Functions of carbohydrates

Function	Description
Source of energy	• The average energy yield is 17kJ/g. Carbohydrates are readily available and easy to digest, hence they are a convenient source of energy.
Support	• 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	• Excess carbohydrates can be converted into amino acids and fats. Some may be used to form nucleic acids.
Production of nectar	• 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	• **Glucose + Fructose → Sucrose + Water** • Sucrose 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	• **Glucose + Glucose → Maltose + Water** • Maltose is formed when starch is partially digested. • It is found in barley seeds which can be used during fermentation to produce beer.
Lactose	• **Glucose + Galactose → Lactose + Water** • It 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.

$$\text{e.g. Sucrose + Water} \xrightarrow[\text{Sucrase}]{\text{Dilute HCl}} \text{Glucose + Fructose}$$

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	• 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	• 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	• **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**	• 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. ✓ tiny amount → blue to green mixture ✓ moderate amount → blue to yellow or orange precipitate ✓ large amount → blue to brick-red precipitate

Non-reducing sugars	Sucrose	**Dilute hydrochloric acid** + **Hydrogen carbonate** + **Benedict's solution**	• 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**	• 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.