AQA Biology GCSE

Topic 4: Bioenergetics

Notes

Content in bold is for higher tier only.
Content is for both separate science and double award students unless indicated in heading.

Photosynthesis (4.1)

Photosynthetic Reaction (4.1.1)

Photosynthesis is the process by which plants make glucose from sunlight. It is an **endothermic reaction** in which energy is transferred from the environment to the chloroplasts by light.

The equation for photosynthesis is:

$$\text{carbon dioxide + water} \xrightarrow{\text{light}} \text{glucose + oxygen}$$

Each compound has its own chemical symbol:
Carbon dioxide: CO_2
Water: H_2O
Oxygen: O_2
Glucose: $C_6H_{12}O_6$

Rate of Photosynthesis (4.2.1)

The rate of the process is affected by a number of factors.

Factor	Effect
Temperature	With an increase in temperature, the rate of photosynthesis increases. As the reaction is controlled by **enzymes**, this trend continues up to a certain temperature until the enzymes begin to **denature** and the rate of reaction decreases.
Light Intensity	For most plants, the higher the light intensity, the faster the rate of the reaction.
Carbon dioxide concentration	Carbon dioxide is also needed to make glucose (see equation). As the concentration of carbon dioxide increases, the rate of reaction increases.
Amount of **chlorophyll**	Chlorophyll is a pigment in the leaf that converts light energy to food for the plant, and is therefore essential. If, for example, chlorophyll levels are reduced through a magnesium deficiency, then the rate of photosynthesis would decrease.

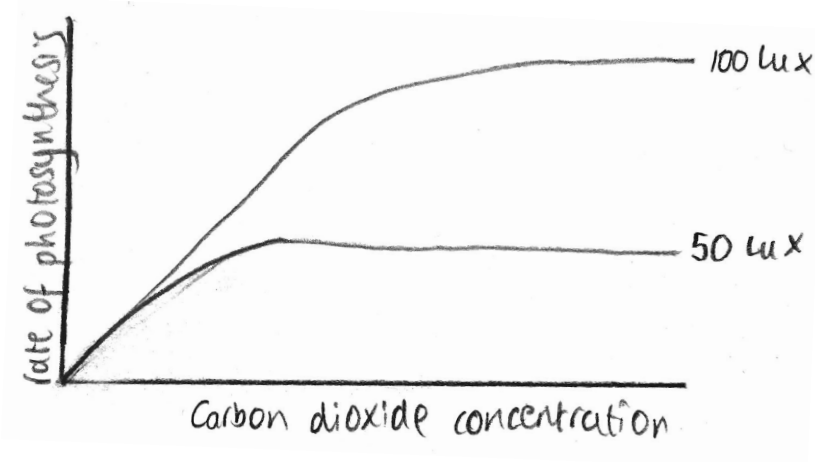
By carrying out an experiment measuring the **oxygen production** of a plant, you can calculate the rate of photosynthesis.

- Pondweed is placed in a test tube full with water. The top is sealed with a bung. A **capillary tube** also containing water leads into the test tube, and it is attached to a syringe.
- A lamp is placed at a measured distance from the test tube.
- As it photosynthesises, oxygen is produced, forming a gas tube in the capillary tube
- The distance the bubble has moved is measured using a ruler to calculate the volume of oxygen produced.
- Many variables can be changed to observe their effect on photosynthesis: the temperature (using a **water bath**), time the pondweed is left, the light intensity (varied by the distance the lamp is from the plant).
- It is important to control all factors that may affect photosynthesis except your **independent variable** (the one you want to observe), so it is a valid experiment.

Any of the factors above may become a limiting factor. This is an environmental condition (such as light intensity) which, in low levels, restricts any increase in the rate of photosynthesis. Despite increases in other factors (such as temperature or carbon dioxide concentration), the rate of photosynthesis will not increase any more. This can be seen on a graph as the curve levelling off.

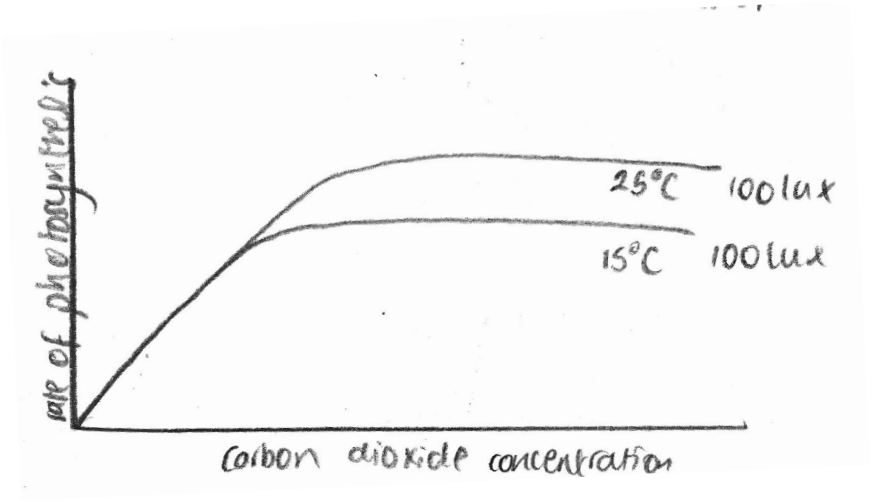
- **A graph involves one limiting factor if it has one line which levels off, with the factor on the horizontal axis and rate of photosynthesis on the vertical axis.**

- **A graph with two lines represents two limiting factors in two experiments. The investigation involves increasing the factor on the horizontal axis, and is carried out at two different other environmental conditions, such as two different temperatures.**



Light intensity is measured in lux and in this graph we can see that the limiting factor is light intensity. This is because the 50 lux levels limits the rate of photosynthesis compared to the 100 lux experiment, showing that at 50 lux light intensity was the limiting factor - it had the potential to increase the rate of photosynthesis further if it were increased.

- **A graph involves three limiting factors is similar to the one above, but another factor is stated on each line, which is the same in each**



The limiting factor is temperature as light intensity is the same in each and carbon dioxide is increasing.

Farmers can use the knowledge of limiting factors to enhance the conditions in the greenhouse for a greater rate of photosynthesis. This will increase growth leading to increased profits.

Inverse proportion describes a relationship between two factors which involves one increasing whilst one decreasing. As the distance between the light source and the plant increases, the light intensity decreases. The light intensity is inversely proportional to the square of the distance- called the inverse square law.
Light intensity $\propto 1/\text{distance}^2$

This means that if a lamp is 2 metres away from a plant, then the light intensity of the lamp is a ¼ of its original value.

$1/2^2 = ¼$

Uses of Glucose From Photosynthesis (4.1.3)

1. For respiration
2. Converted into insoluble **starch** for storage (in roots, stems and leaves)

3. To produce fat or oil for storage (in seeds)
4. To produce cellulose to strengthen cell walls
5. Combined with nitrates (absorbed from the soil) to form amino acids which produce proteins

Respiration (4.2)

Aerobic and Anaerobic Respiration (4.2.1)

Respiration occurs in every cell in the body, and it is the process of transferring energy from glucose so living processes can occur. All living things undergo respiration.

- It is **exothermic** as energy is transferred to the environment
- It can take place **aerobically** (with oxygen) or **anaerobically** (without oxygen)

Aerobic respiration	Anaerobic respiration
This uses oxygen. It yields the most energy. Most of the reactions that make up aerobic respiration occur in the mitochondria. **$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$** **$C_6H_{12}O_6$ = glucose** **O_2 = oxygen** **CO_2 = carbon dioide** **H_2O = water**	Occurs when there is not enough oxygen. It does not yield as much energy as aerobic respiration. It is only used as a last resort, for example during a sprint where it is difficult to breathe in enough oxygen. The oxidation of glucose is complete. In animals: **Glucose ($C_6H_{12}O_6$) ---> Lactic acid** In plant and yeast cells it is called fermentation): **Glucose ($C_6H_{12}O_6$) ---> Ethanol + Carbon dioxide (CO_2)** This reaction is used to make bread and alcoholic drinks.

Response to Exercise (4.2.2)

During exercise, more energy is needed in order for the muscles to contract. This means respiration has to occur faster, and therefore more oxygen needs to be supplied to cells (and more CO_2 removed). This is done by:

- Heart rate increasing
- Breathing rate increasing
- Breath volume increasing

If there is not enough oxygen being supplied (for example when you undertake vigorous exercise) anaerobic respiration takes place instead. As lactic acid is a byproduct of this reaction, it builds up creating an oxygen debt (as oxygen is needed to break lactic acid down). **Oxygen debt is the amount of extra oxygen the body needs after exercise to react with the accumulated lactic acid and remove it from the cells.** This results in the muscles tiring and not contracting properly.
Blood flowing through the muscles transports the lactic acid to the liver where it is converted back to glucose.

Metabolism (4.2.3)

Metabolism is the sum of all the reactions in a cell or the body. The energy transferred in the cells by respiration is used in the processes of metabolism to make new molecules. These processes are controlled by enzymes.

Examples of metabolic reactions:

1. Glucose molecules being converted to starch, glycogen and cellulose by being joined together
2. A glycerol molecule and three molecules of fatty acids forming a lipid molecule
3. Glucose and nitrate ions forming amino acids, which are used to form proteins
4. The reactions in respiration
5. Urea forming from the breakdown of proteins for excretion