Biology: Investigation 3

Investigating the Effect of Light Intensity on Photosynthesis

Criteria: PI (a), PI (b)

Background

The candidate is asked to design an experiment to investigate the influence of light on photosynthesis. The candidate is given a sample of *Elodea*, and access to the appropriate laboratory equipment is provided.

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<th>Criterion</th>
<th>PI (a)</th>
<th>PI (b)</th>
<th>DC</th>
<th>DPP</th>
<th>CE</th>
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<tr>
<td>Achievement level awarded</td>
<td>2</td>
<td>3</td>
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<td>Achievement of aspects</td>
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Planning (a)

Defining the problem or research question

The general aim put forward by the teacher has been modified a little, but still remains vague. For example, the type of plant used in the investigation should be mentioned in the aim. The level of achievement for this aspect is partial.

Formulating a hypothesis or prediction

A clear hypothesis, which includes a quantitative prediction, is stated. The level of achievement for this aspect is complete.

Selecting variables

A very clear understanding of the variables is shown. The independent and controlled variables are discussed at the beginning of the investigation, while the dependent variable is discussed in the section “Set-up/Measurement”. The level of achievement for this aspect is complete.

Planning (b)

Selecting appropriate apparatus or materials

The discussion of the variables, together with the ideas included in the section “Set-up/Measurement” and the diagram of the apparatus, provides sufficient evidence that appropriate apparatus and materials are used. The level of achievement for this aspect is complete.

Designing a method for the control of variables

Ways of controlling the variables are discussed very well and in detail. The candidate’s intention is to use the same piece of *Elodea* so, although there is no discussion of the size of the piece of plant or the number of leaves, there is sufficient information to believe that the essential variables are taken into consideration. The level of achievement for this aspect is complete.

Designing a method for the collection of sufficient relevant data

Readings are taken with the light at several different intervals (every 10 cm, up to 1 m). This provides a suitable range of readings. The method proposes to count the bubbles produced by the plant for 30 minute periods, which could be considered as $30 \times 1$ minute observations. This is not exactly replication, but it should provide sufficient results to identify inconsistencies in the data. The level of achievement for this aspect is complete.
Biology Planning: Investigate the Effect of Light Intensity on Photosynthesis

Variables Involved:
- Photosynthesis is dependent upon light, so light is our variable factor.
- As photosynthesis is dependent upon carbon dioxide, the availability of carbon dioxide has to be kept constant.
- Temperature will affect photosynthesis, especially after a certain light intensity, which is a limiting factor, so that needs to be kept constant.
- Wind and water movement may also have an effect, so these must be kept constant if they are to be involved in an experiment.

How to deal with the variables:
- Light intensity is the independent factor and so must be adjusted. A good way to do this would be using a light source which could be moved at different distances from the plant in question. The light intensity of the lamp can be measured (the assumption being that it will be constant and that distance will affect the light intensity reaching the plant) and the beam of light can be concentrated by using a paper cone.

To prevent outside light, other than the light source, from interfering, the experiment could be performed in a dark room, at least without windows.
- To ensure that CO₂ is available, the plant can be suspended in water, containing a known amount of NaHCO₃, and replaced each time the light intensity is changed. In this way, the same amount of CO₂ will be available at the different light intensities.
- Temperature can be kept constant by means of a water bath. The plant will already be suspended in water, but heat from the light source may then still affect it, so another, external water bath can be placed in between the plant and the light source.
- The water won’t be moving particularly fast as it will be contained within a beaker.

Set-up/Measurement:
- The plant that would be very useful here would be Elodea. It can be suspended in a test tube in a water bath, and bubbles will come off as it photosynthesises. It will be important to ensure that no oxygen escapes (for instance, if the Elodea is in an upside down test tube, no leaves should stick out the bottom, allowing oxygen to escape into the water bath, and if oxygen is being collected at the top, all bubbles need to be collected into the bulb).
- Counting the bubbles that come off the Elodea can be the way that the rate of photosynthesis is measured. It is also possible to look directly at water displacement (if the Elodea is in an upside down test tube, oxygen will accumulate at the top and displace water) or the bubbles can be accumulated into a bulb and drawn into a capillary tube by means of a syringe.
- If oxygen bubbles are counted, a couple of trial runs will be necessary to establish a relationship between a certain amount of bubbles and an amount of water displaced. The bubbles should all be about the same size for this to work.
- The experiment can be set up at a certain light intensity, say, by having the light source 10 cm away from the plant. The bubbles can be counted for half an hour. Then, the water solution is replaced to replenish the carbon dioxide availability, and the light source is removed another 10 cm further. This process can be repeated several times, for example until one meter is reached.

Predictions:
- As light intensity is a limiting factor in photosynthesis, it can be expected that the amount of bubbles produced will increase as light intensity increases (indicating that photosynthesis is
speeding up), until a certain plateau is reached, where temperature becomes a limiting factor, and so light intensity will have no effect on photosynthesis any longer.

- As the intensity of light reaching the Elodea is inversely proportional to the square of its distance from the source of the illumination, one would expect that if the distance of the source is doubled, the light intensity will have decreased four times. In this way, the different light intensities can be measured.

Diagram: