GCSE Biology Edexcel

YOUR NOTES
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1.1 Cell Structure

CONTENTS

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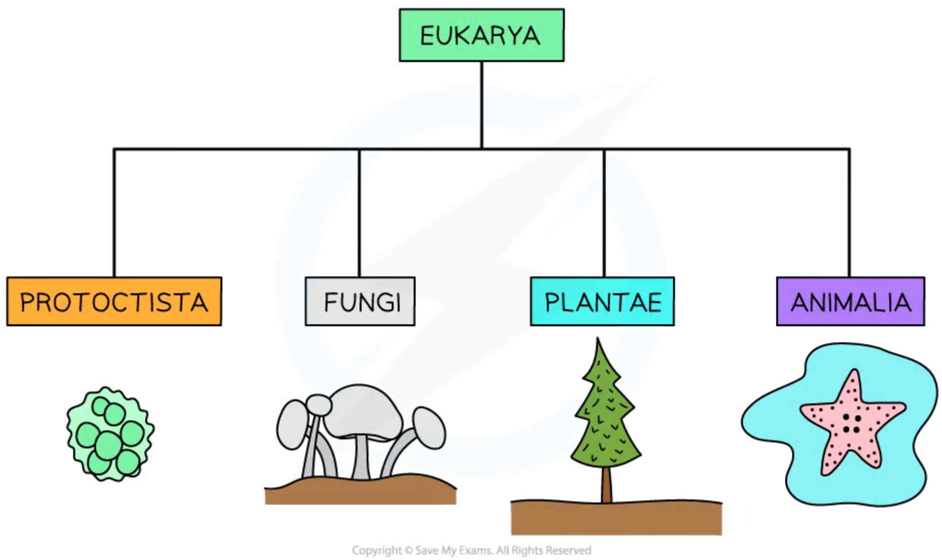
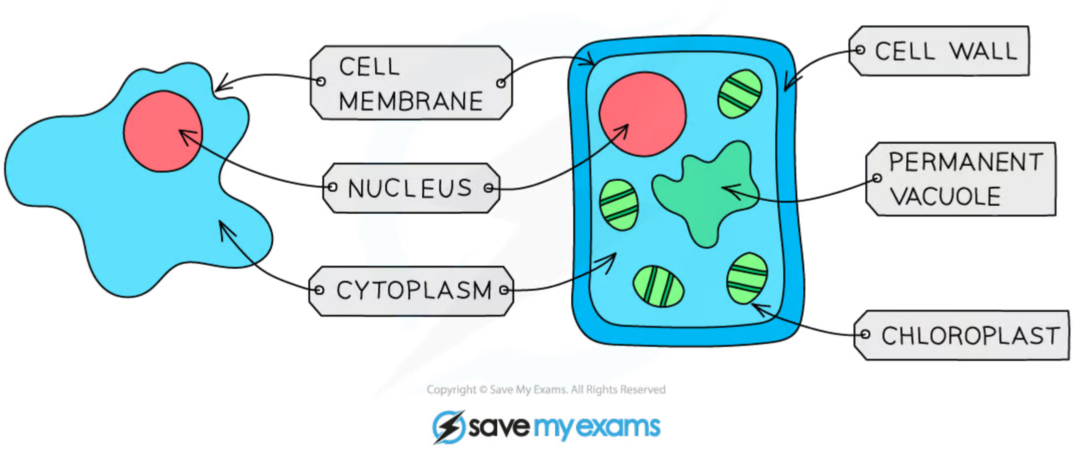
Common Features of Eukaryotic Organisms: Basics

- All living organisms can be grouped or 'classified' using a classification system that consists of **five kingdoms**. These five kingdoms are:
  - **Animals**
  - **Plants**
  - **Fungi**
  - **Protoctists**
  - **Prokaryotes**
- The first four kingdoms in this list (the animals, plants, fungi and protoctists) can actually be **grouped together**, as they are all **eukaryotic organisms** (also known as **eukaryotes**)



Animals, plants, fungi and protoctists are all eukaryotes

- Eukaryotic organisms can be **multicellular or single-celled** and are made up of cells that contain a **nucleus** with a **distinct membrane**



An animal cell (left) and plant cell (right) as seen under a light microscope. They are both eukaryotic cells as they both have a distinct membrane-bound nucleus.

- **Prokaryotic organisms** (also known as **prokaryotes**) are in a **separate kingdom** and are **different** from eukaryotes as they are **always single-celled** and **do not contain a nucleus** (instead, the **nuclear material** of prokaryotic cells is found in the **cytoplasm**)
  - **Bacteria** are prokaryotic organisms
- Prokaryotic cells are substantially **smaller** than eukaryotic cells

1.1.2 Eukaryotic Organisms: Animals & Plants

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Animals

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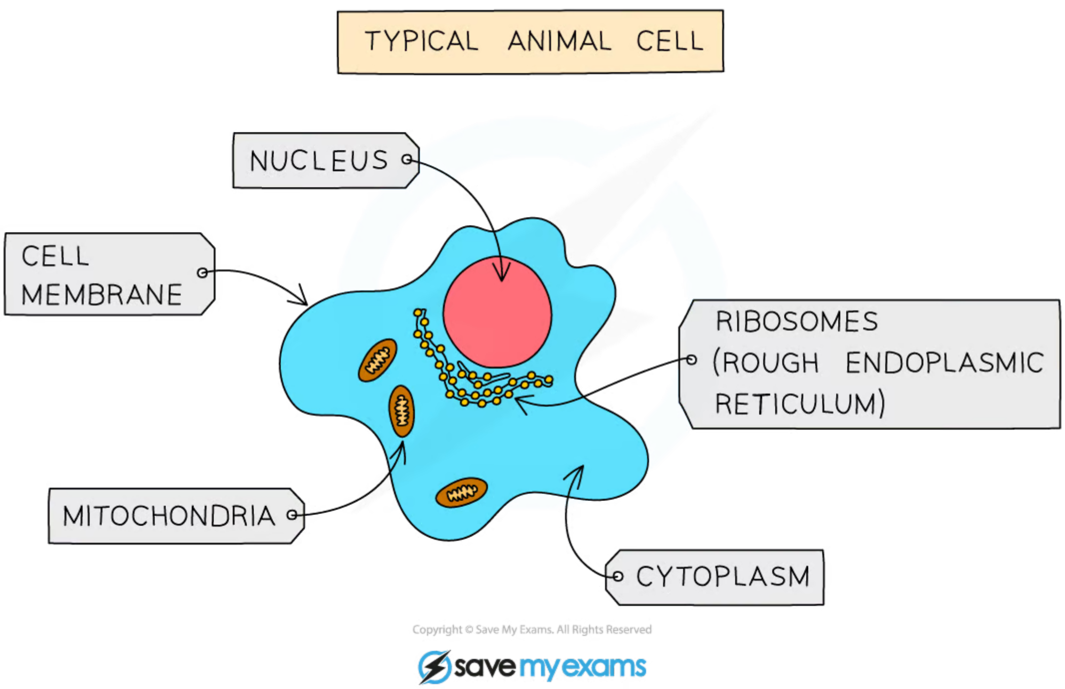
- **The main features of animals:**
  - They are **multicellular**
  - Their cells contain a **nucleus** with a **distinct membrane**
  - Their cells **do not** have **cellulose cell walls**
  - Their cells **do not** contain **chloroplasts** (so they **are unable** to carry out **photosynthesis**)
  - They feed on organic substances made by other living things
  - They often store carbohydrates as **glycogen**
  - They usually have **nervous coordination**
  - They are able to **move** from place to place



A typical animal cell

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Cell Structures Found in Both Animal and Plant Cells 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

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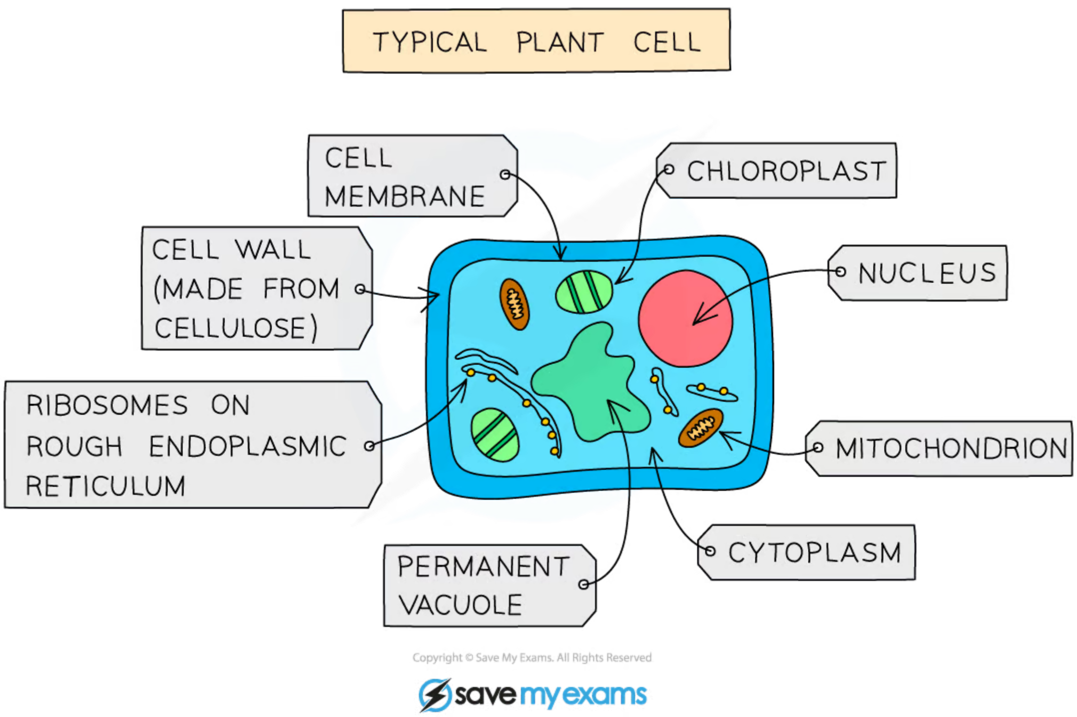
Plants

- **The main features of plants:**
  - They are **multicellular**
  - Their cells contain a **nucleus** with a **distinct membrane**
  - Their cells have **cell walls** made out of **cellulose**
  - Their cells contain **chloroplasts** (so they can carry out **photosynthesis**)
  - They feed by **photosynthesis**
  - They store carbohydrates as **starch** or **sucrose**
  - They **do not** have nervous coordination



A typical plant cell

Cell Structures Found Only in Plant Cells Table

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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

Exam Tip

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

1.1.3 Eukaryotic Organisms: Fungi & Protoctists

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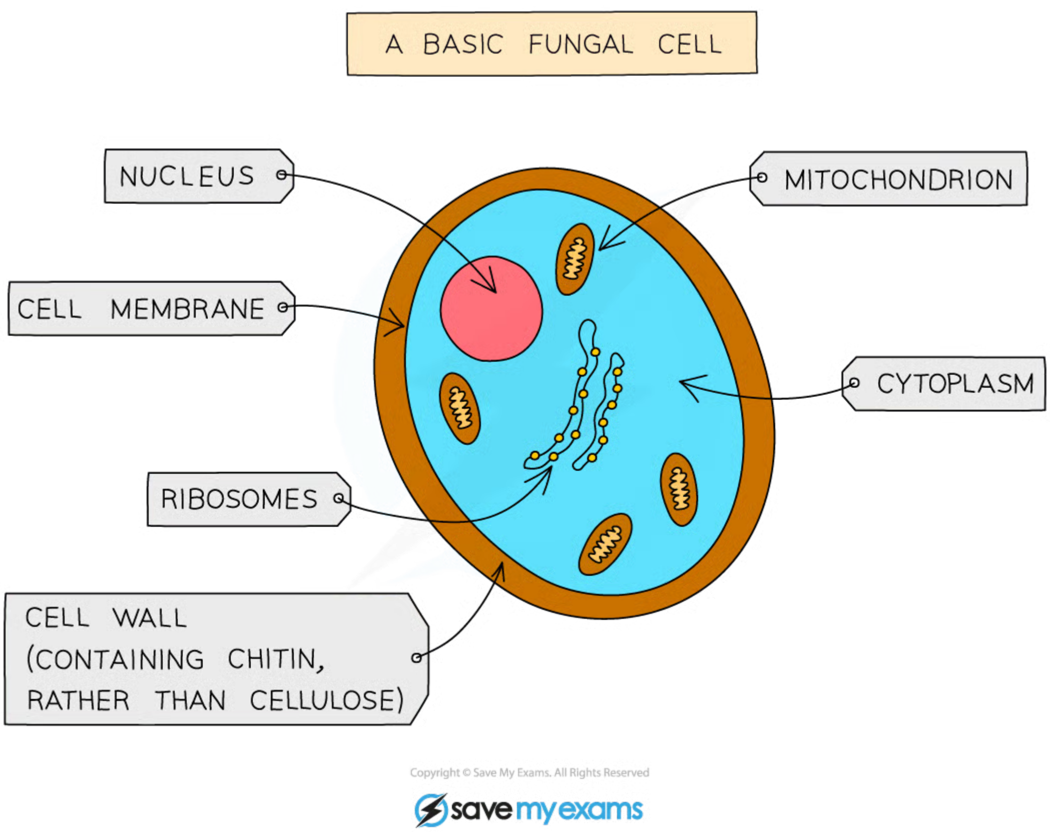
Fungi

- **Main features of fungi:**
  - They are **usually multicellular** but some are **single-celled** (e.g. yeast)
  - Multicellular fungi are mainly made up of **thread-like structures** known as **hyphae** that contain **many nuclei** and are organised into a **network** known as a **mycelium**
  - Their cells contain a **nucleus** with a **distinct membrane**
  - Their cells have cell walls made of **chitin** (chitinous cell walls)
  - Their cells **do not** contain **chloroplasts** (so they **cannot** carry out **photosynthesis**)
  - They feed by **secreting extracellular digestive enzymes** (outside the mycelium) **onto the food** (usually decaying organic matter) and then absorbing the digested molecules. This method of feeding is known as **saprotrophic nutrition**
  - Some fungi are **parasitic** and feed on **living material**
  - Some fungi store carbohydrates as **glycogen**
  - They **do not** have **nervous coordination**
  - Examples of fungi include: moulds, mushrooms, yeasts



A typical fungal cell

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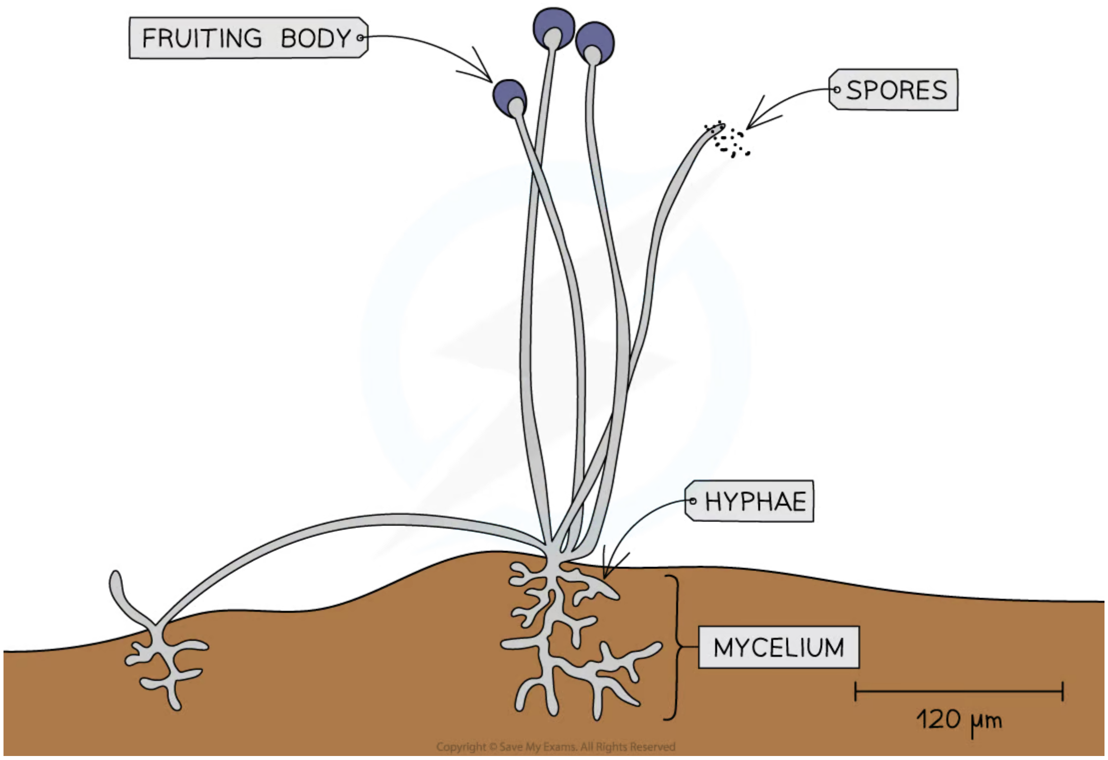

The typical structure of a multicellular fungus e.g. Mucor (bread mould)

Protoctists

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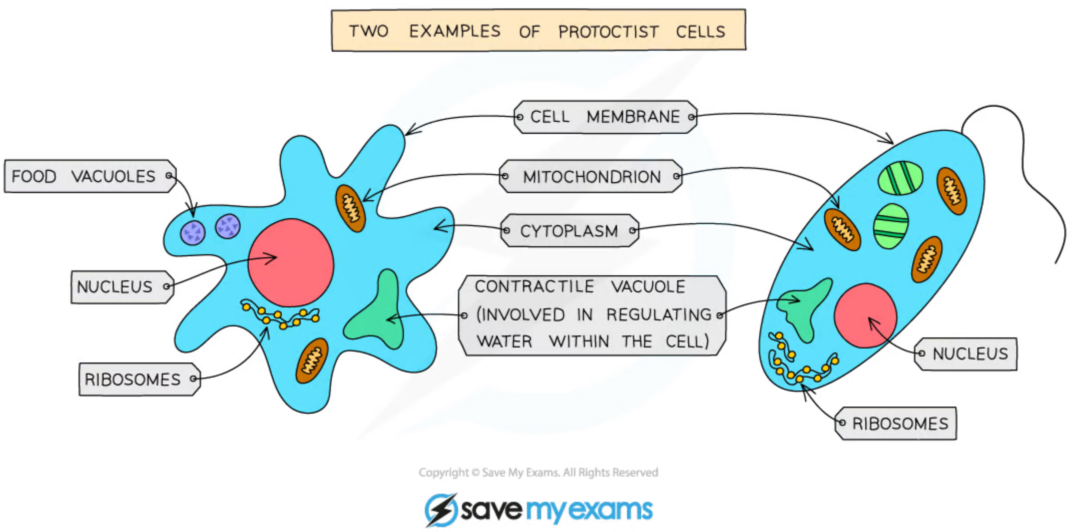
- **Main features of protoctists:**
  - The protoctists are a very **diverse** kingdom of organisms that don't really belong in any of the other eukaryotic kingdoms (animals, plants and fungi)
  - They are **mainly microscopic and single-celled** but some **aggregate** (group together) into **larger forms**, such as colonies or chains of cells that form filaments
  - Their cells contain a **nucleus** with a **distinct membrane**
  - Some have features making them more like animal cells e.g. ***Plasmodium*** (the protoctist that causes **malaria)**
  - Some have features, such as **cell walls** and **chloroplasts**, making them more like plant cells e.g. **green algae**, such as ***Chlorella***
  - This means **some** protoctists **photosynthesise** and some feed on organic substances made by other living things
  - They **do not** have **nervous coordination**
  - Examples of protoctists include: amoeba, *Paramecium*, *Plasmodium*, *Chlorella*



Two examples of protoctist cells

Exam Tip

You need to be able to recognise, draw and interpret images of cells, so practice drawing and labelling fungal cells and protoctist cells as part of your revision.

1.1.4 Prokaryotic Organisms

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Prokaryotes

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- All living organisms can be grouped or 'classified' using a classification system that consists of **five kingdoms**. These five kingdoms are:
  - **Animals**
  - **Plants**
  - **Fungi**
  - **Protoctists**
  - **Prokaryotes**

- The **prokaryotes** are **different** from the other four kingdoms (which are all **eukaryotes**) as prokaryotic organisms are **always single-celled** and **do not contain a nucleus**
- Instead, the **nuclear material** of prokaryotic cells is found in the **cytoplasm**
- Prokaryotic cells are also **much smaller** (about x1000 smaller) than eukaryotic cells
- They are too small to contain chloroplasts or mitochondria
- **Bacteria** are prokaryotic organisms

Bacteria

- Bacteria, which have a wide variety of shapes and sizes, all share the following biological characteristics:
  - They are **microscopic single-celled organisms**
  - Possess a **cell wall** (made of **peptidoglycan**, not cellulose), **cell membrane**, **cytoplasm** and **ribosomes**
  - **Lack a nucleus** but contain a **circular chromosome of DNA that floats in the cytoplasm**
  - **Plasmids** are present in prokaryotes - these are **small rings of DNA** (also floating in the cytoplasm) that contain **extra genes** to those found in the chromosomal DNA
  - They **lack mitochondria, chloroplasts and other membrane-bound organelles** found in eukaryotic cells

- Some bacteria also have a **flagellum** (singular) or **several flagella** (plural). These are **long, thin, whip-like tails** attached to bacteria that allow them to **move**
- Examples of bacteria include:
  - **Lactobacillus** (a rod-shaped bacterium used in the production of yoghurt from milk)
  - **Pneumococcus** (a spherical bacterium that acts as the pathogen causing pneumonia)

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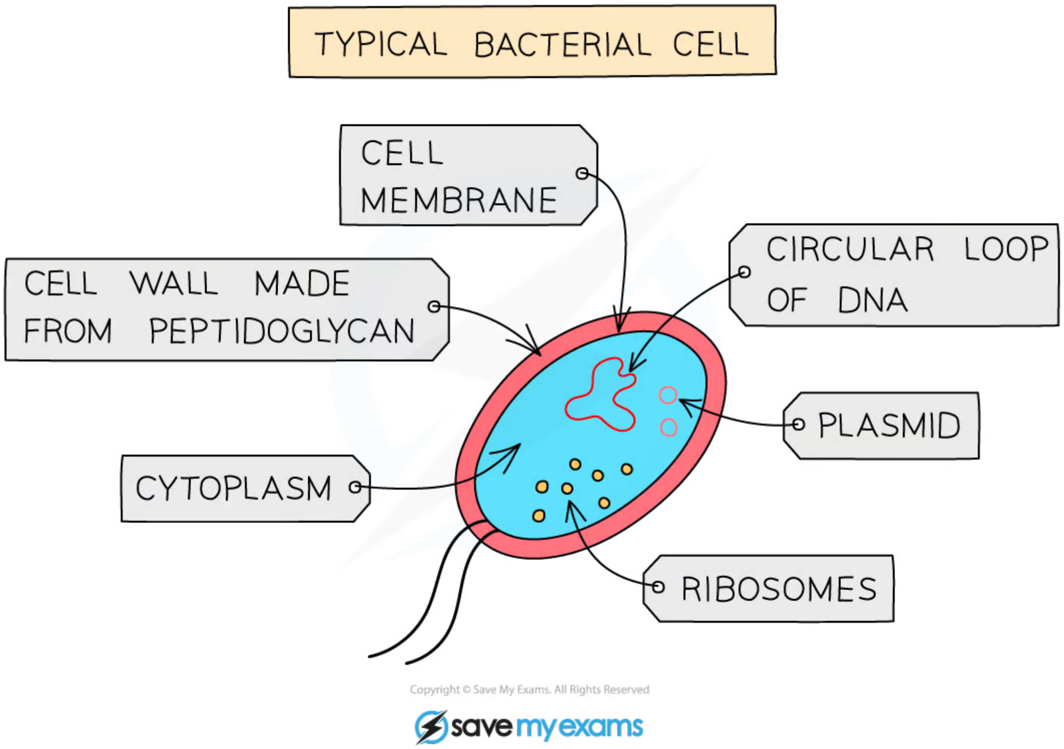

A typical bacterial cell

1.1.5 Specialised Cells

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Specialised Cells

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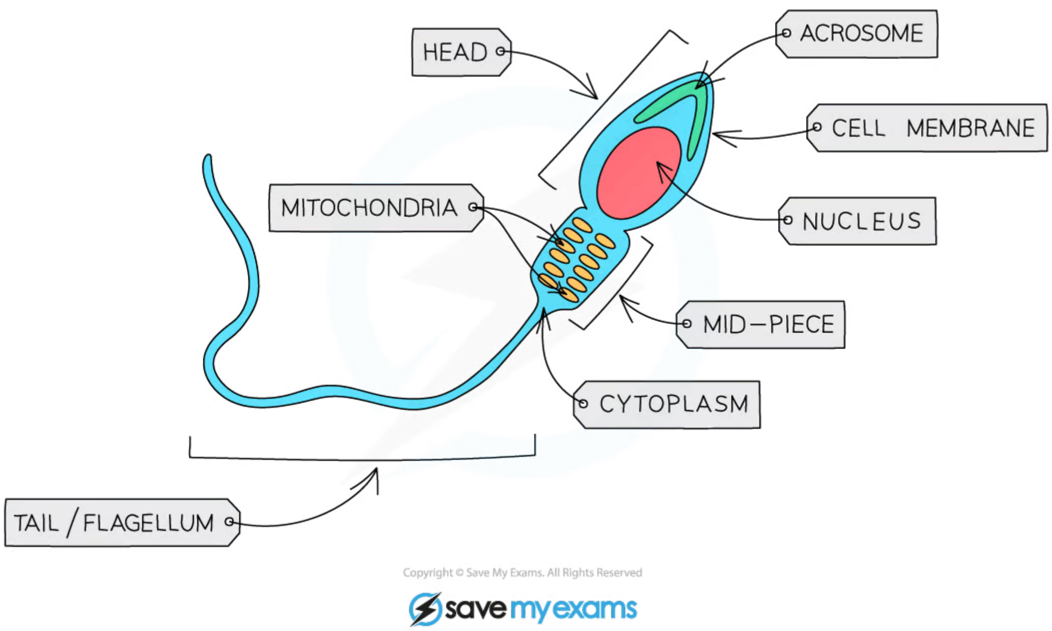
- Specialised cells are those which have **developed certain characteristics** (known as **adaptations**) in order to **perform particular functions**
- Cells specialise by undergoing **differentiation**: this is a process by which cells develop the structure and characteristics needed to be able to carry out their functions
- Examples of specialised cells in animals include:
  - **Sperm cells**
  - **Egg cells**
  - **Ciliated epithelial cells**

Sperm cells

- Sperm cells are **highly specialised** for their role in **reproduction** i.e. to carry the DNA of the male to the egg cell (the ovum) of the female



Sperm cell

Sperm Cell Adaptations Table

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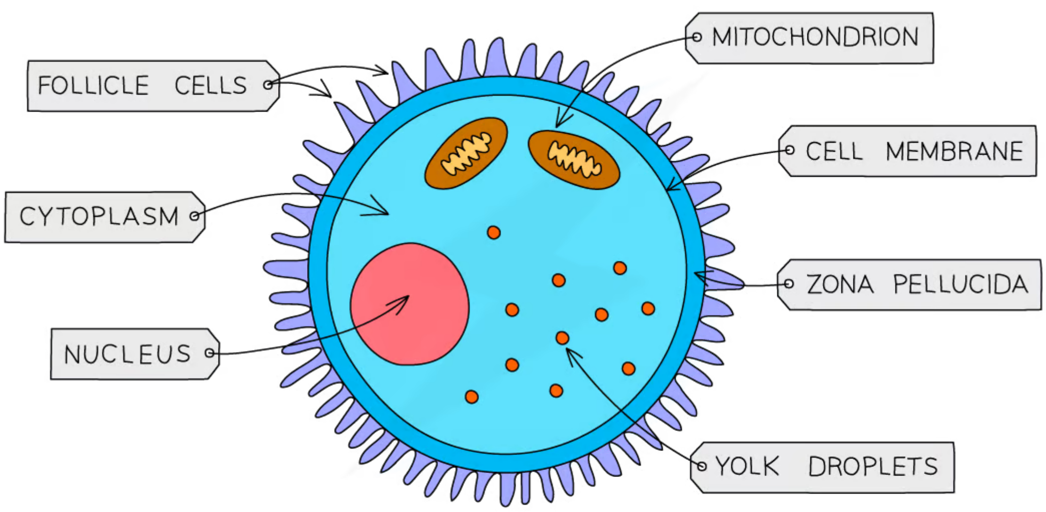
Cell	Function	Adaptations
Sperm cell	Reproduction	◦ The head contains the genetic material for fertilisation in a **haploid nucleus** (containing half the normal number of chromosomes) ◦ The **acrosome** in the head contains digestive **enzymes** so that a sperm can penetrate an egg ◦ The mid-piece is packed with **mitochondria** to release **energy** needed to swim and fertilise the egg ◦ The **tail** enables the sperm to **swim**

Egg cells

- Egg cells are also **highly specialised** for their role in **reproduction** i.e. to be fertilised by a single sperm and to develop into an embryo



Egg cell

Egg Cell Adaptations Table

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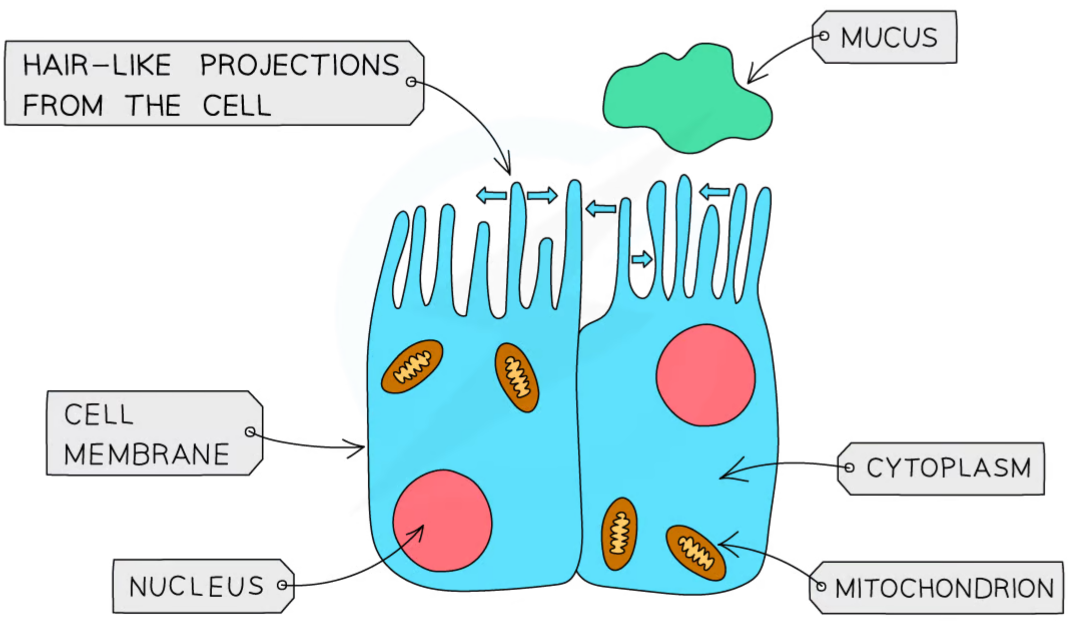
Cell	Function	Adaptations
Egg cell (ovum)	Reproduction	◦ Contains a **lot of cytoplasm** which has **nutrients** for the growth of the early embryo ◦ **Haploid nucleus** contains the genetic material for fertilisation ◦ Cell membrane **changes after fertilisation** by a single sperm so that **no more sperm** can enter

Ciliated epithelial cells

- Ciliated epithelial cells are **highly specialised** for their role in **wafting bacteria and other particles** (trapped by **mucus**) up to the **throat** (to be coughed out) or down to the **stomach** (to be digested)



Ciliated epithelial cells

Ciliated Epithelial Cell Adaptations Table

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Cell	Function	Adaptations
Ciliated cell	Movement of mucus in the trachea and bronchi	∘ Extensions of the cytoplasm at the surface of the cell form hair-like structures called **cilia** which **beat to move mucus** and trapped particles up to the throat

Exam Tip

Remember: Cilia and microvilli are not the same.

Cilia are hair-like projections that can move ('waft') mucus along, whereas microvilli are multiple indentations of the small intestinal epithelial cell membrane, designed to increase the surface area for absorption. Microvilli cannot move by themselves as cilia can.

1.1.6 Microscopy

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A Brief History of the Microscope

- Microscopy techniques have **developed over time**, increasing our understanding of **cell structures** and **organelles**
  - This has also increased our understanding of the **role** of subcellular structures
- The first **light microscopes** were developed in the **17th Century**
- Scientists such as Anton van Leeuwenhoek and Robert Hooke are responsible for using microscopes to develop our first understanding of cells
  - The first cells (of a **cork**) were observed by Robert Hooke in **1665** using a light microscope
- Light microscopes use **light** and **lenses** to form a **magnified image** of a **specimen**
- Over the centuries, the design of the light microscope has evolved, **increasing magnification** and **resolution** to enhance the detail of what can be visualised
- With a modern light microscope, it is possible to see images of **cells** and **large subcellular structures** (like **nuclei** and **vacuoles**), although **stains** are often required to highlight certain parts of cells
  - The most powerful light microscopes today have a maximum magnification of approximately **1000 to 2000×**
- The first **electron microscopes** were developed in the **first half of the 20th Century** (in the **1930s**)
  - Electron microscopes use **beams of electrons**, rather than light, to visualise specimens
  - The **wavelength** of an electron beam is much **smaller** than that of visible light, which gives electron microscopes a much **higher resolution** and **magnification**

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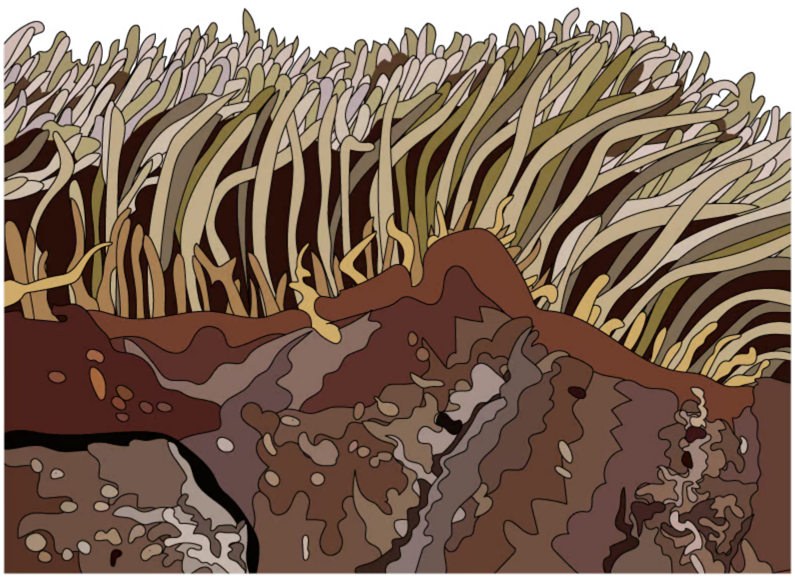
Electron Microscopes

- 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 **mitochondria**, **chloroplasts** and **ribosomes**
- They have also helped biologists develop a better understanding of the structure of the **nucleus and cell membrane**
- Electron microscopes have a maximum magnification of approximately **2,000,000×**



An example of an electron micrograph (of ciliated epithelium tissue) produced by an electron microscope. Notice the high level of detail included. The colour has been added by a computer programme.

Magnification Calculations

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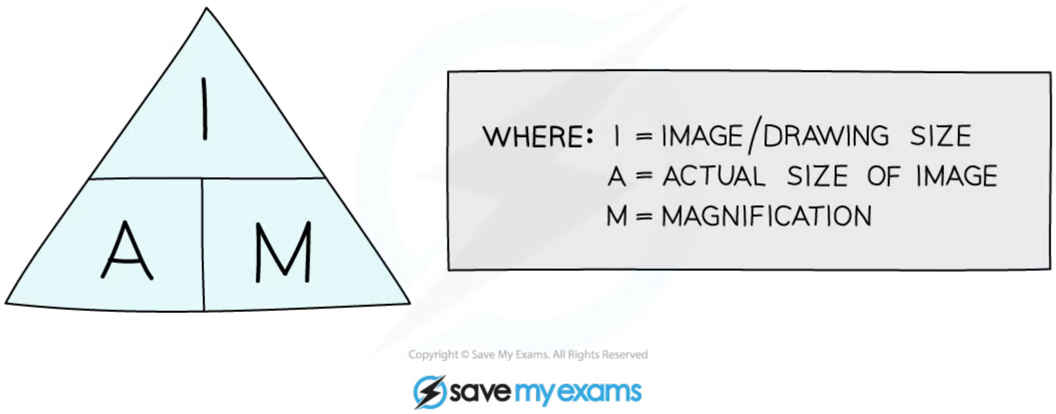
- Magnification is calculated using the following equation:

Magnification = Drawing size ÷ Actual size

- A better way to remember the equation is using an **equation triangle**:



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 = actual size × magnification
- Remember magnification **does not have any units** and is just written as 'X 10' or 'X 5000'

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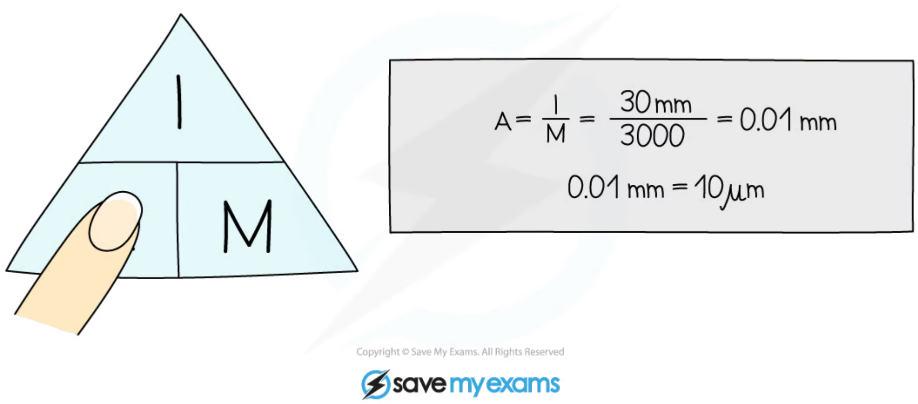
Worked Example

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

- You may also be asked to calculate the **total magnification** of a light microscope if given the magnification of the **eyepiece lens** and the magnification of the **objective lens**
- As these are two separate parts of a light microscope, each with its own magnifying power, you can simply **multiply the two values** to calculate the total magnification:

Magnification of light microscope = Magnification of eyepiece lens × Magnification of objective lens

Exam Tip

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!

1.1.7 Practical: Microscopy

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Practical: Microscopy

- Many biological structures are **too small** to be seen by the **naked eye**
- **Optical microscopes** are an invaluable tool for scientists as they allow for **tissues**, **cells** and **organelles** to be seen and studied
- Light is directed through a thin layer of **biological material** (containing the tissue(s), cell(s) or organelle(s) to be observed) that is supported on a **glass slide**
- This light is focused through several **lenses** so that an image is visible through the eyepiece

Apparatus

- The key components of an optical microscope you will need to use are:
  - The eyepiece lens
  - The objective lenses
  - The stage
  - The light source
  - The coarse and fine focus
- Other apparatus used:
  - Forceps
  - Scissors
  - Scalpel
  - Coverslip
  - Slides
  - Pipette

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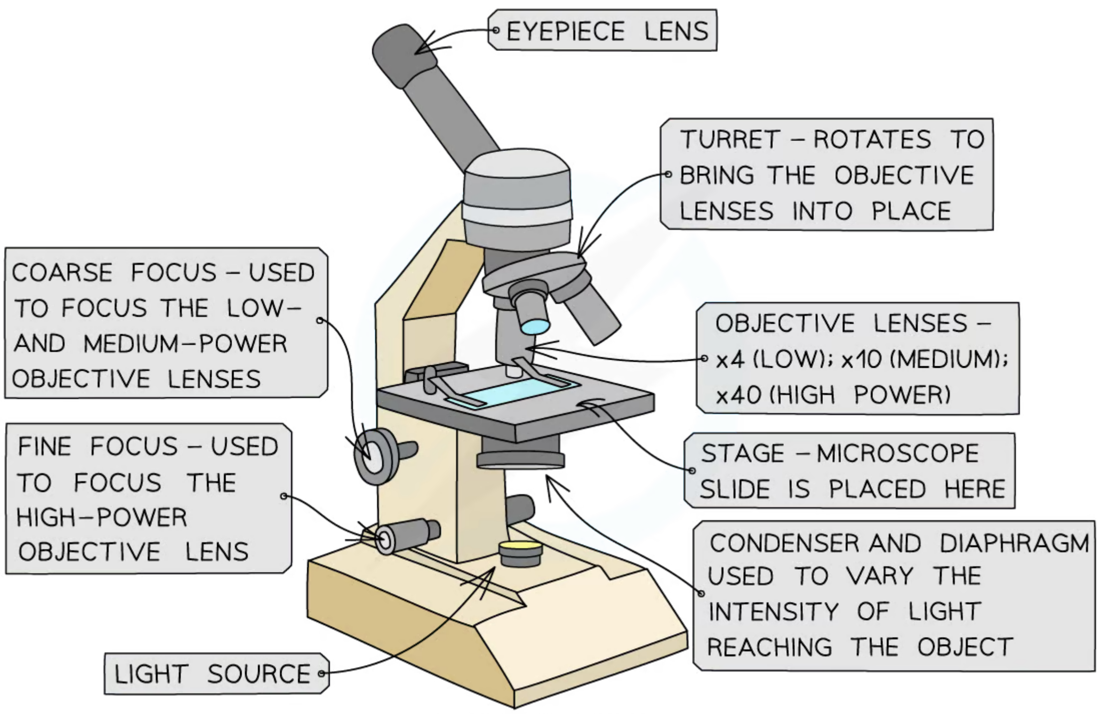

The components of an optical microscope

Method

- **Specimens** must be **prepared** on a **microscope slide** to be observed under a light microscope
- This must be done **carefully** to avoid **damaging** the biological specimen and the structures within it
- The most common specimens to observe under a light microscope are **cheek cells** (animal cells) and **onion cells** (plant cells)
- Preparing a slide using a **liquid specimen**:
  - Add a few drops of the sample to the slide using a **pipette**
  - Cover the liquid/smear with a coverslip and gently press down to **remove air bubbles**
  - **Wear gloves** to ensure there is no cross-contamination of foreign cells
- Preparing a slide using a **solid specimen**:
  - Use scissors to cut a small sample of the tissue
  - Peel away or cut a **very thin layer** of cells from the tissue sample to be placed on the slide (using a scalpel or forceps)
  - Some tissue samples need to be treated with chemicals to kill/make the tissue rigid
  - Gently place a coverslip on top and press down to **remove any air bubbles**
  - A **stain** may be required to make the structures visible depending on the type of tissue being examined. Commonly used stains include **methylene blue** to stain **cheek cells** and **iodine** to stain **onion cells**
  - Take care when using sharp objects and wear gloves to prevent the stain from dying your skin
- When using an optical microscope always **start with the low power objective lens**:

- It is **easier to find** what you are looking for in the field of view
- This helps to **prevent damage** to the lens or coverslip in case the stage has been raised too high

- Preventing the dehydration of tissue:
  - The thin layers of material placed on slides can **dry up rapidly**
  - Adding a drop of water to the specimen (beneath the coverslip) can prevent the cells from being damaged by dehydration

- Unclear or blurry images:
  - Switch to the lower power objective lens and try using the **coarse focus** to get a clearer image
  - Consider whether the specimen sample is **thin enough** for light to pass through to see the structures clearly
  - There could be **cross-contamination** with foreign cells or bodies

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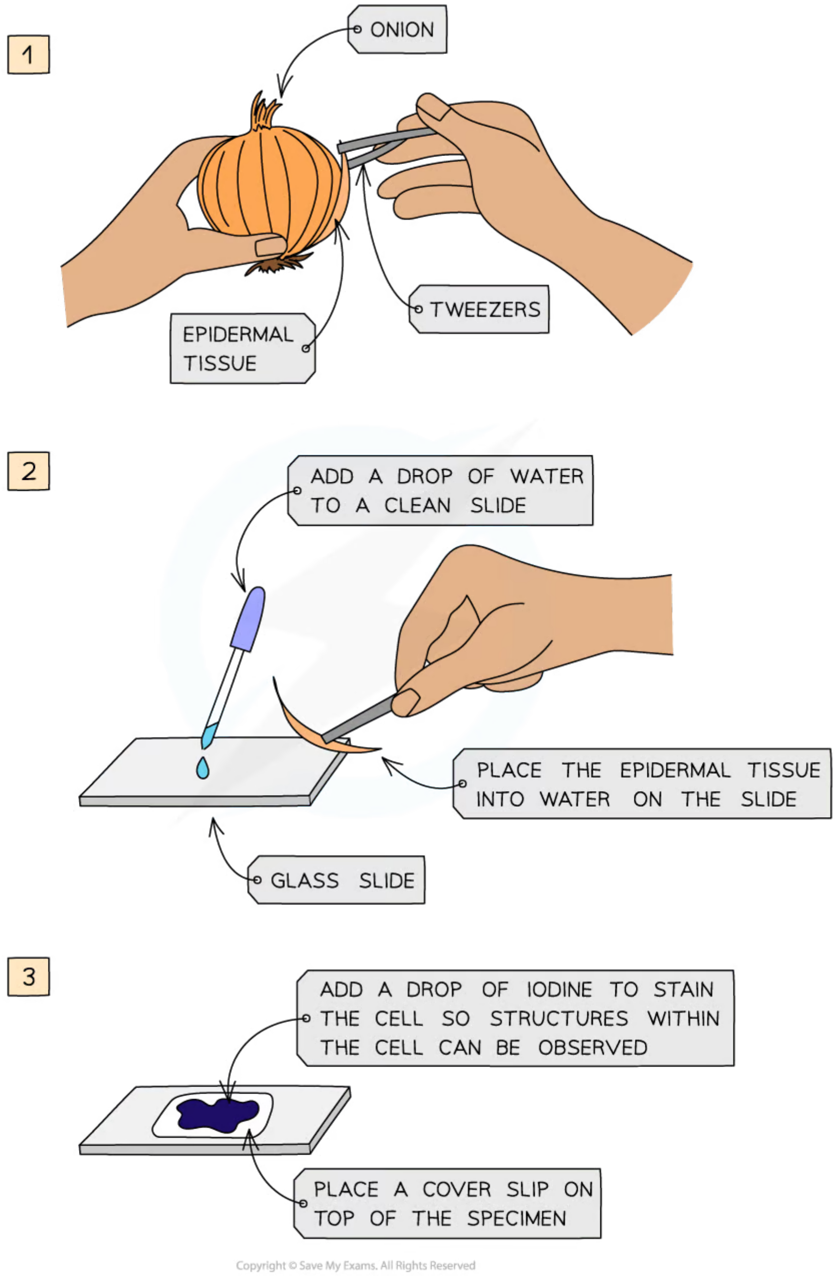

Care must be taken to avoid smudging the glass slide or trapping air bubbles under the coverslip

Results: using a graticule to measure cells, cell structures and organelles

- In order to take measurements of cells, you need to use a **calibrated** graticule
- An **eyepiece graticule** and **stage micrometer** are used to measure the size of the object when viewed under a microscope

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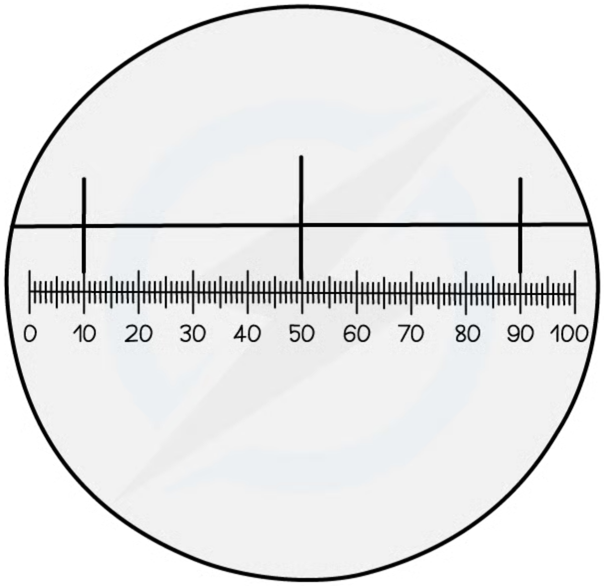

The three lines of a stage micrometer and the 100 division-markings of the eyepiece graticule, as seen if looking down the lens of a light microscope

Results - producing labelled scientific drawings from observations

- 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

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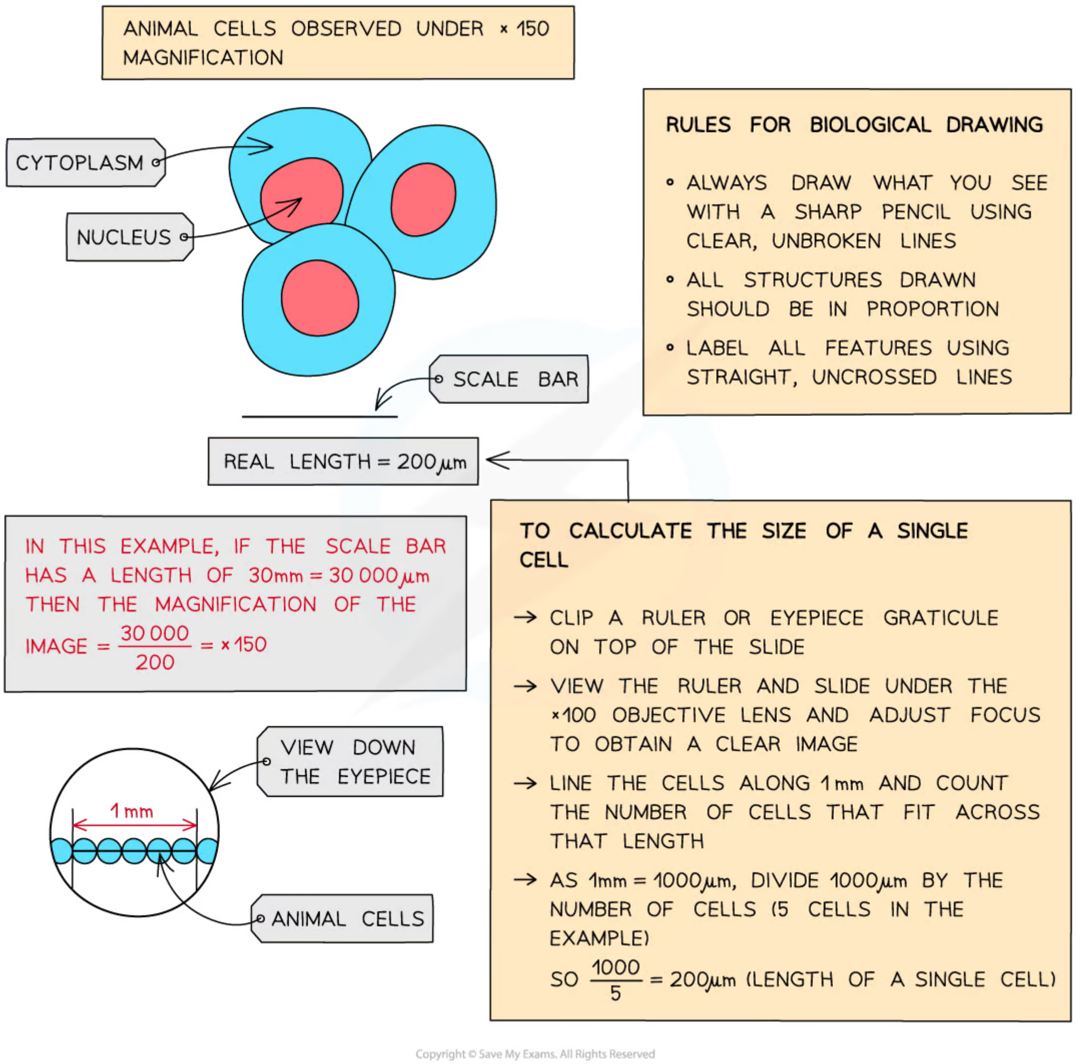

Biological drawings should be as large as possible – aim to take up at least half of the space available on the page with your drawings

Limitations

- The size of cells or structures of tissues may appear inconsistent in different specimen slides
    - Cell structures are **3D** and the different tissue samples will have been **cut at different planes** resulting in inconsistencies when viewed on a **2D slide**
- Optical microscopes do not have the same magnification power as other types of microscopes and so there are some structures that cannot be seen
- The treatment of specimens when preparing slides could alter the structure of cells

1.1.8 Using Units

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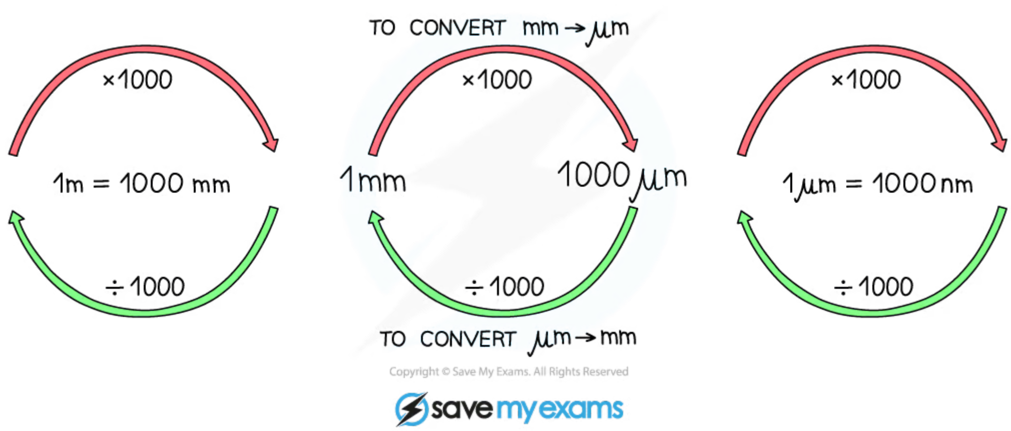
Converting Units

- 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)
- Remember the following to help you convert between mm (millimetres), µm (micrometres) and nm (nanometres):



Converting between mm (millimetres), µm (micrometres) and nm (nanometres)

- If you are given a question with **two different units** in it, make sure you make a conversion so that **both** measurements have the **same** unit before doing your calculation
- For example:

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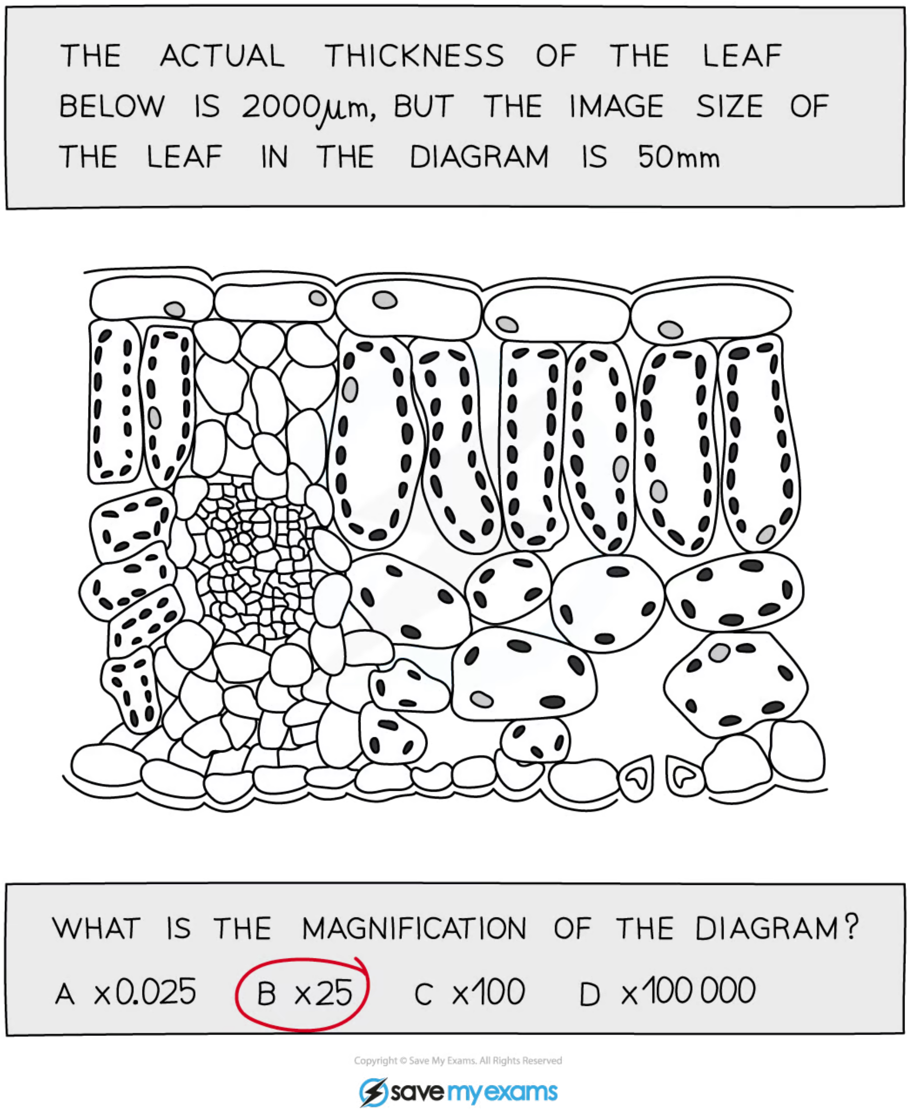
Worked Example



Step One:

- Remember that 1 mm = 1000 µm
- So to get from µm to mm you need to divide by 1000

Step Two: Calculate the thickness of the leaf in mm

- 2000 ÷ 1000 = 2, so the actual thickness of the leaf is 2 mm and the drawing thickness is 50 mm

Step Three: Put these values into the equation for calculating magnification

- Magnification = image size ÷ actual size

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- $= 50 \div 2$
- $= 25$

- So the magnification is **x 25**

Standard form

- When doing calculations and unit conversions, it is common to come across **very big** or **very small** numbers
- Standard form can be useful when working with these numbers
- Standard form is a way of writing very big and very small numbers using **powers of 10**

How to use standard form

- Using standard form, numbers are always written as follows: $\mathbf{a \times 10^n}$
- The rules:
  - $\mathbf{1 \leq a < 10}$ (the number 'a' must always be between 1 and 10)
  - $\mathbf{n > 0}$ for LARGE numbers ('n' = how many times 'a' is multiplied by 10)
  - $\mathbf{n < 0}$ for SMALL numbers ('n' = how many times 'a' is divided by 10)

Using standard form to convert between units

- For example, you can write **1 metre** in **millimetres** using standard form:
  - 1 m = 1000 mm
  - So, 1 m = 1 mm × 1000
  - So, 1 m = 1 mm × 10 × 10 × 10
  - So, as we had to **multiply** 1 mm by 10 **three times** to get 1 m, we write this as:
  - 1 m = 1 $\mathbf{\times 10^3}$ mm

- Writing **1 millimetre** in **metres** using standard form is also possible and is just the **opposite**:
  - 1 mm = 0.001 m
  - So, 1 mm = 1 m ÷ 1000
  - So, 1 mm = 1 m ÷ 10 ÷ 10 ÷ 10
  - So, as we had to **divide** 1 m by 10 **three times** to get 1 mm, we write this as:
  - 1 mm = 1 $\mathbf{\times 10^{-3}}$ m

- Exactly the same process can be used if you needed to convert **micrometres** into **millimetres**. For example:
  - 1 µm = 0.001 mm
  - So, 1 µm = 1 mm ÷ 1000
  - So, 1 µm = 1 mm ÷ 10 ÷ 10 ÷ 10
  - So, as we had to **divide** 1 mm by 10 **three times** to get 1 µm, we write this as:
  - 1 µm = 1 $\mathbf{\times 10^{-3}}$ mm

Examples of using standard form in conversion calculations

- You could be asked to state 45 centimetres in millimetres using standard form:
  - 1 cm = 10 mm
  - So, 45 cm = 450 mm
  - So, 45 cm = 4.5 mm × 10 × 10
  - So, as we had to **multiply** 4.5 mm by 10 **two times** to get 45 cm, we write this as:

- 45 cm = 4.5 × 10^2 mm

- You could also be asked to state 250 micrometres in millimetres using standard form:
  - 1 µm = 0.001 mm
  - So, 250 µm = 0.25 mm
  - So, 25 µm = 2.5 mm ÷ 10
  - So, as we had to **divide** 4.5 mm by 10 just once to get 250 µm, we write this as:
  - 250 µm = 2.5 × 10^{-1} mm

YOUR NOTES
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