Do sun and shade plants respond differently to green light?

Objective

The purpose of this experiment is to show that some plants have naturally evolved traits to enable them to photosynthesise more efficiently in the shade.

By understanding photosynthesis and the different adaptations plants have developed to be able to thrive in different environments, researchers can develop different varieties of crops to be able to meet the growing demand for food and to cope with our changing climate. Photosynthesis is essential for all life on Earth. It is the process in which plants take light energy from the sun and use it to convert carbon dioxide and water into the molecules that all living things need – glucose and oxygen.

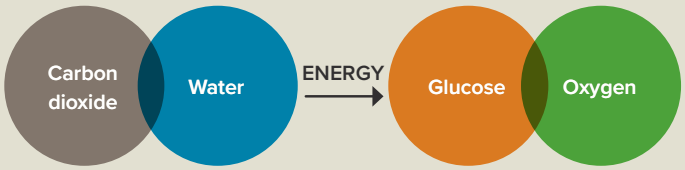
Plants use the green molecule chlorophyll and other pigments to absorb the wavelengths of light needed for this process. Those which live in direct sunlight receive white light and absorb the blue and red light from it in order to photosynthesise. Green light is reflected off plant leaves, which is why they appear green. Plants that live in the shade receive light which has been filtered through the canopy so they may need to be able to use many other wavelengths of light, such as green light, in order to photosynthesise.

Introducing the experiment

Identify prior knowledge of photosynthesis by asking students to note down any facts they remember about the process. Help students to create the word equation for photosynthesis and remind them that light is the energy source for this reaction.

You might also want to examine leaf adaptations and compare leaves from sun and shade plants to note the differences.

Photosynthesis word equation



During the experiment

- Refer to technician notes for further information on the items needed to set-up the experiment.
- Students create their own results table, so need to read through the experiment first before starting it. If appropriate, a table can be provided for them or one worked out as a class.
- Prior to students carrying out the experiment, arrange a maximum time to wait for the leaf discs to rise – say 15 or 20 minutes. Assume they will never float after that time.
- Timings will be shorter if good illumination is provided (eg light bank (1,200 lumens or more) or a warm, sunny windowsill) and if the sodium hydrogen carbonate solution is warm (20 – 30°C). If the sodium hydrogen carbonate solution is cold to start with, heat from the lights will probably increase its temperature as the experiment proceeds, influencing the results.

Discussion points after the experiment

- Discuss with your students the limitations of the experiments:
  - were the results reliable?
  - Was it a fair investigation?
- Can they identify the variables in this experiment:
  - Dependent: time taken for discs to float
  - Independent: type of light (white or green)
  - Control: size of discs, volume of solution, distance from the lamp etc.
- What are the advantages to being able to perform photosynthesis well using different wavelengths (colours) of light?
- What do you think is responsible for different plants being able to use different colours of light for photosynthesis?
- Relate to topic on absorption and reflection of blue, red and green light.

The science behind this experiment

All plants need chlorophyll to photosynthesise, but there is not just one type of chlorophyll. Sun plants have more chlorophyll 'a' in their leaves which is the main pigment for light capture and can absorb light from both ends of the spectrum. Those plants that grow in the shade have more of a different pigment: Chlorophyll 'b' which can absorb some of the wavelengths of light that have been reflected from other leaves (the blue end of the spectrum). Plants that can grow in the shade also have more chloroplasts per square centimetre, and larger chloroplasts too, allowing them to capture more light in general.

For more school experiments and to access the accompanying videos, visit **royalsociety.org/schoolexperiments**

THANKS

This activity is based on an original activity, called *Investigating Photosynthesis with Leaf Discs*, designed by SAPS (Science & Plants for schools www.saps.org.uk) who have kindly agreed to its use in the Royal Society Brian Cox school experiments.

Do sun and shade plants respond differently to green light?

Your task is to investigate how the rate of photosynthesis varies between sun and shade plants in different colours of light.

Instructions

Before you start read through the steps below and draw up a table for results using correct headings and appropriate units.

1. Using the cork borer or straw, cut out three discs from a shade plant.
2. Remove the plunger from a 10 cm^3 transparent plastic syringe. Place your finger over the nozzle, add about 5 cm^3 0.2 M sodium hydrogen carbonate solution.
3. Carefully put the leaf discs into the solution in the syringe.
4. Carefully replace the plunger and point the syringe upwards.
5. Push out all of the air.
6. Place a finger over the nozzle. Gently pull the plunger down. Many bubbles will appear on the leaf discs.
7. Once the bubble production has slowed down, release your finger from the nozzle and tap the syringe vigorously so that the air bubbles rise to the top. Repeat steps 5, 6 and 7 until all the leaf discs sink.
8. Put the syringe close to the strong light source and start a stopwatch. Record the time taken for each leaf disc to rise.
9. Calculate the average time for the leaf discs to float.
10. Repeat the experiment using three discs from a sun plant.
11. Resink the leaf material, cover each syringe with a green filter and again note the time for the leaf material to float.
12. Calculate the average time for the leaf discs to float as before. Discuss with your teacher the maximum time you should wait for the discs to rise. Having waited this length of time it can be assumed they will never respond.

EQUIPMENT LIST

Materials for each student/group

- 2 x 10 cm^3 syringes
- 20 cm^3 sodium hydrogen carbonate solution
- Stop clock
- 2 syringe covers made from a green filter sheet

Materials to be shared

- No. 3 cork borer/straw or hole punch
- Shade plant leaves
- Sun plant leaves
- Strong light source
- Sheet of glass or perspex (optional)

SAFETY PRECAUTIONS

- Safety goggles are recommended for this experiment to avoid chemicals getting into eyes.
- Make sure to clean up any spills immediately. If you break any glassware, make sure to tell your teacher immediately. Do not try to clean up broken glass yourself.
- Care needs to be taken to avoid burns from the heat of the lamp. Using LEDs reduces this risk.

Questions

1. **Why are 3 leaf discs taken from each plant instead of just 1 or 2?**

2. **If you use more than 3 discs per syringe, the discs may overlap when lying at the bottom of the syringe. Why is this a problem and what steps can be used to avoid overlapping even when using 3 discs?**

3. **How do you think heat from the light source will affect the results? How can this be prevented?**

4. **What other measurements need to be kept constant throughout the experiment? How can this be achieved?**

THANKS

This activity is based on an original activity, called *Investigating Photosynthesis with Leaf Discs*, designed by SAPS (Science & Plants for schools www.saps.org.uk) who have kindly agreed to its use in the Royal Society Brian Cox school experiments.

Do sun and shade plants respond differently to green light?

Background

By understanding photosynthesis and the different adaptations plants have developed to be able to thrive in different environments, researchers can develop different varieties of crops to be able to meet the growing demand for food and to cope with our changing climate.

This experiment provides a fun way for students to get hands-on when investigating photosynthesis and natural adaptations.

Students punch out small discs from leaves and float them in a syringe of sodium hydrogen carbonate solution. Once gas is evolved by photosynthesis, the leaf discs will rise.

Preparation notes

For reasons that are not immediately obvious, only certain plants work in this practical so it is worth testing them quickly beforehand.

Timings will be shorter if good illumination is provided (eg light bank (light equal to at least 1,200 lumens) or a warm, sunny windowsill) and if the sodium hydrogen carbonate solution is warm (20 – 30°C). If the sodium hydrogen carbonate solution is cold to start with, heat from the lights will probably increase its temperature as the experiment proceeds, influencing the results.

Sheets of glass or perspex can also be provided to prevent heat from the light reaching the syringe (it is unlikely to be needed given the speed of the experiment, especially if using LED bulbs).

Make up 0.2 M sodium hydrogen carbonate (20 cm^3 per group/student) with water that has been allowed to come up to room temperature (20 – 30°C).

Add 4 – 5 drops of detergent to a litre of solution. This helps prevent the discs from sticking to the sides of the syringe.

Green syringe covers – green coloured filter sheets which can be easily cut to make covers.

Cut a piece of filter sheet 10.5 x 5.5cm. Fit this around a 10cm^3 syringe. Use sellotape to seal the seam. Ensure the edges of the filter do not overlap otherwise it will make it difficult for students to see the discs rising (ie make sure there is only one layer of green filter).

EQUIPMENT LIST

Materials for each student/group

- 2 x 10 cm^3 syringes.
- 20 cm^3 of 0.2M sodium hydrogen carbonate solution (baking soda).
- Stop clock.
- 2 syringe covers made from a green filter sheet (green cellophane can be used).

Materials to be shared

- No. 3 cork borer or wide plastic straw. A hole punch without the waste-catching cover may also work depending on the type of leaves used.
- Shade plant eg aspidistra, ivy, laurel.
- Sun plant eg cress, geranium.
- Strong light source (over 1,200 lumens).
- Sheet of glass or perspex (optional – although unlikely to be used).

SAFETY PRECAUTIONS

- Care needs to be taken to avoid burns from the heat of the lamp. Note that using LEDs reduces this risk.
- Safety goggles are recommended for this experiment to avoid chemicals getting into eyes.

THANKS

This activity is based on an original activity, called *Investigating Photosynthesis with Leaf Discs*, designed by SAPS (Science & Plants for schools www.saps.org.uk) who have kindly agreed to its use in the Royal Society Brian Cox school experiments.