The chemicals of life

Biological molecules

Water

Most cells contain about 70% water, the space between our cells are also filled with a watery fluid called tissue fluid.

- ***Importance of water***
- Water is a good solvent.
- Water form a transport medium for many substance, for example, glucose, amino acids, urea ……
- Water molecules take part in a great many vital chemical reaction (metabolic reactions). e.g. photosynthesis and hydrolysis.
- Water pressure in the plant vacuoles keeps the cell turgid (firm).
- Water has a high thermal capacity. It absorbs a lot of heat without changing temperature of the body.

Carbohydrates

- All carbohydrates contain three kinds of elements/atoms - carbon, together with hydrogen and oxygen.
- The ratio of hydrogen to oxygen atoms in the molecules is usually 2:1

Group	Properties	Examples
Monosaccharides (simple sugars) With ring form	small molecules sweet tasting; crystalline; readily soluble in water; Reducing sugars;	hexoses, e.g. glucose, fructose and galactose; all with a chemical formula ($C_6H_{12}O_6$)
Disaccharides (double sugars)	small molecules sweet tasting; crystalline; soluble in water, but less readily than monosaccharides; Reducing sugars except sucrose;	sucrose, maltose, lactose; all with chemical formula $C_{12}H_{22}O_{11}$
Polysaccharides	large molecules do not taste sweet; not crystalline; insoluble or not readily soluble in water; Non-reducing complex sugars.	glycogen, starch, cellulose; Each with n molecules of glucose molecules;

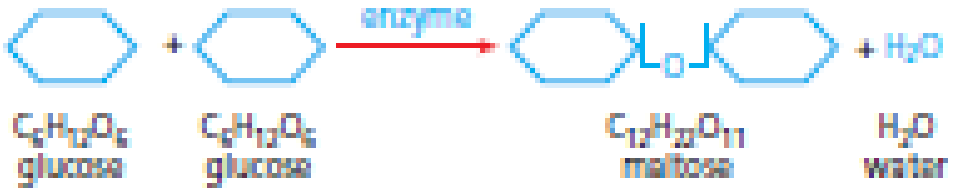


Figure 4.2 Formation of maltose

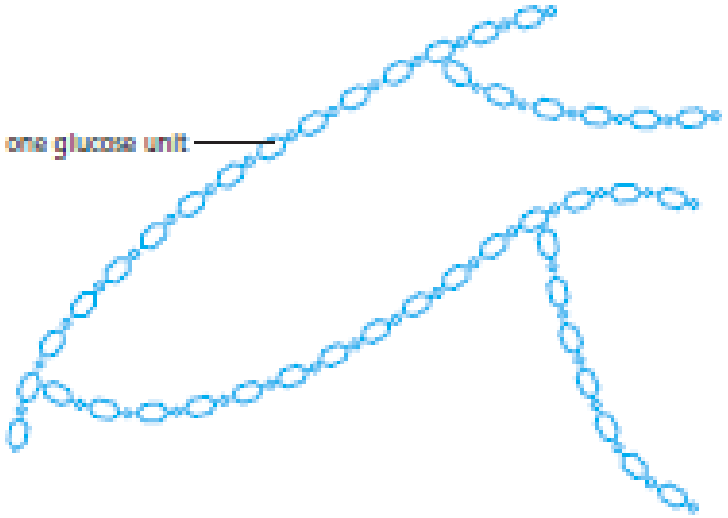


Figure 4.3 Part of a glycogen molecule

Glucose

- The common sugar is glucose ($C_6H_{12}O_6$).
- - They are the main source of energy for many cells ;
- Easily oxidized;

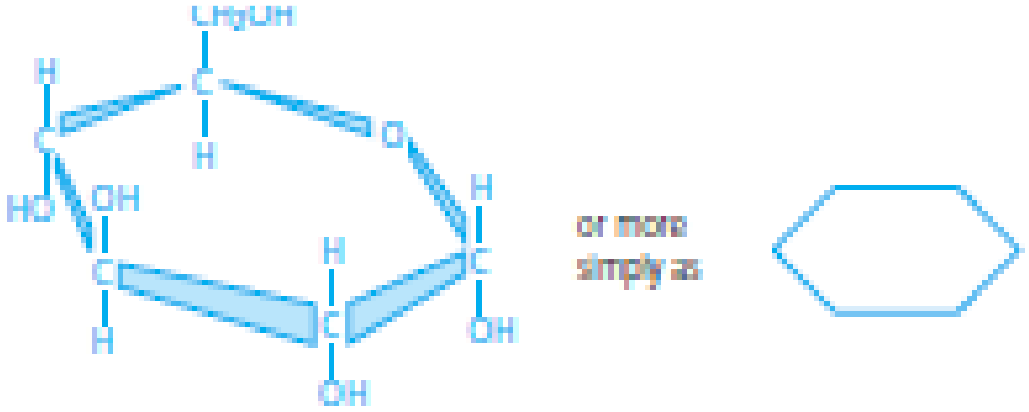
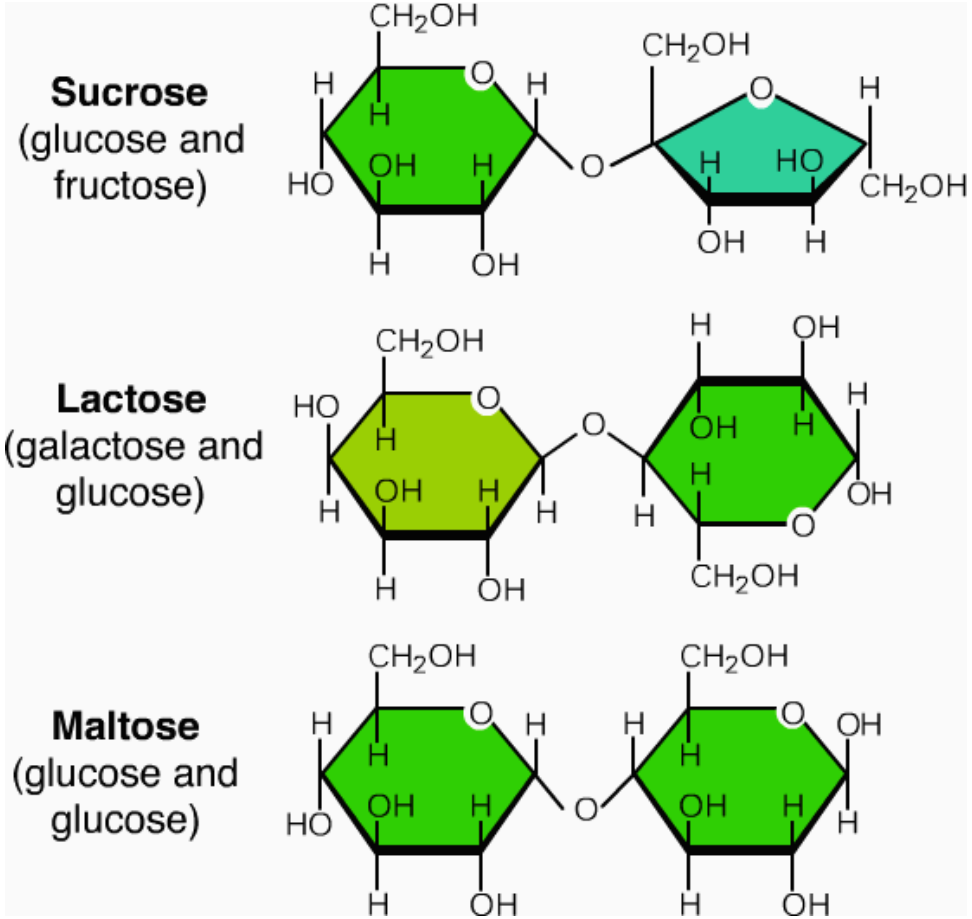


Figure 4.1 Glucose molecule showing ring structure

Disaccharides

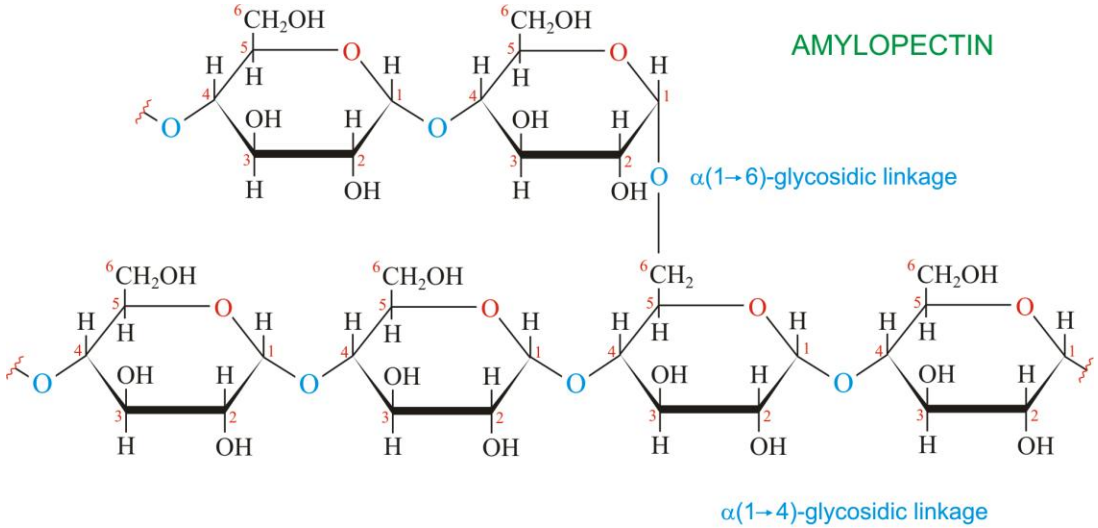
- Disaccharides form from two simple sugars joined together.
- For example, maltose (malt sugar) made up of glucose and glucose;
- Sucrose (table sugar) made up of glucose and fructose;
- Lactose (milk sugar) made up of glucose and galactose;

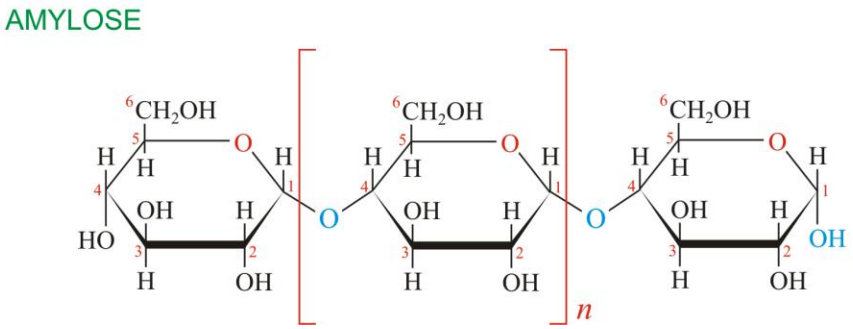


Polysaccharides

Examples

- Glycogen: food (energy) storage in animals (liver and muscle cells).
- Starch: food (energy) storage in plant cells.
- Cellulose: consists of longer chains of glucose, which are grouped together to form the criss-crossing tough microscopic fibers, which form the cell wall in plant cells.





Functions of carbohydrates

- Carbohydrates are needed for energy;
- 1 g of a carbohydrate releases 16 kj of energy, the energy is released in respiration;
- The carbohydrate that is normally used in respiration is glucose;
- Glucose is the blood sugar dissolved in the blood plasma transported to all the cells;
- Plants transports sucrose instead of glucose, sucrose is less reactive than glucose;
- Plants store carbohydrates as starch (long term energy storing molecule) in chloroplasts, seeds and potato tubers;
- Animal cells store carbohydrates as glycogen instead of starch, glycogen is mostly stored in the cells in the liver and the muscles;
- The polysaccharide cellulose is used to make the criss-crossing fibers which make plant cell walls. Cellulose fibers are very strong, so the cell wall helps to maintain the shape of the plant cell and their turgidity.

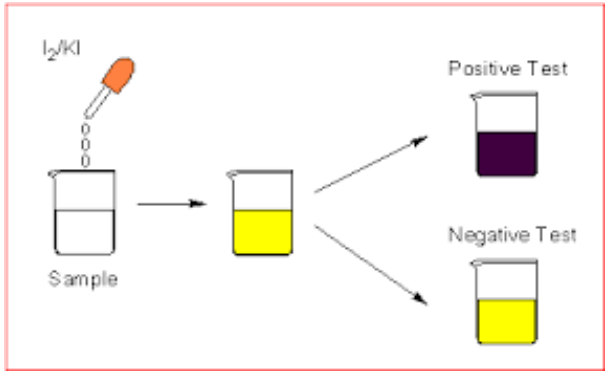
Testing for carbohydrates

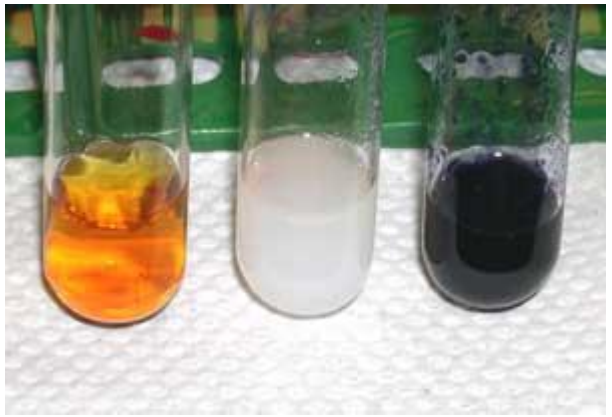
- ***Testing for starch (Iodine Test)***

shake a little starch powder in a test tube with some cold water and then boil it to make a clear solution.

When it is cold, add 3 or 4 drops of iodine solution. A ***dark blue*** color should be produced.

If there is no starch, the iodine solution remains ***orange –brown***.





Testing for carbohydrates

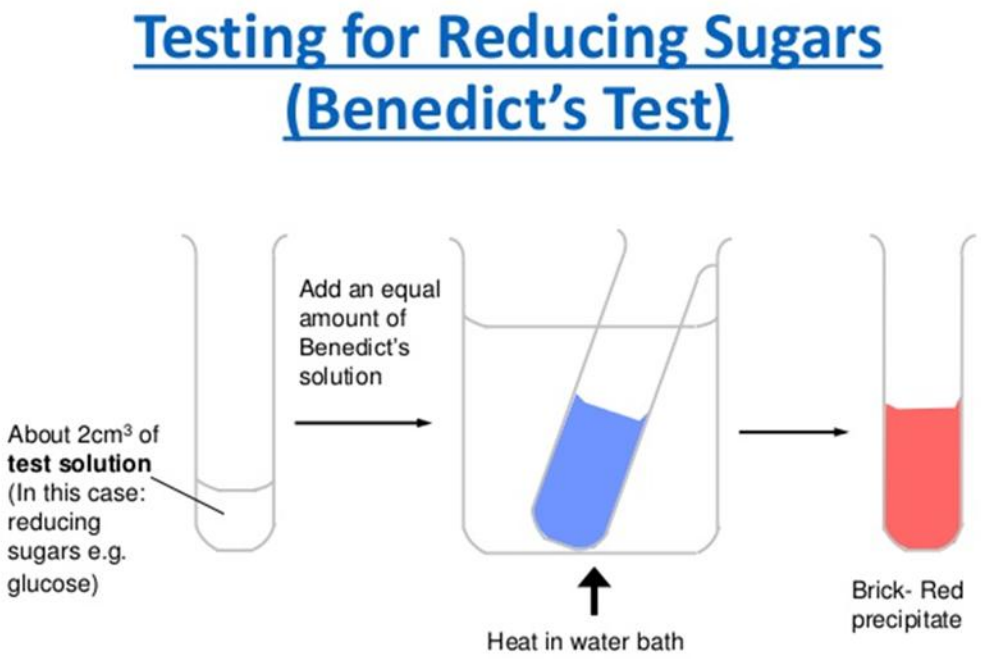
- ***Testing for glucose or reducing sugar (Benedict's Test)***

Heat a little glucose with same volume of benedict solution in a test tube.

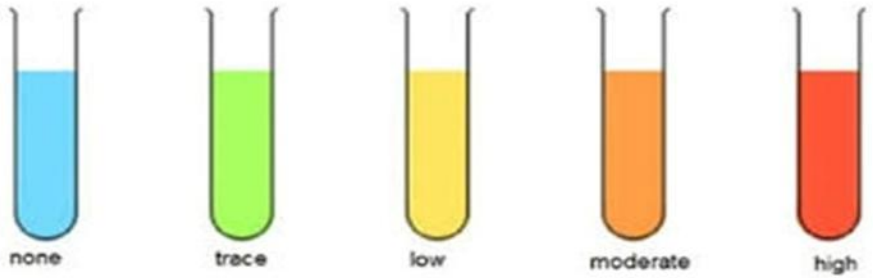
The heating is done by placing the test tube in a beaker of boiling water.

The solution will change from clear blue to cloudy green, then yellow, orange and finally to a brick red precipitate of copper I oxide.

Note, if there is no reducing sugar, then the Benedict's remains blue.



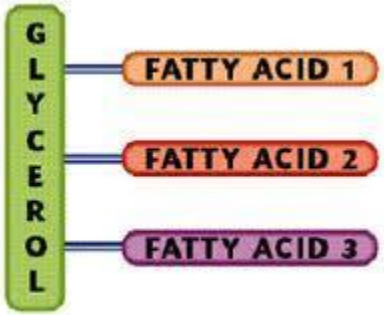
Reducing Sugar Test: Colour Changes



The more reducing sugar (glucose) present, the greater the colour change.
Lots of reducing sugar in food gives **orange/red colour**.

Lipids

- They are organic compounds and contain the elements carbon, hydrogen and oxygen.
- The building units of lipids are fatty acids and glycerol.
- One triglyceride molecule is made up of 3 molecules of fatty acids and a glycerol molecule.
- Some lipids contain saturated fatty acids (more common in animal food) and others contain unsaturated fatty acids (with at least one carbon – carbon double bond – with less hydrogen atoms, they are more common in plant food).
- Lipids are insoluble in water.
- Lipids that are solids at room temperature are called fats. Lipids that are liquid at room temperature are called oils.



Functions of lipids

- Lipids are used in the cells of the body to form part of the cell membrane and other membrane systems.
- Droplets of fats /oil form a source of energy when stored in the cytoplasm. (1 g of fat provides the cell with 39 Kj of energy).
- The fatty tissue, adipose tissue, under the skin forms a layer, which can reduce heat loss from the body.
- They also provide electrical insulation around nerve cells/nerves.
- Fats around some organs (for example the kidneys) form a protective layer.
- Excess of fat can be stored in the body, so providing a mean of long-term storage of energy in fat depots called adipose tissue.

Testing for fats and oils (emulsion test)

- Firstly, you chop the food and shake it up with ethanol;
- Next, pour the ethanol into water;
- If there was any fat in the food, then the fat-ethanol mixture breaks up into many tiny droplets when it is mixed with the water;
- This mixture is called emulsion, it looks white and opaque, like milk;
- If there was no fat in the food, the mixture of water and ethanol remains transparent.

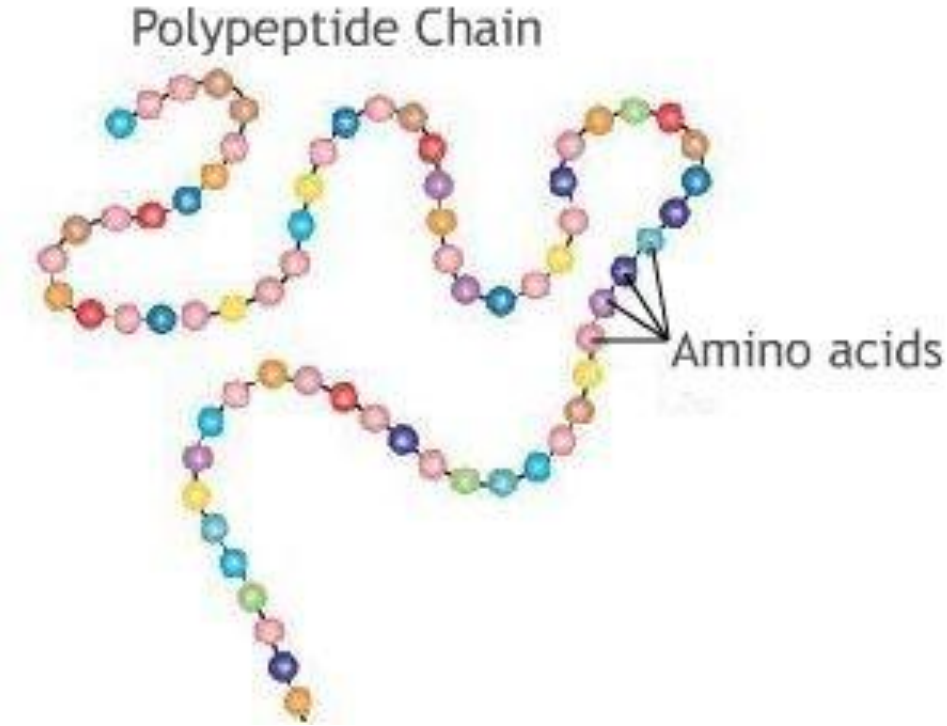
TEST FOR OIL AND FAT

- Place about 1cm^3 of ethanol in a test tube.
- Add a few drops of oil and mix by shaking.
- Add an equal amount of water and shake again.
- Positive Result :
  - **A cloudy emulsion forms**
- Negative results:
  - **Liquid remains clear**
- *Note*

  Food with solid fats can be tested by crushing them in ethanol.

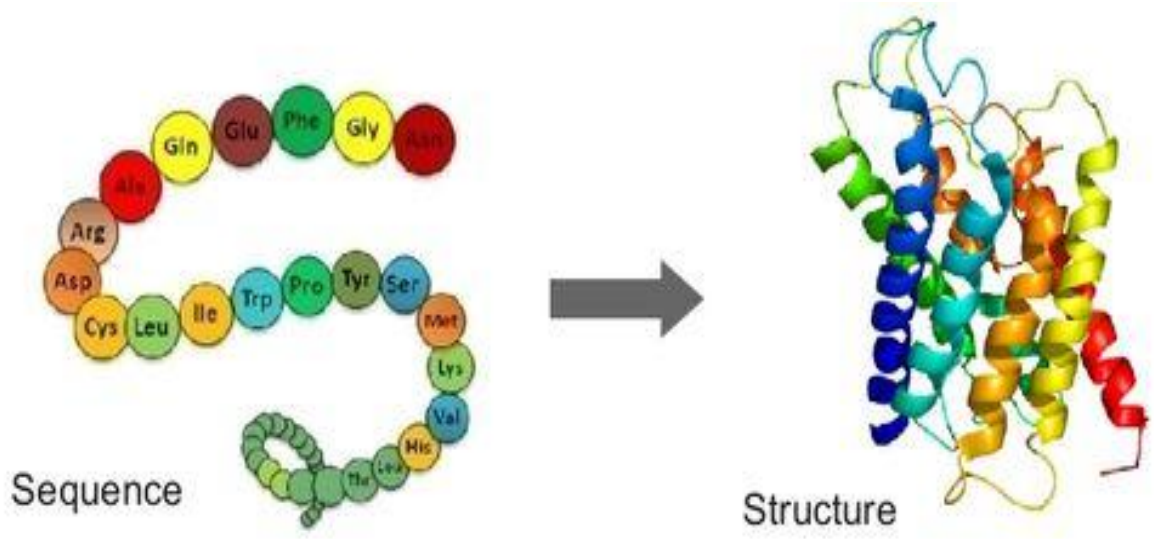
Proteins

- They are organic compounds.
- They contain the elements/atoms carbon, hydrogen, oxygen, nitrogen and sometimes Sulphur.
- Their molecules are made up of long chain of simpler chemicals called amino acids (basic units of proteins).
- In the chain of amino acids in a protein, the bonding between two neighbour amino acids is called peptide bond.
- When it's between two non neighbours is called cross linkage.
- When two amino acids join together, they form a dipeptide.
- When many amino acids join up by peptide bonds, they form a polypeptide.



Functions of proteins

- As enzymes;
- As transport molecules (for example, haemoglobin in the blood);
- As structural materials (such as in cell membranes and in muscles), these proteins are also used for growth and repair;
- As hormones;
- In defense against disease (antibodies);

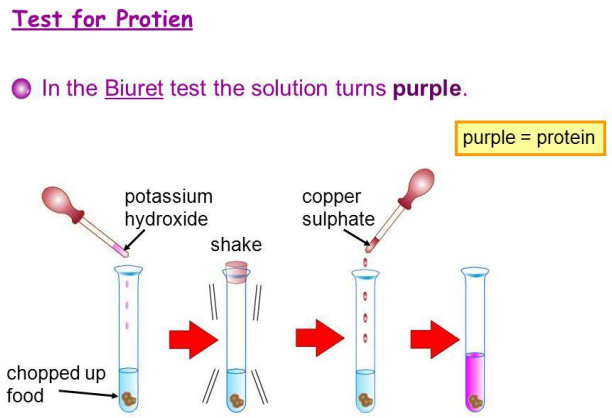


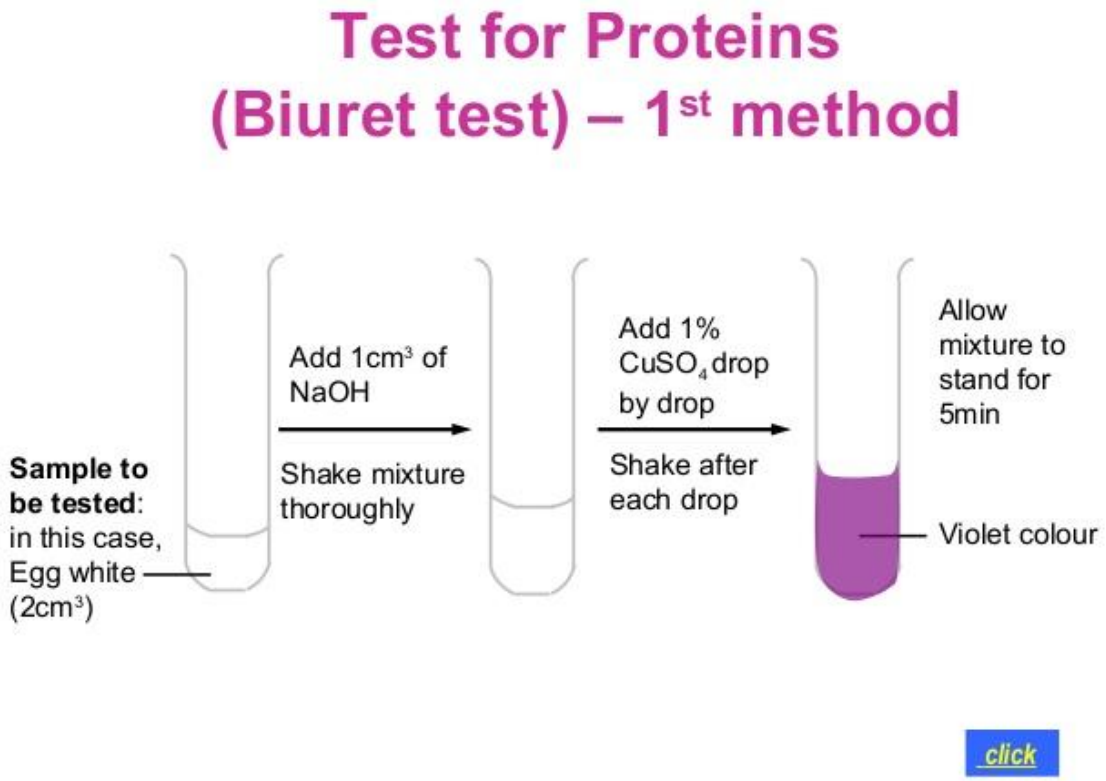
Proteins and temperature

- When a protein is heated to temperature above 50 ^{0}C, cross linkages in its molecules break down and protein molecules lose their shape and never regain it, the protein is said to be denatured.
- When proteins are denatured, enzymes and cell structures will stop working and cell will die.

Test for protein (Biuret test)

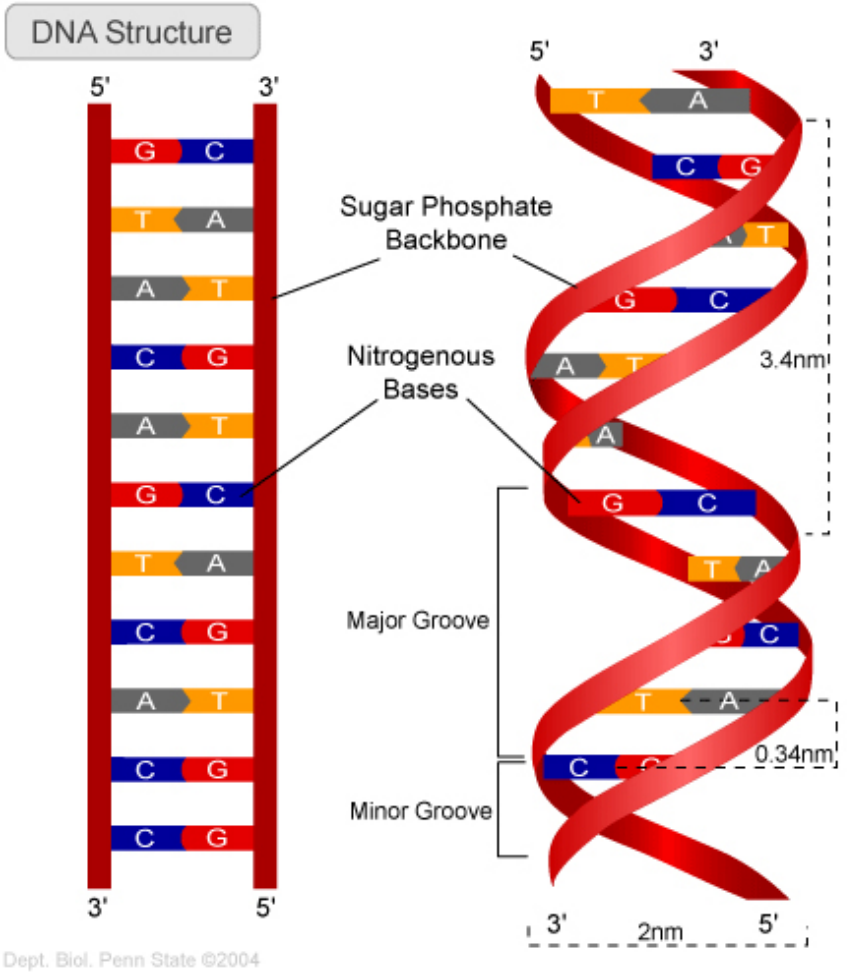
- To a solution of albumen add 5 cm^3 dilute sodium hydroxide followed by few drops of copper sulphate solution. Purple color indicates protein.





DNA

- DNA stands for deoxyribonucleic acid;
- DNA is the chemical that makes up our genes and chromosomes;
- It is the material that we inherit from our parents, which gives us many of our characteristics such as hair colour, blood group, …
- DNA is made of two long strands, each with a series of bases arranged along it;
- There are four kinds of bases, Known by the letters A (Adenine), T (Thymine), C (Cytosine) and G (Guanine);
- The bases on the two strands are held together by bonds;
  - A always pairs with T;
  - C always pairs with G;



- The two strands then twist together into a spiral called a helix;
- The sequence of bases in our DNA provides a code that is used to determine the sequence of amino acids in a polypeptide in other words it determines the kind of proteins that are made in our cells;
- This in turns, determines how our cells, tissues and organs develop.