# Haemoglobin

Haemoglobin molecules:

- ***Primary structure:*** *Four polypeptide chains.*
- ***Secondary structure:*** *Each of the polypeptide chains are coiled into a helix.*
- ***Tertiary structure:*** *Each polypeptide chain is folded into a precise shape.*
- ***Quaternary structure:*** *All four polypeptides are linked to form a spherical molecule. Each polypeptide is associated with a haem group which contains an iron ion- combines with a single $O_2$ molecule making four $O_2$ molecules carried by a single haemoglobin molecule.*

The role of haemoglobin:

The role of haemoglobin is to transport oxygen. To be efficient at transporting oxygen it must:

- Readily associated with oxygen at the surface where gas exchange takes place.
- Readily dissociate from oxygen at tissues requiring it.

In the presence of carbon dioxide, the new shape of haemoglobin binds more loosely to oxygen which makes haemoglobin release its oxygen.

Why have different haemoglobins?

**Haemoglobins with a high affinity for oxygen-** Take up oxygen more easily but release it less readily.

**Haemoglobin with a low affinity for oxygen-** Take up oxygen less easily but release it more readily.

Scientists found a correlation between the type of haemoglobin in an organism and factors in which it lived or its metabolic rate. Explanations are as follows:

- An organism in an environment with little oxygen requires haemoglobin that readily combines with oxygen
- An organism with a high metabolic rate needs to release oxygen readily into its tissues.

Loading and unloading oxygen

The process when haemoglobin combines with oxygen is called **loading** or **associating.**
The process where haemoglobin released its oxygen is called **unloading** or **dissociating.**

# Oxygen dissociation curves

When haemoglobin is exposed to different partial pressures of oxygen it doesn't absorb it evenly. At low concentrations of oxygen the four polypeptides of the haemoglobin molecule are closely united and so it's difficult to absorb the first oxygen molecule.

The graph tails off at very high oxygen concentrations because haemoglobin is almost saturated with oxygen.

The further to the left of the curve, the greater the affinity for oxygen (takes up readily but releases less easily).

The further to the right of the curve, the lower the affinity for oxygen (takes up less readily but releases more easily).

Effects of carbon dioxide concentration

Haemoglobin has a reduced affinity for oxygen in the presence of carbon dioxide.
The greater the concentration of carbon dioxide the more readily the haemoglobin releases its oxygen.

- At the gas exchange surface the level of $CO_2$ is low because it diffuses across the exchange surface and is expelled. The affinity for oxygen is increased which means that oxygen is readily loaded by haemoglobin.
- In respiring tissues the level of $CO_2$ is high. The affinity for oxygen is reduced which means oxygen is readily unloaded from haemoglobin into the muscle cells.

Loading, transport and unloading of oxygen

- At the gas-exchange surface $CO_2$ is constantly being removed.
- The pH is raised due to the low level of $CO_2$.
- The higher pH changes the shape of haemoglobin into one that loads oxygen readily.
- The shape increases the affinity for oxygen so it's not released during transportation.
- In the tissues $CO_2$ is produced by respiring cells.
- $CO_2$ is acidic in solution so the pH of the blood in the tissues is lowered.
- The lower pH changed the shape of haemoglobin into one with a lower affinity for oxygen.
- Haemoglobin releases its oxygen into respiring tissues.

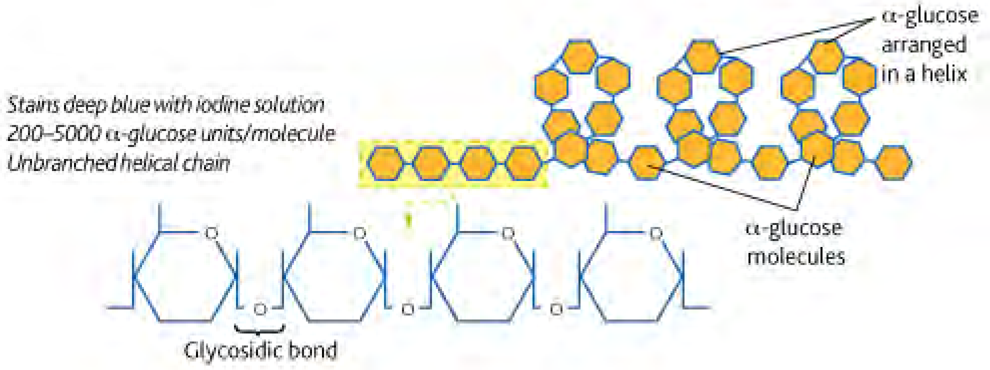
The higher the rate of respiration, the more $CO_2$ the tissues produce.
The lower the pH, the greater the haemoglobin shape changes.
The more readily oxygen is unloaded, the more oxygen available for respiration.

# Starch, glycogen and cellulose

## Starch

This is a polysaccharide found in parts of a plant in the form of small grains.
It forms a large component of food and is the energy source in most diets.
Starch is made up of chains of α-glucose monosaccharides linked by glycosidic bonds formed by condensation reactions.
The unbranched chain is wound into a tight coil that makes the molecule very compact.

Starch is suited for energy storage because:




- It's insoluble and doesn't draw water into cells.
- It doesn't easily diffuse out of cells.
- It's compact so a lot can be stored in a small space.
- When hydrolysed it forms α-glucose which is easily transported and readily used in transpiration.

## Glycogen

This is similar to starch but has shorter chains and is more highly branched. In animals it is stored as small granules mainly in the muscles and liver.

## Cellulose

This differs from starch and glycogen as it's made of monomers and β-glucose. The main reasons for differences in the structure and function is that in the β-glucose units the positions of the –H group and the –OH group are reversed. In the β-glucose the –OH group is above the ring. This means to form glycosidic links the molecule must be rotated 180°.

Cellulose has straight unbranched chains that run parallel to one another allowing hydrogen bonds to form cross-linkages between adjacent chains.

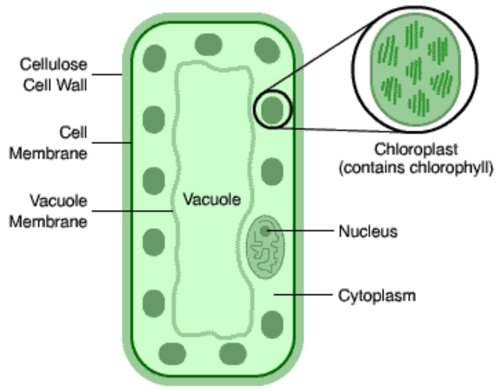
The cellulose molecules are grouped to form microfibrils which are arranged in parallel groups called fibres.

Cellulose is a major component of plant cell walls and provides rigidity. The wall also prevents the cell from bursting as water enters by osmosis. It exerts an inward pressure that stops further influx of water.

# Plant cell structure

## Leaf palisade cell

The main features that suit it to photosynthesis include:
- Long, thin cells that form a layer to absorb sunlight.
- Chloroplasts that arrange themselves to collect max. amount of light.
- Large vacuole that pushes cytoplasm and chloroplasts to the edge of the cell.

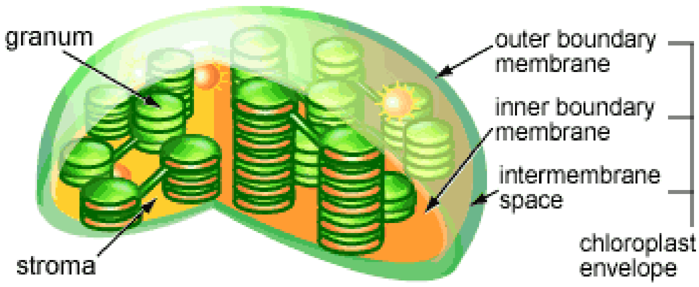



## Chloroplasts

These vary in shape and size but are disc-shaped, 2-10 μm and 1 μm in diameter. Their main features include:

- ***The chloroplast envelope:*** *A double plasma membrane that surrounds the organelle. It's highly selective in what enters/exits the cell.*
- ***The grana:*** *Stacks of up to 100 thylakoids. Within these is the pigment chlorophyll. Some thylakoids have tubular extensions that join up with others in adjacent grana.*
- ***The stroma:*** *Fluid-filled matrix where the second stage of photosynthesis takes place.*

Chloroplasts are adapted to their function in the following ways:
- The granal membranes provide a large surface area for attachment of chlorophyll, electron carriers and enzymes that carry out the first stage of photosynthesis.
- The fluid of the stroma possesses all enzymes needed to carry out the second stage of photosynthesis.
- Chloroplasts contain DNA and ribosomes so the can quickly manufacture proteins needed for photosynthesis.




## Cell wall

- They consist of polysaccharides.
- There is a thin layer called the middle lamella, which marks the boundary between adjacent cell walls and cements them together.

The functions of the cellulose cell wall are:
- To provide mechanical strength.
- To allow water to pass along it.

| Plant cells | Animal cells |
|---|---|
| Cellulose cell wall surrounds the cell. | Only a cell-surface membrane surrounds cell. |
| Chloroplasts present in large numbers. | Chloroplasts are never present. |
| Large, single, central vacuole filled with sap. | If vacuoles are present they are small + scattered. |
| Starch grains used for storage. | Glycogen granules are used for storage. |