

What a plant needs for photosynthesis

Investigate the need for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To show that chlorophyll, light and carbon dioxide are each needed for photosynthesis, by testing destarched leaves for starch with iodine solution.

Background

Plants make glucose by **photosynthesis** from carbon dioxide and water, using energy from light absorbed by **chlorophyll**. Some of the glucose is changed into **starch** and stored in the leaf. If a leaf contains starch, photosynthesis has taken place in it.

To make this a fair test, the plant is first **destarched**: it is kept in the dark for 24 to 48 hours, so that it uses up its starch in respiration. A leaf from a destarched plant gives a negative starch test, so any starch found later must have been made during the investigation.

Each investigation removes one requirement and keeps the others. A **control** is set up with the requirement present, so that the only difference is the factor being investigated. The result is judged using **iodine solution**, which turns from orange-brown to blue-black when starch is present.

Hypothesis

Starch will be made only in parts of a leaf that have chlorophyll, light and carbon dioxide, because all three are needed for photosynthesis.

Variables

Independent	The requirement being removed: chlorophyll (variegated leaf), light (foil) or carbon dioxide (soda lime)
Dependent	The colour of the leaf after the iodine test (blue-black = starch present, orange-brown = no starch)
Control	• Same type of plant and leaves of similar age and size • All plants destarched for the same time (48 hours) • Same time in the light after destarching • Same temperature and light intensity for all the plants • Same method and time in boiling water, ethanol and iodine solution for every leaf

Equipment

- 4 destarched potted geranium (Pelargonium) plants: A is a variegated plant, B, C and D have all-green leaves
- Aluminium foil and paper clips
- Soda lime (about 10 g) in a small dish, and a spatula
- A second small dish containing 10 cm³ of water

- 2 large clear polythene bags, elastic bands and petroleum jelly
- Lamp (or a bright windowsill)
- 250 cm³ beaker, kettle of freshly boiled water, and tongs or forceps
- Boiling tube and ethanol (about 10 cm³)
- Second 250 cm³ beaker for a hot-water bath
- White tile, dropping pipette and iodine solution
- Marker pen and labels, scissors
- Eye protection

Risk assessment

Hazard	Risk	Precaution
Ethanol (flammable)	The vapour catches fire if it is near a naked flame.	Turn off all Bunsen burners and flames before using ethanol. Heat the ethanol only in a beaker of hot water from the kettle. Wear eye protection.
Soda lime (corrosive / irritant)	Dust or grains can irritate or burn the skin and eyes.	Wear eye protection. Handle with a spatula, not the fingers. Wash hands after use. Keep the soda lime in its dish and do not touch it.
Boiling water	Scalds.	Use tongs or forceps. Stand the beaker on a heat-proof mat and pour slowly away from the body.
Iodine solution	Stains skin and clothes; irritant to eyes.	Wear eye protection and wash off any splashes at once.

Method

1. Put on eye protection. Collect four destarched plants labelled A (variegated leaves), B, C and D. Your teacher has kept them in the dark for 48 hours.
2. Remove one leaf from plant B and test it for starch, using steps 9 to 13, to check that the plants are starch-free.
3. Plant A: choose one leaf and draw it, showing which areas are green and which are white. Attach a label to the leaf.
4. Plant B: cover the middle part of one leaf, on both sides, with aluminium foil so that no light reaches it. Fold the foil over the leaf and hold it with paper clips.
5. Plant C: use a spatula to put about 10 g of soda lime in a small dish and stand the dish on the soil. Cover the plant and the dish with a clear polythene bag and seal the bag around the pot with an elastic band and petroleum jelly.
6. Plant D (control): treat in the same way as plant C, but put 10 cm³ of water in the dish instead of soda lime.
7. Stand all four plants close together in bright light, for example the same distance from a lamp, for 24 hours.
8. Remove one leaf from each plant: the labelled variegated leaf from A, the foil-covered leaf from B (remove the foil), and one leaf from inside each bag for C and D.
9. Pour just-boiled water from a kettle into a 250 cm³ beaker. Use forceps to hold the first leaf in the water for about 30 seconds, then remove it.
10. Check that there are no flames. Put the leaf in a boiling tube with about 10 cm³ of ethanol and stand the tube in a second beaker of hot water. Leave it until the leaf is pale or white.

- L1 . Use forceps to take out the leaf, rinse it in the hot water to soften it, and spread it flat on a white tile.
- L2 . Add drops of iodine solution to cover the leaf. Wait 1 minute.
- L3 . Record the colour of each part of the leaf. Draw outlines of leaves A and B and mark the areas that turned blue-black.
- L4 . Repeat steps 9 to 13 for the other leaves, using fresh hot water and ethanol each time. Wash your hands and clear away.

Results

Colour of the leaf with iodine solution			
leaf	part of leaf tested	colour with iodine solution	starch present (yes or no)
A (variegated)	Green area		
A (variegated)	White area		
B (foil)	Uncovered area		
B (foil)	Area covered by foil		
C (soda lime)	Whole leaf		
D (water, control)	Whole leaf		

Exam questions 10 questions · 31 marks

- 1** The plants were kept in the dark for 48 hours before the investigation. State what is being done to the plants and explain why this is necessary. **[2 marks]**

- 2** A leaf is placed in boiling water for about 30 seconds before it is tested for starch. Give two reasons why this is done. **[2 marks]**

- 3** The leaf is then placed in hot ethanol. (a) State why the leaf is placed in ethanol. (b) Explain why the ethanol is heated in a beaker of hot water and not over a Bunsen burner flame. **[3 marks]**

4 A variegated leaf has green areas and white areas. It was left in the light, then tested for starch. Describe the colour of the green area and of the white area after iodine solution was added, and explain the difference. **[3 marks]**

5 A student covered the middle of one leaf with foil to investigate whether light is needed for photosynthesis. State what the control is in this investigation and why it is a good control. **[2 marks]**

6 Soda lime absorbs carbon dioxide. A destarched plant was sealed in a polythene bag with a dish of soda lime and left in the light for 24 hours. (a) Describe a suitable control. (b) State the result you would expect for the leaf from the bag with soda lime and explain it. **[4 marks]**

7 Ethanol is flammable and soda lime is corrosive. For each chemical, state one safety precaution. **[2 marks]**

- 8** Table 1.1 shows the treatment of four leaves from destarched plants. Complete the table by stating whether starch is present (yes or no) in each leaf after the iodine test. **[4 marks]**

Table 1.1		
leaf	treatment during the investigation	starch present (yes or no)
A	Green leaf in the light, in air	
B	White area of a variegated leaf in the light, in air	
C	Green leaf wrapped completely in foil, in air	
D	Green leaf in the light, in a sealed bag with soda lime	

- 9** A student did not destarch the plant. (a) Predict what the student would see when the leaf covered with foil was tested with iodine solution. (b) Explain why the result would not show that light is needed for photosynthesis. (c) Suggest one way that the foil could affect the covered area other than by blocking light. **[4 marks]**

- 10** Describe how you would test a leaf for starch. **[5 marks]**

Teacher answers

Practical skill 5: What a plant needs for photosynthesis. The example results are practice data, not real measurements.

Example results

Example results (practice data)			
leaf	part of leaf tested	colour with iodine solution	starch present (yes or no)
A (variegated)	Green area	Blue-black	Yes
A (variegated)	White area	Orange-brown	No
B (foil)	Uncovered area	Blue-black	Yes
B (foil)	Area covered by foil	Orange-brown	No
C (soda lime)	Whole leaf	Orange-brown	No
D (water, control)	Whole leaf	Blue-black	Yes

Conclusion

Starch was found only in the green parts of the variegated leaf, so chlorophyll is needed for photosynthesis: the white areas have no chlorophyll, so they cannot absorb light energy. Starch was found only in the uncovered parts of the leaf in foil, so light is needed. The leaf in the bag with soda lime, which absorbs carbon dioxide, had no starch, but the control leaf in the bag with water did, so carbon dioxide is needed. In each investigation the control, either the part of the same leaf or plant D, had starch, which shows that the lack of starch was caused by the factor that was removed. The starch-free leaf from the destarched plant shows that the starch had been made during the investigation.

Errors and improvements

Error	Effect on the results	Improvement
The plant is not fully destarched.	Starch left in the leaf gives a blue-black colour in the parts that should be orange-brown, so the results are wrong.	Keep the plant in the dark for at least 48 hours and test a leaf for starch before starting.
The leaf is not left in ethanol long enough, so chlorophyll remains.	The green colour hides the colour change with iodine, so a blue-black colour is hard to see.	Leave the leaf in hot ethanol until it is pale, and replace the ethanol if it is very green.
Carbon dioxide from the air or from breathing gets into the bag with the soda lime, or the soda lime is used up.	Some photosynthesis occurs, so the leaf may contain some starch and the result is less clear.	Seal the bag tightly with petroleum jelly, do not breathe into it, and use fresh soda lime.
Foil does not completely cover the leaf, or the foil changes the temperature of the covered part.	Some light reaches the covered area, or the covered and uncovered parts are at different temperatures, so the test is not fair.	Fold the foil tightly over both sides of the leaf and use a lamp that gives little heat.
Only one leaf is tested for each factor.	An unusual leaf could give a misleading result.	Repeat with several leaves from different plants and compare results.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- the plants are destarched / the starch is removed (1)
- so that any starch found in the leaves was made during the investigation / so the test is a fair test (1)

2. [2]

- kills the cells / denatures the enzymes so reactions stop (1)
- breaks down the cell membranes / makes the leaf soft so that iodine solution can enter the cells (1)

3. [3]

- (a) removes chlorophyll / decolourises the leaf (1)
- so the colour with iodine can be seen (1)
- (b) ethanol is flammable / may catch fire (1)

4. [3]

- green area blue-black and white area orange-brown / brown (1)
- white area has no chlorophyll (1)
- so no photosynthesis / no starch made in the white area (1)

5. [2]

- the part of the leaf that was not covered by foil (1)
- same leaf so same plant, age, temperature, water supply and carbon dioxide / only light differs (1)

6. [4]

- (a) an identical plant in a sealed bag (1)
- with a dish of water instead of soda lime / no soda lime (1)
- (b) leaf stays orange-brown / no starch (1)
- no carbon dioxide so no photosynthesis (1)

7. [2]

- ethanol: no naked flames / heat in a hot-water bath / use eye protection (1)
- soda lime: wear eye protection / use a spatula / do not touch with fingers / wash hands (1)

8. [4]

- A yes (1)
- B no (1)
- C no (1)
- D no (1)

9. [4]

- (a) the covered area is blue-black / contains starch (1)
- (b) starch was already in the leaf before the investigation (1)
- so it cannot be shown that the starch was made during the investigation / that photosynthesis did not occur in the covered area (1)
- (c) foil changes the temperature / reduces gas exchange or evaporation of water from the covered area (1)

10. [5]

- place the leaf in boiling water (for about 30 seconds) (1)
- turn off the Bunsen burner / no naked flames (before using ethanol) (1)
- place in (a boiling tube of) ethanol in a hot water bath until it is pale / the chlorophyll is removed (1)
- rinse and spread the leaf on a white tile (1)
- add iodine solution, blue-black shows starch is present (1)

Exam tips

- Learn the order of the starch test: boiling water, hot ethanol, rinse, iodine. Say why each step is done: kill the cells, remove chlorophyll, soften the leaf, show starch.
- Always give both colours in full: orange-brown (no starch) and blue-black (starch). Do not write 'purple'.
- Name the control for each investigation: the green part of the leaf, the uncovered part of the leaf, or the plant with water instead of soda lime. Say that it shows the factor removed caused the result.
- Destarching is done so that any starch found was made during the experiment. Many candidates just write 'to remove the starch'.
- Never say 'ethanol is heated in a flame'. It is flammable, so use a water bath with the Bunsen burner off.