Introduction

Aim

My aim in this coursework is to investigate the factors, which affect photosynthesis. My aim is to confirm which factors increases or decreases the rate of photosynthesis.
The factors are

- Carbon dioxide,
- Chlorophyll
- Light intensity
- Water

The building-up of complex food molecules from simpler substances is called **a synthesis** and it needs enzymes and energy to make it occur. Enzymes those are present in the plant's cells and the energy for the first stages in the synthesis comes from sunlight. The process is, therefore, called **photosynthesis** ('photo' means light).

Photosynthesis is the main type of auto tropic nutrition. There are two fundamentally different methods of nutrition. Animals and certain other organisms take in ready-made organic substances, this is known as heterotrophic nutrition. Other organisms, notably plants, take in simple inorganic substances which they then build up into complex organics substances, this is known as auto tropic nutrition.

The importance of photosynthesis

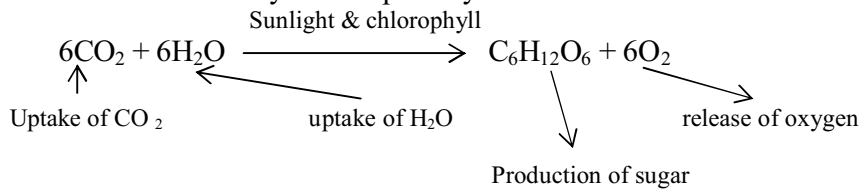
Heterotrophs, including humans, all depend on photosynthesis for making their food. The manufacturing of sugar (starch) during the process of photosynthesis is astounding. For example: a hectare of maize can convert as much as 10 000 kg of carbon form carbon dioxide into the carbon of sugar in a year, giving a total yield of 25 000 kg of sugar per year. This example is a fact that was ascertained by my previous Biology teacher.

For photosynthesis to take place a plant requires carbon dioxide, water, light, chlorophyll and a suitable temperature. The necessity for these factors can be demonstrated by simple experiments either on whole plants or single leaves.

The main product that is produced during the process of photosynthesis is sugar, although this is often built up into starch for storage. As an indication of whether or not photosynthesis has been taking place, leaves are tested for starch. At first the plant has to be de-starch a plant. This has been explained further during this coursework. Hence photosynthesis is a very important to take place.

Experiment to test photosynthesis

In this case the hypothesis is that plants make their food by photosynthesis. The following equation is one of the ways to test photosynthesis:



In order to keep the equation simple, glucose is shown as the food compound produced. This does not imply that it is the only substance synthesized by photosynthesis.

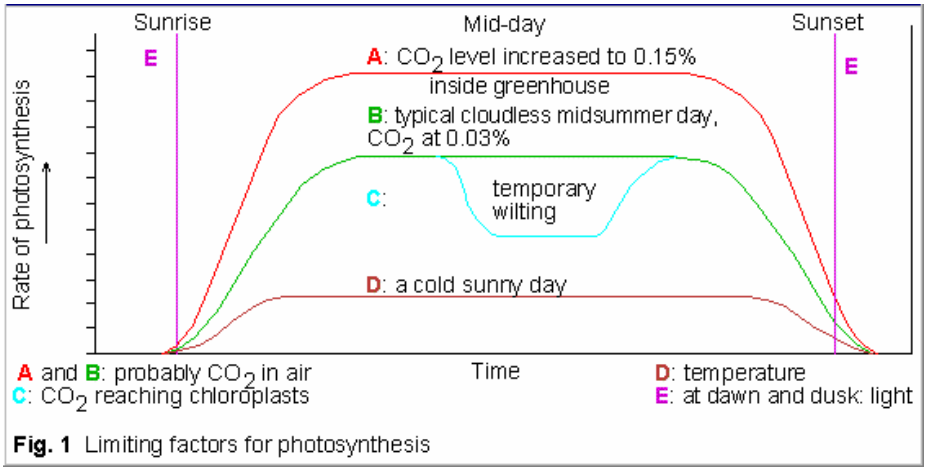


Fig. 1 Limiting factors for photosynthesis

If photosynthesis is going on in a plant, then the leaves should be producing glucose (sugar). In many leaves, as fast as sugar is produced it turns into starch. Since it is easier to test for starch that for sugar, we regard the production of starch in a leaf as evidence that photosynthesis has taken place.

In all the experiments described are designed to see if the leaf can make starch without chlorophyll, sunlight or carbon dioxide, in turns. If the photosynthesis story is sound, then the lack of any one of these three conditions should stop photosynthesis, and so stop the production of starch.

In designing the experiments, it is very important to make sure that only one independent variable is altered. If, for example, the method of keeping light from a leaf also cuts off its carbon dioxide, it would be impossible to decide whether it was the lack of carbon dioxide, which stopped the production of starch. To make sure that the experimental design has not altered more than one variable, a control is set in each case. This is an identical solution, except that the conduction missing from the experiment.

De-starching a plant

Apparatus required during the experiment

- A plant
- A dark cupboard

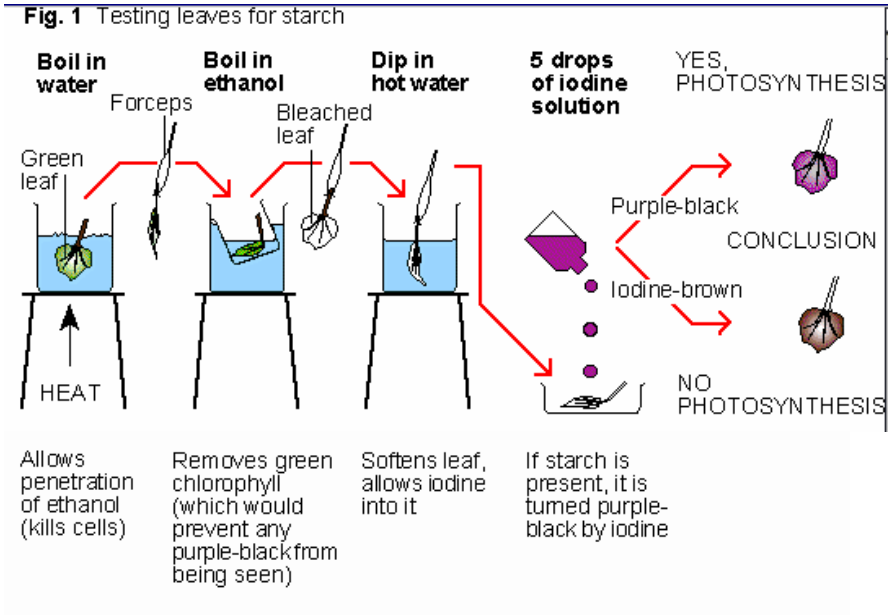
It is not possible to remove the starch chemically, without damaging the leaves; so simply leaving in the darkest for 2 or 3 days de-starches a plant. Leaving them in a dark cupboard for a few days de-starches potted plants. In the darkness, any starch in the leaves will be changed to sugar and carried away from the leaves to other parts of the plant. For plants in the open, the experiment is set up on the day before the test. During the night, most of the starch will be removed from the leaves. If better results are needed, then the leaves are wrapped in aluminium foil for 2 days while they are still on the plant. Then one of the leaves is tested to see that no starch is present.

Starch test

Apparatus required during the experiment

- Boiling H_2O in a beaker
- Beaker
- Ethanol (alcohol)
- Test tube
- Heatproof mat
- Tripod
- Iodine
- Bunsen burner

This starch test shows us that if the plant contained starch or not. The process of the starch test is shown below:



Background information

There are many different types of leaves; they are called evergreen, monocot, succulents and pin variegated. Simple demographic carnivorous and compound stages of evolution are going through these leaves. This means when the leaves change and adapt to their surrounding such as climate, etc.

Evergreen plant has chlorophyll present in it. Chlorophyll is a green substance, which contains chloroplasts and makes the leaves green. Chlorophyll is important for photosynthesis. Magnesium is a green element, which is found in chlorophyll. Therefore plants are green.

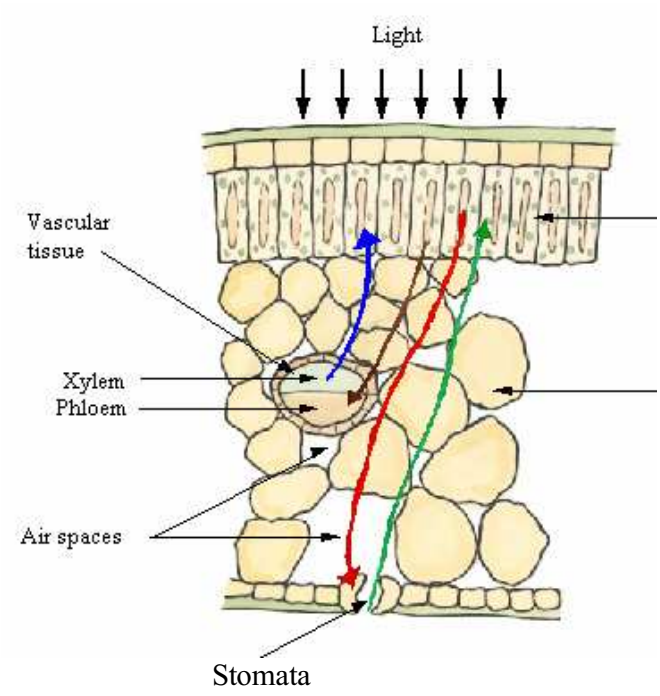
Chlorophyll covers a large amount of area of a plant. The chlorophyll contains many rows of membranes and chlorophyll.

Limiting factors are important to plants in their natural surroundings. For instance, on a warm summer day, light and temperature are generally well above their minimum value for plants living in the open, and carbon dioxide is the factor that is limiting of photosynthesis. But in a cool day, morning or evening, light or temperature may become limiting factor as they do not get much light when it is winter.

Habitat is also important for living plants that live in shady places such as the floor of a forest or wood, light will be the limiting factor most, it not all, the time. This has been explained in the above paragraph.

When a chemical process depends on more than one essential condition being favourable, its rate is limiting by that factor which is nearest its minimum value.

Where photosynthesis takes place.



OXYGEN OUT
CARBON DIOXIDE IN
GLUCOSE OUT
WATER IN

The above diagram shows a thin slice cut out from any plant leaf. It is a magnified picture. The process of photosynthesis that takes places are described in the following points:

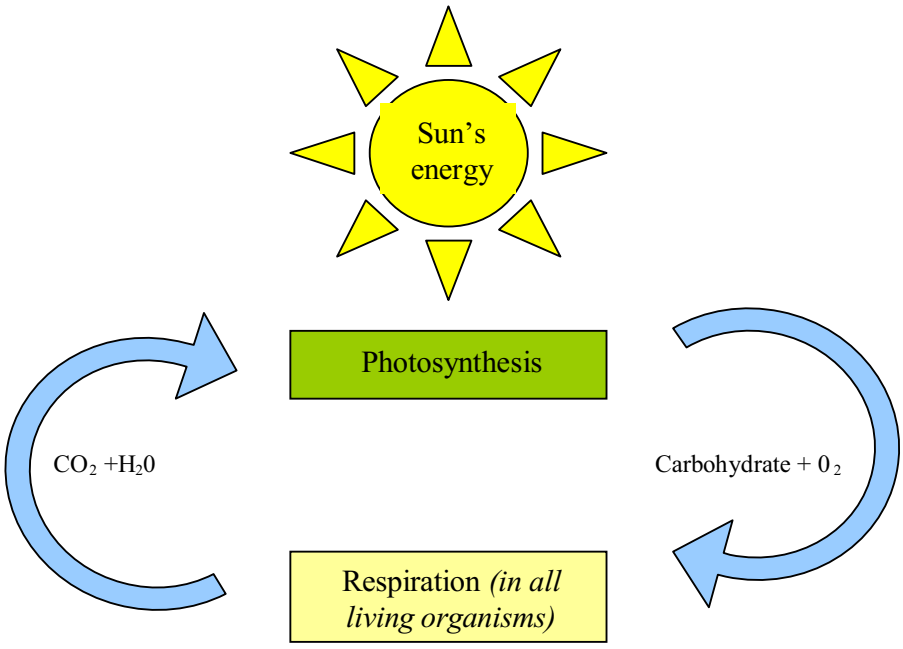
- Water moves into the leaf cells by osmosis. This water is then evaporated into the air spaces and diffuses out of the leaf as vapour.
- Water and dissolved minerals move through the xylem vessels to the stem and then to the leaves.
- The process of osmosis does this.
- Light enters the leaf and at the same time carbon dioxide enters the leaf by the palisade layer of cells and oxygen comes out from the stomata.
- Carbon dioxide comes form the xylem vessel and oxygen comes from the palisade layer.
- Glucose is then released out form the palisade layer into the phloem, where the water is absorbed and taken in by the palisade layer.

Prediction

My prediction is that the more intense the light, or more the chlorophyll, water and carbon dioxide the faster the rate at which photosynthesis is carried out. In other words I think the greater the light intensity, water, chlorophyll or carbon dioxide the greater the rates of photosynthesis. This is explained in the hypothesis below:

Hypothesis

If there is no carbon dioxide (CO_2), water (H_2O), sunlight or chlorophyll the plant cannot make starch, as these factors are vital for photosynthesis.



Fair test

In order for the experiment to be a fair test and the results to be accurate as possible, it is convenient to do the following points:

- When de-starching a plant, keep in a dark room, making sure that the plant is exposed to no light at all.
- When boiling a leaf in ethylated spirit, boil until green pigment (chlorophyll) is removed, once this has taken place the leaf will become like a paste, therefore the experiment will be approximately impossible to be carried out.
- All the factors that are being experimented during this coursework should be kept the same to achieve fair and accurate experimental results.
- During each the starch test that is taken into consideration, a certain amount of Iodine is to be used. This make the experiment a fair test as it is at a fixed concentration.
- The time that each experiment should have taken place in, should be at a constant point in time.

Safety Precautions

While conducting this experiment many harmful substances and dangerous equipment were used. Therefore safety precautions were taken place. Below are the safety precautions:

- All beakers and test tubes should be kept of the edges.
- Long hair should always be tied at the back so that it does not come in the way during the experiment.
- Large lab coats should be worn instead some chemical stains your clothes.
- During the experiment many harmful acids were used. They can be very strong acids. Therefore safety goggles and large lab coats should be worn.
- A fire extinguisher should be kept to one side as a precaution.
- Shoelaces should be tied properly as some one falls
- Thermometers should be kept away form the edges
- There should be no running around during the experiment
- Special water baths and test tubes will be used that could withstand extreme temperatures and corrosions.
- Potassium hydroxide and sodium hydrogen carbonate are alkaline, therefore can burn and are corrosive.
- No eating or drinks should be brought in the lab.
- Ties should be tucked in and all lose clothes also should be tucked in.
- No toxic chemicals to be handled directly.
- Always do as instructed by a teacher
- After each experiment benches must be tucked away.
- Ethylated spirit is toxic and can cause blindness, therefore it is important to wear goggles.
- Ethanol should not be heated directly as it can be very harmful to naked skin, therefore as I have mentioned before large lab coats and goggles should be worn.
- While heating/boiling ethanol, it should be put into be akers that is then placed a large water bath (that is large enough for the beaker to easily fit in). This is show that the ethanol is not directly heated.
- Chemical resistant gloves should be worn- so no damage is caused to the hands.
- Tweezers should be used, to pick up hot objects.

Secondary resources

During this coursework, I had getting some information from some certain books, the Internet and the library. To be specific I have names these in the list below:

- www.s-cool.com
- www.gcsehelp.com
- Stratford Library.
- Co-ordinated Science.
  Biology for Higher Tier.
  Brian Beckett and Rosemarie Gallagher.
  2001
- www.encater.com

Factors that affect photosynthesis.
Carbon Dioxide

Aim

In this part of my coursework my aim is to discover whether or not carbon dioxide is necessary for photosynthesis to take place.

Prediction

It can be deduced that carbon dioxide is required for photosynthesis to take place. Explanation for this prediction has been shown below in the Hypothesis.

Hypothesis

Looking at the photosynthesis formula below, it seems obvious that carbon dioxide is required for photosynthesis. In the formula it is quite logical because it contains carbon dioxide as a reactant:

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

$6H_20 + 6CO_2 \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} 6O_2 + C_6H_{12}O_6$

There is a second reason why carbon dioxide is known as a primary factor for photosynthesis, because within glucose ($C_6H_{12}O_6$) there are two particles, which are carbon and oxygen. These particles are also found in carbon dioxide. Therefore it is assumed that carbon dioxide is required in photosynthesis to produce glucose.

Looking at the diagram shown below can represent the necessity for carbon dioxide.

Fair test

In order for the experiment to be a fair test and the results to be accurate as possible, it is convenient to do the following points:

- The conical flasks should be airtight.
- When the starch test will be taken under consideration, the same amount of iodine should be used to test both leaves.

Planning

Apparatus required during the experiment

- Potted plant such as geranium (Pelargonium)
- Sodium Hydrogen Carbonate $NaHCO_3$ – this is needed so that it gives CO_2
- 2 conical flasks.
- Rubber bung – both should be split in halves.
- 2 Clamp Stands – these are needed to hold the conical flasks up right.
- Soda lime – this is needed so that the CO_2 could be fully absorbed.

The apparatus is assembled like the diagram shown on the next page:

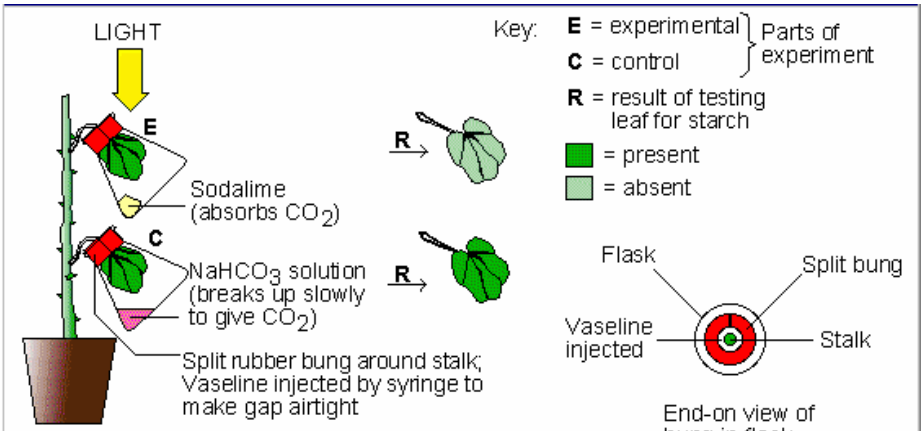


Fig. 3 Testing the need for carbon dioxide in photosynthesis

De-starching a plant

Apparatus required during the experiment:

- A plant
- A dark cupboard

It is not possible to remove the starch chemically, without damaging the leaves; so simply leaving in the darkest for 2 or 3 days de-starches a plant. Leaving them in a dark cupboard for a few days de-starches potted plants. In the darkness, any starch in the leaves will be changed to sugar and carried away from the leaves to other parts of the plant. For plants in the open, the experiment is set up on the day before the test. During the night, most of the starch will be removed from the leaves. If better results are needed, then the leaves are wrapped in aluminium foil for 2 days while they are still on the plant. Then one of the leaves is tested to see that no starch is present.

Method

- At first the de-starching experiment is taken into consideration. This is shown above.
- After the de-starching experiment is completed, the potted plants are watered and their shoots will be enclosed in two conical flasks.
- The conical flasks are held upright with the help of using a clamp stand. This gives the leaves of the plant more support.
- The key E that is shown in figure 3: *Testing the need for carbon dioxide in photosynthesis* (above), shows the leave that are covered with a conical flask and contains soda lime, this is used so that all the carbon dioxide that is present inside the leave is absorbs.
- In the other conical flask, Key C, the leaves is covered with a conical flask that is placed with Sodium Hydrogen Carbonate $NaHCO_3$, this is used so that it breaks up slowly and produces carbon dioxide.
- The compound used in Key E is a carbon dioxide reducing compound.
- Now these two conical flasks must be air tight, so no gases (i.e.: carbon dioxide) can penetrate through the gaps.
- A rubber bung is then used; it is split in half so that it can fit around the stem of the leave firmly and be air tight as possible.

- The plant is then placed in the light for several hours and then both leaves are tested for starch.
- The starch test was then carried out and the results were observed and recorded.

Safety Precautions

While conducting this experiment many harmful substances and dangerous equipment were used. Therefore safety precautions were taken place. Below are the safety precautions:

- During the experiment Iodine was used, this substance us very dangerous towards the skin, it can change colour of the skin. Therefore Lab coats, plastic gloves and goggles were worn to protect the bare skin.
- Ethylated spirit is also very harmful upon bare skin. It can actually burn human skin, to protect the hands plastic gloves were worn. Goggles were worn to protect eyes and large lab coats were worn to protect any other bare skin.

Results

The plants that was given no carbon dioxide they had no starch in that plant, but the other plant that received al the necessary substances showed signs of starch. This proves that carbon dioxide is necessary for photosynthesis to occur.

It was found that the control leaf (Key C) had found to form a significant quantity of starch, the other leaf was found to have little starch present.

A plant will have no starch when only three factors for photosynthesis are present (light, water and chlorophyll) and no carbon dioxide is in attendance.
All four factors are required for photosynthesis to produce starch.

Conclusion

It has been concluded this experiment was a successful investigation. It has been proved that carbon dioxide is required for photosynthesis to transpire. I have also gained knowledge that carbon dioxide is a limiting factor. It reduces the rate of photosynthesis.

Evaluation

My prediction that I had made in the planning was correct, as we know that the leaf that contained a carbon dioxide reducing compound, there were no starch present after conducting the starch experiment. Hence, I had stated that photosynthesis would not take place if there were no carbon dioxide; therefore this is accurate, as no photosynthesis had taken place in this part on the leaf, whereas in the other there were signs of starch, which shows that photosynthesis was taking place.

During the experiment there were no problems or errors. The two compounds Soda lime and Sodium Hydrogen Carbonate, which were used to reduce the amount of

carbon dioxide and slowly break up to produce carbon dioxide respectively. These two substances/solutions were left for several hours to make sure that they would take affect.

The 2 conical flasks act as a mini habitat, giving the effect of a green house effect, consequential in the increase in temperature and increase of light intensity, the factor had very little effect on the experiment, but it would effect a more elaborate experimentation.

The rate of depletion in carbon dioxide influences the rate of photosynthesis and makes it stop at a certain time limit. Hence it is a limiting factor.

Improvements

During this experiment many bits and pieces could have been added in, this would have given us an accurate result. The following points show some improvements that could have been made:

- To make sure the rubber bungs in both conical flasks were air tightened, they been injected with Vaseline to make sure that the gap was airtight and no gases would enter or escape the conical flask. This has been shown on the diagram that was shown at the beginning of this experiment.

Factors that affect photosynthesis.
Chlorophyll

Aim

In this part of the course work my aim is to observe whether chlorophyll is necessary for photosynthesis or not.

Prediction

It seems comprehensible that chlorophyll is required by plants to produce their own nutrition. There is an explanation fro this written below:

Hypothesis

It is well known that chlorophyll is required for photosynthesis because it is present in the photosynthesis formula below:

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

$6H_20 + 6CO_2 \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} 6O_2 + C_6H_{12}O_6$

This hypothesis cannot be directly justified from the formula, as chlorophyll is neither a reactant not a product. In this manner chlorophyll is knows as an enzyme that is a biological catalyst, which is also an effecting factor.

Studying the distribution of starch in a variegated leaf can show that chlorophyll is required for photosynthesis. In this experiment I have used a variegated leave to represent that chlorophyll is needed for the process of photosynthesis to take place.

A variegated leaf is one, which lacks chlorophyll in some parts, giving it a cream appearance wherever the green pigment is absent. This will be proved during the experiment.

Planning

Apparatus required during the experiment

- A plant with variegated leaves. (This will have green and white leaves)

The apparatus is assembled like the diagram shown on the next page:

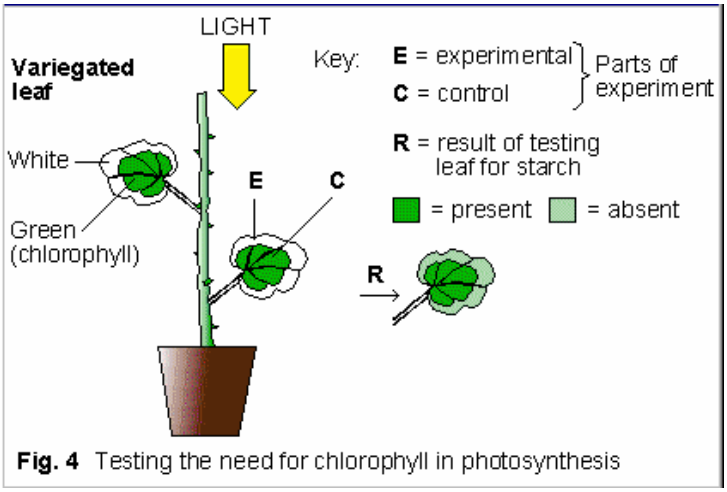


Fig. 4 Testing the need for chlorophyll in photosynthesis

The white part of the plant is where no chlorophyll is present.

Method

It is possible to remove chlorophyll from a plant without killing it, so the following steps are achieved to confiscate the chlorophyll that is present in the plant:

- First the plant is placed in a dark room for two to three hours. This is to de-starch the plant.
- After de-starching the plant it is deprived to sunlight for a few hours.
- Now a single leaf is sampled. On this leap a starch test is carried out.
- The results were observed and recorded.
- These results are shown after the safety precautions.

Safety Precautions

Whilst conducting the experiment many harmful substances and dangerous equipment were used. However safety precautions were taken into consideration. Below are the precautions that were exercised:

- During the starch experiment, which was a main part of the experiment, Iodine was used, this substance us very dangerous towards the skin, it can change colour of the skin. Therefore Lab coats, plastic gloves and goggles were worn to protect the bare skin.
- Ethylated spirit is also very harmful upon bare skin. It can actually burn human skin, to protect the hands plastic gloves were worn. Goggles were worn to protect eyes and large lab coats were worn to protect any other bare skin.

Results

The test proved that chlorophyll is needed for photosynthesis because the area of the plant where chlorophyll was a present showed sign of starch but the area with no chlorophyll did not show any starch.

Conclusion

In this conclusion my prediction was correct and thus chlorophyll is essential for photosynthesis to take place. Since starch is present only in the parts which originally contained chlorophyll. I can easily conclude that chlorophyll is needed for photosynthesis. As the results I had received were positive and my prediction were correct.

A variegated leaf is one, which lacks chlorophyll in some parts, giving it a cream appearance wherever the green pigment is absent. This will be proved during the experiment.

The distribution of starch in a variegated leaf demonstrates that photosynthesis can only take place in the green parts of a plant, and this suggests that the process is closely associated with chlorophyll. Chlorophyll is normally contained within chloroplasts so it is logical to conclude that photosynthesis takes place in or close to the chloroplasts.

Therefore it seems reasonable to suppose that chlorophyll is needed for photosynthesis.

Evaluation

There were no problems during the experiment. My prediction that I had made was correct.
Since starch is present only in the parts, which originally contained chlorophyll, it seems reasonable to suppose that chlorophyll is needed for photosynthesis.

Factors that effect the rate of photosynthesis.
Light intensity.

Aim

In this section of the coursework my aim is to discover whether or not the variation in light intensity affects the rate of photosynthesis.

Prediction

I predict that without light photosynthesis in a plant cannot be taken into consideration. My prediction is explained below in my hypothesis.

Hypothesis

It is obvious that sunlight is necessary for photosynthesis to take place. This is proven with the help from the below formula that is the process of photosynthesis:

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

This shows that sunlight is necessary for photosynthesis because if even one component of this above equation is missing then the process cannot be taken place.

Planning

Apparatus required during the experiment

- Elodea (Pond weed)
- Boiling tube- this will contain the elodea (pond weed) and the thermometer.
- A ruler- this is needed to measure the light distance.
- Thermometer- to maintain the temperature at constant.
- Light source (60 Watt bulb)
- Water bath – I chose the correct size to maintain the temperature at chosen levels and also large enough to make sure that the test tube present inside is very spacious.
- Potassium Hydrogen Carbonate ($KHCO_3$)- this strengthens the amount of carbon dioxide.
- Plasticine- holds the test-tube in place, prevents it from falling.

The apparatus is assembled like the diagram shown on the next page:

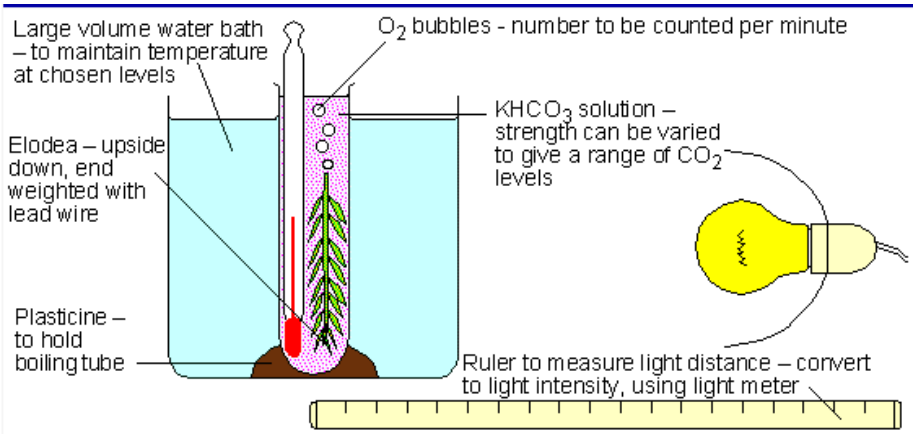


Fig. 1 Measuring the rate of photosynthesis

Method

- At first we check the temperature, with the thermometer, to insure that the temperature remained constant at 35^0c.
- The normal pondweed was put into the boiling tube.
- The first reading was taken when the light source was 40 cm away from the plant.
- The same was done again so that with three trials we could conclude on the average.
- The bubbles that were emitted from the aquatic plant within one minute were counted and recorded.
- Then the light source was moved to 30 cm and the previous steps were repeated.
- These same steps were repeated, as the light source was now at 20cm, 15 cm and 10 cm away form the plant.

The formula that calculated the rate of photosynthesis is shown below:

$$\text{Rate of photosynthesis} = \frac{\text{Number of bubbles}}{\text{Time in which bubbles where counted.}}$$

Safety precautions

While performing the experiment many injurious substances and hazardous equipment were used. However the below safety precautions were taken into deliberation. The below bullet points show the safety precautions that were taken into thought:

- While conducting this experiment I had to make sure I was using white light and not coloured light as this may slow down the process of photosynthesis.
- Potassium hydrogen carbonate is an alkaline, therefore it can burn and arc corrosive, to prevent any accidents to occur lab coats should be worn at all times and any parts of skin that can be burnt of affected should be covered.
- Safety goggles should be worn at all times.

Results

The table below has been created to show the amount of bubbles that were emitted according to the distance of the light source form the subject plant. The results shown below were taken every 3 minutes:

Distance (cm)	Trail 1 (Number of Bubbles)	Trial 2 (Number of Bubbles)	Trail 3 (Number of Bubbles)	Average (Number of Bubbles)
10	294	295	293	294
15	238	242	240	240
20	201	204	198	201
30	173	177	175	177
40	132	131	133	132

Graphs

The graph on the next page shows the distance of the light source and the number of bubbles of all three trials:

The next line graph demonstrates the average results of the trails

Conclusion

My prediction was certainly correct. Sunlight is required for photosynthesis, which was demonstrated. The closer the light source was to the plant the more bubbles where obtained. Therefore the increase in light intensity resulted in an increase in the rate of photosynthesis. However it was not proven that there was a limit on photosynthesis. This was because the range of tested light intensities was not very large. If it had been larger then it may have been proven.

Evaluation

Counting bubbles was an indirect method of measuring the rate of photosynthesis. The following points show why the experiment was not so accurate:

- The pressure within the water may have affected the emission of bubbles.
- The size of the leaf may have affected readings due to the number of stomata pores.
- The bubbles did not have a fixed size. The sizes were variable.
- The pondweed was contained in a microenvironment; the test tube may have affected the emission of bubbles.
- The Elodea had many branches; their branches may have trapped oxygen bubbles beneath them.
- Some of the bubbles were expected to have merged together. Therefore there were not a large number of bubbles.
- $KHCO_3$ was added at the beginning of the experiment and was not changed at all. $KHCO_3$ affected the first few results but may not have had the same effect upon the last result because it had been used up.

Improvements

During this experiment many bits and pieces could have been added in, this would have given us an accurate result. The following points show some improvements that could have been made:

- The result from the intensity formula should have been multiplied by 1000 so that the results would be easier to plot.
- Intensity $\propto 1/(\text{Distance})^2$. This formula shows that light intensity is inversely proportional to distance between the subject plant and the light source.
- An alternative method of conduction this experiment has been shown below. If this experiment would have been taken under consideration then it would have been much more easier and efficient:

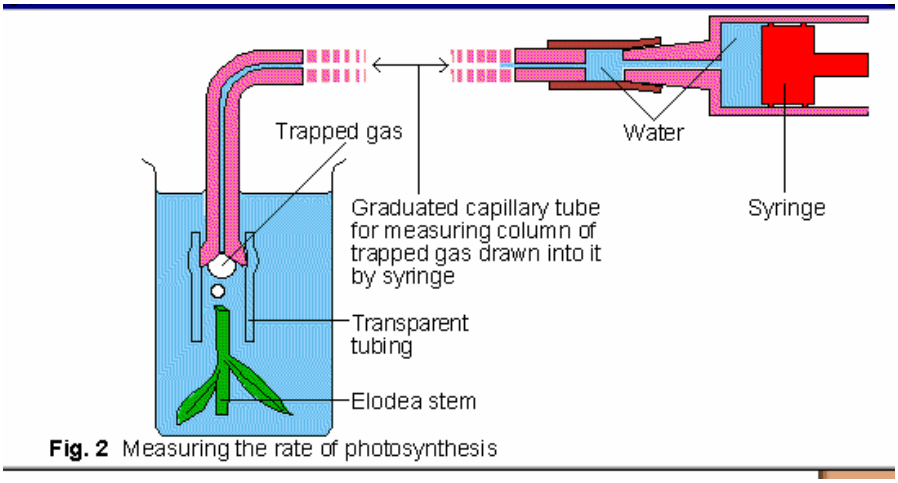


Fig. 2 Measuring the rate of photosynthesis

In this case the number of bubbles were not counted but the volume of gas evolved is recorded, along with the time taken for the certain specified amount of gas to evolve form the pondweed. In this case, the evolution of the gas is collected in a syringe, and a graduated capillary tube is used to record the speed of movement of the trapped gas in the recorded time interval. This is an much resourceful experiment than the one I conducted.

Factors that effect the rate of photosynthesis.
Temperature experiment

Aim

My aim in this part of the coursework is to answer the following questions. Is water necessary for photosynthesis to occur? Can photosynthesis be taken into consideration in plants without water?

Prediction

It is understandable that water is required for photosynthesis to take place. Below my prediction is explained in my hypothesis:

Hypothesis

It is known that water is required for photosynthesis because the substances, water, is present in the formula for photosynthesis below:

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

$6H_20 + 6CO_2 \xrightarrow[\text{Sunlight}]{\text{Chlorophyll}} 6O_2 + C_6H_{12}O_6$

It can also be said that water is needed for photosynthesis because within the chemical formula for glucose ($C_6H_{12}O_6$) there are both hydrogen and oxygen particles, which are also, present in water.

Planning

Apparatus required during the experiment

- Two plants. One is just a branch. The roots are removed to ensure that the plant could not absorb any water.

The apparatus is assembled like the diagram shown below:

Method

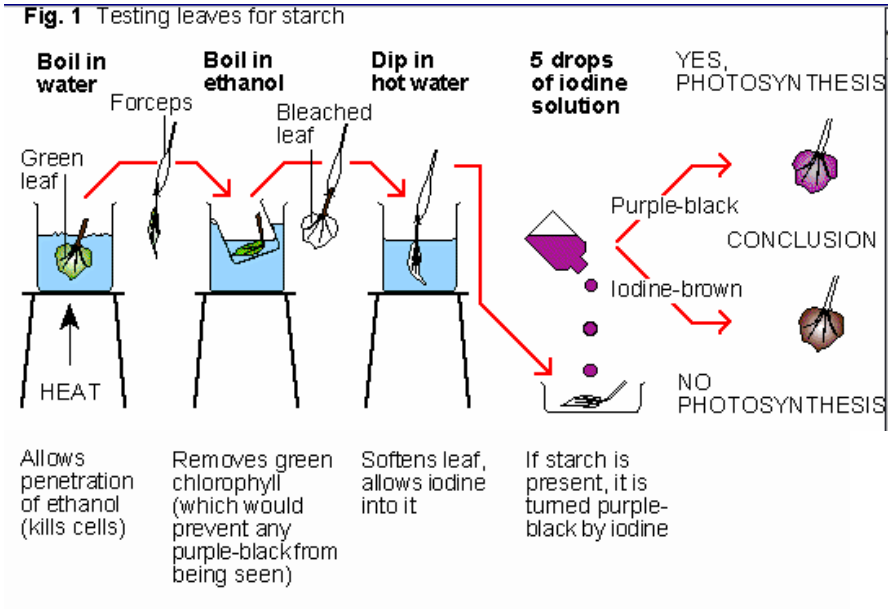
- Both plants are kept within a dark room for about two-three days (this is to de-starch the plant).
- The branch is provided with carbon dioxide and still has its chlorophyll, but it is not given water.
- The other has carbon dioxide water and chlorophyll.
- Once the other plant is taken out the dark room and de starched they are subjected to 6 hours of artificial light or alternatively sunlight.
- This means that the plants is deprived from light
- Then the starch test is carried out
- The results are observed and recorded.

Starch test

Apparatus required during the experiment

- Boiling H_2O in a beaker
- Beaker
- Ethanol (alcohol)
- Test tube
- Heatproof mat
- Tripod
- Iodine
- Bunsen burner

This starch test shows us that if the plant contained starch or not. The process of the starch test is shown below:



Results

The branch that did not receive any water did not have any starch present in it, the other plant that had received water had signs of starch present in it. This is concluded that water is necessary for photosynthesis to take place.

Conclusion

The prediction that I had stated earlier was correct. The branch that did not receive any water did not show signs of starch. But the plant that had received water did show signs of starch present in it.

Evaluation

The experiment was first conducted with two normal plants. One plant was not supplied with water and was not in soil. This is proved that it was in effective. Little starch was present in the plant without water. I think that my prediction may have been incorrect. Although this result was not satisfactory, one of the plants had their roots removed and then there were no signs of starch so it can be concluded that the plant may have obtained water form the water vapour in the air.

Factors that effect the rate of photosynthesis.
Temperature experiment

Aim

My aim in this part of the coursework is to answer the following questions. Does temperature affect the rate of photosynthesis?

Prediction

In this experiment I predict that the temperature will affect the arte of photosynthesis in a plant. Nevertheless I don not think that my prediction is very correct, as it is also believed that photosynthesis has a complete limit.

Hypothesis

It can be said that the temperature affects the rate of photosynthesis, but this is also a limiting factor. It seems that the more the temperature the rate of photosynthesis will increase most probably. But then if the temperature will be increasing and never decreasing the rate of photosynthesis will always increase, this is incorrect as there is never a continuous increase of temperature or rate of photosynthesis.
It is already known that photosynthesis has a limit. The most common three limiting factors are:

- Light intensity
- Carbon dioxide
- And temperature

For example if a plant is given full light intensity and carbon dioxide then the rate of photosynthesis will speed up, but if only the temperature is not kept at a considerable rate then the whole rate of photosynthesis will be limited.

Planning

Apparatus required during the experiment

- Pond weed
- Water bath
- Test tube
- Ruler
- Thermometer
- Plasticine
- $KHCO_3$
- Light source

The following formula was used to calculate the rate of photosynthesis:

Rate of photosynthesis = Number of bubbles/ time in which bubbles were counted.

The apparatus was set as shown below:

Method

- The water is heated at the temperature that is inside the test tube is kept at 35^0c.
- As soon as the first bubble appears the counting begins.
- The numbers of bubbles produced every 5 minutes are recorded.
- The same steps are taken into deliberation, but this time the temperatures rise till 54^0c.

Results

The following table shows the three trails and the average number of bubbles that were recorded during the experiment:

Temperature (^{0}c)	Trial 1 (number of bubbles)	Trial 2	Trial 3	Average
35	238	240	242	240
37	402	394	398	398
40	480	479	481	480
43	540	541	539	540
53	-	-	-	-

Using the formula mentioned above, I found out the rate of photosynthesis, which was much easier to plot on graph paper:

Temperature (^{0}c)	Rate of photosynthesis (Bubbles/Sec)
35	4
37	6.633
40	8
43	9
53	-

Graphs

The tables above have been plotted on the graphs on the next few pages:

Conclusion

The prediction I had made was correct. As the temperature increased the rate of photosynthesis increased as well. But as I had mentioned that it has a limit, I did nto seem to come across a limit.

Evaluation

Counting bubbles was an indirect method of measuring the rate of photosynthesis. The following points show why the experiment was not so accurate:

- The pressure within the water may have affected the emission of bubbles.
- The size of the leaf may have affected readings due to the number of stomata pores.
- The bubbles did not have a fixed size. The sizes were variable.
- The pondweed was contained in a microenvironment; the test tube may have affected the emission of bubbles.
- The Elodea had many branches; their branches may have trapped oxygen bubbles beneath them.
- Some of the bubbles were expected to have merged together. Therefore there were not a large number of bubbles.
- $KHCO_3$ was added at the beginning of the experiment and was not changed at all. $KHCO_3$ affected the first few results but may not have had the same effect upon the last result because it had been used up.