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Photosynthesis coursework

3/10/02

Problem

Investigate the relationship between wavelength of light and the rate of photosynthesis using pondweed.

Background information

- **Photosynthesis:**

Photosynthesis is a process where by plants produce their own food using carbon dioxide and water in the presence of light absorbed by chlorophyll.

$$\text{Carbon Dioxide+ Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Glucose+ Oxygen}$$

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

The rate of photosynthesis may be affected by things called limiting factors, such as:

- **Temperature,**
- **Carbon dioxide,**
- **Light**
- **Water.**
- The *temperature* of a surrounding area affects photosynthesis; therefore it's a limiting factor. An increase of 10 c can double the rate of photosynthesis, but above 40 c photosynthesis will stop because the enzymes, which chemically react during photosynthesis, will be denatured. Different plants have different temperatures at which they grow best, this is know as their optimum temperature. The greater the quantity of *carbon dioxide* in the surrounding area around a plant, the faster the plant will photosynthesise. The brighter the source of *light*, the faster the rate of photosynthesis. Pond water produces bubbles in light and this information can be used to investigate the affect of light upon the rate photosynthesis. . *Water* can also be called a limiting factor like light, temperature and Carbon dioxide. Water is essential for the photosynthesis process for example if a plant lacks water, photosynthesis will take place at a much slower rate. The water needs to contain nitrate ions in it for healthy growing for the synthesis of proteins.

- **Chlorophyll**

- The chlorophyll molecule is the active part that absorbs sunlight, in order to do it's job, synthesising carbohydrates, it needs to be attached to a very complicated protein. Chlorophyll absorbs the sunlight and uses it to synthesise carbohydrates from carbon dioxide and water. This process is known as photosynthesis and is the basis for sustaining the life process of all plants.
- The job of chlorophyll is to convert light energy into chemical energy. Chlorophyll absorbs the light energy and therefore enables it to be used for building up sugar.
- The chlorophyll uses light energy to carry out photosynthesis and it can perform the process at the rate light is provided. White light made up of a range of colours or wavelengths called a spectrum. Once white light passes through chlorophyll, the blue and red colours disappear because the chlorophyll absorbs them, whereas the others pass straight through or are reflected. If a plant becomes deprived of red or blue light then photosynthesis will not take place correctly and will not produce all the necessary starch.

- **Chloroplast Pigments**

- Chlorophyll is a mixture of pigments. To be able to see all the different pigments, it can be easily demonstrated by using a chromatography experiment. Doing this experiment five pigments can be identified: Chlorophyll a (blue-green), chlorophyll b (yellow-green), Xanthophylls (yellow) and Carotene (orange). The fifth pigment is a breakdown product of chlorophyll called Phaeophytin (grey). By taking separate solutions of each pigment, it can be determined the absorption spectrum of each colour. This will show that chlorophyll a and b absorb red, blue and violet parts of the spectrum, whilst Xanthophylls and Carotene absorb light only from the blue and violet part of the spectrum.

- Chlorophyll a is the most abundant pigment and is of universal occurrence in all-photosynthesising plants.

- **Wavelength**

- Photosynthesis can only take place at the rate at which it is provided to the plant. The only light that chlorophyll absorbs is at the end of the visible light spectrum. No green light is absorbed because that is transmitted and reflected back. The light intensity, colours and wavelength, which are not the right ones can hinder photosynthesis.

Prediction

I predict that when blue or red light becomes exposed through the ray box to the Canadian pondweed, more bubbles shall be produced. In my background knowledge I establish out that chlorophyll merely absorbs the two end parts of the visible light spectrum, this is the slowest and the fastest part of the detectable light spectrum by the human eye, these colours are red and blue. Red has a longer wavelength meaning it is slower than blue and has lower energy. Where as blue light has a shorter wavelength with high energy. This means that when a plant is open to the elements of red and blue light, photosynthesis will be take place at a more rapid rate, producing a greater amount of oxygen, which can be noticed by the quantity of bubbles given off by the Canadian pondweed. The chlorophyll pigments a and b fond in Canadian pondweed take in light from red and blue/violet parts of the spectrum, there for by using these wavelength of the light the speed at which the photosynthesis takes place will be quicker.

When pondweed is uncovered to green light, a less significant amount of bubbles compared with red and blue light will be as chlorophyll transmits and reflects back the green light somewhat than absorbing it. This will have a great effect on the photosynthesis process, because green light has a reduced amount of energy, needed for photosynthesis.

Plan

Apparatus needed:

1. Ray box
2. Light Filters (red, blue, green, magenta and yellow white). White light is without a filter.
3. Test tubes.
4. 500ml Measuring Cylinder.
5. Pondweed.
6. Timer.
7. Paper and pen to record data, or any other apparatus, which does this job.
8. Power Unit, for the supply of electricity to the ray box therefore producing light
9. Five pieces of 5 cm long Canadian pondweed.
10. Five lots of 25ml lots of water. The water needs to contain nitrate ions in it for healthy growing for the synthesis of proteins.
11. A 30cm by 30cm square piece of paper to reflect back any light to the Canadian pondweed, to make sure the maximum amount of photosynthesis can take place, by using the light source to its full potential. This will scatter the light back on to the test tube, which is not used by it the first time it passes by it.

This should be carried out in dark surroundings to ensure precise results. There should be no other light sources present around the experiment while it takes place.

In this experiment, I need to investigate the relationship between the different lengths of wavelengths of light and the rate of photosynthesis in pondweed. Firstly I will set up a ray box to be the light source. The next step is to place the white piece of paper upright facing the ray box leaving a big enough gap for the test-tube to be placed in, with Canadian pondweed and water inside it. Then I shall measure out 25ml of water into a test tube and place in one of the test tubs, after that the specially cut Canadian pondweed will be placed in the test tube. I then proceed to place this in front of the ray box, which has not yet been turned on, to provide a light source for photosynthesis to take place. I shall start he experiment by turning the box exposing the pondweed to white light given from the ray box for one minute, while this is happening I shall keep a tally on the number of bubbles that are produced. The amount of bubbles that are given out by the pondweed will show the rate of photosynthesis. The more bubbles produced indicate that the plant is photosynthesising at a quicker rate. When the one-minute is up I will record the number of bubbles admitted by the plant, and the colour of light, making sure no mistakes are made.

Then I shall repeat the experimental process, which I have mentioned above, but using fresh water measured to 25ml, a new piece of cut pondweed and then change the colour of the filter in front of the ray box e.g. blue. Then count the number of bubbles admitted in one minute. This will be repeated for all the other colour filters, which are blue, green, magenta and yellow.

The wavelength of the coloured light is the independent variable, which will change as the filter is changed. The light filters will be placed in front of the ray box, so that only the colour of the filter is the colour light coming from the ray box. Special care must be taken in assuring that no other colours of light are being admitted from the ray box, this will cut down on the chance of any anomaly's. By using this variable the different wavelengths can be investigated and experimented with.

The results produced from the experiment need to have a high level of accurate, which is consistently maintained through out the experiment. This is important in order to investigate the relationship between the different wavelengths of light in the visible light spectrum and the rate at which photosynthesis takes place. Therefore we need to make sure that everything in the experiment is carried out fairly. The room in which the experiment will take place should have no other light source in it apart from the ray box. So that the only light, which comes into contact with the Canadian pondweed, is from the ray box it. To ensure more accuracy in this experiment it I'm going repeat this experiment at least once, so a firm conclusion can be drawn from it. This will reduce the chance of any anomalies results.

Observations

After one minute, the total number of bubbles produced by the pondweed.

Colour of light	Red	Green	Blue	Yellow	Magenta	White
1st run through	20	5	29	10	20	30
2nd run through	30	8	32	16	26	33

The table above shows that from the 2nd run through of the experiment, showed that blue light produced the most bubbles. After that the most bubbles produced were from the white light closely followed by red light, green, magenta and finally yellow. In the second run through, it did not show the same results, as white light produced the most bubbles, directly followed by blue, and then red light. Surprisingly yellow and magenta both higher oxygen admittance and still with a low bubble count was green light. The 1st runs through results were very in accurate so I decided to take them out of the experiments, in order to draw a firm conclusion.

Analysis

The bar chart represents results collected in the second experiment because these were more accurate than the first lot. I discovered that the white light produced the most bubbles on both experiments. The white light carried photosynthesis out at the fastest rate, producing the greatest amount of oxygen bubbles. In both the first experiment, the second experiment the fact that the blue light and then red light as well in the second experiment produced a unexpected amount bubbles was an anomalous result, I was expecting it to produce an amount of bubbles which had a considerable decrease compared to the white light. The next highest was red light, it the second experiment the amount bubbles that were produced were considerably higher than the first, the amount produced in the second experiment came close to the amount produced by the white light in both experiments. Magenta carried out photosynthesis at the next fastest rate there, yellow then followed. At the bottom as expected was green light, there was a big space in between it and yellow light. This indicated that green light photosynthesis at the slowest rate out of all the wavelengths of light. In the repeat experiment oxygen admitted from red, blue and white light were all very close. In the repeat experiment all the amounts of oxygen, which was admitted from all the different wavelengths, were all greater than, in the first experiment.

Conclusion

The data I collected and the observations I made show that the wavelengths of white light and the rate of photosynthesis produced:

- Observations to show that white light produces the most in a minute indicating that it carried photosynthesis at the fastest rate. This was down to the wavelengths investigated make up white light so it contains all colours resulting in pondweed photosynthesising more efficiently.
- The wavelength of light, which produced the most amounts of oxygen bubbles, at the quickest rate of photosynthesis, was blue light, which was predicted along with blue light. Blue light did not photosynthesis at the same rate as red light it was little bit slower but it came very close to the speed of red light. These results were very reliable in the second experiment as red and blue light produced around the same amount of oxygen, which was predicted. In the first experiment, the amount of oxygen which red light produced cane up as an anomalous result.
- Photsythesis is carried out by the chlorophll part of of a cell

Different wavelengths of white light affect the rate of photosynthesis in pondweed. Photosynthesis is carried out by chlorophyll in the plant However it only absorbs certain lights due to the nature of chlorophyll itsel~ these are red and blue light The structure of the chlorophyll molecule absorbs energy of particular wavelengths. These specific wavelengths are from each end of the spectrum being the violet-blue wavelength and the orange-red wavelength. The chlorophyll molecule has different optimums of energy being both high and low obtained from long and short wavelengths. The wavelengths of red and blue light cause changes in the molecule. The chlorophyll absorbs the red and blue light energy where it gathers in the molecule, exciting the electrons. This triggers a serious of reactions, which transfers energy, resulting in a chemical reaction when the pondweed carries out photosynthesis. *v*

Pondweed contains chlorophyll a, which absorbs its energy from the blue and red wavelengths found at either end of the spectrum and this is why the most bubbles are produced in red light. However it is expected that in blue light the pondweed will photosynthesis at a faster rate than other wavelengths of light The observations disagree with this and undermine the original prediction. The results from the blue wavelength are anomalous results. V"

My results for red light were supported by my prediction, as was my prediction for green light. Few bubbles were produced in green light as the chlorophyll transmits and reflects the green wavelength; this is why the pondweed appears green. It does not absorb the light energy of the green wavelength therefore it carries out photosynthesis at a slower rate. The red wavelength of white light causes the fastest rate of photosynthesis due to the fact that chlorophyll absorbs this colour and uses the light energy from it in a serious of chemical reactions by where, the plant carries out photosynthesis and produces oxygen as represented by bubbles in water and gJrJduc~s / starch. *A--"r* Evaluatio.

The investigation was carried out with a reasonably high degree of success. Evidence was obtained supporting my prediction that red light would enable pond weed to carry out photosynthesis at a faster rate than other wavelengths, therefore producing more bubbles. Results also agreed with my prediction that green light would not produce many bubbles because the chlorophyll in the pondweed transmits and reflects the green light therefore the rate of photosynthesis is carried out ~t a slower rate.

However, in relation to my background information and my own knowledge, the results from blue light would appear to be inaccurate and undermined my prediction. Chlorophyll absorbs blue light and uses the light energy for photosynthesis therefore a larger number of bubbles should be released from the pondweed. However the results show that yellow light produced more oxygel!- than blue did, indicating that photosynthesis was carried out at a faster rate when exposed to ,/ yellow light. This is incorrect and the results from the blue wavelength could be classed as anomalous results.

A number of factors could have affected the experiment impairing the results. Different pondweed was used in the 1 st and repeat experiments, which could have had implications on the results. To event this the same ndweed must be used each time. Anim rtant factor which

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7?"f""?f Le in temperature increases the rate of photosynthesis; therefore the results may not be *~;:ir"* accurate or reliable. The temperature of the water must be controlled and could be achieved by '0 changing the water after each experiment. This would ensure that the water tempera~ was kept constant and fairer results produced.

Yellow light could have produced a large volume of oxygen, more than blue because the chlorophyll in the pond weed could have contained more accessory pigments, which a~rb other colours which chlorophyll a, does not.

On the whole my results were fairly accurate, yet they were not precise enough to draw a firm conclusion with evidence to support it. The different wavelengths of white lights produced reliable results except blue light. The temperature of the water or the surrounding light could have affected the results. To minimise the risk of inaccurate results to provide reliable evidence for a conclusion, control the water temperature of the pondweed in the test tube and carry out the experiment in a completely dark room where no light can be absorbed by the pondweed from the surroundings. The experiment was repeated but to provide fIrmer evidence for the conclusion repeat more than twice. To provide additional evidence for the conclusion and to extend the enquiry further, a wider variety of wavelengths could be experimented with such as cyan and as well as observing the volume of oxygen given off, the pondweed could be tested for the amount of starch produced. Starch can be tested for using iodine; if the iodine goes blue/black then starch is present. All observations carried out in the investigation must be done with accuracy and precision in order to produce reliable results, which can be used to draw a firm conclusion. V' G *(p*