Cell level systems: Introduction

When and how to use these pages

This chapter builds on the idea that the cell is the building block of life. Plant, animal and bacteria cells are studied using microscopy and important cell level processes of photosynthesis and respiration are explored.

This chapter links to all chapters in which the structure and functions of different systems are considered. There are links to Chapter 5, Genes, inheritance and selection, and several spreads in Chapter 2 Scaling up, particularly to 2.5 Cell division and 2.8 Cell development.

Overview of the chapter

In this chapter, students will learn about the structure of plant, animal, prokaryotic and eukaryotic organisms, and the functions of major structures. They will compare the level of detail revealed by light and electron microscopes, calculating magnifications. Students will investigate the structure of DNA and how the DNA base code is used to synthesise proteins. They will then learn about the role of enzymes in digestion and investigate the effect of pH on enzyme activity. Students will consider the differences between aerobic and anaerobic respiration, and learn about the uses of anaerobic respiration in baking and brewing. Students will learn about the process of photosynthesis, including the many uses of glucose in the plant. They will also test a leaf for the presence of starch and investigate how to change the rate of photosynthesis.

This chapter offers a number of opportunities for the students to use mathematics to carry out magnification calculations, plan and carry out investigations into the use of anaerobic respiration in baking, plan and carry out investigations into factors affecting photosynthesis.

Obstacles to learning

Students may need extra guidance with the following terms and concepts:

- Cells and related topics use abstract concepts and are hard to visualise. The use of cell models may help some students to make connections between different types of cells. Students often believe that cells are inactive, two-dimensional structures and the use of videos and electron micrographs will enable them to see this is not the case.
- Students may believe that bacterial cells are the same as animal cells.
- Understanding exactly how proteins are synthesised using the DNA code can become extremely complex. This topic should be avoided with students that will definitely only be entered for the foundation tier.
- Most students will understand that enzymes speed up reactions but few will understand why. Opportunities to interpret enzyme-controlled reactions will help with this understanding.
- Respiration is often confused with breathing (ventilation), and needs to be linked to the mitochondria within cells so its role within each cell can be emphasised.
- Students need to appreciate that the process of photosynthesis only produces sugars. All the other substances that a plant needs are made from this sugar and plants often need additional minerals to supply other elements.
- Many students, even at A level, think that plants respire at night and then switch to photosynthesis during the day. The continual nature of respiration needs to be emphasised.

Practicals in this chapter

In this unit students will do the following practical work:

- Practical: Prepare plant and animal slides and observe them using a light microscope
- Modelling DNA structure
- Investigate the amount of energy in food

- Test a leaf for the presence of starch
- Investigate the effect of amylase on starch
- Practical: Investigate the effect of pH on the rate of reaction of amylase enzyme
- Practical: Use qualitative reagents to test for a range of carbohydrates, lipids and proteins
- Practical: Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed

	Lesson title	**Overarching objectives**
1	The light microscope	How to observe animal and plant cells using the light microscope and its limitations.
2	Looking at cells	Describe the structure of eukaryotic cells and functions of subcellular components.
3	Practical: Using a light microscope to observe and record animal and plant cells	How to look at everyday material and cells using a light microscope. Understand the difference between low and high power; draw and describe images at high and low magnification.
4	Primitive cells	Describe the differences between prokaryotic and eukaryotic cells, and how they might have evolved over time.
5	Looking at cells in more detail	Compare the light microscope with the electron microscope, explaining how the development of the electron microscope has increased our understanding of cells.
6	Maths skills: Size and number	Making estimates, ratio and proportion, standard and decimal form.
7	The structure of DNA	Describe the structure of DNA in terms of DNA bases, double helix structure and having complementary strands.
8	Proteins	Describe how proteins are synthesise according to the DNA template of a gene.
9	Explaining enzymes	Describe what enzymes are and how they work.
10	Practical: Investigating enzymes	Investigate the effect of pH on the rate of reaction of amylase enzyme.
11	Cells at work	Explain the process of aerobic respiration.
12	Living without oxygen	Describe the process of anaerobic respiration and compare it to aerobic respiration.
13	Enzymes at work	Investigating the digestive enzymes.
14	Practical: testing food	Use qualitative reagents to test for a range of carbohydrates, lipids and proteins
15	Looking at photosynthesis	Explain how plants use the products of photosynthesis.
16	Explaining photosynthesis	Describe the process of photosynthesis.
17	Practical: rate of photosynthesis	Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pond weed.
18	Increasing photosynthesis	Identify factors that affect the rate of photosynthesis and explain the interaction of factors in limiting the rate of photosynthesis.
19	Maths skills: Extracting and interpreting information	To extract and interpret information from tables, charts and graphs.

Lesson 1: The light microscope

Lesson overview

OCR specification reference

OCR B1.1a

Learning objectives

- Describe how to use a microscope.
- Observe plant and animal cells with a light microscope.
- Understand the limitations of light microscopy.

Learning outcomes

- Describe how to prepare a microscope slide of animal and cheek cells. [O1]
- Make observations of cheek and animal cells. [O2]
- Calculate the size of objects using ideas about magnification. [O3]

Skills development

- WS 1.4b Recognise the importance of scientific quantities and understand how they are determined.
- WS 1.4d Use prefixes and powers of ten for orders of magnitude.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.

Maths focus

- 2h Make order of magnitude calculations.

Resources needed Worksheet 1.1; Practical sheet 1.1; Technician's notes 1.1

Digital resources PowerPoint

Key vocabulary magnification, micrographs, resolving power

Teaching and learning

Engage

- Show students some images of plant or animal cells from the PowerPoint slide. Ask students to **identify** the plant cells and the animal cells. They should justify their responses. Ask students how scientists came to obtain such images. [O2]
- Use the PowerPoint slide to demonstrate how the light microscope works. Students should **read** page 14–15 of the Student Book. [O1]

Challenge and develop

- Demonstrate how to use a microscope, and how to work out the magnification of an object using the PowerPoint slide. Students should **answer** the questions in the Student Book to determine the magnification of different objects. [O2, O3]
- Provide students with Practical Sheet 1.1. Ask them to follow the procedures given to produce a slide of a cheek cell and an onion cell. Students should observe their cells under a light microscope and record their observations. [O1, O2]

Explain

- Ask students to **work out** the magnification of the images they recorded. [O3]
- Students should **explain** the differences in their images, using ideas about cell structure. [O2]

Consolidate and apply

- Students should **produce** a poster about the light microscope. They could **carry out** further research on this if required. [O1]
- High demand students should **explain** how to work out the actual sizes of the objects from the microscope. [O3]

Extend

Ask students who are able to progress further to:

- **work out** the magnification, size of images and size of objects on the extension task from the worksheet. [O3]

Plenary suggestions

- Ask students to **write** 10 top tips for preparing plant and animals cell slides and observing them under a microscope. [O1, O2]
- Students should **summarise** all the limitations of using a microscope in three sentences. [O3]

Answers to Worksheet 1.1

Explaining differences

Plant cells should be highly ordered, with a much more distinctinctive cell wall. The cells may contain vacuoles, but these can be hard to observe.

Animal cells have a less distinctive shape and no vacuole.

Extension

Object	Measured size	Magnification
Ant	20 mm	20/3 = 6.7
Hair diameter	3000 µm	3000/100 = 30
Leaf cell	35 000 µm	35 000/70 = 500
Red blood cell	20 000 µm	20 000/7 = 2857
Bacterium	25 000 µm	25 000/1 = 25 000
HIV	30 000 000 nm	30 000 000/100 = 3 000 000
DNA	5 000 000 nm	5 000 000/2.5 = 2 000 000
Carbon atom	34 000 000 nm	34 000 000/0.34 = 100 000 000

Lesson 2: Looking at cells

Lesson overview

OCR specification reference

OCR B1.1b

Learning objectives

- Describe the structure of eukaryotic cells.
- Explain how the main sub-cellular structures are related to their functions.

Learning outcomes

- Name the parts in a eukaryotic cell. [O1]
- Relate the size of a cell to other objects. [O2]
- Explain the function and reasons for sub-cellular structures. [O3]

Skills development

- WS 1.4a Use scientific vocabulary, terminology and definitions.
- WS 1.4b Recognise the importance of scientific quantities and understand how they are determined.
- WS 1.4e Interconvert units.

Maths focus

- 1b Recognise and use expressions in standard form.
- 2h Make order of magnitude calculations.

Resources needed Worksheet 1.2.1 (low demand); Worksheet 1.2.2 (standard demand); Worksheet 1.2.3 (high demand)

Digital resources PowerPoint

Key vocabulary chloroplast, chlorophyll, chromosome, eukaryotic, order of magnitude

Teaching and learning

Engage

- Ask students to **write down** 10 things they already know about cells. Show students slide 1 on the PowerPoint and discuss students' responses as to what the images have in common. Elicit what a cell is and what features they have. [O1]
- Use slide 2 to introduce the term 'eukaryotic' to describe a cell with a true nucleus. Ask students to **compare** the images and **identify** what they have in common. [O1]
- Ask students to **imagine** how big a cell might be. **Discuss** what they would compare the size to. [O2]

Challenge and develop

- Show students the simulation which will help them to **identify** the order of magnitude of cells in relation to other objects. This can be found using the search terms 'cell size' and 'scale' at http://learn.genetics.utah.edu. In addition, students could look at page 17 of the Student Book. [O2]
- Discuss the different units of size. Ensure students understand the relationships between mm, μm, nm and m. Ensure they are familiar with standard form. Use page 17 from the Student Book to help or use PowerPoint slide 3 to demonstrate how to compare orders of magnitude.
- High demand, standard demand and low demand students to carry out the appropriate card sort: low demand, Worksheet 1.2.1; standard demand, Worksheet 1.2.2; higher demand, Worksheet 1.2.3.

- Provide students with the card sort from the appropriate worksheet. They should group the cards into sizes of the same dimension. For example, 1 m could be grouped with 1000 mm and 100 cm. This card sort is differentiated for different learners. [O2]
- Show students worksheet task 2. Ask students to imagine the diameter of a human hair scaled up to 70 mm. Ask higher and standard demand students to work out the relative lengths of the other cells in the table. Ask all students to draw these lengths on their graph and compare the diameter of a hair as given on the worksheet. Ask students to draw conclusions about the sizes of cells. [O2]

Explain

- Ask students to **read** page 16 of the Student Book to remind themselves of the different parts of animal and plant cells. Students should answer all the questions from the Student Book. [O2, O3]

Consolidate and apply

- Ask students to **draw and summarise** the differences between animal and plant cells in the table given on the worksheet. [O2, O3]
- Students could work in small groups and **make** a three-minute presentation about cells to the class. They should include ideas about size, as well as explaining what a cell is and explaining the differences between animal and plant cells. [O1, O2, O3]

Extend

Ask students who are able to progress further to:

- **research** the history of the development of cells and **identify** on the timeline when eukaryotic cells first evolved. [O1, O2, O3]
- **compare** the structure of the 'cyanobacteria' with that of a typical plant cell. [O1, O2, O3]

Plenary suggestions

- Use the PowerPoint slide showing plant and animal cells with many mistakes on it. Ask students to **correct** the mistakes.
- Provide students with a list of structures from the PowerPoint. Ask them to **put them in order** of magnitude.

Answers to Worksheet 1.2

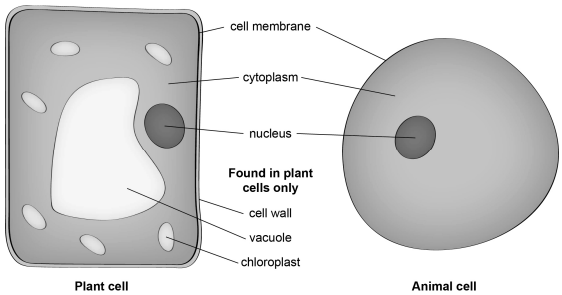
1.

1 m	1 metre		100 cm	10^3 mm	1 000 000 µm	
1 cm	1 centimetre	10^{-2} m		10 mm	10^4 µm	
1 mm	1 millimetre	10^{-3} m			1000 µm	1 000 000 nm
1 µm	1 micrometre	10^{-6} m		10^{-3} mm		1000 (10^3) nm
1 nm	1 nanometre	10^{-9} m	10^{-7} cm	10^{-6} mm	10^{-3} µm	

2.

Object	Original size (µm)	New size (mm)
Human hair diameter	70	70
Bacterium	1	1
Red blood cell	7	7
Leaf cell	70	70
HIV	0.1	0.1

All lengths are drawn to the new size and graphs are labelled



3.

Animal cell	Plant cell	Function of structure in the cell
nucleus	nucleus	controls reactions in the cell; contains DNA; controls reproduction of the cell
cell membrane	cell membrane	controls which substances enter and leave the cell
cytoplasm	cytoplasm	where all the chemical reactions in the cell take place
	vacuole	contains cell sap to provide internal strength to the cell
	chloroplasts	absorb light energy for photosynthesis
	cell wall	made from cellulose; provides strength and protection for the cell

Lesson 3: Practical: Using a light microscope to observe and record animal and plant cells

Lesson overview

OCR specification reference

OCR B1.1a; B1.1b

Learning objectives

- Apply knowledge to select techniques, instruments, apparatus and materials to observe cells.
- Make and record observations and measurements.
- Present observations and other data using appropriate methods.

Learning outcomes

- Use a light microscope to observe a range of different objects. [O1]
- Record observations from a light microscope using simple diagrams of low and high power magnification. [O2]
- Use a scale bar to identify the size of images from microscope slides. [O3]

Skills development

- WS 2.6 Make and record observations and measurements using a range of apparatus and methods.
- WS 3.1 Present observations and other data using appropriate methods.
- WS 3.5 Interpret observations and other data.

Maths focus

- 2h Make order of magnitude calculations.

Resources needed Range of materials to look at through the microscope, e.g. human hair, newspaper, string, prepared range of animal and plant cells. Worksheet 1.3.1 (low and standard demand); Worksheet 1.3.2 (high demand); Practical sheet 1.3.1 (low and standard demand); Practical sheet 1.3.2 (high demand) Technician's notes 1.3

Digital resources

Key vocabulary field of view, scale

Teaching and learning

Engage

- Provide each pair of students with a microscope. Ask them to **recap** and **discuss** the name and function of each part of the microscope and how it should be used. [O1]

Challenge and develop

- **Discuss** the importance of staining the slides and of why mounting animal cells in saline solution instead of water is important. [O1]
- Ask students to **look at** the images on Worksheet 1.3.1 (low and standard demand) or 1.3.2 (high demand). Ask them to **identify** if they were taken under low or high resolution. [O1, O2]
- Ask students to **observe** a range of everyday materials first through the microscope. Students should follow the instructions on Practical sheet 1.3.1 (low and standard demand) or 1.3.2 (high demand). They should **make annotated drawings** of their observations on both low power and then high power, as accurately as possible on a poster, which can then be later displayed. They should **explain** what they see in as much detail as possible. Where appropriate, students should **count** the numbers of cells they observe.

- High demand students should **discuss** the use of a scale bar using the section on recording images on page 21 of the Student Book. They should also **estimate** the actual size of individual cells on their worksheet by using the given scale bars. [O2]
- If possible, provide students with a range of different prepared animal and plant tissue. Ask students to **identify** if the cells are animal or plant, and to **draw** what they see, on low power first and then on high power, as accurately as possible. Students should **identify** different regions of the tissues in the slides as accurately as possible, where appropriate. [O2]

Explain

- Low and standard demand students should **write** a short explanation on their posters of the importance of viewing an object on a low magnification first and then on a higher magnification. [O1, O2]
- High demand students should **write** an explanation of how to determine the appropriate scale bar to use on their posters. They should **highlight** the importance of ensuring it is appropriate. [O3]

Consolidate and apply

- **Discuss** with students the success criteria for determining what a good image from a microscope looks like and write a class list for students to follow.
- Display all the posters on the wall. Ask students to **peer assess** their images, using post-its, providing one or two strengths and one area for development. [O1, O2, O3]
- Students should **read** pages 18–19 of the Student Book and **answer** questions 1–6.
- High demand students should also **answer** questions 7–8.

Extend

Ask students able to progress further to:

- **find out** how scale bars are determined for very small objects. [O3]

Plenary suggestion

Students could prepare a 1-minute talk on the importance of the light microscope, how to use it correctly, what information can be observed and how to record these observations appropriately. [O1, O2, O3]

Answers to Worksheet 1.3

1. Low resolution – A, B and D; high resolution – C
2. (High demand): A = ~2 µm; B = ~5 µm; C = ~2 µm; D = ~10 µm

Lesson 4: Primitive cells

Lesson overview

OCR specification reference

OCR B1.1b

Learning objectives

- Describe and explain the differences between prokaryotic cells and eukaryotic cells.
- Explain how the main sub-cellular structures of prokaryotic and eukaryotic cells are related to their functions.

Learning outcomes

- Recognise that cells without a nucleus are prokaryotic cells. [O1]
- Compare and contrast prokaryotic and eukaryotic cells. [O2]
- Explain the evolutionary link between prokaryotic and eukaryotic cells. [O3]

Skills development

- WS 1.1a Understand how scientific methods and theories develop over time.
- WS 1.4f Present reasoned explanations including relating data to hypotheses.
- WS 1.4a Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.4

Digital resources PowerPoint

Key vocabulary eukaryotic, genome, nucleic acid, plasmid, Prokaryota, prokaryotic

Teaching and learning

Engage

- Show students the PowerPoint slide of the oldest fossil on Earth. Ask students to **generate** five questions regarding things they would like to know about this fossil. Take feedback and write a list of questions on the board. [O1]
- Ask the class to vote for the top five questions to which they would like to find the answers. [O1]

Challenge and develop

- Show students the slide of eukaryotic cells and a prokaryotic cell. Ask students to **identify** all the similarities and differences between the images, on the worksheet. [O1, O2]
- **Discuss** the features of prokaryotic cells using the PowerPoint slide. [O1, O2]
- Low demand students could **use** the Student Book to help them.
- Ask students to **draw and label** a diagram of a prokaryotic cell on the worksheet. [O1]
- Ask students to **carry out** the mystery exercise from the card sort. They should **sort the cards** into groups of similar information. They should **use these cards** to produce a timeline of cell development from the information given. [O1, O2, O3]

Explain

- Students should **explain** whether prokaryotic or eukaryotic cells are more successful, with evidence to back up their ideas. [O1, O2, O3]
- High demand students should **explain** the advantages and disadvantages prokaryotic and eukaryotic cells have over the other. [O2, O3]

Consolidate and apply

- Students should read the section from the Student Book on how the classification system for early life developed, and **answer** the relevant questions. [O3]
- Students could **prepare** a 2-minute talk on prokaryotic cells and explain how they are different from eukaryotic cells. Students should **explain why** they are thought to be more primitive. [O1, O2, O3]

Extend

Ask students who are able to progress further to:

- **research** mitochondria and chloroplasts in greater depth and **write** a scientific paper about them from their research. They should **explain** their structure, their relevance and provide evidence which suggests they were once independent organisms before they became symbiotic with larger cells. Students could **explore** the advantages of this relationship. [O2, O3]

  The following link could help (search terms: 'amazing cells' and 'the evolution of the cell')
  http://learn.genetics.utah.edu

Plenary suggestions

- Provide students with the images from the PowerPoint slide. They should **say five things** about each image. They should be able to **classify** the objects shown on the cards as eukaryotic, prokaryotic or archaea and subdivide again into, animal, plant or bacterial, or structures in the cytoplasm. [O1, O2]
- Go back to the questions from the starter activity. See if any of these can now be answered. [O1, O2, O3]

Answers to Worksheet 1.4

1.

Cell 1	Cell 2	Cell 3
Plant cell Contains a nucleus and vacuole Contains mitochondria Contains many structures in the cytoplasm DNA is in the nucleus Has a cell wall No tail	Animal cell Contains a nucleus but no vacuole Contains mitochondria Contains many structures in the cytoplasm DNA is in the nucleus No cell wall No tail	Bacterial cell No nucleus or visible vacuole No mitochondria Contains few structures in the cytoplasm DNA is free in the cytoplasm Has a cell wall Has a tail

2. Drawing should show a flagellum, no nucleus, no mitochondria or internal structures, DNA floating freely, cell wall and capsule may be present, circular ring of DNA labelled as plasmid.

3. Mystery cards – many possibilities, but generally, the following should be grouped together:
1 on its own; 2 and 4; 3 and 5; 6 and 9; 7, 10 and 12; 8, 10 and 11;
Order of timeline: 1, 3, (2, 4), (8, 6 and 9), (7 and 10), 12

Lesson 5: Looking at cells in more detail

Lesson overview

OCR specification reference

OCR B1.1c

Learning objectives

- Identify the differences in the magnification and resolving power of light and electron microscopes.
- Describe simply how electron microscopes work in comparison to light microscopes.
- Explain how electron microscopy has increased our understanding of sub-cellular structures.

Learning outcomes

- Describe what features can be seen with an electron microscope. [O1]
- Explain the differences in magnification and resolving power between a light and electron microscope. [O2]
- Explain the impact of the electron microscope on our understanding of cellular structures. [O3]

Skills development

- WS 1.1a Understand how scientific methods and theories develop over time.
- WS 1.4c Use SI units and IUPAC chemical nomenclature unless inappropriate.
- WS 1.4d Use prefixes and powers of ten for orders of magnitude.

Resources needed Worksheet 1.5

Digital resources PowerPoint

Key vocabulary scanning electron microscope, transmission electron microscope

Teaching and learning

Engage

- Show students the images from an electron microscope and from a light microscope on the PowerPoint slide. Ask students to **answer** the following questions about the images: [O1, O2]

  Where do the images come from?

  What might they show?

  Why are there differences between the images?

  How might the images have been taken?

Challenge and develop

- Ask students to **read** the sections in the Student Book and/or on the worksheet on electron microscopes and light microscopes. Ask them to use the table on the worksheet to **compare and contrast** the electron microscope with the light microscope. [O1, O2]
- Show students the interactive simulation of internal structures of plant and animal cells found using the search term ‘inside a cell’ at http://learn.genetics.utah.edu. [O1]
- Introduce students to further structures found in the cytoplasm from studies using electron microscopes; ribosomes and mitochondria. Ask students to **answer** the differentiated questions in Worksheet 1.5 ‘What is inside a cell?’ section (low demand, Q1–3; standard demand, Q4; high demand, Q5–7). [O1, O2]

Explain

- Students should **write** a short explanation about the impact the electron microscope has had on our understanding of cells. [O3]

Consolidate and apply

- Students could **answer** the questions from the Student Book.
- Students should use ideas about magnification to **explain** which of the examples on the worksheet can be viewed by an electron microscope and which can be viewed by a light microscope.

Extend

Ask students who are able to progress further to:

- **research** other structures that have been found using electron microscopes and **present** a case to the class for the further impact these inventions have had on the developments made in cell biology.

Plenary suggestions

- Students could **imagine** that a biology research lab is in need of further optical equipment. Half of the class could represent a company selling light microscopes, the other half a company selling electron microscopes. Each half should **prepare a case** to sell their equipment.

Answers to Worksheet 1.5

1.

Optical microscope	Electron microscope
Used for hundreds of years	Very recently invented
Uses light rays	Uses electron beams of high energy
Specimen can be living	Specimen is dead
×1000 to ×2000 magnification	About ×2 000 000 magnification
Not possible to see internal structures inside the cytoplasm clearly	Internal structures inside the cytoplasm can be viewed
Quite cheap	Very expensive
Anyone can use this and observe images	Highly trained scientists needed to operate and analyse results
Not much space needed	Lots of space required
2D image only	3D image can be produced
Not possible to get better magnification with this technology	Technology can be improved over time

2.

1) Mitochondria
2) Ribosomes
3) Chloroplasts
4)
   a) Ribosomes – both animal and plant
   b) Mitochondria – both animal and plant
   c) Chloroplasts – plant only
5) Light microscope does not have a high enough magnification or resolution to view these structures.
6) The internal structures of these organelles; for example, the folds inside the mitochondria and the chloroplasts
7) How these organelles move, reproduce and function under normal conditions

3. Many answers are possible – here is an example:

If we still only had the light microscope, we would only be able to see the main structures of the cell, like the nucleus and cell membrane in animal cells, and vacuole and nucleus inside plant cells.

We would not understand that the cytoplasm is made up of many different types of structures. We would not be able to determine the function of different organelles inside the cytoplasm and could not make breakthroughs regarding health and the fight against viruses and cancers.

The electron microscope has enabled us to have a better understanding of how cells work and how to fight against diseases.

4.

1) Nucleus – visible under both microscopes
2) Cell wall – visible under both microscopes
3) Mitochondria – mainly visible by electron microscope; too small for optical
4) White blood cell ingesting a bacteria – only optical as the cells must be alive
5) Chloroplast – electron
6) Embryo dividing – only optical as cells must be alive
7) Sperm cell swimming – only optical as cell must be alive
8) Ribosomes – electron microscope
9) Detailed structure of the cytoplasm – electron microscope; Fertilisation taking place – only optical as cells must be alive

Lesson 6: Maths skills: Size and number

Lesson overview

Learning objectives

- To make estimates of the results of simple calculations, without using a calculator.
- To use ratio and proportion to calibrate a microscope.
- To recognise and use numbers in decimal and standard form.

Learning outcomes

- Make estimates and explain why they may be important. [O1]
- Describe how to use ratio and proportion to calibrate a microscope. [O2]
- Convert numbers from decimal to standard form, and vice versa. [O3]

Skills development

- WS 1.4b Recognise the importance of scientific quantities and understand how they are determined.
- WS 1.4d Use prefixes and powers of 10 for orders of magnitude.

Maths focus

- 1a Recognise and use expressions in decimal form.
- 1b Recognise and use expressions in standard form.
- 1c Use ratios, fractions and percentages.
- 1d Make estimates of the results of simple calculations.

Resources needed Worksheet 1.6.1 (low demand); Worksheet 1.6.2 (standard and high demand)

Key vocabulary cell size, estimate, order of magnitude, stage micrometer

Teaching and learning

Engage

- Introduce the learning outcomes for the lesson. Tell students they are going to make some estimates of sizes. Show students a metre rule and ask them to find as many objects in the classroom that are approximately 1 m long. Repeat the activity for 30 cm and 1 mm. Ask students to **identify why** making estimates is sometimes useful, before making accurate measurements. [O1]
- Ask students to work in pairs and **write a list** of things it is useful to estimate first, before accurately working out. [O1]
- Recap units of measurement and model how to convert millimetres to metres, and vice versa. Remind students of how to use standard form and ask them to **complete** the task on Worksheets 1.6.1 (low demand) or 1.6.2 (standard and high demand). They may need reminding of how to interconvert various units. [O3]

Challenge and develop

- Use the Student Book to show students microscope image of cells. Ask students to **identify why** it is important to know the size of a cell. **Explain how** to make an estimate of a cell's size using the example given in the Student Book. [O1]
- Ask students **to estimate** the size of the cells given in the worksheet. [O1]
- Explain how to use a stage micrometer to make accurate microscope measurements using the Student Book. Use the example given to show how the size of a cell may be accurately determined. Ask students to **answer the questions** on the worksheet. [O2, O3]

Explain

- Ask students to **write a help sheet** for another student to explain how to convert numbers into standard form, and how to make accurate measurements using a stage micrometer. [O2, O3]

Consolidate and apply

- Students could **answer** all the questions in the Student Book. They should complete the task in the worksheet. [O1, O2, O3]

Extend

Ask students who are able to progress further to:

- **find out** how blood samples are analysed and **identify** any estimates that are given. They **could prepare** a talk for the class to **explain how** to determine the number of red blood cells in the blood, which measurements are made accurately and which might be estimated, and how this is done. [O1–O3]

Plenary suggestions

- Ask students to **review** the skills from the learning outcomes using the 'traffic light' system.

Answers to Worksheets 1.6.1 and 1.6.2

1.

Worksheet 1.16.1 (low demand)

a) 1×10^{1}, 1×10^{2}, 1×10^{3}, 1×10^{-6}, 1×10^{4}, 1×10^{-3}

b) 10 000, 1/100 000, 100 000 000, 1/100

Worksheet 1.16.2 (standard and higher demand)

a) 3×10^{3}, 5.2×10^{2}, 7.3×10^{-3}, 4.2×10^{1}, 5.3×10^{-4}

b) 200, 700 000, 1/4000, 1/7 500 000

µm	mm	cm	m
1 000 000	1000	100	1
1	1×10^{-3}	1×10^{-4}	1×10^{-6}
1×10^{4}	1×10^{1}	1	1×10^{-2}
1×10^{3}	1	1×10^{-1}	1×10^{-3}

2.

a) 12 (cells across the field of view)

b) 500/12 = 41.7 µm

(High demand)

c) 120

d) 24

3.

a) 2.8 µm

b) 20

c) 56 µm

d) 40 µm

Lesson 7: The structure of DNA

Lesson overview

OCR specification reference

OCR B1.2a; OCR B1.2b; OCR B1.2c

Learning objectives

- Describe the structure of DNA as repeating nucleotide units.
- Identify the four bases in DNA.
- Explain that the bases A and T, and C and G, are complementary.

Learning outcomes

- Recall that DNA is polymer made up of repeating nucleotide units. The nucleotides form two strands joined together in the shape of a double helix. [O1]
- Recall that a nucleotide is made up of a sugar molecule and a phosphate molecule attached to one of four different bases. [O2]
- Identify the four bases in DNA as A, T, C and G, and that in the complementary strands, a C is always linked to a G on the opposite strand and a T to an A. [O3]

Skills development

- WS 1.1b Use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 1.2c Apply a knowledge of a range of techniques, instruments, apparatus, and materials to select those appropriate to the experiment.
- WS 1.4a Use scientific vocabulary, terminology and definitions.

Resources needed Video of DNA structure (search 'DNA structure GCSE biology'). Worksheet 1.7.1 (low demand); Worksheet 1.7.2 (standard and high demand); Practical sheet 1.7; Technician's notes 1.7

Digital resources

Key vocabulary base, complementary, double helix, genetic code, nucleotide, polymer

Teaching and learning

Engage

- Ask students to **crack** the code on section 1 of Worksheet 1.7.1 (low demand) or Worksheet 1.7.2 (standard and high demand). [O1]
- Link this to the idea that DNA is a code for making proteins in the body. [O1]

Challenge and develop

- **Show** students an image or model of DNA; for example, on page 23 of the Student Book. [O1]
- **Ask** students what they notice about the letters running down the centre of the DNA. [O2, O3]
- **Explain** that these letters are bases and they are the part of the DNA that codes for proteins. [O2, O3]
- **Explain** that a sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein. [O2, O3] (*This concept is part of lesson 6, but it is all that students entered for a foundation paper will require from that lesson. It is suggested that this concept is included here so that foundation tier students may miss out lesson 6 at the discretion of the teacher.*)

Explain

- Use the diagram or model or a video (search 'DNA structure GCSE biology') to **discuss** the complete structure of DNA including ideas about nucleotides, bases and double helix. Students do not need to know the names of the bases, only the letters; however, high demand students may find it useful to be familiar with the names. Low demand students do not need to know the base pairs; however, without knowing this they cannot make their model later. [O1, O2, O3]
- Low demand students should **complete** section 2 'The structure of DNA' on Worksheet 1.7.1. [O1, O2, O3]
- Standard and high demand students should complete section 2 'The structure of DNA' on Worksheet 1.7.2. [O1, O2, O3]

Consolidate and apply

- **Introduce** the model-building activity described on Practical sheet 1.7. Divide the class into small groups and ask them to **complete** the activity. It is easiest to do this in groups of about four. Two students concentrate on a strand between them. Each pair of students takes a length of wire – it can be 50 cm, 1 m or longer depending on how much space, time and patience you have. You may wish to give less-able students a base sequence consisting of 20 base pairs. [O1, O2, O3]
- Students then **evaluate** their DNA model by completing the questions on Practical sheet 1.7. [O1, O2, O3]

Extend

Ask students able to progress further to:

- (high demand) **complete** questions 5 and 6 on page 27 of the Student Book. [O3]

Plenary suggestions

- **Ask** the students to **judge** which group has made the best DNA model.

Answers to Worksheet 1.7

1 DNA code

1. Genes are made of DNA. Your DNA contains a genetic code. The code is used to put amino acids together to make proteins.

2 The structure of DNA

1. nucleotide, base, phosphate, sugar
2. double helix, nucleotides, sugar, phosphate, C, T and G (any order), polymer, three, protein

(High demand): The description should be very similar to the following:

DNA has a structure like a twisted ladder, the structure is called a double helix.
DNA has two strands; each strand is made up of units called nucleotides, joined together.
Each unit contains three parts: bases, a sugar molecule and phosphate group.
There are four different bases each represented by the letters A, T, C and G.
The two strands are complementary with A linked to T and C to G.
As there are many units the whole structure is called a polymer.
A sequence of three bases is the genetic code for a particular amino acid.
The order of bases controls the order in which amino acids are assembled to produce a particular protein.

Lesson 8: Proteins

Lesson overview

(*The concept that 'A sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein' is part of this lesson but it is all that students entered for a foundation paper will require from this lesson. The concept was also included in lesson 7 so that foundation tier students may miss out lesson 8 at the discretion of the teacher*.)

OCR specification reference

OCR B1.2d; OCR B1.2e

Learning objectives

- Describe how proteins are synthesised according to the DNA template of a gene.
- Explain that the genetic code of a gene specifies the protein to be made.

Learning outcomes

- Recall that DNA contains genes and each gene consists of a different sequence of bases. [O1]
- Understand that a sequence of three bases is a code for a particular amino acid. [O2]
- Explain that the base sequence is used to determine the order of amino acids in a protein. [O3]

Skills development

- WS 1.1b use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts
- WS 1.3i Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions.
- WS 1.4a Use scientific vocabulary, terminology and definitions.

Maths focus

- 1c Use ratios, fractions and percentages.

Resources needed Video of protein synthesis (search 'protein synthesis GCSE'); poster material. Worksheet 1.8.1 (standard demand); Worksheet 1.8.2 (high demand)

Digital resources

Key vocabulary amino acid, mRNA, ribosome, transcription, translation, triplet code

Teaching and learning

Engage

- **Write** the term 'amino acid' on the whiteboard. [O1, O2]
- Students should **discuss** in groups what they know about amino acids. Some students will already know that amino acids are used to make proteins. [O1, O2]
- Groups then **report back** their ideas in a class discussion. [O1, O2]

Challenge and develop

- **Explain** to students that amino acids are the basic units of proteins and that we obtain amino acids by eating proteins. [O1, O2]
- Ask the students to **suggest** what must happen to these amino acids so they become proteins again and how the structure of one protein may be different from another. [O2, O3]
- **Remind** students that a sequence of three bases is the code for a particular amino acid. The order of bases controls the order in which amino acids are assembled to produce a particular protein. [O2, O3] (*This concept was covered in Lesson 7; see note at the top of the page.)*

- Show the students a sequence of about 21 bases and ask them to **calculate** the number of amino acids it would put together. [O2, O3]

Explain

- Use a diagram or a video (search 'protein synthesis GCSE') to **explain** how the DNA code is used to make proteins. Explain that proteins are synthesised on ribosomes, according to a template. Carrier molecules bring specific amino acids to add to the growing protein chain in the correct order. They do not need to know the structure of mRNA or tRNA, but it is easier to explain the process if the terms are used. The Student Book refers to them as messenger molecules and carrier molecules; however, other sources of information used may have the correct names. [O1, O2, O3]
- **Explain** that, when the chain is complete, it folds up to form a unique shape. This unique shape enables the proteins to carry out their function. [O1, O2, O3]

Consolidate and apply

- Standard demand students then **complete** the questions on Worksheet 1.8.1, which has images to help them draw their diagram. [O1, O2, O3]
- High demand students then **complete** the questions on Worksheet 1.8.2, which has no images to help them draw their diagram. [O1, O2, O3]

Extend

Ask students able to progress further to:

- (high demand) **complete** Questions 5 and 6 on page 29 of the Student Book. [O3]

Plenary suggestions

- Ask the students to pair up; one member of each pair then **describes** the process of protein synthesis to their partner without the aid of the book.

  The second student should then **evaluate** their description, **explain** what they got right and what they missed out.

Answers to Worksheet 1.8

1. A pairs with T, and C pairs with G.
2. So that it can leave the nucleus; DNA molecules are too large to leave the nucleus.
3. three
4. Diagram should be similar to that in Student Book (pages 28 and 29).

Lesson 9: Explaining enzymes

Lesson overview

OCR specification reference

OCR B1.2f; OCR B1.2g

Learning objectives

- Describe what enzymes are and how they work.
- Explain the lock-and-key theory.

Learning outcomes

- Understand that enzymes are biological catalysts that speed up chemical reactions in living organisms. [O1]
- Use the lock-and-key theory to explain why enzymes are specific. [O2]
- Explain the effects of temperature and pH on enzyme activity. [O3]

Skills development

- WS 1.3e Interpreting observations and other data.
- WS 1.4a Use scientific vocabulary, terminology and definitions.
- WS 2a Carry out experiments.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.

Maths focus

- 4a Translate information between graphical and numeric form.

Resources needed Worksheet 1.9; Practical sheet 1.9; Technician's notes 1.9

Digital resources

Key vocabulary biological catalyst, denatured, lock and key, metabolism, optimum

Teaching and learning

Engage

- Show the students a beaker containing 20 cm^3 of hydrogen peroxide. Inform them that if left, the hydrogen peroxide will eventually turn into oxygen and water. [O1]
- Add a small piece of liver or yeast to the hydrogen peroxide.
- Ask the students to **suggest** what has caused the reaction to speed up. [O1]

Challenge and develop

- Discuss the reaction with students and introduce the terms 'enzyme', 'substrate', 'active site' and 'biological catalyst'. [O1]
- (Low demand) Ask students to **complete** section 1 of Worksheet 1.9. [O1]
- (Standard and high demand) Ask students to **write** a summary explaining what they have just seen using the terms 'enzyme', 'substrate', 'active site' and 'biological catalyst'. [O1]
- Students then **investigate** the effect of amylase on starch. They should set up the experiment, which then needs to be left for at least 10 minutes. [O1]

Explain

- While the test tubes are left in the water bath for 10 minutes, discuss with the students the idea of the lock-and-key theory. Ask the students to **suggest** why the enzyme in the liver is different from the one they are using with the starch. Link this to the terms 'substrate' and 'active site' mentioned earlier. [O1, O2]
- Ask students to **complete** their investigation and answer the questions on Practical sheet 1.9. [O1, O2]

Consolidate and apply

- Ask students to **suggest** why the investigation was carried out at 37 °C. If the investigation had been done at room temperature or at 100 °C, **predict** how the results might have been different. [O3]
- Ask students to **look** at the graphs on page 35 of the Student Book that show the effect of temperature and pH. Discuss the graphs with the students and explain the effects in terms of denaturing and collisions. [O3]
- Students then **complete** section 2, questions 1 and 2 of Worksheet 1.9. [O2, O3]

Extend

Ask students able to progress further to:

- (standard demand) **suggest** how they could change the investigation from the lesson to investigate the effect of temperature on amylase. [O3]
- (high demand) **complete** Question 3 on Worksheet 1.9. [O2, O3]

Plenary suggestions

- Sketch a graph on the board that shows the optimum pH for three different enzymes; peaks should be at approximately pH 2, pH 7 and pH 8. Ask the class to describe and explain the patterns they see in the graph.

Answers to Worksheet 1.9

1 Enzymes and chemical reactions

1. enzyme, oxygen, protein
2. enzyme, active (site)

2 Optimum conditions

1. 35 °C
2. Become denatured, active site changes shape, substrate can no longer fit into active site
3. Temperatures below 35 °C: molecules have less energy so fewer collisions, as temperature increases then more collisions occur so rate increases; high temperatures above 35°C: enzymes become denatured, active site changes shape, substrate can no longer fit into active site

Answers to Practical sheet 1.9

1. A reducing sugar
2. no
3. Active site on the catalase is the wrong shape for amylase to fit into; enzymes are specific.

Lesson 10: Practical: Investigate the effect of pH on the rate of reaction of amylase enzyme

Lesson overview

OCR specification reference

OCR B1.2f; OCR B1.2g

Learning objectives

- Describe how safety is managed, apparatus is used and accurate measurements are made.
- Explain how representative samples are taken.
- Make and record accurate observations.
- Draw and interpret a graph from secondary data using knowledge and observations.

Learning outcomes

- Use a water bath safely to control the temperature of an enzyme-controlled reaction. [O1]
- Measure the rate of the reaction by the colour change of an iodine indicator. [O2]
- Explain the effects of pH on the activity of amylase. [O3]

Skills development

- WS 2b Make and record observations and measurements using a range of apparatus and methods.
- WS 1.3e Interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.
- WS 1.3g Being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility.

Maths focus

- 1c Use ratios, fractions and percentages.

Resources needed Worksheet 1.10.1 (low demand); Worksheet 1.10.2 (standard demand); Worksheet 1.10.3 (high demand); Practical sheet 1.10; Technician's notes 1.10

Digital resources

Key vocabulary amylase, iodine, rate of reaction, starch

Teaching and learning

Engage

- Show the following pieces of apparatus: boiling tube containing starch solution, test tube of amylase solution, both tubes should be sitting in a water bath (electronic or beaker of water), dropping pipette, spotting tile containing drops of iodine solution.
- Mix the amylase and starch solutions and put them back into the water bath. Take a drop of the mixture and add it to one of the wells on the spotting tile; at this point the iodine solution should turn blue-black.
- Ask the students to **explain** what would happen if you took another sample from the mixture every 30 seconds for about 10 minutes.

Challenge and develop

- Show the students a bottle containing buffer solution. Explain that the buffer solution will maintain a constant pH. [O1, O2]
- Ask students to **suggest** how they could use the buffer solution and the demonstration they have just seen to investigate the effect of pH on amylase activity. [O1, O2]
- Students then **investigate** the effect of pH on amylase enzyme activity using Practical sheet 1.10. Each group should be given a pH to start at. If they complete that pH, they just move onto the next one. In this way

a range of pH values should be covered by the class with some repeats. The pH values used will depend on the those available in the school. However, the range should include strong acid, strong alkali and neutral. [O1, O2]

Explain

- Collect together the class results. Students then **complete** the questions about their investigation on Worksheet 1.10.1 (low demand), Worksheet 1.10.2 (standard demand) or Worksheet 1.10.3 (high demand). [O3]

Consolidate and apply

- Ask students to **evaluate** their investigation by answering the evaluation on their worksheet. [O3].

Extend

Ask students able to progress further to:

- (high demand) **complete** the questions on Q_{10} values on Worksheet 1.10.3. [O3]

Plenary suggestions

- Select individual students to **identify** one problem with their investigation and **explain** how they could improve the investigation to help solve the problem.

Answers to Worksheet 1.10

NB. Low demand: questions 1 and 2 of section 1 and all of section 2; standard demand: up to the end of section 2; high demand: all questions

1 Enzyme experiment

2.
   a. Should be pH 7 or close to this value
   b. Low and high pH may not have worked, as extreme pH may denature amylase.
   c. As the pH increases or decreases from optimum of pH 7, the time to breakdown the starch decreases
3. At high or low pH the shape of the active site changes so the starch molecule can no longer fit into it – amylase has become denatured.
4. Small intestine as lower pH in stomach would denature amyalse

2 Evaluating

1. Depends on the results
2. Main problem will be maintaining the temperature or identifying end point
3. Several repeats are needed so that anomalies can be identified

3 Calculating Q_{10}

1. 0.017/0.005 = 3.4, much higher than expected; inaccuracy in the investigation, such as maintaining temperature. Also they are measuring the change every 30 seconds this will not give them an accurate time for the investigation in which to measure rate.

Lesson 11: Cells at work

Lesson overview

OCR specification reference

OCR B1.3a; OCR B1.3b

Learning objectives

- Explain the need for energy.
- Describe aerobic respiration as an exothermic reaction.

Learning outcomes

- Identify a range of different reasons why different organisms need energy. [O1]
- Explain aerobic respiration as a word equation, with glucose as the source of energy. [O2]
- Relate the activity of a cell to the amount of mitochondria present. [O3]

Skills development

- WS 1.3e Interpret observations and other data.
- WS 2a Carry out experiments.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.

Resources needed Worksheet 1.11; Practical sheet 1.11; Technician's notes 1.11

Digital resources PowerPoint

Key vocabulary aerobic respiration, exothermic, respiration

Teaching and learning

Engage

- Ask students to work in pairs to **write a list** of why animals and plant cells need energy. They should use the pro forma in the worksheet. Ask pairs to **team up** with another pair, **comparing and adding** to their lists. Take feedback from the students and show them the PowerPoint, to see if they identified all the different reasons organisms need energy. [O1]

Challenge and develop

- Demonstrate the 'screaming jelly baby' experiment which shows energy release from glucose through a chemical reaction. See Practical worksheet 1.11 for details. See the video of this reaction on the BBC website (www.bbc.co.uk) by searching for 'aerobic and anaerobic respiration'. [O2]
- Explain that bread is made of starch, which comes from glucose. Ask students to **carry out an investigation** whereby they burn a known mass of bread over a boiling tube of water and **determine** the increase in temperature of the water. Ask students to make some inferences about glucose from the reactions. They should **deduce** that, when glucose is burnt in oxygen, an exothermic reaction takes place and lots of energy is released. Use the PowerPoint slide to explain what is happening. [O2]
- Ask students to **relate** these demonstrations to what happens inside cells. Ask them to **identify** where glucose and oxygen come from and how they get to the cells. Remind students of the role of mitochondria in cells using the PowerPoint slide. [O2, O3]

Explain

- Ask students to **annotate** the diagram of the human body on their worksheet to explain where the most sugar and oxygen are likely to be found. High demand students should write a full explanation of how these materials reach the cells, including the role of the heart and lungs. [O2]
- Ask low and standard demand students to **summarise** aerobic respiration as a word equation.

- Ask high demand students to **summarise** it as a balanced symbol equation. [O2]

Consolidate and apply

- Ask students to look at the different cell types on the worksheet. Ask them to **rank** these in order of which carries out the most aerobic respiration and ask them to say where the greatest concentration of mitochondria is likely to be found. They should **analyse the data** and use this to help them and **answer** the questions. [O2, O3]

Extend

Ask students who are able to progress further to:

- **carry out** some research and find out whether the statement 'animals respire more than plants because they move about more' is true or false. They should **use evidence** they uncover to back up their arguments.

Plenary suggestions

- Present students with the key words from the PowerPoint slide. Ask them to make up five sentences about what they have learnt using as many key words as possible.

Answers to Worksheet 1.11

1. Energy is needed:
   - to drive the chemical reactions that are needed to keep us alive
   - to build large molecules like proteins from smaller ones, such as amino acids
   - for movement
   - to make our muscles expand and contract
   - to keep our bodies warm and at a constant temperature
   - to transport substances around the body
   - for cell division
   - for active transport, whereby molecules are moved from a low concentration to a high concentration, for example, in mineral uptake in plants
   - to transmit nerve impulses.

2. Glucose comes from food – molecules are broken down in the digestive system and absorbed by the blood. They are transported by the blood to all cells.

   Oxygen comes from the air and is absorbed by the lungs into the blood. It is transported to all cells by red blood cells in our blood. The heart pumps the blood around the body to reach all cells.

   glucose + oxygen → carbon dioxide + water

   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

3. Muscle cell; sperm cell; nerve cell; red blood cell.

   Muscle cells will have the most mitochondria.

   1) Retinal eye cells have the most mitochondria and may be the most actively respiring cells.

   2) No; bacteria cells respire but do not use mitochondria; they have alternative mechanisms.

Lesson 12: Living without oxygen

Lesson overview

OCR Specification reference

OCR B1.3c

Learning objectives

- Describe the process of anaerobic respiration.
- Compare the processes of aerobic and anaerobic respiration.

Learning outcomes

- Describe the situations when aerobic and anaerobic respiration take place [O1]
- Write a word equation for anaerobic respiration [O2]
- Compare and contrast aerobic and anaerobic respiration [O3]

Skills development

- WS 1.2b Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.
- WS 1.3g Be objective, evaluate data in terms of accuracy, precision, repeatability and reproducibility and identify potential sources of random and systematic error.
- WS 1.4a Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.12

Digital resources PowerPoint

Key vocabulary anaerobic respiration, fermentation

Teaching and learning

Engage

- Show students the PowerPoint slide showing alcohol, bread and yeast. Ask students to **make a connection** between the images. Take feedback and **discuss** their ideas. [O1]

Challenge and develop

- Show students some readymade dough that has risen. Discuss what has happened to the dough and what has been added to the flour in the process. Use the PowerPoint slide in your discussion. [O1]
- Also show students a video from www.science.howstuffworks.com (search terms: 'episode 7: bread making'). [O1]
- Now show students the fermentation process of making alcohol using yeast. [O1] www.science.howstuffworks.com (search terms: 'episode 5: fermentation').
- Show the students the video 'Use of microbes in the food and drink industry': www.bbc.co.uk (search terms: 'microbes' and 'food and drink').
- Ask students to **plan** their own investigation into anaerobic fermentation by investigating conditions for making their own dough. See the worksheet for details. [O1]

Explain

- Ask students to **draw a cartoon strip** to explain the process of anaerobic respiration in fermentation. They should explain the process using a word equation. [O1, O2]
- High demand students should **write a balanced symbol equation** for the process. [O2]

Consolidate and apply

- Students should **compare and contrast** the key differences between aerobic and anaerobic respiration, on the worksheet. [O1, O2, O3]

Extend

Ask students able to progress further to:

- **draw a graph** of the data from the worksheet to **compare** the amount of carbon dioxide produced from the fermentation of yeast at different temperatures. They should **explain why** there might be differences. [O3]

Plenary suggestions

- Ask students to work in pairs and **prepare their own card sort** to compare and contrast the processes of aerobic and anaerobic respiration. They should **present** their cards to another pair to **sort out**. [O1, O2, O3]

Answers to Worksheet 1.12

1. *What are the variables in the investigation?* Amount of glucose, amount of yeast, temperature

   What will you choose as the independent variable? Amount of yeast (1 g, 2 g, 3 g, 4 g, 5 g and 10 g)

   What will the dependent variable be and how will you measure this? How high the bread rises

   What are the control variables and how will you control them? Same amount of glucose (e.g. 5 g); same temperature
   (35 °C), same amount of flour and water

   How will you produce reliable results? Repeat the investigation until results are consistent

   How can you check that your procedure is reproducible? Give the procedure to someone else to carry out

   How can you check that your procedure is repeatable? Carry it out again and see if the results are the same

   Sources of random error – not all the flour is mixed in to the same extent; yeast is unevenly distributed

   Sources of systematic error – not all the dough is warmed to the same 35 °C, there will be some heat loss.The same yeast cells are not being used; there may be genetic differences which affect the rate of respiration.

   Write your procedure here:

   Mix 100 g of flour to required amount of yeast. Add about 100 ml of warm water at 35 °C to ensure a smooth dough is produced. Mix thoroughly to make a smooth dough. Leave to rise at 35 °C for half an hour. Measure the height of the dough before and after rising. Repeat with another amount of yeast.

2. 2 Glucose → ethanol + carbon dioxide (+energy released)

   $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

3.

Aerobic respiration	Anaerobic respiration
Glucose used	Glucose used
Uses oxygen	No oxygen
Lots of energy produced	Some energy produced
	Use in fermentation
	Alcohol produced
CO_2 produced	CO_2 produced
Water produced	Water not produced

Extension

1. The amount of carbon dioxide increases linearly with temperature until 400 °C, after which there is a rapid decline.This is beacause enzymes in the yeast have denatured and therefore the rate of anaerobic respiration decreases. At 500 °C the yeast cells have nearly all died.
2. Place yeast at different water baths at different temperatures in the same conditions and measure the volume of carbon dioxide with a gas syringe. Use the same amount and species of yeast, the same type of sugar and the same amount of water.
3. There would be higher levels of carbon dioxide, but the overall shape of the graph would be the same.

Lesson 13: Enzymes at work

Lesson overview

OCR specification reference

OCR B1.3d; OCR B1.3e; OCR B1.3f

Learning objectives

- Explain how enzymes break down fats, proteins and carbohydrates.
- Name the sites of production and action of specific digestive enzymes.
- Interpret data about digestive enzymes.

Learning outcomes

- Understand that physical digestion increases the surface area of the food. [O1]
- Recall the enzymes, substrates and products of digestion in the different parts of the digestive system. [O2]
- Interpret data to link optimum pH of an enzyme with conditions inside the digestive system. [O3]

Skills development

- WS 1.3i Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions.
- WS 1.4a Use scientific vocabulary, terminology and definitions.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.

Resources needed Internet access; materials for making posters. Worksheet 1.13

Digital resources

Key vocabulary carbohydrase, lipase, monomer, polymer, protease

Teaching and learning

Engage

- Show students an image of a beef burger and ask them to **suggest** the food types found within the burger.
- Ask them to describe what would happen to the burger in the digestive system.

Challenge and develop

- Ask students to chew slowly on a piece of bread. They should then **describe** what happened to the bread in their mouths. [O1]
- Describe the difference between physical and chemical digestion and how the mouth can carry out both of these processes. Link back to the demonstration from the last lesson and their work on enzymes. [O1, O2]
- Ask low demand students to **complete** section 1 of Worksheet 1.13.

Explain

- **Discuss** the idea of the different enzymes in the digestive system and their function; include the substrate and products of each enzyme. [O2]

Consolidate and apply

- Students should then **produce** a PowerPoint presentation using the instructions on Worksheet 1.13 (section 2). [O1, O2, O3]
- Low demand students could be asked to **produce** a poster instead of the PowerPoint using the instructions on Worksheet 1.13 (section 3). [O1, O2, O3]

Extend

Ask students able to progress further to:

- **evaluate** the presentation of another group. [O1, O2, O3]

Plenary suggestions

- Ask individual students to present their PowerPoints to the class.

Answers to Worksheet 1.13

1 Digestion

1. broken, physical, swallow, stomach
2.

Food type	Enzyme	Products of digestion	Part of digestive system where digestion takes place
starch	carbohydrase / amylase	simple sugars / glucose	mouth and small intestine
protein	protease	amino acids	stomach and small intestine
fat	lipase	fatty acids and glycerol	small intestine

Lesson 14: Practical: Use a range of reagents to test for a range of carbohydrates, lipids and proteins

Lesson overview

OCR specification reference

B1.3d; B1.3e; B1.3f

Learning objectives

- Suggest appropriate apparatus for the procedures.
- Describe how safety is managed and apparatus is used.
- Describe how accurate measurements are made.
- Interpret observations and make conclusions.

Learning outcomes

- Able to use apparatus safely when completing food tests. [O1]
- Identify appropriate reagents used to test for carbohydrates, lipids and proteins. [O2]
- Interpret qualitative observations to identify the types of substances present in food. [O3]

Skills development

- WS 2.2 Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.
- WS 2.4 Carry out experiments.
- WS 2.6 Make and record observations and measurements using a range of apparatus and methods.
- WS 2.7 Evaluate methods and suggest possible improvements and further investigations.
- WS 3.1 Presenting observations and other data using appropriate methods.
- WS 3.5 Interpreting observations and other data.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Image of some food. Practical sheet 1.14.1 (low demand); Practical sheet 1.14.2 (standard and high demand); Technician's notes 1.14

Digital resources

Key vocabulary Benedict's test, carbohydrates, qualitative reagents

Teaching and learning

Engage

- **Show** students a picture of some food; this could be a beef burger to follow on from the previous lesson. [O2]
- **Discuss** with the students the chemicals within the food linking back to the ideas on digestion from the previous lesson. Can they remember the terms protein, carbohydrate and lipid and what these foods groups are needed for in the body. [O2]
- Ask the students to suggest how we can find out which food types are in the burger; they should have come across food tests in KS3 – they will have tested a leaf for starch so should know the iodine test.

Challenge and develop.

- Provide the students with Practical sheet 1.14.1 (low demand) or 1.14.2 (standard and high demand). **Discuss** the idea that we can use different chemicals to test for the different food groups. Some students can get confused by the terms food and food groups; explain that we eat food and that food is made up of the chemicals our body needs; we divide those chemicals into different groups, carbohydrates, lipids and protein. Carbohydrates are further split into starch and sugar. [O1, O2]
- Ask the students to **complete** the practical. They will be testing different food for sugar, starch, proteins and lipids. [O1, O2]
- Before they start they should **produce** a results table that can show all their observations; Practical sheet 1.14.1 has a template that low demand students could use. [O1, O2]
- Low demand students will find it difficult to cope with four methods and different foods. They should be given just the one food substance to start with and asked to do the tests on that alone. [O1, O2]

Explain

- **Discuss** the results of the practical with the class. [O2, O3]
- Ask students to **suggest** any improvements they could have made to their investigation. [O2, O3]

Consolidate and apply

- Low demand should **complete** questions 1–4 on pages 40–41 of the Student Book. [O2]
- Standard demand students should **complete** questions 1–6 on pages 40–41 of the Student Book. [O2]
- High demand students should **explain** to the students that Benedict's reagent produces a series of colours depending on the amount of sugar present. Ask the students to **discuss** how they could compare the sugar content of two different foods. Ideas should include the need for controlling temperature in a water bath and time, as well as the mass of each food sample and the volume of Benedict's reagent used. [O2, O3]

Extend

Ask students able to progress further to:

- **complete** the ‘Interpreting observations’ section on page 41 of the Student Book. [O3]

Plenary suggestions

- Put the following words on the whiteboard: starch, glucose, protein, lipid, Benedict's, biuret, ethanol, iodine, purple, blue-black, red, milky white. Ask the students to match the words into four groups.

Answers to Practical sheet 1.14

Evaluation

1. They should find all the food types present; they may not all be found in each food tested as this will depend on the plant material
2. Some observations are difficult as the food colour may affect the colour observed; biuret change can be difficult to spot
3. Improvements could include crushing the food, dissolving the food in water first, holding the tubes against a white background to see the colour change more clearly

Lesson 15: Looking at photosynthesis

Lesson overview

OCR specification reference

OCR B1.4a; OCR B1.4b

Learning objectives

- Explain the importance of photosynthesis.
- Explain how plants use the glucose they produce.

Learning outcomes

- Understand that photosynthesis is an endothermic reaction that converts light energy to chemical energy. [O1]
- State that carbon dioxide and water are the raw materials used in photosynthesis and that glucose and oxygen are the products. [O1]
- Describe the functions of fats, oils, cellulose, starch and proteins in the plant. [O3]

Skills development

- WS 1.1a Understand how scientific methods and theories develop over time.
- WS 1.2b Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.
- WS 2a Carry out experiments appropriately.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.

Maths focus

- 3d Solve simple algebraic equations.
- 4a Translate information between graphical and numeric form.

Resources needed Time-lapse photography of growing plants (search Internet for 'plant growth time lapse'). Image of a woodland in autumn. Worksheet 1.15; Practical sheet 1.15; Technician's notes 1.15

Digital resources

Key vocabulary endothermic, veins

Teaching and learning

Engage

- Show students a time-lapse video of a plant growing. Ask students to **discuss** what the plant needs for growth. [O1]
- Ask students to **predict** what would happen if the plant could not get any light. [O1]

  Students should **provide reasons** for their prediction, which can then lead into the next part of the lesson.

Challenge and develop

- Show students a variegated leaf. Explain that the white part of the leaf does not have any chlorophyll so cannot photosynthesise. Ask the students to **predict** if starch would be found in the white part of the leaf. [O1]
- Ask standard and high demand students to **plan** how they could test their prediction using the method on page 46 of the Student Book (Explaining photosynthesis). They could use Worksheet 1.15 investigation plan to help them plan their investigation.
- Low demand students should be provided with Practical sheet 1.15; this gives the method for them.

Explain

- Discuss the idea of light energy being needed and that the energy is taken in and converted to chemical energy. Ask them to **decide** if that makes the process an endothermic or exothermic reaction. [O1]
- Low demand students should **answer** the questions on Practical sheet 1.15. [O1]
- Standard and high demand students should **complete** the questions on interpreting results on Worksheet 1.15. [O1, O2]

Consolidate and apply

- Ask students to **suggest** what happens to the glucose produced in photosynthesis other than being stored as starch. [O2]
- Discuss the different uses of glucose in the plant with the students. Explain to high demand and standard demand students why the relative solubility of glucose and starch requires glucose to be converted to starch for storage. [O2, O3]
- Students should **answer** all the questions in the Student Book. [O1, O2, O3]

Extend

Ask students able to progress further to:

- (high demand) **write** a summary that **explains** why deforestation may be linked to global warming. [O1]

Plenary suggestions

- Explain to students that to maximise growth a gardener may add carbon dioxide to their greenhouse. Ask them to **suggest why**. Then ask them to **explain why** lighting a greenhouse with green light would not be much use.

Answers to Worksheet 1.15

Investigation plan

1. Students should predict that there will be no starch present as there are no chloroplasts.
2. This should include the following: beakers, boiling tube, kettle or heating apparatus, ethanol, white tile, iodine solution, leaves, tongs, forceps, eye protection.
3. Ideas may include:
    - Ethanol is flammable, so do not use near a Bunsen flame.
    - Iodine solution stains, so do not get onto hands.
    - Using harmful chemicals, so wear eye protection.
    - Boiling tube may get hot, so use tongs to remove from hot water.
4. Methods may vary but the basic idea is the one seen in the Student Book. For example:
    - Put the leaf in a beaker of hot water and leave for 1 minute.
    - Take out the leaf, put it into a boiling tube and cover it with ethanol.
    - Put the tube into a beaker of hot water.
    - Pour the ethanol into a waste beaker and dip the leaf back into the hot water to remove the ethanol.
    - Spread the leaf out on the white tile.
    - Add about five drops of iodine to the leaf and leave for 2 minutes.

Interpreting results

1. This will depend on their prediction and results but the iodine solution on the white area should remain orange.
2. Photosynthesis is when the plant uses light energy to make carbohydrates. Starch will be found in the cells that photosynthesise. The cells in the white area have no chloroplasts. The chlorophyll in the chloroplasts is needed to absorb the light. No starch is made as there is no photosynthesis taking place inside these cells.

Answers to Practical sheet 1.15

1. green
2. chlorophyll
3. Photosynthesis only takes place in the green part where chlorophyll is present.

Lesson 16: Explaining photosynthesis

Lesson overview

OCR specification reference

OCR B1.4c; OCR B1.4d

Learning objectives

- Identify the raw materials and products of photosynthesis.
- Describe photosynthesis by an equation.
- Recall that photosynthesis is a two-stage process that takes place in chloroplasts.
- Explain gas exchange in leaves.

Learning outcomes

- State the word and symbol equations for photosynthesis. [O1]
- Explain that glucose can be converted to other substances in plants. [O2]
- Interpret photosynthesis investigations to explain the direction of gas exchange in leaves. [O3]

Skills development

- WS 1.1b Use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 1.2c Apply a knowledge of a range of techniques, instruments, apparatus and materials to select those appropriate to the experiment.
- WS 2a Carry out experiments.

Resources needed Images of unusual plants. These can be found by searching ‘amazing plants’. Sort cards for photosynthesis equations. Worksheet 1.16; Technician’s notes 1.16

Digital resources

Key vocabulary carbohydrate, chlorophyll

Teaching and learning

Engage

- Show students images of some very different plants that they may not have seen before. These could include *Lithops*, corpse flower, Venus flytrap or pitcher plant.
- Ask students to **discuss** why all the plants seen need carbon dioxide. [O1]
- Ask students to **predict** what would happen if all the plants in the world died. Students should **provide** reasons for their prediction, which can then lead into the next part of the lesson. [O1, O2]

Challenge and develop

- Provide the students with the words and symbols that make up the equation for photosynthesis. This can be in the form of sort cards or written on the whiteboard. Students then **rearrange** them to produce the correct word equation (standard demand) or symbol equation (high demand). [O1]
- Show students a leaf that has been partially covered in black card and another from a plant that has had no carbon dioxide. Ask the students to **predict** if starch would be found in any parts of either leaf. [O2]
- Each group could be given a leaf that has been given a different condition (partially covered by black card / left without carbon dioxide / left in full light with carbon dioxide). They should not be told the conditions the leaves were left in. [O1]
- Ask students to **test** the leaves for starch. They should use the same method used in the last lesson. [O1]

Explain

- Ask each group to inform the rest of the class which of the conditions the leaves were left in and to **explain** how they know this. [O1]
- Ask students to **complete** 'Testing a leaf for starch' on Worksheet 1.16. [O1]
- Explain that there are two stages of photosynthesis. Use the word equations from earlier in the lesson to describe how light energy splits the water molecule, releasing oxygen (as a gas) and hydrogen ions (1) and that the hydrogen then reacts with the carbon dioxide to make glucose (2).

Consolidate and apply

- Low demand: List the following words on the whiteboard: cellulose, oxygen, starch, protein. Read out a use for one of these substances and ask the students to **choose** the substance that matches the use. [O2]
- Standard demand: Students should **complete** the table 'Using glucose' on Worksheet 1.16. [O3]
- High demand: List the following words on the whiteboard: glucose, nitrates, amino acids, proteins. Ask the students to **write** a paragraph that links all the words together and **explains** how plants make proteins (detail of chemical reactions and molecular structure is not required at this level). [O2, O3]
- Ask students to look at the gas exchange investigation on spread 1.16 of the Student Book. In groups ask students to **interpret** the results of the investigation. Then as individuals they **complete** the questions. [O3]

Extend

Ask students able to progress further to:

- (high demand) **predict** what would happen if a snail had been placed in tube 2 with the leaf and **explain** their prediction. (The indicator is likely to stay orange or turn yellow depending on how fast the plant uses carbon dioxide released by the snail.) [O3]

Plenary suggestions

- Ask students to **suggest** reasons why our understanding of the reactions of photosynthesis has changed over time.

Answers to Worksheet 1.16

1 Testing a leaf for starch

1.

Questions	**Observations**		
	left in full light with carbon dioxide	partially covered by black card	left without carbon dioxide
What colour did the leaf turn when iodine was added?	blue-black	area covered is orange; uncovered is blue-black	orange
Did any part of the leaf contain starch?	all of it	uncovered areas	no

2. Needs light and carbon dioxide

2 Using glucose

1.

Substances	**How it is made**	**Uses**
starch	by building glucose into large starch molecules	storage of energy
proteins	by combining sugars with nitrate ions and other minerals to make amino acids for protein synthesis	growth repair
lipids	by turning sugar molecules into fats and oils for storage	energy store
cellulose	by building sugars into large cellulose molecules	make cell walls

2. Respiration

Lesson 17: Practical: Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed

Lesson overview

OCR specification reference

OCR B1.4d; OCR B1.4e

Learning objectives

- Use scientific ideas to develop a hypothesis.
- Use the correct sampling techniques to ensure readings are representative.
- Present results in a graph.

Learning outcomes

- Identify the variables when investigating the effect of light on photosynthesis. [O1]
- Construct a graph to show the effect of light on photosynthesis. [O2]
- Evaluate the investigation and suggest improvements. [O3]

Skills development

- WS 2a Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements, and health and safety considerations.
- WS 2b Make and record observations and measurements using a range of apparatus and methods.
- WS 2c Presenting observations and other data using appropriate methods.
- WS 2d Communicating the scientific rationale for investigations, methods used, findings and reasoned conclusions.

Maths focus

- 1a Recognise and use expressions in decimal form.
- 1c Use ratios, fractions and percentages.
- 2g Use a scatter diagram to identify a correlation between two variables.
- 4a Translate information between graphical and numeric form.
- 4b Understand that $y=mx+c$ represents a linear relationship.
- 4c Plot two variables from experimental or other data.

Resources needed Worksheet 1.17; Practical sheet 1.17.1 (low demand); Practical sheet 1.17.2 (standard demand); Practical sheet 1.17.3 (high demand); Technician's notes 1.17

Digital resources

Key vocabulary chloroplasts, hypothesis, light intensity, mesophyll cells, photosynthesis

Teaching and learning

Engage

- Show students a video of pondweed producing bubbles of oxygen (search videos for 'pondweed oxygen production'). The video should not show how to investigate the rate of photosynthesis just oxygen being produced. Alternatively show them the actual apparatus they will be using in their investigation.
- Explain to students that they can use the apparatus to measure the rate of photosynthesis. [O1]
- Ask students in groups to **list** on mini-whiteboards the variables that might affect the rate of photosynthesis. As a prompt tell them to think about the equation for photosynthesis. [O1]
- Groups report back on their lists to compile a complete list on the main whiteboard.

Challenge and develop

- Explain to students that they are going to use the apparatus to measure the rate of photosynthesis and how it may be affected by light intensity. [O1]

- Ask students to **list** on mini-whiteboards the variables that they would change, measure and control. [O1]
- Ask students to **state** a question they could test about light intensity and photosynthesis. This could be: 'Will increasing the light intensity increase the rate of photosynthesis?' [O1, O2]
- Provide students with Practical sheet 1.17.1 (low demand), Practical sheet 1.17.2 (standard demand) or Practical sheet 1.17.3 (high demand). Ask them in groups to **measure** the rate of photosynthesis. As this can take a long time, it is suggested that each group starts with a different distance. [O1]

Explain

- Low demand students should **complete** questions on Practical sheet 1.17.1.
- Standard demand students should **complete** questions on Practical sheet 1.17.2.
- High demand students should **complete** the questions on Practical sheet 1.17.3. [O1, O2, O3]

Consolidate and apply

- Ask students to **suggest** how they could change their investigation to find out about the effect of temperature or carbon dioxide levels on the rate of photosynthesis. [O3]

Extend

Ask students able to progress further to:

- (high demand) **complete** the questions on Worksheet 1.17. [O2, O3]

Plenary suggestions

- Collate the class results. Ask students to **decide** if the class results were reproducible. Ask them to **explain** the difference between reproducible and repeatable.

Answers to Worksheet 1.17

1. 0.2 = 25, 0.4 = 6.25, 0.6 = 2.78, 0.8 = 1.56
2. The idea that there are other factors involved in photosynthesis so it does not follow a simple rule; e.g. when get close to the lamp it is already at a maximum and cannot increase anymore

Answers to Practical sheet 1.17

NB. Low demand: questions 1–4 and 6; standard demand: questions 1–4, 6 and 7; high demand: all questions

1. Number of bubbles produced
2. Distance or lamp / light intensity
3. Size of pondweed, lamp, amount of carbon dioxide, temperature (to some extent if large beaker is used)
4. Water spillage could result in somebody slipping so clear up any spillages; lamp could get hot, let it cool down before moving it
5. The *x*-axis should be 'distance of light' and the y-axis 'average number of bubbles per minute'; line of best fit should be a curve through most points – the shape should show more bubbles when the lamp is closer.
6. For example, the closer to the pondweed you place the lamp, the more bubbles you get.
7. More light absorbed so more energy for photosynthesis and more oxygen released; levels off as you get closer as other factors have an effect
8. Not very accurate as bubbles will be different sizes so they may suggest measuring the volume of gas produced
9. How repeatable the results were will depend on their results; it is unlikly that the repeated results are close together for each distance.

Lesson 18: Increasing photosynthesis

Lesson overview

OCR specification reference

OCR B1.4e; OCR B1.4f

Learning objectives

- Identify factors that affect the rate of photosynthesis.
- Interpret data about the rate of photosynthesis.
- Explain the interaction of factors in limiting the rate of photosynthesis.

Learning outcomes

- State that the rate of photosynthesis is affected by temperature, light intensity, carbon dioxide levels and the amount of chlorophyll. [O1]
- Interpret graphs of photosynthesis rate involving one limiting factor. [O2]
- Explain graphs of photosynthesis rate involving two or three factors and decide which one is the limiting factor. [O3]

Skills development

- WS 1.1b Use models to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 1.3b Translating data from one form to another.
- WS 1.4a Use scientific vocabulary, terminology and definitions.

Maths focus

- 4a Translate information between graphical and numeric form.

Resources needed Worksheet 1.18; Technician's notes 1.18

Digital resources

Key vocabulary limiting factor, tundra

Teaching and learning

Engage

- Show students the images on spread 1.18 of the Student Book – Plants in different habitats.
- Ask students to **discuss** Questions 1 and 2 in pairs. [O1]
- Then, as a class, **produce** a combined list of factors affecting photosynthesis in each habitat.

Challenge and develop

- (Low demand) **Discuss** the idea that growth of a plant will depend on the rate of photosynthesis.
- (Low demand) Ask students if they have noticed when grass grows the most – summer or winter? Students then **complete** 'Photosynthesis and growth' on Worksheet 1.18. [O1, O2]
- (Standard and high demand) Show students a graph of light intensity against rate of photosynthesis. There is one on spread 1.18 of the Student Book. Ask the students to **compare** the graph with their results from the previous lesson. Why is it a different shape? (They plotted number of bubbles not rate so the curve was the other way round.) [O1, O2]
- (Standard and high demand) Ask students to **suggest** why the graph levels off. Introduce the term 'limiting factor' and explain that at the start light is the limiting factor; at the end it is something else, such as carbon dioxide levels. [O1, O2]

Explain

- Ask students to **complete** the 'Limiting factors 1' questions on Worksheet 1.18. [O1, O2]

Consolidate and apply

- Ask students to **produce** a summary of what they know about photosynthesis. They should include ideas from all five lessons. The summary can be in the form of bullet points or a mind map. (High demand candidates should miss out this activity and complete the Extend instead.)

Extend

Ask students able to progress further to:

- (high demand) **complete** 'Limiting factors 2' and 'Limiting factors 3' on Worksheet 1.18. [O3]

Plenary suggestions

- Try the 'true or false' activity given in the Technician's notes.

Answers to Worksheet 1.18

1 Photosynthesis and growing

1. 65
2. June. Temperatures are getting warmer, there is maximum light and also water is available so the grass photosynthesises more and grows more.
3. Temperatures are too low so the grass does not grow.

2 Limiting factors 1

1. Carbon dioxide concentration
2. Carbon dioxide is no longer the limiting factor; it might be light or temperature or the amount of chlorophyll.

3 Limiting factors 2

1. light intensity
2. For line C there is a higher temperature so rate can increase faster than for D as light intensity increases; line C levels off at a higher rate as D will be limited by the lower temperature.
3. For line A there is a higher level of carbon dioxide so rate can increase faster than for C as light intensity increases; line A levels off at a higher rate as C will be limited by the lower levels of carbon dioxide.

4 Limiting factors 3

1. 130 units into the plant
2. The light intensity is not the limiting factor; some other factor is limiting the reaction.
3. about 200 arbitrary units
4. They are equal.

Lesson 19: Maths skills: Extracting and interpreting information

Lesson overview

Learning objectives

- To extract and interpret information from tables, charts and graphs.

Learning outcomes

- Able to interpret data in a table. [O1]
- Able to construct a graph when given a table of data. [O2]
- Able to interpret data in a graph. [O3]

Skills development

- WS 1.3a Presenting observations and other data using appropriate methods.
- WS 1.3b Translating data from one form to another.
- WS 1.3c Carrying out and representing mathematical and statistical analysis.
- WS 1.3e Interpreting observations and other data.

Maths focus

- 2c Construct and interpret frequency tables and diagrams, bar charts and histograms.
- 2g Use a scatter diagram to identify a correlation between two variables.
- 4a Translate information between graphical and numeric form.
- 4c Plot two variables from experimental or other data.
- 4d Determine the slope and intercept of a linear graph.

Resources needed Worksheet 1.19.1 (low demand); Worksheet 1.19.2 (standard demand); Worksheet 1.19.3 (high demand)

Digital resources

Key vocabulary classify, compare, correlation, trend

Teaching and learning

Engage

- Ask students to look at Figure 1.53 on page 53 of the Student Book.
- In groups ask students to **write down** five different pieces of information from the graph. Explain that we are not just looking for the pattern but information about the axes and scales.
- Each group should then **report** back to the class; expected ideas may include the trend, the labels on each axis, the two different scales.
- Ask them if they can spot any missing information (there are no units or title).

Challenge and develop

- Use the starter activity to lead into a discussion about interpreting data from graphs and tables. **Explain** that when a set of results has been obtained from an investigation it is often important to draw a graph to identify any trends. However, sometimes this can be done directly from the table. [O1]
- Ask the students to **identify** the trend in the results table on page 52 of the Student Book. Explain that their answer must refer to the headings in both columns (often they will just say ‘it goes up’). Encourage them to look for an ‘er’ ‘er’ statement – for example, ‘the high**er** the light intensity, the high**er** the rate of photosynthesis’. [O1]

- Ask the students to **suggest** what sort of graph they would draw from the data, bar chart or line graph? Once you have determined it is a line graph, ask them to **suggest** some data that would need a bar chart (e.g. eye colour of a class). [O1, O2]

Explain

- Low demand students **answer** questions 1 and 2 on page 52 of the Student Book. [O1, O2, O3]
- Standard and high demand students **answer** questions 3 and 4 on page 53 of the Student Book. [O2, O3]

Consolidate and apply

- Low demand students then use Worksheet 1.19.1 to construct a table of results, draw a graph and interpret the data. The low demand students may also need help with the scale on their graph. [O1, O2, O3]
- Standard demand students use Worksheet 1.19.2 to construct a table of results, draw a graph and interpret the data. [O1, O2, O3]
- High demand students use Worksheet 1.19.3 to construct a table of results, draw a graph and interpret the data. [O1, O2, O3]

Extend

Ask students able to progress further to:

- **explain** the difference between a line graph and a scatter graph. (The line on a line graph connects each data point; whereas the line of a scatter graph – if drawn – just shows the trend.)

Plenary suggestions

- Draw two axes on the board. Invite students to **draw** a line on the graph that represents different relationships. For example, zero correlation, negative correlation, higher temperature – faster reaction.

Answers to Worksheet 1.19.1

1. Units of seconds and cm^3 added to headings, time in ascending order with matching volumes
2. Time should be on *x*-axis and volume on *y*-axis.
3. As time increases, so does the volume of oxygen; it then levels off at 120 seconds.

Answers to Worksheet 1.19.2

1. Units of seconds and cm^3 added to headings, time in ascending order with matching volumes
2. Headings of '3 g of liver' and '9 g of liver' added to the two columns under volume heading
3. Axes as per worksheet 1.19.1; two lines plotted separately and clear indication as to which is which
4. As per worksheet 1.19.1 for 3 g of liver; for 9 g of liver: same pattern but the volume collected is higher for each time interval
5. 9 g of liver will conatin more enzyme so the reaction can go faster.

Answers to Worksheet 1.19.3

1. Table drawn with correct headings including units of seconds and cm3 added, time in acending order with matching volumes; headings similar to that on Worksheet 1.19.2 (plus '15 g of liver')
2. Axes as per Worksheet 1.19.2; three lines plotted separately and clear indication as to which is which
3. As per answer to Worksheet 1.19.2 (plus 9 g and 15 g are similar)
4. This will depend on line of best fit but approximately – 3 g = 0.13 cm^3/s, 9 g and 15 g = 0.3 cm^3/s
5. 9 g of liver will conatin more enzyme so the reaction can go faster, students may understand that there are more active sites available for the reaction to take place quicker. 9 g and 15 g are similar as the enzyme is not limiting the reaction, instead it could be limited by hydrogen peroxide concentration or temperature.