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## Air bubbles on the leaf

Level: S4-5

Emphasis: Scientific investigation



### Introduction

Scientific investigation involves defining problems, formulating hypotheses, designing and conducting investigations, and interpreting results. It allows students to understand how science is done, how to clarify questions, how to design an experiment, how to record and interpret data, and how to communicate the knowledge generated. In this investigation, students will have the opportunities to engage in the processes of scientific inquiry, experimental design, investigation and analysis. Teachers are encouraged to design open-ended investigations according to the abilities and interest of their students.

### Objectives

Students should:

1. identify and analyse problems.
2. apply biological concepts and principles to solve the problems.
3. propose hypothesis and action plan.
4. take necessary safety measures.
5. record observation and present clearly.
6. suggest improvements on the experiment.

### Skills and Processes

1. Collaboration
2. Communication
3. Information handling
4. Problem-solving
5. Scientific thinking



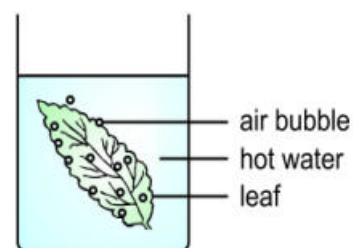
*Step 1: Considering the prior knowledge of the students*

- The investigation could be carried out either before or after the introduction of a specific topic.
- Teachers should arrange the appropriate time for investigation according to their teaching scheme and strategies. However, students' prior knowledge and experiences should be carefully considered and should be accorded in top priority.
- In this investigation, students will be expected to have an understanding of the internal structures of leaf.
- If this activity is introduced before the study of transpiration, teachers should guide their students to realise the followings during the discussion:
  - ♦ stoma in the leaf is a common passage for both air and water vapour;
  - ♦ the weight of leaf decreases when it loses water content to the air; and
  - ♦ the number of stomata in upper epidermis and lower epidermis may not be the same.
- If this activity is introduced after the study of transpiration, teachers should expect students to have an understanding of the stomatal distribution on both leaf surfaces and the processes of transpiration.

*Step 2: Preparing a scenario*

- Teachers might prepare a scenario as a starting point for discussion. An example is illustrated as below:

*One day, Peter put a leaf in hot water. After a while, he noted that a lot of air bubbles appeared on the lower surface of the leaf, but only a few air bubbles were found on the upper surface.*



***Step 3: Leading students to brainstorm ideas***

- Ask students to think and brainstorm the scenario thoroughly. The following questions may be raised:
  1. Where did the air bubbles come from?
  2. Was there any air inside the leaf?
  3. What would happen to the air when it is heated?
  4. Suppose the air bubbles came from the leaf, how did they escape from the leaf?
  5. Why did more air bubbles appear on the lower surface of the leaf?
  6. Was there any difference in the structure of both surfaces of the leaf?

***Step 4: Setting a task for the students***

- The task should be clear and workable.
- Ask students to explain the phenomenon shown in the scenario.
- Ask them to design an experiment to obtain evidence for supporting their explanation.

***Step 5: Guiding students to propose a hypothesis***

- Ask students to propose a list of hypotheses. Some may be appropriate, but some may not.
  - Teachers should respect their ideas and guide them to choose the most appropriate hypothesis to solve the problem.
  - In this investigation, the following hypotheses may be raised by the students:
    1. Lower surface of the leaf has more holes (stomata) than that of upper surface.
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2. Cells at lower surface of the leaf have faster photosynthetic rate to release oxygen.
3. Lower surface of leaf has a chemical that may react with water to form air bubbles.
4. Stomata in the lower epidermis may be bigger than that of upper epidermis.
5. Air may leave faster at the lower surface than that of upper surface.

*Step 6: Helping students to prepare an action plan*

- An action plan may include the following:
  1. Objectives

Ask the students to state the objective of their work. The objective must be closely related to the hypothesis set previously.
  2. Materials and equipment

To minimize the workload of preparation, teachers may provide a list of materials and equipment to the students. However, students are encouraged to suggest appropriate materials and equipment for the investigation.

In this investigation, teacher may provide the followings to the students:

    - ♦ microscope
    - ♦ forceps
    - ♦ microscopic slides and cover slips
    - ♦ two leafy shoots with similar leaf blade size
    - ♦ two beakers of water
    - ♦ cellotape (large enough to cover the leaf)
    - ♦ paraffin oil
    - ♦ dropper
    - ♦ seesaw (or an old beam balance without the glass case)

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### 3. Design and arrange the practical work

Teachers may pose questions for students to discuss. Meanwhile, teachers should remind the students of the necessary safety precautions. The following questions may be raised:

- ◆ How could you stop air flowing between the leaf and the air?
- ◆ What would happen to the weight of the leaf if it loses water?
- ◆ What is the use of the seesaw?
- ◆ How do you prevent water loss from a beaker of water?
- ◆ How do you prevent air blockage in the xylem vessels of the leafy shoot?
- ◆ Why a dropper is given to you? What is its use?

Note: For safety purpose, students should seek teachers' advice and approval before implementation.

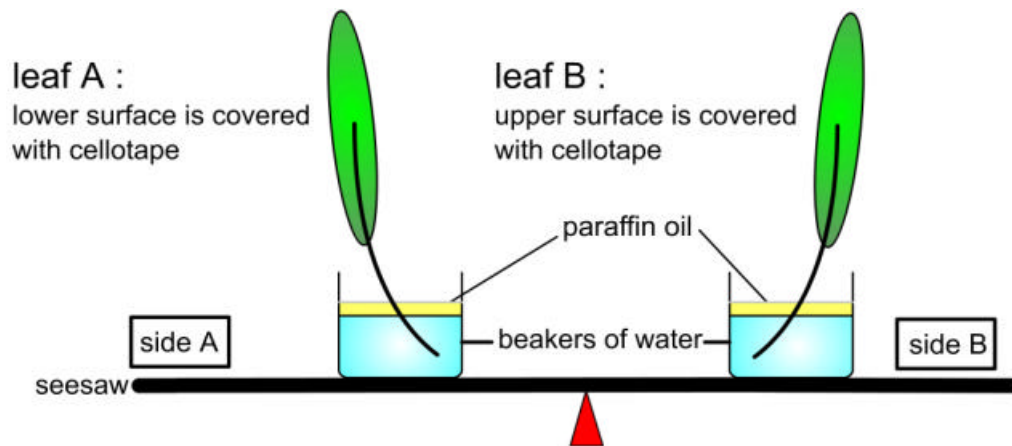
To verify hypothesis 1 in Step 5, a variety of methods can be employed. Two of the possible methods are listed on the following pages for teachers' reference.

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### Method A

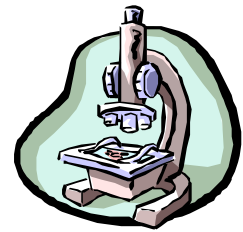
- a. Prepare the setup as below:



- b. Use cellotape to cover leaf surfaces tightly. Cover the lower surface of leaf A and the upper surface of leaf B.
- c. Cut 1-2 cm of the shoot from the bottom under water to avoid air blockage in the xylem vessels.
- d. Place the leafy shoots in two beakers of water respectively.
- e. Add a layer of paraffin oil on the water surface to avoid evaporation.
- f. Use a dropper to add water in the beakers to equalise the weight at the two sides of the seesaw.
- g. Leave the whole setup for at least 30 minutes to have a significant result.

**Method B**

- a. Peel a thin layer from the lower epidermis of the leaf with forceps.
- b. Place the thin layer on a microscopic slide.
- c. Add a drop of water on the slide and cover with a cover slip.
- d. Place the slide under microscope with lower power magnification, i.e. X100.
- e. Count the number of stomata appeared in the field of view.
- f. Repeat step (a) to (e) but with thin layer taken from the upper epidermis.
- g. Compare the number of stomata of upper and lower epidermis.

**Step 7: Asking students to write a report**

- An investigation report should include an action plan, result, interpretation, conclusion and comments.
  1. Action plan  
(Refer to Step 6)
  2. Result  

Students may describe their observation, tabulate the data they obtained, and present their findings graphically.

For **method A**, result may be presented in written description, e.g.:

*Side A of seesaw fell down and side B went up.*

For **method B**, result may be presented in the form of a table, e.g.:

<i>Number of stomata appeared in the field of view</i>	
<i>Lower epidermis</i>	<i>Upper epidermis</i>
<i>20</i>	<i>40</i>

3. Interpretation

How do you explain the scenario with the result obtained from the experiment?

4. Conclusion

What conclusion could you draw from the result?

5. Comments

The following questions may help students to think more about the investigation:

- a. What is the use of the two beakers of water? Are they necessary for the experiment? Should they contain equal amount of water?
- b. In order to complete the experiment in a shorter time, what would you do?
- c. Which precautions i.e. leaf size, physiological state (fresh or dehydrated), environmental conditions etc., should be noted in this experiment?
- d. With respect to your conclusion, what is the biological significance to the plants for them to survive in terrestrial habitat?
- e. Is it difficult to peel off a thin layer of epidermis? How would you improve this?