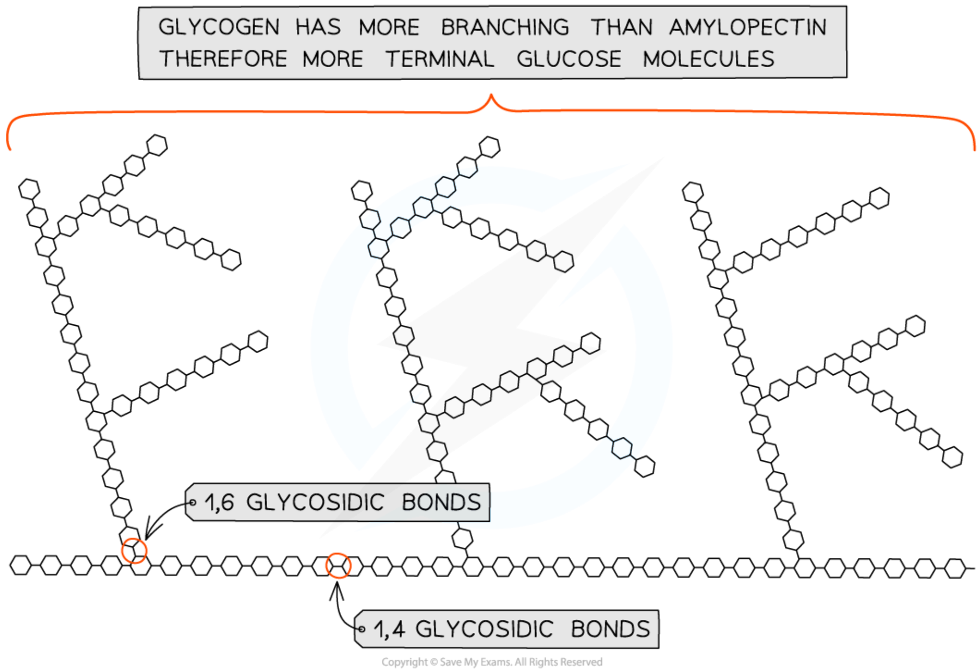
Glycogen: structure

- Glycogen contains both **1,4** and **1,6 glycosidic bonds**
- Glycogen is **more branched than amylopectin**
  - The branching provides more terminal glucose molecules which can either be **added to or removed by hydrolysis**; this allows the **quick** storage or release of glucose to suit the demands of the cell

Your notes

- This is essential in animal cells as animals are very metabolically active

- Glycogen is compact, which means that much can be stored in a small space
  - Liver and muscles cells have a high concentration of glycogen, present as **visible granules**; this enables a high cellular respiration rate
- Glycogen is insoluble



Glycogen is a highly branched molecule used as a storage polysaccharide in animals and fungi

Glycogen: function

- Glycogen is the **storage** polysaccharide of **animals** and **fungi**
- Glycogen is **more branched than amylopectin**
  - The branching provides more terminal glucose molecules which can either be **added to or removed by hydrolysis**; this allows the **quick** storage or release of glucose to suit the demands of the cell
    - This is essential in animal cells as animals are very metabolically active
- Glycogen is compact which means that much can be stored in a small space
  - Liver and muscles cells have a high concentration of glycogen, present as **visible granules**; this enables a high cellular respiration rate

Summary of Storage Polysaccharides Table

Your notes

Your notes

Feature	Starch		Glycogen
	Amylose	Amylopectin	
Monomer	α−glucose	α−glucose	α−glucose
Branched	No	Yes (~ every 20 monomers)	Yes (~ every 10 monomers)
Helix (coiled) shape	Yes	No	No
Glycosidic bonds present	1,4	1, 4 and 1,6	1, 4 and 1,6
Source	plant	plant	animal

Types of Carbohydrate Summary Table

	Monosaccharide	Disaccharide	Polysaccharide
Definition	single sugar monomer, all are reducing sugars	a sugar formed from **two** monosaccharides joined by a **glycosidic** bond in a condensation reaction	a **polymer** formed by **many** monosaccharides joined by **glycosidic** bonds in a **condensation** reaction
Examples	◦ glyceraldehyde (3C) ◦ ribose (5C) ◦ glucose (6C)	◦ maltose (α−glucose + α−glucose) ◦ sucrose (α−glucose + fructose) ◦ lactose (α−glucose + β−galactose)	◦ cellulose (β−glucose) ◦ starch (α−glucose in the form of amylose and amylopectin) ◦ glycogen (α−glucose)
Function	◦ source of energy in respiration ◦ building blocks for polymers	◦ sugar found in germinating seeds (maltose) ◦ mammal milk sugar (lactose) ◦ sugar stored in sugar cane (sucrose)	◦ energy storage (plants – starch and animals – glycogen) ◦ structural – cell wall

Your notes

Your notes

Concentration of Sugars

- There are a number of tests that can be carried out quickly and easily in a lab to determine if a sample contains a certain type of sugar
- Depending on how the tests are carried out, they can produce qualitative or semi-quantitative results
- Sugars can be classified as **reducing** or **non-reducing**; this classification is dependent on their ability to donate electrons (a reducing sugar that is able to donate electrons is itself oxidised)
  - **OILRIG** in Chemistry

Qualitative Benedict's test: detecting the presence of reducing sugars

- Benedict's reagent is a **blue** solution that contains copper (II) sulfate ions ($CuSO_4$); in the presence of a reducing sugar copper (I) oxide forms
  - Copper (I) oxide is not soluble in water, so it forms a **precipitate**

Apparatus

- Beaker
- Bunsen burner
- Tripod
- Gauze
- Test tubes
- Test tube rack
- Tongs
- Heatproof gloves
- Goggles
- Benedict's reagent
- Test sample
- Water bath

Method

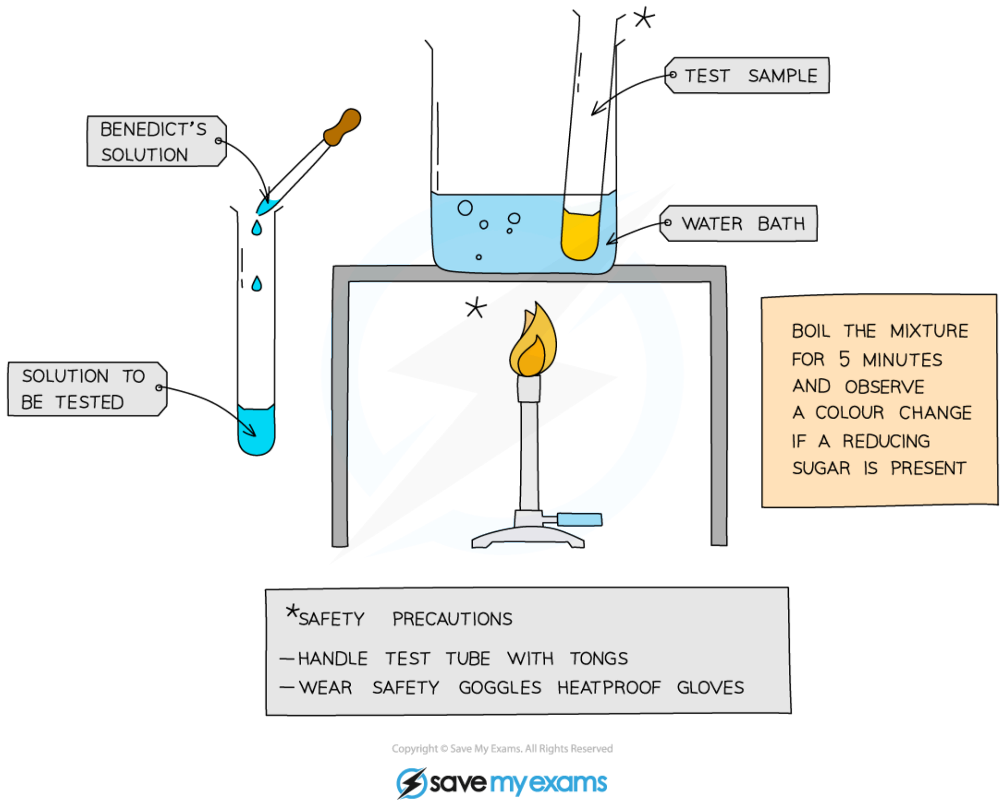
1. Add **Benedict's reagent** (which is blue as it contains copper (II) sulfate ions) to a sample solution in a test tube

2. **Heat** the test tube in a water bath or beaker of water that has been brought to a boil for a few minutes
3. If a reducing sugar is present, a coloured precipitate will form as copper (II) sulfate is reduced to copper (I) oxide which is insoluble in water
    - It is important that an **excess** of Benedict's solution is used so that there is more than enough copper (II) sulfate present to react with any sugar present

Your notes

Results and analysis

- A positive test result is a colour change somewhere along a colour scale from blue (no reducing sugar), through green, yellow and orange (low to medium concentration of reducing sugar) to **brown/brick-red** (a high concentration of reducing sugar)



The Benedict's test for reducing sugars produces a colour change from blue towards red if a reducing sugar is present

Testing for non-reducing sugars

- Some sugars don't react with Benedict's reagent; these are known as **non-reducing** sugars
- A few extra steps can be taken to test for non-reducing sugars using Benedict's reagent

Method

Your notes

1. Add **dilute hydrochloric acid** to the sample and heat in a water bath that has been brought to the boil
2. **Neutralise** the solution with **sodium hydrogencarbonate**
   - Use a suitable indicator (such as red litmus paper) to identify when the solution has been neutralised, and then add a little more sodium hydrogencarbonate as the conditions need to be slightly alkaline for Benedict's test to work
3. Then carry out Benedict's test as normal
   - Add Benedict's reagent to the sample and heat in a water bath that has been boiled – if a colour change occurs, a reducing sugar is present

Results and analysis

- The addition of acid will **hydrolyse any glycosidic bonds** present in any carbohydrate molecules
- The resulting monosaccharides left will have an aldehyde or ketone functional group that can **donate electrons** to copper (II) sulfate (reducing the copper), allowing a precipitate to form

Reducing & Non-reducing Sugars Table

Reducing Sugars	Non-Reducing Sugars
Galactose Glucose Fructose Maltose	Sucrose – the only one you really need to know!

Semi-quantitative Benedict's test: estimating the concentration of reducing sugars

- Benedict's solution can be used to carry out a semi-quantitative test on a reducing sugar solution to determine the **concentration** of reducing sugar present in the sample
  - It is important that an excess of Benedict's solution is used so that there is more than enough copper (II) sulfate present to react with any sugar present
- The **intensity of any colour change** seen relates to the **concentration** of reducing sugar present in the sample
  - A positive test is indicated along a spectrum of colour from green (low concentration) to brick-red (high concentration of reducing sugar present)

Additional apparatus

- Colourimeter
- Cuvettes
- Pencil
- Graph paper
- Water
- Pipettes
- Stopwatch

Method

1. Set up **standard solutions** with known concentrations of a reducing sugar (such as glucose)
   - These solutions should be set up using a **serial dilution** of an existing stock solution
2. Each solution is then treated in the same way
   - Add the same volume of **Benedict's** reagent to each sample and **heat** in a water bath that has been boiled (ideally at the same temperature each time) for a **set time** (5 minutes or so) to allow colour changes to occur
   - It is important to ensure that an **excess** of Benedict's solution is used
3. The same procedure is carried out on a sample with an **unknown concentration** of reducing sugar which is then **compared to the stock solution colours**
4. To avoid issues with human interpretation of colour, a **colourimeter** is used
   - A sample of each known solution is added to **cuvettes** which are then inserted into a colourimeter to measure the **absorbance** or **transmission of light** to establish a range of values that form a **calibration curve**

Results and analysis

- The **unknown sample can be compared** against the calibration curve to estimate the concentration of reducing sugar present

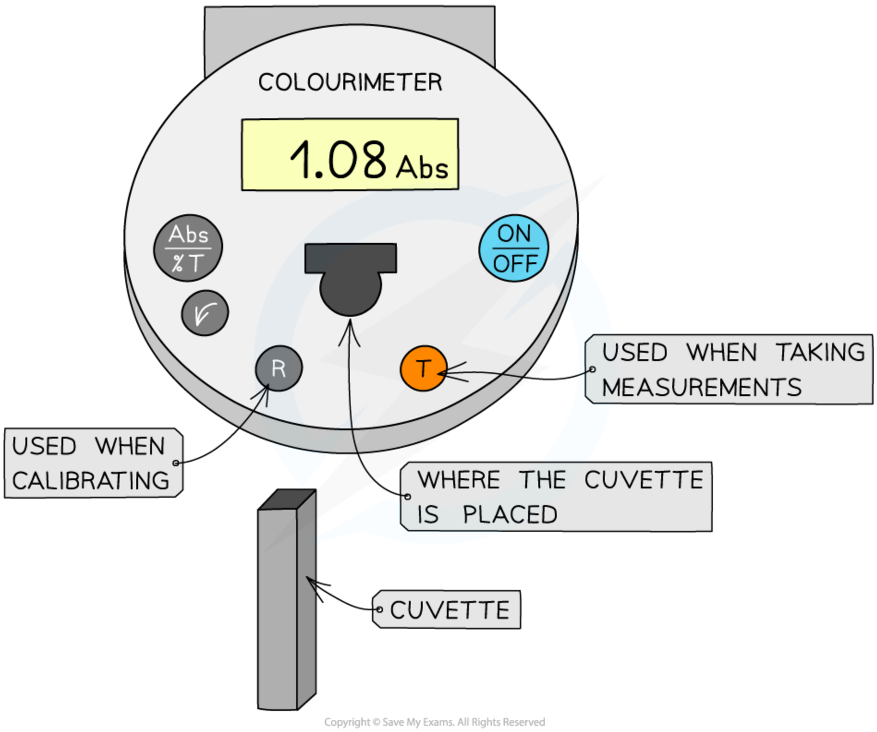
Colorimeter

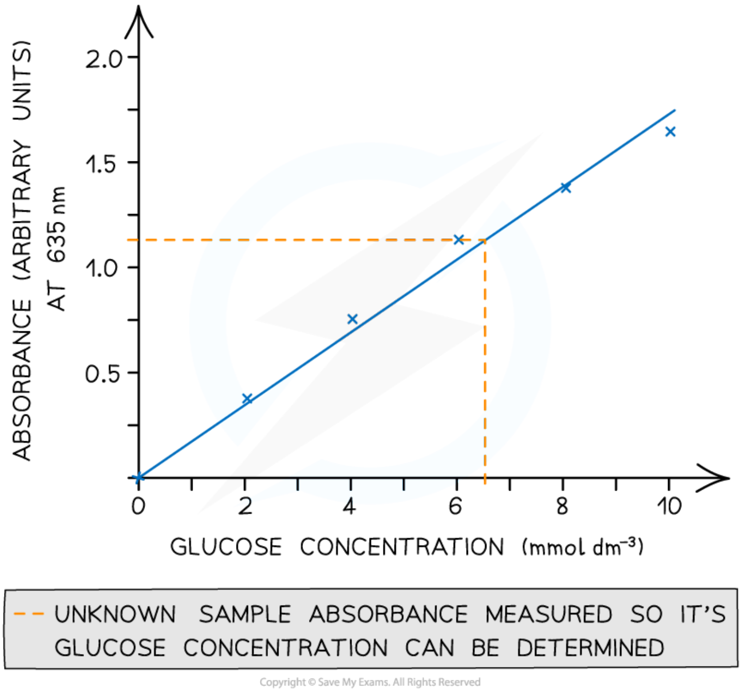
- A colorimeter is an instrument that beams a specific wavelength (colour) of light through a sample and measures how much of this light is **absorbed** by the sample
  - Colour filters are used to control the light wavelength emitted
  - The colour used will be **in contrast** to the colour of the solution, e.g. Benedict's solution turns orange in the presence of sugar, so the colorimeter will *assess the intensity of the orange* colour; in order to do this a blue light filter would be used to shine blue light through the sample
    - Blue light is absorbed by an orange solution as orange light is reflected to give the orange appearance

Your notes

Your notes

    - The extent to which the blue light is absorbed will differ depending on the intensity of the orange colour; a solution that is orange/green will absorb less blue light than a solution that is brick red
    - The absorbance value therefore provides a **quantitative** measure of the strength of the orange colour
- Colorimeters must be **calibrated** before taking measurements
    - This is completed by placing a blank into the colorimeter and taking a reference; it should read 0 (that is, no light is being absorbed)
    - This step should be repeated periodically whilst taking measurements to ensure that the absorbance is still 0
- The results can then be used to plot a calibration or standard curve
    - Absorbance against the known concentrations can be used
    - Unknown concentrations can then be determined from this graph



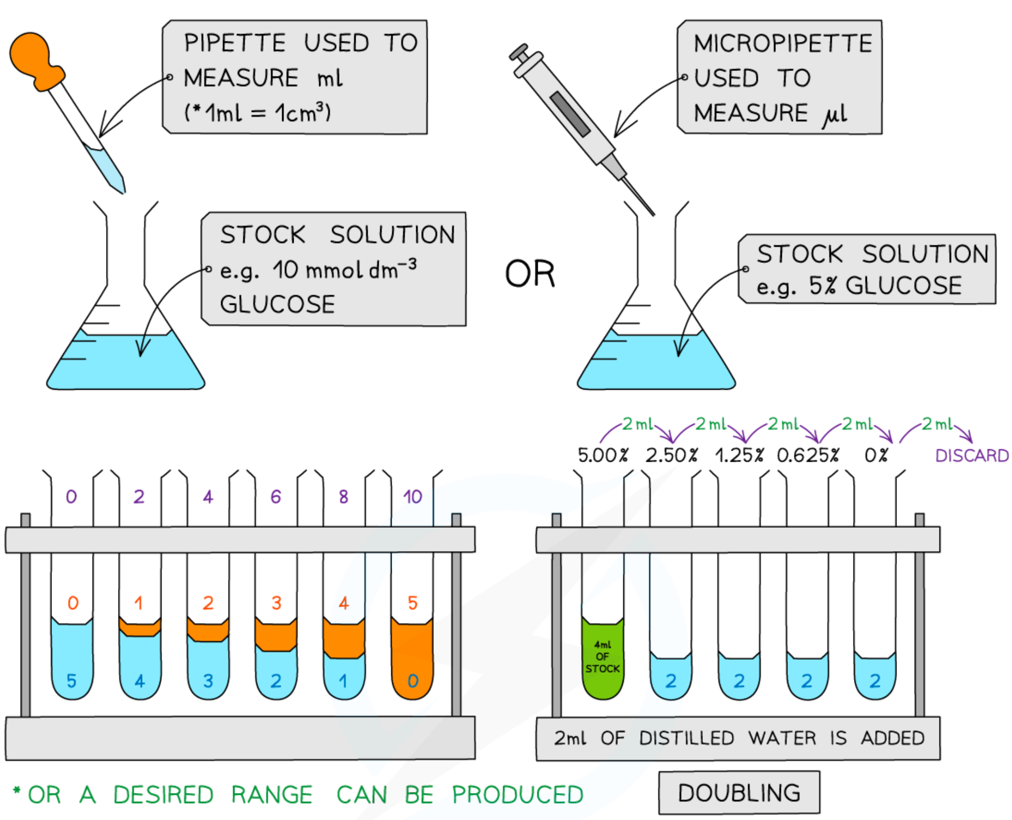


A colourimeter is used to obtain quantitative data that can be plotted to create a calibration curve to be used to find unknown concentrations

Serial dilutions

- Serial dilutions are created by taking a series of dilutions of a stock solution. The concentration decreases by the **same** quantity between each test tube
  - They can either be 'doubling dilutions' (where the concentration is halved between each test tube) or a desired range (e.g. 0, 2, 4, 6, 8, 10 mmol dm^{-3})
- Serial dilutions are completed to create a standard to compare unknown concentrations against
  - The comparison can be:
    - Visual
    - Measured through a calibration/standard curve
    - Measured using a colourimeter
  - They can be used when:
    - Counting bacteria or yeast populations
    - Determining unknown glucose, starch, protein concentrations

Your notes



*OR A DESIRED RANGE CAN BE PRODUCED
e.g.

Glucose conc. mmol dm^{-3}	Vol of distilled H_2O $(cm)^3$	Vol of glucose stock solution $(cm)^3$
0	5	0
2	4	1
4	3	2
6	2	3
8	1	4
10	0	5

THESE QUANTITIES ARE DETERMINED BY:

$$\frac{\text{DESIRED CONCENTRATION}}{\text{CONCENTRATION OF STOCK}} \times \text{VOLUME WANTED}$$

e.g. $\frac{2}{10} \times 5\,cm^3 =$ 1 cm^3 OF GLUCOSE STOCK SOLUTION

Making serial dilutions

Concentration of Starch

Qualitative iodine test: detecting the presence of starch

- Iodine solution can be used to test for the presence of starch in a test sample

Apparatus

- Test sample
- Iodine solution
- Spotting tile
- Gloves

Your notes

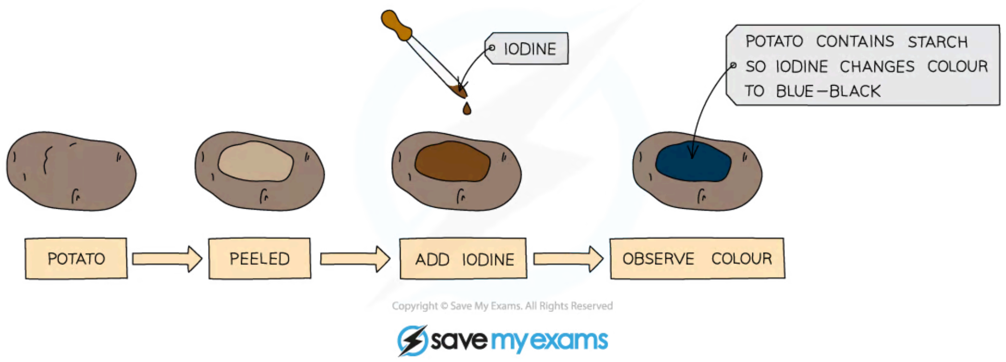
- Goggles

Method

1. Add a few drops of **orange/brown iodine** solution to the test sample

Results and analysis

- If starch is present, iodide ions in the solution interact with the centre of starch molecules, producing a complex with a distinctive **blue-black colour**
- This test is useful in experiments for showing that starch in a sample has been digested by enzymes



Iodine test for the presence of starch

Semi-quantitative iodine test: estimating the concentration of starch

- Iodine solution can be used to carry out a semi-quantitative test on a food sample to determine the **concentration** of starch present in the sample
- The **intensity of any colour change** seen relates to the **concentration** of starch present in the sample
  - A positive test is indicated along a spectrum of colour from dark brown (low concentration) to blue-black (high concentration of starch present)

Additional apparatus

- Colourimeter
- Cuvettes
- Pencil
- Graph paper
- Test tubes
- Test tube rack
- Water

Your notes

- Pipettes
- Liquid food sample
- Stopwatch

Method

1. Set up **standard solutions** with known concentrations of starch
   - These solutions should be set up using a **serial dilution** of an existing stock solution
2. Each solution is then treated in the same way
   - Add the same volume of **iodine solution** to each sample and allow colour changes to occur within a set time
3. The same procedure is carried out on a sample with an **unknown concentration** of starch (food sample) which is then **compared to the stock solution colours**
4. To avoid issues with human interpretation of colour, a **colourimeter** is used
   - A sample of each known solution is added to **cuvettes** which are then inserted into a colourimeter to measure the **absorbance** or **transmission of light** to establish a range of values that form a **calibration curve**

Results and analysis

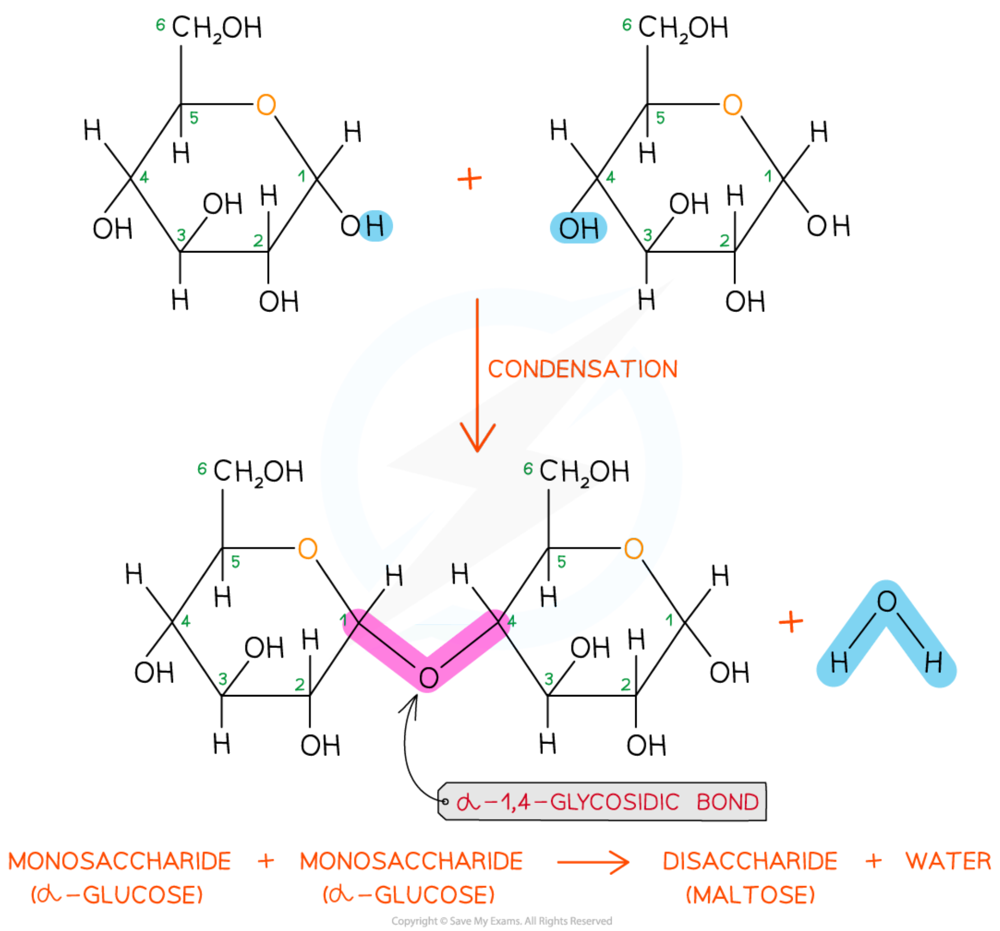
- The **unknown sample can be compared** against the calibration curve to estimate the concentration of starch present

Your notes

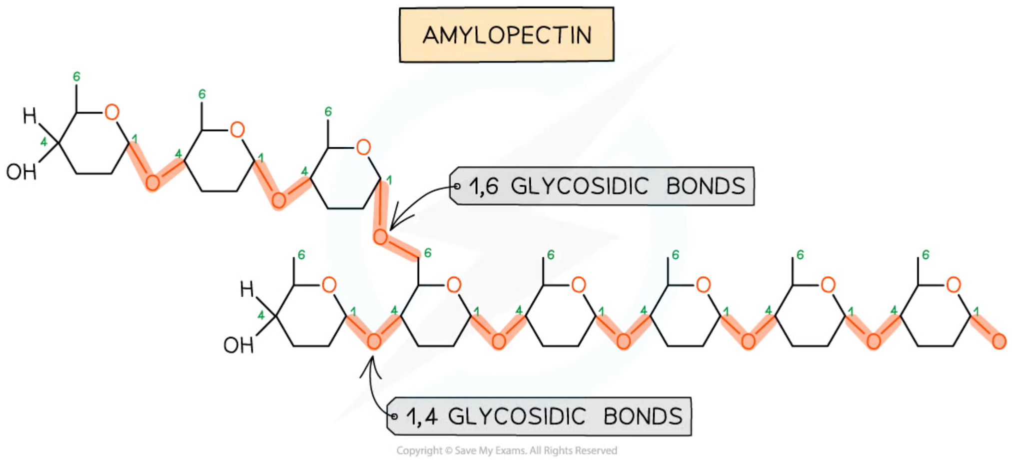
Condensation & Hydrolysis

Forming a glycosidic bond: condensation reaction

- To make monosaccharides more suitable for storage they are bonded together to form **disaccharides** and **polysaccharides**
  - Polysaccharides are insoluble so have less influence on the process of osmosis
- Disaccharides and polysaccharides are formed when **two hydroxyl (OH) groups** on different monosaccharides interact to form a **strong covalent bond** called a **glycosidic bond**
- The name of the glycosidic bond that forms depends on the **location of the OH groups** on the monosaccharides concerned, e.g.
  - If the OH groups are located on carbon 1 of one monosaccharide and carbon 4 of the other, a **1,4 glycosidic bond forms**
  - If the OH groups are located on carbon 1 of one monosaccharide and carbon 6 of the other, a **1,6 glycosidic bond forms**
- Every glycosidic bond results in **one water molecule being released**, thus glycosidic bonds are formed by a **condensation reaction**



Glycosidic bonds form through condensation reactions, during which a water molecule is released. When two glucose molecules are joined by a glycosidic bond, the resulting disaccharide is maltose



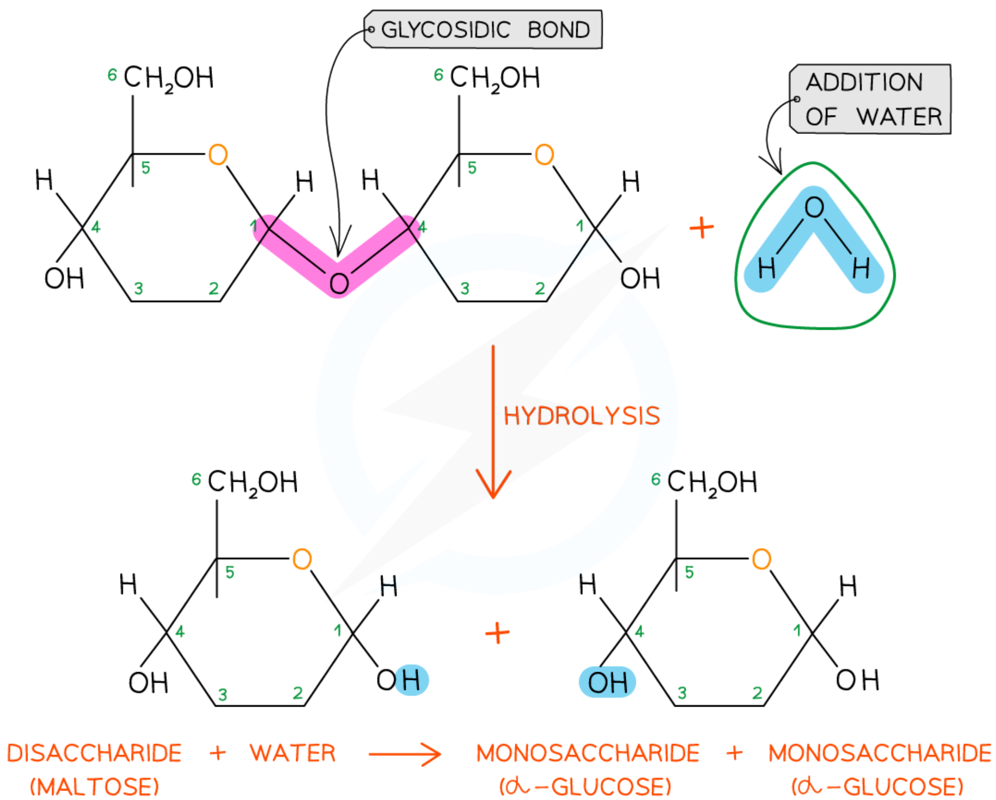
Glycosidic bonds can link monosaccharides together to form polysaccharides such as amylopectin, a form of starch. Amylopectin contains 1,4 and 1,6 glycosidic bonds

Your notes

- There are many different types of monosaccharide, which join together to form **different disaccharides,** e.g.
  - Two molecules of glucose join to form **maltose**
  - Glucose joins with the monosaccharide fructose to form **sucrose**
  - Glucose joins with the monosaccharide galactose to form **lactose**

Breaking a glycosidic bond: hydrolysis reaction

- The glycosidic bond is broken when **water is added** in a **hydrolysis reaction**
  - Hydro = water
  - Lysis = to break
- Examples of hydrolytic reactions include the **digestion of food** in the alimentary tract and the **breakdown of stored carbohydrates** in muscle and liver cells for use in cellular respiration



Glycosidic bonds are broken when water is added in a hydrolysis reaction

Your notes

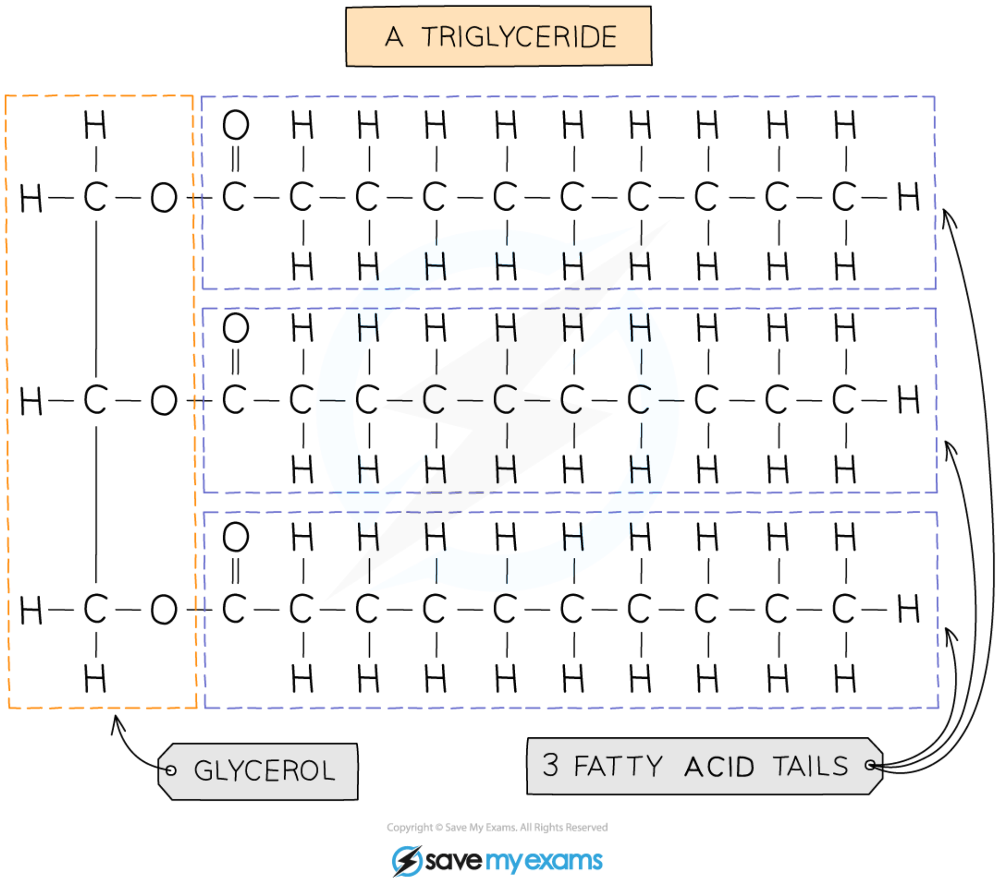
Triglyceride Formation

Lipids

- Lipids are macromolecules that contain carbon, hydrogen and oxygen atoms. Unlike carbohydrates, lipids contain a lower proportion of oxygen
- Lipids are non-polar and **hydrophobic** (**insoluble** in water)
- **Triglycerides** are a kind of lipid that forms the main component of fats and oils
- Lipids play an important role in **energy yield, energy storage, insulation and hormonal communication**

Triglycerides

- Are non-polar, hydrophobic molecules
- The monomers are **glycerol** and **fatty acids**
- Glycerol is an alcohol (an organic molecule that contains a hydroxyl group bonded to a carbon atom)
- Fatty acids contain a **methyl** group at one end of a **hydrocarbon** chain known as the R group (chains of hydrogens bonded to carbon atoms, typically 4 to 24 carbons long) and at the other is a **carboxyl** group
  - The shorthand chemical formula for a fatty acid is **RCOOH**



The basic structure of a triglyceride

Function of lipids

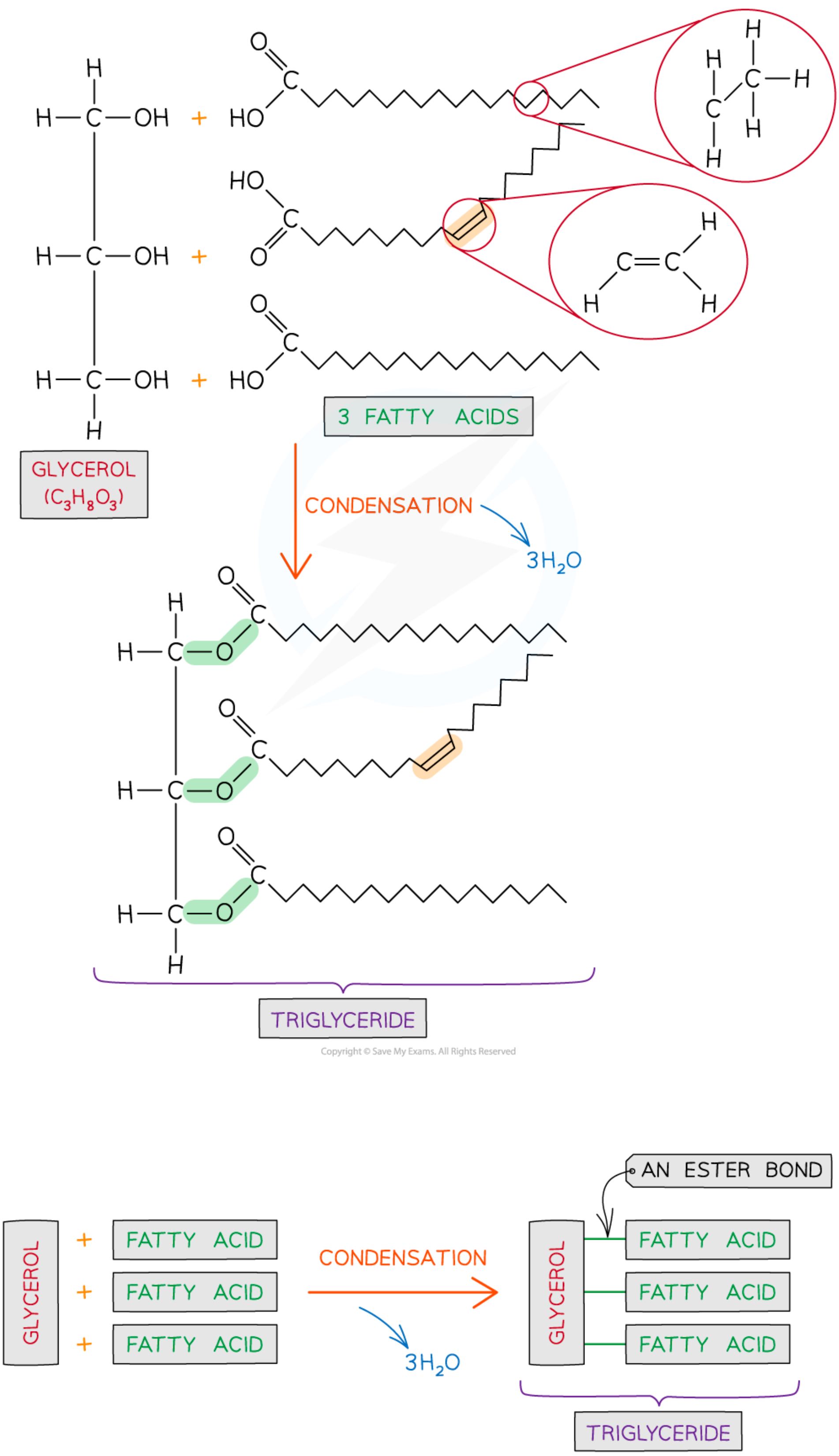
- Triglycerides are **fats and oils**
- **Fatty acid and glycerol molecules** are the components that make up triglycerides
- Fats and oils have a number of important functions in organisms: **energy storage**, **insulation**, **buoyancy**, and **protection**

Forming an ester bond: condensation reaction

- Triglycerides are formed by **esterification**
- An **ester bond** forms when the hydroxyl (-OH) group of the glycerol bonds with the carboxyl group (-COOH) of the fatty acid
  - The formation of an ester bond is a **condensation reaction**
  - For each ester bond formed a water molecule is released
  - **Three fatty acids** join to **one glycerol** molecule to form a **tri**glyceride
  - Therefore for one triglyceride to form, **three water molecules** are released

Your notes

Your notes



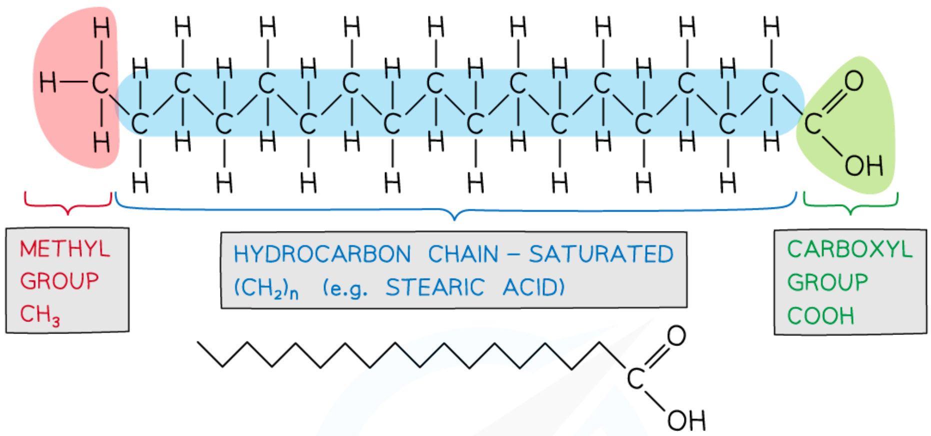
Formation of a triglyceride from a glycerol molecule and three fatty acid molecules by the process of esterification

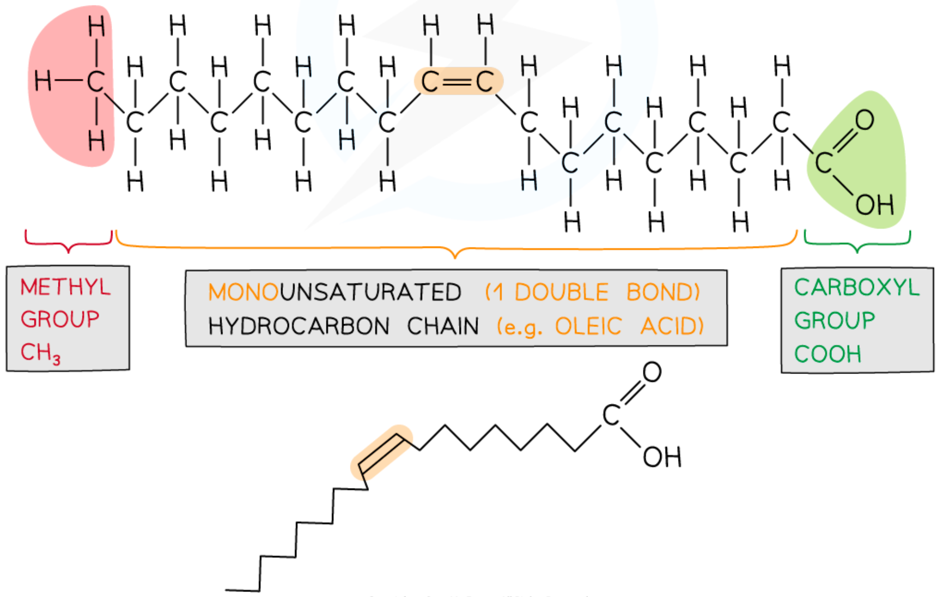
Types of Fatty Acid in Lipids

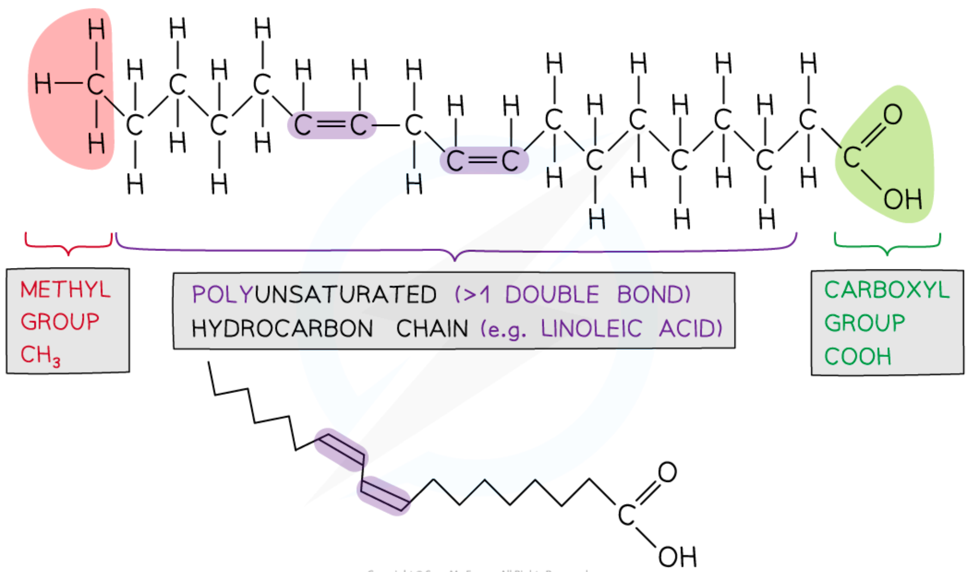
Your notes

- Fatty acids contain a **methyl** group at one end of a **hydrocarbon** chain known as the R group (chains of hydrogens bonded to carbon atoms, typically 4 to 24 carbons long) and at the other is a **carboxyl** group
  - The shorthand chemical formula for a fatty acid is **RCOOH**
- **Fatty acids** can vary in two ways:
  - **Length** of the hydrocarbon chain (R group)
  - The fatty acid chain (R group) may be **saturated** (mainly in animal fat) or **unsaturated** (mainly vegetable oils, although there are exceptions e.g. coconut and palm oil)
- **Saturated** fatty acids contain **no carbon-carbon double bonds**
  - The hydrocarbon chain is **saturated with hydrogen atoms** due to the absence of double bonds
  - They form unbranched, linear chains
- **Unsaturated** fatty acids can be **mono** or **poly-unsaturated** depending on the number of carbon-carbon double bonds present
  - If H atoms are on the same side of the double bond they are *cis*-fatty acids and are metabolised by enzymes
  - If H atoms are on opposite sides of the double bond they are *trans*-fatty acids and cannot form enzyme-substrate complexes, therefore, are not metabolised. They are linked with coronary heart disease

Your notes


METHYL GROUP CH_3
HYDROCARBON CHAIN – SATURATED $(CH_2)_n$ (e.g. STEARIC ACID)
CARBOXYL GROUP COOH


METHYL GROUP CH_3
MONOUNSATURATED (1 DOUBLE BOND) HYDROCARBON CHAIN (e.g. OLEIC ACID)
CARBOXYL GROUP COOH


METHYL GROUP CH_3
POLYUNSATURATED (>1 DOUBLE BOND) HYDROCARBON CHAIN (e.g. LINOLEIC ACID)
CARBOXYL GROUP COOH

Examples of different types of fatty acids with the functional groups and presence of double bonds highlighted

Your notes

Examiner Tips and Tricks

Ensure you are confident with the structure of a triglyceride so you can recognise whether they are saturated or unsaturated.