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CAMBRIDGE IGCSE

INTERNATIONAL GENERAL CERTIFICATE OF SECONDARY EDUCATION

IGCSE BIOLOGY 0610/0970

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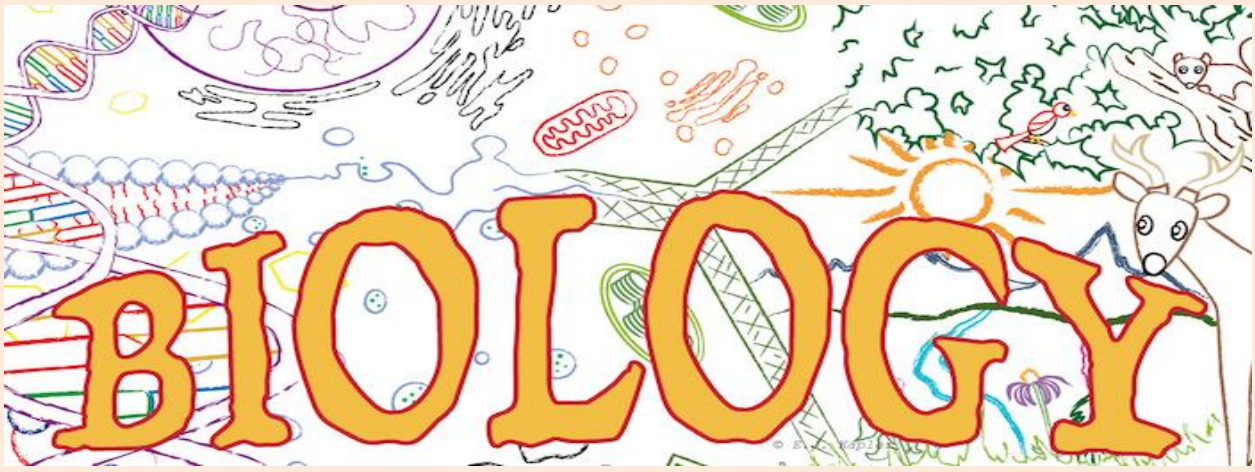


BIOLOGY IGCSE

CHARACTERISTICS OF LIVING ORGANISMS

A living organism must have all the following seven characteristics:

- **Movement**: an action by an organism or part of an organism causing a change of position or place
- **Respiration**: the chemical reactions in cells that break down nutrient molecules and release energy for metabolism
- **Sensitivity**: the ability to detect or sense stimuli in the internal or external environment and to make appropriate responses
- **Growth**: a permanent increase in size and dry mass by an increase in cell number or cell size or both
- **Excretion**: removal from organisms of the waste products of metabolism (chemical reactions in cells including respiration), toxic materials, and substances in excess of requirements
- **Reproduction**: the processes that make more of the same kind of organism
- **Nutrition**: taking in of materials for energy, growth and development; plants require light, carbon dioxide, water and ions; animals need organic compounds and ions and usually need water

CLASSIFICATION

Each organism is referred to by a specific binomial name consisting of two parts, 'Genus' and 'species'

Example: Human beings are referred to as Homo sapiens, where Homo is the genus and sapiens is the species name. Loxodonta africana (African elephant), Panthera pardus (Leopard)

N.B. Genus name starts with a capital letter, unlike species name.

DNA SEQENCING

DNA sequencing can show how close the organisms are together; the more distant the organisms are the more the changes in their DNA sequences.
Organisms within the same species, Ex: Humans, Have the same number of chromosomes 46, same genes, but SIMILAR DNA sequence.

Organisms are classified to 5 kingdoms; Plants, Animals, Bacteria, Fungi, Protozoa
Each kingdom is further classified to families, orders, classes, genus and species
Species: a group of organisms that have similar morphology and can interbreed producing a fertile offspring

PLANTS

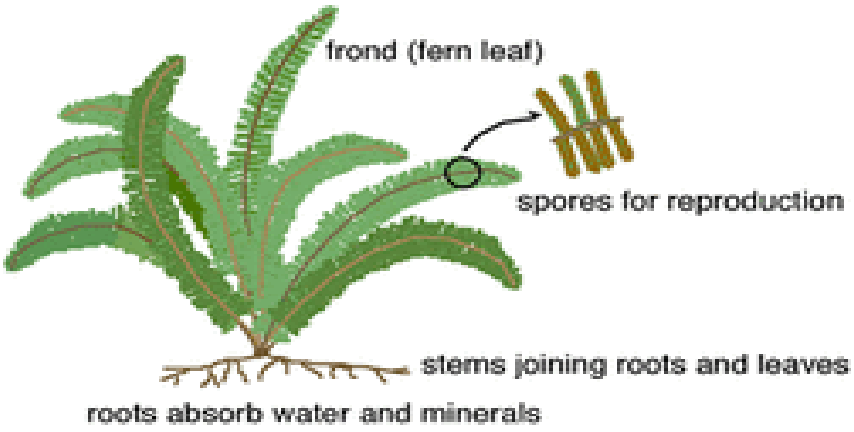
Either flowering or non-flowering

Non-flowering plants:

Plants that **don't** undergo sexual reproduction, they **don't** have reproductive organs (flowers), they have leaves and **reproduce by spores (asexual reproduction)**

They are able to make their own food by photosynthesis.

Example: Ferns



Flowering: *Either Monocotyledonous or Dicotyledonous*

*** Most important features**

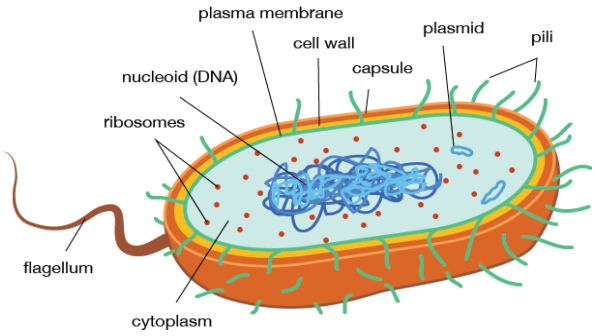
Point of comparison	Monocotyledonous	Dicotyledonous
Example	Corn, Wheat	Beans, Sunflowers
Leaf		
		
Shape*	Long and narrow	Short and broad (wide)
Veins*	Parallel veins	Midrib (Main vein) with branching veins
Stalk	Absent	Present
Flower		

		
Number of petals*	Multiples of 3 i.e. 3, 6, 9	Multiples of 4 and 5
Stem		
Vascular bundles	Scattered irregularly in stem	Organized in a ring pattern
Root		
Shape*	Main root with branches	Irregular rootlets
Seed		
Cotyledon	One	Two
Testa	Transparent	Opaque

BACTERIA

Bacteria are referred to as **prokaryotes** , they are primitive unicellular organisms having the following structure

- **Flagellum for motility**
- **Capsule to stick to the surface of host cells**
- **Plasmid which is a circular DNA that has the ability to transfer from one bacterium to another exchanging genetic material**
- **They reproduce asexually through binary fission, NOT MITOSIS.**



DIFFERENCE BETWEEN A 'EUKARYOTE' (ANIMAL OR PLANT CELL) AND 'PROKARYOTE'?

- Cell wall in bacteria made of murein
- Loop of naked DNA in bacteria
- Flagellum and capsule in bacteria
- Nucleus in eukaryotes
- Mitochondria and other organelles such as RER in eukaryotes
- Chloroplasts in plant cells
- Cell wall made of cellulose

Exclusive to bacteria
Common between plant cells and animal cells
Exclusive to plant cells

SIMILARITIES BETWEEN A 'EUKARYOTE' (ANIMAL OR PLANT CELL) AND 'PROKARYOTE'?

- Both have cell membrane
- Both have genetic materials (DNA and RNA)
- Both plant cells and bacteria have cell walls

This kingdom is sub classified into vertebrates and invertebrates

Vertebrates include Mammals, Birds, Reptiles, Fish and Amphibians

Mammals

- Have hair or fur
- Have whiskers
- Have mammary glands
- Give birth
- Have external ear
- Warm blooded

Ex: Humans, Mice, Cats, Dogs, Horses

Birds have

- Feathers
- Peak
- Scaly legs
- Wings

Ex: Pigeons, Owls, Eagles

Reptiles have

- Dry scaly skin
- 4 limbs (2 legs and 2 arms), N.B. except for snakes

Ex: Crocodiles, Lizards, Snakes

Fish have

- Gills
- Moist scaly skin
- Fins
- Lay eggs
- Cold blooded

Amphibians have

- Moist skin
- Can live on land or under water

Ex: Frogs

N.B. If asked how to identify this organism as a reptile, it's possible to include in the answer features of mammals not present in reptiles that led you to your assumption.

Example:

1- Dry scaly skin
2- Four limbs
3- **No external ears**
4- **No fur**

Invertebrates include Arthropods

Arthropods are characterized by:

- **Exoskeleton**
- **Jointed legs**
- **Segmented body**
- **Antennae**

Arthropods are further classified into Insects, Arachnids, Crustaceans, and Myriapods

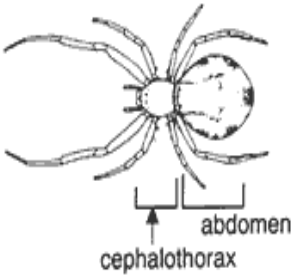
Insects have

- 3 Pairs of jointed legs
- 3 body parts (head, thorax and abdomen)
- 1 or 2 pairs of wings
- A pair of antennae

Example: Flies, Bees, Ants

Arachnids have

- 4 pairs of legs



- 2 body parts (cephalothorax and abdomen)
- Chelicerae (mouth part)

Example: Spiders, Scorpions

CRUSTACEANS HAVE:

More than 4 pairs of jointed legs
2 body parts (cephalothorax and abdomen)
Hard exoskeleton
Compound eyes
A pair of antennae

Example: Crabs

MYRIAPODS HAVE:

Many pairs of jointed legs (20-30)
Many body parts
Each body part has a pair of legs

Example: Centipedes, Millipedes

Fig 1.1 Shows *Penaeus monodon*, an organism that lives in freshwaters

Q1. What is the genus name of this organism?

A1. **Penaeus**

Q2. What features **visible** in fig 1.1 shows that this organism belongs to **Arthropods?**

A2.

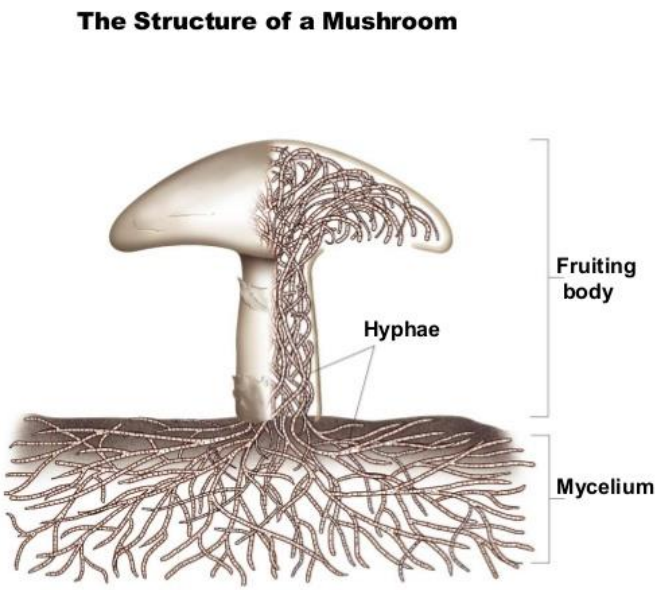
- **Jointed legs**
- **Exoskeleton**
- **Segmented body**
- **antennae**

Q3. To which family does this organism belong?

A3. **Crustaceans**

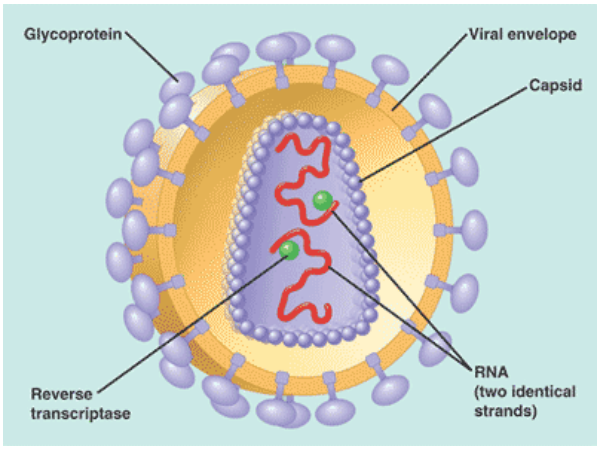
FUNGI

- They are multicellular organisms having nuclei and cell walls made of **chitin.**
- They reproduce asexually by forming spores, when spores land on a suitable environment they germinates forming a new fungus
- The functioning unit of fungi is called the ***hyphae.***
- A group is hyphae is called a ***mycelium***
- A fungus obtains its new nutrition by secreting **extracellular** digestive enzymes into the food by its feeding hyphae and then absorbs the digested products.
- Example: Mushroom



VIRUS

- It's non-living
- It lives inside host cells
- It consists of a protein viral envelope and genetic material (DNA **OR** RNA)
- It replicates using DNA inside the host cell to produce its protein coat and form a new virus
- Example: **HIV**, Variola, Varicella



Dichotomous key

How to create a dichotomous key?

Choose features that vary between organisms **of the same family (Insects, Arachnids,…).**

Examples:

- Length of legs in two different insects
- Length of antennae in two different insects
- Number of wings in two different insects
- Number of body segments in two different Myriapods

1. One Pair of Wings .... Go to 2.
   Two Pair of Wings .... Go to 3.

2. Does the insect have filaments at end of abdomen?
   a. Yes .... Mayflies (***Ephemeroptera***)
   b. No .... Flies (***Diptera***)

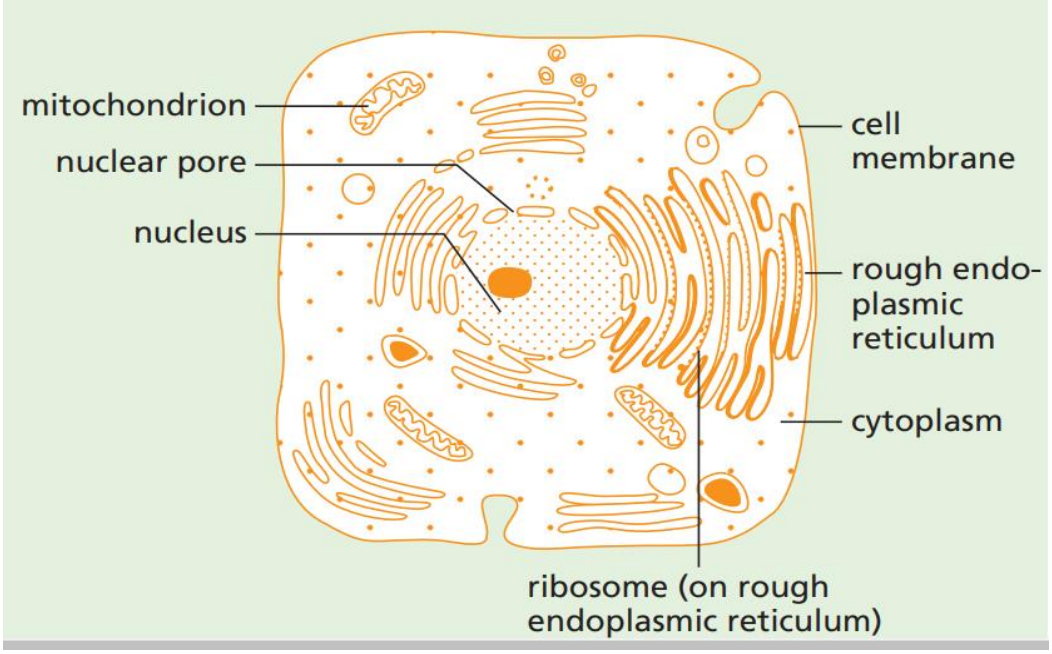
3. Is the the forewing ...
   a. hard .... Go to 4.
   b. not hard .... Go to 5.

4. Does the insect have forcepts (or pinchers) on its abdomen?
   a. Yes .... Earwigs (***Dermoptera***)
   b. No .... Beetles (***Coleoptera***)

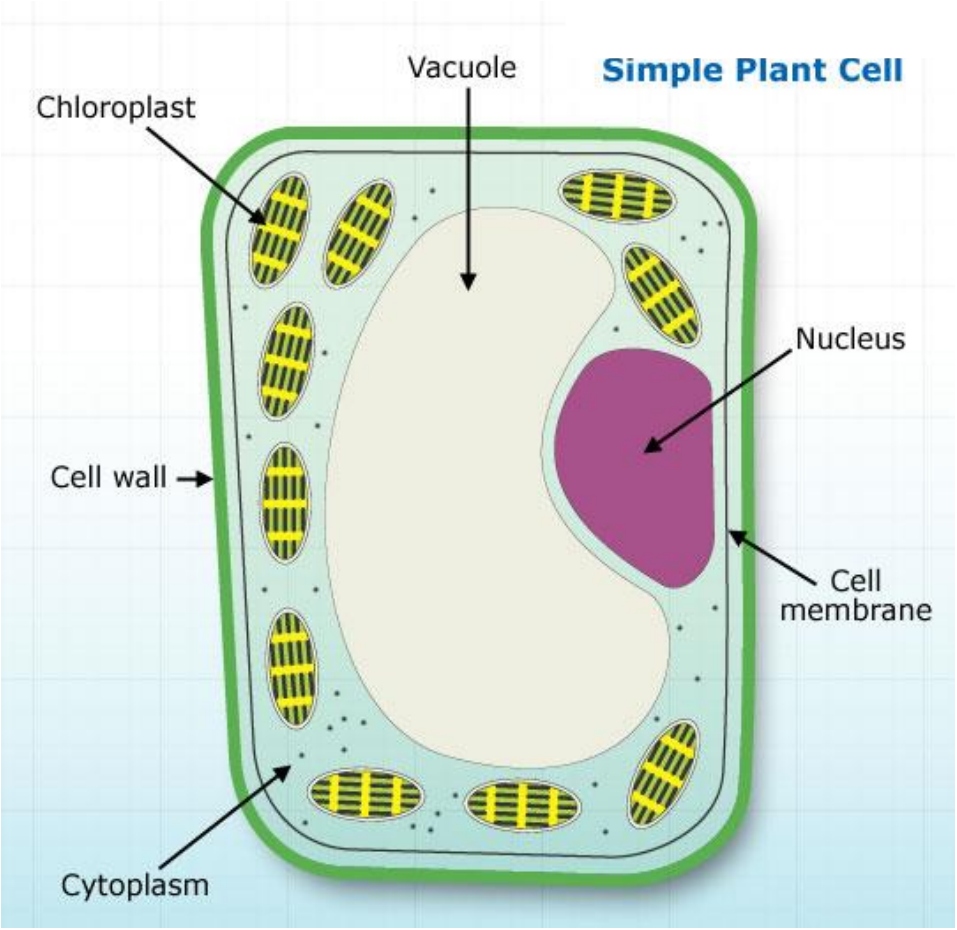
5. Is the forewing ...
   a. membranous .... Dragonflies (***Odonata***).
   b. covered with scales .... Butterflies & Moths (***Lepidoptera***).

CELL STRUCTURE

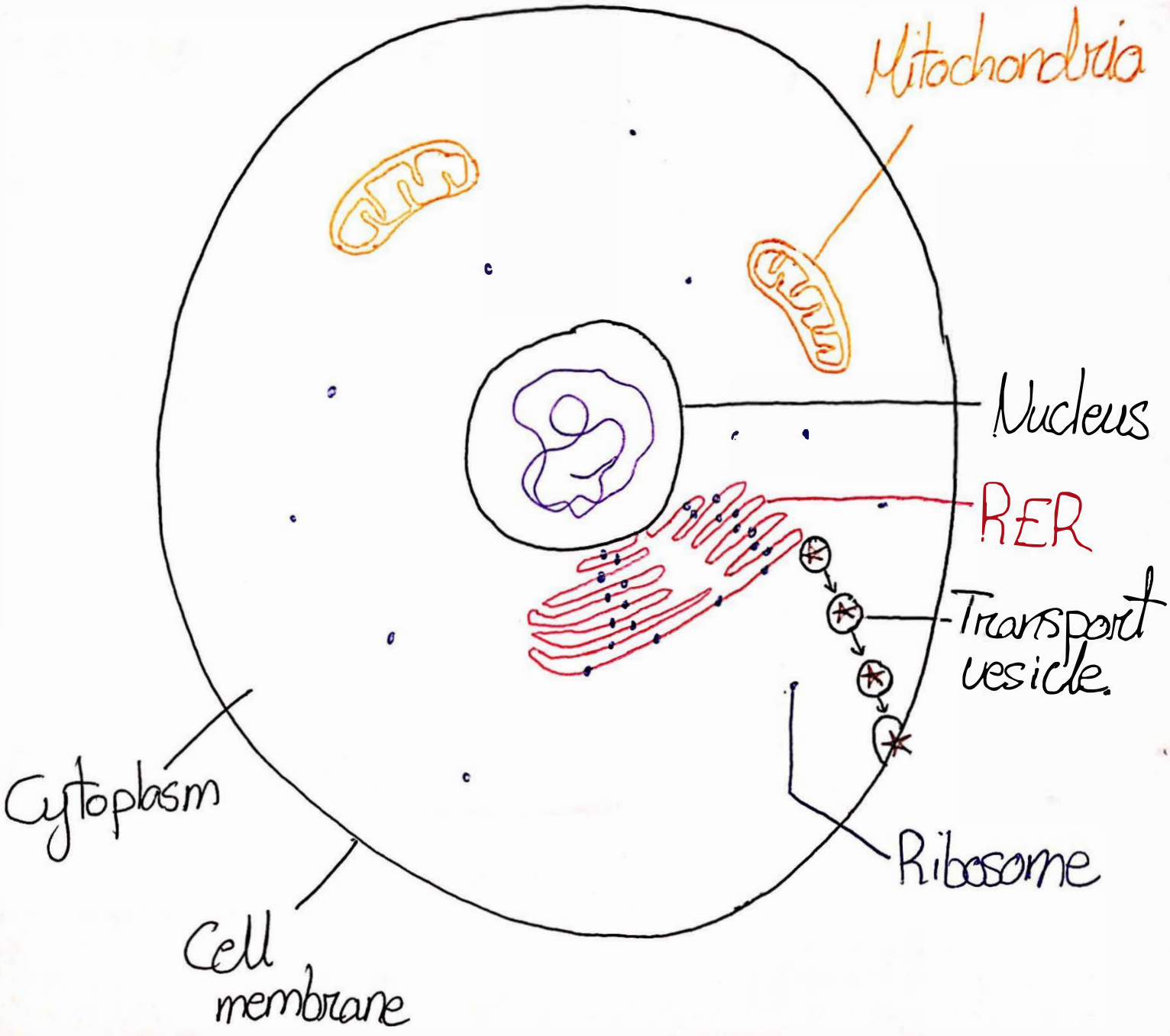
Typical animal cell



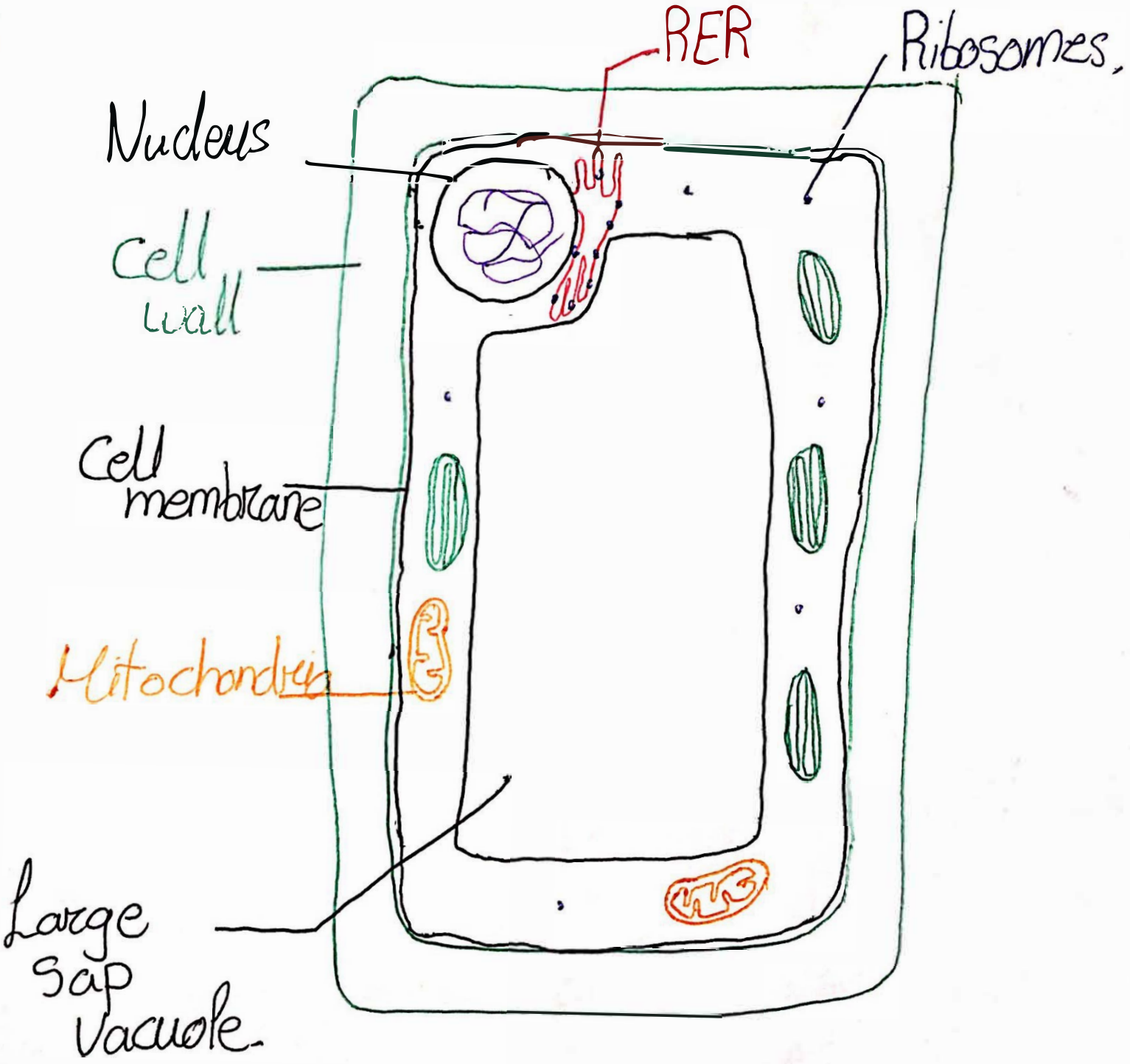
Typical plant cell (Palisade cell)



Animal cell.


Mitochondria
Nucleus
RER
Transport vesicle
Cytoplasm
Ribosome
Cell membrane

Plant cell


RER
Ribosomes.
Nucleus
cell wall
Cell membrane
Mitochondria
Large sap Vacuole.

Organelles

Cells contains smaller structures known as organelles, each have a different function as given below.

Nucleus

- Contains genetic material (DNA & RNA)
- Controls the functions of the cell.
- Controls cell division.

Cell membrane

- Partially permeable membrane.
- Controls passage of ions and water into and out of the cell.

Cytoplasm

- Provides a medium for chemical reactions inside the cell, example: anaerobic respiration.
- Gives the shape of the cell and acts as a medium for organelles to move.

Mitochondria

- Site of **aerobic** respiration, so produces energy.

Ribosomes

- Site of protein synthesis.

RER

- A membranous structure that have ribosomes attached to it
- Site of protein synthesis for use outside the cell ex: hormones, fibrinogen and other plasma proteins

Chloroplast

- Contains chlorophyll
- Site of photosynthesis

Large vacuole*

- Concentrated with ions to help in water absorption (explained later)
- Stores water to provide turgor pressure
- Site of chemical reactions in plant cells

Cell wall

- Fully permeable
- Resists internal pressure of the cell
- Prevent rupture of plant cells

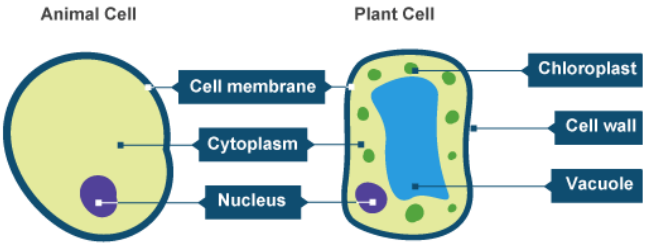
- Present in plant cells only

Plant cells differ from animal cells in having a cell wall, chloroplast and a large vacuole

N.B. plant cells are not always regular in shape.

***N.B. vacuoles are also present in animal cells but play a different rule, such as in transport of substances through the cell, phagocytosis, etc. where they are called vesicles**

N.B. both animal and plant cells have a cell membrane.



Stem Cells

They are unspecialized cells that have the ability to differentiate into other types of cells
They are present in the skin and the alimentary canal, to replace continuous loss of cells from these areas.

Levels of organization

From smallest to largest:

Level	Examples
Cell	Root hair cell, neuron, sperm
Tissue	Muscle, xylem, epithelium
organ	Liver, skin, root, flower
Organ system	Respiratory system, digestive system

Tissue is a group of cells of the same type that perform the same function.
Organ is a group of different tissues.

Important structures

Red blood cell (RBC)

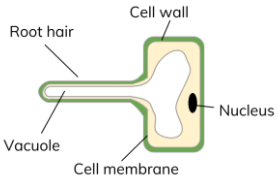
Role: Transport of oxygen
Adaptations

- Has haemoglobin that binds to oxygen.
- No nucleus or organelles to carry more haemoglobin.
- Biconcave to increase the surface area.
- Thin and elastic walls to squeeze through narrow capillaries.

Root hair cell

A cell present on the surface of plant roots that absorbs water and minerals.
Adaptations:

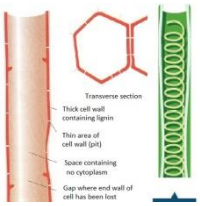
- Has a finger like projection to increase the surface area for more absorption.
- Many mitochondria for more active transport.
- Concentrated sap vacuole to absorb more water by osmosis.



Xylem (tissue)

Role: **Conduction** of water and **support** in plants
Adaptations:

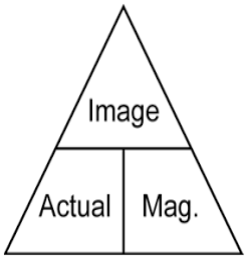
- Lignified walls for support and to avoid collapsing.
- No organelles or end walls between cells to provide minimum resistance for water flow.
- Have pits in its wall to supply water to the
- surrounding.



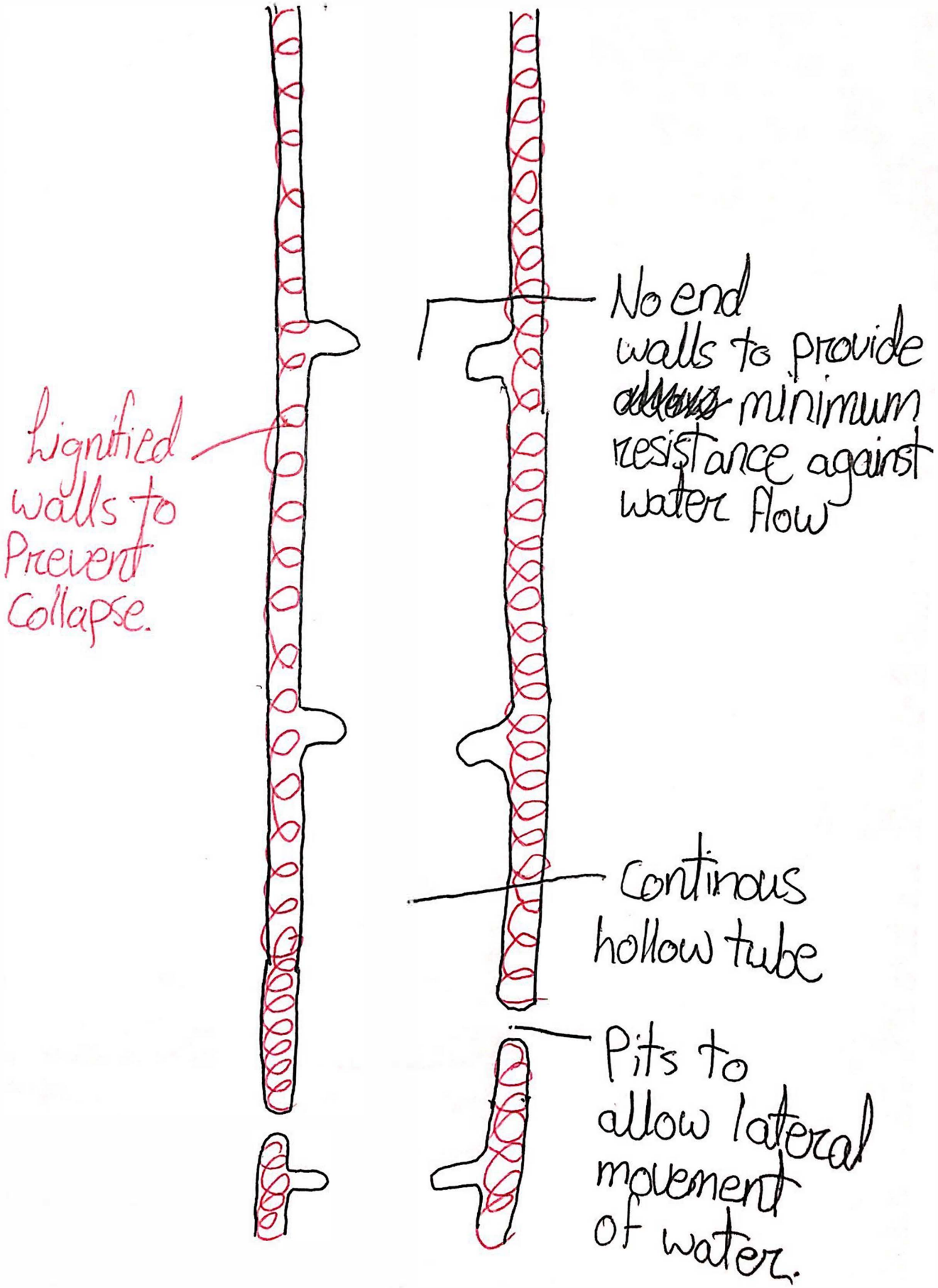
Magnification of specimens

To calculate the magnification, measure using a ruler the size of the image given and divide it by the actual size of the specimen.

All units **should be the same** before performing calculations.



Xylem vessel



BIOLOGICAL MOLECULES

Different biological molecules in living organism exist, they include

- Proteins
- Fats
- Carbohydrates
- DNA
- Vitamins
- Mineral ions
- Fibres

Proteins

- They are complex structures; their simplest unit is **amino acids.**
- **All** proteins consist of carbon (C) Hydrogen (H) Oxygen (O) and Nitrogen (N), they are broken down to their simplest unit by **protease** enzymes, ex: **Trypsin, Pepsin**, etc.

Uses of proteins

Proteins are needed for growth, for the synthesis of

- Enzymes
- Hormones
- Muscles
- Haemoglobin
- Antibodies
- Fibrinogen and other plasma proteins

Protein synthesis

Protein synthesis takes place in ribosomes,
The DNA contains genes, **a gene codes for a specific protein**, DNA can't leave the nucleus.

So the following steps take place:

1. **mRNA is produced inside the nucleus**
2. **mRNA carries a copy of the DNA sequence**
3. **mRNA leaves the nucleus and travels to the ribosomes**
4. **Ribosomes read the mRNA sequence and translate it to a protein by joining amino acids together**

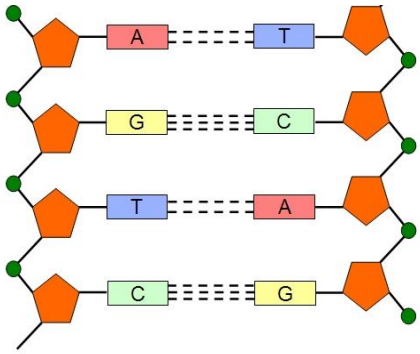
The above steps are extremely important and should be revised every once in a while

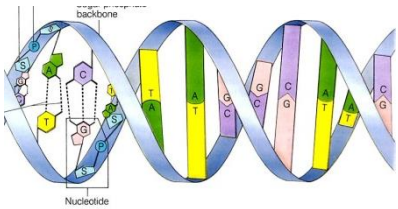
DNA

Consists of genes, where each gene codes for a **specific** protein.

DNA structure

- **Two strands coiled together in an *double helix* structure.**
- **Each strand consists of nucleotides.**
- **There are four types of nucleotides A, T, C and G.**
- **There is base pairing between A and T by two hydrogen bonds, and between C and G by three hydrogen bonds, which connects the two strands together.**





Fats

- Consists of C, H and O only.
- Each fat molecule consists of **3 fatty acids and 1 glycerol** joined together.
- Broken down into its simplest units by Lipase enzyme.
- Stored under the skin and around certain organs such as the kidney.

Uses of fat

- Insulation for mammals in cold winters
- Used as a source of energy
- Shock absorber
- Supports and protects internal organs such as the kidney

Carbohydrates (Sugars)

They consist of C, H and O only, in a ratio of 1:2:1.

Either monosaccharide (ex: **Glucose, Fructose**), disaccharide (consists of two sugars ex: **Sucrose**) or polysaccharide (complex sugars, ex: **Starch, Glycogen or Cellulose,** they are all made of glucose)

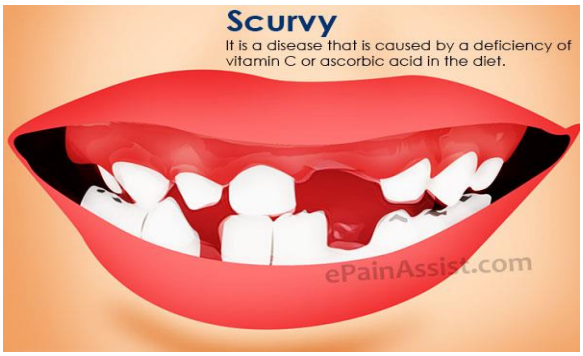
Uses

- Main source of energy during respiration.
- Enters in the formation of cell membrane
- Enters in the formation of hormones
- Cell wall supports the plant cells

VITAMINS

Vitamin C

- Present in fresh fruits and vegetables especially lemons
- Needed for the formation of collagen
- Its deficiency causes **scurvy disease**, which is characterized by: **bleeding gums, loosening of teeth, delayed healing of wounds, easy bruising.**



Vitamin D

- Present in eggs, milk and fish
- Needed for normal formation of bones
- Activated by sunlight
- Its deficiency causes **rickets** in children, and **Osteomalacia** (weak bones) in adults

Vitamin A

- Present in carrots and liver.
- Needed for proper vision.
- Deficiency causes night blindness

Mineral ions

Iron^{2+}

- Present in liver and meat
- Needed for haemoglobin formation
- Its deficiency causes **anaemia** which is characterized by: **easy fatigue, pallor of the skin, rapid heart rate and dizziness.**

Calcium^{2+}

- Present in eggs, milk and cheese
- Needed for normal bone formation

Magnesium^{2+}

- Needed for chlorophyll formation
- Its deficiency leads to a pale leaf

Nitrate ions

- Needed by the plant for amino acids production to form proteins needed for growth
- Its deficiency leads to a short plant

Fibres

- They are the undigested parts of the food (for example: lettuce and other leafy vegetables
- They are necessary to stimulate peristalsis*, so, prevent constipation and colon cancer.

*Peristalsis is the rhythmic waves of contraction in the digestive system that allows movement of food through the alimentary canal.

MOVEMENT INTO AND OUT OF THE CELL

Diffusion

Definition

The net movement of ions from their high concentration to their lower concentration, as a result of their random movement.

*Diffusion takes place everywhere in the body

Examples:

- Diffusion of oxygen and carbon dioxide from and into the alveoli to blood capillaries.
- Diffusion of glucose and other ions across the cell membrane in small intestines, but this requires a concentration gradient.

Factors affecting diffusion

- **Temperature;** increasing temperature increase the kinetic energy of particles, so increases the rate of diffusion
- **Surface area;** increasing the surface are increases the rate of diffusion
- **Concentration gradient;** increasing the concentration gradient i.e. the difference between the higher and lower concentration, increases the rate of diffusion
- **Distance moved by particles;** increasing the distance travelled by particles decreases the rate of diffusion

Active transport

Definition

It is movement of ions from their low concentration to their high concentration by using energy from respiration through carrier proteins.

*Ions interact with protein carrier, to change the shape of the protein, then passes through the protein

Importance of active uptake

- Uptake of ions by root hair cells from the soil.
- Glucose absorption by epithelial cells of villi and kidney tubules.

N.B. active transport takes place when there is no concentration gradient i.e. concentration inside the cells equal to outside the cells

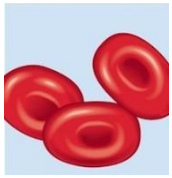
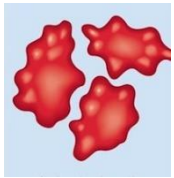
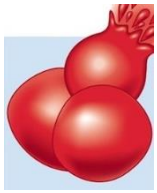
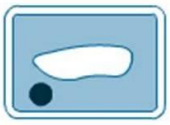
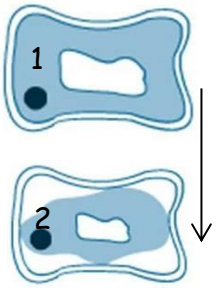
Osmosis

Definition

It is the net movement of water from high water potential to low water potential through a partially permeable membrane.

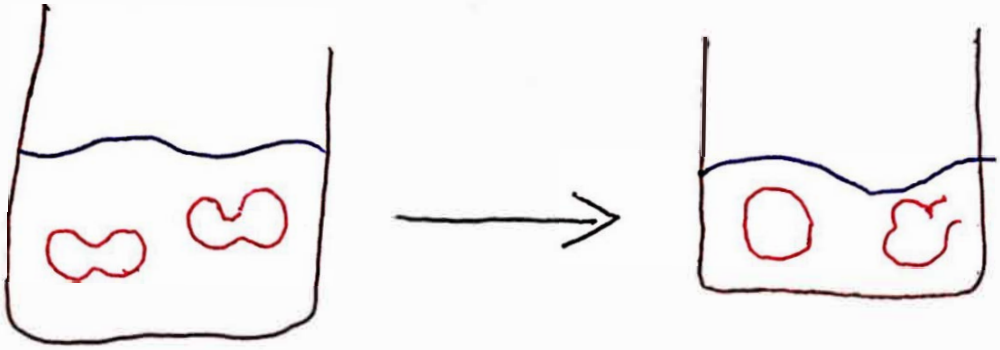
'Salts attract water'

Every cell has a concentration of salts inside its cytoplasm or vacuole.

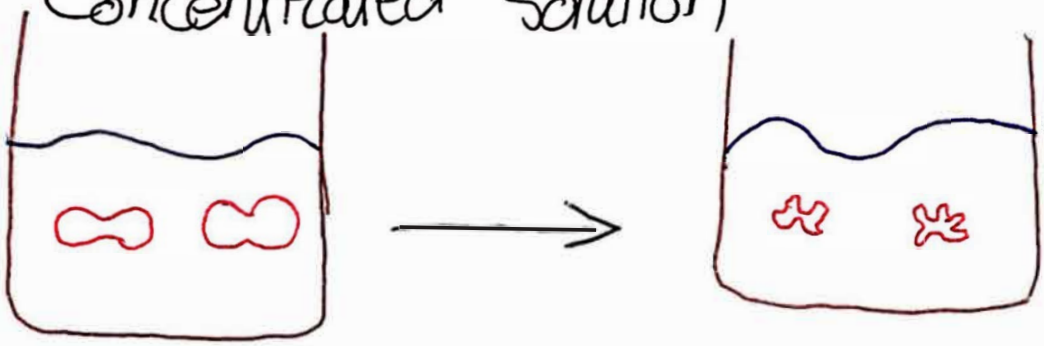
	Lefts for 10 minutes in a	
Normal appearance of the cell	Concentrated solution	Dilute solution
Animal cell 	The cell will **shrink** 	The cells will swell and **burst** 
Plant cell 	Will become **flaccid**[1] then **plasmolysis**[2] 	The cell will become turgid but **won't burst** due to the presence of inelastic cell wall. 

Osmosis

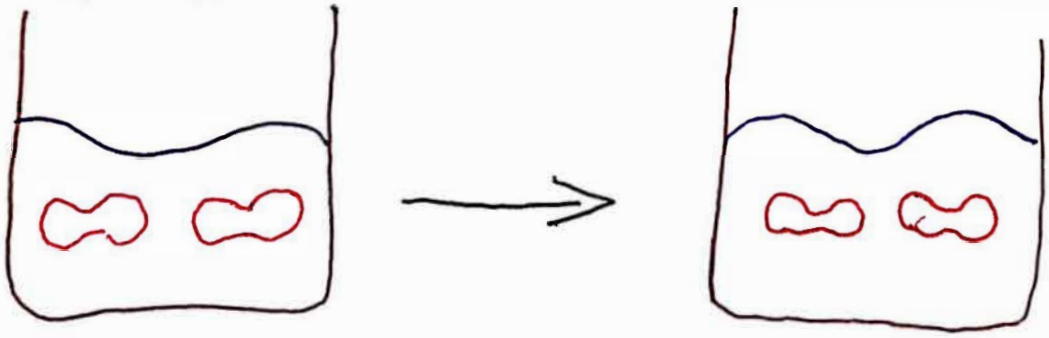
Dilute solution



Concentrated solution



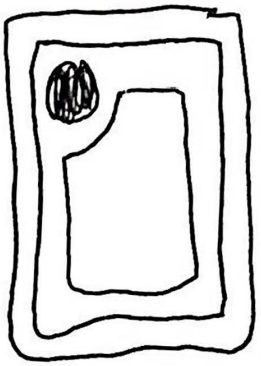
Same concentration.



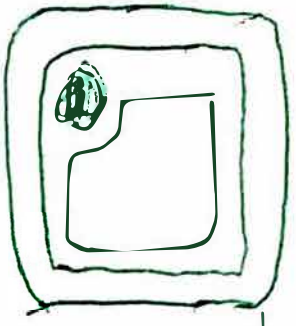
 = RBC.

Plant cells

Normal

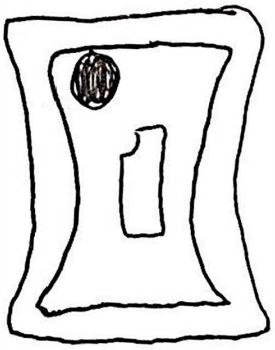


Dilute sol.



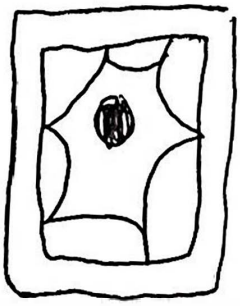
Turgid

Conc. Solution



Flaccid

Very conc. solution



Plasmolysed

N.B. plants are supported by the turgor pressure within cells, where water pressure acts against an inelastic cell wall.

How to explain the results? Let's take the RBCs placed in a dilute solution as an example

Water moves by osmosis from the region of higher water potential outside the cell to low water potential inside the cell through a partially permeable membrane, so the cell swells and bursts.

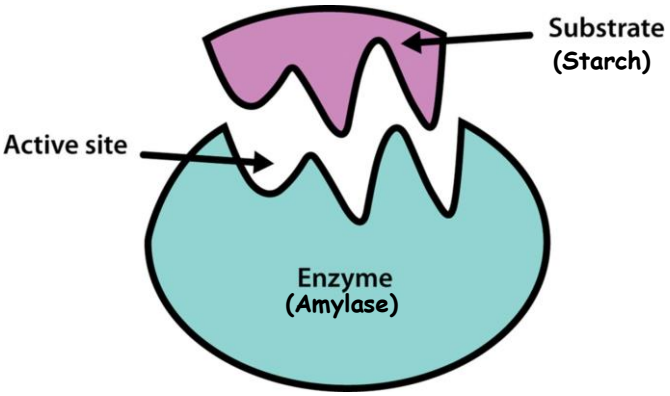
Describe the appearance of the plant cell placed in the concentrated solution

Water leaves the cell vacuole so it becomes **flaccid**, then the cell membrane is pulled and separated from the cell wall, this is known as **plasmolysis**.

ENZYMES

Definition: **A biological catalyst, protein in nature, that speeds up the rate of reaction without being used up.**

Structure of an enzyme

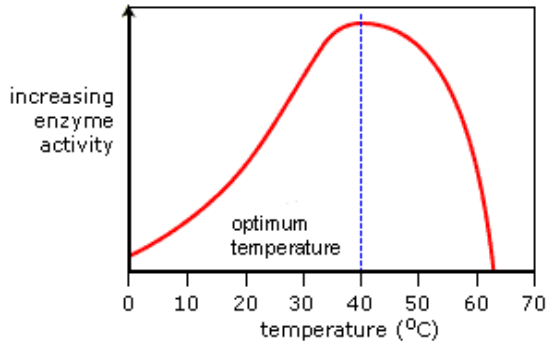


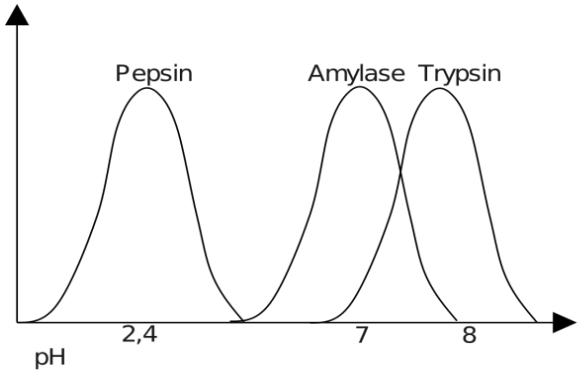
How does the structure of the enzyme accounts for its specificity?

Each enzyme has a different active site which is complementary to a specific substrate, the substrate fits exactly into the active site of the enzyme, in a key-lock configuration, forming an enzyme substrate (ES) complex, then substrate is broken down and its products are released.

Factors affecting enzymatic activity

- **Temperature**; increasing the temperature increases the kinetic energy of the molecules so more chance of ES complex formation, till the optimum temperature where above that, the enzyme denatures and the activity becomes zero
- **pH**; each enzyme works at an optimum pH, changing the pH considerably, denatures the enzyme
- **Surface area**; increasing the surface area enables more enzyme molecules to be visible to the substrate so more ES complexes
- **Concentration of enzyme and substrate**; both are directly proportional to the enzymatic activity.





Important enzymes that you must know

Proteins $\xrightarrow{\textbf{Protease}}$ Amino Acids

Fats $\xrightarrow{\textbf{Lipase}}$ Fatty acids and glycerol

Hydrogen peroxide $\xrightarrow{\textbf{Catalase}}$ Water + Oxygen

Lactose $\xrightarrow{\textbf{Lactase}}$ Simple sugars

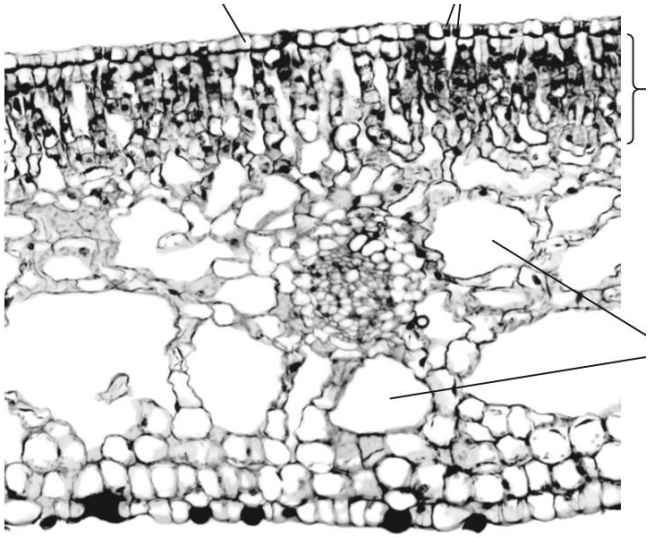
Pectin $\xrightarrow{\textbf{Pectinase}}$ Simple sugars

Starch $\xrightarrow{\textbf{Amylase}}$ Maltose $\xrightarrow{\textbf{Maltase}}$ Glucose

NUTRITION IN PLANTS

Leaf structure

Tissues in the leaf:



Upper epidermis:

- Secretes cuticle which is water proof.
- It is transparent to allow light to reach palisade cells
- Palisade mesophyll for photosynthesis, it is adapted to its function by being
- Tightly packed
- Arranged perpendicular to the surface
- contain many chloroplasts

Spongy mesophyll:

- Have air spaces between the cells
- Cells are polygonal in shape to increase the surface area for more absorption of gases
- Have a few chloroplasts for photosynthesis

Lower epidermis:

- transparent and have stomata (sing. Stoma) Stomata are openings on the surface of the leaves that allows diffusion of CO2, O2 and water vapour. They are surrounded by guard cells, when guard cells lose water stomata closes to prevent further loss of water from the plant.

N.B. Chloroplasts are present in palisade, spongy, and guard cells, while they're absent from upper and lower epidermis

Plants are autotrophs; they make their own food by photosynthesis

Photosynthesis

It is the synthesis of carbohydrates from raw materials using energy from light

Balanced equation

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

Chlorophyll transfers light energy into chemical energy in molecules, for the synthesis of carbohydrates.

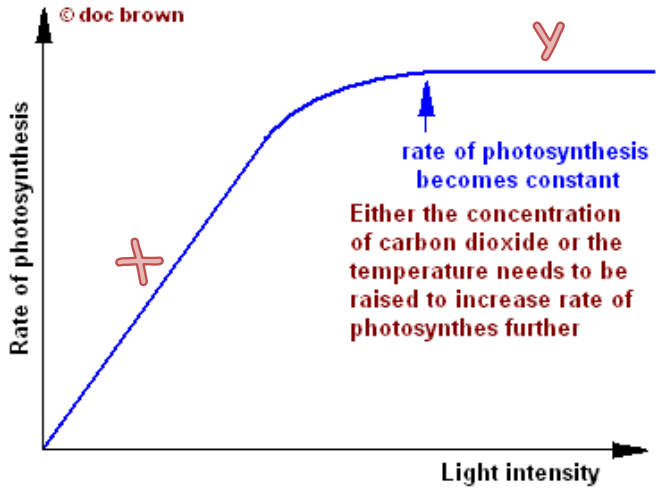
Use of produced carbohydrates:

- Respiration to release energy
- Stored as starch for later use
- Formation of cellulose cell wall
- Transported in phloem as sucrose

*Organs of storage include the root, stem or the leaf itself. Stored starch is used in winters and at nights where there is no sunlight.

The rate of photosynthesis will keep increasing as long as you supply the raw materials with no limiting factors.

Limiting factor is something present in the environment in such short supply that it restricts life processes.



As light intensity increases the rate of photosynthesis increases till it reaches a plateau, this is because at region x light is the limiting factor, while at region y light is no longer the limiting factor, other factors are limiting such as CO2 or temperature.

Glass houses

In countries where the weather is not suitable for agriculture, glass houses are used to increase the yield, glass houses maintain optimum conditions through

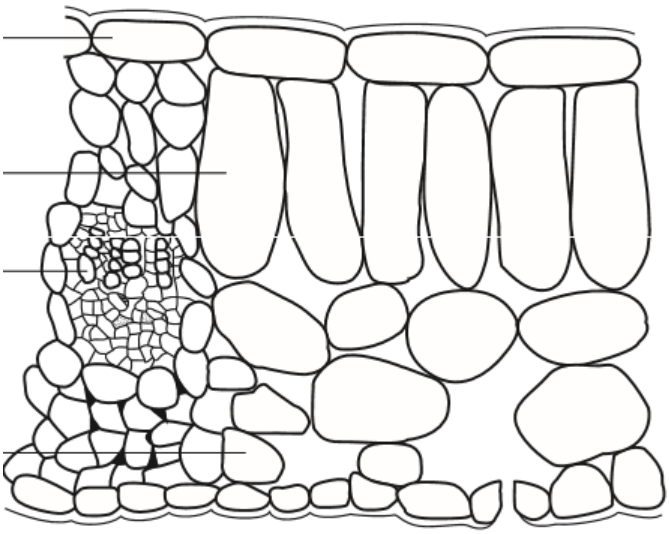
- Optimum temperature using air conditioning
- Optimum light intensity using artificial lamps
- Optimum nutrients level using fertilizers
- Optimum CO2 level using CO2 enrichment.

Mineral requirements in plants

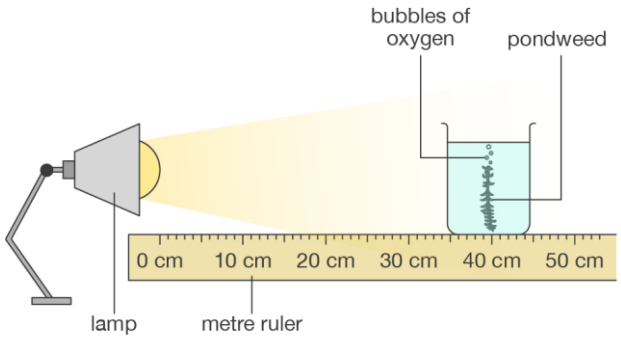
Nitrates ions for making amino acids to form proteins needed for growth, so nitrates deficiency leads to thin and short plants

Magnesium ions for making chlorophyll, so magnesium deficiency leads to pale leaves

N.B. nitrates deficiency causes pale leaves since chlorophyll contains nitrogen.



Does Light Intensity Affect the Rate of Photosynthesis?



NUTRITION IN HUMANS

What is a balanced diet?
It's a diet that contains all 7 essential nutrients in the right amount according to age, gender or activity.

Essential nutrients include

- Carbohydrates
- Proteins
- Fats
- Vitamin C and D
- Iron and Calcium
- Fibres
- Water

Malnutrition is abnormal nutrition that might lead to starvation, constipation, obesity and coronary heart diseases.

Obesity increases the risk of heart diseases, high blood pressure and diabetes.

Ingestion is taking substances into the body through the mouth.

Egestion is passing out undigested food in the form of faeces through the anus.

Diarrhoea is the loss of watery faeces; it is treated by Oral rehydration by saline solution

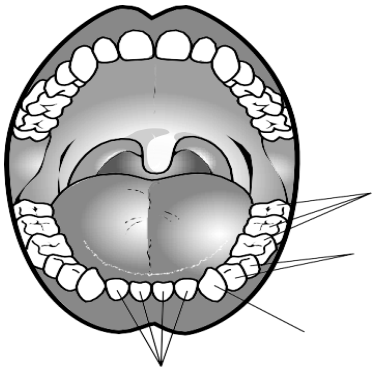
Chemical digestion
It's the breakdown of large insoluble molecules into small water-soluble molecules by enzymes to be easily absorbed.

Mechanical digestion
It's the breakdown of food into smaller pieces to increase the surface area for chemical digestion.

THE ALIMENTARY CANAL

Mouth

Mechanical digestion:



Teeth
There are 4 types of teeth in man, **incisors, canines, premolars and molars**

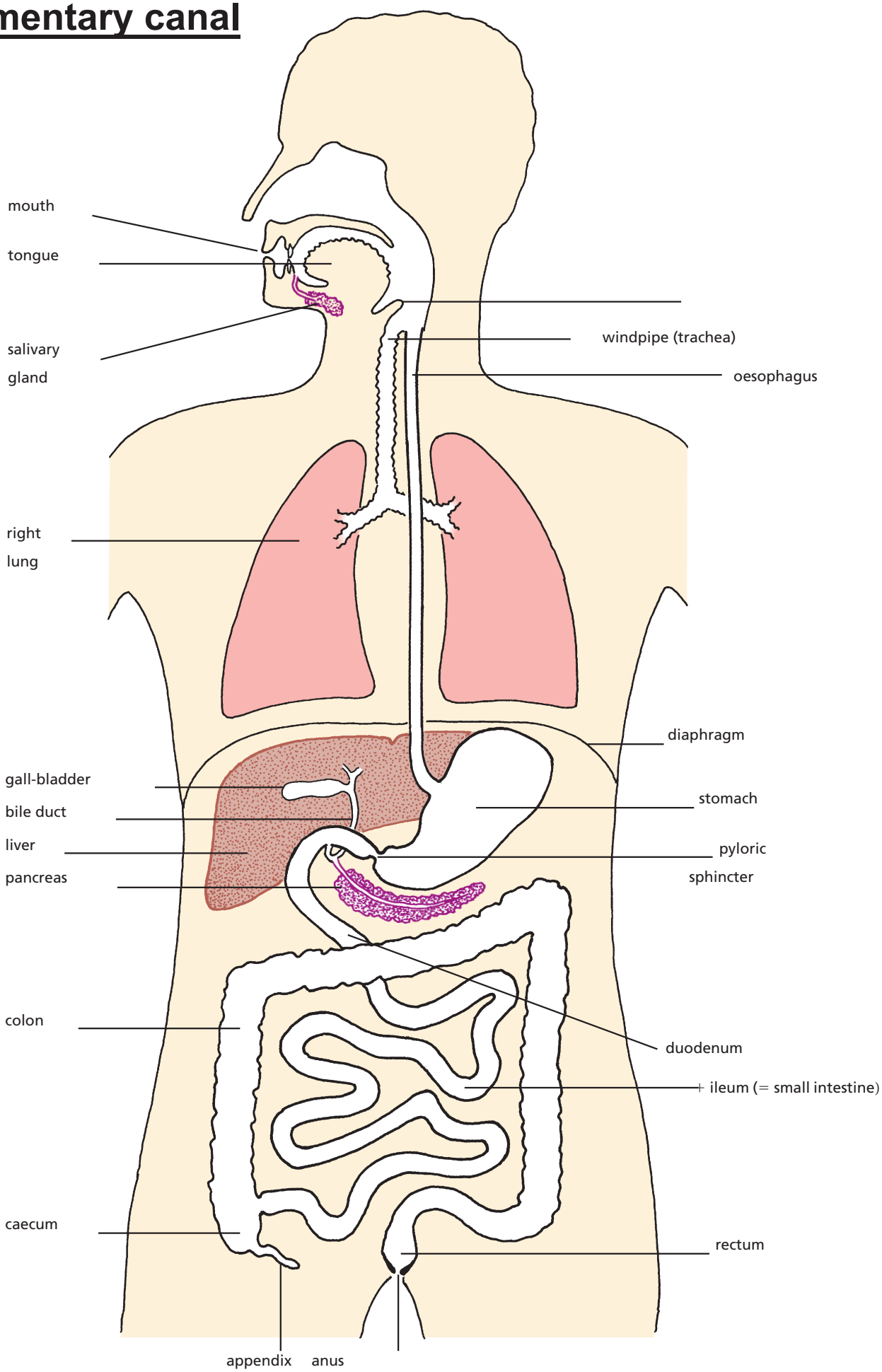
Teeth consists of 3 layers; enamel, dentine and pulp. The pulp contains nerves and blood vessels.
*Crown is the visible part of the tooth, while the root is the part deep within the gums
***The enamel is only present in the crown, in the root it is replaced by cement**
***Premolars and molars crush the food to increase the surface area for enzymatic digestion.**

*Incisors and canines are for **tearing the food.**

Chemical digestion:

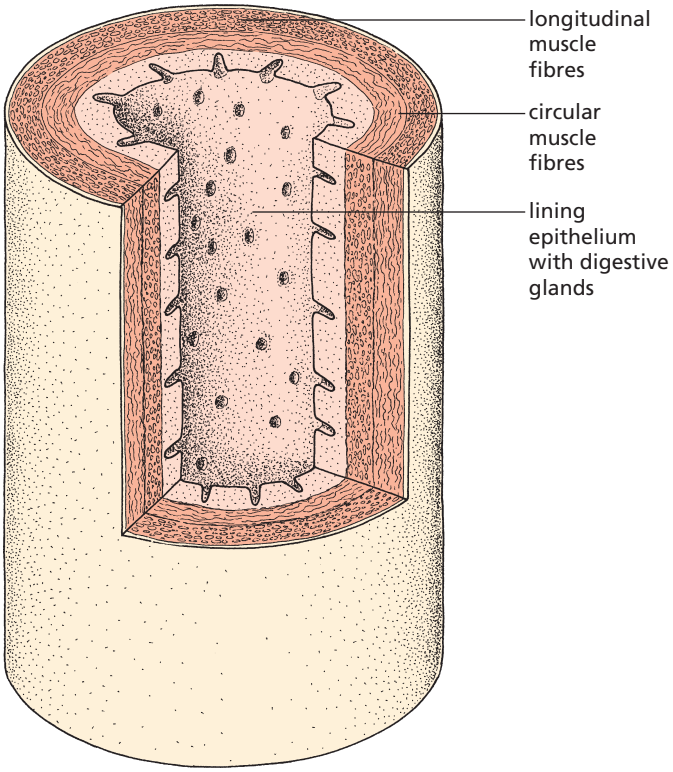
Salivary glands produce saliva which consists of water and **salivary amylase**. Amylase breakdown starch into maltose

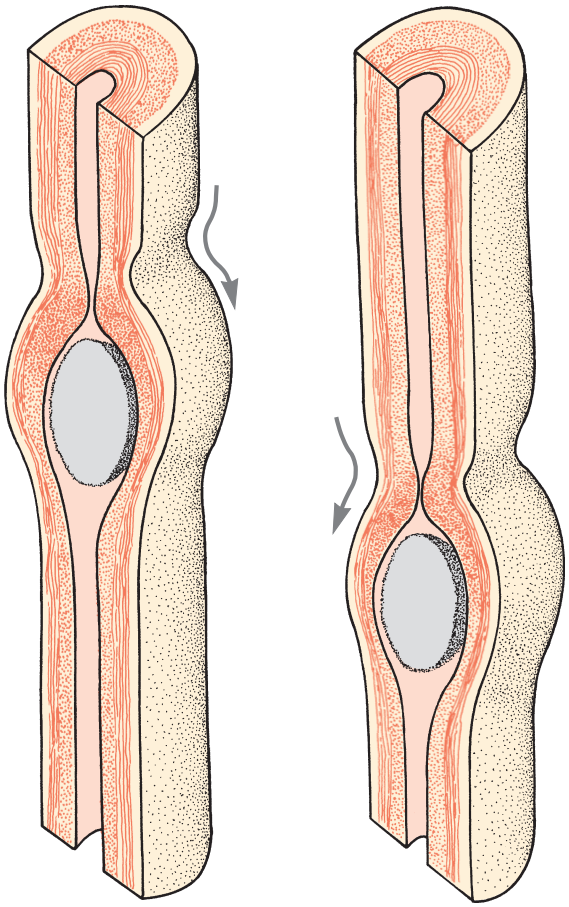
Alimentary canal



Peristalisis

Rhythmic waves of contraction that allows passage og food through the alimentary canal





Oesophagus

Food moves along the oesophagus by peristalsis; which is **the rhythmic waves of contractions that allows food to pass through the alimentary canal and other muscle tubes.**

Stomach

Mechanical digestion

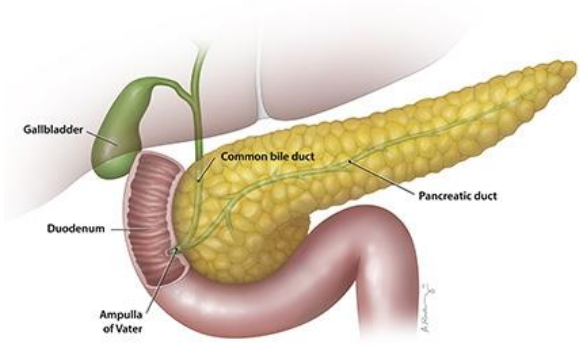
It has strong muscular walls, producing **churning** movements to mix the chime with the juice

Chemical digestion

Stomach glands produce **gastric juice** which consists of

- Pepsin: a protease that digests proteins into smaller peptides
- HCl: provides the optimum pH for pepsin and denatures the enzymes in harmful microorganisms in food.

Pancreas



It secretes pancreatic juice, through pancreatic duct to reach the duodenum.

It contains

- Pancreatic lipase
- Pancreatic amylase
- Trypsin

Bile salts are produced by the liver and stored in the gall bladder, where it's released after fatty meals into the duodenum, it is **responsible for neutralizing the acidity of the chyme,** to provide optimum pH for pancreatic enzymes

Small intestines

It consists of two parts, duodenum and ileum.

Mechanical digestion

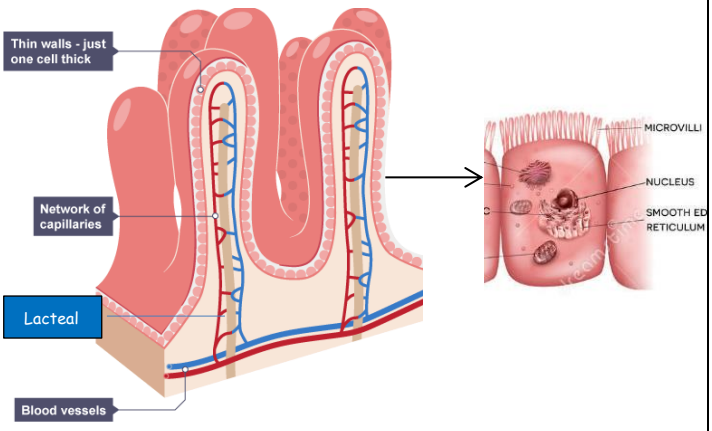
Bile salts are responsible for **emulsification of fats to increase its surface area to be easily digested by lipase enzyme to fatty acids and glycerol.**

Chemical digestion takes place by the enzymes in the pancreatic juice plus **maltase** which is present on the **membrane of the lining epithelium** of the small intestine.

Absorption

It's the movement of small food molecules and ions through the wall of the intestine into the blood.

Small intestine is the region of absorption of digested food.



VILLU

Assimilation

It's the movement of digested food molecules into the cells of the body where they are used, becoming part of the cells.

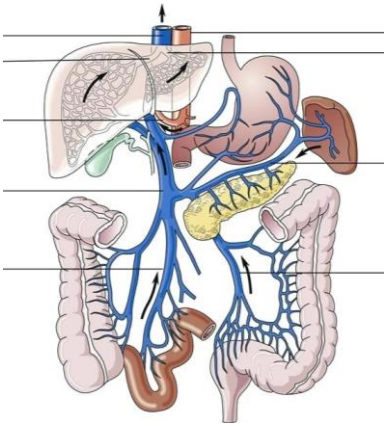
Structural unit of absorption is the **Villus** (pl. villi), which is adapted to its function by having

- Microvilli to increase the surface area for more absorption.
- Thin wall for easier diffusion.
- Contains many capillaries to increase the rate of diffusion.
- The lining cells have many mitochondria for more active transport.
- Have lacteal to absorb fatty acids and glycerol.
- Have muscles to move and get in contact with more food

All substances are absorbed to the blood except fatty acids and glycerol they are absorbed into lacteal, which is part of the lymphatic system.

Blood carrying the nutrients leaves the intestines and enters the liver through the **hepatic portal vein.**

Inside the liver the following occurs:



- Detoxification of toxic substances.
- The breakdown of excess amino acids to urea to be excreted by the kidneys.
- Regulation of blood glucose level (discussed in *homeostasis*).

Large intestines

Consists of 3 parts; colon, rectum and anus

Water absorption takes place in the large intestines. However, **most water absorption takes place in the ileum.**

Uses of water in the digestive system

- Chemical digestion of food by hydrolysis
- solvent for enzymes and food
- softens food makes it easier to be swallowed
- Easier to move along the alimentary canal

Uses of water in the body

- Cools the body through sweating
- Dissolves nutrients to be transported easily

Excessive loss of water from the body leads to dehydration

Fibres

- They are the undigested parts of the food (for example: cellulose in food)
- They are necessary to stimulate peristalsis, so, prevent constipation and colon cancer.

Cholera

A disease caused by bacterium Vibrio cholera; it is characterized by watery diarrhoea that might lead to dehydration.

It is transmitted through ingestion of contaminated food and affects the **small intestines.**

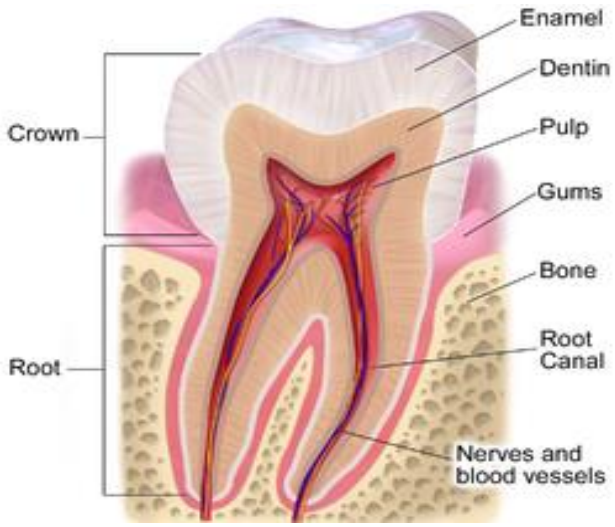
It causes the wall of the ileum to secrete chloride ions into the lumen, causing water to leave the blood and enter the lumen by osmosis.

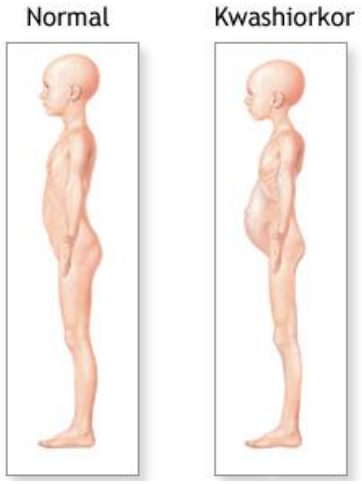
It is treated by Oral rehydration of saline solution, and antibiotics.

Tooth decay

Coating of bacteria and food on teeth, bacteria respire sugars in the food producing acid which dissolve the enamel and dentine.

It can be avoided by regular brushing of teeth, using fluoride containing tooth paste and less sugary diet.





Malnutrition diseases

Kwashiorkor: a protein malnutrition disease, the individual with the condition is characterized by a thin body and an enlarged abdomen which is fluid filled.

Marasmus: a general malnutrition disease, where the individual with the condition lacks all nutrients e.g.

- No carbohydrates or fats so appears thin with low energy
- No proteins so low muscle mass
- No vitamin C so suffers from scurvy
- No vitamin D so suffers from rickets
- No mineral ions such as Ca^{2+} so suffers from weak bones and weak contractions

TRANSPORT IN PLANTS

Water uptake

Water is absorbed from the soil by root hair cells by osmosis then passes to the root cortex then to the xylem, going up through the plant then passes to mesophyll cells.

N.B. water moves up the xylem by the aid of transpiration pull.

Water is needed by the plant in

- Photosynthesis
- Maintaining turgidity
- Activation of enzymes
- Solvent for chemical reactions

Transport in plant involves to systems; transpiration through xylem and translocation through phloem.

Transpiration

It is loss of water vapour from plant leaves by diffusion through the stomata down concentration gradient.

this lowers the water potential in the mesophyll cells so attracts water by osmosis from xylem, this causes a negative pressure in the top part of xylem, so water moves upwards as one column due to cohesion force between water molecules.

N.B. loss of water vapour is high due to large surface area of mesophyll cells surfaces interconnecting air spaces and stomata.

Xylem transports **water** and **mineral ions**

Factors affecting transpiration:

- **Temperature:** increasing the temperature increases the evaporation of water from the surface of mesophyll cells so increases transpiration.
- **Humidity:** increasing the humidity lowers the concentration gradient of water vapour between the air spaces and the atmosphere so decreases transpiration.
- **Wind speed:** reduces humidity so increases transpiration.

Translocation

It is the movement of sucrose and amino acids from source to sink through the phloem

It is an active process which requires energy.

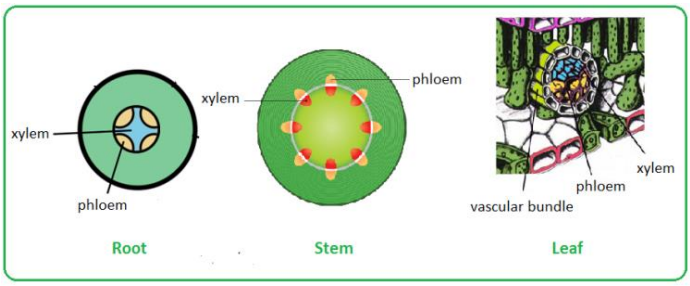
The source is usually the leaves, and the sink might be the flower, root, stem…

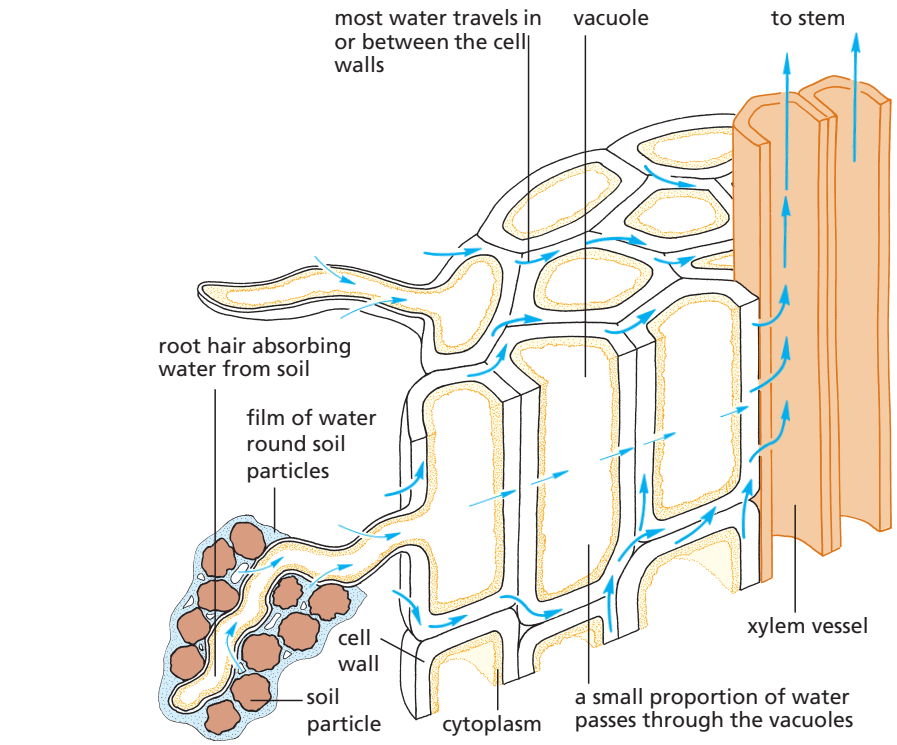
However, for some instances the leave may not be the source as during autumn; where leaves fall, or during germination, where leaves haven't developed and in this case the seed is the source.

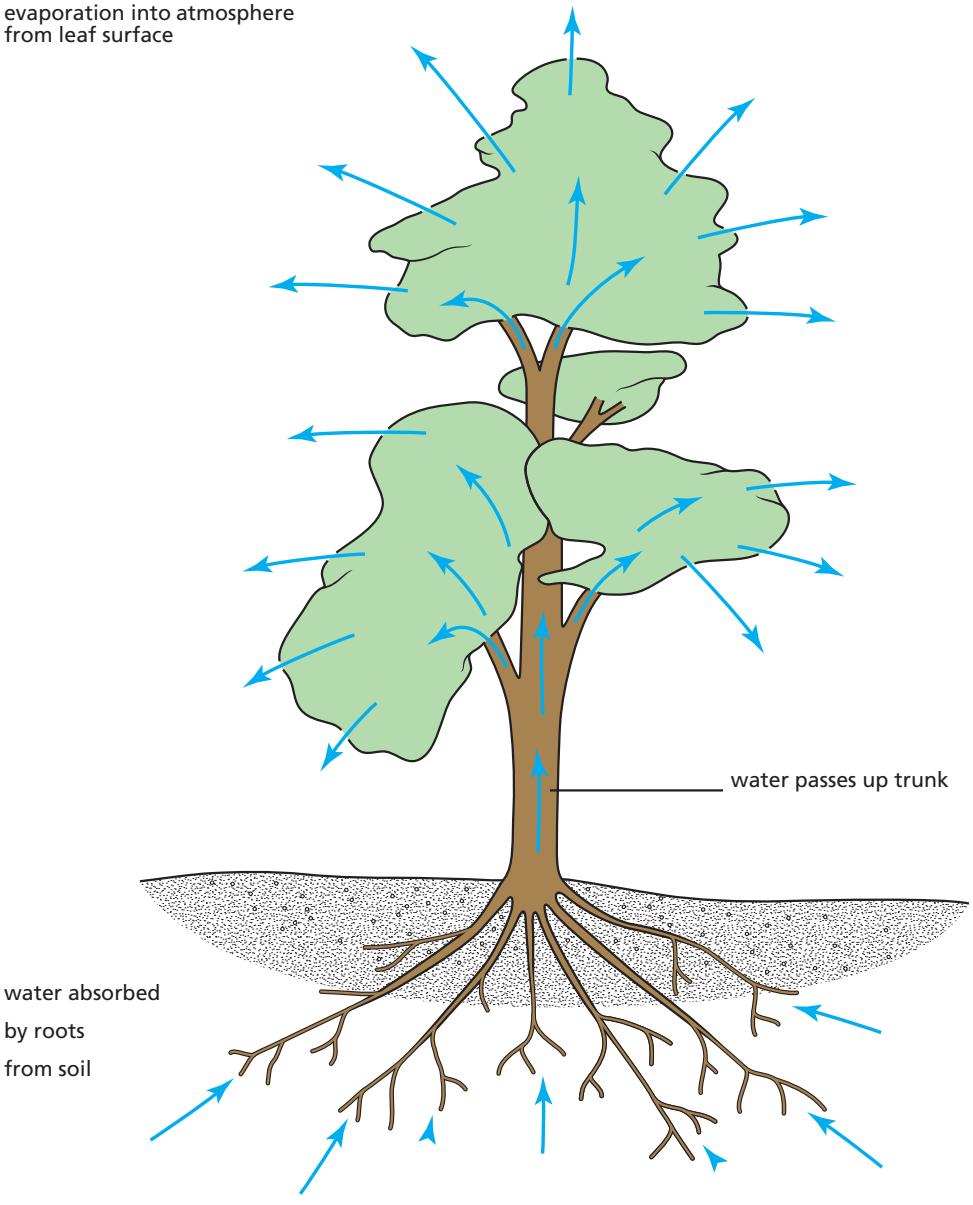
Wilting

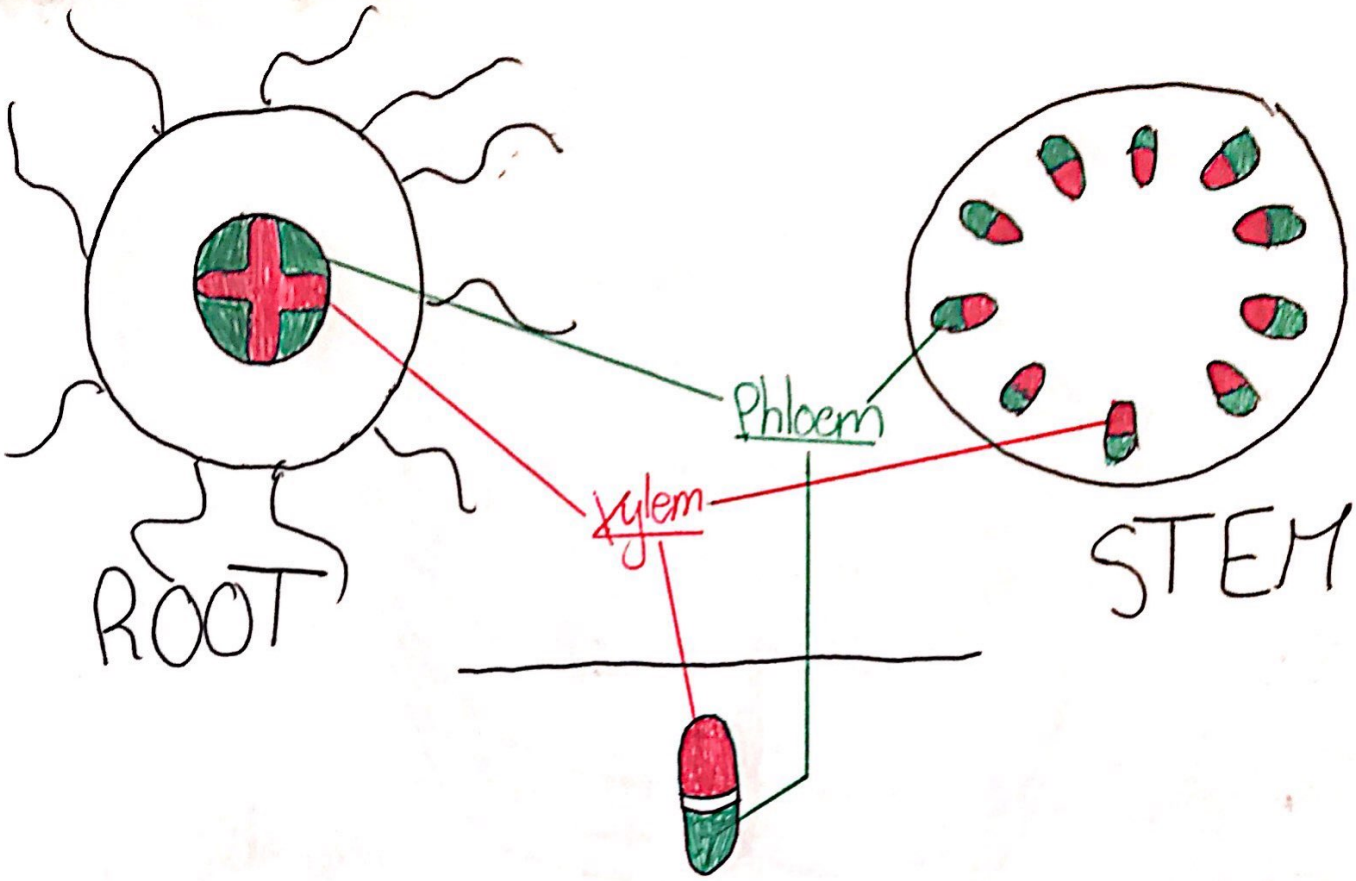
Wilting occurs when water loss is higher than water uptake, it can occur when environmental factors accelerate transpiration such as, very high temperatures, high wind speed, dry air..etc.

Locations of xylem and phloem:

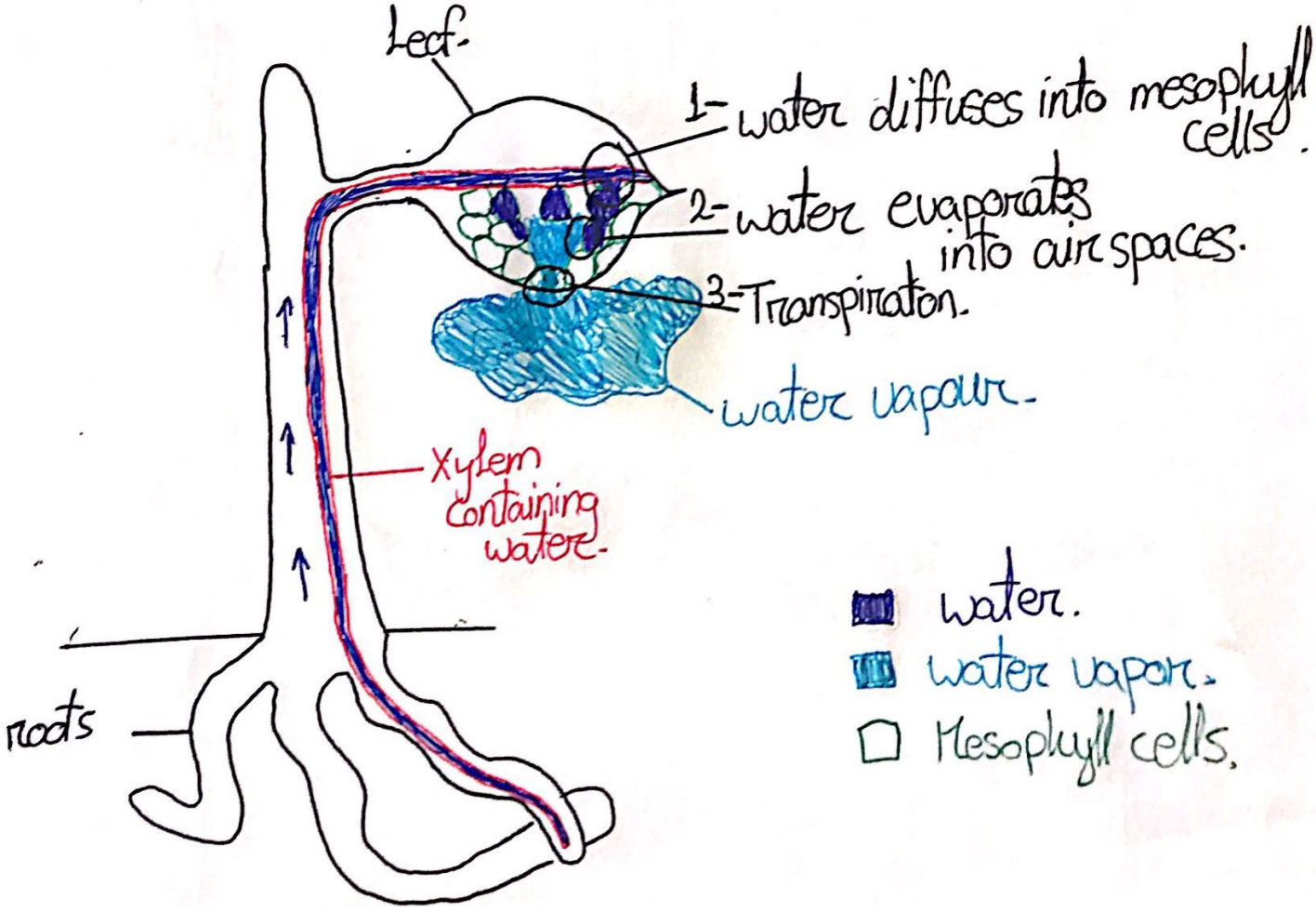



most water travels in or between the cell walls
vacuole
to stem
root hair absorbing water from soil
film of water round soil particles
cell wall
soil particle
cytoplasm
a small proportion of water passes through the vacuoles
xylem vessel


evaporation into atmosphere from leaf surface
water passes up trunk
water absorbed by roots from soil

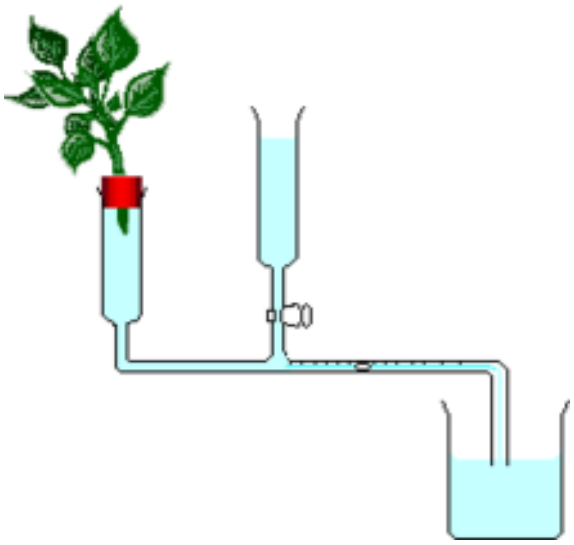


LEAf



Scanned with CamScanner

Potometer



It is a device used to measure the rate of water uptake by a plant

The shoot will absorb water from the test tube causing the small air drop to move towards the shoot.

The above syringe is used to return the air drop to the starting point.

Leave the shoot for 5 minutes and measure the distance travelled by the air spot, then divide it by 5 to get the rate of water uptake.

To investigate the effect of **temperature** on water uptake you must use **5 different plants** on **5 different temperatures** using air conditioning, all other variables should be kept constant such as

- Species, size, and number of leaves in the 5 plants
- Wind speed
- Humidity
- Time

Precaution: cut the plant under water to prevent the entry of air into the xylem.

CIRCULATORY SYSTEM

The circulatory system consists of 3 parts; heart, blood vessels and blood.

The circulatory system in man is a double circulatory system which means that the **blood passes through the heart twice in one cycle**; it is pumped from the heart to the lungs then returns to the heart where it is pumped to all body organs

However, organisms such as fish have a single circulatory system where the blood passes from the heart to the gills to be oxygenated then flows directly from the gills to all its body organs.

As the blood passes through the lung, its speed of flow decreases as it enters lung capillaries in order to allow more time for gaseous diffusion, so it must return to the heart first to increase its pressure to flow at high speed to reach all body organs, so the advantage of a double circulatory system

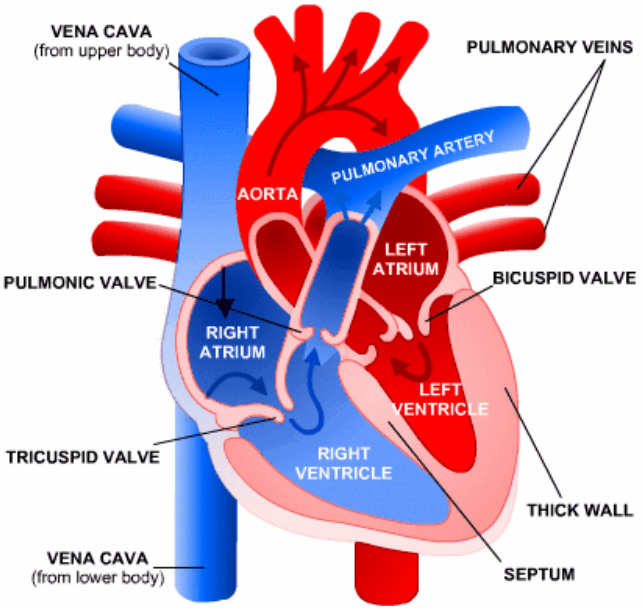
Advantages of a double circulatory system

- **Regenerates pressure as pressure is lost as blood passes through the lung**
- **Prevent mixing of oxygenated and deoxygenated blood**

Heart

The mammalian heart consists of two sides separated by a septum, the left (oxygenated) and right (deoxygenated) side, each side consists of two chambers, an atrium and a ventricle; they are separated by an atrio-ventricular valve.

The heart has four main vessels to transport and



receive the blood; Aorta, Pulmonary artery, vena cava and pulmonary veins.Blood is pumped away from the heart into arteries and returns to the heart in veins

The heart muscle is supplied by **coronary vessels** with nutrients.

Deoxygenated blood enters the heart through the vena cava to the right atrium, then right atrium contracts so atrio-ventricular valve opens and blood passes to the right ventricle, then blood is pumped to the lungs through the pulmonary artery through open semi-lunar valves, to be oxygenated, then returns to the left atrium through the pulmonary veins, then atrium contracts so atrio-ventricular valve opens and blood passes to the left ventricle, the blood is pumped to all body organs through the aorta passing through open semi lunar valves.

The left ventricle is thicker than the right, as it pumps the blood to a longer distance (all

the body) than the right (lungs) so it need higher pressure to overcome the higher resistance in the systemic circulation.

Cardiac cycle

It consists of three stages; atrial systole, ventricular systole, and heart diastole where systole refers to contraction.

Stage/valves	Atrio-ventricular	Semi-lunar
Atrial systole	Open	Close
Ventricular systole	Close	Open
Heart diastole	Open	Closes

Atrio-ventricular valves

They prevent the backflow of blood to the atria, the valves open when the pressure in the atria rise above the pressure in the ventricles, this happens during atrial systole, the valves close when the pressure in the ventricles rise above the pressure on the atria, this occurs during ventricular systole, the valves are attached to the wall of the ventricles by tendons that prevent the valves from over flapping to the atria.

Semi lunar valves

They prevent the backflow to the ventricles, they open when the ventricles contract and close whenever the ventricles relax (atrial systole, heart diastole).

Effect of exercising on the heart

During exercise, adrenaline hormone is released which causes the heart rate to increases to pump more blood to supply more oxygen and nutrients such as glucose to muscles and remove wastes such as CO_2 and lactic acid faster as it respire at a higher rate to release more energy for contraction.

N.B. Regular exercises reduce the resting heart rate

How to monitor the activity of the heart

- ECG
- Pulse rate, where you ress an artery against a bone and count the pulses in one minute, normal is 60-90 beats
- Listening to sounds of the valves as they close

Coronary heart disease

Risk factors such as diet, stress, smoking, genetic predisposition, age and gender causes coronary heart disease: **fats deposit on the wall of the artery, leading to the formation of a blood clot, which blocks the flow of blood to heart muscles** so heart won't be able to function properly leading to heart failure.

Treatment

- **Aspirin: This is a drug that reduces the risk of blood clotting.**

Surgeries such as

- **Stents:** a tube that hold arteries open.
- **Angioplasty:** balloon inserted into artery and inflated to widen artery.
- **By-pass:** a piece of blood vessel attached to carry blood around the blocked artery.

Blood

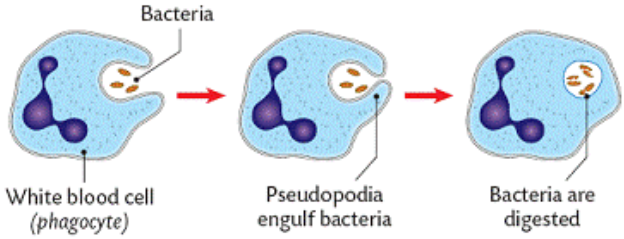
Blood consists of two main parts; blood cells and plasma

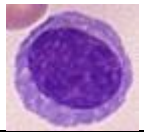
Blood cells

1. *Red blood cells*

It was discussed earlier in chapter 1

2. *White blood cells*



	
Action: **Antibody production**	Action: **Phagocytosis**
1. Antibodies label the bacteria to be easily engulfed. 2. Antibodies form pores in the cell wall of the bacteria causing it to burst. 3. Antibodies neutralize toxins. 4. Antibodies prevent the spread of bacteria.	They engulf the bacteria into a vesicle, then kills it by releasing hydrolytic enzymes into the vesicle digesting the pathogen

They are either lymphocytes or phagocytes

Lymphocytes	Phagocytes

3- *Platelets*

Responsible for blood clotting which prevents blood loss and prevents entry of pathogens

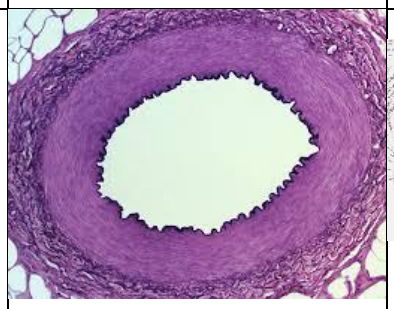
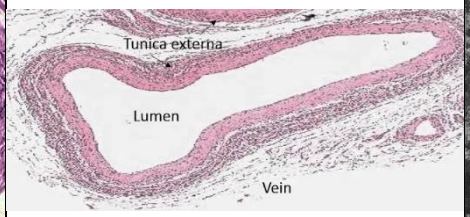
Plasma

It consists mainly of water; **all** substances are dissolved in the plasma and transported. Except for O_2 (which is carried by RBC)

Blood clotting

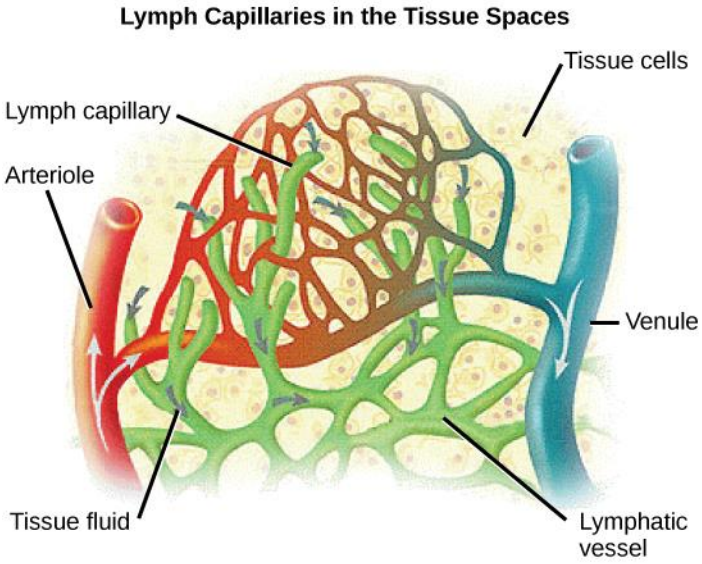
When blood is exposed to air, a soluble plasma protein called fibrinogen is converted into an insoluble fibrin in the presence of thrombin enzyme; fibrin forms a meshwork that traps red blood cells and platelets forming a clot that stops bleeding.

Blood vessels

Vessel/function	Artery	Vein	Capillary
Wall	1. **Thicker to withstand high pressure of blood.** 2. **Elastic to prevent rupture and maintain high pressure.**	Thinner as blood flows with low pressure.	**One cell thick for shorter distance for diffusion, also contains pores for easier diffusion**
lumen	**Narrow**	**Wide**	
lining	Wrinkled to be stretched easily since the wall is elastic.	Smooth to allow blood to flow to the heart with minimal resistance	
How blood flows	By the pressure produced form the heart	**<u>contractions of the surrounding muscles squeezes the blood inside and veins have valves to allow uni-directional flow of blood</u>**	
			

Tissue Fluid

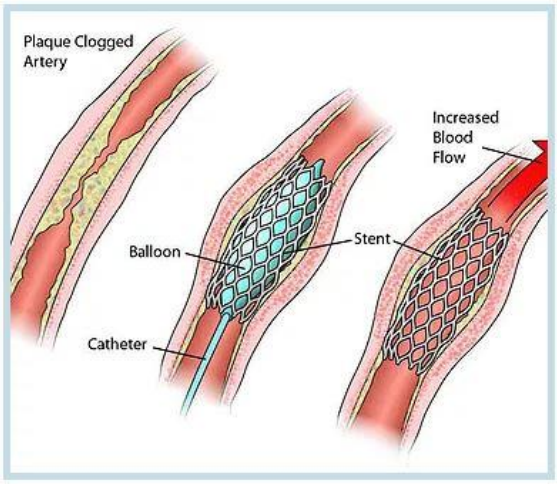
Capillaries have the thinnest wall, so it's in contact with the cells for exchange of substances, capillaries surround cells in tissues, all the content of the blood in the capillaries leak to the tissue space except for the proteins and red blood cells, as they are large.
Once the plasma leaves the capillaries, it's called tissue fluid.
Most of the Tissue fluid is absorbed back to the capillaries, however some is absorbed by a lymph vessel and transported back to the blood later



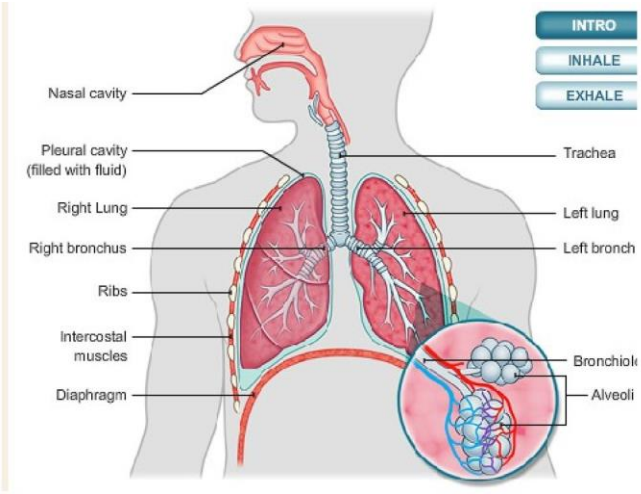
Lymphatic system

Consists of lymph, lymph nodes and lymph vessels . Lymph vessels have valves, and lymph moves by contraction of surrounding muscles.

Its function is to <u>protect the body against infections</u>, and <u>circulation of fluids in the body.</u>



GAS EXCHANGE



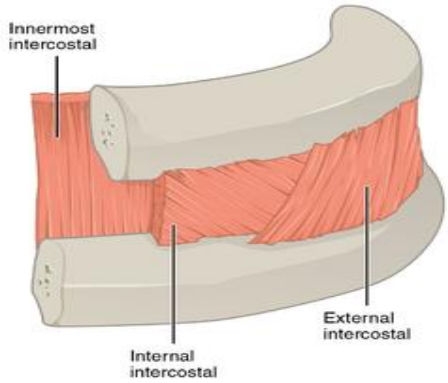
Inspired air passes through the following structure:

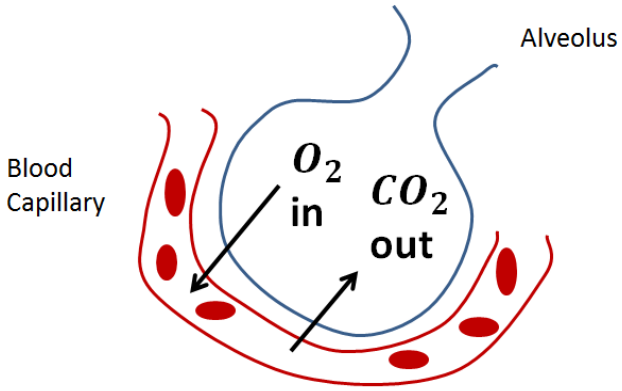
- Trachea
- Bronchi
- Bronchioles
- Alveoli which are the site of gaseous exchange

The trachea and bronchi have cartilage which is required to maintain the air way open to allow air to be inspired freely without collapsing.

How are the alveoli adapted for gaseous exchange?

- Thin wall to provide a short distance for diffusion
- Surrounded by any blood capillaries to maintain concentration gradient
- It has large surface area for more diffusion
- Moist to dissolve gases





Breathing

Breathing consists of two phases, inspiration and expiration

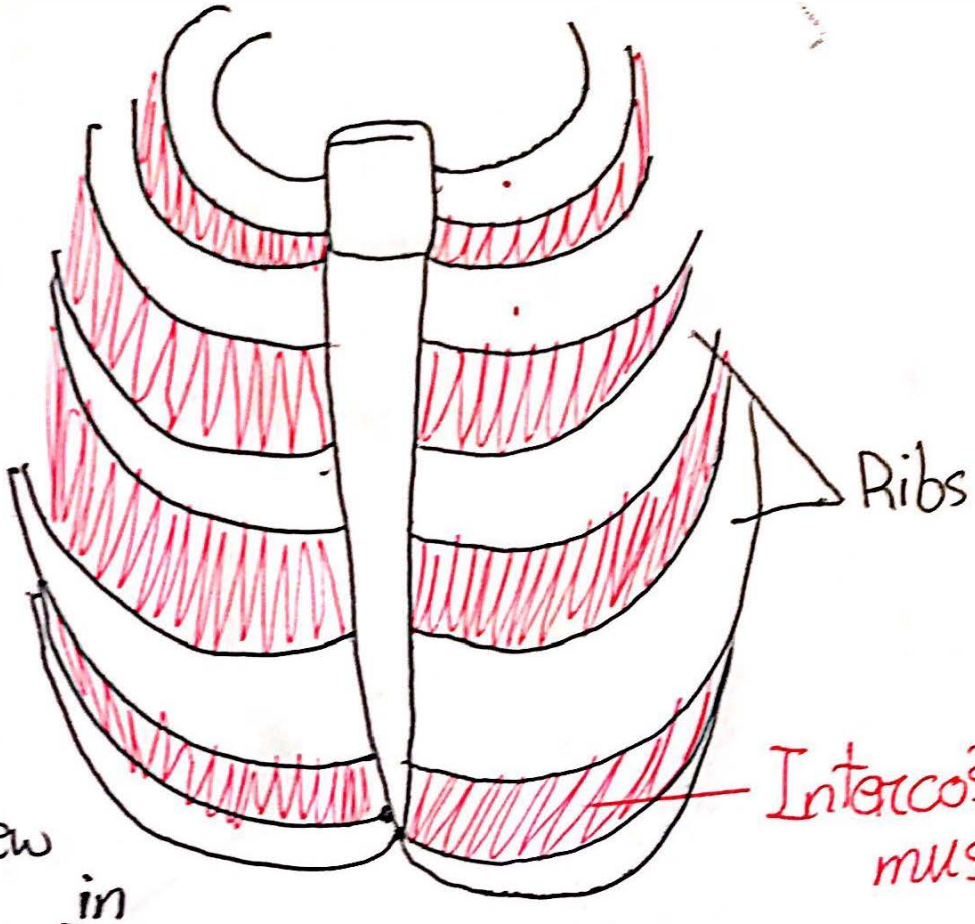
There are two types of muscles between the ribs structure that protects the lungs); **internal intercostal muscle** that lowers the ribcage and **external intercostal muscle** the raises the ribcage. Below the ribcage there is the **diaphragm** that contracts to move downwards and increase the volume of the chest.

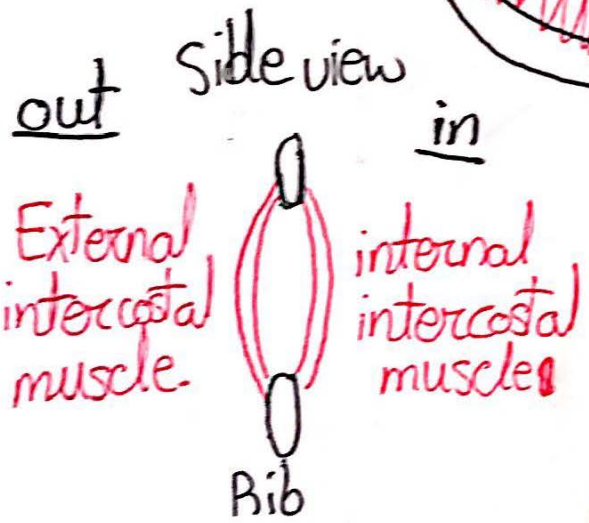
Inspiration

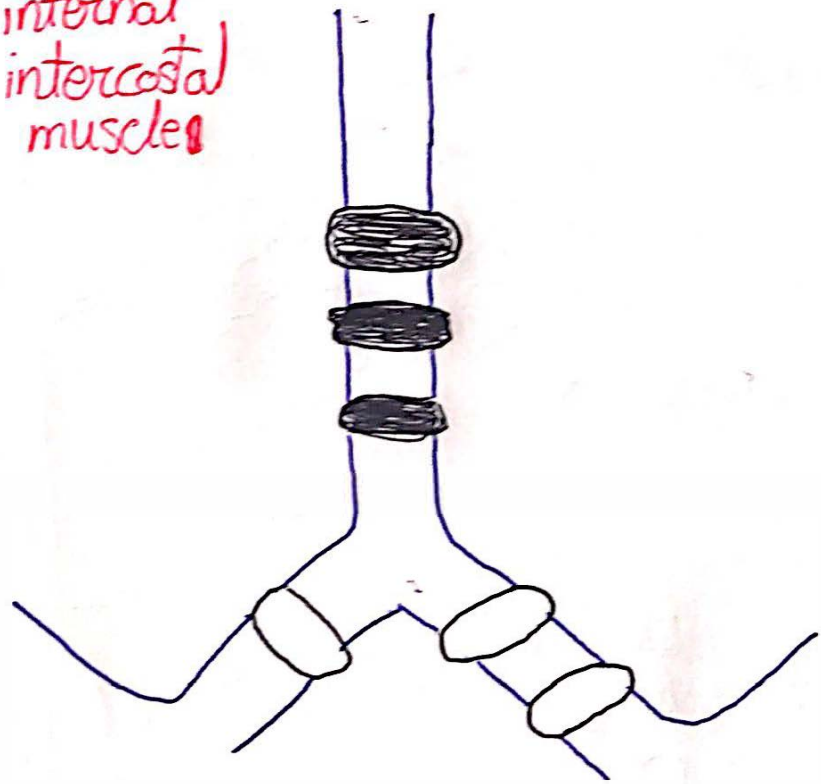
The external intercostal muscles contract, the diaphragm contracts and the internal intercostal muscles relax, causing the volume of the chest to increase so the pressure decreases causing the air to rush inside.

Expiration

The internal intercostal muscles contract, the diaphragm relaxes and the external intercostal muscles relax, causing the volume of the chest to decrease so the pressure increases causing the air to rush outside.







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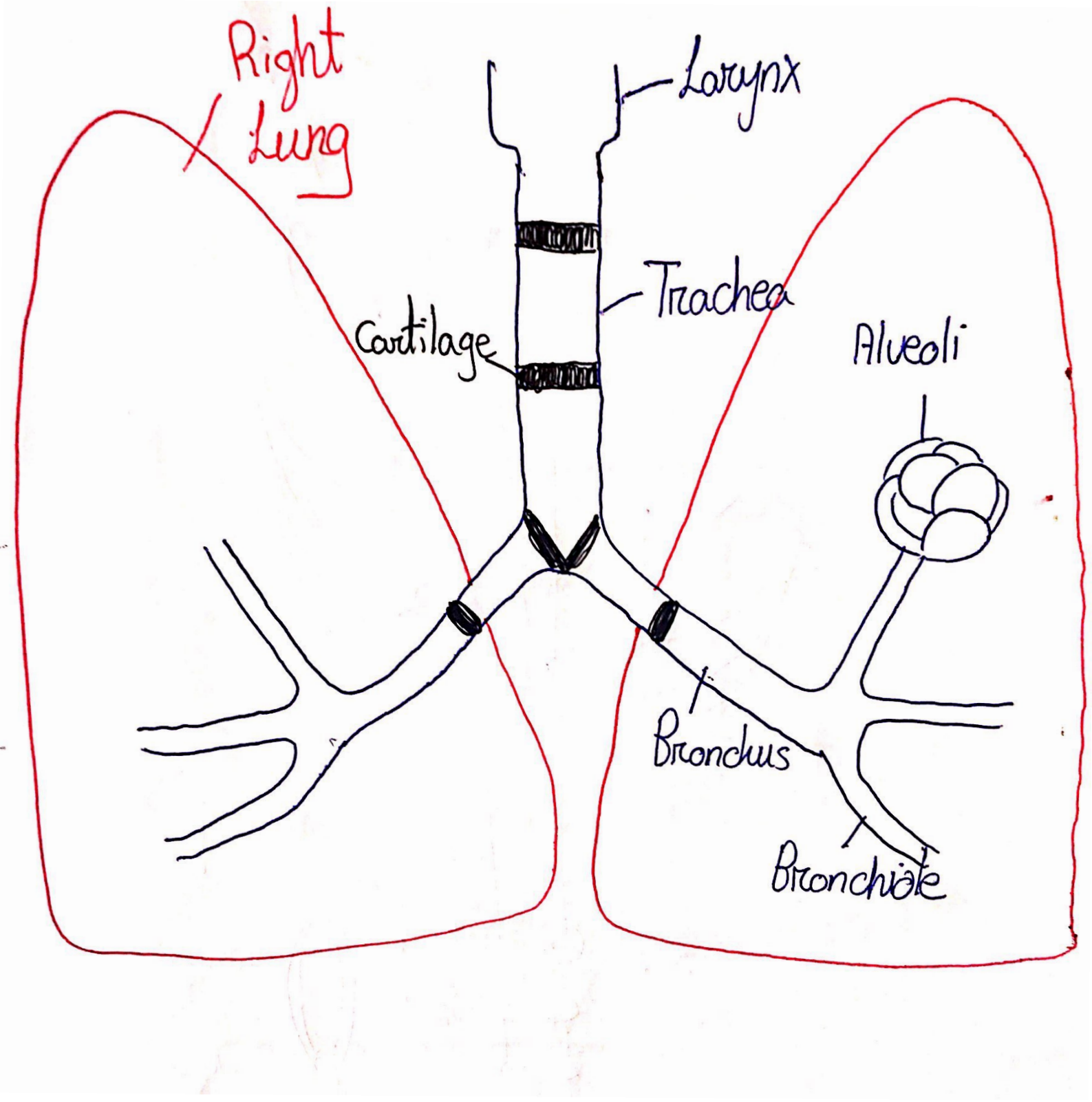

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During exercises the **rate and depth** of breathing increases.

How is an increase in breathing rate coordinated?

During exercise, respiration rate increases produces CO_2 during aerobic and lactic acid during anaerobic, where both products are acidic and decrease the pH of the blood, the brain detects this using receptors and send impulses to intercostal muscles and diaphragm to contract more frequently.

Differences between inspired and expired air :

Air/gas	inspired	Expired
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	78%	78%

Smoking

Tobacco smoking has different compounds that are toxic to the human body

Carbon monoxide

It has a higher affinity to haemoglobin than oxygen so binds to it and reduces RBC's efficiency to carry oxygen.

Nicotine

It causes stimulation of the nervous system and heart so increases the heart rate. It also causes addiction i.e. inability to stop smoking.

Tar

It causes lung cancer, and paralysis of cilia.

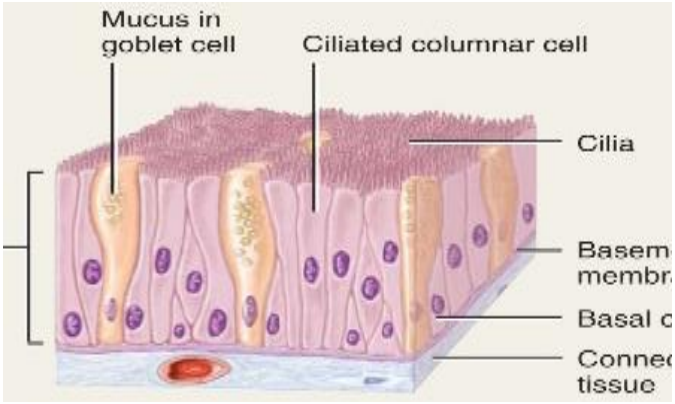
Smoke particles

causes COPD such as emphysema

Ciliated epithelium

It lines the respiratory tract and consists of two types of cells; goblet cells and ciliated cells, it protects against pathogens through;

Goblet cells secretes mucus which is sticky so traps dust and bacteria, cilia vibrates and moves the mucus upwards to be swallowed and bacteria killed by stomach acid.



RESPIRATION

Respiration is the breakdown of food to release energy

Uses of energy in the body:

- Muscle Contraction.
- Protein Synthesis.
- Cell Division.
- Active Transport.
- Growth.
- The Passage of Nerve Impulses.
- Maintenance of a Constant Body Temperature.

Respiration takes place in all body cells except red blood cells which lacks mitochondria.

N.B. enzymes are involved in the process of respiration, so respiration rate is affected by pH and temperature.

There are two types of respiration

1. **Aerobic respiration**
2. **Anaerobic respiration**

Aerobic respiration

It is the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy.

Word equation:

Glucose + Oxygen ⟶ Carbon dioxide + Water

Chemical equation

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

Anaerobic respiration

It is the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen

N.B. Aerobic respiration produces much more energy than anaerobic

Anaerobic respiration in microorganisms

Glucose ⟶ Ethanol + Carbon dioxide

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

Anaerobic respiration in muscles

Glucose ⟶ Lactic acid

$$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$$

Oxygen debt

When a person starts performing exercises his breathing rate increases to supply the increasing need of oxygen for aerobic respiration to produce energy, during vigorous exercises oxygen taken in is not sufficient, so the person resorts to anaerobic respiration and produces lactic acid.

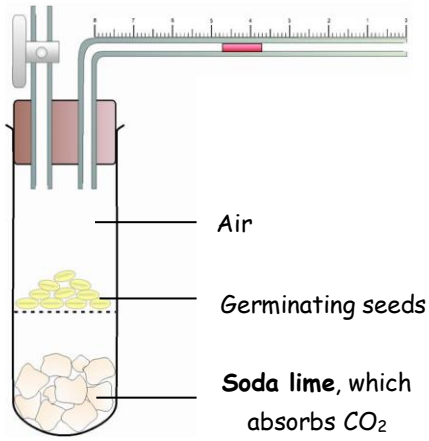
When the exercise is finished, the person's heart rate remains high to transport the lactic acid from muscles to liver, also the breathing rate remains high as he needs more oxygen than normal to 'repay' the oxygen debt during anaerobic respiration, for aerobic respiration of lactic acid in the liver, and this is an example of homeostasis.

How is an increase in breathing rate coordinated?

During exercise, respiration rate increases produces CO_2 during aerobic and lactic acid during anaerobic, where both products are acidic and decrease the pH of the blood, the brain

detects this using receptors and send impulses to intercostal muscles and diaphragm to contract more frequently

Investigate the effect of different



factors on respiration of germinating seeds.

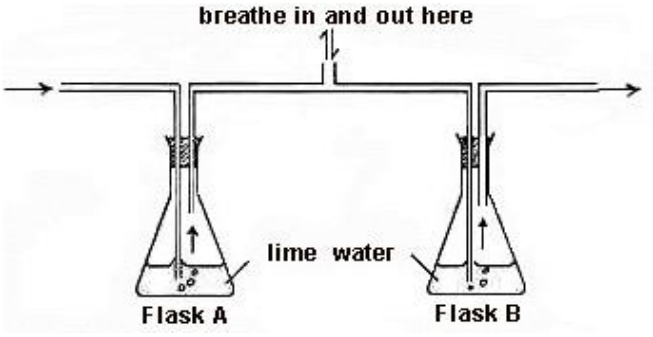
After leaving the apparatus for a while the red dye starts to move **towards** the germinating seeds.

This is because, the seeds respire aerobically, absorbing the oxygen from the air and produce CO_2, which is absorbed by the soda lime, and this creates a negative pressure in the test tube pulling the red dye towards it.

To investigate the effect of factors such as the type of seeds, set 2 of this apparatus, each one should contain different types of seeds. Other factors that might affect the respiration should be kept constant, this includes:

- Mass of seeds
- Mass of soda lime
- Temperature
- Time
- amount of dye added

Investigate different CO_2 amount in inspired and expired air



Breathe in and out gently through the mouth piece, both flasks contain limewater, but flask B will become cloudy first as expired air is bubbled through it, which contains a higher percentage of CO_2.

DISEASES AND IMUNIITY

Pathogen is a disease-causing organism.

Transmissible disease is a disease in which the pathogen can be passed from one host to another.

Modes of transmission

Direct contact: through blood (virus C) or other body fluids as sexual contact (HIV).

Indirectly: from contaminated surfaces or food, from animals, or from the air.

Body defences against pathogens

Mechanical barriers: such as skin and hairs in the nose

Chemical barriers: such as mucus *(see gaseous exchange)* and stomach acid.

Cellular immunity: phagocytosis and antibody production by lymphocytes

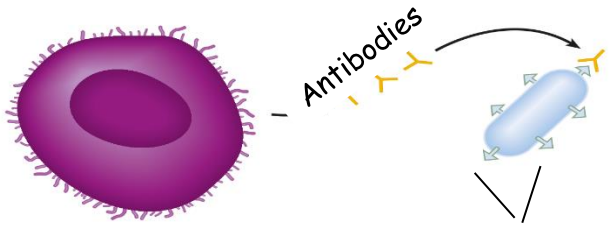
Antibodies

Antibodies are proteins produced by lymphocytes they lock on antigens then attack pathogens by either

- Direct destruction
- Marking of pathogens for destruction by phagocyte

Pathogens have proteins on their wall called antigens, each pathogen has its own antigens, which have specific shapes, and so specific antibodies which fit the specific shapes of the antigens are needed.

So the sequence of amino acids in antibodies is important to be in the correct order for the antibody to work



Immunity

There are two types of immunity, active and passive

Active immunity

It is a defence against a pathogen by antibody production in the body

It is gained after an infection by a pathogen, or by vaccination

<u>Vaccination</u>

The steps of vaccination against a certain disease are:

- harmless pathogen, which has unique antigens, is injected into the body
- antigens trigger an immune response by lymphocytes which produce antibodies specific to the antigen
- memory cells are produced that give long-term immunity
- This provides protection against re-infection

Passive immunity

It is a short-term defence against a pathogen by antibodies acquired from another individual, e.g. mother to infant

Memory cells are **NOT** produced in passive immunity
It is important for breast-fed infants, since they have a weak immunity and are susceptible to several diseases, such as lung and intestinal infections.

Autoimmune diseases

They are diseases caused by the immune system targeting and destroying body cells, such as Type 1 diabetes, where lymphocytes produce antibodies which target the cells of the pancreas that secretes insulin.

How to control the spread of diseases?

Food hygiene

- Wash food properly before eating
- Cook food properly
- Don't mix raw meat with cooked meat
- Don't keep food at room temperature for long periods

Personal

- Wash hands properly
- Clip nails
- Wear clean clothes

Vaccination

Vaccination campaigns can eliminate certain diseases, as it provides immunity to the population

Proper waste disposal

Proper sewage treatment to control water borne diseases

EXECRETION

Excretion is getting rid of

1. Waste products of metabolism
2. Toxic substances
3. Substances in excess

Organs of excretion include:

- Kidney ⟶ urea, excess water and salts
- Lungs ⟶ Carbon dioxide

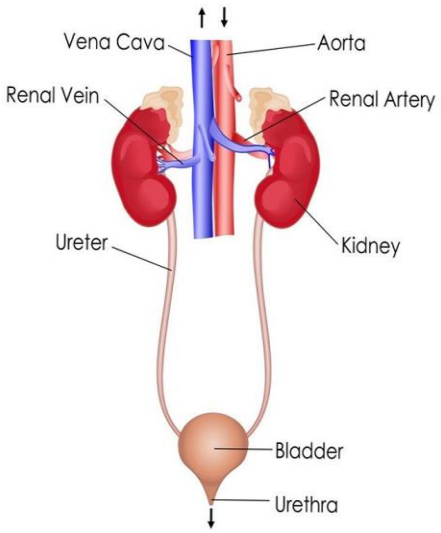
Why is excretion important?
Because urea is toxic it damages the brain, also CO_2 is acidic so will affect the pH of the blood.

Amino acids

Ingested proteins are broken down into amino acids and absorbed to reach the liver

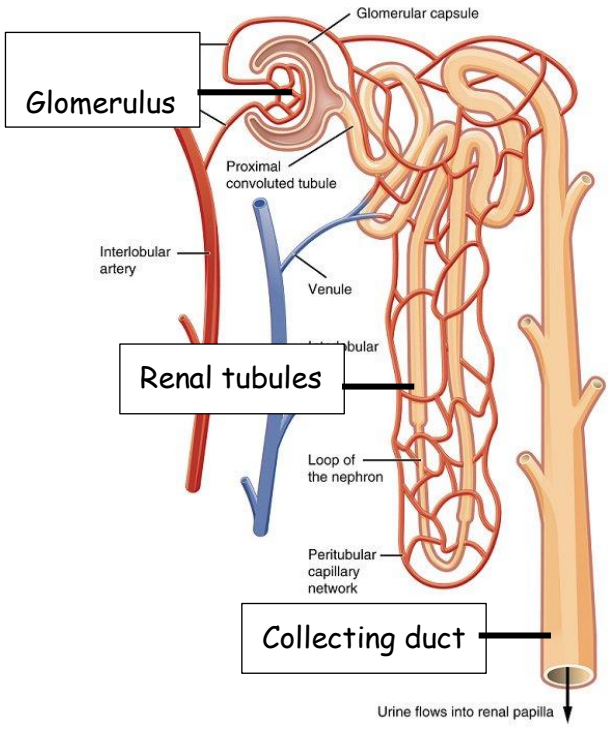
Liver is responsible for assimilation of amino acids into proteins including plasma proteins; e.g. Fibrinogen
Excess amino acids are deaminated in the liver

Deamination
It is the removal of the nitrogen-containing part of amino acids to form urea.

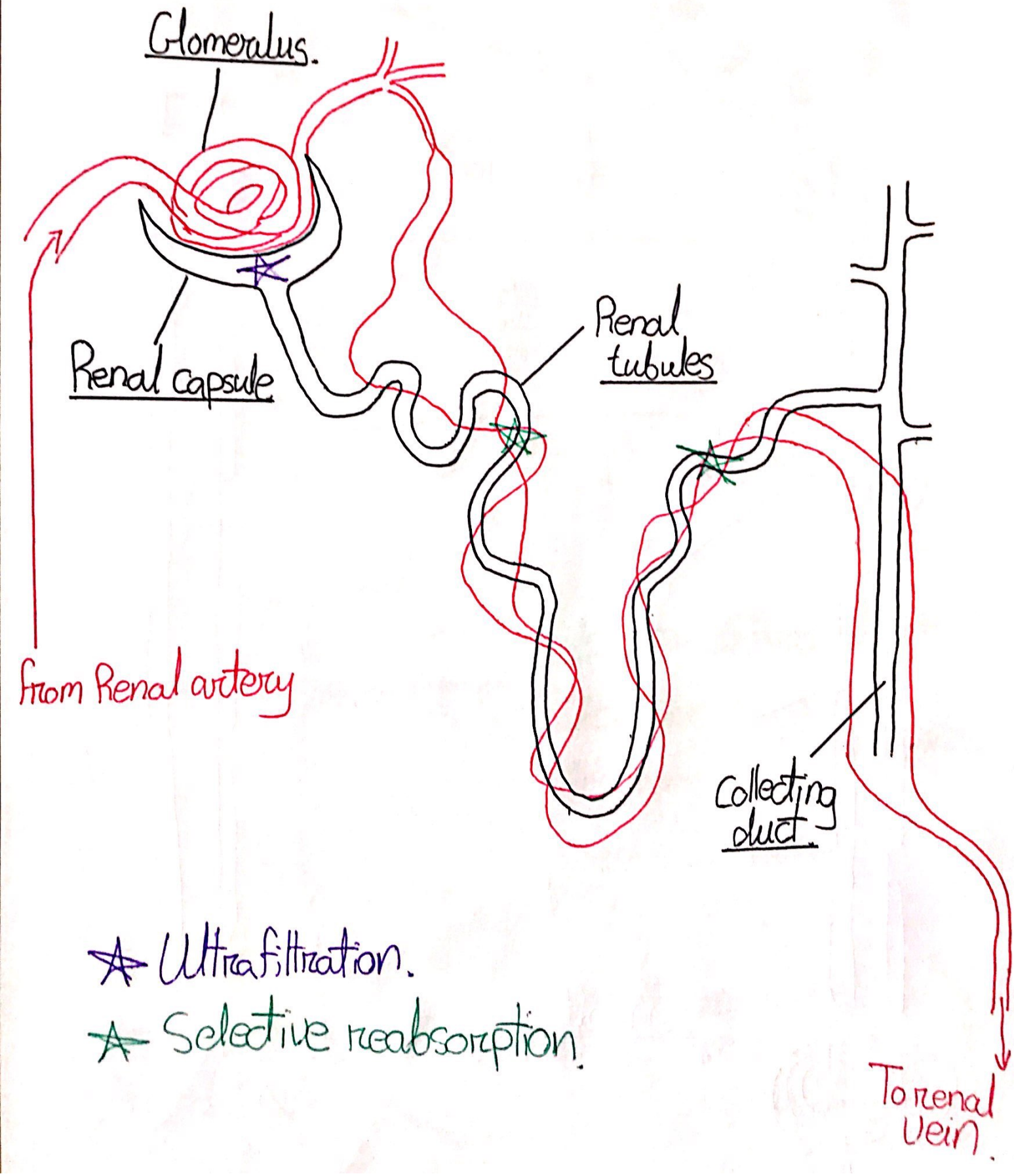


Kidney

It consists of three layers; **cortex, medulla and renal pelvis**
The functional unit of the kidneys is the nephron which consists of the following parts with the following functions



Structure	Function
Glomerulus	**Ultrafiltration** where all the contents of the plasma (except RBCs and proteins) leave the glomerulus
Renal (Bowman's) capsule	Collects the filtrate from glomerulus
Renal tubules	**Selective reabsorption** of molecules needed by the body such as glucose[1], some salts and water, which concentrates urea in urine



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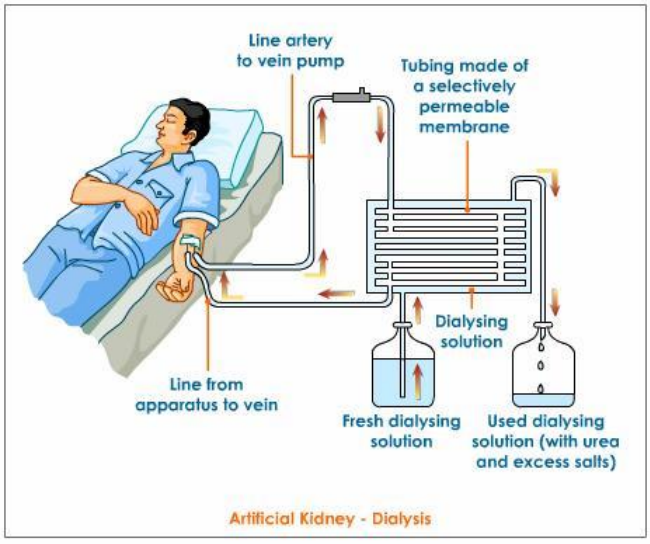
Collecting duct	Reabsorption of water, it controls the amount of water in the urine[2]

[1] Glucose reabsorption takes place through **diffusion** then **active transport**

[2] When the weather is hot, there is a high rate of water loss through sweating so the collecting duct absorbs more water to conserve it, making the urine concentrated. And vice versa in winters.

Kidney dialysis



Dialysis refers to salt balance, maintenance of glucose concentration and removal of urea.

A kidney dialysis machine replaces the kidney by doing its function of dialysis

1. The blood is taken from the patient arm and passes through a pump
2. The blood enters the dialysis machine and passes along a tube made of partially permeable membrane (to allow osmosis of excess water) surrounded by dialysis fluid
3. The dialysis fluid has no urea and a small concentration of salts, so urea and excess salts diffuse out.
4. The dialysis fluid has the same concentration of glucose as patient to avoid loss of glucose
5. The dialysis fluid should be replaced continuously
6. Then the blood returns to the patient.

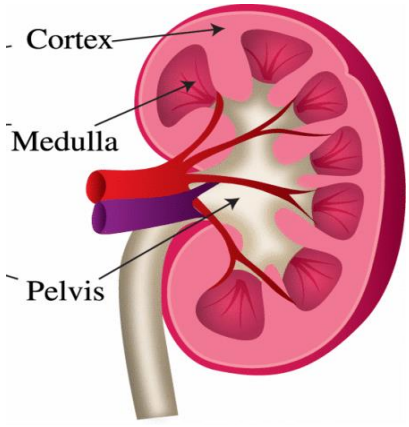
What are the advantages and disadvantages of kidney transplants compared with dialysis?

Advantages:

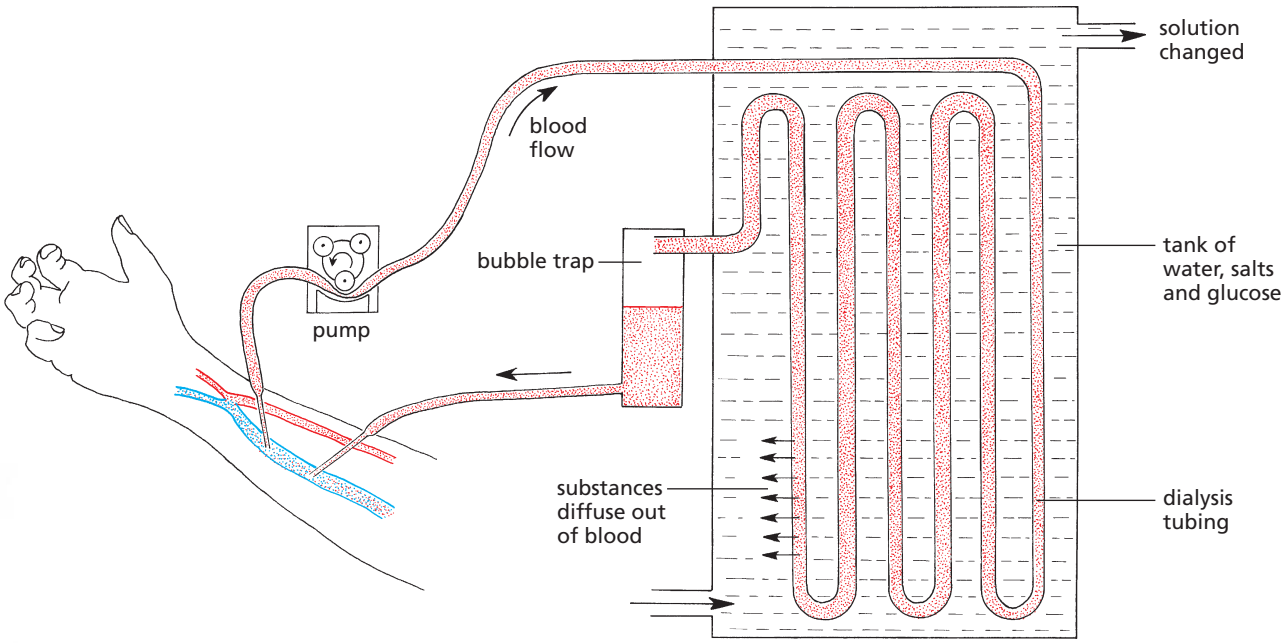
- Wider range of diet
- Better lifestyle
- Less time consumed going to hospitals

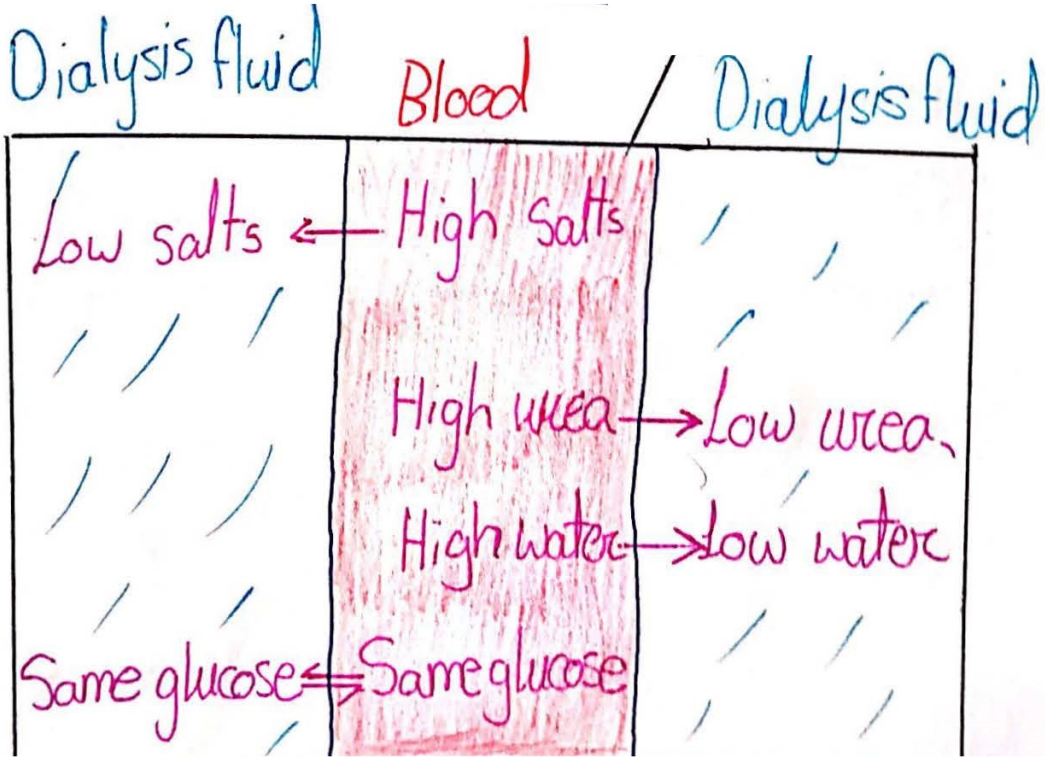
Disadvantages:

- **Expensive**
- **Must take immune-suppressive drugs** which lowers the immunity to avoid tissue rejection, and this will increase the risk of infections.



Dialysis machine





HOMEOSTASIS

Definition:

It is the maintenance of constant internal environment

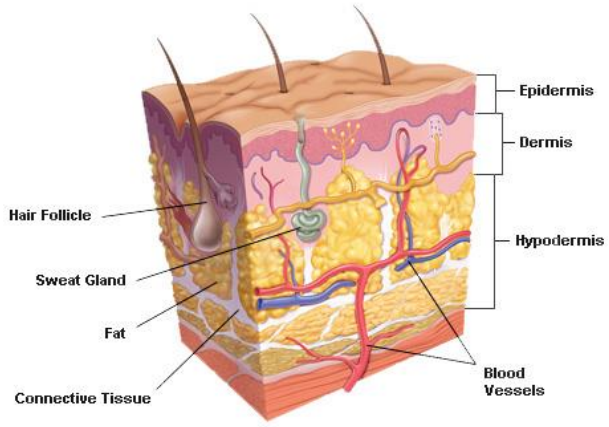
Homeostasis is the control of internal conditions within limits, such as;

- The temperature of the body which is maintained at 37 at all times
- Blood glucose concentration maintained at 80-140 mg/dl
- Water content of plasma must be contained constant to avoid altering osmotic pressures
- The pH of the blood maintained at 7.35 - 7.45
- Other electrolytes in the blood constant, example: Calcium ions, Sodium ions, etc.

The above **values** are not required in the syllabus except for the **temperature**

Temperature homeostasis

There are two possible scenarios, either you are in a cold surrounding or a hot one. If you stay in a hot environment for a period of time your body temperature starts to rise. However, the body has it's mechanisms to overcome the heat and maintain its normal temperature, the opposite occurs when you stay at a cold place.



Hot weather

Temperature change is sensed by the blood temperature receptors in the brain, then the brain sends impulses through motor neurones to skin effectors leading to:

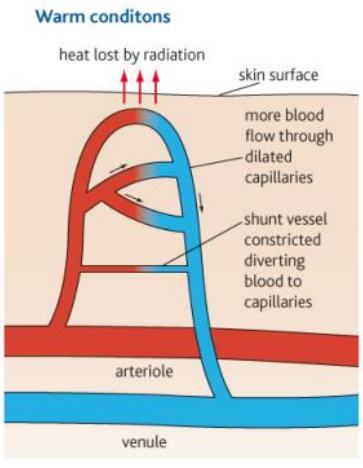
1. **Sweating**; where sweat glands produce sweat which evaporates and cool the surface of the skin.
2. **Vasodilation of arterioles supplying the surface of the skin and vasoconstriction of shunt vessel* to increase the blood flow to the skin to increase heat loss by convection and radiation.**
3. **Thirst sensation.**

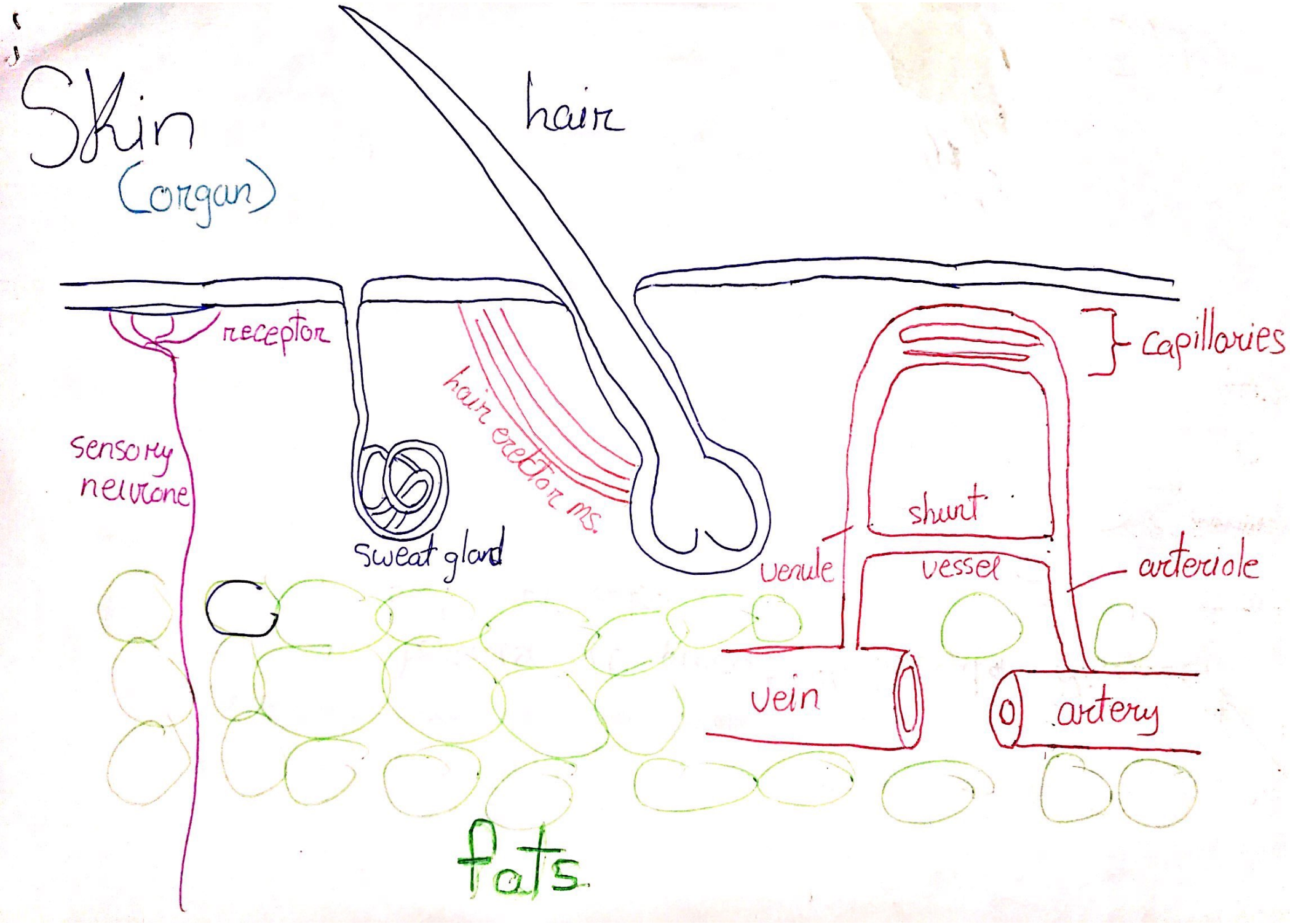
Cold weather

The body responds through the same nervous mechanism in hot weather but with the following differences:

1. **Vasoconstriction of arterioles supplying the surface of the skin and vasodilation of shunt vessel to reduce the blood flow to the skin**, to preserve as much heat as possible.
2. **Shivering**; which are rapid muscular contractions that generate heat.
3. **Hair on the skin is raised to trap a layer of warm air**; since air is a poor conductor of heat it will remain warm for a period of time.

*shunt vessel is a vessel that links an artery to a vein **directly**. When it constricts the blood remains in the artery for a longer time (i.e. remain near the skin surface for more heat loss), when it dilates the blood is poured to veins then to the heart and circulates to the whole body faster (i.e. away from the cold skin surface).





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Blood glucose homeostasis

- When the blood glucose concentration **rises**, as after eating a meal rich in carbohydrates:

  1. The pancreas senses the rise in blood glucose and secretes **insulin** hormone **DIRECTLY** into the blood*.
  2. Insulin reaches the **liver** and **muscles** and stimulates them to increase uptake of glucose from the blood and convert it to glycogen then store it.
  3. Insulin causes all other cells of the body to increase respiration rate to break more glucose.

- When the blood glucose concentration **decreases** as after fasting for 8 hours:

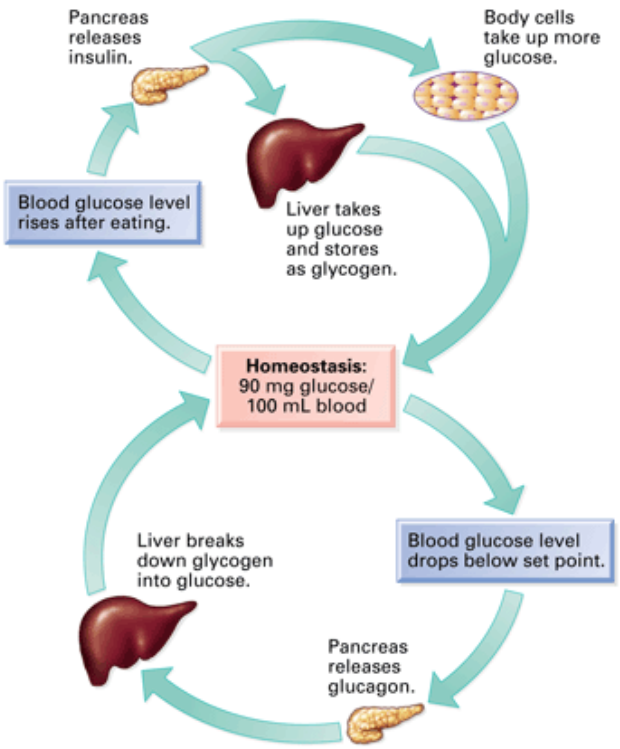
  1. The pancreas senses the decrease in blood glucose and secretes **glucagon** hormone **DIRECTLY** into the blood.
  2. Glucagon reaches the liver **ONLY** and stimulates it to convert stored glycogen to glucose and release it into the blood.

*We can conclude that the pancreas is both an endocrine and exocrine gland, where it secretes hormones into the blood, and pancreatic juice (see *digestive system*) into the pancreatic duct

Negative feedback

One way of controlling the internal conditions within limits is negative feedback control.

Example: when blood glucose increase, pancreas detects it and secretes insulin which lowers the blood glucose;
Then the low blood glucose will reach the pancreas and inhibit further release of insulin, this is known as negative feedback.



Diabetes

Diabetes is a condition where blood glucose level is higher than the normal range, there are two types of diabetes, type I and II, only type I will be discussed

Type I

Cause: it is an autoimmune disease where the body produces antibodies against pancreatic cells

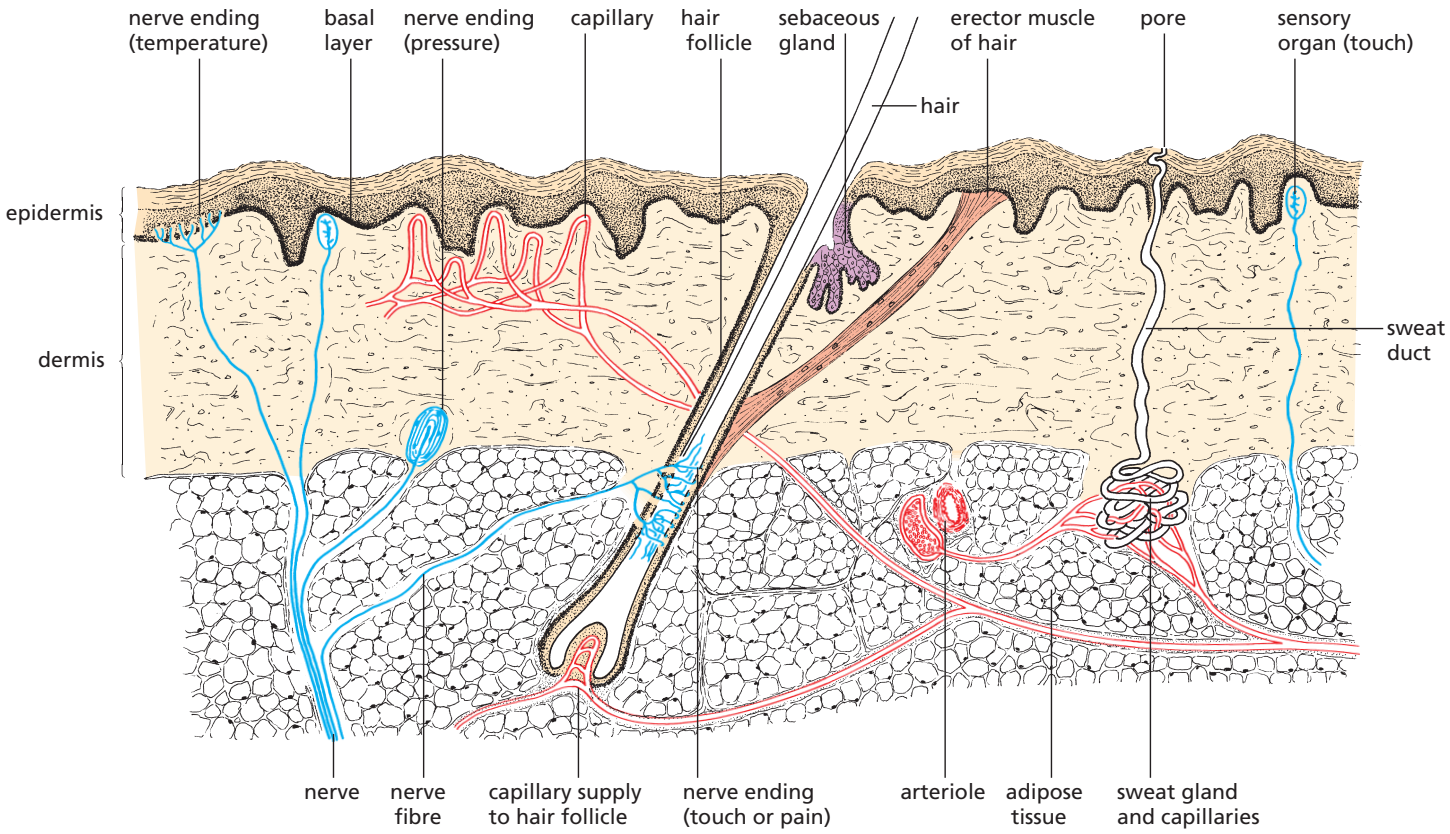
Symptoms

- Fatigability
- Thirst and hunger
- Frequent urination
- Mood swings
- Confusion
- Coma

Management

- Insulin **injection**
- Avoid sugary foods and drinks
- Regular visits to the doctor
- Regular blood glucose measurements
- Eating healthy food and frequent exercises

Skin


nerve ending (temperature)
basal layer
nerve ending (pressure)
capillary
hair follicle
sebaceous gland
hair
erector muscle of hair
pore
sensory organ (touch)
epidermis
dermis
sweat duct
nerve
nerve fibre
capillary supply to hair follicle
nerve ending (touch or pain)
arteriole
adipose tissue
sweat gland and capillaries

COORDINATION AND RESPONSE

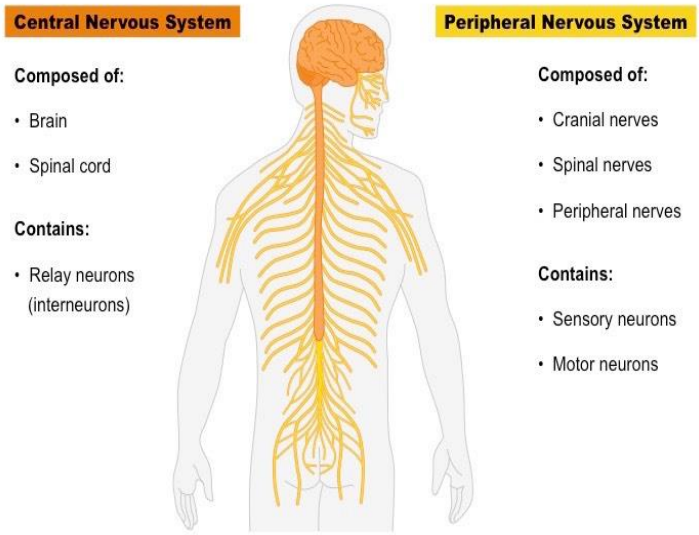
Coordination in human is either nervous or hormonal

Comparison between both is shown

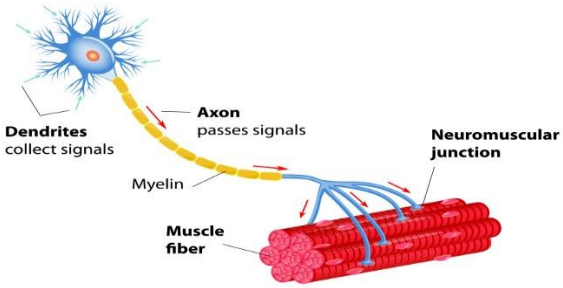
Nervous	Hormonal
Faster	Slower
Lasts for a short duration	Lasts for a long duration
Involves nerve impulses which is **an electrical signal that passes along nerve cells**	Involves chemical messengers called hormones
Coordination through nerves	Hormones released to the blood

Nervous system

It consists of two parts: central and peripheral nervous system.
Nervous system is made up mainly of nerve cells called neurones; there are three type of neurones; motor, sensory and relay neurone



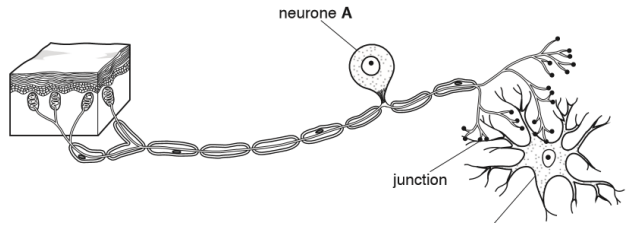
Motor neurone



Cell body is present at one end, many branching dendrites arising from the cell body, and an axon which is long

It carries nerve impulses from the central nervous system to the effector

Sensory neurone



Cell body is present hanging from one side; it has a long Dendron and a short axon

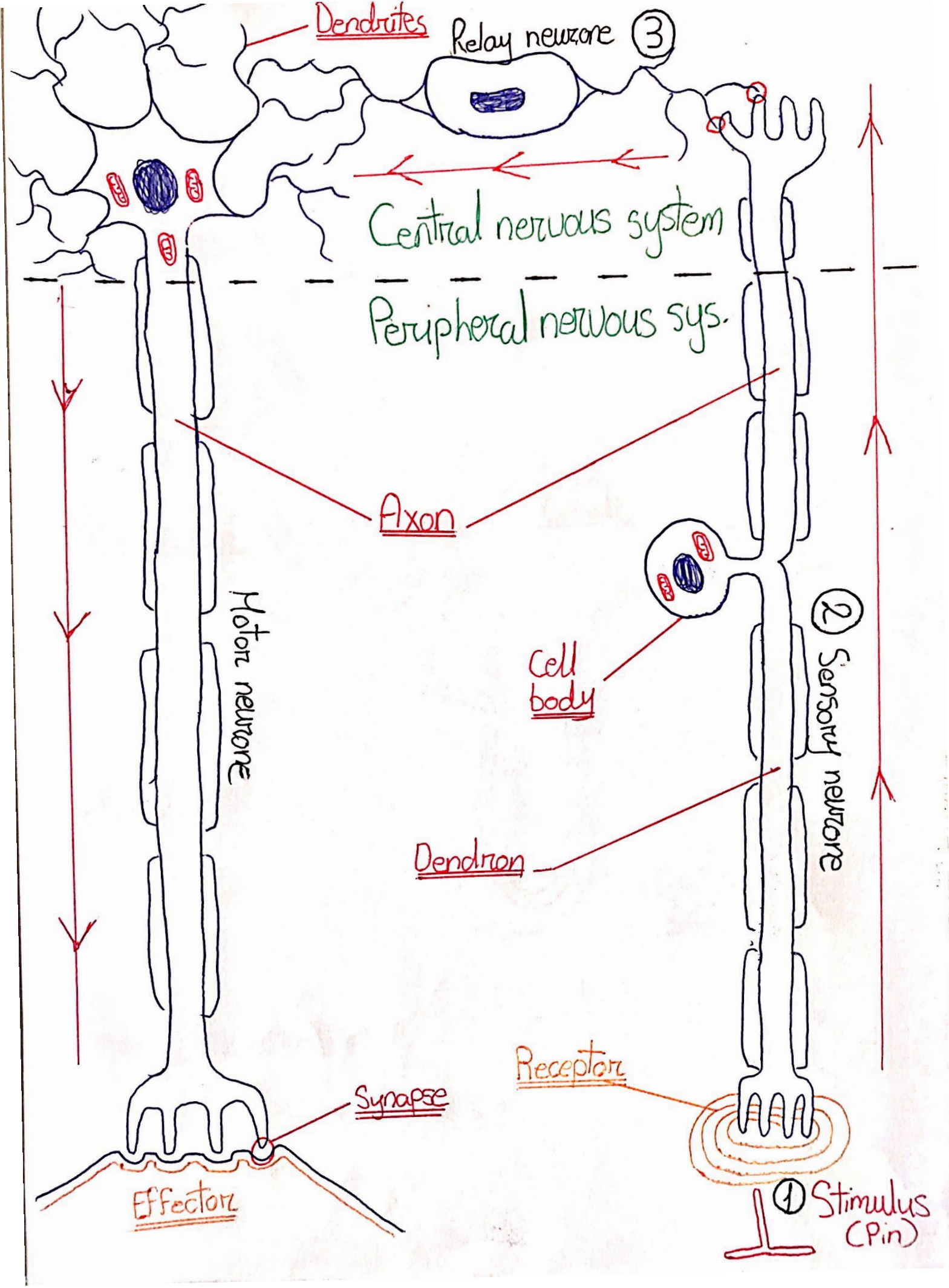
It carries nerve impulses from receptors to the central nervous system

Relay neurone

It has no definite shape, it is present inside the central nervous system and coordinates the movement of impulses, e.g. **connects a sensory neurone to a motor neurone.**

Actions done by the body are either voluntary or involuntary:

Voluntary	Involuntary
Slower	Faster
Done consciously	Done unconsciously
Involves the brain and spinal chord	Involves the spinal cord mainly



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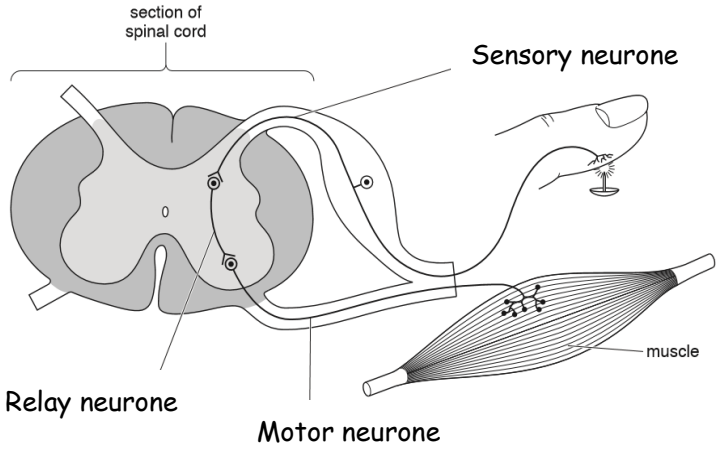
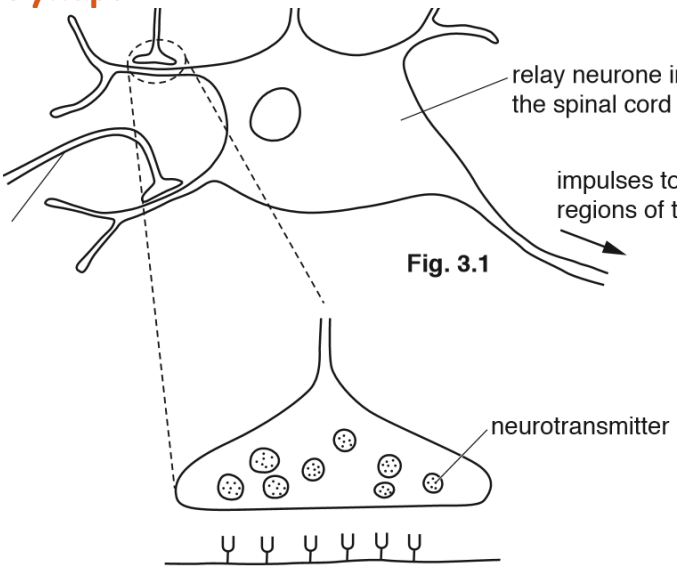
A common example of involuntary action is **reflex action**

Reflex arc



The fire acts as a stimulus, detected by receptors under the skin, which transports the impulse through a sensory neurone to a relay neurone in the spinal cord, which passes the impulse through a motor neurone to the effector which is a muscle, causing its contraction leading to an action

Synapse



A synapse is a junction between two neurones.

When an impulse reaches the end of an axon it stimulates the movement of vesicles containing neurotransmitter to the membrane to release its contents into the gap between the two neurones, the neurotransmitter moves by diffusion towards the receptors on the opposite side binding to them to cause the initiation of a nerve impulse in the following neurone

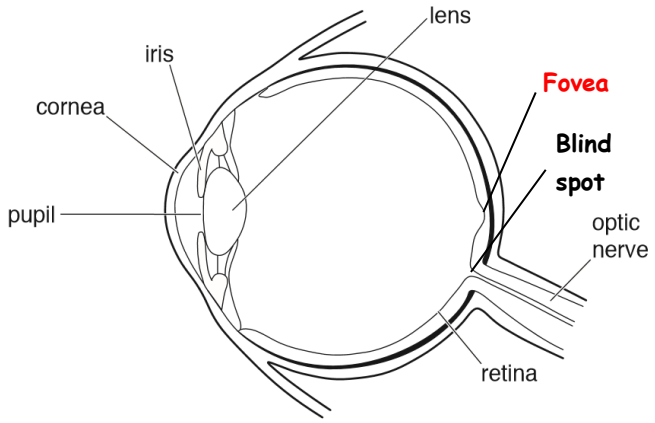
Synapse ensures one way flow of impulse since the neurotransmitter is released from one end and the receptors are present on the opposite end only.

Many drugs can acts upon synapses such as heroin and adrenaline.

Sense organs are groups of receptor cells responding to specific stimuli e.g. eye responds to light, ears respond to sound etc.

Eye

The eye is a sense organ that detects light and transmits it to the brain to give us the ability to see.



Parts of the eye

Cornea: causes refraction of light, it's transparent (has no blood vessels) to allow the light to pass to the retina.

Iris: coloured part of the eye; it controls the diameter of the pupil through the action of circular and radial muscles. When the radial contracts the circular relaxes and the pupil dilates and vice versa, these muscles work as antagonistic muscles where when one contracts the other relaxes.

Lens: focuses the light onto fovea.

Ciliary body: controls the thickness of the lens when it contracts the suspensory ligaments loosen and the lens becomes thicker increasing its power thus allows us to see near objects, this is known as **accommodation**, when the ciliary muscles relax, the suspensory ligaments are pulled causing the lens to become thinner reducing its power in order to see far objects.

Retina: the retina is where detection of light takes place; it has two types of sensory cells rods and cones;

Rods: they are more in number in the retina, absent in the fovea and the blind spot
Role: night vision, since its ability to detect low light intensity, but it can't discriminate colours.

Cones: Less than rods in the retina, they are absent in the blind spot but concentrated in the fovea.

Role: coloured vision, it can discriminate colours since it's of **three types**; red, green and blue.

Light reflex

When the amount of light enters the eye increases, the circular muscles contract and the radial muscles relax so the pupil constricts to prevent damaging of the retina by excess dangerous ultraviolet rays.

Hormonal control

Hormone: chemical substance, produced by a gland and carried by the blood, which alters the activity of one or more specific target organs

Gland	Hormone secreted
Pancreas	Insulin/Glucagon
Adrenal gland	Adrenaline
Pituitary gland	FSH/LH
Ovaries	Oestrogen/Progesterone
Testes	Testosterone

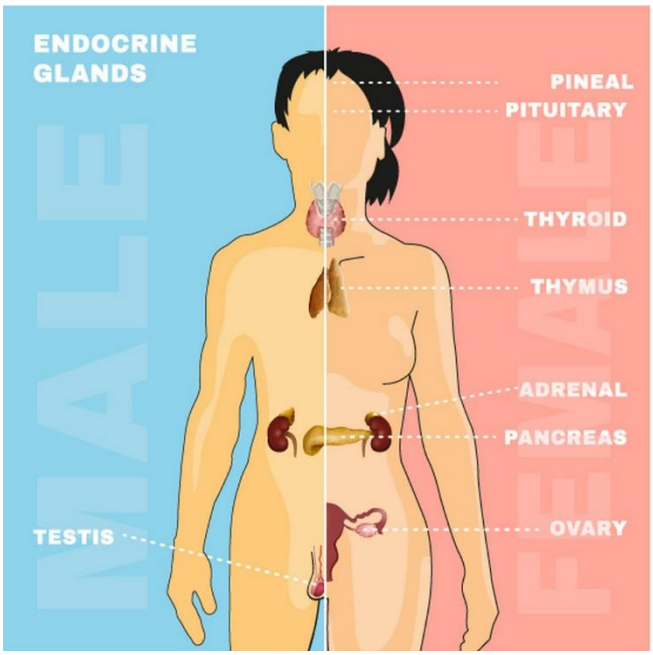
Several types of hormones control body functions and maintain homeostasis

Adrenaline

It is secreted from the adrenal gland during a situation of fight, fright or flight (for example; running away from danger, strenuous exercise, fighting)

It has the following effects on the body:

Heart: increase the heart rate to supply more blood containing more glucose for more respiration (see respiration)



Breathing: increases the rate and depth of breathing to supply more oxygen for aerobic respiration and get rid of more carbon dioxide.

Muscles: Vasodilation of blood vessels supplying muscles to increase blood flow to them

Liver: breakdown of glycogen into glucose and release it to the blood

Pupil: Widens to increase the field of vision

Coordination in plants

Plants response to different stimuli such as light and gravity

Phototropism: a response in which parts of a plant grow towards or away from the direction from which light is coming

Gravitropism: a response in which parts of a plant grow towards or away from gravity

Positive tropism means towards the stimulus, negative tropism means away from the stimulus e.g. positive phototropism is growth towards light, negative gravitropism is growth away from gravity.

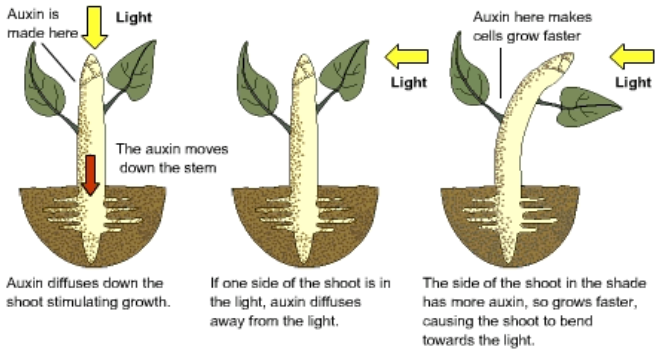
Auxins

The above responses are controlled by plant hormones called auxins, which stimulates cell elongation in plants

N.B. Auxins stimulate cell elogation in the shoot and inhibits growth in the root.

Phototropism

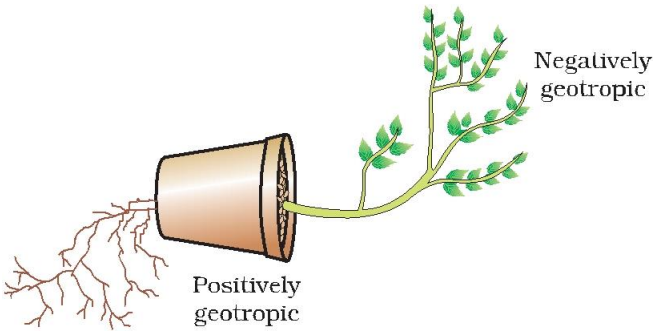
Auxins are released from the shoot tip and spread to all parts of the plant, auxins then moves towards the shade, so it becomes unequally distributed in the shoot, as a result one side (shaded) has cell elongation more than the other side causing bending towards the light.



An advantage of such response is to reach more sunlight for more photosynthesis.

Gravitropism

When a plant is placed horizontally, auxins produced at the tip of the shoot and spreads throughout the plant, then auxins move downwards by the effect of gravity so it becomes unequally distributed in the shoot, as a result one side (lower) has cell elonagtion more than the other side causing bending upwards of the shoot, to reach more sunlight.



However auxins will inhibit the growth of the lower part of the root so it will bend downwards, an advantage of this is to reach as much nutrients and water in the ground as possible.

2,4 D

2,4 D is a synthetic auxin used as a weedkiller, it is absorbed by weed leaves only, causing excessive elongation without enough nutrients to support, so they die

DRUGS

Drugs: any substance taken into the body that modifies or affects chemical reactions in the body. Two categories of drugs will be discussed; medicinal and misused drugs

Medicinal drugs

Antibiotics

They are drugs that treat bacterial infection as it damages bacteria

Overuse of antibiotics lead to some bacteria becoming resistant to many antibiotics reducing the effectiveness of using antibiotics to treat bacterial infections

The most concerning case of antibiotic resistant is the emergence of MRSA bacteria, which is a type of bacteria resistant to the most potent antibiotics.

The development of MRSA bacteria can be minimised by:

- Using antibiotic only when necessary
- Don't use antibiotic for viral infections
- Completion of the treatment course of antibiotics

Antibiotics have no effect on viruses as it target structures present only in bacteria such as cell wall, ribosomes etc.

Misused drugs

Heroin

When heroin is taken into the blood it is converted to morphine and diffuses to the synapses where it binds to endorphin receptors blocking the transmission of impulses.

Heroin is a powerful depressant drug and an overdose will shut down the brain causing death

Sharing needles while injecting heroin will transmit HIV.

Effects of heroin abuse:

- Reduces reaction times and self-control
- Addiction
- Tolerance; i.e. has to increase the dose every time.
- Overdose causes death.
- Withdrawal symptoms such as fear, panic, anxiety, excessive sweating.
- Negative social implications, e.g. inability to socialise, crime.

Alcohol

It is a drug that is broken down in the liver, so excessive intake for long periods causes liver damage (liver cirrhosis), as well as brain damage.

Effects of excessive consumption of alcohol:

- Damages brain nerve cells
- Reduces reaction times and self-control
- Addiction
- Negative social implications, e.g. inability to socialise, crime, and suicide.

Tobacco smoking

Discussed in *Gaseous exchange*

Tobacco smoking also contains smoke particles that can lead to chronic obstructive pulmonary diseases (COPD) such as **emphysema; where the elasticity of alveoli is decreased, so a decreased ability of exhalation**

Steroids

Used to boost sporting performance, they include testosterone and anabolic steroids.

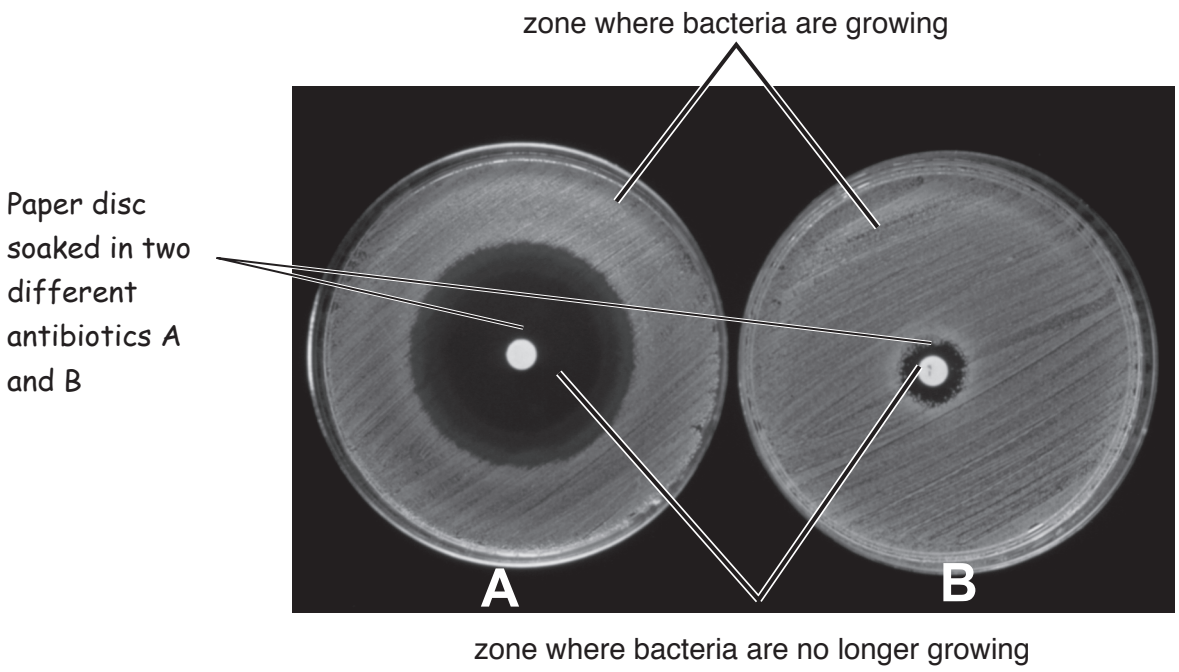
They increase muscle mass and aggression, leading to more powerful muscular contraction so a better performance.

However it has serious side effects, as it can lead to sterility, liver disease and some cancers.

Also it is illegal as it makes competitions unfair.

Antibiotic sensitivity test

a paper disc is soaked in an antibiotic and placed in a petri dish containing cultured bacteria
the antibiotic diffuses and kills bacteria creating **a clear zone around the antibiotic**
if bacteria is resistant to the antibiotic **no clear zone** is produced



We can conclude that bacteria are resistant to antibiotic B as there is no clear zone produced around it, which means bacteria is still growing and reproducing

REPRODUCTION

There are two types of reproduction, sexual and asexual

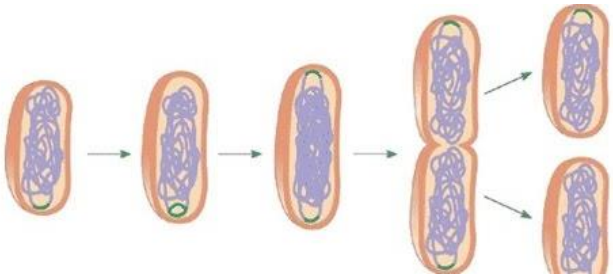
Asexual reproduction

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

Examples of asexual reproduction

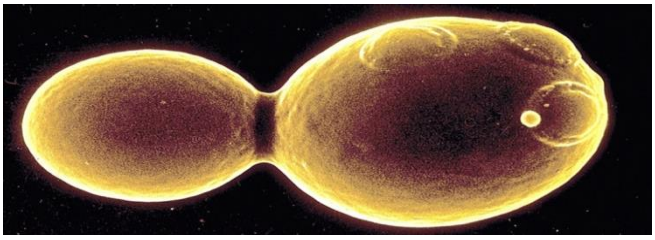
Bacteria

Binary fission: bacteria split forming two copies through binary fission **(not mitosis)**,



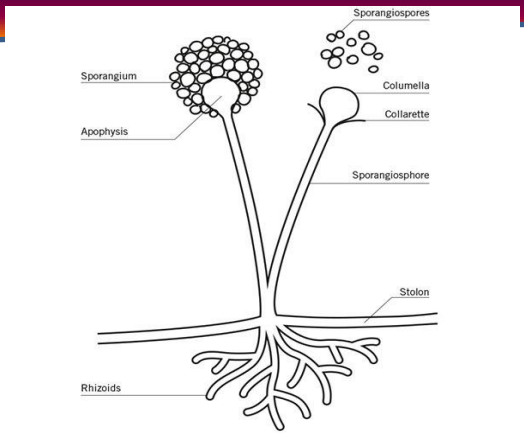
Budding

By yeast where a new yeast buds from the original one



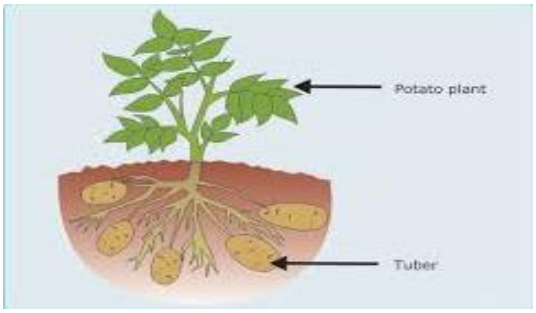
Fungi

Discussed in classification



Potato tubers

Potato tuber is ploughed into soil where tuber acts as a source and translocation takes place to new growing sinks such as leaves, then leaves make photosynthesis to produce glucose in order to form new potato tubers



Advantages and disadvantages of asexual reproduction for crop plants

advantages	Disadvantages
Fast and cheaper	No genetic variation
Increase in the yield of crops	Less chance of adapting to changing conditions
All positive traits of parent is transmitted	All crops will die if a disease is introduced

Advantages and disadvantages of asexual reproduction for wild species

advantages	Disadvantages
Less energy needed, faster to colonize an area	No genetic variation
Suitable when there is a small number of	Less chance of adapting to changing

possible mates	conditions
All positive traits of parent is transmitted	All crops will die if a disease is introduced

Sexual reproduction

It is a process involving the fusion of the nuclei of two gametes (sex cells) to form a zygote.

It produces an offspring that is genetically different from the parent.
Fertilization is the fusion of gametes
Gametes have haploid nuclei which means that they have one set only of chromosomes, they include sperms, pollen and egg cells while zygote has a **diploid nucleus** (two sets of chromosomes)

Advantages of sexual reproduction are:

Causes genetic variation, so there is more chance of adapting to changing conditions,

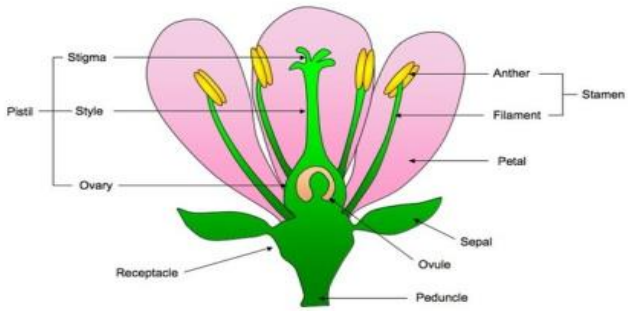
Disadvantages:

Two parents are needed so consumes energy, undesired recessive traits might be expressed

Sexual reproduction in plants

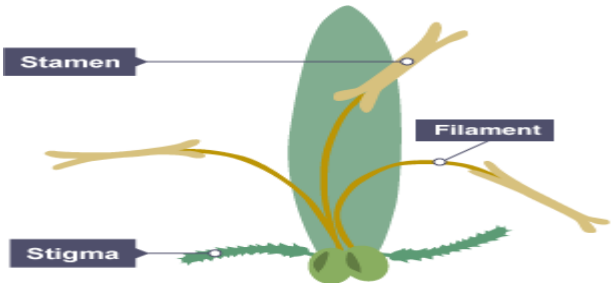
The flower is the reproductive organ in plants, there male, female or both (bisexual) flowers

The following diagram is for an insect pollinated flower



Sepals: protect the flower when in bud
Petals: colourful to attract insects
Anther: forms pollen grains
Stigma: receives pollen grains during pollination
Ovary: contains ovules that have the female gametes, it becomes the fruit after fertilization.

The following diagram represents a wind pollinated flower



Pollination

Pollination is the transfer of pollen grains from the anther to the stigma
There are two types of pollination

- **self-pollination** as the transfer of pollen grains from the anther of a flower to the stigma of the same flower or different flower on the same plant
- **cross-pollination** as transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species

There are two types of cross pollination

- Insect pollination
- wind pollination

feature	Insect pollinated flower	Wind pollinated flower
PETALS	COLOURED	NOT COLOURED
STAMEN	INSIDE THE FLOWER	LONG AND PROJECTED OUTSIDE THE FLOWER
STIGMA	SMALL	LARGE FEATHERY TO INCREASE THE SURFACE AREA TO CATCH MORE POLLEN
POLLEN	LARGE AND SPIKY TO STICK TO INSECTS	SMALL AND LARGE IN NUMBER TO BE EASILY CARRIED BY WIND

Discuss the implications to a species of self-pollination

- Less genetic variation
- Less chance to adapt to changes in the environment
- Doesn't require a pollinating agent
- Less wastage of pollen and energy

N.B. Self-pollination decreases heterozygosity, and leads to inbreeding depression.

Discuss the implications to a species of cross-pollination

- More genetic variation
- More chance to adapt to changes in the environment
- Requires pollinating agent
- There is wastage of pollen

When pollen is transferred to a stigma it forms a pollen tube by secreting enzymes that extends down the style where the haploid nucleus travels to reach ovules.

Fertilisation occurs when a pollen nucleus fuses with a nucleus in an ovule

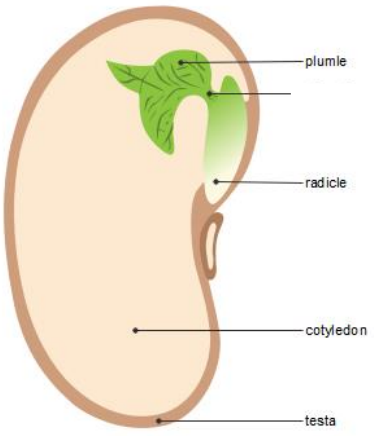
After fertilization, zygote divides by mitosis forming embryo which develops to radicle and plumule, cotyledon forms, petals fall, sepals persist, ovules become the seeds and the carpel becomes the fruit.

Germination

In order for seeds to germinate it requires

- oxygen: aerobic respiration
- water: to activate enzymes
- suitable temperature: for optimum enzymatic activity

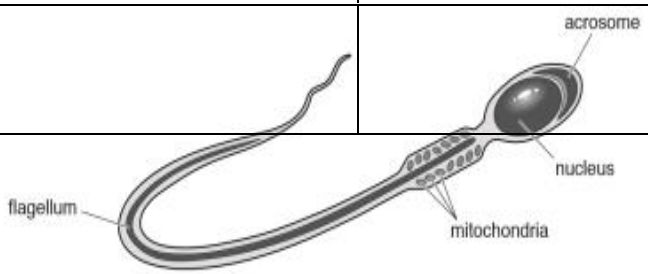
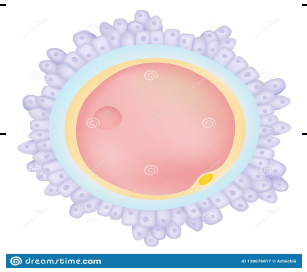
Parts of a Seed



REPRODUCTION IN HUMANS

Gametes

Gametes are produced as the result of reduction division (meiosis), so they are haploid (n)
Male gametes are called sperm, while female gametes are egg cells
Comparison between both gametes

Gamete/feature	Sperm	Egg cell
Size	Smaller	Larger
Number	Millions daily	One monthly
Motility	Motile	Non-motile
Structure		

Fertilization

It is the fusion of male gamete with female gamete forming a zygote which is diploid (2n)

Sperms are adapted to their function by having:

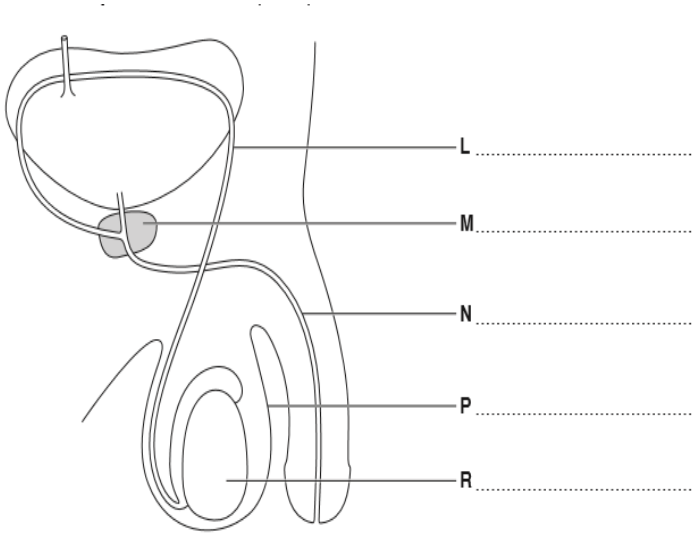
- Tail to move towards the egg cell
- Acrosome which contains hydrolytic enzymes to digest through the outer layer of the egg cell
- Many mitochondria for more aerobic respiration to provide energy for motility

Egg cells have the following adaptive features

- Large energy stores as it will provide the energy for cell division of the zygote and embryo
- Jelly coat that allows the entry of a single sperm only as its structure changes after fertilization

Male reproductive system

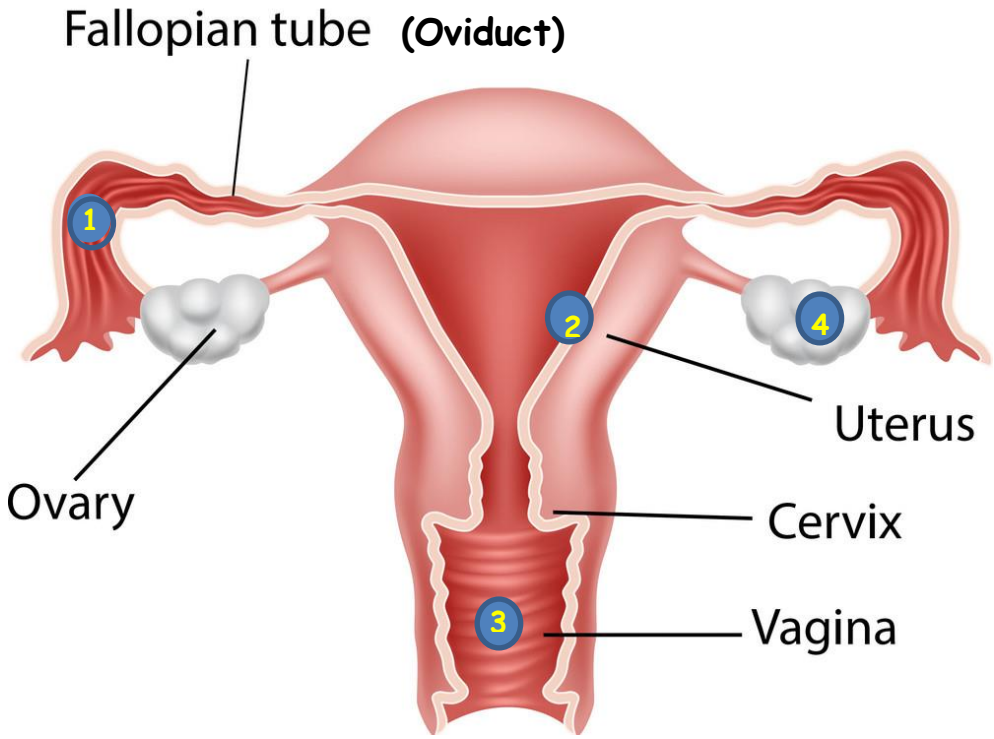
- **Scrotum** is the skin that covers the testes
- **Testis** produces testosterone and sperm cells
- **Vas deferens (sperm duct)** transfers sperm cells to be ejaculated
- **Prostate** secretes seminal fluid which provides nutrition for the sperms
  And is alkaline to neutralise acidity of the vagina
- **Penis** is the organ of sexual intercourse.



Testosterone

This is the hormone which is responsible for development and regulation of male secondary sexual characteristics such as deep voice, growth of muscles, and development of facial hair.

FEMALE REPRODUCTIVE SYSTEM

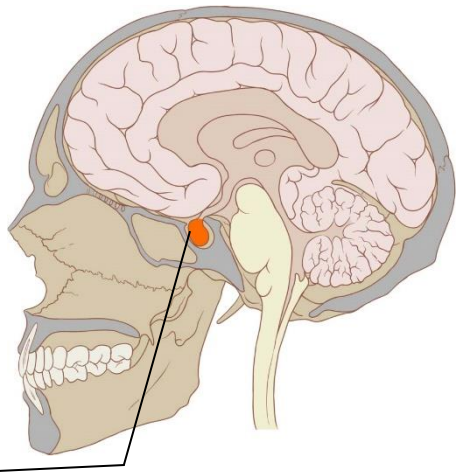


1. Site of <u>fertilization</u>
2. Site of <u>implantation</u>
3. Site of penis insertion during <u>sexual intercourse</u>
4. Site of production of
   - <u>Ovum (egg cell)</u>
   - <u>Oestrogen</u>
   - <u>Progesterone</u>

Female hormones

FSH, LH → Released from the <u>pituitary gland</u>

Oestrogen, Progesterone → Released from the <u>ovaries</u>



FSH

'Follicle Stimulating Hormone' released from the pituitary gland and stimulates the formation of follicles in the ovary which is the site of oestrogen and progesterone secretion as well as egg cell formation.

LH

Luteinizing Hormone released from the pituitary gland and causes ovulation; which is the rupture of the follicle to release the mature egg cell into the oviduct at **day 14** of the menstrual cycle.

Oestrogen

- Causes the lining of the uterus to **INCREASE** in thickness to be ready for implantation.
- Responsible for the female secondary sexual characteristics, example: Fat distribution, breast development, high pitch voice, etc.
- Inhibits FSH release during menstrual cycle
- Stimulates LH release at day 14

Progesterone

- **MAINTAINS** the lining of the uterus thick to be ready for implantation
- Inhibits FSH release during menstrual cycle

N.B. thick lining of uterus is maintained by oestrogen initially and by progesterone later on.

The menstrual cycle

Points to understand

- Oestrogen and progesterone act as messengers from the ovary that notifies the pituitary gland about the status of the follicle, when they are produced in large quantities this indicates that the follicle is mature enough and ready to release the mature egg cell; so LH is released.

- When they are in very low concentrations, this indicates that there is no follicle; so FSH is released.

The following sequence takes place continuously from puberty till menopause [1]

Day 7-14

1- FSH is released from the pituitary gland in response to low oestrogen and progesterone; it travels to the ovary and causes the maturation of a follicle.

2- The mature follicle will secrete oestrogen and progesterone which will inhibit the FSH to prevent further formation of follicles [2]

Day 14

3- When oestrogen level increases significantly, LH is released and causes ovulation, the ruptured follicle is now called 'corpus luteum' or yellow body

Day 14-28

4- If fertilization of the egg cell occurs, the yellow body persists for 3 months to continue to secrete progesterone to maintain the lining of the uterus thick during pregnancy, until the placenta is developed and starts producing progesterone.

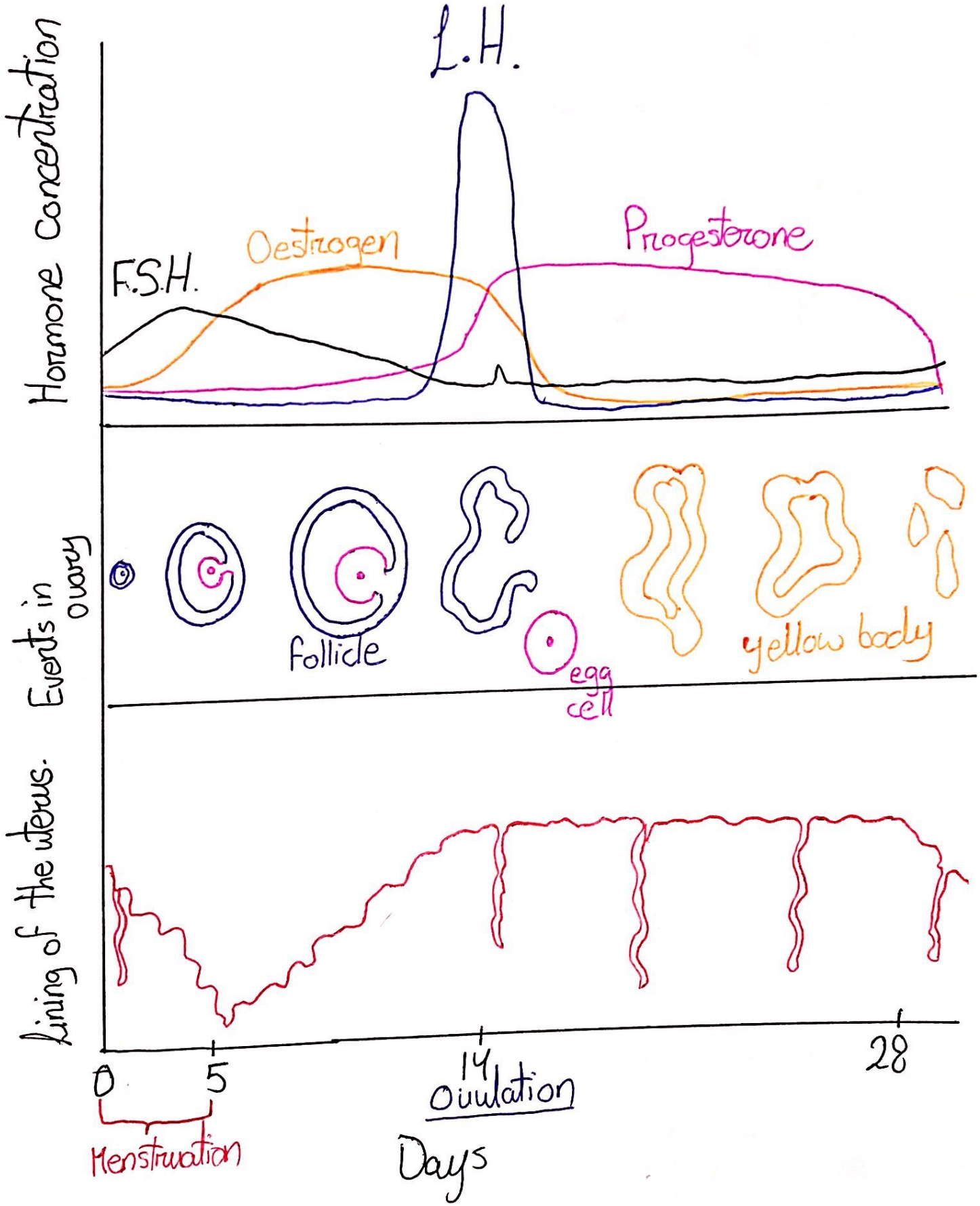
Day 1-7

5- If no fertilization occurs, the yellow body breaks down after a few days so progesterone levels will decrease significantly, so as a result, the thick lining of the uterus will break down in the form of bloody material and descend through the vagina causing bleeding (menstruation)

6- Now read step 1

[1] Menstrual cycle stops at a certain age which differs from a female to another i.e. females can only be pregnant till a certain age only usually 45-50 this is called menopause

[2] If FSH continues to be released, more follicles would be produced, which means more than one egg cell, i.e. twins.



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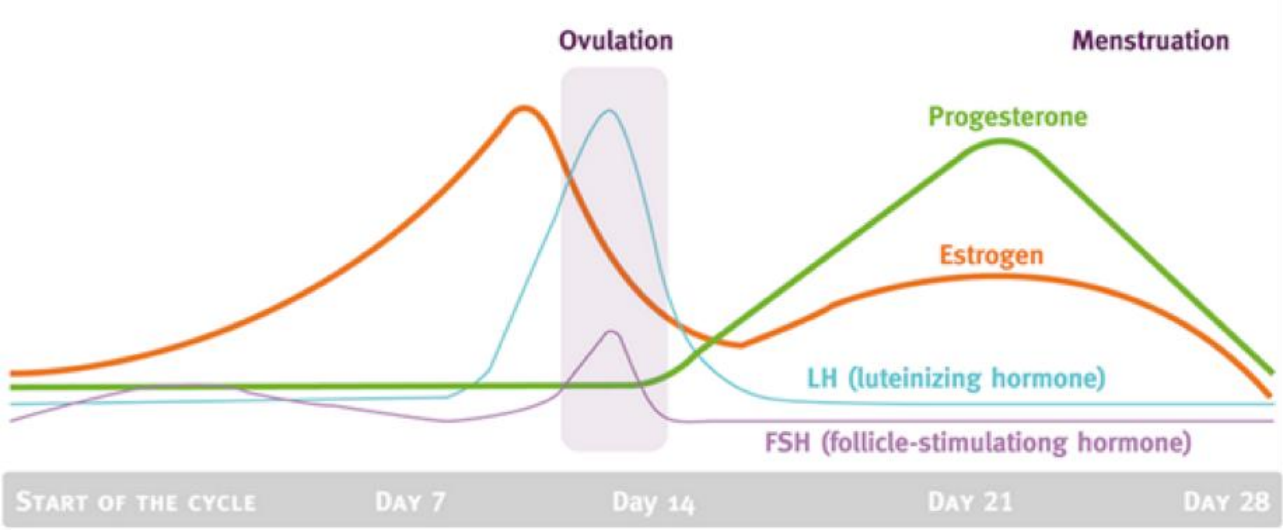
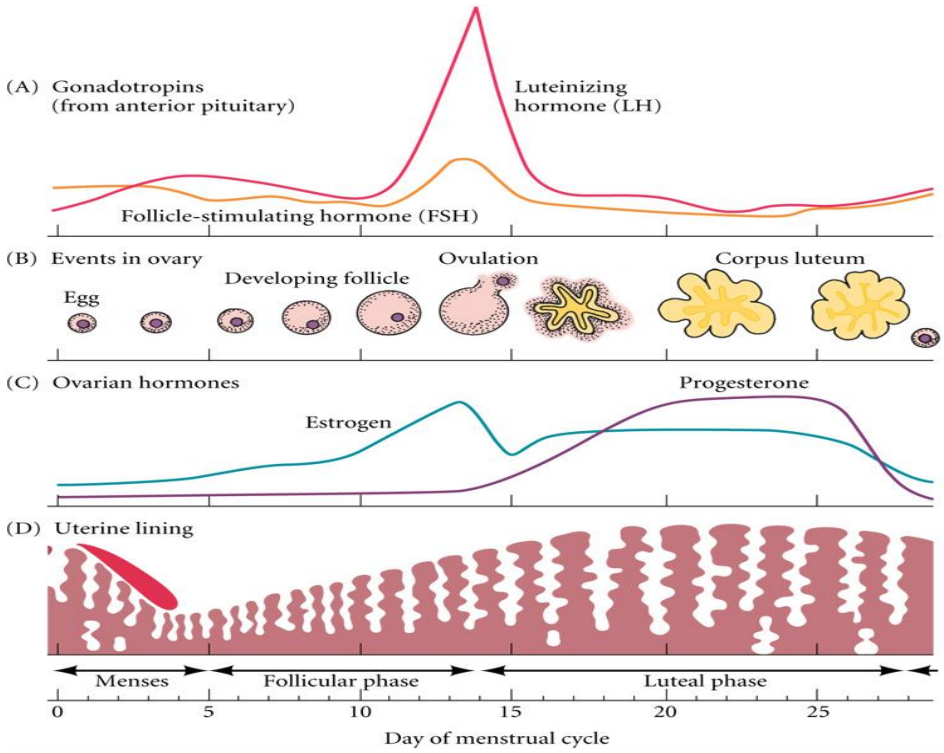


Understanding the graph

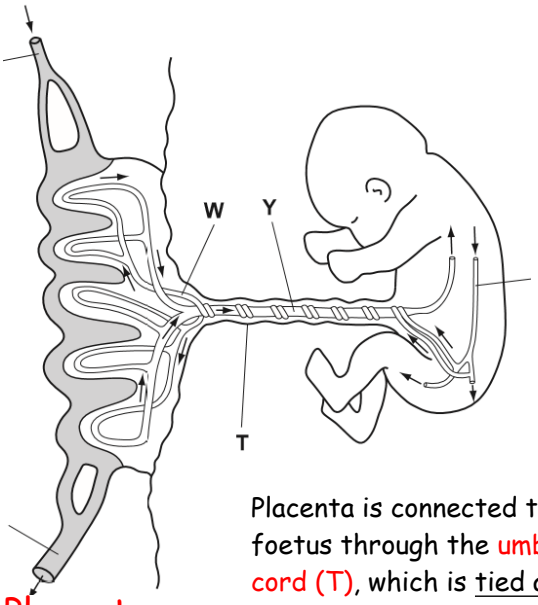
- At day 14, LH hormone peaks due to the previous rise of oestrogen
- As FSH increases oestrogen increases, and when oestrogen increases FSH decreases.
- When levels of progesterone and oestrogen fall at the end of the cycle, menstruation occurs.



Pregnancy

After fertilization, the zygote divides by mitosis forming a ball of cells called the embryo, the embryo moves by peristalsis from the oviduct to the uterus to be implanted

Then the embryo continues dividing and develops into the foetus.



Placenta

Placenta is connected to the foetus through the umbilical cord (T), which is tied and cut during pregnancy

A new organ forms during pregnancy called the placenta which plays a very important role during foetal development:

- Secretes progesterone
- Diffusion of nutrients from maternal blood to foetal blood
- Diffusion of wastes from foetal blood to maternal blood to be excreted by the mother
- Prevents mixing of maternal blood which is of high pressure with the foetal blood
- Barrier to toxins and pathogens

However some toxins such as **nicotine** can pass and affect the baby and some diseases such as **rubella** can be transmitted to the foetus through the placenta, which causes the baby to be born deaf and blind

The foetus is surrounded by amniotic sac which is filled with fluid called the amniotic fluid

Amniotic sac: Protects the fetus from outside pathogens and secretes the amniotic fluid

Amniotic fluid has the following roles:

- shock absorber
- allows free movement of the foetus and reduces friction
- Prevents drying out
- provides suitable temperature

Pattern of fetal growth

During first weeks, growth and development takes place where stem cells become specialised cells, while during last weeks only growth takes place

Labour

1. Breaking of the amniotic sac
2. Contraction of the muscles in the uterus wall
3. Dilation of the cervix
4. Passage through the vagina
5. Tying and cutting the umbilical cord
6. Delivery of the afterbirth

Breastfeeding

Breastfeeding has the following advantages in comparison to bottle feeding:

- Free and available all the time
- Contains the essential nutrients of the baby and changes in composition to match the baby's need
- Provides immunity to the baby
- Strengthen the bond between the baby and the mother.

Disadvantages:

- Painful and embarrassment to the mother
- Transmission of HIV / Virus B
- Can't know how much the baby has consumed

Birth control

There are several types of birth control

Natural
Avoid sexual intercourse around the period of ovulation (day 11-19 of the cycle, as sperms can survive 3 days in the uterus and the egg cell can survive for 5 days), monitor body temperature and cervical mucus.

Chemical
Using contraceptive pills; they are oestrogen and progesterone hormones taken to suppress the release of FSH in a negative feedback way, so low FSH leads to no egg cell formation.
IUD; a device inserted into the uterus that secretes hormones to reduce fertility

Mechanical
Condom; it blocks the exit of sperm
Diaphragm; inserted into the cervix below the uterus) to block the entry of sperm into the uterus.

Surgical
Vasectomy; it is tying and cutting the sperm duct.
Female sterilisation; same as male but the oviduct is the target.
N.B. female fertility can be increased by injection of FSH hormone which will stimulate the formation of an egg cell.

Methods of fertilization

Same males may be sterile due to reduced sperm count or produces abnormal sperm.
Some females may be sterile due to disruption in the hormonal control of menstrual cycle.

These individuals resort to either **artificial insemination (AI)** or ***in vitro* fertilization**.

AI

Sperm is obtained from a sperm bank and inserted into the vagina around the period of ovulation.

In vitro

FSH is injected into the female to produce multiple egg cells, which are extracted and added to a test tube; sperms are then introduced into the test tube to allow fertilization.

Social implications:

In AI the child would like to know his biological father. Also some religions are against this method
In *In vitro* multiple embryos will be produced which might lead to multiple pregnancies, or else the parents have to decide which embryos to kill.

Sexually transmitted infections (STIs)

It is an infection that is transmitted via body fluids through sexual contact

STIs include human immunodeficiency virus (HIV)

HIV

It is a virus that affects the immune **system through attacking lymphocytes reducing its number, so as a result there would be less antibodies production and reduced immunity to infections.**

It is transmitted during **sexual intercourse** with an infected person or through **blood transfusion** from an infected person.
It can be controlled through:

- Using condoms
- Avoid having sexual contact with multiple partners
- Avoid sharing needles (syringes) and razor

INHERITANCE

Inheritance is the transmission of genetic information from generation to generation.

Chromosome is a thread-like structure of DNA, carrying genetic information in the form of genes.

***Gene** is a length of DNA that codes for a protein.

Allele is a version of a gene.

N.B. The sequence of bases in a gene is the genetic code for putting together amino acids in the correct order to make a specific protein.

DNA controls cell function by controlling the production of proteins, some of which are enzymes, antibodies and receptors for neurotransmitters.
Protein synthesis is described in chapter *Biological Molecules*
All body cells in an organism contain the same genes, but many genes in a particular cell are not expressed because the cell only makes the specific proteins it needs.

***Haploid nucleus** is a nucleus containing a single set of unpaired chromosomes, e.g. in gametes.

Diploid nucleus is a nucleus containing two sets of chromosomes, e.g. all body cells such as liver cells.

In a diploid cell, there is two of each type of chromosome (one from the father and one from the mother) so in a human diploid cell there are 23 pairs of different chromosomes (total of chromosomes)

Mitosis	**Meiosis**
A nuclear division that gives rise to genetically identical cells.	a reduction division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells
Growth Repair of damaged tissues Asexual reproduction	Gametes formation (sexual reproduction)

Before mitosis takes place, the exact duplication of chromosomes occurs. During mitosis, the copies of chromosomes separate, so that each daughter cell receives identical genetic material to the parent cell, maintaining the chromosome number.

Explanation:
A cell contains 46 chromosomes, (46 x |) duplication occurs creating two copies **WITHIN** the same chromosome (46 x X) then during mitosis the two copies separate, each daughter cell receives a copy and have 46 chromosomes (46 x |)

Meiosis produces variation, how?
By producing **haploid** gametes which are genetically **different** as a result of random arrangement of maternal and paternal chromosomes creating new combinations, then gametes fuse at random. No duplication of chromosomes occurs before meiosis.

Monohybrid inheritance

Genotype is the genetic make-up of an organism in terms of the alleles present.

Phenotype is the observable features of an organism.
Homozygous is having two identical alleles of a particular gene. **(EE or ee)**
N.B. homozygous individuals that breed together will be pure-breeding

Heterozygous is having two different alleles of a particular gene. **(Ee)**

Dominant is an allele that is expressed if it is present

Recessive is an allele that is only expressed when there is no dominant allele of the gene present.

How to draw a genetic diagram

Example: the pod color of peas is either green or yellow, green (**G**) is dominant to yellow (g) allele.

Example 1:
A test cross between two parents one have green pods and the other have yellow, all the offspring had green pods

Draw the genetic diagram to explain this.

Parents' phenotype Green pods X Yellow pods
Parents' genotype GG X gg

Gametes (G) X (g)

Offspring's genotype Gg
Offspring's phenotype Green pods

Ratio 100% green pods

Example 2: A 2 heterozygous individuals mated

Draw a genetic diagram to find the ratio between the offsprings

Parents' phenotype Green pods X Green pods
Parents' genotype Gg X Gg

Gametes (G) (g) X (G) (g)

Offspring's genotype GG : Gg : Gg : gg
Offspring's phenotype Green pods : yellow pods

Ratio 3 : 1

Example 3: a heterozygous male mated with a homozygous small eyed female

Draw the genetic diagram to find the ratio between the offsprings

Parents' phenotype Green pods X Yellow pods
Parents' genotype Gg X gg

Gametes (G) (g) X (g)

Offspring's genotype Gg : gg
Offspring's phenotype Green pods : Yellow pods

Ratio 1 : 1

Punnet squares

It is a different way to draw a genetic diagram, recent questions require drawing punnet squares.

	E	e
e	Ee	ee
e	Ee	ee

Ratio is 1 large eyes : 1 small eyes

A test cross is a cross with a homozygous recessive individual (gg) with another individual showing a dominant feature to identify its genotype as it could be either (Gg or GG)

Co-dominance

Co-dominance is when neither alleles are dominant over each other, both alleles are present in the phenotype giving an intermediate,

For example

A red flowered plant was crossed with a white flowered plant, all the offsprings were pink flowered.

Co-dominant alleles are represented in the form of indices ($C^WC^W \times C^RC^R \rightarrow C^WC^R$)

Blood groups

The most important example of co-dominance is blood group, there are three alleles for the blood group gene (I^A, I^B, I^O), I^A and I^B are co-dominant alleles, I^O is recessive to them, for example if the genotype I^AI^O the phenotype is A, if I^BI^O the phenotype is B, but if the genotype is I^AI^B the phenotype would be blood group AB (as they are co-dominant), the only occasion where the blood group is O is when it's homozygous recessive, so we can conclude that if two parents whose blood groups are not O mated and produced and offspring with blood group O this means that they both were heterozygous with a hidden I^O.

Example:

Parents' phenotype Blood group A X B

Parents' genotype I^AI^O X I^BI^O

Gametes I^A I^O X I^B I^O

Offspring's genotype $I^AI^B : I^AI^O : I^BI^O : I^OI^O$

Offspring's phenotype AB : A : B : O

Ratio A chance of 25% for each blood group

All 4 types of blood groups are produced when two heterozygous parents (one A and the other B) mate.

Sex-linked characteristics

A characteristic in which the gene responsible is located on a sex chromosome, this makes it more common in one sex than in the other

Examples:

- Colour blindness
- Haemophilia

if a characteristic is present on the X chromosomes it will be more common in males, and there will be no carriers

Example

Colour blindness is sex linked recessive condition

Parents' phenotype normal male X color blind female

Parents' genotype X^BY X X^bX^b

Gametes X^B Y X X^b

Offspring's genotype $X^BX^b : X^bY$

Offspring's phenotype Female carrier : Color blind male

Ratio 1 : 1

Sex inheritance

A human cell has 44 autosomes and 2 sex chromosomes (X or Y), the sex chromosomes determines the sex of the individual

Males have XY, females have XX

Parents' phenotype Male X Female

Parents' genotype XY X XX

Gametes X Y X X

Offspring's genotype XX : XY

Offspring's phenotype Female : Male

Ratio 1 : 1

VARIATION AND SELECTION

Variation

It is the differences between individuals of the same species

There are two types of variation

- Continuous
- discontinuous

Continuous variation results in a range of phenotypes between two extremes, e.g. height and skin colour in humans.
It is caused by genetic and environmental factors.

Discontinuous variation results in a limited number of phenotypes with no intermediates, e.g. tongue rolling, Blood grouping (A, B, AB, O)
It is caused by genetic factors alone.

Mutation is a sudden a change in base sequence of DNA that leads to formation of new alleles,

N.B. mutations and meiosis are the reason why variation exists

Factors that increase the risk of genetic mutations include:

- Ionising radiation
- Chemicals such as tar and asbestos

Sickle cell anaemia

It is due to a change in the base sequence in the gene coding for haemoglobin leading to abnormal haemoglobin and sickle-shaped red blood cells.

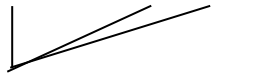
Symptoms:

1- Less haemoglobin so less oxygen transported to tissues
2- Less respiration so easy fatigue
3- Headache
4- Less elastic RBCs can block small capillaries which causes pain

Inheritance of sickle cell disease

Parents' phenotype Normal X Sickle cell anemia
Parents' genotype H^NH^N X H^SH^S

Gametes H^N X H^S H^S



Offspring's genotype H^NH^S
Offspring's phenotype 100% sickle cell **carrier**

People who are sickle cell carriers are resistant to a disease called malaria; which attacks liver and red blood cells

Adaptive feature: an inherited functional features of an organism that increase its fitness

Fitness: the probability of an organism surviving and reproducing in the environment in which it is found

Example: fish have gills to be able to live in water; chameleons change their colour for camouflage, polar bears have fur and fat for insulation.

Xerophytes are plants that can survive in hot conditions, they have:

- Rolled leaves to reduce the surface area
- Long underground roots to absorb deep water
- Fleshy stem as it stores water
- Sunken stomata surrounded by hairs to trap humidity

Hydrophytes are plants that can live on water, they have:

- Stomata on upper surfaces for easier gaseous exchange
- Large air spaces to float on water

Selection

There are two types of selection

- natural selection
- artificial selection

Natural selection

There is variation within populations and they produce many offspring so there is a competition for resources that leads to a struggle for survival, individuals that are better adapted to the environment than others reproduce and pass on their alleles to the next generation.

Antibiotic resistance in bacteria

Mutation occurs leading to the formation antibiotic resistance allele in bacteria, producing variation within bacteria which are competing for resources, overuse of antibiotics acts as a selection pressure, where bacteria with the new allele survive and reproduce passing the allele to their offspring, while others die

Evolution is the change in adaptive features of organisms over time as the result of natural selection

Adaptation is the process, resulting from natural selection, by which populations become more suited to their environment over many generations

Artificial selection (selective breeding)

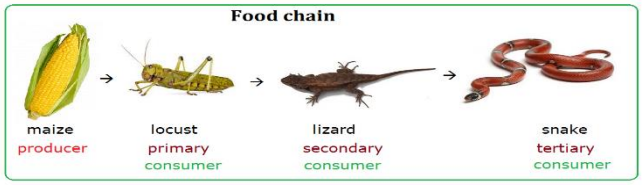
Humans select individuals with desirable features, and then cross these individuals to produce the next generation, then select the offspring showing the desirable features and repeat the process for several generations.

N.B provide examples when asked about artificial selection, for example: (humans select cows with a large milk production..)

ORGANISMS AND THEIR ENVIRONMENTS

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

Food chain: showing the transfer of energy from one organism to the next, beginning with a producer



Food chain consists of trophic levels starting with the producer of chemical energy which is a photosynthetic organism (e.g. plants), then it's eaten by a primary consumer, eaten by a secondary consumer, then tertiary and then **quaternary** consumer. the direction of arrow represents transfer of energy.

N.B. note that if a lot of the primary consumer was killed, the number of the producer would increase, and the number of the secondary and tertiary consumer would drop, this would disrupt the food chain.

A producer: is an organism that makes its own organic nutrients using energy from sunlight, through photosynthesis.

A consumer: is an organism that gets its energy by feeding on other organisms.

Trophic level: is the position of an organism in a food chain, food web, pyramid of numbers or pyramid of biomass.

A food chain usually ends with decomposers.

Herbivore: an animal that gets its energy by eating plants.

Carnivore: an animal that gets its energy by eating other animals.

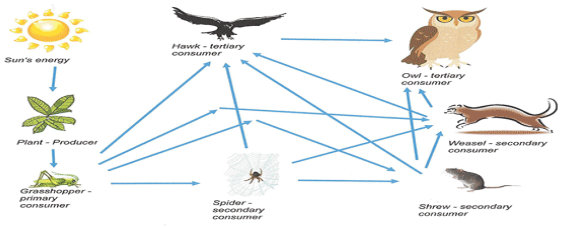
Decomposer: an organism that gets its energy from dead or waste organic material

N.B. The transfer of energy along a food chain is inefficient as 90% of energy is lost from one trophic level to another through:

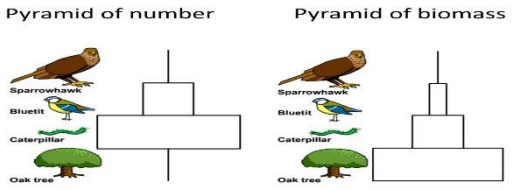
- Not all the plant is eaten/digested
- Energy is lost in respiration
- Energy is lost in faeces
- Energy lost as heat to the surrounding.
- Energy lost in growth

That's why food chains usually have fewer than five trophic levels.

This also explains why there is a greater efficiency in supplying plants as human food, and that there is a relative inefficiency in feeding crop plants to animals then use the animals as food.



Food web: is a network of interconnected food chains, it provides complex feeding relationships as it shows that some organisms have more than one trophic level



using a pyramid of biomass rather than a pyramid of numbers to represent a food chain is preferred as **there is a difficulty in counting certain types of organisms**, also **it represents the dry mass of organisms so provides a more accurate estimation of energy content**, and **it's always pyramid in shape so easier to draw and interpret.**

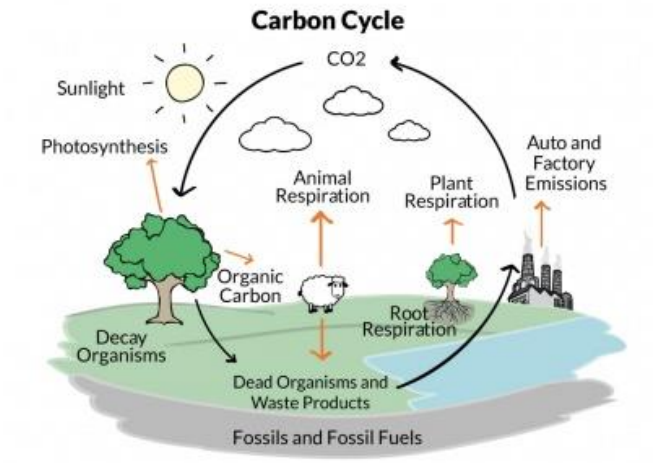
Cycles

Carbon cycle

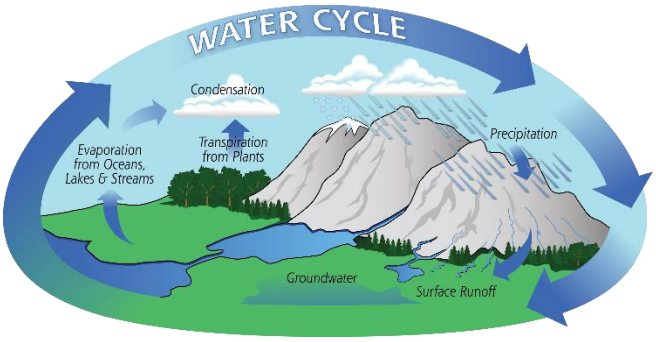
Carbon compound in

- The atmosphere is **carbon dioxide**.
- Living organisms is **glucose/starch**.

Increase in combustion of fossil fuels and deforestation increases the atmospheric CO_2.



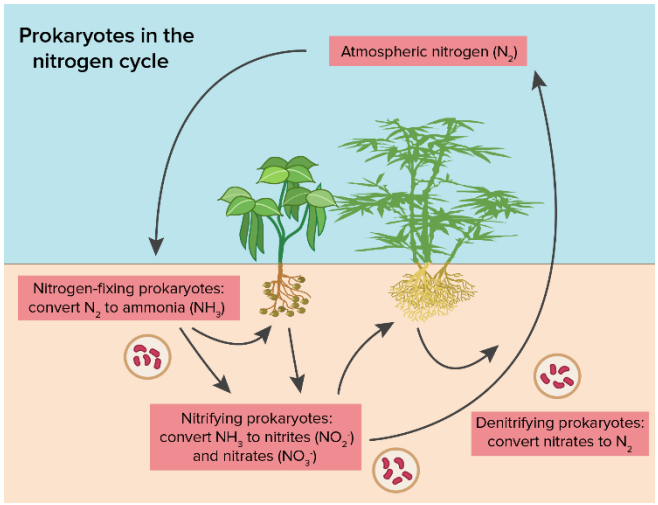
Water cycle



Evaporation of water from lakes and oceans, as well as **transpiration** from plants increases the water vapor in the air, and then **condensation** of this water vapor forms the cloud, where **precipitation** (raining) occurs.

Nitrogen cycle

1. **Decomposers*** decompose dead plants and animals forming ammonium ions
2. **Nitrogen fixation** of nitrogen gas into ammonium ions by **nitrogen fixing bacteria and lightning**
3. **Nitrification** of ammonium ions into nitrites then nitrates by **nitrifying bacteria**
4. **Denitrification** of nitrates in soil to nitrogen gas by **denitrifying bacteria***.



N.B. Leguminous plants have roots that possess root nodules which contains nitrogen fixing bacteria that is able to convert nitrogen into ammonium ions in exchange with carbohydrates from the plant as a source of energy.

*Decomposers break down dead animals' proteins into amino acids then reduce amino acids to ammonium ions

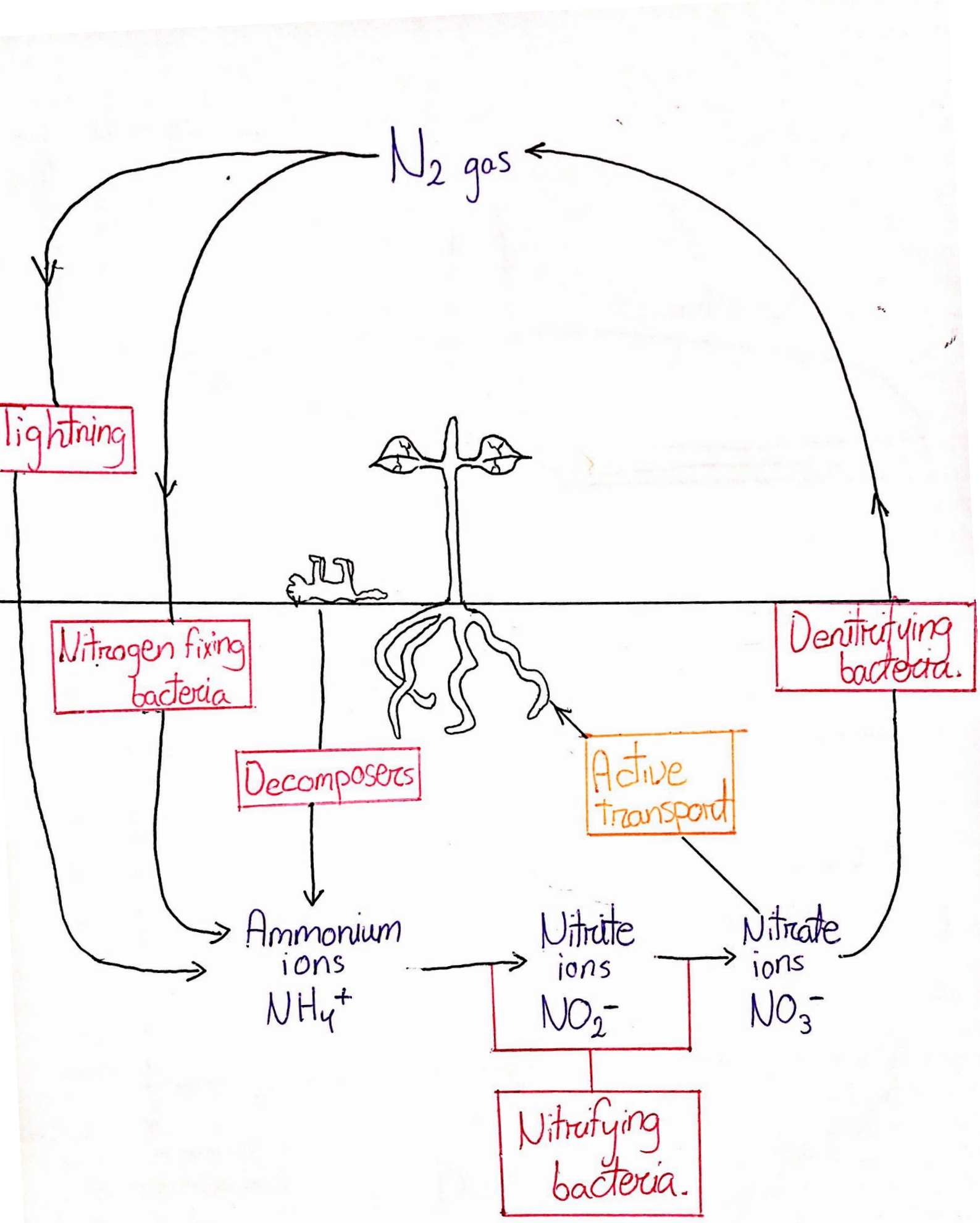
*Denitrifying bacteria are anaerobes, so the soil should be aerated to kill these bacteria to avoid denitrification

Ecosystem

Population: a group of organisms of one species, living in the same area, at the same time.

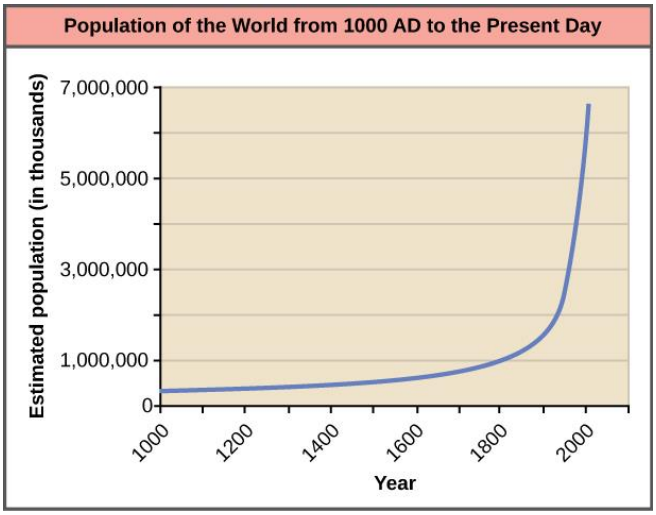
Factors that affect the size of population include:

- Food supply
- Predation
- Disease



Scanned with CamScanner

Human population



Note that during the past 250 years the human population increased significantly, before that the growth was minimal, as from year 1000 to 1200 the population has risen by 100 million, while from 1800 to 2000 it increases by 6 billion.

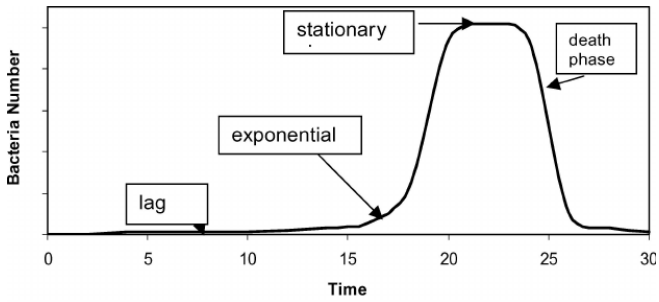
Community: Are all of the populations of different species in an ecosystem.
Ecosystem: is a unit containing the community of organisms and their environment, interacting together, e.g. a decomposing log, or a lake.

Sigmoid curve

It represents the growth of a population in an environment with limited resources.
It consists of three phases; lag, exponential (log), stationary and death phases.

Lag phase is due to:
Small number of organisms to start with, and organisms take time to adapt (not bacteria)

Log phase is due to:
Asexual reproduction at a high rate due to absence of any limiting factors, there's plenty of food, space, oxygen and there are no diseases.



Stationary phase is due to:

Rate of birth equals rate of death, as there is competition for food, space and oxygen.

Death phase is due to:
Rate of death is higher than rate of birth due to spread of diseases, shortage of food and space.

BIOTECHNOLOGY

Biotechnology refers to using living organisms to produce products that we want.

The most common organisms used are bacteria, because:

- They have a **rapid reproduction rate** and an **ability to make complex molecules.**
- There is **lack of ethical concerns** over their manipulation and growth
- **Genetic code** shared with all other organisms
- Presence of **plasmids**, which can be exchanged with other bacteria

Yeast

Yeast perform anaerobic respiration in absence of oxygen

Glucose ⟶ Ethanol + Carbon Dioxide

Biofuel

Ethanol produced is used a biofuel which is a source of renewable energy, since the glucose used is obtained from maize

Bread

Carbon dioxide produced is used to make dough rise to make bread.

Biological washing powders

They contain enzymes that digest food stains on clothes making them water soluble to be easily washed by water, enzymes include protease which digests proteins, lipase digests fats and amylase digests starch.

Apple juice extraction

Apple pulp contains pectin which stores a lot of sugars, so pectinase is added to apples during juice extraction to:

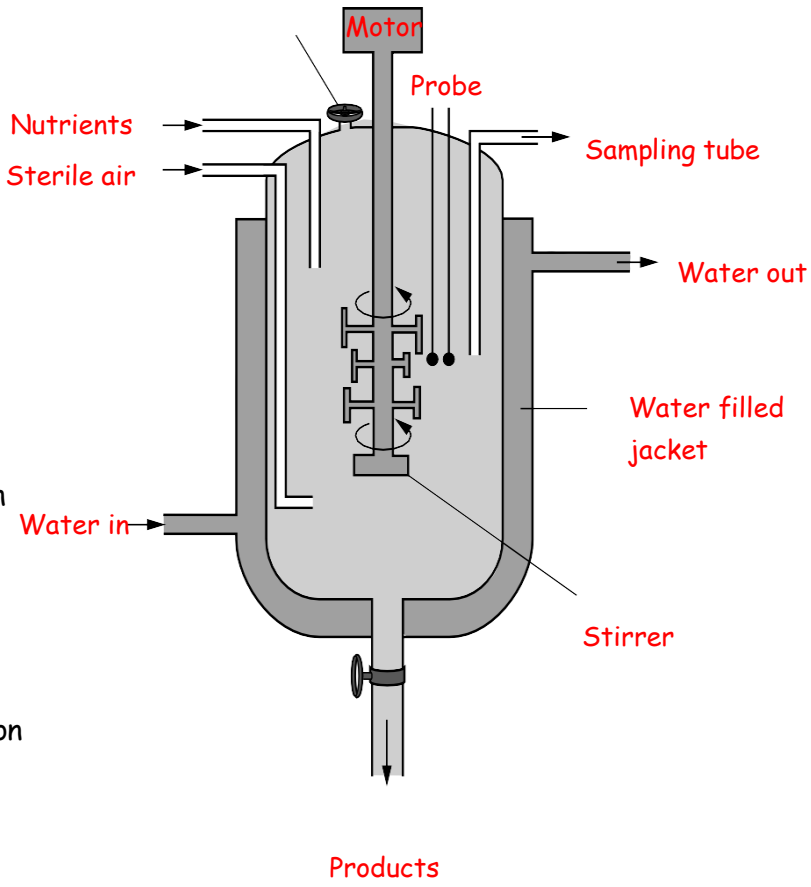
- Increase the volume of juice produced
- Has a sweeter taste
- Less parts of the apples wasted

Penicillin

It is made from a fungus called *Penicillium*

Penicillium is obtained and grown in a **fermenter**

Fermenter



Penicillium is cultured in a fermenter where nutrients such as glucose are pumped to provide energy, air and ammonia are pumped to provide oxygen and mix the fungi with the nutrients, a suitable temperature is maintained by the **water jacket**, and the **probe** is used to monitor the state of different variables (pH, temperature).

Then the penicillin produced is filtered and made into tablets

Before starting the process the fermenter should be sterilized, using gamma rays or steam, to avoid growth of other micro-organisms.

Genetic engineering

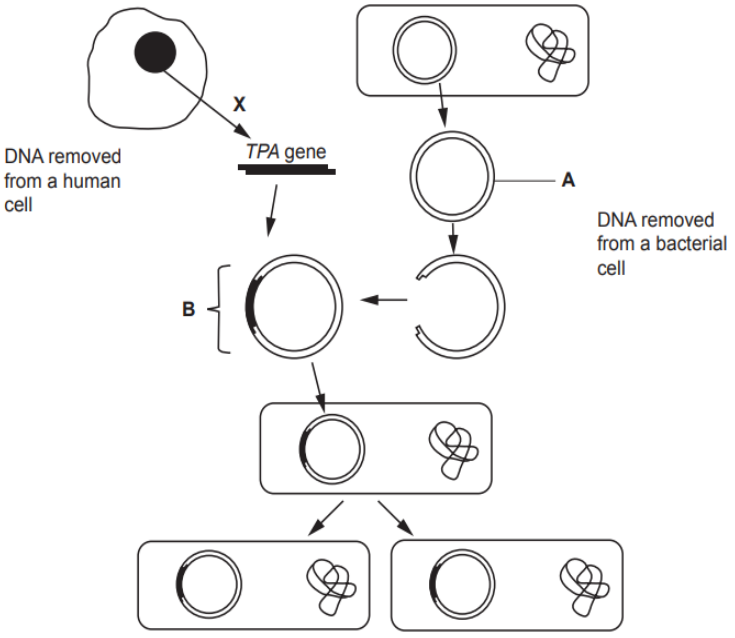
Genetic engineering means changing the genetic material of an organism by removing, changing or inserting individual genes.

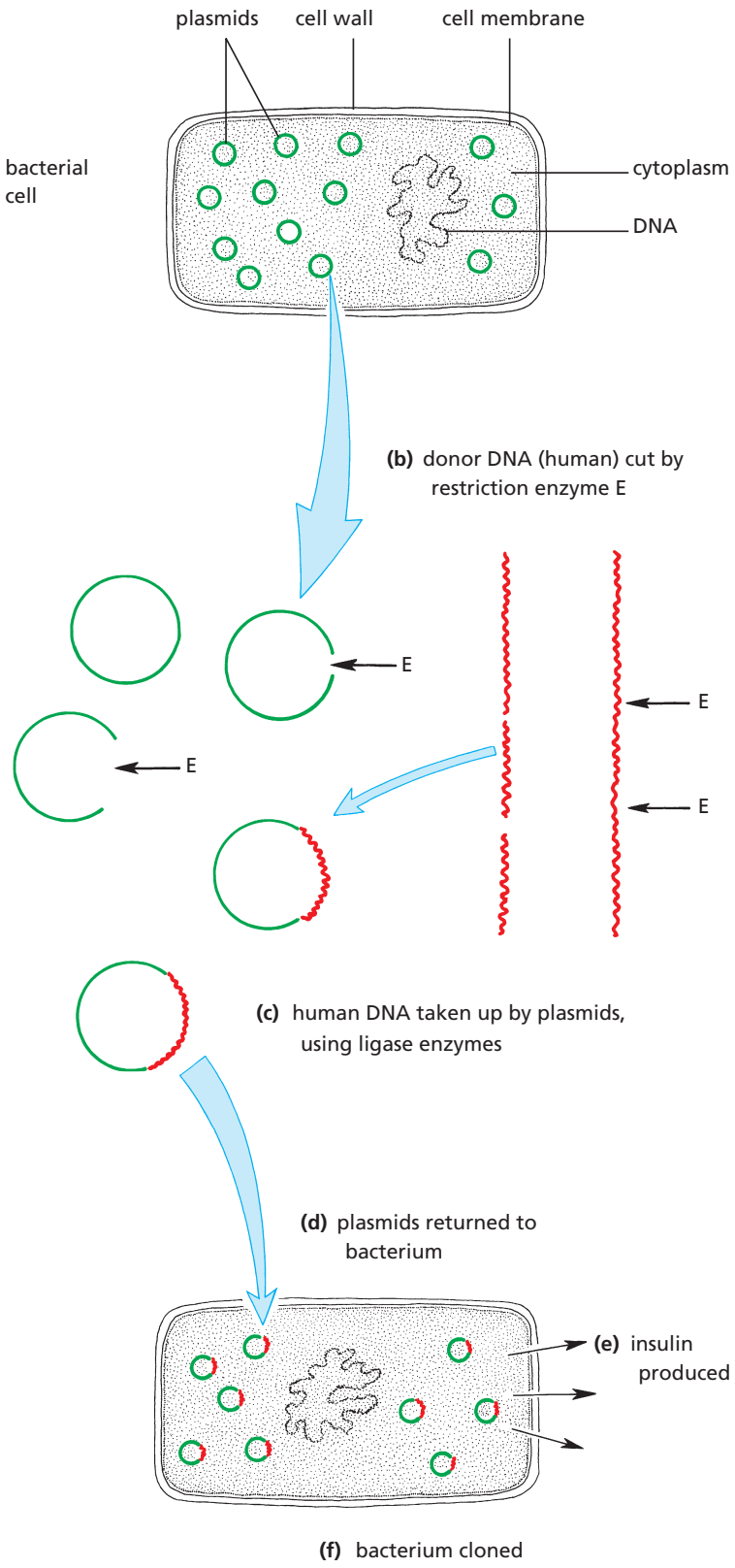
Some uses of genetic engineering include:

- The insertion of human genes into bacteria to produce human insulin
- The insertion of genes into crop plants to provide resistance to herbicides
- The insertion of genes into crop plants to provide resistance to insects
- The insertion of genes into crop plants to provide additional vitamins

Genetic engineering technique for production of human proteins:

- The gene required to be produced is isolated from the human genome using **restriction enzymes.** The removal of this genome causes the formation of sticky ends
- Part of bacterial DNA is in the plasmid which moves in and out of the bacteria freely
- This plasmid is also cut with the same restriction enzyme forming sticky ends complementary to those formed in the human genome
- The human DNA fragment is inserted into the bacterial plasmid using **DNA ligase enzyme** to form recombinant plasmid
- The recombinant plasmid is then re inserted into the bacteria
- The bacteria with the recombinant plasmid is then provided with suitable environment (fermenter) to replicate expressing the gene inserted and producing the human protein.




plasmids
cell wall
cell membrane
bacterial cell
cytoplasm
DNA
(b) donor DNA (human) cut by restriction enzyme E
E
E
E
E
(c) human DNA taken up by plasmids, using ligase enzymes
(d) plasmids returned to bacterium
(e) insulin produced
(f) bacterium cloned

HUMAN INFLUENCES ON ECOSYSTEM

Food supply

Modern technology has resulted in increased food production by:

- **Agricultural machinery** which use larger areas of land and improve efficiency.
- **Chemical fertilisers** to improve yields.
- **Insecticides** to improve quality and yield.
- **Herbicides** to reduce competition with weeds.

Monocultures of crop plants is growing the same crop in a land its consequences are

- spreading of diseases
- extinction of species
- disruption of food chains
- loss in habitat
- loss of nutrients in soil
- Soil erosion
- Improved crop yield so less land required

Human overpopulation leads to shortage of food because

- Land needed for more buildings so not enough land to grow crops, also an increase in food production damages land leading to soil erosion.
- An increase in demand for food makes food too expensive for poorer people to buy and difficult to distribute food.

Deforestation

Clearing out forests by cutting trees to:

- Provide more land for buildings and roads
- More land for agriculture
- Extract natural resources

Consequences of deforestation are

- Habitat destruction which might lead to extinction
- Disruption in food chain
- soil erosion
- Flooding
- Increase of carbon dioxide in the atmosphere

Pollution

Air pollution

Acid rain

Sulphur dioxide: produced by burning of fossil fuels containing sulphur
Oxides of nitrogen: from car engines by the reaction between nitrogen and oxygen at high temperatures

These gases dissolve in rain forming acid rain that corrodes buildings, lowers pH of lakes, and kills fish and trees.

*To avoid acid rain:

- Use low sulphur fuels
- Reduce use of coal
- Flue gas desulfurization
- Catalytic converters
- More public transport
- Car sharing

Global warming

Heat energy from the sun hit the Earth's surface and reflect directly back to space, Greenhouse gases such as CO2 and methane trap heat energy so prevent some of it from being reflected, this is important to maintain warmth of the atmosphere. However, high amount of greenhouse gases would absorb much heat leading to global warming, which would melt ice caps, causing flooding, and extreme climate change.

Water pollution

Eutrophication

Overuse of fertilizers causing it to leach into nearby lakes and rivers, this causes overgrowth of algae on the surface blocking the sunlight from producers leading to their death, then decomposition of producers by decomposers which consume more oxygen for aerobic respiration, this reduces oxygen concentration in lakes causing fish to die.This can also happen through entry of untreated sewage to rivers/lakes

Female contraceptive hormones

Female hormones in water courses are dangerous as it leads to reduced sperm count in males and feminization of aquatic organisms.

Non-biodegradable plastic

- Remains for a long time in the ecosystem
- Fills landfil sites causing visual pollution and burns to produce toxic gases
- May choke animals

. covers lakes blocking light from aquatic plants so no photosynthesis
. accumulates along food chain

Treatment of sewage

1. Filtration to remove insoluble wastes
2. Sedimentation
3. Introducing aerobic bacteria to digest soluble wastes, also anaerobic bacteria could be introduced to produce natural gas
4. Chlorine to kill all micro-organisms

Other pollutions

Pesticides: which is not broken down by organisms so accumulates along a food chain, i.e. has the highest concentration in the highest trophic levels.
Nuclear radiation: causes damage to DNA leading to mutations

Conservation

Sustainable resource: one which is produced as rapidly as it is removed from the environment so that it does not run out, some resources can be made sustainable such as forests and fish stocks.

Sustainable development: as development providing for the needs of an increasing human population without harming the environment

Some species might be endangered or extinct due to:

- Climate change
- Habitat destruction
- Hunting
- Pollution
- Introduced species

Endangered species can be conserved by:

- Monitoring and protecting species
- Protecting habitats
- Education
- Captive breeding programmes
- Seed banks

Problems with captive breeding?

stress in captivity
mates may be rejected
when introduced to the wild, they can't find their food or escape from predators
also they are more susceptible to diseases in the wild

*Importance of conservation programs:

- Reducing extinction
- Maintain biodiversity
- Maintaining ecosystem functions
- Ethical reasons
- Conserve the species for future generations

*How to conserve fish stock by preventing overfishing?

- Education
- laws against fishing certain species
- Use fish nets with large holes to allow young fish to escape
- No fishing zones
- limited fishing seasons
- Apply fines against overfishing
- Captive breeding
- fish farming

*The risk to a species of having a small population:

- High risk of extinction as there is less chance of reproduction
- High risk of genetic diseases as there is less variation
- Reduced number of alleles
- Less likely to adapt to change in environment

How to conserve forests?

encourage replanting trees
laws against deforestation
education
Coppicing
selective felling