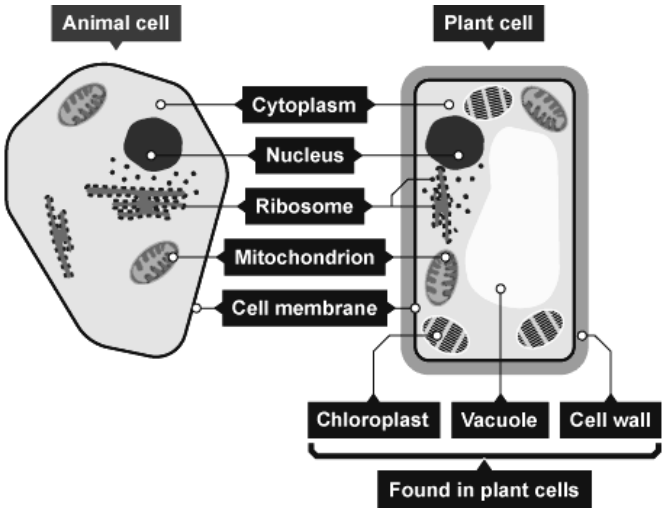
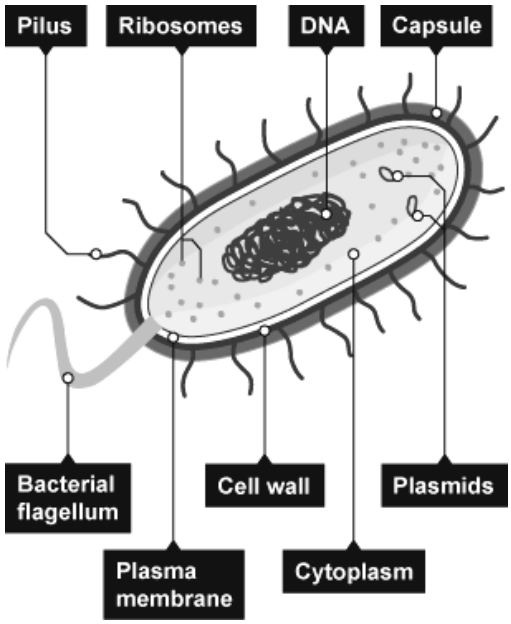
B1 Eukaryotic and Prokaryotic cells

Plant and animal cells are examples of **eukaryotic** cells. All eukaryotic cells have a **cell membrane**, **cytoplasm** and genetic material enclosed in a **nucleus**.



Bacterial cells are examples of **prokaryotic** cells. Prokaryotic cells are much smaller than eukaryotic cells. They have **cytoplasm** and a **cell membrane** surrounded by a **cell wall**. The genetic material is **not enclosed in a nucleus**. It is a single DNA loop and there may be one or more small rings of DNA called plasmids.

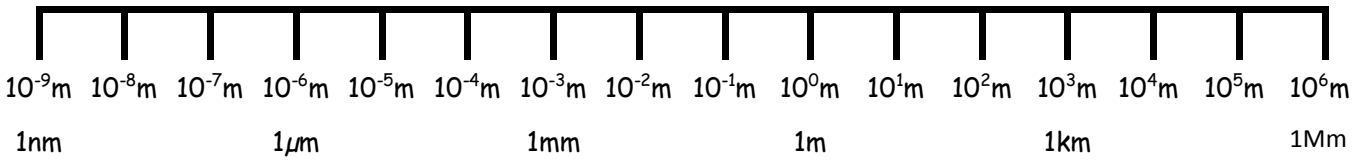


Orders of magnitude are used to give a general idea of how big or small something is. To find an objects order of magnitude: first write its size in standard form, the objects order of magnitude is just the power of 10 it has at the end.

E.g. The order of magnitude of a cell $4 \times \mathbf{10^{-4}}$ m wide is $\mathbf{10^{-4}}$ m.

The order of magnitude of a bacteria cell $3.4 \times \mathbf{10^{-6}}$ m wide is $\mathbf{10^{-6}}$ m.

To find the **order of magnitude difference** between two objects just find the difference in their powers of 10. (i.e. how many jumps between the two numbers on the number line below?)



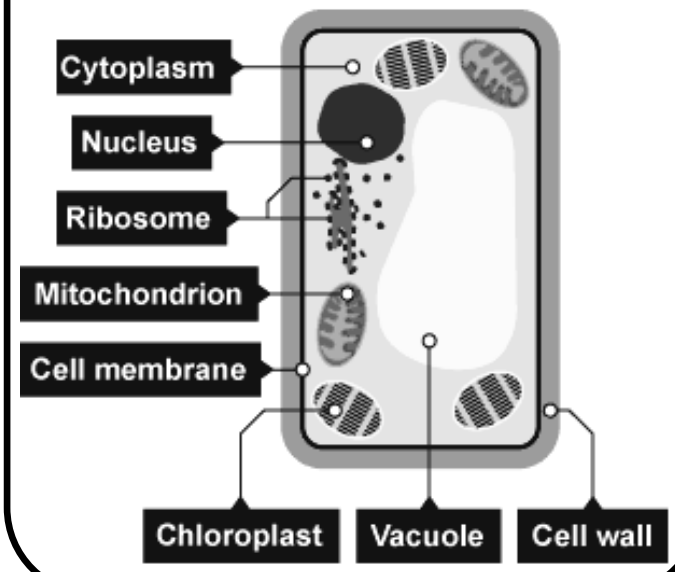
E.g. A small animal cell has a length of 10μm, a large plant cell has a length of 100μm. What is their order of magnitude difference?

Animal cell: $10\mu m = 10^{-5}m$ Plant cell: $100\mu m = 10^{-4}m$

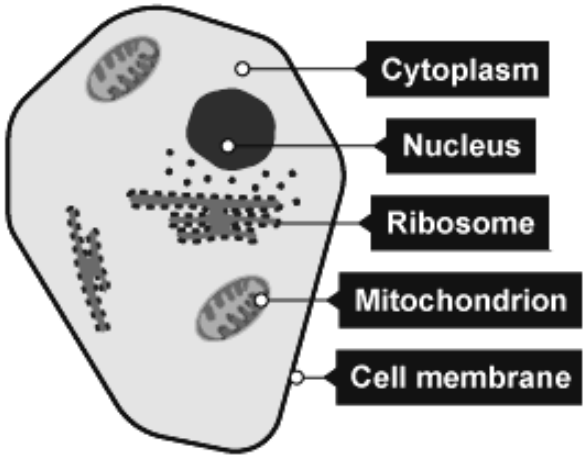
1 jump = 1 order of magnitude difference

B1 Plant and Animal Cells

Most plant cells contain: **nucleus, cytoplasm, cell membrane, mitochondria, ribosomes, chloroplasts, cell wall** (made of cellulose) and a **vacuole** (filled with cell sap)



Most animal cells have the following parts: **nucleus, cytoplasm, cell membrane, mitochondria, ribosomes.**



Nucleus: Controls all the activities in the cell, it contains the genes in the chromosomes which carry all the genetic information. Generally around 10μm wide.

Cytoplasm: A jelly like substance where organelles are suspended and where many chemical reactions take place.

Cell membrane: controls the substances which enter and leave the cell, such as glucose, oxygen and mineral ions.

Mitochondria: Structures in the cytoplasm where aerobic respiration takes place, releasing energy for the cell. They are very small (around 1μm long and 0.5μm wide).

Ribosomes: Where protein synthesis takes place, making all the proteins needed in the cell.

Cell wall: Found in plant and algal cells. The cell wall is made of cellulose. It strengthens the cell and gives it support.

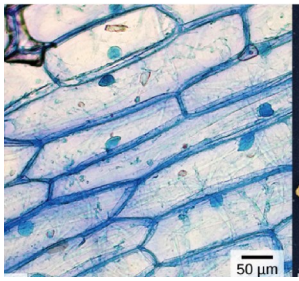
Chloroplasts: These contain the green substance chlorophyll, which absorbs light for photosynthesis. They are around 3-5μm long.

Vacuole: (Sometimes called the permanent vacuole) It is a space filled with cell sap in the middle of a cell, it keeps the cell rigid to support the plant.

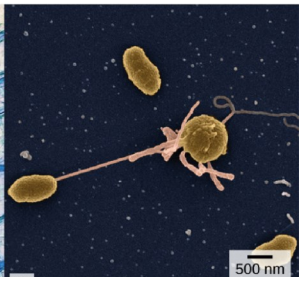
To figure out the size of a cell or sub-cellular structure measure the length of the scale bar, then measure the length of a cell in the picture.

$$\text{Real size of cell} = \frac{\text{Real size of bar}}{\text{Measured size of bar}} \times \text{measured size of cell}$$

Onion cells



Bacterial cells



B1

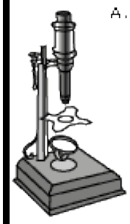
Microscopy

Z. Janssen

14th century - lenses are developed in Italy.

A. van Leeuwenhoek

1590 - Hans and Zacharias Janssen make the first microscope by putting 2 lenses in a tube.



1667 - Hooke studies objects with a microscope.

1675 - Leeuwenhoek uses a microscope to observe cells.

E. Abbe

R. Zsigmondy

1830 - Lister discovers combining lens makes a clearer image.

F. Zernike

E. Ruska

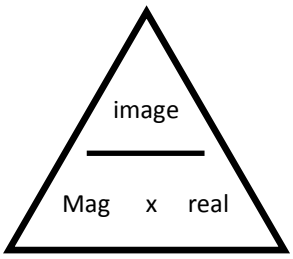
1938 - Ruska develops the electron microscope which improves resolution and magnification.

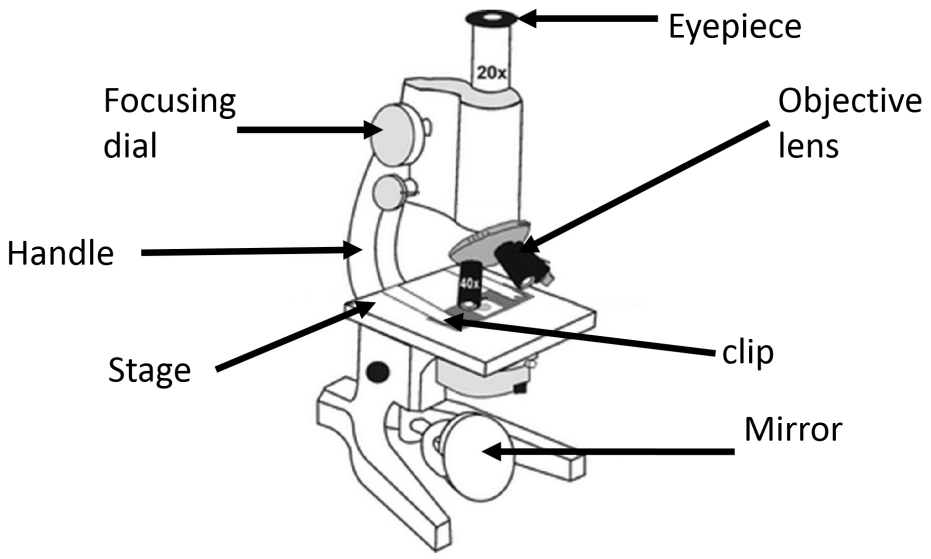
G. Binnig and H. Rohrer

An electron microscope has much **higher magnification and resolving power** than a light microscope.
This means that it can be used to study cells in much finer detail.
This has enabled biologists to see and understand many more sub-cellular structures.
An electron microscope is a lot **more expensive** than a light microscope.

(Magnification is how much bigger you can make an image.)
(Resolution is how much detail you can see on an image.)

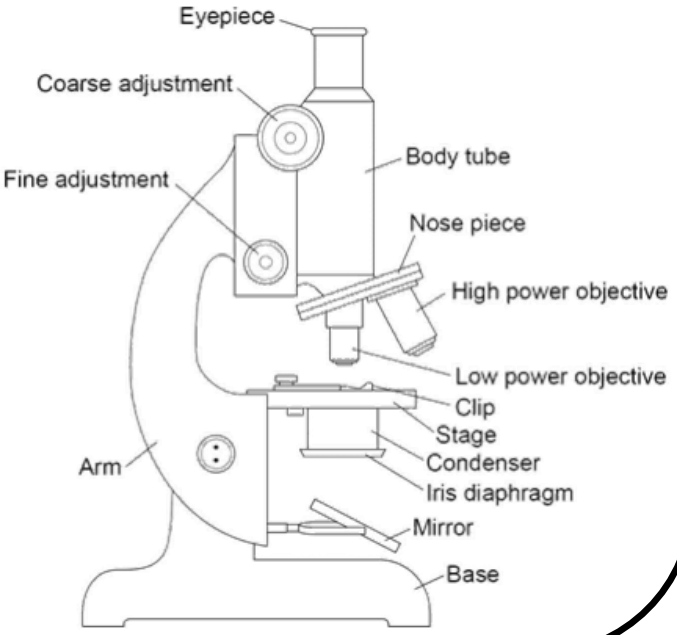
magnification =
size of image ÷ size of real object





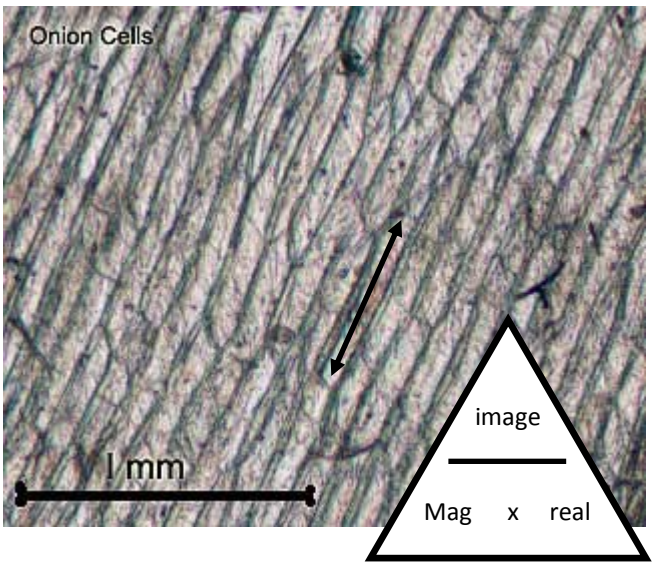
B1 Required Practical: Microscopy

1. Put the slide on the microscope stage.
2. Turn the nose piece to select the lowest power objective lens (this is usually ×4 objective lens). The end of the objective lens needs to almost touch the slide.
3. Turn the coarse adjustment knob to move the lens towards the slide. Look from the side (not through the eyepiece) when you are adjusting the lens.
4. Now look through the eyepiece. Slowly turn the coarse adjustment knob in the direction to increase the distance between the objective lens and the slide. Do this until the cells come into focus.
5. Slightly turn the fine adjustment knob to bring the cells into a clear focus. Use the low power objective lens (totalling ×40 magnification) to look at the cells.
6. When you have found some cells, turn the nose piece to switch to a higher power lens (×100 or ×400 magnification).
7. You will have to use the fine adjustment knob again to bring the cells back into focus.
8. Make a clear, labelled drawing of some of the cells. Make sure that you draw and label any component parts of the cell. Use a pencil to draw the cells.
9. Write the magnification underneath your drawing. Remember to multiply the objective magnification by the eyepiece magnification.



To determine the real size of a cell in an image with a scale bar:

1. **Figure out the magnification** of the image by measuring the size of the scale bar with a ruler and dividing the size it measures with a ruler by the size the scale bar tells you it is (These values must be in the same units).
2. Measure the length of a cell with a ruler and divide by the magnification to **get its real size**.

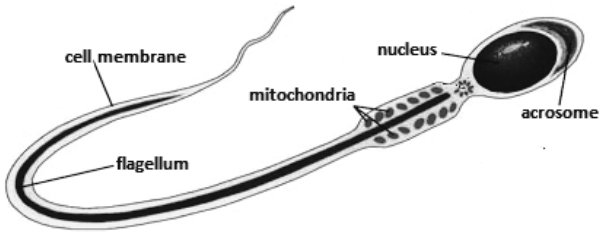


E.g. magnification = 38mm ÷ 1mm = x38
Measured length of cell with arrow = Image size = 21mm
Real size of cell with arrow along = 21mm ÷ 38 = 0.55mm

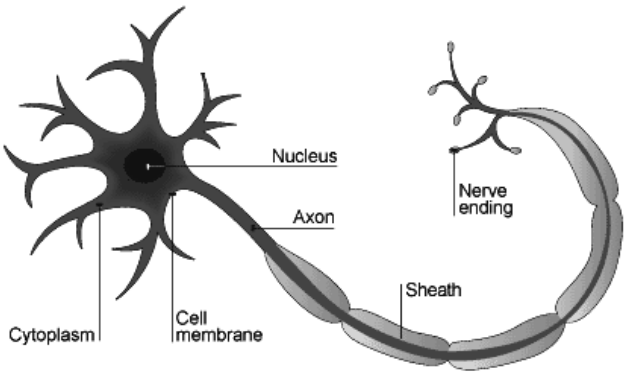
B1 Cell specialisation and Cell differentiation

Animal cells

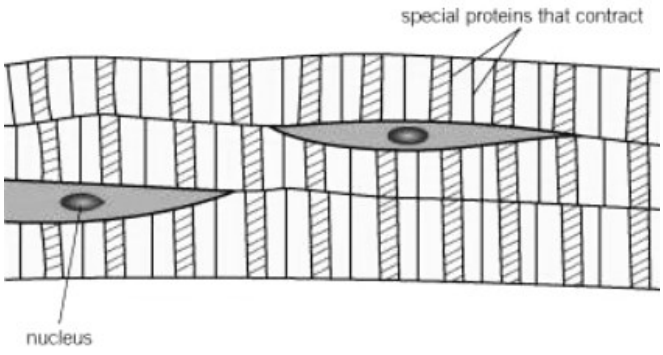
Sperm cells:



Nerve cell:

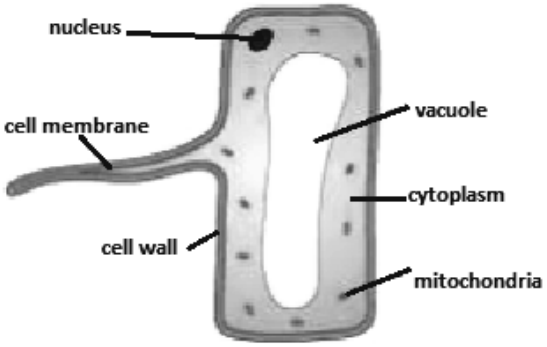


Muscle cell:

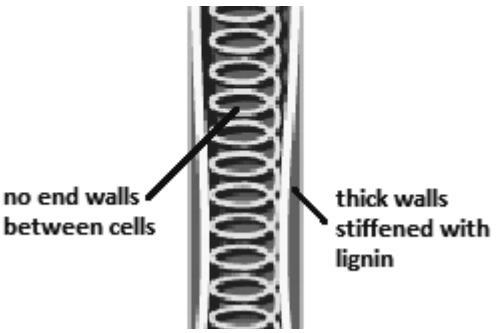


Plant cells

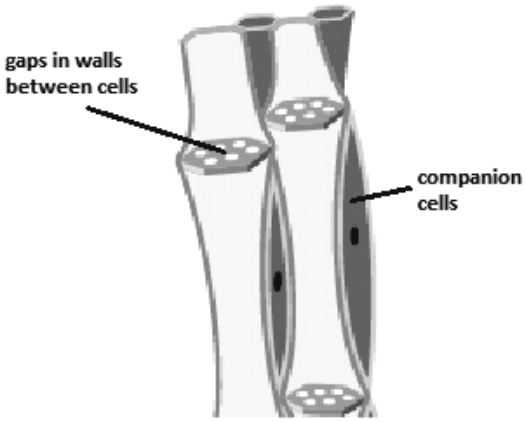
Root hair cell:



Xylem cell:



Phloem cell:



As an organism develops, cells **differentiate** to form different types of cells. As a cell differentiates it acquires different sub-cellular structures (organelles) to enable it to carry out a certain function. It has become a **specialised cell**.

Differentiation in animal cells

Most types of animal cell differentiate at an **early stage**.
In mature animals, cell division is mainly restricted to **repair and replacement**.

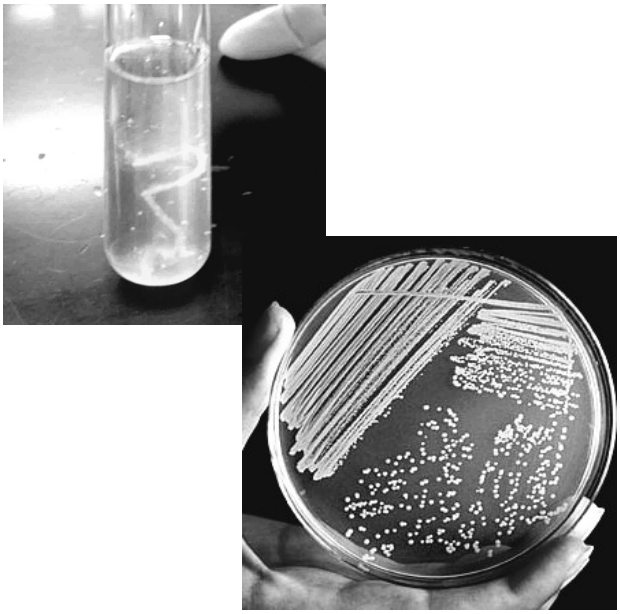
Differentiation in plant cells

Many types of plant cells retain the ability to **differentiate throughout life**.

B1 Culturing microorganisms

Bacteria multiply by simple cell division (**binary fission**) as often as once every 20 minutes if they have enough nutrients and a suitable temperature.

Bacteria can be grown in a **nutrient broth** solution or as colonies on an agar **gel** plate.



In order to grow an uncontaminated sample of bacteria, it is necessary to work **aseptically**.

For example:

- Petri dishes and culture media must be **sterilised** before use
- Inoculating loops used to transfer microorganisms to the media must be **sterilised** by passing them through a flame
- The lid of the Petri dish should be **opened as little as possible** when spreading the bacteria.
- The lid of the Petri dish should be secured with adhesive tape and **stored upside down**
- In school laboratories, cultures should generally be **incubated** at 25°C for around 48 hours.

To calculate the number of bacteria in a population after a certain time:

1. First figure out **how many times the bacteria cells have divided**. (e.g. if they divide every 30 mins and it has been 120 mins, they have divided 4 times).
2. Second **multiply the starting number of bacteria by 2**, to find out how many bacteria you had after they first divided, then multiply the answer you get by 2, then multiply the answer to that by 2. Do this **as many times as the bacteria have divided**. (i.e. if they have divided 4 times then multiply by 2 4 times.)

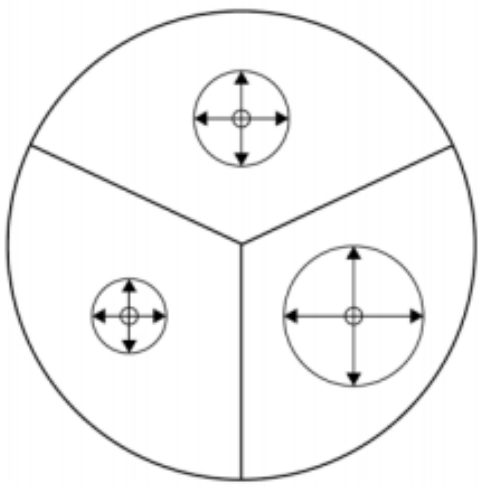
Example: A bacteria colony begins with 20 bacteria cells. The bacteria divide every 20 mins. How many bacteria will there be after 60mins?

1. The bacteria will divide 3 times in 60 minutes.
2. 1st time dividing: 20 x 2 = 40 bacteria
   2nd times dividing: 40 x 2 = 80 bacteria
   3rd time dividing: 80 x 2 = 160 bacteria

After 60 mins there will be 160 bacteria in the colony.

B1 Required Practical: Zones of inhibition

1. Make sure your hands and work space are thoroughly **clean before and after the experiment**.
2. Spray the bench where you are working with disinfectant spray. Then wipe with paper towels.
3. Use a permanent marker to **mark the bottom** of the nutrient agar plate (not the lid) as shown in the diagram below. Make sure that the **lid stays in place** to avoid contamination.
   - Label on the plate where you are going to put the three paper discs with the antiseptics on
   - add your initials, the date and the name of the bacteria.
4. Wash your hands with the antibacterial hand wash.
5. Put a different **antiseptic onto each of the three paper discs**, being careful to shake off excess liquid to avoid splashing.
6. Carefully lift the lid of the agar plate at an angle away from your face. Do **not open it fully**.
7. Use the forceps to carefully put each disc onto one of the dots you drew on with the marker.
8. **Make a note of which antiseptic is in each section**.
9. **Secure the lid** of the agar plate in place using two small pieces of clear tape. Do not seal the lid all the way around as this creates anaerobic conditions. (Anaerobic conditions will prevent the bacteria from growing and can encourage some other very nasty bacteria to grow).
10. **Incubate** the plate at 25 °C for 48 hours.
11. **Measure the diameter** of the clear zone around each disc. Measure again at 90° to your first measurement, then calculate the mean diameter.
12. Divide the diameter by 2 to get a value for the **radius** of your zone of inhibition. Use the equation for the area of a circle ($A = \pi r^2$) to **calculate the area of your zone of inhibition**.
13. **Compare** the zones of inhibition of the different antiseptics to find which was the most effective at killing bacteria.



B1

Stem cells

A stem cell is an **undifferentiated cell** of an organism which is capable of giving rise to many more cells of the same type, and **from which certain other cells can arise** from differentiation.
The function of stem cells in embryos is for growth, in adult animals it is for repair and replacement and in the meristems in plants it can be for growth or repair.

Stem cells from **human embryos can be cloned** and made to differentiate **into most different types of human cells.**

Stem cells from adult bone marrow can form **many types of cells** including blood cells.

Meristem tissue in plants can **differentiate into any type of plant cell**, throughout the life of the plant.

Treatment with stem cells may be able to help conditions such as diabetes and paralysis.

In **therapeutic cloning** an **embryo is produced** with the **same genes as the patient**. Stem cells from the embryo are **not rejected by the patient's body** so they may be used for medical treatment.

The use of stem cells has **potential risks** such as **transfer of viral infection**, and some people have **ethical or religious objections**.

Stem cells from meristems in plants can be used to produce clones of plants quickly and economically. Rare species can be cloned to **protect from extinction**. Crop plants with special features such as **disease resistance can be cloned to produce large numbers** of identical plants for farmers.

B1

Cell division

The **nucleus** of a cell **contains chromosomes** made of DNA molecules. Each chromosome carries a large number of genes. In body cells the **chromosomes are normally found in pairs**.

Cells divide in a series of stages called **the cell cycle**.

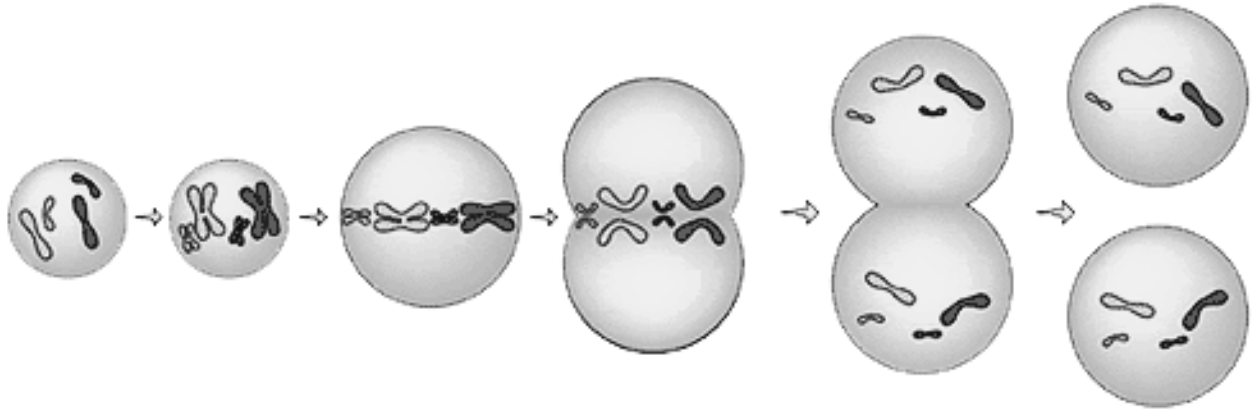
During the cell cycle the **genetic material is doubled** and **then divided** into two identical cells.

Before a cell can divide it needs to grow and **increase the number of sub-cellular structures** such as ribosomes and mitochondria.

The **DNA replicates** to form **two copies of each chromosome**.

In mitosis **one set of chromosomes is pulled to each end** of the cell and the nucleus divides.

Finally the **cytoplasm and cell membranes divide** to form two identical daughter cells.



Cell division by mitosis is important in the **growth and development** of multicellular organisms.

B1

Osmosis

Water may move across cell membranes via osmosis. Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.

A plant cell in a dilute solution.
Water enters the cell, it becomes turgid.

A plant cell in a concentrated solution.
Water leaves the cell, it becomes flaccid.

Active Transport

Active transport **moves substances** from a **more dilute solution to a more concentrated solution** (against a concentration gradient). This **requires energy** from respiration.

Active transport allows mineral ions to be absorbed into plant root hairs from very dilute solutions in the soil. Plants require ions for healthy growth.

It also allows sugar molecules to be absorbed from lower concentrations in the gut into the blood which has a higher sugar concentration. Sugar molecules are used for cell respiration.

B1

Diffusion

Diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in a net movement **from an area of higher concentration to an area of lower concentration.**

Some of the substances transported in and out of cells by diffusion are oxygen **and carbon dioxide in gas exchange**, and of the **waste product urea** from cells into the blood plasma for excretion in the kidney.

Factors which affect the rate of diffusion are:

- the **difference in concentrations** (concentration gradient)
- the **temperature**
- the **surface area** of the membrane.

A single-celled organism has a relatively large surface area to volume ratio. This allows sufficient transport of molecules into and out of the cell to meet the needs of the organism.

The small intestine and lungs in mammals, gills in fish, and the roots and leaves in plants, are adapted for exchanging materials by having a large surface area.

In multicellular organisms, surfaces and organ systems are specialised for exchanging materials. This is to allow sufficient molecules to be transported into and out of cells for the organism's needs.

The effectiveness of an exchange surface is increased by:

- having a large surface area
- a membrane that is thin, to provide a short diffusion path
- (in animals) having an efficient blood supply
- (in animals, for gaseous exchange) being ventilated.

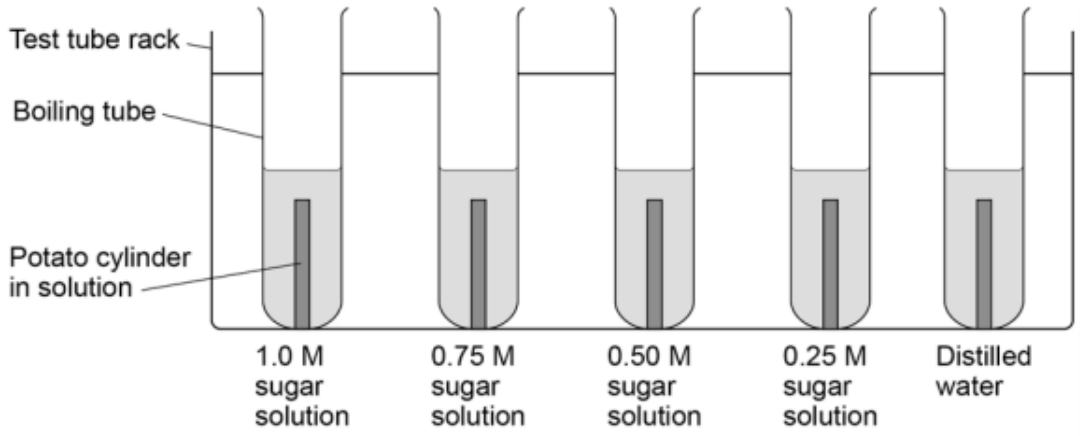
B1

Required practical: Osmosis

1. Use a cork borer to **cut five potato cylinders** of the same diameter.
2. Use the knife to trim off any potato skin on each potato cylinder. Then trim each potato cylinder so that they are all the same length.
3. Accurately **measure the mass of each potato** cylinder.
4. Record your measurements in a table like the one shown.

	1.0 M sugar solution	0.75 M sugar solution	0.5 M sugar solution	0.25 M sugar solution	Distilled water
Initial mass in g					
Final mass in g					
Change in mass in g					
Percentage change in mass %					

5. Measure **10 cm^3 of each concentration of sugar or salt solution** and put into boiling tubes. Label each boiling tube clearly.
6. Measure 10 cm^3 of the distilled water and put into the fifth boiling tube. Label the boiling tube clearly.
7. Add **one potato cylinder to each boiling tube**.



8. **Leave the potato** cylinders in the boiling tubes for a chosen amount of time.
9. Remove the potato cylinders from the boiling tubes and carefully blot them dry with the paper towels.
10. **Measure the new mass of each potato** cylinder again. Record your measurements for each concentration in your table.
11. **Calculate the percentage change** in mass of each potato.

% change = change in mass ÷ initial mass