BIG IDEA:	**Cells are alive**
Prior Learning:	Pupils will be familiar from KS3 with the structure of basic animal and plant cells (and their differences), as well as a range of specialised cells. They will be able to relate the structure of specialised cells to their functions. Pupils will be able to identify the parts of a light microscope and be able to describe how to use this to observe cells. They will be able to calculate total magnifying power by multiplying the eyepiece lens magnification by the objective lens magnification. Pupils should have an appreciation for how small cells are. 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 as relating liquids and gases.
Future Learning:	This unit forms the basis of more advanced study of cellular processes. 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.
Key misconceptions:	There are some very common misconceptions around prokaryotic and eukaryotic cells. From B1.1 pupils have been taught that the nucleus contains the genetic material so it can be difficult for some pupils to adjust to the idea of plasmids and loops in prokaryotic cells. They have also been taught that cells are the simplest building blocks of life so assume that plant and animal cells are the simplest cells and equating that with them being prokaryotic as they are smaller and often have fewer organelles. Many pupils also hold the misconception that all microorganisms are harmful (i.e. 'germs') and so will assume that the aseptic technique is used to prevent the growth of any microorganisms at all (hence completely sealing the petri dish) rather than used to grow a specific culture. Some pupils may still hold the misconception that cells all look exactly the same (like the 2D image) and so will find it difficult to identify cells and organelles when presented in a different format. Pupils can often be confused with the difference between the size of an image and the actual size of an object (particularly if their numeracy and idea of scale is weak) so it is important to model the method to calculate magnification, as well as using the other quantities as unknowns. If pupils do not have a secure understanding of concentration they are at risk of holding on to misconceptions in diffusion and osmosis where they are unable to distinguish between a high and low concentration of solute and a dilute and concentrated solution. Consistency of language is key for this concept, and it is useful to use simple diagrams to show relative particle concentrations. A common misconception in cell division is that pupils can assume the whole process is mitosis rather than just the actual splitting of the genetic material so it is useful to highlight the mitosis stage when explaining or modelling the process.
Unit sequencing:	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.

Unit title	Lesson code	Lesson title	What do my students need to know by the end of the lesson?	Spec references	What could help my students to understand this knowledge?	What do my students need to be able to do by the end of the lesson?	What prior knowledge do I expect my students to have? Where is this likely to have come from?	What practical activities are planned? What apparatus and chemicals are required?	What are the core practical, enquiry and maths skills that students will learn and practise? Key: Skills in **bold** are taught for the first time here	What misconceptions may students arrive at the lesson with? What could they leave the lesson thinking if we are not careful? How can I address this directly? NOTE: More misconceptions are discussed in the 'notes' section of the powerpoints	What exit ticket questions will the students be required to answer by the end of the lesson?	What alternative activities could I do in this lesson?	What keywords am I introducing in this lesson that students may find difficult?
	B3.1.1	**Prior Knowledge Review**	Key knowledge for pupils before starting this unit should be the following at a minimum: Describing features of plant and animal cells and the functions of each organelle Describing structure and function relationships of specialised cells Describing the process of gas exchange and adaptations Stating required resources and chemical equations for photosynthesis and respiration		Pupils should be able to make the link between structure and function as this is key to the big idea of cells being alive, then building this to explain how tissues and organs are adapted. They should have an understanding of some	• Identify plant and animal cells from diagrams • Identify sub-cellular structures from diagrams • Describe the functions of the	B1.1 Cell structure, specialised cells, microscopes and cell organisation, C1.1 diffusion, B2.1 tissues and organs	If you know that your pupils will struggle with microscopes and calculating magnification later in this unit, you may want to have a further practice of using a	Using a microscope, understanding the features and prepairing a slide. Pupils do not necessarily need to practice using microscopes in this lesson as there is plenty of	Key misconception to check for is that pupils are aware humans are animals, if this has previously been missed.	1.Which organelles do plant cells have but animal cells do not? a.Nucleus, cell membrane and cytoplasm b.Cell wall, vacuole, chloroplasts c.Chloroplasts, cell membrane, nucleus 2.Which is the best explanation for the function of a microscope?	Use questions from previous mastery quizzes as a pre unit quiz to identify gaps.	Nucleus, organelle, slide, specimen, cytoplasm, chloroplast
	B3.1.2	**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 nucleus contains DNA and controls the cell's activities • 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 diagrams are smaller than eukaryotic diagrams	4.1.1.1, 4.1.1.2, 4.1.1.3	Eu (meaning true) and karyo (kernel/nut/nucleus) for etymology. You may want to use a tool (e.g. scale of the universe) to show pupils the relative sizes of these different cell types, and how there can be a range of sizes. It can be beneficial to show pupils different examples of eukaryotic and prokaryotic cells so they learn to look at the features of each cell, rather than the overall appearance of it, which may not always look similar.	• Name the sub-cellular structures in eukaryotic and prokaryotic cells • Describe the function of all sub-cellular structures • Identify eukaryotic and prokaryotic cells from diagrams	B1.1 Cell structure, specialised cells, microscopes and cell organisation. Pupils should know the organelles in plant and animal cells and be able to explain their functions. They should also be able to identify features of specialised cells and explain how they are related to the cell's function.	Look at pre-made slide samples of eukaryotic and prokaryotic cells under the microscope.		Stosiy (1990) - pupils have been drilled that the nucleus is the location of DNA so often assume that prokaryotic cells not containing a nucleus means they have no DNA. Emphasise to pupils that DNA is stored in plasmids or loops. Cells are the simplest form of life and examples of cells have always been plant and animal cells, so pupils tend to assume that they will be the simpler cells (i.e. prokaryotic)	1.Which of these is an example of a prokaryotic cell? a.Animal cell b.Plant cell c.Bacterial cell 2.What is the relative size of eukaryotic cells and prokaryotic cells? a.Prokaryotic cells are larger than eukaryotic cells b.Eukaryotic cells are larger than prokaryotic cells c.Prokaryotic cells and eukaryotic cells are roughly the same size 3.Which statement best explains the difference between eukaryotic and prokaryotic cells? a.Eukaryotic cells contain DNA within a nucleus, prokaryotic cells contain DNA in loops and plasmids b.Eukaryotic cells contain DNA in loops and plasmids, prokaryotic cells contain DNA within a nucleus c.Prokaryotic cells contain mitochondria to provide them with energy so they can move"	Compare and contrast electron micrograph images of eukaryotic and prokaryotic cells.	Eukaryotic, prokaryotic, nucleus, plasmid, organelle, mitochondria, flagellum,
	B3.1.3	**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	**4.1.1.6 (Biology only)**	**You may want to carry out this practical before L2 (depending on timetabling), so that pupils have the opportunity to look at their prepared culture before they use the aseptic technique again for the antibiotic practical.** This is not a required practical by itself but it very useful to prepare for the antibiotic required practical. Although both are biology only, they are a useful practical for all pupils to carry out, especially to see the function of antibiotics and discuss the wider implications of antibiotic resistance.	•Identify apparatus used in the aseptic technique • Describe the aseptic technique • Explain why apparatus must be sterilised	Sterilisation refers to any process that removes or kills microorganisms - pupils should be aware of hand sanitisers, bleach etc used to destroy microorganisms.	Practice prepairing an uncontaminated culture using the aseptic technique - very useful for pupils to see what bacterial growth will look like when left for 48 hours, making it particularly clear the difference that antibiotics can make.	**36. Application of aseptic technique.**	Some students will try and tape round the entire petri dish so nothing can get in', but this includes oxygen - bacteria need the oxygen to respire aerobically so that we are able to see the relative growth with the antibiotics	1. Which best explains why the aseptic technique is used? A. To ensure that there is no contamination when preparing a culture B. To ensure that the Petri dish is clean C. To ensure that all microorganisms are allowed to grow 2. Which is not a feature of the aseptic technique? A. Sterilising the inoculating loop using a flame B. Securing the Petri dish by making an airtight seal C. Sterilising the agar before use 3. What is the function of the agar in a Petri dish? A. To provide nutrients B. To sterilise the petri dish. C. To destroy any microorganisms.		Aseptic, antibiotic, culture, agar medium, inoculating loop, sterilisation
	B3.1.4	**Growth of 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	**4.1.1.6 (Biology only)**	This lesson is a great opportunity to explain how antibiotics work on bacteria (not viruses), and relate this to the imminent threat of antibiotic resistance. As this is the second practice of preparing a culture, this lesson can focus more on the mathematical and analysis skills rather than the aseptic technique preparation skills.	• Explain why bacteria are able to grow in agar medium • Identify the number of bacterial colonies on a petri dish • Calculate bacterial growth	Eukaryotic and prokaryotic cells. Pupils should know that bacteria reproduce asexually, producing clones. They should also be able to identify that the new cell would be identical to the parent cell.		13 a. Suggest a hypothesis to explain given observations or data. b. Explain why a certain hypothesis was chosen, with reference to scientific theories and explanations	All bacteria/microbes are harmful so antibiotics are used to kill them all.	Which best explains the purpose of this investigation? A. To look at how best to make bacteria grow to spread disease B. To ensure no bacteria is allowed to grow C. To determine the location with the most/fewest microorganisms 2. Which is a feature of the aseptic technique? A. Ensuring there are no nutrients in the agar medium B. Ensuring there is no contamination in the agar medium C. Ensuring that oxygen is not allowed into the agar medium Why is the plate incubated at 25oC? A. To kill all bacteria B. To minimise the risk of dangerous microorganisms from growing C. Bacteria will not grow at lower temperatures	Different groups can culture different bacteria as the independent variable to test which is the most resistant.	Aseptic, antibiotic, culture, agar medium, inoculating loop
	B3.1.5	**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= (Size of image)/(Size of object) • A scale bar can be used to calculate the magnification of an irregular object	4.1.1.5	Pupils should understand the function of a microscope and the functions of the different parts. They should also be able to explain how microscopes have developed our understanding of cell theory.	• Explain the difference between magnification and resolution • Compare light and electron microscopes • Explain how to use a light microscope at a given magnification • Calculate the total magnification (eyepiece lens x objective lens) • Calculate the magnification used by doing image size /object size (including this calculation rearranged for object size) • Convert between different units (mm, um, nm)	B1.1 Microscopes practical, preparation of sample of cell	Show pupils images of electron microscopy to compare with their own slides under a light microscope.	33. Obtain a clear image using a light microscope.	Students may hold the misconception that cells are 2D, having exclusively seen them in photos or diagrams. Making and discussing 3D models can address this (Tregidgo and Ratcliffe, 2000; Lazarowitz and Naim, 2014)	A. Both light microscopes and electron microscopes allow us to look at large objects that are far away on a much smaller scale. B. Light microscopes have the greatest magnification and allow us to look at sub-cellular structures C. Electron microscopes have greater magnification than light microscopes and have enhanced understanding of sub-cellular structures 2. The image on the right shows a strand of human hair. The diameter bar measures 20 mm and the width of the hair is 0.001 mm. Which statement is correct? A. image size is 20 mm, actual size of object is 0.001 mm B. image size is 0.001 mm, actual size of object is 20 mm C. You need to know the magnification to calculate the image size and actual size 3. What is the magnification of this image using the given information? A. 0.02 B. 20000 C. 0.00005		Image, object, magnification, scale, sub-cellular, resolution
	B3.1.6	**Observing Cells**	Magnification = size of image/size of real object	4.1.1.5	Pupils should be confident with preparing and viewing a slide under the microscope so the focus of this lesson should be on scale and how to calculate magnification using measurements.	• Explain how to make a microscope slide (onion cell) • Explain how to use a light microscope at a given magnification	B1.1 Microscopes practical, preparation of sample of cell	Required practical activity 1: use a light microscope to observe, draw and label a selection of plant and animal cells. A magnification scale must be included.	**34. Prepare a slide with cells for viewing under the light microscope.** 66. Change the subject of an equation.	Many pupils tend to get mixed up with image size and size of actual object. It can be useful to remind them that a microscope is used to view smaller objects (meaning that the object must always be smaller than the image, and that the calculation should always result in a number greater than 1- if the calculation comes out as less than 1, they have their image and object values inverted).	1. Which statement is correct? B. Light microscopes are useful for looking at relative sizes of cells C. Light microscopes are useful for discovering new cell structures 2. Which is a precaution for looking at slides under a light microscope? A. Ensure that there is no stain on the slide so it does not obstruct the sample B. Ensure that the cover slip is carried and applied from the middle C. Ensure that the sample of cells is a very thin layer 3. Which states the correct functions of the focusing wheels? A.The fine focusing wheel is used to get the cells into the frame and the coarse focusing wheel is used to focus closely B.The coarse focusing wheel is used to get the slide into the right position and the fine focusing wheel is used to get the cells into the frame C. The coarse focusing wheel is used to get the cells into the frame and the fine focusing wheel is used to sharpen the image		Image, object, magnification, scale, sub-cellular, resolution
	B3.1.7	**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 • Surface area to volume ratio is calculated by dividing the surface area by the volume	4.1.3.1	Pupils should know the definition of diffusion from C1.1. It may be useful to remind pupils of the particle model, explaining why diffusion cannot happen in solids. It may also be useful to introduce/recap terms such as solute, solvent and solution at this point before they are encountered in osmosis.	• Define diffusion • Identify the direction of diffusion from diagrams, percentage concentrations and scenarios • Describe how the surface area to volume ratio changes as the length of the side of the model cell increases • Calculate surface area, volume and SA:vol	B1.1 Cell structure and specialised cells, B2.1 gas exchange, organ systems C1.1 diffusion	Demonstration - diffusion of potassium permanganate, or air freshener throughout classroom		Marek et al. (1994) - majority of pupils will confuse diffusion with a chemical change, i.e. they will assume that potassium permanganate is reacting with the water instead of simply being dispersed throughout it. To remove this misconception it may be useful to draw diagrams of what has actually happened to the solution and recap the terms solvent, solute etc. If possible heat or leave the solution for a longer time to evaporate some of the water so that you are again left with just the crystals and pupils can see it is a physical process rather than a chemical change.	1. Which is the best definition for diffusion? A. Spreading out of liquid or gas particles resulting in net movement from high concentration to low concentration. B. Spreading out of particles resulting in net movement from concentration to low concentration. C. Bits of liquid or gas moving around to make the concentration the same everywhere 2. Which of these changes would not increase the rate of diffusion? A. Increasing temperature B. Increasing surface area C. Decreasing concentration gradient 3. Which of these correctly states a stage in the process of gas exchange? A. Oxygen diffuses from the alveoli into the bloodstream. B. Carbon dioxide diffuses from the alveoli into the bloodstream. C. Urea diffuses from the bloodstream into cells.	Use this PHET interactive animation to model how the rate of diffusion changes when these variables are changed. https://phet.colorado.edu/sims/html/diffusion/latest/diffusion_en.html	Diffusion, concentration, gradient, passive, permeable, surface area to volume ratio

B3.1 Growth and Diffe	B3.1.8	**Diffusion in Living Things**	• 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	4.1.3.1	It is not required for pupils to understand and state the overall structure of the leaf at this point but it is difficult to show a diagram of the sponge mesophyll cells without referring to palisade mesophyll cells, so you may also want to link this back to structure and function (packed together with lots of chloroplasts to maximise photosynthesis). Pupils also do not need to know about gills in great detail at this point but it can be useful to make a comparison with breathing and fish obtaining oxygen from water.	• Explain why multicellular organisms rely on transport systems • Describe why diffusion is important to plants and animals using named examples of substances • Explain how the lungs, small intestine and root hair cells are adapted for diffusion of substances • Identify how previously unseen organisms/structures are adapted for diffusion of substances (eg gills on axolotl)	Pupils should understand the difference between unicellular and multicellular organisms. P1.3 Heat - Surface area to volume ratio B1.3 Competition, biotic and abiotic factors B2.2 Photosynthesis	You may want to use cubes to physically show surface area to volume ratio, or (if available) you may want to show a sample of gill tissue so that pupils can actually see the filament structures, as this makes surface area very visible.		Taylor (2008) found a correlation between reasoning scores and ability to understand scale. Pupils very commonly assume that a larger object must have a larger surface area to volume ratio - whilst it may have a larger surface area, its volume will also be larger so the ratio becomes smaller. It can be useful to explain this with comparative diagrams or a 3D model if possible.	1. Which describes an example of diffusion? A. Oxygen molecules moving from an area of low concentration in the bloodstream to an area of high concentration in the cells B. Glucose molecules moving from an area of high concentration in the small intestine to an area of lower concentration in the bloodstream C. Gills taking in water molecules to allow respiration in fish 2. Which would be useful adaptations to increase the rate of diffusion? A. A long path for diffusion and thick blood vessels B. A short path for diffusion and thick blood vessels C. A short path for diffusion and an efficient blood supply 3. Unicellular organisms generally allow efficient diffusion because... A. They are very small so don't need many molecules to have a high concentration B. They have a relatively large surface area compared to their volume C. They have a relatively large volume compared to their surface area		Adaptation, diffusion, passive, surface area to volume ratio
	B3.1.9	**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	4.1.3.2	In many textbooks, osmosis is referred to as the movement of water from high water concentration to low water concentration, to make it easier to compare the process to diffusion. This is fine to use but can cause serious confusion with pupils if you switch between discussing water concentration and solute concentration so ensure you choose which terms you are using at the beginning and then stick with them.	• Define osmosis • Define a partially permeable membrane • Identify the direction of water movement via osmosis from diagrams, percentage concentrations and scenarios	Pupils should be confident with the meanings of solute, solution, concentrated and dilute, but it may be worth using diagrams to recap. B1.3 Competition, biotic and abiotic factors B2.2 Photosynthesis	You may want to show pupils a plant that has not been watered so they can see the effect on the plant tissue (or hard boiled egg demonstration).		McKnight (1993 - common misconception is that pupils often cannot imagine particles moving independently of the body of matter they are contained in. In this case it may be useful to recap the particle theory. The other major misconception is that where the words dilute and concentrated are used. Teachers need to be conscious of using consistent language but also show examples of where the relative concentration of the solute is mentioned, e.g. in application questions. Many textbooks will refer to a high and low water concentration but questions could provide relative solute concentrations rather than water concentrations. It may be useful to use diagrams with dots for water/solvent and solute and showing pupils how a dilute solution has a low concentration of solute (and high water concentration). "	1. Which best states the definition of osmosis? A. Water going out of cells into salty water. B. The diffusion of water molecules from a dilute solution to a concentrated solution. C. The movement of molecules from a high concentration to a low concentration 2. Which scenario would result in a plasmolysed cell? A. A plant cell being placed in a hypertonic solution B. An animal cell being placed in a hypertonic solution C. A plant cell being placed in a hypotonic solution 3. A hypotonic solution is... A. A solution that has a higher concentration than the cell/sample B. A solution that has the same concentration as the cell C. A solution that has a lower concentration than the cell/sample	Demonstration using hard boiled eggs with shell removed, one placed in pure water and one placed in salt water for 24 hours	Osmosis, dilute, concentrated, hypotonic, hypertonic, isotonic, partially permeable membrane
	B3.1.10	**Osmosis Investigation**	• 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	4.1.3.2	This is an opportunity to make predictions based on understanding of different types of solution. For more able pupils you may also want to extend this practical to get them to estimate/determine the relative sugar concentration of a piece of fruit/vegetable tissue.	• Describe how to investigate the effect of solute concentration on osmosis in plant tissue • Calculate percentage change • Plot percentage change (+ve and -ve) on a graph and draw a line of best fit • Use the line of best fit to estimate the solute concentration of plant tissue • Evaluate a method used to investigate osmosis in plant tissue	Pupils should be able to use this new information from the osmosis theory lesson to make predictions.	Required practical activity 3: investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue. AT skills covered by this practical activity: AT1 Use of appropriate apparatus to make and record a range of measurements accurately, including length, area, mass, time, temperature, volume of liquids and gases, and pH (links to A-level AT a). 16. Identify in a given context: a. the independent variable as the one that is changed or selected by the investigator b. the dependent variable that is measured for each change in the independent variable 25. Measure mass accurately. B4. a. Use percentages b. calculate percentage increase and decrease.	Kramer (2012) - Osmosis is not just a "special case of diffusion", and that osmosis is limited to liquids (it can also occur in gases).	1.What was the independent variable in this experiment? A.Mass of potato cylinder B. Concentration of sugar solution C. Change in mass of potato cylinder 2.What would you expect to happen if a piece of onion was left in a hypertonic solution? A. The onion would disappear as the cells would lyse B. The onion would decrease in mass. C. The onion would increase in mass. 3.What would you expect to happen if a sample of animal cells were left in a hypotonic solution? A. They would expand and become turgid B. They would expand and burst C. They would become shrivelled		Osmosis, dilute, concentrated, variables, hypotonic, hypertonic
	B3.1.11	**Active Transport**	• Active transport moves substances from a more dilute solution to a more concentrated solution, requiring energy from respiration • Active transport works against the concentration gradient • 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	• 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	It can be really useful to show pupils diagrams with different concentrations, so they can show the direction of the concentration gradient. A useful analogy for active transport is swimming upstream (it needs energy and active participation) rather than drifting with the flow of the water. It is also useful to go over the small intestine - diffusion and active transport are both required so you may want to use diagrams to show when each process would occur (based on the relative concentrations of glucose in the small intestine and the bloodstream).	• Define active transport • Identify that active transport is an active process that require energy from respiration • Identify the direction of active transport from diagrams, percentage concentrations and scenarios • Suggest substances that move via active transport in plants and animals • Explain why active transport is important to root hair cells	Pupils should understand the idea that diffusion is a passive process, down a concentration gradient. B1.1 Specialised cells B1.3 Competition and biotic/abiotic factors B2.1 Gas exchange and Digestive system			Vithvarana (2015) found that a large proportion of pupils confused osmosis of water into root hair cells with active transport of minerals into root hair cells because they were not able to identify the relative concentrations. Ensure any diagrams are annotated with relative mineral concentrations so that pupils are easily able to work out the direction of the concentration gradient.	1. Active transport is... A. When molecules go the wrong way round and need energy to give them a push B. When molecules go from low to high concentration, releasing energy C. The movement of molecules from low to high concentration, requiring energy 2. When would active transport take place? A. When a person has eaten a couple of hours ago and has lots of glucose in their gut B. When a plant takes in important minerals for growth through the soil C. When a plant takes in water for photosynthesis 3. Diffusion does not require energy because... A. Molecules are travelling in the same direction as the concentration gradient B. Molecules are travelling in the opposite direction to the concentration gradient C. It is more important that the cell keeps the energy to use in respiration		Active transport, concentration gradient, passive, dilute, concentrated
	B3.1.12	**Cell 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 membranes) 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 10-9 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	4.1.2.2	Mitosis specifically refers to the part of cell division where the genetic material is split - cell division and mitosis are not the same thing.	• Suggest why it is important that different types of cells divide • Interpret diagrams of the cell cycle • Describe the growth phase, replication phase and mitosis •	Pupils should be clear on the difference between sexual and asexual reproduction and the offspring produced in each case. They should also be clear on the difference between DNA, genes and chromosomes. B1.1 Cell structure B1.2 Sexual and asexual reproduction B2.3 Variation	You may want to model the stages using a 3D model, such as pipe cleaners for chromosomes.		Dikmenli (2010) found that this was a topic that many student teachers identified as a topic they find difficult to teach because of their own misconceptions. Prior to teaching this lesson teachers need to ensure they are confident with the process in more detail than the residual knowledge in order to deal with questions effectively. Biggest pupil misconception is confusing mitosis and meiosis (Smith (1991), Kindfield (1994)), which is taught in a later unit, so it is crucial that pupils understand mitosis at this point to prevent deepening the misconception later on. Pupils may find it helpful to have more in depth coverage of what is happening during each stage and the reasoning behind it, i.e. why the DNA must be replicated.	1. Mitosis is... A. The process of making new cells B. The process of cells dividing to make two new cells C. The process of cells replicating their DNA and sub-cellular structures 2. Which is a stage of cell division? A. Replication of DNA and sub-cellular structures B. One cell being replaced by a newer cell C. A cell producing two new cells alongside it 3. Which best describes the cells that are produced at the end of mitosis? A. Two daughter cells that have half the number of chromosomes as the original cell B. Two daughter cells that have the same number of chromosomes as the original cell C. One daughter cell that has double the number of chromosomes as the original cell		Cell division, mitosis, chromosome, daughter cells
	B3.1.13	**Cancer**	• 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		This is a very sensitive issue, as most pupils will have been affected by cancer (directly or indirectly). They may also have family members who smoke or are obese, so discussing risk factors must be very sensitive. Pupils do not necessarily need to know the different stages of cancer or the different types but it can be quite interesting for them to learn (details in PP notes).	• Explain how cancers form • Describe the difference between benign and malignant tumours • Describe how tumours can spread to other parts of the body • Suggest risk factors for cancers • Interpret different sets of data about cancer rates and survival rates	Pupils should be confident with healthy living choices (generally around balanced diets, exercise and energy requirements).		9. a. identify and assess risks to health related to lifestyle habits and the risk of disease. b. Suggest sensible precautions to reduce risk.	Charlton (1977) found majority of pupils incorrectly thought of cancer as causing the most deaths. This is still the case as cancer usually has much more coverage than other conditions and most pupils will know someone/know of someone that has had cancer. Pupils also tend to assume that cancer is a death sentence, so this is a topic that has to be covered with great sensitivity. Pupils (particularly those who may be affected) may find it useful to see statistics on diagnosis stage and survival, especially the advances in the last 20 years.	1. Cancer is... A. The process of making new cells B. When mitosis is controlled C. Uncontrollable cell division 2. What is the difference between a benign and a malignant tumour? A. Benign tumours are isolated in one area, malignant tumours are always all over the body B. Benign tumours are isolated in one area, malignant tumours have the potential to spread to form new tumours around the body C. Benign tumours are all over the body, malignant tumours are isolated in one area 3. A risk factor is... A. An unhealthy lifestyle choice that means a person will get cancer B. A gene that is passed down and causes cancer C. A gene or lifestyle choice that will can increase the likelihood of a person developing cancer	Design promotional public health resources about the risk factors for cancer.	Cancer, risk factor, malignant, benign
	B3.1.14	**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	4.1.1.4, 4.1.2.3	For this stage, it is not necessary to go into too much detail about the different types of stem cell. The focus here is on the difference between adult stem cells and embryonic stem cells, although this is a field which is still rapidly evolving - most exciting development is the discovery of induced pluripotent stem cells (IPSCs or iPS cells), which are adult stem cells that scientists have coaxed back to an earlier stage of pluripotency, which is the ability to turn into any cell within the human body. You may want to go into this with varying levels of detail and it can be very interesting as a research project.	• Define a stem cell • Describe the differences between embryonic and adult stem cells • Suggest diseases that could be treated with stem cells • Identify where meristems are found • Suggest why some people may be against the use of stem cells • Evaluate the therapeutic use of embryonic stem cells taking religious and ethical concerns into consideration	Pupils should be secure in their structure/function relationships of specialised cells. Pupils should also know from B2.1 that bone marrow is responsible for making new blood cells. B1.1 Cell structure, specialised cells, cell organisation B1.2 Sexual and asexual reproduction, embryo development		**6. Outline a simple ethical argument about the rights and wrongs of a new development, discovery or technology.** **10. Explain that there are hazards associated with science-based technologies which have to be considered alongside the benefits.**	Concannon et al. (2009) - students have heard a lot about the possibilities of stem cell research and so have developed the idea that they can be used to regrow organs etc very easily. Stem cells create a lot of possibility but cannot currently be used to completely regrow organs because of their division potential. It may be useful (to more able pupils in particular) to go through some of the current specific uses of stem cells - i.e. growing cultures of motor neurons and insulin-producing pancreatic tissue. Some pupils (from religious backgrounds) will have heard about stem cells in the media and equate stem cells with unborn foetuses. Ensure that pupils know that these embryos would not have been able to develop into embryos but would have been destroyed.	1. Stem cells are... A. Cells that can differentiate to form different specialised cells B. Cells that can undergo cell division C. Cells that can differentiate to form one type of specialised cell 2. Why are embryonic stem cells considered more useful therapeutically than adult bone marrow stem cells? A. They can be cloned to form new organisms with desired features B. They can differentiate to form different types of cell rather than just blood cells C. They can differentiate to form a foetus with many different types of cell 3. A religious/ethical objection to the use of embryonic stem cells is... A. The embryo would be destroyed if it was not used B. The embryo could be used to create designer babies C. The embryo cannot give its permission to be used	"Debate around the issue of stem cell research - which type of stem cells should be used? What are the arguments for both sides? Research project on different types of stem cells, and their uses, including the most up to date research."	Stem cell, embryonic, bone marrow, meristem, differentiation,
	B3.1.15	**Feedback lesson**													