Collins

DRAFT

AQA GCSE (9-1)

Biology

Teacher Pack

Advance draft material for the 2016 specifications

Louise Smiles
Series editor: Ed Walsh

How the lesson plans work

Every chapter and every lesson plan follows the same structure.

Chapter introductions

- give an overview of the of the content and skills covered in the chapter
- help in assessing prior learning and identifying misconceptions
- list the overarching learning objectives to help medium-term planning.

Learning objectives and outcomes

- **Learning objectives** for each topic are listed and also shared with students in the Student Book for short-term planning.
- **Learning outcomes** at three levels are listed, and it is shown which learning activities contribute to achieving each outcome.
- **Skills development** show how the lesson will develop aspects of working scientifically.

Resources needed and digital resources

These give an overview of all the resources needed for a lesson. Every lesson has an associated differentiated worksheet to support written work. Practical sheets are provided to give support for planning, carrying out and analysing practical work. Technician's notes are provided to explain the materials and setup and help with planning. These can be downloaded from the Collins website at www.collins.co.uk/GCSEscience.

Key vocabulary

This is highlighted throughout to support literacy.

Teaching sequence

The lesson plans all use the same learning sequence. This is based on the idea that learning develops in stages during a lesson and that different parts of the lesson have different functions. In addition to the learning cycles, the lesson plans all have three levels of differentiation: low, standard and high.

- **Engage** This section draws students in to thinking about the ideas, and includes possible starter activities. Here students encounter ideas that will make them want to find out more.
- **Challenge and develop** Students meet something that will challenge their existing understanding. It might be questions, ideas, demonstrations or experiments that make them realise the inadequacy of a simpler explanation.
- **Explain** Students are encouraged to develop a good explanation and supported in capturing ideas in words or graphically. Differentiation ideas are given for students making less or more than expected progress.
- **Consolidate and apply** Students realise how the new learning is to be consolidated and applied, including real-world applications. Again, differentiation ideas are given for students making different levels of progress.
- **Extend** Addresses how the ideas of the topic can be extended to stretch students able to progress further.
- **Plenary suggestions** Varied activities help in gauging student progress.
- **Answers** All answers to worksheet questions are provided.

Cell Biology: Introduction

When and how to use these pages

This unit: builds on ideas that the cell is the building block of life. Cells can be specialised and be part of multicellular or unicellular organisms, like bacteria. This chapter links to all chapters where the structure and functions of different systems are considered, for example, Photosynthesis and Health and where meiosis is explained.

Overview of the unit

In this unit, 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 describe how cells divide by mitosis and applications of this in cloning techniques. The use of stem cells in producing new tissues and organs will be evaluated in terms of ethical and moral considerations. Students will consider the differences between aerobic and anaerobic respiration, and learn about the uses of anaerobic respiration in baking and brewing. They will learn how to grow cultures of bacteria safely and investigate the effectiveness of different disinfectants on bacterial growth.

This unit 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, evaluate the effectiveness of disinfectants by preparing bacterial cultures and use graphical skills to analyse data in a number of different contexts. Students will debate the use of embryonic stem cells in terms of moral and ethical considerations.

Obstacles to learning

The students may need extra guidance with the following terms and concepts:

- Cells and related topics are all abstract concepts and are hard to visualise. The use of cell models may help some students to make and see 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.
- Mitosis is also a difficult concept to follow, and the use of models will help students see the process more clearly and follow the stages more easily. Students often think that cells grow by simply becoming bigger, rather than by cell division.
- The idea that stem cells can become a nerve cell, or a muscle cell, can also be difficult for students to come to terms with.
- Students may believe that bacterial cells are the same as animal cells.
- Respiration is often confused with breathing, and needs to be linked to the mitochondria within cells so its roles within each cell can be emphasised.

Practicals in this unit

In this unit students will do the following practical work:

- Prepare plant and animal slides and observe them using a light microscope
- Investigate the amount of energy in food
- Prepare uncontaminated cultures of bacteria
- Required Practical: Investigate the effect of antiseptics on bacterial growth

	Lesson title	**Overarching objectives**
1	Looking at cells	Describe the structure of eukaryotic cells and functions of subcellular components.
2	The light microscope	How to observe animal and plant cells using the light microscope and the limitations it has.
3	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.
4	Primitive cells	Describe the differences between prokaryotic and eukaryotic cells and how they might have evolved over time.
5	Cell division	Describe the process of mitosis using models.
6	Cell differentiation	Explain the importance of cell differentiation and link specialised cells to their tissues, organs and body systems. Describe the organisation within a multicellular organism.
7	Cancer	Describe what cancer is and the factors that can trigger cells to become cancerous.
8	Stem cells	Describe the function and uses of stem cells. Compare the use of embryonic and adult stem cells and their ethical implications.
9	Stem cell banks	Explain the uses and risks of using stem cells in medicine, evaluating their benefits and disadvantages.
10	Key concept: Cell development	Revise ideas about cell structure, division and stem cells. Describe how plant meristems can be used in cloning.
11	Cells at work	Explain the process of aerobic respiration.
12	Life without oxygen	Describe the process of anaerobic respiration and compare it to aerobic respiration. Plan an investigation to factors affecting anaerobic respiration in dough making.
13	Growing microorganisms	Describe how to prepare uncontaminated cultures of microorganisms and how bacteria reproduce.
14	Investigating disinfectants	Investigate and evaluate the effectiveness of disinfectants on the growth of bacteria.
15	Size and number	Making estimates, ratio and proportion, standard and decimal form.

Cell Biology: Lesson 1

Lesson overview

Learning objectives

- Describe the structure of eukaryotic cells
- Recognise the order of magnitude of 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 4.1 Use scientific vocabulary, terminology and definitions.
- WS 4.2 Recognise the importance of scientific quantities and understand how they are determined.
- WS 4.5 Interconvert units.

Maths focus

Recognise and use expressions in standard form

Resources needed Worksheets 1.1.1, 1.1.2 and 1.1.3

Digital resources PowerPoint

Key vocabulary DNA, 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 5 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 5 from the Student Book to help or use PowerPoint slide 3 to demonstrate how to compare orders of magnitude.
- Higher demand, standard demand and lower demand to carry out the appropriate card sort: lower demand, Worksheet 1.1.1; standard demand, Worksheet 1.1.2; higher demand, Worksheet 1.1.3.

  Provide students with the card sort of different sizes 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]
- Lower, standard and higher demand to carry out the appropriate task (Worksheets 1.1.1, 1.1.2 and 1.1.3, respectively).

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 length with this diameter of a hair. Ask students to **draw conclusions** about the sizes of cells. [O2]

Explain

- Ask students to **read** page 4 of the Student Book to remind them of the different parts of the animal and plant cell. 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 3 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 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 Worksheets 1.1.1, 1.1.2 and 1.1.3

1.

1 m	1 metre		100 cm	103 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	

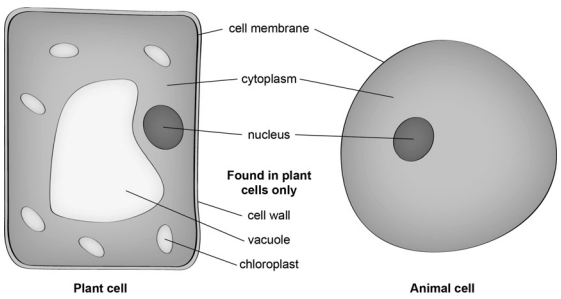
2.

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



Cell Biology: Lesson 2

Lesson overview

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 1.2 Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 2.6 Make and record observations and measurements using a range of apparatus and methods.
- WS 4.2 Recognise the importance of scientific quantities and understand how they are determined.

Maths focus

Make order of magnitude calculations

Resources needed Worksheet 1.2.1; Practical sheet 1.2.1; Technician's notes 1.2.1

Digital resources PowerPoint

Key vocabulary iodine, magnification, methylene blue, resolving power

Teaching and learning

Engage

- Show students some images of plant or animal cells from the PowerPoint slide. Ask students to **identify** whether they are plant or animal cells. They should justify their responses. Ask students how we came to obtain such images. [O2]
- Use the PowerPoint slide to demonstrate how the light microscope works. Students should **read** page 6-7 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 text book to determine the magnification of different objects. [O2, O3]

  Provide students with Practical Sheet 1.2. Ask them to **follow** the procedures given to produce a slide of a cheek and 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 on the light microscope. They could **carry out** further research on this if required. [O1]

- Higher demand

  Students should **explain** how to work out the actual sizes of the objects from the microscope. [O3]

Extend

Ask students 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 1.2.1

Explaining differences

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

Animal cells will 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

Cell Biology: Lesson 3

Lesson overview

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 understanding cellular structures [O3]

Skills development

- WS 1.1 Understand how scientific methods and theories develop over time.
- WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.3.1

Digital resources PowerPoint

Key vocabulary mitochondria, ribosome, scanning electron microscope, transmission electron microscope

Teaching and learning

Engage

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

  Where do the images come from?

  What might they be of?

  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 1.3 ‘What is inside a cell’ section (Lower demand, Q1–3; standard demand, Q4; higher 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 page 36.

- 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 able to progress further to:

- **Research** other structures that have been found by electron microscopes and **present** a case to the class for further impact these inventions have had on the development 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 1.3.1

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 are possible
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, cell membrane, vacuole and nucleus inside plant and animal cells.

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

The electron microscope has enabled us to have a better understanding of how cells work and how to fight against viral 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 cell must be alive
5) Chloroplast – electron
6) Embryo dividing – only optical as cell 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
10) Fertilisation taking place – only optical as cell must be alive

Cell Biology: Lesson 4

Lesson overview

Learning objectives

- Describe and explain the differences between prokaryotic cells and eukaryotic cells
- Explain how prokaryotic and eukaryotic cells evolved over time

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 1.1 Understand how scientific methods and theories develop over time.
- WS 3.6 Present reasoned explanations including relating data to hypotheses.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.4.1

Digital resources PowerPoint

Key vocabulary domain, genome, nucleic acid, plasmid, prokaryotic

Teaching and learning

Engage

- Show students the PowerPoint slide of the oldest fossil on earth. Ask students to **generate five questions** 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 they would like to find the answers to. [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]
- Lower 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]
- Students should **read** the section on Archaean bacteria and **answer** the questions from the Student Book. [O3]

Explain

- Students should **explain** whether prokaryotic or eukaryotic cells are more successful with evidence to back up their ideas. [O1, O2, O3]

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

Extend

Ask students able to progress further to:

Research mitochondria and chloroplasts further 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 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

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

Cell Biology: Lesson 5

Lesson overview

Learning objectives

- Describe the process of mitosis in growth, and mitosis as part of the cell cycle
- Describe how the process of mitosis produces cells that are identical genetically to the parent cell

Learning outcomes

- Recognise why cells need to be replaced, grow and multiply [O1]
- Describe the steps in mitosis [O2]
- Explain which cells undergo mitosis and explain why all cells do not [O3]

Skills development

- WS 1.2 Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 3.1 Present observations and other data using appropriate methods.

Resources needed Worksheets 1.5.1 and 1.5.2, Technician's notes 1.5.1

Digital resources PowerPoint

Key vocabulary cell division, chromosomes, DNA, growth, mitosis, nucleus

Teaching and learning

Engage

- **Show** students a model using bubbles of cell growth. See the technician's notes for details. **Question** students about how they think cells grow. [O1]
- **Show** students a short video of bacterial cells growing. Emphasise this has been vastly speeded up. It can be found by searching 'dividing bacteria' at the following link www.cellsalive.com. **Question** students about what they think is happening and explain they will find out during the lesson. [O1]

Challenge and develop

- Students should **look at** the images of chromosomes, nucleus and DNA from the PowerPoint slide, and, working in pairs, they should **explain** the relationship between them in the worksheet. Show students the PowerPoint slide and ask them to **correct** their diagrams. [O1, O2]
- Show students the images in the worksheet showing cells dividing, or in the video http://www.dailymotion.com, which can be found by entering the search terms 'stages of mitosis'. Students should **identify** five things they can see in the images. [O2]
- Students should **make models** of chromosomes using pipe cleaners. Students should use their model and other materials **to demonstrate** what is happening during the cell cycle. They could **use the information** in the Student Book to help them or the PowerPoint slide. [O2]

Explain

- Ask students to **write an explanation** about what is happening in mitosis, which cells undergo this and how often. They should **consider** which cells do not undergo mitosis and why this is so. Ask students to **identify** where the energy and raw materials for mitosis might come from. [O1–O3]

Consolidate and apply

- Ask students to **read** the section about chromosomes from the Student Book and **answer** the questions. [O1, O2]

- Students could **use the data** from the worksheet and **draw a graph** of the life span of each of the cells identified.

  Lower demand (Worksheet 1.5.1) – **draw data** from just one table and **answer** respective questions. [O1]

  Standard and higher demand (Worksheet 1.5.2) – **draw data** from both tables and **answer** respective questions. [O1, O3]

Extend

Ask students able to progress further to:

- **Find out** the differences between binary fission and mitosis. They could **compare** the advantages and disadvantages of each process. [O1–O3]

Plenary suggestions

- Ask students to **decide** if the statements on the PowerPoint slide are true or false. [O1–O3]
- Show students images from the PowerPoint slides showing the different stages in mitosis. Ask students to **arrange** the images in order of each sequence. [O2]

Answers to Worksheet 1.5.1 and 1.5.2

1. The nucleus of the cell is made up of chromosomes.
   In every human cell, except the sex cells and red blood cells, there are 23 pairs of chromosomes inside the nucleus. Each chromosome is one strand of DNA. DNA is our genetic material. It gives instructions to the cells about the chemical reactions which keep us alive and make us human.
   Five things could be: 1) Two cells are made from every one; 2) the new cells are the same size as the original; 3) inside the nucleus the chromosomes are pulling apart; 4) the dividing cells are twice as big as the parent cell; 5) the cytopasm is also replicating.

2. Explaining mitosis:
   Each chromosome makes a copy of itself. This is to ensure each new cell has the same genetic material. Each copy of a chromosome migrates to opposite ends of the cell. The cytoplasm also replicates. This ensures each new cell has all the materials it needs in order to carry out all its reactions. The cell divides into two. Each cell has the same number of chromosomes as the original cell and is usually an exact copy. These are daughter cells. They are exact copies so they can carry out the same work as the original cell.

3. Low demand:
   1) Egg cell
   2) Liver cells
   3) No pattern

   Standard and high demand:

   1) Their life span is short because they have to be made by other cells. They are very active cells and therefore do not last very long.

   2) If cells are much more complicated, like nerve cells, it is inefficient to keep on making new ones. It is better to have cells that last much longer.

   3) They are constantly being worn away and need to be replaced.

Cell Biology: Lesson 6

Lesson overview

Learning objectives

- Explain the importance of cell differentiation
- Understand size and scale in relation to cells, tissues, organs and body systems
- Describe how cells, tissues, organs and organ systems are organised to make up an organism

Learning outcomes

- Name some specialised cells and explain how their structure is adapted to their function [O1]
- Explain the hierarchy of organisation in a multicellular organ system [O2]
- Describe the scale of size in relation to cells, tissues, organs and body systems [O3]

Resources needed Worksheet 1.6.1

Digital resources PowerPoint

Key vocabulary differentiation, organ, specialised, system, tissue

Teaching and learning

Engage

- Pair talk: students should **discuss** the questions: are all cells the same? How do they know? Why might cells be different? How different can they be? [O1]
- Ask students to work in pairs and **write down** the names of as many organs, tissues and specialised cells as they can. Ask pairs to **join** another pair and **add** to their ideas, and groups of fours to join another group of four and again, **add** to their lists. They should **complete** the table in the worksheet. [O1, O2]

Challenge and develop

- If possible show students some real slides of different types of animal and plant cells, including root hair cells, red blood cells, palisade cells and muscle cells. Alternatively show students images of these cells on PowerPoint slides. Ask students to **identify** the cells as animal or plant cells and **justify** their reasons. [O1]
- Ask students to **read** page 14 of the Student Book to explain how cells become differentiated. Provide students with the worksheet and ask them to **explain** how each of the cells are adapted to carry out their jobs. [O1]
- Provide students with images to show how a multicellular organism is organised and of all the organ systems present. Students should **sort** the cards in their respective organ systems and order of levels of organisation.

Explain

- Show students the image in the Student Book of a foetus. Students should **write** an explanation of how the different cells were formed and why different cells are needed. They should **explain** the levels of organisation in the foetus. [O1, O2]

Consolidate and apply

- Students could **build scale 3D models** of specialised cells, their tissues, organs and systems, using the data from the worksheet. [O1–O3]
- Ask students to work with another group. They should **use** their three dimensional model or role play **to explain** the organisation in the body for two different systems. They should **explain** the features of any specialised cells in the system and the function of these cells within the system. [O1–O3]

Extend

Ask students able to progress further to:

- **Compare and contrast** the organisation in a multicellular organism with that of a single celled organism, like a bacterium. They could **explain** the advantages and disadvantages of each. [O2]

Plenary suggestions

Play 'lucky dip'. Have a bag with different word cards from the card sort. Ask one student to pick one card from the bag. They should **identify** the type of cell in the organ system, **explain** how it is adapted to perform its job and **describe** the tissues and organs it is related to. [O1, O2]

Ask students to return to the list they produced in the table at the start of the lesson. They should **correct** any misconceptions and add to their list. They should **complete** any gaps and **add** to their list, so that all aspects of the hierarchy are filled for all the suggestions they made. [O1, O2]

Answers to Worksheet 1.6.1

1.

Skeletal system	Bone cell	Bone	Bone marrow
Reproductive system	Egg cell	Ovary	Epithelial tissue
Cardiovascular system	Red blood cell	Artery	Epithelial tissue
Respiratory system	Alveoli	Lung	Epithelial tissue
Nervous system	Motor neurone	Eye	Retina
Endocrine system		Adrenal gland	Glandular tissue
Digestive System		Stomach	Epithelial tissue
Excretory system		Kidney	
Integumentary system	Sweat glands	Skin	Connective tissue

2.

a) Sperm cell: tail for swimmining; large head packed with chromosomes; lots of mitochondria for energy
b) Red blood cell: no nucleus so maximum area for haemoglobin; bow-shaped body to increase surface area; thin cell membrane for shortest diffusion path so oxygen can enter quickly and be released quickly
c) Muscle cell: long fibrous elastic strand which can expand and contract; large blood capillary network surrounding it for oxygen and glucose; lots of mitochondria
d) Nerve cell: long axon for transmitting messages; axon is protected by insulative layer so electrical conductivity remains in the axon; cell body contains many mitochondria; synapses release chemical messages

Cell Biology: Lesson 7

Lesson overview

Learning objectives

- Describe cancer as a condition resulting from changes in cells that lead to their uncontrolled growth, division and spread
- Understand some of the risk factors that trigger cells to become cancerous
- Use data to analyse and evaluate the impact of cancer

Learning outcomes

- Describe what cancer is and factors that cause it to occur [O1]
- Explain why cancer causes damage and death [O2]
- Use and analyse data to evaluate different types of cancer [O3]

Skills development

- WS 1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise.
- WS 3.5 Interpret observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.
- WS 3.6 Present reasoned explanations including relating data to hypotheses.

Resources needed Worksheets 1.7.1, 1.7.2 and 1.7.3

Digital resources PowerPoint

Key vocabulary benign tumour, carcinogen, malignant tumour, mutation, secondary tumour

Teaching and learning

Engage

- Ask students to work in pairs and **discuss** what they already know about cancer and if anyone close to them has had it. Be aware of the sensitivities around this topic. [O1]
- Show students the PowerPoint slide of tumorous tissues. **Discuss** these slides with students. Ask students: What can they deduce about cancer from these images? [O1]

Challenge and develop

- Students should **look at** all the stages of cancer in the worksheet. Students should **answer** the differentiated questions in the worksheet about this flow diagram.

  Lower demand, answer questions 1–3 on Worksheet 1.7.1; standard demand answer questions 1–3 on Worksheet 1.7.2 and higher demand answer questions 1–3 on Worksheet 1.7.3. [O1, O2]
- Show and **discuss** with students the newspaper article on Angelina Jolie and breast cancer. Ask students why it was she might have taken this decision, even though she did not have breast cancer. [O1, O2]
- Go to www.dailymail.co.uk and enter the search terms ‘Angelina Jolie’ and ‘double mastectomy’.
- Students should **analyse** and **evaluate** the data in the worksheet and **answer** the questions relating to this. [O3]
- Show and **discuss** with students the PowerPoint slides and/or some short videos relating to different types of cancers and causes of cancer.

Explain

- Students should **write an explanation leaflet** for a doctor's surgery, explaining what cancer is, how it is obtained and which people are most likely to be at risk. They should **use data** from the Student Book and/or other sources to back up their arguments. [O1, O2]

Consolidate and apply

- Students should work in groups of four. They should **role play** an interview in the doctor's surgery using the role play information cards in the worksheet. Students should **read** the information in the cards and **use further information** from the lesson to **prepare** what they will say. The doctor **needs to decide** who needs to have an X-ray to see if cancer is present and who just needs some antibiotics. [O1, O2, O3]

Extend

Ask students able to progress further to:

- **Research further data** to establish which type of cancer causes the most deaths in the world and why. They should **try and explain** why certain types of cancer are more likely and why others are very rare. [O2, O3]

Plenary suggestions

- Ask students to **write a list** of 10 questions they need to ask someone if they suspect they might have cancer. [O1, O2]
- Ask students to work in small groups and **produce** a 1 minute talk to explain why breast and lung cancer are the most common forms of cancer in the UK.

Answers to Worksheet 1.7.1, 1.7.2 and 1.7.3 questions

1.

Worksheet 1.7.1 (lower demand)

a) Uncontrollable growth of cells

b) Mitosis

c) In a different part of the body

Worksheet 1.7.2 (standard demand)

a) Uncontrollable growths can cause blockages in blood supplies, pressure on organs and stop organs from functioning properly.

b) More parts of the body are affected and cancer growths use up more of the body's oxygen and glucose in their growth. People are more tired and lose a lot of weight quickly. More blockages occur in the body, affecting more organs.

c) Through the blood

Worksheet 1.7.3 (higher demand)

a) They need oxygen and glucose and nutrients to reproduce and grow, so they need their own blood supply for these nutrients and to remove their waste.

b) The capillary would burst and cells relying on the capillary would die.

c) Because it is caused by your own body cells. Your immune system does not recognise that these cells are enemy cells.

2.

a) As the amount of animal fat increases, the death rate by breast cancer increases.

b) More developed and richer countries

c) More developed countries are likely to have a greater rate of breast cancer.

d) No; genetic factors and other health factors have not been taken into account.

e) The genetic factors related to breast cancer need to be accounted for; the age of the women in the study; and other factors like exposure to radiation, UV radiation, whether women smoke, and if they are exposed to other chemicals that cause cancer.

Cell Biology: Lesson 8

Lesson overview

Learning objectives

- Identify cells as being differentiated or stem cells
- Describe the function of stem cells in embryonic and adult animals
- Explain how stem cells can be useful

Learning outcomes

- Describe and recognise stem cells [O1]
- Explain how stem cells can be used to cure diseases and damaged tissues and organs [O2]
- Evaluate the advantages and disadvantages of using stem cells in ethical and moral terms [O3]

Skills development

- WS 1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise.
- WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Plants that have been grown from cuttings; or a plant from which cuttings may be taken, rooting hormone; Worksheets 1.8.1 and 1.8.2

Digital resources PowerPoint

Key vocabulary adult stem cell, culture, embryonic stem cell, in vitro fertilisation, therapeutic cloning

Teaching and learning

Engage

- Ask students to **name and draw** some differentiated cells. Show them the PowerPoint which shows the cells of an embryo. Ask students to **describe** the different types of cells they see. Ask students to **discuss** in pairs how ordinary cells turn into specialised cells. [O1]
- Show students cuttings of plants that have been grown into new plants, or demonstrate taking a cutting from a plant. Ask students to **discuss** in pairs how different plant structures might have been grown from simple cuttings. [O1]
- Introduce the term stem cell as a cell that is undifferentiated, using the PowerPoint slide. Explain that under the right hormonal and genetic signals stem cells can be turned into a cell with a particular function. [O1]

Challenge and develop

- Ask students to **watch** the following video on the use of stem cells. [O1, O2]
- www.cells4life.co.uk (search terms: ‘video’ and ‘how do stem cells work’)
- Show students the PowerPoint slides of different types of stem cells and applications relating to them. [O1, O2]

Ask students to **read** and **discuss** the information in Worksheet 1.8.1 (lower and standard demands) or Worksheet 1.8.2 (higher demand) and answer the differentiated tasks relating to it.

Low and standard demand

Write a list of the advantages and disadvantages of using stem cells.

Why are some religions against the use of stem cells?

High demand

Write an argument: Do the benefits outwiegh the moral arguments against the use of human embryonic stem cells? Explain your answer [O1–O3]

Explain

- Students should **read** the section on stem cells from page 18 of the Student Book. They should **write an explanation** for another class of where different stem cells come from and how they can be used by doctors and scientists. [O1, O2]

Consolidate and apply

- Ask students to **write and present a news bulletin** on what stem cells are and what applications they could have for the future. They should **use information** from the lesson to **explain** the advantages and disadvantages. [O2, O3]

Extend

Ask students able to progress further to:

- **Watch** the video on tissue engineering using stem cells. www.cells4life.co.uk (search terms: 'video' and 'tissue engineering')

  They should **use** this to **prepare** their own PowerPoint presentation to **present** to the class about different applications of stems cells and some of the problems scientists have had to overcome to grow tissues and organs. [O2, O3]

Plenary suggestions

Ask students to work in small groups and **make up** 10 questions about stem cells. Each group should present their questions to another group to **answer**. [O1, O2]

Students should **present a case** for whether they are for or against the use of stem cells, **using reasoned arguments**. [O1–O3]

Answers to questions on Worksheet 1.8.1

1. **Advantages of using stem cells:**
   Replacement of blood, tissues, for example, bone, skin and eye, repair damage to organs and nerve cells. Millions of people may benefit.

   Disadvantages:
   Human stem cells are painful to remove and may introduce disease. Embryos have the right to live; interfering with stem cells is unnatural, against religious beliefs.

   Some religions believe that life starts at the moment of conception and it is wrong to interfere with its development.

Cell Biology: Lesson 9

Lesson overview

Learning objectives

- Explore the use of stem cells in medicine
- Identify the risks in using stem cells
- Evaluate the benefits and disadvantages of using stem cells

Learning outcomes

- Explain the uses of stem cells in medicine [O1]
- Describe what is meant by the term therapeutic cloning [O2]
- Explain the advantages and disadvantages in using different techniques for producing stem cells [O3]

Skills development

- WS 1.3 Appreciate the power and limitations of science and consider any ethical issues which may arise.
- WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.9.1

Digital resources PowerPoint

Key vocabulary donor, gene, mutation, therapeutic cloning, umbilical cord

Teaching and learning

Engage

- Ask students to **write** their own true or false statements about stem cells from the previous lesson. [O1]
- Ask students to **complete** the first activity on the worksheet. They should **identify** the similarities and differences between stem cells from embryos, from plants and from adult humans. [O1]

Challenge and develop

- Show students the video on using stem cells to make new heart muscle cells to recap the benefits of using stem cells www.eusem.com (search terms: 'ComScience', 'events' and 'stem cells') [O1]
- Show students the PowerPoint slides on the uses of umbilical cord and therapeutic cloning as alternatives for the production of stem cells, rather than using human embryos. [O1, O2]
- Provide students with a card sort on stem cells and their uses. Ask them to **group** the cards into common areas. [O1, O2, O3]
- In small groups, students should use the card sort to **produce a list** of benefits and risks for the use of different types of stem cells. [O3]

Explain

- Students should **write a letter** to their local MP to either to support or to refute the use of stem cells. They should support their arguments with evidence from the last two lessons. They should **explain** how stem cells are available from different areas. [O2, O3]

Consolidate and apply

- Ask students to work in small groups. They should **imagine** they will provide a significant sum of money to sponsor scientific developments. Ask them to **justify** which cause it will go to, adult or embryonic stem cell development? They should **explain** why they have not chosen to sponsor development in stem cell technology from other areas. [O1, O2, O3]

Extend

Ask students able to progress further to:

- **Research the legislation** surrounding the use of stem cells and explain why this has changed over the years. Students could **evaluate** the impact this has had on scientific developments and ethical considerations. [O2, O3]

Plenary suggestions

Ask students to **summarise** the arguments for and against the use of embryonic stem cells, adult stem cells, embryonic stem cells and therapeutic cloning on the worksheet.

Answers to Worksheet 1.9.1

Card sort

Embryonic stem cells	Therapeutic stem cells	Umbilical cord stem cells	Adult stem cells
Many stem cells are produced which can be made into any other cell in the body	Many stem cells could be produced by this articifical technique	This is a rich source of stem cells formed from a waste product	Small numbers of stem cells are found mainly in the bone marrow, blood vessels, skin and other organs
Egg cells need to be extracted, which can be painful and infections are possible	The stem cells produced will closely match the patient	No painful or intrusive techniques applied	Require often painful techniques to extract them
Storage of embryos requires a lot of energy and space. There is a time limit for how long they can be stored	Human egg cells need to be extracted, which can be painful and infections can arise	These stem cells have been used to treat a variety of blood disorders	Rejection of stem cells implants are a problem, if used on other humans
Immunosuppressant drugs are needed to avoid rejection of tissues and organs developed	Minimal use of immunosuppressant drugs will be needed, as the stem cells will closely match the patient	Immunosuppressant drugs will be needed if the cells are used to develop bones and other tissues	Immunosuppressant drugs are needed
Embryos are produced specifically for making stem cells and then discarded. This raises ethical issues.	An embryo is produced by this technique which is discarded once stem cells have been extracted	There are no ethical issues relating to the use of these stem cells, only consent from the mother is needed	No ethical issues relating to the use of these stem cells

Summary of arguments for and against

Embryonic stem cells	Therapeutic stem cells	Umbilical cord stem cells	Adult stem cells
For Many stem cells available Can be turned into any type of cell All tissues and organs could be possibly grown	**For** Many stem cells available Can be turned into any type of cell All tissues and organs could be possibly grown Fewer immunosuppressant drugs and rejection issues as stem cells from patient are used	**For** Many stem cells are available No embryos are involved Already successfully used in treating blood disorders for children	**For** Own cells can be used so rejection issues are minimal and few immunosuppressant drugs needed No embryos are involved
Against Ethical issues with the use of human embryos Immunosuppressant drugs will be needed Technology is still developing Other stem cells could be used without using human embryos	**Against** Ethical issues with the use of human embryos Technology is still developing Other stem cells could be used without using human embryos	**Against** Immunosuppressant drugs will be needed Only success with blood disorders, other types of tissues are at a developmental stage	**Against** Only a few stem cells are available Not all cell types can be grown Painful techniques needed to extract stem cells

Cell Biology: Lesson 10

Lesson overview

Learning objectives

- Revise ideas about cell structure, cell division and stem cells
- Apply ideas about cells to unfamiliar contexts
- Describe how plant meristems can be used in cloning

Learning outcomes

- Make links between cell structure, cell division and stem cells [O1]
- Compare the structure and function of fungi and viruses to normal cells [O2]
- Compare the use of meristems in cloning with animal cell cloning [O3]

Skills development

- WS 1.2 Use a variety of models such as representational, spatial, descriptive, computational and mathematical to solve problems, make predictions and to develop scientific explanations and understanding of familiar and unfamiliar facts.
- WS 1.4 Explain everyday and technological applications of science; evaluate associated personal, social, economic and environmental implications; and make decisions based on the evaluation of evidence and arguments.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Worksheets 1.10.1 and 1.10.2

Digital resources PowerPoint

Key vocabulary meristems, virus, yeast

Teaching and learning

Engage

- Ask students to work in pairs and **make a word wall** on poster paper. They should **split** the paper into four sections. On each of the sections they should **discuss and write down** all the words relating to animal cells, plant cells, cell division and cloning, respectively. [O1]
- Students should **join** another pair and compare the words on their posters. Discuss and check students' ideas as a class and ask them to **add in** any omissions. [O1]

Challenge and develop

Low and standard demand

- Ask students to **read** the first section from the Student Book or use the PowerPoint to **discuss** the structure of a fungus. Ask students to then **complete** task 1 from Worksheet 1.10.1 where they **compare** this structure to the typical animal and plant cell. [O2]
- Check students' ideas using PowerPoint slide. [O2]

High demand

- Students should **read** the section on viruses in Worksheet 1.10.2. They should **answer** the questions in the worksheet and **justify** the point of view that a virus is not living. [O2]
- Show students PowerPoint and discuss the importance of meristems in cloning. They should **discuss** animal and plant cloning in pairs and **compare** the use of meristems with animal cloning, on the worksheet. [O3]

Explain

- Ask students to **explain** how different cells, or organisms, divide and what form they become in the end. They should **answer** this on the worksheet. [O1–O3]

Consolidate and apply

- Students could draw an annotated diagram of what happens in the cloning of plants. They should **explain** on the diagram where mitosis occurs and **use as many key words** from their word wall as they can.

Extend

Ask students able to progress further to:

- **Find out** more about other types of cell division, for example, meiosis. They could **compare and contrast** mitosis, meiosis, budding and forms of asexual reproduction. [O1]

Plenary suggestions

Students could be asked to write all the definitions of the words on their word wall.

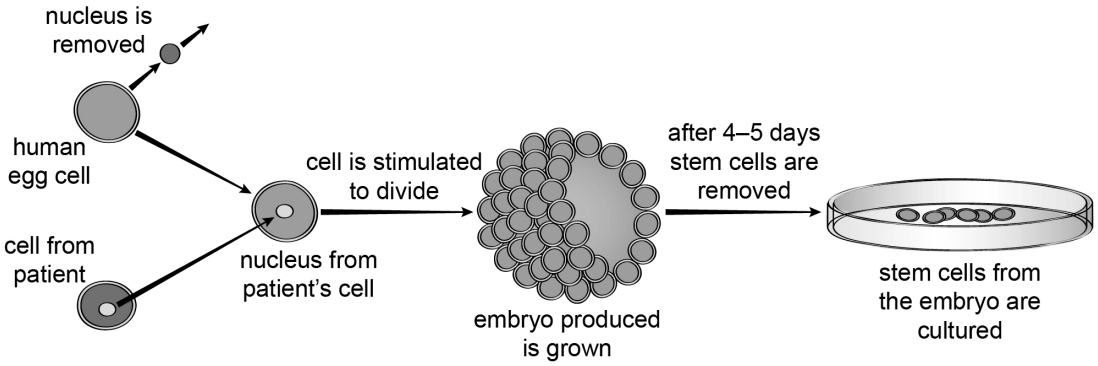
They should **make up** at least five short paragraphs **connecting** words from each section of the word wall together.

Answers to Worksheets 1.10.1 and 1.10.2

1. **Worksheet 1.10.1:**
   Fungi have cytoplasm, nucleus, mitochondria and ribosomes. There are no divisions between the cells and the cytoplasm and many nuclei run throughout the fungus. There are no chloroplasts. It does not have a cell membrane between cells. There is also a cell wall.

   Worksheet 1.10.2:
   a) (Viruses posses) genetic material
   b) The virus is completely dependent on other cells for reproduction; it cannot do this by itself. It does not excrete, respire or feed.

2. How animal cells are cloned:



Similarities	Differences
Identical daughter cells produced Daughter cells have same number of chromosomes as parent Stem cells are used	Nucleus of meristem cells do not have to be removed No electrical shock is needed No ethical considerations with the use of meristems Only cells from one organism are involved

3.
   a) Mitosis – two new animal cells – identical daughter cells to parent cell
   b) Mitosis – two now plant cells – identical daughter cells to parent cell
   c) Mitosis – differentiated cells – identical daughter cells – different to parent cell
   d) Mitosis – differentiated cells – identical daughter cells – different to parent cell
   e) Budding – two new yeast cells – identical daughter cells to parent cell

Cell Biology: Lesson 11

Lesson overview

Learning objectives

- Recognise that all organisms respire
- Explain respiration as the process of making 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 2.4 Carry out experiments appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.
- WS 2.6 Make and record observations and measurements using a range of apparatus and methods.
- WS 3.5 Interpret observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions.

Resources needed Worksheet 1.11.1; Practical sheet 1.11.1; Technician's notes 1.11.1

Digital resources PowerPoint

Key vocabulary active transport, aerobic respiration

Teaching and learning

Engage

- Ask students to work in pairs and **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, **compare and add** to their lists. Take feedback from the students and show them PowerPoint, to see if they identified all the different reasons organisms need energy. [O1]

Challenge and develop

- Demonstrate the 'screaming jelly baby' experiment which also shows energy release from glucose through a chemical reaction. See Practical worksheet 1.11 for details of each. 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** where 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 and 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 now look at the different organisms and cells in the worksheet. Ask them to **rank** these in order of which will undergo aerobic photosynthesis the most to the least and where the greatest concentration of mitochondria are likely to be found. They should **analyse the data** and use this to help them and **answer** the questions relating. [O2, O3]

Extend

Ask students 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

1. Energy is needed:
   - To drive chemical reactions 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, where molecules are moved from a low concentration to a high concentration, for example, 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.

Cell Biology: Lesson 12

Lesson overview

Learning objectives

- Describe the process of anaerobic respiration
- Explain when anaerobic processes occur
- 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 2.2 Plan experiments or devise procedures to make observations, produce or characterise a substance, test hypotheses, check data or explore phenomena.
- WS 3.7 Be objective, evaluate data in terms of accuracy, precision, repeatability and reproducibility and identify potential sources of random and systematic error.
- WS 4.1 Use scientific vocabulary, terminology and definitions.

Resources needed Worksheet 1.12.1

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, in the worksheet. [O1–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

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.

Cell Biology: Lesson 13

Lesson overview

Learning objectives

- Describe the techniques used to produce uncontaminated cultures of microorganisms
- Describe how bacteria reproduce by binary fission
- Calculate the number of bacteria in a population

Learning outcomes

- Describe how to prepare an agar plate culture of microorganisms [O1]
- Explain how binary fission differs to mitosis [O2]
- Analyse data from agar plates and make inferences [O3]

Skills development

- WS 1.5 Evaluate risks both in practical science and the wider societal context, including perception of risk in relation to data and consequences.
- 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 appropriately having due regard for the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations.

Resources needed Worksheet 1.13.1; Practical sheet 1.13.1; Technician's notes 1.13.1

Digital resources PowerPoint

Key vocabulary agar plate, autoclave, bacteria, colony, incubation, inoculating loop, nutrient broth, Petri dish, sterilisation

Teaching and learning

Engage

- Show students the clip about bacteria (search terms: 'microorganisms and us') at www.bbc.co.uk. [O1]
- Ask students work in pairs and **discuss** where they think the most number of bacteria may be found in our bodies and why. Ask students to **discuss** how they might investigate this idea. Take feedback from students' ideas. [O1]

Challenge and develop

- Show students the short clip of bacteria dividing (search terms: 'Escherichia coli') at www.cellsalive.com. [O1, O2]
- Ask students to **look at** the population growth chart of bacteria in the worksheet and on the PowerPoint slide. In pairs, ask them to **discuss** the results and why it might have this pattern. [O3]
- **Discuss** with the class how this data might have been obtained and use the PowerPoint slides to support.
- Show students the video of growing bacteria (search terms: 'microorganisms and bacteria') at www.bbc.co.uk

  Ask students to **discuss** how binary fission compares and contrasts to mitosis. Use the PowerPoint slides to help. [O1–O3]
- Demonstrate how to produce an agar plate of bacteria. Pay strict attention to the need for following safety guidelines and ensuring the dishes are not completely sealed so some oxygen can get in and prevent the growth of pathogenic bacteria. Again the PowerPoint slides can be used to help. [O1, O2]
- Ask students to **follow the instructions** on the Practical sheet and produce their own cultures of bacteria from swabbing everyday items or their hands. [O1]

Explain

- Show students a set of results from the worksheet. Ask them to **explain the observations** and **draw conclusions** from the data. They should **answer** the differentiated questions from the worksheet. [O1, O3]

Consolidate and apply

- Ask students to **write** their own practical instructions to find out if animals carry more or less bacteria than humans. [O1]
- Ask students to **read** the section about binary fission from the Student Book and **explain how it works** in a flow diagram. [O1, O2, O3]
- Students should **compare and contrast** binary fission with mitosis. [O3]

Extend

Ask students able to progress further to:

- **Find out** about how the first bacteria were grown and how aseptic techniques were developed so bacteria could be studied further. [O1, O2, O3]

Plenary suggestions

- **Show** students the short video to show how penicillin was first discovered at www.bbc.co.uk (search terms: 'Fleming and the discovery of penicillin').
- **Ask** students to explain what they see and to write some instructions to Mr Fleming about how to safely make up an agar plate. Ask them to predict the outcomes if he had been extremely safe and followed aseptic procedures. [O1, O3]

Answers to Worksheet 1.13.1

1. Bacteria first grow at a steady rate, which then increases directly proportionally, and then remains constant before decreasing rapidly.

   The first part is steady as there is no replication of bacteria. They are getting used to their environment. In the second part they are increasing at a constant rate as each bacteria becomes two. Then the population growth becomes steady as some begin to die off due to lack of nutrients, or lack of space, or build up of toxic waste products. Here growth rate = death rate. Finally bacteria begin to die due to lack of nutrients.

2. a) **Low demand** (*Describe in full what you see on the agar plates*)**:**

   First plate shows uneven distribution of red bacterial growth with more growing on the edges than in the centre. Second plate shows relatively even distribution of two different types of bacteria, yellow and white. They are growing round the centre and hardy any grow round the edges. The final slide shows lots of different species of bacteria growing in specific places, where they have been placed.

   Standard and high demand:

   In the first plate the way the plate was innoculated suggests that the edges were swiped first before the centre. Or there is something in the centre that is killing the bacteria off. In the second plate, there are even amounts of white and yellow, but not as much growth has taken place as in the first so the bactreria are in clumps. Maybe as they are growing each type is producing something toxic to the other type. In the third, the sample contains lots of different types of bacteria; some are growing faster than others, that is why some spots are greater than others.

   b) Prepare 3 agar plates using the techniques shown in the lesson. Take a sterilised swab from a hand and dab it onto the agar plater; do the same with a animal paw and leave the third as a control. Seal the plates, leaving an air gap and incubate for 2–3 days at 25 °C.Take care to disinfect all equipment afer use.

3.

Binary Fission	Mitosis
Cells divide into two	Cells divide into two
Circular strand of NA replicates	All chromosomes replicate
Circular strands migrate to opposite ends of the cell	Chromosomes line up at the centre before parting to opposite ends
Cytoplasm replicates and divides into two	Cytoplasm replicates and divides into two
Two identical daughter cells are formed, identical to the parent	Two identical daughter cells are formed, identical to the parent

4. Instructions as per practical sheet, with special attention to using sterilised equipment. If Fleming had used these instructions, antibiotics would not have been discovered.

Cell Biology: Lesson 14

Lesson overview

Learning objectives

- Carry out experiments with due regard to health and safety
- Present and process data, identifying anomalous results
- Evaluate methods and suggest further investigations

Learning outcomes

- Describe how to investigate the effect of disinfectants on bacteria [O1]
- Present and analyse data [O2]
- Evaluate methods and suggest improvements and methods to reduce the growth of bacteria [O3]

Resources needed Worksheet 1.14.1; Practical sheet 1.14.1; Technician's notes 1.14.1

Key vocabulary antiseptic, bacteria, diffusion, incubation, sterilisation

Teaching and learning

Engage

- Look at the agar plates students produced from last lesson, or ones prepared for the lesson. **Identify** which plates produced the greatest number of bacterial colonies and which produced the greatest variety. [O1]
- Tell students that now we know bacteria are everywhere, ask 'How can we keep ourselves safe from bacteria?' **Discuss** their ideas. [O1]
- Show students a range of different disinfectants. Ask students to work in small groups and **plan** an investigation on the worksheet that would enable them to find out which disinfectant was the best value for money. [O1]
- Take feedback from the students and **discuss** their ideas. [O1]

Challenge and develop

- Ask students to **swap** their plans with another group. Ask them to **look at** the procedure from the practical worksheet and **peer assess** the practical plans. They should **highlight** the strengths and weaknesses from the plans. [O1]
- Students should **follow** the given procedure with utmost care and precision, paying great attention to safety, and produce their own agar plates to test different disinfectants. [O1]
- Ask students to **read** the labels of the disinfectants and **predict** which are the most likely to kill off the most bacteria. Ask students to **draw a diagram** to **predict** what the plate would look like after a few days and then after a few weeks. [O2]

Explain

- Show students a set of results from the worksheet after a few hours and then after a few days. Ask students to **explain** these results using ideas about binary fission. [O2]
- Students should answer the differentiated questions on the worksheet (Low demand: Describe the pattern in the data; Standard demand: Explain the differences in the results; High demand: Predict what the results would look like in a few weeks and justify your reasons). [O2]
- Students should **explain** any sources of error in their investigation and **make some suggestions** for improvement. This should be done on the practical sheet. [O3]

Consolidate and apply

- Students should **use** their results to **promote** the brand of disinfectant they believe to be the best value for money. They should **produce** a short commercial for the brand, **explaining** what a disinfectant is and how we know it works. [O1–O3]

Extend

Ask students able to progress further to:

- **Find out** about aseptic techniques over the years and **produce** a short presentation to the class about the history of disinfectants. [O1–O3]

Plenary suggestions

Tell students it is important that hospitals keep bacterial levels to a minimum. Ask students to **imagine** they are in charge of hygiene in the hospital. They should **write a leaflet** explaining what test should be done to ensure the hospital is safe from harmful bacteria. They should **write an information leaflet** for patients to **explain why** it is important to wash hands regularly, particularly after the toilet and before food. They should explain why it is important to keep on washing hands throughout the day and why once is not enough. [O3]

Answers to Worksheet 1.14.1

1. See practical instructions.
   Predictions – after a few days there will be clear patches around the circles of disinfectant, with bacterial growth elsewhere.

2. Circle 4 has the largest area of clear patch around it, whereas circle 12 has the least area. Large areas are seen for spots 2, 3, 5, 7, 9 and 10, whereas only small areas are seen for circles 6, 8 and 11.

   Standard demand:
   Circle 4 contains the strongest disinfectant, whereas circle 12 contains the weakest
   Spots 2, 3, 5, 7, 9 and 10 contain similar concentrations of disinfectant
   Spots 6, 8 and 11 contain weaker concentrations, or the bacteria are most resistant to these disinfectants

   Higher demand:
   Predictions after a few weeks: the area around the clear patches may be smaller, as some resistant bacteria develop and grow. Also the strength of the disinfectant will reduce after a few weeks.

3. Areas regularly used by patients should be sterilised and every couple of hours, swabs should be taken and grown onto an agar plate. The types of bacterial colonies should be identified, particularly pathogenic bacteria. Areas should be sterilised again using stronger disinfectants and the procedure repeated until no pathogenic bacteria are observed.

Cell Biology: Lesson 15

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 this 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 4.2 Recognise the importance of scientific quantities and understand how they are determined.
- WS 4.4 Use prefixes and powers of 10 for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano).

Maths focus

Making estimates, ratio and proportion, standard and decimal form

Resources needed Worksheets 1.15.1 and 1.15.2;

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 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 something 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** in Worksheets 1.15.1 (low demand) and 1.15.2 (standard and higher demand). They may need reminding of how to convert various dimensions into each other. [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 the 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** in 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–O3]

Extend

Ask students able to progress further to:

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

Plenary suggestions

Ask students to traffic light which of the skills they can do from the learning outcomes.

Answers to Worksheets 1.15.1 and 1.15.2

1.

Worksheet 1.15.1 (low demand)

a) 1 × 101, 1 × 102 1 × 103, 1 × 10–6, 1 × 104, 1 × 10–3

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

Worksheet 1.15.2 (standard and higher demand)

a) 3 × 103, 5.2 × 102, 7.3 × 10–3, 4.2 × 101, 5.3 × 10–4

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

µm	mm	cm	m
1000000	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

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