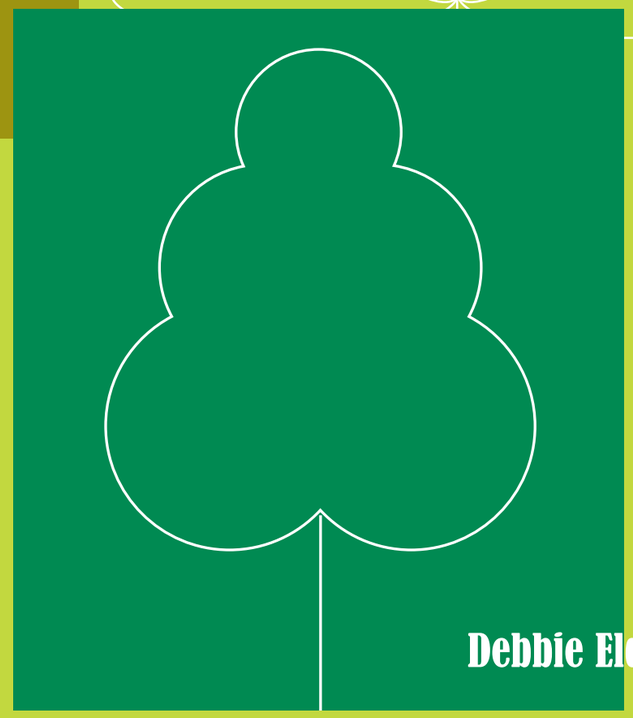
SAPS

Technical guide

Photosynthesis — A survival guide



Debbie Eldridge

Activity sheet

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What sort of carbohydrates do plants make?

Background information

A variety of plants and plant products can be tested for glucose, starch and cellulose. Plants which give interesting results include onion, apple, pear, celery, potato and grapes. It is also interesting to test materials such as cotton wool, paper towel, egg boxes and other materials made from recycled paper. These show up clearly the high proportion of cellulose fibres.

Benedict's reagent will not give a coloured product with all simple sugars.
All monosaccharide sugars such as glucose, fructose, and galactose will give a positive result as well as some disaccharide sugars such as maltose and lactose. Sucrose will not give a positive result with Benedict's reagent.

Equipment and materials required for each working group

- White tile
- Knife/scalpel
- 5 – 6 boiling tubes – one for each type of food
- Small pestle and mortar
- Small bottle of Benedict's solution
- Small bottle of iodine solution
- Paper towels

Activity sheet

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Equipment and materials required centrally

- Access to water bath set at 85 – 90°C
- Food samples containing carbohydrate stores e.g. onion, apple, pear, celery, potato, grapes.
- Optional extras: cotton wool, paper towels, egg boxes, flour, rice, powdered glucose.
- Buckets/plastic containers for food remains

1 bottle of Schulze's reagent (to be administered by the teacher)

Hazards:

- Water bath at 85 – 90°C
- Use of scalpel
- Schulze's reagent should be made up fresh, contained in a small stoppered bottle and administered only by the teacher. Label the bottle CORROSIVE

Fig 1–Positive result

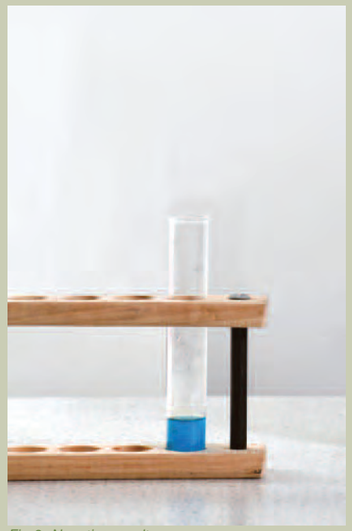

Fig 2–Negative result

Activity sheet

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Method/Preparation of materials

To make the solutions:
Benedict's reagent – CLEAPSS recipe card No 8
Iodine solution – CLEAPSS recipe card No 39
Schulze's reagent – CLEAPSS recipe card No 12 (G).

Ideally the samples for testing should be chopped into small pieces about 1 cm^3 maximum so that students can easily select three pieces to carry out their tests.

Disposal of materials:

In the laboratory have one or two large plastic containers in which students place their waste so that sinks do not get blocked.

Suppliers:

All regular scientific suppliers provide chemicals needed for preparation of solutions. See suppliers list at end of technical guide.

Fig 1–Egg carton stained with Schulze's reagent

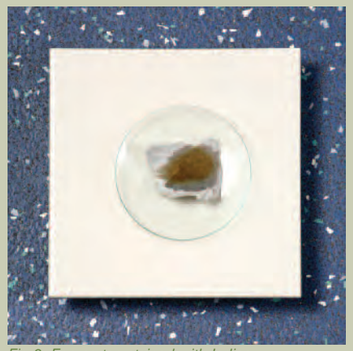

Fig 2–Egg carton stained with Iodine

Fig 3–Cotton wool stained with iodine

Fig 4–Cotton wool stained with Schulze's reagent

Fig 5–Apple stained with Schulze's reagent

Activity sheet

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How can we show that plants use carbon dioxide?

Background information

Students will use hydrogencarbonate indicator to detect changes in carbon dioxide concentration. They will place an aquatic plant into a container of hydrogencarbonate indicator and illuminate under different conditions. It is recommended to make hydrogencarbonate indicator from the pure dyes rather than buy it from an external supplier as the latter can be very variable in quality.

Equipment and materials required for each working group:

- 4 transparent containers[1]
- 4 stoppers for containers or Parafilm
- Hydrogencarbonate indicator[2]
- *Cabomba*.[3] One long sprig
- Light source[4]
- Filters[5]
- Flat sided transparent tank[6]
- Scissors for cutting *Cabomba* into equal sized pieces.

Activity sheet

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Notes

1 Any clear container with a lid would be suitable. They can be boiling tubes (which can be sealed with Parafilm®) – or universals or small squat chemical jars with lids. They need to be wide enough for a small sprig of *Cabomba*.

2 The volume of indicator required depends on the containers used. There needs to be enough to cover the plant within the containers plus a little excess for rinsing out the container prior to the activity.

3 *Cabomba* is an aquatic plant that is highly responsive to changes in lighting conditions. One long sprig of *Cabomba* will be cut into a few equal sized pieces, one for each container.

4 If this experiment is to work quickly then the light source has to be very powerful. If it is a bright day – sunlight on a windowsill is fine. 150 W halogen lamps are very good for photosynthesis work but they do get hot so a heat barrier is necessary to prevent the plant getting scorched. The experiment is best set up in one lesson and the students collect the results a couple of hours later to look at the colour changes or take a few digital images. If this is not possible it may be useful to set one up earlier so that typical results can be seen. Slides on a PowerPoint show some typical results.

5 Layers of thin cotton muslin can screen out some of the light or neutral density filters can be used. Neutral density filters are 'grey' filters which can be purchased in large sheets and cut down to cover the transparent containers. They reduce the intensity of light of all wavelengths equally.

6 A flat sided transparent container is needed to act as a heat screen. Chromatography tanks are useful but a cheaper alternative is to purchase a few flat sided glass vases or use medicinal flats.

Activity sheet

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Suppliers:
Cabomba is an aquatic plant available from most tropical fish suppliers and Blades Biological, Cowden, Edenbridge, Kent, TN8 7DX (tel: 01342 850 242) email: sales@blades-bio.co.uk

Neutral density filters can be purchased from LEE Filters (Central Way, Walworth Industrial Estate, Andover, Hants SP10 5AN (tel 01264 366245); www.leefilters.com. Typically a sheet of filter (measuring 1.22 m x 0.55 m) costs £4.01 + VAT. A useful filter is number 209 which allows 50% of available light to be transmitted. The transmission properties of each of the filters are available both from the Lee Filters and SAPS websites (www.saps-plantsci.cam.ac.uk).

150 W halogen lamps are available from most DIY suppliers or Rapid Electronics. Rapid Electronics Ltd, Severalls Lane, Colchester, Essex, CO4 5JS (tel: 01206 751166) email: sales@rapidelec.co.uk

Hazards:
150 W halogen lamps give out heat and should be left to cool down before moving.

Method/preparation of materials
Hydrogencarbonate indicator can be purchased from all the main scientific suppliers but it does vary a great deal. It is normally purchased in concentrated form and has to be diluted x 10 and then aerated before use. Some indicator is barely red when purchased in a concentrated form and another bottle might contain a deep purple liquid. The key thing is to use your indicator from a single source and not to mix them. If you can find a good source – the deep purple colour seems to give the best depth of colour and most obvious colour changes.

The indicator can also be made quite easily from cresol red and thymol blue (CLEAPSS recipe card No 34):

1. Dissolve 0.10 g of cresol red and 0.20 g of thymol blue in 20 cm^3 ethanol.
2. Dissolve 0.85 g sodium hydrogencarbonate in about 200 cm^3 of freshly boiled distilled water.
3. Add the ethanol solution and dilute to 1000 cm^3 with water.
4. For use, dilute the stock solution ten times with freshly boiled distilled water
5. Bubble air through the diluted solution to equilibrate it with atmospheric carbon dioxide.

The solution should be a deep cherry red when ready for use. Hydrogencarbonate indicator is a very sensitive pH indicator so it is important that all glassware used is rinsed out with a little of the indicator before use. Avoid breathing over open vessels of the diluted indicator; the exhaled carbon dioxide may alter the pH.

Activity sheet

8

Measuring photosynthesis by oxygen evolution

Background information:
In this practical students will place an aquatic plant into a container of 1% sodium hydrogencarbonate and count the bubbles of oxygen produced at different distances from a light source. Background light should be kept to a minimum whilst the experiment is carried out. Sometimes there are too many bubbles to count by eye and pupils can be encouraged to think of possible ways of collecting the gas and measuring the volume.

Equipment and materials required for each working group:

- 1 glass measuring cylinder (250 cm^3)
- A sprig of *Cabomba*[1]
- Sodium hydrogencarbonate solution (1%, 400 cm^3)
- A pair of scissors
- A stopclock
- A bright lamp (e.g. a 150 W halogen lamp)[2]
- A flat sided glass tank (to act as a heat screen)[3]
- A one metre ruler

Activity sheet

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Notes:

1 *Cabomba* is an aquatic plant that is highly responsive to changes in lighting conditions.
2 If this experiment is to work well then the light source has to be very powerful. 150 W halogen lamps are very good for photosynthesis work but they do get hot so a heat barrier is necessary to prevent the plant getting scorched.
3 A flat sided transparent container is needed to act as a heat screen. Chromatography tanks are useful but a cheaper alternative is to purchase a few flat sided glass vases or use medicinal flats.

During the experiment it is important that the temperature of the water is controlled as far as possible. It is also important to make sure the pupils give the plant time to equilibrate in the new surroundings each time they change the distance from the lamp.

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Hazards:
150 W halogen lamps give out heat and should be left to cool down before moving.

Suppliers:
Cabomba is an aquatic plant available from most tropical fish suppliers and Blades Biological, Cowden, Edenbridge, Kent, TN8 7DX (tel: 01342 850 242) email: sales@blades-bio.co.uk
150 W Halogen lamps are available from most DIY suppliers or Rapid Electronics, Severalls Lane, Colchester, Essex, CO4 5JS (tel:01206 751166) email: sales@rapidelec.co.uk

Activity sheet

10

What are chloroplasts?

Background information:
The aim of this practical is to let students observe chloroplasts directly under the microscope.

Following this they take a thin section of potato tissue and stain it to show starch grains.

Equipment and materials required for each working group:
- One microscope
- One bench lamp
- Microscope slides and cover slips
- A small piece of potato
- A small sprig of plant material.[1]
- Iodine solution
- A scalpel or razor blade

Students should select a single leaf from the *Elodea* plant and place it on a microscope slide. Place a drop of water on the leaf and then gently lower a cover slip onto the slide

Notes:
[1]A variety of plants are suitable – most aquatic plants with fine leaves or the edges of a leaf of *Elodea*. The more fleshy moss species e.g. *Mnium* spp. also give good results.

The digital image resource on the SAPS website (see www.plantscienceimages.org.uk/pages/intro.aspx) has some chloroplast images which can be used.

Activity sheet

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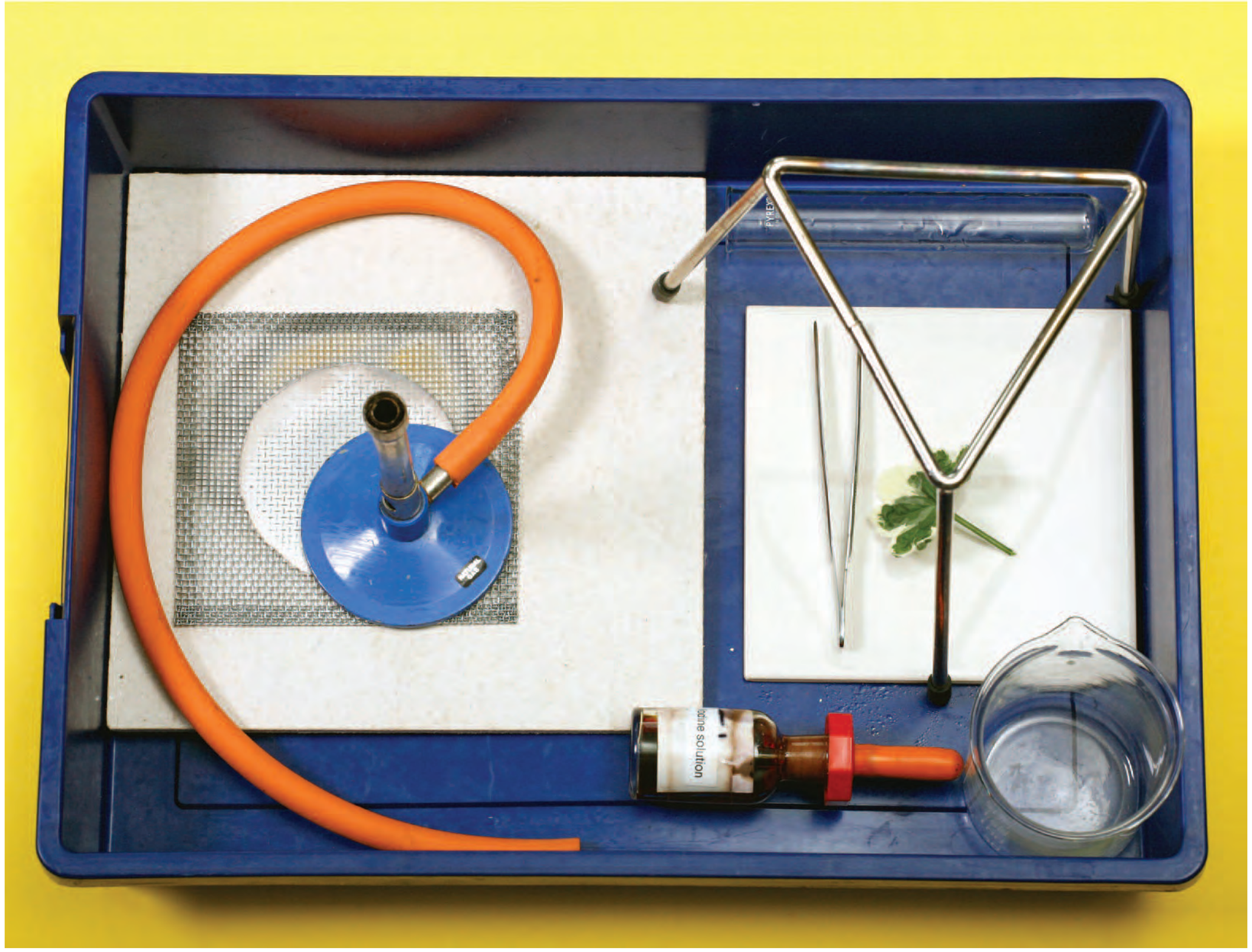
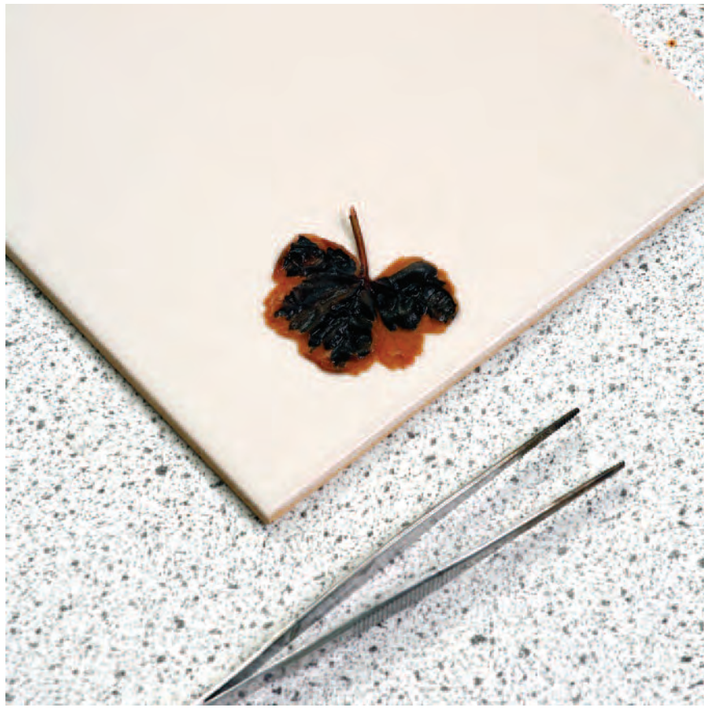
Can we show that only the green parts of the leaf produce starch in photosynthesis?



Background information:
Students carry out a starch test on a variegated leaf to demonstrate that only the parts containing chloroplasts are able to synthesise starch.

Equipment and materials required for each working group:
- A leaf from a variegated pelargonium[1]
- One 250 cm^3 beaker
- One boiling tube
- A Bunsen burner
- Heatproof mat
- Tripod and gauze
- One white tile
- Iodine solution in dropping bottle
- A pair of forceps



Materials to be shared
500cm³ ethanol (industrial alcohol) – Approximately 25 cm³ to be given out to each group by the teacher.

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Hazard:
Ethanol is highly flammable; harmful if swallowed.

Do not allow students access to ethanol whilst the Bunsen burner is still lit.

Notes:
[1]Place the variegated leaf under bright light for at least 24 hours prior to the practical.