# Does light intensity affect the rate of photosynthesis?

## Introduction

Photosynthesis is the chemical process, which takes place in every green plant to produce food in the form of glucose. Oxygen is also produced as waste.

I am going to investigate the factors that affect the rate of photosynthesis. The factor I have chosen to investigate is light intensity. Does varying degrees of light intensity affect the rate of photosynthesis in a green plant.

Canadian pondweed (Elodea) will be used for this experiment, as when placed in water it gives of bubbles of oxygen from the cut end. This factor makes it ideal for observing the amount of oxygen given off when placed under varied light intensities.

## Aim

The aim of this experiment is to determine whether the intensity of light affects the rate of photosynthesis in plants.

## Background Knowledge

Photosynthesis occurs only in the presence of light. It is a chemical process used to turn inorganic compounds, carbon dioxide and water into organic compounds, carbohydrates. Photosynthesis occurs in chloroplasts, which are tiny membrane-bound bodies containing the light-trapping pigment chlorophyll. The equation for photosynthesis is:

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$$\text{Carbon dioxide} + \text{Water} \xrightarrow{\text{Chlorophyll, Sunlight}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow{\text{Chlorophyll, Sunlight}} C_6H_{12}O_6 + 6O_2$$

There have been many experiments proving that all plants need light in order to photosynthesise. The reason that light intensity does effect the rate of photosynthesis is because as light falls on the chloroplasts in a leaf, it is trapped by the green pigment chlorophyll, which makes the energy available for the drive of the chemical reaction in the plant. Therefore, as the amount of sunlight, or in this case light from the lamp, falls onto the plant, more energy is absorbed, so more energy is available for the chemical reactions, and so more photosynthesis takes place in a given time.

Light intensity, temperature and the concentration of carbon dioxide are all factors that affect the rate of photosynthesis. The maximum rate of photosynthesis will be constricted by a limiting factor, even if the other conditions needed for photosynthesis are improved, the limiting factor will prevent the rate of photosynthesis rising indeterminately. I will therefore control these factors though out my experiment so not to let them affect the reliability of the investigation. The amount of oxygen given off (result of photosynthesis) can be measure by counting the amount of bubbles of gas.

## Prediction

I predict that as the intensity of the light increases, so does the rate of photosynthesis. Adding to this I hypothesis, that due to other limiting factors (probably temperature), that if the light intensity increases, the rate of photosynthesis will increase until a certain level is reached. Then the rate of increase will level off, as the increase of light intensity will have no further effect on the rate of photosynthesis. This is demonstrated in the graph on page 3.

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## Preliminary work

I am going to test whether the colour of the light source effects the rate of photosynthesis using the simulation of learnpremium.co.uk. I will use red, orange, yellow, blue and green coloured filters taped over a normal lamp. Also I will do a test with out a coloured filter using just the lamp.

I will put the lamp 10cms away for every colour I test. I will count how many bubbles of oxygen are produced in 1 minute.

## Results table of preliminary work

| Coloured sheet | Red | Orange | Yellow | Green | Blue | No filter |
|---|---|---|---|---|---|---|
| No. of bubbles | 45 | 2 | 0 | 0 | 41 | 10 |

I have found that colour of the light source is important for the photosynthesis. Most plants appear green because they reflect green light. The results of my preliminary work show that the colours such as green, yellow and orange produced the least amount of bubbles as the light was transmitted. The colours near the blue and red end of the spectrum produced a much higher number of bubbles than those near the green end showing that colours are important for photosynthesis.

## Variables

The light intensity will be varied, by increasing and decreasing the distance from the light source to the Elodea.

The controlled variables are the colours of the light, as shown in my preliminary work chlorophyll easily absorbs blue and red light. However it does not easily absorb green or yellow light, it actually reflects them, decreasing the amount of light absorbed, and therefore affecting the rate of photosynthesis. Using a normal, clear, non-colour lamp can easily control this. The concentration of carbon dioxide can also become a limiting factor, thus affecting the reliability of my experiment, if there is too little $CO_2$. In this case as the experiment is done over a short period of time, the amount of carbon dioxide used up by the plant will not be enough to cause the concentration of carbon dioxide to become a limiting factor. If I were to

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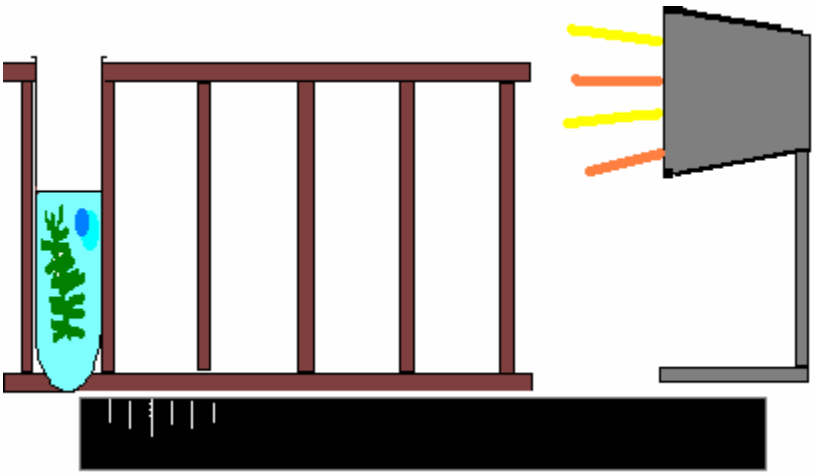
Perform my experiment over a longer period of time I would add a fixed amount of Sodium hydrogen carbonate to the water, to ensure a large enough supply of carbon dioxide. Water is also another limiting factor in this experiment, as water is needed for photosynthesis. When a plant is lacking water, the plants stomata closes to prevent further water loss, the closing of the stomata cells also leads to little carbon dioxide being able to diffuse through. This should not be a problem as long as the water plant is fully submerged in water at all times. I am going to perform my experiment at room temperature, but I am aware that the heat off the lamp may raise the temperature, but due to lack of resources this is beyond my control. I will however attempt to resolve this by, after each experiment I will refill the test tube with water, then each experiment will be started in the same conditions. I will take this into consideration when obtaining my results.

## Apparatus list

- Desk lamp x1
- Canadian pondweed-Elodea
- Tap water
- Boiling tube rack
- Boiling tube x1
- Ruler
- Stop watch
- 250cm3 Measuring cylinder

## Diagram of Apparatus



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## Method

I set up the apparatus as shown in my (above) diagram (not adding the Elodea). I used 30ml of water and measured the Elodea to be 7.5cms. To change the light intensity I placed the lamp 2cms away from the boiling tube. Varying the distance the lamp is from the beaker changes the light intensity, this happens because, the further a beam of light travels, the wider the beam becomes, when the beam hits a surface the light is spread over the surface, but if the surface was closer the beam would not be as wide and therefore more intense. Next I cut the bottom of the stem of the Elodea and placed in to the water upside down. I left the Elodea for one minute before I started to time the amount of oxygen bubble in the three minutes. I did this because as I am using the same piece of Elodea for each experiment, therefore I can make sure that photosynthesis was not taking place. After the one minute, I started the stopwatch and counted the amount of oxygen bubbles released by the plant. I recorded my results on my result table. I then changed the water and repeated the experiment measuring the lamp 4cms away. Next I repeated the experiment with the lamp 6cms away, then 8cm away, and final 10cms away. When I looked at my results I notices an anomalous result for 6cms distance, therefore I repeated this distance.

## Results table

| Distance away from Elodea (cms) | Frequency of oxygen bubbles (in 3 min period) |
|---|---|
| 2 | 71 |
| 4 | 55 |
| 6 | 68 Retest result-39 |
| 8 | 21 |
| 10 | 9 |

## Risk Assessment

While carrying out this investigation many accidents could have taken place. Water may have been spilt near the electrical equipment. Test tubes could

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Have been smashed and cut somebody if not reported straight the way. In order to prevent accidents equipment was treated with care and I worked safely and maturely.

## Conclusion

The points on the graph shows a clear pattern, indicating that the rate of photosynthesis increased as the light intensity increased. This was because photosynthesis is a reaction, which needs energy from light to work, so as the amount of energy available increased, so did the amount of oxygen produced as a product of photosynthesis. However, as I expected in my hypothesis, it does appear that my graph shows clearly, the increase in rate is inverse to the increase in light intensity (i.e. a very near straight line). Overall my graph and my results support my prediction fully. My idea that the rate of photosynthesis would increase with light intensity was totally backed up by my result. This is because a higher light intensity involves a greater level of light energy, which is then transferred into the environment, which is designed to convert the energy.

## Initial rates

The initial rates for the experiments are:

2cms-71 bubbles of oxygen produced per 3 minutes
4cms-55 bubbles of oxygen produced per 3 minutes
6cms-39 bubbles of oxygen produced per 3 minutes
8cms-21 bubbles of oxygen produced per 3 minutes
10cms-9 bubbles of oxygen produced per 3 minutes

## Gradient

The gradient of my graph shows that for every 1cm away from the Elodea the lamp was, a decrease of 6.5 oxygen bubbles was obtained. My graph also shows negative correlation indicating the decrease in number of oxygen bubbles, when the light intensity was lowered.

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## Evaluation

Although I feel that my experiment was overall very successful and the method was appropriate for this investigation. There were many areas of accuracy, which let the experiment down.

Firstly, the distance between the light source (lamp) and the Elodea was not measure to a very high degree of accuracy, especially when the distance should have been measured from the filament of the light bulb to the centre of the plant. It is possible here to find a percentage error.

The second major inaccuracy was in measuring the volume of oxygen given off. I only counted the number of oxygen bubble given off, but when you take into account size of each bubble (a bigger bubble-more oxygen, smaller bubble-less oxygen) a large percentage error could have been made here. If I were to complete the experiment again I would use a different method which would take into account the size of the bubble. I would use an upside down measuring cylinder in a tub of water, which would make me able to measure how much oxygen has been produced by the decrease in water volume. I also could have used a gas syringe, but decided against that method as not enough oxygen would have been produced over the given space of time, making inaccurate results.

Another error could have taken place due to the background lighting in the laboratory. But due to practical reasons, we could not perform the experiment in a separate room. Therefore other students light pollution could have effected the final results. The temperature turned out not to cause a problem, as over the short period taken the temperature did not rise at all. If I were to extent the time to 5 minutes for example, I would have had to find some way of keeping the temperature the same.

Also there is very little chance the amount of carbon dioxide could have created a large error, due to the short space of time. If I were to complete the experiment over a longer period of time as explained my background knowledge I would have added a fixed amount of sodium hydrogen carbonate.

The last small inaccuracy that could have been produced is the time keeping. If the times before the stopwatch was started and finish differed even for a few seconds the time for each experiment would not have been

Fair. I therefore made sure that I started and stopped the stopwatch as soon as the Elodea was added and the one-minute was up. Then as soon as the 3 minutes was up I stopped the stopwatch.

There was one anomalous (odd) result during this experiment, which was when I was obtaining the result for the distance of 6cms away from the Elodea. I got the result 68 bubbles of oxygen in 3 minutes, which was more bubbles produced than 4cms way, following the pattern 6cms away should have produced less bubbles than 4cms away. This could have been due to a number of errors (see above), but as it did not fit in with the pattern I decided to retake this test to ensure the most accurate results. The retest experiment produced 39 oxygen bubble following the pattern that I predicted, and the pattern other experiments. The anomalous result has been added in my graph.

If I were to do this experiment again I would change my method using a measuring cylinder as described above. My experiment is more than adequate to use in schools, with limited equipment. But the amount of errors in my method was not reliable enough for top scientist to use. This is because of the high level of errors which where beyond my control. A top scientist would have the equipment need to produce an experiment to the highest degree of accuracy.

To extend this investigation further I would change the variables for example the type of plant I was using. I would try different types of plant and see if the results are similar for each type of plant. Also I could investigate the rate of photosynthesis when I changed the in take of Carbon dioxide or change the temperature. If I was to change the variable of my experiment. Eg. Temperature. I would still more or less follow my method, only using a hot water bath and a thermometer to record the temperature and the number of oxygen bubbles produced. I would record the number of oxygen bubbles given off at 20oC, 30oC, 40oC, 50Oc and 60oC. If I decide to investigate this variable I predict that as the temperature increased the cells would be killed therefore decreasing the rate of photosynthesis.