Topic 1 – Cell Biology

Table of Content

1.1 Cell structure

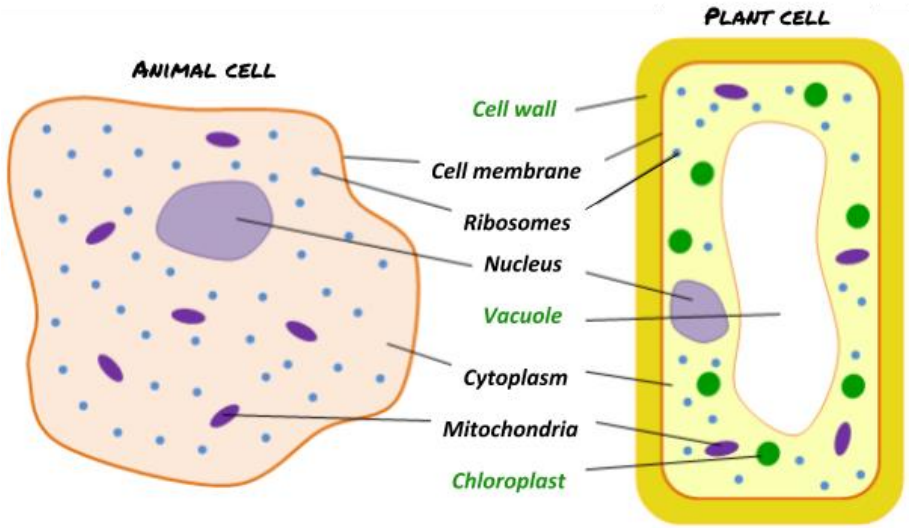
1.1.1 Eukaryotes and prokaryotes

Eukaryotic cell

- Animal, plant, fungi
- Has a cell membrane, cytoplasm & genetic material enclosed in a nucleus
- More complex

1.1.2 Animal and plant cells

Animal cell



Nucleus	• Contains genetic material (DNA) • Control cell's activities
Mitochondria	• Where aerobic respiration takes place • Releasing energy for cells to work
Cytoplasm	• Gel-like substance • Where chemical reaction takes place • Contains enzymes to control chemical reaction
Ribosome	• Where protein synthesis happens • Make proteins using amino acids
Cell membrane	• Hold cells together • Controls movement of substances in & out of cell

Plant cell

Cell wall	• Supports & strengths cell by cellulose
Permanent vacuole	• Contains air sap (weak solution of sugar & salt) • Keep cells rigid to support plant
Chloroplast	• Contains chlorophyll that absorb light for photosynthesis • Where photosynthesis occurs

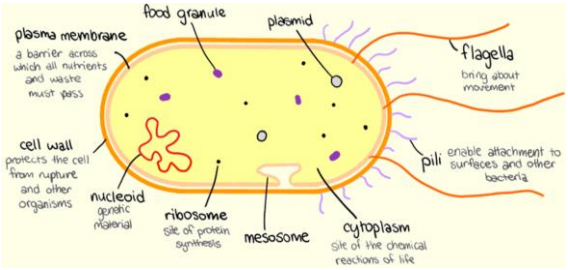
Prokaryotic cells

- Bacteria
- Have cytoplasm & cell membrane surround by cell wall
- Genetic material is not enclosed in a nucleus
- Its DNA is found as a loop in the cell & there may be one or more plasmids

Why are prokaryotic cells smaller & simpler?

- Larger SA : volume ratio
- Short diffusion distance
- Allow sufficient transport of molecules into & out of cell to meet needs of organism

Bacteria cell



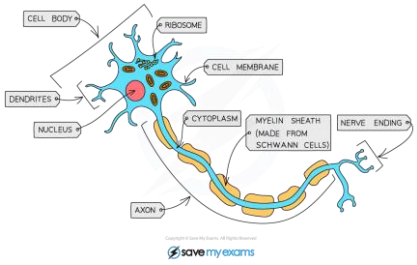
Slime capsule	• Protect cell
Plasmid	• A small ring of DNA
Flagellum	• Move themselves around

1.1.3 Cell specialisation

- Specialisation – cell differentiate to become specialized

Animal cells

Nerve cells



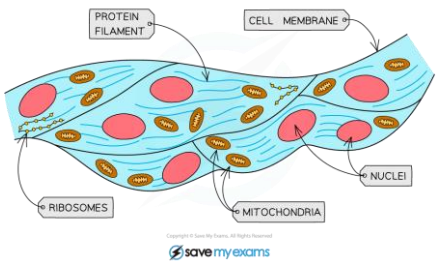
Function

- Transmit electrical impulses around the body

Adaptation

- Have lots of **dendrites** to connect other nerve cells
- **Axon** is very long to cover more distance
- **Synapses** contain lots of mitochondria to provide energy to make transmitter chemicals
- **Myelin** act as an electrical insulator to stop electrical impulse from leaking out

Muscle cells



Function

- Contract and relax to bring about movement

Adaptation

- Contain **protein fibre** to change length of cell (↓fibre ↓length)
- Contain many **mitochondria** to provide energy for contraction and respiration
- Store **glycogen** which can be broken down in cellular respiration to transfer energy

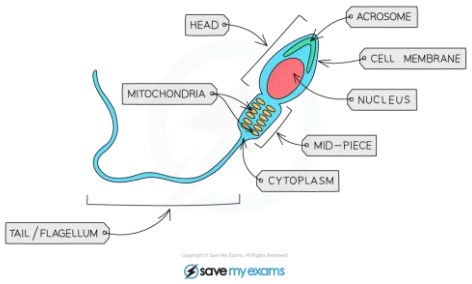
Sperm cells

Function

- Carry father's genetic information and fertilise the egg

Adaptation

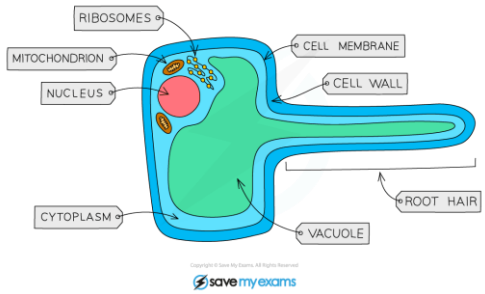
- Have **long tails** & **streamlined** to help swim to egg & reduce cells energy requirements to travel to egg



- **Acrosome** contain digestive enzymes to break through egg cell membrane
- **Nucleus** contains DNA / 1 set of chromosome to be passed on & preserves the chromosome no when the egg is fertilised
- **Nucleus** contains 23 chromosomes
- **Mid-section** contains mitochondria to provide energy in respiration for tail to work

Plant cells

Root hair cells



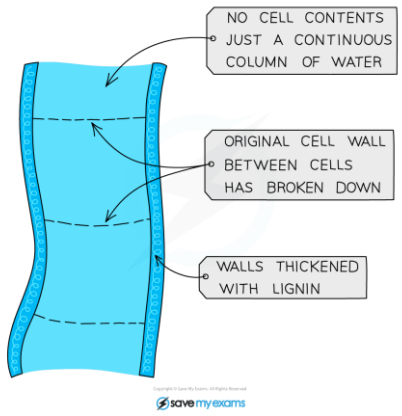
Function

- To absorb water by osmosis & mineral ions by active transport from soil efficiently

Adaptation

- Have **large SA** to absorb water & mineral ions
- Have **large permanent vacuole** to speed up movement of water by osmosis
- Contain **mitochondria** to provide energy to transport mineral ions into cell

Xylem cells



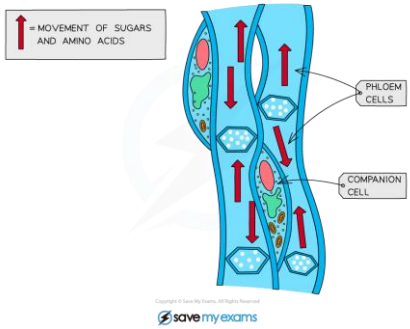
Function

- Transport water & mineral ions from root to stems & leaves

Adaptation

- Have **strong lignin spirals** which allow them to withstand water pressure to transport water in **transpiration stream** & support plant stem
- Cell die & form long **hallow tube** which is strengthened by lignin spirals allow water & mineral ions to move up easily
- Few cell structures & so they are dead for more space & supported by lignin

Phloem cells



Function

- Transport dissolved sugar through **translocation** from leaves to rest of plant for immediate use or storage

Adaptation

- Cell walls between cells break down to form sieve plates - allow water carrying dissolved food move freely up & down tube to where it's needed
- Companion cells keep them alive & contain mitochondria to provide energy to move dissolved food up & down plant

1.1.4 Cell differentiation

Differentiation

- Process where cells become specialised for a particular function
- As an organism develops, cells differentiate to form different types of cells
- Most types of **animal** cell differentiate at an **early stage**
- Many types of **plant** cells **retain the ability to differentiate throughout life**
- In **mature animals**, cell division is mainly restricted to **repair** & **replacement**
- As a cell differentiates, it acquires different sub-cellular structures to enable it to carry a particular function. It has become a specialised cell

1.1.5 Microscopy

Microscope

1. **Light microscope**
- Use light & lenses to form image of specimen & magnify
2. **Electron microscope**
- Use electron
- Have high magnification & resolution
- Used to study cells in much finer detail & enable biologist to see & understand many more sub-cellular structure

Formula of magnification

- Magnification = Size of Image / Size of Real Object

Units

- 1m=1000mm
- 1mm=1000µm

1.1.6 Culturing microorganisms (biology only)

- Bacteria in culture medium contains carbohydrates, minerals, proteins & vitamins
- Cell multiples to form colony
- Need uncontaminated culture to investigate action of disinfectants & antibiotics

Steps

Pre-inoculation

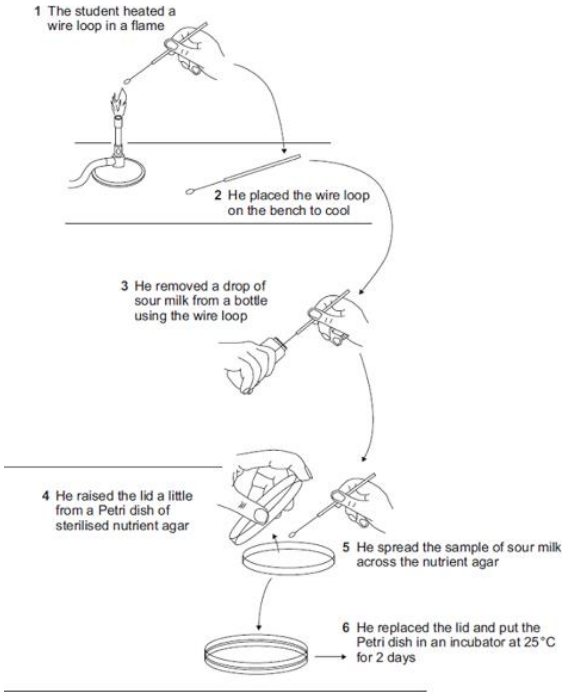
1. **Sterilize Petri dish & agar before use**
   - Kill & prevent unwanted microorganism affect result
2. **Pass inoculating loop through flame**
   - Sterilize loop

Inoculation

3. **Use loop to spread bacterium onto agar**
   - Open lid as little as possible so fewer bacteria from air to enter

Post-inoculation

4. **Secure lid with tape**
   - Prevent bacteria from air to enter
5. **Store Petri dish upside down**
   - Prevent drops of condensation fall onto agar surface
6. **Growth of bacteria**



Calculation - cross-sectional area - πr^2

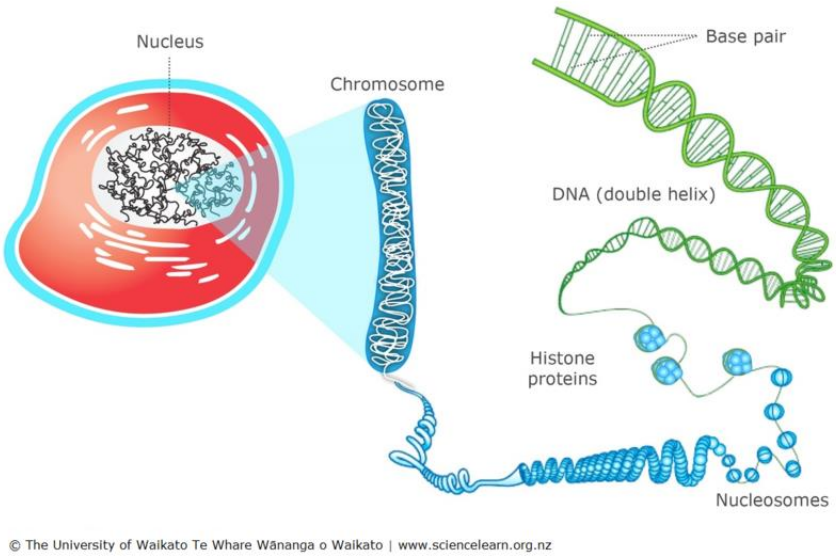
Why some agar area has no bacteria?

- Bacteria killed
- Larger are no bacteria - better
- Maybe harmful to ppl

In school lab - 25°C - prevent growth of pathogens
In industrial conditions - higher temperature - grow faster

1.2 Cell division

1.2.1 Chromosomes



What does the nucleus contain?

- Chromosomes made of DNA molecules
- Each chromosome carries a large no of genes

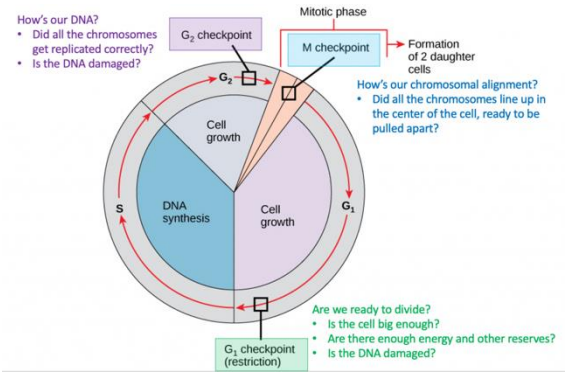
Why do most organisms have an even number of chromosomes in body cells?

- In body cells, chromosomes are normally found in pairs

1.2.2 Mitosis and the cell cycle

Define cell cycle.

- Cells divide in series of stages
- During cell cycle, genetic material is doubled & divided into 2 identical cells



Describe stages of cell cycle involving mitosis.

Stage 1 (Before cell divides)

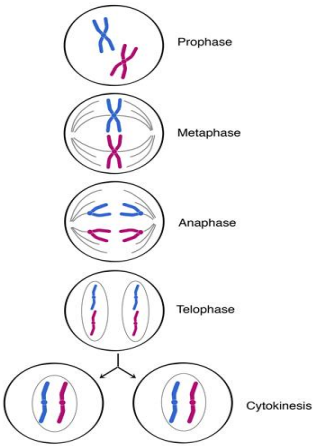
- Cell grows & increase no of sub-cellular structures eg mitochondria & ribosomes
- DNA replicates to form 2 copies of each chromosome

Stage 2 (Mitosis takes place)

- In mitosis, one set of chromosomes is pulled to each end of cell & nucleus divides

Stage 3 **Describe what is happening in mitosis. (2)**

- Cytoplasm & cell membrane dividing to form 2 identical daughter cells



When a cell divides by mitosis the new cells are **genetically identical**

What causes the cells to be genetically identical?

- DNA replicates

Why is the ability of body cells to divide important? (1)

- For growth & development of multicellular organisms
- For repairing of organism
- For asexual reproduction

1.2.3 Stem cells

Define stem cells (3)

- Undifferentiated cells that are able to divide & can differentiate to form lots of cells of the same type, & from which certain other cells can arise from differentiation

Describe the function of stem cells in human embryos. (2)

- Can be cloned & made to differentiate into different types of human specialised cells eg nerve cells

Advantages	Disadvantages
• Can develop into most other types of cells & can treat many diseases • Each cell divides every 30 min, plentiful • Low chance of rejection & painless	• Cause death to embryo • Unreliable procedure • The embryos can't give consent that poses ethical issues

Describe the function of stem cells in adult bone marrow. (2)

- Can be cloned & form many different types of cells eg blood cells

Advantages	Disadvantages
• Procedure is well tested & relatively safe • Give consent for the procedure to take place, which removes any ethical issues	• Risk of infection from operation • Painful to donate stem cells so may deter donors

• Quick recovery	• Few types of cells

Why do some scientists have concerns about the use of stem cells?

- Could cause cancer

What are the sources of adult stem cells?

- Bone marrow, umbilical cord, blood, skin

Why might stem cells from embryos be more useful than adult stem cells?

- Can be cloned & form many different types of cells eg blood cells

Therapeutic cloning

How stem cells can be used for medical treatment through therapeutic cloning? (4)

- An embryo is produced with same genes as patient
- Stem cells from embryo aren't rejected by patient's body so may used for medical treatment
- Once inside patient, stem cells can differentiate to replace cells which aren't working properly
- Can help conditions eg diabetes & paralysis

Advantages	Disadvantages
• May cure diseases • Produce replacement cells • Treat diabetes & paralysis • Cells unlikely to be rejected • Cells & tissues of any type can be made • Many cells are produced • Reduces waiting time for transplants	• Potential life is killed • Shortage of egg donors • May transfer viral infection • Poor success rate

What are the potential risks of using stem cells? (2)

- Transfer of viral infection
- Ppl have ethical or religious objections

Plants

Define meristems in plants.

- Plant stem cells that can differentiate into any type of plant cell throughout the life of the plant

What can plant stem cells be used for?

- They can be used to make clones of plants quickly & economically

Describe and explain the functions of stem cells in meristem tissue in plants. (4)

- Differentiate into any type of plant cell, throughout life of plant
- Used to produce clones of plant quickly & economically
- Protect rare species from extinction
- To produce large no of identical plants for farmers eg disease resistance crops

1.3 Transport in cells

1.3.1 Diffusion

- Spreading out of particles of any substance in solution, or particles of a gas, causing a net movement from an area of higher concentration to an area of lower concentration

What substances in animals & plants are transported in & out of cells by diffusion?

- O_2 & CO_2 in gas exchange
- Urea (waste product) from cells into blood plasma for excretion in the kidney

Factors affect rate of diffusion

Concentration gradient	↑ concentration gradient, ↑ rate
Temperature	↑temp, particles ↑KE, move faster, ↑rate
Surface area	↑SA, ↑particle exposed, ↑availability to react, ↑rate

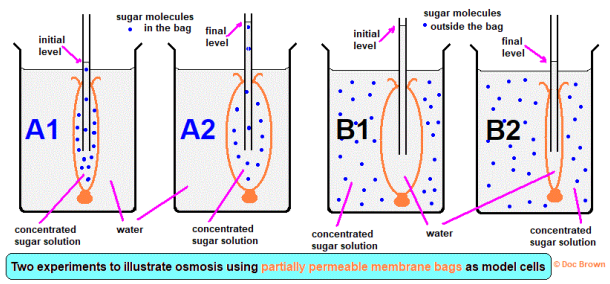
How ____ is adapted for exchange?

Small intestine	• Small intestine is very long, which gives plenty of time to complete absorption • Villi are covered with microvilli, which increases SA to absorb quicker • Villi contain blood capillaries, which provide rich blood supply to maintain a steep concentration gradient to assist quick absorption • Villi have thin walls for short diffusion pathways into blood • Have lots of mitochondria to provide energy from respiration
Lungs	• Lots of alveoli to increase SA • Thin membrane for a short diffusion pathway • Good ventilation and lots of blood capillaries to provide rich blood supply to maintain a steep concentration gradient
Gills in fish	• Gills has threads to increase SA • Thin surface membrane for a short diffusion pathway to increase exchange • Good ventilation and lots of blood capillaries to provide rich blood supply to maintain a steep concentration gradient
Roots	• Large SA • Thin surface membrane for a short diffusion pathway • Lots of mitochondria to provide energy from respiration for active transport
Leaves	• Large SA • Thin surface for short diffusion pathway • Air spaces between cells

1.3.2 Osmosis

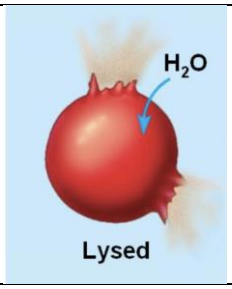
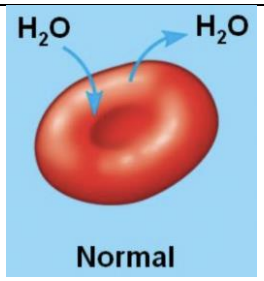
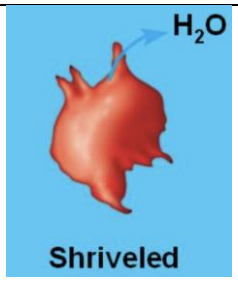
- Movement of water from a dilute to concentrated solution through a partially permeable membrane

Isotonic - concentration of solutes in solution outside & inside cells are same
Hypertonic - concentration of solutes in solution outside higher than inside of cell
Hypotonic - concentration of solutes in solution outside lower than inside of cell

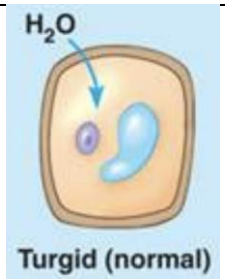
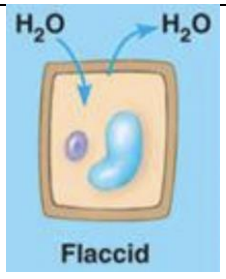
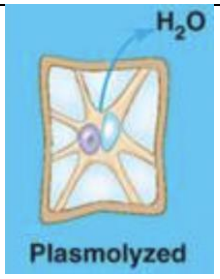


- Net movement of water into bag by osmosis
- Volume of water in bag increases
- Bag expand & increases water level

Animal cell

		
• **Hypotonic** solution • Net movement of water **into** cell by osmosis • Cell **swells**, then **burst**	• **Isotonic** solution • No osmosis occurs	• **Hypertonic** solution • Net movement of water **out** of cell by osmosis • Cell **shrivels**

Plant cell

		
• **Hypotonic** solution • Net movement of water into cell by osmosis • Cell **turgid** • **X burst** coz cell membrane press against cell wall	• **Isotonic** solution • No osmosis occur • Cell **flaccid**	• **Hypertonic** solution • Net movement of water out of cell by osmosis • Cell membrane shrank away from cell wall (**plasmolysis**) • Cell **flaccid**

1.3.3 Active transport

- Movement of substances across a membrane from a low to high concentration of solution (against a concentration gradient)
- Process requires energy from respiration
- In animals, absorption of sugar in the gut from a low to high concentration into blood for cell respiration
- In plants, absorption of mineral ions into plant root hairs for healthy growth