investigating factors that affect the rate of photosynthesis

The aim of my experiment was to determine whether intensity of light would affect the rate of photosynthesis in a plant. To do this, I placed a piece of Canadian pondweed in varying light intensities, and observed the amount of oxygen being given off. I used Canadian pondweed because of its unusual quality of giving off bubbles of gas from a cut end, when placed in water.

Introduction

Photosynthesis occurs only in the presence of light, and takes place in the chloroplasts of green plant cells. Photosynthesis can be defined as the production of simple sugars from carbon dioxide and water causing the release of sugar and oxygen. The chemical equation for photosynthesis can be expressed as: (light) $6CO_2 + 6H_2O$ ($C_6H_{12}O_6 + 6O_2$ (in the presence of chlorophyll)

The fact that all plants need light in order to photosynthesise has been proven many times in experiments, and so it is possible to say that without light, the plant would die. The reason that light intensity does affect the rate of photosynthesis is because as light, and therefore energy, falls on the chloroplasts in a leaf, it is trapped by the chlorophyll, which then makes the energy available for chemical reactions in the plant. the amount of sunlight, or in this case light from a bulb, falls on 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.

There are many factors, which affect the rate of photosynthesis, including light intensity, temperature and carbon dioxide concentration. The maximum rate of photosynthesis will be constrained by a limiting factor. This factor will prevent the rate of photosynthesis from rising above a certain level, even if the other conditions needed for photosynthesis are improved. It will therefore be necessary to control these factors throughout the experiment so as not to let them affect the integrity of my investigation into the effect of light intensity.

The resources I have used in this is " the living world " by Michael Roberts – pages 140, 146, 147.

Sample table

Predictions

I predicted that as the intensity of light increased, so would the rate of photosynthesis. Furthermore, I think that if the light intensity increases, the rate of photosynthesis will increase at a proportional rate until a certain level is reached, and the rate of increase will then go down. Eventually, a level will be reached where an increase in light intensity will have no further effect on the rate of photosynthesis, as there will be another limiting factor, in this case probably temperature.

Method

Input variables – light intensity is to be varied by increasing and decreasing the voltage of the light source to the plant

Output variables – volume of oxygen produced (rate of photosynthesis) is to be measured by finding the volume of oxygen produced in a minute, and thus finding the rate of photosynthesis

Control variables –Light wavelength (colour) – light energy is absorbed by the pigment, chlorophyll, in the leaf. Chlorophyll easily absorbs blue light, and also easily absorbs red light. However it does not easily absorb green or yellow light, rather it reflects them, decreasing the amount of light absorbed, and therefore the rate of photosynthesis. This can easily be controlled, simply by using the same lamp throughout the experiment.
Carbon dioxide concentration – This can affect the rate of photosynthesis, since if there is too little CO_2, it can become the limiting factor, thus impeding the viability of the experiment. In this case, as long as the experiment is done over a short period of time, the amount of carbon dioxide used up by the plant will not be sufficient enough to cause the carbon dioxide concentration to become the limiting factor. If my experiment were to be performed over a longer period of time, for instance 24 hours, I would add a fixed amount of Sodium hydrogen carbonate to the water, thus ensuring a large enough supply of carbon dioxide.
Water availability – water is also required in the photosynthesis reaction, and when it is lacking, the plants' stomata close to prevent further water loss. This closing of the stomata cells also leads to little carbon dioxide being able to diffuse through. Clearly, in a water plant, like the pondweed, as long as the plant is fully submerged in water at all times, this will not be a problem.
Temperature – Enzymes are used in the photosynthesis reactions of a plant. Therefore, temperature will increase the rate of photosynthesis, until a point at which the enzymes denature. Although performing the experiment at a temperature slightly higher than room temperature, perhaps 25°C, would have a positive effect on the accuracy of the readings I took, as it would reduce the

percentage error, by increasing the volumes, I decided that the inaccuracy of maintaining a constant temperature would outweigh any advantages. I am therefore going to perform the experiment at room temperature, checking the temperature frequently, in case the heat given off from the light should slightly raise the temperature, in which case I shall simply refill the beaker with more water after each experiment.

class results

My graph was in the form of a best-fit curve. I drew it as a curve rather than a straight line because of the clear pattern of the points. This meant 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 from light increased with the rise in light intensity, so did the amount of oxygen produced as a product of photosynthesis. My graph showed that the relationship between the light intensity and the rate of photosynthesis was non-linear, as my graph produced a best-fit curve. However, as I expected, it does appear that for the very first part of the graph, the increase in rate is in fact proportional to the increase in light intensity (i.e. a straight line) As light intensity increases, the photosynthetic rate is being limited by certain factors, such as carbon dioxide and temperature. These factors do not immediately limit the rate of photosynthesis, but

rather gradually. As light intensity increases further, so the rate of photosynthesis is being limited by other
factors more and more, until the rate of photosynthesis is constant, and so is almost certainly limited in full by another factor. Overall, both graph and my results support my predictions fully. My idea that the rate of photosynthesis would increase with light intensity was comprehensively backed up by my results. This is because a higher light intensity involves a greater level of light energy, which can then be transferred to a special protein environment designed to convert the energy. Here, the energy of a photon is used to transfer electrons from one chlorophyll pigment to the next. When enough energy has been gathered at a reaction centre, adenosine triphosphate (ATP) can be synthesised from adenosine diphosphate (ADP). The oxygen collected in the experiment is in fact the by-product of this reaction, and so it is clear to see that the more light energy, the more ADP is being converted into ATP and more oxygen is produced as a result.

The resource I used for this is :
http://www.xrefer.com/

Evaluation

Although I feel that my experiment was sound overall, I thought there were many points at which the accuracy was not perfect. I was relying on all the bubbles being the same size, which they clearly weren't, however many of the smaller inaccuracies also apply to my main experiment. Firstly, the voltage on the Canadian Pondweed was not measured to a very high degree of accuracy. Overall, I felt that due to the small volumes of oxygen involved, my experiment was not as accurate as it could have been. Improvements could have been made. To extend my enquiries into the rate of photosynthesis, I could perhaps try to link in some of the other limiting factors to the same experiment, as well as investigating them in their own right. It could also be interesting to explore the effects of coloured lights on the rate of photosynthesis, which could lead to the question of whether or not other types of light, such as fluorescent lights or halogen lights, would have a different effect on the rate of photosynthesis.

By Chris Bott.