Factors affecting the rate of photosynthesis

http://www.passmyexams.co.uk/GCSE/biology/factors-affecting-rate-of-photosynthesis.html

The term rate always involves time, so the rate of photosynthesis can be considered to be how fast photosynthesis takes place. This can be measured by the amount of glucose produced by a plant over a given time. This topic is especially important to scientist and farmers. By understanding the factors that affect the rate of photosynthesis they can do work to try and increase the rate of photosynthesis to increase the yield of a crop.

The three main things affecting the rate of photosynthesis are:

1. **Light**
2. **Temperature**
3. **Carbon dioxide**

These three factors are called **LIMITING FACTORS**.

In a process like photosynthesis which is affected by more than one factor, its rate is limited by the factor which is closest to its minimum value. So at any point in time if one of the three factors is in low supply, this factor will be the **limiting factor**. Only a change to the limiting factor will increase or decrease the rate of photosynthesis. Changing the other two will have no effect.

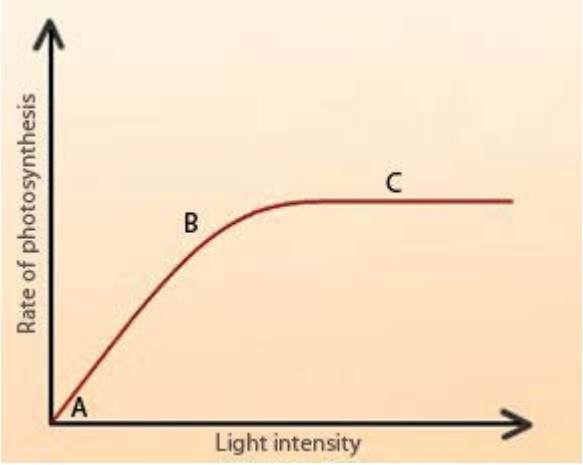
In addition to the three main factors above are other factors such as chlorophyll concentration, water and pollution. Only the three main factors identified above will be considered in further detail.

1. Light

The rate of photosynthesis increases when light gets brighter.

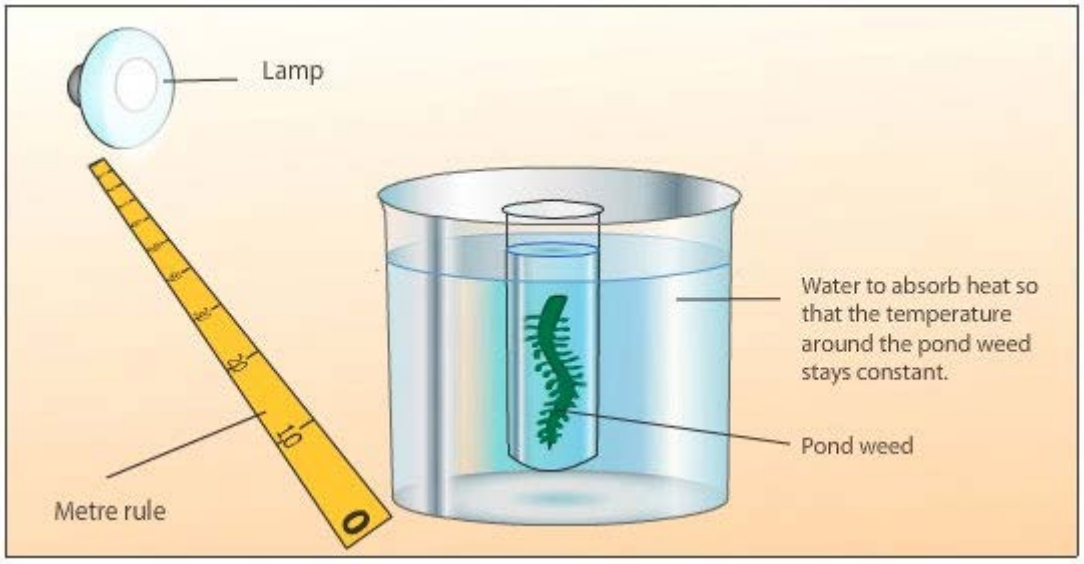
The rate of photosynthesis increases linearly with increasing light intensity (from point A to B on the graph).

Gradually the rate falls of and at a certain light intensity the rate of photosynthesis stay constant (from point B to C on the graph). Here a rise in light intensity has no affect on the rate of photosynthesis as the other factors such as temperature and carbon dioxide become limiting.

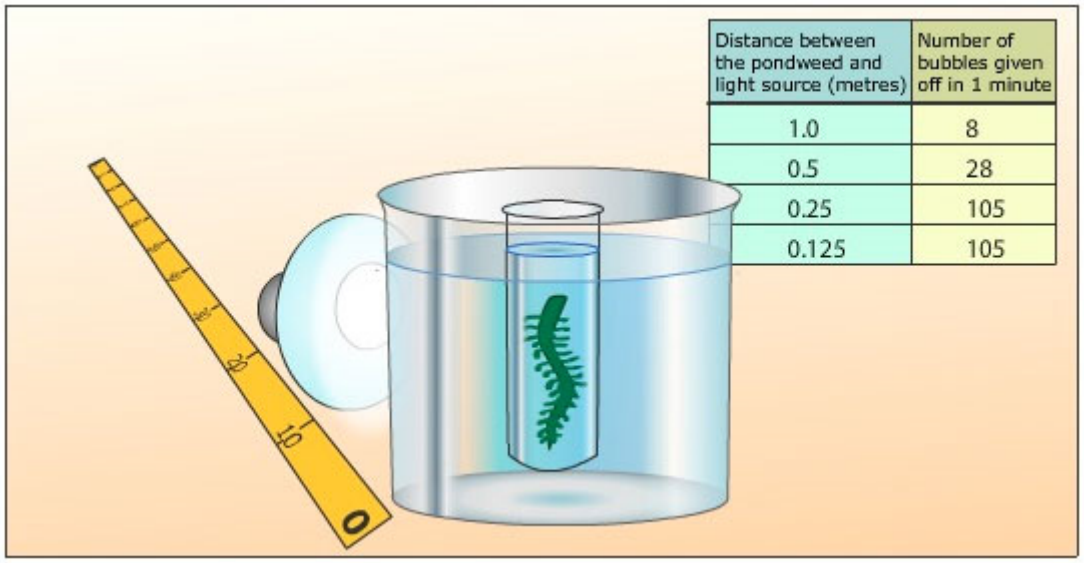


Many plants spread out their leaves in such a way that each leaf maximises the amount of light falling on them and the lower leaves are not shaded by the ones above. Too much light at a high intensity can damage chloroplasts. Some woodland plants photosynthesize more efficiently in dim light and are so called shade plants.

The animation below describes an experiment to investigate the effects of light on photosynthesis.



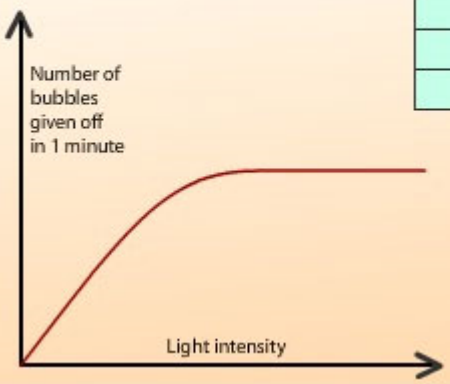
The effect of light on photosynthesis can be investigated using the experimental setup shown. A water plant such as Elodea pond weed or Cabomba pond weed is placed upside in a test tube containing water. The pond weed is weighted down with a paperclip to ensure it remains fixed in position. The test tube is placed in a beaker containing water. This so the large volume of water in the beaker maintains a constant temperature around the pond weed. The light source is provided by a lamp and light intensity is measured by the distance of the lamp in relation to the pond weed.



Distance between the pondweed and light source (metres)	Number of bubbles given off in 1 minute
1.0	8
0.5	28
0.25	105
0.125	105

With light present the pond weed undertakes photosynthesis and gives of oxygen gas which can be seen as bubbles. By counting the number of bubbles given of in a fixed time period for e.g one minute the rate of photosynthesis can be determined. At the start of the experiment the lamp is positioned 1m from the pond weed and the number of gas bubbles produced is recorded. The lamp is then brought closer to the pond weed and the respective distance and number of bubbles recorded.

Distance between the pondweed and light source (metres)	100W bulb light intensity = Power/Area light intensity W/m² = 100W/4πr²	Number of bubbles given off in 1 minute
1.0	7.96	8
0.5	31.85	28
0.25	127.39	105
0.125	510.20	105



The light intensity for the lamp can be calculated using the formula:

Light Intensity = Power/Area

In this experiment a 100 Watt bulb was used. As the bulb emits light in all direction we use the area of a sphere with the radius being the distance from the pond weed. The number of bubbles given off in a minute is taken as the rate of photosynthesis and plotted against the calculated light intensity. From the graph it can be seen that the rate of photosynthesis increase with light intensity to a point until the other factors such as carbon dioxide and temperature become the limiting factors.

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2. Temperature

The higher the temperature then typically the greater the rate of photosynthesis, photosynthesis is a chemical reaction and the rate of most chemical reactions increases with temperature. However, for photosynthesis at temperatures above 40°C the rate slows down. This is because the enzymes involved in the chemical reactions of photosynthesis are temperature sensitive and destroyed at higher temperatures.

To better understand the effects of temperature on photosynthesis it is important to know the effect of temperature on the enzymes involved in photosynthesis. Enzymes are affected a great deal by temperature. If the temperature is too cold the enzymes move around too slowly to meet the substrate and for a reaction to occur.As the temperature increases though, so does the rate of reaction. This is because heat energy causes more colli sions between the enzyme and the substrate. However as you will remember all enzymes are proteins and at too high temperatures the proteins break down. The active site of the enzyme becomes distorted and so the substrate no longer fits and hence the reaction does not occur. We say that the enzyme has been **denatured**.

Greenhouses are used to capitalise on the effects of higher temperatures increasing the rate of photosynthesis. Plants from regions of warmer climates can successfully grow in colder regions by using greenhouses.

The rate of photosynthesis does not increase with higher temperatures for all plants. Plants which grow in colder climates have an optimum rate of photosynthesis at low temperatures. Therefore different types of plants have optimum temperatures for photosynthesis.

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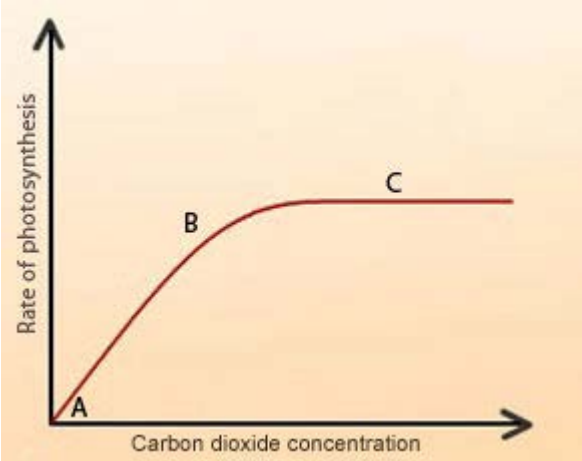
3. Carbon Dioxide

Carbon dioxide is used to make sugar in the photosynthesis reaction. The concentration of carbon dioxide in the Earth's atmosphere varies between 0.03% and 0.04%. An increase in the concentration of carbon dioxide gives an increase in the rate of photosynthesis. It is difficult to do this out in the open air but is possible in a greenhouse.

The rate of photosynthesis increases linearly with increasing carbon dioxide concentration (from point A to B on the graph).

Gradually the rate falls of and at a certain carbon dioxide concentration the rate of photosynthesis stays constant (from point B to C on the graph). Here a rise in carbon dioxide levels has no affect on the rate of photosynthesis as the other factors such as light intensity become limiting.



Many crops such as tomatoes and lettuce give higher yield when grown in greenhouses. Farmers add additional carbon dioxide into the greenhouse to increase the concentration and so the rate of photosynthesis of the crops. The additional cost of the carbon dioxide is worthwhile because of the increased yield.

Some companies have used this to great environmental use. Rather than pump waste carbon dioxide into the atmosphere as a pollutant they redirect it into big greenhouses where plants such as tomatoes use it during photosynthesis. This not only reduces their carbon footprint but gives an additional profitable product.