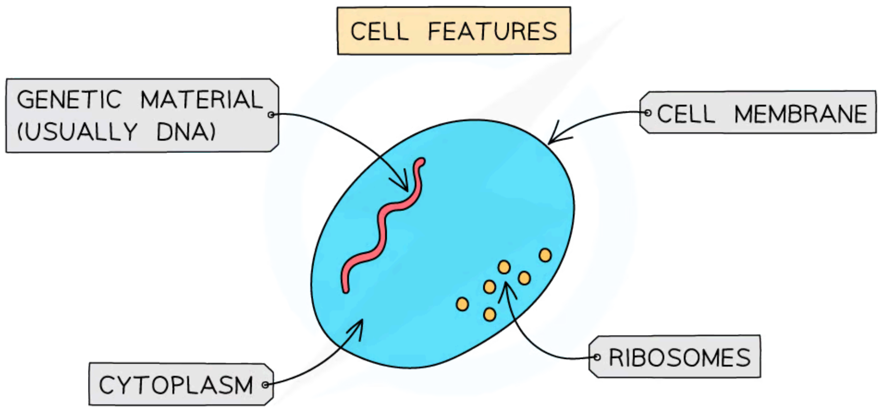
AQA GCSE Biology

Your notes

Cell Structure

Contents

Cells in biology



Use this image

All cells have a number of features in common with each other

- For a cell to be a cell, it has to have the following components:

Cellular components & functions table

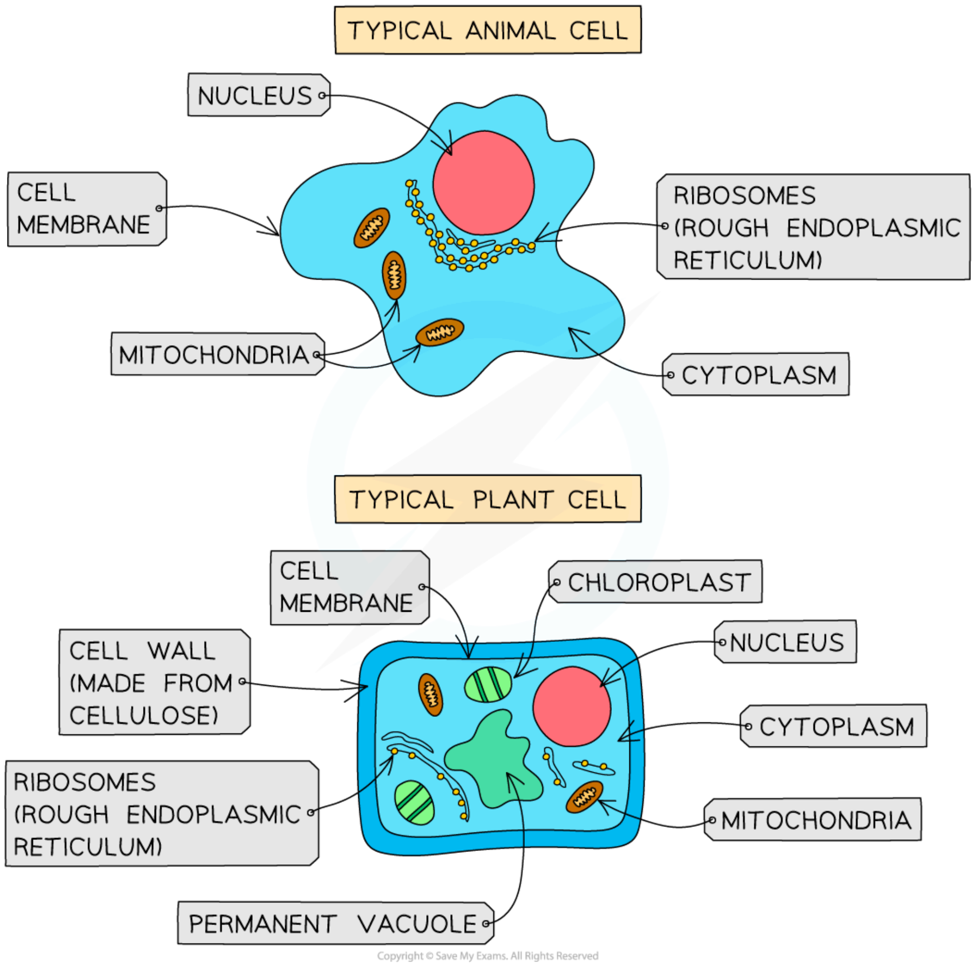
Cellular component	Function
Cell membrane	Hold the cell together, separating the inside of the cell from the environment outside, controlling what can and cannot enter or leave the cell
Cytoplasm	A jelly-like substance where many chemical reactions inside the cell happen. Surrounds sub-cellular structures
DNA	The genetic material that controls the activities of the cell
Ribosomes	The site of protein synthesis in the cell

Use this image

- There are two distinct types of cell – eukaryotic and prokaryotic

Eukaryotic cells

- Plant and animal cells are both eukaryotic cells
- They have the components listed in the table above (so a cell membrane, cytoplasm and ribosomes), as well as others
- A defining feature of eukaryotic cells is that their genetic material (DNA) is enclosed within a nucleus
- Eukaryotic cells vary in size, usually between 10 and 100 µm



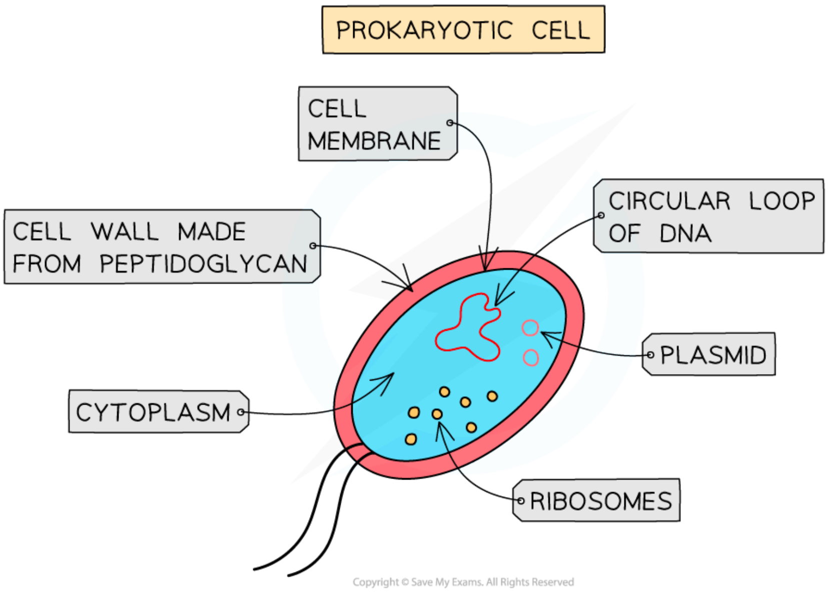
Use this image

Animal and plant cells are both eukaryotic cells as their genetic material is packaged in a nucleus

Prokaryotic cells

- Bacterial cells are a type of prokaryotic cell
- A defining feature of prokaryotic cells is that their genetic material is not enclosed within a nucleus, it is found as a single loop of DNA within the cytoplasm

- Additional smaller, circular pieces of DNA called plasmids may also be present
- The cell membranes of all prokaryotic cells are surrounded by a cell wall (usually made from a substance called peptidoglycan)
- Prokaryotic cells are much smaller in comparison to eukaryotic cells, with many measuring ~ 1 μm in size



Use this image

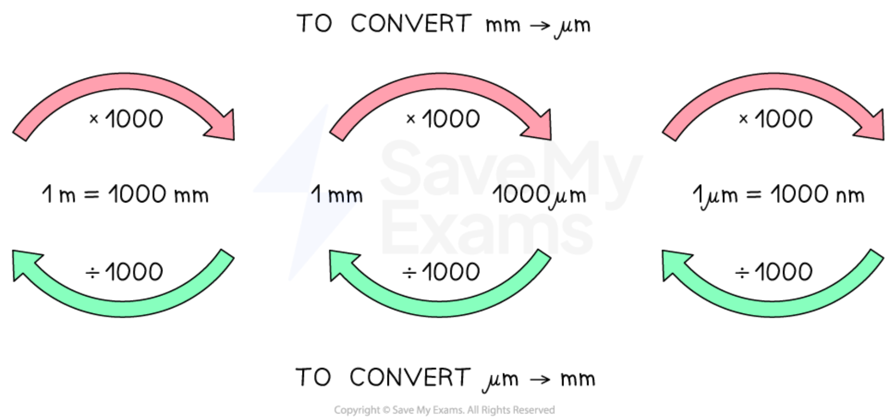
Prokaryotic cells do not have a nucleus, and are much smaller than eukaryotic cells

Prokaryotic cells table

Component	Eukaryotes	Prokaryotes
Cell membrane	Y	Y
Cytoplasm	Y	Y
Genetic material	Y – in a nucleus	Y – in the cytoplasm
Nucleus	Y	N
Cell wall	Some types	Y – made from peptidoglycan

Scale & the size of cells

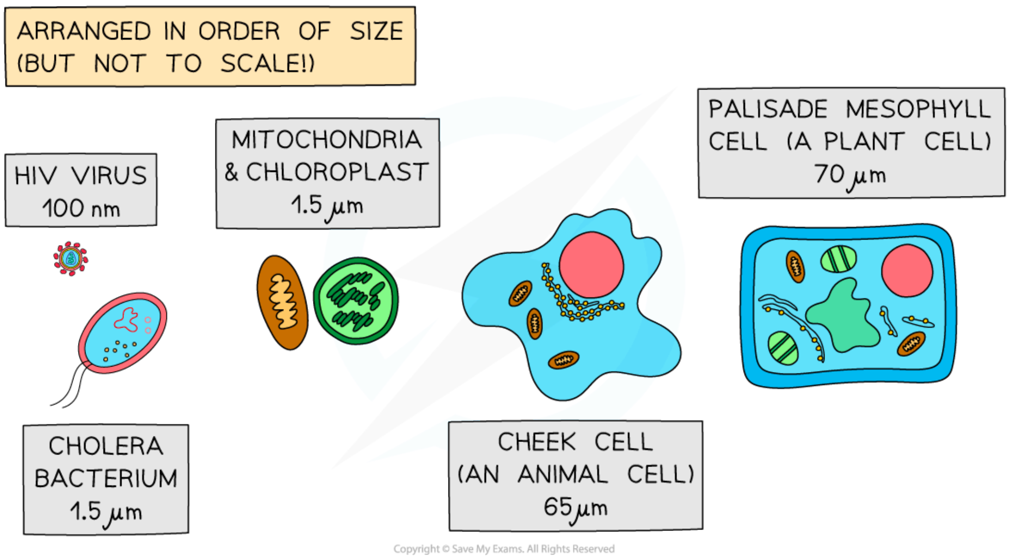
- Scientists measure the size of cells in micrometers (µm)
- There are 1000 µm in 1 mm, so:
  - 1 µm = 0.001 mm
  - 1 µm = 1×10^{-3} mm
  - 1 µm = 1×10^{-6} m
- You need to be able to convert between different units of measurement, particularly mm and µm



It is possible to convert between units by multiplying or dividing values by 1000

Use this image

- You need to show an understanding of the size and scale of cells (and the subcellular structures within them)



Many subcellular structures in eukaryotic cells are the same size as, or bigger than, prokaryotic cells

Your notes

Use this image

- Differences in size can be described as differences in **order of magnitude**, essentially the difference in size calculated by a factor of 10

Size of cells table

NUMBER	MULTIPLES OF 10	POWER
1000	10 × 10 × 10	10^3
100	10 × 10	10^2
10	10	10^1
1	1	10^0
0.1	1/10	10^{-1}
0.01	1/100	10^{-2}
0.001	1/1000	10^{-3}

Use this image

Examiner Tips and Tricks

A common exam question is to ask you to calculate the size of subcellular structures and then to suggest why they may or may not be present in a certain type of cell. For example: Why do bacterial cells not contain mitochondria?

How to use standard form

- When biologists talk about the size of cells and the structures within them, they are dealing with very small numbers.
- Very small (or very big) numbers are represented using standard form; this helps to avoid confusion
- Let's say we want to represent the length of a *Vibrio cholerae* cell, which is 1.5μm, in mm
    - First, we need to convert the measurement in μm into mm (see image in Scale & the Size of Cells)
        - 1.5 μm ÷ 1000 = 0.0015 mm
    - Then we convert this into standard form

Your notes

    - $0.0015 = 1.5 \times 10^{-3}$
- To convert numbers into standard form:

NUMBER	MULTIPLES OF 10	POWER
1000	10 × 10 × 10	10^3
100	10 × 10	10^2
10	10	10^1
1	1	10^0
0.1	1/10	10^{-1}
0.01	1/100	10^{-2}
0.001	1/1000	10^{-3}

Use this image

Examiner Tips and Tricks

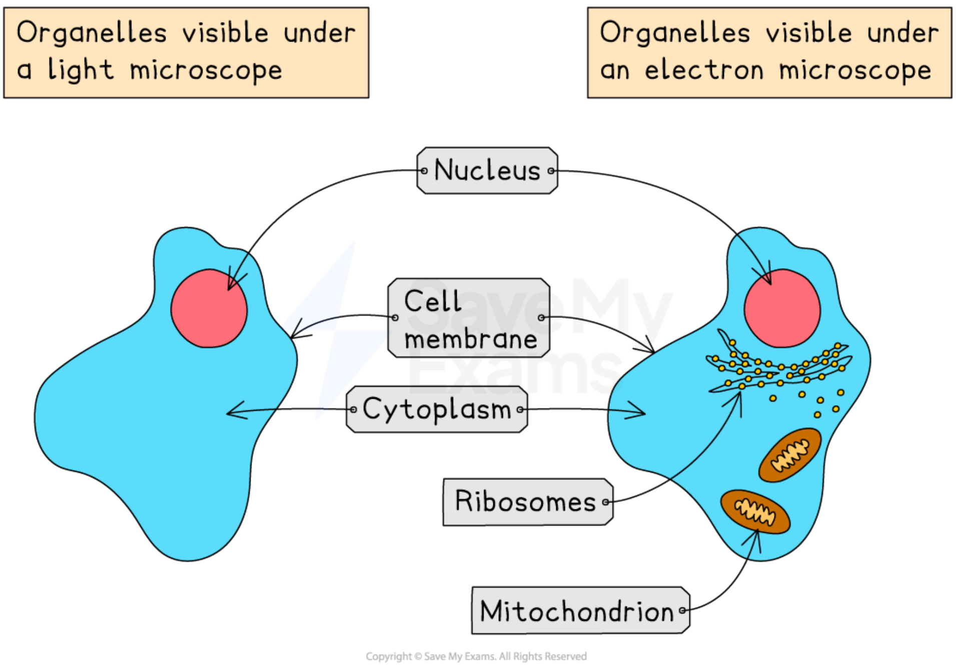
Take care to look at the units in which measurements of cells and subcellular structures are given.

Your notes

Your notes

Animal Cells

- Eukaryotic cells have subcellular structures, each carrying out a particular function
- Organelles are subcellular 'compartments' where specific processes take place within the cell
- The main subcellular structures in animal cells are:
  - The nucleus
  - Cell membranes
  - Mitochondria
  - Ribosomes
  - Cytoplasm



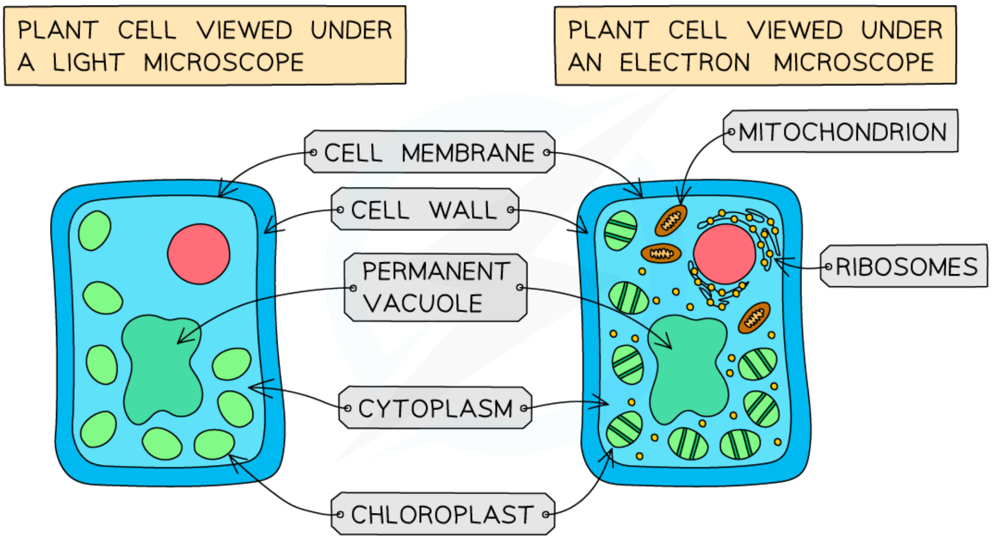
Some cellular structures can only be seen when viewed with an electron microscope

Cell structures table

STRUCTURE	FUNCTION
NUCLEUS	• CONTAINS THE GENETIC MATERIAL (DNA) WHICH CONTROLS THE ACTIVITIES OF THE CELL
CYTOPLASM	• A GEL–LIKE SUBSTANCE COMPOSED OF WATER AND DISSOLVED SOLUTES • SUPPORTS INTERNAL CELL STRUCTURES • SITE OF MANY CHEMICAL REACTIONS, INCLUDING ANAEROBIC RESPIRATION
CELL MEMBRANE	• HOLDS THE CELL TOGETHER, SEPARATING THE INSIDE OF THE CELL FROM THE OUTSIDE • CONTROLS WHICH SUBSTANCE CAN ENTER AND LEAVE THE CELL
RIBOSOMES	• FOUND IN THE CYTOPLASM • SITE OF PROTEIN SYNTHESIS
MITOCHONDRIA	• SITE OF MOST OF THE REACTIONS INVOLVED IN AEROBIC RESPIRATION, WHERE ENERGY IS RELEASED TO FUEL CELLULAR PROCESSES • CELLS WITH HIGH RATES OF METABOLISM (CARRYING OUT MANY DIFFERENT CELL REACTIONS) HAVE SIGNIFICANTLY HIGHER NUMBERS OF MITOCHONDRIA THAN CELLS WITH FEWER REACTIONS TAKING PLACE

Plant Cells

- In addition to the subcellular parts found in animal cells, plant cells have:
  - A cell wall made of cellulose (algal cells also have this structural feature)
  - A permanent vacuole filled with cell sap
- Plant cells found in the leaf and stem may also contain chloroplasts



The plant cell shown above contains chloroplasts, so it would be found in the leaves of a plant

Plant cell structure & function table

STRUCTURE	FUNCTION
CELL WALL	• MADE OF CELLULOSE (A POLYMER OF GLUCOSE) • GIVES THE CELL EXTRA SUPPORT, DEFINING ITS SHAPE
CHLOROPLASTS	• CONTAINS GREEN CHLOROPHYLL PIGMENTS (TO ABSORB LIGHT ENERGY) AND THE ENZYMES NEEDED FOR PHOTOSYNTHESIS
A PERMANENT VACUOLE	• CONTAINS CELL SAP; A SOLUTION OF SUGARS AND SALTS DISSOLVED IN WATER • USED FOR STORAGE OF CERTAIN MATERIALS • ALSO HELPS SUPPORT THE SHAPE OF THE CELL

Your notes

Examiner Tips and Tricks

You need to be able to recognise, draw and interpret images of cells, so make sure to get some practice of drawing and labelling animal and plant cells as part of your revision.

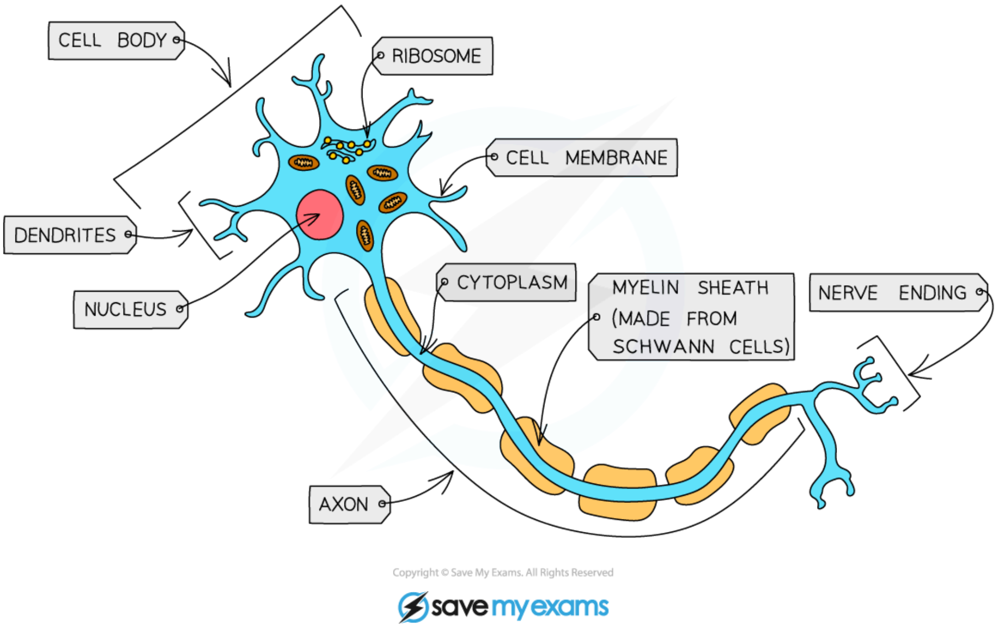
Your notes

Specialised cells

- A specialised cell is a cell that has a **structure that aids its specific function**
  - This could relate to **cell shape**, or the **combination of cellular structures** present within the cell
- Cells specialise by undergoing a process known as differentiation

Specialised cells in animals

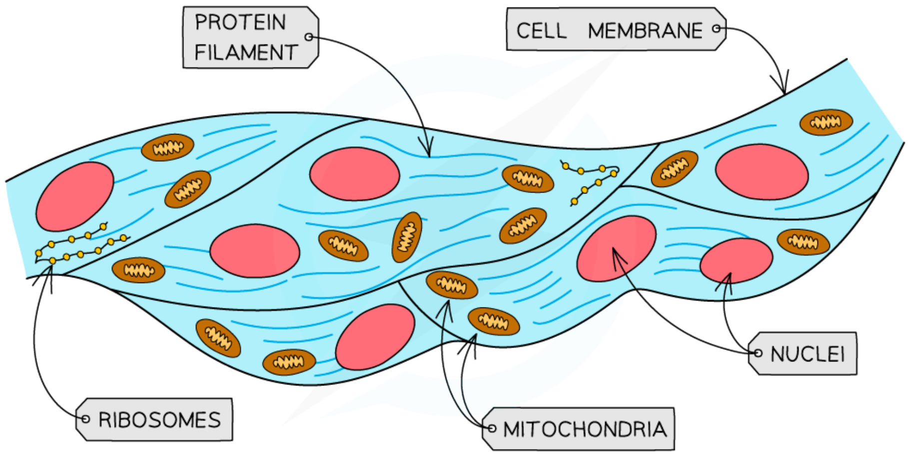
Nerve cells



Nerve cells (neurones) have an elongated structure which allows them to coordinate information from the brain and spinal cord with the rest of the body

- Function:
  - Conduction of electrical impulses
- Special features that aid function:
  - Nerve cells are **long**, meaning that they can **conduct nerve impulses** between different areas of the body
  - Extensions of the cytoplasm known as **dendrites** allowing nerve cells to **communicate** with other nerve cells, muscles and glands
  - The axon is covered with a **fatty sheath** which **speeds up** nerve impulse transmission

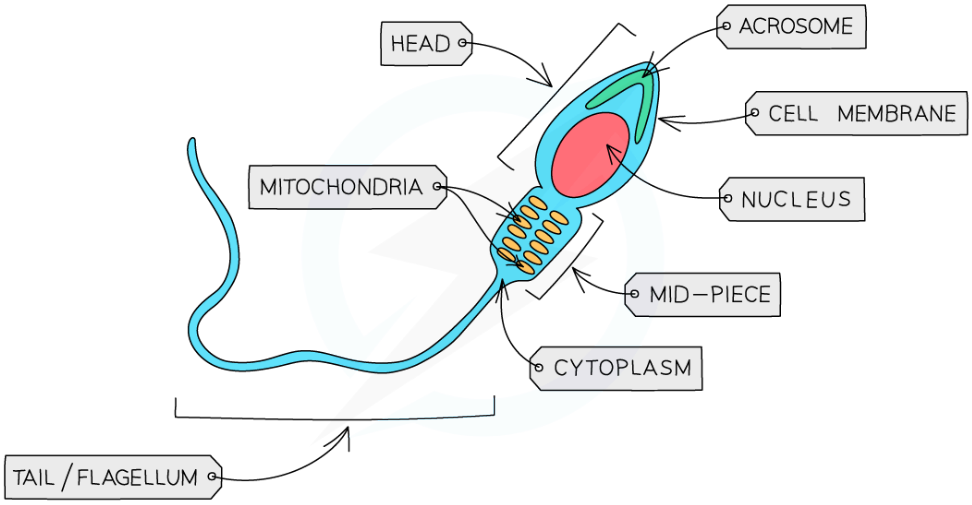
Muscle cells



Muscle cells contain layers of fibres which allow them to contract

- Function:
  - Contraction for movement
- Special features that aid function:
  - Muscle cells have many **mitochondria** to **release energy** for contraction
  - All muscle cells contain **protein filaments** that can slide over each other to allow muscle **contraction**

Sperm cells

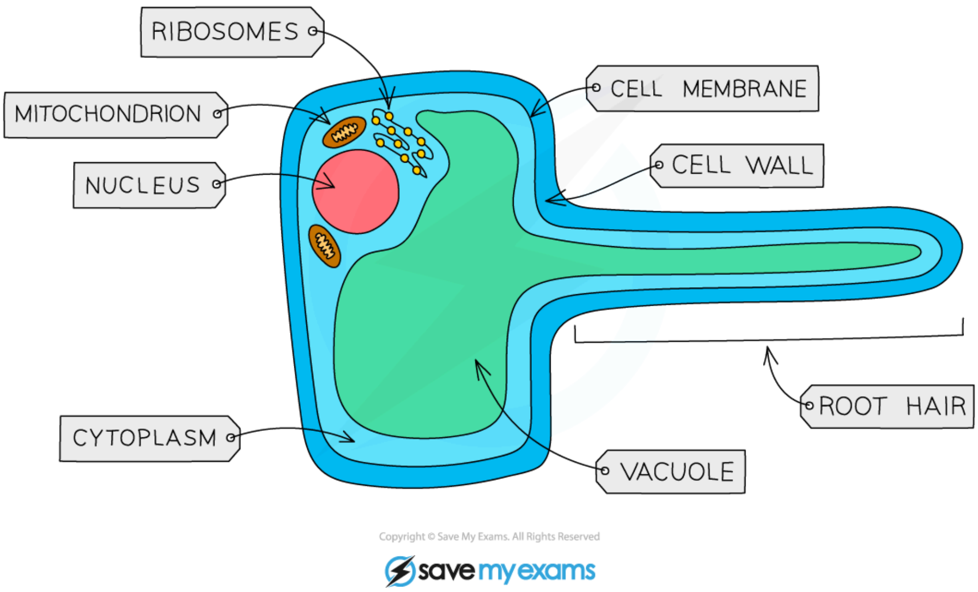


Sperm cells are mobile – their tail helps propel them forward in search of an egg cell

- Function:
  - Transfer of genetic material to an egg cell for fertilisation
- Special features that aid function:
  - The mid-piece is packed with **mitochondria** to release **energy** (via respiration) for the tail
  - The **tail** rotates, propelling the sperm cell forward and allowing it to **move**
  - The **acrosome** in the head contains **digestive enzymes** that can **break down the outer layer of an egg cell** so that the haploid nucleus can enter to fuse with the egg's nucleus
  - The head contains a **nucleus** with **half** the normal number of **chromosomes**, allowing the sperm cell to fuse with an egg cell to **restore the normal chromosome number**

Specialised cells in plants

Root hair cells



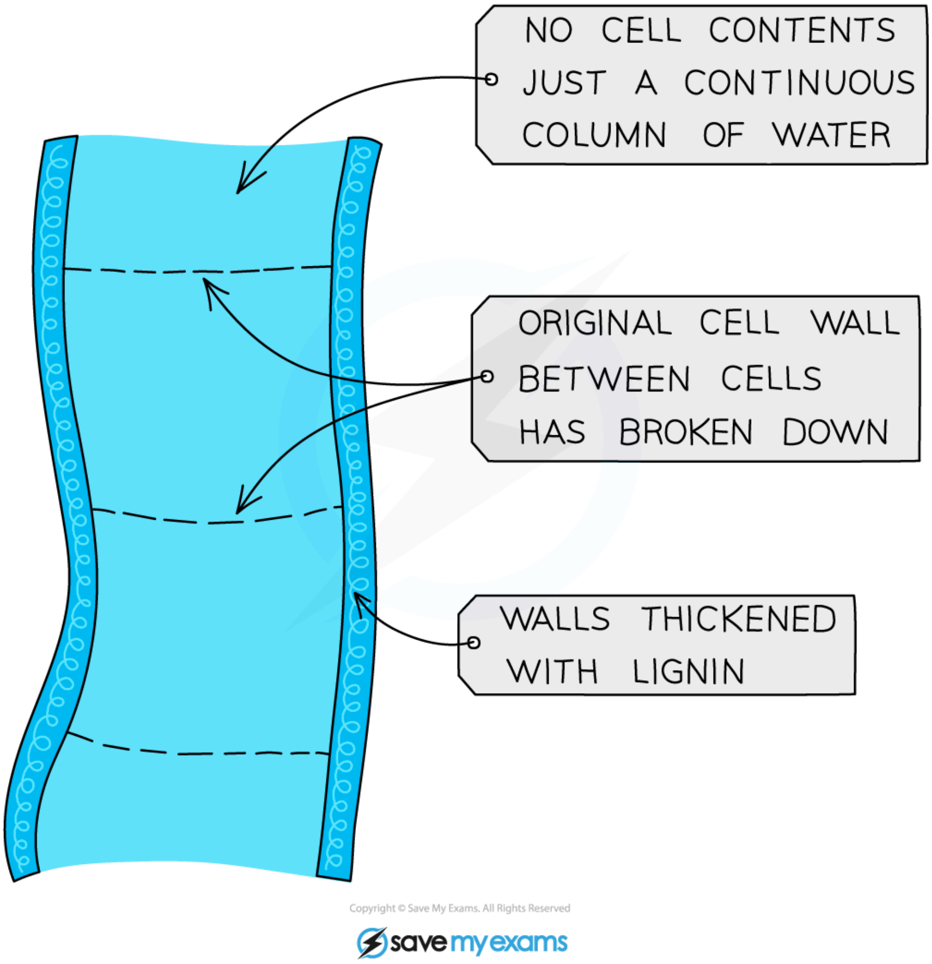
The root hair is an extension of the cytoplasm, increasing the surface area of the cell in contact with the soil to maximise absorption of water and minerals

- Function:
  - Absorption of water and mineral ions from soil
- Special features that aid function:
  - **Root hairs** increase **surface area** (SA) so the rate of water uptake by osmosis is greater

Your notes

- **Thinner walls** than other plant cells so that water can move through easily due to **shorter** diffusion distance
- **Mitochondria** release **energy for active transport** of mineral ions

Xylem vessels

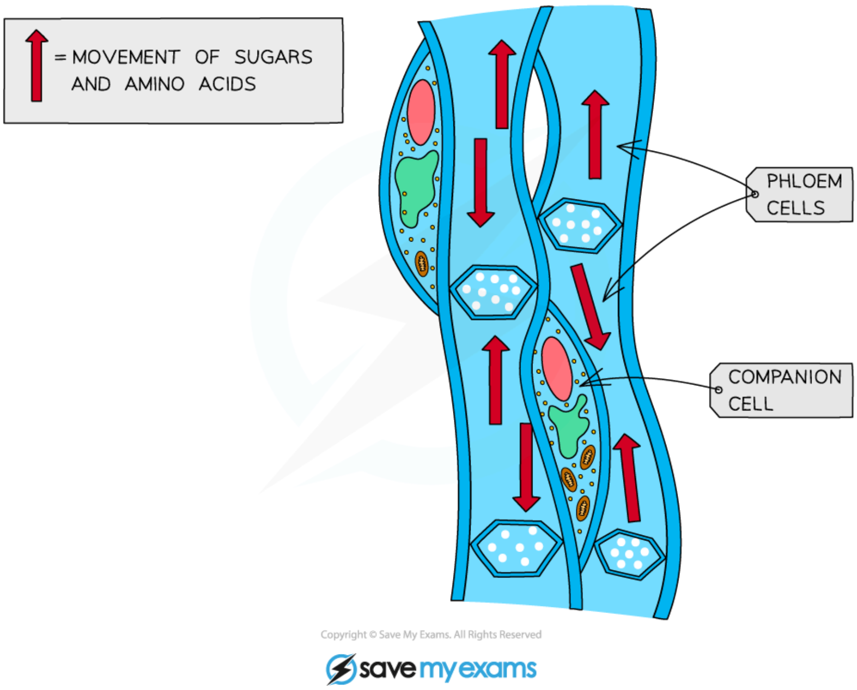


Xylem cells lose their top and bottom walls to form a continuous tube through which water moves from the roots to the leaves

- Function:
  - Transport of water and dissolved ions
- Special features that aid function:
  - **No walls** between cells to form **continuous hollow tubes** through which water is drawn upwards towards the leaves
  - Cells contain **no organelles or cytoplasm**, allowing **free passage of water**
  - Outer walls are **thickened** with a substance called **lignin**, **strengthening** the tubes and providing **support** for the plant

Your notes

Phloem cells



Phloem cells are adapted for the transport of dissolved sugars and amino acids

- Function:
  - Transport of dissolved sugars and amino acids
- Special features that aid function:
  - Cells are **joined** end-to-end and contain **holes in the end cell walls** (sieve plates); this forms tubes which allow sugars and amino acids to **flow easily**
  - Cells have very **few subcellular** structures to aid the flow of materials

Examiner Tips and Tricks

You may be given some information (including an image) about an unfamiliar cell in an exam and asked to describe how it's able to carry out its function. Remember to look at the shape of the cell and its internal structures. Does the cell have a shape which increases its surface area? Are there lots of ribosomes to make proteins (such as enzymes or hormones), or lots of mitochondria to transfer energy?

Your notes

Differentiation: Basics

- Structural differences between different types of cells enables them to perform specific functions within the organism
- Cell differentiation is an important process by which a cell changes to become specialised
- Cells that have not differentiated are therefore unspecialised. As an organism develops, cells differentiate to form different types of cells
- Almost all of the cells in a multicellular organism will contain the same genetic information (the same genes or alleles), but depending on what role one particular cell needs to have, only some of the total sum of genes in a particular cell are used to control its development
- When a cell differentiates, it develops a structure and composition of subcellular structures which enables it to carry out a certain function
    - To form a nerve cell the cytoplasm and cell membrane of an undifferentiated cell must elongate to form connections over large distances

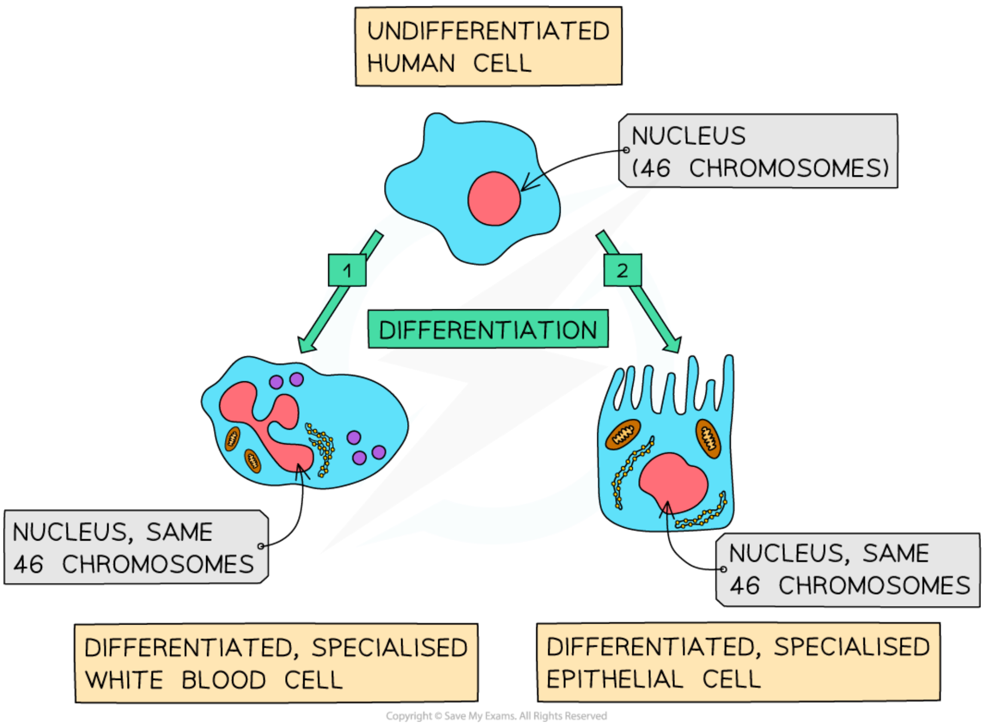


Diagram showing the differentiation of a human cell

Differentiation & Development

- As a multicellular organism develops, its cells differentiate to form specialised cells

- In an animal, most cells differentiate at an early stage of its development. Cell division is mainly restricted to repair and replacement in mature animals
  - Animal cells therefore lose their ability to differentiate after they have become specialised early in the life of the animal
  - Some cells in various locations throughout the body of an animal retain the ability to differentiate throughout the life of the animal. These cells are called adult stem cells and are mainly involved in replacing and repairing cells (such as blood or skin cells)
- Plants differ from animals in that many types of plant cell retain the ability to fully differentiate throughout the life of a plant, not just in the early stages of development

Your notes

A brief history of the microscope

How have microscopy techniques developed over time?

- Microscopy techniques have advanced over time, enhancing our understanding of subcellular structures.
  - **17th century**: Development of the first light microscopes.
    - **Light microscopes** use light and lenses to magnify specimens, allowing visualisation of cells and large subcellular structures like nuclei and vacuoles, often with the aid of stains
    - Their design has evolved to improve **magnification** and **resolution** over time
  - **20th century**: Introduction of the first electron microscopes.
    - **Electron microscopes** use electron beams instead of light, providing much higher resolution and magnification due to the smaller wavelength of electron beams

Electron microscopes

Why are electron microscopes better?

- An electron microscope has much higher **magnification and resolving power** than a light microscope
- They can therefore be used to study cells in much finer detail, enabling biologists to see and understand many more **subcellular structures** such as the **mitochondrion**
- They have also helped biologists develop a better understanding of the structure of the **nucleus and cell membrane**

Magnification calculations

Magnification equation

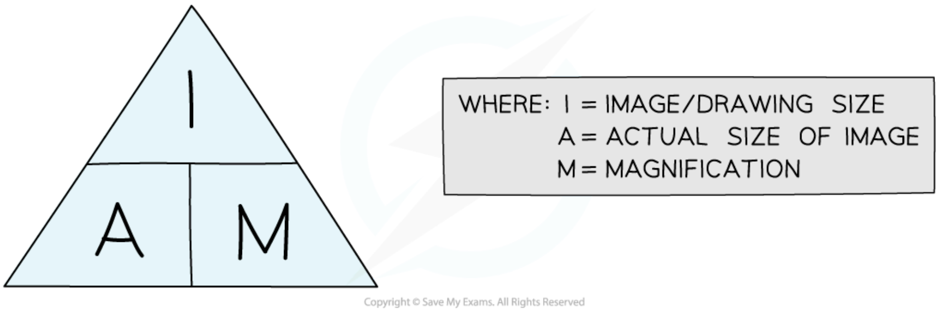
- Magnification is calculated using the following equation:

Magnification = Drawing size ÷ Actual size

Magnification equation triangle

- An equation triangle can help with rearranging simple equations

Your notes

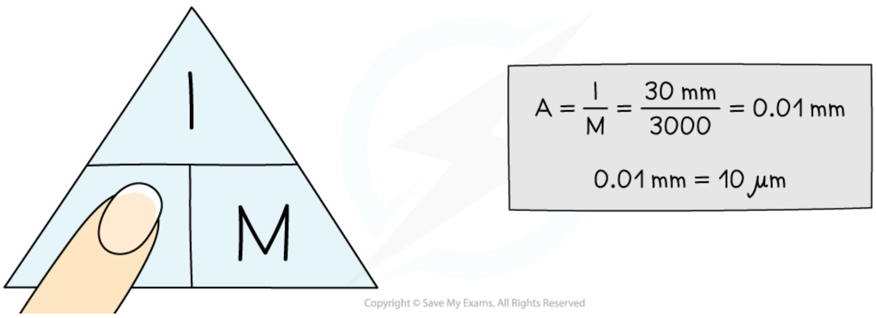


An equation triangle for calculating magnification

- Rearranging the equation to find things other than the magnification becomes easy when you remember the triangle – **whatever you are trying to find, place your finger over it and whatever is left is what you do**, so:
  - Magnification = image size / actual size
  - Actual size = image size / magnification
  - Image size = magnification x actual size
- Remember magnification **does not have any units** and is just written as 'X 10' or 'X 5000'

Worked example

- An **image** of an animal cell is 30 mm in size and it has been **magnified** by a factor of X 3000. What is the **actual** size of the cell?
- To find the **actual** size of the cell:



Worked example using the equation triangle for magnification

Examiner Tips and Tricks

It is easy to make silly mistakes with magnification calculations. To ensure you do not lose marks in the exam:

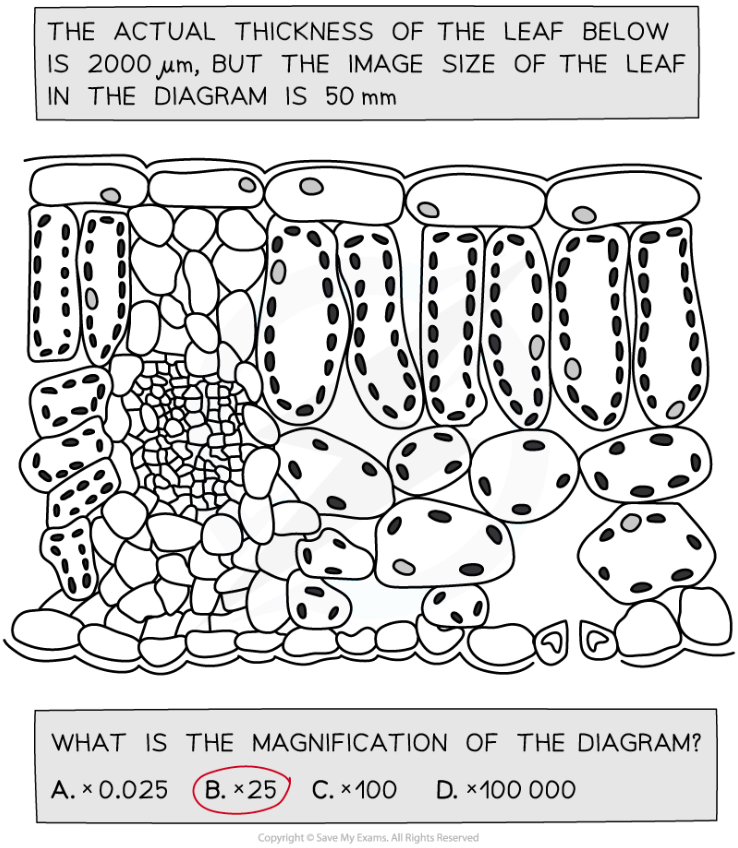
- **Always look at the units** that have been given in the question – if you are asked to measure something, most often you will be expected to measure it in millimetres NOT in centimetres – double-check the question to see!
- **Learn the equation triangle** for magnification and always write it down when you are doing a calculation – examiners like to see this!

Your notes

Converting Units

Converting units in Biology

- You may be given a question in your Biology exam where the measurements for a magnification calculation have **different units.**
- You need to ensure that you **convert them both into the same unit** before proceeding with the calculation (usually to calculate the magnification)
- For example:



Example of an extended magnification question

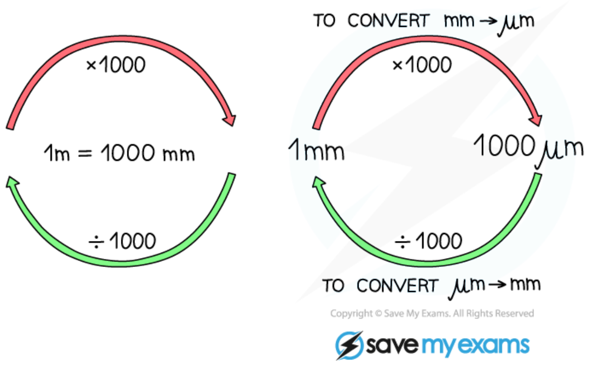
>

- Remember that 1mm = 1000µm
- 2000 / 1000 = 2, so the actual thickness of the leaf is 2 mm and the drawing thickness is 50 mm

- Magnification = image size / actual size = 50 / 2 = 25
- So the magnification is x 25

Examiner Tips and Tricks

If you are given a question with **2 different units** in it, make sure you make a conversion so that **both** measurements have the **same** unit before doing your calculation. Also, watch out for the units you are given in the answer-prompt space.Remember the following to help you convert between mm and μm:



Test yourselfFlashcardsNext topic

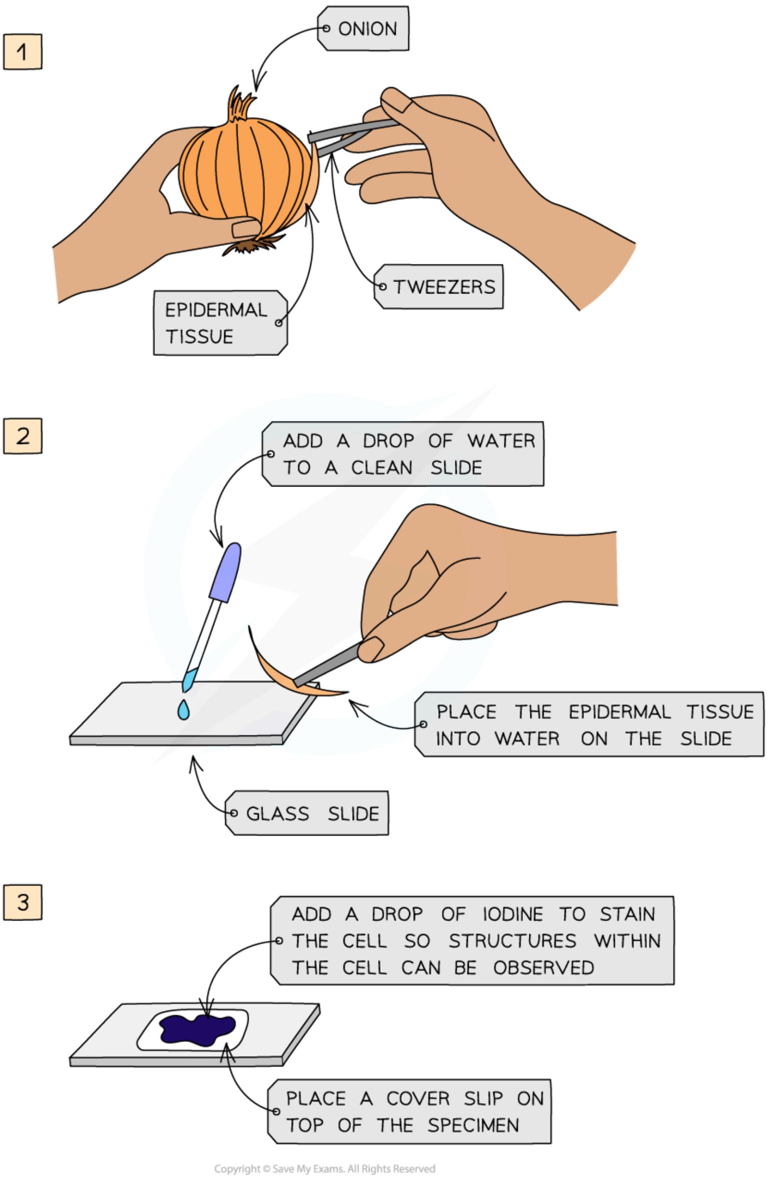
Your notes

Using a Light Microscope

- Aim: To use a light microscope to observe, draw and label a selection of plant and animal cells, including a magnification scale
- You will:
  - Use a light microscope to make observations of biological specimens and produce labelled scientific drawings
  - Include a magnification scale

Preparing a microscope slide

- Specimens must be prepared on a microscope slide to be observed under a light microscope
- This must be done carefully to avoid damaging any biological specimen
- The most common specimens to observe under a light microscope are cheek cells (animal cells) and onion cells (plant cells)
- Stains are used to highlight structures within cells – methylene blue is used to stain cheek cells, iodine for onion cells

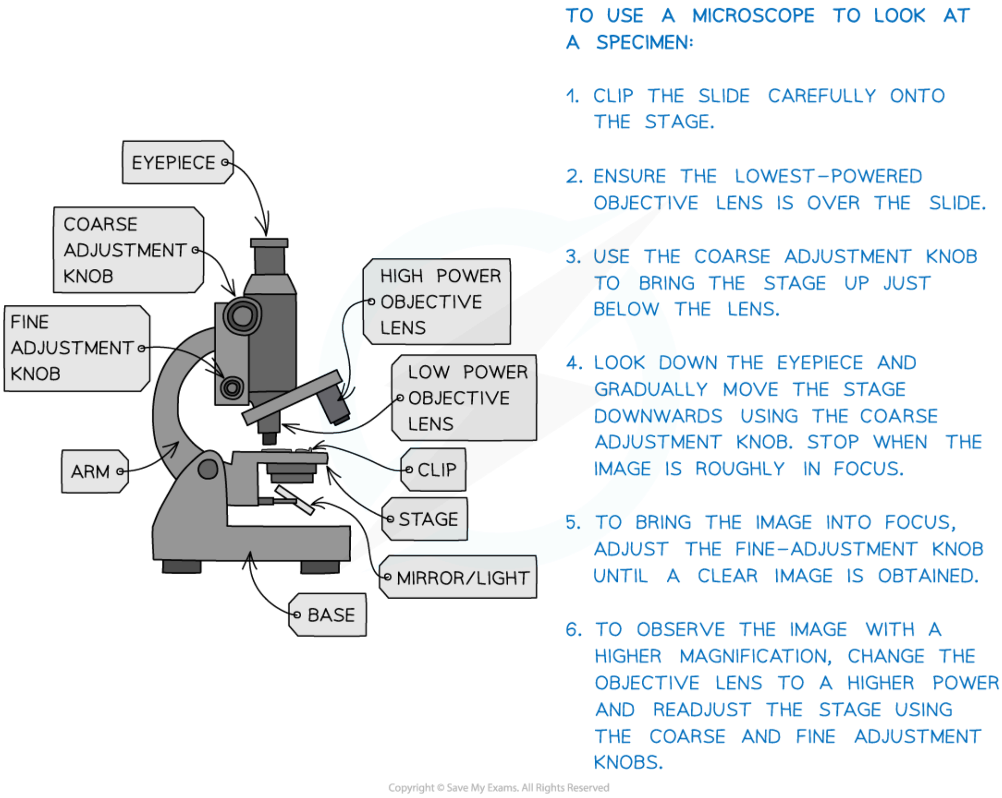


Care must be taken to avoid smudging the glass slide or trapping air bubbles under the coverslip

Using a microscope

- Understanding the main features of a light microscope is essential if you are to use it correctly
- Always hold the microscope by the arm when moving it around the lab, and always start your observation with the lowest-powered objective lens

Your notes

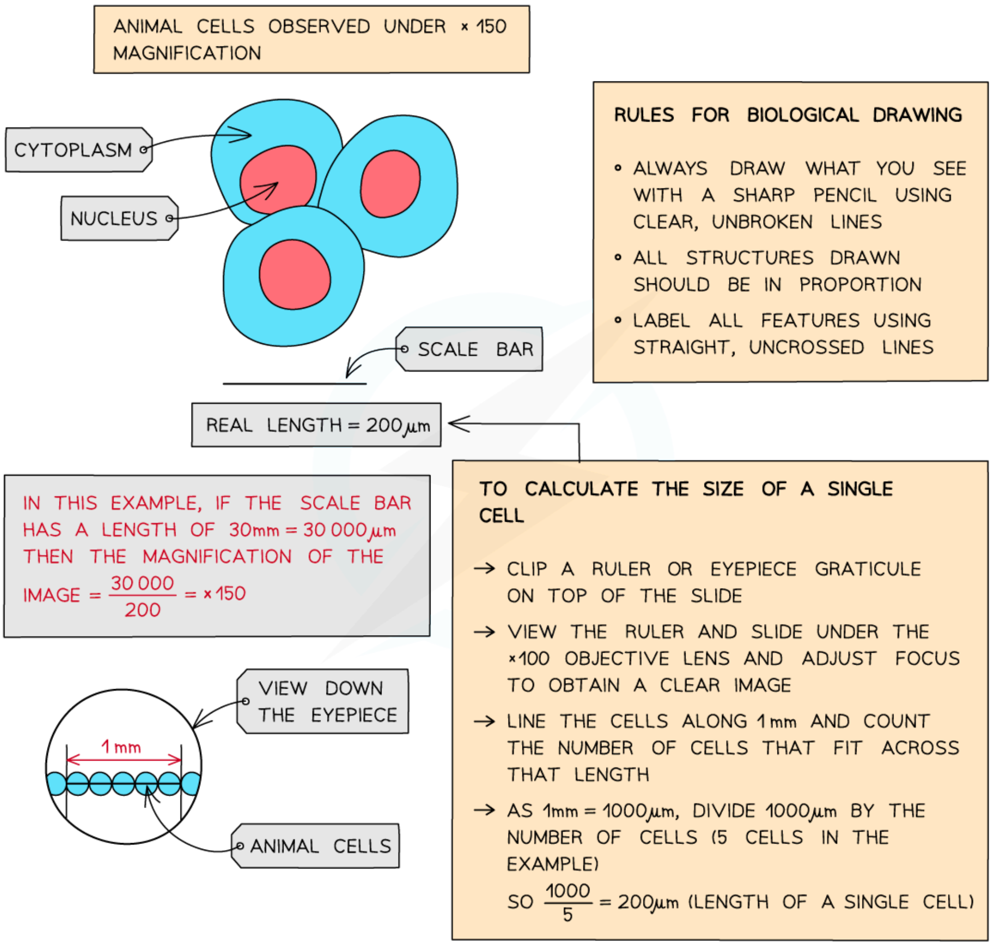


Light microscopes have a lens in the eyepiece which is fixed and two or three objective lenses of different powers

Biological drawings

- Producing biological drawings of what you see under the microscope is a key skill
- The key is not to try to be too artistic with your drawings – they are supposed to be scientific so make sure you follow the rules

Your notes



Biological drawings should be as large as possible – aim to take up at least half of the space available on the page with your drawings

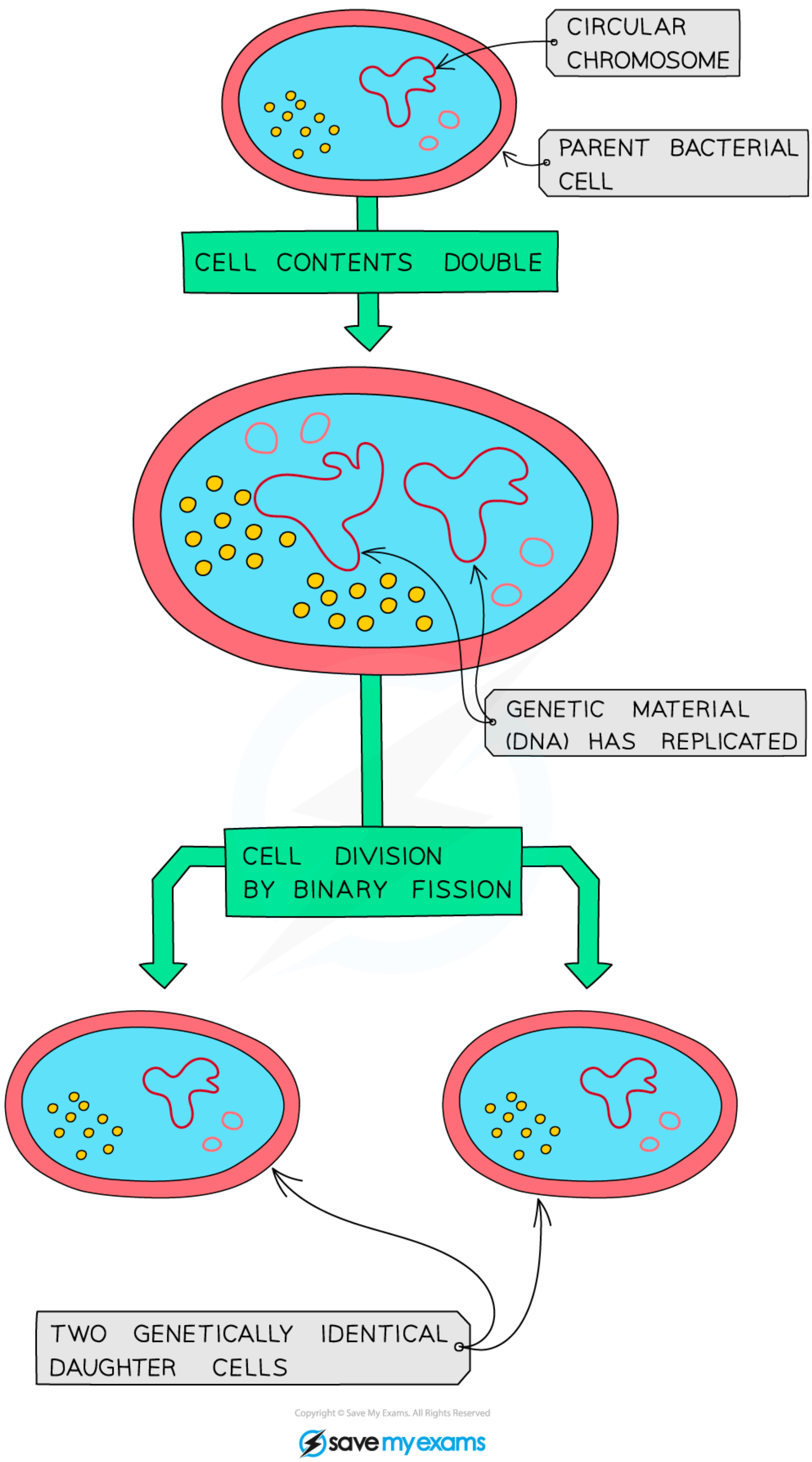
Your notes

Binary fission

- Bacteria multiply by a type of simple cell division known as **binary fission**

  In the right conditions, a bacterial cell prepares to divide by replicating its genetic material before it increases in size

- A copy of each piece of circular DNA moves to each end of the cell before the cytoplasm divides, and new cell walls form around each daughter cell



Each division of one cell produces two cells, so the number of cells increases by a power of 2 each time binary fission occurs

Your notes

Growing bacterial cultures in the lab

- The effect of **disinfectants** and **antibiotics** on microorganisms can be investigated using cultures of bacteria grown in the lab
- Under the right conditions, some species of bacteria can multiply as frequently as once every **20 minutes**.
  - This is ideal for microbiologists as large cultures of bacteria for study can be grown in relatively short periods of time
- To multiply this quickly, bacteria require an adequate supply of **nutrients** and an **appropriate temperature** in which to grow
  - Warmer temperatures promote faster growth, but in a school lab the maximum safe temperature for growth is 25 °C
  - Above this temperature, more harmful pathogens are likely to grow
- Bacteria can be grown in a **nutrient broth solution** or as colonies on an **agar gel plate**

Uncontaminated cultures & aseptic techniques

- It is vital that **contamination free** cultures of microorganisms are grown in the lab
  - Competing species can affect the growth of cultures, as well as the validity of any study performed
- Some important aseptic techniques are outlined in the table below:

Technique	Explanation
All work should be carried out in front of a lit Bunsen burner	Hot air rises, creating a convection current that prevents airborne microorganisms from landing on the plate
Hot agar jelly is poured into a sterilised Petri dish. The agar is left to cool and set	The Petri dish and culture medium are heated to a high temperature to kill any microorganisms that could contaminate the experiment
An inoculating loop is passed through a hot flame before it is used to transfer bacteria to the culture medium	Any microorganisms on the loop are killed by the high temperature
The Petri dish lid should only be partly lifted when transferring cultures	This reduces the risk of airborne microorganisms landing on the plate

Your notes

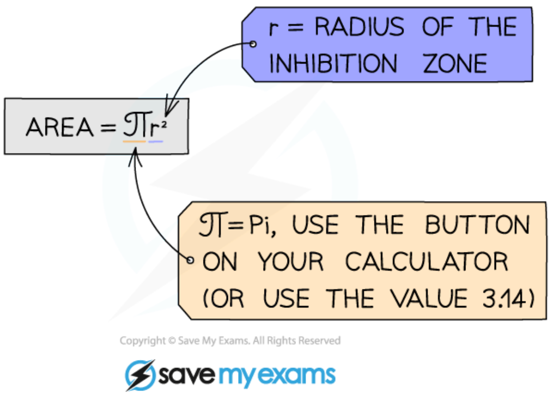
The lid of the Petri dish should be secured with tape at intervals around the edges	This prevents the lid from falling off while still allowing oxygen to enter
The dish should be stored upside down	Condensation from the lid does not drip onto the agar
Cultures should not be incubated above 25 °C in a school laboratory	This restricts the growth of harmful pathogens, which are more likely to grow at higher temperatures

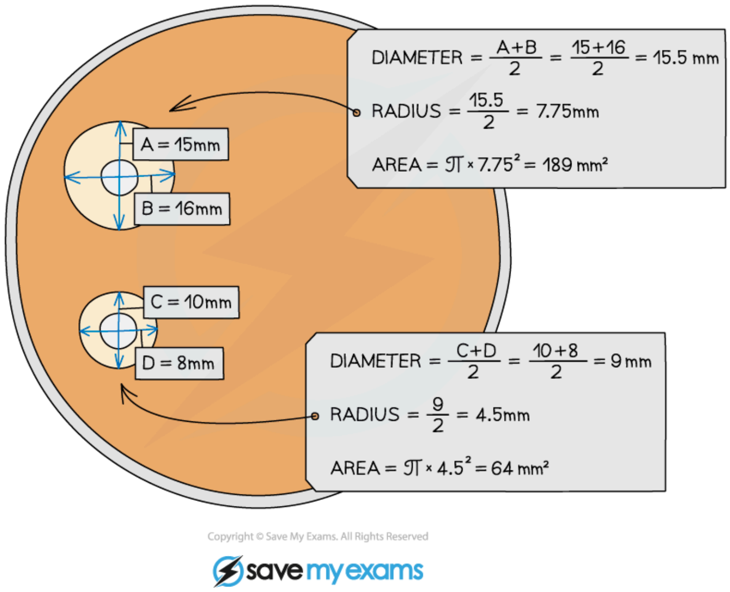
Your notes

Calculating inhibition zone area

- The effectiveness of different **antibiotics**, **antiseptics** or **disinfectants** can be determined by calculating the area of an **inhibition zone** around a disc of the substance being tested
- To calculate the area of an inhibition zone you should use the equation:

area of a circle = πr^2





The area of a zone of inhibition can be calculated using the formula for the area of a circle

Examiner Tips and Tricks

It is far more accurate to measure the diameter of an inhibition zone than the radius, but remember to halve it before using the area equation above.

If the zone of inhibition is not perfectly circular then you will need to take at least two diameter measurements and find the mean.

Calculating bacteria in a population

- The average length of time taken for a bacterial cell in a population to divide is the **mean division time**
- It is possible to determine the **number of divisions** that have taken place as follows:

no. of divisions = time for which division has been taking place ÷ mean division time

- The number of cells that have been produced can then be determined using the formula ***2^n***, where n = number of divisions

Worked Example

If a bacterial cell has a mean division time of 24 minutes and has been dividing for 4 hours, how many cells will it have produced?

Answer

Step 1: convert units

4 hours = **240** minutes

Step 2: calculate the number of divisions

time for which division has been taking place ÷ mean division time

240 ÷ 24 = **10** divisions

Step 3: calculate the number of cells

number of cells = 2^{10}

= 1024 cells

Examiner Tips and Tricks

Check that both the mean division time and the time for which the cell has been dividing have the same units (either hours or minutes).

Calculations in standard form

Higher Tier Only

- If you are calculating the number of bacteria present in a population, you are likely to be handling very large numbers
- You should be able to express the number of bacteria in **standard form**

Worked Example

A bacterial cell has a mean division time of 1260 seconds and has been dividing for 6 hours.

Calculate the number of bacterial cells produced during this time. Give your answer in standard form.

Answer

Step 1: convert units to match

6 hours = 360 minutes = **21 600** seconds

Step 2: use formula to calculate number of divisions

time for which division has been taking place ÷ mean division time

= 21 600 ÷ 1260

= 17.1

Your notes

= **17** divisions

Step 3: calculate the number of cells

$$\text{number of cells} = 2^{17}$$

$$= 131\,072$$

Step 4: convert to standard form

$$131\,072 = 1.31 \times 10^{5}$$

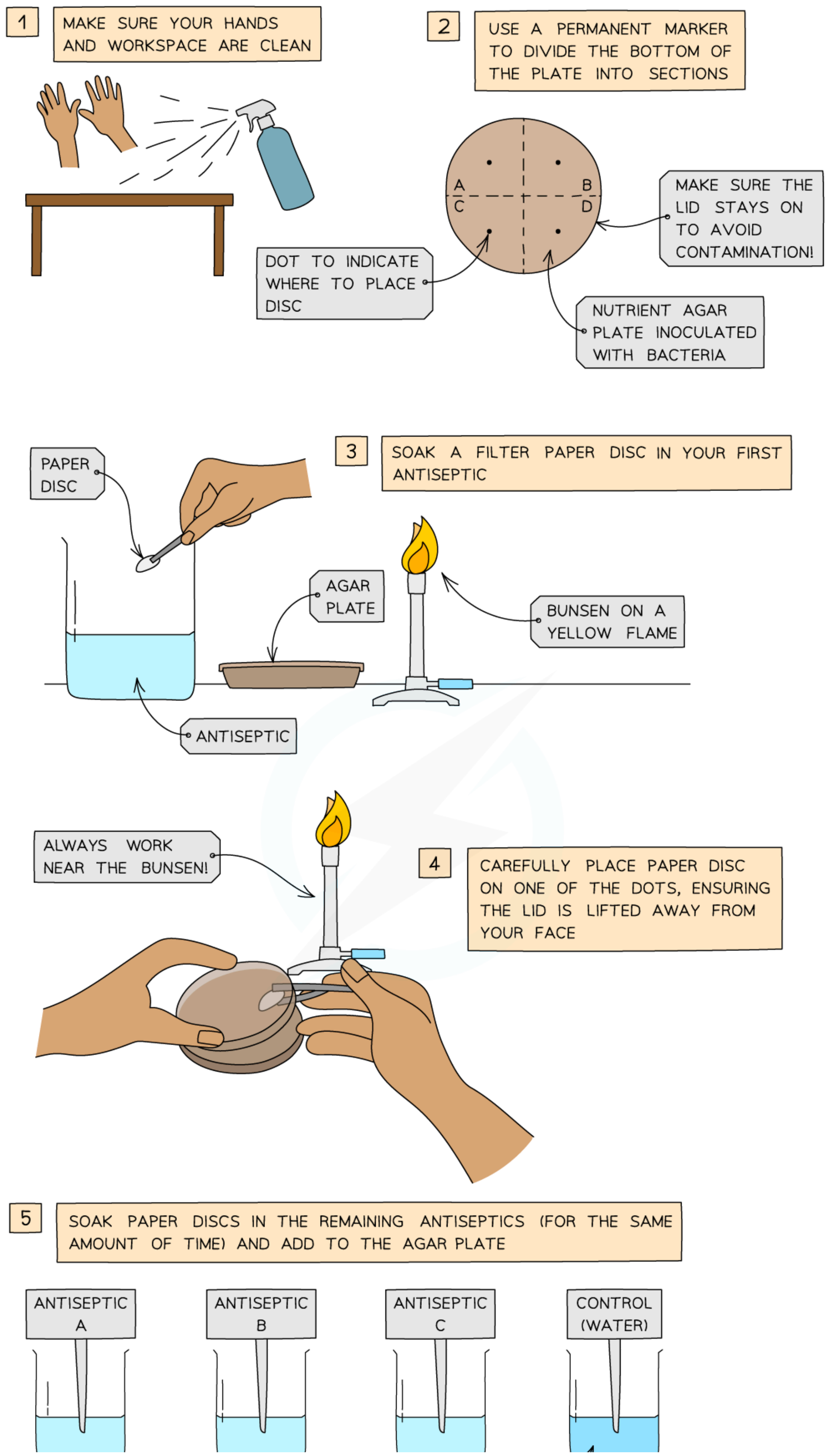
Your notes

Your notes

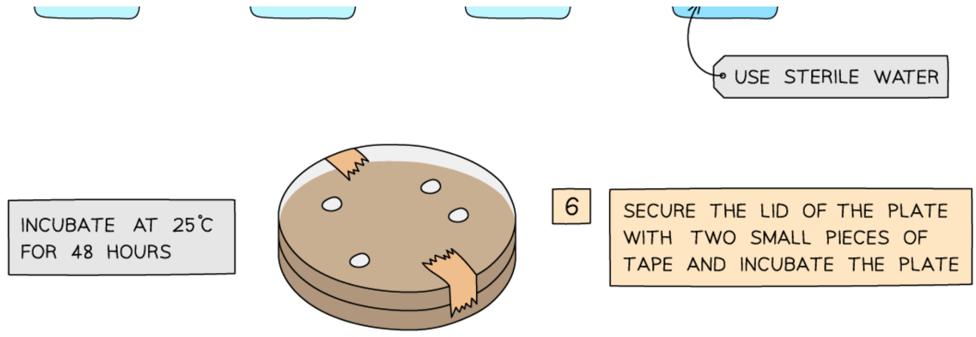
Microbiology required practical

- **Aim**:
  - To investigate the effect of **antiseptics** or **antibiotics** on **bacterial growth** using agar plates and measuring **zones of inhibition**
- **Procedure**:
  - Use an **aseptic technique** to place filter paper discs soaked in different antiseptics/antibiotics onto **uncontaminated agar plates** containing bacteria
  - Measure the **zone of inhibition** around the growing **colonies of bacteria** to compare the effect of different antiseptics/antibiotics
  - **Calculate** the area of each zone
- In this practical, prepared Petri dish plates should be provided which are used to investigate bacterial growth
- It is important to be aware of good microbial aseptic techniques (Culturing Microorganisms)
  - **Preventing contamination** is vital in any microbiology investigation to ensure that only the effect of any antiseptic or antibiotic on the bacterial species is investigated
  - It is also important to provide the ideal **temperature** for bacterial growth, in school this will be **25 °C**
    - This is important to **reduce the chances of growing harmful pathogens** which can lead to various diseases.
- You will most likely use safe strains of *coli* or *Micrococcus luteus* bacterial cultures in your practical
- A **control** group should be used
  - It is vital that one of the paper discs placed on the bacterial agar plate is **not** soaked in antiseptic or antibiotic but **sterile water** instead
  - This is to ensure that any **differences** in bacterial growth observed can be attributed to the presence of the antiseptic or antibiotic used and not some other factor (such as the paper discs for example)

RP GROWTH: METHOD



Your notes



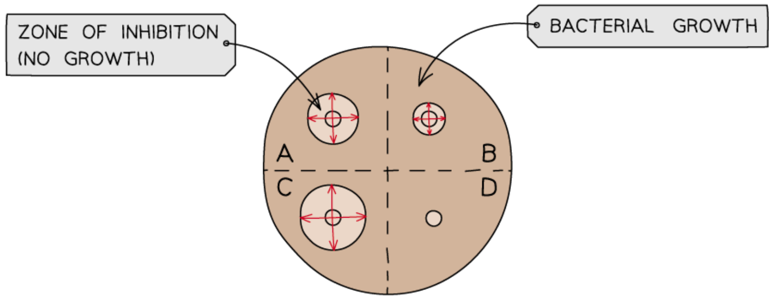
Whilst carrying out this practical it is important to reduce the risk of contaminating the Petri dish with other sources of bacterial

- Commercially produced **antibiotic discs** are available rather than soaking discs in disinfectants
- Incubating the plates allows the bacteria in the agar to multiply by **binary fission**, this may be visible by the agar darkening or by **colonies** appearing
- The antiseptics present in the discs will **diffuse** into the agar, with the concentration **decreasing** with distance from the disc
  - Where the concentration is sufficient to prevent bacterial growth or kill bacteria, the **agar will remain clear**
- It is possible to judge which antiseptic or antibiotic is the most effective by the eye, but it is far more accurate to **calculate the diameter of each clear zone** around the paper disc and from this **calculate the area** of each inhibition zone
- Clear zones of inhibition are not always perfectly circular, so the diameter of each zone should be measured **twice** (at 90° angles to each other) and a **mean diameter** and **area** calculated for each clear zone

Your notes

RP GROWTH: ANALYSIS

1 MEASURE THE DIAMETER OF THE CLEAR ZONE AROUND DISC. REPEAT MEASUREMENT AT A 90° ANGLE



2 CALCULATE THE MEAN DIAMETER OF EACH ZONE AND FROM THESE VALUES CALCULATE THE CROSS-SECTIONAL AREA OF THE CLEAR ZONES AROUND THE BACTERIAL COLONIES

TYPE OF ANTISEPTIC	DIAMETER OF CLEAR ZONE (mm)			MEAN RADIUS (mm)	CROSS SECTIONAL AREA (mm^2)
	1	2	MEAN		
A	17.0	15.0	16.0	8.0	201
B	8.0	7.0	7.5	3.75	44
C	21.0	22.0	21.5	10.75	363
D	0	0	0	0	0

REMEMBER AREA = πr^2

3 CONCLUDE WHICH TYPE OF ANTIBIOTIC WAS THE MOST EFFECTIVE AGAINST BACTERIAL GROWTH

THE MOST EFFECTIVE ANTIBIOTIC WAS ANTISEPTIC C BECAUSE IT HAD THE LARGEST CLEAR ZONE AROUND THE DISC WITH AN AREA OF 363 mm^2

Record the diameter of each clear zone to the nearest whole mm, and remember to calculate the area using the radius