# Biology PAG 5: Photosynthesis

# Combined Science PAG B4: Photosynthesis

# Suggested Activity 1: Investigating the factors that can affect the rate of photosynthesis

## Instructions and answers for teachers & technicians

This practical activity is composed of two parts; a teacher/technician section and the learner activity which can be found on [page 11](#_Student_Activity). This Practical activity supports OCR GCSE Biology.

**When distributing the activity section to the learners either as a printed copy or as a Word file you will need to remove the teacher instructions section.**

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| This is a **suggested** practical activity that can be used as part of teaching the GCSE (9-1) Gateway Science (A) and Twenty First Century Science (B) specifications.  These are **not controlled assessment tasks**, and there is **no requirement to use these particular activities**.  You may modify these activities to suit your learners and centre. Alternative activities are available from, for example, [Royal Society of Biology](https://www.rsb.org.uk/education/teaching-resources/secondary-schools), [Royal Society of Chemistry](http://www.rsc.org/learn-chemistry), [Institute of Physics](http://www.iop.org/education/teacher/resources/index.html), [CLEAPSS](http://science.cleapss.org.uk/) and [publishing companies](https://global.oup.com/education/content/secondary/key-issues/gcse_science_2016/?region=uk), or of your own devising.  Further details are available in the [specifications](http://www.ocr.org.uk/science) (Practical Skills Topics), and in these [videos](https://www.youtube.com/playlist?list=PLBD9B84FF4BD54AA4). |

**OCR recommendations:**

**Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.**

**CLEAPSS resources are useful for carrying out risk-assessments: (**<http://science.cleapss.org.uk>**).**

**Centres should trial experiments in advance of giving them to learners. Centres may choose to make adaptations to this practical activity, but should be aware that this may affect the Apparatus and Techniques covered by the learner.**

### Introduction

The importance of plants and photosynthesis in biology cannot be underestimated.

Plants are the producers for numerous food chains. They can remove carbon dioxide from the atmosphere. They produce oxygen which is essential for respiration in other organisms. They can be used for the bioremediation of waste. They are the source for many essential drugs. They provide raw materials for numerous processes and products.

One of the advantages of plants is that they can provide a supply of suitable experimental material without too much controversy. Unfortunately, since setting up the PAG list one of the better aquatic plants to use for this task (*Cabomba spp. -* common names: fanwort, Green Cabomba and Red Cabomba) is no longer available in the UK, due to the Invasive Plant Directive. SAPS recommends *Myriophyllum scabratum* or *Egeria densa* as alternatives.

<http://www.saps.org.uk/secondary/teaching-resources/749-using-cabomba-pondweed-in-the-lab>.

*Cabomba caroliniana* is becoming more difficult to obtain under the European regulation (EU 1143/2014) to control the spread of invasive non-native plants (<http://science.cleapss.org.uk/Resource/Bulletin-156-Summer-2016.pdf>). Alternatives are Red Cabomba (*C. furcataI*) may be used – for the moment. Discussion of this with the students can be used as a novel approach to discuss safe and ethical use of living organisms.

This protocol is a classic and rather than reinvent the wheel we will direct you to the SAPS website for a very detailed and robust protocol.

### DfE Apparatus and Techniques covered

The codes used below match the OCR Practical Activity Learner Record Sheet ([**Biology**](http://www.ocr.org.uk/Images/-295601-gcse-biology-learner-record-sheet.doc) / [*Combined Science*](http://www.ocr.org.uk/Images/304431-gcse-combined-science-learner-record-sheet.doc)) and Trackers ([**Biology**](http://www.ocr.org.uk/Images/323480-gcse-biology-practical-tracker.zip) / [*Combined Science*](http://www.ocr.org.uk/Images/323483-gcse-combined-science-practical-tracker.zip)) available online. **There is no requirement to use these resources.**

**1** *[1]***:** Use of appropriate apparatus to make and record a range of measurements accurately, including: **vi**[*vi*]) volume of liquids**; vii**[*vii*]) volume of gases

**3** *[3]*: Use of appropriate apparatus and techniques for the: i) observation of biological changes and/or processes; ii) measurement of biological changes and/or processes

**4** *[4]*: Safe and ethical use of living organisms (plants or animals) to measure: i) physiological functions; ii) responses to the environment

**5** *[5]*: Measurement of rates of reaction by a variety of methods including: i) production of gas

### Aims

To measure the rate of photosynthesis by the production of oxygen in aquatic plants.

### Intended class time

This activity will take 60 minutes.

### Links to Specifications:

### Gateway

B1.4c describe photosynthesis as an endothermic reaction

B1.4d describe experiments to investigate photosynthesis

B1.4e explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis

B1.4f explain the interaction of these factors in limiting the rate of photosynthesis

### Twenty First Century

B3.1.1 describe the process of photosynthesis, including the inputs and outputs of the two mains stages and the requirement of light in the first stage, and describe photosynthesis as an endothermic process

B3.1.1b describe practical investigations into the requirements and products of photosynthesis

### Mathematical Skills covered

Understand and use simple compound measures such as the rate of a reaction

Translate information between graphical and numerical form

Plot and draw appropriate graphs, selecting appropriate scales and axe

Extract and interpret information from graphs, charts and tables

**Understand and use inverse proportion – the inverse square law and light intensity in the context of factors affecting photosynthesis**

### Gateway Working scientifically references covered

WS1.2a use scientific theories and explanations to develop hypotheses

WS1.2b plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena

WS1.2c apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment

WS1.2d recognise when to apply a knowledge of sampling techniques to ensure any samples collected are representative

WS1.2e evaluate methods and suggest possible improvements and further investigations

WS1.3apresenting observations and other data using appropriate methods to include: methods to include descriptive, tabular diagrammatic and graphically

WS1.3b translating data from one form to another

WS1.3c carrying out and representing mathematical and statistical analysis to include: statistical analysis to include arithmetic means, mode, median

WS1.3d representing distributions of results and make estimations of uncertainty

WS1.3e interpreting observations and other data data to include: presentations to include verbal, diagrammatic, graphical, symbolic or numerical form interpretations to include identifying patterns and trends, making inferences and drawing conclusions

WS1.3f presenting reasoned explanations relating data to hypotheses

WS1.3g being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility

WS1.3h identifying potential sources of random and systematic error

WS1.3i communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions presentations through paper-based presentations using diagrammatic, graphical, numerical and symbolic forms

WS1.4a use scientific vocabulary, terminology and definitions

WS1.4b recognise the importance of scientific quantities and understand how they are determined

WS1.4c use SI units and IUPAC chemical nomenclature unless inappropriate base units & derived units

WS1.4e interconvert units

WS1.4f use an appropriate number of significant figures in calculation

WS2a carry out experiments to include: due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations, and following written instructions

WS2b make and record observations and measurements using a range of apparatus and methods keeping appropriate records

WS2c presenting observations using appropriate methods to include: methods to include descriptive, tabular diagrammatic and graphically

WS2d communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions presentations through paper-based and electronic reports and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms

### Twenty First Century IaS references covered

IaS1.1 in given contexts use scientific theories and tentative explanations to develop and justify hypotheses and predictions

IaS1.2 suggest appropriate apparatus, materials and techniques, justifying the choice with reference to the precision, accuracy and validity of the data that will be collected

IaS. 3.recognise the importance of scientific quantities and understand how they are determined

IaS1.4 identify factors that need to be controlled, and the ways in which they could be controlled

IaS1. 5 suggest an appropriate sample size and/or range of values to be measured and justify the suggestion

IaS1. 6 plan experiments or devise procedures by constructing clear and logically sequenced strategies to:

* make observations
* produce or characterise a substance
* test hypotheses
* collect and check data
* explore phenomena

IaS1.7 identify hazards associated with the data collection and suggest ways of minimising the risk

IaS1. 8 use appropriate scientific vocabulary, terminology and definitions to communicate the rationale for an investigation and the methods used using diagrammatic, graphical, numerical and symbolic forms

IaS2.1 present observations and other data using appropriate formats

IaS2.2 when processing data use SI units where appropriate (e.g. kg, g, mg; km, m, mm; kJ, J) and IUPAC chemical nomenclature unless inappropriate

IaS2.4 be able to translate data from one form to another

IaS2.5 when processing data interconvert units

IaS2.6 when processing data use an appropriate number of significant figures

IaS2.7 when displaying data graphically select an appropriate graphical form, use appropriate axes and scales, plot data points correctly, draw an appropriate line of best fit, and indicate uncertainty (e.g. range bars)

IaS2.8 when analysing data identify patterns/trends, use statistics (range and mean) and obtain values from a line on a graph (including gradient, interpolation and extrapolation)

IaS2.9 in a given context evaluate data in terms of accuracy, precision, repeatability and reproducibility, identify potential sources of random and systematic error, and discuss the decision to discard or retain an outlier

IaS2.10 evaluate an experimental strategy, suggest improvements and explain why they would increase the quality (accuracy, precision, repeatability and reproducibility) of the data collected, and suggest further investigations

IaS2.12 explain the extent to which data increase or decrease confidence in a prediction or hypothesis

IaS3.1 use ideas about correlation and cause to:

1. identify a correlation in data presented as text, in a table, or as a graph
2. distinguish between a correlation and a cause-effect link
3. suggest factors that might increase the chance of a particular outcome in a given situation, but do not invariably lead to it
4. explain why individual cases do not provide convincing evidence for or against a correlation
5. identify the presence (or absence) of a plausible mechanism as reasonable grounds for accepting (or rejecting) a claim that a factor is a cause of an outcome

### Equipment (all equipment in this section is per group)

This practical is available from the following web site:

<http://www.saps.org.uk/secondary/teaching-resources/190-using-pondweed-to-experiment-with-photosynthesis>

Here there are links to:

* [Learner sheets](https://www.saps.org.uk/attachments/article/190/SAPS%20-%20Bubbling%20pondweed%20-%20Student%20Sheet.doc)
* [Teaching notes](https://www.saps.org.uk/attachments/article/190/SAPS%20-%20Bubbling%20pondweed%20-%20Teaching%20Notes.doc)
* [Technical notes](https://www.saps.org.uk/attachments/article/190/SAPS%20-%20Bubbling%20pondweed%20-%20Technical%20notes.doc)

### Health and Safety

**Burn hazard** from the lit splint and use of oxygen

**Allergen** whilst there is little data on allergic responses to aquatic plants please be aware that there may be students that are sensitive to some aspects of the experiment e.g. the plant itself, contents of the water the plant was grown in etc.

### Use of non-native species

If using a non-native species for this practical correct disposal is essential. Even the smallest part of the plant has the potential to become a massive problem. Even the water that the plant has been grown in can be dangerous to the environment. Ensure that the plants are destroyed before they leave your site. Wrapping them well and disposal in land fill has been suggested for the plants themselves. Water can be emptied into the drains if they do not directly enter water courses or it can be added to lawns or houseplants (sources: <http://science.cleapss.org.uk/Resource/Bulletin-156-Summer-2016.pdf> or <http://www.nonnativespecies.org/home/index.cfm>).

### Method

See <http://www.saps.org.uk/secondary/teaching-resources/190-using-pondweed-to-experiment-with-photosynthesis>

### Technician Notes

These can be found on <http://www.saps.org.uk/secondary/teaching-resources/190-using-pondweed-to-experiment-with-photosynthesis>

### Quiz questions – answers

1. An experiment was done to see how the distance from a light source affected the rate of photosynthesis.

Three aquatic plants were used: *Elodea*, *Cabomba* and Hornwort were used.

The number of bubbles at each distance was counted. The experiment was done three times for each species. With each experiment the 10 cm distance was done first, then the 20 cm distance and so on.

The plants were all bubbling at about the same rate before the experiment

The following data was obtained:

|  | Mean number of bubbles produced over a 10 minute period | | |
| --- | --- | --- | --- |
| Distance from the light source | Elodea | Cabomba | Hornwort |
| 10 cm | 0 | 100 | 120 |
| 20 cm | 0 | 25 | 90 |
| 30 cm | 0 | 11 | 60 |
| 40 cm | 1 | 6 | 30 |
| 50 cm | 0 | 4 | 0 |

1. What can be done to improve the table? **[1 mark]**

|  |
| --- |
| The units/cm needs to be in the column heading not in the body of the table |

1. On graph paper plot the graph for *Cabomba* **[5 marks]**

|  |
| --- |
| X axis – distance and Y axis – mean number of bubbles  Labelled axis  Linear scale for both axis  Appropriate scale so that the plotted line covers at least ½ the page  All point plotted accurately |

1. In your own words talk about the shape of the graph for *Cabomba*.**[3 marks]**

|  |
| --- |
| As the distance gets bigger/larger/longer  The number of bubbles gets less/fewer or there are fewer/less bubbles  Doubling the distance more than 1/2s the number of bubbles |

1. What could have happened to the Elodea experiment? **[2 marks]**

|  |
| --- |
| More sensitive to heat/overheated near the bulb  Denatured enzymes |

### Document updates

v1 Published on the qualification pages

v1.1 January 2017 Consolidated labelling and formatting of activities



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v1.2 June 2021 Update to meet digital accessibility standards

# Biology PAG 5: Photosynthesis

# Combined Science PAG B4: Photosynthesis

# Suggested Activity 1: Investigating the factors that can affect the rate of photosynthesis

## Learner Activity

The importance of plants and photosynthesis in biology cannot be underestimated.

Plants are the producers for numerous food chains. They can remove carbon dioxide from the atmosphere. The produce oxygen which is essential for respiration in other organisms. They can be used for the bioremediation of waste. They are the source for many essential drugs. They provide raw materials for numerous processes and products.

This is a classic experiment and was first done in 1779 by Jan Ingenhousz.

### Aims

To measure the rate of photosynthesis by the production of oxygen in aquatic plants.

### Method

Your teacher will give you a hand-out for this experiment from the SAPS website

<http://www.saps.org.uk/secondary/teaching-resources/190-using-pondweed-to-experiment-with-photosynthesis>.

### Quiz questions

An experiment was done to see how the distance from a light source affected the rate of photosynthesis.

Three aquatic plants were used: *Elodea*, *Cabomba* and Hornwort were used.

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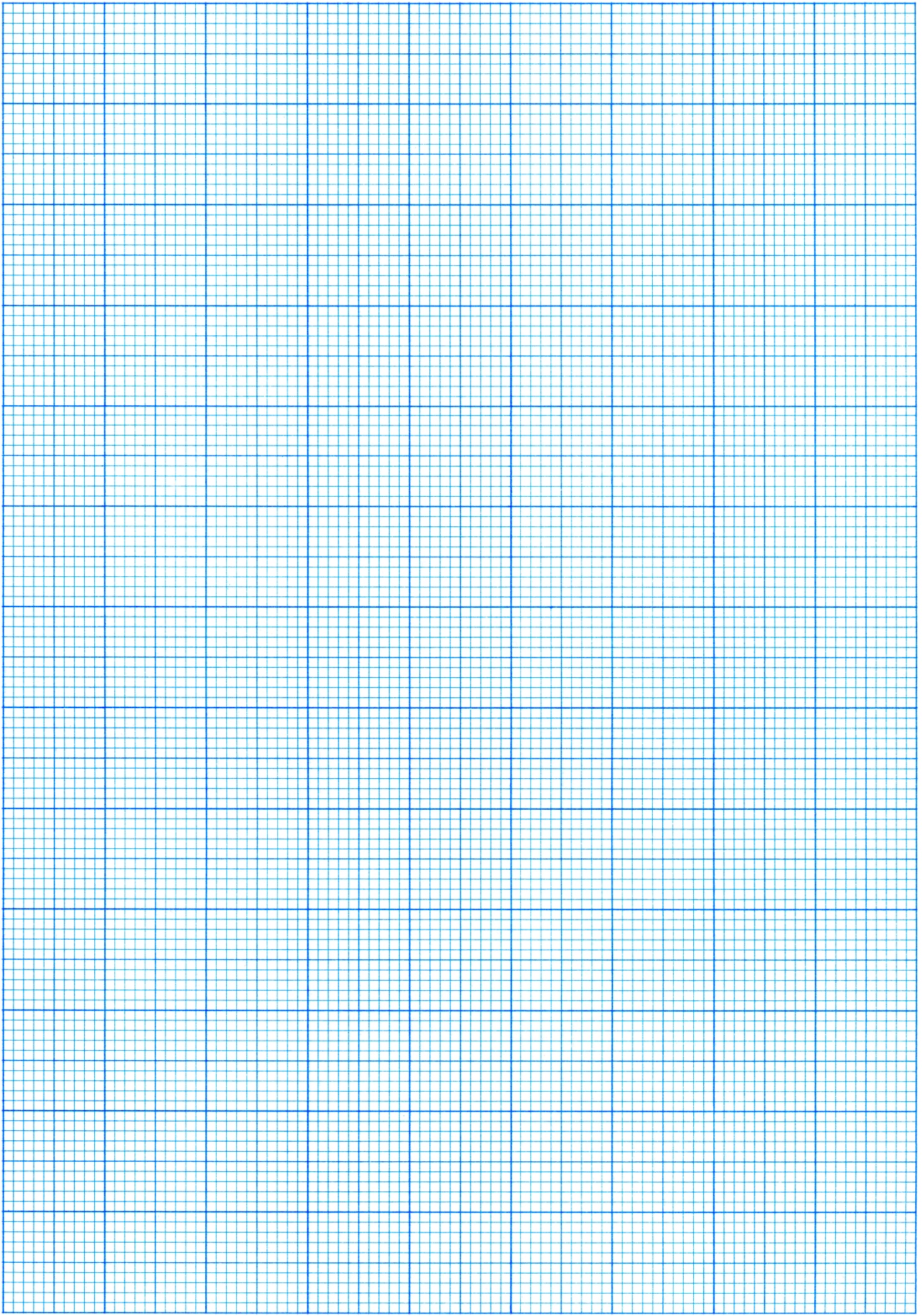
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1. What can be done to improve the table? **[1 mark]**

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1. On graph paper plot the graph for *Cabomba* **[5 marks]**



1. In your own words talk about the shape of the graph for *Cabomba*.**[3 marks]**

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1. What could have happened to the Elodea experiment? **[2 marks]**

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### DfE Apparatus and Techniques covered

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| **Biology** | | | |  | ***Combined Science*** | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1-vi | 1vii | 3-i | 3-ii |  | *1-vi* | *1-vii* | *3-i* | *3-ii* |
| 4-i | 4-ii | 5-i |  |  | *4-i* | *4-ii* | *5-i* |  |