PROVISIONAL

DELIVERY GUIDE

Topic: Cell Level Systems

February 2015

GCSE (9–1)
Gateway Science Suite, Biology A

GCSE REFORM

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PROVISIONAL

This resource is an exemplar of the types of materials that will be provided to assist in the teaching of the new qualifications being developed for first teaching in 2016. It can be used to teach existing qualifications but may be updated in the future to reflect changes in the new qualifications. Please check the OCR website for updates and additional resources being released. We would welcome your feedback so please get in touch.

Introduction

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

KEY

Click to view associated resources within this document.

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Curriculum Content B1.1 Cell Structures

B1.1 Cell Structures
This section of the delivery guide focuses on use of microscopy to examine cells and sub-cellular structures.

A clear development of the practical skills required in both the use and interpretation of images from light microscopes is required from learners. This will require learners to be practically involved in activities that encourage the acquisition of these skills.

Learners are expected to know the main sub-cellular structures in eukaryotic and prokaryotic cells and understand how these relate to their functions within the cell. The learner should be able to locate such structures on cell diagrams and pictures. Learners should be able to explain how these structures help the cell perform any specialized function it may have.

With an understanding of the limitations of the light microscope, learners should be able to identify the use of the electron microscope as a method for observing structures that are beyond the limitations of a light microscope.

a) *describe how light microscopes and staining can be used to view cells to include: lenses, stage, lamp, use of slides and cover slips, and the use of stains to view colourless specimens or to highlight different structures/tissues and calculation of the magnification used.*

b) *explain how the main sub-cellular structures of eukaryotic cells (plants and animals) and prokaryotic cells are related to their functions to include: nucleus, genetic material, chromosomes, plasmids, mitochondria (contain enzymes for cellular respiration), chloroplasts (contain chlorophyll) and cell membranes (contain receptor molecules, provides a selective barrier to molecules).*

c) *explain how electron microscopy has increased our understanding of sub-cellular structures to include: increased resolution in TEM.*

Thinking Conceptually B1.1 Cell Structures

Approaches to teaching the content

Cells are the fundamental units of living organisms. Cells contain many sub-cellular structures that are essential for the functioning of the cell as a whole. Microscopy is used to examine cells and sub-cellular structures. This part of the delivery guide provides scope for developing the necessary practical skills involved in using the light microscope and should be seen as very much a 'hands-on' experience. These skills will also enable the mathematical learning outcomes like demonstrating an understanding of number, size and scale and the quantitative relationship between units to be developed.

Learners should be familiar with cells as the fundamental unit of living organisms, and with the use of light microscopes to view cells. They should also be familiar with some sub-cellular structures, and the similarities and differences between plant and animal cells.

Learners will develop skills in using light microscopes and use staining techniques to identify important cellular structures in animal and plant cells. Magnification calculations are included and these will allow learners to appreciate the size and scale of cells and sub-cellular structures, often a difficult concept to grasp. Using the microscopy skills developed, learners will develop an understanding of the main cellular differences between eukaryotic (plants and animals) and prokaryotic cells.

Common misconceptions or difficulties students may have

Learners are required to develop microscopy skills and this often poses challenges in that learners often lack the fine motor skills needed to focus on cellular structures. These can be encouraged and developed using virtual microscopes, of which there are a number of examples currently available on the market. The use of virtual microscopes would allow learners to develop skills and avoid the frustrations of being unable to focus on 'live' cellular structures. If the fine motor skills are developed the experience for learners when making stained slides of 'live' material will be more productive.

Learners commonly have difficulty understanding the concept of a cell as a 3D structure, so this should be addressed during the teaching of this topic. There are a number of approaches that can be used involving modelling the cell and its sub-structures such as making a 3D cell with a plastic bag, golf ball peas and water. The 3D nature of the cell can be shown, then placed on an OHT to project the image onto a whiteboard. On the 2D projection the image can then be drawn around on the board. These approaches can be both motivating and concept-developing for learners.

Thinking Conceptually B1.1 Cell Structures

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course.

The microscopy skills developed in this section of the delivery guide will be used in a number of other topics in the specification. Using a light microscope is a skill directly needed in several topics. These include observations of blood smears and the gross structure of blood vessels in animals as well as observing root hair cells and locating the position of xylem and phloem in plants.

The knowledge and understanding of sub-cellular structures will provide a precursor to the work on 'What happens in cells'. This involves looking at the structure and function of DNA and important cellular reactions controlled by enzymes such as respiration and photosynthesis. This is covered in the next section of this delivery guide.

Thinking Contextually B1.1 Cell Structures

Approaches to teaching the content

The topic lends itself to a wide range of practical activities both real and virtual. It is vital that learners are provided with practical opportunities to develop appropriate microscopy skills. Learners should have the opportunity to gain skills that will be used again in a number of areas of the specification. As skills are an important aspect of this section, there are a number of activities that could be set up to be used over a period of time in order to continue to develop skills (Activity 2 and Activity 5).

There are many activities that can be used as starters or plenaries (such as Activity 7) and these mini-activities can support engagement and assessment for learning. This is particularly important in a topic that can be seen as challenging, both in terms of practical and mathematical skills required in using light microscopes and interpretation of microscopic images. The use of Venn diagrams in Activity 8 can support an understanding of the similarities and differences between plant and animal cells and could be used in assessment situations.

Interactive software (such as Activity 6) can provide a useful vehicle to reinforce learning of cell sub-structures. Learners have a 3D visual representation of the sub-structures to support their learning and also it helps them to locate the size and positioning within the cell.

Activities B1.1 Cell Structures

Activities	Resources
Activity 1 **Virtual reality microscopy** Learners can engage in a skill development programme to enhance their use of microscopes when using them in real life situations. This can be productive in building confidence in using equipment and set-ups that can be quite daunting in reallife situations. It can ultimately save time and frustration when learners use actual light microscopes. Virtual Compound Light Microscope, University of Delaware, http://www.udel.edu/biology/ketcham/microscope/scope.html Interactive programme for the use of light microscopes. Virtual microscopes, school discovery, http://school.discoveryeducation.com/lessonplans/interact/vemwindow.html Interactive programme for the use of electron microscopes.	Click here Click here
Activity 2 **MICRODOT kit** http://www.timstar.co.uk/mi94128-microdot-kit.html This kit is designed to help students improve their skills and confidence in using microscopes, before moving on to mounted specimens/thin sections or live organisms. It consist of various images printed onto acetate slides. These can be placed under the microscope and provide a reliable, uniform image to focus on. There are a number of structures ranging from a single letter (e) to printed line images of a bacterium, fungus, protist and a virus. The kit also allows measurements to be taken and size of objects determined.	Click here

Activities B1.1 Cell Structures

Activities	Resources
Activity 3 **Looking at pictures, of light micrographs and diagrams of a range of cells.** Set up a display of pictures, light micrographs and diagrams of objects/cells/sub-cellular structures that can be seen by: - the naked eye - hand lens - light microscope low magnification (eg x100) medium magnification (eg x200) high magnification (eg x400) - electron microscope Arrange this display around the side of the room and space them out according to the correct position on a banner that has the measurement scale of: **Metre Centimetre Millimetre Micrometre Nanometre Picometre** This will familiarise students with the units of measurement required for different levels of magnification and support their understanding of scale. Students can observe the images and complete a table that identifies the structure, size and type of magnification device required to see the structure.	
Activity 4 **Calculating magnification of an image under a light microscope** **How to calculate magnification with examples** TES Teaching Resources http://www.tes.co.uk/ResourceDetail.aspx?storyCode=6008077 This site provides a worksheet with examples of how to use the equation to work out the actual size of an image when you know the magnification and actual size, or be able to work out the magnification if you know the image and actual size or the actual size when you know the image size and magnification.	Click here

Activities B1.1 Cell Structures

Activities	Resources
The video can be used to support this activity as either a starter or plenary activity: **How to calculate magnification** Elevate Education Ltd. http://www.youtube.com/watch?v=NFVSWOaU0f0 A video that outlines the relationship between units used to measure microscopic images.	Click here to see the clip
Activity 5 **Cell size and scale** University of Utah Health Sciences- Genetic Science Learning Center http://learn.genetics.utah.edu/content/cells/scale/ This interactive webpage allows students to move a slider from images that can be seen by the naked eye to those that require an electron microscope. It provides a grid with scaled measurements of various objects/cells/sub-cellular structures. The human eye can see objects down to approximately 100µm, e.g. a human egg cell. It is possible to detect some cells using a hand lens (eg snowberry berry cells *Symphoricarpos albus*, although care should be taken as these berries are toxic, causing vomiting, dizziness and slight sedation in children). To visualise smaller cells one needs to use a light microscope. A light microscope can be used to visualise most cells including larger bacteria, however it is not powerful enough to visualise viruses. Light microscopes can even resolve some internal cellular structures (eg nucleus, mitochondria and chloroplasts), but not the smaller organelles. The problem is caused by the wavelength and scattering of light used to visualise the sample. To see smaller objects one would need the magnification and resolving power of the electron microscope. These microscopes use a beam of electrons rather than light. Typically this electron beam is either directed through the object (transmission electron microscopes TEMs), or onto the surface of suitably prepared samples (scanning electron microscopes or SEMs). Although there are some specialist electron microscopes eg tunnelling electron microscopes that can even resolve molecules and atoms.	Click here
Activity 6 **Inside a cell** University of Utah Health Sciences- Genetic Science Learning Center http://learn.genetics.utah.edu/content/cells/insideacell/ This interactive software allows learners to track across a 3D diagram of an animal cell and focus in and click on the sub-cellular structures which then magnifies and animates the chosen structure providing information on its function. It also allows the learner to click and convert the image to a plant cell to see the additional features that a plant cell contains.	Click here

Activities B1.1 Cell Structures

Activities	Resources
Activity 7 **Cell structure: Rap/poem memory aid** TES Teaching Resources http://www.tes.co.uk/teaching-resource/Cell-Structure-Rap-Poem-Memory-Aid-3011184/ This is a Rap/Poem covering the main sub-structures of animal and plant cells. It could be used as a starter to recap prior learning or to provide a memory aid. An extension activity could be for students to consider writing their own rap memory aid.	Click here
Activity 8 **Plant and animal cells** TES Teaching Resources http://www.tes.co.uk/ResourceDetail.aspx?storyCode=6330798& This PowerPoint provides a suggested approach to delivering activities that encourage learning of the components and functions of plant and animal cells. It has assessment for learning activities that includes interactive diagram labelling, Venn diagram construction for overlap of plant/animal cell structures, true/false statements and extended writing.	Click here
Activity 9 **Understanding the structure and function of plant and animal cells.** Students need to be able to describe how to prepare microscope slides and also how to set up and use a microscope. This activity describes how to develop these skills. Care needs to be taken when using the slides and coverslips and also in obtaining the cheek cell swab, both of these would require a centre based risk assessment. The cheek cell slides need to be decontaminated after the practical and this is an opportunity to discuss good microbiological techniques. **Animal & plant cells** TES Teaching Resources http://www.tes.co.uk/teaching-resource/Animal-and-amp-Plant-Cells-6436606/ This site provides a PowerPoint resource that has starter and plenary activities to support this activity along with diagrams to guide students in how to obtain the best results from the slide preparations.	Click here

Activities B1.1 Cell Structures

Activities	Resources
Activity 10 **Making 3D models of cells** **Cell structure using sweets** TES Teaching Resources http://www.tes.co.uk/teaching-resource/CELL-STRUCTURE-using-sweets-6119744/ A brief description of how to make 3D models of cells using jelly and various types of sweets. There are several suggested alternatives for sweets that can be used for sub-cellular structures. **Build 3D models of animal and plant cells** WikiHow http://www.wikihow.com/Build-3D-Models-of-Animal-and-Plant-Cells This gives two alternative methods for making 3D model cells, either using jelly and sweets or by using craft resources.	Click here Click here
Activity 11 **Specialised cells in amazing african violets** African Violets *(Saintpaulia Spp.)* are excellent plants for investigating specialised cells. Students investigate a variety of specialised cells using light microscopy and see cytoplasmic streaming in trichomes. The link below includes further details on this investigation. **How to see some specialised cells on the leaves:** • Take thin slices from the underside of the leaf using a scalpel/razor blade. **Take care!** Extreme caution should be taken when using sharp instruments. • Mount on a microscope slide in a drop of water and add a cover slip. • Observe using the low magnification objective lens. Photos can be taken using a camera over the eye piece. Camera phones work particularly well for this activity. **Trichomes** The hairs are made of large cylindrical shaped cells. **Stomata and guard cells** Guard cells have no pink pigment unlike the cells around them. They stand out as white against the pink background.	

Activities B1.1 Cell Structures

Activities	Resources
Specialised cells in amazing african violets Science and Plants for Schools (SAPS). http://www.saps.org.uk/secondary/teaching-resources/784-microscopy-specialised-cells-in-african-violets Students can also observe a video showing movement of chloroplasts by cytoplasmic streaming in Elodea. **Microscopic world** http://www.youtube.com/watch?v=BB5rvjZzgFU Cytoplasmic streaming in Elodea can also be seen very well done practically, especially if there is the facility of projecting a microscope image. About 10-15 minutes after preparing a wet mount of an Elodea leaf, evaporation of some of the water makes it possible to see chloroplasts in motion inside of the cytoplasm.	Click here Click here to see the clip

Curriculum Content B1.2 What Happens in Cells (and What do Cells Need)?

B1.2 What happens in cells (and what do cells need)?

This section introduces the learners to the key molecules of life. They will be aware of the structure of DNA and how this structure codes for the production of proteins. They will also investigate the importance of enzymes, key protein molecules, which help control cellular reactions.

DNA and protein synthesis

a) *describe DNA as a polymer*

b) *describe DNA as being made up of two strands forming a double helix*

c) *describe that DNA is made from four different nucleotides; each nucleotide consisting of a common sugar and phosphate group with one of four different bases attached to the sugar, including:*
- *the pairs of complementary bases*

d) *recall a simple description of protein synthesis including:*
- *the unzipping of the DNA molecule containing the gene, copying to mRNA in nucleus (transcription), (translation) of the nucleotide sequence, in the cytoplasm*

e) *explain simply how the structure of DNA affects the proteins made in protein synthesis including:*
- *triplet code and its use to determine amino acid order in a protein*

Enzymes

f) *describe experiments that can be used to investigate enzymatic reactions*

g) *explain the mechanism of enzyme action including:*
- *the role of enzymes in metabolism, the role of the active site, enzyme specificity (lock and key hypothesis) and factors affecting the rate of enzyme controlled reactions (pH, temperature, substrate and enzyme concentration)*

Thinking Conceptually B1.2 What Happens in Cells (and What do Cells Need)?

Approaches to teaching the content:

Life processes depend on biological molecules whose structure is related to their function. Inside every cell is genetic material and this is used as a code to make proteins. Enzymes are important proteins in biology. Metabolic processes such as photosynthesis and respiration are controlled by enzymes. Organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life. Life on Earth is dependent on photosynthesis, in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen.

Underlying knowledge and understanding

Learners should have a simple understanding of the double helix model of DNA. Learners should be familiar with the idea of enzymes as biological catalysts.

Common misconceptions or difficulties students may have:

One misconception is that once synthesized on the ribosome, proteins remain in their folded state. Learners often believe that after a protein is released from the ribosomes, there are no further modifications that occur. We are not synthesising enzymes when we are in translation; we are using chains of amino acids to then go on and make proteins. Review the purpose and functions of proteins. Explain to learners that they are still able to undergo changes after being released from the ribosomes.

Learners commonly hold the misconception that all enzymes have an optimum temperature of 37°C (human body temperature). The range of optimum temperatures of enzymes should be introduced through the teaching of this topic and further addressed when considering homeostatic mechanisms for controlling temperature.

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course:

The understanding of the way in which biological molecules such as DNA and enzymes are made and behave is fundamental to many topics including 'Supplying the cell', 'Inheritance', 'Feeding the human race' and 'Monitoring and maintaining health'. These include cell division, describing how genetic variants may influence phenotype, genetic engineering and the detection of pathogens.

The knowledge and understanding of 'What happens in cells' builds on the work covered previously in Section B1.1 Cell structures sub-cellular structures. This topic involves looking at the structure and function of DNA and enzymes and links to important cellular reactions controlled by enzymes such as respiration (Section B1.3) and photosynthesis (Section B1.4).

Approaches to teaching the content

Continuing with the experimental nature of the topic as a whole, this section again provides a wide range of practical activities, both real and virtual. It is crucial that learners are provided with practical opportunities to develop appropriate skills but importantly this will encourage a deeper understanding of the complex aspects of the cellular reactions that are to be studied.

Activity 1 is a starter activity that allows for a quick check on prior learning. Provide learners with mini-whiteboards for them to write the answer to questions that have quick one word/number/ answers. There are many activities that can be used as starters or plenaries (such as 'bingo' seen in Activity 5 and 'chequerboard' in Activity 6) and these mini-activities can support both engagement and assessment for learning. The type of resource seen in Activity 6 can easily be adapted to serve as a vehicle for assessment for learning throughout the course. It could be adapted to show pictures of important structures/ concepts substituted behind the numbers/colours. Learners will recognise this 'numbers board' concept used in many TV quiz programmes such as 'Question of Sport'.

Interactive online software (such as found in Activity 5) can provide an opportunity to reinforce learning of difficult concepts that are hard to visualise. Learners have the facility to manipulate structures in 3D that are not normally able to be seen moving in 2D representation. This can only serve to increase their awareness and understanding of the mechanisms involved.

Activities B1.2 What Happens in Cells (and What do Cells Need)?

Activities	Resources
Activity 1 **Reviewing DNA structure** As a starter activity use mini-whiteboards to review the structure of DNA. Get learners to write answers to the questions to gauge level of prior learning. Example questions include: • What are the four nucleotide bases of DNA? • What are the complementary base pairs? • What does a section of DNA (a gene) code for? Show learners a video clip of transcription of DNA, for example some teachers might like to show their classes this video at: https://www.youtube.com/watch?v=zwibgNGe4aYZ	Click here to see the clip
Activity 2 **Extraction of DNA from a living organism (eg kiwi, leek, onion, peas, wheat germ)** A good worksheet to guide learners through the process of extracting DNA is available at: http://www.ut.ee/biodida/eibe/pdf/Unit01EN.pdf (pages 12-13) This is an easy way to get a visible quantity of DNA. The DNA precipitates in the alcohol layer and appears as a clump of long thin strands. This is an impressive way to introduce learners to DNA. Onions or leek are a very good source to extract DNA from. Further details on methods of DNA extraction can be found at: http://www.planet-science.com/categories/experiments/biology/2012/03/extract-your-own-dna.aspx http://wikieducator.org/Lab:_DNA_extraction	Click here Click here Click here
Activity 3 **Revising terminology related to DNA structure** Learners complete a crossword to review all the relevant terminology and meanings related to DNA structure. Biology Corner www.biologycorner.com/worksheets/DNA_crossword.html This provides a quick way to assess learners recall and understanding of keywords for the many unfamiliar words covered in this topic area.	Click here

Activities B1.2 What Happens in Cells (and What do Cells Need)?

Activities	Resources
Activity 4 **Making 3D models of the structure of DNA** Provide learners with materials to build a model of DNA. Learners follow instructions and apply the principles previously learnt of the structure of DNA to complete the model. A good model can be found at: CSIRO http://www.csiro.au/portals/education/programs/do-it-yourself-science/biological-sciences-activities/dna-model-activity Learners can self-evaluate their models against an exemplar model. They could then work in pairs and swap models to peer-evaluate.	Click here
Activity 5 **Transcription of DNA and translation of mRNA** Describe how sequences of 3 bases code for individual amino acids and that these 3 base sequences are called codons. Learners could play 'Codon Bingo' to help understand the link between the DNA codon and the amino acid it codes for. Biology Corner www.biologycorner.com/worksheets/codon-bingo.html Learners can then write out a DNA chain of bases say 21 bases long. Ask learners to 'translate' the coded sequence into a chain of amino acids using the chart provided. An interactive whiteboard activity on a model of transcription can be found at: TES Teaching Resources https://www.tes.co.uk/teaching-resource/Transcription-and-translation-6064468/ An alternative web based activity can be found at: Learn Genetics learn.genetics.utah.edu/content/molecules/transcribe/	Click here Click here Click here

Activities B1.2 What Happens in Cells (and What do Cells Need)?

Activities	Resources
Activity 6 **Enzyme starter activity** This is a very quick and interactive PowerPoint that provides a 'snappy' visual assessment for learning opportunity. Learners take it in turns to choose a coloured square, which reveals an answer to a question. In an interesting 'spin' on the usual Q&A approach, here the learner selects a coloured square on the chequerboard with an answer to specific question on enzymes and they have to then provide the question. The PowerPoint can be found at: TES teaching resources https://www.tes.co.uk/teaching-resource/Enzymes-starter-activity-6050328/	Click here
Activity 7 **Micro scale investigations of catalase activity in plant extracts** This activity investigates the action of catalase, a widespread enzyme, found in nearly all aerobic cells (animals, plants and microbes). Catalase enzyme catalyses the decomposition of hydrogen peroxide into molecular oxygen and water. $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$ This activity is a simple, small-scale method to monitor the oxygen produced by the decomposition reaction. The enzyme is extracted then adsorbed onto paper disks. The disks are then dropped into hydrogen peroxide and sink to the bottom of the tube. The oxygen produced causes the disks to float. Timing this reaction can be used to measure the action of the catalase enzyme. Additional details of this investigation can be found at: Science and Plants for Schools (SAPS) http://www.saps.org.uk/secondary/teaching-resources/293-student-sheet-24-microscale-investigations-with-catalase The Nuffield Foundation http://www.nuffieldfoundation.org/practical-biology/microscale-investigations-catalase-activity-plant-extracts	Click here Click here

Curriculum Content B1.3 Respiration

B1.3 Respiration

Having identified and understood the roles of DNA and enzymes in Section B1.2, learners will investigate two important cellular reactions that provide cells with the resources necessary to maintain life.

Respiration

a) *describe cellular respiration as a universal chemical process, continuously occurring in all living cells that supplies ATP*

b) *describe cellular respiration as an exothermic reaction including:*
– in plants/fungi and animals the different conditions, substrates, products and relative yields of ATP

c) *compare the processes of aerobic and anaerobic respiration*

Metabolism

d) *explain the importance of sugars in the synthesis and breakdown of carbohydrates including:*
– use of the terms monomer and polymer

e) *explain the importance of amino acids in the synthesis and breakdown of proteins including:*
– use of the terms monomer and polymer

f) *explain the importance of fatty acids and glycerol in the synthesis and breakdown of lipids*

Thinking Conceptually B1.3 Respiration

Approaches to teaching the content

Metabolic processes such as respiration are controlled by enzymes. Organic compounds are used as fuels in cellular respiration to allow the other chemical reactions necessary for life.

Underlying knowledge and understanding

Learners should also have some underpinning knowledge of respiration. This should include that respiration involves the breakdown of organic molecules to enable all the other chemical processes necessary for life. Learners should be able to recall the word equation for respiration.

Common misconceptions or difficulties students may have:

Learners commonly hold the misconception that ventilation is respiration. They can also get confused between the terms breakup and breakdown. The word and symbol equation for aerobic respiration is also easily mixed up with that of photosynthesis covered in Section B1.4. This is understandable as it is the reverse, however, care must be taken to avoid this common difficulty.

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course:

Respiration is a ubiquitous reaction found in living organisms. It is specifically covered in the topic 'Ecosystems' where it is considered in terms of decomposition.

In the topic 'Maintaining Internal Environments' respiration is seen as a key factor involved in maintaining a constant internal environment. There will be many other areas where an understanding of respiration will underpin the reasons for other biological processes.

Approaches to teaching the content

Continuing with the experimental nature of the topic as a whole, this section again provides a wide range of practical activities, both real and virtual. It is crucial that learners are provided with practical opportunities to develop appropriate skills but importantly this will encourage a deeper understanding of the complex aspects of the cellular reactions that are to be studied. Activity 1 introduces the idea of exothermic reactions set in a real-life context that learners will be familiar with.

Activities B1.3 Respiration

Activities	Resources
Activity 1 **Demonstrating an exothermic reaction** Commercial heat packs can be used to a show exothermic reaction. To conduct a very quick demonstration as a starter activity: • Set off heat packs and pass them around the learners. **Note**: be sure to get the heat packs back! They are reusable! Heat packs are saturated sodium acetate solutions. Flexing the metal disc inside provides a crystallization site, and the solution crystallizes within seconds. The crystallization is a strongly exothermic process. This can be used as a discussion point to raise a Q&A session on where the heat is generated in our bodies (cellular respiration). For the curious, a video explanation of how the heat pack works can be found at: http://www.youtube.com/watch?v=zNRk7z7UCGQ	Click here to see the clip

Curriculum Content B1.4 Photosynthesis

B1.4 Photosynthesis

In Section B1.3, learners investigated two important cellular reactions that provide cells with the resources necessary to maintain life. This section will look at the reaction necessary to provide one of the reactants needed for cellular respiration.

Photosynthesis

- ***a)*** *describe photosynthetic organisms as the main producers of food and therefore biomass for life on Earth*
- ***b)*** *describe the process of photosynthesis including:*
  - *reactants and products, two-stage process, location of the reaction (in the chloroplasts)*
- ***c)*** *describe photosynthesis as an endothermic reaction*
- ***d)*** *describe experiments to investigate photosynthesis*
- ***e)*** *explain the effect of temperature, light intensity and carbon dioxide concentration on the rate of photosynthesis*
- ***f)*** *explain the interaction of these factors in limiting the rate of photosynthesis*

Thinking Conceptually B1.4 Photosynthesis

Approaches to teaching the content:

Life on Earth is dependent on photosynthesis, in which green plants and algae trap light from the Sun to fix carbon dioxide and combine it with hydrogen from water to make organic compounds and oxygen.

Underlying knowledge and understanding:

Learners should have an understanding that plants make carbohydrates in their leaves by photosynthesis, and be able to recall word summaries for photosynthesis.

Common misconceptions or difficulties learners may have:

Learners may have a fairly unscientific idea of plant nutrition, often thinking that plants suck it ('food') up from the soil through the roots. However, this may be because they believe water is food for plants and this is compounded by the everyday description of fertilisers as 'plant food' leading to frequent confusion.

Learners have problems realising that one of the raw materials for photosynthesis is the 'invisible' gas carbon dioxide. It may be necessary to convince pupils that carbon dioxide does have mass.

Some learners think that the sunlight absorbed is food. Somewhere in their education they may have been told that plants make their food using sunlight and from this they seem to think that light is converted into food. It will be beneficial if learners can understand that sunlight 'energy' gets stored into the internal energy of the bonds of the carbohydrates formed.

Learners find it confusing when text books make inconsistent references to the products of photosynthesis, such as 'food' 'starch' 'sugar' and 'glucose' If they can understand that all of these are terms which can be applied to the products of photosynthesis, they are less likely to be confused.

Conceptual links to other areas of the specification - useful ways to approach this topic to set students up for topics later in the course:

Photosynthesis is a reaction found in producer organisms. It is specifically covered in the topic 'Ecosystems' where it is considered in terms of application to abiotic factors affecting communities and in an understanding of pyramids of biomass.

In the topic 'Feeding the Human Race' consideration of the key factors involved in photosynthesis will need to be applied to factors affecting food security and possible agricultural solutions. There will be many other areas where an understanding of photosynthesis will underpin the reasons for other biological processes.

Approaches to teaching the content

A link to Section B1.3 can be made with Activity 2, demonstrating the type of reaction that requires energy to be added to the system for the reaction to proceed. Here Activity 2 will allow learners to practically measure the temperature changes in an easily managed endothermic reaction.

Learners should have the opportunity to gain investigative skills that will be used throughout the specification through Activity 4. This will allow learners to plan and manage an investigation to make sure that it is:

- manageable
- time-efficient
- reliable
- safe.

If practical resources, or time, are limited then there are a number of interactive online software (such as those identified in Activity 4) that can provide an opportunity to reinforce learning of investigative skills. Learners have the facility to manipulate structures in 3D in order to change variables and measure the effect on photosynthesis.

Activities B1.4 Photosynthesis

Activities	Resources
Activity 1 **'Where does the wood come from?'** The idea of this activity is to get learners to examine their misconceptions about photosynthesis. (Activity sheet 1 or PowerPoint presentation 1 plus cards 1A – 1D) It is an activity that gets learners to engage with historical evidence of photosynthesis and the approach could easily be applied to the evidence provided by other historical scientists, such as Priestley's experiment using *Cabomba* to collect oxygen or Ingenhousz's experiment to show mass gain. The information covers the historical work done by Jean Bapiste van Helmont in the 16th Century. After reading an extract from van Helmont's diary, learners discuss his interpretations. Four typical student responses to van Helmont's experiment are given in the speech bubbles. Learners are given cards (A – D) as stimulus to talk in structured groups about each of the statements and examine data and pictures of more recent experiments. They summarise their thoughts and feedback to the rest of the class. Throughout the discussion it is important to introduce and reinforce the idea that an increase in mass (biomass) is good evidence that photosynthesis has taken place and carbon dioxide from the air contributes to this. Details of this activity, and many more designed to overcome misconceptions associated with photosynthesis, can be found at: Science and Plants for Schools (SAPS) http://www.saps.org.uk/secondary/teaching-resources/134-photosynthesis-a-survival-guide-teaching-resources	Click here
Activity 2 **Demonstrating an endothermic reaction** A very quick, easy method to demonstrate an endothermic reaction. Equipment: • 25ml citric acid solution • 15g baking soda • polystyrene cup • thermometer • stirring rod	

Activities B1.4 Photosynthesis

Activities	Resources
Procedure: 1. Pour the citric acid solution in a polystyrene cup. Use a thermometer or other temperature probe to record the initial temperature. 2. Stir in the baking soda (sodium bicarbonate). Monitor the change in temperature over time. The reaction is: $H_3C_6H_5O_7(aq) + 3NaHCO_3(s) \longrightarrow 3CO_2(g) + 3H_2O(l) + Na_3C_6H_5O_7(aq)$ 3. When you have completed your demonstration or experiment, wash the cup out in a sink. 4. Extension activities could include varying the concentration of the citric acid solution or the quantity of sodium bicarbonate. An endothermic is a reaction that requires energy to be added to the system to enable it to proceed. The intake of energy may be observed as a decrease in temperature as the reaction proceeds. Once the reaction is complete, the temperature of the mixture will return to room temperature. The activity could be introduced by demonstrating or learners actually making a 'bath bomb' such as can be found at: Cool Science GIFS http://coolsciencegifs.tumblr.com/post/76834606021/home-made-bath-bomb-dissolving-in-water-pro-tip This kind of endothermic reaction can then be seen in the context of photosynthesis.	Click here
Activity 3 **'Algal balls' - Photosynthesis using algae wrapped in jelly balls** In this practical, learners use algae to look at the rate of photosynthesis. Since algae are tiny and are difficult to work with directly in the water, the first part of the practical involves 'immobilising' the algae as algal balls. This effectively traps large numbers of algal cells in 'jelly like' balls made of sodium alginate. Sodium alginate is not harmful to the algae, and they will continue to photosynthesise once immobilised.	

Activities B1.4 Photosynthesis

Activities	Resources
A video showing how to make 'algal balls' and subsequent experiments that can be done is found at: http://www.youtube.com/watch?v=fl3x68CkKW0&list=PLecUOehIE87dGWKFft-QtP9ysSVEK-kP0 Further details of the experiment can be found at: Science and Plants for Schools (SAPS) http://www.saps.org.uk/secondary/teaching-resources/235-student-sheet-23-photosynthesis-using-algae-wrapped-in-jelly-balls	Click here to see the clip Click here
Activity 4 **Pupil-led photosynthesis investigation** The 'algal balls' learners made earlier, details found above, can be used to promote investigative skills in providing reliable and easily managed photosynthetic material. Alternatively, *Cabomba* species of pondweed can be used. A framework for learners to plan, carry out and evaluate their own investigation into factors affecting photosynthesis and to develop their investigative skills can be found at: TES Teaching Resources https://www.tes.co.uk/teaching-resource/Pupil-Led-Photosynthesis-Investigation-6112342/ If practical resources and equipment are limited there are several proprietary software packages that allow investigations of factors affecting photosynthesis to be carried out interactively. One example can be found at: Focus Educational http://www.focuseducational.com/product/Science-iPad-Android-Apps-Pack/231 The Focus suite of interactive science resources available as an online version compatible with iPads, Android tablets, Windows & Mac. This suite has a Science Apps Pack that allows learners access to a range of interactive resources that they can access on tablets and computers both in school and at home. A free online resource can be found at: Syngenta http://www3.syngenta.com/country/uk/en/about/learning-zone/KS345/biology/Pages/Photosynthesis_in_Action_Large.aspx	Click here Click here Click here


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