

Functions of carbohydrates

| Function | Description |
|--|---|
| Source of energy | <ul style="list-style-type: none">The average energy yield is 17kJ/g. Carbohydrates are readily available and easy to digest, hence they are a convenient source of energy. |
| Support | <ul style="list-style-type: none">Some carbohydrates are able to form supporting structures, e.g. cellulose in the cell walls of plants. |
| Starting point for the manufacture of other substances | <ul style="list-style-type: none">Excess carbohydrates can be converted into amino acids and fats. Some may be used to form nucleic acids. |
| Production of nectar | <ul style="list-style-type: none">Carbohydrates are used to produce nectar in flowers. |

Groups of carbohydrates

- There are three main groups of carbohydrates:
 - ✓ Simple sugars (Monosaccharides)
 - ✓ Complex sugars
 - Disaccharides
 - Polysaccharides

Monosaccharides

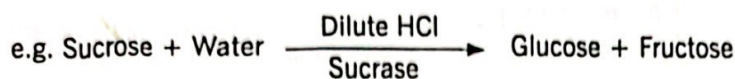
- Monosaccharides are simple sugars which include **glucose**, **fructose** (fruit sugar) and **galactose** (milk sugar).
- All simple sugars have the formula of $C_6H_{12}O_6$ but differ in the arrangement of various atoms in the molecule. This gives rise to different chemical and biological properties.
- Glucose** is most readily transported in the bodies of organisms. In this way it is easily metabolised when needed, eg. glucose circulating in the blood in human body.

Disaccharides

- Glucose has to be converted into a transport form before it can be moved from place to place, so that it is less readily consumed.
- Disaccharides are the result of the **combination of two simple sugars**. All of them have the same chemical formula of $C_{12}H_{22}O_{11}$.
- Disaccharides are **formed during condensation reactions** whereby two simple sugars are combined together with the **loss of one water molecule**.

| Type of disaccharide | Description |
|----------------------|---|
| Sucrose | <ul style="list-style-type: none">Glucose + Fructose → Sucrose + WaterSucrose is a common transport form of sugar in plants.It is found in sweet fruits and sugar cane stems.Sucrose is not found in mammals. |
| Maltose | <ul style="list-style-type: none">Glucose + Glucose → Maltose + WaterMaltose is formed when starch is partially digested.It is found in barley seeds which can be used during fermentation to produce beer. |
| Lactose | <ul style="list-style-type: none">Glucose + Galactose → Lactose + WaterIt is found in the milk of all mammals. |

- Disaccharides are split by treating them with an **acid** or a **suitable enzyme**. They are said to undergo a **hydrolytic reaction** or **hydrolysis** as a water molecule has been added to the disaccharide.



Polysaccharides

- Glucose can be converted into an **insoluble form** for storage.
- Polysaccharides consist of monosaccharide sugar **subunits** joined together in a long chain.
- This process of joining monosaccharides into a long chain is called **polymerisation**.

| Type of polysaccharides | Description |
|-------------------------|---|
| Starch | <ul style="list-style-type: none"> Long chain polysaccharide formed from glucose subunits Relatively insoluble and thus ideal for storage Not formed or stored by animals Amylase can partially hydrolyse starch to form maltose which is further broken down to glucose by maltase |
| Cellulose | <ul style="list-style-type: none"> Cellulose is not easily broken down, hence it is suitable as a biological structural material Consists of glucose subunits linked together in a straight chain Major component of dietary fibre for humans |
| Glycogen | <ul style="list-style-type: none"> Storage form of carbohydrates in animals and fungi In humans, glycogen is stored in the liver and muscles Formed when many glucose molecules condense into a highly branched chain |

Test for carbohydrates

| Type of carbohydrates | Example | Testing reagent | Description |
|------------------------|-------------------------------------|----------------------------|--|
| Reducing sugars | Glucose, maltose, lactose, fructose | Benedict's solution | <ul style="list-style-type: none"> Some sugars have reducing properties and will produce a red precipitate when boiled with Benedict's solution. Benedict's solution contains copper(II) sulfate which is blue in colour. This salt is reduced to a red precipitate of copper (I) oxide. This test is semi-quantitative. This means that it can give an approximate indication of how much reducing sugar is present. <ul style="list-style-type: none"> ✓ tiny amount → blue to green mixture ✓ moderate amount → blue to yellow or orange precipitate ✓ large amount → blue to brick-red precipitate |

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| Non-reducing sugars | Sucrose | Dilute hydrochloric acid + Hydrogen carbonate + Benedict's solution | <ul style="list-style-type: none"> • There is no direct test for sucrose as it is a non-reducing sugar and it will not reduce copper(II) sulfate. • It can be hydrolysed into glucose and fructose before carrying out the Benedict's test. It is the only sugar that will give a negative Benedict's test before hydrolysis and a positive test afterwards. • To hydrolyse a sample of sucrose, boil it with dilute hydrochloric acid for a few minutes. Then neutralise the solution by adding a small amount of hydrogen carbonate until effervescence stops. Test as before for reducing sugars. |
| Starch | — | Iodine solution | <ul style="list-style-type: none"> • Add a few drops of iodine solution to the food sample. • A complex (called starch-polyiodide) is formed during a positive test and the characteristic blue-black colouration appears. |