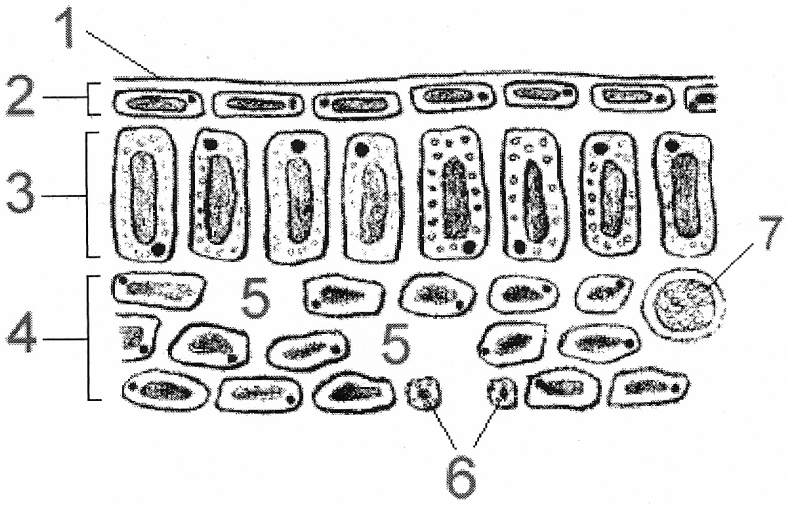
Leaf structure



1. **Waxy Cuticle** - Forms a waterproof layer to stop any loss of water.

2. **Upper Epidermis** - Consisting of epidermal cells. These have no chloroplasts.

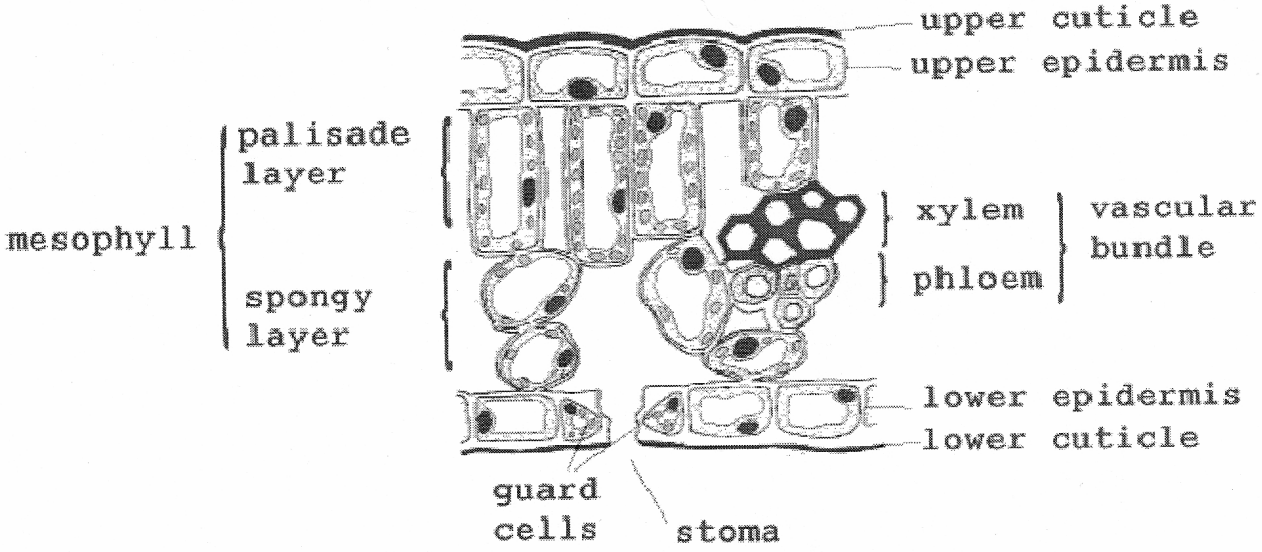
3. **Palisade cells** - These contain lots of chloroplasts, which contain lot of chlorophyll. This is where photosynthesis is carried out.

4. **Spongy Mesophyll Layer**

5. **Air Spaces** - allow for diffusion of water vapour etc...

6. **Guard Cells** - These form stomata (pores) which allow for the diffusion of gases in and out of the plant.

7. **Leaf Vein** - containing xylem and phloem tubes.



External Features

The waxy cuticle at the top of the leaf is transparent, allowing light to enter for photosynthesis. It also stops transpiration for happening throught the leaf, other than in the stomata.

The upper epidermal cells are also transparent to allow light in to reach the chloroplasts for photosynthesis.

The lower epidermis has stomata, which allow gaseous exchange to occur. Gasious exchange being the intake of CO_2 and the release of O_2, which is essential for photosynthesis.

The leaf is thin, and has a very large surface area - making it ideal for diffusion and absorbsion. The larger the surface area, the more sunlight can be absorbed. The leaf is also thin so that the mesophyll cells are closer to the surface - reducing the diffusion distance of CO_2 from the surroundings to the mesophyll cells.

Internal Features

Vascular Tissue
This is to do with the xylem and the phloem. Remember that the xylem is always at the top of the leaf, and the phloem at the bottom. This is because the xylem transports water(needed for photosynthesis) to the leaf cells, and diffuses into the chloroplasts.
The phloem transports food from the mesophyll cells to the rest of the plant.
The xylem and phloem are vascular tissue that are situated in the leaf vein.
The vein is supported by fibres(sclerenchyma), which keep the shape of the leaf, flat.

Mesophyll
There are two main types of Mesophyll cells, the palisade and spongy cells.
Palisade - contain the most chloroplast, and are at the top of the leaf. Are closely packed - allowing more cells and therefore more chloroplasts to be near the surface. There are small intercellular spaces inbetween them which allows gaseous exchange to occur.

Spongy - have less chloroplasts, and larger intercellular spaces. They also store carbohydrates made by photosynthesis. Dissolved carbohydrates diffuse into the phloem, to be transported to the rest of the plant.

Chloroplasts
These are the structures which contain chlorophyll, and this is where the photosynthesis actually happens! They have a double membrane, which is selectively permiable. This allows H_2O and CO_2 to diffuse into it, and O_2 to diffuse out of it.

Photosynthesis: leaves for the job

Trees, bushes, grass and flowering plants make our surroundings look attractive, but they have a much more important role. Plants are part of our food chain, so without them we would die!

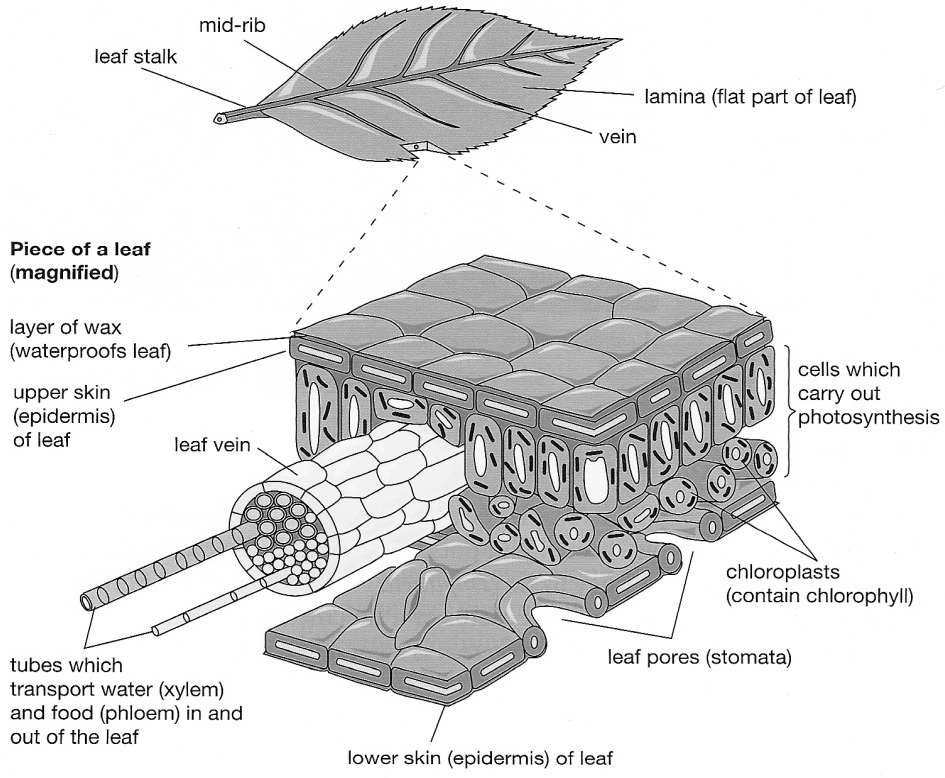
Green plants need sunlight.

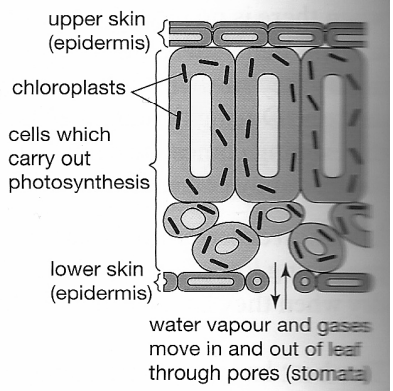
Plants make their food from non-living things by a process called **photosynthesis**. The raw materials used are carbon dioxide from the air, and water from the soil. These are combined to make sugar (glucose) and starch.

Photosynthesis uses light energy from the Sun. The chemical **chlorophyll** traps this energy. Chlorophyll is contained in **chloroplasts**.

Oxygen is a product of photosynthesis. Oxygen is needed by other living things.

Leaves are the 'food factories' of plants. This is where photosynthesis takes place. Leaves are well adapted for their job. Their broad, flat, thin shape provides a large surface area, ideal for the absorption of carbon dioxide and sunlight.





Questions

1 What is photosynthesis?

2 How does the shape of leaves help them to do their job?

3 Why is the upper surface of a leaf transparent?

4 Why do you think there are more chloroplasts in the upper part of a leaf than in any other cells?

The chemistry of photosynthesis

Photosynthesis is not one simple chemical reaction, but a series of complicated reactions. Each reaction is controlled by special chemicals called **enzymes**. (You can read about enzymes on page 33.)

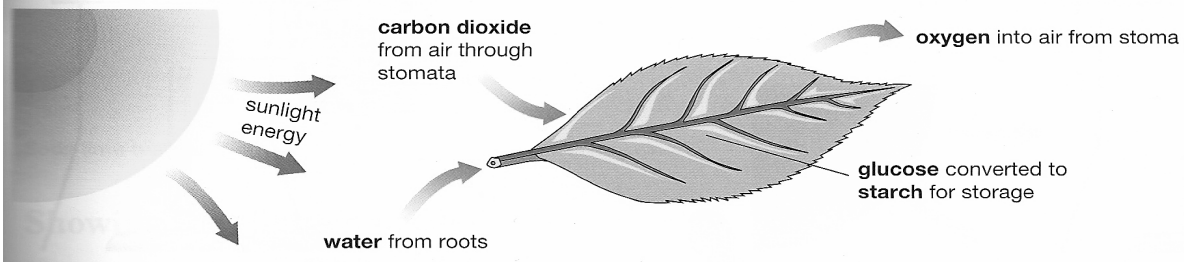
We can represent what happens during photosynthesis by one equation:

$$\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \xrightarrow{\text{sunlight absorbed by chlorophyll}} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$$

Carbon dioxide enters the leaf through the stomata by **diffusion**. Water is carried to the leaf in the xylem. Both carbon dioxide and water pass into the chloroplasts, where photosynthesis takes place. In the chloroplasts, light energy is absorbed by chlorophyll. Carbon dioxide and water become part of a chemical reaction that produces glucose and oxygen.

Usually, the glucose made in this way is converted to starch. This is stored for a time in the leaf until it is needed.

Oxygen is a by-product of photosynthesis. It diffuses out of the leaf through the stomata into the surrounding air.



Where does the oxygen come from?

For many years, scientists wondered where the oxygen came from. Was it the carbon dioxide or the water? To investigate this, scientists watered plants with special water that had been 'labelled' with atoms of oxygen that were slightly heavier than normal oxygen. These atoms were called oxygen-18 (^{18}O). Normal oxygen is oxygen-16 (^{16}O).

When the oxygen given off was tested, it was also 'labelled' with oxygen-18. This proved that the oxygen came from the water and not the carbon dioxide.

Questions

1 *Photo* means 'light' and *synthesis* means 'building up'.

a) What chemical do green plants have in order to 'trap' sunlight?

b) What large molecule is built up during photosynthesis?

c) What two simple chemicals are needed for photosynthesis to take place?

d) What gas is given off as a by-product of photosynthesis?

2 Suggest why *Potomageton natans* has its stomata on the upper surface of its leaves, not the lower. (Hint: *Potomageton natans* is a water plant that has floating leaves.)

Photosynthesis: the starch test

An easy way of finding out if a plant is photosynthesizing is to see if its leaves have produced any starch or not.

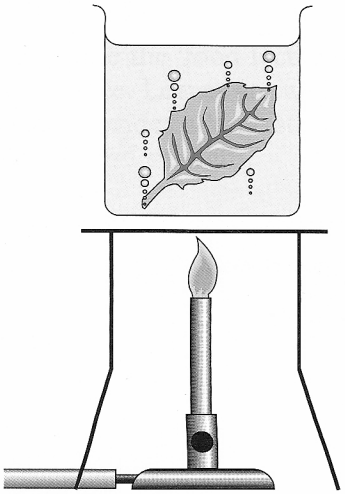
A leaf that has been kept in the dark for a day or so will not contain any starch.

Starch reacts with iodine. Iodine turns from brown to blue-black when added to starch. If a leaf contains starch, it will turn blue-black when iodine is dropped on it. This shows that the leaf has photosynthesized. If the leaf has not been photosynthesizing, it will not turn blue-black.

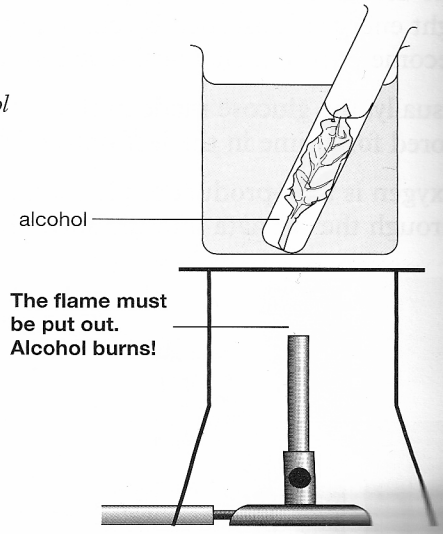
Testing a leaf for starch

Remember to wear safety glasses.

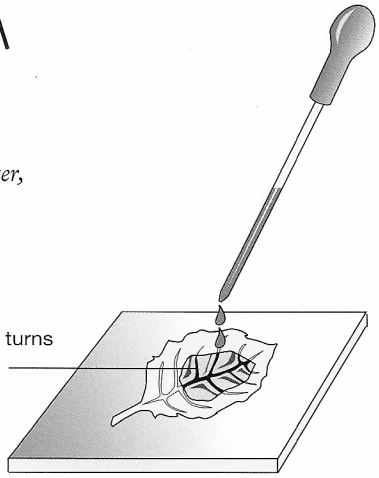
1 *Put a leaf in boiling water for about two minutes to soften it.*



2 *Heat it in alcohol to take away the green colour.*



3 *Soften it in boiling water, then add iodine to it.*



Questions

1 How does the starch test show that a plant has been photosynthesizing?

2 What does iodine do when added to starch?

3 During the starch test:
a) Why is the leaf boiled in water for a short time?
b) What is the job of the alcohol?
c) Why dip the leaf in water again before addi the iodine?

4 Give one important safety precaution that must be taken during the starch test. Why is it important

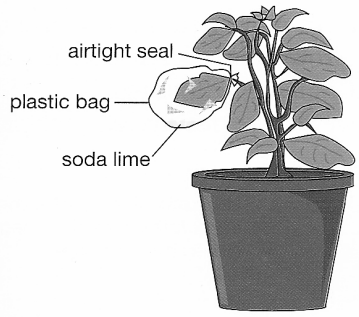
Photosynthesis: testing the equation

Now that you know the starch test, it is possible to use it to show that carbon dioxide, light, and chlorophyll are needed for photosynthesis.

We can also show that oxygen is produced, by carrying out another simple experiment.

Showing that carbon dioxide is needed

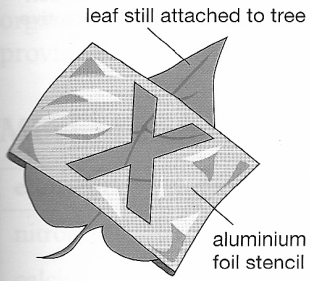
Put some soda lime into a plastic bag and carefully tie it around a leaf. (Soda lime absorbs carbon dioxide.) Leave the leaf attached to the plant. After a day, do the starch test on the leaf.

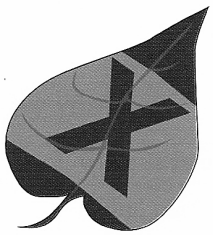


Soda lime test

Showing that light is needed

Put a piece of foil around part of a leaf and leave it attached to the plant. After a day, do the starch test on the leaf.

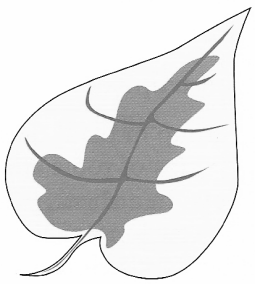


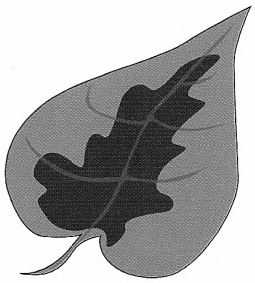


Before starch test **After testing for starch**

Showing that chlorophyll is needed

Do the starch test on a variegated leaf (a leaf that has no chlorophyll in the white bits).

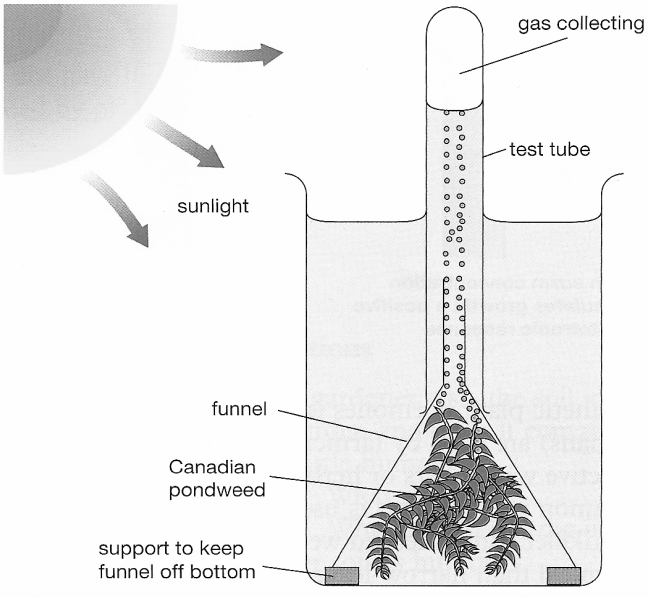




Variegated leaf **After testing for starch**

Showing that oxygen is produced

Set up the apparatus below in a well-lit place, and leave it until the test tube is full of gas. To see if the gas is oxygen, test it using a glowing splint.



Oxygen test

Questions

1 What gas is absorbed by soda lime?

2 Describe a variegated leaf.

3 Suggest why foil is only put around part of a leaf in the experiment to show that light is needed for photosynthesis to take place.

4 Why is it important to leave the leaf attached to the plant, in the experiment to show carbon dioxide is needed for photosynthesis?

5 What does a glowing splint do when it is put into oxygen?