AQA 4.4 Bioenergetics – Photosynthesis Journey of Knowledge

Context and Introduction to Unit

In this section we will explore how plants harness the Sun's energy in photosynthesis in order to make food. This process liberates oxygen which has built up over millions of years in the Earth's atmosphere. Both animals and plants use this oxygen to oxidise food in a process called aerobic respiration which transfers the energy that the organism needs to perform its functions. Conversely, anaerobic respiration does not require oxygen to transfer energy. During vigorous exercise the human body is unable to supply the cells with sufficient oxygen and it switches to anaerobic respiration. This process will supply energy but also causes the build-up of lactic acid in muscles which causes fatigue.

Prior knowledge

KS3 - Pupils learn the equation for photosynthesis and the key components of plants. This is further built upon in Year 10 – Organisation unit, then followed by Bioenergetics.

CORE KNOWLEDGE

4.4.1.1 Photosynthetic reaction

Photosynthesis is represented by the equation: carbon dioxide + water ⟶ glucose + oxygen

Students should recognise the chemical symbols: CO2 , H2 O, O2 and C6 H12O6 .

Photosynthesis as an endothermic reaction in which energy is transferred from the environment to the chloroplasts by light.

4.4.1.2 Rate of photosynthesis

The limiting factors for photosynthesis are: temperature, light intensity, carbon dioxide concentration, and the amount of chlorophyll on the rate of photosynthesis.

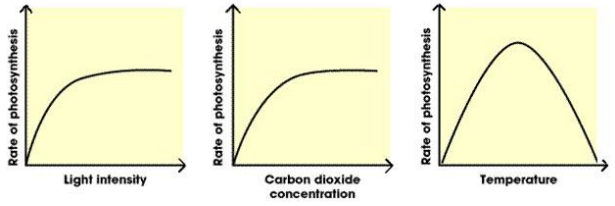
Temperature affects photosynthesis due to enzymes. Eventually an increase in light and carbon dioxide will plateau due to other limiting factors.

Required practical activity 6: investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.

In aquatic plants such as pondweed, the rate of photosynthesis can be measured by counting oxygen bubbles or collecting oxygen produced.

Independent variable: light intensity (distance of lamp from pondweed). **Dependent variable:** rate of photosynthesis (measured as number of bubbles/volume of gas per minute). **Control variables:** temperature, CO_2 concentration, pondweed species/size, time allowed for measurement.

- Place pondweed (e.g. *Elodea*) in a beaker of water.
- Cut the end cleanly to allow gas to escape.
- Place a light source at a set distance from the pondweed.
- Allow the plant to acclimatise.
- Count the number of bubbles released in a set time OR measure the volume of gas collected.
- Repeat at different distances (changing light intensity).



Keep variables constant: same pondweed length, same temperature (possibly by using a water bath), same CO_2 concentration (e.g. by adding sodium hydrogen carbonate), same wavelength of light.

(HT only) These factors interact and any one of them may be the factor that limits photosynthesis.

(HT only) Students should be able to explain graphs of photosynthesis rate involving two or three factors and decide which is the limiting factor

(HT only) Students should understand and use inverse proportion – the inverse square law and light intensity in the context of photosynthesis. (HT only) Limiting factors are important in the economics of enhancing the conditions in greenhouses to gain the maximum rate of photosynthesis while still maintaining profit.

4.4.1.3 Uses of glucose from photosynthesis

The glucose produced in photosynthesis may be: • used for respiration • converted into insoluble starch for storage • used to produce fat or oil for storage • used to produce cellulose, which strengthens the cell wall • used to produce amino acids for protein synthesis. To produce proteins, plants also use nitrate ions that are absorbed from the soil.

DISCIPLINARY KNOWLEDGE

(HT only) WS 1.4 Use data to relate limiting factors to the cost effectiveness of adding heat, light or carbon dioxide to greenhouses.

Required practical activity 6: investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed

AT 8 Tests to identify starch, glucose and proteins using simple qualitative reagents

VOCABULARY

Photosynthesis
Palisade Mesophyll
Chloroplasts
Chlorophyll
Limiting factors
Nitrates
Magnesium

READING IS POWER

Uses of glucose reading activity – Cornell note taking

WHERE NEXT?

This is a core Biology reaction which underpins all future units.

AQA 4.4 Bioenergetics– Respiration Journey of Knowledge

Context and Introduction to Unit
In this section we will explore how plants harness the Sun's energy in photosynthesis in order to make food. This process liberates oxygen which has built up over millions of years in the Earth's atmosphere. Both animals and plants use this oxygen to oxidise food in a process called aerobic respiration which transfers the energy that the organism needs to perform its functions. Conversely, anaerobic respiration does not require oxygen to transfer energy. During vigorous exercise the human body is unable to supply the cells with sufficient oxygen and it switches to anaerobic respiration. This process will supply energy but also causes the build-up of lactic acid in muscles which causes fatigue.

Prior knowledge
KS3 - Pupils learn the equation for respiration. This is further built upon in Year 10 – Organisation unit, then followed by Bioenergetics.

CORE KNOWLEDGE

4.4.2.1 Aerobic and anaerobic respiration
The energy transferred supplies all the energy needed for living processes. Respiration in cells can take place aerobically (using oxygen) or anaerobically (without oxygen), to transfer energy. Compare the processes of aerobic and anaerobic respiration with regard to the need for oxygen, the differing products and the relative amounts of energy transferred. Organisms need energy for: • chemical reactions to build larger molecules • movement • keeping warm.
Aerobic respiration is represented by the equation:

Glucose	+	oxygen	→	carbon dioxide	+	water
$C_6H_{12}O_6$		$6O_2$		$6CO_2$		$6H_2O$.

Anaerobic respiration in muscles is represented by the equation:
glucose → lactic acid.
As the oxidation of glucose is incomplete in anaerobic respiration much less energy is transferred than in aerobic respiration.
Anaerobic respiration in plant and yeast cells is represented by the equation:
glucose → ethanol + carbon dioxide
Anaerobic respiration in yeast cells is called fermentation and has economic importance in the manufacture of bread and alcoholic drinks.

4.4.2.2 Response to exercise
During exercise the human body reacts to the increased demand for energy. The heart rate, breathing rate and breath volume increase during exercise to supply the muscles with more oxygenated blood. If insufficient oxygen is supplied anaerobic respiration takes place in muscles. The incomplete oxidation of glucose causes a build up of lactic acid and creates an oxygen debt. During long periods of vigorous activity muscles become fatigued and stop contracting efficiently.
(HT only) Blood flowing through the muscles transports the lactic acid to the liver where it is converted back into glucose. 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.

4.4.2.3 Metabolism
Metabolism is the sum of all the reactions in a cell or the body. The energy transferred by respiration in cells is used by the organism for the continual enzyme controlled processes of metabolism that synthesise new molecules. Metabolism includes: • conversion of glucose to starch, glycogen and cellulose • the formation of lipid molecules from a molecule of glycerol and three molecules of fatty acids • the use of glucose and nitrate ions to form amino acids which in turn are used to synthesise proteins • respiration • breakdown of excess proteins to form urea for excretion. All of these aspects are covered in more detail in the relevant specification section but are linked together here.

DISCIPLINARY KNOWLEDGE
AT 1, 3, 4 Investigations into the effect of exercise on the body.

VOCABULARY
Aerobic respiration
Anaerobic respiration
Lactic acid
Fatigue
Metabolism
Oxygen debt.

READING IS POWER

Reading activity for metabolism – Cornell note taking opportunity.

WHERE NEXT?
This is a core Biology reaction which underpins all future units.