

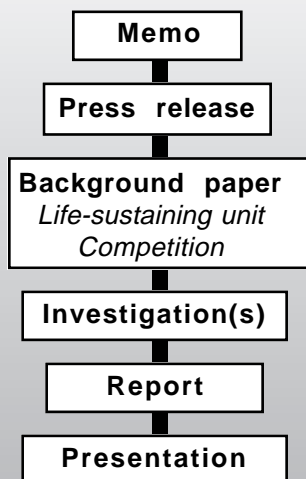
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- green plants photosynthesise when it is light
- during photosynthesis light energy is absorbed by chlorophyll, found in chloroplasts in some plant cells
- this light energy is used to convert carbon dioxide and water into sugar (glucose)
- oxygen is released as a by-product
- the rate of photosynthesis is limited by low temperatures, shortage of carbon dioxide and shortage of light
- for healthy growth plants need a range of mineral ions
- the body needs a balanced diet to remain healthy
- the more active people are, the more carbohydrate and fat they need for energy

Route through the Brief



Introduction

In this Brief pupils take on the role of research scientists in a university department of bioastronomy. They are asked to carry out some preliminary work to use in a competition to design a life-sustaining unit for use in a crewed flight to Mars. They are asked to carry out investigations into various aspects of photosynthesis, to work out what plants could best be used in the life-support system, and into human physiology to work out what needs a crew would have for oxygen and food on the journey. The Brief is based on an article which appeared in *New Scientist* in the Spring of 1996. All the research activities mentioned in the background paper are real, as are the research institutions cited.

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting this Brief pupils should have covered some basic work on photosynthesis and methods for measuring the rate of photosynthesis, but this can be taught during the unit.

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Teachers' Notes continued

Running the Brief

Pupil grouping

Pupils can work in a number of groupings during the Brief. Suggestions are:

<i>Initial briefing, memo and press release</i>	-	whole class; teacher introduces the topic and sets a context for the activities
<i>Background paper Life-sustaining Unit Competition</i>	-	whole class or small groups
<i>Carrying out investigations and other research</i>	-	pairs, threes or fours (depends on availability of equipment)
<i>Report</i>	-	small groups, or individuals if the work is to be assessed
<i>Presentation</i>	-	each group presents their results to the whole class.

Timing

This Brief involves pupils carrying out a number of investigation. This work could take 3 to 5 hours of classroom time, depending on how many investigation and research tasks are done.

Activities

The teacher should issue pupils with the **Study Guide** which provides pupils with a summary of what they should produce as they work through the Brief. It can also be used as checklist so that they can monitor their own progress. The director of the research team (the teacher) issues the researchers (pupils) with the **memo** and **Press release**. These set the scene for the work the pupils will be doing. The background paper **Life-sustaining Unit Competition** should then be issued. Teacher and pupils go through this paper, which gives details of the real work that is being done to develop the life-sustaining unit for a crewed Mars mission. The handwritten notes in the margins of this paper provide a series of investigations and other activities which pupils could do. The teacher allocates tasks to pupil groups. Alternatively, the teacher could select a series of investigations which all pupils should carry out in sequence. The Brief covers a number of key

investigations on the topic of photosynthesis, which, taken together, form a stimulating way to tackle parts of this topic. Following their investigation(s), pupils are required to write a report of their work. A nominated member of each group should provide feedback to the whole class during the plenary session.

Investigation details

A key investigation in this Brief is into the factors which affect photosynthesis. The background paper mentions that a research team is trying to develop the use of flashing LEDs to illuminate plants. Pupils should investigate the effect of colour (wavelength of light) on the rate of photosynthesis. Since LEDs come in red, green, blue and yellow, these colours should be chosen for the investigation. Pupils do not need to use LEDs for the work. They could illuminate pondweed (*Elodea canadensis*) with light from a lamp fitted with a filter. Different pupil groups could investigate different colours. Before carrying out these experiments the pupils should design a standard method, so that the work of different groups can be compared. An important factor to control is the light intensity for each of the colours of light being tested.

The other tasks and investigations mentioned are:

A dietary analysis for eight people on a space mission
This would be based on researching into secondary sources.

Methods for recycling water
Pupils could investigate ways to evaporate and condense water. Although not strictly a biological investigation, it provides a context-based approach to the water cycle.

How physical activity affects oxygen consumption and carbon dioxide production
This could involve using a spirometer, or calibrated breathing bag, to measure breathing rate and tidal volumes when a pupil is at rest and during different levels of activity.

The combination of nutrients needed to be supplied for healthy plant growth
This provides a context for carrying out hydroponics experiments.

The effect of light intensity on the rate of photosynthesis
Pondweed under different light regimes.

The effect of light and dark periods on plant development
Research into secondary sources on the need for light

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Teachers' Notes Continued

and dark periods of certain lengths to cause the onset of flowering. The need for dark periods will affect the potential for oxygen production.

The effect of CO₂ concentration and temperature on plant growth

Pondweed in water containing various amounts of sodium hydrogen carbonate, which provides plant with CO₂. Temperature can be varied using ice baths, room temperature and a range of temperatures created by using water baths.

The range of plants needed for a balance between protein production and efficient photosynthesis

This is a link back to the activity to design a diet for the long space trip. If the spacecraft is taking food plants along to supply the crew, what are the best plants to produce a balanced diet? This is likely to be a secondary source search, most likely involving diet tables.

A note at the end of the paper asks for any further suggestions for investigative work. Pupils may suggest testing a range of food plants to see which ones are the most efficient at photosynthesising. This may not produce conclusive results, but it could be a worthwhile experiment to try - if only to show that sometimes scientists do not get definite answers. One possible approach would be to illuminate various food plant leaves (as fresh as possible) in a closed environment with a CO₂ indicator (such as bicarbonate/indicator solution).

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Many suggestions for independent pupil investigations are contained in this Brief.

All pupil plans should be subjected to check and risk assessment by the teacher before being allowed to proceed.

Assessment issues for *Experimental Investigative Science* (National curriculum for England and Wales, Northern Ireland Curriculum)

Depending on the activities carried out by pupils, the full mark range for **Skill Areas P, O, A and E** should be available.

Scottish syllabus coverage

Standard Grade Biology - *World of Plants, Body in Action*.