



Figure 8: A greenhouse

Light enters the greenhouse through the roof and heat is trapped inside the structure. Greenhouses can be used to maintain the optimal levels of the factors affecting the rate of photosynthesis. This is done in the following ways:

- Light passes through the transparent structure. Artificial lights can be used to allow the plants to photosynthesis for longer periods of time.
- Carbon dioxide is present in the atmosphere but more can be pumped into the greenhouse or be produced by burning gas lamps.
- The temperature can be kept at the optimum level by using heating and cooling devices.

The greenhouse effect is a natural phenomenon where heat is trapped in the atmosphere of the Earth by carbon dioxide. This is very important to keep Earth at a temperature which allows for life to occur. Without the greenhouse effect, the Earth would be too cold to support life.

Due to carbon dioxide in the atmosphere increasing, the greenhouse effect is becoming enhanced and this is leading to global warming.

Investigations

There are investigations which can be performed to determine if a factor is required for photosynthesis or to determine the rate at which photosynthesis is occurring. In the investigations, one plant (**the experiment**) is given all of the requirements except for the factor being tested. Another plant is given all of the requirements in the same

investigation and is referred to as the **control**. In most of the investigations, a test for starch is performed at the end to prove that photosynthesis took place.

Destarching a plant

Before starting the investigations, starch must be removed from the plant. To do this:

- the plant is placed in a dark cupboard for 48 hours
- the plant uses the stored starch during the 48 hour period
- it can be proved that the starch present at the end of the investigation is due to photosynthesis occurring.

The starch test can be used to prove that starch is a product of photosynthesis

Investigation 1: The Starch Test

The Starch Test: https://www.youtube.com/watch?v=0s_xZqvwm_s

During photosynthesis glucose is produced which is converted into starch. To determine whether photosynthesis occurred, a test for starch can be performed.

If starch is present, then it can be concluded that photosynthesis occurred. If starch is not present, then it can be concluded that photosynthesis did not occur.

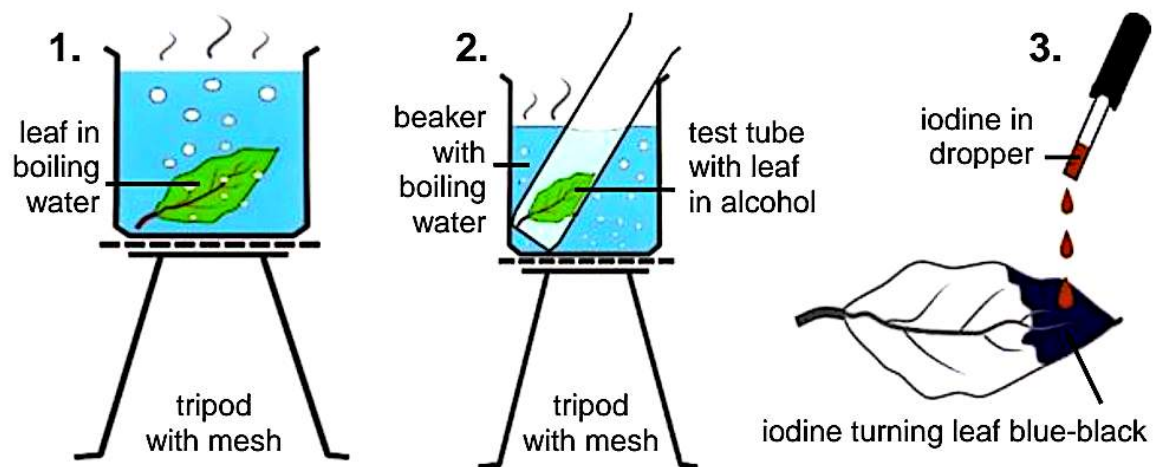


Figure 9: Experimental set-up to show starch is produced during photosynthesis

Method:

1. Place a leaf in a beaker of boiling water (see Figure 9). This softens the leaf and kills the cells to stop metabolism
2. Place the leaf into a test tube containing ethanol (alcohol).

3. Allow the test tube to stand in a beaker of boiling water (water bath) for approximately 10 minutes
Ethanol cannot be exposed to direct heat because it is highly flammable and has a boiling temperature lower than water, this is why it is placed into the water bath.
Chlorophyll is soluble in alcohol and will be extracted from the leaf.
The leaf will turn white in colour and become brittle.
4. Carefully remove the brittle leaf from the alcohol and rinse it in water to soften it.
5. Spread the leaf on a tile and pour a few drops of iodine solution onto it.

Results:

The leaf turns blue black which proves that starch has been produced by photosynthesis.

The following investigations can be used to show the requirements and products of photosynthesis.

Investigation 2: Light is required for photosynthesis

Light is one of the requirements for photosynthesis. An investigation can be performed to show that without light, starch will not be produced and therefore no photosynthesis took place.

Aim: To prove that light is required for photosynthesis

Method:

- Destarch a potted plant by placing it in a dark cupboard for 48 hours
- Cover a portion of the leaf, still attached to the plant, with aluminium foil (Figure 10)

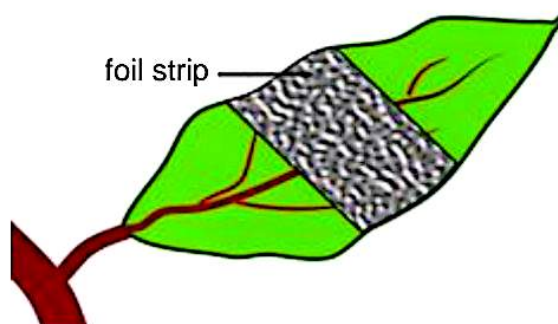


Figure 10: Aluminium foil covering part of a leaf

- Place the plant in a sunny area for 48 hours
- Pick the leaf and remove the foil
- Test for the presence of starch using the starch test.

The experiment is the part of the leaf covered by the foil, as it does not receive light. The part of the leaf left uncovered is the control as it receives all of the requirements for photosynthesis, including light.

Results:

Experiment (leaf covered with tinfoil): the iodine solution remains light brown.

Control (leaf left uncovered): the iodine solution turns blue-black.

Conclusion:

The parts that turn blue-black in colour contain starch. The part which remains light brown does not contain starch.

Light is essential for photosynthesis to take place.

Investigating the effect of light intensity on the rate of photosynthesis:

https://www.youtube.com/watch?v=id0aO_OdFwA

Investigation 3: Carbon dioxide is required for photosynthesis

Carbon dioxide is a requirement for photosynthesis. An investigation can be performed to show that without carbon dioxide, starch will not be produced and no photosynthesis will take place. To do this, sodium hydroxide, potassium hydroxide or soda lime can be used to **remove** carbon dioxide. Sodium bicarbonate or potassium bicarbonate can be used to **add** carbon dioxide.

Aim: To prove that carbon dioxide is required for photosynthesis

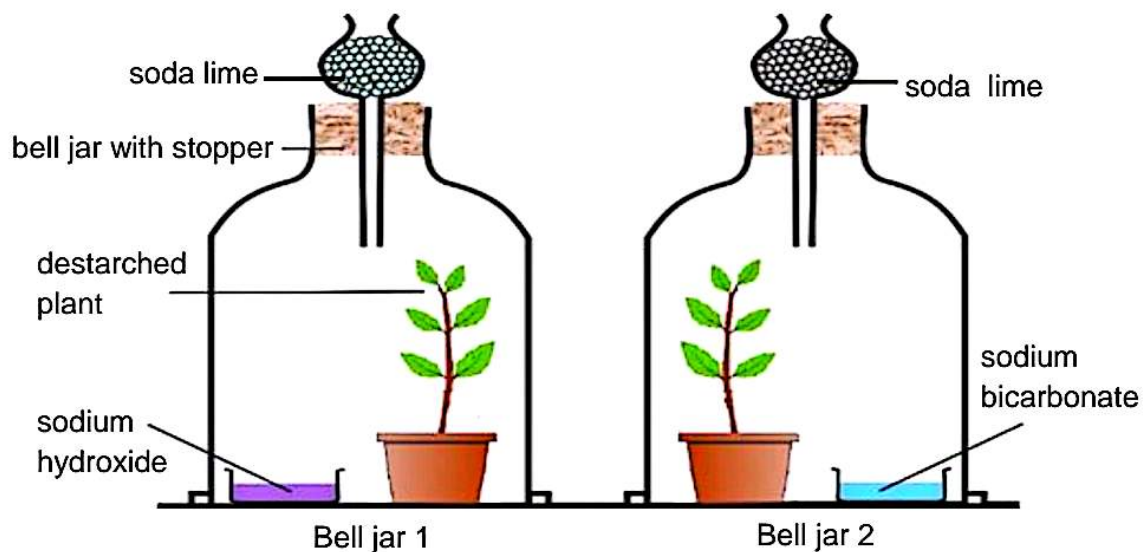


Figure 11: Set-up to investigate effect of CO₂ concentration on photosynthesis

Method:

- Destarch two potted plants by placing them in a dark cupboard for 48 hours
- Set up the apparatus as shown in Figure 11 above and water plants well.
- Sodium hydroxide is used to absorb carbon dioxide from the air in bell jar 1
- Sodium bicarbonate releases carbon dioxide into bell jar
- Place the sealed bell jars into a sunny area for 48 hours
- Pick a leaf from each plant and test for the presence of starch (using the method in investigation 1).

Results:

- Bell jar 1 leaf: iodine solution remains light brown.
- Bell jar 2 leaf: iodine solution turns from light brown to blue-black.

Conclusion:

- Bell jar 1 leaf: No starch is produced. No photosynthesis can take place in the absence of carbon dioxide.
- Bell jar 2 leaf: Starch is produced. Photosynthesis takes place in the presence of carbon dioxide.

Carbon dioxide in photosynthesis: https://www.youtube.com/watch?v=lji6Zx3_E30

Investigation 4: Chlorophyll is required for photosynthesis

Chlorophyll is one of the requirements for photosynthesis. A variegated leaf is used to prove that without chlorophyll, starch will not be produced and therefore no photosynthesis took place. A variegated leaf contains green parts (with chlorophyll) and white parts (without chlorophyll) (see Figure 12). This leaf does not require destarching as the experiment and control are on the same leaf.

Aim: To prove that chlorophyll is required for photosynthesis

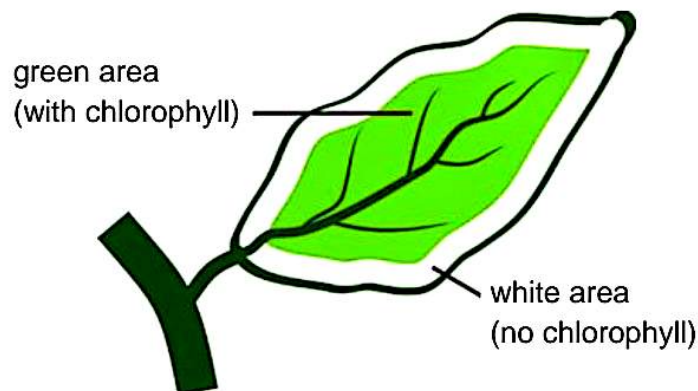


Figure 12: Chlorophyll is required for photosynthesis

Method:

- Place a potted plant with variegated leaves (white and green parts) in a sunny place for a few hours
- Remove a leaf from the potted plant
- Test for the presence of starch (using the method in investigation 1)

Results:

- Experiment (White part): iodine solution remains light brown.
- Control (Green part): iodine solution turns from light brown to blue-black.

Conclusion:

- Experiment (White part): Contains no starch. No photosynthesis can occur without chlorophyll.
- Control (Green part): Contains starch. Photosynthesis takes place using chlorophyll.
- Chlorophyll is essential for photosynthesis.

Investigation 5: Photosynthesis produces oxygen

Oxygen is produced during photosynthesis. A glowing splint test is used to show that oxygen is produced during photosynthesis. A test uses a small wooden stick that has been lit. The splint glows more brightly or re-ignites in the presence of oxygen.

Aim: To prove that oxygen is produced during photosynthesis

Method:

- Set up the apparatus as shown the diagram in Figure 13 below

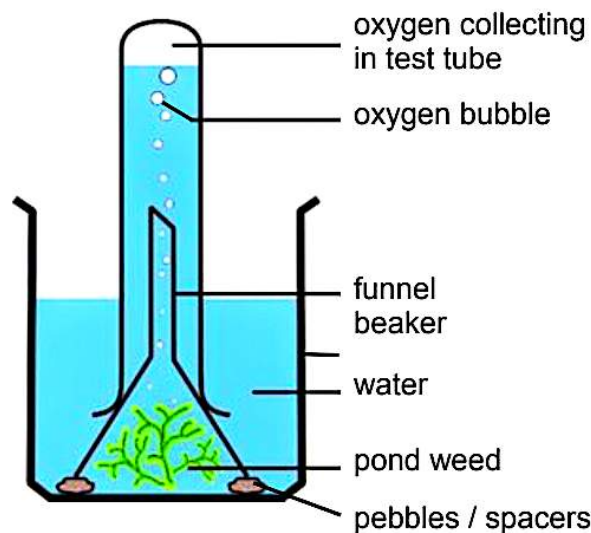


Figure 13: Experimental set-up to show that oxygen is produced in photosynthesis

- Place the apparatus in a sunny area for a few hours
- A small amount of sodium bicarbonate can be dissolved in the water. Sodium bicarbonate will add carbon dioxide to the water
- After a while gas bubbles will start to form. These gas bubbles will collect in the test tube.
- Once enough gas has been trapped in the test tube, remove the test tube from the funnel but keep the opening of the test tube submerged under the water
- Seal the test tube using a rubber stopper while under the water
- Once it has been sealed, remove the test tube from the water
- Insert a glowing wooden splint into the test tube

Results:

The glowing splint re-ignites or burns more brightly.

Oxygen is present in the test tube.

Conclusion:

Oxygen is produced during photosynthesis.

Activity 2: Investigating photosynthesis

A learner has conducted an experiment in the classroom by following various steps. Study the procedure and diagram below to answer the questions that follow.

- a) A variegated plant was left in the dark for 3 to 4 days
- b) A starch test was conducted by removing one of the leaves
- c) The plant was then left in the light for four hours
- d) A leaf was removed and a drawing of it was made to show the distribution of green and white areas (Diagram 1)



Diagram 1: leaf before second starch test

- e) The leaf was then tested for the presence of starch
- f) After the addition of a few drops of diluted iodine solution, a second drawing of the leaf was made to show the distribution of blue- black and brown areas of the leaf (Diagram 2 – not shown here)

Questions

1. State the aim of this experiment. (1)
2. Why was the plant left in the dark for 3 to 4 days? (1)
3. Why should the plant have been tested for the presence of starch after step (a), before exposing the plant to light? (2)