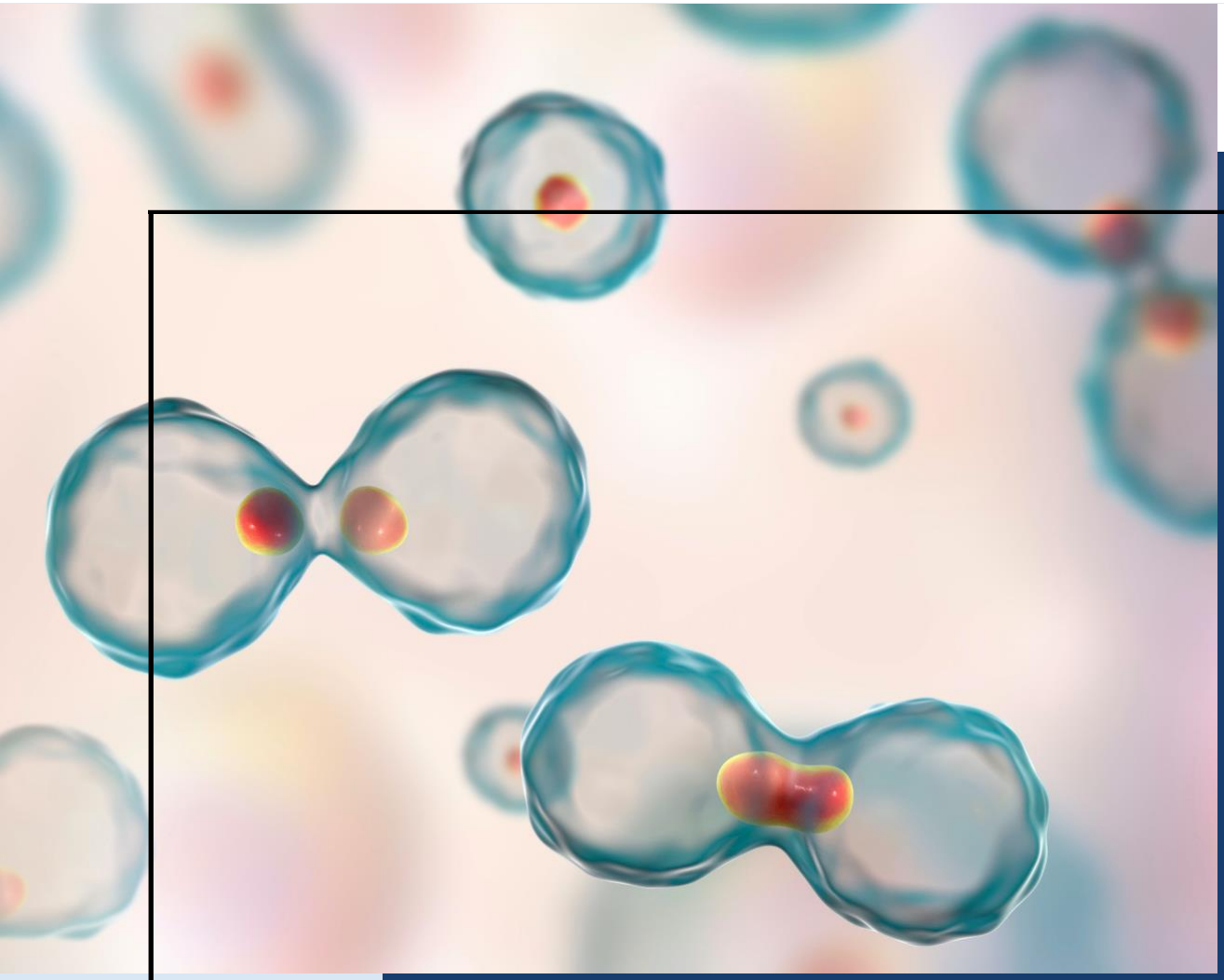


Unit Preparation Booklet

B3.1 Growth and Differentiation

Teacher name:

Science Mastery

Ark Curriculum+

Science Mastery

Contents

Steps to Success

		What?	Why?	Who?	Page #
Preparing to teach	**1**	☐ Print this booklet or save a copy in a personal folder	To allow for engagement during planning and co-planning	*All teachers*	
	2	☐ Engage with the unit preparation checklist	To prepare for delivering the sequence of lessons	*All teachers*	3
	3	☐ Read the scope and sequence for the unit	To review the scope and sequence of the unit	*All teachers*	4
	4	☐ Complete the pre-unit quiz reflections task after administering to class	To plan how to remedy prior knowledge gaps	*New to teaching the unit only*	13
	6	☐ Complete the Mastery Quiz and exam-style questions activity	To learn/revisit the key assessment objectives of the unit	*New to teaching the unit only*	14-22
	7	☐ Complete the misconception activities	To develop a strong understanding of the most common misconceptions for the unit and how to address them	*New to teaching the unit only*	23-27
Delivering the unit	**8**	☐ Use the lesson by lesson objectives to monitor progression through the unit	To maintain a record of completion and to recognise what needs to be reviewed after each lesson	*Novice teachers only*	28-43
Utilise other features of the booklet	**9**	☐ Complete the advanced subject knowledge activity	To develop an understanding of where the unit can lead	*Non A-level specialists*	44
	10	☐ Engage in the keywords and new scientists for the unit	To identify the correct definitions for keywords throughout the unit	*Novice teachers only*	45-46

Unit preparation checklist

Resources can and should be tailored to meet your pupils' needs. We have aimed to do as much resourcing as possible so that teachers' time can be spent on co-planning and preparation; however, they are only ready for your pupils once you have decided how to make use of them.

Here is a suggested checklist:

Locate:

- ☐ **Find** the unit resources using MyMastery or SharePoint

Engage:

- ☐ Work through the preparation booklet. Complete the pre-unit quiz and mastery quiz yourself and reflect (all enclosed)
- ☐ Set your class the **pre-unit quiz** (in advance of the unit).
- ☐ Note which topics are **areas of weakness** for the class (space available in this booklet or on the planning pro-forma)
- ☐ **Decide** which topics you will re-visit 'in advance' and which to tackle during the unit (space available in this booklet or on the planning pro-forma)
- ☐ Identify where in the sequence of learning there are opportunities for embedding **guided reading**
- ☐ Use the **lesson planning guidance** to develop a grasp of the purpose of each lesson element

Adapt:

- ☐ Consider key timings for each lesson. Identify which lessons may need to be adapted to account for the length of your lessons or ability level of your class
- ☐ Identify what could be used as **homework** activities to support in-class learning in line with school policy
- ☐ Review the resources ahead of each lesson and ensure you are clear on the objectives of each lesson
- ☐ **Select** appropriate activities for each lesson from the selection within each lesson folder/on the slide deck
- ☐ **Administer** exit tickets and use outcomes of this to plan 'fix-it' tasks to tackle misunderstanding or misconception.
- ☐ Set the **mastery quiz** for your class. Use the information to plan a suitable re-teach lesson and further response, using the resources available.

Scope and Sequence

Scope

In this unit, pupils will develop their understanding of cell structure and specialisation. Pupils will learn to classify cells as eukaryotic or prokaryotic according to some basic features and revisit the function of the main sub-cellular structures. Pupils will have another opportunity to use microscopes to investigate cells and learn how scientists now use electron microscopes to study cells in more detail. Pupils will also have the opportunity to investigate bacterial growth using agar and develop their skills in using aseptic techniques. This unit also introduces pupils to the three main methods of cell transport: diffusion, osmosis and active transport. Pupils will consider how different cells are adapted for efficient exchange and apply their learning about methods of cell transport to different contexts. Pupils will also study cell specialisation and learn how cells divide by mitosis to allow for growth and repair. Pupils will be introduced to cancers as a group of diseases that can arise from uncontrolled cell growth. They will also learn how scientists use stem cells to study and treat different diseases.

Sequence

Prior to this unit, pupils will know that cells are the building blocks of all life on Earth and will have studied the basic structure of animal and plant cells as well as a range of specialised cells. Pupils will have studied a number of organ systems and considered a range of cellular processes including respiration and photosynthesis, so will have an understanding of how cells are organised into tissues and organs. Although most pupils will not be familiar with cell division, most will have heard of cancer as a serious disease; many pupils will know someone or have heard of someone who has had cancer. Many pupils will be aware that certain lifestyle choices increase the risk of cancer, such as not wearing sunscreen or smoking. In chemistry, pupils have studied diffusion of particles, and they have applied this learning to the movement of gases across the alveoli. Pupils will begin this unit revisiting the structure of cells and will learn to classify cells as eukaryotic or prokaryotic. Pupils will then practice a range of experimental techniques used for investigating cells, including microscopy. Pupils will already be familiar with the parts of a microscope and will develop this knowledge to include calculations of magnification and size. Pupils will also learn the importance of aseptic technique when growing bacterial colonies. Pupils will then learn about the three methods of cell transport, considering the different substances that move in and out of different cells. They will apply this learning to both eukaryotic and prokaryotic cells. Pupils will then learn how cells replicate during the cell cycle and the process of mitosis as part of this. Pupils will develop their skills in interpreting images to calculate the length of time that different cells are undergoing mitosis. Pupils will then consider what happens when cell division is not controlled, beginning their learning about cancers. Pupils will finish this unit learning about stem cells in both plants and animals, and how scientists use stem cells to study and treat disease. Pupils will develop a range of experimental techniques in this unit, from microscopy to accurate measurement of change in mass. Pupils may not yet be able to obtain repeatable results, so will revisit the more complex experiments of this unit in later years, namely investigating osmosis. This unit forms the basis of more advanced study of cellular processes. Pupils will study revisit cell division when they study meiosis and apply their knowledge of specialised cells in all biology units that follow. Pupils will apply their knowledge of cell transport to a range of processes in both animals and plants across KS4 biology units. Pupils will revisit the topic of cancer when they study disease. Pupils will revisit the use of stem cells for treating disease and further debate the ethics surrounding their use. They will also consider how scientists use knowledge of prokaryotes in genetic

engineering. At A-level, pupils will build on the learning in this unit to learn in more depth about the reactions and processes that occur on a cellular level. They will study cell division in more depth, including the various stages that cells undergo when dividing. They will study how cells obtain the nutrients and oxygen they need in greater detail. The microscopy techniques studied here will be used by pupils going forward in a range of topics, for example in observing the stomata on the underside of leaves. Aseptic technique and a knowledge of the growth of bacteria is especially useful in a range of careers, including in the pharmaceutical, forensic science and medical industries
a fundamental basis to their understanding of genes, inheritance, control and gene therapies.

A full set of knowledge objectives for this unit can be found as **Appendix 5.**

1	**2**	**3**	**4**
Prior knowledge review	Eukaryotic and prokaryotic Cells	Aseptic Technique	Growth of Bacteria
5	**6**	**7**	**8**
Microscopes	Observing cells	Diffusion	Diffusion in Living Things
9	**10**	**11**	**12**
Osmosis	Osmosis practical	Active Transport	Cell Division
13	**14**	**15**	**16**
Cancer	Stem Cells	Feedback lesson	Review and Reteach

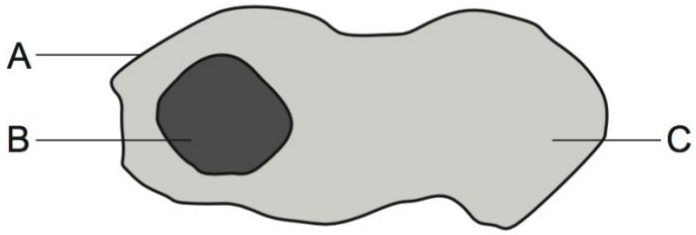
TASKS:

New teachers: Organise the lesson titles into those you feel most to least confident about *Experienced teachers:* Reflect on prior experience of teaching this unit. Which lessons have gone well? Which would you like to target for improvement this year?

Pre-unit quiz

TASK: Below is the pre-unit quiz available for your pupils. Complete yourself and set for your pupils ahead of starting the unit. There is space to record the key outcomes from marking the quiz for your class. **See Appendix 1 for the mark scheme.**

The diagram below shows a cell.



(a) What is the name of the part labelled A? [1]

Tick (✓) **one** box.

(a) Cell wall ☐

(b) Cytoplasm ☐

(c) Cell membrane ☐

(b) What is the function of the part labelled B? [1]

Tick (✓) **one** box.

(a) Controls what enters and leaves the cell ☐

(b) Contains DNA and controls activities in the cell ☐

(c) Makes food for the cell using light ☐

1. Which statement is correct about cytoplasm? [1]
Tick (✓) **one** box.

(a) Cytoplasm is only found in animal cells ☐

(b) Cytoplasm is only found in plant cells ☐

(c) Cytoplasm is found in **both** animal cells and plant cells ☐

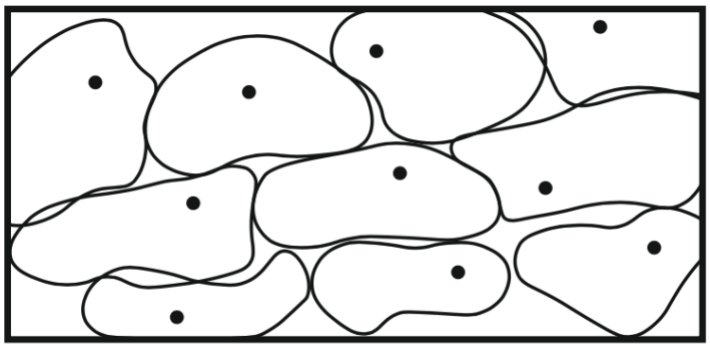
2. A type of yeast is used to bake bread. The yeast is made of single cells. Which statement **best** describes these yeast cells? [1]
Tick (✓) **one** box.

(a) Yeast is a unicellular organism ☐

(b) Yeast is a multicellular organism ☐

(c) Yeast is made of plant cells ☐

3. A student uses a microscope to magnify a specimen from a leaf. Iodine solution is used to stain the specimen. The drawing below shows what the student saw in the microscope.



(a) Describe how this scientific drawing could be improved. [1]
Tick (✓) **one** box.

(a) Draw more cells so more of the tissue can be seen ☐

(b) Increase the magnification ☐

(c) Add labels for the nucleus, cell membrane and cytoplasm ☐

(b) Why are microscopes needed to see cells? [1]
Tick (✓) **one** box.

(a) Cells are see-through so cannot be seen by eye ☐

(b) Cells are too small to be seen by eye ☐

(c) Cells can only be seen on a slide ☐

(c) How would the student magnify one cell to study it in more detail? [1]
Tick (✓) **one** box.

(a) Move the coarse focus wheel ☐

(b) Change the eye piece lens to a greater magnification ☐

(c) Change the objective lens to a greater magnification ☐

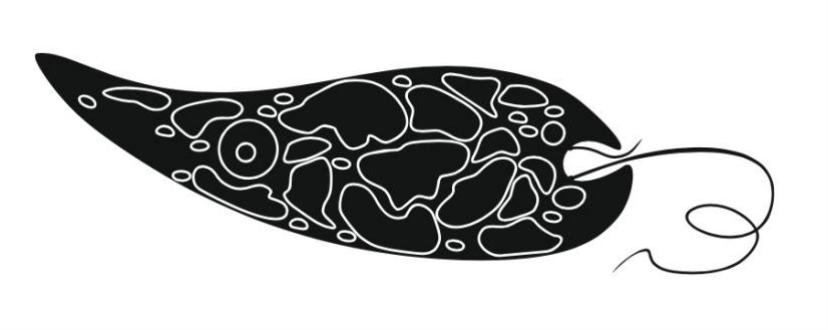
(d) The student thinks that the dot seen in each cell is a chloroplast.
Do you agree with the student? [1]
Tick (✓) **one** box.

(a) Yes ☐

(b) No ☐

(c) Need more information ☐

4. The diagram below shows a cell called Euglena.



(a) How is the cell adapted for moving? [1]
Tick (✓) **one** box.

(a) It has a tail ☐

(b) It moves to get food ☐

(c) It is a sperm cell ☐

(b) The cell makes food using sunlight.
Which part of the cell carries this process out? [1]
Tick (✓) **one** box.

(a) Cytoplasm ☐

(b) Chloroplast ☐

(c) Vacuole ☐

Total = ___ /10

Pre-unit quiz reflections

To be completed once you have reviewed your pupils' response to the pre-unit quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout the unit?

Other notes

Mastery Quiz

TASK: Below is the mastery quiz available for your pupils to sit at the end of the unit. Complete yourself and consider the key misconceptions this quiz aims to address. See **Appendix 2** for the mark scheme.

Section A

1. Choose the option that would have the fastest rate of diffusion of tea. [1]

   Tick (✓) **one** box.

   A. Another tea bag being added to a warm cup of tea ☐

   B. A tea bag being added to cold water ☐

   C. A tea bag being added to hot water ☐

2. Choose an example of a prokaryotic cell. [1]

   Tick (✓) **one** box.

   A. Animal cell ☐

   B. Plant cell ☐

   C. Bacterial cell ☐

3. Eukaryotic cells have genetic material … [1]

   Tick (✓) **one** box.

   A. contained in a nucleus. ☐

   B. free in the cytoplasm. ☐

   C. organised into plasmids and a loop. ☐

4. An embryonic stem cell can differentiate into all types of cell and is taken from … [1]

Tick (✓) **one** box.

A. a developing embryo. ☐

B. adult bone marrow. ☐

C. a fertilised egg cell. ☐

5. When using a light microscope you should … [1]

Tick (✓) **one** box.

A. ensure that the objective lens is touching the slide. ☐

B. not put your eye too close to the objective lens. ☐

C. use the lowest power objective lens first. ☐

6. An empty beaker had a mass of 200 g.

Water was added to the beaker and the mass increased to 250 g.

Calculate the percentage increase in mass. [1]

Tick (✓) **one** box.

A. 80 % ☐

B. 25% ☐

C. 20% ☐

7. Active transport is the movement of particles from … [1]

Tick (✓) **one** box.

A. a low concentration to a high concentration, using energy. ☐

B. a high concentration to a low concentration, using energy. ☐

C. a low concentration to a high concentration, without energy. ☐

D. a high concentration to a low concentration, without energy. ☐

8. A cube of potato was placed in a beaker of water.

Choose how the mass of the cube of potato changed after a day. [1]

Tick (✓) **one** box.

A. No change in mass ☐

B. Increase in mass ☐

C. Decrease in mass ☐

9. Choose the only correct statement about surface area to volume ratio. [1]

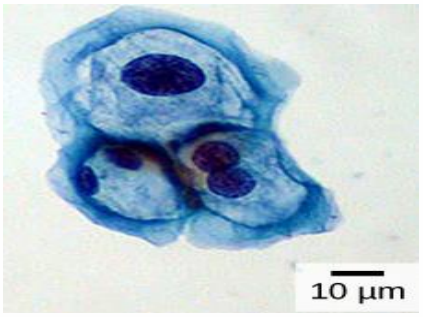
Tick (✓) **one** box.

A. Single-celled organisms are small and therefore have a large surface area to volume ratio ☐

B. As organisms get larger, their surface area to volume ratio increases ☐

C. The smaller the surface area to volume ratio, the faster the rate of diffusion ☐

10. Below shows an image from a light microscope.



The length of the scale bar is 1 cm.

(a) Calculate the magnification used. [1]

Tick (✓) **one** box.

A. 0.1 ☐

B. 100 ☐

C. 1000 ☐

(b) A scientist wanted to observe the shape of ribosomes in these cells.

The scientist had to use an electron microscope for this because... [1]

Tick (✓) **one** box.

A. it uses electrons instead of light to see the specimen. ☐

B. it has a greater magnifying power than a light microscope. ☐

C. it has a lower resolution than a light microscope ☐

11. Urea is a waste product that diffuses from the liver into blood. This means that the concentration of urea in the liver is … [1]

Tick (✓) **one** box.

A. greater than in blood. ☐

B. less than in blood. ☐

C. the same as in blood. ☐

12. Choose the value that is equal to 41 μm. [1]

Tick (✓) **one** box.

A. 4.1×10^{-3} m ☐

B. 4.1×10^{-5} m ☐

C. 4.1×10^{-6} m ☐

13. There are 5 bacterial cells in a sample.

Calculate how many bacterial cells are in the sample after 3 cell divisions. [1]

Tick (✓) **one** box.

A. 8 ☐

B. 15 ☐

C. 40 ☐

14. Choose the best description of aseptic technique. [1]

Tick (✓) **one** box.

A. Methods used when working with microorganism, so that surfaces are kept sterile and microorganisms can be grown safely ☐

B. When an inoculating loop is sterilized using a Bunsen burner to transfer bacteria ☐

C. How a Petri dish is prepared to grow a specific type of bacteria that is found on a particular surface ☐

15

Section B

1. Define osmosis.

_____

_____

2. Lifestyle risk factors for cancer include poor diet, lack of exercise, smoking, UV exposure.

   Explain what is meant by the term 'lifestyle risk factors'.

_____

_____

3. Describe the stages of the cell cycle.

_____

_____

_____

_____

_____

_____

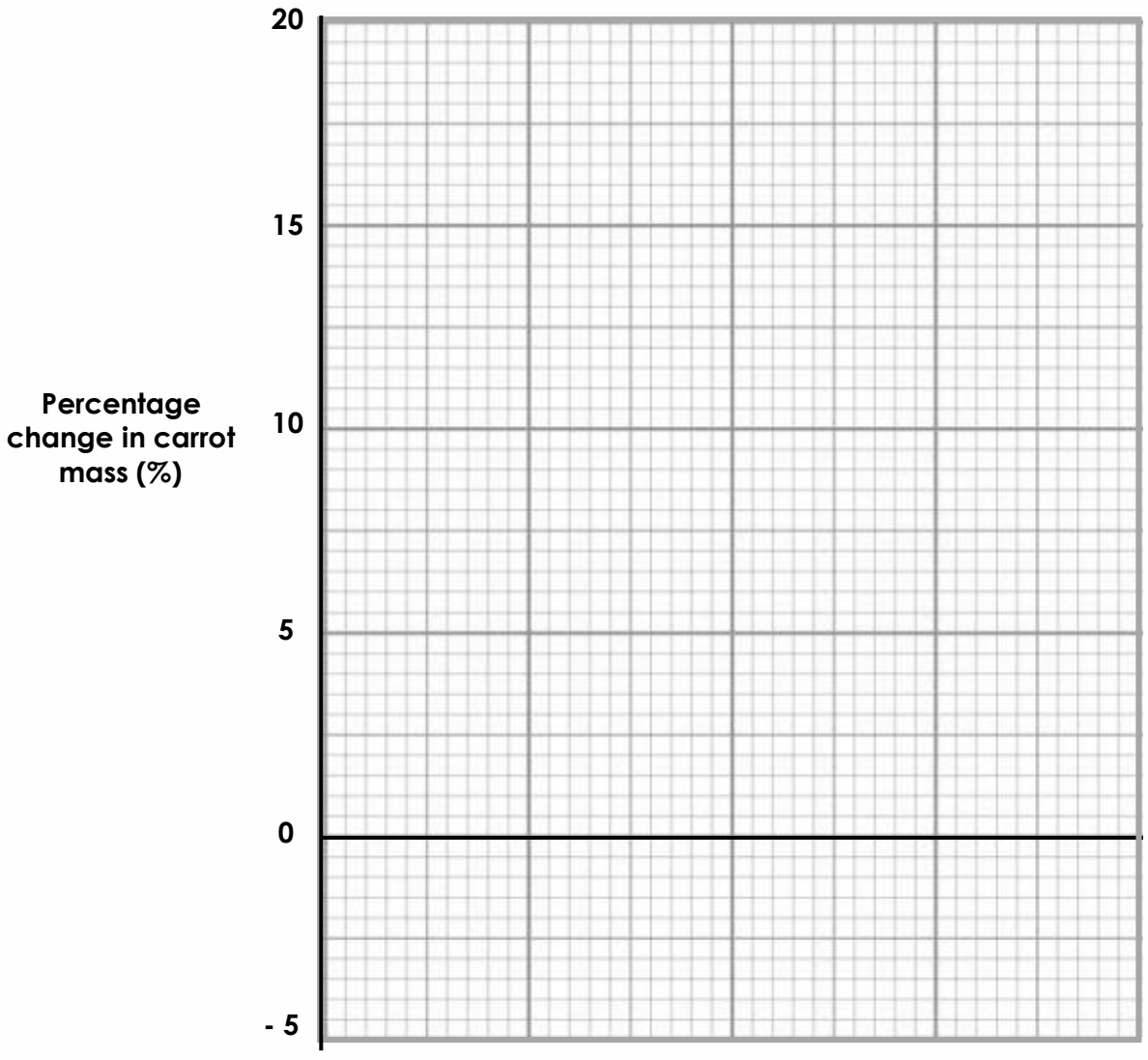
PLEASE TURN OVER FOR QUESTION 4

4. A student investigated osmosis in carrot tissue by placing a piece of carrot in test tubes containing different concentrations of sucrose solution.

The percentage change in mass was calculated and the results shown in the table below.

Complete the graph below using data shown in the results table.

Sucrose solution concentration (g/dm^3)	Percentage change in carrot mass (%)
0.0	16.1
0.2	11.2
0.4	3.6
0.6	- 4.5



Mastery quiz reflections

Which aspects of this unit are likely to be the most challenging to teach?	
What are your pupils likely to find most challenging and why?	
Challenging.....	Because....
E.g. The number of new keywords	*They are abstract words that aren't used in other areas of science*
How can you pre-empt some of the key misconceptions the mastery quiz aims to identify?	
Misconception	**How to avoid**

Exam-style questions

TASK: Using exampro (or the software used by your exam board), look through the typical exam-style questions for this topic. These sorts of questions are posed throughout the unit and pupils should be prepared to answer similar questions in the end-of-year assessments.

Suggested questions to guide this process:

How is knowledge from this unit typically assessed? What are the most common questions?
Which question types are the most challenging?
What general trends can you spot in the typical errors pupils make (from examiner reports/notes)?
How could you help prepare your students for answering these types of questions?

Common mistakes, errors and misconceptions

How would you tackle the following common mistakes, errors and misconceptions by pupils?

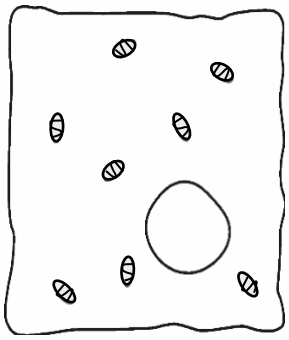
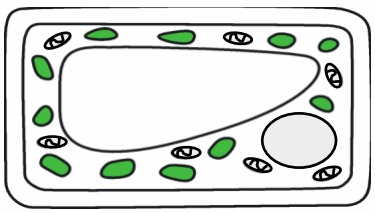
TASK: Consider why each of the following typically seen statements is a mistake/misconception. What possible approaches can you plan to pre-empt and respond to this? Which lessons do these correlate to?

CHALLENGE: Cover the middle column and explain yourself why each is a mistake.

Mistake	**Reason why it's a mistake**	**Possible approaches to pre-empt and respond?**
The function of a microscope is to see objects that are very far away	The function of a microscope is to make small objects easier to view by increasing the size of the image	
Magnification and resolution are the same	To magnify is to make something bigger while resolution is the ability to distinguish between two points	
The cell wall controls what enters and leaves the cell	The function of the cell wall is to give structure and to keep the cell rigid	
Prokaryotic cells do not contain mitochondria because they do not respire	Prokaryotic cells do respire using mesosomes. They do not contain mitochondria because mitochondria are membrane-bound. Mitochondria and prokaryotic cells are around the same size and so mitochondria would not fit in a prokaryotic cell	
Cells are the simplest forms of life	Prokaryotes are the simplest forms of life	
Securing the petri dish lid by making an airtight seal is part of the aseptic technique	Making an airtight seal does not mean that the equipment has not already been contaminated. In addition, an airtight seal would prevent oxygen reaching the culture that you need to grow on the petri dish	
The fine focusing wheel is used to get cells into the frame	The coarse focusing wheel gets cells into frame, the fine focussing wheel sharpens the image	
When using a microscope, the highest objective lens should be used first	When using a microscope, the lowest objective lens should be used first	
The larger the surface area to volume ratio, the larger the object	It is more likely that the larger the object the smaller the surface area to volume will be	
Diffusion does not require energy	Diffusion does not require energy as it is a passive process and	

because it is more important that the cell keeps the energy to use in respiration	molecules are moving down a concentration gradient . The cell requires energy released during respiration for many processes. For example, active transport moves molecules against a concentration gradient and energy is required to do this	
Unicellular organisms use mitosis to replace damaged cells	Unicellular organisms only have one cell so only divide in order to replicate	
DNA is replicated during mitosis	Mitosis is just one part of the cell cycle. DNA is replicated during interphase	
A risk factor is something that will make someone have cancer	A risk factor makes it more likely that something will happen	
Stem cells are only found in humans	Stem cells are found in all living organisms.	

Planning for the misconceptions

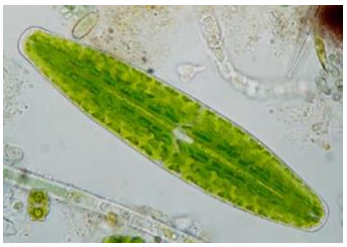
Misconception: Cell wall controls what enters and leaves the cell
The function of the cell wall is to give structure and to keep the cell rigid. All cells have a cell membrane that controls what enters and leaves the cells.
Supporting pupil understanding     Ask pupils to answer the following questions to understand why plant cells have a cell wall and animal cells do not. - What keep a human upright? - What keeps a plant upright? - What do both cells have in common? Why Is it important that both cells have there organelles?
Taking it further
Pupils could be asked to investigate the cell walls of different organisms and the differing chemical make up (plants, bacteria, fungi) Pupils could investigate the effectiveness of different techniques of extracting chlorophyll from spinach leaves (soaking in boiling water, using rubbing alcohol, crushing using a pestle and mortar). They should develop an understanding that the cell wall must be damaged in order to release the chlorophyll.

Misconception: Magnification and resolution are the same
To magnify is to increase the size of an image while resolution is the ability to distinguish between two points. Pupils can also incorrectly state the magnifying means to 'zoom in'.

Supporting student understanding

The following questions should help the pupils make associations between words to lead to greater understanding. Once the word magnify is clearly understood there should be no confusion between 'magnify' and 'resolution'.

- What does the word 'magnify' remind you of?
- What does a magnifying glass do?
- Which of the images below has a greater resolution? Explain how you know.



Taking it further

Resolution is the ability to distinguish between two points (e.g. how clear the image is). So 1 nm resolution means that we can clearly see two objects apart that are 1 nm apart.

Ask pupils to look at a ruler that has centimeters on one side and millimeters on the other. Ask them to identify the resolution of the ruler.

Misconception: DNA is replicated during mitosis

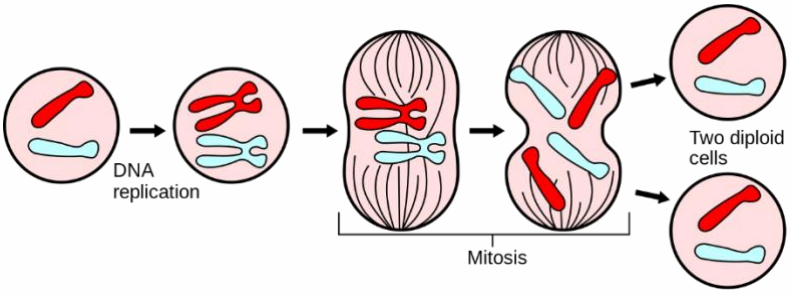
DNA is replicated during interphase. This is just one part of the cell cycle, and occurs before mitosis. Interphase typically takes up the majority of the cell cycle, with mitosis occuring only to separate the genetic material.

Supporting student learning

Pupils mistake the whole process of cell division for mitosis. Mitosis is the second stage of cell division and begins when the chromosomes line up in the middle of the cell.

Asking pupils explicitly what happens at each stage of cell division should make clear that mitosis is a part of cell division.

- Explain what happens during interphase
- Explain what happens during mitosis
- Explain what happens during cytokinesis



Taking it further

Pupils could be asked to compare how long interphase takes with the length of mitosis and cytokinesis and suggest reasons for the difference. They could compare the length of the cell cycle of different organisms and consider reasons for the differences.

Unit objectives: knowledge, skills and concepts

As you teach the lessons, track here the objectives you meet.

TKT = to know that TBAT = to be able to

Critical: it is critical that all pupils become proficient; future learning will be very challenging for them if they do not and it is likely they will not come across this content again. These are priority objectives for reteaching, revision, and intervention. Before moving on, discuss a strategy with your HOD if some pupils are not making progress with these objectives.
Core: it is important for all pupils to learn this, and it will be essential for success at GCSE. However, it will not impede them in other units if they are not (yet) proficient in it as they are likely to revisit it again in subsequent units.
Stretch: pupils should have the opportunity to be work on this aspect of science. This content is crucial for pupils to achieve the highest GCSE grades and to succeed at A-level.
Key skill: pupils should have the opportunity to develop this key skill as part of this unit.

Intended outcome for separate sciences pupils are denoted in blue and italised.

Lesson 1: Prior knowledge review

Intended outcome	Example questions
*This lesson is a review of content from previously studied units relating to this big idea	
TKT differences between animal and plant cells	State which organelles are not common between animal and plant cells? Explain why do animal cells not have the same organelles as plant cells?
TBAT describe the features of plant and animal cells and the functions of each organelle	Describe the function of all the organelles of an animal cell? Describe the function of all the organelles of a plant cell? Explain why sperm cells contain lots of mitochondria? Explain why root hair cells do not have any chloroplast?
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 2: Eukaryotic and Prokaryotic Cells

Intended outcome	Example questions
TBAT state examples of eukaryotic and prokaryotic cells	State two examples of prokaryotic cells? State two examples of eukaryotic cells?
TBAT describe the differences between eukaryotic and prokaryotic cells	Explain why a white blood cell a eukaryotic cell? Explain why is a bacteria cell a prokaryotic cell
TKT prokayotic cells do not have mitochondia and why	Explain why prokaryotic cells do not have mitochondria
TKT organelles in prokaryotic and eukaryotic cells have different functions	Describe the function of all the organelles of a prokaryotic cells? Describe the function of all the organelles of a eukaryotic cell?
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 3: Aseptic Technique

Intended outcome	Example questions
TBAT state the stages of aseptic technique when growing bacteria	*Give an example of an organism that uses asexual reproduction?* *Explain why the inoculating loop is passed through a flame first* *Describe the steps of the aseptic technique* *State the name of the apparatus used to transfer the bacteria to the agar gel*
TBAT describe the function of the agar medium	*Describe what 'agar gel' is* *Explain how agar gel beneficial when growing bacteria* *State which nutrient is the main source of energy for microorganisms*
TKT the petri dish is not secured with an air tight seal when growing bacteria and why	*Explain why the petri dish is not secured with an airtight seal* *Explain why the petri dish is stored upside down*
TKT the petri dish must be sterilised before use	*Describe the implications of not sterilising the petri dish before use* *Explain why it is important to only lift the lid of the petri dish a little bit*
TBAT describe the conditions that agar must be stored in to allow bacteria to grow	*State the ideal temperature for cultures to be incubated at*
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 4: Growth of Bacteria

Intended outcome	Example questions
TBAT state the steps involved in aseptic technique	*Describe the steps involved in aseptic technique* *Explain why each step is required*
TBAT calculate how many bacteria are present in a culture from the mean division time	*State the general equation used to calculate the final number of bacteria?* *Calculate how many divisions would have occurred after 24 hours if bacteria has a mean division time of 30 minutes and you start with one bacteria?*
TBAT use the aseptic technique to grow bacteria	*Plan a method to grow bacteria* *State the name of the technique used to transfer bacteria*
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 5: Microscopes

Intended outcome	Example questions
TKT the equation to calculate magnification is image size / actual size	State the equation used to calculate magnification? Re arrange the equation to make image the subject and the to make actual size the subject
TBAT describe the difference between a light microscope and electron microscope in terms of magnification and resolution	Explain what is meant by the term resolution? Explain what is meant by magnification? Explain what the difference between magnification and resolution is Describe how an electron microscope different than the light microscope
TBAT give examples of when a light or electron microscope are used	Give examples where a light microscope might be used Give an example when an electron microscope might be used
TKT total magnification can be calculated by multiplying together the eyepeice lense and objective lens magnifications	Describe how the sequence of bases on a DNA strand determines the shape of a protein Explain how a change in one amino acid in an enzyme molecule could stop the enzyme working
TBAT calculate orders of magnitude	State how are millimetres converted to micrometres State how are nanometres converted to micrometres Convert 7 micrometres to nanometres
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 6: Observing Cells

Intended outcome	Example questions
TBAT decribe how to look at a specimen under a light microscope	Plan a method to look at an onion cell under a microscope State which lens should be used when looking at a specimen State the function of iodine on a slide
TBAT name the different parts of a light microcope and their functions	Describe the function of the objective lens Describe the function of the stage? Describe the function of the course wheel?
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 7: Diffusion

Intended outcome	Example questions
TKT diffusion is the movement of fluid particles from an area of high concentration to an area of low concentration	Define the term 'diffusion'
TBAT explain what a concentation gradient is	Describe what a concentration gradient is
TBAT explain why surface area to volume ratio decreases with size	Explain what is meant by surface area to volume ratio Explain why surface area to volume ratio decreases with size Describe how the surface area of a regular shape calculated Describe how the volume of a regular shape calculated
TKT temperature, concentration gradient and surface area all change the rate of diffusion	Explain how temperature effects the rate of diffusion Explain how surface area effects the rate of diffusion Explain how the concentration gradient effects the rate of diffusion
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 8: Diffusion in Living Things

Intended outcome	Example questions
TBAT describe how multicellular organisms are adapted to allow the efficient exchange of substances	Define the term 'multicellular organism' Give examples of substances exchanged in the body Describe how multicellular organisms are adapted to exchange substances
TBAT explain why unicellular organisms do not need the same adaptations as multicellulr organisms to survive	Define the term 'unicellular organism' Describe the surface area to volume ratio of a unicellular organism Explain why unicellular organisms do not need the same adaptations as multicellular organisms for diffusion to occur
TBAT give examples of diffusion occuring in both animals and plants	Give an example of diffusion happening in an animal and how it is adapted for efficiency Give an example of diffusion happening in a plant and how it is adapted for efficiency
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 9: Osmosis

Intended outcome	Example questions
TKT osmosis is the movement of water from an area of high concentration to an area of low concentration through a semi permeable membrane	Define the term 'osmosis' Describe what a semi permeable membrane is State what substance is required for osmosis to occur
TBAT describe the difference between hypertonic, hypotonic and isotonic solutions	Define the terms 'hypertonic, isotonic and hypotonic' solutions Define the term 'dilute'
TBAT explain how cells can become flaccid and tugid	State the term used to describe a plant cell when water has left it State the term used to describe a plant cell when water has left it Explain what would happen to an animal cell that is placed in a hypotonic solution
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 10: Osmosis Practical

Intended outcome	Example questions
TBAT state the independent dependent and control varibales of an investigation	Describe what is meant by the independent, dependent and control variable When investigating the movement of water into and out of cells identify the independent dependent and control variables
TBAT describe the movement of water by osmosis when a potato is placed in different solutions	Describe the direction water moved in when the potato is placed in pure water and why Describe the direction water moved in when put in a sugar solution and why
TBAT explain how to determine the concentration of the potato	Describe how to determine the concentration of the potato When provided with a graph showing the sugar concentration against the percentage change in mass Explain if it is possible to determine the concentration of the potato without a graph
TBAT investigate the movement of water into and out of cells	Plan a method to investigate the movement of water into and out of potatoes including the different variables and the table headings
TBAT calculate percentage change in mass	State the general equation used to determine percentage change in mass of the potato Explain why percentage change in mass is used and not just mass
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 11: Active Transport

Intended outcome	Example questions
TBAT define active transport	Define the term 'active transport'
TBAT describe the difference between passive and active processes	Explain the difference between a passive process and an active process State what organelles would you expect to see an abundance of when active transport is occurring and why
TBAT give exampes of active transport in both animals and plants and why active transport is needed	Give an example of when active transport is used in an animal cell and why it is needed Give an example of when active transport is used in a plant cell and why it is needed
TBAT compare diffusion, osmosis and active transport	Compare the three different modes of transport giving at least one example for each
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 12: Cell Division

Intended outcome	Example questions
TKT there are three stages of the cell cycle	*State the three stages of the cell cycle* *Explain how cell division can be used in unicellular and multicellular organisms*
TBAT describe what happens at each stage of the cell cycle	*Describe what happens at each stage of the cell cycle* *Describe how cells divide to produce two identical daughter cells* *State the type of cell division that produces two identical daughter cells*
TBAT identify the stage of the cell cycle from a diagram or photo	*State what stage of the cell cycle is being shown in each picture*
TBAT explain the importance of each stage of the cell cycle	*Explain why DNA must be replicated during interphase*
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 13: Cancer

Intended outcome	Example questions
TBAT describe how cancer is caused	Describe what cancer is

	Explain how cancer occurs State the name given to uncontrolled cell division
TKT there are two different types of tumors	State the two different types of tumours Explain which type of tumour is usually more dangerous Describe what happens when the tumour has metastasised
TBAT describe how risk factors increase the likelehood of having cancer	Explain what a risk factor is State three risk factors for skin cancer Explain if there are any ways to reduce risk factors
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 14: Stem cells

Intended outcome	Example questions
TBAT state the definition of a stem cell	Define the term 'stem cell'
TBAT describe the difference between	Describe what an embryonic stem cell

embryonic and adult stem cells	Describe what an adult stem cell is Describe the limitations of adult stem cells
TBAT describe what meristems are and how to obtain them	*Define the term 'meristem'* *Describe where meristems are obtained from* *Suggest advantages and disadvantages for using meristems in farming*
TBAT explain the ethical objection to use of stem cells	Explain the ethical issues surrounding the use of embryonic stem cells
TBAT describe how stem cells can be used in theraputic medicine	Describe some of the therapeutic uses of stem cells and some of the proposed used of stem cells
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Mastery Quiz re-teach planning

To be completed once you have reviewed your pupils' response to the mastery quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout another unit? When will that be taught?

Other notes

Lesson 16: Feedback lesson

Intended outcome	Example questions
This should be completed based upon your classes performance in the Mastery Quiz	
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Advanced subject knowledge

Where does this learning lead?

At A-level, pupils will be expected to know in detail the process of cell division:

- Interphase – DNA replicates
- Prophase – Chromosomes become visible
- Metaphase – Chromosomes align at the centre of the cell attached to spindle fibres
- Anaphase – Chromatids move towards the pole
- Telophase and cytokinesis - Chromatids are in groups at the poles

This builds on what was learnt at KS4 where cell division was explained in terms of interphase, mitosis and cytokinesis.
Pupils will underdstand that mitosis consists of the middle three stges described above and willl need to be able to identify these stages both via description and pictorially.

Have a look at the questions below and think about what this means for this unit.

How does learning from this unit develop at KS4?
What content from this unit is fundamental to student understanding at KS4?
How could you check that students have grasped these fundamentals?

(3)

Vocabulary and literacy

Tier 3 vocabulary and phrases in this unit that pupils are likely to already know:

Word	Definition	Example in context
Active transport	The movement of molecules from a dilute to a more concentrated solution against a concentration gradient using energy from respiration.	Mineral ions move into root hair cells using active transport
Cancer	When cell division happens uncontrollably so cell numbers increase rapidly and can form tumours.	Cancer is a disease that is affected by lifestyle and genetic risk factors.
Chromosome	A structure found in the nucleus made of DNA.	Human body cells contain 23 pairs of chromosomes.
Concentration gradient	The difference in concentrations of a substance between two areas.	The larger the concentration gradient the faster the rate of diffusion
Diffusion	The movement of particles from a high concentration to a low concentration	Oxygen travels from the alveoli into the blood via diffusion
Magnify	The process of enlarging the image of an object.	Microscopes are used to magnify objects.
Mitochondria	A membrane bound structure in a cell that is the site of aerobic respiration	Muscle cells contain many mitochondria because they require a high amount of energy.
Mitosis	The phase of cell division when one cell divides into two.	After DNA is replicated in the cell cycle, mitosis occurs.
Partially permeable membrane	A membrane that lets particular substances through it (either in or out).	Cell membranes are examples of partially permeable membranes.
Organelle	A sub-cellular structure that has a specific function inside the cell.	Mitochondria are the organelles where aerobic respiration takes place.
Passive	A process that does not require energy.	Diffusion and osmosis are passive processes.

Tier 3 vocabulary that will need to be explicitly taught in context:

Word	Definition	Example in context

Benign	A tumour where the mass of cells is contained to one area.	The tumour was benign because it could not spread around the body.
Bone marrow	The spongy centre of long bones where blood cells are produced.	Adult stem cells can be extracted from bone marrow.
Flagellum	A whip-like structure found in some prokaryotic cells.	The bacteria have flagella to enable them to move.
Eukaryotic	A cell that contains membrane bound organelles.	Plant and animal cells are both types of eukaryotic cells or eukaryotes.
Prokaryotic	A cell which does not contain membrane bound organelles.	Bacteria are prokaryotic cells or prokaryotes
Embryonic	From an embryo or developing baby.	Embryonic stem cells can develop into all human cell types.
Hypotonic solution	A solution in which the external solution has a lower concentration of solute than the cell.	When a cell is placed in a hypotonic solution water will move into the cell by osmosis.
Hypertonic solution	A solution in which the external solution has a higher concentration of solute than the cell.	When a cell is placed in a hypertonic solution water will move out of the cell by osmosis.
Isotonic solution	A solution in which the external solution has the same concentration of solute as the cell.	If a cell is placed in an isotonic solution, there will be no net movement of water.
Resolution	The ability to distinguish between two points in an image.	The image was blurry because it had a low resolution.
Stem cell	An undifferentiated cell that can form other cell types	Stem cells could be used to treat paralysis.
Surface area	The outside surface of an object.	The surface area of the leaf was large so it could absorb lots of sunlight.
Plasmid	A small piece of circular DNA located in a prokaryotic cell	Prokaryotes do not have a nucleus, instead their DNA can be found in plasmids.
Inoculating loop	A piece of apparatus used to transfer a sample of microorganism to an agar plate.	The inoculating loop must be sterilised before use to prevent contamination.
Agar medium	A jelly like substance containing all the nutrients needed to culture microorganisms.	Students cultured bacteria in the lab using agar medium.
Aseptic	Free from contamination of microorganisms.	The aseptic technique is used to prevent contamination of agar plates.

Appendices

Appendix 1: Mark scheme for pre-unit quiz

Qu	Answer	Marks	Supporting information for fix-it tasks
1a	C	1	Answering A is the common misconception that the cell wall and the cell membrane are the same or get confused. *Task: Showing different diagrams and micrographs of the cell wall and the cell membrane alongside comparing their functions should practise differentiating these parts.* Answering the distractor B shows a lack of understanding of the different key words. *Task: Practising labelling cell diagrams or identifying errors on mislabelled cell diagrams could address this.*
1b	B	1	Answering the distractor A shows that the term 'control' is confused when comparing the functions of the nucleus and cell membrane. *Task: Writing a paragraph to compare the functions of the cell membrane and the nucleus would reinforce the different functions.* Answering C shows that there is a lack of understanding that the largest, roughly circular structure is the nucleus rather than chloroplasts (which are smaller, numerous and rod shaped). *Task: Showing different diagrams and micrographs of plant cells comparing labelling of the chloroplasts and the nucleus will practice differentiating these parts.*
1c	C	1	Answering A or B shows a lack of understanding of either the function of the cytoplasm or how to label the cytoplasm in cell diagrams. *Task: Completing a table listing the cell parts in both animal and plant cells and listing the parts only in plants would summarise and practise this key residual knowledge.*
2	A	1	Answering B shows a lack of understanding of the key words 'unicellular' and 'multicellular'. *Task: Discussing that uni = one and multi = many in the context of more familiar words (e.g. unicycle, unicorn, uniform and multicolour, multiply) will reinforce this vocabulary.*

			Answering C shows an issue with reading the question, since there is no information to suggest that this is a plant cell. Or it may demonstrate confusion in the new context of a 'yeast cell'.
3a	C	1	Answering A shows a lack of understanding about how to improve the scientific drawing since drawing more cells wouldn't improve the quality of the drawing. *Task: Practise another 'how would you improve…' question, since this is a challenging AO3 skill.* Answering B shows that students understand that increasing the magnification could improve the amount of detail seen but not how to specifically improve the quality of the drawing. *Task: Practise another 'how would you improve…' question, since this is a challenging AO3 skill.*
3b	B	1	Answering the distractor A shows confusion about why we stain of cells to make them visible in the microscope and why we use microscopes to see cells more generally. *Task: Show a micrograph of red blood cells without staining to show that not all cells need iodine/methyl blue stains to see them.* Answering the distractor C shows confusion about a functions of a different piece of equipment from the microscope practical; the slide. *Task: Comparing the functions of the slide, stage and focussing wheels should reinforce that the slide is just where the specimen is placed so that focussing can happen. This can be done as an annotation of a diagram following a discussion or as a written paragraph.*
3c	C	1	Answering the distractors A or B shows confusion about the functions of different parts of the microscope. *Task: Comparing the functions of the objective lens, eyepiece lens and focussing wheels should reinforce the different functions. This can be done as an annotation of a diagram following a discussion or as a written paragraph.*
3d	B	1	Answering A or C shows a lack of understanding that there are several chloroplasts per cell or a lack of understanding that there are 10 cells shown each containing a stained dot.

			Task: The dot stained is actually the nucleus because iodine solution stains cell walls and nuclei. Asking students why we need to stain cells and discussing that not all parts will be stained could address this.
4a	A	1	Answering B shows a lack of understanding of the difference between structure and function. B is the potential function of the tail structure. *Task: Practise by comparing the structure and function of adaptations in other cell types, e.g. tail (structure) in sperm cell to swim t egg (function) or lots of chloroplasts (structure) in leaf cells to carry out more photosynthesis (function).* Answering C shows a lack of ability to apply knowledge in a new context since 'sperm cell' is a cell type with a tail that has been taught, but is not the focus of this question. *Task: Underlining the key information in the question (e.g. Euglena, adapted, moving) could improve focus on the key information in the question.*
4b	B	1	Answering A potentially shows a confusion with the several new key words starting with 'c'. *Task: Showing different diagrams and micrographs of plant cell and labelling the cytoplasm and chloroplasts, alongside comparing their functions, should practice differentiating these parts.* Answering C potentially shows knowledge that plant cells make their own food and that the vacuole is only found in plants. *Task: Discussing functions of the chloroplasts and vacuole then writing a comparative paragraph should reinforce the very different functions of these parts.*

Appendix 2: Mark scheme for mastery quiz

Section A

Qu	Answer	Marks	Supporting information for fix-it tasks

1	C	1	Answering A suggests that students have understood the relationship between rate of diffusion and temperature but have not been able to apply the idea that a cup of tea will have a smaller concentration gradient than water by itself. *To fix it, ask students to define 'concentration gradient' and then explain why diffusion rate is slower in option A as compared to option C.* Answering B suggests a fundamental gap in knowledge about the effect of temperature on diffusion rate. *To fix it, reteach why diffusion happens faster when the temperature is greater and this can be demoed using a beaker of hot and cold water, place tea bags in both and observe the difference in diffusion rate.*
2	C	1	Answering B or C suggests a gap in knowledge about examples of prokaryotic and eukaryotic cells. *To fix it, ask students to write definitions for prokaryotic and eukaryotic, including an example organism for each.*
3	A	1	Answering B suggests that students can recall that plasmid and loops are in prokaryotic cells, however it shows in gap in knowledge that eukaryotic cells have genetic material stored in the nucleus. *To fix it, reteach the etymology of the words eukaryotic (true-kernal (nucleus)) and prokaryotic (before-kernal (nucleus)). Then ask students to describe how DNA is arranged in prokaryotic and eukaryotic cells.* Answering C suggests a confusion of eukaryotic and prokaryotic genetic material organisation. *To fix it, ask students to compare eukaryotic and prokaryotic cells.*
4	A	1	Answering B suggests some understanding that adult bone marrow cells can differentiate into blood cell types, but does show a gap in knowledge that only embryonic stem cells can differentiate into **any** cell type. *To fix it, reteach the difference between adult bone marrow stem cells and embryonic stem cells and then ask students to write their own definitions for these.* Answering C suggests a gap in knowledge about stem cells, since a zygote/fertilised egg cell is a single cell. *To fix it, ask students to explain what a stem cell is and where they are found.*
5	C	1	Answering A suggests a gap in knowledge because option A is an example of what students should **not** do. *To fix it, students should annotate a microscope diagram with the steps they should follow to view cheek cells under the light microscope.* Answering B suggests that students have confused the objective and eyepiece lens. *To fix it, students should label*

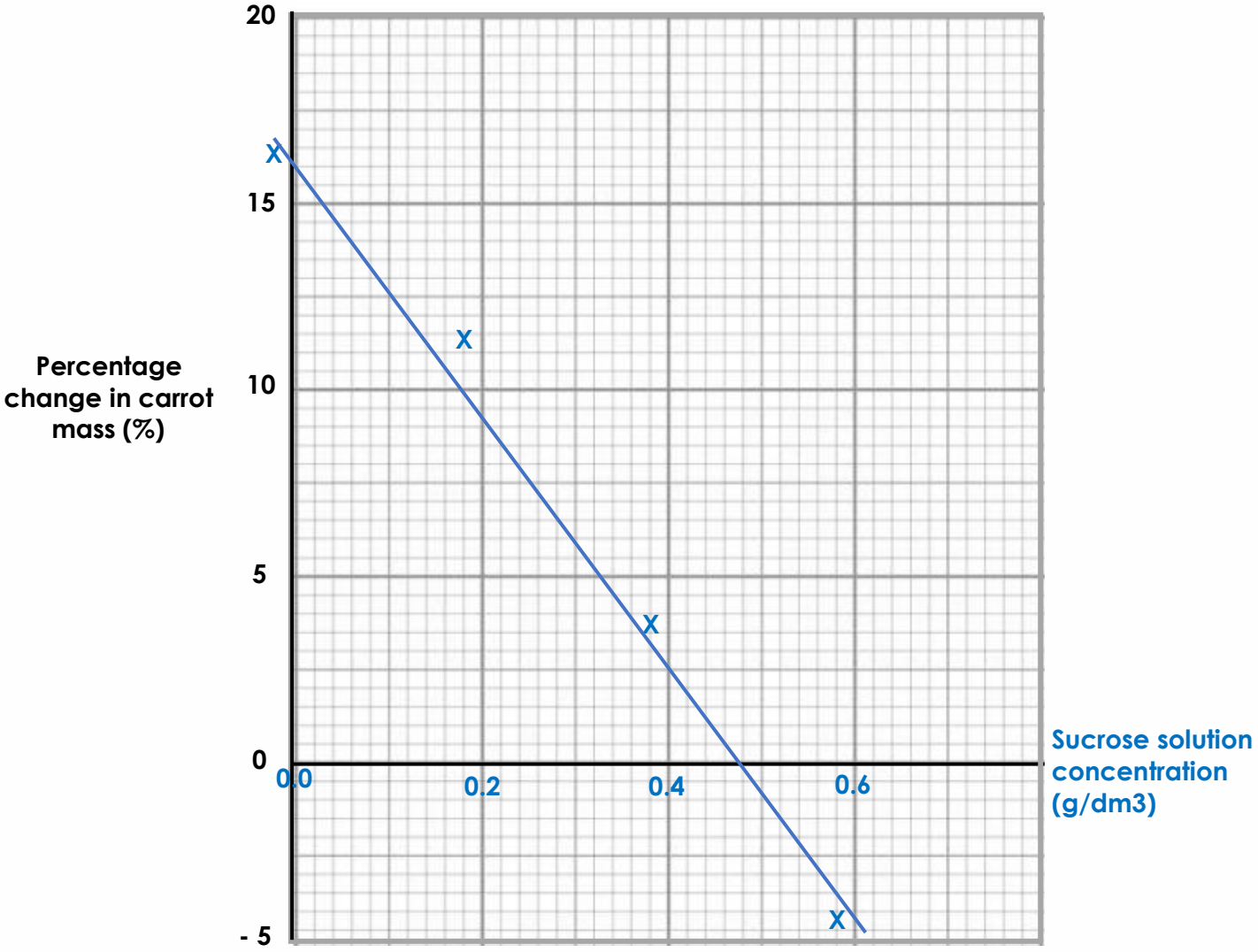
			a microscope diagram with particular focus towards the different lenses and then students should describe the functions of the eyepiece and objective lenses.
6	B	1	Answering A suggests that students have calculated the percentage of the original beaker mass of the final beaker mass instead of the percentage increase in mass. Answering C suggests that students have divided 50 by 250 (the final mass) instead of 50 divided by 200 (the original mass). *To fix it, students should be given a selection of calculations to complete which involve firstly calculating percentages, and then percentage increase and decrease.*
7	A	1	Answering B suggests the correct knowledge that energy is required, but the concentration gradient described is for diffusion. *To fix it, ask students to describe an example in an organism where active transport is used, ensuring they include the concentration gradient.* Answering C suggests some understanding, since the concentration gradient here is correct, however it identifies a gap in knowledge that energy is required. *To fix it, ask students to explain why energy is required in active transport.* Answering D suggests a confusion with the definition for diffusion. *To fix it, ask students to compare and contrast diffusion and active transport.*
8	B	1	Answering A suggests that students have a misconception that there is no osmosis when water is used. *To fix it, ask students to explain why the mass is the same when placed in 0.2 g/dm^3.* Answering C suggests that students know that osmosis would take place because of a difference in concentration but have incorrectly chosen the direction of water movement. *Give students more questions with writing down relative concentrations to practise choosing the direction of water movement.*
9	A	1	Answering B suggests the misconception that an increase in volume, increases the surface area : volume ratio. *To fix it, reteach, using diagrams, how the ratio decreases when the volume of the organism increases. Then give students some values to calculate the ratio for a small and larger organism to compare.* Answering C shows that students do not understand the relationship between SA:volume ratio and the rate of diffusion. *To fix it, ask students to describe and explain the*

			different factors that affect the rate of diffusion.
10a	C	1	Answering A suggests that students have not converted the values to have the same unit before performing the division calculation. *To fix it, ask students to practice converting values from mm to μm and cm to mm.* Answering B suggests an error in converting units for this calculation. *To fix it, ask students to write out how many mm in 1 cm, μm in 1 mm, etc to practise this.*
10b	B	1	Answering A shows some understanding of how an electron microscope works, but it shows a gap in knowledge in the greater magnifying power of the electron microscope. *To fix it, ask students to compare the magnifying power of the light and electron microscopes.* Answering C suggests a gap in knowledge about what resolution is because it would make it easier to resolve/tell apart two ribosomes so it would be beneficial to have a greater resolving power, like the electron microscope has. *To fix it, ask students to explain what is meant by magnification and resolution.*
11	A	1	Answering B or C suggests a fundamental gap in knowledge about the concentration gradient required for diffusion to happen. *To fix it, model this example using simple shapes for urea showing that there is more in the liver, less in the blood so more will diffuse into blood. Then ask students to explain why oxygen diffuses from alveoli into blood, including details about the difference in concentration.*
12	B	1	Answering A suggests a confusion with converting micro with milli. *To fix it, reteach the value of m, mm and μm, then ask students to write then units out from smallest to largest value, annotating the different in magnitude between each unit.* Answering C suggests the misconception that any value in micrometres is always 10^{-6} m. *To fix it, model why answer B is correct and then give students more similar practice questions.*
13	C	1	Answering A suggests that students have a gap in knowledge that one bacterium divides into two bacteria during cell division. *To fix it, ask students to explain why mitosis makes two cells from one parent cell.* Answering B suggests a misconception that simply multiplying the number of cells by the number of division events results in total cell number. *To fix it, model for students using circles and arrows, how many cells are produced at each division event. Then ask students to calculate how many cells would be present if there were 4 cells in the sample and there were 4 division events*

			(answer = 64).
14	A	1	Answering B suggests that students know one step involved in aseptic technique, however there are other steps involved in an aseptic technique method. *To fix it, ask students to describe how to transfer a fungal sample from a tube to a Petri dish using an inoculating loop, ensuring they include more steps than written in option B.* Answering C suggests that students have confused a specific practical investigation with aseptic technique in general. *To fix it, ask students to explain what would happen if a scientist growing one species of yeast on a Petri dish didn't use aseptic technique.*

Section B

Qu	Model answer	Supporting information ***Suggestions for fix-it tasks***
1	Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane	Students be confused with the many tier 3 words in this definition. *To fix it, annotate this definition, explaining what each part means. Then ask students to explain how osmosis is different to diffusion using the key words annotated.*
2	A lifestyle risk factor is a lifestyle choice that can increase the likelihood of a person developing a disease.	A potential error here might be the confusion with the inherited or genetic risk factor, since students will know that there is a genetic risk factor to cancer too. *To fix it, ask student to describe two types of risk factors that contribute to cancer.*
3	The cell cycle starts with a growth phase where the cell grows to double sub-cellular structures such ribosomes, cell membrane and DNA. During mitosis DNA, arranged into chromosomes, is pulled to separate ends of the cell ready for division. The final part of the cell cycle is when the cell membrane splits to produce two identical cells.	A common error here is to confuse mitosis with the cell cycle, so only mitosis could be described. *To fix it, show students the pie-chart diagram of the stages of the cell cycle and then ask them to rewrite their answer.*
4	See the exemplar graph below. Success criteria: - x-axis scale regularly spaced - x-axis correctly labelled - 4 points plotted correctly - Line of best fit (straight line that aims to go through all the points)	A common error is not drawing the line of best fit, or drawing it as a curved or smooth line like a 'dot-to-dot'. *To fix it, model how to draw the line of best fit for this data and then ask students to peer assess each other's lines and give a www and ebi.*



Appendix 3: Core knowledge statements

Eukaryotic and Prokaryotic Cells

- Eukaryotic cells have membrane-bound organelles and have genetic material contained in the nucleus
- An organelle is a part of a cell that carries out a specific function
- Plant and animal cells are examples of eukaryotic cells
- Eukaryotic cells are typically between 10-100 µm in size

- 1 µm is equal to 1 x 10-6 m
- All eukaryotic cells have a nucleus, mitochondria, ribosomes, cytoplasm and a cell membrane. Plant cells also have a cell wall, vacuole and
- chloroplasts
- Mitochondria are the site of aerobic respiration which releases energy for cellular processes
- Ribosomes are the site of protein synthesis
- Chloroplasts contain chlorophyll to allow for photosynthesis
- The cell membrane controls the movement of substances in and out of a cell
- The cytoplasm is the site of chemical reactions within a cell
- The cell wall provides support and rigidity to plant cells and is made of cellulose
- The vacuole contains cell sap and provides rigidity to plant cells
- Prokaryotic cells do not contain membrane-bound organelles
- Prokaryotic cells are much smaller than eukaryotic cells. They are typically between 1-10 µm in size.
- Prokaryotic cells are approximately 10 orders of magnitude smaller than eukaryotic cells · Prokaryotic cells contain genetic material in small rings called plasmids, or in larger loops · Prokaryotic ribosomes are smaller than eukaryotic ribosomes

Aseptic Technique

- Petri dishes are used to produce cultures of bacteria and other micro-organisms
- Cultured bacteria are grown on a nutrient medium in controlled conditions
- Aseptic techniques must be used to prepare cultures to prevent contamination of the culture and the growth of harmful bacteria ·
- Petri dishes, inoculating loops and culture media must be sterilised before use. A flame can be used to sterilise equipment
- An inoculating loop is a piece of equipment used to transfer bacteria to the petri dish
- The lid of a Petri dish should be partially secured with tape to ensure bacteria cannot escape but conditions remain aerobic
- The Petri dish must be stored upside down to prevent condensation affecting bacterial growth
- In school laboratories, cultures should generally be incubated at 25 °C to prevent the growth of harmful bacteria
- A cotton wool swab can be used to transfer a sample to a Petri dish to investigate bacterial growth
- Bacteria on a Petri dish divide rapidly whilst the nutrient supply is rich. Every time the bacteria reproduce, the number doubles. The total number of bacteria can be calculated using the following formula: Final number of bacteria = Initial number of bacteria x 2number of divisions

Microscopes

- Microscopy is the field of using microscopes to view samples that cannot be seen with the naked eye
- Microscopy has developed over time
- Light microscopes allow us to see the largest organelles, including the nucleus, cell membrane, cell wall and cytoplasm. A stain is often used to make the organelles clearer
- The parts of a light microscope include the eyepiece lens, objective lenses, stage, coarse focusing wheel, fine focusing wheel, light/mirror
- A sample used with a light microscope must be very thin to allow light to pass through
- The specimen to be viewed under a microscope is placed on the stage and secured with stage clips
- The eyepiece lens and objective lens are used to increase the size of the image
- The coarse focusing wheel is used to move the stage and get the cells into frame ·The fine focusing wheel is used to sharpen an image
- The total magnification of a microscope can be calculated using the following equation: Total magnification = Objective lens x eyepiece lens
- Electron microscopes have a greater magnification and resolution than light microscopes. They are much more expensive than light microscopes
- Magnification is the number of times larger an image is than the object
- Resolution is the ability to distinguish between two points
- Electron microscopes allow are to see more organelles and study cells in greater detail
- Magnification can be calculated using the following equation: $Magnification = \frac{Size\ of\ image}{Size\ of\ object}$
- A scale bar can be used to calculate the magnification of an irregular object
- Magnification does not have a unit because it is a ratio

Diffusion

- Diffusion is the spreading out of particles, of a gas or liquid, resulting in net movement from an area of high concentration to low concentration
- Diffusion of some substances can happen through the cell membrane
- In gas exchange, oxygen and carbon dioxide diffuse between the alveoli and the blood
- Urea is a waste product made by cells that needs to be excreted by the kidneys. Urea diffuses from cells into blood
- The rate of diffusion is increased by: an increase in temperature, an increases in the difference in concentrations (concentration gradient) and by a greater surface area
- Unicellular organisms have a relatively high surface area to volume ratio allowing for sufficient transport of all required substances
- Large, multicellular organisms have adaptations to increases the surface area to volume ratio to allow for efficient exchange of substances
- The cell membrane is very thin so provides a short diffusion path

- In plants, the structure of leaves and roots increases the surface area for diffusion
- The lungs of mammals, birds and reptiles are well ventilated, have a large surface area and an efficient blood supply to maximise the rate of diffusion
- The gills of fish have a large surface area and efficient blood supply to maintain a high concentration gradient for diffusion

Osmosis

- Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane
- Only water can move by osmosis
- A partially permeable membrane is a membrane that lets particular substances pass through it, either into or out of the cell
- A hypertonic solution is one in which the external solution has a higher concentration of solute than the cell.
- Water always moves out of a cell that is placed in a hypertonic solution, causing the cell to shrivel or become flaccid
- Tissue placed in hypertonic solutions decreases in mass
- A hypotonic solution is one in which the external solution has a lower concentration of solute than the cell. Water always moves into a cell that is placed in a hypotonic solution, causing the cell to swell or become turgid
- Tissue placed in hypotonic solutions increases in mass
- An isotonic solution is one in which the external solution has the same concentration of solute as the cell. Water will not move in or out of cells placed in an isotonic solution so their size will stay constant
- Guard cells open and close due to the movement of water by osmosis
- The mass of plant tissue can be measured before and after being placed in a solution of known concentration to calculate the percentage change in mass due to osmosis

Active Transport

- Active transport is the movement of substances from a more dilute solution to a more concentrated solution, requiring energy from respiration
- Active transport works against the concentration gradient
- Some substances are moved into a cell by both diffusion and active transport
- Active transport is used in the small intestine/gut to transport glucose into the blood for transport to cells for respiration
- Active transport is used in root hair cells to absorb mineral ions from the soil that are essential for plant growth
- Plants growing in waterlogged soils cannot absorb mineral ions because the cells do not have access to oxygen for respiration

Cell Growth and Division

- Both eukaryotic and prokaryotic cells undergo cell division
- Cells increase in number by dividing into two
- The eukaryotic cell cycle contains a growth phase where the cell grows to double sub-cellular structures (such ribosomes and cell membrane) and DNA, then the cell splits into two during mitosis
- The cell cycle of different cells lasts different lengths of time
- A microscope can be used to observe cells in different stages of the cell cycle
- The length of time in a certain stage of the cell cycle can be calculated using the following formula: $observed\ number\ of\ cells\ at\ that\ stage total\ number\ of\ cells\ observed\ x\ total\ length\ of\ time\ of\ cell\ cycle$
- The mass of DNA in a cell doubles during the growth phase of the cell cycle
- The mass of DNA in a cell can be measured in picograms
- 1 picogram = 1 x 109 g · During mitosis DNA (arranged into chromosomes) is pulled to separate ends of the cell ready for division
- The final part of the cell cycle is when the cell membrane splits to produce two identical cells
- Mitosis is used by eukaryotic organisms for growth and repair
- Mitosis is used by eukaryotic organisms that asexually reproduce
- Mitosis does not occur in prokaryotic cells because they do not possess a nucleus
- Checkpoints in the cell cycle control the rate of cell division
- Cancer is caused by uncontrolled cell division
- A tumour is a mass of cells caused by uncontrolled cell division
- Benign tumours are a mass of cells contained in one area
- Malignant tumours are formed of cancer cells that invade other tissues and spread around the body where they form secondary tumours
- A risk factor is a gene or lifestyle choice that can increase the likelihood of a person developing a disease
- Lifestyle risk factors for cancer include poor diet, lack of exercise, smoking, UV exposure
- Genetic risk factors for cancer include gene mutations

Stem Cells

- Specialised cells arise from stem cells
- Stem cells are cells that are capable of differentiating into other types of cell
- When a cell differentiates, it acquires specific structures needed for that cell type
- Most animal cells differentiate at an early stage of development
- Embryonic stem cells can differentiate into all human cell types
- Adult bone marrow contains stem cells that can differentiate into different types of blood cell
- Embryonic stem cells can be used to study and treat diseases.
- There are religious and ethical objections to using embryonic stem cells in scientific research
- Plants contain meristem tissue at the tips of shoots and roots that retains the ability to differentiate throughout a plant's life