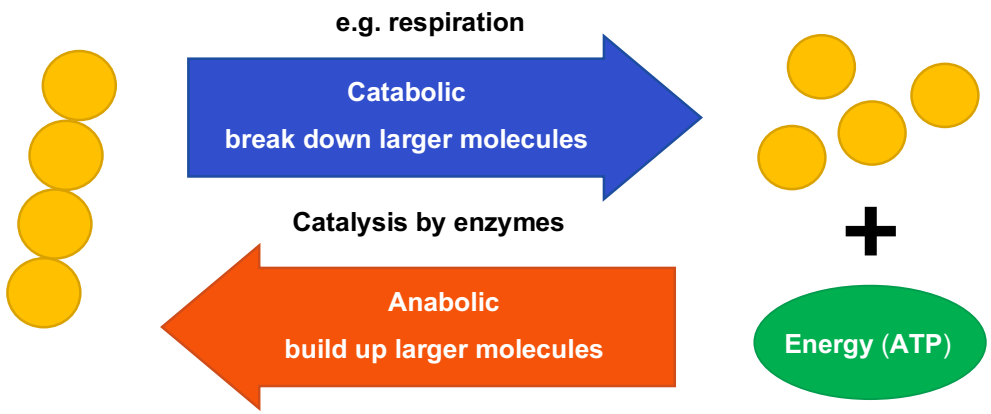
CONTENTS

1 CHARACTERISTICS AND CLASSIFICATION OF LIVING ORGANISMS

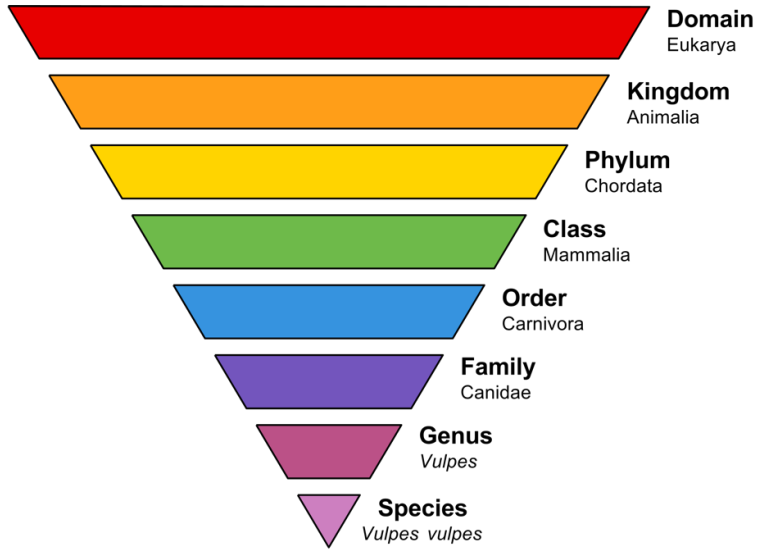
CHARACTERISTICS OF LIFE (MRS. GREN)

Characteristic	Description
Movement	**Action** by an organism or part of an organism causing a **change** of **position or place**
Respiration	**Chemical reactions** in cells that **break down nutrient** molecules and **release energy** for **metabolism**
Sensitivity	Ability to **detect** and **response** to **changes** in the **internal** or **external environment**
Growth	A **permanent increase** in **size** or **dry mass**
Reproduction	Processes that make **more** of the **same** kind of organism
Excretion	**Removal** from an organism of: • **waste** products of **metabolism** • substances in **excess** of requirements
Nutrition	**Taking in** of materials for **energy**, **growth** and **development**

- **Metabolism** is a general term for **all chemical reactions** taking place in cells, in which **respiration** is included. There are two types of metabolic reactions:



CLASSIFYING ORGANISMS



Red fox (*Vulpes vulpes*)

The **binomial name** of each organism is an **internationally agreed system** in which the **scientific name** of an organism is made up of two parts showing the **Genus** and **species**.

A species is a group of organisms that can reproduce to produce fertile offspring.

- Organisms can be classified into groups by their **shared features**.
- Classification can be done based on **DNA base sequences**.
- DNA base sequences are **more similar** among organisms which share a more recent ancestor (are **more closely related**).

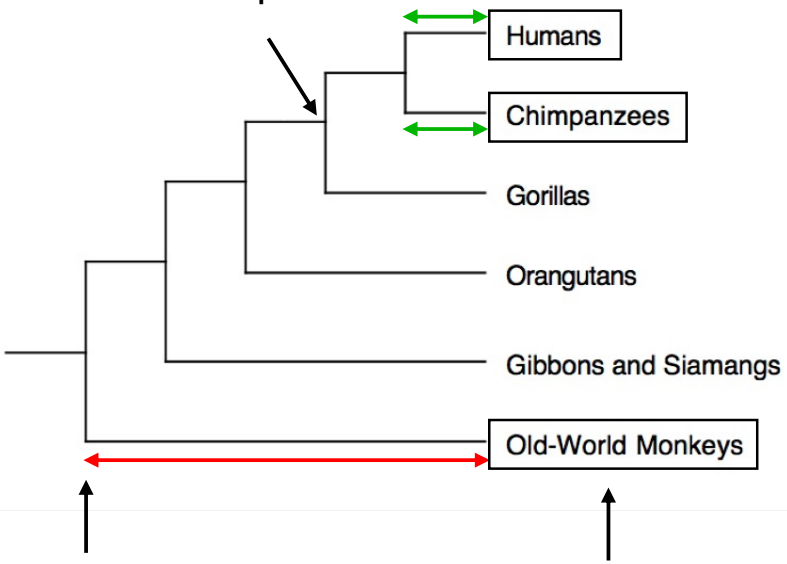
CLADOGRAMS

Branch point

= a common ancestor from which its offspring started to evolve into different species

Shortest distance

= most closely related



Initial common ancestor of all organisms shown

Longest distance

= most distantly related to all others

Species that are more closely related in evolution will:

- Share a **shorter distance** from a **branching point**
- (So) share a more **recent common ancestor**
- (So) have **split** from each other more **recently**
- (So) have had **less time** for **mutations** to occur and accumulate
- (So) have more **similar DNA base sequences** in specific genes.

THE FIVE KINGDOMS

	Animal	Plant	Fungi	Prokaryote	Protoctist
Nucleus	✓	✓	✓	×	✓
Cell wall	×	✓	✓	✓	**Some**
		Cellulose	**Each have a different composition**		
Unicellular or multicellular	**M**	**M**	**M – most U – some**	**U**	**M – some U – most**
Chlorophyll	×	**Green plants**	×	×	**Some**

THE VERTEBRATES

Vertebrate group	Distinctive features	Breathing
MAMMALS **Warm-blooded**	• **Hair** or **fur** • Produce **milk** from mammary glands • Placenta • Diaphragm	Use **lungs**
BIRDS **Warm-blooded**	• Feathers • Beaks • Wings (most can fly) • Lay **hard-shelled** eggs	Use **lungs**
REPTILES	• **Dry, scaly** skin • Lay eggs with **leathery** shells	Use **lungs**
FISH	• **Wet** scales • **Fins** for moving • **External** fertilisation	Use **gills**
AMPHIBIANS	• **Smooth**, **wet**, **permeable** skin • Young live in **water**, adults live on **land**	Young – **gills** Adult – **lungs**

THE ARTHROPODS

Common features

- Exoskeleton
- Jointed legs
- Segmented body

Insects

- 3 body parts
- 3 pairs of legs
- Many have 4 wings
- Compound eyes
- 2 antennae

Arachnids

- 2 body parts
- 4 pairs of legs
- No wings
- Simple eyes
- No antennae

Crustaceans

- Chalky exoskeleton
- 10 – 14 legs
- No wings
- Simple eyes
- 4 antennae

Myriapods

- Elongated bodies
- Many body parts
- Many pairs of legs
- Centipedes – 2 legs per segment
- Millipedes – 4 legs per segment

THE PLANT KINGDOM

Flowering plants

Monocotyledons

One cotyledon in seeds

Flower parts in multiples of 3

Leaves are strap-shaped

Leaves have parallel veins

Branched (fibrous) roots

Dicotyledons

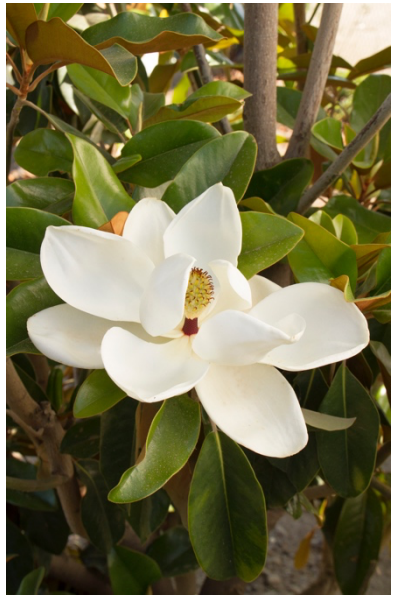
Two cotyledons in seeds

Flower parts in multiples of 4 or 5

Leaves are broad and wide

Leaves have branched veins

Tap roots



Ferns = non-flowering plants

Do not produce flowers

Leaves are called fronds

Reproduce using spores

Spores on underside of leaves

2 ORGANISATION OF THE ORGANISM

ANIMAL CELL

Rough endoplasmic reticulum

- Attached with **ribosomes**
- Produces **proteins** to be **taken outside** of the cell

Free ribosome

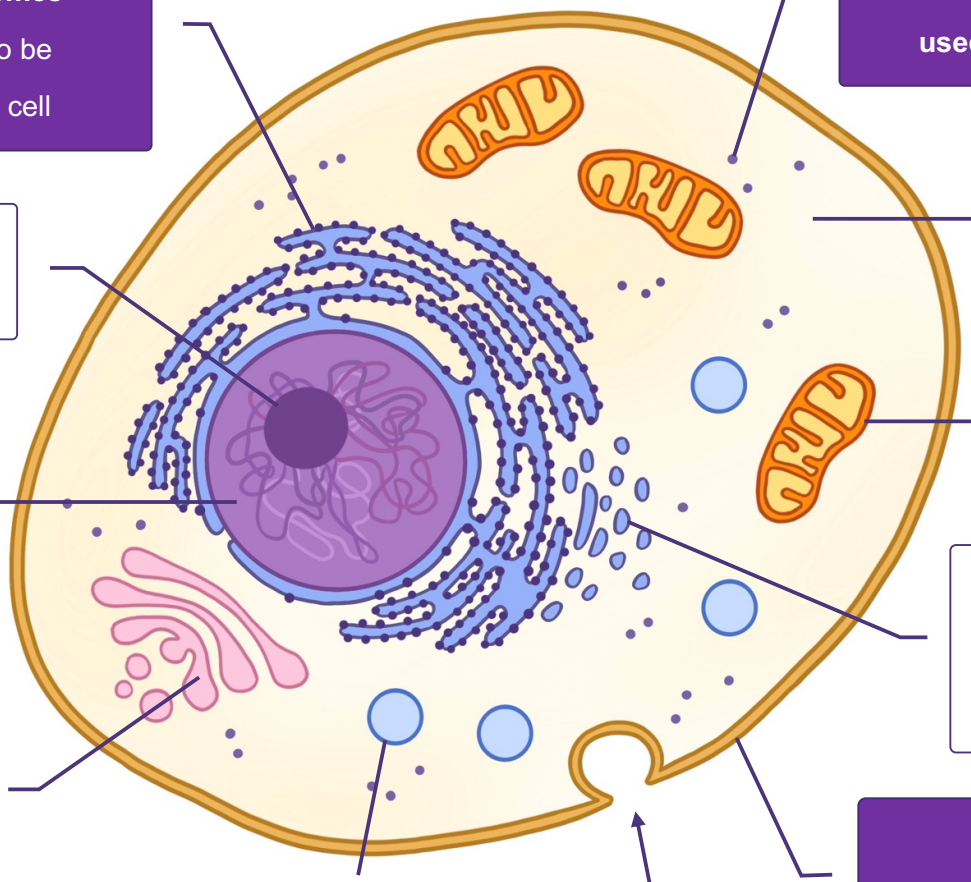
Produces **proteins** to be **used inside** of the cell

Nucleolus

Site of ribosome production

Cytoplasm

Site of chemical reactions



Nucleus

- Contains **DNA** (chromosomes)
- **Controls** the cell's **activities**

Mitochondrion

Site of aerobic respiration

Smooth endoplasmic reticulum

- No ribosomes attached
- Synthesises lipids

Golgi apparatus

Processes proteins made in the rough ER, and releases them in vesicles for export

Cell membrane

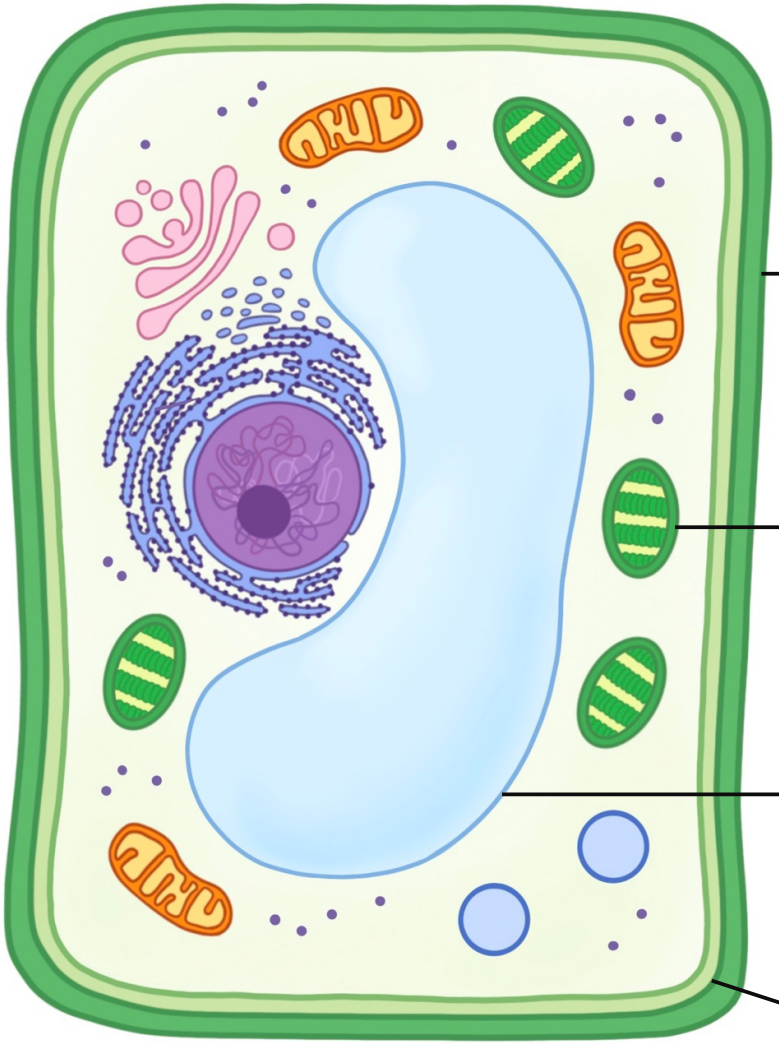
Controls **movement** of substances in and out of the cell

Vesicle

Sac that contains materials to be **exported** out of the cell

Vesicle fusing with cell membrane

PLANT CELL



THREE ADDITIONAL STRUCTURES

Cell wall

- Provides strength, support, shape and protection
- Made of cellulose

Chloroplast

- Contains the green pigment chlorophyll
- Absorbs light for photosynthesis
- Only present in plant cells exposed to light

Large vacuole

- Large sac that contains dissolved sugars and salts
- Maintains turgor pressure against the cell wall

Cell membrane

PROKARYOTIC CELL

= present in all bacteria = in some bacteria only

Free ribosome

- Produces **proteins**
- Smaller than the ribosomes in animal and plant cells

Capsule

Protection against **drying out** and **antibiotics**

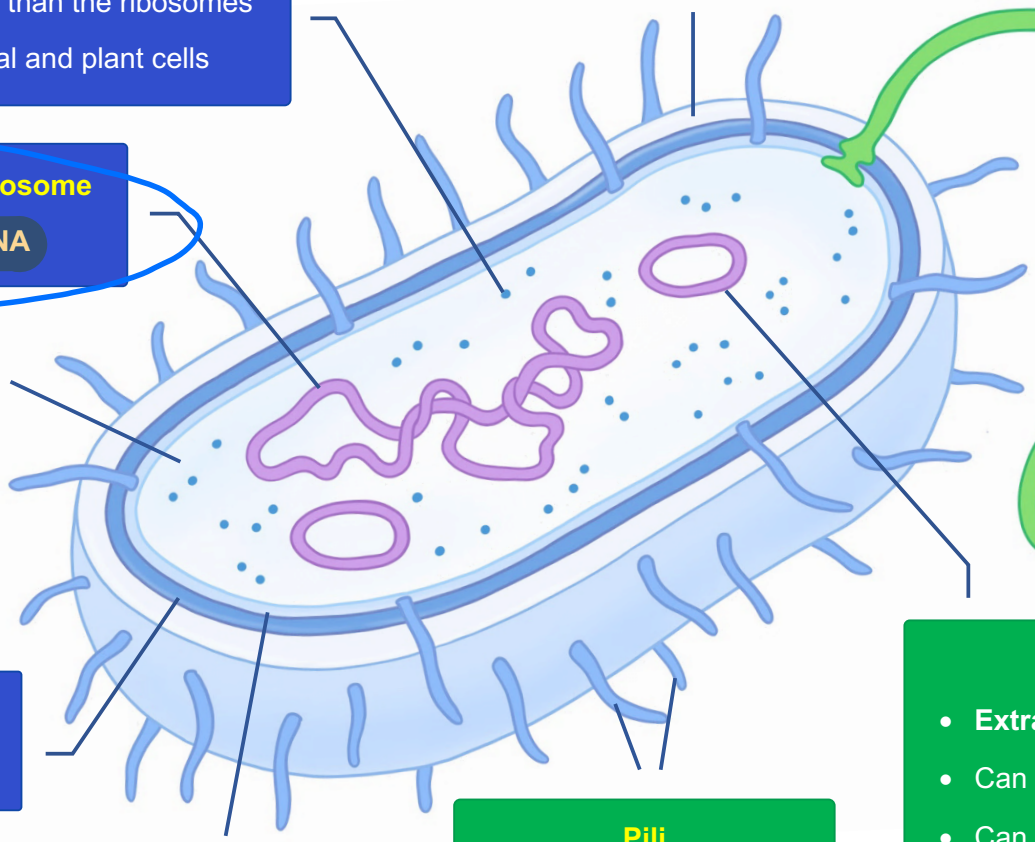
Flagellum

For **movement**

Circular bacterial chromosome

A strand of **naked DNA**

Cytoplasm



Bacteria do not have membrane-bound organelles, such as:

- Nucleus
- Mitochondria
- Chloroplasts
- Rough ER

Cell wall

Not made of cellulose

Cell membrane

Pili

For **attachment** to cells

Plasmid

- **Extra** circular **DNA**
- Can carry **antibiotic resistance genes**
- Can be transferred between bacteria

Cells with **high rates of metabolism**,

such as **muscle** cells and **pancreas** cells have:

- **Large amounts** of **rough endoplasmic reticulum** to **produce** and **secrete proteins** such as **enzymes** or **hormones**
- **Large numbers** of **mitochondria** for **respiration** to release sufficient **energy**

Calculating magnification

$$\text{Magnification} = \frac{\text{Image size}}{\text{Actual size}}$$

1 mm = 1000 µm **KEEP UNITS THE SAME! ☺**

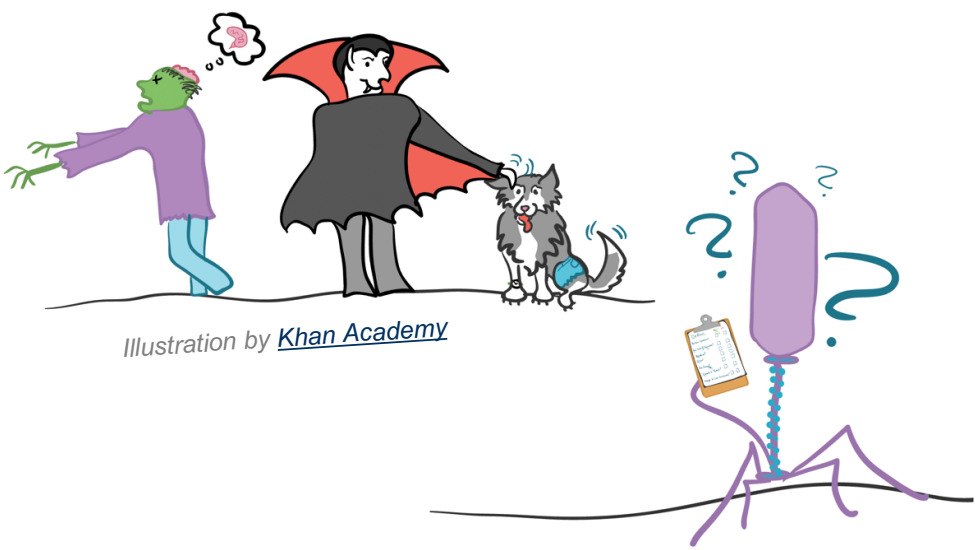
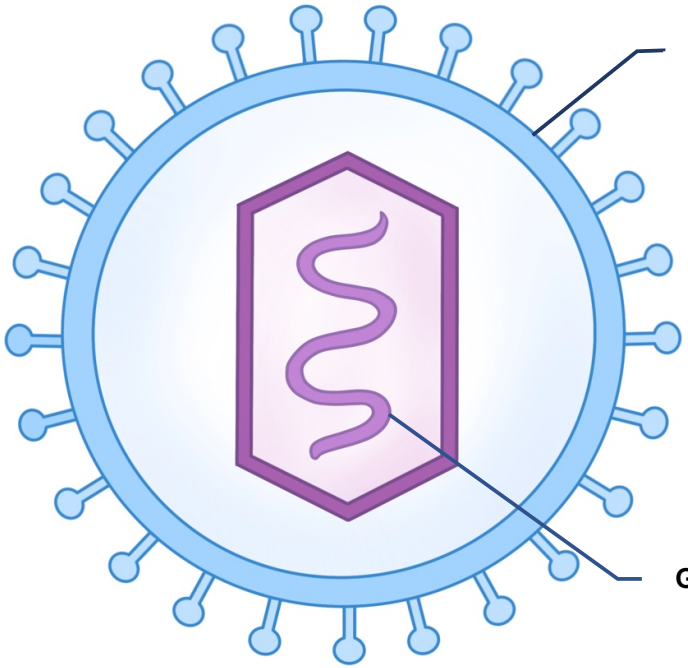


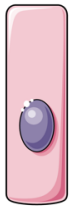
Illustration by Khan Academy

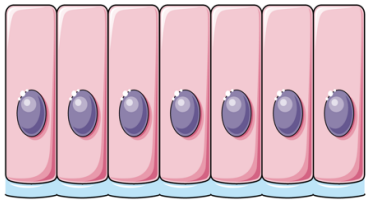
VIRUSES

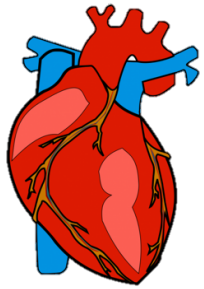


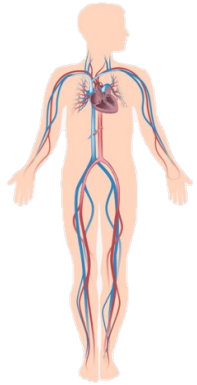
- Viruses are generally considered as **non-living**.
- Viruses are **not** made of **cells**, so do not have nuclei or cell organelles.
- They **do not grow**, and cannot **metabolise** or **reproduce** independent of a **host cell**.

LEVELS OF ORGANISATION









Cell

The **basic structural** and **functional unit** of life. **New** cells are produced by **division** of **existing** cells.

- Ciliated cells
- Root hair cells
- Palisade mesophyll cells
- Nerve cells
- Red blood cells
- Sperm cells
- Egg cells

Tissue

A **group** of **cells** with **similar structures**, working together to perform a **shared function**

- Muscle
- Connective
- Epithelial
- Xylem
- Phloem

Organ

A **group** of **tissues** working together to perform **specific functions**

- Root
- Stem
- Leaf
- Brain
- Stomach
- Liver
- Skin

Organ system

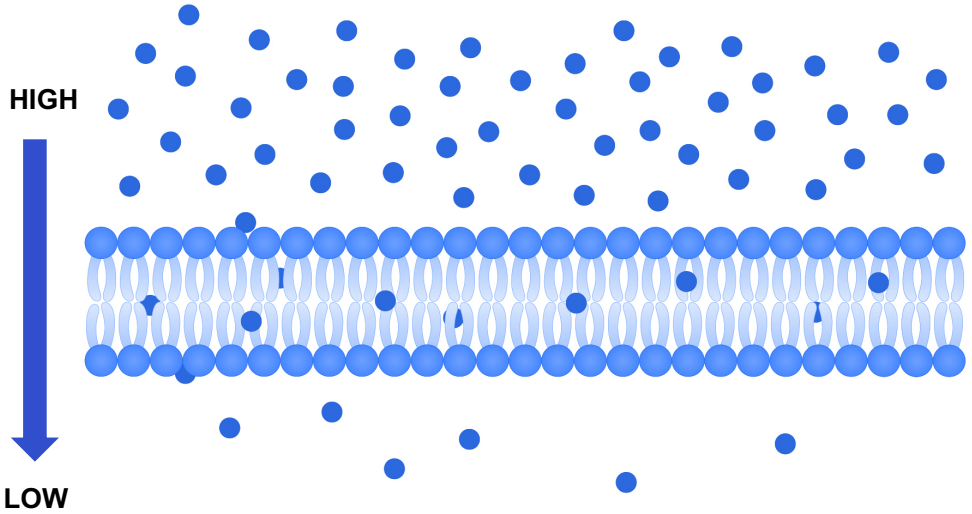
A **group** of **organs** with **related functions**, working together to perform **body functions**

- Reproductive
- Respiratory
- Circulatory
- Digestive
- Excretory
- Skeletal
- Nervous
- Hormonal

3 MOVEMENT IN AND OUT OF CELLS

DIFFUSION

The net movement of particles from a higher to lower concentration, down a concentration gradient, due to their random movement



The energy for diffusion comes from the kinetic energy of the random movement of molecules and ions.
It does not come from respiration.

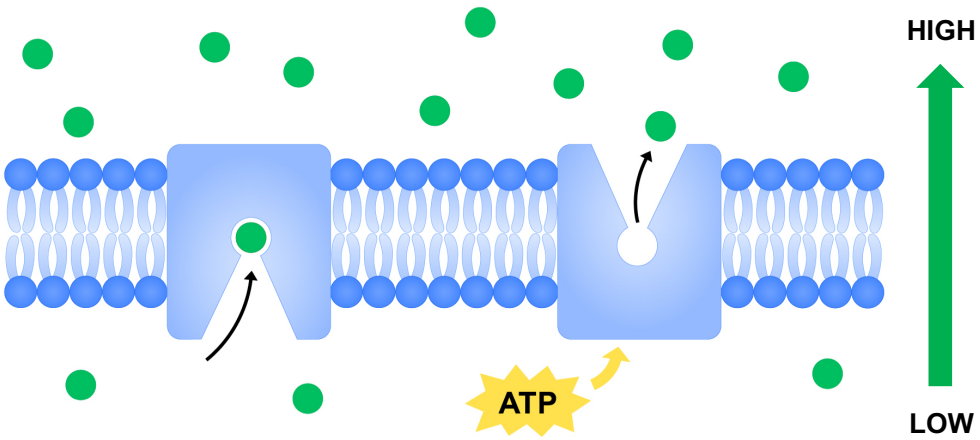
INCREASE
Temperature
Surface area
Concentration gradient

Faster diffusion

DECREASE
Distance

ACTIVE TRANSPORT

The net movement of particles from a lower to higher concentration, against a concentration gradient, using energy from respiration



Molecule **enters** pump protein and **binds** to a **specific site**

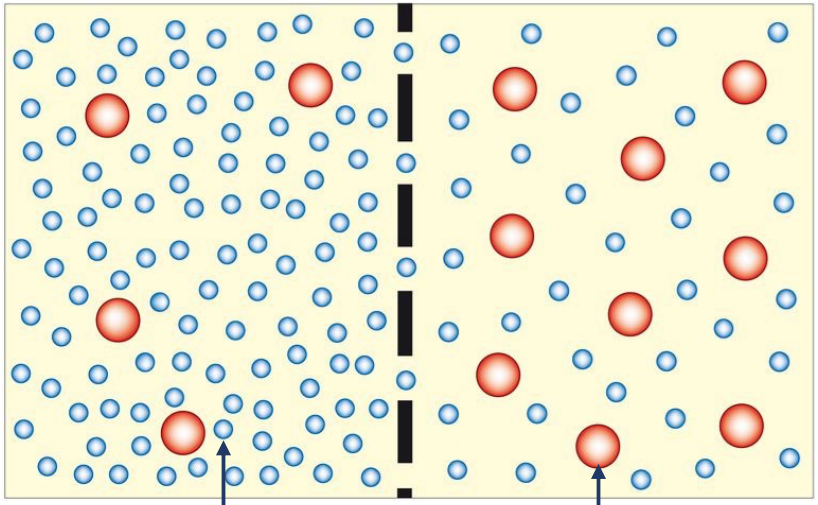
Pump protein **uses energy** from **respiration** to **change shape** and **move** the molecule(s) **across** the cell membrane

Since active transport is dependent on the energy released by respiration, its rate will be affected by the factors that affect the rate of respiration, such as temperature, pH and O_2 concentration.

OSMOSIS

Dilute solution
Higher water potential

Concentrated solution
Lower water potential



water molecule

solute molecule

Net movement of water molecules

- **Water's solvent property** allows osmosis to occur in living organisms.

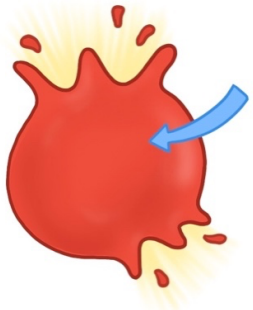
The net movement of water molecules
from a higher water potential to a lower water potential
through a partially permeable membrane

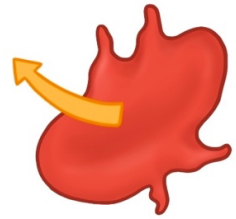
Cell placed in:

DILUTE SOLUTION

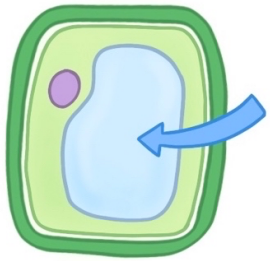
CONCENTRATED SOLUTION

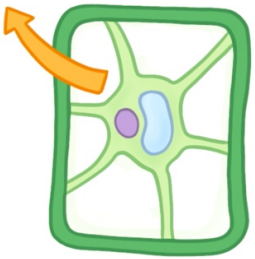
Animal cell





Plant cell





Higher water potential	Outside cell	Inside cell
Water moves by osmosis from	Higher → lower water potential	
Direction	Into the cell	Out of the cell
Pressure in cell	Increases	Decreases
Volume of cell	Increases	Decreases
Cytoplasm (plant)	Pushes against cell wall	Detaches from cell wall
Turgor pressure	Increases	Decreases
Cell becomes	Animal = lysed Plant = turgid	Animal = crenated Plant = flaccid then plasmolysed

SUMMARY

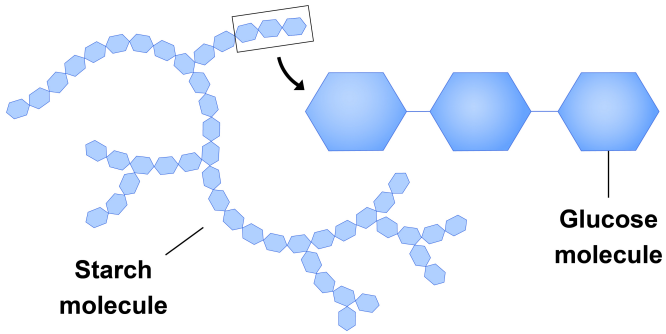
	Diffusion	Osmosis	Active transport
Direction of net movement	**Down a concentration gradient**	**Down a concentration gradient**	**Against a concentration gradient**
Uses energy	**No**	**No**	**Yes**
Must have a partially permeable membrane	**No**	**Yes**	**Yes**
Examples	• Movement of **carbon dioxide**, **oxygen** and **water vapour** in and out of **plant cells** • **Gas exchange** through **tissue fluid** and **alveoli** in humans	• **Plant cells** are **supported** due to osmosis (provides **stiffness**) • Movement of **water** from the **soil** into **xylem** of plants	• **Ion uptake** by **root hair** cells • **Glucose uptake** by **epithelial** cells of the **small intestine** and **kidney tubules**

4 BIOLOGICAL MOLECULES

TYPES OF BIOLOGICAL MOLECULES

CARBOHYDRATES

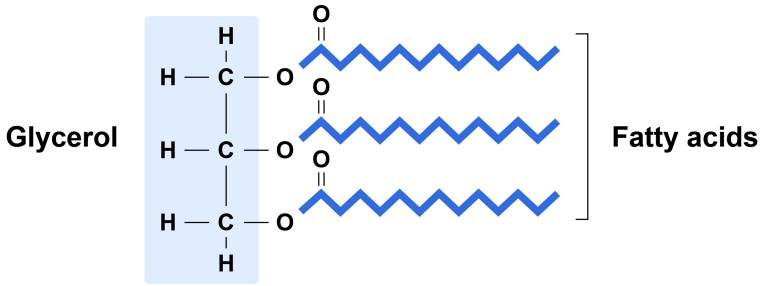
Only contain: C , H , O



- Large carbohydrate molecules (polysaccharides) are made up of many **simple sugar** units (monosaccharides) linked together.
- **Starch**, **glycogen** and **cellulose** are all insoluble polysaccharides built up from many **glucose** molecules.

LIPIDS

Always contain: C , H , O

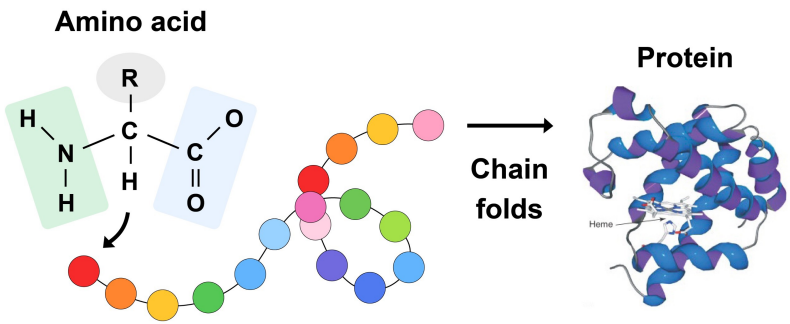


- Lipids are molecules that are **insoluble in water** but **soluble in non-polar solvents**. Fats are one group of lipids.
- Fat molecules (called triglycerides) are made up of 3 **fatty acid** molecules bonded to one **glycerol** molecule.
  - Oils are fats that are in liquid state at room temperature.

FOUR MAJOR GROUPS

PROTEINS

Always contain: C , H , O , N



- Proteins are large molecules built up from simple units called **amino acids**.
- **20 types** of amino acids are used by living things to synthesise proteins.
- The **shape** of a protein molecule is determined by its **amino acid sequence**.

NUCLEIC ACIDS

Only contain: C , H , O , N , P

- **DNA** and **RNA** are two types of nucleic acids found in cells.
- They are long molecules (much longer than proteins) made up of **chains** of units called **nucleotides** (see unit 17).

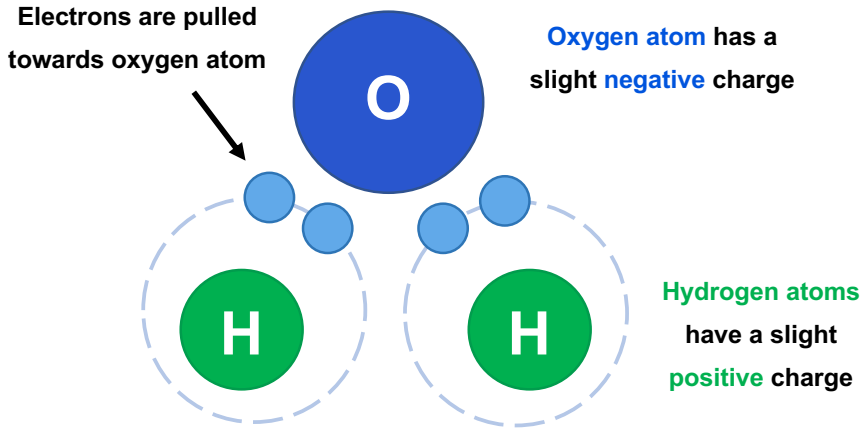
Large molecule	Smaller molecules it is made from	Role
Starch	**Glucose**	**Storage** carbohydrate in **plant** cells
Glycogen		**Storage** carbohydrate in **animal** cells
Cellulose		**Strengthens** plant **cell walls**
Protein	**Amino acids**	Cell **growth** and **repair**
Fats & oils	**Glycerol & fatty acids**	**Energy store**, **insulation** and **protection**

FOOD TESTS

Test	Method	Colour change if present
Starch	Add **iodine** solution	**Brown → blue-black**
Reducing sugar (glucose)	**Heat** with **Benedict's** solution	***Blue → red**
Protein	Add **Biuret** solution	**Blue → purple**
Fat (lipid)	Add **ethanol** **Shake** well Add **equal volume** of **water**	**White emulsion**
Vitamin C	Add **DCPIP**	**Blue → colourless**

*Benedict's solution changes colour from **blue** → **green** → **orange** → **red** depending on the **concentration** of **reducing sugar** present.

WATER AS A SOLVENT



Water is a polar molecule with a positive region (H atoms) and negative region (O atom).
This makes water a good solvent as polar water molecules can attract and dissolve other polar molecules.

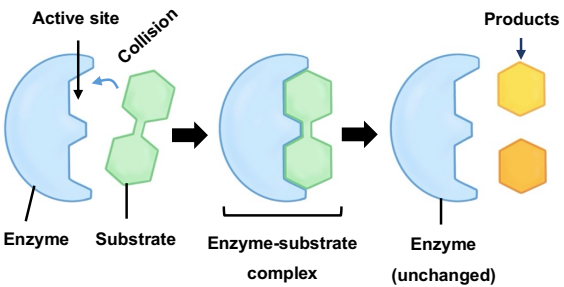
- Water is used as a **solvent** in **transport** (e.g. in xylem, phloem and blood plasma), **digestion** and **excretion**.
- **Nonpolar** substances such as **lipids** are **insoluble** in water, so although water is sometimes called the "universal solvent" it cannot really dissolve anything it meets.

5 ENZYMES

Catalyst = a substance that increases the rate of a chemical reaction and is not changed by the reaction

Enzymes are proteins that are involved in all metabolic reactions, where they function as biological catalysts

THE 'LOCK AND KEY' MODEL



- The **active site** of an enzyme has a **complementary shape** to a **specific substrate**, allowing them to fit together
- The substrate binds to the active site, forming an **enzyme-substrate complex**
- **Bonds are weakened** in the substrate
- **Activation energy** for the reaction is lowered
- Products are released and the enzyme is **unchanged**

EFFECT OF TEMPERATURE AND PH ON ENZYME ACTIVITY

Optimum temperature = highest rate of reaction

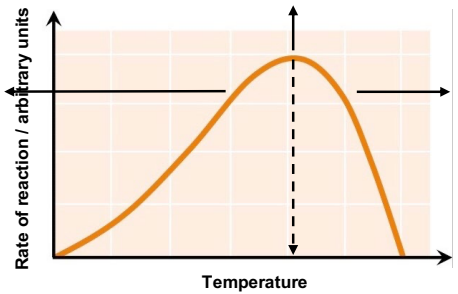
Most successful collisions

No denaturation

As temperature increases, rate of reaction increases

More kinetic energy

More collisions between active site and substrate



As temperature increases, rate of reaction decreases

Enzymes becomes denatured

Vibrations break bonds

Active site changes shape

Substrate cannot fit in

Optimum pH = highest rate of reaction

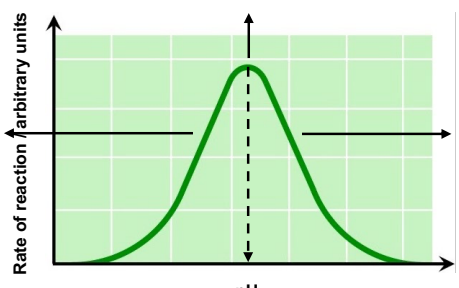
Most successful collisions

No denaturation

Below optimum pH Denaturation occurs

Excess of H^+ ions break bonds within enzymes

Active site changes shape



Above optimum pH Denaturation occurs

Excess of OH^- ions break bonds within enzymes

Active site changes shape

DENATURATION

Enzyme loses its 3D shape

Active site is no longer a complementary shape to substrate

Substrate cannot fit in

6 PLANT NUTRITION

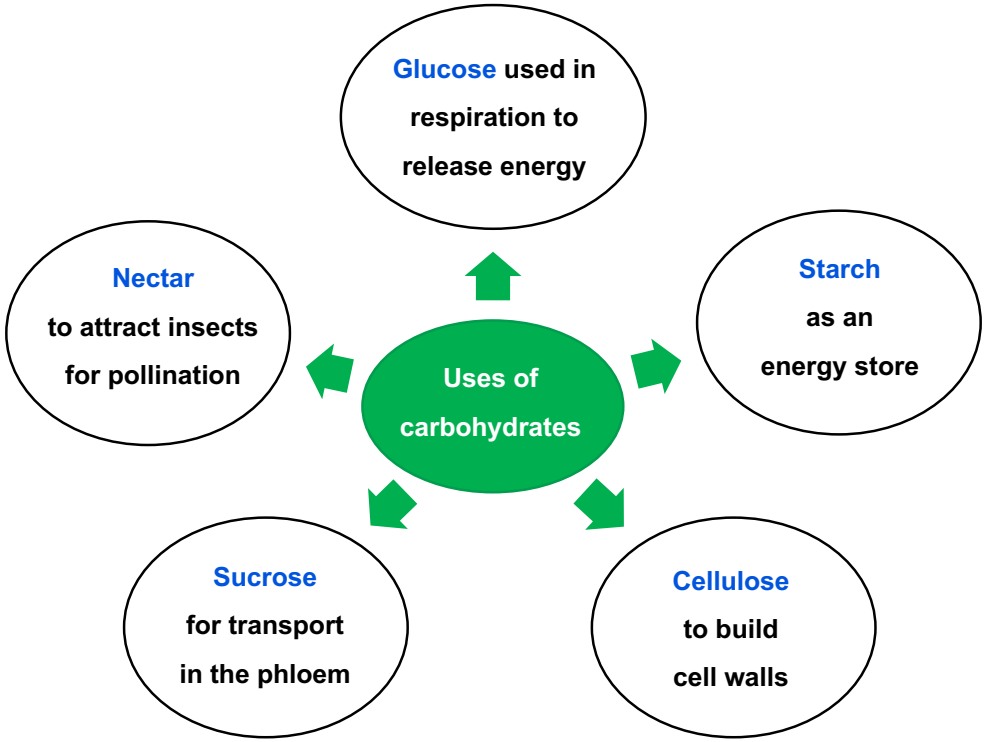
PHOTOSYNTHESIS

The process by which plants synthesise carbohydrates from raw materials using energy from light

$$\text{CARBON DIOXIDE} + \text{WATER} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{GLUCOSE} + \text{OXYGEN}$$

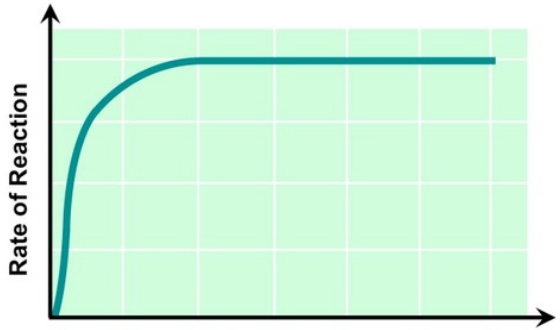
$$6\ CO_2 + 6\ H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} 6\ C_6H_{12}O_6 + 6\ O_2$$

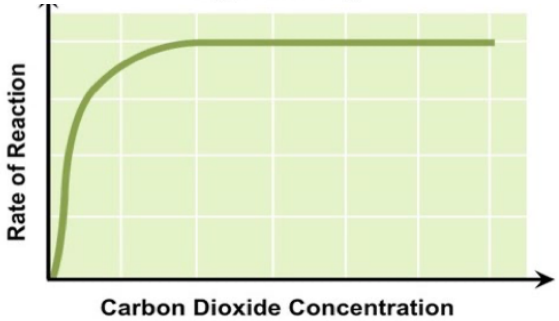
- **Chlorophyll** is a **green pigment** that is found in **chloroplasts**.
- They **transfer** the **energy from light** into **energy in chemicals** (ATP molecules). This chemical energy is then used to **synthesise carbohydrates**.

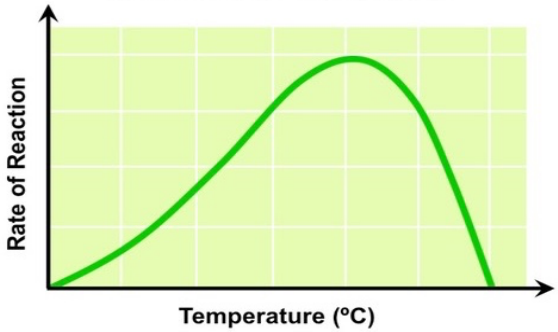


LIMITING FACTORS OF PHOTOSYNTHESIS

- **Light intensity**, **carbon dioxide concentration** and **temperature** are factors that affect the rate of photosynthesis.
- The **limiting factor** is the one that is in **shortest supply** (farthest from its optimum) at a particular time, causing the rate to be **limited**.

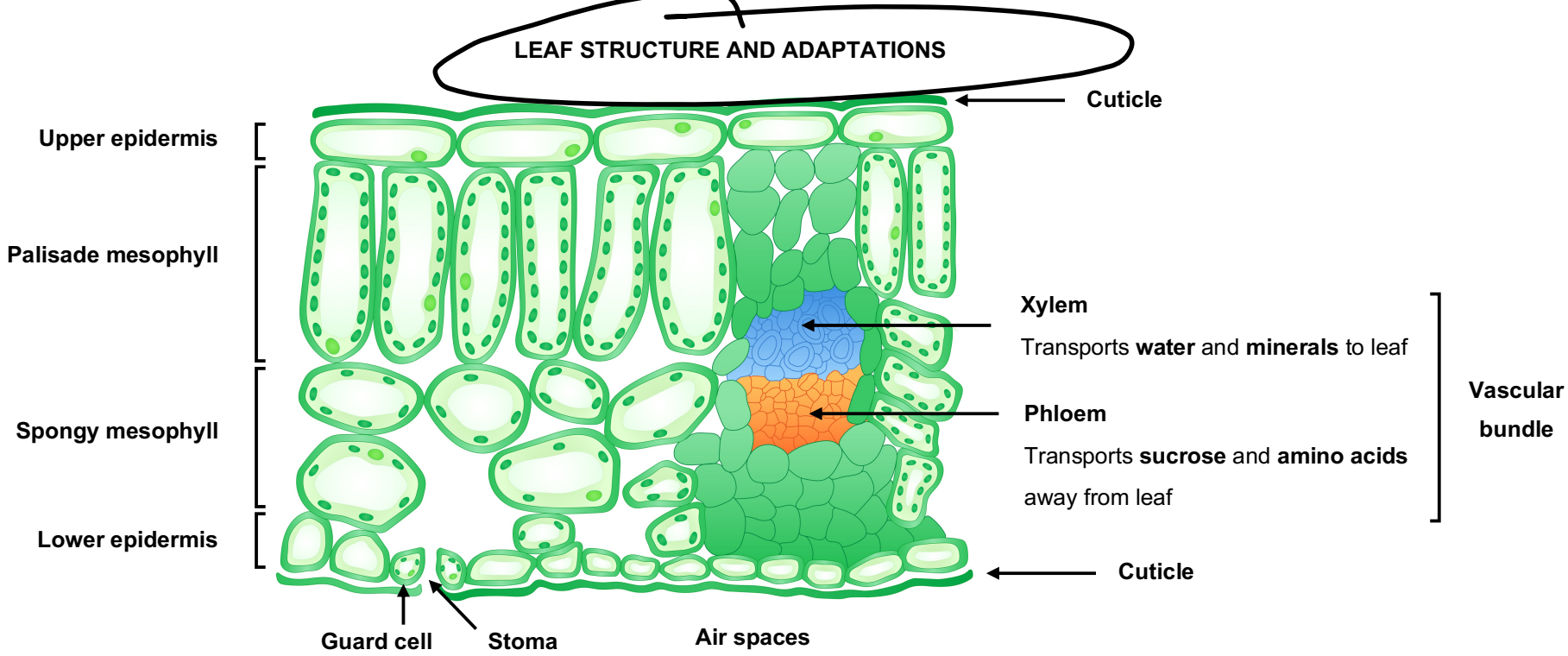






*** Photosynthesis is controlled by enzymes!**

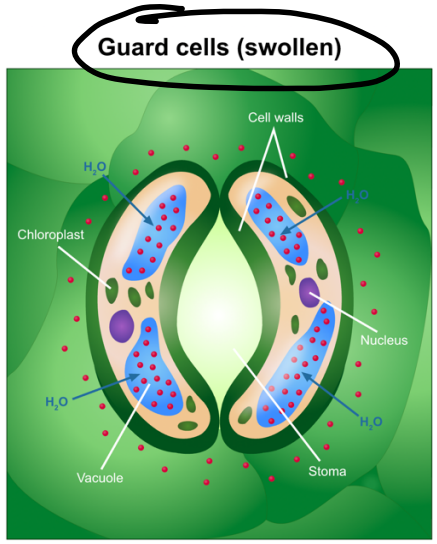
LEAF STRUCTURE AND ADAPTATIONS

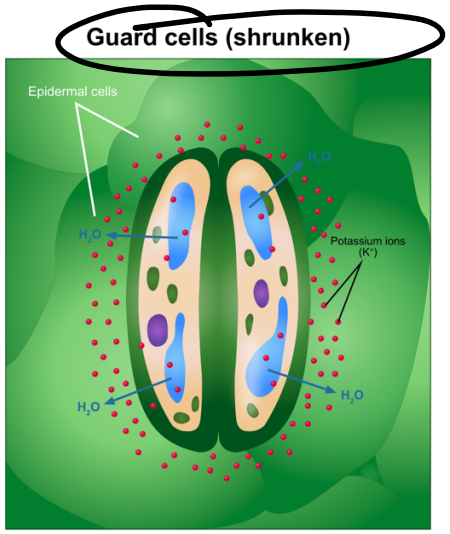


Leaf shape	• Most leaves have a **large surface area** and are **thin** (small volume), maximising surface area to volume ratio • (So) more light energy can be absorbed as a **greater area is exposed** • (And) **reduced distance** for **sunlight** and **CO_2** to reach **chloroplasts**
Waxy cuticle	• **Waterproof** – prevents water loss due to evaporation
Upper epidermis	• Cells are **thin** and **transparent** with **no chloroplasts** • Allows **light** to **pass through** and reach the **chloroplasts** in mesophyll cells
Palisade mesophyll	• Cells contain **many chloroplasts** and are **tightly packed near the surface** – **maximises light absorption**
Spongy mesophyll	• Cells are **loosely packed** with intercellular **air spaces** • Allows **faster diffusion** of gases throughout the **whole leaf**
Stomata	• **Holes** that let gases in and out of the leaf – **CO_2** and **O_2** in **photosynthesis**, **water vapour** in **transpiration**
Guard cells	• Work in pairs to **control** the **opening** and **closing** of **stomata** in the lower epidermis

HOW GUARD CELLS WORK

- Light triggers guard cells to take in ions by active transport
- (So) water potential inside guard cells is lowered
- (So) water enters by osmosis
- (So) guard cells become turgid and expand, opening the stoma





- Ions are released from guard cells
- (So) water potential inside guard cells is raised
- (So) water leaves by osmosis
- (So) guard cells become flaccid and shrink, closing the stoma

STOMA OPENING **STOMA CLOSING**

HOW A LEAF IS INVOLVED IN PHOTOSYNTHESIS

1. **CO_2 diffuses** down a concentration gradient through **stomata** into a leaf.
2. **CO_2 diffuses** throughout the leaf in the intercellular **air spaces**.
3. **CO_2 dissolves** in a **film of water** that surrounds the **mesophyll cells**.
4. **CO_2 diffuses in solution** into the **mesophyll cells** and passes to **chloroplasts** where **photosynthesis** occurs.
5. **Sugars** made by photosynthesis are **carried away** from the leaf by the **phloem**.
6. **O_2 diffuses** down a concentration gradient from the mesophyll cells into the air spaces, out through **stomata** into the atmosphere.

7 HUMAN NUTRITION

BALANCED DIET

Provides all nutrients, in their correct amounts, to maintain health and the body's energy requirements

Nutrient	Role	Main sources
Carbohydrate	Provides **energy**	• Pasta, rice, bread • Potatoes
Fat	**Energy** source and **storage** **Insulation** and **protection**	• Butter & margarine • Cooking oils
Protein	**Cell growth** and **repair**	• Meat • Dairy products
Vitamin C	**Healthy gums** – prevents scurvy Healthy **bones** and **teeth** Skin repair and **wound healing**	• Oranges • Lemons • Limes • Broccoli & spinach
Vitamin D	Helps body to **absorb calcium** for strong **bones** and **teeth**	• Oily fish • Milk and cereals
Iron	Producing **red blood cells** (component of haemoglobin)	• Red meat • Eggs • Green vegetables
Calcium	For **bones** and **teeth**, **muscle** action and **blood clotting**	• Flour • Milk
Fibre	**Pushing food** through the **gut** Prevents **constipation**	• Cereals • Nuts • Brown rice • Fruits & vegetables
Water	**Chemical reactions** occur within it	

NUTRIENT DEFICIENCIES

Vitamin C deficiency → **SCURVY (bleeding gums)**

Vitamin D deficiency → **RICKETS (soft and bent bones)**

PHYSICAL VS CHEMICAL DIGESTION

Physical digestion

Breakdown of food into smaller pieces without chemical change to the food molecules

↓

Increased surface area for action of digestive enzymes

Speeds up →

Chemical digestion

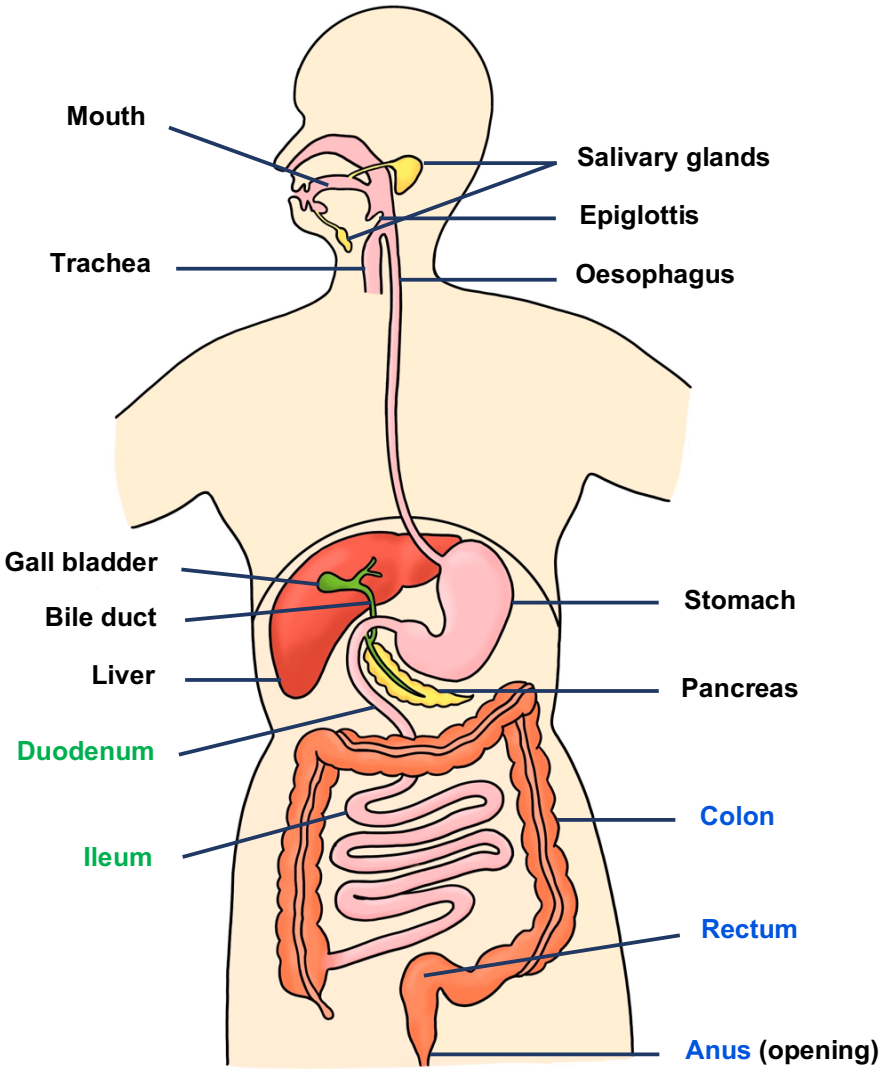
Breakdown of large, insoluble molecules into small, soluble molecules

↑

Can be absorbed through intestinal walls, enter the bloodstream and carried to cells for assimilation

	PHYSICAL	CHEMICAL
Involves enzymes	✗	✓
Breaks down molecules	✗	✓
Chemically changes food molecules	✗	✓
Produces soluble molecules	✗	✓

THE HUMAN ALIMENTARY CANAL



- **The small intestine is made up of the duodenum and ileum**
- **The large intestine is made up of the colon, rectum and anus**

FUNCTIONS OF DIFFERENT ORGANS

ORGAN	FUNCTION(S)
Mouth	• **Ingestion**: taking of substances into the body • **Physical**: **chewing** by **teeth** • **Chemical**: action of **amylase**
Oesophagus	• **Lined with mucus** to help swallowing • Muscle contractions push food toward the stomach
Stomach	• **Physical**: food is **churned** by muscle contractions • **Chemical**: action of **pepsin**
Liver	• **Produces bile**
Gall bladder	• **Stores bile**
Pancreas	• Produces **all types** of **digestive enzyme**: **carbohydrase**, **protease** and **lipase**
Small intestine	• **Absorption** of **digested food**: movement of nutrient molecules through the intestinal wall into the blood • **Absorption** of **most water** • **Chemical**: action of **maltase**, **trypsin** and **lipase**
Large intestine	• **Colon**: absorption of **salts** and **less water** • **Rectum**: **storage** of **faeces** • **Anus**: **egestion**: removal of **undigested food** from the body as faeces

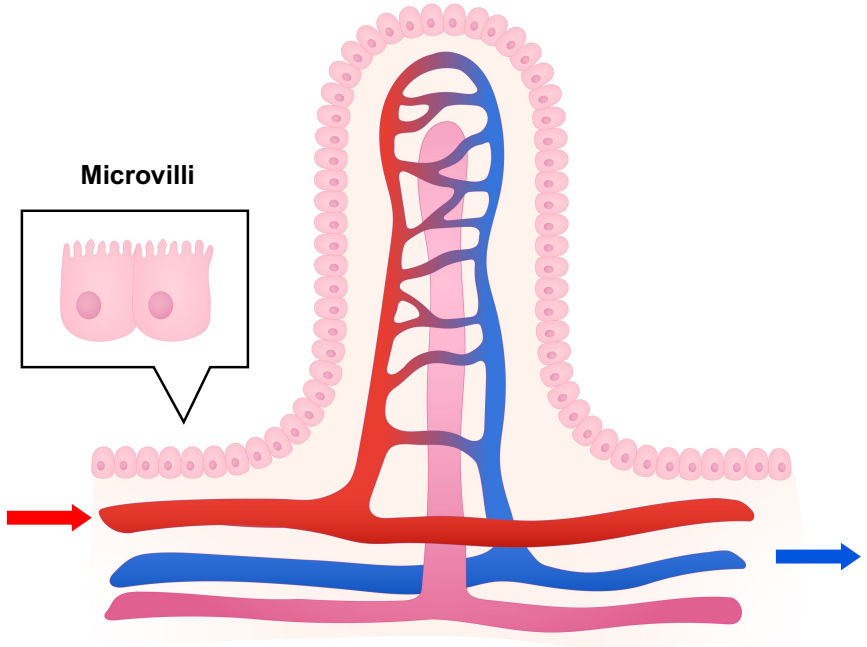
- Most water is absorbed by the small intestine, but some is also absorbed by the colon.
- **Assimilation** is the **uptake** and **use** of **nutrients** by **body cells.**

DIGESTIVE ENZYMES

Enzyme	Site of production	Site of action	Substrate	Product(s)
AMYLASE	**Salivary glands** **Pancreas**	**Mouth** **Small intestine**	**Starch**	**Maltose**
MALTASE	**Small intestinal wall** **Pancreas**	On the **membranes** of the **epithelial cells** lining the **small intestine**	**Maltose**	**Glucose**
PEPSIN	**Stomach**	**Stomach** **Acidic** optimum pH	**Proteins**	**Peptides**
TRYPSIN	**Pancreas**	**Small intestine** **Alkaline** optimum pH	**Peptides**	**Amino acids**
LIPASE	**Pancreas**	**Small intestine**	**Fats**	**Glycerol** **Fatty acids**

- **Amylase and maltase are carbohydrase enzymes; pepsin and trypsin are protease enzymes.**

STRUCTURE OF A VILLUS



Structure	Adaptation to function
Many microvilli on epithelium	**Large surface area** for **faster diffusion**
Close to blood capillaries	**Short diffusion distance** = **faster diffusion** of soluble food molecules into the **blood**
Thin wall (single cell layer)	
Many mitochondria	More **respiration** to release more **energy** for **active transport**
Lacteal (lymph vessel)	Carries **fatty acids** and **glycerol** to the **heart** so that fat does not enter the blood too quickly
Venule	Carries **absorbed nutrients** to the **liver**

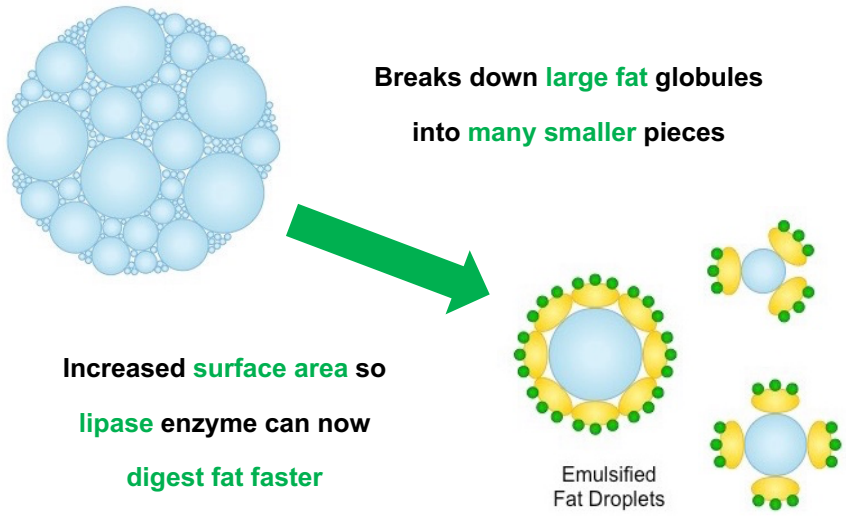
ROLE OF STOMACH ACID

Stomach acid (HCl) has a low pH which:

- **Kills bacteria in ingested food**
- **Provides an acidic pH for optimum enzyme activity**

ROLE OF BILE

Function 1 – Emulsification



Function 2 – Neutralisation

- Bile **neutralises stomach acid** in food entering the small intestine.
- This provides an **alkaline optimum pH** for **enzymes** that work in the **small intestine** (e.g. amylase, maltase, trypsin and lipase)

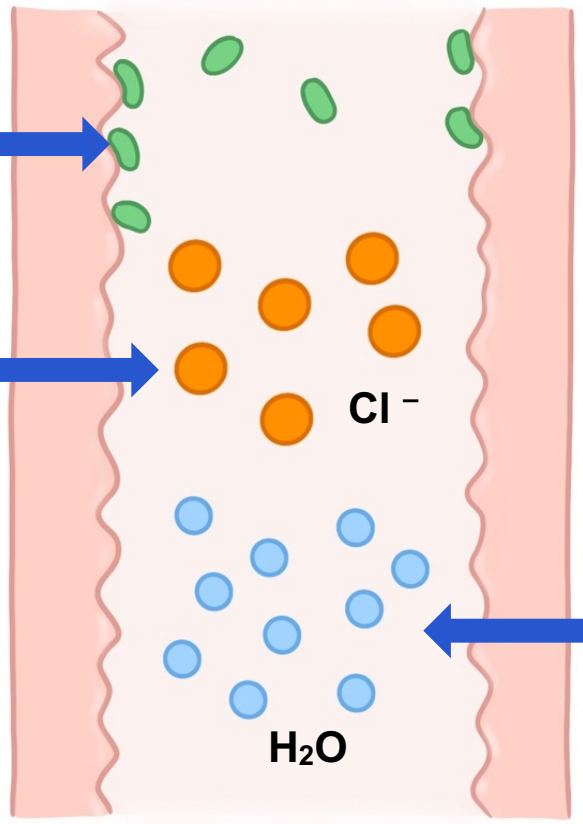
HOW CHOLERA IS CAUSED

- Cholera is a disease caused by a bacterium which is transmitted in contaminated water.

Cholera bacterium produces a toxin

1. Toxin attaches to wall of the small intestine

This causes surrounding cells and capillaries to secrete Cl^- ions into the small intestine lumen

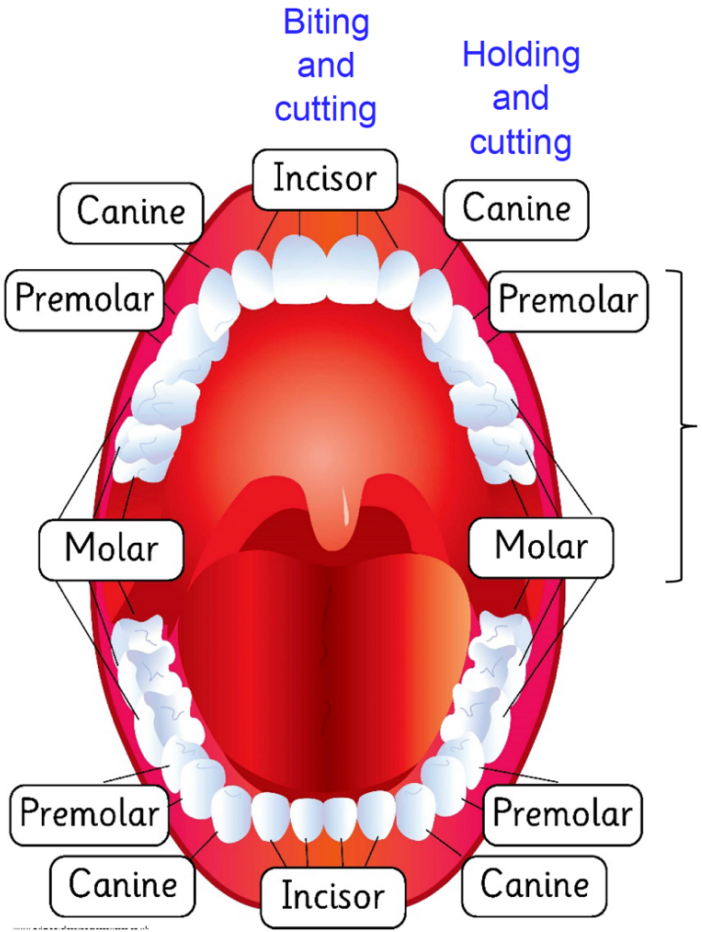


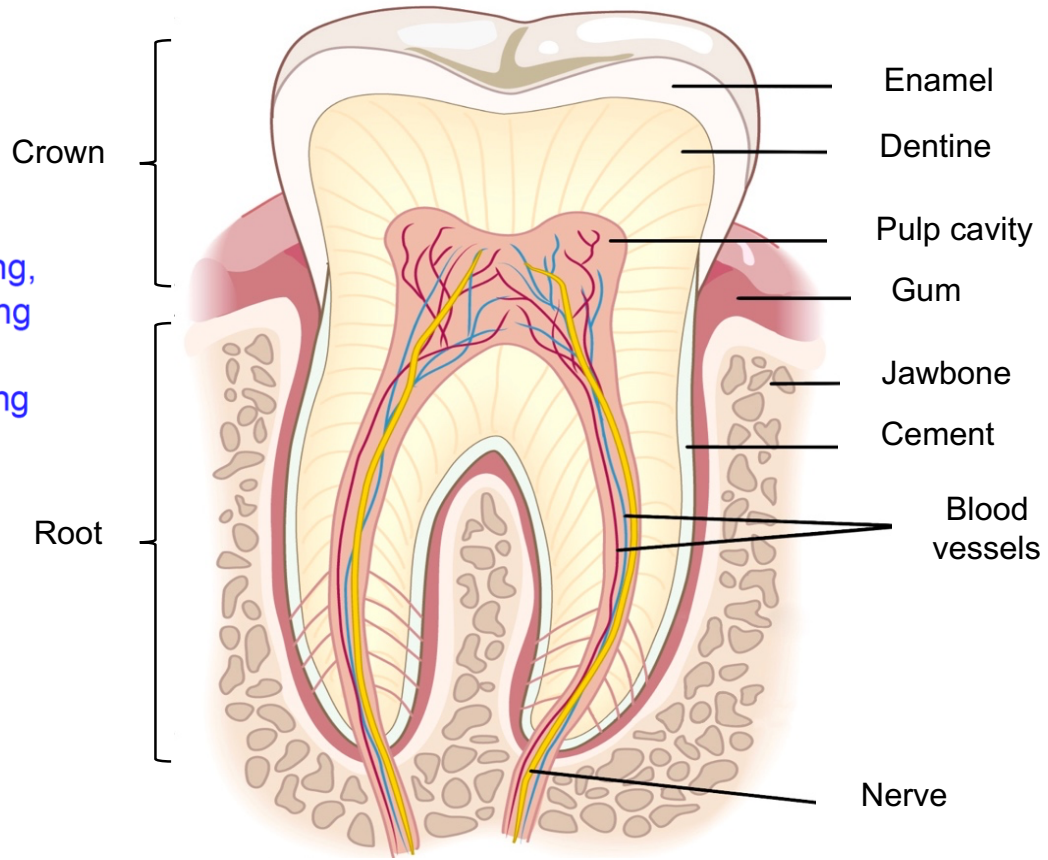
2. Water potential in the small intestine lumen decreases

3. (So) water enters the small intestine lumen by osmosis

4. (So) more water enters the faeces and leaves the anus, causing diarrhoea

TEETH


Biting and cutting
Holding and cutting
Incisor
Canine
Canine
Premolar
Premolar
Molar
Molar
Premolar
Premolar
Canine
Incisor
Canine
Grinding, crushing and chewing


Crown
Root
Enamel
Dentine
Pulp cavity
Gum
Jawbone
Cement
Blood vessels
Nerve

8 TRANSPORT IN PLANTS

TRANSPORT TISSUES IN PLANTS

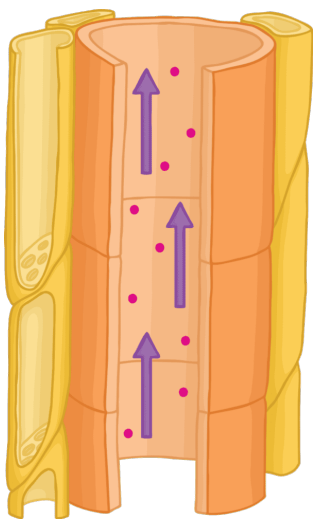
	Xylem	Phloem
What is transported	Water Mineral ions	Sugar as sucrose Amino acids
Direction of transport	Unidirectional (up only)	Bidirectional (up and down)
Made of cells that are:	Dead (hollow)	Living (release energy)

ADAPTATIONS OF XYLEM

No cell contents

No end walls between vessels

Forms a long continuous tube which gives little resistance to water



Walls thickened with lignin

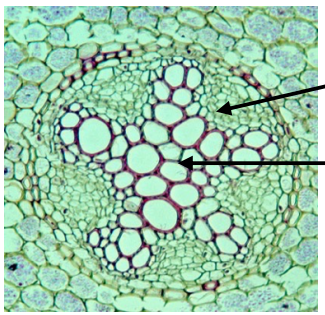
Waterproofs xylem, withstands water pressure and provides structural support

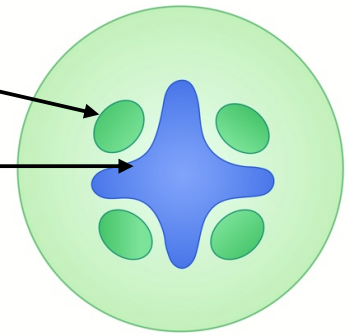
Pores in cell walls

Allow water to move between vessels and into adjacent leaf cells

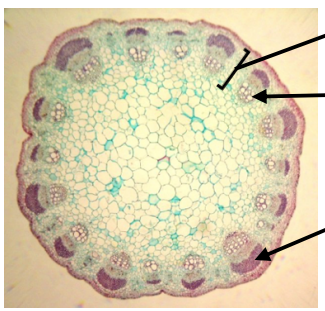
POSITIONS OF THE VASCULAR BUNDLE

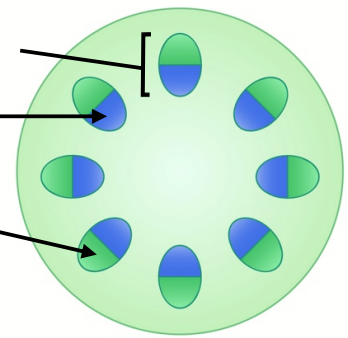
IN THE ROOT



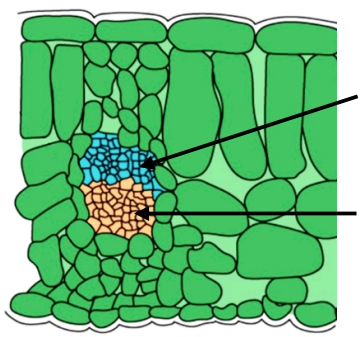


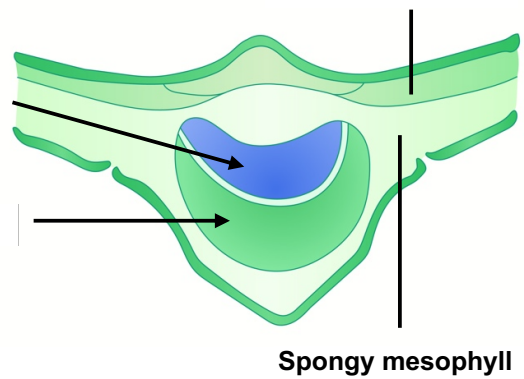
IN THE STEM



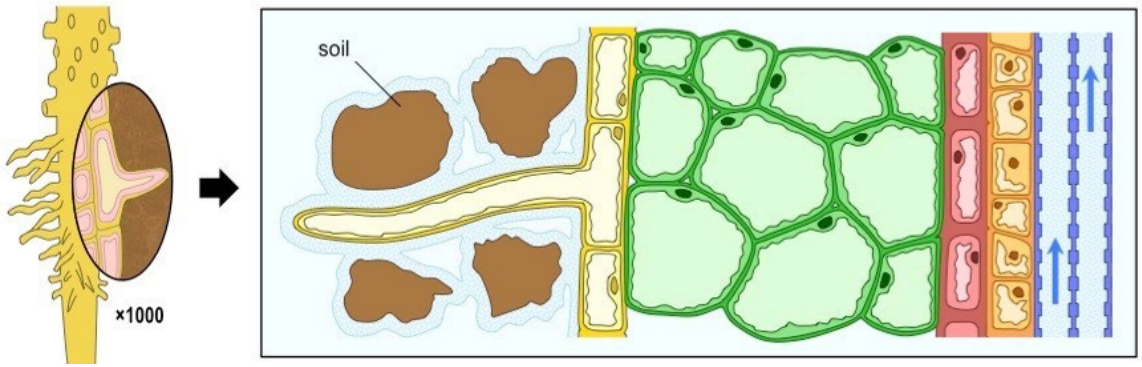


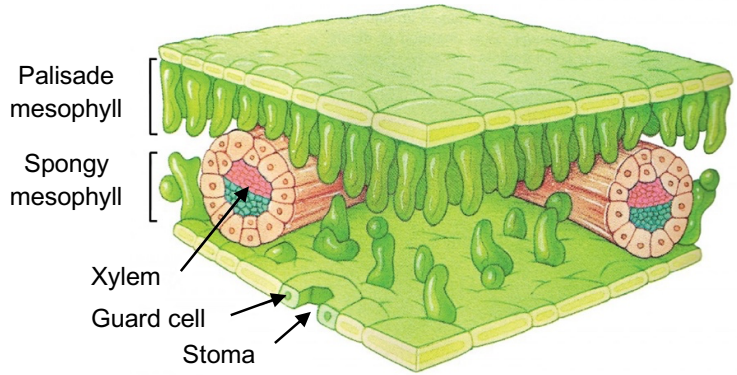
IN THE LEAF





PATHWAY OF WATER UPTAKE





Soil → **Root hair** → **Root cortex** → **Xylem** → **Mesophyll cells** → **Stomata** → **Atmosphere**

In the root | **In the stem** | **In the leaf**

Highest water potential → **Water moves by osmosis down water potential gradient** → **Lowest water potential**

HOW ROOT HAIR CELLS ABSORB WATER

- **Mineral ions enter** root hair cells by **active transport**:
  Carrier proteins use **energy** from **respiration** to move the ions across the cell membrane, **against** a concentration gradient.
- This **lowers** the **water potential inside** the cells, so that the soil now has a higher water potential.
- **Water enters** root hair cells by **osmosis down** the **water potential gradient** (across partially permeable membranes).

HOW ROOT HAIR CELLS ARE ADAPTED TO ABSORB WATER QUICKLY

Cells are long and numerous
Large surface area
= faster absorption

Thin cell walls
Short distance
= faster absorption

Contain many mitochondria
for respiration to release energy for active transport

TRANSPIRATION

DEFINITION

- Transpiration is the **loss** of **water vapour** from **plant leaves**.
- Water evaporates from the surfaces of mesophyll cells into the air spaces,
- and then diffuses out through the stomata as water vapour.

- Plants transport water from the roots to the leaves in xylem vessels to replace losses from transpiration.

HOW WATER IS SUPPLIED BY XYLEM FOR TRANSPIRATION

Light causes **stomata** to **open**
(to allow photosynthesis)

↓

Evaporation of **water** from **mesophyll cells**
and **diffusion** of **water vapour** through **stomata**

↓

Reduction of **water potential** at **top** of the plant
(so) water **enters** **xylem** by **osmosis**

↓

Water molecules 'stick' together due to **cohesion**

↓

Water is **drawn up** by the **transpiration pull**
in a **continuous column**

FACTORS THAT AFFECT TRANSPIRATION RATE

LIGHT INTENSITY

- Bright light causes **stomata** to **open**
  (so CO_2 can diffuse in for photosynthesis)

= **faster transpiration**

TEMPERATURE

- Water molecules have **more kinetic energy**:
- **More evaporation**
- **Faster diffusion** of water vapour

= **faster transpiration**

WIND SPEED

- Wind **blows** water molecules **away** from leaf surfaces
- (So) **higher** water potential gradient between inside and outside of leaf
- (So) **faster diffusion** of water vapour

= **faster transpiration**

HUMIDITY

- **Higher** concentration of **water vapour** in the air = **smaller** water potential gradient
- (So) **slower diffusion** of water vapour

= **faster transpiration**

WILTING

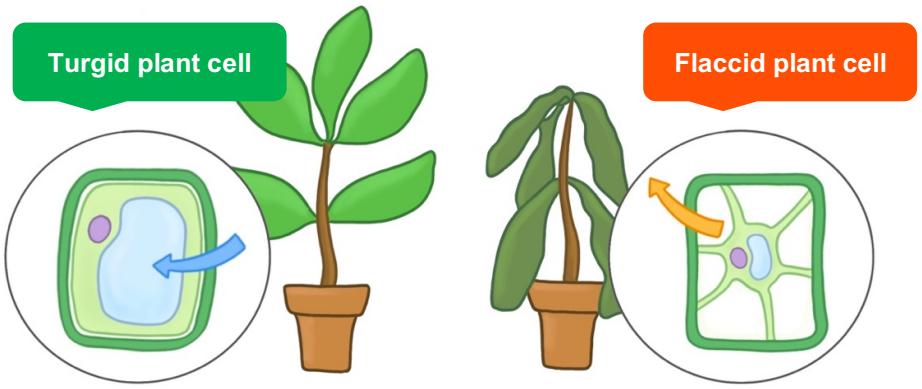
- When water in plant cells is not being **replaced** as quickly as it is being **lost**, a plant wilts due to the lack of water needed for structural support.

Conditions that can cause wilting

- Lack of water
- High temperature
- Low humidity

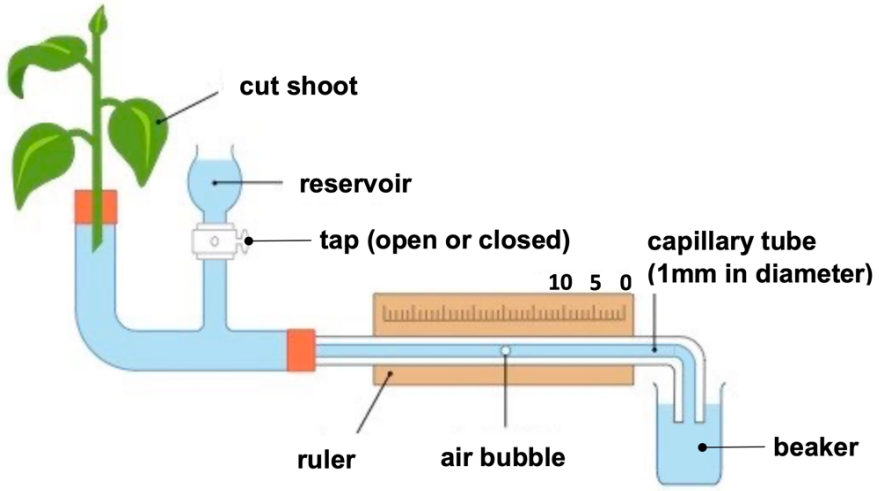
An advantage to plants

Wilting allows plant leaves to **expose less surface area** to the sun, which **reduces** further **water loss** so that water can be conserved for other processes in the plant.



	Turgid plant	Wilting plant
Higher water potential	Outside cells	Inside cells
Water moves	Down water potential gradient by osmosis	
Direction	Enters cells	Leaves cells
Pressure of water against cell wall	Increases	Decreases
Cells become	Turgid	Flaccid
Plant stem and leaves	Gain stiffness	Lose stiffness

MEASURING TRANSPIRATION RATE USING A POTOMETER



Preventing air bubbles from forming in the tube

- **Cut** the shoot **underwater** at an **angle** (prevents air entering xylem)
- **Seal** all **joints** with **Vaseline**

How it is used

- The air bubble is placed at **zero (0)**
- As the plant **transpires** it will take up water, causing the air bubble to **move left** towards the plant
- Measure the **distance** moved by the air bubble in a **fixed time period**
- Open the **tap** to move the air bubble back to **zero** for **repeats**

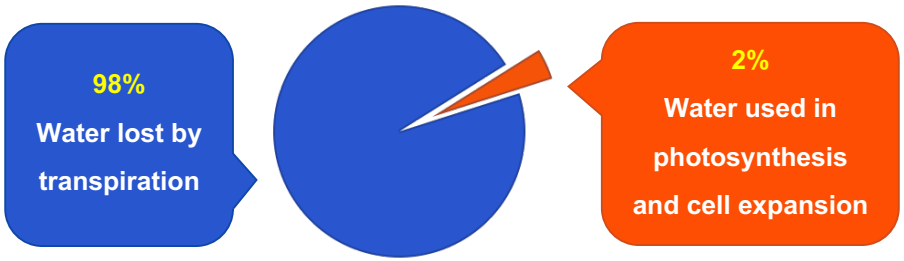
2 ways of calculating transpiration rate

1. **Distance** moved by air bubble / **unit time**

Volume of water uptake (area = πr^2 where r = radius) :

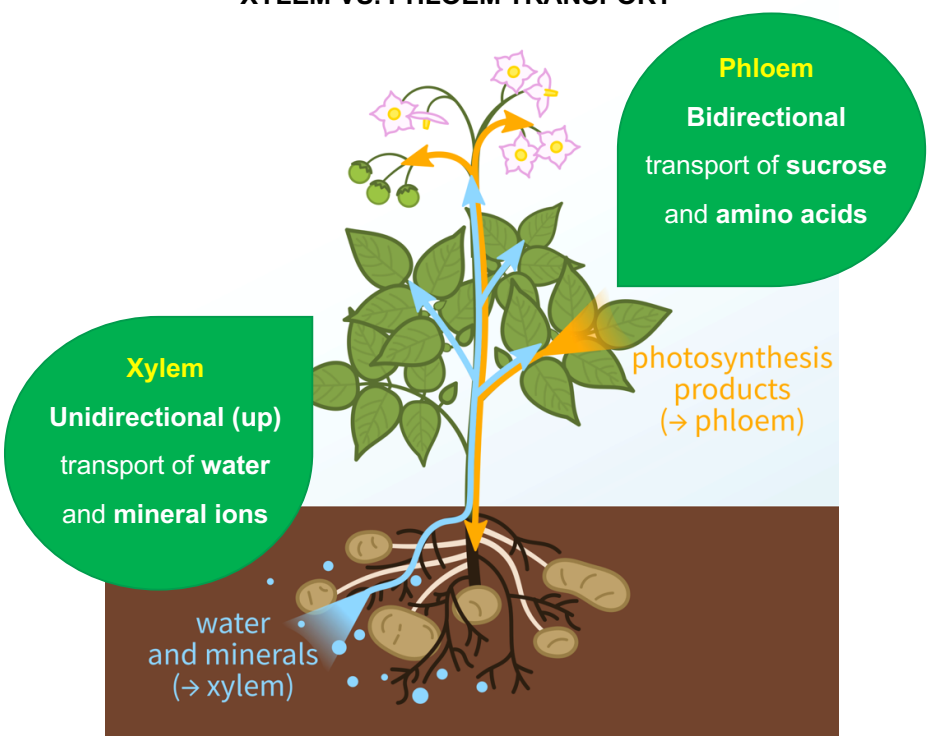
2. **Distance** moved by air bubble $\times$ **area** of capillary tube / **unit time**

TOTAL WATER UPTAKE BY A PLANT



- A potometer **directly** measures the **rate of water uptake**, which mostly depends on the **rate of transpiration** (**indirectly** measured).
- However, they cannot be exactly the same as a small amount of water is also used in **photosynthesis** and to **make cells turgid** for support.

XYLEM VS. PHLOEM TRANSPORT



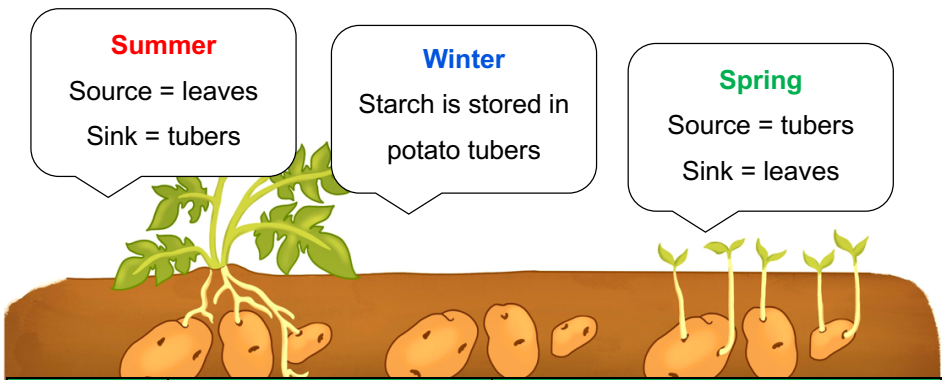
TRANSLOCATION

DEFINITION

The **movement** of **sucrose** and **amino acids** in the **phloem**:

- From **source** – regions that **release** sucrose or amino acids
- To **sink** – regions that **use** or **store** sucrose or amino acids

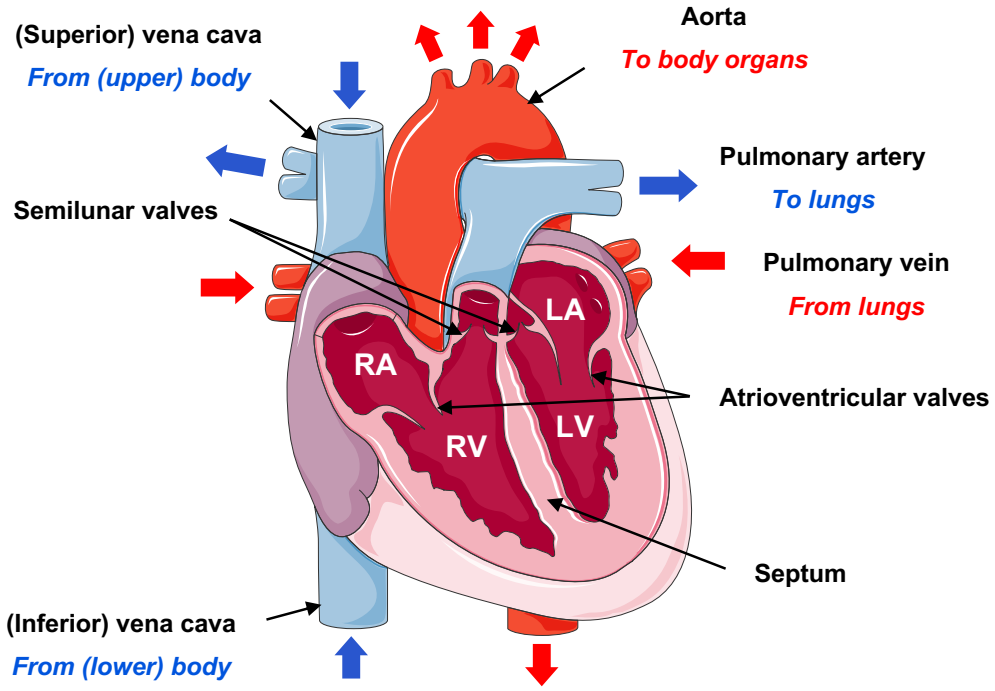
- **Phloem** can transport sucrose and amino acids **both up and down** a plant.
- This means that some parts can be **both** a **source** and a **sink** at **different times**:



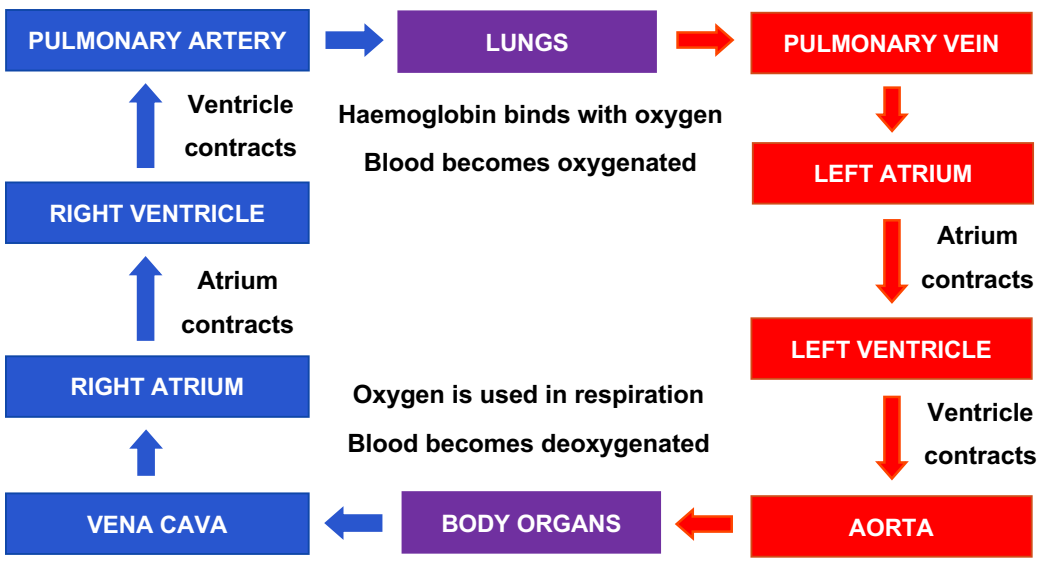
Season	Source	Sink
Summer	**Leaves** **Glucose** is produced by **photosynthesis** and converted to **sucrose**	**Roots** where sucrose is **stored** as **starch** **Growing regions** where sucrose is converted to **glucose** for **energy** (respiration)
Spring	**Roots** Stored **starch** is converted to **sucrose** and **released**	**Growing leaves** Sugars are used for **respiration** and **growth** until the leaves can photosynthesise sufficiently

9 TRANSPORT IN ANIMALS

HEART STRUCTURE



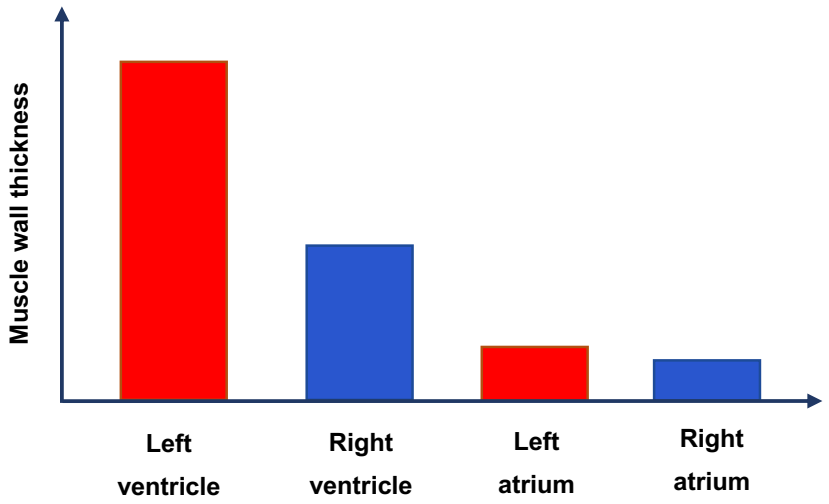
THE JOURNEY OF BLOOD



STAGES OF A HEARTBEAT

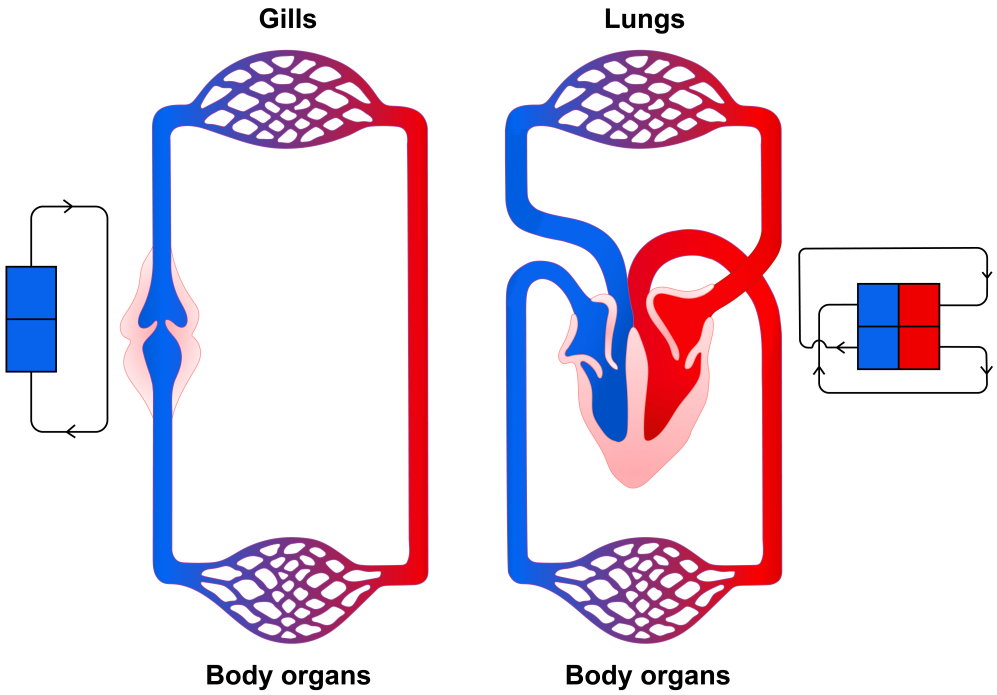
Movement of blood	Atria → ventricles	Ventricles → arteries
Atria muscles	Contract	Relax
Ventricle muscles	Relax	Contract
Blood pressure	Atria > ventricles	Ventricles > arteries
Atrioventricular valves	Open	Closed
Semilunar valves	Closed	Open

RELATIVE THICKNESS OF HEART CHAMBERS



Left ventricle	Right ventricle
Thicker muscle wall	Thinner muscle wall
Pumps blood to body organs over a greater distance	Pumps blood only to the lungs over a shorter distance
Higher pressure generated	Lower pressure generated

SINGLE VS. DOUBLE CIRCULATION



SINGLE CIRCULATION (FISH)	DOUBLE CIRCULATION (MAMMALS)
Blood flows through the heart once in one complete circuit around the body	**Blood flows through the heart twice in one complete circuit** around the body
Heart has **2 chambers**: **Oxygenated** and **deoxygenated blood** are **not separated** in the heart	Heart has **4 chambers**: **Oxygenated** and **deoxygenated blood** are **separated** completely by a septum
Blood **is not returned** to the **heart** after passing through **capillaries** in the **gills** (So) **pressure is lost**	Blood is **returned** to the **heart** after passing through **capillaries** in the **lungs** (So) **high pressure** can be **maintained**

The circulatory system is a system of blood vessels with a pump and valve to ensure one-way flow of blood

ADVANTAGES OF A DOUBLE CIRCULATION

- Generates a **higher blood pressure** than a single circulation
- (So) allows mammals to have **higher metabolic rates**
- **Oxygenated** and **deoxygenated** blood **do not mix**

FUNCTION OF THE SEPTUM

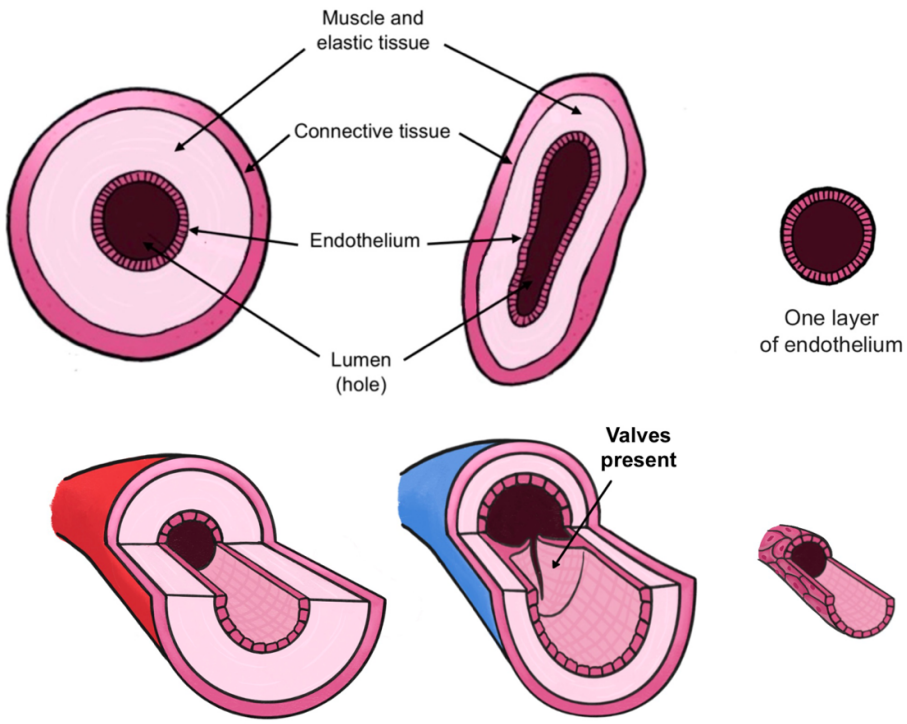
- **Separates** the **left and right atria and ventricles**
- **Prevents oxygenated** and **deoxygenated blood** from **mixing**
- Allows **double circulation**

FUNCTION OF HEART VALVES

- **Prevent backflow of blood:**
- **Atrioventricular** valves prevent backflow from **ventricles** to **atria**
- **Semilunar** valves prevent backflow from **arteries** to **ventricles**

- **If the septum and valves were not present, blood leaving the heart would contain less oxygen**
- **(So) our cells would respire less and release less energy**

TYPES OF BLOOD VESSELS



	ARTERY	VEIN	CAPILLARY
Function	Carries blood **away** from the heart	Carries blood **back** to the heart	**Connects** arteries & veins for **exchange**
Wall thickness	**Thick** layer of muscle and elastic tissue	**Thin** layer of muscle and elastic tissue	**Very thin** – only one layer of cells
Lumen diameter	**Small**	**Large**	**Very small**
Blood flow	**High** pressure	**Low** pressure	**Very low** pressure
Contains valves	Yes	No	Yes

ADAPTATIONS OF BLOOD VESSELS

- The **structures** of arteries, veins and capillaries are adapted to suit the **pressure of blood** that they transport.

ARTERIES

STRUCTURE	HOW IT IS RELATED TO FUNCTION
Thick wall of muscle and elastic tissue	• **Withstands high blood pressure** • **Flexible** to **prevent bursting** • **Stretches** and **recoils** to **smooth out** blood flow
Small lumen	• **Maintains** a high blood pressure

VEINS

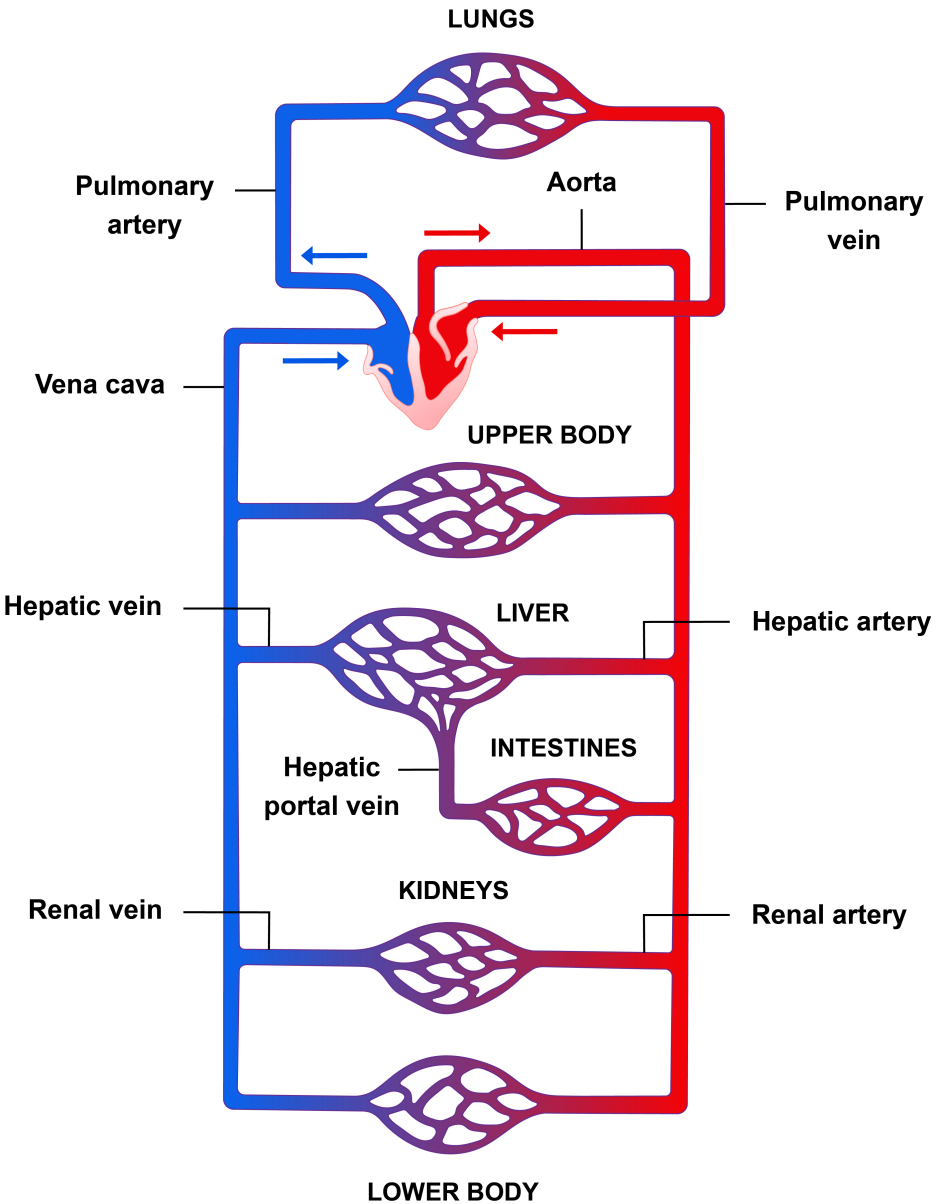
Contains valves	• **Prevents backflow** of blood due to the **low blood pressure** and **gravity**
Wide lumen	• Allows blood to flow with **little resistance**

CAPILLARIES

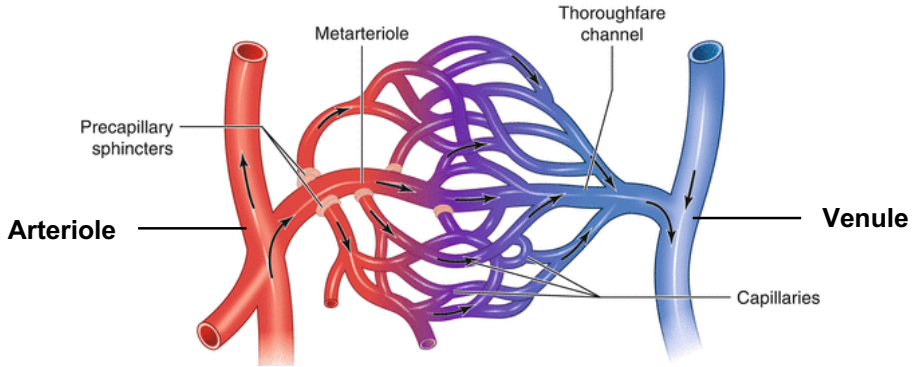
Pores in walls	• Allows substances to **pass in and out** of the blood easily
Thin wall	• **Short diffusion distance** for efficient exchange
Very small lumen	• Allows passage of only **one red blood cell at a time** to **maximise exchange**
Large number	• Forms an extensive network • (So) **large surface area** for **diffusion** • Can reach every cell throughout the body

THE HUMAN CIRCULATORY SYSTEM

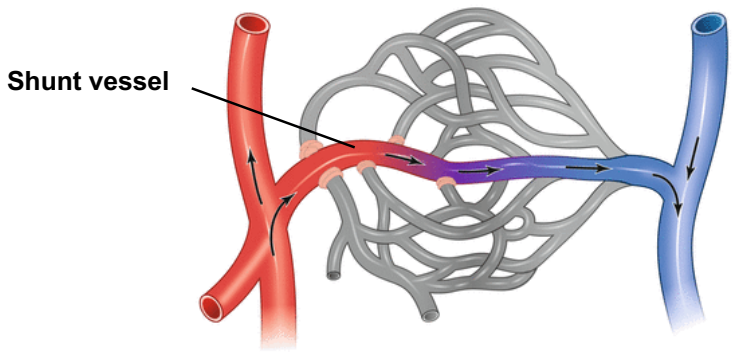
- Please remember the blood vessels leading to and from the heart, lungs, kidney and liver.



ARTERIOLES, VENULES AND SHUNT VESSELS



Sphincter muscles relaxed

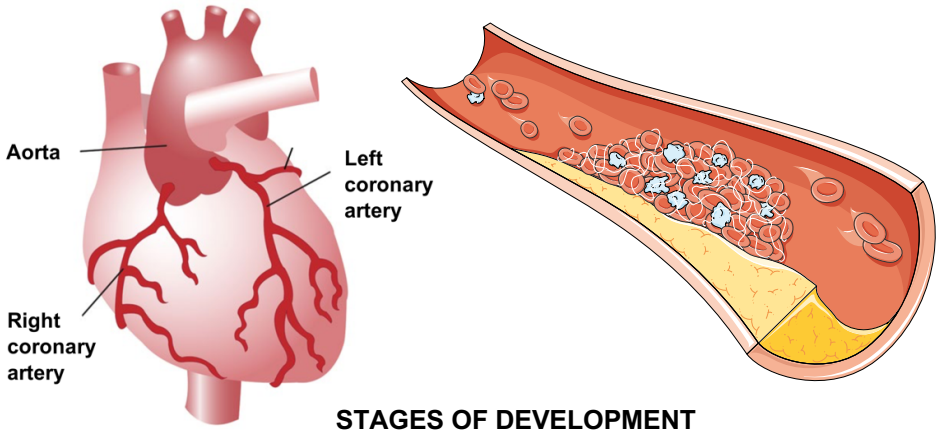


Sphincter muscles contracted

When the body is too cold	When the body is too hot
Arterioles constrict **= vasoconstriction** **Less** blood flow to **skin capillaries**	**Arterioles dilate** **= vasodilation** **More** blood flow to **skin capillaries**
Shunt vessels **dilate** **More blood diverted** away from skin	Shunt vessels **constrict** **Less blood diverted** away from skin
Less heat is lost from the **blood**	**More heat is lost** from the **blood**

CORONARY HEART DISEASE

- The **aorta** branches off to form the **coronary arteries**, which supply the **heart muscle** with blood containing **oxygen** and **glucose** for respiration.



STAGES OF DEVELOPMENT

Fats and cholesterol are deposited in the wall of an artery

↓

Plaque forms and cuts the artery lining, causing a blood clot to form

↓

A coronary artery becomes blocked by a blood clot, causing blood flow to the heart muscle to be restricted

↓

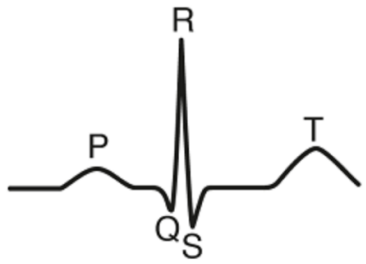
The heart muscle receives less oxygen and glucose (So) it respires less and releases less energy

Complete blockage may cause part of the heart muscle to stop contracting, leading to a heart attack

RISK FACTORS

CAN CHANGE	CANNOT CHANGE
Diet high in saturated fat (cholesterol)	Age
Diet high in salt	Gender
Alcohol	Genetics
Smoking cigarettes	Race
Lack of exercise	
Stress	

MONITORING HEART ACTIVITY



1. **Electrocardiogram (ECG)**

2. **Listening to sounds of valves closing**

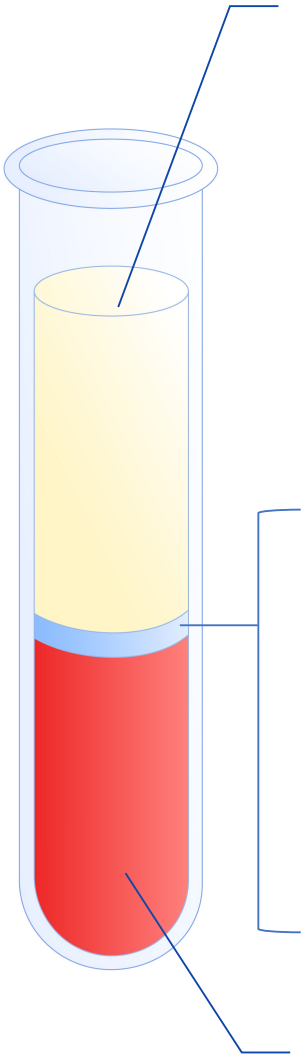
RADIAL PULSE (WRIST)

CAROTID PULSE (NECK)

3. **Measuring pulse rate**

10 DISEASES AND IMMUNITY

COMPOSITION OF BLOOD



BLOOD PLASMA (92% WATER)

Transport of:

- Blood cells
- Ions
- Proteins
- Nutrients
- Urea and carbon dioxide
- Hormones

WHITE BLOOD CELLS

- Lymphocytes produce antibodies
- Phagocytes engulf pathogens by phagocytosis

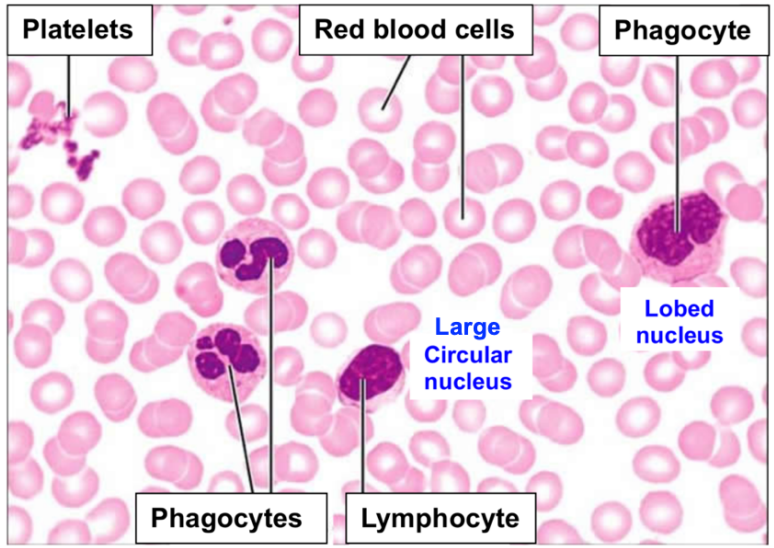
PLATELETS

Fragments of cells involved in blood clotting

RED BLOOD CELLS

Contain haemoglobin to transport oxygen

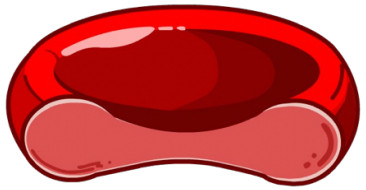
A MICROSCOPE SLIDE OF BLOOD



ADAPTATIONS OF A RED BLOOD CELL

Biconcave disc shape
Large surface area for fast diffusion of oxygen

Large amount of haemoglobin
Can attach to and release oxygen



Flexible membrane
To squeeze through small capillaries

No nucleus or cell organelles
More space for haemoglobin to transport more oxygen

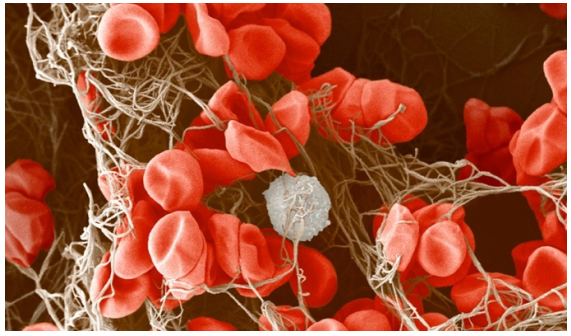
BLOOD CLOTTING

- Blood clotting occurs in a successive series of reactions, triggered by **platelets** and ending in the **conversion** of **fibrinogen** to **fibrin**.

When a blood vessel is cut, platelets release proteins called clotting factors that cause an enzyme to be produced.

Soluble fibrinogen → **Conversion by enzyme** → **Insoluble fibrin**

Fibrin forms a mesh that traps red blood cells to form a clot, which then dries and hardens into a scab.



TWO ROLES OF BLOOD CLOTTING:

- **Prevents further loss of blood**
- **Prevents pathogens from entering the body**

TRANSMISSIBLE DISEASES

Pathogen

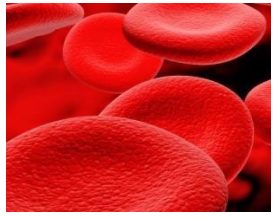
- **A disease-causing organism**
- **E.g. bacteria, fungi, protozoa and viruses**

Transmissible disease

- **A disease caused by a pathogen, which can be passed from one host to another**

Transmission

DIRECTLY



Body-to-body contact through fluids such as:

- **Blood**
- **Sexual fluids**

INDIRECTLY

- **Air**
- **Food**
- **Water**
- **Surfaces**
- **Animal bites**

Most diseases that are not caused by pathogens are not transmissible:

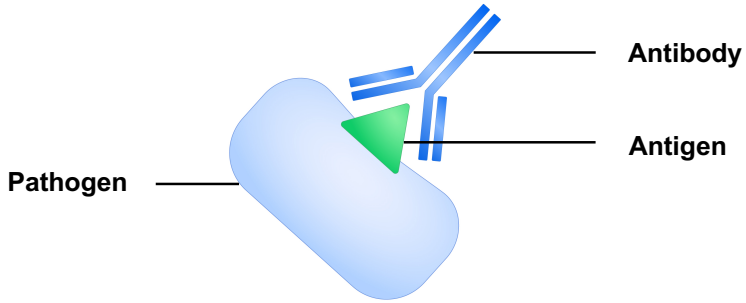
- Examples are **CHD**, most **cancers**, **diabetes** and **malnutrition** diseases.
- **Type 1 diabetes** is an **autoimmune disease** caused by our body's own **antibodies** attaching to and destroying **pancreas cells** that make **insulin**.

THE BODY'S DEFENCES AGAINST PATHOGENS

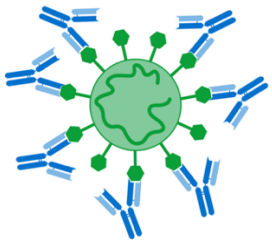
Skin	**Impermeable** covering that contains **glands** that secrete **fatty acids** to **reduce bacterial growth**
Nose hairs	**Trap pathogens** in inhaled **air**
Mucus	**Traps pathogens** that enter the **trachea**, helping **cilia** to move them to the **throat**
Stomach acid	**Kills bacteria** in **food**
Lymphocytes	**Produce antibodies** that **attach** to and **destroy specific pathogens**
Phagocytes	**Engulf** and **digest** pathogens using **enzymes** (Non-specific as they may kill any type of pathogen)

CONTROLLING THE SPREAD OF DISEASE

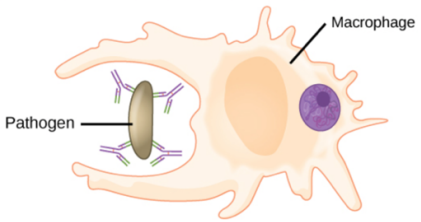
HOW ANTIBODIES WORK



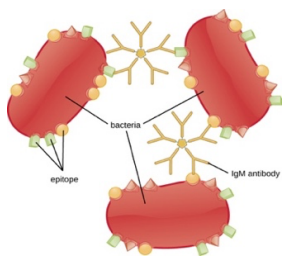
- Each **pathogen** has its own **antigens**, which have **specific shapes**.
- **Antibodies** are **proteins** that have **specific** binding sites with **complementary shapes** which **fit specific antigens**.
- Here are some ways in which antibodies can work (don't need to memorise):



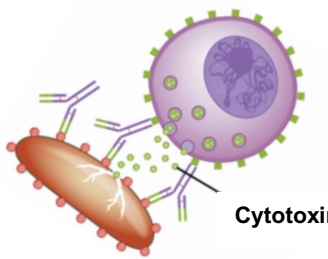
Neutralisation – coat pathogens to prevent them from binding to target cells



Opsonisation – mark pathogens for destruction by phagocytes



Agglutination – 'clump' pathogens together for easier destruction

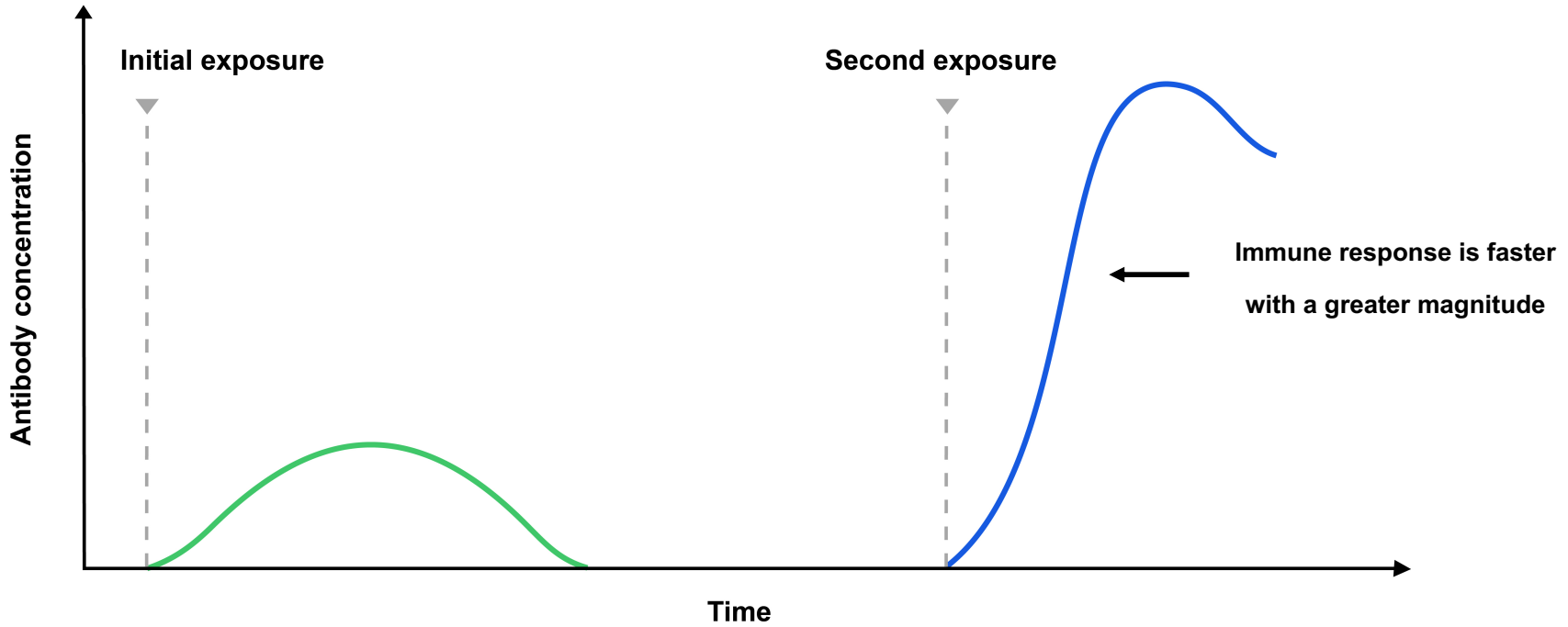


Activate proteins that can cause cell lysis and inflammation

ACTIVE IMMUNITY

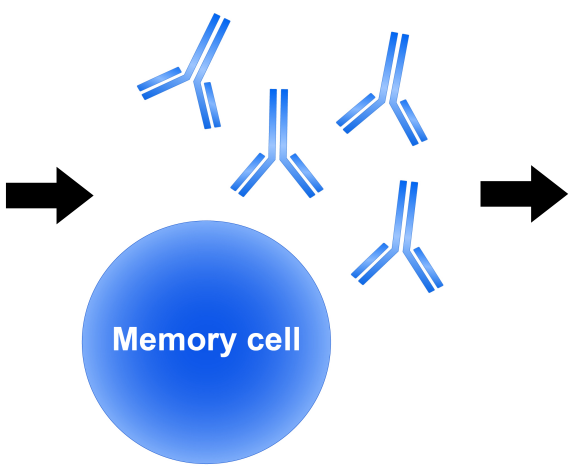
PRIMARY IMMUNE RESPONSE – 1ST ENTRY OF PATHOGEN

SECONDARY IMMUNE RESPONSE – RE-INFECTION BY SAME PATHOGEN



- The pathogen's antigen triggers lymphocytes to produce specific antibodies, but this takes time.
- Meanwhile, the pathogen can reproduce quickly so we become ill.
- Antibodies eventually destroy the pathogen, allowing us to recover.

Specific lymphocytes divide to produce memory cells, which remain in the blood for a long time.



- **Memory cells** remain from the first infection to give long-term immunity.
- These make sure that **antibodies** will be produced **faster** and in a **greater amount** if infected by the **same pathogen** again in the future.

VACCINATION

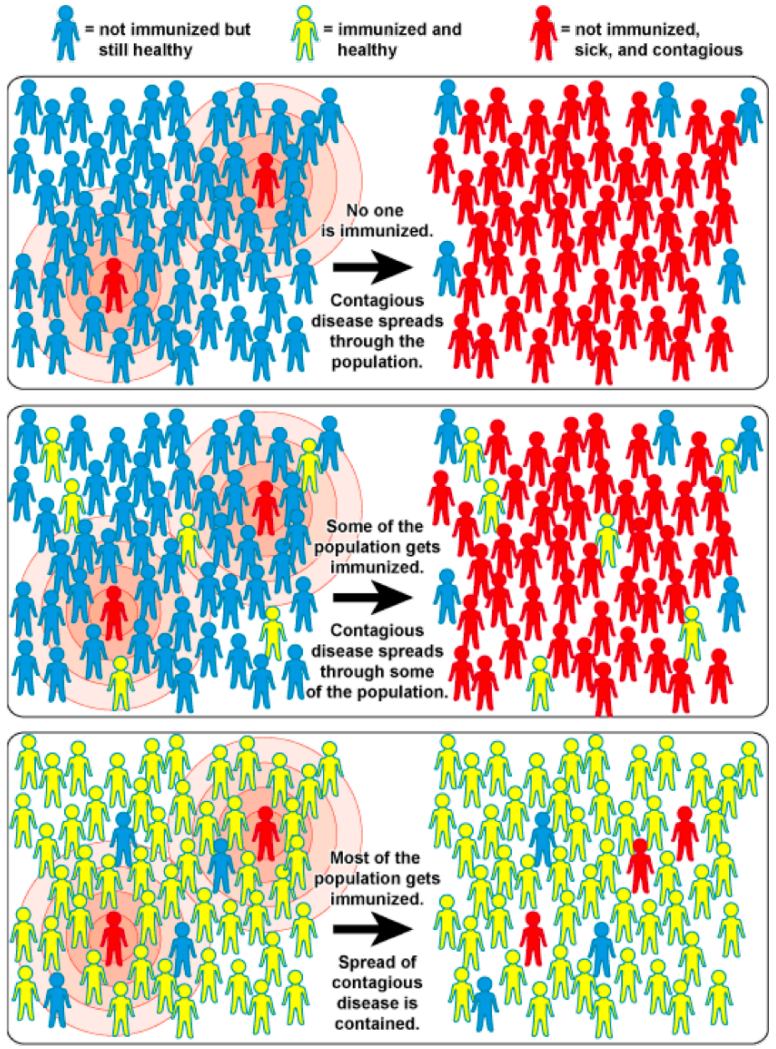
1. A vaccine containing a **weakened pathogen** or its **antigens** is **injected** into the body.
2. The antigens trigger an **immune response** by **lymphocytes**, which produce **specific antibodies** with a **complementary shape**.
3. These antibodies **attach to** and **destroy** the pathogen.
4. **Memory cells** are produced that remain to give **long-term immunity**.
5. (So) **rapid immune response** will occur if **re-infected** by the **same pathogen**.

ACTIVE VS PASSIVE IMMUNITY

	Active immunity	Passive immunity
Meaning	**Long-term** defence against a pathogen by **antibody production in the body**	**Short-term** defence against a pathogen by **antibodies acquired from another individual**
Where the antibodies come from	**Your own body**	**From another person or animal**
Memory cells	**Yes**	**No**
Efficiency	**Slower response on first exposure to antigen**	**Gives immediate protection**
Examples	**Gained after infection by a pathogen or vaccination**	• **Antibodies** pass from **mother to baby** across the **placenta** and in **breast milk** • **Injecting antibodies** in **anti-venom** to **treat snake bites**

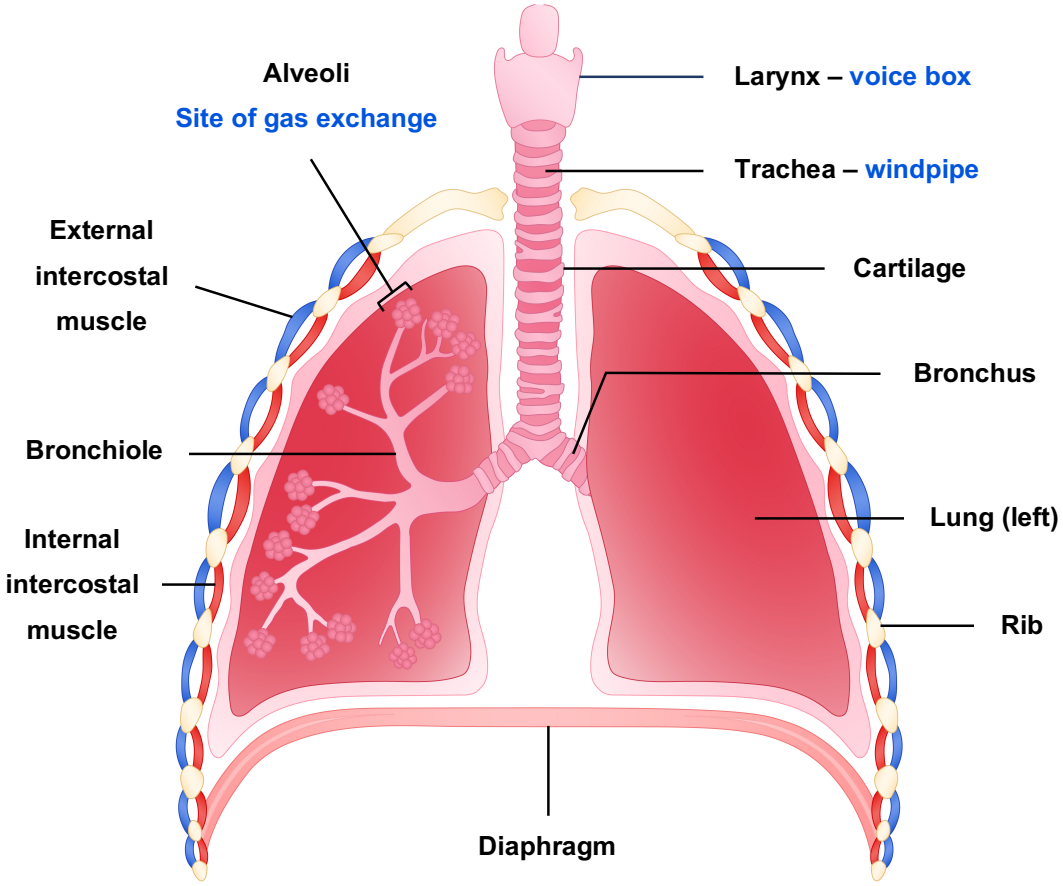
CONTROLLING THE SPREAD OF DISEASE

- **Herd immunity** can be achieved when a **high percentage of a population** is **vaccinated**.
- This makes it difficult for an infectious disease to spread as there will be **few people that are susceptible**.



11 GAS EXCHANGE IN HUMANS

STRUCTURE OF THE BREATHING SYSTEM



Function of cartilage rings

- **Protects** and **supports** the **trachea** and **bronchi**
- Allows free flow of air into the lungs
- Allows **flexibility** for **breathing**

Air leaves the lungs

Larynx

Trachea

Bronchi

Bronchioles

Alveoli

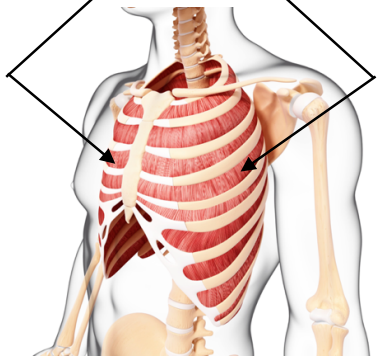
Air leaves the lungs

CONTROL OF BREATHING RATE

BRAIN
contains **receptors** that detect

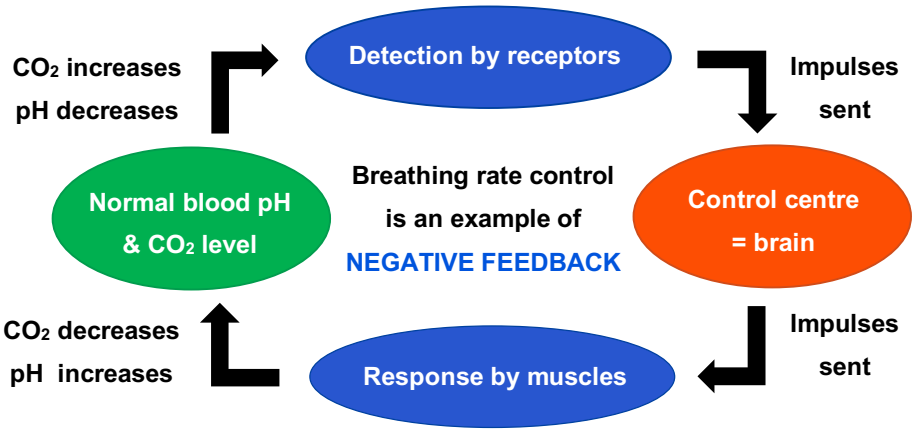
- an increase in blood CO_2 **concentration**
- a **decrease** in **blood pH**

more impulses sent to **intercostal muscles** and **diaphragm muscle**



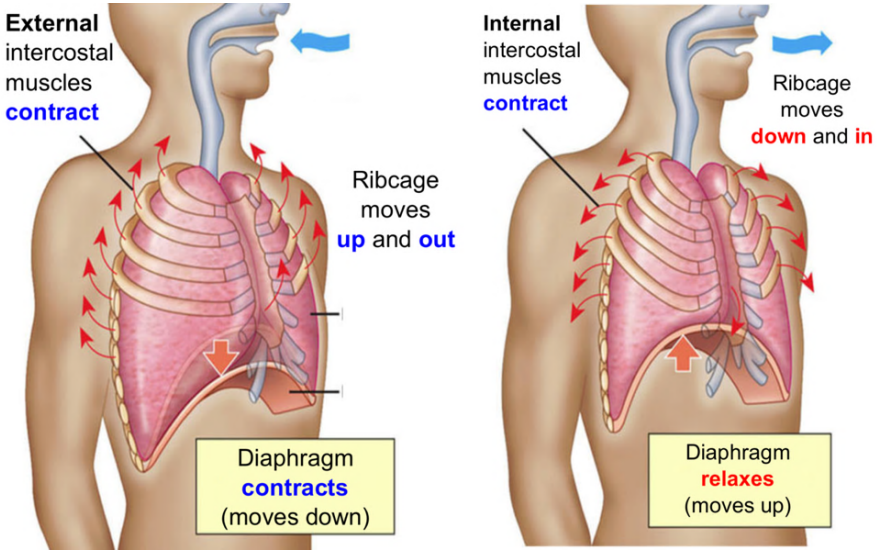
intercostal muscles and **diaphragm muscle contract more frequently**

breathing is **faster** and **deeper**, so **more CO_2 is exhaled** and **removed** from the **blood**



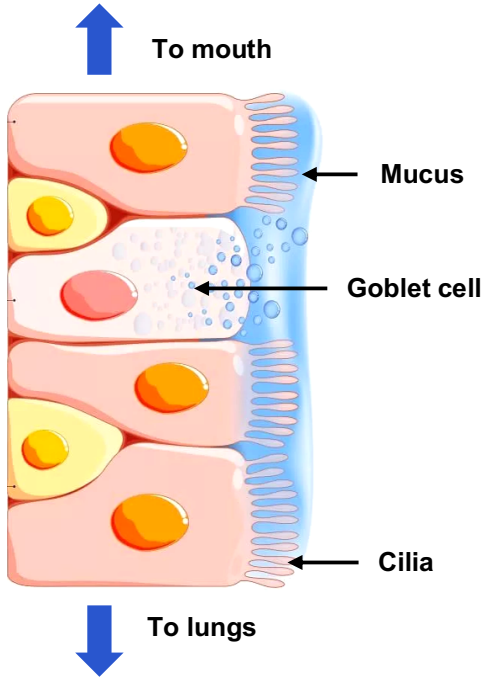
Increased **rate** and **depth** of breathing

HOW WE BREATHE IN AND OUT



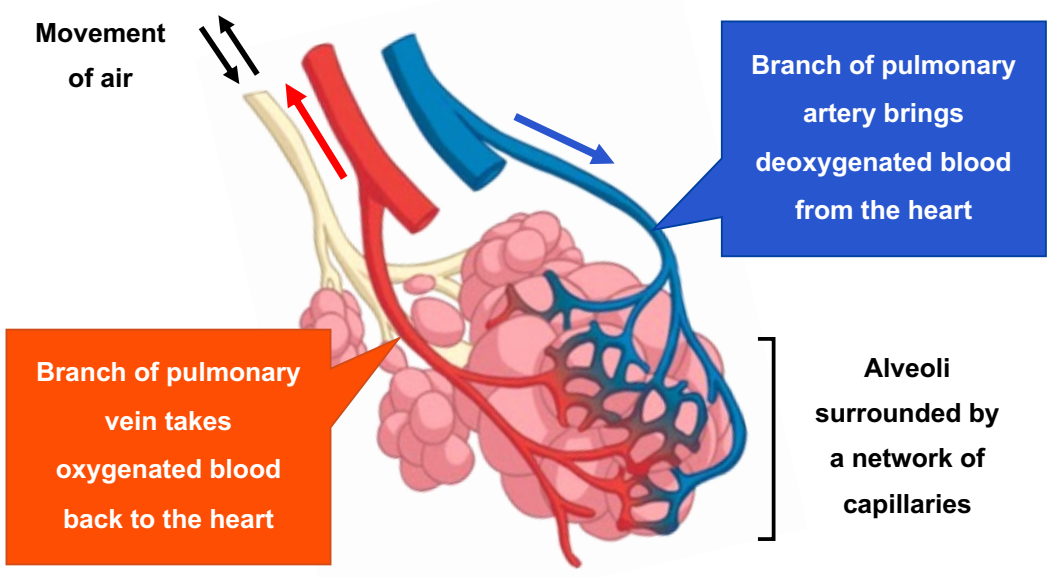
	Inhaling	Exhaling
Ext intercostal muscles	Contract	Relax
Int intercostal muscles	Relax	Contract
Ribcage moves	Up and out	Down and in
Diaphragm	Contracts (moves down)	Relaxes (moves up)
Volume of thorax	Increases	Decreases
Air pressure in thorax (lungs)	Decreases	Increases
Air moves	HIGH → LOW PRESSURE	
Direction	Enters chest	Leaves chest

THE BREATHING SYSTEM'S DEFENCE AGAINST PATHOGENS

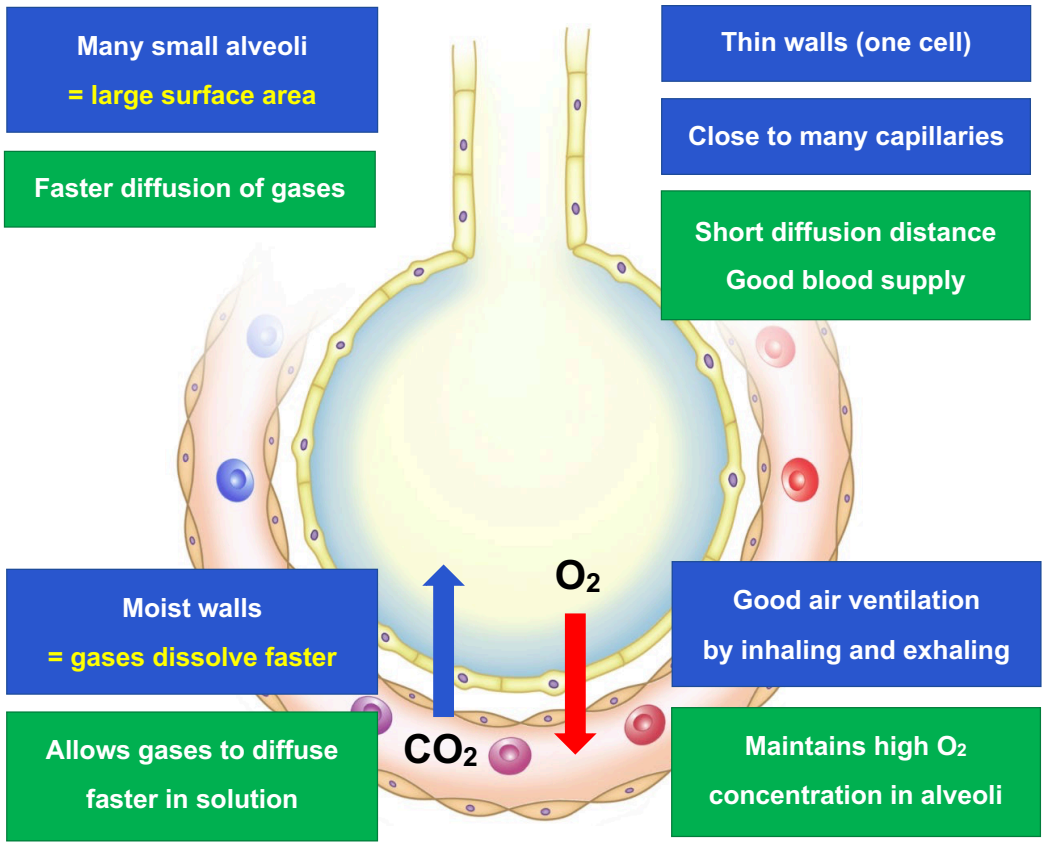


- Pathogens in inhaled air are **trapped** by **nose hairs**.
- **Goblet cells** produce sticky **mucus** which **traps** pathogens
- **Cilia** lining the trachea '**beat**' to **move mucus** up and out towards the **mouth**
- The mucus is then **swallowed**, and pathogens are killed by **stomach acid** and **phagocytes**.

ALVEOLI AND GAS EXCHANGE



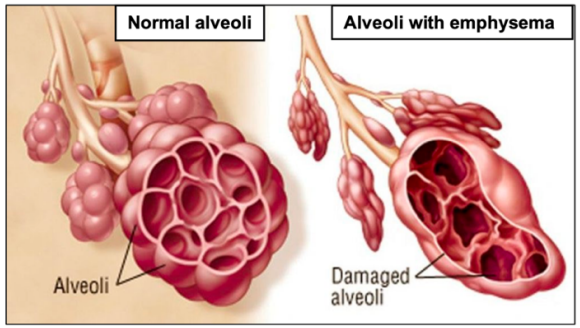
HOW ALVEOLI ARE ADAPTED FOR FAST GAS EXCHANGE



COMPOSITION OF INHALED AIR VS. EXHALED AIR

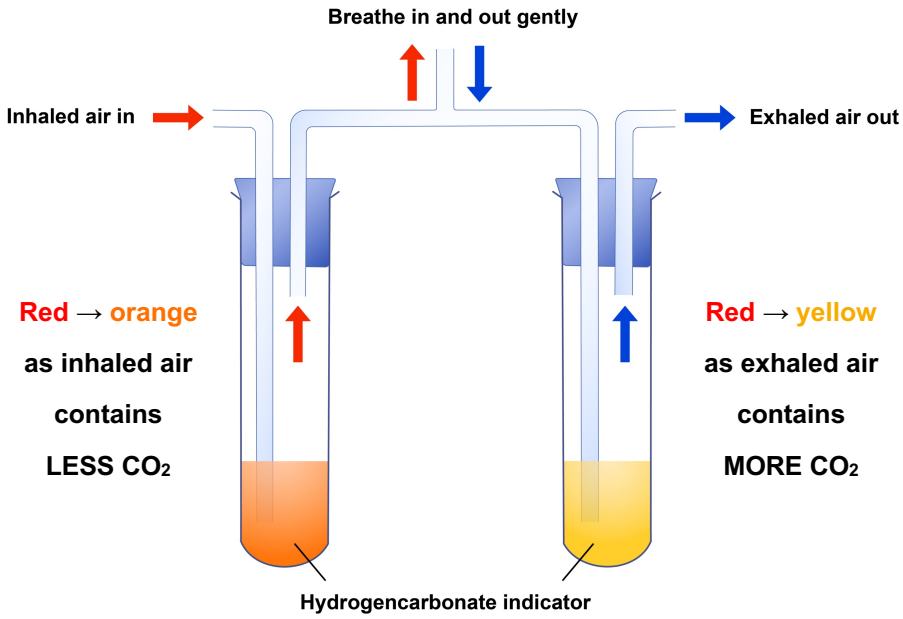
Gas	Inhaled air / %	Exhaled air / %	Reason for difference
OXYGEN	21	16	Used in respiration
CARBON DIOXIDE	0.04	4	Produced in respiration
WATER VAPOUR	Small amount	Larger amount	Produced in respiration
NITROGEN	78	78	Not used in the body

EMPHYSEMA



- **Alveoli walls break down**
- (So) **alveoli** have a **lower surface area**
- (So) **slower diffusion** of **oxygen** into the **blood**
- (So) **less respiration** so **less energy released**
- (So) feel more **tired**

TESTING FOR CO_2 IN INHALED AND EXHALED AIR



12 RESPIRATION

Aerobic respiration

The **chemical reactions** in cells that **use oxygen** to **break down nutrient** molecules and **release energy**

glucose + oxygen → carbon dioxide + water

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$

Uses of energy released

- Growth and repair
- Muscle contraction
- Cell division
- Metabolic reactions
- Protein synthesis
- Active transport
- Passage of nerve impulses
- Maintaining body temperature

Anaerobic respiration

The **chemical reactions** in cells that **do not use oxygen** to **break down nutrient** molecules and **release energy**

In muscles

glucose → lactic acid

In yeast

glucose → ethanol + carbon dioxide

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

	Aerobic respiration	Anaerobic respiration
Oxygen needed	Yes	No
Uses	Glucose or fats	Glucose only
Amount of energy released per glucose molecule	More Glucose molecules are broken down completely into CO_2 and water	Less Glucose molecules are partially broken down – energy is 'trapped' in lactic acid ($C_3H_6O_3$)
Products	CO_2 and water	Humans – lactic acid only Yeast – alcohol and CO_2
Controlled by enzymes	Both – rate of respiration is affected by temperature and pH	

EFFECT OF EXERCISE ON BREATHING AND HEART RATE

Exercise starts

- Muscles **contract harder**
- Demand of **energy and oxygen** increases
- Rate of **aerobic respiration** increases

An increase in pulse rate and breathing rate allows:

- More **blood** containing glucose and oxygen to be supplied to the muscles
- More **CO_2** to be transported to the lungs and exhaled from the body
- More **heat loss** through increased blood circulation

If demand of oxygen exceeds availability…

- **Oxygen** is not supplied to **muscles** fast enough from the heart / lungs
- Muscles respire **anaerobically** and produce **lactic acid**
- Lactic acid **builds up** in muscles, causing an **oxygen debt** to develop
- An equal amount of **extra oxygen** is needed after exercise to **break down** all **lactic acid** and "pay off" the debt

Immediately after stopping exercise

- **Pulse rate** continues to be **high**
- **Breathing** continues to be **faster** and **deeper**
- (So) **more oxygen** supplied to muscles and liver to **break down** lactic acid
- Lactic acid diffuses from **muscles** into **blood**, which transports it to the liver
- In the **liver**, lactic acid is **broken down** by **aerobic respiration**, or used to rebuild glucose molecules.

13 EXCRETION IN HUMANS

EXCRETION

Removal from the organism of waste products of metabolism and substances in excess of requirements

TWO MAIN EXCRETORY ORGANS

KIDNEYS → Excrete in urine → Urea (toxic), Excess water, Excess salt

LUNGS → Excrete by exhaling → CO_2 produced by respiring cells

ROLES OF THE LIVER

Proteins for use & urea for excretion → Vena cava / To heart

ASSIMILATION	DEAMINATION
Uses amino acids to synthesise proteins	Removal of the nitrogen-containing part of amino acids to form urea
Needed	Excess

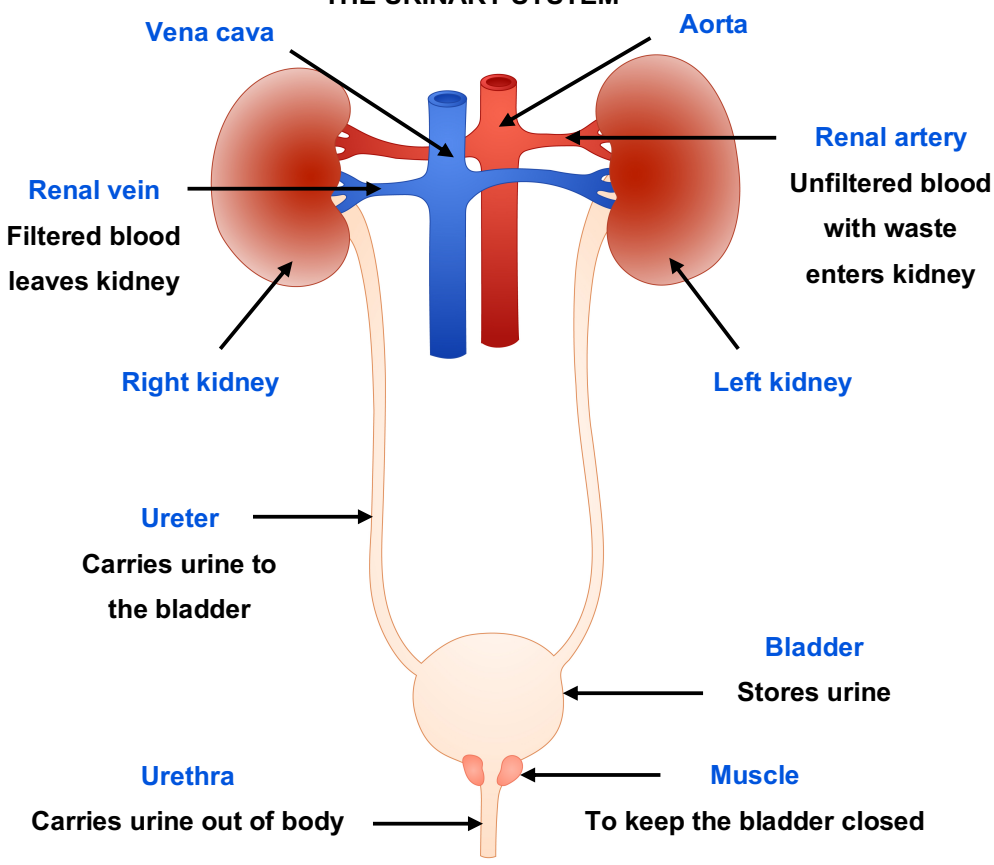
Amino acids absorbed from the small intestine ← Hepatic portal vein / From liver

EGESTION VS. EXCRETION

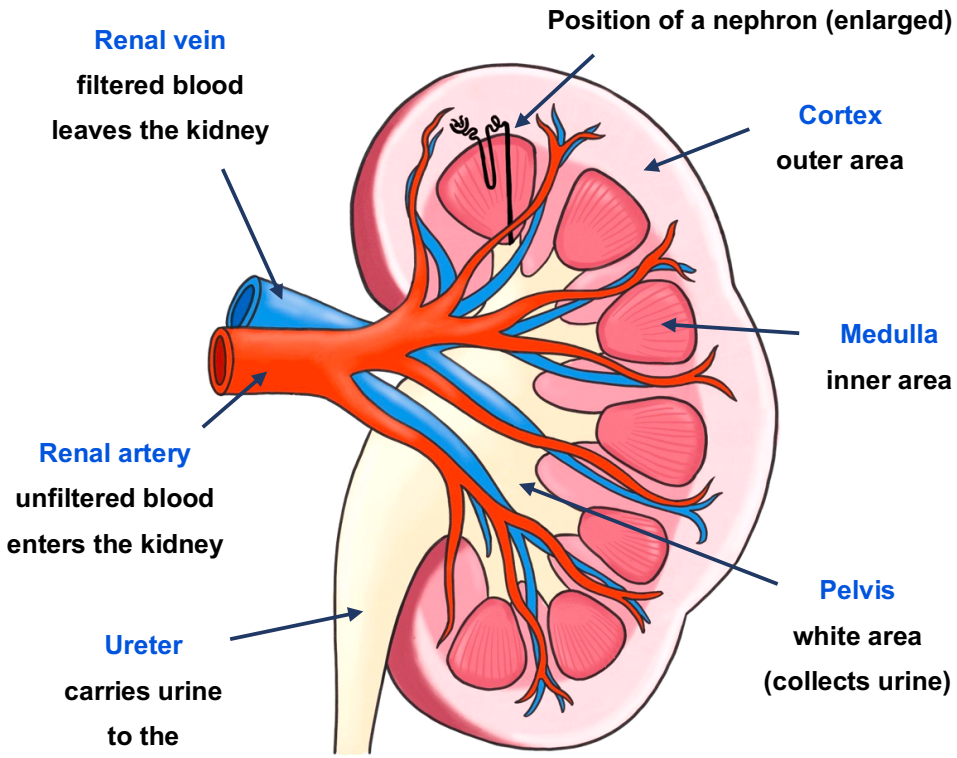
- Egestion is generally not considered as a part of excretion.

Egestion	Excretion
A part of digestion	A separate life process
Removes undigested food in faeces (unaffected by human digestive enzymes – not a product of metabolism)	Removes waste products of metabolic reactions e.g. urine, CO_2, sweat
Through the anus	Through excretory organs

THE URINARY SYSTEM

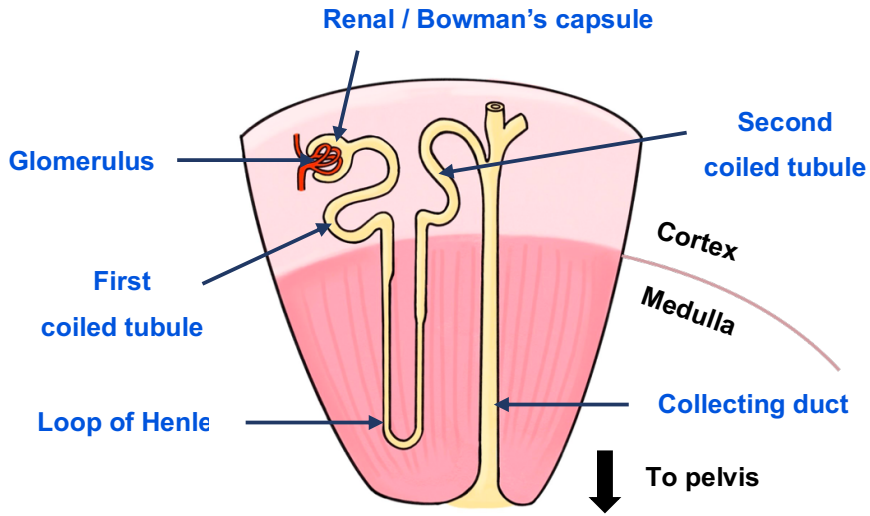


STRUCTURE OF THE KIDNEY

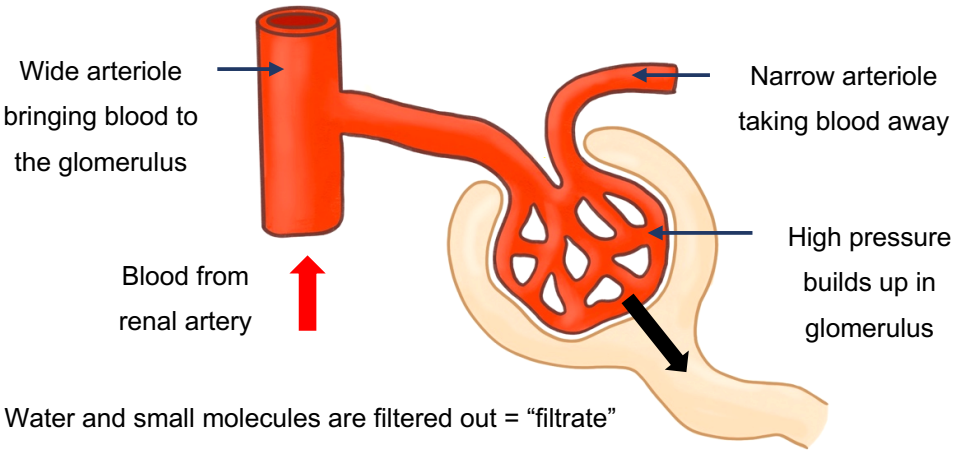


	Renal artery	In the kidney	Renal vein
Urea	More	Large amounts are **removed** in **urine**	Less
Water & ions	More	**Reabsorbed** and **excess** is **removed**	Less
Glucose & oxygen	More	**Used** by **kidney cells** in **respiration**	Less
Carbon dioxide	Less	**Produced** by **kidney cells** in **respiration**	More

STRUCTURE OF A KIDNEY TUBULE (NEPHRON)



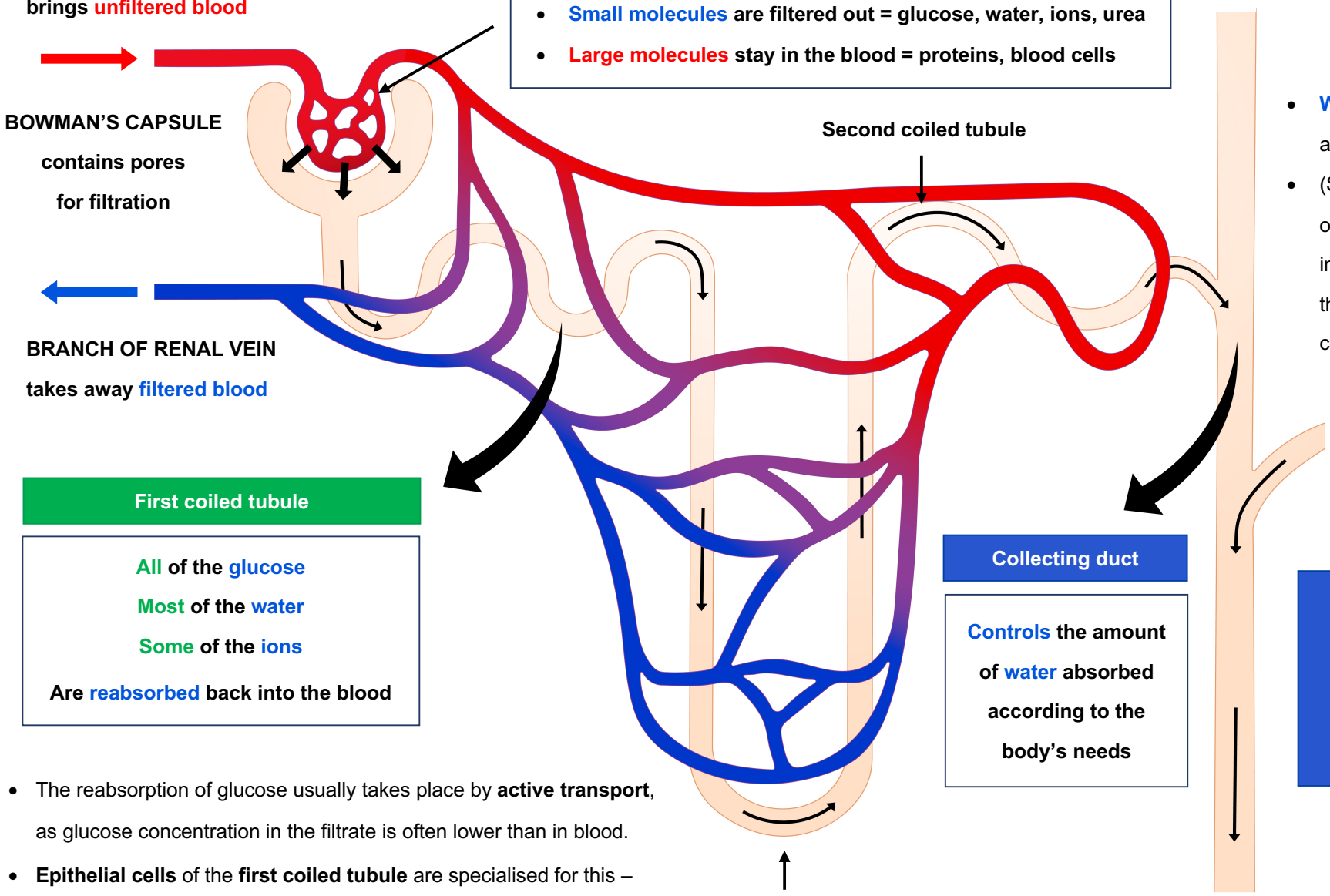
THE GLOMERULUS



Water and small molecules are filtered out = "filtrate"

- The **glomerulus** is a ball-shaped **knot** of **capillaries**, **surrounded** by the **Bowman's capsule** at one end of each nephron.
- It **provides blood at high pressure** to **speed up filtration**.
- Glomerular **capillary walls** and the adjacent wall of the **Bowman's capsule** contain **pores** through which **blood** is **filtered** into the **kidney tubule**.

REABSORPTION AND URINE FORMATION IN A NEPHRON



BRANCH OF RENAL ARTERY

brings unfiltered blood

BOWMAN'S CAPSULE

contains pores for filtration

BRANCH OF RENAL VEIN

takes away filtered blood

Glomerulus = site of filtration

- Small molecules are filtered out = glucose, water, ions, urea
- Large molecules stay in the blood = proteins, blood cells

Second coiled tubule

- Water is reabsorbed along the kidney tubule.
- (So) the concentration of **urea**, **ions** and **toxins** in urine is higher than in the filtrate as urine contains less water.

First coiled tubule

All of the glucose

Most of the water

Some of the ions

Are reabsorbed back into the blood

Collecting duct

Controls the amount of water absorbed according to the body's needs

Urine containing:

Urea

Excess water

Excess ions

Toxins

- The reabsorption of glucose usually takes place by **active transport**, as glucose concentration in the filtrate is often lower than in blood.
- **Epithelial cells** of the **first coiled tubule** are specialised for this – they contain **many mitochondria** and are **lined with microvilli**.

Loop of Henle

To ureter and bladder

TWO CHOICES

Renal artery takes unfiltered blood containing useful substances and waste to the kidneys

KIDNEYS
(filter the blood)

USEFUL

Glucose
Water
Ions

Reabsorbed into the blood by the renal vein

= NOT LOST FROM BODY

WASTE

Urea
Excess water
Excess ions

Waste in urine enters ureter → bladder

= LOST FROM BODY

SUMMARY – THREE ROLES OF THE KIDNEYS

- **Produce urine** to get rid of waste from the blood
- **Reabsorb** useful substances back into the blood
- **Control** the amount of **water** and **ions** in the blood

URINE FORMATION

Substance	Filtered through Bowman's capsule?	How much is reabsorbed in the first coiled tubule?	Should it appear in urine?
GLUCOSE	Yes	All	No
WATER	Yes	Most	Yes – excess
IONS	Yes	Some	Yes – excess
PROTEINS	No	None	No
RED BLOOD CELLS	No	None	No
UREA	Yes	None	Yes

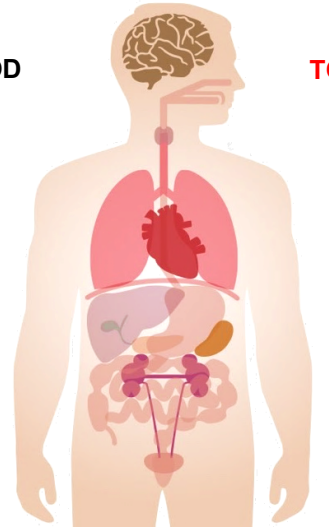
OSMOREGULATION BY THE KIDNEYS

Receptors in the hypothalamus

TOO MUCH WATER IN BLOOD

Pituitary gland releases less ADH

Less water is reabsorbed in the collecting duct



TOO LITTLE WATER IN BLOOD

Pituitary gland releases more ADH

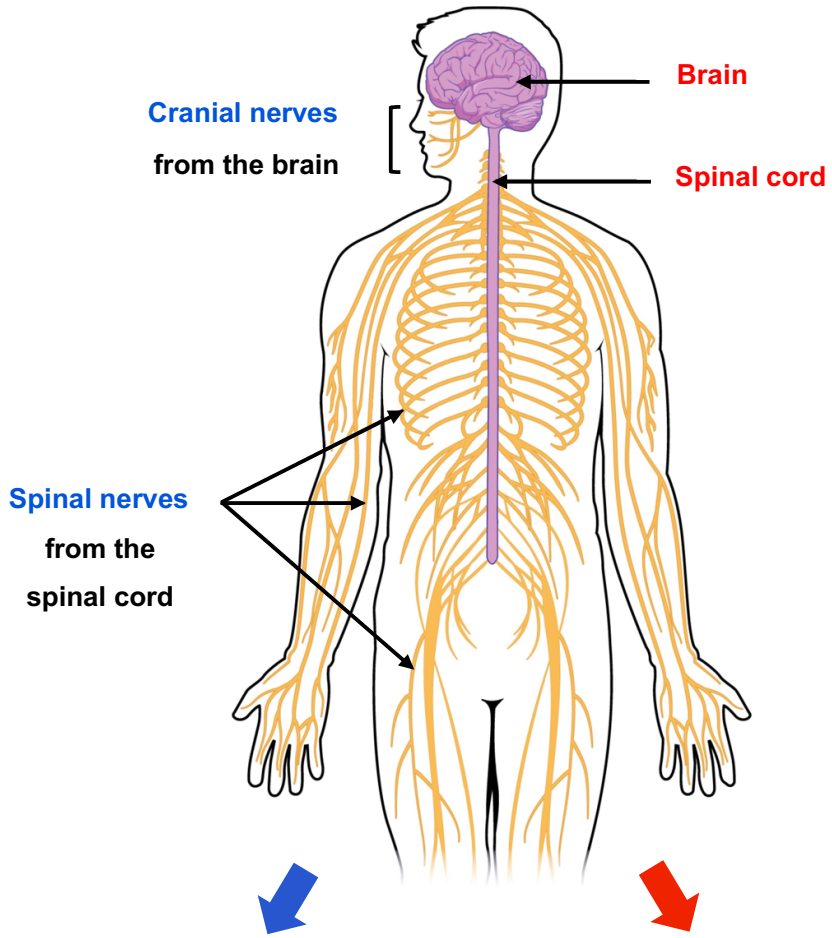
More water is reabsorbed in the collecting duct

Blood water level returns to normal

- The **anti-diuretic hormone (ADH)** causes the collecting duct to **reabsorb more water.**

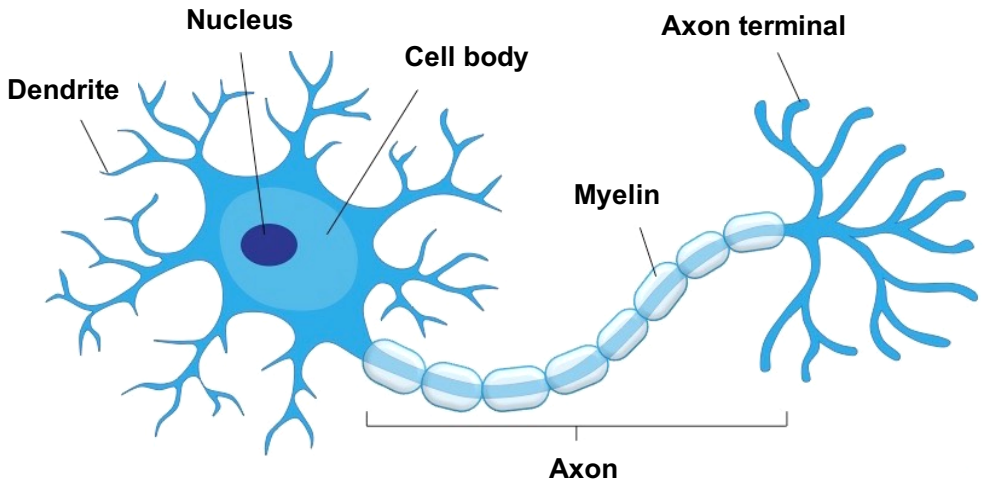
14 COORDINATION AND RESPONSE

THE HUMAN NERVOUS SYSTEM



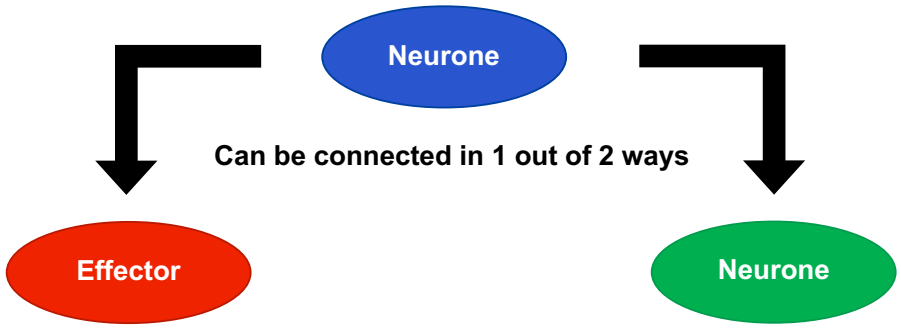
Peripheral nervous system	Central nervous system (CNS)
Nerves that **start** from the **brain** or **spinal cord** and **lead** to other **body organs**	• **Brain** • **Spinal cord**

STRUCTURE OF A NEURONE



Direction of electrical impulse

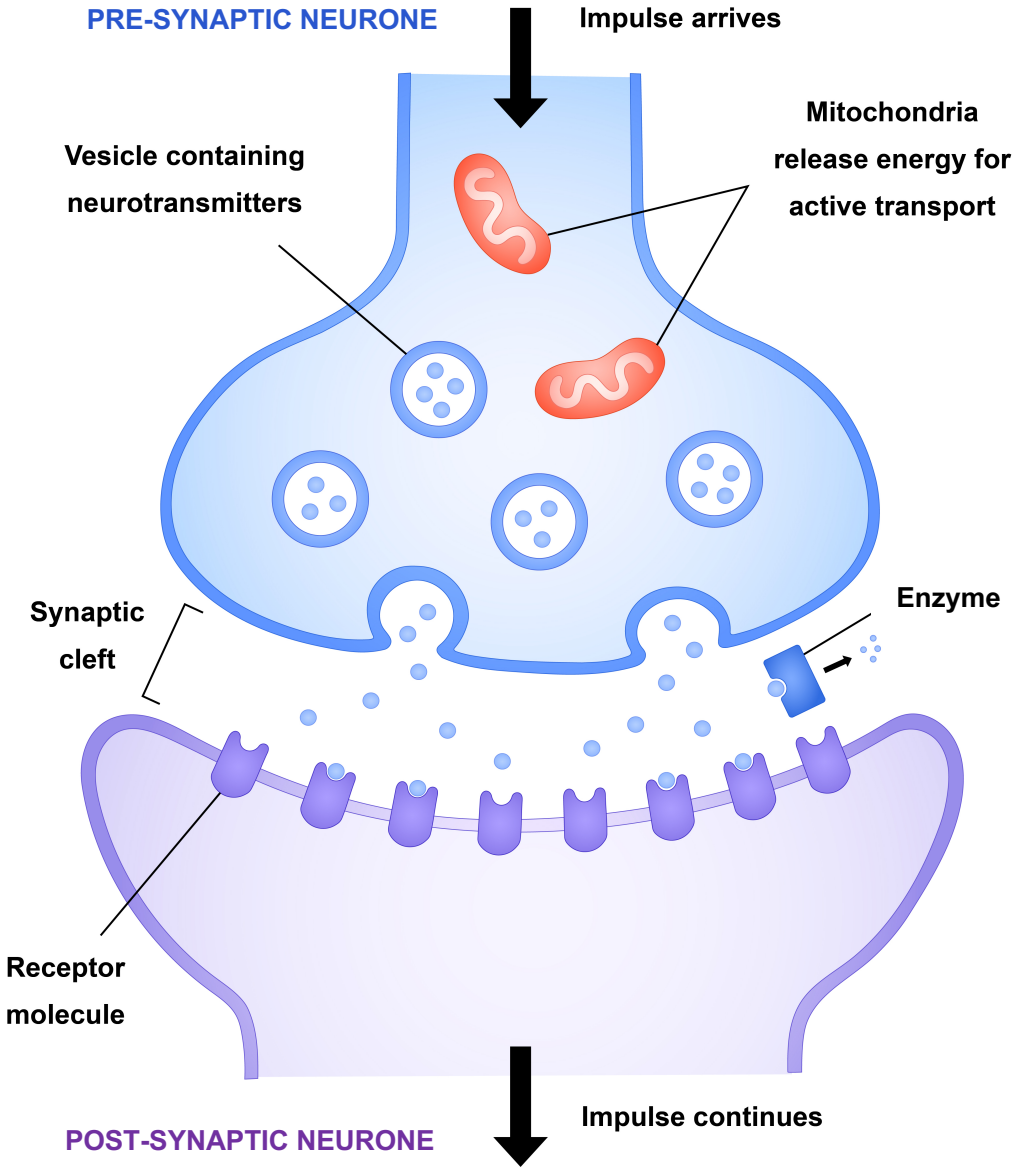
- **Long axon** = can transmit impulses quickly over **long distances**.
- **Myelin sheath** (made of protein and fats) **insulates** the **axon**, which **speeds up** the transmission of electrical impulses.



An impulse must cross a synapse in order to be passed on from one neurone to the next

SYNAPSE BETWEEN TWO NEURONES

A synapse is a junction between two neurones



Impulse triggers vesicles to fuse with the (pre-synaptic) cell membrane

↓

Neurotransmitters are released from vesicles into the synaptic cleft

↓

Neurotransmitters diffuse across the synaptic cleft and bind to specific receptors on the membrane of the next neurone

↓

An electrical impulse is then stimulated in the next neurone, allowing the message to continue

↓

Neurotransmitters are broken down by enzymes in the synapse

ENERGY CHANGES

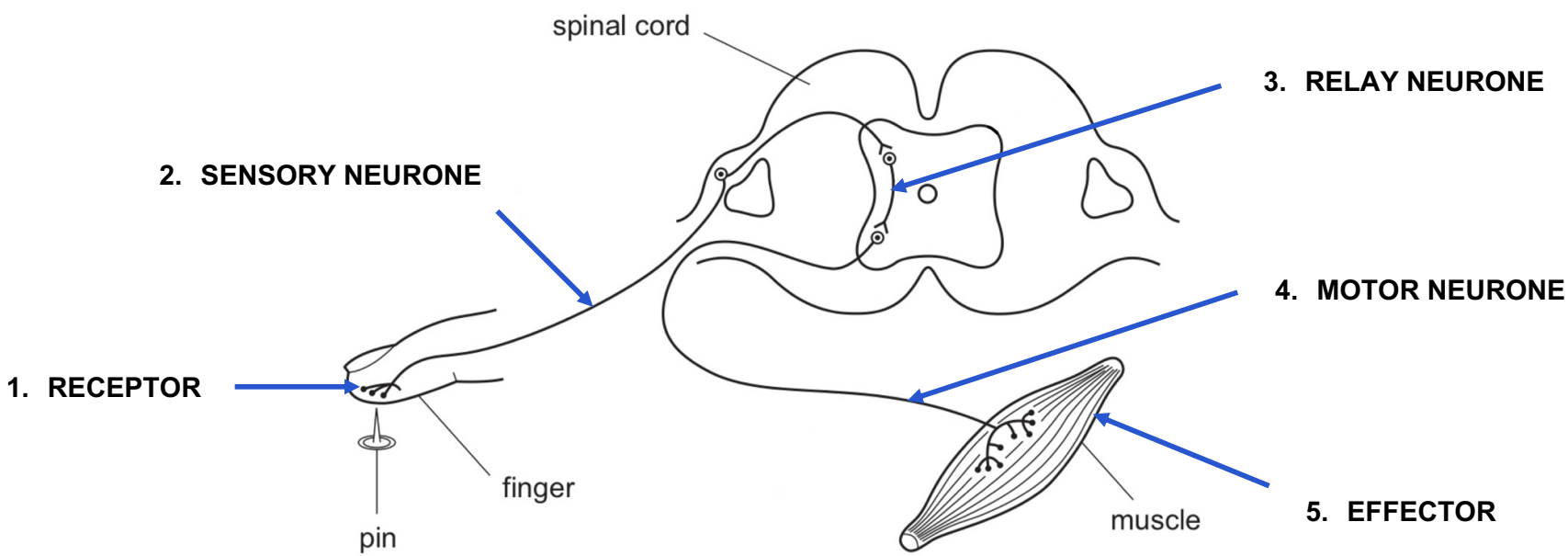
Neurone	Synapse	Neurone
Electrical	→ Chemical	→ Electrical

- Electrical impulses travel from the dendrites to nerve endings of a neurone.
- Since the vesicles that release neurotransmitters are only found at the nerve endings, impulses can only pass in **one direction** across a synapse.

GENERAL PATHWAY FOR NERVE IMPULSES

	A change in the environment	Cells that detect the change	Processes this information	Corrects the change	What finally happens
	Stimulus	**Receptor**	**Coordinator**	**Effector**	**Response**
	Temperature Pressure / sound Light Chemicals	Skin – thermoreceptors Skin – mechanoreceptors Eye – photoreceptors Nose / tongue – chemoreceptors	Central nervous system (CNS) OR Spinal cord only	Muscle which contracts OR Gland which secretes fluid or enzymes	

A REFLEX ARC



STRUCTURE OF THE EYE

Sense organs are **groups** of **receptor cells** responding to **specific stimuli**: **light**, **sound**, **touch**, **temperature** and **chemicals**.

The eye is a sense organ that reacts to light and allows vision.

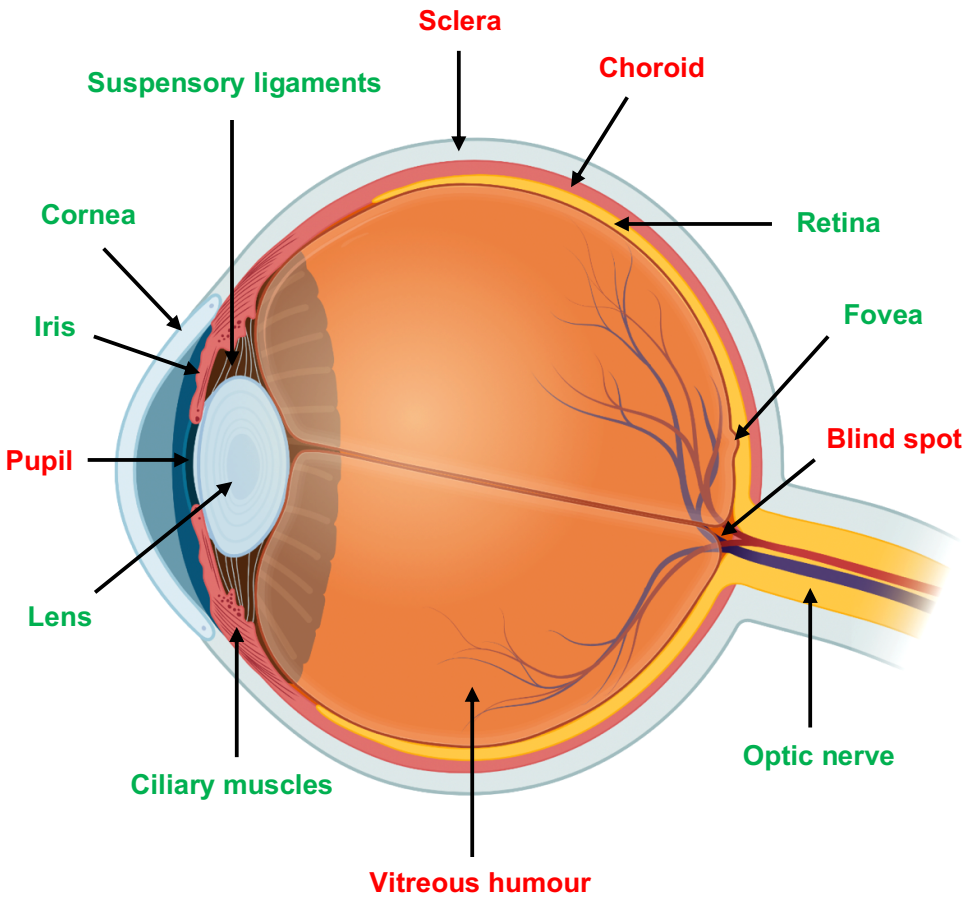


Diagram from BioRender.com

= on syllabus

Structure	Function
Cornea	**Transparent** and **refracts light** onto the **lens**
Lens	Refracts and **focuses light** onto the **fovea**
Retina	**Light-sensitive** tissue Contains **light receptor cells** (**rods** and **cones**)
Fovea	A pit in the retina which gives the **most detailed image** Contains **only** and the **highest concentration** of **cone cells**
Optic nerve	Made up of **sensory neurones** Carries **electrical impulses** to the **brain**
Iris	Controls **how much light** enters the **pupil**
Suspensory ligaments	**Slacken or tighten** to change the **shape** of the **lens** for **focusing**
Ciliary muscles	**Contract or relax** to change the **shape** of the **lens** for **focusing**
Pupil	A **hole** which allows light to enter
Blind spot	Where the **optic nerve** leaves the eye – **no light receptors**
Choroid	Contains a **black pigment** to **absorb light** and stop it being **reflected back out** of the eye
Sclera	**Tough**, **white protective** layer
Vitreous humour	**Jelly-like** and it **maintains** the **inside pressure** and **shape** of the eye

HOW WE SEE A FOCUSED IMAGE

1. Light rays reflect off from an object and enter the cornea
2. Cornea refracts the light rays inwards
3. Light rays pass through the pupil and lens
4. Shape of the lens is changed so that it refracts light either more or less
5. Light rays are focused onto the retina, stimulating light receptors
6. Light receptors generate electrical impulses which are sent to the brain along the optic nerve

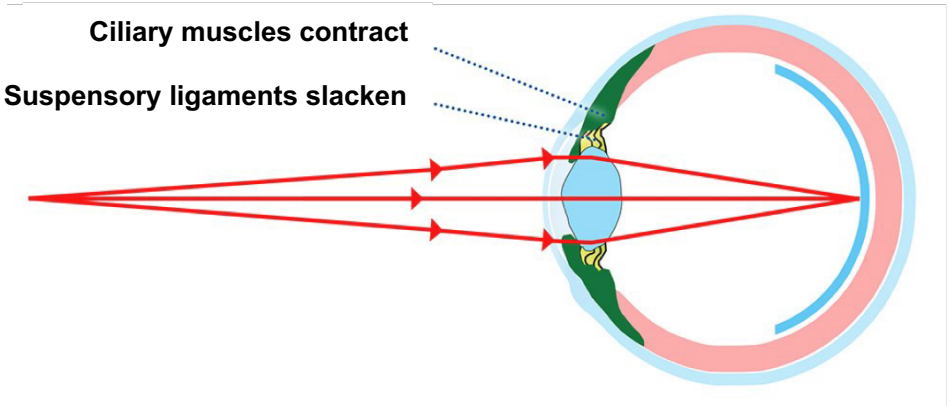
ACCOMMODATION (FOCUSING)

NEAR OBJECT

Incoming light rays diverge greatly

Ciliary muscles contract

Suspensory ligaments slacken



Lens become short and fat (more rounded)

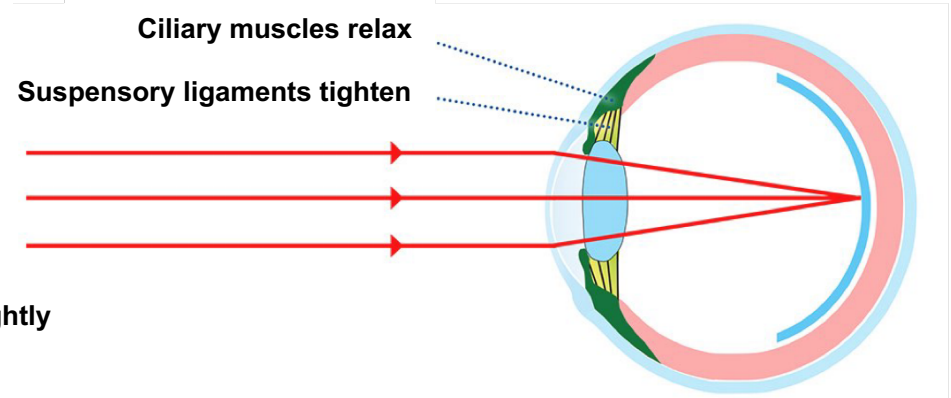
Light is refracted more

DISTANT OBJECT

Incoming light rays diverge only slightly

Ciliary muscles relax

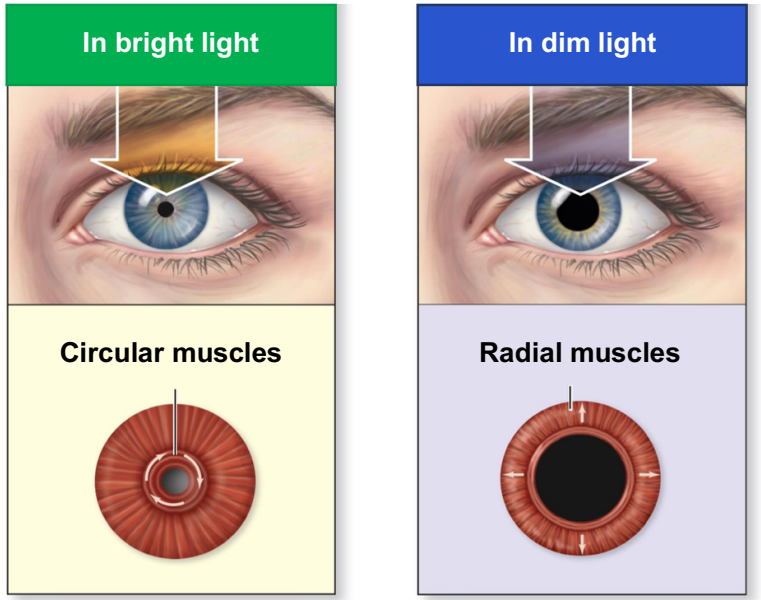
Suspensory ligaments tighten



Lens become long and thin (less rounded)

Light is refracted less

THE PUPIL REFLEX

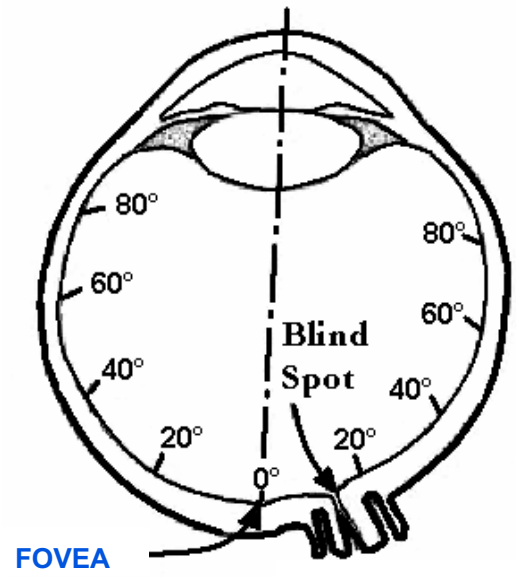


Circular muscles contract Radial muscles relax	Circular muscles relax Radial muscles contract

ROD AND CONE CELLS

	RODS	CONES
Light sensitivity	High	Low
Work in	Dim light (night vision)	Bright light (day vision)
Vision	Black and white	Colour
Number of types	One	Three that respond to red, green & blue light

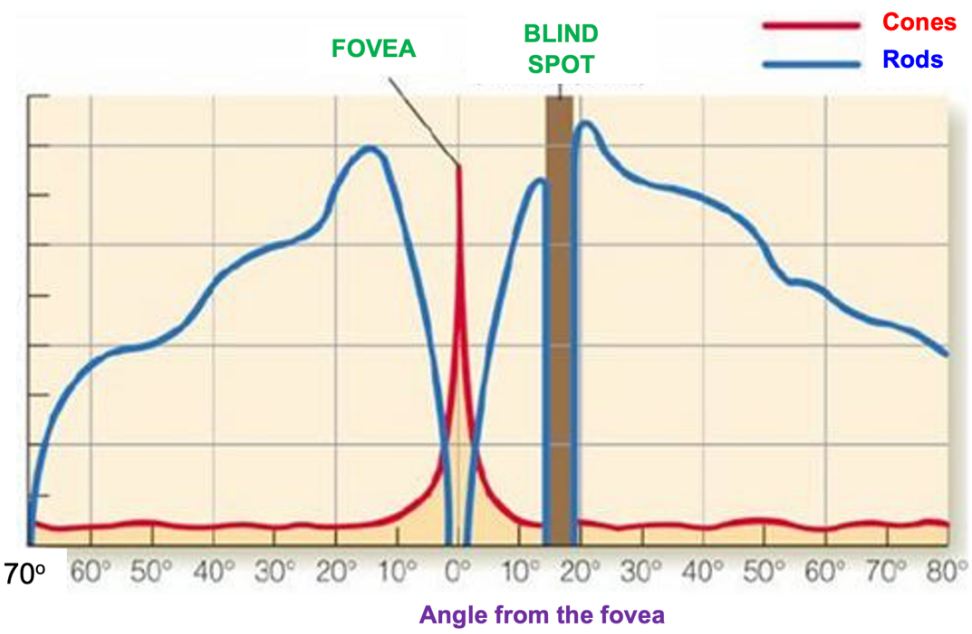
RELATIVE DISTRIBUTION IN THE RETINA



FOVEA

most cone and no rods

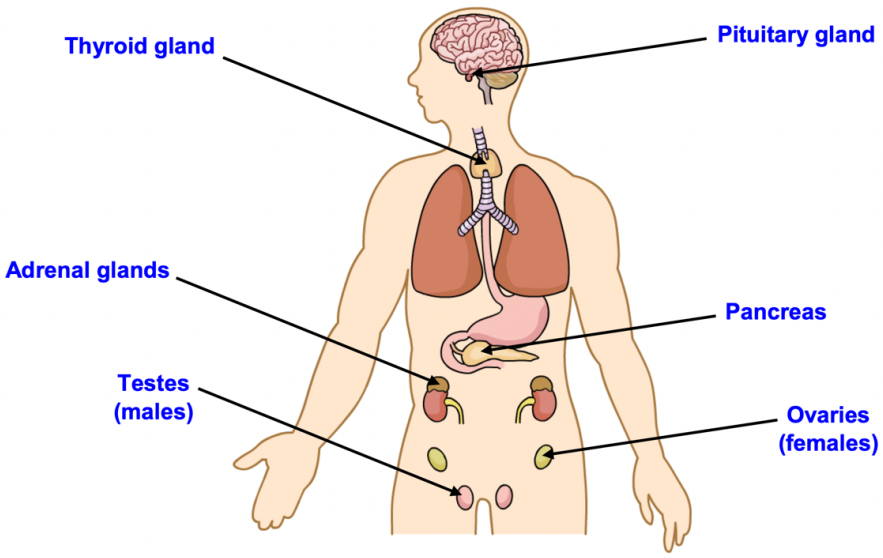
OPTIC NERVE - no light receptors



HORMONES

A hormone is a chemical, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs.

- The **hormonal system** is also known as the **endocrine system**.
- Hormones are **made** by **endocrine glands** (ductless glands) which **release** them **directly** into the **bloodstream**.
- Some endocrine glands also have exocrine functions (such as the pancreas).



Endocrine gland	Main hormone(s) it secretes
Pituitary gland	FSH and LH
Adrenal glands	Adrenaline
Pancreas	Endocrine – insulin and glucagon
Testes	Testosterone
Ovaries	Oestrogen and progesterone

ADRENALINE

- Produced by the **adrenal glands**.
- When we are **nervous**, **frightened** or **excited** = **'fight or flight'** situations.
- Adrenaline **controls** our **metabolic activity** and can get us **away from danger fast**.
- It acts on a **variety** of **organs**:

Target organ	Effect
HEART	**Heart rate** increases
LUNGS	**Breathing rate** increases
LIVER	Stimulates **breakdown** of **glycogen** to **glucose**, causing **blood glucose concentration** to **increase**
EYES	**Pupils** dilate
MUSCLE	**Arterioles** in muscle dilate (widen)
SKIN / GUT	**Arterioles** in skin / gut constrict

This ensures that:

- More glucose and oxygen are diverted to muscles
- (So) more respiration
- (So) more energy released
- (So) more muscle contraction
- To allow us to run faster

Blood is diverted away from the skin and gut as temperature control and digestion are less important when in danger

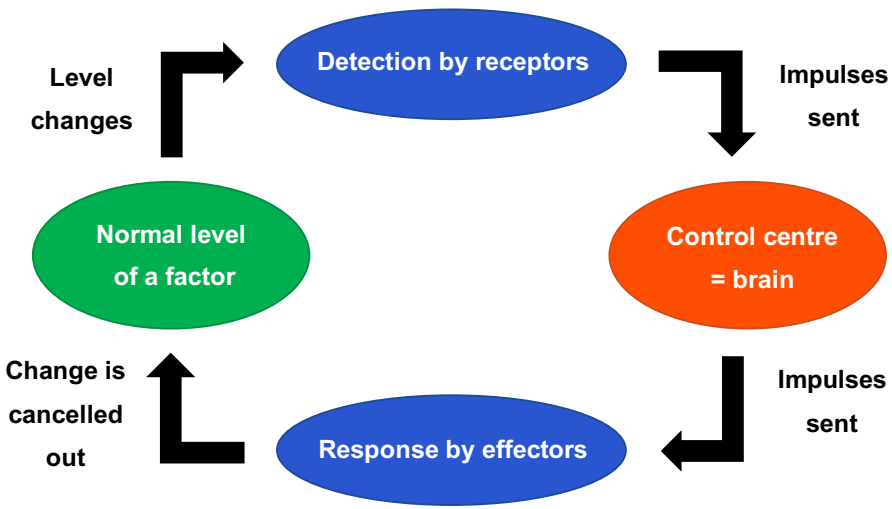
HOMEOSTASIS

Homeostasis is the maintenance of a stable internal environment.

It is the control of internal conditions within set limits.

- Homeostasis is achieved by **negative feedback**, a process where a change automatically sets off a response that offsets that change itself.
- Negative feedback allows a level to **return to normal**, often because a hormone is switched off.

NEGATIVE FEEDBACK LOOP

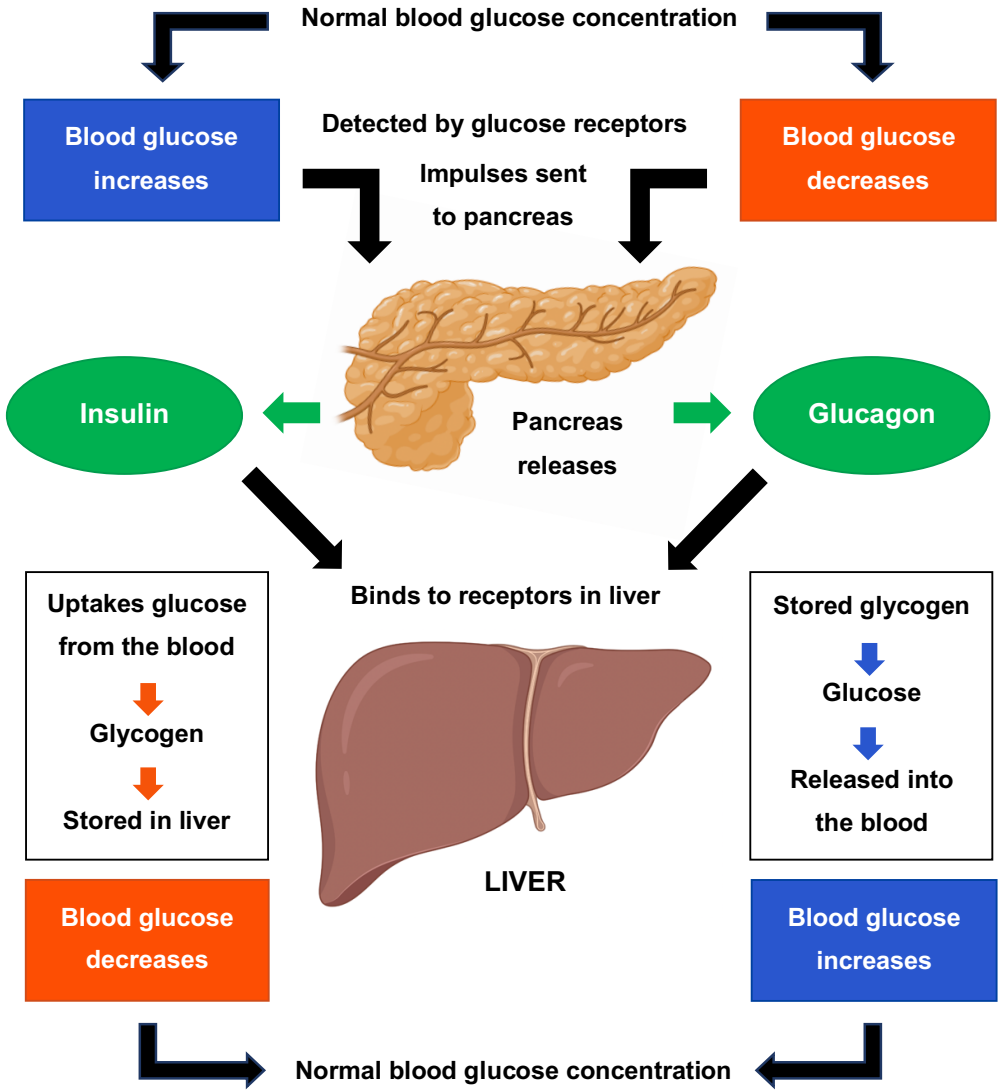


Examples of negative feedback in the human body:

- Control of blood glucose concentration
- Control of body temperature
- Control of water and salt balance (by the kidneys)
- Control of breathing rate

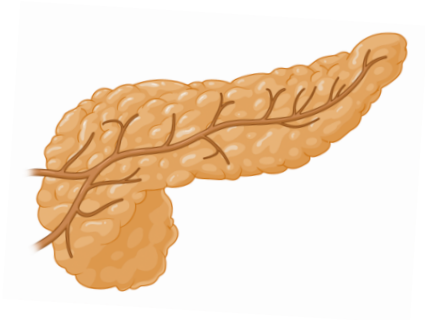
CONTROLLING BLOOD GLUCOSE CONCENTRATION

- Controlled by **two hormones** produced by the **pancreas**: **insulin** and **glucagon**.
- The **target organ** of these hormones is the **liver**.



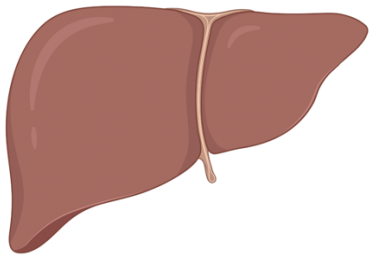
Glycogen is larger than glucose and insoluble, making it ideal as a storage sugar.

TYPE 1 DIABETES



Pancreas cells are damaged by the immune system

Insulin is not secreted



Glucose is not:

- Taken out of the blood
- Converted to glycogen and stored in the liver

Blood glucose concentration is **higher than normal**

- **Treatment involves:** insulin injections, regular blood glucose tests, less carbohydrates in diet, regular meals and exercise.

COMPARING THE NERVOUS AND ENDOCRINE

	NERVOUS SYSTEM	ENDOCRINE SYSTEM
Structures involved	Nerves	Glands
Form of information	Electrical impulses	Chemical hormones
Pathway	Along neurones (to specific effectors)	Transported in blood (throughout the body)
Area of response	Localised	Widespread
Speed of transmission	Faster	Slower
Duration of effects	Short-lived	Longer lasting

STRUCTURE OF SKIN

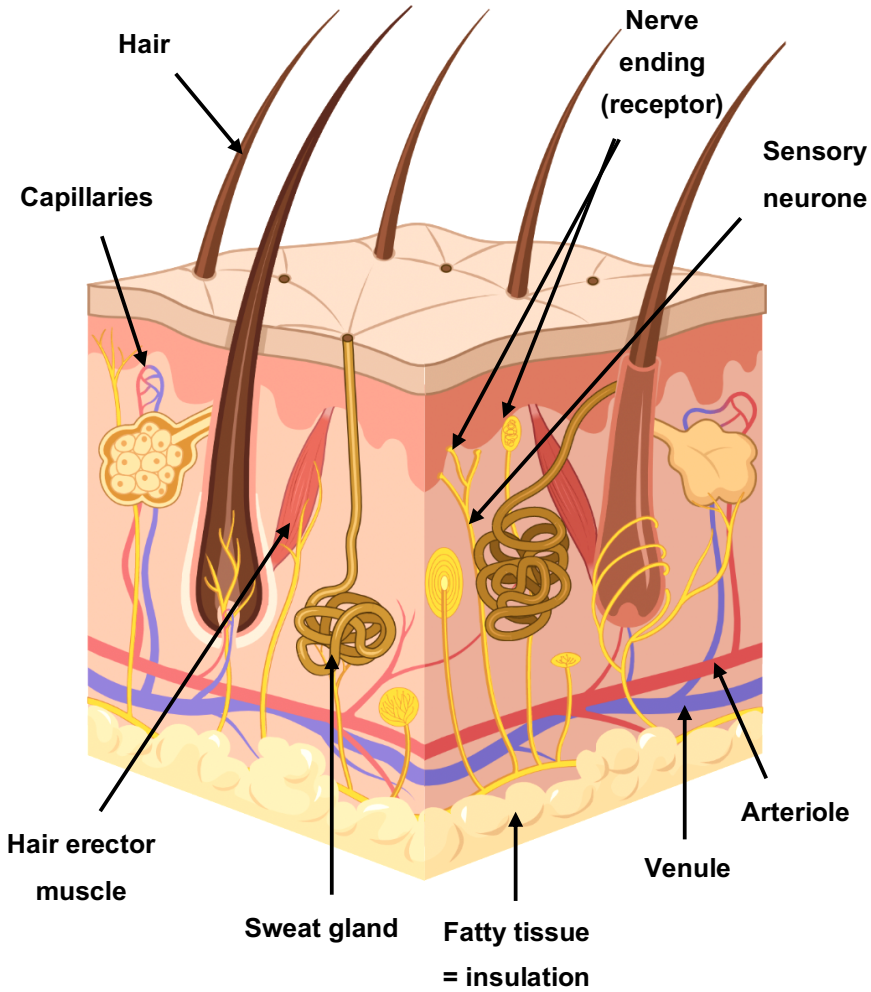


Diagram from BioRender.com

CONTROLLING BODY TEMPERATURE

- **Temperature receptors** detect the change in **temperature** of the **skin** and **blood**.
- The **hypothalamus** in the brain **coordinates** a response by sending **electrical impulses** to **muscles** and **sweat glands**.

	TOO HOT	TOO COLD
SWEATING	Increases More sweat evaporates from skin surface so more heat is lost	Decreases Less sweat evaporates from skin surface so less heat is lost
ARTERIOLES	Muscles relax Widen = vasodilation More blood flows to skin surface capillaries so more heat is lost	Muscles contract Narrower = vasoconstriction Less blood flows to skin surface capillaries so less heat is lost
SHUNT VESSELS	Constrict	Dilate
SHIVERING	Decreases	Increases Muscles contract more often Respiration increases More heat energy released
HAIRS ON SKIN	Hair erector muscles relax Hairs do not stand up Allows movement of air across the skin Less air insulation	Hair erector muscles contract Hairs stand up A layer of air is trapped between them More air insulation

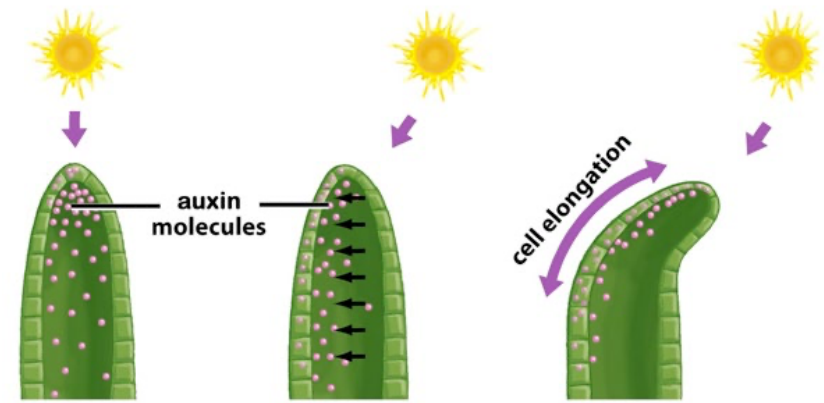
PLANT TROPISMS

Phototropism
A response in which parts of a plant grow towards or away from the direction of the **light source**

Gravitropism
A response in which parts of a plant grow towards or away from the direction of **gravity**

	Shoots	Roots
Phototropism	**Positively** phototropic towards light	**Negatively** phototropic away from light
Gravitropism	**Negatively** gravitropic opposite direction as gravity	**Positively** gravitropic same direction as gravity

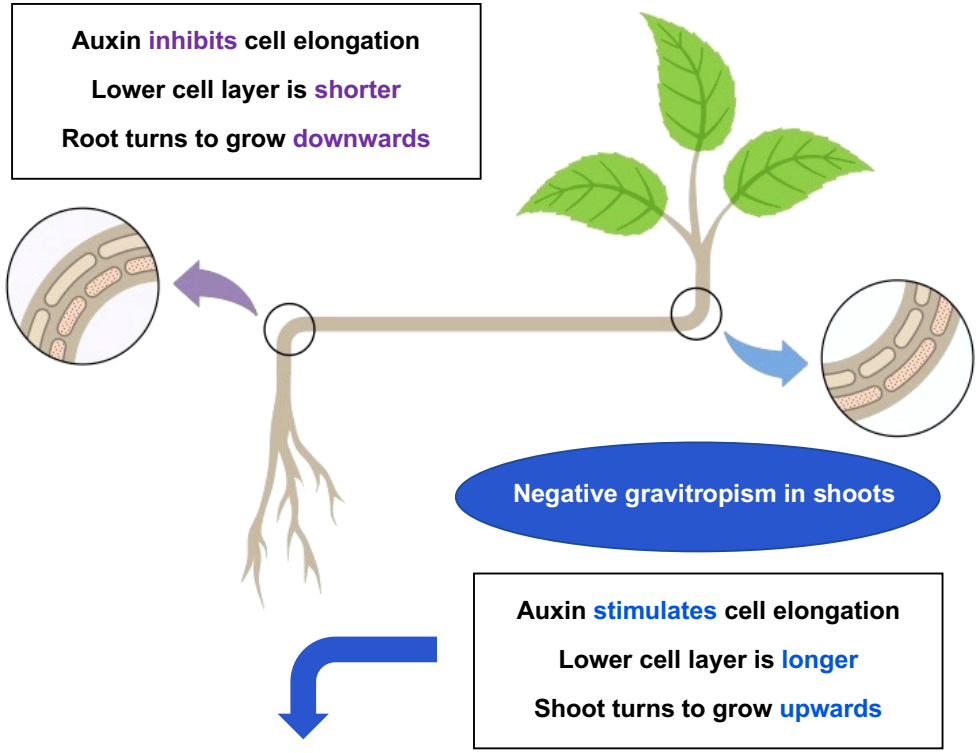
POSITIVE PHOTOTROPISM IN SHOOTS



- **Auxin** is **produced** at the **shoot tip**.
- **Light** is **detected** by the shoot tip, causing **more auxin** to **diffuse** down the **shaded side** of the stem than the side facing light.
- Accumulation of **auxin** causes **more cell elongation** on the **shaded side** by making cells absorb more water, so the shoot **bends towards the light**.

Positive gravitropism in roots

Auxin **inhibits** cell elongation
Lower cell layer is **shorter**
Root turns to grow **downwards**



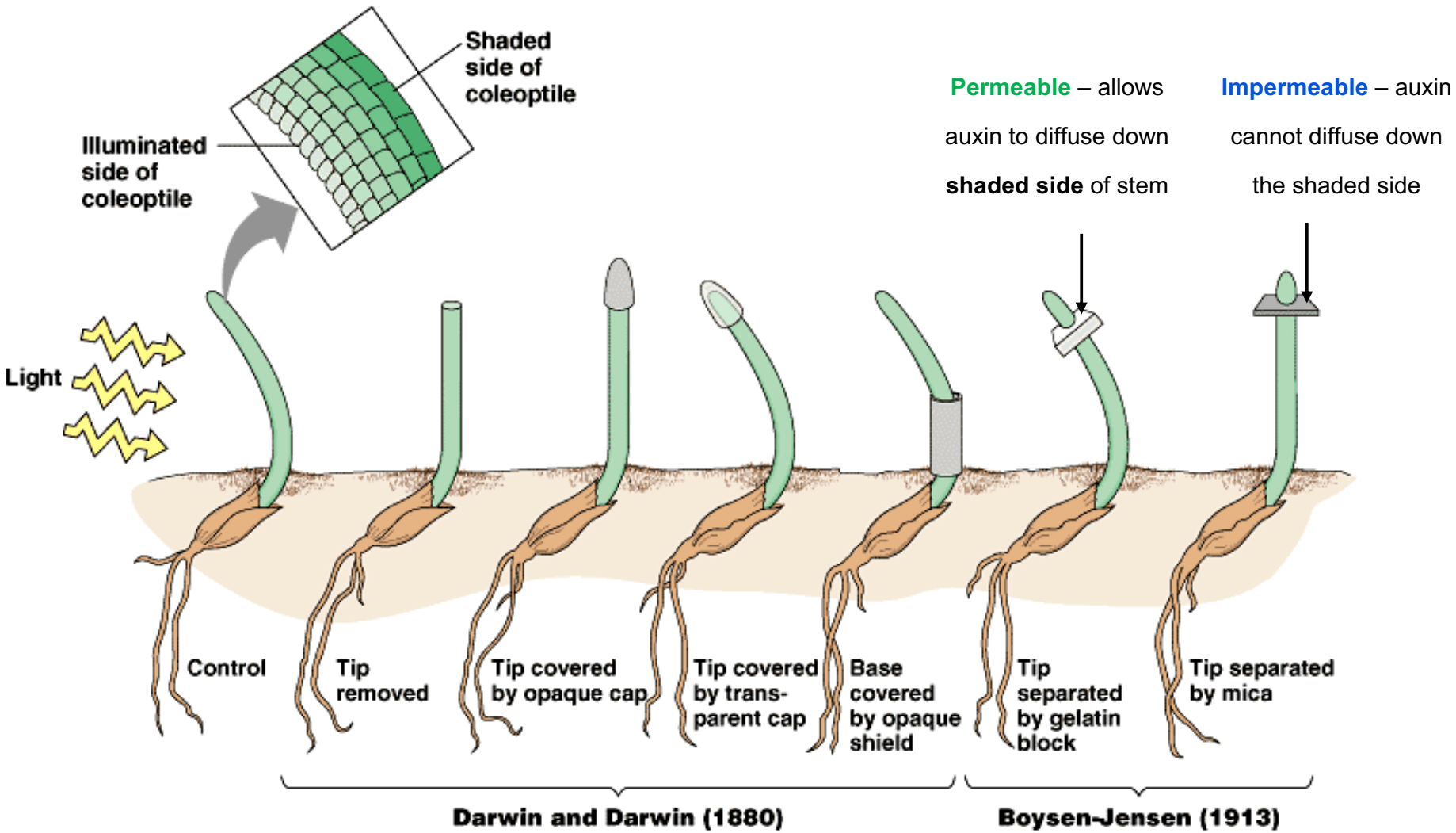
Negative gravitropism in shoots

Auxin **stimulates** cell elongation
Lower cell layer is **longer**
Shoot turns to grow **upwards**

- **Auxin** is **produced** at the **shoot tip**.
- **Gravity** is **detected** (by organelles called statoliths), causing **more auxin** to **diffuse** across the stem and **collect** on the **lower side**.
- **Auxin** causes **more cell elongation** on the **lower side**, so the shoot **bends upwards away from the pull of gravity.**

- Scientists believe that both root and shoot growth are affected by auxin.
- It is thought that root and shoot cells have different levels of sensitivity to auxin, so that the same concentration of auxin inhibits cell elongation in roots but stimulates cell elongation in shoots.

EXPERIMENTS ON PHOTOTROPIC RESPONSES



15 DRUGS

DEFINITION

A drug is any substance taken into the body that modifies or affects chemical reactions in the body

HOW ANTIBIOTICS WORK

- Antibiotics are drugs used to treat bacterial infections.
- Antibiotics kill bacteria by acting on targets that are absent or different in human cells, so that our cells will not be harmed.
- They do not affect viruses which do not have any antibiotic targets.

PREVENT CELL WALL SYNTHESIS

- (So) bacteria will burst (lyse)
- Human cells do not have cell walls

PREVENT PROTEIN SYNTHESIS

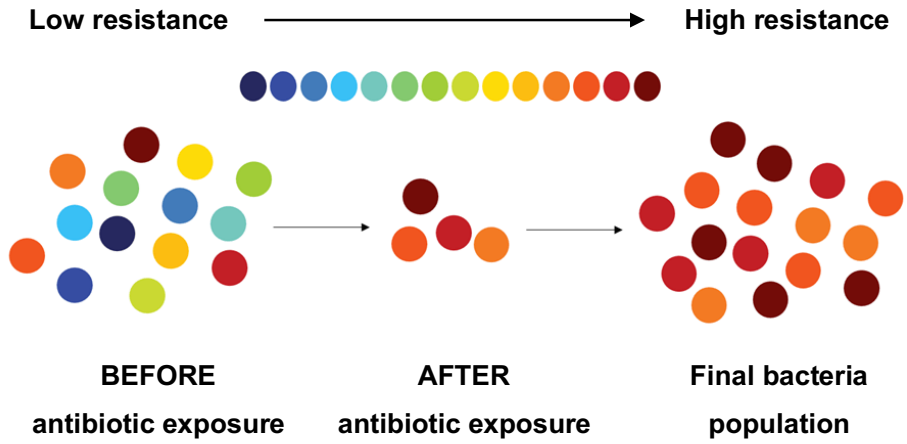
- (So) bacteria cannot make enzymes
- Human ribosomes have a different structure

PREVENT DNA SYNTHESIS

- (So) bacteria cannot reproduce
- Human enzymes used to make new DNA have a different structure

ANTIBIOTIC RESISTANT BACTERIA

- Antibiotic resistance can develop in populations of bacteria, which reduces the effectiveness of antibiotics.
- MRSA is a type of bacteria that is resistant to several antibiotics.



MINIMISING DEVELOPMENT OF ANTIBIOTIC RESISTANCE

1. Doctors should **prescribe** antibiotics **less often**.
2. **Do not prescribe** antibiotics for **viral infections**.
3. Make sure people **complete the full course** of antibiotics.
4. Use **different combinations** of antibiotics.
5. **Do not** use the **same antibiotic for too long**.
6. **Reduce** the use of antibiotics in **farming** (e.g. cattle).
7. **Isolate patients** with **antibiotic-resistant** strains of **bacteria**.

16 REPRODUCTION IN HUMANS

MALE REPRODUCTIVE SYSTEM

Prostate gland

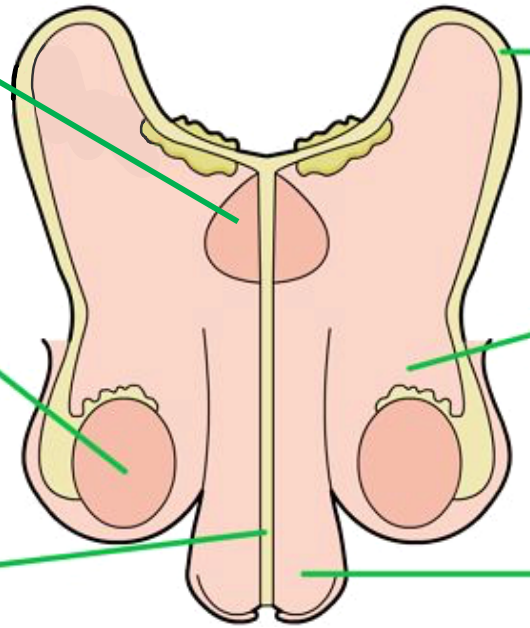
Secretes mucus, which mixes with sugars to form semen. This allows sperm to respire so they can swim.

Testicle

Produce sperm and the sex hormone testosterone

Urethra

Carries urine or sperm out of the body – but never both together.



Sperm duct

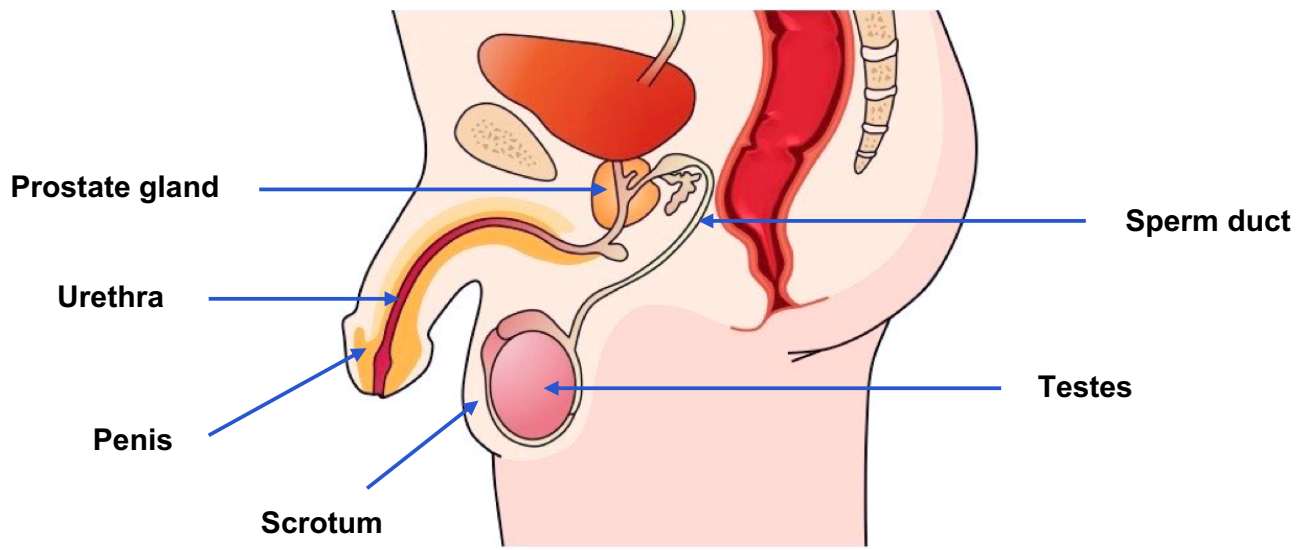
Carries sperm from the testes to the urethra.

Scrotum

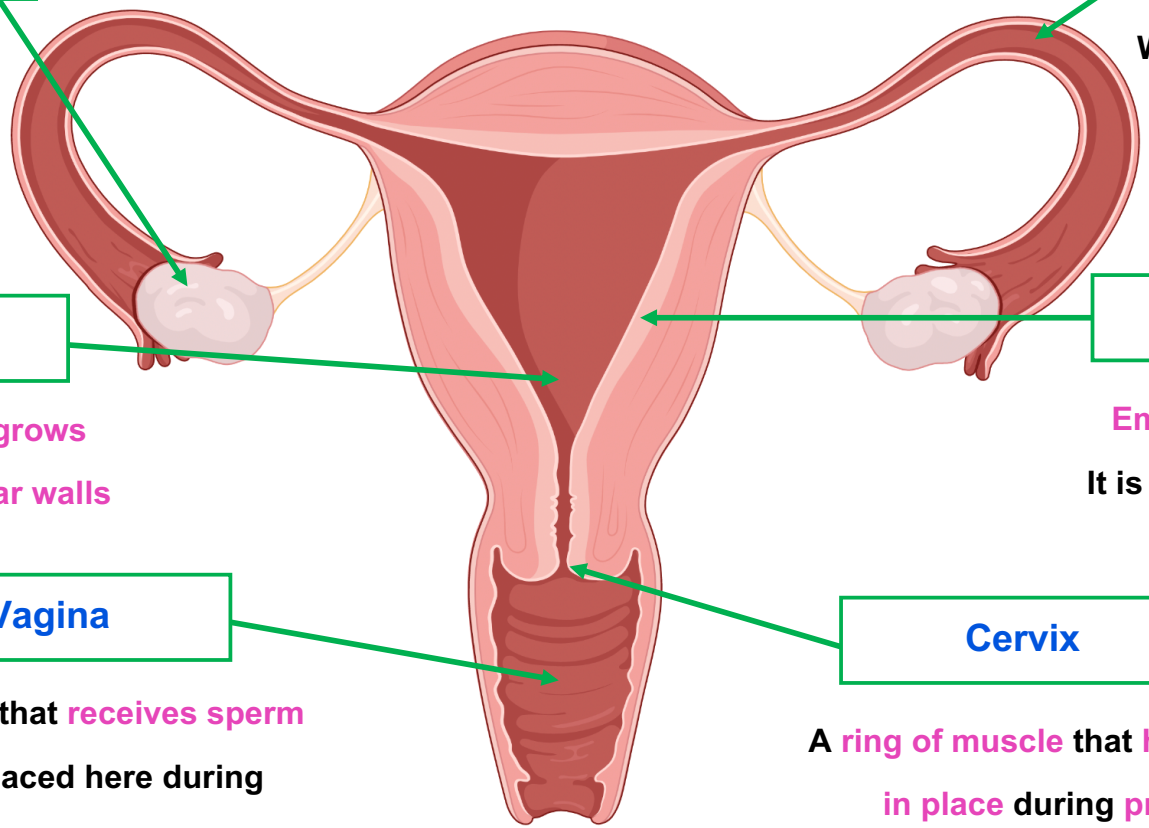
A bag of skin that holds the testes outside the body. This keeps them cooler for better sperm development.

Penis

Passes semen into the vagina of the female during sexual intercourse.



FEMALE REPRODUCTIVE SYSTEM



Ovary

Produces, stores and releases eggs

Oviduct

Where fertilisation happens

Uterus

Where the embryo grows

It has strong muscular walls

Uterus lining

Embryo attaches here

It is thick and has a good blood supply

Vagina

A muscular tube that receives sperm

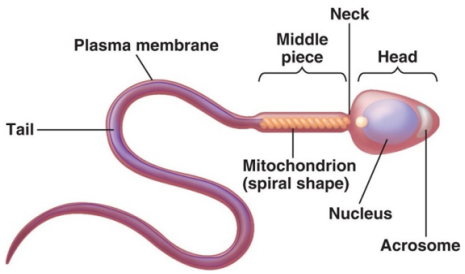
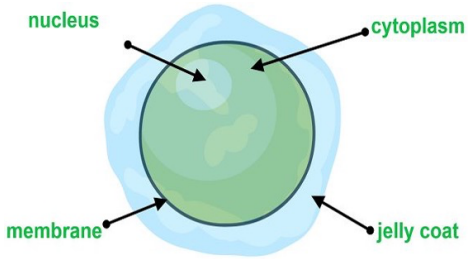
The penis is placed here during sexual intercourse

Cervix

A ring of muscle that holds the baby in place during pregnancy.

It is the opening to the uterus.

SPERM AND EGG CELLS

SPERM CELL	EGG CELL
	
Flagellum allows **movement**	**Jelly coat** **hardens** after **fertilisation** so **no more sperm** can **enter**
Mitochondria – aerobic **respiration** releases **energy** for **movement**	**Jelly coat** releases **chemicals** that **attract sperm**
Acrosome contains **digestive enzymes** that **break down** the **egg cell membrane**, so the sperm and egg nuclei can fuse	**Large cytoplasm** with **energy stores** to make **new cell structures**, **enzymes** And provide **energy** for **cell division**
Haploid nucleus ensures **diploid** number is **restored** at fertilisation	**Haploid nucleus** ensures **diploid** number is **restored** at **fertilisation**

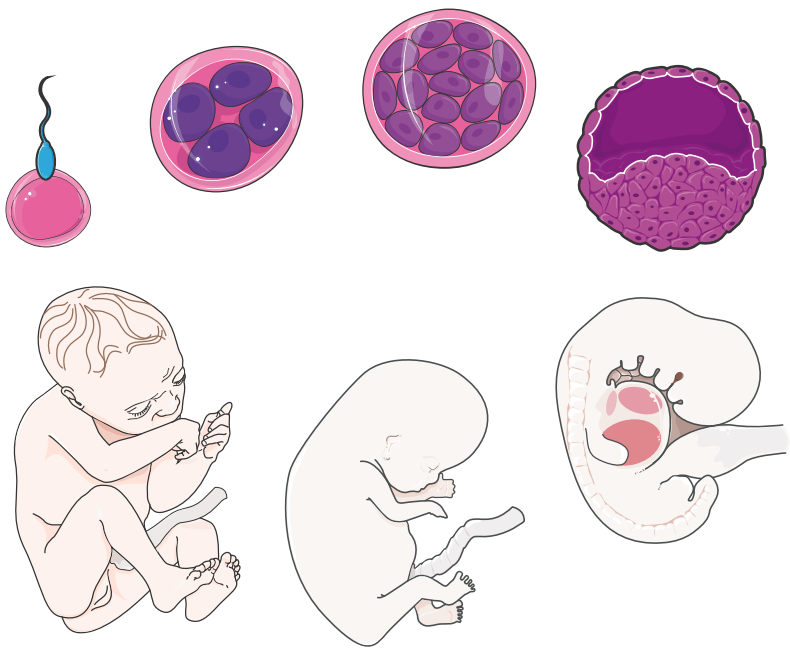
	SPERM CELL	EGG CELL
Size	**Small**	**Larger**
Mobility	**Motile**	**Not motile**
Structure	**Flagellum** **Many mitochondria** **Acrosome**	**Large cytoplasm** **Jelly coat**
Food store	**No**	**Yes**
Number released	**Millions (many)**	**One per month (few)**
When produced	**Puberty**	**Before birth**

FERTILISATION

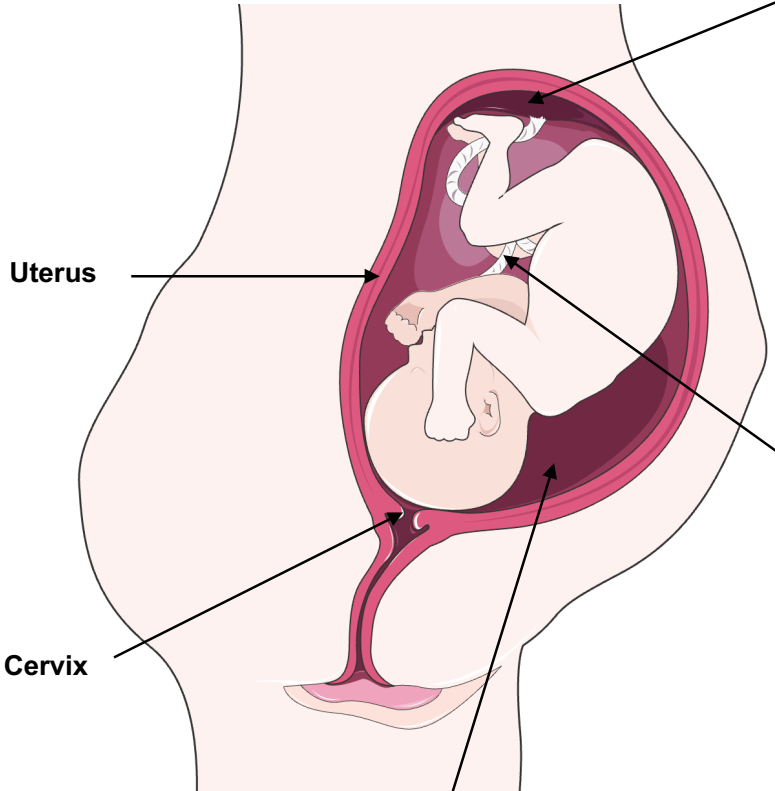
Fusion of the nuclei from the male gamete (sperm) and female gamete (egg) to form a diploid zygote

EMBRYO DEVELOPMENT

- The single fertilised egg (**zygote**) **divides** by **mitosis** to form an **embryo** (a ball of cells).
- The embryo travels down the **oviduct** to the **uterus**, and **implants** into the **uterus lining**.
- The **placenta** releases **progesterone** to **maintain** the **uterus lining**.
- **Exchange of substances** between the mother and fetus occurs through the **placenta** and **umbilical cord** by **diffusion**.



DURING PREGNANCY

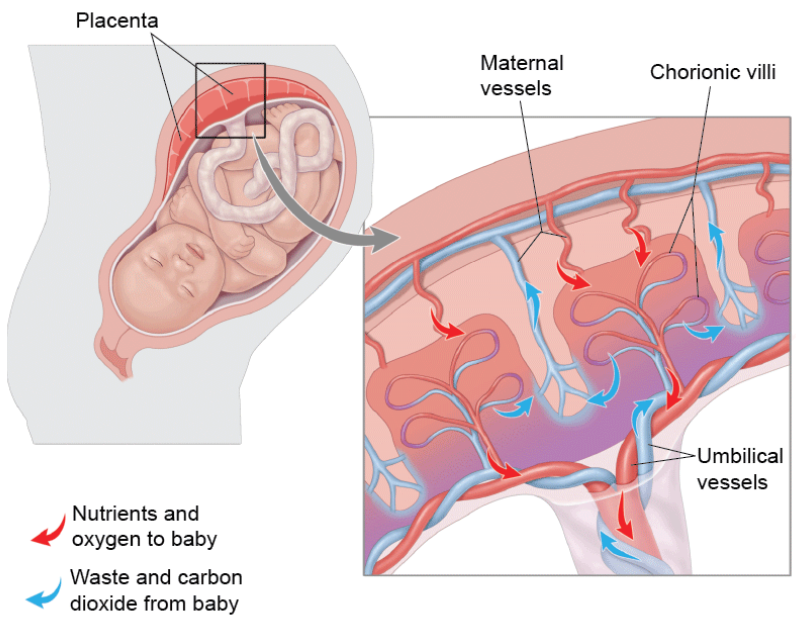


PLACENTA

1. **Exchanges materials between maternal and fetal blood without direct contact – they are separated by a membrane.**
   - **Dissolved nutrients** and O_2 to the child
   - **Waste** such as CO_2 and **urea** to mum
2. **Protects the fetus:**
   - From the mother's immune system
   - Against dangerous fluctuations in the mother's blood pressure
3. **A barrier to toxins and pathogens** (but **not nicotine** or **rubella virus**)
4. **Produces most progesterone during pregnancy to maintain the uterus lining.**

UMBILICAL CORD

- Connects the **placenta** to the **fetus**
- Carries **dissolved nutrients**, **gases** and **waste** between the two



AMNIOTIC SAC

Contains amniotic fluid that has many functions:

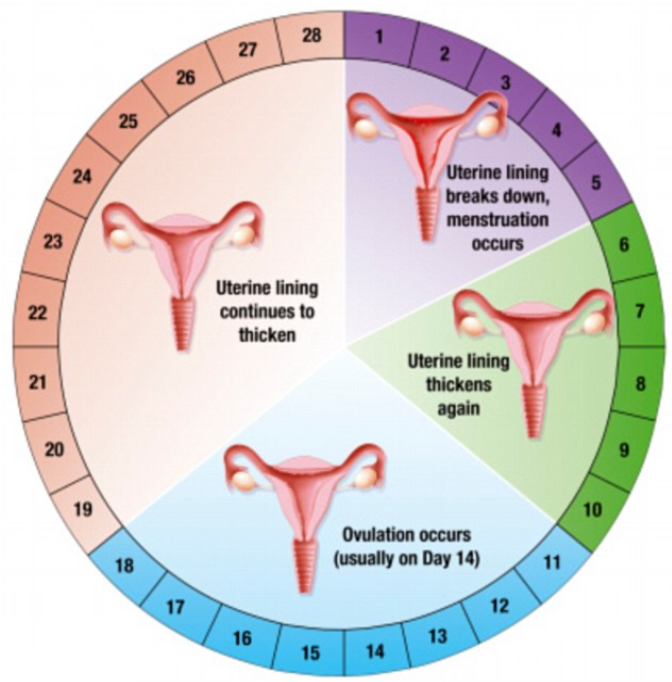
- acts as a **shock absorber** to protect the fetus from knocks
- maintains the **temperature**
- provides a **sterile environment**
- provides **support**
- provides **lubrication**
- allows some **movement** of the fetus

MALE AND FEMALE SEX HORMONES

Testosterone Boy → Man	Oestrogen Girl → Woman
Growth of male sex organs	Growth of female sex organs
Testes make sperm cells	Start of menstrual cycle
Facial hair growth	Body parts grow hair
Voice deepens	Breasts develop
Muscle growth	Hips widen

THE MENSTRUAL CYCLE

- **Prepares** a woman's body for **pregnancy** by **thickening the uterus lining** and **releasing an egg** (ovulation).
- A **period** marks the very start of this cycle.



HOW HORMONES CONTROL THE MENSTRUAL CYCLE

- The **pituitary gland** releases the hormones **FSH** and **LH**.
- The **ovaries** release the hormones **oestrogen** and **progesterone**.

START

FSH
Ripens an egg
Stimulates oestrogen release

LH
Causes ovulation
Stimulates progesterone release

Oestrogen
Thickens uterus lining
Stimulates LH release

Progesterone
Thickens uterus lining
Inhibits FSH and LH release

EGG IS FERTILISED **OR** **EGG IS NOT FERTILISED**

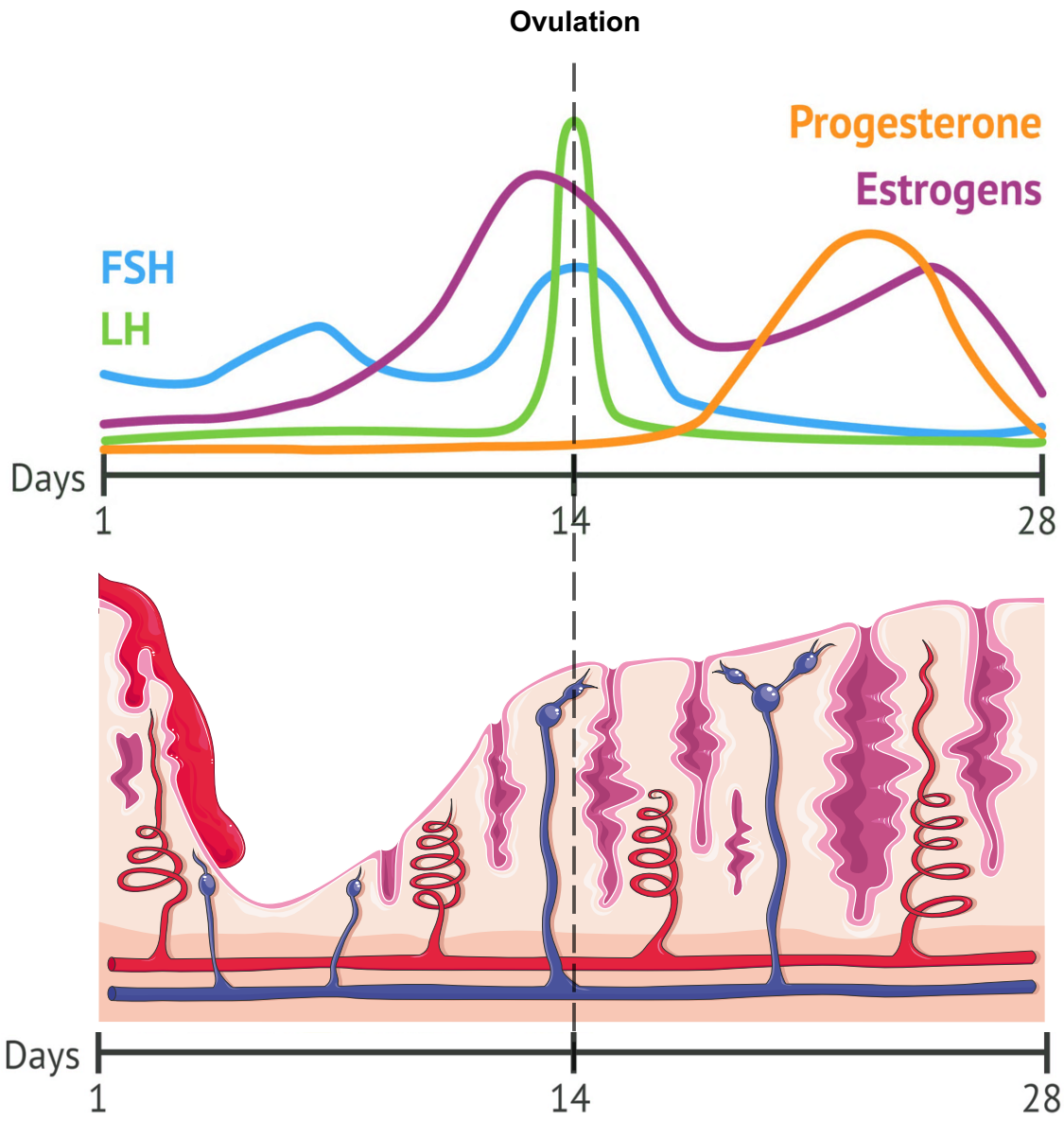
Progesterone level increases

Progesterone level falls

FSH and LH are inhibited
Stops ripening / releasing of eggs
Thick uterus lining is maintained

Uterus lining leaves the body with blood (a period)
Menstrual cycle restarts

HORMONE LEVELS DURING THE MENSTRUAL CYCLE



- The optimum conditions for implantation remains for **6-7 days** after **ovulation**, and is maintained by an **increasing** concentration of **progesterone**.

SEXUALLY TRANSMITTED INFECTIONS (STIs)

- The **human immunodeficiency virus (HIV)** destroys **lymphocytes** in the body, meaning that **less antibodies** can be produced.
- **AIDS** (acquired immunodeficiency syndrome) is the late stage of HIV infection, diagnosed when a person's T cell count falls below a specific threshold, or if they develop opportunistic infections.

HIV is transmitted by…

- Having sex without a condom
- From mother to baby across the placenta and in breast milk
- Sharing injecting equipment
- Unscreened blood transfusions & organ transplants

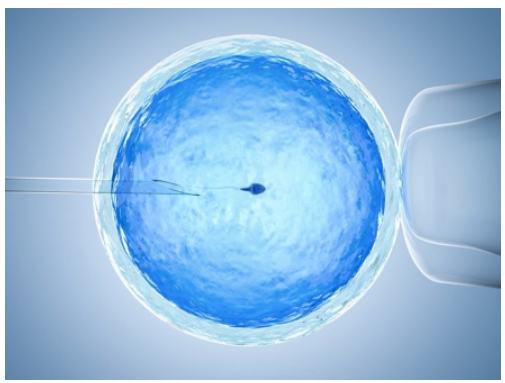
HIV is NOT transmitted by…

- Saliva, e.g. kissing, sneezing, coughing, sharing cutlery
- Insect bites
- Touching
- Sharing toilet seats

FERTILITY METHODS

IN-VITRO FERTILISATION (IVF)

"In-vitro" = **outside** a living organism. **Egg cells** are **removed** from a woman's **ovaries** and **fertilised** with sperm in a **laboratory**.

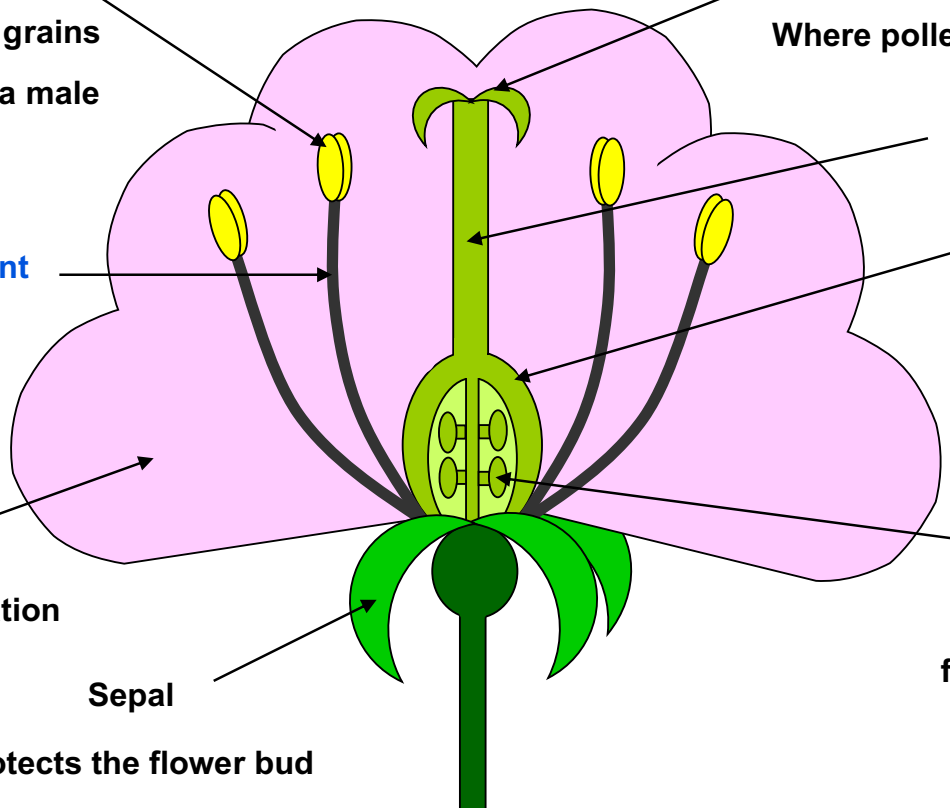


ARTIFICIAL INSEMINATION (AI)

Sperm cells are directly **injected** into a woman's **uterus** (**fertilisation** happens **inside the body**).

16 REPRODUCTION IN PLANTS

FLOWER STRUCTURE



Stamen
= male sex organs

Anther
Produces pollen grains each containing a male gamete

Filament

Stigma
Where pollen grains land

Style

Ovary
Contain ovules (egg cells) for fertilisation

Ovule
Contains the female gamete (nucleus)

Carpel
= female sex organs

Petal
Attract insects for pollination

Sepal
Protects the flower bud from wind and cold

- The primary function of a **flower** is **reproduction** – to produce sex cells and ensure that fertilisation occurs.
- Most flowers have **both male** and **female** sexual organs on the same individual (can **self-pollinate**).

Plants can reproduce both sexually and asexually

Sexual reproduction

A process resulting in the production of genetically different offspring, which involves the fusion of the nuclei of two gametes to form a zygote

- **Self-pollination**
- **Cross-pollination**

Asexual reproduction

A process resulting in the production of genetically identical offspring from one parent

E.g. potato stem tubers, strawberry runners

Offspring grow by mitosis – gametes are not involved

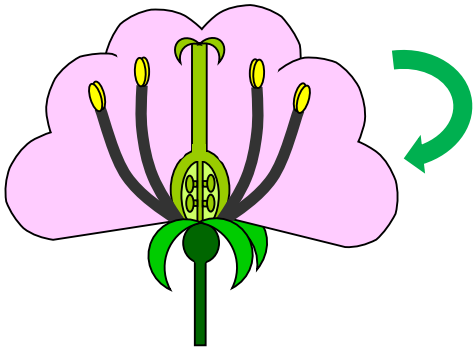
Pollination and fertilisation do not occur

	Advantages	Disadvantages
SEXUAL REPRODUCTION	• **More genetic variation** • **More able** to **adapt to changes** in the **environment** • Can **disperse seeds** to **colonise new areas** if the **environment** is **unfavourable**	• May need **two plants** – relies on **pollinator** • **Slow** • **Pollen / seeds** are **wasted** • (So) **energy is lost**
ASEXUAL REPRODUCTION	• Only **one parent** needed – **no pollinators** • **Fast** • **No sex cells** are needed – **saves energy** • Advantageous **adaptations** of **parent plant** will be passed on to **all offspring**	• **No genetic variation** • **Less able** to **adapt to changes** • May **all be killed** by the **same infectious disease**

SELF VS. CROSS POLLINATION

The transfer of pollen grains from the anther to the stigma of:

TWO TYPES OF POLLINATION

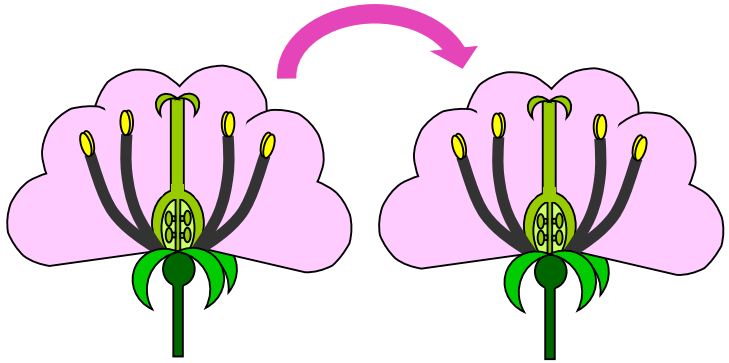


Self-pollination

the same flower

OR:

a different flower on the same plant



Cross-pollination

a flower on a different plant

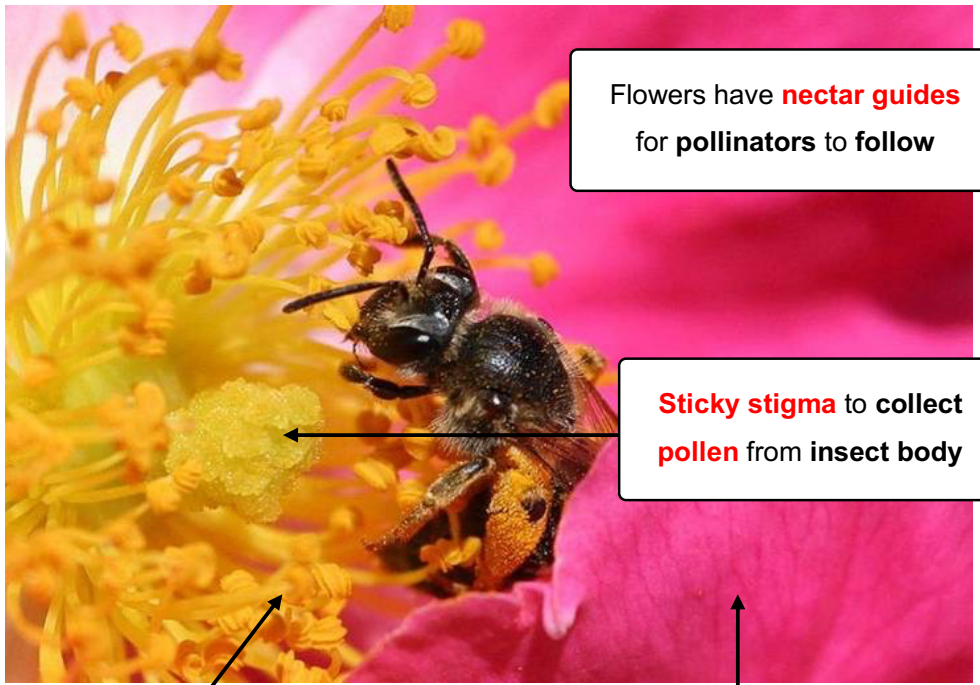
of the same species

- Self-pollination increases the chances of pollination and fertilisation.
- This is useful if a plant is geographically isolated from others.
- However, there are still many disadvantages due to the limited genetic variation.

	SELF-POLLINATION	CROSS-POLLINATION
Genetic variation	Lower	Higher
Capacity to respond to environmental changes	Lower	Higher
Needs a pollinating agent (insects / wind)	No	Yes

INSECT VS. WIND POLLINATED FLOWERS & THEIR POLLEN GRAINS

Insect-pollinated flower

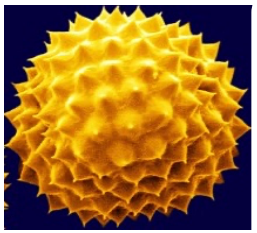


Flowers have **nectar guides** for **pollinators** to **follow**

Sticky stigma to **collect pollen** from **insect body**

Anthers firmly positioned to **transfer pollen** when **insects brush against them**

Large, brightly coloured petals Usually are **scented** and **produce nectar** to **attract insects**

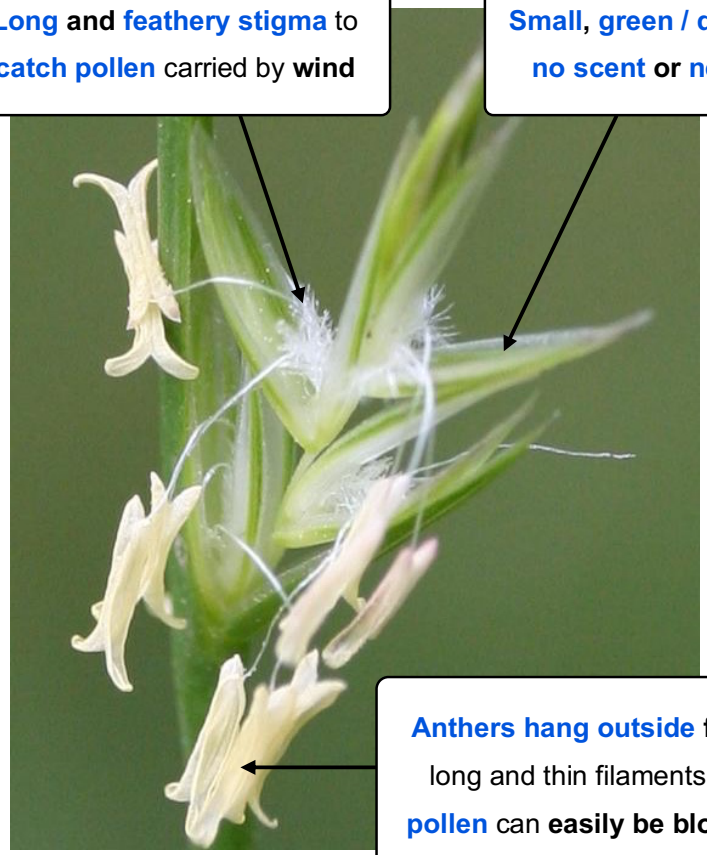


- **Larger**
- Produced in **smaller numbers**
- **Sticky** and **spiky** for **attachment** to hairs on the insect's body

Wind-pollinated flower

Long and feathery stigma to **catch pollen** carried by **wind**

Small, green / dull petals **no scent or nectaries**

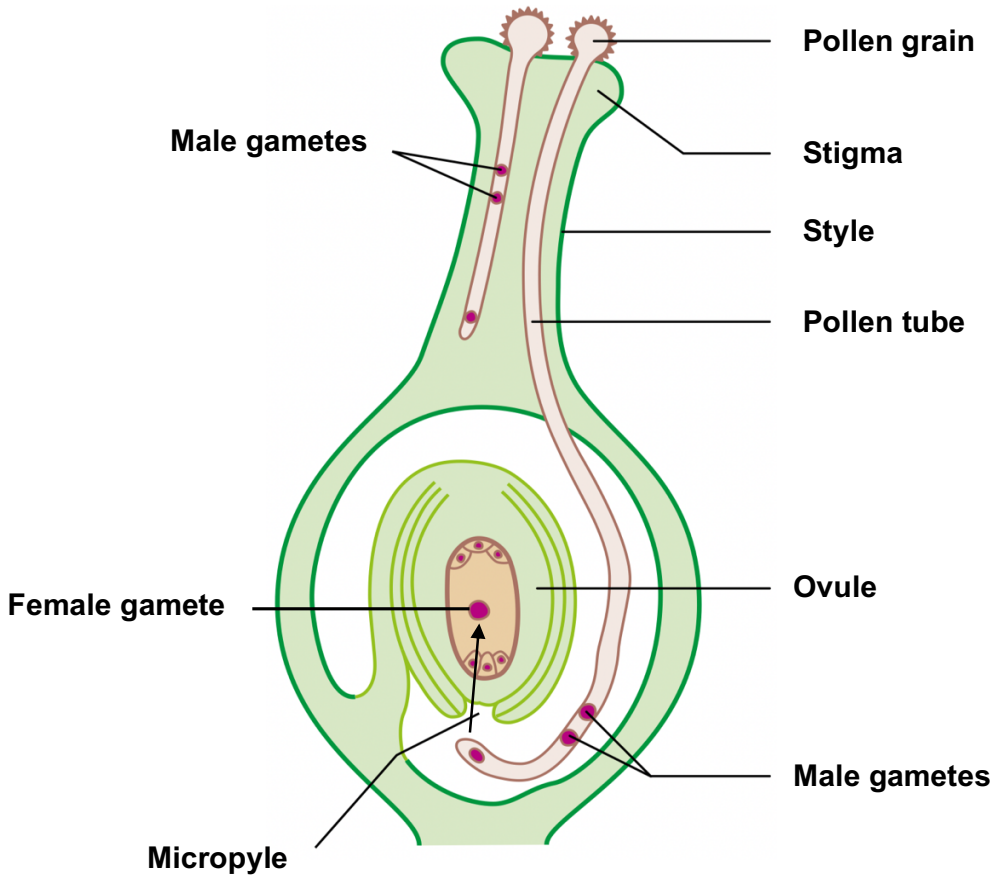


Anthers hang outside flower on long and thin filaments, so that **pollen** can **easily be blown away**

- **Smaller**
- Produced in **larger numbers**
- Have **'wings'**
- Smooth and light – easily carried by wind

POLLINATION, FERTILISATION TO SEED & FRUIT FORMATION

Fertilisation occurs when the nuclei of a pollen grain and an ovule join



- **Pollen grain** lands on **stigma** = **pollination**
- **Pollen tube** forms and **grows down** through the **style** to the **ovary**
- Pollen tube **enters** the **ovary** through its micropyle
- **Pollen grain nucleus** is released and **fuses** with an **ovule nucleus** = **fertilisation**

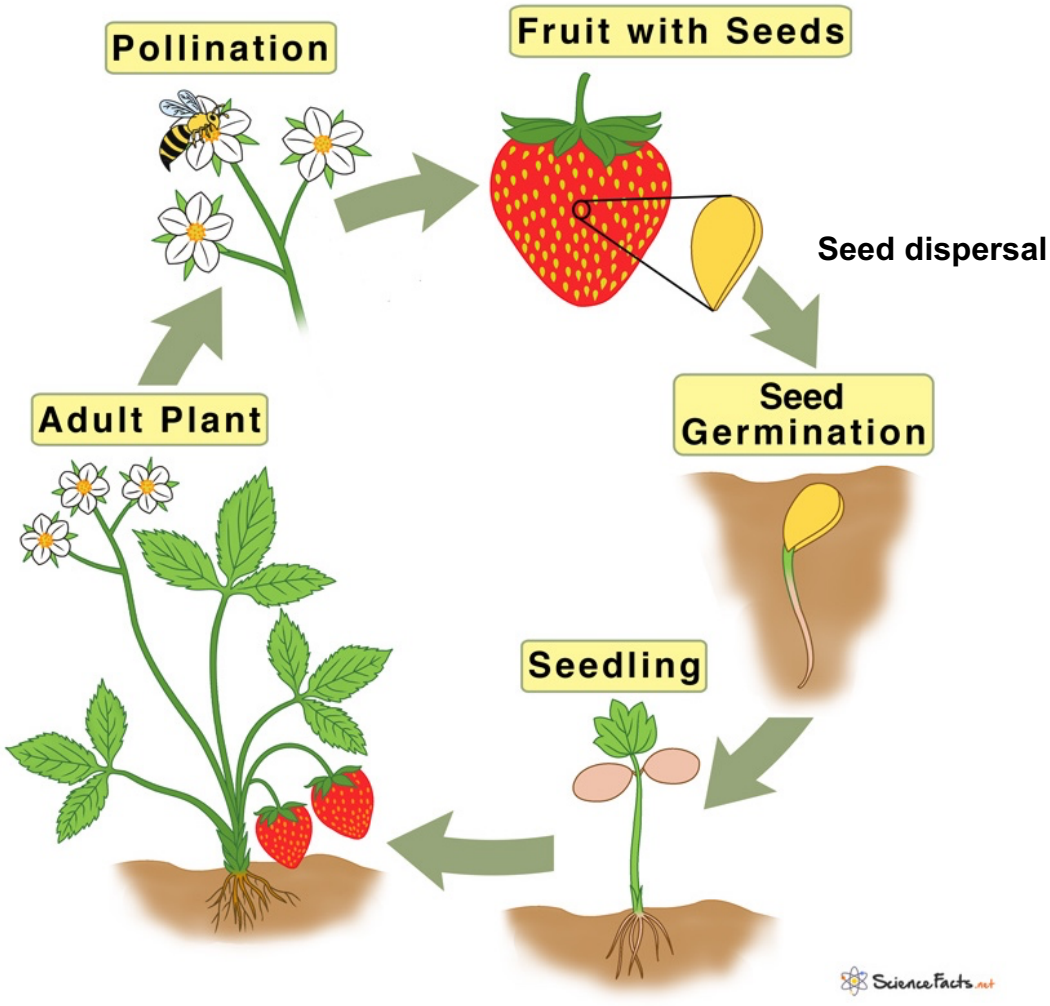
- **Fertilised ovule** develops into an **embryo plant**
- **Water leaves** = becomes **dehydrated**
- The **ovule** develops into a **seed**
- The **ovary** develops into a **fruit**

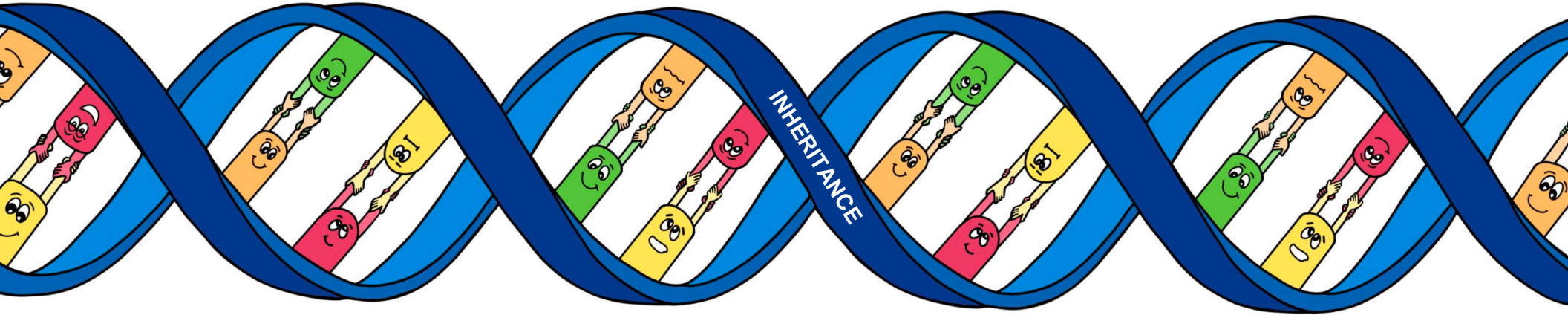
- The seed **dehydrates** and becomes **dormant** so **metabolic reactions stop**.
- This **saves energy** if environmental conditions are **not favourable for growth**.
- It is then **dispersed** by some 'agent' (e.g. **wind**, **water** or ingested by **animals**) and **carried away** from the parent plant.
- Under the **correct conditions** the seed **germinates** to produce a **young plant**.

SEED GERMINATION

Water	To activate enzymes in the seed for metabolism
Oxygen	For respiration so that energy can be released
Warmth	To allow enzymes to work close to optimum

LIFE CYCLE OF A FLOWERING PLANT

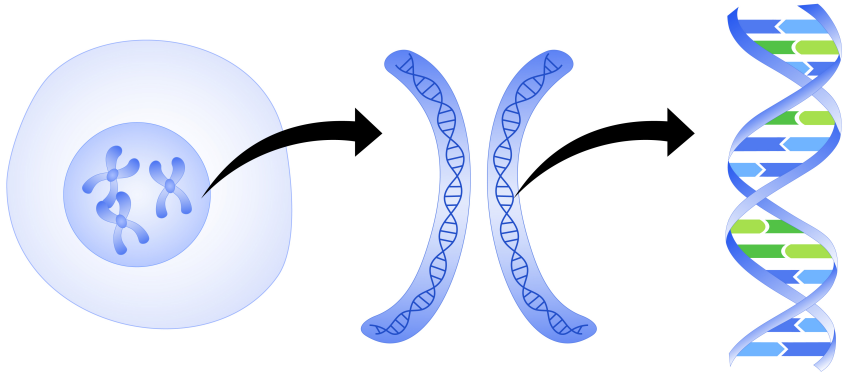



INHERITANCE

VOCABULARY

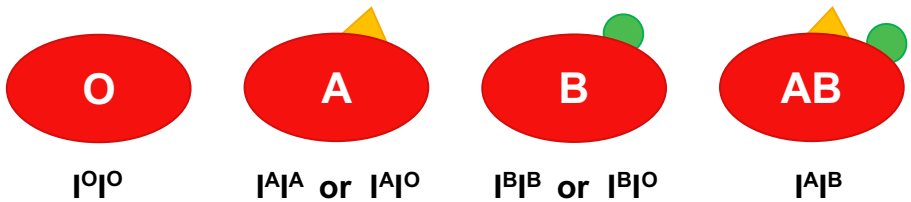
WORD	DEFINITION
Inheritance	The **transmission** of **genetic information** from **generation to generation**
Chromosome	Made of a long molecule of **DNA**, which contains **genetic information** in the form of **genes**
Gene	A **length of DNA** that **codes for a protein**
Allele	An **alternative form** of a **gene**
Dominant allele	An allele that is **expressed if it is present in the genotype**
Recessive allele	An allele that is **only expressed if** there is **no dominant allele of the gene present in the genotype**
Homozygous	Having **two identical alleles** of a **gene**, e.g. TT / tt **Two identical homozygous individuals** that **breed** together will be **pure-breeding**
Heterozygous	Having **two different alleles** of a **gene**, e.g. Tt A heterozygous individual **will not be pure-breeding**
Genotype	The **alleles** that an organism carries for a **gene** (2 for each)
Phenotype	The **observable features** of an organism due to its **genotype**
Co-dominance	When **two alleles** have **equal dominance**, so both are **expressed** if an individual is **heterozygous**, resulting in a new phenotype.
F1 generation	**Offspring** from the **first mating**
F2 generation	**Offspring** form the **second mating**

NUCLEUS → CHROMOSOME → DNA



THE HUMAN ABO BLOOD GROUP SYSTEM

- This is an example of both co-dominance and multiple alleles.
- The gene has **3 alleles** – I^A, I^B and I^O, but each person can **only carry 2**.
- I^A **and** I^B are **codominant**, while I^O is **recessive** to both.



- Alleles I^A and I^B code for different enzymes that help to make A and B antigens present on the surface of red blood cells.
- I^O does not code for these enzymes, so neither A or B antigens will be made if a person has the genotype I^OI^O.

	I^B	I^O
I^A	I^AI^B	I^AI^O
I^O	I^BI^O	I^OI^O

Parents with genotypes I^AI^O and I^BI^O are able to have children of all four blood groups at equal chance (25%)

MONOHYBRID CROSSES

- **These are crosses for traits controlled by one gene.**

Cystic fibrosis is a lung disease caused by the recessive allele f.
The following crosses show the possible combinations of parental genotypes and the corresponding genotypes and phenotypes of their offspring.

	f	f
F	Ff	Ff
F	Ff	Ff

FF X ff

Homozygous dominant Homozygous recessive

Recessive phenotype (cystic fibrosis) = 0%

Dominant phenotype (healthy) = 100%

	F	f
F	FF	FF
F	Ff	Ff

FF X Ff

Homozygous dominant Heterozygous

Recessive phenotype (cystic fibrosis) = 0%

Dominant phenotype (healthy) = 100%

	F	f
F	FF	Ff
f	Ff	ff

Ff X Ff

Heterozygous Heterozygous

Recessive phenotype (cystic fibrosis) = 25%

Dominant phenotype (healthy) = 75%

	F	f
f	Ff	ff
f	Ff	ff

Ff X ff

Heterozygous Homozygous recessive

Recessive phenotype (cystic fibrosis) = 50%

Dominant phenotype (healthy) = 50%

Two **identically homozygous** individuals that breed together are described as **pure breeding**. All offspring will have the same genotype and phenotype of the trait.

TEST CROSSES

- Used to determine the **genotype** of an individual with a **dominant phenotype**.
- The individual is **mated** with a partner with the **recessive phenotype**.
- The **parent's genotype** is determined by observing **offspring phenotypes**.

Homozygous dominant parent	Heterozygous parent
<table><tr><th></th><th>R</th><th>R</th></tr><tr><td>r</td><td>Rr</td><td>Rr</td></tr><tr><td>r</td><td>Rr</td><td>Rr</td></tr></table>	<table><tr><th></th><th>R</th><th>r</th></tr><tr><td>r</td><td>Rr</td><td>rr</td></tr><tr><td>r</td><td>Rr</td><td>rr</td></tr></table>
All offspring will have the dominant phenotype	**Both dominant and recessive phenotypes will be seen in offspring**

SEX-LINKED CHARACTERISTICS

When the gene responsible is located on a sex chromosome, X or Y.
This makes the characteristic more common in one sex than the other.

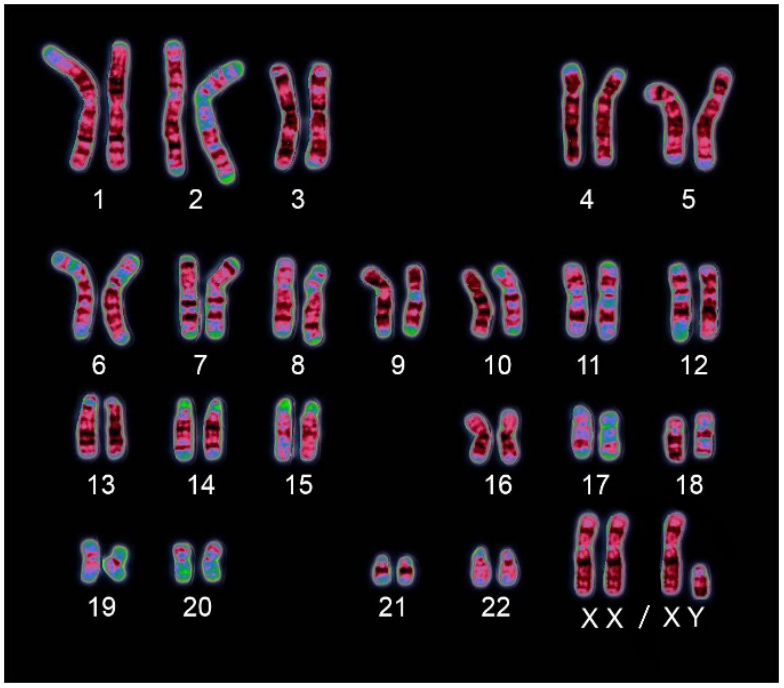
- Examples in humans are **haemophilia** and **red-green colour blindness**.
- Both are caused by **recessive alleles** located on the **X-chromosome**.
- In recessive X-linked genetic diseases, **more males** will be affected than females:

X^hY X^HX^h

Males have one X-chromosome	Females have two X-chromosomes
Cannot be carriers / heterozygous	Can be carriers / heterozygous
Cannot also carry the dominant allele to mask the effect of the recessive allele	Can also carry the dominant allele to mask the effect of the recessive allele

DIPLOID NUCLEUS

Human diploid number (2n) = 46



Body cells

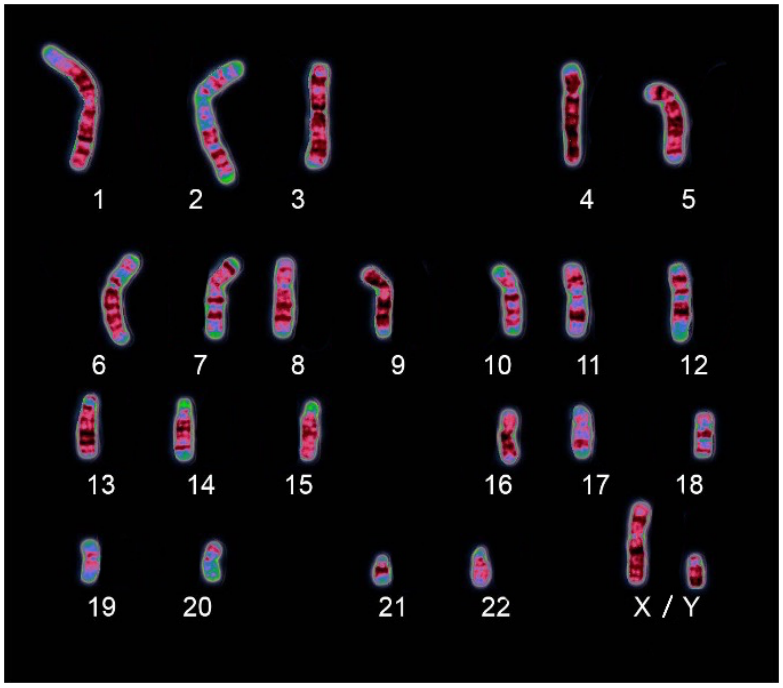
Two sets of chromosomes in pairs

One chromosome pair of each kind,

one from mum and one from dad

HAPLOID NUCLEUS

Human haploid number (n) = 23



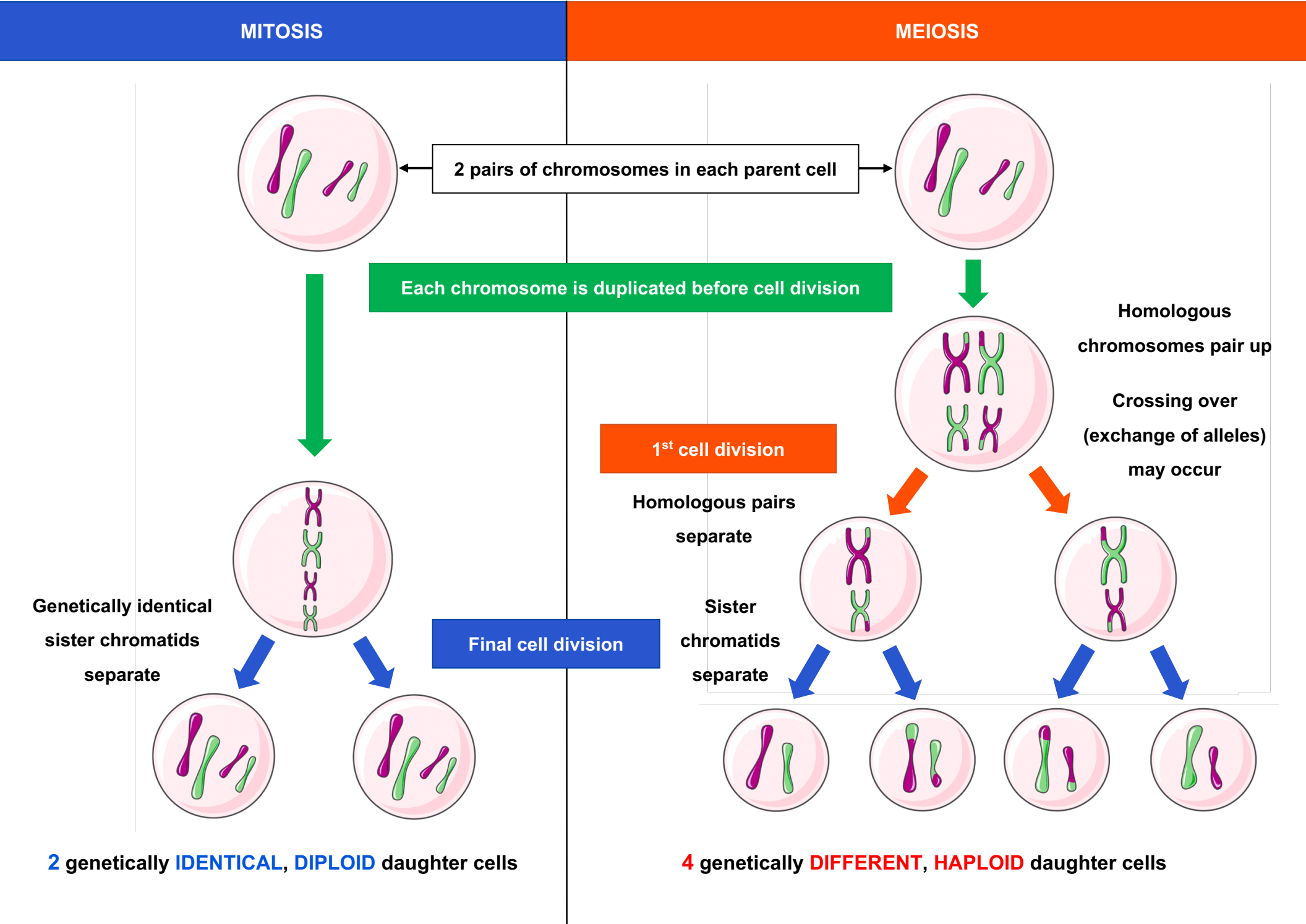
Sex cells

One set of unpaired chromosomes

One chromosome of each kind,

either from mum or from dad

- In diploid cells, the two chromosomes of each pair are called homologous chromosomes.
- They are about the same length and contain genes responsible for the same characteristics in the same positions.
- However, the genes can be in different forms (alleles), which can be combined in various ways to give different phenotypes.


MITOSIS
MEIOSIS
2 pairs of chromosomes in each parent cell
Each chromosome is duplicated before cell division
Homologous chromosomes pair up
Crossing over (exchange of alleles) may occur
1st cell division
Homologous pairs separate
Genetically identical sister chromatids separate
Final cell division
Sister chromatids separate
2 genetically IDENTICAL, DIPLOID daughter cells
4 genetically DIFFERENT, HAPLOID daughter cells

MITOSIS VS MEIOSIS

Chromosomes are duplicated before cell division

Nuclear division that produces:

- **Diploid body cells**
- **Genetically identical**

Mitosis

Nuclear division that produces:

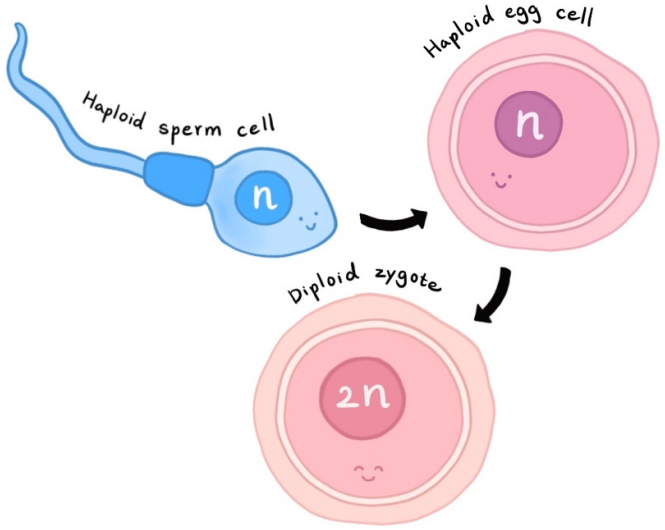
- **Haploid gametes**
- **Genetically different**

by reducing the chromosome number from diploid to haploid

Meiosis

	MITOSIS	MEIOSIS
Roles	• **Growth** • **Repairs** damaged **tissues** • **Replacement** of **cells** • Maintains the **diploid** chromosome number • **Asexual** reproduction	• Increases **genetic variation** • **Halves** the **chromosome number** so that the **diploid** number can be **restored** in the **zygote** by **fertilisation** • **Sexual** reproduction
Where it occurs	**All body organs**	**Testes** and **ovaries**
Number of cells produced from the original cell	**2**	**4**
Number of divisions	**1**	**2**
What it does to the chromosome number	**Maintains it**	**Halves it**

FERTILISATION



HOW MEIOSIS CONTRIBUTES TO GENETIC VARIATION

During meiosis

Homologous chromosomes exchange alleles during crossing over = new combinations of alleles

+

Homologous chromosomes align randomly = many different possible combinations of maternal and paternal chromosomes in gametes

+

Haploid gametes from two parents fuse randomly

↓

Zygotes (offspring) are genetically different

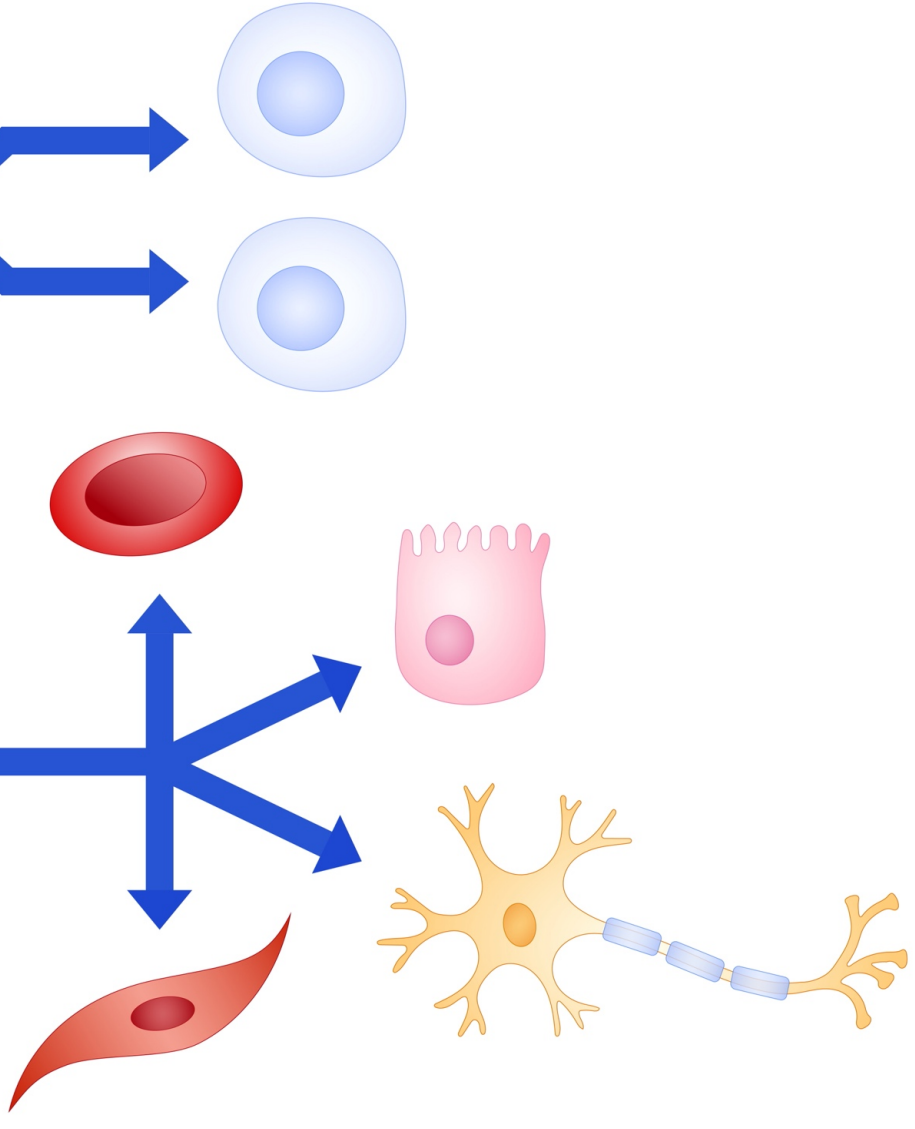
Stem cells can divide by mitosis to produce more unspecialised daughter cells.

SELF-RENEWAL

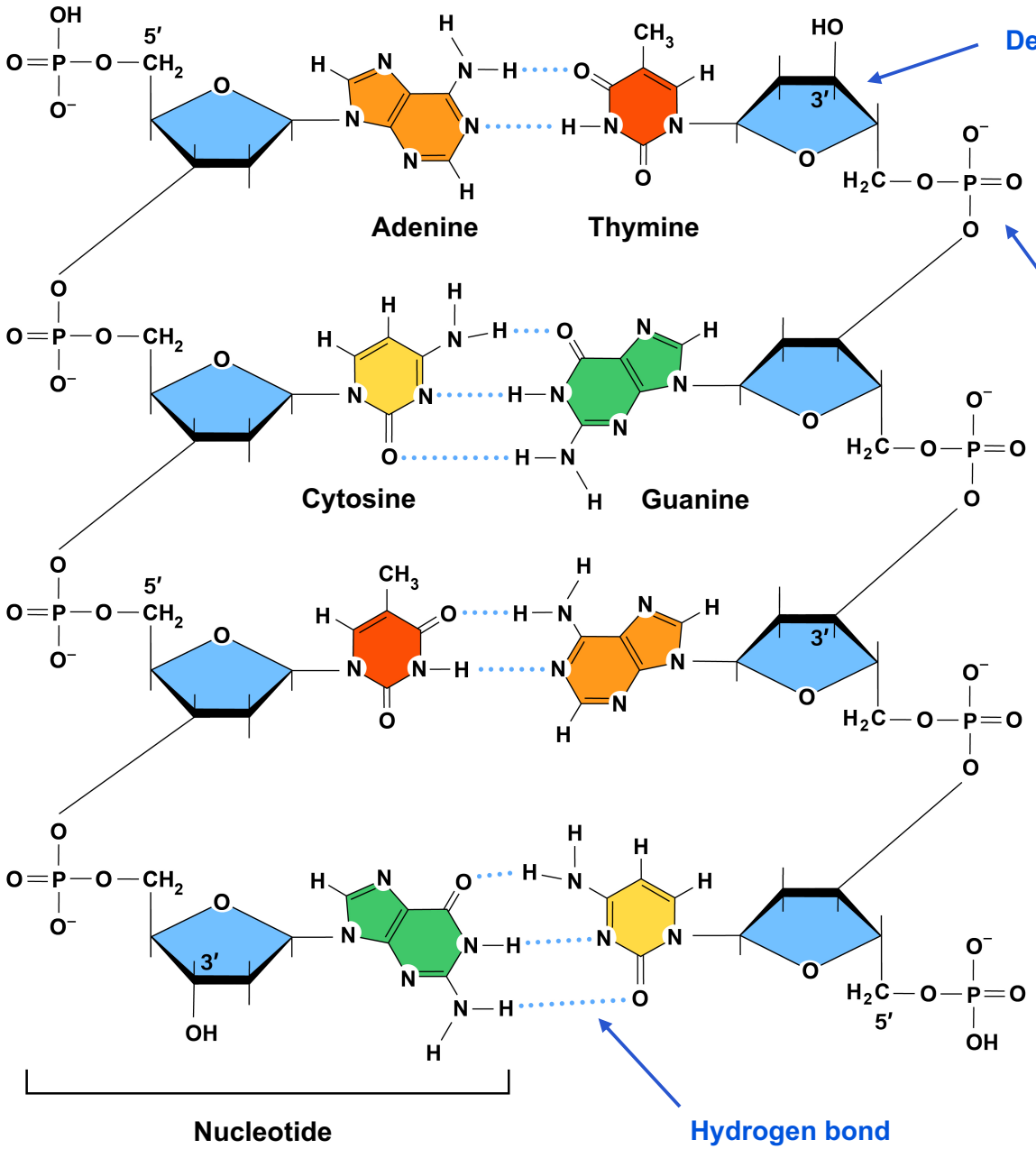
STEM CELL

DIFFERENTIATION

Certain chemicals can cause transcription of different genes in stem cells, allowing them to differentiate and become specialised cells.



STRUCTURE OF DNA

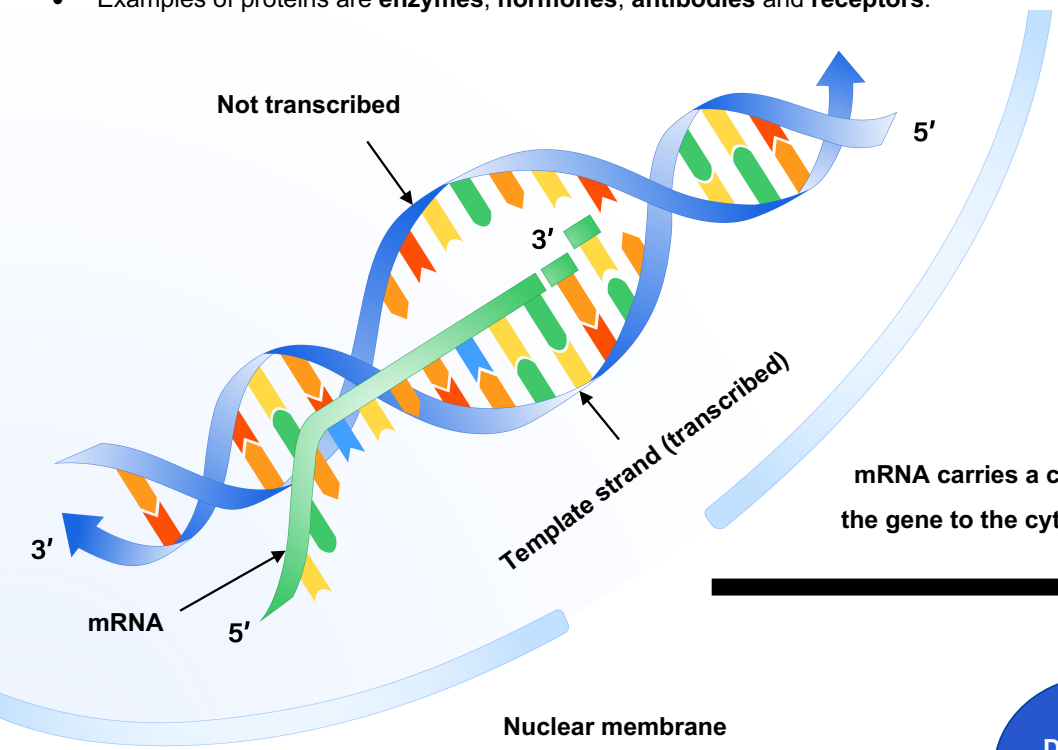


DNA 'twists' into a double helix structure

The two strands of DNA have the same chemical structures, but run in opposite directions

PROTEIN SYNTHESIS

- A **gene** is a **sequence of DNA** that **codes for a specific protein**.
- Different genes have different sequences of DNA bases and code for different proteins.
- Examples of proteins are **enzymes**, **hormones**, **antibodies** and **receptors**.



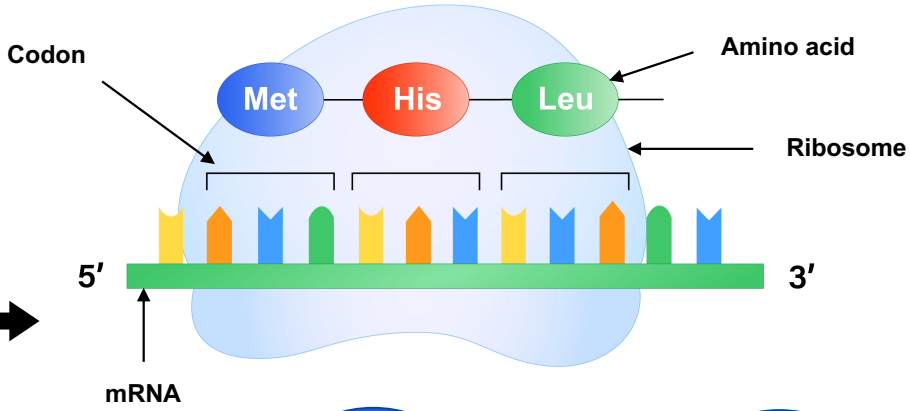
mRNA carries a copy of the gene to the cytoplasm

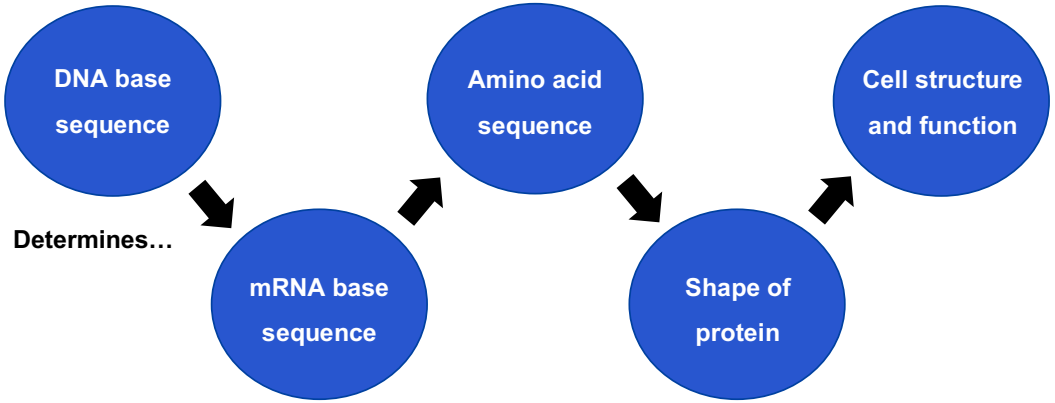
PART 1 – TRANSCRIPTION: IN THE NUCLEUS

- A **gene** is **copied** onto an **mRNA** molecule
- In **mRNA**, the base **T (thymine)** is replaced by **U (uracil)**
- The **DNA** (gene) coding for the protein **stays** in the **nucleus**

PART 2 – TRANSLATION: IN THE CYTOPLASM

- A **ribosome** attaches to the **mRNA** molecule
- It **reads** the mRNA in **sets of 3 bases** (codons)
- **Amino acids** are brought **in order** specified by the codons to the **ribosome**, which then assembles them into a **chain**





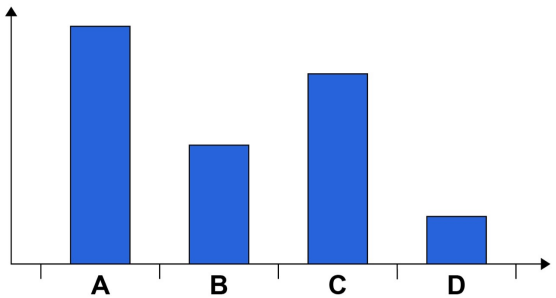
18 VARIATION AND SELECTION

VARIATION

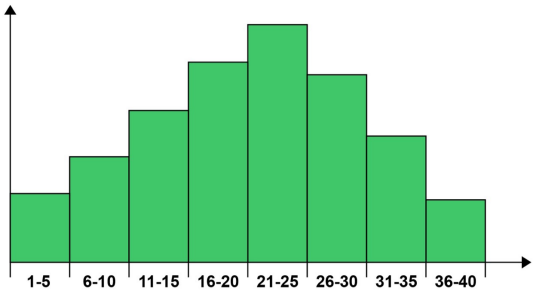
Variation is differences between individuals of the same species

Two types

DISCONTINUOUS



CONTINUOUS



Discontinuous variation	Continuous variation
Caused by genes only	Caused by both genes AND the environment
Limited number of phenotypes with no intermediates	Range of phenotypes between two extremes
Tend to be qualitative (cannot be measured with numbers)	Tend to be quantitative (can be measured with numbers)
ABO blood groups Seed shape and colour in peas	Body length Body mass
Draw as a bar chart	Draw as a frequency histogram

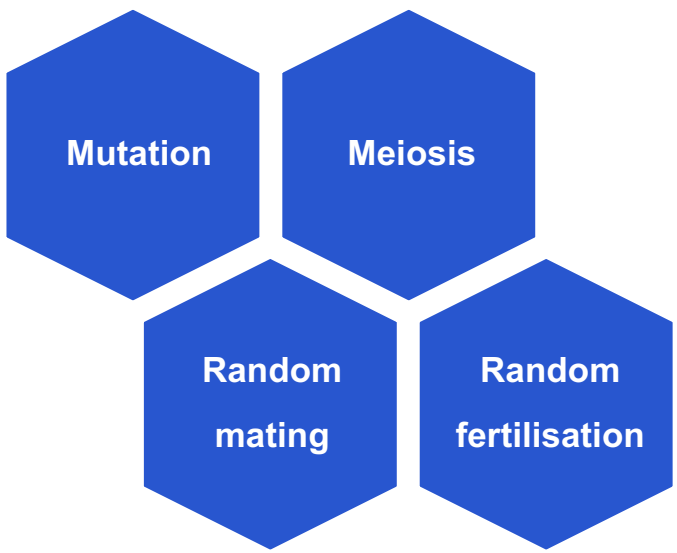
GENE MUTATION

- This is a **random change** in the **base sequence of DNA**.
- Mutation is the way in which **new alleles** are formed.

CAUSES

Ionising radiation	Mutagenic chemicals
X-rays UV rays Gamma rays Alpha particles from radioactive isotopes	Mustard gas Benzene Asbestos Tar in tobacco

SOURCES OF GENETIC VARIATION IN POPULATIONS



NATURAL SELECTION

Mutation causes genetic variation within a population.
Some genes produce more advantageous phenotypes.

↓

Overproduction of offspring leads to struggle for survival, including competition for resources.

↓

Individuals with a selective advantage are more likely to survive, reproduce and pass on their alleles to their offspring.

↓

Over many generations, the frequency of this allele increases in the population.

ADAPTIVE FEATURE

An inherited feature that helps an organism to survive and reproduce in its environment.

ADAPTATION

The process, resulting from natural selection, by which populations become more suited to their environment over many generations.

ARTIFICIAL SELECTION

Parent individuals with desirable features are selected by humans

↓

These individuals are crossed to produce the next generation

↓

Offspring showing improvement in the desirable feature are selected and crossed together

↓

Selecting and breeding is repeated over many generations

Natural selection	Artificial selection
Caused by environmental pressures Selected features are advantageous adaptations to the environment	Features are selected by human choice
Maintains genetic variation	Reduces genetic variation
Increases chances of survival	Usually reduces chances of survival
Speciation is slower	Speciation is faster
Mating is random	Selected organisms are mated
Inbreeding is less common	Inbreeding is more common
Involves competition for survival	Competition is not involved

ADAPTIVE FEATURES OF:

XEROPHYTES & HYDROPHYTES

- Leaves reduced to spines = reduced surface area
- Thick, waxy cuticle on leaf surface = reduces transpiration
- Stomatal hair traps a layer of moisture
- Stomata sunken in pits & close during the day = reduces water loss
- Swollen stems for water storage & extensive roots for absorption
- Shiny surfaces to reflect light and heat

- Leaves and stem have little or no cuticle as no need to conserve water
- Stomata on upper surface of floating leaves for gas exchange
- Large air spaces in the spongy mesophyll has two jobs:
  1. Buoyancy (floating) – keeps plant close to light
  2. Stores O_2 and CO_2
- Rely on water for support = produce little or no xylem (saves energy)
- Roots are absent / poorly developed with no root hairs, as no need to absorb water or minerals

19 ORGANISMS AND THEIR ENVIRONMENT

VOCABULARY

Word	Definition
Food chain	Shows the **transfer** of **energy** from one organism to the next, beginning with a **producer**.
Food web	A network of **interconnected food chains**.
Producer	An organism that makes its own **organic nutrients**, using **energy from sunlight**, by **photosynthesis**.
Consumer	An organism that gets its **energy** by **feeding** on **other organisms**.
Trophic level	The **position** of an **organism** in a **food chain**, **food web**, pyramid of **numbers** or pyramid of **biomass**.
Herbivore	An animal that gets its **energy** by **eating plants**.
Carnivore	An animal that gets its **energy** by **eating other animals**.
Omnivore	An animal that gets its **energy** by **eating plants and other animals**.
Decomposer	An organism that gets its **energy** from **dead or waste organic material**.
Population	A **group** of **organisms** of **one species**, living in the **same area**, at the **same time**.
Community	**All** of the **populations** of **different species** in an **ecosystem**.
Ecosystem	A **unit** containing the **community** of **organisms** and their **environment**, **interacting** together.
Biomass	The **total mass** of **living organisms** in a **given area** at a **given time**.

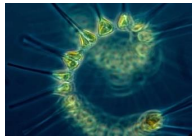
FOOD CHAINS

The Sun is the principal source of energy input to all biological systems

Light energy

Energy is lost as heat during respiration

1st trophic level – Phytoplankton



PRODUCER

10%

2nd trophic level – Zooplankton

Primary consumer – Herbivore

10%

3rd trophic level – Tuna

Secondary consumer – Carnivore

10%

4th trophic level – Marlin

Tertiary consumer – Carnivore

10%

5th trophic level – Shark

Quaternary consumer – Top carnivore

Producers convert **light energy** from the sun to **chemical energy** during **photosynthesis**.

Chemical energy is then **transferred** between successive organisms in a food chain by **ingestion**.

Death / Excretion

Decomposers – fungi, bacteria, worms

Energy flow is not cyclic – it is never recycled!

Light energy → Chemical energy → Heat energy

- Respiration is not 100% efficient – about 60% of the energy in glucose is **lost** to the atmosphere as **heat energy**.
- Living organisms cannot convert heat to other forms of energy.

Why energy transfer between trophic levels is inefficient

- Energy is lost as **heat** during **respiration**
- Energy is lost in **faeces** and **urine** during **excretion**
- Energy is lost as **bones** and **teeth** of organisms are **undigested**
- Energy in **waste** / **dead organisms** will eventually be transferred to **decomposers** and lost as heat due to inefficient respiration, which **cannot be recycled**.

- Since **90% energy is lost** from a food chain when passed on from one trophic level to the next, there will **rarely be enough energy** to support **more than 5 trophic levels**.
- Higher trophic levels would die out if the energy used to hunt prey exceeds the energy available from the food eaten.

SUPPLYING LIVESTOCK VS. SUPPLYING CROPS AS HUMAN FOOD

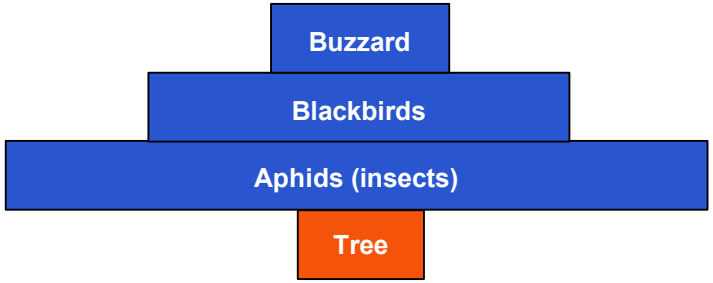
Feeding crops to livestock that are then used for food
Energy is lost from livestock
Only 1% of the initial energy in crops will be passed on to humans

Using crops directly as human food
Only 2 trophic levels in this food chain = more energy efficient
(10% energy received)

Pyramid of NUMBERS
Shows the **number** of organisms at each **trophic level** of a **food chain**

PYRAMID OF NUMBERS VS. PYRAMID OF BIOMASS

Pyramid of BIOMASS
Shows the **mass** of organisms (g/m^2 or kg/m^2) at each **trophic level** of a **food chain**

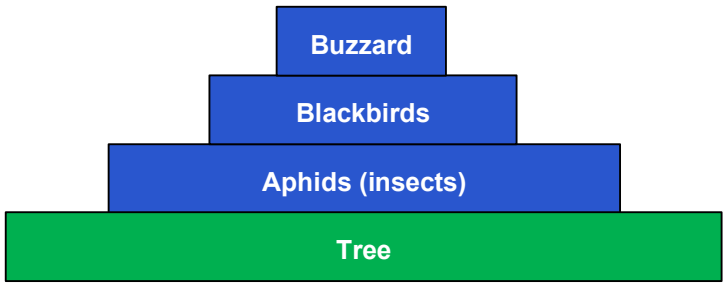


4th level – Tertiary consumer

3rd level – Secondary consumer

2nd level – Primary consumer

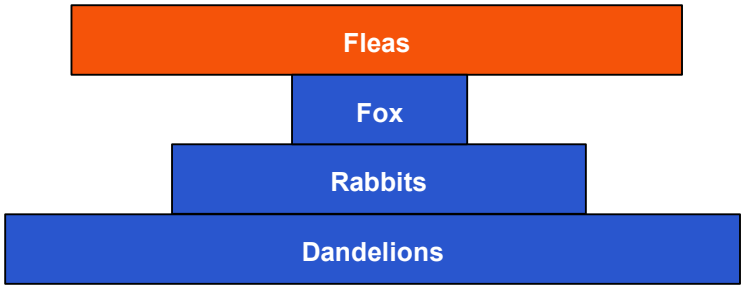
1st level – Producer



Shorter producer bar
Producer is large (e.g. tree or bush)
Smaller number of trees in a given area
one tree is large enough to feed many small aphids

Normal pyramid shape
Greater total biomass of trees at any one time
as biomass is always lost between trophic levels

Pyramid of numbers



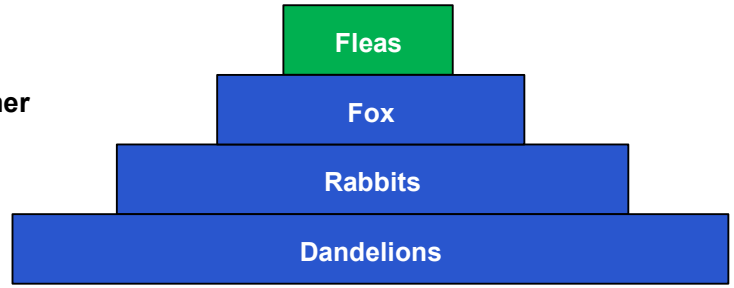
4th level – Tertiary consumer

3rd level – Secondary consumer

2nd level – Primary consumer

1st level – Producer

Pyramid of biomass



Wider consumer bar

Consumer is very small (e.g. fleas or ticks)

More consumers in a given area as they are very small

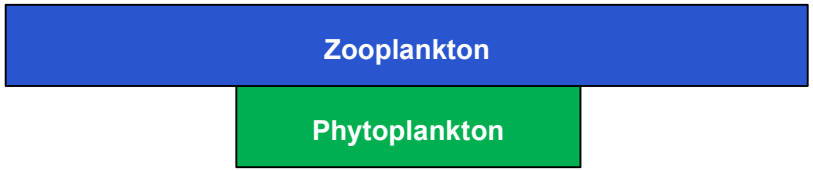
Many small fleas feed off one fox

Normal pyramid shape

Smaller total biomass of fleas at any one time

as biomass is lost between trophic levels

A pyramid of biomass can occasionally be inverted

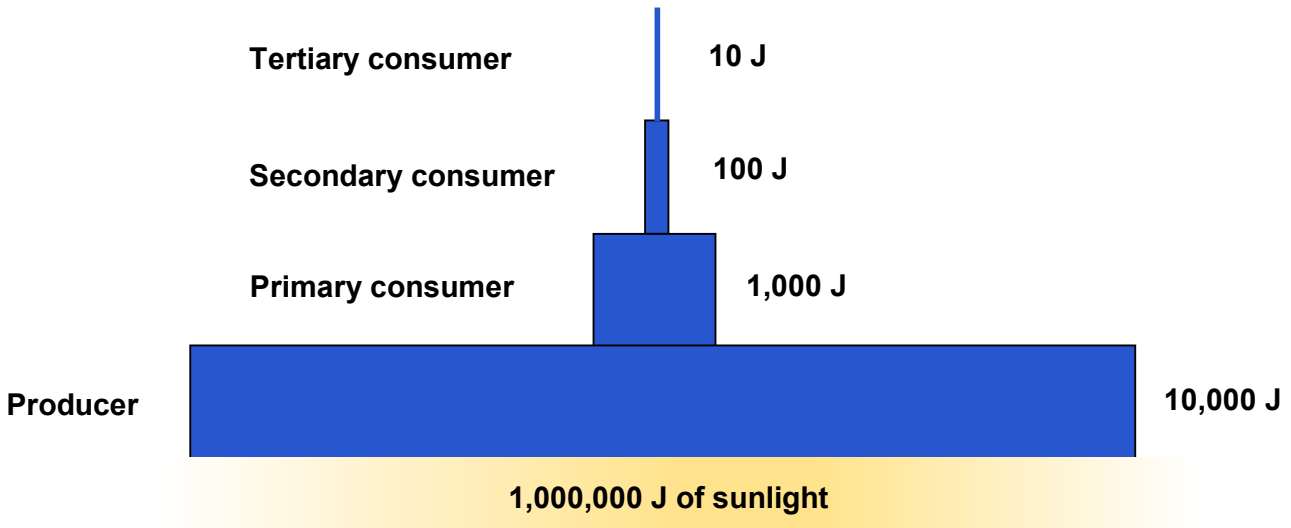


- A pyramid of biomass shows only a single 'snapshot' in time, so cannot show how fast the biomass at a trophic level is renewed.
- Phytoplankton have a much **shorter lifespan** than zooplankton.
- They **reproduce rapidly** but are also **eaten very quickly** by zooplankton.
- The biomass of phytoplankton **at any one time** is small (shown by the pyramid), however the total amount of biomass produced **over a year** would be huge.

PYRAMID OF ENERGY

This shows the amount of energy present (e.g. KJ m^{-2} $year^{-1}$) at each trophic level of a food chain.

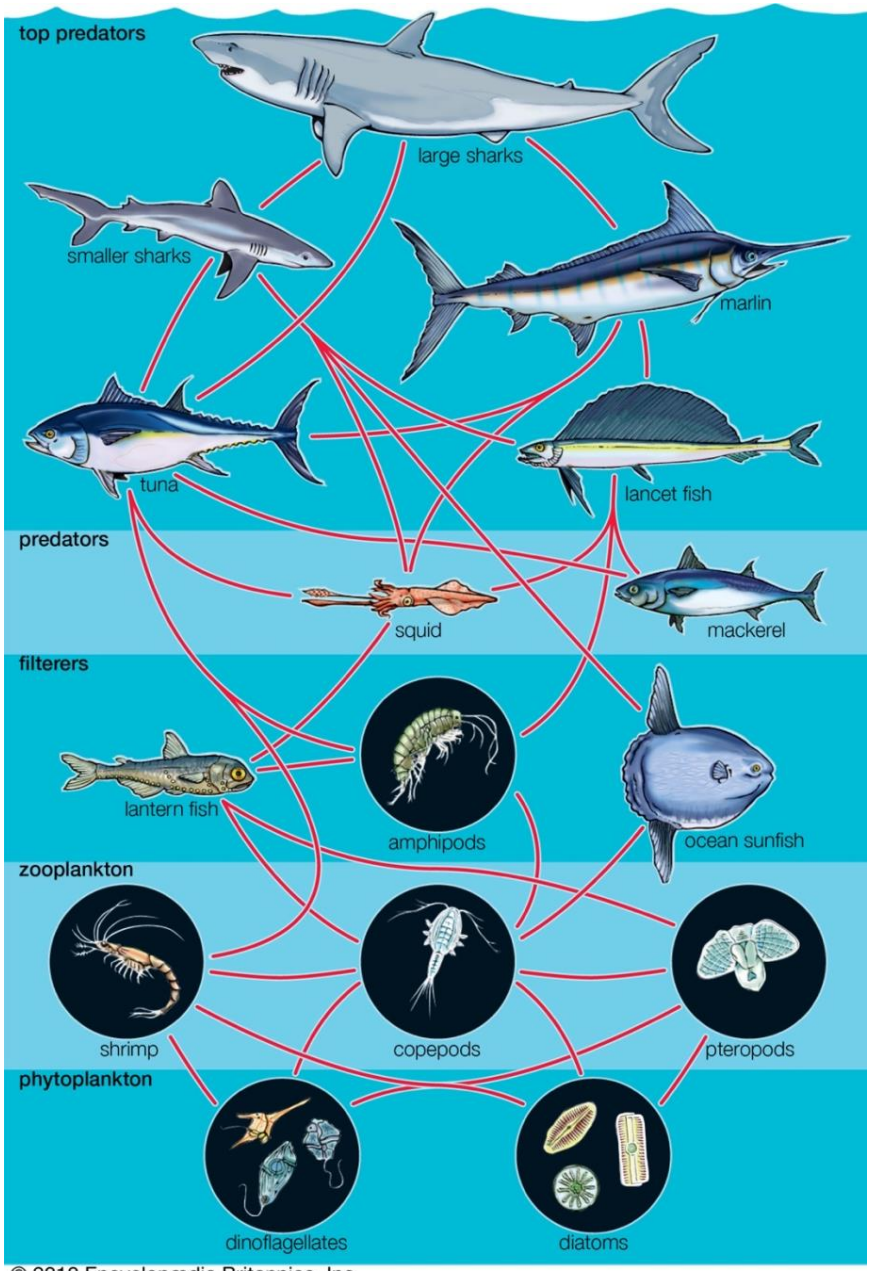
Each level is about 1/10 the width of the preceding level as energy transfer is only 10% efficient.



Most wavelengths of sunlight cannot be absorbed by chlorophyll – only about 1% of the energy from the sun is absorbed and used in photosynthesis.

Advantages of a pyramid of biomass over a pyramid of numbers	Advantages of a pyramid of energy over both
Pyramid is not usually inverted	**Pyramid is never inverted**
Takes into account the **size of organisms**, while a pyramid of numbers does not	Takes into account the **rate of energy production over a period of time** Between species with very different **life spans**, productivity is directly comparable but biomass is not
Biomass is a more accurate indication of the amount of energy available at each trophic level than the number of organisms	**Most accurate** – shows actual quantity and efficiency of energy transfer (Organisms with the same dry mass may contain different amounts of energy)

A MARINE FOOD WEB



Starting from a producer (not from the sun if included):

1 arrow = primary consumer

2 arrows = secondary consumer

3 arrows = tertiary consumer

4 arrows = quaternary consumer

Some organisms can act as more than one type of consumer in the same food web.

- **Humans** can impact food chains and food webs by **overharvesting food species** or **introducing harmful foreign species**.

FACTORS AFFECTING RATE OF POPULATION GROWTH

SIGMOID POPULATION GROWTH CURVE

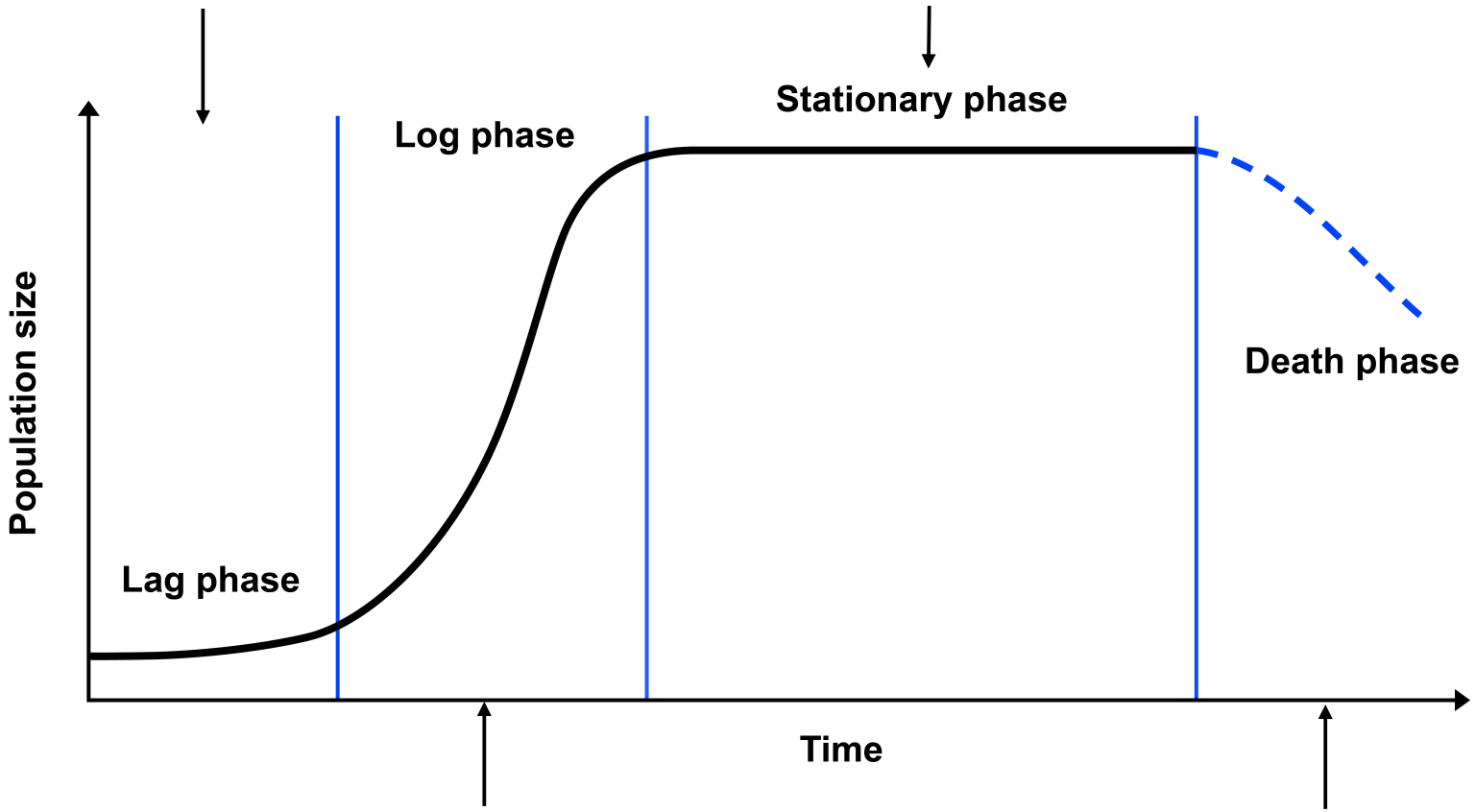
Reproduction rate > death rate

Few reproductive individuals present

Doubling in number has little effect as the total population is very small

Reproduction rate = death rate

Death rate increases and population growth **slows down** due to **limiting factors** e.g. food shortage, competition, carrying capacity of environment, disease, build up of waste



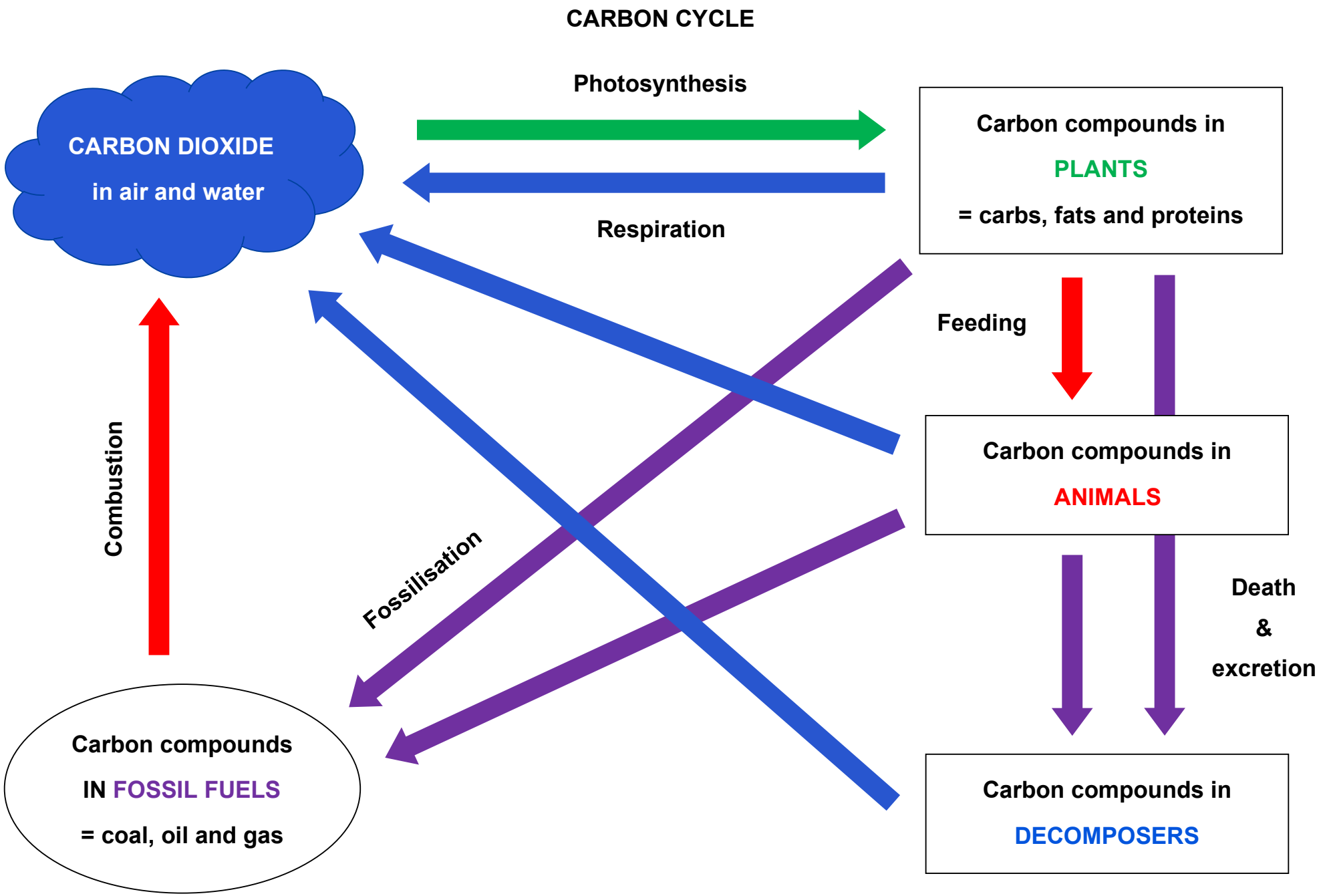
Reproduction rate > death rate

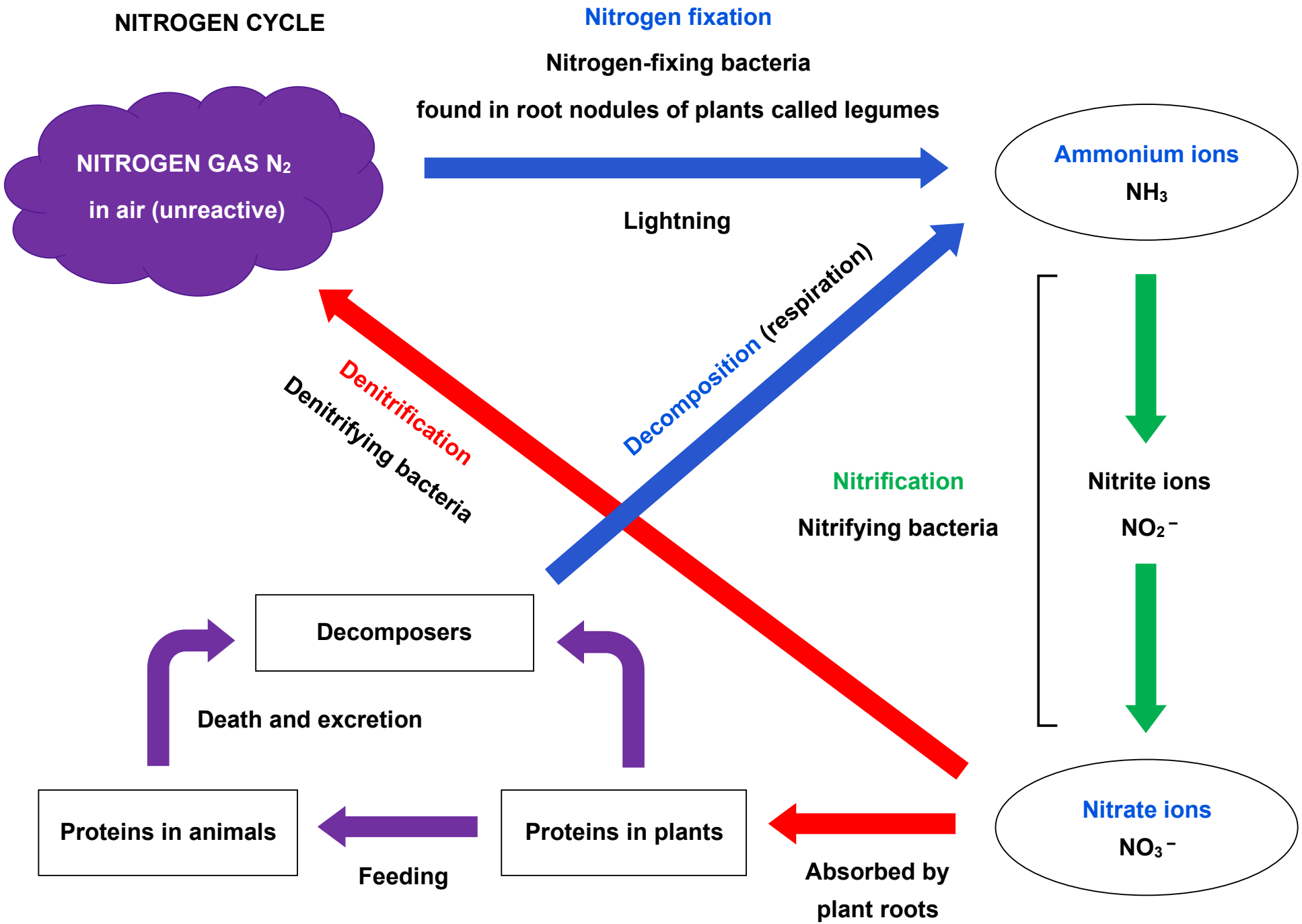
Population **increases exponentially** – doubles each time

No limiting factors to population growth

Death rate > reproduction rate

This occurs when microorganisms are cultured in closed systems, due to the accumulation of **waste products**.


CARBON CYCLE
CARBON DIOXIDE
in air and water
Photosynthesis
Respiration
Carbon compounds in
PLANTS
= carbs, fats and proteins
Feeding
Carbon compounds in
ANIMALS
Death
&
excretion
Carbon compounds in
DECOMPOSERS
Combustion
Fossilisation
Carbon compounds
IN FOSSIL FUELS
= coal, oil and gas


NITROGEN CYCLE
Nitrogen fixation
Nitrogen-fixing bacteria
found in root nodules of plants called legumes
NITROGEN GAS N_2
in air (unreactive)
Lightning
Ammonium ions
NH_3
Decomposition (respiration)
Denitrification
Denitrifying bacteria
Nitrification
Nitrifying bacteria
Nitrite ions
NO_2^-
Decomposers
Death and excretion
Proteins in animals
Feeding
Proteins in plants
Absorbed by
plant roots
Nitrate ions
NO_3^-

20 HUMAN INFLUENCES ON ECOSYSTEMS

HOW HUMANS HAVE INCREASED FOOD PRODUCTION

Chemical fertilisers	**to improve yield**
Herbicides	**to reduce competition with weeds**
Insecticides	**to improve quality and yield**
Agricultural machinery	**to use larger areas of land and improve efficiency**
Selective breeding	**to improve production by crop plants and livestock**

LARGE-SCALE MONOCULTURES OF CROP PLANTS

1. One infectious **disease** can **kill the entire crop** – little genetic variation
2. **Deforestation** causes increased **soil erosion** and **desertification**
3. Causes **depletion** of specific **nutrients** in the soil
4. Loss of **variety in habitats** and **biodiversity**
5. Disrupts **food chains**
6. Excess **fertilisers** can cause **eutrophication** in water sources
7. Overuse of **herbicides** and **insecticides** can cause **pollution**
8. **Efficient food production** so **less land needed**

INTENSIVE LIVESTOCK PRODUCTION

1. **Diseases spread easily**
2. **Feed is expensive**
3. **Animal welfare** concerns
4. **Chemicals** used to **control disease** (e.g. antibiotics) can cause **pollution**
5. **Waste feed** can cause **eutrophication**
6. **More energy efficient** to feed humans on **crops**

Biodiversity is the number of **different species** that live in an area

REASONS FOR HABITAT DESTRUCTION

- Increased **area** for **housing**, **crop plant** and **livestock production**
- **Extraction** of **natural resources**
- **Freshwater** and **marine pollution**

NEGATIVE IMPACTS OF DEFORESTATION

1. **Loss** of **habitats** and **biodiversity**
2. Disrupts **food chains**
3. Increased risk of **flooding** as there are **no trees to absorb water**
4. **Soil erosion** increases as **plant roots die** and **cannot bind to the soil**
5. Causes **silting of rivers**
6. **Soil fertility** is reduced as **nutrients** are **removed**
7. Increased rate of **evaporation** so **less soil water**, causing **desertification**
8. **Less photosynthesis** so increased **atmospheric CO_2** concentration, accelerating the **greenhouse effect**
9. **Decreased transpiration** can cause **reduced rainfall** in distant regions

EUTROPHICATION

Nitrates in **fertilisers** and **untreated sewage** enter a river / lake

↓

Causes **fast growth** of **producers** = an "**algal bloom**"

↓

Plants on the surface **block sunlight** from entering water

↓

Plants below the surface **cannot photosynthesise** and die

↓

Increased decomposition of dead plants by **bacteria**

↓

Increased aerobic respiration by **bacteria**

↓

Dissolved oxygen in water is **used up**

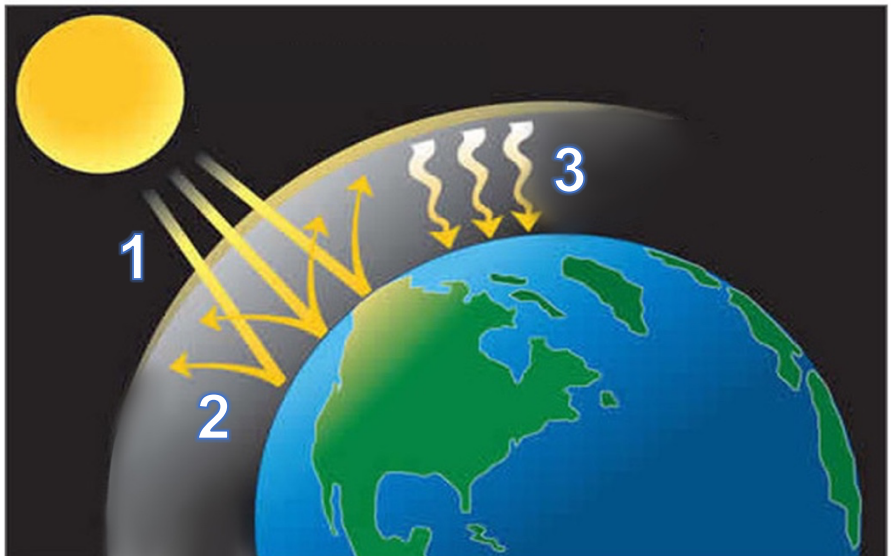
↓

Fish **cannot respire** due to **lack of oxygen** so they die

NEGATIVE EFFECTS OF NON-BIODEGRADABLE PLASTICS

1. **Visual pollution**
2. **Habitat destruction**
3. Can **block digestive** or **respiratory systems** of **animals**
4. Marine animals can get **tangled** in plastic – difficult to **move** and **find prey**
5. Release **chemicals**, **toxins** and **fumes** if they are burned
6. Plastic **accumulates** in organisms as it is passed up **food chains**
7. **Do not break down** – **remain** in the **ecosystem** for a **long time**
8. **Block sunlight** so producers **cannot photosynthesise**
9. (So) less energy enters food chains
10. **Block roots**
11. Block **drainage** channels causing waterlogging of soils and flooding

THE GREENHOUSE EFFECT



1. **Sunlight** passes through the **atmosphere** to reach **Earth's surface**

Sunlight = short-wave radiation

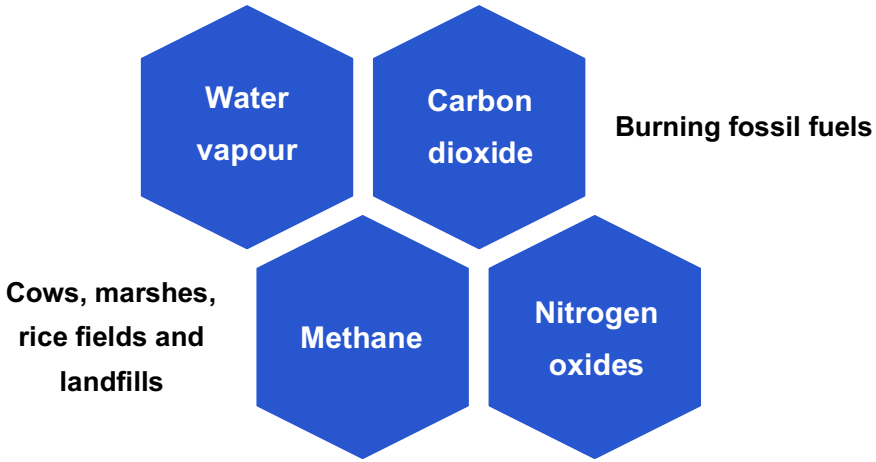
2. **Earth's surface re-emits** this as **long-wave radiation** = **heat**

3. **Greenhouse gases absorb long-wave radiation** (**heat**)

They **reflect** this heat **back to Earth** = temperature increases

The Greenhouse Effect is a natural process that has been artificially speeded up by humans

FOUR MAIN GREENHOUSE GASES



SUSTAINABLE RESOURCE

One which is produced as rapidly as it is removed from the environment so that it does not run out

MAINTAINING FOREST RESOURCES

1. **Replanting** trees (afforestation)
2. **Quotas** for cutting down trees
3. **Education**
4. Set up **protected areas** e.g. national parks
5. **Selectively cut trees** so that growth of other trees is unaffected

Why are replanted forests often less useful for conservation?

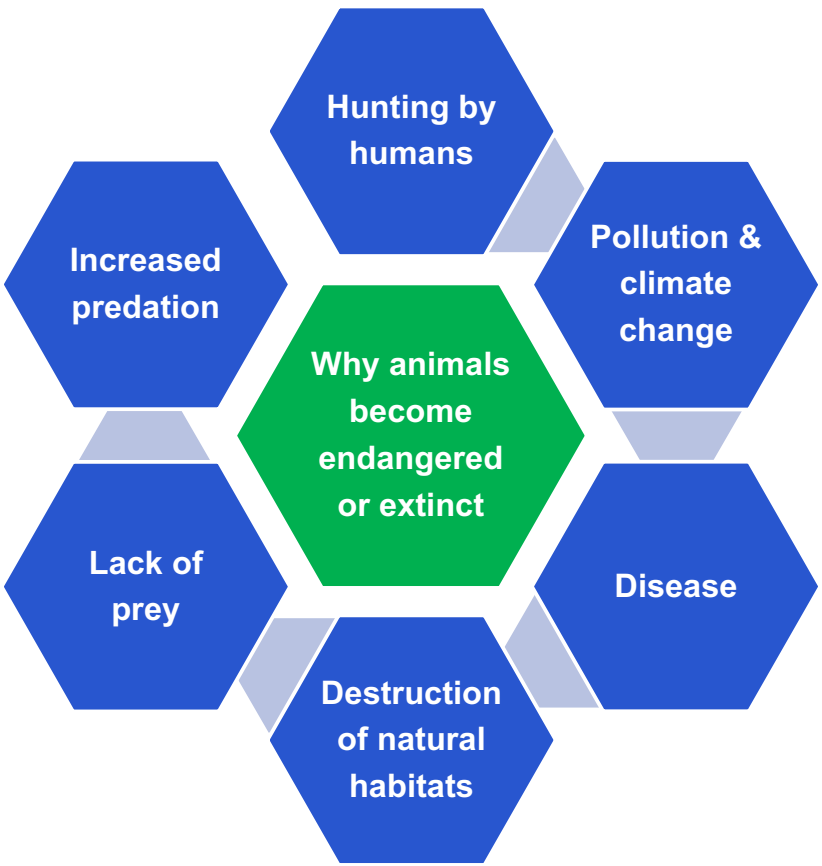
- A replanted forest is usually a **monoculture**
- Plants lack **genetic variation** – more susceptible to **diseases**
- Reduces **variety** of local **habitats** and **biodiversity**
- **Invasive foreign species** may be introduced
- Replanted trees take a **long time to reach maturity**.

MAINTAINING WILD FISH STOCKS

1. Set **quotas** on the number of fish caught
2. **Fines** for **overfishing**
3. **Captive breeding** and **fish farms**
4. **Restock** fish by returning more fish than is removed
5. **Ban fishing** during **breeding seasons**
6. Set up **no-catch zones**
7. **Restrict net sizes** and **return young fish** if caught
8. **Education**
9. **Reduce pollution** of rivers / lakes / seas

RISKS TO A SPECIES IF THE POPULATION SIZE DROPS

1. **Less chances of reproduction**
2. **Higher risk of extinction**
3. **Less genetic variation** as the **number** of **different alleles** in the population **decreases** (inbreeding is more likely = increased homozygosity)
4. (So) **less likely** to **adapt to change** in the **environment**, e.g. the whole population could be susceptible to a new infectious disease
5. Higher risk of **genetic diseases**



WAYS TO CONSERVE ENDANGERED SPECIES

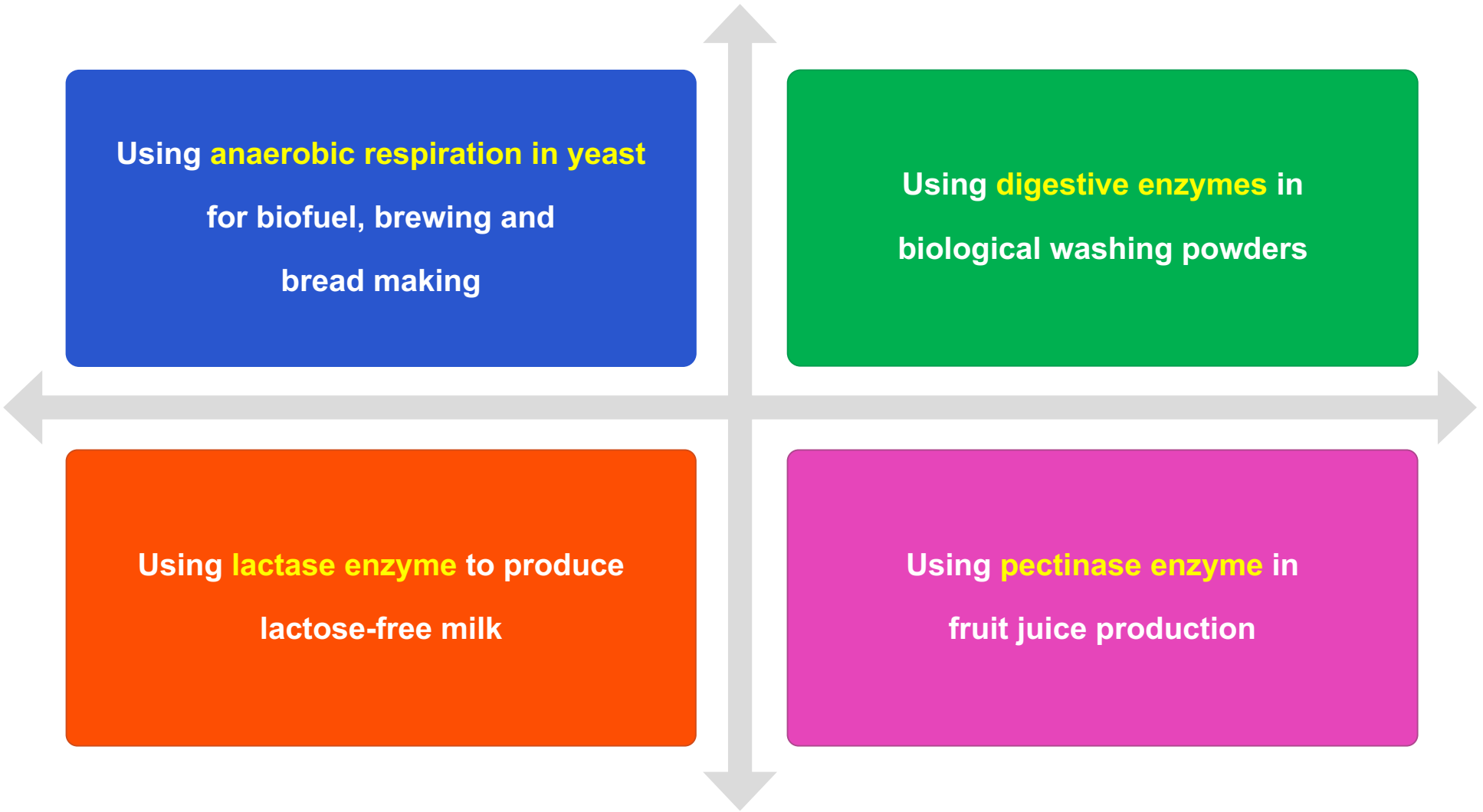
1. **Monitor number** of individuals to detect **changes in the population**
2. **Protect habitats**
3. Remove **foreign species** to reduce **competition**
4. **Captive breeding** programmes
5. **Release** the animals that are bred back into the wild
6. **Legislations** to reduce **pollution**
7. **Ban hunting**
8. **Seed banks** to conserve **genetic variation** in plant species
9. Raise awareness through **education**

BENEFITS OF CONSERVATION PROGRAMMES

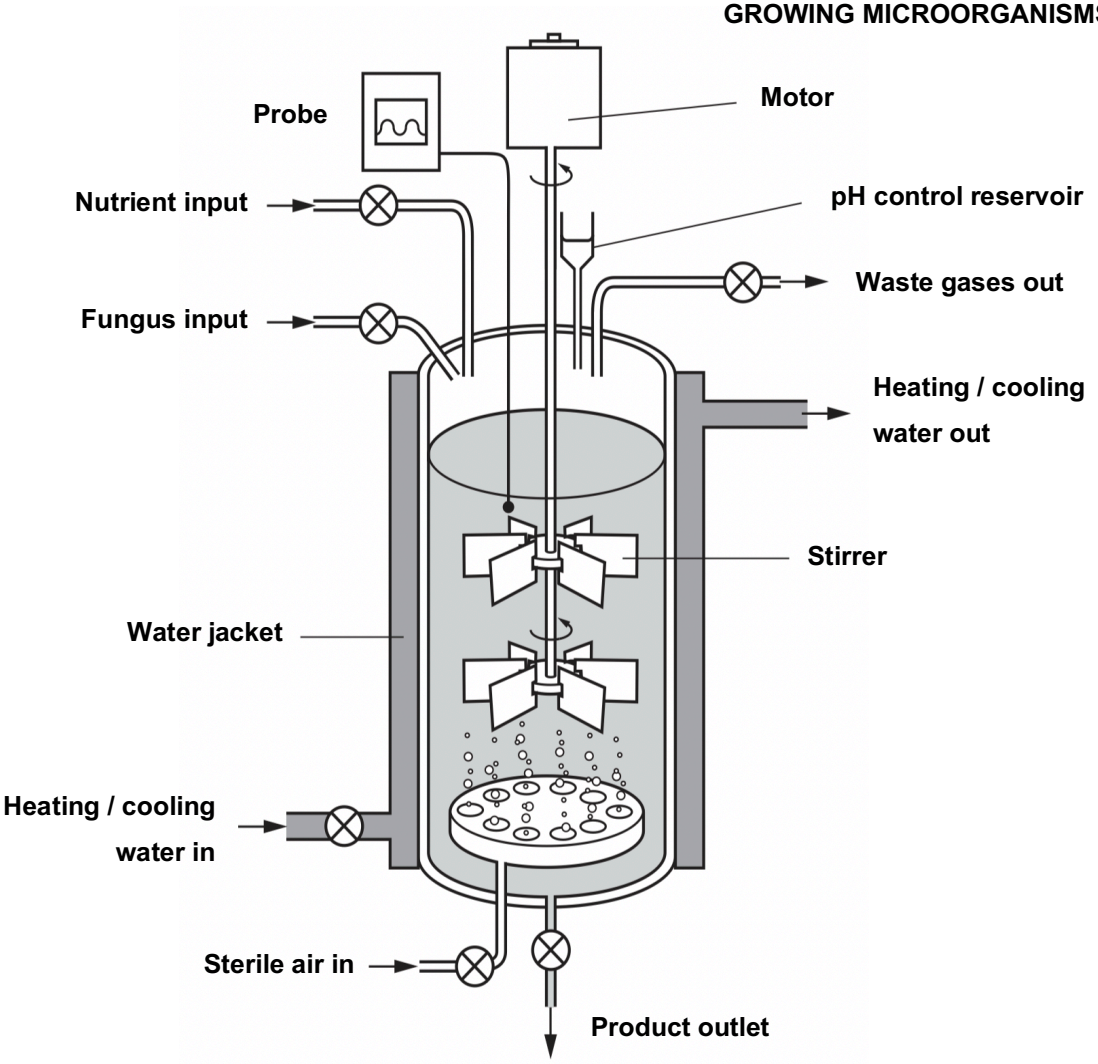
1. **Protects vulnerable environments** and prevents habitat loss
2. **Reduces extinction** of species
3. Maintains **recycling of nutrients**
4. Maintains / increases **genetic variation** and **biodiversity**
5. Provides **resources** such as **food**, **drugs**, **fuel** and **genes**
6. Prevents disruption of **food chains**
7. Prevents **flooding** caused by **deforestation**
8. Provides **shelter** and **breeding** grounds
9. Provides **aesthetically beautiful areas** that can attract **tourists**

21 BIOTECHNOLOGY AND GENETIC MODIFICATION

USES OF BIOTECHNOLOGY IN INDUSTRIAL PROCESSES



GROWING MICROORGANISMS IN A FERMENTER



- Fermenters can be used for **large-scale production** of **useful products** by growing large populations of **bacteria** and **fungi**, including:

- **Insulin** – made by **genetically modified bacteria with human insulin genes**
- **Penicillin** – made by the **fungus Penicillium**
- **Mycoprotein** – made by the **fungus Fusarium**

AIR SUPPLY

- Provides **oxygen** for **aerobic respiration** of the microbe

NUTRIENT SUPPLY

- **Glucose / carbohydrates** as an energy source
- **Amino acids** for protein synthesis

GAS OUTLET

- **Removes waste CO_2** produced by **respiration**, as CO_2 will become **toxic** to the microbe if it **builds up**

STIRRER

- Keeps the microbe **suspended**
- (So) ensures that the microbe is always **in contact with nutrients**
- Maintains an **even temperature** throughout the mixture

WATER JACKET

- **Reduces heat energy released** from **respiration** by the microbe to prevent the temperature from increasing
- Maintains an **optimum temperature** for **enzymes**

TEMPERATURE / PH PROBES

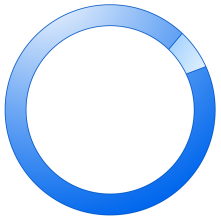
- **Monitor the pH and temperature** of the mixture

ACID OR ALKALI

- Added to **maintain an optimum pH** for **enzymes**
- Prevents enzymes from **denaturing**
- Ensures **maximum rate of reaction** = **maximum yield**

MAKING HUMAN INSULIN PROTEIN USING BACTERIA

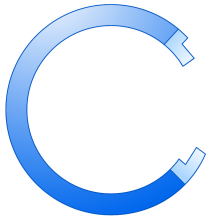
Human chromosome



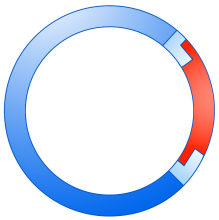
1. Cut out insulin gene from human DNA using a restriction enzyme

2. Cut a plasmid using the same restriction enzyme

3. Gene and plasmid have complementary sticky ends

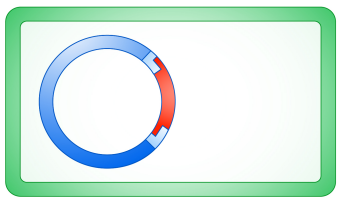


4. Seal human gene into plasmid using DNA ligase enzyme by complementary base pairing to form a recombinant plasmid



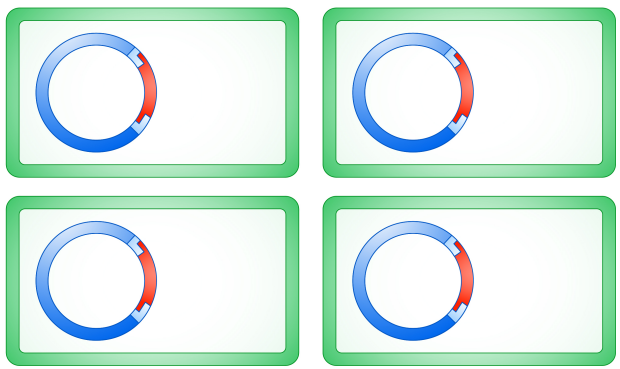
7. Bacteria express the human insulin gene and secrete insulin, which is extracted from the fluid and purified

5. Insert recombinant plasmid into bacteria



6. Bacteria undergo asexual reproduction in fermenters

All new bacteria will contain the recombinant plasmid



First things to identify from the given experiment procedure:

Independent variable — and how it is changed

Dependent variable — and how it is measured

Drawing a table for data

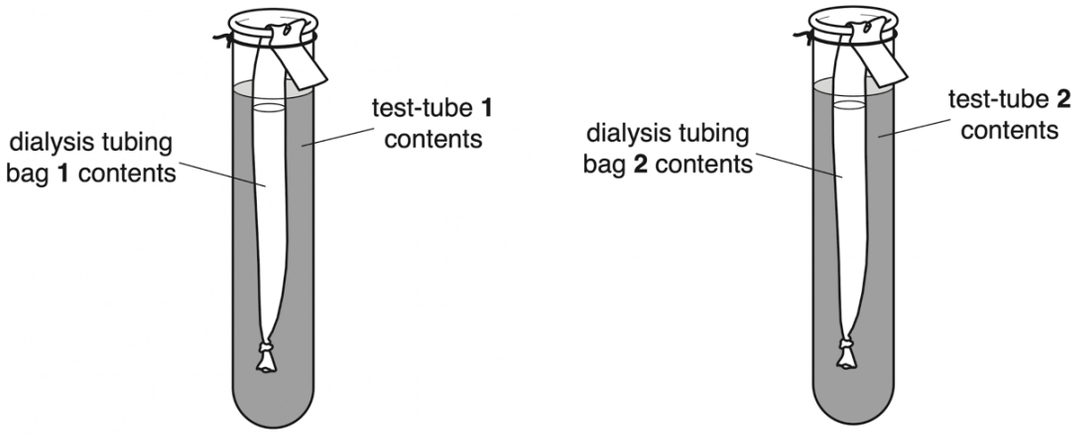
Example 1: recording numbers *and* mean of bubbles produced by three potato pieces

Piece of potato	Number of bubbles in 3 minutes		
	Slice 1	Slice 2	Mean
A	5	3	4
B	18	11	14.5
C	12	10	11

Example 2: recording temperature change with time of water in two beakers

Time / minutes	Temperature / ˚C	
	Beaker A	Beaker B
0	83	83
1	81	76
2	78	72
3	76	68.5
4	74	64

Example 3: recording colour observations from food tests



Food test	Observations			
	Dialysis tubing bag		Test-tube	
	1	2	1	2
Starch	Brown	Blue-black	Brown	Brown
Reducing sugar	Brick-red	Blue	Orange	Blue

Giving a conclusion – e.g., "describe the effect of … on …"

- There will usually be a correlation between the two variables, so we can describe the trend i.e. as the greater the **independent** variable, the greater / smaller the **dependent** variable.
- Use **comparative data** to support (if the question has more than 1 mark).
- Pay attention to whether the question needs you to "**explain**" the reason.

Content that may be tested in experiments

ENZYME-CATALYSED REACTIONS

Factors affecting enzyme activity:

- **Temperature**
- **pH**
- **Concentration of enzyme / substrate**
- **Surface area – larger SA = more enzyme in contact with substrate**

DIFFUSION AND OSMOSIS

Factors affecting rate:

- **Temperature**
- **Concentration gradient**
- **Surface area**

FOOD TESTS

Test	Brief method	Colour change if present
Starch	Add **iodine solution**	**Red/brown → black**
Reducing sugar (glucose)	**Heat** with **benedict's solution**	**Blue → brick red**
Protein	Add **biuret solution**	**Blue → purple**
Fat (lipid)	Add **ethanol** **Shake** well Add an **equal volume** of **water**	**White emulsion**
Vitamin C	Add **DCPIP**	**Blue → colourless**

RESPIRATION

Factors affecting rate:

- Temperature
- pH

Could be measured by:

- A respirometer
- CO_2 production

PHOTOSYNTHESIS

Factors affecting rate:

- Temperature
- pH
- Light intensity
- CO_2 concentration
- Leaf surface area

Could be measured by:

- O_2 production
- Carbohydrate production
- Increase in mass

TRANSPIRATION

Factors affecting rate:

- Temperature
- Light intensity
- Humidity
- Wind speed
- Leaf surface area

Could be measured by:

- A potometer
- A stem & a stain
- Decrease in mass (balance and stopwatch)

Factors affecting rate:

- **Water**
- **Oxygen**
- **Warmth**

Light is NOT needed!

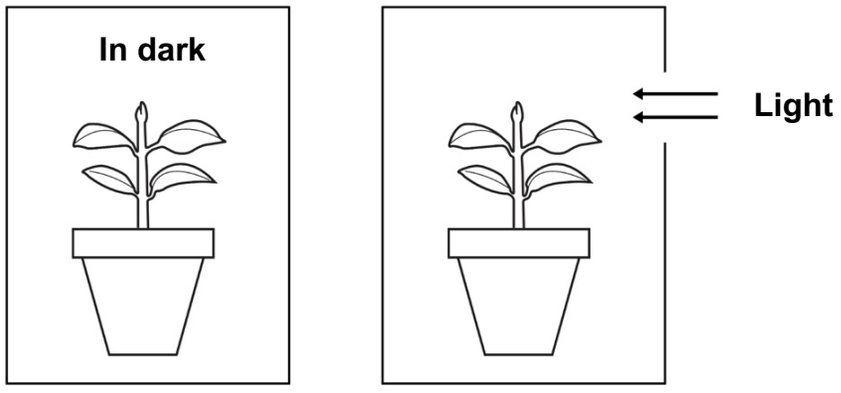
GERMINATION

Could be measured by:

- **Count number of germinated seeds after a set time**
- **Changes in dry mass (decreases then increases)**

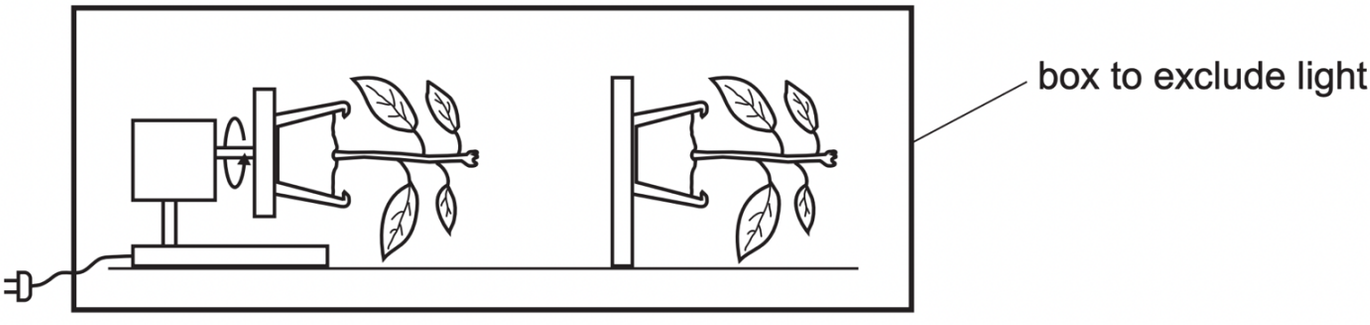
PLANT TROPIC RESPONSES

PHOTOTROPISM



CONTROL

GRAVITROPISM



CONTROL

- The plant used as the **control** is **constantly rotated** on a **clinostat**.
- This **negates** the **effect of gravity** on **one side** of the plant **only**, allowing **comparison** of response with the other plant.

HEART AND BREATHING RATES

EXERCISE

Varying intensity:

Same exercise type

Different durations

Varying type:

Different exercise types

Same duration

MEASURING BREATHING RATE

- Measure increase in chest circumference
- Count the number of breaths over 1 min

MEASURING HEART RATE

- Digital heart rate monitor
- Count pulse over 1 min

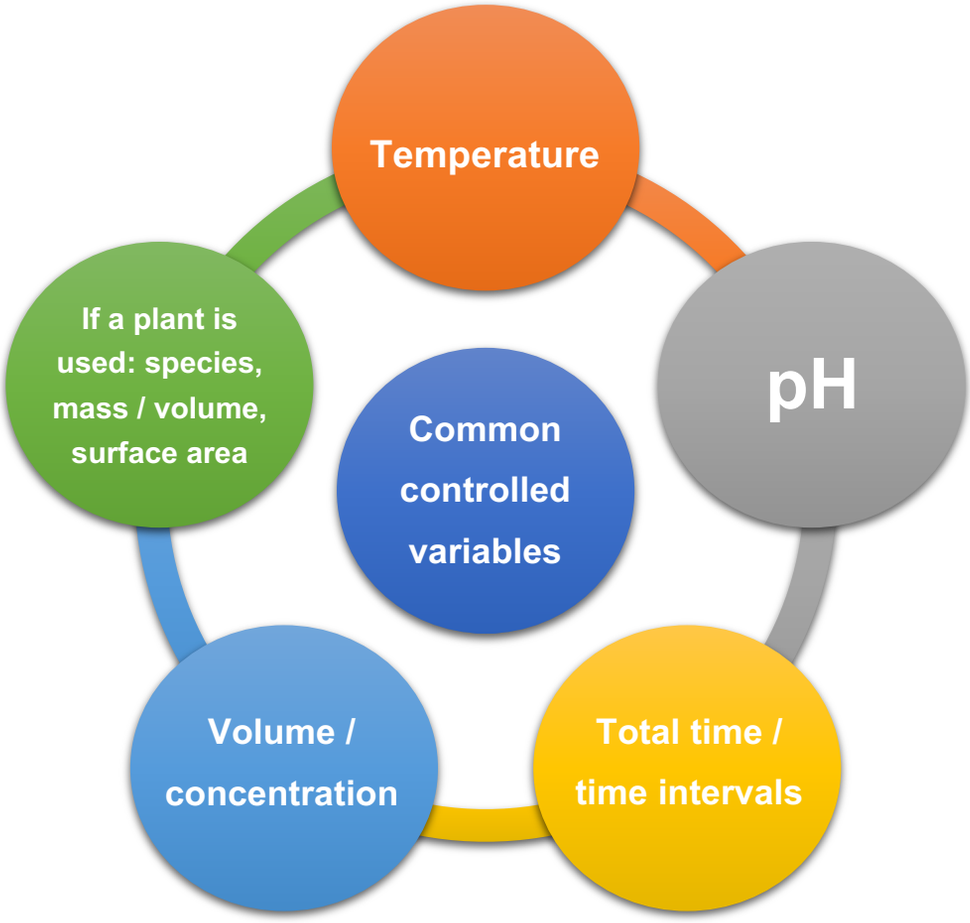
Consider the following for controlled variables:

- Gender
- Age
- Level of fitness
- Environmental conditions
- Resting time between exercises

- How to repeat: test on the same person for multiple times, or test on multiple participants.
- Remember to mention the health conditions of participants as a safety precaution.

<u>Possible ways of measuring a dependent variable</u>

A colour change happens	**Use a colorimeter / colour chart for comparison** • **Measure time taken to reach a set endpoint, or:** • **Record colour at set time intervals over a fixed time**
A gas is produced	• **Measure volume of gas using a gas syringe / inverted measuring cylinder over a fixed period of time** • **Counting bubbles is less accurate**



Possible error sources and improvements

Source of error	Improvement
Temperature not maintained	Use a **thermostatically controlled water-bath**
Judging colour change by eye	Use a **colorimeter**
Imprecise measuring of volume	**Liquid** – use a **burette** **Solid** – use a **ruler** to measure same dimensions **Gas** – use a **gas syringe** instead of counting bubbles
Many processes are done at the **same time** – errors more likely	Do processes **sequentially**
Equipment unwashed – can cause contamination	**Wash and dry** equipment (to prevent dilution) Use **new** ones each time
No repeats	**Repeat** 3 times to increase **reliability**
Variable not controlled	Method to keep it the same
Insufficient intervals of IV	Test a wider range / more and smaller time intervals
Imprecise scale of equipment	Use equipment with a more **graduated scale**

- Try to pick “obvious” errors in the method as usually not all will be accepted by the mark scheme.

Planning an investigation

Example: investigating the effect of temperature on the activity of amylase enzyme

Independent variable

- **Specify range of values** – 15˚C, 25˚C, 35˚C, 45˚C, 55˚C
- **How to control the IV** – use a thermostatically controlled water bath to maintain each temperature

Dependent variable

- **If set endpoint** – time taken for iodine solution to change from brown to colourless, using a colorimeter
- **If measured at intervals** – take samples from the amylase & starch mixture every 1 min for 10 min

Controlled variables

- Same concentration and volume of starch suspension
- Same concentration and volume of amylase
- Same pH (using a buffer solution)

Control group

- Keep **all conditions the same**
- Except add **water** to starch **instead** of **amylase**

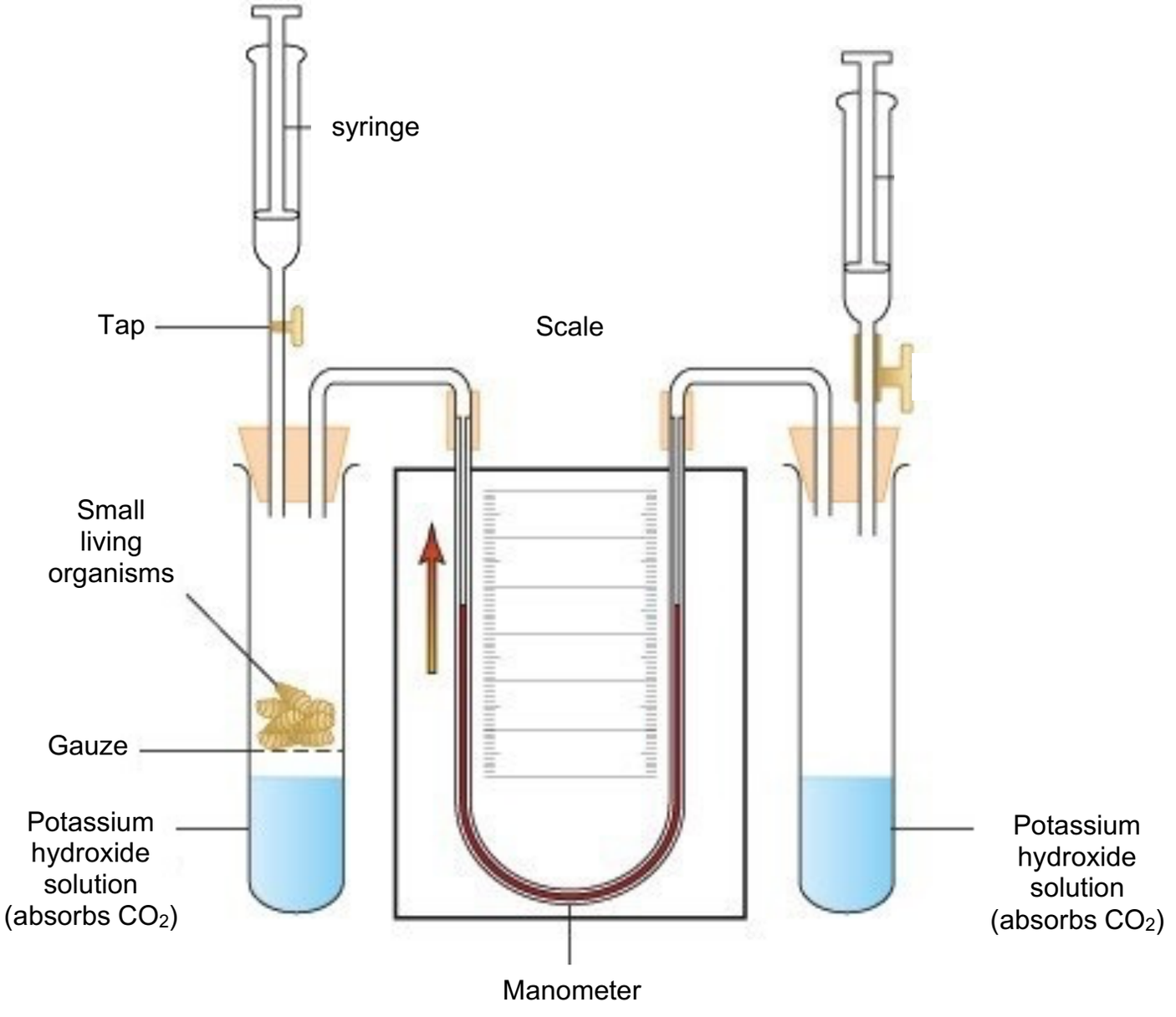
Repeats & safety

- **Repeat** investigation 3 times and calculate a **mean**
- Wear safety goggles and gloves

- **Control variables** are held constant throughout both experimental and control groups. This ensures that only the effect of the independent variable on the dependent variable is investigated.
- A **control group** is not exposed to the independent variable, to compare with the experimental group. This is to show that no factor other than the independent variable is causing an effect.

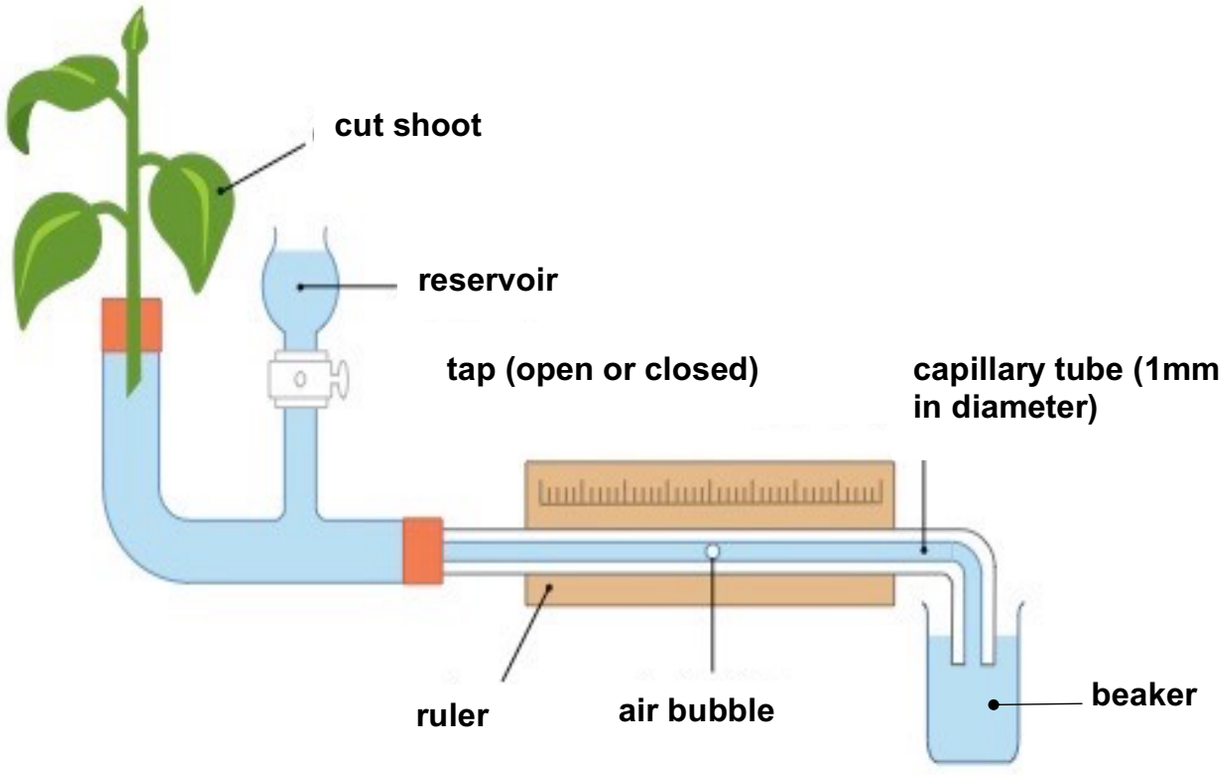
Possible hazard in experiment	Safety precaution
Use of acid / alkali / enzyme	Wear safety **goggles** and **gloves**
Use of Benedict's solution	
Heating	Use a **water bath** to heat and not a Bunsen burner
Use of knife for cutting	Cut on a **solid surface** and **away from hands**
Use of ethanol – flammable	Keep **away from flames**

Respirometer – used to measure the rate of respiration



- Living organisms are placed in a **sealed glass container**.
- As the animals respire they would **use O_2** and the liquid in the manometer would move **towards them (up)**. However, they would also **produce CO_2**, which would move this liquid **away from them (down)**.
- **Potassium hydroxide** or **soda lime** (alkali) is added to the tube, which absorbs **CO_2**.
- This ensures that **only** the **O_2 used** is responsible for **moving** the **liquid**.
- The **greater the distance** the liquid moves towards them, the **greater the rate of respiration**.
- The **temperature must be kept the same** throughout as it **affects the rate of respiration** due to **decreased or increased enzyme activity**.

Potometer – investigating the effect of …… on the rate of transpiration



Preparation before starting:

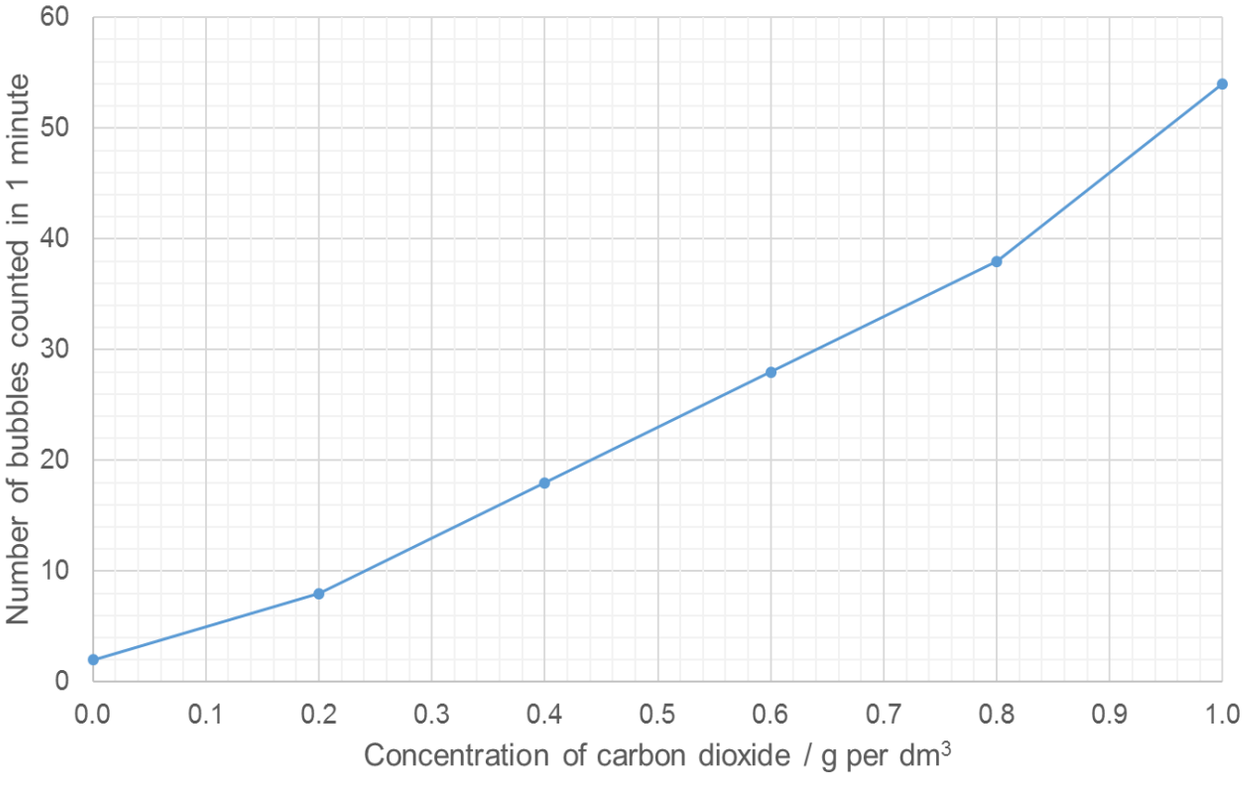
- **Cut the shoot underwater and at an angle to prevent air outside from entering the xylem**
- **Seal all joints with Vaseline to prevent entry of air and evaporation of water**

Independent variable	How to change it	Dependent variable
TEMPERATURE	Set up the **potometer** in a **thermostatically controlled waterbath**, each time using a **different temperature**	**Measure distance moved by the air bubble over a fixed period of time** **Divide the distance by time to calculate the rate of transpiration (rate of water uptake)**
LIGHT INTENSITY	Place a **lamp** at **different distances** from the **plant**	
HUMIDITY	**Cover the plant** with a **plastic bag** and **spray different amounts of water** inside **Unit for humidity = g per m^3**	
WIND SPEED	**Use a fan at different wind speeds**	
SURFACE AREA	Use the **same plant** / plants of the **same species** with **different numbers of leaves**	

- **Except for the factor that you are investigating, all the others shown above should be controlled.**
- **Open the tap to reset the air bubble for three repeats, then calculate a mean value.**

Line graphs

Amount of carbon dioxide / g per dm^3	Number of bubbles counted in 1 minute
0.0	2
0.2	8
0.4	18
0.6	28
0.8	38
1.0	54



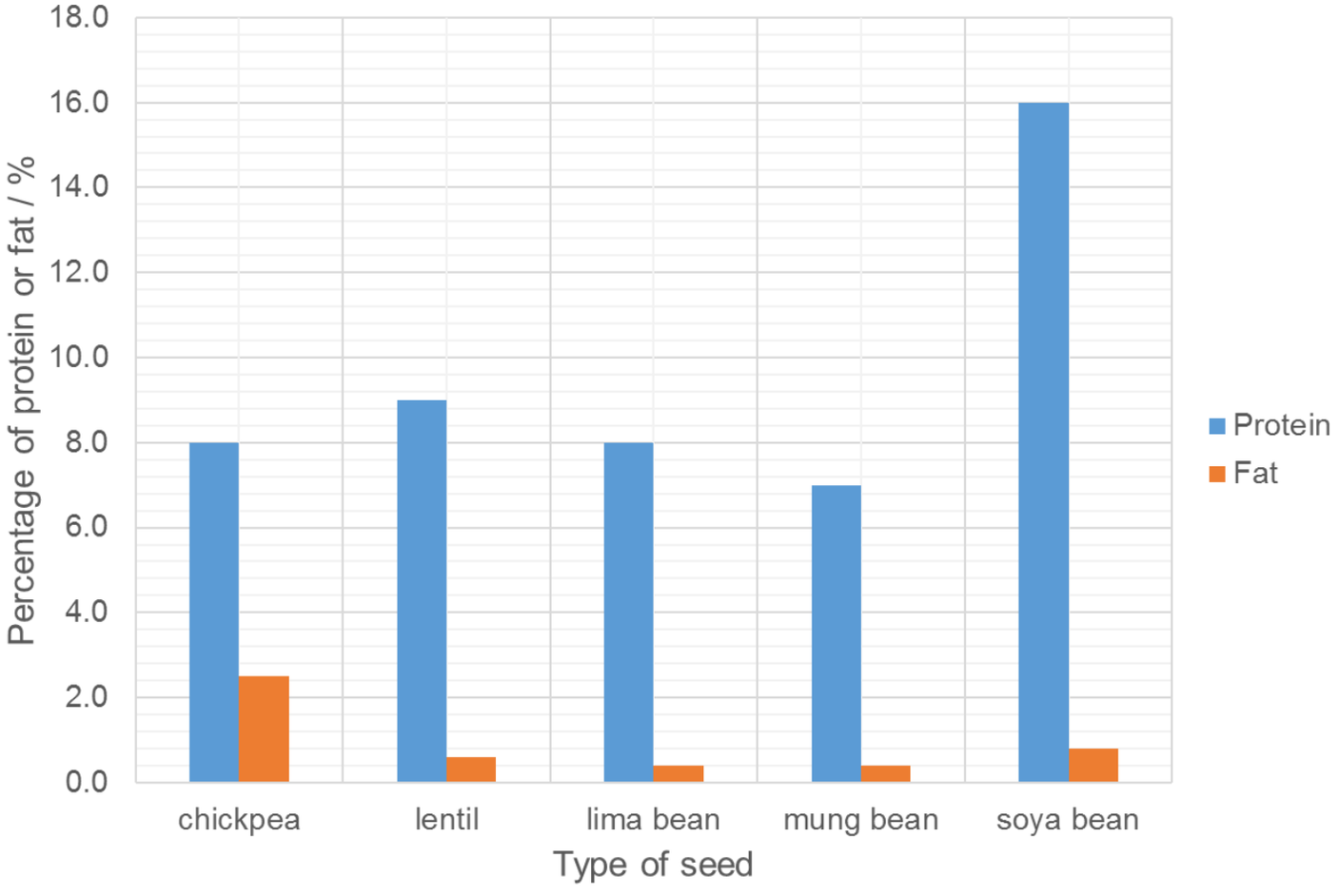
1. **Use an even scale that takes up most of the graph paper**
2. **Use a suitable scale – starting values do not have to be 0 or the same**
3. **Both axes should have titles and units (if appropriate)**
4. **Use a key (e.g. "x" and "+" for plotting) or label each line (if appropriate)**
5. **Plot points accurately (use an "x" to plot)**

- If you are asked to plot information given in a table, then the independent and dependent variables can be found directly in the table's column headings.
- Clearly anomalous points should be ignored when drawing a best-fit line.

Bar graphs

- Used to represent **discontinuous data**, i.e. when one of the variables contains **distinct categories**.

Type of seed	Percentage of protein / %	Percentage of fat / %
chickpea	8.0	2.5
lentil	9.0	0.6
lima bean	8.0	0.4
mung bean	7.0	0.4
soya bean	16.0	0.8

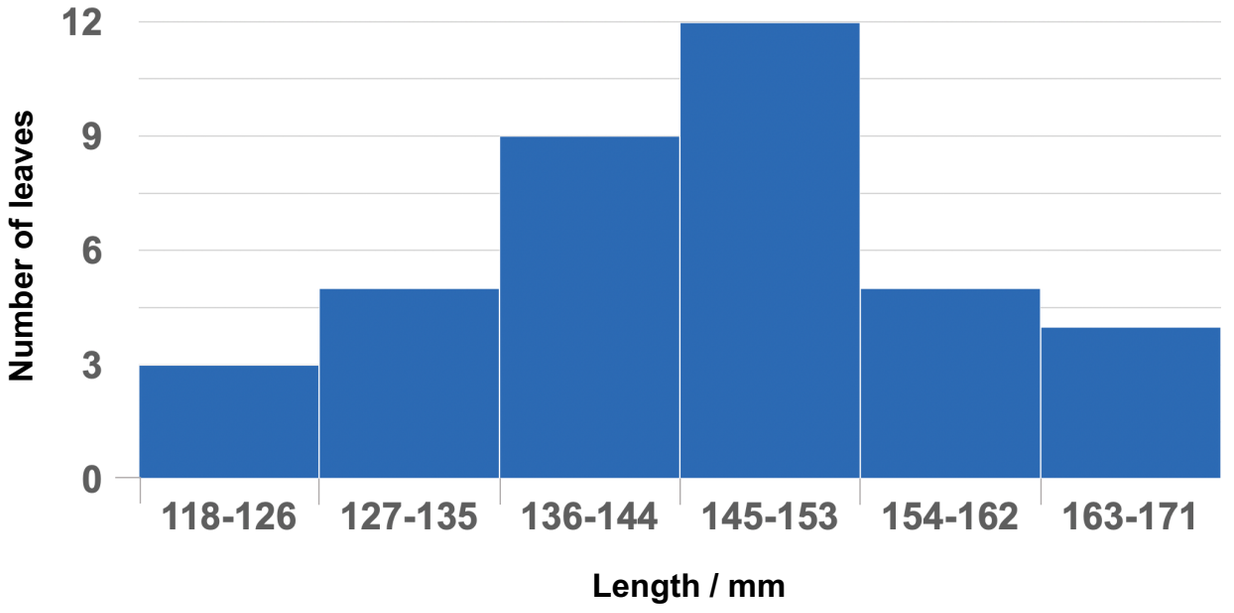


1. Bars of different categories should have gaps of equal width in between
2. All bars should have the same width
3. Both axes should have titles and units (if appropriate)
4. Use a key when there are multiple bars for each category

Frequency histograms

- Used to represent **discontinuous data** where frequencies of the categories are measured.
- The graphing question will usually tell you which type of graph to draw, but histograms are not often tested on paper 6.

Length / mm	Number of leaves
118 – 126	3
127 – 135	5
136 – 144	9
145 – 153	12
154 – 162	5
163 – 171	4



1 All blocks should be touching and have the same width

2 Label each category on the x-axis by class ranges (e.g. 118-126, 127-135)
OR by putting the lowest number in each range (e.g. 118, 127, 136) at the start

3 Both axes should have titles and units (if appropriate)
Frequency is represented by the y-axis

4 Use a key when there are multiple bars for each category

Describing the trend of a line graph

- Do the variables have a **positive** or **negative** correlation?
- Is the relationship **linear** or **exponential**?
- Describe the trend – **increase** / **decrease** (steep or gradual?) / **constant** / **levels off**
- Are there any **maximum** / **minimum** points?
- Use comparative **data** with **units**

Improving data

Accurate = close to the "true", error-free value

Reliable = similar results are obtained when repeated

	Reliable	Unreliable
Accurate	The correct value is obtained all the time	The correct value on average, but results vary between repetitions
Inaccurate	The same incorrect value all the time	An incorrect value on average, and results vary between repetitions

Why should we do repeats?

1. **To make the average (mean) more reliable**
2. **To identify anomalies** (results that do not fit the general trend)

How to get a representative sample

- **Simple random sampling** is a technique used to **avoid bias** – this ensures that all individuals in a group have an equal chance of being selected.
- The **sample size** must also be **large** enough so that the distribution of data will unlikely be skewed due to anomalies.

Calculating percentage concentration

	test-tube number						
	1	**2**	**3**	**4**	**5**	**6**	**7**
volume of 1% protein solution / cm^3	0.00	0.25	0.50	1.00	2.00	3.00	4.00
volume of distilled water / cm^3	5.00	4.75	4.50	4.00	3.00	2.00	1.00
percentage concentration of protein solution	0.00	0.05	**0.10**	0.20	0.40	0.60	**0.80**

$$\frac{\text{Volume of solute}}{\text{Total volume of diluted solution}} = \frac{1}{\text{Dilution factor}}$$

$$\text{\% Concentration} = \frac{\text{\% of concentrated solution}}{\text{Dilution factor}}$$

Solution to example:

Test tube 3

0.50 / 5.00 = 1 / 10

Dilution factor = 10

% conc = 1 % / 10 = 0.10 %

Test tube 7

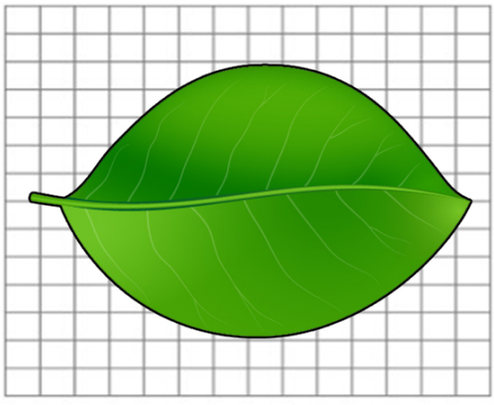
4.00 / 5.00 = 1 / 1.25

Dilution factor = 1.25

% conc = 1 % / 1.25 = 0.80 %

Measuring leaf area using a grid

1. **Trace** around the **leaf outline** on the grid
2. **Count** the **number of squares** occupied
3. Include any squares more than half covered



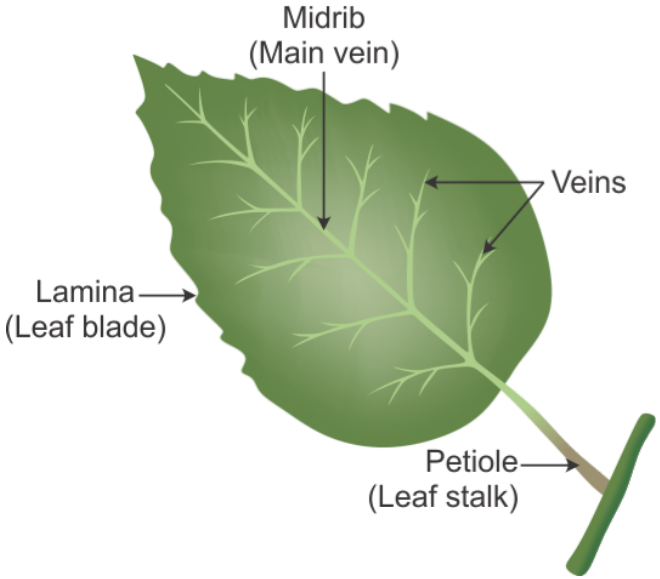
Calculating magnification

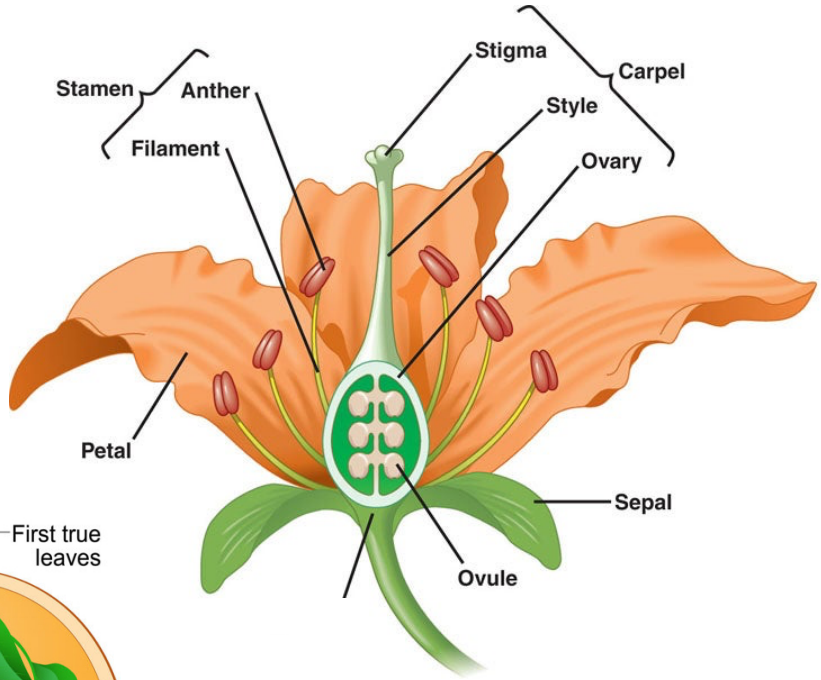
$$\text{Magnification} = \frac{\text{Image size}}{\text{Actual size}}$$

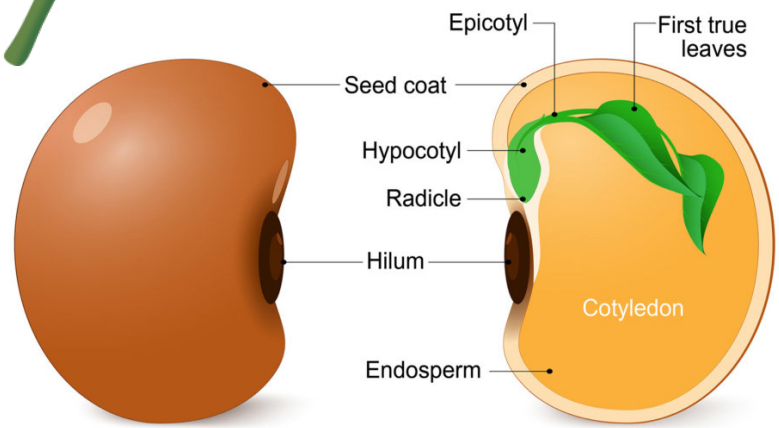
1 mm = 1000 µm KEEP UNITS THE SAME! ☺

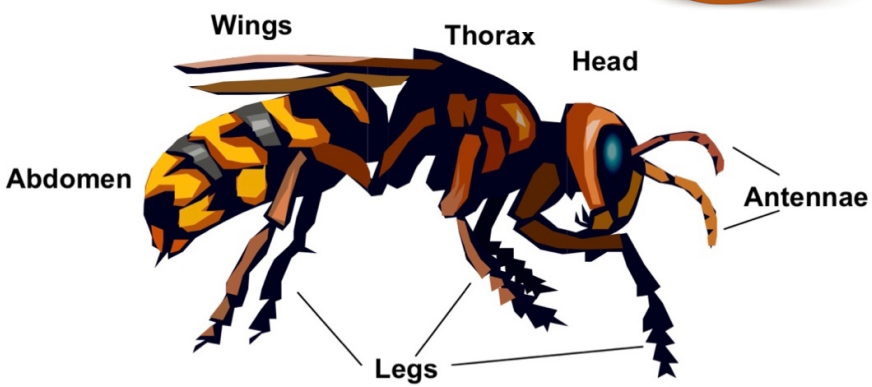
- When measuring things in paper 6, using **millimetres** would be better than centimetres.

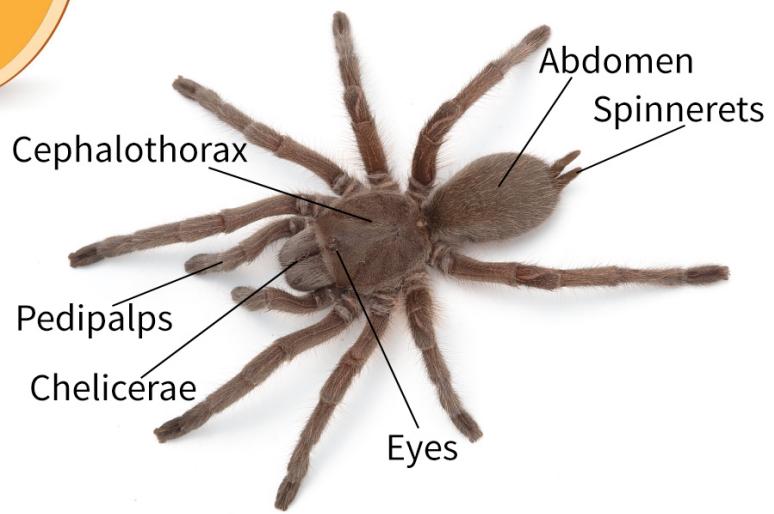
LABELLING DIAGRAMS











TESTS FOR CARBON DIOXIDE

HYDROGENCARBONATE INDICATOR

High CO_2 concentration ← Atmospheric CO_2 → Low CO_2 concentration

TURNS YELLOW

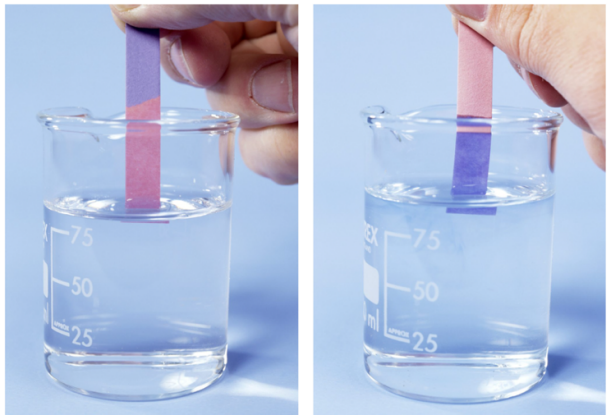
TURNS PURPLE

LIMEWATER TEST

Limewater turns milky when CO_2 is bubbled through

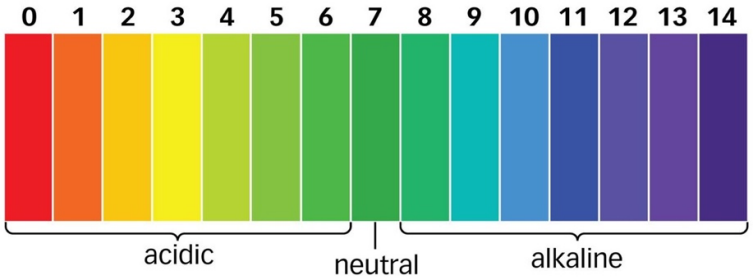
TESTS FOR PH

BLUE / RED LITMUS PAPER TEST

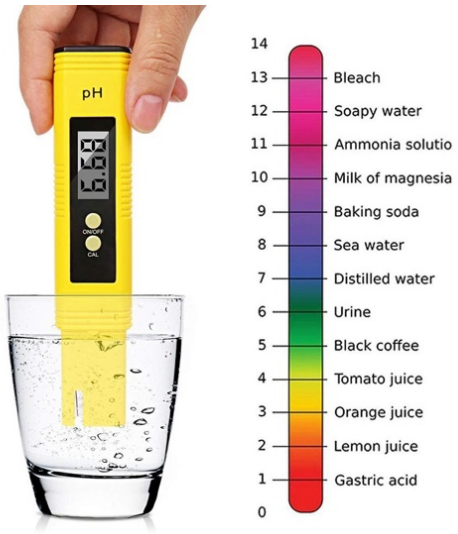


ACID ALKALI

UNIVERSAL PH INDICATOR



DIGITAL PH METER



- Note that litmus is the less accurate than the other two as it cannot give an exact pH value.

Image sources

UNIT 1

Breen, Annina. “The Major Ranks: Domain, Kingdom, Phylum, Class, Order, Family, Genus, and Species, Applied to the Red Fox, Vulpes Vulpes.,” *Wikipedia*, 29 May 2015, en.wikipedia.org/wiki/Taxonomic_rank.

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