The effect of light intensity on the rate of photosynthesis in *Hygrophilla difformis*

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Headings in structured abstracts should be bold and followed by a period. Each heading should begin a new paragraph. For example:

**Background.** The background section text goes here. Next line for new section.

**Methods.** The methods section text goes here.

**Results.** The results section text goes here.

**Discussion.**The discussion section text goes here.

# Introduction

This experiment explores the correlation between the light intensity and the photosynthesis rate on *Hygrophilla difformis*, an aquatic plant. This experiment observes the concepts of photosynthesis and cell respiration. Photosynthesis is defined as the process used by plants and bacteria to harness the light energy from the sun and turn into chemical energy.

$CO\_{2}+H\_{2}O+Light Energy=C\_{6}H\_{12}O\_{6}+O\_{2}+H\_{2}O$

As light is a reactant in the process of photosynthesis, therefore the higher the light intensity (lux), the higher the rate of photosynthesis reaction. To achieve this, we use a Vernier light intensity sensor which could be adjusted to varying light intensity.

As oxygen is a byproduct of photosynthesis, measuring it would determine the relative rate of photosynthesis. For this experiment, counting the bubbles produced by the aquatic plant for one minute would allow us to estimate the photosynthesis rate.

# Personal connection

Ever since a young child, I was known as a curious explorer. When my Ever since a young child, I was known as a curious explorer. When my uncle built a large aquarium at his house, I was fascinated by the organisms he placed in the aquarium. During family gatherings at his house, I would feed the fish and maintain the plants. I felt strong curiosity towards autotrophs as they could make their own food, an ability that we lack. I have decided to explore into this for the IA because photosynthesis is the basis of all plants. Then, I decided to explore changing light intensity because of the common saying “the sun is the source of all life.”

# Research question

What is the effect of changing light intensity (lux) on the rate of photosynthesis in *Hygrophilla difformis* plants?

# Independent variable

The independent variable would be the light intensity. The experiment would use 5 different light intensities (10 lux, 25 lux, 40 lux, 55 lux, 70 lux).

# Dependent variable

Rate of photosynthesis, measured through the counting of bubbles for one minute

# Controlled

Carbon Dioxide concentration, this will be controlled by placing 10 grams of baking soda ($NaHCO3$) into the water at every trial.

The volume of $H\_{2}O$, this will be controlled by using 150mL of distilled water for every trial.

Room temperature will be controlled by placing the container holding the plant (beaker) into a water bath and set to 25 Celcius. An optimum temperature needs to be ensured so that enzymes will be working at its optimum rate of catalysis.

Size of the plant will be controlled by cutting 5 cm \* 5 cm pieces as the surface area of a plant will affect the rate of absorbing the reactants.

Duration of submersion will be controlled through a timer. The plant will be submerged for five minutes.

# Hypothesis

Null: The increase in light intensity would have no effect on the rate of photosynthesis.

Alternative: The increase in light intensity would increase the rate of photosynthesis until it reaches the optimum level, where further increase in light intensity will have no effect on the photosynthesis rate.

# Apparatus

* 10 L Distilled Water
* 500 g of Baking Soda
* 1 Electronic scale
* 5 Beakers (200 mL)
* Vernier Light Intensity Probe
* 1 sheet of Paper Towel
* Ruler (20 cm)
* 1 Meter Stick
* Electronic Timer
* 5 Hygrophilla difformis plant
* 1 Scissor
* 2 measuring cups
* 1 Glass rod
* 1 laptop
* 1 water bath

# Risk

There are no known risks or hazards of any kind for this experiment but glassware and scissors should be handled carefully to prevent breakages.

# Methods



Apparatus setup, replace desk lamp with Vernier Light Intensity Probe for improved accuracy(“Photosynthesis - Revision 4 - KS3 Biology - BBC Bitesize”, n.d.)

1. Pour 150 mL of water into the 200 mL beaker to ensure the volume of water is controlled
2. Pour 10 grams of baking soda ($NaHCO3$) into the water, mix using glass rod to ensure that the quantity of carbon dioxide is controlled
3. Cut *Hygrophilla difformis* into 5cm \* 5cm pieces (15 pieces total), using a ruler to measure to ensure that the size of the surface area of the plant is kept at a constant
4. Set up the Vernier light intensity probe in the same manner as the diagram shown above (Vernier probe replacing the lamp)
5. Connect Vernier light intensity device to a laptop, the software should display a light intensity of 10 lux
6. Place the 5cm \* 5cm *Hygrophilla difformis*into the beaker
7. Place the beaker into the water bath (25 degrees Celcius) and leave for five minutes to acclimatize to light intensity
8. Count bubbles in one minute after the five minutes elapsed
9. Move the Vernier light intensity probe towards the beaker until 25 lux is displayed on the laptop, repeat steps 1-7, the same should be done for 40 lux, 55 lux, and 70 lux
10. 5 Trials should be carried out at each light intensity

# Results

## RAW DATA

The Number of Bubbles Emitted at 10 lux for 5 trials

|  |  |
| --- | --- |
| Light Intensity (LUX) | TEST |
| 10 | 2 |
| 10 | 1 |
| 10 | 2 |
| 10 | 2 |
| 10 | 1 |

The Number of Bubbles Emitted at 25 lux for 5 trials

|  |  |
| --- | --- |
| Light Intensity (LUX) | TEST |
| 25 | 3 |
| 25 | 2 |
| 25 | 4 |
| 25 | 5 |
| 25 | 5 |

The number of bubbles emitted at 40 lux for 5 trials

|  |  |
| --- | --- |
| Light Intensity (LUX) | TEST |
| 40 | 6 |
| 40 | 4 |
| 40 | 7 |
| 40 | 8 |
| 40 | 8 |

The number of bubbles emitted at 55 lux for 5 trials

|  |  |
| --- | --- |
| Light Intensity (LUX) | TEST |
| 55 | 13 |
| 55 | 13 |
| 55 | 11 |
| 55 | 12 |
| 55 | 12 |

The number of bubbles emitted at 70 lux for 5 trials

|  |  |
| --- | --- |
| Light Intensity (LUX) | TEST |
| 70 | 14 |
| 70 | 12 |
| 70 | 12 |
| 70 | 12 |
| 70 | 11 |

The number of bubbles emitted, rounded to the nearest integer

|  |  |
| --- | --- |
| Light Intensity (LUX) | Number of bubbles emitted per minute (AVG. rounded) |
| 10 | 1 |
| 25 | 4 |
| 40 | 7 |
| 55 | 12 |
| 70 | 12 |

# Conclusion

Photosynthesis, the process that allows plants to produce glucose for use in cell respiration, depends on light. Light-dependent reactions in chloroplasts (thylakoid membranes) require the conversion of light energy into chemical energy. Light is absorbed by the pigments like chlorophyll (different pigments are responsible for different types of wavelengths). The steps are outlined below:

1. Photoactivation: pigments in photosystem absorb light energy and boost electrons to a higher energy level, electrons accepted by carrier protein in the electron transport chain.
2. PS2 replace lost electrons by taking new electrons from water. Water splits into electrons, hydrogen ions, and oxygen using light energy (photolysis). Oxygen byproduct is released (measured in this experiment to determine the relative rate of photosynthesis).
3. Electrons move to PS1, losing energy but pumps protons into the thylakoid. Protons flow from thylakoid into channel protein. ATP is formed.
4. Light energy absorption photoactivates PS1 exciting electrons. New electrons from PS2 replace displaced ones. Electrons at higher energy levels combine with $NADP^{+}$ to become $NADP+H^{+}$. (Walpole, Merson-Davies, and Dann 2017)



Rate of photosynthesis when light intensity increase(“As Light Intensity Increases, What Happens to the Rate of Photosynthesis? | Socratic”, n.d.)

The results are in line with the hypothesis, which means the null hypothesis is rejected. We can see from the data that the rate of photosynthesis increase from 10 lux to 55 lux as electrons are becoming more excited, activating the light-dependent reactions. This would result in abundant $NADP+H^{+}$. However, it would plateau at 70 lux because the next step of photosynthesis, the Calvin Cycle, requires carbon dioxide and that remained a controlled variable in the experiment. Therefore, as the light intensity increase, the rate of photosynthesis increase until it reaches a saturation point (55 lux).

# Evaluation

The Vernier light probe is highly accurate, which means the light intensity is measured accurately. Although the independent variable is accurate, the dependent variable lacks significance due to the unreliable nature of the methodology.

The method of counting the number of bubbles means that the size of bubbles is unaccounted for. Large bubbles would carry more oxygen than smaller bubbles. Furthermore, human error is prevalent in this methodology. For example, the experimenter might miscount the number of bubbles emitted. An improved method would be calculating the change in DO concentration using a DO probe as explained below.

As seen from the photosynthesis equation, the process of creating glucose results in oxygen as a byproduct, which could be recorded to indicate the rate of photosynthesis. An aquatic plant will release the oxygen byproduct into the water, creating bubbles. The dissolved oxygen will be calculated to measure the change in the percentage of dissolved oxygen before and after five minutes during which the plant is submerged in a tank and undergoing photosynthesis and respiration.

$\% change in DO concentration=\frac{\left(final DO−Initial DO\right)}{Initial DO}⋅100$

Also, more trials and independent data tests could be performed to increase the significance and reliability of the data. Instead of 5, 10 trials would create a greater number of data sets and the accuracy of the experiment. More independent variable data tests could be performed at smaller intervals (10 lux, 20 lux, 30 lux, 40 lux, 50 lux, 60 lux, 70 lux) would also increase the accuracy.

# References

n.d. <https://www.bbc.com/bitesize/guides/zpwmxnb/revision/4.> <https://www.bbc.com/bitesize/guides/zpwmxnb/revision/4.>

Walpole, Brenda, Ashby Merson-Davies, and Leighton Dann. 2017. *Biology for the Ib Diploma Coursebook*. Cambridge University Press.

n.d. <https://socratic.org/questions/as-light-intensity-increases-what-happens-to-the-rate-of-photosynthesis.> <https://socratic.org/questions/as-light-intensity-increases-what-happens-to-the-rate-of-photosynthesis.>