PHOTOSYNTHESIS

Learning intentions

By the end of this topic you should be able to:

- Describe how the earth is dependant on photosynthesis
- Explain the process of photosynthesis
- Describe photosynthesis as a chemical and biological process
- Name and explain the factors that affect photosynthesis
- Describe an experiment to show that light is necessary for photosynthesis
- Explain how the knowledge of photosynthesis can be used to improve crop yields.

Photosynthesis

Important words

- Photosynthesis
- Chlorophyll
- Chloroplast
- Carbon cycle
- Process
- Chemical
- Biological

Photosynthesis

How Earth is dependent on photosynthesis

- Most living organisms need oxygen to survive.
- If carbon dioxide levels rise above 10 per cent, animals could be poisoned and die.
- Photosynthesis maintains an adequate level of carbon dioxide whilst providing oxygen for living organisms.
- Food is provided for living organisms through the process of photosynthesis.

Biochemical process

- A biochemical process is a series of chemical reactions in a living thing.
- Photosynthesis and respiration are biochemical processes.
- Both photosynthesis and respiration involve energy:
  - In respiration energy is released from food.
  - In photosynthesis energy is used to make food.

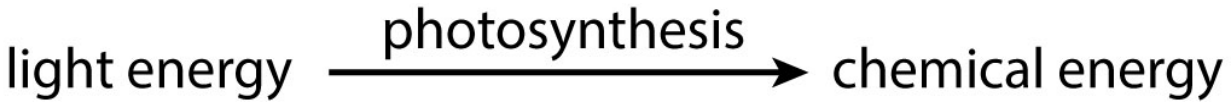
Photosynthesis

Photosynthesis is:

- the conversion of solar (sunlight) energy into
- chemical energy (in the form of glucose).

Plants make their own food by photosynthesis.

The word equation for photosynthesis is:



Photosynthesis

What is photosynthesis?

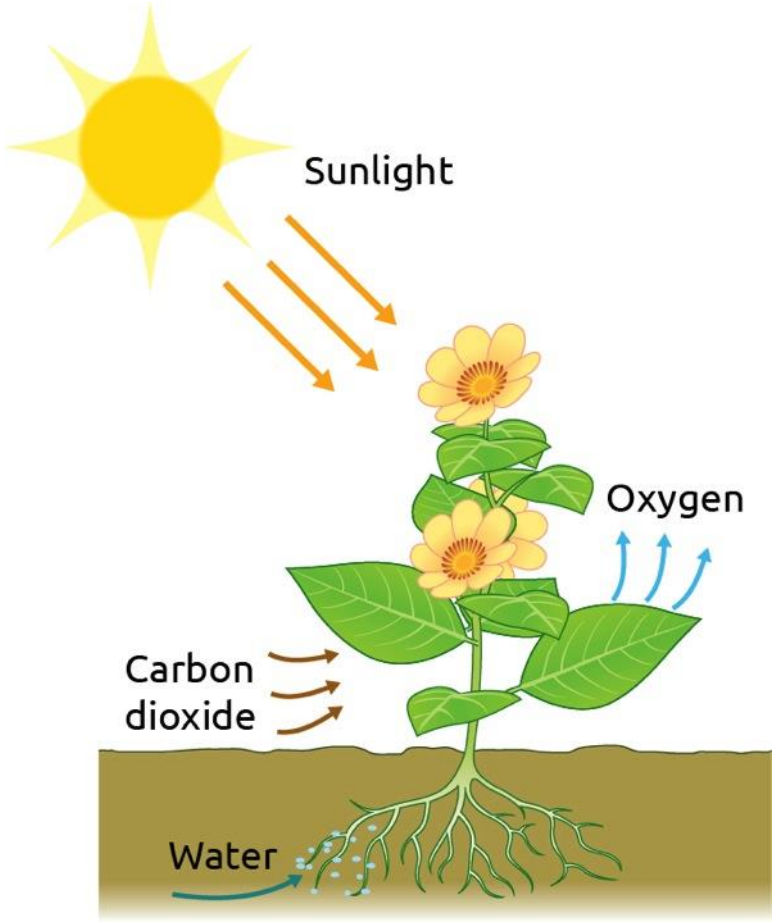
- Photosynthesis is the way plants make their own food using light.

- Word equation:

$$\text{carbon dioxide + water} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \text{glucose + oxygen}$$

- Chemical equation:

$$6CO_2 + 6H_2O \xrightarrow[\text{sunlight}]{\text{chlorophyll}} C_6H_{12}O_6 + 6O_2$$

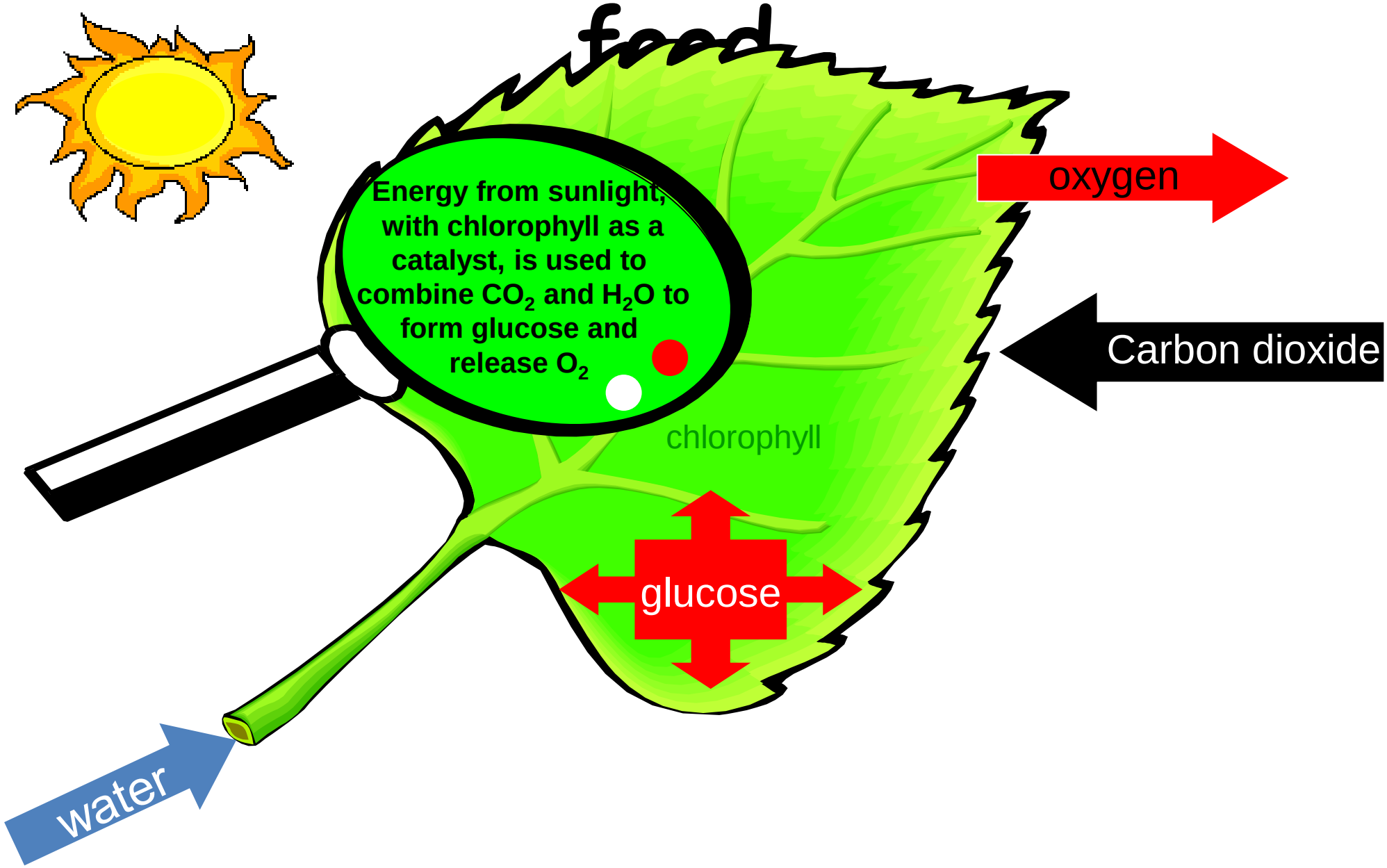


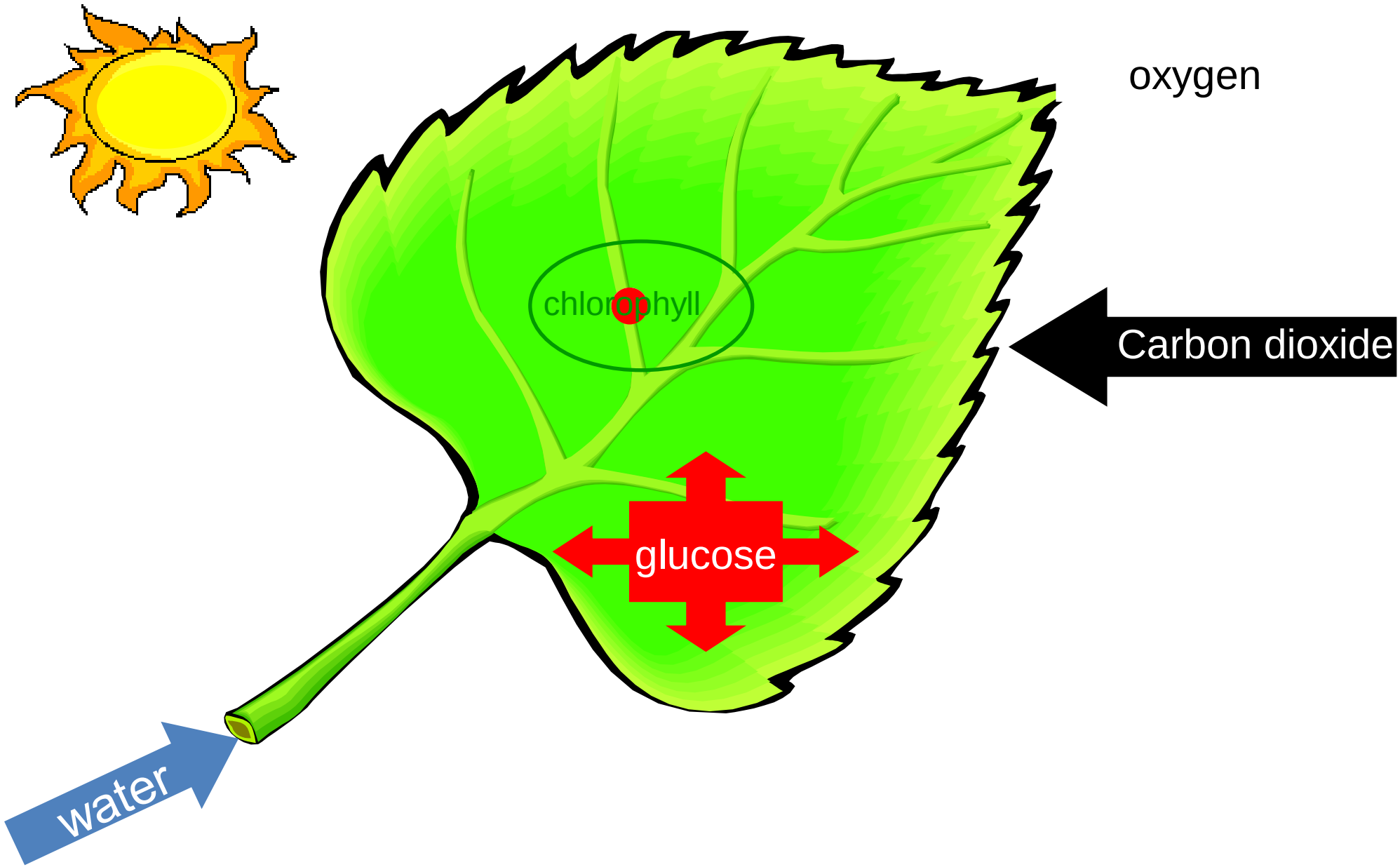
Ever wondered why?

Some plants lose their leaves in winter? It is because they find it difficult to carry out photosynthesis…

…using your word equation, can you give TWO reasons a plant could not carry out photosynthesis in winter?

How plants make their food




oxygen
chlorophyll
Carbon dioxide
glucose
water

Factors affecting Photosynthesis

The factors affecting photosynthesis are:

- light
- water
- temperature
- carbon dioxide
- chlorophyll.

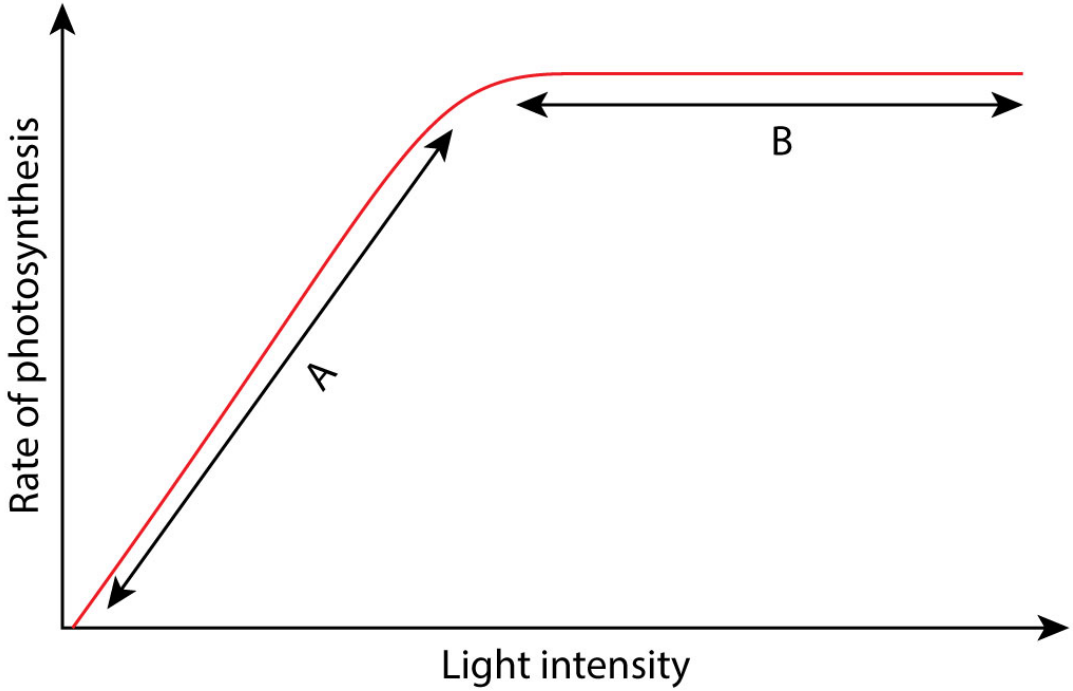
Light

Light is:

- produced by the sun
- trapped by leaves (which is why they have large flat surfaces)
- the source of energy to form food.

Increasing light intensity increases the rate of photosynthesis.

Above a certain light intensity the rate of photosynthesis remains constant (due to plants not being able to get enough of a certain substance such as carbon dioxide).



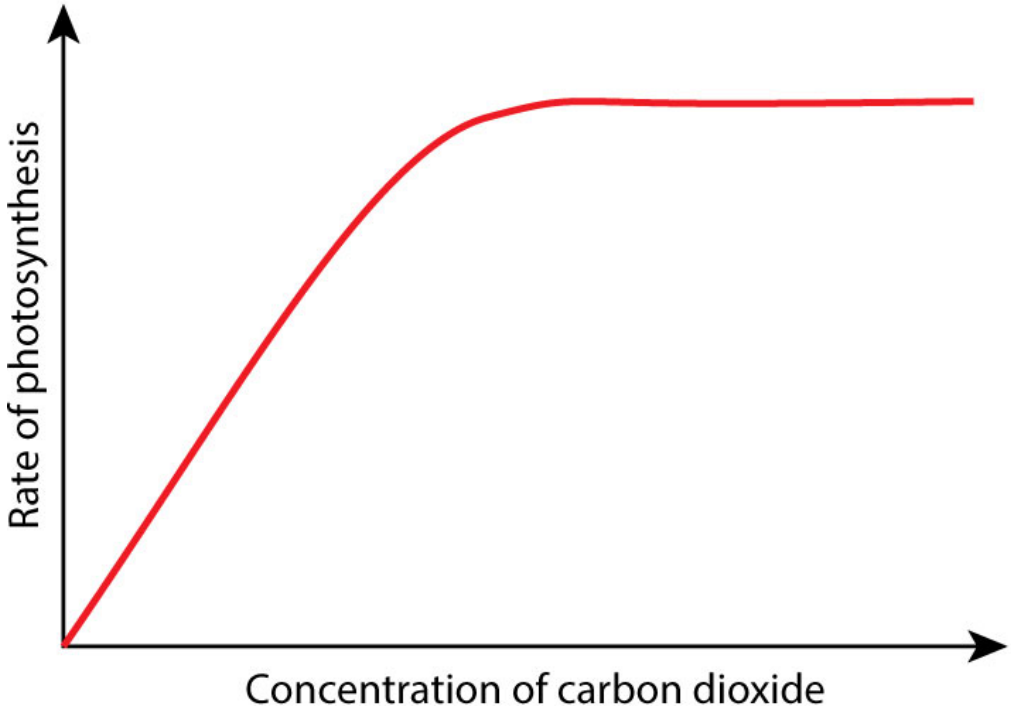
Carbon Dioxide

Carbon dioxide is:

- released into the air by respiration and burning
- taken in by plants from the air
- used to make glucose.

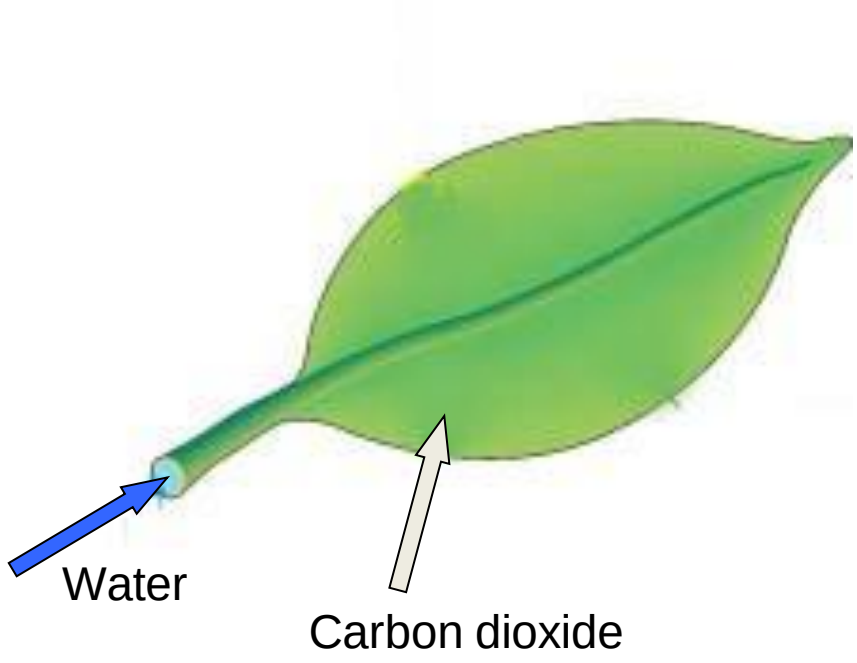
Increasing the concentration of carbon dioxide increases the rate of photosynthesis.

Above a certain concentration of carbon dioxide the rate of photosynthesis remains constant (due to a shortage of another factor such as light).



Factors needed for photosynthesis

- Carbon dioxide (a gas)
  - passes into the leaves from the air
  - enters the under-surface of leaves through tiny openings called stomata.
- Water
  - enters the roots from the soil
  - passes up through the stem XYLEM
  - enters the leaves in the veins.



Other factors affecting photosynthesis

Water is:

- absorbed by roots from the soil
- transported up the stem to the leaves
- used to make glucose and to allow enzymes to work.

Chlorophyll is:

- a green dye or pigment
- made by plants
- a catalyst for photosynthesis (it speeds up the reaction but is not used up)
- essential for photosynthesis.

Temperature:

- affects the rate of enzyme controlled reactions
- affects the rate of photosynthesis (as it is an enzyme controlled reaction).

Products of Photosynthesis

The products of photosynthesis are:

- Glucose which is used
  - to provide energy in respiration
  - to form starch which is stored in plants
  - to form new cells to allow plants to grow.
- Oxygen which is:
  - used for aerobic respiration by the plant
  - released out of the leaves (and can then be used for aerobic respiration by other living things).

Photosynthesis

How do plants photosynthesise?

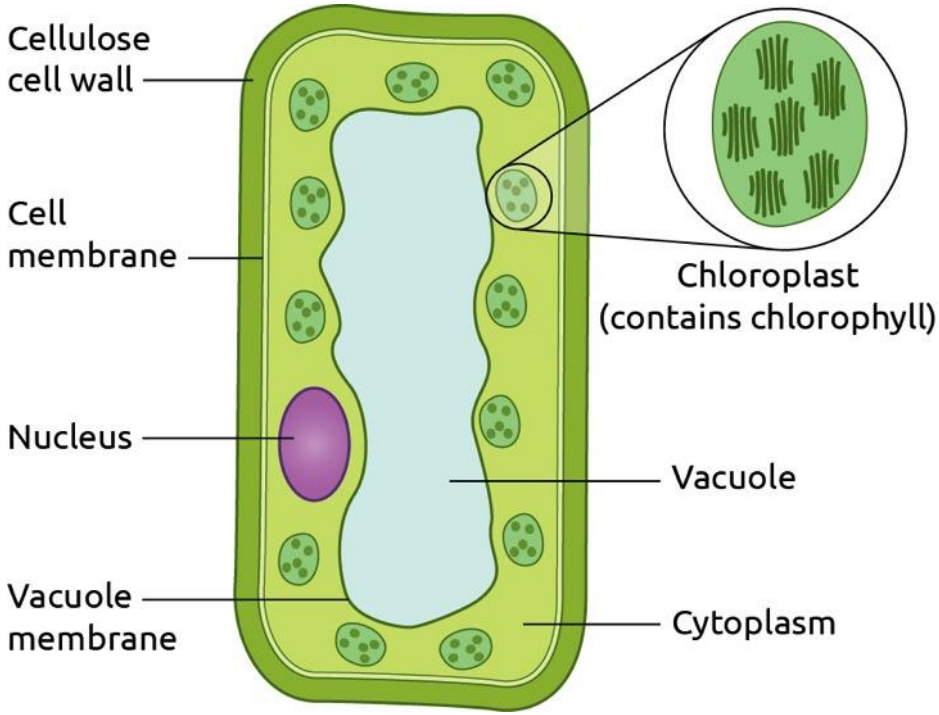
- Carbon dioxide enters a plant through the stomata.
- Water enters a plant through the roots.
- Sunlight energy is absorbed by chloroplasts in the leaves.
- Chlorophyll, with the energy from the sunlight, allows carbon dioxide to combine with water to form glucose.
- Oxygen is released as a waste product.

Photosynthesis

Photosynthesis as a process

1. Photosynthesis as a **chemical process**:
    - It is a process because it involves a number of steps.
    - It is chemical because new substances are formed.

2. Photosynthesis as a **biological process**:
    - It is a biological process because photosynthesis occurs in living cells.



Photosynthesis

The carbon cycle

- The carbon cycle is the recycling of carbon atoms.
- The amount of carbon on Earth is fixed.
- One atom of carbon can be made into different compounds at different times.

Photosynthesis and the carbon cycle

- Carbon in carbon dioxide gets fixed in compounds such as food (glucose).
- Photosynthesis helps in the recycling of carbon and is vital to the carbon cycle.

Photosynthesis

Factors affecting photosynthesis

1. **Carbon dioxide**
   - Levels of carbon dioxide fall ⟶ rate of photosynthesis falls
   - Levels of carbon dioxide rise ⟶ rate of photosynthesis rises

2. **Temperature**
   - Enzymes need a particular temperature to work
   - Temperature is low ⟶ rate of photosynthesis falls
   - Temperature is too high ⟶ enzymes will be destroyed and photosynthesis will stop

3. **Light**
   - Light intensity is low ⟶ rate of photosynthesis falls
   - Light intensity is high ⟶ rate of photosynthesis increases

Photosynthesis

Knowledge of photosynthesis and plant yields

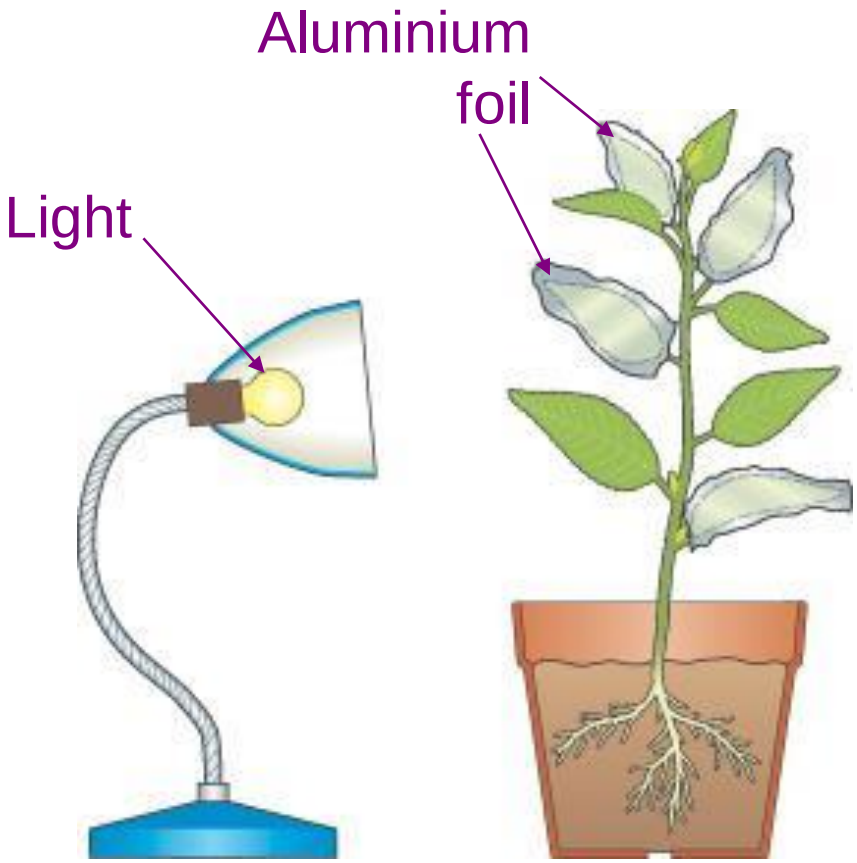
We know carbon dioxide, temperature and light affect the rate of photosynthesis in plants. This information can be used to increase plant yields:

- Growers increase the **temperature** of greenhouses to increase photosynthesis which will produce better crops.
- Adding **carbon dioxide** to greenhouses can increase yields of plants being grown.
- Artificial **light** in greenhouses allows seasonal foods to be grown all year round.

Method

To show that starch is made by a plant in photosynthesis

1. Leave a pot plant in the dark for two days.
   - To destarch the leaves, i.e. the starch moves out of the leaves.
2. Place tinfoil over some of the leaves of the plant.
   - To prevent light reaching the leaves and, therefore, to prevent photosynthesis. These leaves act as a control or comparison in the experiment.
3. Leave the plant in strong light for a few hours.
   - To allow photosynthesis to take place.
4. Test some of the covered and uncovered leaves for starch.
   - To show whether or not photosynthesis took place.



Experiment

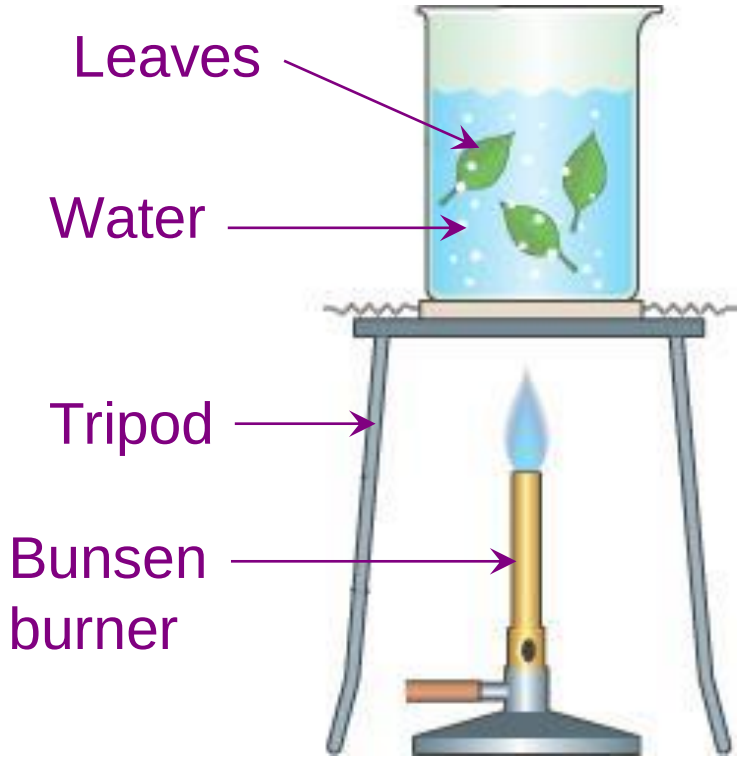
To test leaves for starch

Method

To test leaves for starch

1. Boil the leaves in water for a few minutes.

   This kills and softens the leaves.

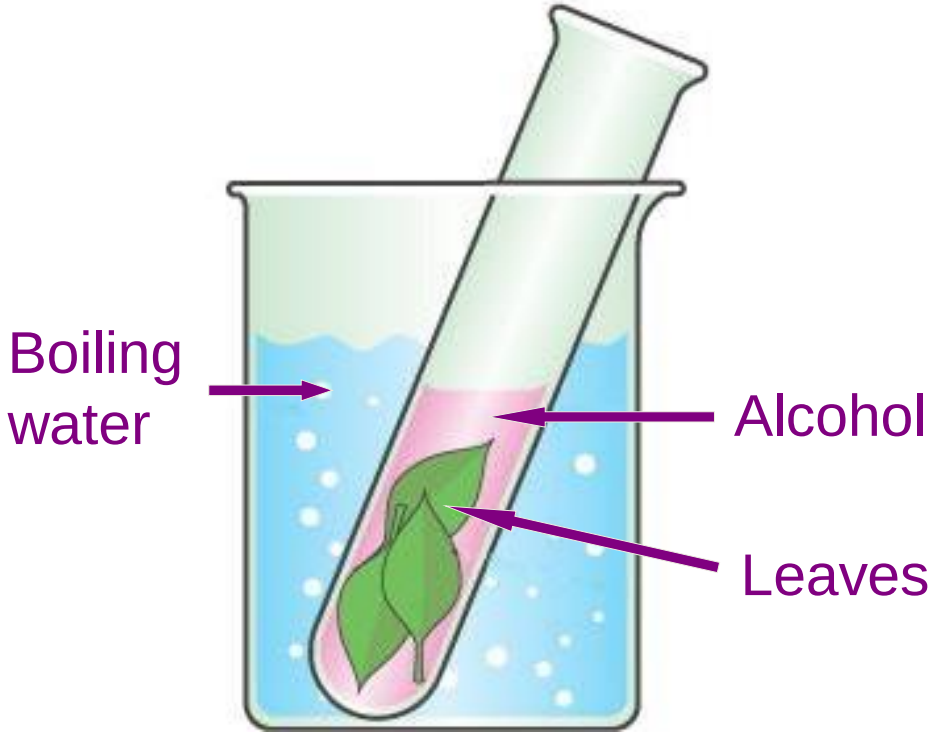


Method cont.

To test leaves for starch

2. Soak the leaves in hot alcohol for ten minutes.

This removes the chlorophyll from the leaves. Removing the green colour allows any later colour changes to be seen.

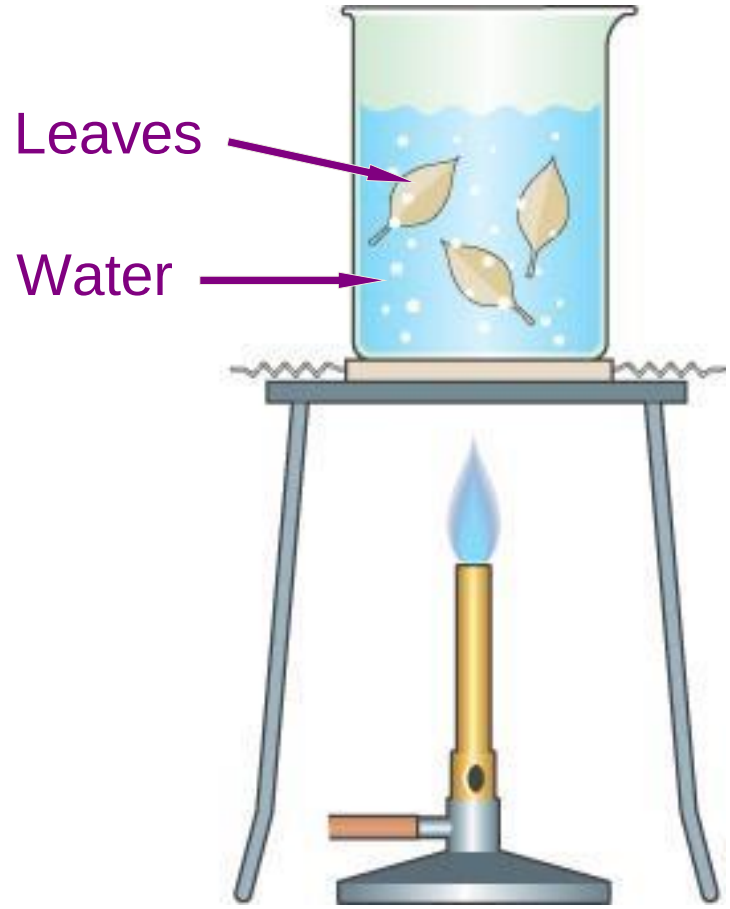


Method cont.

To test leaves for starch

3. Rinse the leaves briefly in boiling water.

Alcohol makes the leaves stiff and brittle. Rinsing off the alcohol will soften the leaves.

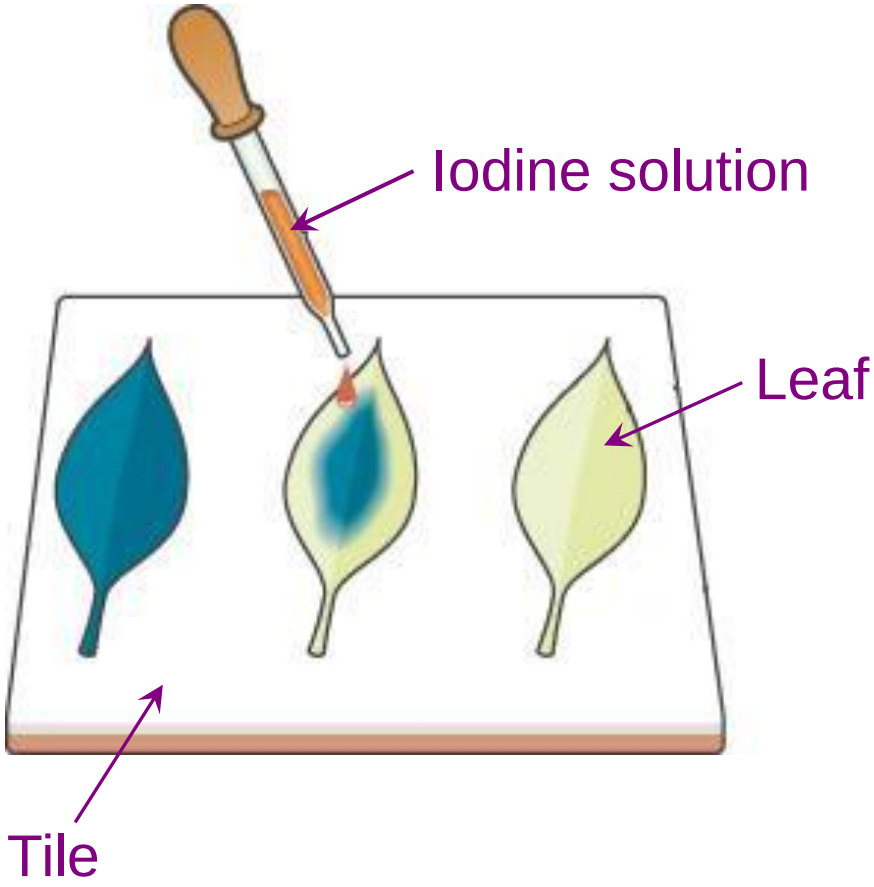


Method cont.

To test leaves for starch

4. Add iodine solution to the leaves.

Iodine turns from a red-yellow colour to blue-black if starch is present.



Results

To test leaves for starch

- The leaves that were uncovered turn blue-black.
  - This shows that starch is present.
- The leaves that were covered remain red-yellow.
  - This shows that starch is not present.

Conclusion

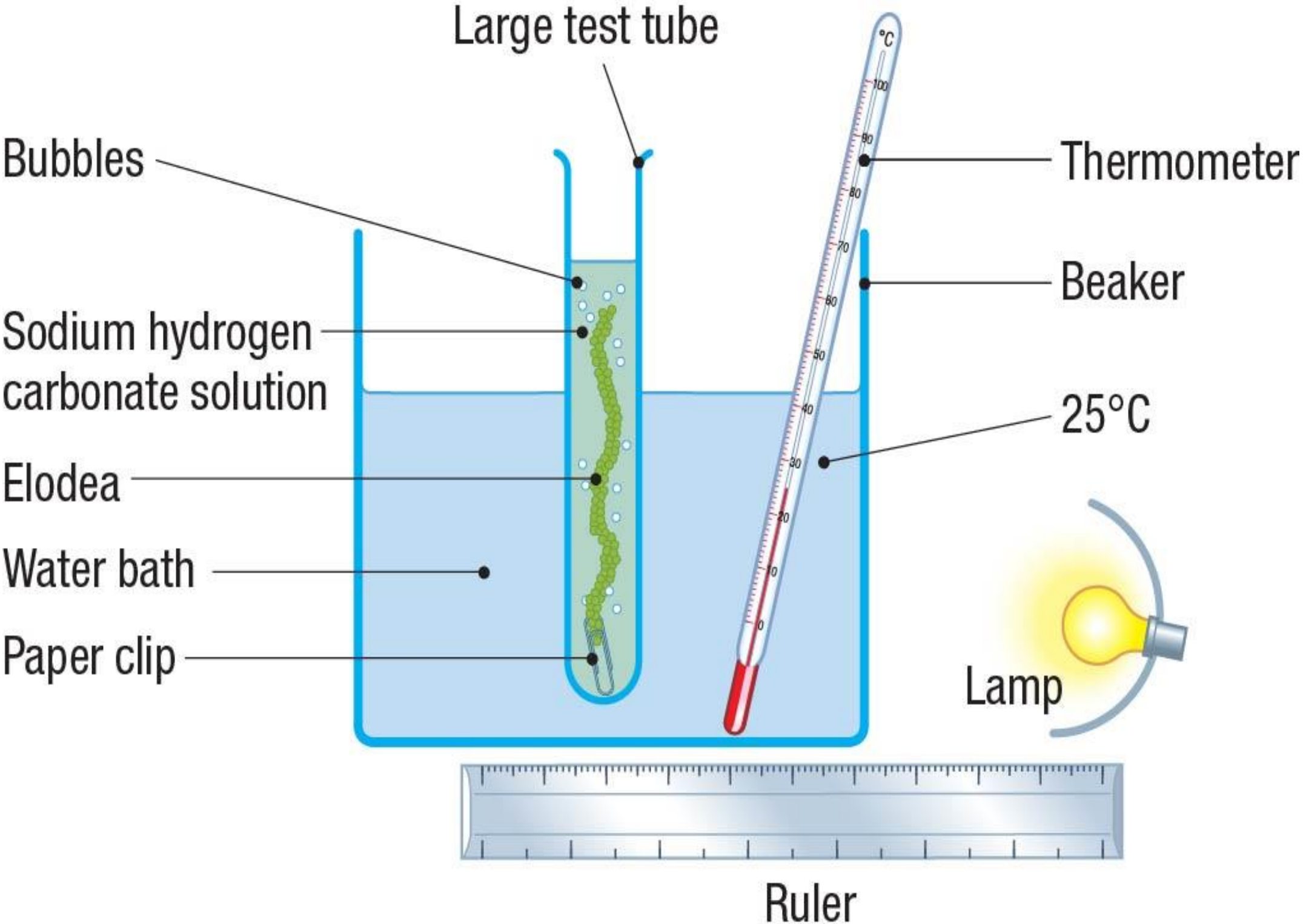
To test leaves for starch

Starch is made by leaves
in the presence of light.

This is called Photosynthesis

To investigate the influence of light intensity on the rate of photosynthesis:

- The number of bubbles of gas released per minute from *Elodea* is counted to calculate the rate of photosynthesis.
- Excess sodium hydrogen carbonate ensures constant CO_2 concentrations.
- A water bath ensures a constant temperature.
- Light intensity is varied by altering the distance between the lamp and the apparatus.
- The results indicate that increasing light intensity increases photosynthesis, up to a point.


Large test tube
Bubbles
Thermometer
Beaker
Sodium hydrogen carbonate solution
25°C
Elodea
Water bath
Paper clip
Lamp
Ruler

Plant responses

- The ability to respond is one of the characteristics of life.
- Plants usually respond slowly (so that often we do not see their responses).
- Plants respond to light and gravity by growing towards or away from light or gravity.
- A **tropism** is the change in growth of a plant in response to an outside stimulus.

Phototropism

Phototropism is the change in growth of a plant in response to light.

- The shoots (aerial parts) of a plant grow towards light due to phototropism.
- Phototropism allows shoots to get more light and make more food.

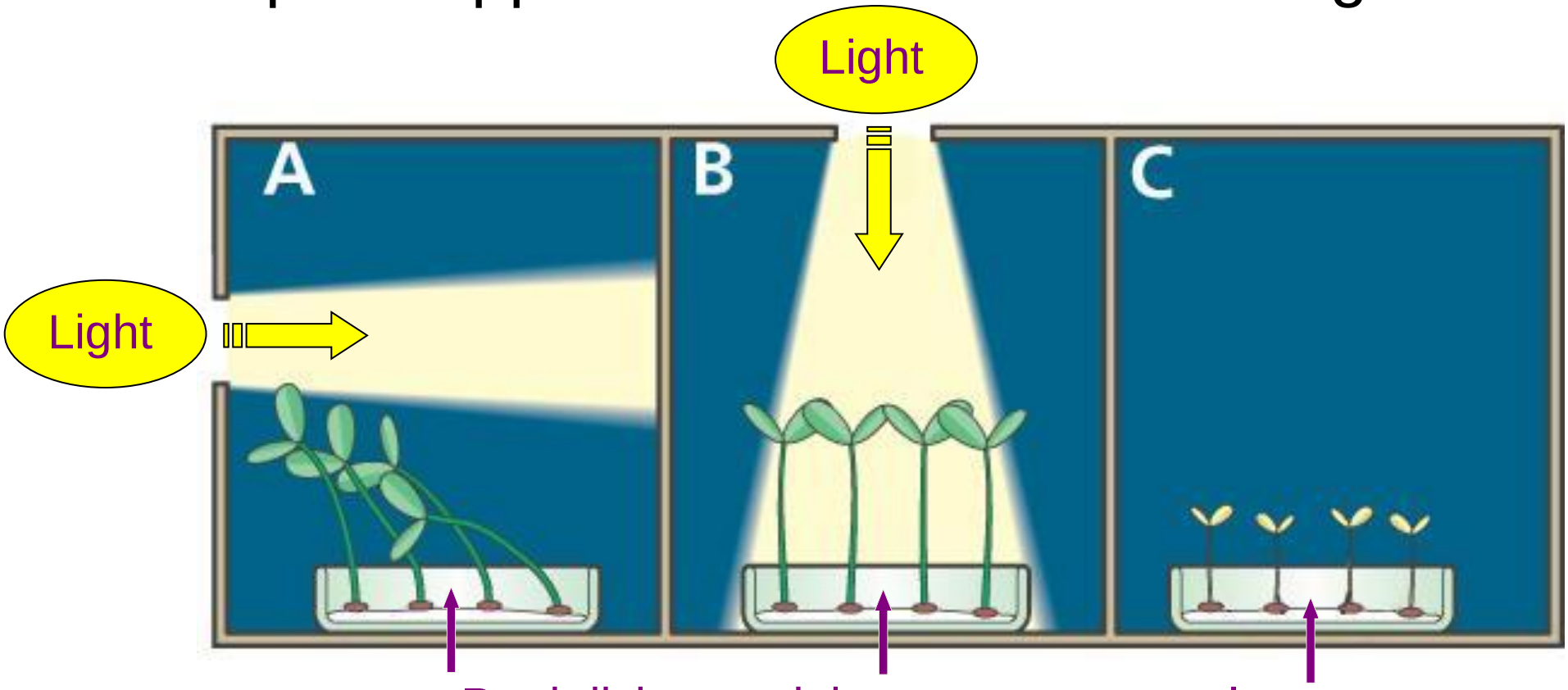
To investigate phototropism

Experiment

Method

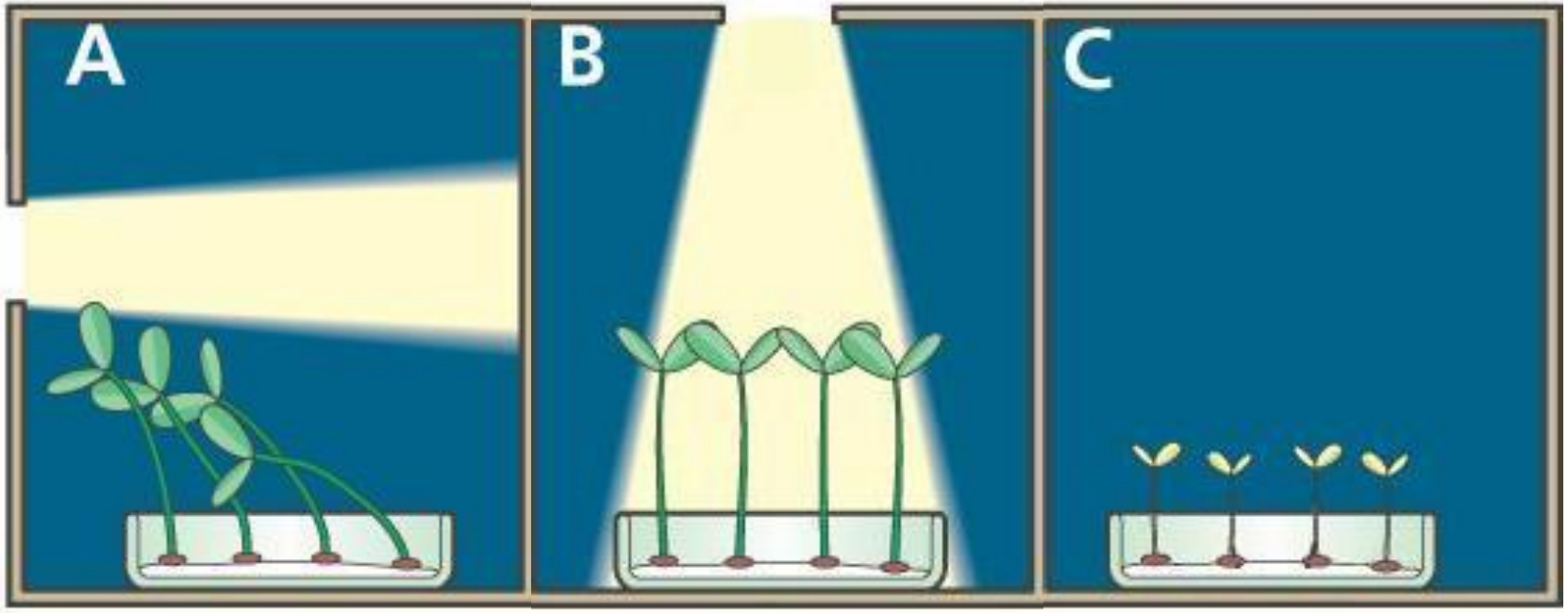
To investigate phototropism

Set up the apparatus as shown in the diagram.



Results

To investigate phototropism



Section A: the seedlings grow towards the light and bend.

Section B: the seedlings grow straight up towards the light.

Section C: the seedlings turn yellow and do not grow.

Conclusion

To investigate phototropism

Seedlings grow towards the light.

Geotropism

Geotropism is the change in growth of a plant in response to gravity.

- The shoots of a plant grow away from gravity.
  - This means they grow upwards towards the light.
- The roots grow towards gravity.
  - This means they grow into the soil to get a better grip and to absorb more water.

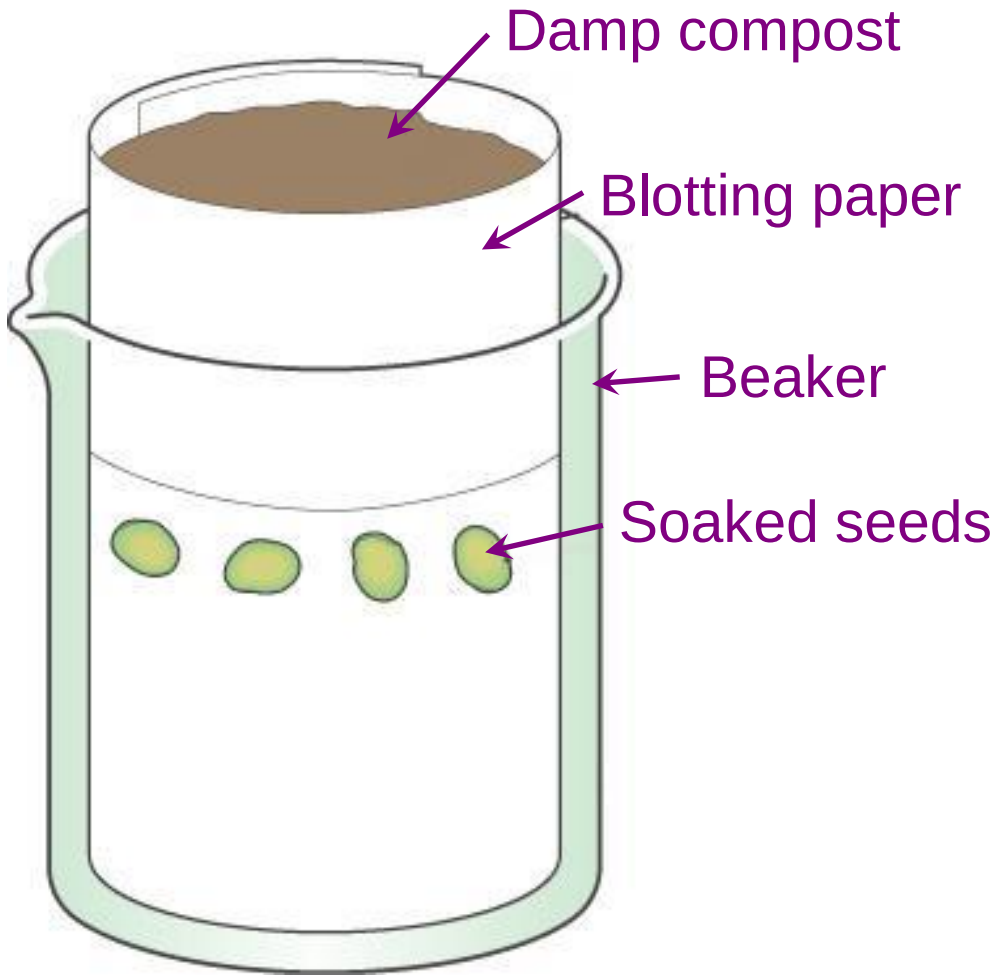
Experiment

To investigate geotropism

Method

To investigate geotropism

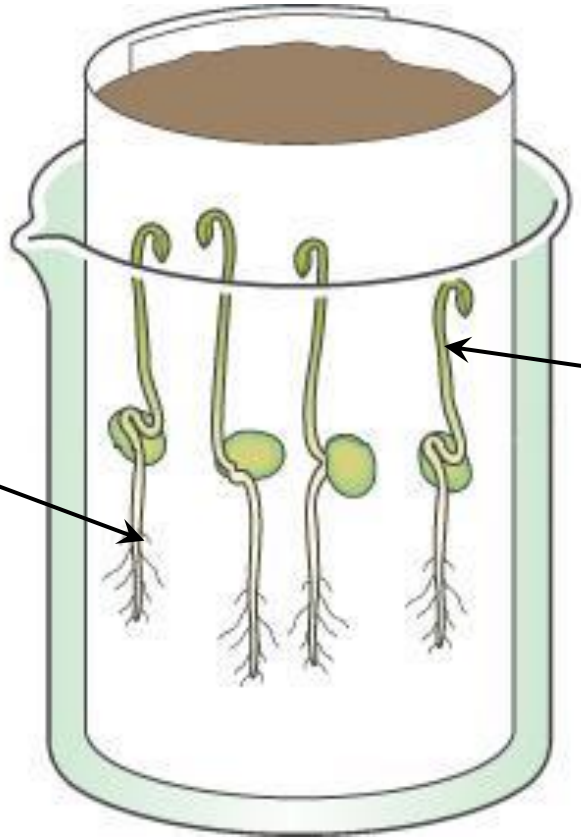
1. Soak some large seeds in water for a day or two.
2. Set up the apparatus as shown in the diagram.
3. Leave the apparatus in a warm dark place for a few days.



Result

To investigate geotropism

As the diagram shows:



The roots grow down towards gravity

The shoots grow up away from gravity

Conclusion

To investigate geotropism

Shoots grow away from gravity and roots grow towards gravity.

Learning Outcomes

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