B4 Bioenergetics

What's the science story?

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.

Previous knowledge:

KS3

Year 7 – Organisation

Year 9 – Photosynthesis and respiration

KS4

B1 Cell biology

B2 Organisation

Next steps…

KS4

B7 Ecology

Keywords

Reactants	Amino acid	Incomplete
Products	Cellulose	Yeast
Carbon dioxide	Starch	Fermentation
Oxygen	Respiration	Heart rate
Chloroplasts	Aerobic	Breathing rate
Chlorophyll	Anaerobic	Oxygen debt
Sunlight	Muscle	Fatty acids
Temperature	Lactic acid	Glycerol

Working scientifically skills:

WS3: Making a prediction

WS8: Writing a method

WS9: Identifying variables

WS10: Selecting equipment

WS11: Hazards and precautions

WS14: Drawing graphs and interpreting graphs

WS16: Using equations

Assessments:

End of unit test (summative) (Out of 30)

Exit tickets x 2/3 (formative)

- **ET Photosynthesis**
- **ET Respiration**

AQA GCSE Combined Science Trilogy (8464)

Lesson No. and Title	Learning objectives	AQA Specification	Practical equipment
1. Photosynthesis	4 -To describe the process of photosynthesis and state the word equation. 6 -To identify the reactants and products of photosynthesis.	Photosynthesis is represented by the equation: carbon dioxide + water $\xrightarrow{\text{light}}$ glucose + oxygen Students should recognise the chemical symbols: CO_2, H_2O, O_2 and $C_6H_{12}O_6$. Students should be able to describe photosynthesis as an endothermic reaction in which energy is transferred from the environment to the chloroplasts by light.	
2. RP - Rate of photosynthesis	4 – To identify the variables from a required practical. 6 – To plan a scientific investigation into the rate of photosynthesis. 8 – To evaluate the investigation and identify the cause of errors.	Students should be able to explain the effects of temperature, light intensity, carbon dioxide concentration, and the amount of chlorophyll on the rate of photosynthesis. Students should be able to: • measure and calculate rates of photosynthesis • extract and interpret graphs of photosynthesis rate involving one limiting factor • plot and draw appropriate graphs selecting appropriate scale for axes • translate information between graphical and numeric form. **Required practical activity 5:** investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.	
3. Photosynthesis – Collecting data	4 – To identify the variables from a required practical. 6 – To plan a scientific investigation into the rate of photosynthesis. 8 – To evaluate the investigation and identify the cause of errors.		REQ PRAC: photosynthesis Pond weed, lamp, metre sticks, large beakers, stop watches

4. Limiting factors	4 – To describe the graphs for the different limiting factors on the rate of photosynthesis. 6 – To understand and use the inverse proportion relationship for light intensity and distance. 8 – To calculate gradients of graphs.	Students should be able to: • measure and calculate rates of photosynthesis • extract and interpret graphs of photosynthesis rate involving one limiting factor • plot and draw appropriate graphs selecting appropriate scale for axes • translate information between graphical and numeric form. (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.	
5. Uses of glucose	4 – To recall how glucose is made in leaves. 6 – To state the uses of glucose as a result of photosynthesis. 8 – To investigate how leaves can be tested for starch.	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.	

6. Aerobic respiration	4 – To define aerobic respiration. 6 – To describe what happens during aerobic respiration. 8 – To construct a word/symbol equation to represent aerobic respiration.	Students should be able to describe cellular respiration as an exothermic reaction which is continuously occurring in living cells. 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. Students should be able to 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 Students should recognise the chemical symbols: $C_6H_{12}O_6$, O_2, CO_2 and H_2O.	PRAC: Investigating yeast Conical flasks, yeast, balloons, measuring cylinders, stop watches
7. Anaerobic respiration	4 – To define anaerobic respiration. 6 – To explain what happens during anaerobic respiration. 8 – To compare aerobic and anaerobic respiration.	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.	PRAC: Anaerobic respiration Stop watch, pegs

8. Response to exercise	4 – To state the changes that occur in the body during exercise. 6 – To explain the concept of oxygen debt and how this impacts upon exercise HT – To explain how lactic acid is removed from the body.	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.	
9. Metabolism	4 – To recall the uses for simple nutrients within the body. 6 – To explain the metabolic reactions that occur in plants and animals.	Students should be able to explain the importance of sugars, amino acids, fatty acids and glycerol in the synthesis and breakdown of carbohydrates, proteins and lipids. 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.	