# Scheme of work

Combined Science: Trilogy

## Biology - Bioenergetics

This resource provides guidance for teaching the Bioenergetics topic from our new GCSE in Combined Science; Trilogy (Biology) 8464. It has been updated from the draft version to reflect the changes made in the accredited specification.

There are some changes to the wording of the required practical in section 4.4.1.2, In addition some minor changes have been made to the specification in sections 4.4.1.2 Rate of photosynthesis, 4.4.2.2 Response to exercise and 4.4.2.3 Metabolism. These alterations have not required changes to the scheme of work.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 4.4 Bioenergetics

### 4.4.1 Photosynthesis

It would be sensible to teach the structure of a leaf (Section 4.2.3.1) when covering photosynthesis. Much of the rest of sections 4.2.3.1 (Plant tissues and organ) and 4.2.3.2 (Plant organ system) could also be taught here.

There are also links with Cell biology (4.1.1.2 Animal and plant cells and 4.1.3.1 Diffusion) and Ecology (4.7.2 Organisation of an ecosystem).

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop Scientific Communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment opportunities and resources**  *Reference to past questions that indicate success candidates should:* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.4.1.1 | Photosynthetic reaction  Word and symbol equation for photosynthesis. | Write the word and symbol equation for photosynthesis  Explain why photosynthesis is important for the survival of other organisms.  Investigate the need for light, carbon dioxide and chlorophyll to make glucose.  Explain why plants should be de-starched before photosynthesis experiments and describe how this is done.  Describe experiments to show that plants produce oxygen in the light. | 1 | Collective memory activity for students on leaf structure – self assess.  Recap food chains KS3 – draw simple food chains for suggested habitat on whiteboards.  Watch BBC video clip to recap how leaves are adapted for photosynthesis.  Discuss what plants need to survive and how plants are useful to other organisms in order to come up with the word equation for photosynthesis.  Set up experiments or demos. Test leaves in following lesson.  Set up a demo to show that plants produce oxygen. Observe results in following lesson.  Write word and symbol equations for photosynthesis – produce cards for equation and put into correct order.  Watch BBC video clip about Van Helmont’s experiment. | Put cards in order to create equation.  Set up experiments to show that light, carbon dioxide and chlorophyll are needed to make starch – follow up with testing a leaf for starch in later lesson. Consider controls.  Predict what will happen and why.  Consider how theories develop over time. | [Exampro user guide Powerpoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX)  [BBC Bitesize – Photosynthesis in plant leaves](http://www.bbc.co.uk/education/clips/zgnwmp3)  Cards  Photosynthesis experiment:   * geraniums * plants with variegated leaves * lamps * black paper and paper clips * bell jars * saturated KOH solution or soda lime.   Oxygen demonstration:   * Elodea/Cabomba * glass funnel * large beaker * test tube.   [BBC Bitesize - Van Helmont’s experiments on plant growth](http://www.bbc.co.uk/education/clips/zxhd2hv) |
| 4.4.1.1 | Photosynthetic reaction  Word and symbol equations | Test to see if a leaf contains starch.  Explain why the leaves are tested for starch and not for sugar.  Describe the test for oxygen.  Interpret results and relate to photosynthesis equation. | 1 | Test leaves for starch, putting the results for all the different experiments into a table.  Use a cut-out to put the steps for the test on a leaf in order, and match a reason for each step.  Observe demo set up previous lesson and test gas collected to see if it is oxygen.  Discuss how this could be used to measure the rate of photosynthesis.  Use computer simulation to investigate factors that affect the rate of photosynthesis. | Carry out the test and interpret the results.  Recall test for oxygen. Interpret results of test and relate to photosynthesis equation.  Amend the method to measure rate of photosynthesis.  Use a model to embed understanding of process. | Oxygen demonstration plants from previous lesson.  Leaf test:   * ethanol * boiling tubes * beakers * glass rods * tiles * iodine solution * heating apparatus * goggles.   Oxygen test: splints to test several tubes of the gas collected. |
| 4.4.1.2 | Rate of photosynthesis  The rate of photosynthesis may be limited by:   * low temperature * shortage of CO2 * shortage of light * shortage of chlorophyll. | State factors that can limit the rate of photosynthesis.  Interpret data showing how factors affect the rate of photosynthesis.  Required practical: plan a method. | 1 | Ask students to consider what would happen to a plant if we:   * put it in the fridge * removed CO2 * put it in a cupboard * took chlorophyll from the leaves.   Discuss how the rate of photosynthesis could be measured and consider different methods.  Required practical: plan a method. | Consider different methods of gathering evidence.  Required practical: plan a controlled investigation.  Interpret graphs and calculate the rate of photosynthesis. | Required practical – see *Practical Handbook*. |
| 4.4.1.2 | Required Practical: Photosynthesis  Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed. | Required practical: carry out an investigation, collect, present and analyse the results.  Calculate the rate using numerical information or graphs. | 1 | Required practical: ask students to identify various factors, select one to control, plan investigation to investigate its effect and explain the procedure and conclusion. | Required practical: carry out an investigation, collect, present and analyse the results. | Required practical – see *Practical Handbook*. |
| 4.4.1.2 | Limiting factors  Factors that can limit the rate of photosynthesis are called limiting factors.  Limiting factors are important economically in greenhouses. | Interpret graphs to decide which factor is limiting the rate.  Explain how conditions in greenhouses can be controlled to optimise the growth of plants.  Relate limiting factors to the cost effectiveness of adding heat, light or carbon dioxide to greenhouses,  Evaluate the benefits of artificially manipulating the environment in which plants are grown. | 1 | Interpret graphs and explain limiting factors.  Design a greenhouse to maintain optimum growth of plants on the moon. Explain all its design features.  Compare growth in different areas and relate to photosynthesis.  Past paper questions showing data, practice drawing graphs from given data eg QM94R5.09  Debate – are underground or vertical farms the answer to providing food in cities?  These are interesting approaches to space saving but how do we ensure the plants get everything they need? Students could design a farm of the future and peer assess. | Plot and interpret data about limiting factors.  Investigate growth of tomatoes in greenhouse, lab and outside.  Use sensors to measure oxygen, light, temperature and carbon dioxide levels. | Mini-greenhouse:   * plastic food containers * cress seeds for a faster turnaround.   Greenhouses:   * tomato plants * pots * compost * fertiliser * sensors * balance.   [The Telegraph – London’s first underground farm opens in WW2 air raid shelter](http://www.telegraph.co.uk/news/earth/agriculture/farming/11706406/Londons-first-underground-farm-opens-in-WW2-air-raid-shelter.html) |
| 4.4.1.3 | Use of glucose  Glucose produced in photosynthesis may be:   * used for respiration * converted into starch for storage * used to produce fats and oils for storage or cellulose to strengthen cell walls * used to produce amino acids for protein synthesis.   To produce proteins plants also use nitrate ions from the soil (links with 4.1.3.3). | List ways in which glucose is used by a plant.  Describe functions of fats, oils, cellulose, starch and proteins in a plant.  Explain how plants obtain nitrate ions and what they are needed for.  Interpret data from the results of bicarbonate indicator experiment. | 1 | Starter: Use TV show style game format and ask ‘How many daily products come from plants?’ See which team can name the most.  Observe exhibition of products (could be images).  Could be a Q&A treasure hunt – images around the room, eg: Which product is high in protein? Which product contains caffeine?  Discuss uses of glucose and produce a Mind map or poster.  Discussion idea: can a vegetarian diet provide all necessary nutrients? Link to chemical tests.  Produce diagrams to illustrate the flow of carbon dioxide and oxygen in and out of a plant in bright light, dim light and darkness.  Explain the link between photosynthesis and respiration using equations – use cards previously made for photosynthesis and rearrange to show respiration.  Relate production of chemicals in plants to food chains.  If not covered elsewhere investigate the effect of mineral ions on plant growth and write a report (based on results from few weeks later). Explain the purpose of the air tube and black paper around the containers. | View exhibition of plant products and suggest where they came from and what useful chemical they contain.  Carry out tests to show plants make glucose and store starch and protein.  Investigate the effect of plants and invertebrates on bicarbonate indicator solution in light and dark. Explain the results.  Carry out a controlled investigation using appropriate apparatus. Decide on suitable observations to evaluate the effect of ions on growth. | Exhibition of plant products:   * sugar * starchy food * protein rich food * plant oils * paper * cocoa * coffee * cotton * rubber * flour * nuts * drugs etc.   Glucose test:   * plant in light * Benedict’s solution * boiling tube * Bunsen burner.   Starch test:   * pieces of apple and potato * tiles * iodine solution.   Protein test:   * beans or nuts * biuret reagent * test tubes.   Bicarbonate indicator experiment:   * bicarbonate indicator solution * acid * alkali * straw * boiling tubes * bungs * black paper * Cabomba * small invertebrates * gauze * lamp.   Minerals test:   * tomato plants * pots * compost or grow cuttings in solutions with and without minerals (eg magnesium and nitrates) * black paper * gas jars or boiling tubes with air tube.   Past BL2 exam questions.  Animations, images and resources:  [SAPS Secondary Resources Homepage](http://www.saps.org.uk/secondary)  [S-cool, the revision website](http://www.s-cool.co.uk/)  Video clips:  [BBC Bitesize – Photosynthesis](http://www.bbc.co.uk/education/guides/zrmg87h/revision)  [BBC Bitesize – Fertilisers and farming](http://www.bbc.co.uk/education/guides/zsf82hv/revision)  AQA resources: [PowerPoint B2.3 Photosynthesis](http://filestore.aqa.org.uk/subjects/gcsescienceassessment/B2-3-PHOTOSYNTHESIS.PPT) |

### 4.4.2 Respiration

Links with 4.1.1.2 – mitochondria, and 4.5.3.7 – adrenaline.

Practical sheets available online – [Biology Experiments/Teaching and Learning Resources](http://www.biology-resources.com/biology-experiments2.html)

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| --- | --- | --- | --- | --- | --- | --- |
| 4.4.2.1 | Aerobic respiration  Respiration can take place aerobically or anaerobically to transfer energy.  Respiration is an exothermic reaction.  Organisms need energy for chemical reactions, movement and to keep warm.  During aerobic respiration glucose and oxygen react to release energy.  Word and symbol equation for aerobic respiration. | State that all animals and plants produce carbon dioxide and water all the time as a by-product of aerobic respiration.  Write the word equation for aerobic respiration.  Define the term ‘aerobic’.  Describe what organisms need energy for.  Describe tests for carbon dioxide and water.  State the site of aerobic respiration and be able to give examples of cells that contain a lot of mitochondria (links with 4.1.1.2). | 2 | Show energy drink, glucose tablets and a plant.  Discuss substance the body uses as a source of energy and what aerobic means in order to build up the word equation for aerobic respiration.  Demonstrate burning food is an exothermic reaction.  Watch BBC video clip about respiration.  Discuss how to show that humans transfer energy and produce water and carbon dioxide. Relate these observations to the word equation for aerobic respiration.  Recap that mitochondria in cells are the site of aerobic respiration (links to 4.1.1.2).  Discuss examples of cells that will contain many mitochondria. | Consider a bottle of Lucozade, glucose tablets and a plant.  Demonstrate the release of energy from food.  Investigate inhaled and exhaled air.  Demonstrate that animals and plants in the dark respire and release carbon dioxide.  Demonstrate that germinating peas/ seeds transfer energy as heat. Observe results in following lesson.  Observe EM images of mitochondria in different types of cells and make conclusions. | Discussion prompts for considering energy release:   * bottle of Lucozade * glucose tablets * plant.   Demonstration of release of energy:   * mounted needle or tongs * piece of food * boiling tube of water * thermometer.   Video clip:  [BBC Bitesize – Aerobic respiration](http://www.bbc.co.uk/education/clips/zdfs34j)  Exhaled air demonstration:   * carbon dioxide in inhaled and exhaled air apparatus * limewater * mirrors * cobalt chloride paper * thermometers.   Demonstrating evidence of respiration in an animal:   * two bell jars connected to two containers of limewater that air is passing through via tubes (first container is fitted with thistle funnel containing soda lime) * pump to draw air through system * small animal * plant * black paper.   Demonstrating energy transfers as heat:   * soaked peas/seeds * boiled and cooled peas * thermos flasks with temperature probes. |
| 4.4.2.1 | Anaerobic respiration  Anaerobic respiration is the incomplete oxidation of glucose so less energy is released than in aerobic respiration.  Word equation for anaerobic respiration in muscle cells.  Word and symbol equation for anaerobic respiration in some plant and yeast cells.  Anaerobic respiration in yeast cells is called fermentation and has economic importance in the manufacture of bread and alcoholic drinks. | Define the term ‘anaerobic’.  Explain why anaerobic respiration is less efficient than aerobic respiration.  Write the word equation for anaerobic respiration in animal cells.  Write the word and symbol equation for anaerobic respiration in yeast cells.  State that anaerobic respiration in yeast is called fermentation.  Explain why yeast is used to make bread and alcoholic drinks.  Interpret data from yeast investigation. | 1 | Anaerobic respiration in muscle cells – see section on exercise below.  Discuss different ways to measure the rate of respiration in yeast cells.  Interpret graphs on the rate of respiration in yeast cells.  Research how yeast is used to make bread, wine and beer. | Investigate the rate of respiration in yeast using carbon dioxide sensors and data loggers.  Investigate the effect of temperature on the rate of respiration in yeast.  How does temperature affect the amount bread dough rises? Make bread dough, place set amount in measuring beaker and observe. | Yeast demonstration:   * water baths * timer * flasks containing yeast and sugar solution * gas syringes.   [Nuffield Foundation – Microbes and bread making using yeast](http://www.nuffieldfoundation.org/practical-chemistry/microbes-and-bread-making-using-yeast) |
| 4.4.2.2 | Response to exercise  During exercise the heart and breathing rates increase and breath volume increases to supply oxygen to muscle cells faster.  Muscle cells can respire anaerobically if there is insufficient oxygen. This produces lactic acid and creates an oxygen debt.  Lactic acid can cause muscle fatigue. The cells stop contracting efficiently.  When exercise stops, the oxygen debt must be repaid by continuing to breathe deeply.  Blood transports lactic acid to the liver where it is converted back into glucose. The oxygen debt is the amount of oxygen needed to oxidise lactic acid. | Describe and explain the changes that occur in the body during exercise.  Design and carry out an investigation about the effects of exercise on the body.  Present and interpret data about heart rate, breathing rate and breath volume.  Interpret data relating to the effects of exercise on the body, eg spirometer tracings.  Describe the effects of long periods of vigorous exercise on the body.  Define the term ‘oxygen debt’.  Explain what happens to lactic acid once exercise stops. | 1 | Mini-practical: start jumps, jog on spot for 1 minute – what do you notice? Why have these changes happened?  Plan an investigation about the effects of exercise on the body.  Interpret line graphs and spirometer tracings to compare rate of breathing before, during and after exercise.  Use spirometer tracings to calculatebreathing rate and depth of breathing.  Interpret data on heart rate, temperature and depth of breathing during exercise.  Interpret data to compare how fit different people are.  Discuss causes and effects of muscle fatigue and relate these to lactic acid build up.  Watch a video showing sprinters and discuss how the body reacts at the end of the race – paying back the oxygen debt.  YouTube has a variety of videos of marathon runners struggling over the finish line – use them as a discussion starter eg:  [Fantastic Marathon finishes and the agony of the feet](https://www.youtube.com/watch?v=BwpNJSeNYqI)  or  [Extraordinary Human Beings in Slow Motion at the Twin Cities Marathon Finish Line](https://www.youtube.com/watch?v=GMlkeI9BhEc) | Investigate the effect of exercise on heart rate, breathing rate, depth of breathing and temperature.  Investigate effect of muscle fatigue on muscle strength and produce an article for a fitness magazine.  Investigate how long it takes muscles to fatigue – repetitive actions, eg step ups or holding masses at arm’s length.  Interpret spirometer traces.  Calculate breathing rate and depth of breathing.  Interpret data and draw conclusions. | [BBC Bitesize – Aerobic and anaerobic respiration](http://www.bbc.co.uk/education/guides/zm6rd2p/activity)  Timer, pulse sensor and spirometer if available.  Muscle strength meters.  Timers and masses.  AQA resources:  [PowerPoint B2.6 Aerobic and anaerobic respiration](http://filestore.aqa.org.uk/subjects/gcsescienceassessment/B2-6-AEROBIC-AND-ANAEROBIC-RESPIRATION.PPT) |
| 4.4.2.3 | Metabolism  Metabolism means all the chemical reactions happening in a living organism.  Metabolism includes:   * the conversion of glucose to starch, glycogen and cellulose * the formation of lipids * the formation of amino-acids and proteins * respiration * the breakdown of excess proteins to form urea for excretion. | Define the term ‘metabolism’.  Give examples of reactions in metabolism.  Name some chemicals formed from glucose molecules (links to 4.4.1.3).  Describe lipid formation from a molecule of glycerol and three molecules of fatty acids.  Describe the use of glucose and nitrate ions to form amino acids, which form proteins.  Describe the formation of urea. | 1 | Discuss what metabolism means and examples of the reactions that make up metabolism.  Produce a mind map or poster to summarise metabolism and its reactions.  Relate this metabolism to other parts of the specification. |  |  |