

SICK PLANTS

Purpose

- To put together ideas about the transport and use of plant minerals.
- To investigate the effect of plant mineral deficiencies.

SAFETY

When carrying out any practical work, your own safety is important, and so is the safety of other people. Also consider how to avoid damage to apparatus.



Think about the design of the apparatus and how everyone can be safe in its vicinity.

Wash your hands thoroughly after handling plant material or growth media.

List any safety issues in your experiment and note how you will deal with each one. The table below shows a way to record this.

Safety issue	How it will be minimised

Identifying sick plants

How are minerals, such as nitrate, calcium and magnesium ions, transported and used in plants? What happens if the plant is not getting enough? Gardeners and fruit growers need to be alert to signs of deficiency and give appropriate treatments.

Figure 1 shows part of an orange plant. The newer leaves in front are a lighter green colour than the older leaves behind.



Figure 1 An orange plant.

Use the photo and the Student Book to answer the questions below.

- Q1** Describe the pattern of dark and light shades of green on the new leaves (look at the mediabank of SNAB Online to see the photo in colour).
- Q2** From your knowledge of plant anatomy, explain how the pattern you have described compares with the distribution of xylem vessels in a plant leaf.
- Q3** Name the green pigment, present in plant leaves, which is needed for photosynthesis.
- Q4** Name the mineral ion needed in the synthesis of this pigment.
- Q5** Putting all the ideas together from questions 1–4:
- explain the pattern of dark and light green in the new leaves of this orange plant
 - suggest a treatment for the plant that will help it to make uniformly dark green leaves.

Investigating plant mineral deficiencies

The Mexican hat plant (*Bryophyllum*) reproduces asexually. Plantlets grow from buds along the leaf edge. After a while they fall off and establish new plants. These miniature plants are ideal for investigating the effect of mineral deficiencies. Alternatively, germinated mung beans could be used.

1 Scientific questions and information research

Research relevant information and state what you are going to investigate.

Before you start planning your experiment you should decide what you think will be the effect of mineral deficiencies on the plant. Write down your idea as a question or hypothesis that you can answer or test and support your idea with biological knowledge. To help you decide on what you are going to investigate and how you will carry out the practical work you will need to research the background science and methods people have used to investigate similar problems.

2 Planning and experimental design

Using Mexican hat plantlets or germinated mung beans, design an experiment to investigate the effect of mineral deficiencies.

You are provided with the following equipment:

- Mexican hat (*Bryophyllum*) plantlets or germinated mung beans
- a range of nutrient solutions, including solutions:
 - with all nutrients present
 - lacking nitrogen
 - lacking magnesium
 - lacking calcium
 - lacking all nutrients
- standard laboratory equipment.

Make sure your plan includes:

- apparatus and a method that will validly answer your question or test your hypothesis
- identification of the independent and dependent variables and, where possible, controls or allows for other variables
- the range of values you will use for the independent variable and the range you might expect to find for the dependent variable
- a fully explained control if appropriate
- replicates if appropriate and an explanation of why these are necessary
- a statement of exactly what observations and measurements you will make and how they will be made to ensure valid, accurate and precise results are obtained
- information about any possible sources of error and how these can be minimised
- a risk assessment that identifies any safety issues and describes how any risks will be reduced.

SAFETY

When carrying out any practical work, your own safety is important, and so is the safety of other people. Also consider how to avoid damage to apparatus.

Think about the design of the apparatus and how everyone can be safe in its vicinity.

Wash your hands thoroughly after handling plant material or growth media.

List any safety issues in your experiment and note how you will deal with each one. The table below shows a way to record this.

Safety issue	How it will be minimised

Have your plan and risk assessment checked by your teacher/lecturer before starting your practical work.

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SAFETY

Ensure eye protection is worn.

Ensure students wash their hands thoroughly after handling plant material or growth media.

Review students' risk assessments.



Identifying sick plants

The first part of the activity sheet is an introduction to plant mineral deficiencies. The exercise reinforces knowledge and understanding of plant anatomy, and the role of xylem in mineral transport. It introduces mineral deficiencies by considering one example.

Students examine a photograph of an orange plant showing signs of mineral deficiency; they diagnose the likely cause and suggest remedies.

Answers

- Q1** The younger leaves show dark lines along the mid-rib of the leaves, with dark lines branching out from these. The edges of the leaves are the palest green.
- Q2** It matches the pattern of xylem vessels in leaves. They follow the mid-line and branch out towards the leaf edge, forming a network of veins (vascular bundles).
- Q3** Chlorophyll.
- Q4** Magnesium ions.
- Q5**
- There is a deficiency of magnesium ions in the plant. Xylem vessels carry magnesium ions to the leaves. In this case, not enough magnesium has reached the leaf extremities, so chlorophyll is not synthesised here. This makes them look paler. It is unusual for the new leaves to be yellow with magnesium deficiency as the chlorophyll in older leaves is normally broken down and the magnesium transported to the new growing leaves.
 - Give the plant a 'feed' using magnesium ions dissolved in water. (It is possible to give a 'foliar feed' in many plant species because the plant is able to absorb some ions through the leaf surface. But in plants with waxy leaves, like the orange, this does not work so well.)

Investigating plant mineral deficiencies

Notes on the procedure

The second part of the sheet requires students to plan an experiment to investigate plant mineral deficiency. The activity sheet is structured to reflect the Developing Practical Skills Framework, which can be found in the support section of SNAB Online. After completion of the experimental work students could use the Developing Practical Skills Self-evaluation Sheet to reflect on what they have done in this practical work.

Brophyllum plantlets are suggested for this investigation. This is because they are not relying on stored nutrients, unlike seeds used in germination experiments. An alternative is to use germinated mung beans. One method for the experiment is provided on page 2. Other methods could be used; for example, SAPS has a good protocol using radishes to investigate mineral deficiency.

Test tubes or boiling tubes can be used, but smaller tubes work better. The plantlet or germinated mung bean is placed on top. The tubes should be wrapped in aluminium foil to exclude light from the solutions and to prevent growth of algae. Place the tubes under a light bank or on a sunny windowsill. Differences should be evident within two weeks. Students may observe visual differences and measure the wet and/or dry mass of the plantlets. Students could pool their results to provide replicate measurements.

Investigating plant mineral deficiencies

YOU NEED	
<ul style="list-style-type: none">• Mexican hat plantlets (<i>Brophyllum</i>)• 7 test tubes or smaller tubes• Test tube holder• Nutrient solutions:<ul style="list-style-type: none">– all nutrients present– lacking nitrogen– lacking magnesium– lacking calcium– lacking all nutrients	<ul style="list-style-type: none">• Measuring cylinder• Cotton wool• Aluminium foil or Parafilm™• Black paper

Procedure

- 1 Using a measuring cylinder, fill a tube with the ‘all nutrients present’ solution.
- 2 Cover the top of the tube in foil or Parafilm™ (a type of scientific cling film) and push down on the covering so there is a ‘well’ in the centre.
- 3 Make a small hole in the foil or Parafilm™.
- 4 Gently push the plantlet roots or the root of the germinated mung bean through the hole so it is in the solution below.
- 5 Repeat these steps using the other solutions. Ensure that the measuring cylinder is rinsed out between solutions.
- 6 Wrap the tubes in black paper or aluminium foil and place them in the holder.
- 7 Place the tubes under a light bank or on a sunny windowsill.
- 8 Top up the solutions as necessary by pouring solution into the well in the top covering.

Observe regularly and note any changes. Make any appropriate measurements to allow comparison of the treatments.

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SAFETY

Wear eye protection.

Potassium nitrate is oxidising and dangerous with some metals and flammable substances.

Iron chloride is harmful as a solid.

Potassium sulfate is low hazard.

Wash your hands thoroughly after handling plant material or growth media.



Requirements per student or group of students	Notes
Mexican hat plantlets (<i>Bryophyllum</i>)	<p>The Mexican hat plant (<i>Bryophyllum</i>) reproduces asexually. Plantlets grow from buds along the leaf edge. After a while they fall off and establish new plants. One plantlet is required for each replicate of each nutrient solution tested.</p> <p>Mung bean seeds can be used as an alternative. The seeds are germinated for a couple of days in a warm incubator. Seedlings with the same size radicle are placed in tubes of solution.</p>
Nutrient solutions	<p>Sachs solution or similar plant nutrient culture medium can be purchased from biological suppliers, including complete culture and solutions minus various nutrients for comparison.</p> <p>To make up your own solutions, a litre of complete Sachs nutrient solution contains:</p> <p>Potassium nitrate 0.70 g Calcium sulfate 0.25 g Calcium phosphate (v) 0.25 g Iron (III) chloride 0.005 g Magnesium sulfate 0.25 g Sodium chloride 0.08 g</p> <p>Make up using distilled water.</p> <p>To make a solution without nitrogen, substitute 0.52 g potassium chloride for the potassium nitrate.</p> <p>To make a solution without calcium, substitute 0.20 g potassium sulfate for calcium sulfate and 0.71 g sodium phosphate for calcium phosphate (v).</p> <p>To make a solution without magnesium, substitute 0.17 g potassium sulfate for magnesium sulfate.</p>
Small sample tubes	If not available, test tubes or boiling tubes can be used.
Parafilm™ or foil	To cover the tops of the tubes.
Black paper	To surround the tubes and prevent growth of algae.