Biology Notes

1) The nature and variety of living organisms

a) Characteristics of Living Organisms

1

- Movement
- Respiration
- Sensitivity
- Growth
- Reproduction
- Excretion
- Nutrition
- Homeostasis - Control their internal conditions

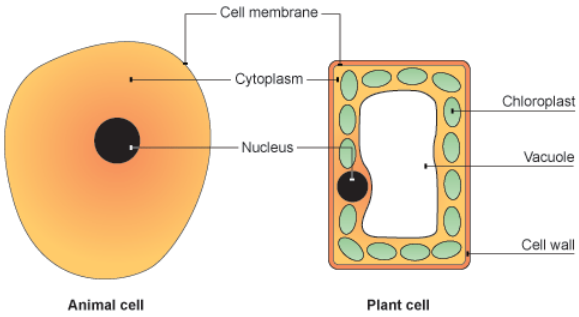
b) Variety of living organisms

2

All organisms fall under one of the following – plants, animals, fungi, bacteria, protoctists and viruses

Plants

- Multicellular
- Contain chloroplasts and carry out photosynthesis
- Have cell walls made of cellulose
- Store carbohydrates as starch or sucrose



Animals

- Multicellular
- Do not contain chloroplasts and cannot photosynthesise
- No cell walls
- Usually have a nervous condition and can move from one place to another
- Store carbohydrate as glycogen

Fungi

- Some single celled but mostly multicellular
- Mae up of thread like filaments called hyphae, the whole network being called a mycelium
- Cannot carry out photosynthesis
- Cell walls made of chitin
- Feed by extracellular secretion of digestive enzymes onto food material and absorb organic products. This is known as saprotrophic nutrition
- They may store carbohydrate as glycogen

Bacteria

- Microscopic single celled organisms
- They have a cell wall, cytoplasm and plasmids
- No nucleus but a circular chromosome of DNA
- Some carry out photosynthesis but most feed off other organisms

Protoctists

- Microscopic single celled organisms
- Some have features like animal cells (e.g. *Amoeba*) while others have those of plants (e.g. *Cholrella*)
- "Dustbin" kingdom

Viruses

- Smallest size
- Parasitic and can only reproduce inside other living cells
- Can infect any type of organism
- No specific shape or size and no cell structure
- Have a protein coat and contain one type of nucleic acid (DNA or RNA)
- Not classified as alive

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Pathogen - a disease causing organisms.

2) Structures and Functions in Living Organisms

a) Levels of Organisation

1

Organelles: These are the structures found within a cell that carry out a specific function

Cells: The units by which all organisms are composed

Tissue: A collection of cells grouped together with a similar function

Organ: A collection of tissues carrying out a particular function

(Organ) System: A series of organs working together to carry out a job

b) Cell structure

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Cell Structure

- **Nucleus**: contains chromosomes which carry the genetic material and control which proteins a cell will make
- **Cell Membrane:** Thin layer on the edge of the cell that forms a boundary between the outside of the cell and the cytoplasm. It is selectively permeable

- **Cell Wall:** Layer of non-living material that is found on the outside of plant cells. It is made of cellulose and helps plant cells to keep their shape against all the water in the cell. It is freely permeable

- **Chloroplasts:** Present in plants but not animals. They absorb light energy and turn it into food via photosynthesis. They are what give plants their green pigment. Any areas that are not green do not have chlorophyll

- **Vacuole:** Large central space surrounded by a membrane filled with cell sap, a mixture of sugars, mineral ions and other solutes present in plants. Animals have small vacuoles but they are temporary

c) Biological Molecules

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Carbohydrates: Made up of C , H , O. They the body's main fuel for supplying energy to cells. Most carbohydrate is found in starch, a long chain of glucose molecules joined together.

Proteins: These are made up of 20 different amino acids which all contain C , H , O and also N. The shape of the protein is determined by the order of amino acids

Lipids (fats and oils): These are made up of glycerol and fatty acids. Only contain C , H , O

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Food tests

- **Starch –** Iodine solution. **Red -> Black**
- **Protein –** Biuret test. Add food solution KOH and mix. Then add two drops of $CuSO_4$. **Blue -> Lilac**
- **Glucose –** Benedict's test. Mix the food solution with Benedict's solution and heat. **Blue -> Brick Red**
- **Smear test –** paper will turn from opaque to translucent in the presence of lipids

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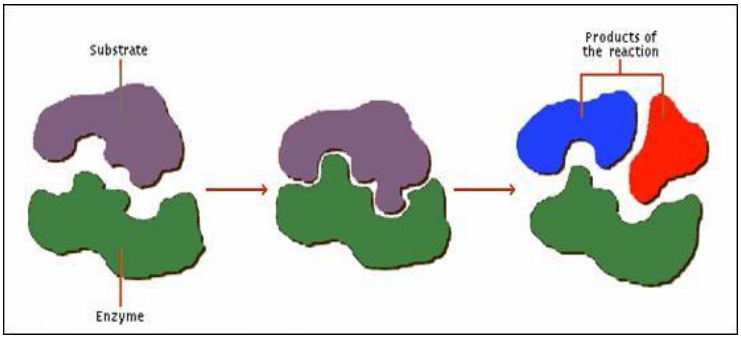
Enzymes

Biological catalysts

Speed up reactions without being used up itself leaving it free to catalyse more reactions

The genes are responsible for which enzymes are produced in a cell and therefore which reactions can occur in the cytoplasm.



This diagram shows how enzymes work, the substrate enters the active site where the reaction is catalysed and the products are formed.

Enzymes are extremely important for survival as without them no reactions would take place as there is not enough activation energy

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Denaturing from temperature or pH

Enzymes have an optimum temperature and pH => if outside this band => enzyme denatures => 3-D structure changes => shape of active site changes => active site is no longer complementary to substrate => substrate does not fit => unable to catalyse more reactions

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Test to show how enzyme activity changes with temperature

1. Prepare a spotting tile with iodine solution
2. Add amylase solution to a starch suspension and place it in a water-bath
3. Test the sample for the presence of starch every 30 seconds for 10 minutes
4. If the amylase is breaking down the starch then the iodine should not change colour, the enzyme is denatured when the iodine turns black
5. Repeat the experiment for different temperatures
6. We should see that at temperatures higher than 40℃ the starch is not broken down

d) Movement of substances in and out of cells

12-13

Diffusion: The movement of particles , from an area of high concentration , to an area of low concentration , down a concentration gradient

Osmosis: The movement of water , from an area of high water potential , to an area of low water potential , down a water potential gradient , across a selectively permeable membrane

Active transport: The movement of particles , from an area of low concentration , to an area of high concentration , against a concentration gradient , using energy from respiration

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Support: in plants, turgid cells (full of water) are stiff and thus aid the plant's structure. If they lose water and become flaccid then the plant wilts and becomes plasmolysed

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Factors affecting rate of movement of particles:

- Temperature
- S.A : V ratio
- Concentration gradient

As these increase, the speed of movement also increases

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Experiment on diffusion

Dyed agar cubes are added to hydrochloric acid. The acid diffuses in and neutralises the potassium permanganate. Pink **->** colourless.

Can be used to find effect of all 3 factors on rate of diffusion

Experiment on Osmosis

Stick potato bores in solutions of different concentrations of glucose

- ⇨ Potatoes in strong solutions will lose mass
- ⇨ Potatoes in weak solutions will gain mass

e) Nutrition

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Nutrition in Plants:

Photosynthesis: This is the process by which plants convert light, carbon dioxide and water into energy and oxygen. The chlorophyll absorbs the light which acts as the energy for this reaction

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

Limiting Factors: all increase rate of photosynthesis but their absence limits photosynthesis

- CO_2 levels
- Light intensity
- Temperature

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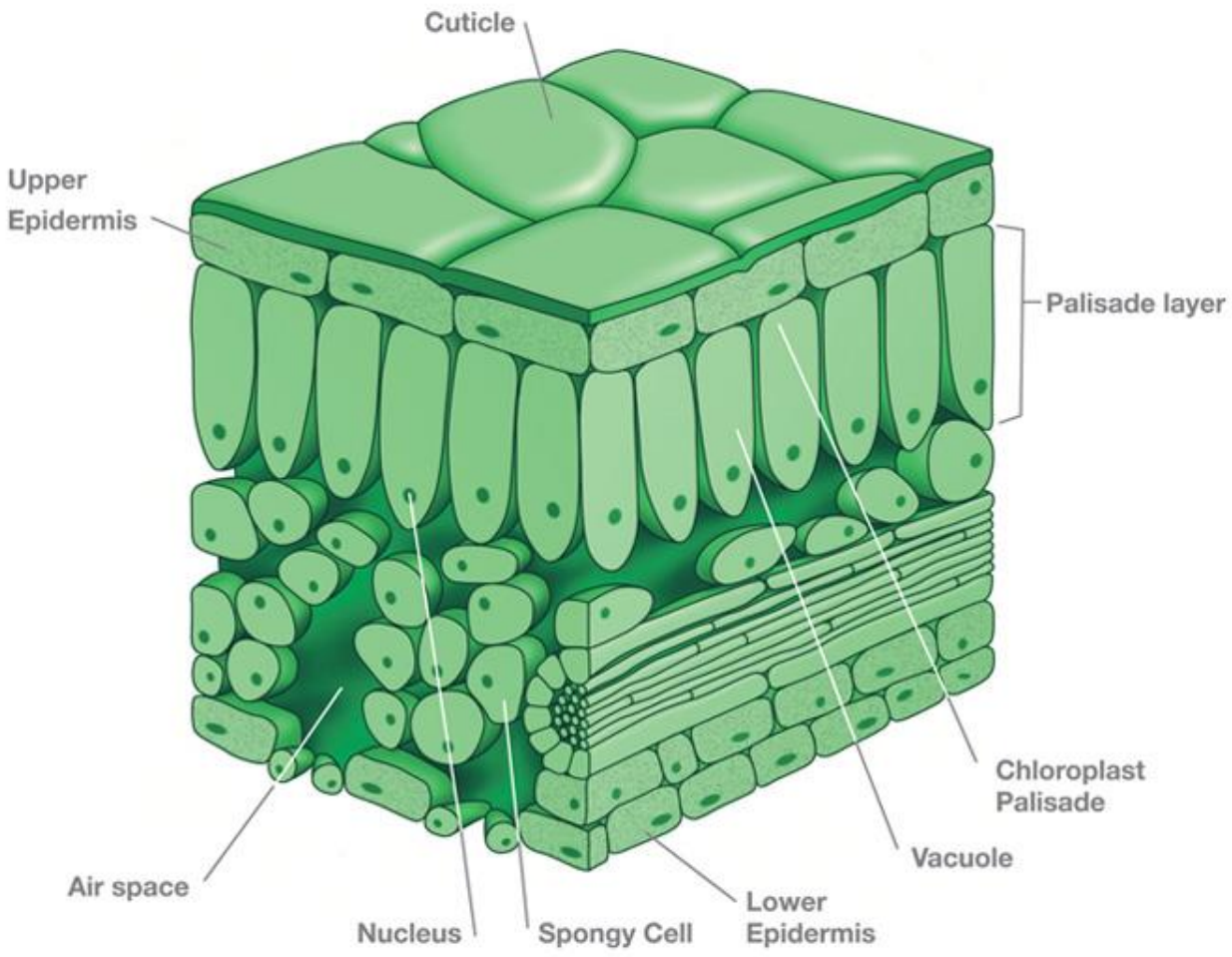
Leaf Structure:



- The upper and lower epidermis are covered by a waxy cuticle which reduces water loss by evaporation
- The lower epidermis has pores called stomata which allow CO_2 to diffuse into the leaf. They also allow H_2O and O_2 to diffuse out
- Each stoma is between two guard cells which can change shape to open or close the stoma => alter rate of transpiration
- The palisade layer is the main sight of photosynthesis due to the huge number of chloroplasts
- The spongy cells are the main gas exchange surface
- Water and mineral ions are supplied by the system in the transpiration stream
- Products of photosynthesis are carried away by the phloem

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Minerals ions

- Plants require a number of minerals for healthy development
    - **Nitrates**: needed for making amino acids, proteins, chlorophyll and DNA.
      Deficiency results in stunted growth or yellow leaves
    - **Phosphates**: needed for making DNA and part of cell membranes
      Deficiency results in poor root growth and younger leaves turning purple
    - **Potassium**: needed for making the enzymes involved in respiration and photosynthesis
      Deficiency results in yellow leaves with dead spots
    - **Magnesium**: needed to make part of the chlorophyll molecule
      Deficiency results in yellow leaves

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Testing the factors of photosynthesis

- **Light**
    - De-starch plant by leaving it in the dark for 2-3 days
    - Cover part of the leaf before exposing it to light again
    - After several days do the following starch test
        - Kill the leaf in boiling water
        - Boil in ethanol to remove the colour
        - Wash in cold water
        - Add iodine solution
    - The covered area will not turn black
- **CO_2**
    - De starch the plant
    - Keep in a closed system with a glass bell jar containing soda lime to absorb CO_2
    - Starch test after a few days
- **Temperature**
    - Using pondweed measure count the number of bubbles produces as temperature increases

Nutrition in Humans:

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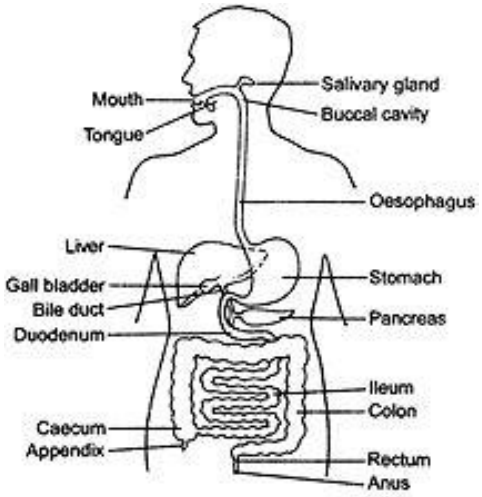
A balanced diet requires

- Carbohydrates
- Protein
- Lipids
- Vitamins
- Minerals
- Water
- Fibre



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Carbohydrate: Serve as the 'fuel' for supplying cells with energy. Glucose (a carbohydrate) is oxidised in respiration to produce energy. Found in potatoes, rice and bread

Proteins: Needed for the growth and repair of tissues as well as the making of enzymes. Found in meat, cheese, eggs

Lipids: Fats are essential as a store of energy as well as acting as insulation to prevent heat loss. Fat around certain organs such as the kidneys can prevent mechanical damage. Found in oils, milk

Vitamin A: Used to make a chemical in the retina of the eye. A deficiency causes night blindness. Found in fish liver oils, butter and carrots

Vitamin C: Sticks together cells lining surfaces such as the mouth. A deficiency causes scurvy. Found in fresh fruit and vegetables

Vitamin D: Helps bones absorb calcium and phosphate. Deficiency causes rickets and bad teeth. Sources are fish liver oils and it is also made in the skin in sunlight

Calcium: Needed for strong bones. Deficiency causes rickets and bad teeth. Found in milk and cheese

Iron: Needed to produce haemoglobin. Deficiency causes anaemia and tiredness. Found in lentils and nuts

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Energy requirements vary depending on age, activity levels and pregnancy

26-31

Human Alimentary Canal:

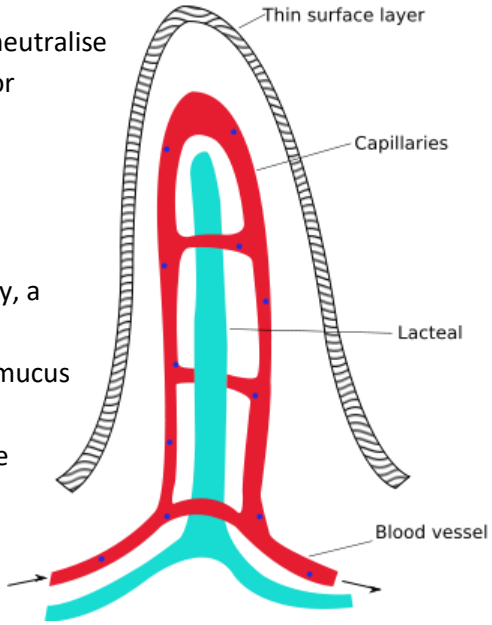
Mouth: Mechanically digests food via mastication as well as chemical digestion via saliva which contains amylase to break down starch. The saliva also moistens the food to facilitate peristalsis. The result of this is the formation of a bolus

Oesophagus: The bolus of food moves down here through peristalsis to enter the stomach

Stomach: In the stomach food is held for several hours. Mechanical digestion occurs here in the form of churning and chemical digestion occurs as pepsin is released to break protein down into amino acids. Hydrochloric acid is released to kill pathogens and break down food. Goblet cells release mucus which protects the stomach lining. Ends up producing chyme

Small intestine

- **Duodenum:**
  - **Bile** which is stored in the gall bladder and made in the liver is released this emulsifies the fat, increasing its S.A as well as being alkaline which neutralises the stomach acid
  - **Pancreatic juice** is also released which is also alkaline to neutralise the stomach acid. It contains all the enzymes necessary for digestion



- **Ileum:**
  - Absorption occurs
  - The ileum is lined with villi which have a good blood supply, a large surface area for absorption (further enhanced by microvilli), muscular walls to keep food moving and have mucus present produced by goblet cells for lubrication
  - Most digested food enters the blood stream; however, the products of fat digestion enter the lacteal, part of the lymphatic system

Large Intestine

- This is where the waste material is eliminated: fibre, some water and living and dead bacteria. The first part of the large intestine, the colon, absorbs the remaining water leaving semi-solid faeces which are expelled through the anus

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Ingestion: Taking food into the body

Digestion: The chemical and mechanical breakdown of food. It coverts large insoluble molecules into smaller soluble ones to be absorbed

Absorption: The soluble products of digestion being taken into the blood

Assimilation: The use of soluble food molecules to build new parts of cells

Egestion: The removal of faeces (undigested material) by the body

Peristalsis: This is the movement of food through the gut via a series of muscular contractions in the alimentary canal. A wave of circular muscle contraction behind the food followed by a longitudinal wave of muscular relaxation in front of the food

Digestive Enzymes

Class of enzyme	Example	Digestive action	Source of enzyme	Where it acts in the gut
Carbohydrases	Amylase	Starch→maltose Maltose→glucose	Salivary glands Pancreas Wall of small intestine	Mouth Small intestine
Protease	Pepsin Trypsin Peptidases	Proteins→peptides Peptides→amino acids	Stomach wall Pancreas Wall of small intestine	Stomach Small intestine
Lipases	lipase	Lipids→ glycerol and fatty acids	Pancreas	Small intestine

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Calorimetry can be used to find out the energy content of food per gram by burning it to heat water and measuring the temperature change using the following equation:

$$Energy\ per\ gram\ (J/g) = \frac{mass\ of\ water\ x\ 4.2\ x\ temperature\ change}{mass\ of\ food}$$

f) Respiration

33-36

Respiration - the process by which energy is released in living organisms.

Aerobic respiration – with oxygen

- Glucose + Oxygen → Carbon dioxide + Water (+ energy)
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (+ 38ATP)

Anaerobic respiration – without oxygen

- **In animals and plants**
  - Glucose → Lactic Acid (+ some energy)
  - $C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$ (+ 2ATP)
- **In fungi**
  - Glucose → Ethanol + Carbon Dioxide (+ energy)
  - $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + CO_2$

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In order to show how carbon dioxide and heat are released from respiration, the following experiment can be carried out:

- Use a control of dead seeds
- Measure the temperature of a vacuum jar
- Add sterilised seeds
- After some time measure the temperature again
- Repeat 3 times
- The temperature rise is provided by the seeds

Alternatively you could have a tube connecting the seeds to limewater to test presence of carbon dioxide

g) Gas Exchange

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Diffusion plays a vital role in gas exchange as gases move form areas of high concentration to low.

Gas Exchange in plants

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- By day: Photosynthesis > Respiration => CO_2 enters leaf, O_2 released
- At night: Photosynthesis < Respiration => CO_2 released, O_2 enters leaf

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- Leaf is adapted to gas exchange by having a spongy mesophyll in which gases can flow
- Stomata can open and close to let gases through or not

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- To test the effect of light intensity on gas exchange:
    - Put hydrogen carbonate indicator into 4 test tubes
        - yellow in high levels of CO_2
        - orange in normal levels of CO_2
        - purple in lower levels of CO_2
    - Have one test tube in bright light, on in the dark, one in translucent material and the fourth also in bright light
    - Add a leaf to all of them except one of the bright lights to act as a control
    - Leave them for a few hours
    - The brighter the light the less CO_2 => the purpler the indicator

Gas Exchange in humans

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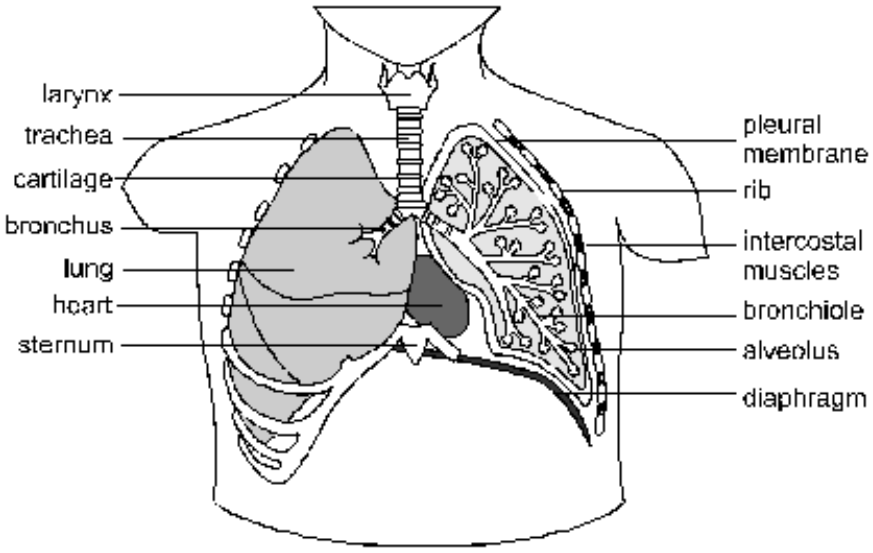
When breathing in

- External intercostal muscles contract
- Internal intercostal muscles relax
- Ribs move up and out
- Diaphragm contracts => flattens
- Volume of pleural cavity increases
- Pressure decreases
- Lungs fill with air



When breathing out

- External intercostal muscles relax
- Internal intercostal muscles contract
- Ribs move down and in
- Diaphragm relaxes => dome
- Volume of pleural cavity decreases
- Pressure increase
- Air pushed out of lungs

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Alveoli: These are where gas exchange occurs in the lungs

The O_2 levels in the air > blood => O_2 diffuses through the alveoli into the capillaries

The CO_2 levels in the air < blood => CO_2 diffuses out

Alveoli adaptations:

- Only one cell thick => less distance for gas to diffuse across
- High S.A => increases the area on which gas exchange can take place
- Very good blood supply => maintains a steep concentration gradient
- Coated in a film of moisture => allows gases to dissolve through the membrane

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Smoking risks

- **Emphysema** – Smoke damages the walls of the alveoli => have a decreased surface area => the area for gas exchange is insufficient => the sufferer is unable to carry out mild exercise
- **Bronchitis** – The tar kills the cilia lining the trachea and bronchi => mucus from goblet cells is not removed => air passageways clogged up => difficulty breathing (smoker's cough)
- **Lung Cancer** – Smoke contains carcinogens => increased risk of lung cancer
- **Carbon monoxide** – It binds preferentially to haemoglobin over oxygen => reduced oxygen capacity. If a pregnant woman smokes she will be depriving her unborn foetus of oxygen => underdeveloped
- **Coronary heart disease** – Nicotine narrows blood vessels which increases blood pressure => increases the risk of plaque coming off arteries and clotting => heart attack

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Testing the effect of exercise on breathing

- Take a resting heart rate and count the amount of breaths taken in a minute.
- Do rigorous exercise for a period of time
- Afterwards record heart rate and breathing rate as before
- Continue to take results every minute until breathing rate returns back to normal.

h) Transport

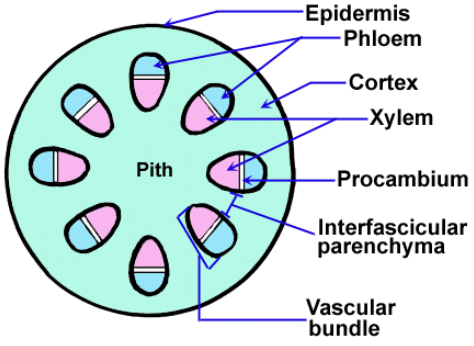
49-50

Unicellular organisms are capable transporting all substances through diffusion as their S.A : V ratio is so small
However, multicellular organisms must rely on a dedicated transport system as they are so large

51-52

Transport in Plants

- **Xylem: water and mineral salts**
  - Composed of dead cells arranged end to end which, when mature, have no cytoplasm.
  - Have a hollow space (lumen) where water passes through
  - Cells are lignified for strength
  - Transports water and mineral salts from the roots to other parts of the plant



- **Phloem: sugar and amino acids**
  - Composed of living cells which are arranged end to end
  - Each end of the cell wall has holes in it called a sieve plate
  - Each cell is linked to the next via the cytoplasm forming a long sieve tube**.**
  - Transports sugar and amino acids between the leaves and other parts of the plant

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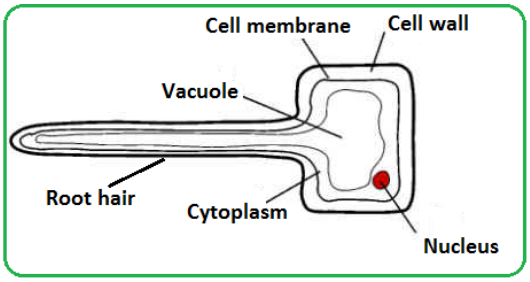
Uptake of water by roots:



- Water moves by osmosis into the cell the soil
- As the water potential in the soil is higher than in the root
- This water then dilutes the contents, increasing its water potential
- => water moves along the root cortex by osmosis until entering the xylem

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Transpiration - the evaporation of water from the surface of a plant

This is what causes water to be 'pulled up' in the xylem

It is a continuous flow known as the transpiration stream

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Factors affecting the rate of transpiration:

- **Light intensity:** The opening and closing of stomata is controlled by light intensity
- **Temperature:** High temperature => faster evaporation => faster transpiration
- **Humidity:** Humid air is saturated has lots of water vapour => the concentration gradient between the air and the plant is lower => transpiration slows
- **Wind speed:** Wind makes air flow away from leaf => maintains steep concentration gradient => faster transpiration

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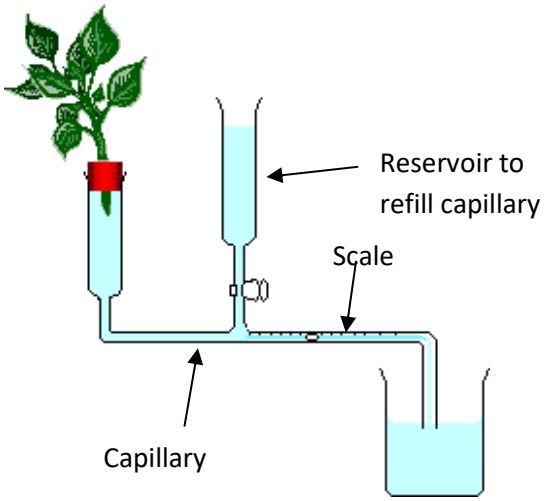
A potometer can be used to measure these factors

The faster the rate of transpiration, the faster the air bubble is moved through the capillary tube.

Must ensure no other air gets into the apparatus => the stem should be put into the rubber tubing under water and then sealed using Vaseline



Transport in Humans

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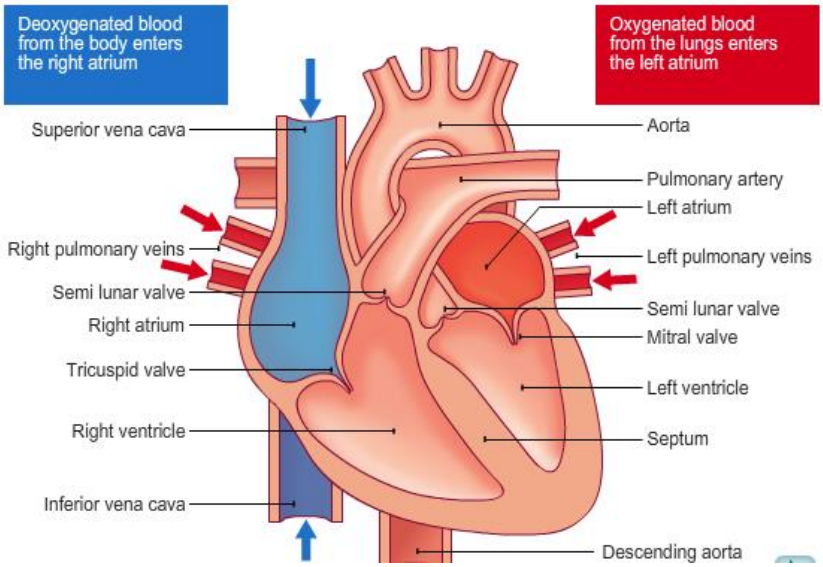
In humans blood is the primary transport system

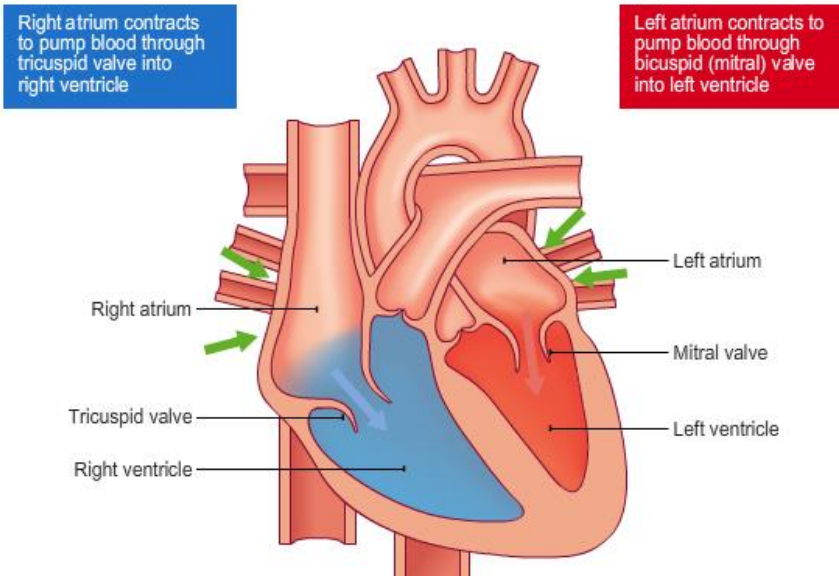
Component of blood		Description of component	Function of component
Plasma		Liquid part of blood, mainly water	Carries: • blood cells • dissolved nutrients • hormones • carbon dioxide • urea • heat energy around the body
Red blood cells		Biconcave, no nucleus => maximise S.A on which to carry O_2	Transport of O_2 Contain haemoglobin which binds weakly to O_2 => allows loading and unloading
White blood cells	Lymphocytes	About the same size as red blood cells with large spherical nucleus	Produce antibodies specific to antigen to bind to pathogens and: • tag them for phagocytes • clump pathogens • neutralise toxins • lyse cells (split open) Some stay in the blood after infection as memory cells => secondary immune response is sooner, faster and larger => symptoms never develop => immune to that pathogen
	Phagocytes	Much larger cells with large spherical nucleus	Engulf pathogens by forming pseudopodia around the pathogen and trapping it in a vacuole The pathogen is digested through the secretion of enzymes => threat neutralised
Platelets		The smallest cells in blood – actually fragments of other cells	Release chemicals to make blood clot when we are cut => prevents: • blood loss • entry of microorganisms

Vaccination: Injecting somebody with a dead / weakened version of the pathogen => results in the production of memory cells which enable future antibody production to occur sooner, faster and in greater quantity => immune

How the heart pumps:



Step one



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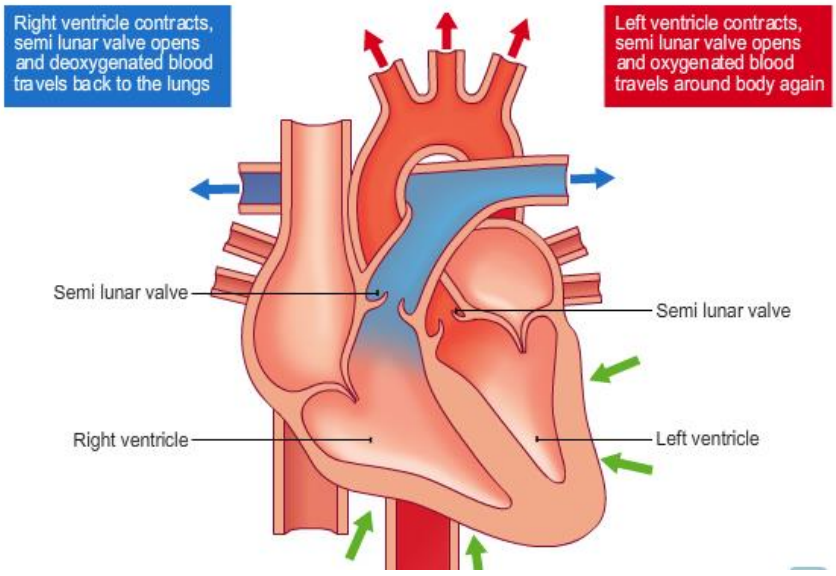

Step three

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Heart Rate:

- Normally 70 bpm
- During exercise the cardiac centre in the medulla oblongata sends a signal to the pacemaker to make the heart to beat faster as the muscles need more oxygen to respire more as they need more energy
- When we are under threat the adrenal glands secrete the hormone adrenaline => speeds up heart rate => supplies extra blood to our muscles => better prepared to "fight or flight"
- When we sleep our heart rate is reduced as our muscles do not need the same amount of energy.

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Blood vessels:

- **Arteries**
  - Carry blood away from the heart
  - All carry oxygenated blood (except the pulmonary artery)
  - Are under high pressure => capable of stretching
  - Made of smooth muscle => able to vaso-dilate / constrict to prioritise blood flow
- **Veins**
  - Carry blood back to the heart from the organs
  - All carry deoxygenated blood (except the pulmonary vein)
  - Are under low pressure => more rigid
  - Have watch-pocket valves to prevent blood flowing back
- **Capillaries**
  - Carry blood through tissue bringing => exchange substances
  - Are small enough to pass through cells
  - Only one cell thick and permeable => facilitate diffusion

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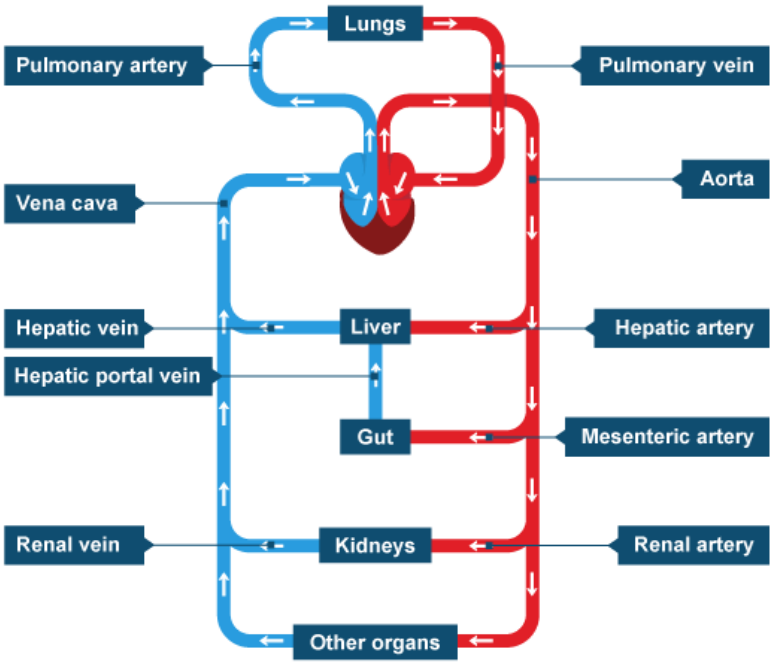
Circulatory System:



i) Excretion

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Plants:

In flowers CO_2 and O_2 are excreted as waste products of respiration and photosynthesis respectively
They are excreted from the stomata on the bottom of leaves

Humans:

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In humans the excretory organs are:

- **the skin**
- **lungs**
- **kidneys**

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The kidneys are an organ of excretion and homeostasis (osmoregulation)
i.e. they remove urea and regulate blood water concentration

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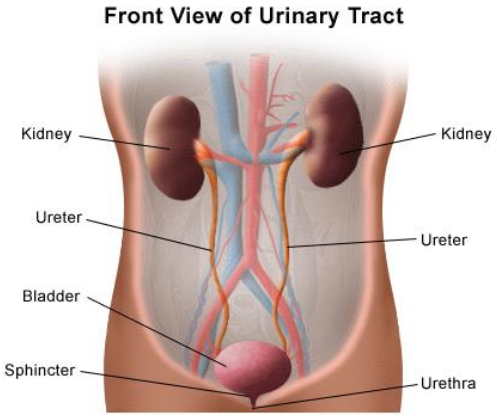
The Urinary System:



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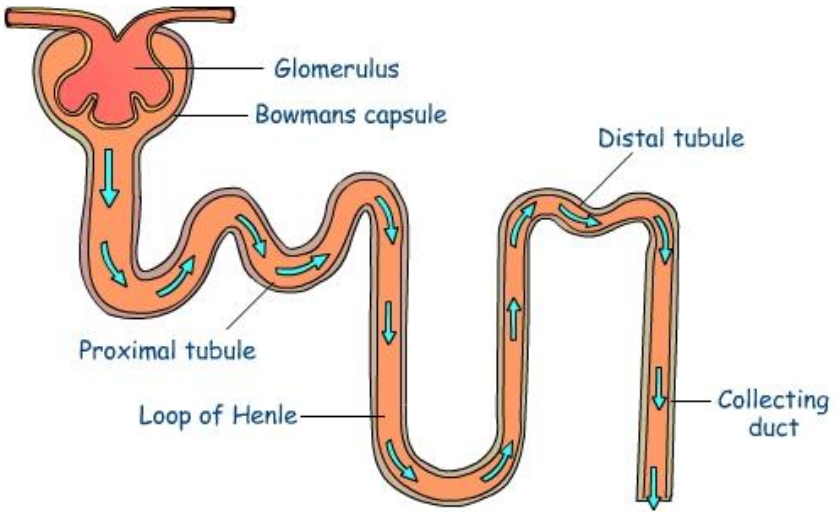
Nephron: filtering unit of kidney



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Ultrafiltration

- filtration under high pressure
- Occurs in the Bowman's capsule
- Larger molecules such as proteins and blood cells are too big and are filtered out of the blood
- The glomerular filtrate consists of: water, glucose, urea, and mineral salts

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Reabsorption in the Nephron

- The water is reabsorbed back into the blood by osmosis
  mainly occurs in the collecting duct
- The glucose is reabsorbed by active transport
  mainly occurs in the proximal convoluted tubule

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ADH – anti-diuretic hormone

The kidneys are responsible for controlling the water concentration of the blood.
The hypothalamus is responsible for monitoring the blood concentration

- if it is too low => ADH is released from the pituitary gland => makes target cells (collecting duct) more permeable => more water to be reabsorbed in the collecting duct => blood becomes more dilute
- If blood is too dilute => ADH is no longer produced => less water is reabsorbed => increases blood concentration

This is an example of a negative feedback loop (response acts to oppose stimulus)

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Urine – contains water, urea and salts

j) Coordination and response

77-79

Homeostasis - maintenance of a constant internal environment despite changes in the external environment
- typically involves a negative feedback loop
- body temperature and water content are examples of homeostasis

Organisms can respond to changes to their environment
A coordinated response requires:

Stimulus => Receptor => Coordination => Effector => Response

Plants:

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Tropism – a plant's growth response to a directional stimulus
- If the plant moves towards the stimulus => positive tropism
- if it moves away => negative tropism

81

- **Geotropism:**
  - The roots of a plant are positively geotropic => grow towards the direction of gravity in order to anchor the plant and find nutrients in the ground
  - The stem of the plant is negatively geotropic => grows away from gravity

82

- **Phototropism:**
  - The stem of the plant is positively phototropic => green parts maximise their exposure to light in order to photosynthesis more
  - The roots of some plants are negatively phototropic however, in most cases they do not respond to light

Auxins – plant growth hormones

Tropism is achieved by the release of more auxin to 'the dark' side of the plant resulting in cell elongation => bending

Humans:

83

Responses can be controlled by either nervous or hormonal communication

Nervous System	**Endocrine system**
Electrical signal	Chemical signal
Transported along neurones	Transported by the blood
Fast response	Slow response
Energy expensive	Energy cheap
Response is usually short-lived	Response is usually longer lasting
Impulses act on individual cells => very localised effect	Hormones can have widespread effects on different organs (provided they have the right receptors)

Nervous system

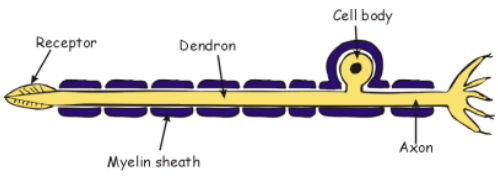
84

CNS - central nervous system
- consists of the spinal cord and the brain
- linked to sense organs by nerves

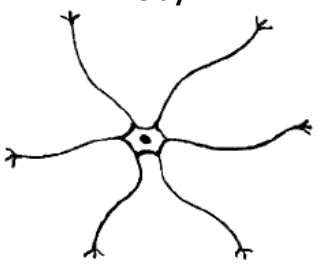
PNS – peripheral nervous system
- consists of all neurones outside the brain / spinal chord
- Contains all effector and receptor organs

Neurone Types:

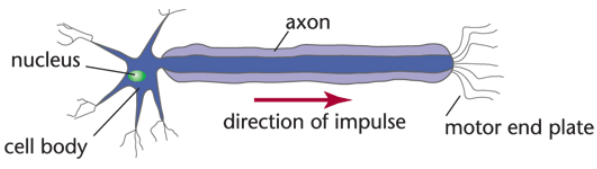
Sensory



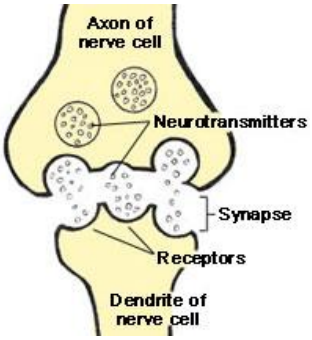
Relay



Motor

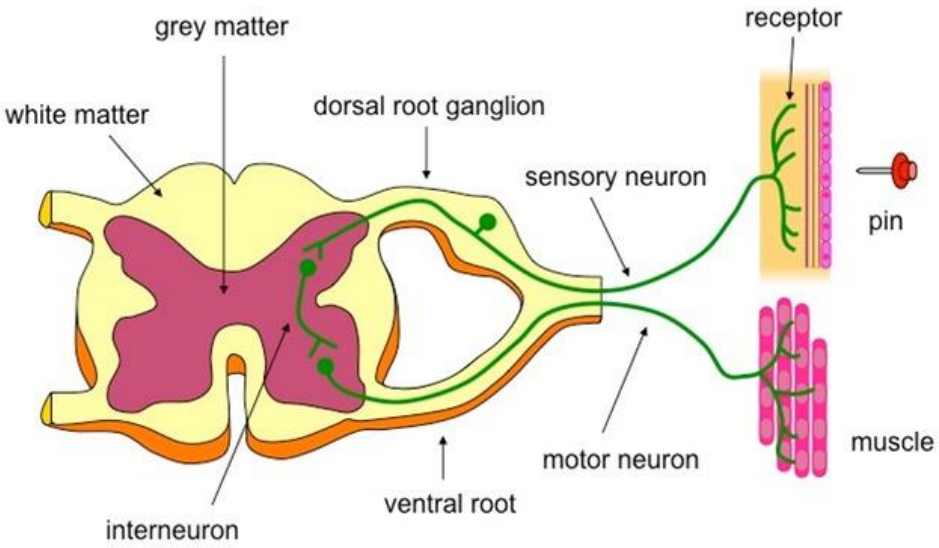


Synapses – neurone terminals



85-6

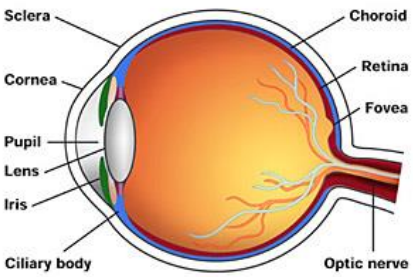
Reflex arc:



Stimulus => receptor => sensory neurone => synapse => relay neurone => synapse => motor neurone => neuro-muscular junction => effector => response

87

The Eye:



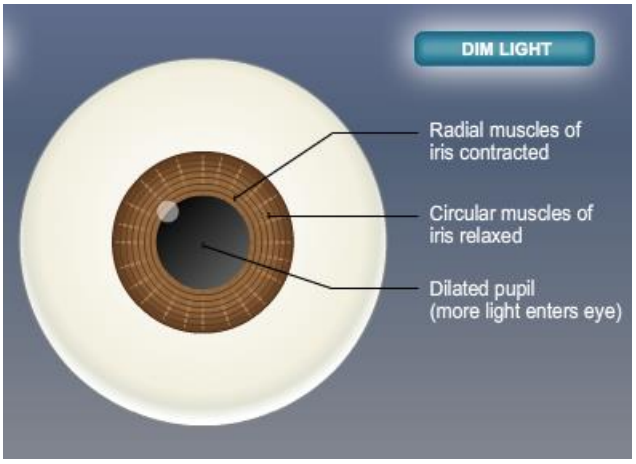
Part	Description	Function
Cornea	Front part of the tough outer coat, the sclera. It is convex and transparent.	Refracts light => begins to focus
Iris	Pigmented so light cannot pass through, can change size.	controls how much light enters the pupil
Lens	Transparent, bi-convex, flexible disc behind the iris attached by the suspensory ligaments to the ciliary muscles.	focuses light onto the retina
Retina	Contains two types of photoreceptor cells: • **Rods** - black and white • **Cones** - sensitive to colour A small area called the fovea in the middle of the retina has many more cones than rods.	contains the light receptors
Optic nerve	Bundle of sensory neurones at back of eye.	carries impulses from the eye to the brain

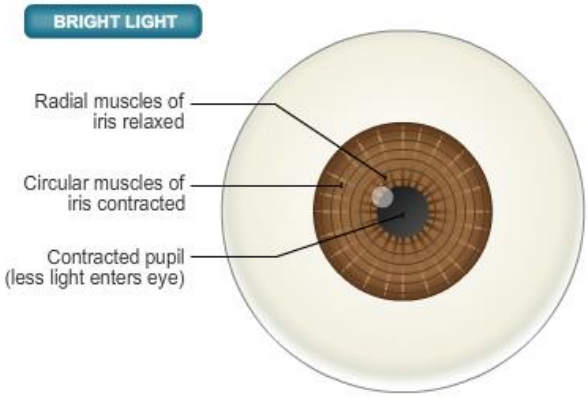
Response to changing light intensity

The eye needs to regulate how much light it lets in

- too much => damages retina
- too little => cannot see

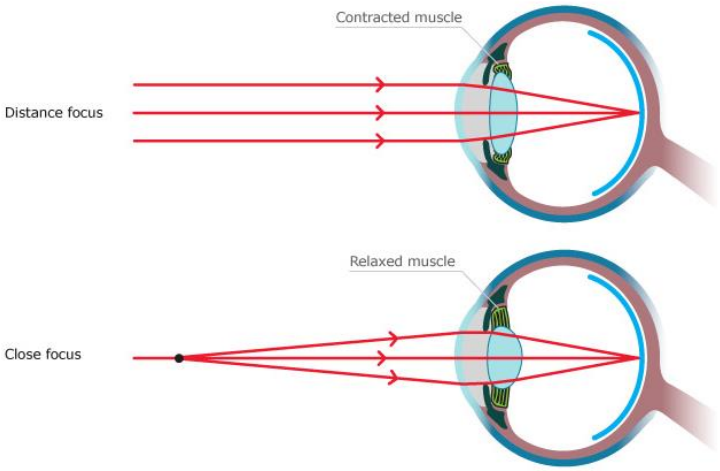
It does this by altering the size of the pupil





Accommodation - focusing

The shape of the lens of the eye can be altered in order to provide a sharper image.
The lens is held by fibres called suspensory ligaments which are attached to a ring of muscle called the ciliary muscle.



object	ciliary muscles	suspensory ligaments	shape of lens
distant	relax	taught	flat
near	contract	slacken	round

89

The skin and temperature regulation:

The skin helps regulate body temperature in 4 ways:

- **Sweating:** when too hot => skin sweats => when it evaporates it absorbs heat (latent heat of vaporization) => this energy is supplied by the body => cools the body

- **Vasoconstriction:** when too cold => the arterioles leading to the surface of the skin constrict => blood flow to the surface is reduced => less heat is lost as a result of radiation

- **Vasodilation:** when too hot => the arterioles leading to the surface of the skin dilate => blood flow to the surface is increased => more heat is lost as a result of radiation

- **Hair erection:** when too cold => hair erector muscles contract => hair stands up => traps air => provides insulating blanket

90

Hormones

Hormone	**Gland**	**Role**
Anti-diuretic hormone	Pituitary	Controls the water content of the blood
Adrenaline	Adrenals	Prepares body for physical activity*
Insulin	Pancreas	Lowers blood glucose
Testosterone	Testes	Controls development of male secondary sexual characteristics
Oestrogen	Ovaries	Controls development of female secondary characteristics and regulates menstrual cycle
Progesterone		Regulates menstrual cycle

***Effects of Adrenaline**

- The breathing rate increases and breaths become deeper => more oxygen in body
- The heart beats faster => more blood to the muscles => respire more
- Blood is diverted away from intestines to the muscles
- In the liver, carbohydrate is converted into glucose and released into the blood => increased respiration in the muscles
- The pupils dilate => increasing visual sensitivity to movement
- Mental awareness is increased => reactions are faster

3) Reproduction and Inheritance

a) Reproduction

1-2

2 types of reproduction:

Sexual:

- Specialised sex cells called gametes are produced through meiosis
- There is usually one mobile male gamete (sperm) and a stationary female one (ovum)
- The sperm and ovum must fuse => fertilisation
- Fertilisation forms a zygote which divides via mitosis into an embryo which grows into a new organism
- 2 parents required
- Offspring is a mix of the parents' genes

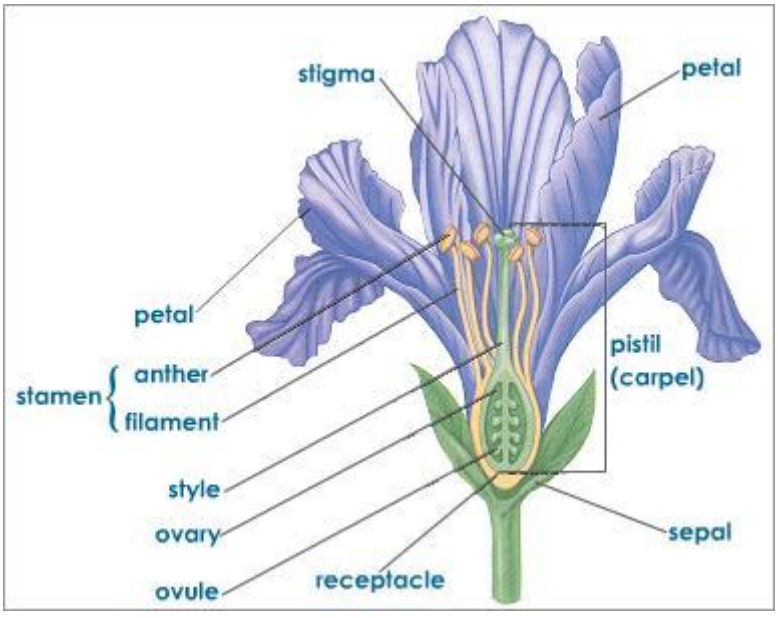
Asexual:

- No specialised gametes
- No fertilisation occurs
- One part of the body divided via mitosis to form a structure that breaks away from the parent body
- Only 1 parent
- Offspring genetically identical to parent

Plants:

4

Flower structure



Feature of flower	Type of flower	
	Insect pollinated	**Wind pollinated**
Position of stamens	Enclosed within flower => insect must make contact	Exposed => wind can easily blow pollen away
Position of stigma	Enclosed within flower => insect must make contact	Exposed => catch pollen blowing in the wind
Type of stigma	Sticky => pollen grains from insects stick	Feathery => catch pollen grains blowing in the wind
Size of petals	Large => attract insects	Small => less energy
Colour of petals	Brightly coloured => attract insects	Not brightly coloured => less energy
Nectaries	Present => nectar is a 'reward' for insects	Absent => less energy
Pollen grains	Small, sticky grains => stick to insects' bodies	Large, inflated grains => carry in the wind

4

Pollination – transfer of the pollen grain to the stigma

Fertilisation – fusion of male and female gametes

- ⇨ When the pollen grain lands on the stigma it is not complete
- ⇨ Pollen digests its way through the style in a pollen tube
- ⇨ Pollen grain reaches the ovary and fertilises the ovum

As a result of this process:

- **Fruit** – fertilised ovary
- **Seed** – fertilised ovule
- The zygote develops into an embryonic plant with a small root (radicle) and shoot (plumule)
- The other contents of ovule develop into cotyledons => food store

5-6

Germination

In order for seeds to germinate they require:

- Warm temperatures => enzymes can act efficiently
- Water => chemical reactions to take place in solution
- Oxygen => respiration

The seed will continue to use food stores until it is able to carry out photosynthesis

7

Asexual reproduction in plants

Asexual reproduction in plants can be carried out by natural or unnatural means.

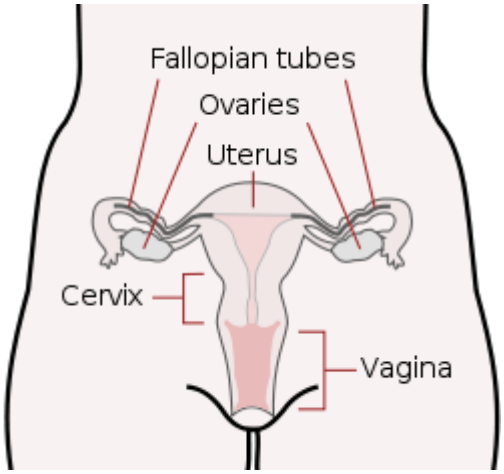
- **Natural**: part of the plant grows => breaks away from the parent plant => forms a new plant

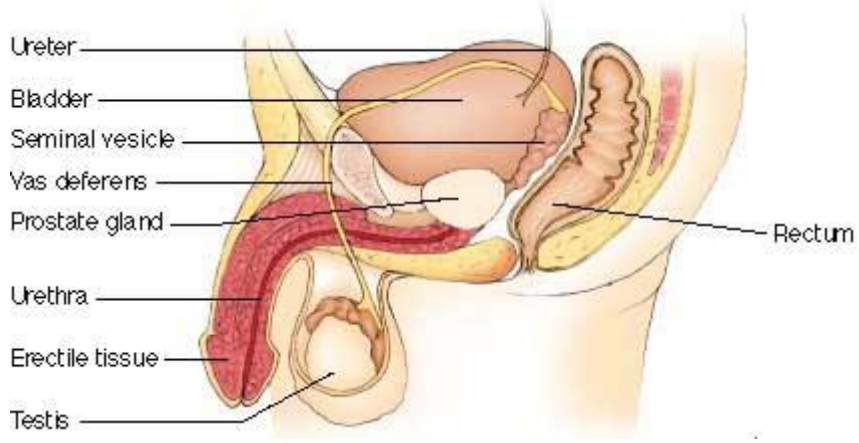
- **Unnatural**: involves taking cuttings from a plant and planting

Humans:

8

Structure of Reproductive organs in humans





9

Menstrual Cycle

An egg is released by a woman every month through ovulation
The cycle is controlled by hormones:

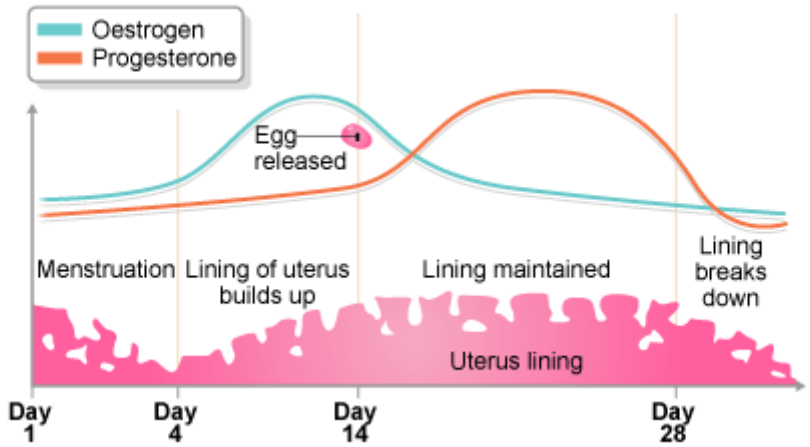
Oestrogen
The hormone oestrogen is secreted by the ovaries

- Triggers thickening of ovary
- Triggers release of an ovum

Progesterone
This hormone is also secreted by ovaries

- it maintains the lining of the uterus and stays high during pregnancy

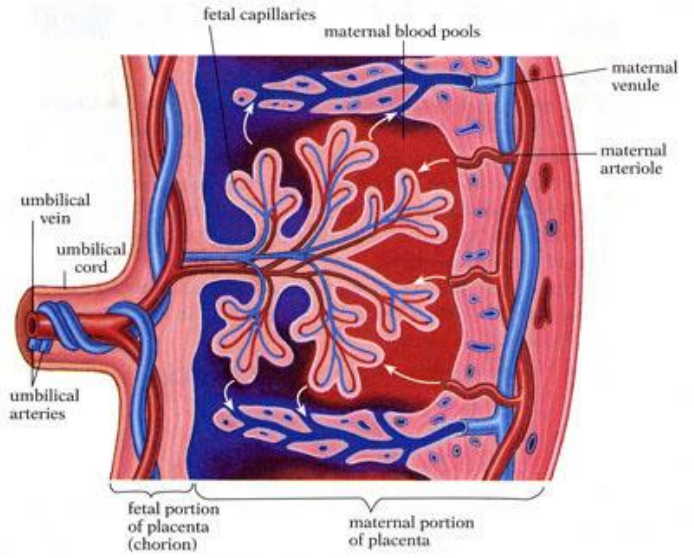
FSH & **LH** also form part but unnecessary at GCSE



10

Placenta:

- The structure that connects mother to embryo
- Anchors it to the uterus
- Allows the embryo to obtain materials such as oxygen and nutrients from the mothers blood
- As well as allowing the embryo to get rid of waste products such as urea and carbon dioxide
- The placenta also secretes hormones, mainly progesterone => prevents the embryo from aborting.



11

During pregnancy a membrane called the amnion encloses the developing embryo
This membrane secretes the amniotic fluid => protect the embryo against any knocks and bumps

12

Secondary sexual characteristics:

Testosterone: males

- Growth of penis and testes
- Growth of facial and body hair
- Breaking of the voice
- Muscle development.

Oestrogen: females

- Breast development
- Widening of hips
- Growth and development of sex organs
- Beginning of menstruation

b) Inheritance

13-17

Nucleus - contains genetic information as chromosomes on which genes are located

Gene - a section of DNA that codes for a specific protein

DNA - The chemical that stores genetic information

- Arranged in two strands of nucleotides coiled together to form a double helix
- The information is encoded through arrangements of nitrogenous bases

These nitrogenous bases are: **Adenine (A)** *which pairs to* **Thymine (T)**

Cytosine (C) *which pairs to* **Guanine (G)**

Alleles: Different forms of the same gene found on the converse chromosome
Any person may have two of the same allele or two different ones
These cause the differences in inherited characteristics

Dominant: An allele that will be expressed in the phenotype in both the homozygote and the heterozygote

Recessive: An allele that will only be expressed in the phenotype of the homozygote

Homozygous: two identical alleles for a gene

Heterozygous: two different alleles for a gene

Phenotype: The expressed characteristics of an organism

Genotype: The genetic makeup of an organism

Co dominance: Both alleles are expressed in the phenotype

18-20

Monohybrid Cross:

A method of finding out the inheritance pattern of a trait between two single organisms

All alleles must be crossed with all others

Recessive genes are given a lower case letter

Dominant genes are given a capital.

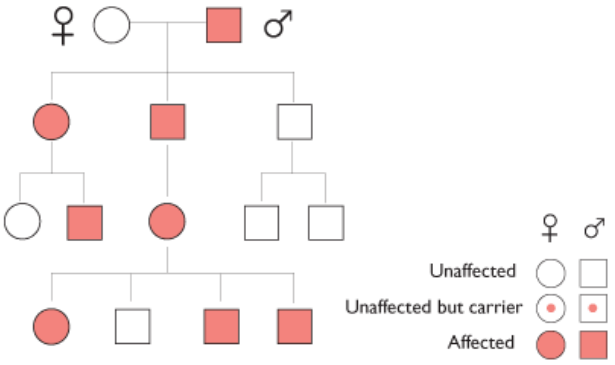
Cross: Aa x Aa

	A	a
A	**AA**	**Aa**
a	**Aa**	**aa**

Family Pedigrees

These are diagrams used to represent the presence of certain phenotypes in organisms within a family.

Males = square Females = circle Affected offspring = shaded Unaffected carries = usually 1/2 shaded



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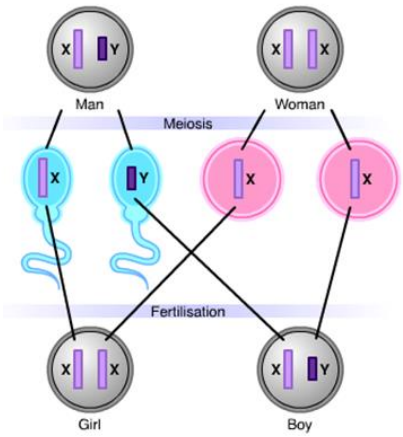
Gender

Gender is controlled by a pair of chromosomes (X & Y)

Females = XX

Males = XY



23-24

Mitosis

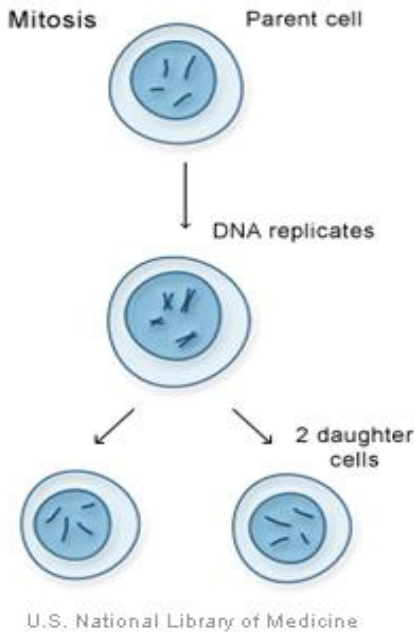
Mitosis produces two daughter cells genetically identical to the parent cell

The process of mitosis goes as follows:

- Every chromosome is copied
- Chromosome sets move to either side of cell
- Cell splits in half

Mitosis is used for:

- Growth & repair
- Cloning
- Asexual reproduction



25-27

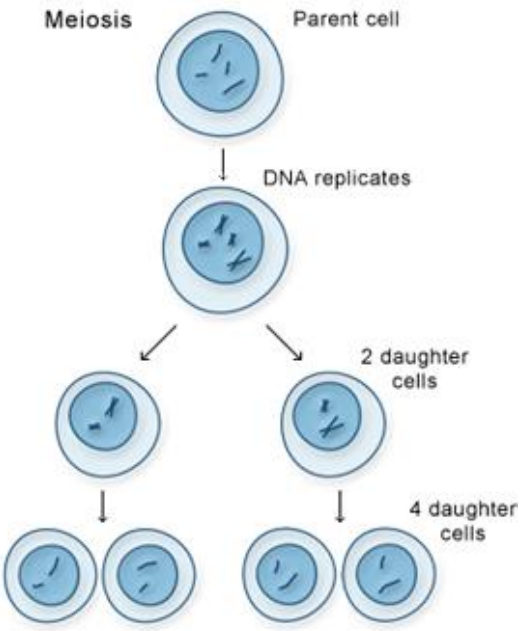
Meiosis

Meiosis is a kind of cell division

Produces male and female gametes

A diploid human cell contains 46 chromosomes arranged in 23 pairs

The gametes are haploid => only contain 23 chromosomes



The process of meiosis goes as follows:

- The cell copies each chromosome to share the genetic information between four daughter cells
- This cell then divides to produce two cells
- These cells then divide to produce four cells each containing one chromosome from each homologous pair
- The mixing and matching of genes allows for much variation

Random fertilisation allows for huge genetic variation

28

Variation within a species: is caused by environmental and genetic factors

29-33

Genetic Mutation

These are random changes in genetic material that can be inherited

Evolution

Natural Selection means that only the fittest survive => over time a population becomes better adapted to its environment

Mutation is a key part of this as it allows radical changes to happen

Effects of mutation

Mutations can be:

- **Beneficial** e.g. antibiotic resistant bacteria
- **Neutral** e.g. red eyes
- **Harmful** e.g. no legs

Risks of Mutation

The chances of mutation are increased by:

- Exposure to ionising radiation (e.g. gamma & X rays)
- Exposure to chemical mutagens (e.g. those present in tobacco)

4) Ecology and the Environment

a) The organism in the environment

1

Population: All the organisms of a particular species found in an ecosystem at any one time

Community: The populations of all species in a particular ecosystem at any one time

Habitat: The place where specific organisms live

Ecosystem: A distinct self-supporting system of organisms interacting with each other and with a physical environment

2-3

Quadrats

These are used to estimate the number of sessile species in a habitat:

- The area of the habitat is first measured
- A series of quadrats are placed randomly in this area using a RNG and a grid system
- The number of species you are interested in are counted inside each quadrat
- This number is scaled up to give a population estimate

Can also be used to sample organism distribution within a habitat:

- Choose the contrasting areas
- Repeat above steps

b) Feeding relationships

4

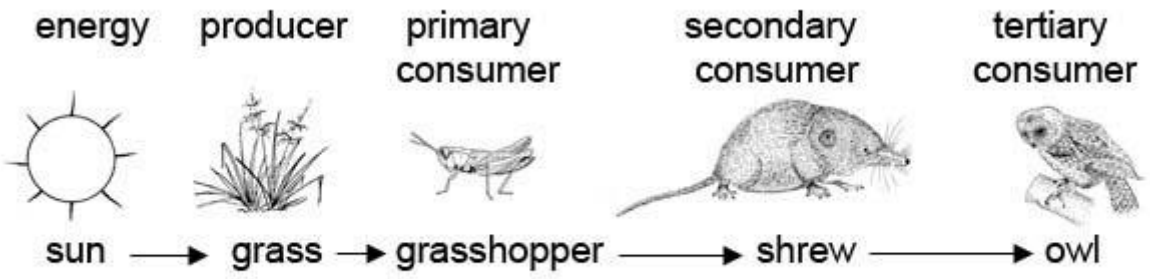
Trophic levels:

1) **Producers:** Plants which photosynthesise to produce their food
⇩
2) **Primary consumers:** An animal which eats the producer. They are herbivores
⇩
3) **Secondary consumer:** An animal which eats the primary consumer
⇩
4) **Tertiary consumer:** An animal which eats the secondary consumer
⇩
5) **Decomposers:** Organisms which feed on dead material => recycle materials in the ecosystem. They are all fungi or bacteria

5-6

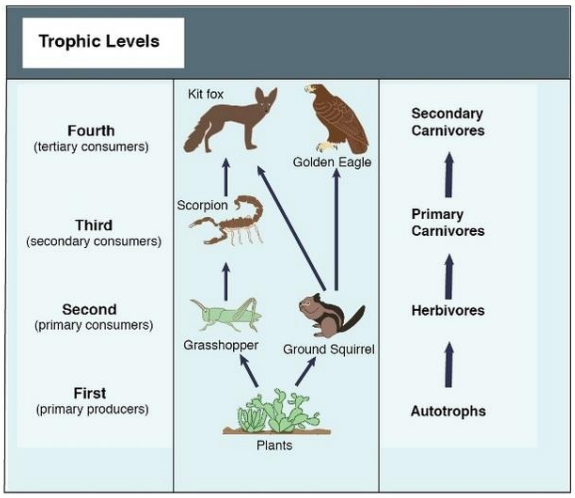
Food chains

Arrows indicate energy transfer



Food Webs

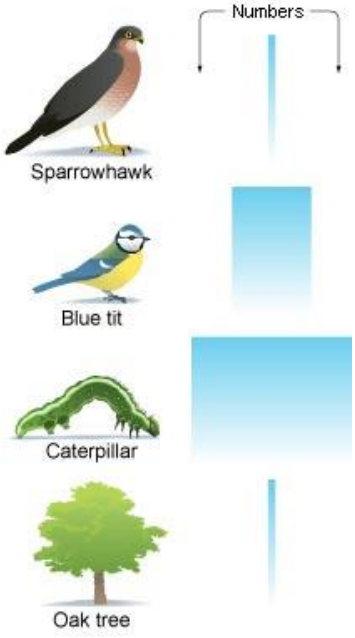
Like a chain but more organisms => shows feeding relationships

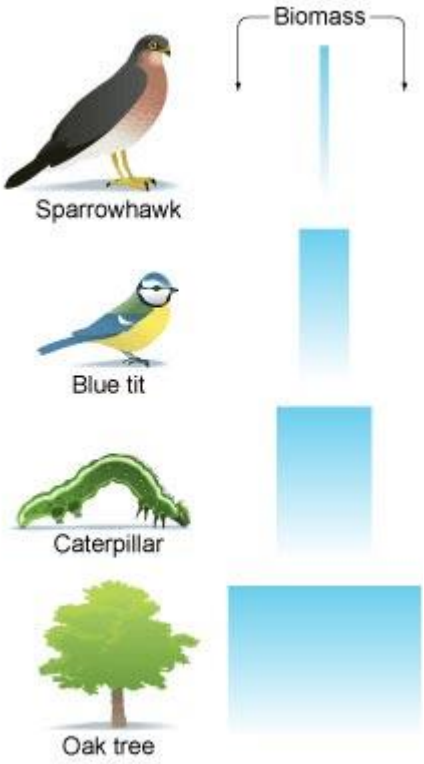


Pyramids of numbers

Bar width = number of organisms in the population

Usually get smaller as you go up due to inefficient energy transfer





Pyramids of biomass

Same as pyramids of numbers but with biomass

Always have to get smaller as you go up due to inefficient energy transfer

7

Inefficient energy transfer:

Energy transfer between trophic levels is only 10% efficient

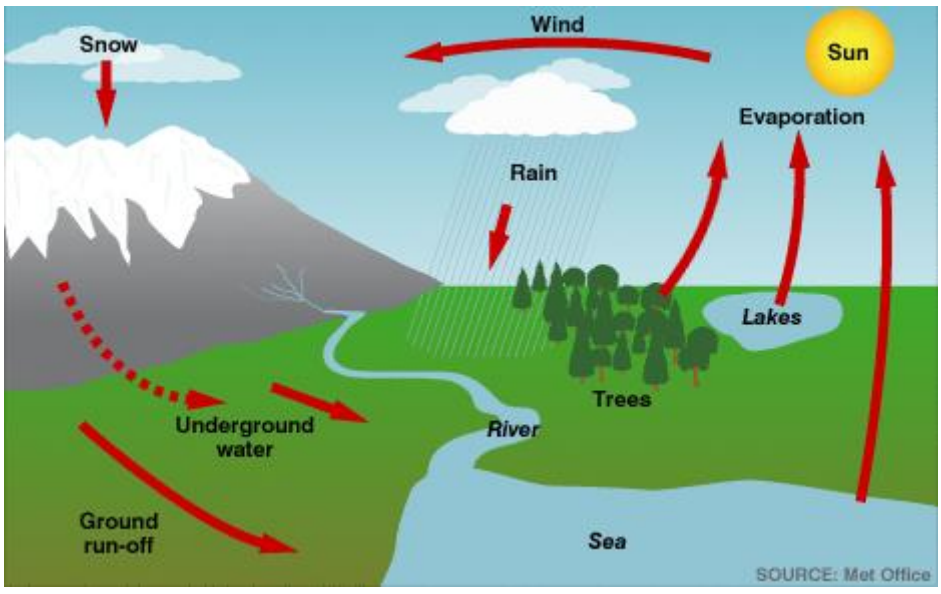
90% of the energy is lost through:

- Not all parts of an organism are eaten
- Some parts are not digested and so are not absorbed
- Some materials absorbed form excretory products
- Many of the materials are respired to release energy

c) Cycles within ecosystems

8

Water Cycle:



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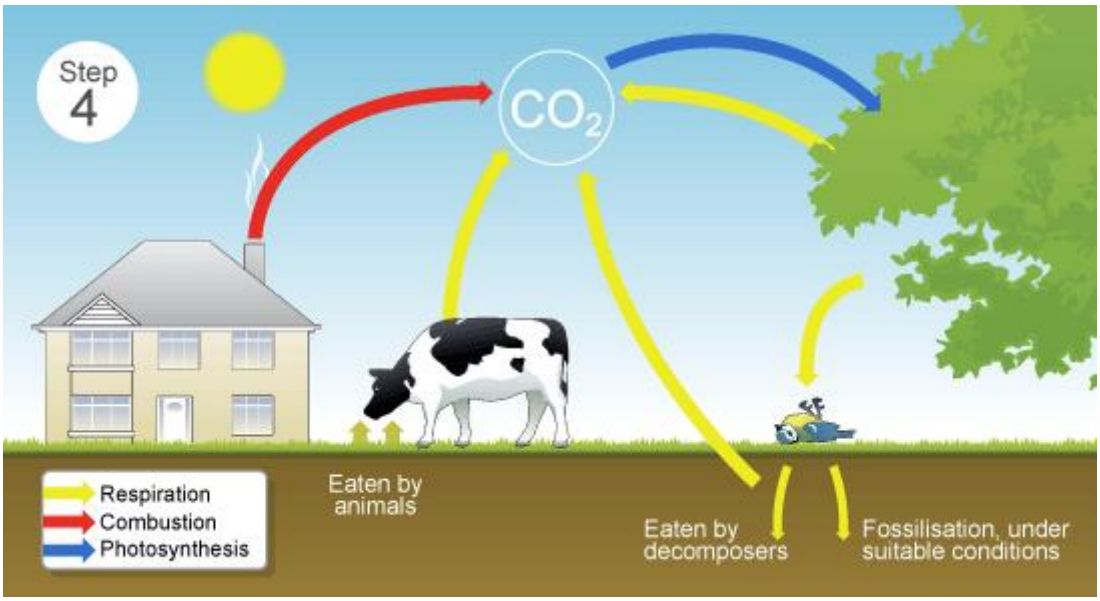
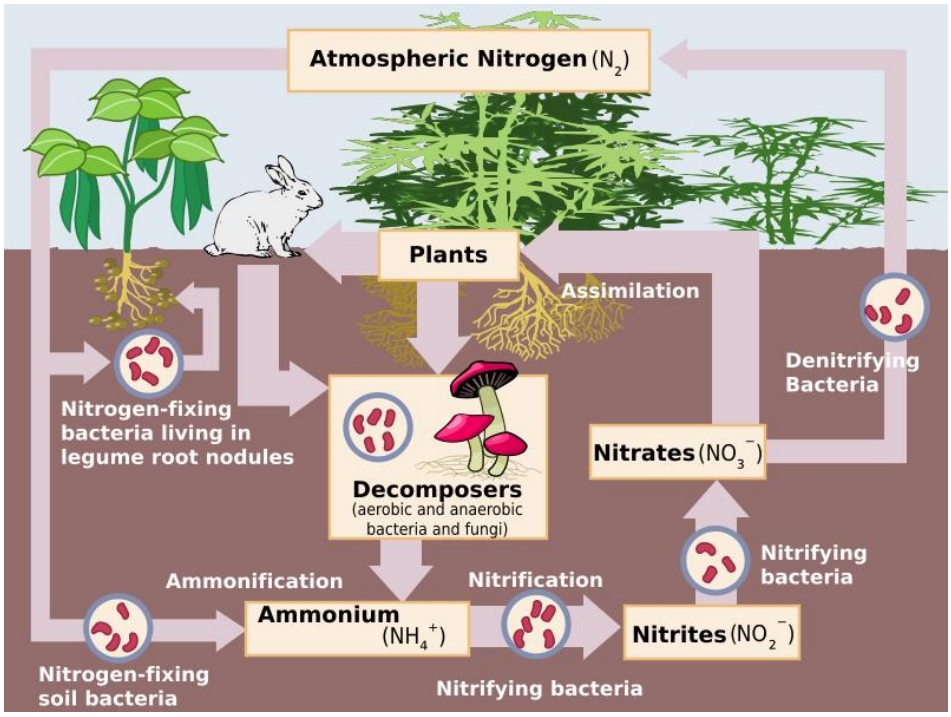
The carbon cycle



10

The nitrogen cycle



d) Human influences on the environment

11-17

Pollution:

Carbon monoxide:

- Formed by incomplete combustion
- It binds more strongly with haemoglobin than oxygen
- => if someone inhales carbon monoxide for a period of time less oxygen can be carried in the blood
- => the person my faint and possibly die.

Sulphur dioxide:

- Sulphur dioxide is formed when fossil fuels are burned
- When it meets water in clouds => acid rain
- causes the acidification of lakes => death of fish and algae
- causes the acidification of soil => makes root hairs less effective => plant growth is slowed

Greenhouse gases:

- Water, carbon dioxide, nitrous oxide, methane and CFCs are greenhouse gases
- These gases trap the sun's heat => may cause global warming
- The effects of a global temperature rise of a few degrees are:
    - Polar ice caps melting => sea level rise
    - More rainfall
    - The nature of many ecosystems could change => if species cannot migrate/adapt quickly to these changes they may become extinct
    - Changes in agricultural practice would be necessary as the abundance of pests would increase as higher temperatures mean they complete their life cycle faster

Freshwater Pollution:

Sewage:

Dumping sewage causes a huge influx of nutrients:

- Aerobic bacteria growth feeding on nutrients
- Reproduce and respire rapidly
- Use up all the oxygen in the water
- Water becomes anoxic => all life in it dies

Fertilisers:

Fertilisers are leached into waterways leading to eutrophication:

- Nitrate levels rise => algal bloom
- The algal bloom prevents light penetrating
- Submerged plants can no longer photosynthesise => die
- The algae die as they run out of nutrients
- Above process occurs

Deforestation:

- Lack of trees prevents soil binding => leaching and soil erosion
- Can also disrupt the water cycle due to reduced transpiration
- Less trees => less photosynthesis => more CO_2 and less O_2

5) Use of biological resources

a) Food production

Crop Plants:

1-2

Crop yield can be improved by controlling a variety of factors

Typically greenhouses or polythene tunnels are used to do this.

Greenhouses/Polythene tunnels: These provide the ideal conditions for plants in the following ways:

- Transparent material allows sufficient natural light in for photosynthesis during summer
- In winter months additional lighting => max photosynthesis
- Keeps temperature high => faster growth
- CO_2 levels can be artificially increased
- The right mineral ions can be supplied to the plant by growing it in a hydroponic culture

3-4

Fertilisers

There are two types of fertilisers used on crops – organic and inorganic.

- **Organic** - typically animal faeces mixed with straw
  - Unable to replace all the lost ions
- **Inorganic** – typically synthesised chemicals
  - Can replace all the lost ions
  - May damage soil structure and lead to eutrophication

Nitrates can be replaced by growing legume crops which have nitrogen fixing bacteria in root nodules => convert nitrogen in the soil to ammonium ions => oxidised into nitrates for next year's crop

Pest control

Pests reduce the crop yield => reduce profits

2 methods of pest control:

- **Pesticides** - are used to kill specific pests on crops when they are significantly damaging the yield
  - They are effective in eradicating the majority of a pest population
  - However, they need frequent reapplication, pests can become immune, can cause environmental damage as they remain in soil and are accumulated along the food chains and also products can no longer be marketed as organic.

- **Biological control** - Involves using another organism rather than a chemical to reduce the numbers of a pest by preying on them
  - These will never completely eradicate the pest population
  - BUT they are not as damaging as pesticides and products are still organic

Microorganisms:

5

Fermentation

This is the conversion of glucose to ethanol and carbon dioxide by the anaerobic respiration of yeast which produces the enzyme, zymase, that catalyses the reaction:

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

6

Investigating the carbon dioxide production by yeast

1. Boil a small amount of water in a boiling tube to drive off any air that is dissolved in the water
2. Dissolve a small amount of sugar in the boiled water and allow it to cool
3. Add a little yeast and stir
4. Set up a test tube containing the yeast + sugar solution with a layer of paraffin to make sure the yeast respire anaerobically and connect via a delivery tube to a solution of lime water
5. Set up the same apparatus with boiled yeast to act as a control
6. Observe for the production of gas bubbles and changes in the indicator solution
7. Repeat the experiment changing the concentration of sugar solution and the temperature

7

Production of Yoghurt

1. Milk is pasteurised at 85-95℃ for 15-30 minutes
2. Milk is homogenised (fat droplets are emulsified)
3. Milk is then cooled to 40-45℃ and inoculated with a starter culture of **lactobacillus** bacteria
4. Mixture is incubated at this temperature for several hour while bacteria digest milk proteins and ferment lactose to lactic acid
5. Thickened yoghurt is stirred and cooled to 5℃ => swank may be added later

8

Industrial Fermenter

Need to consider:

Aseptic precautions => prevent infection

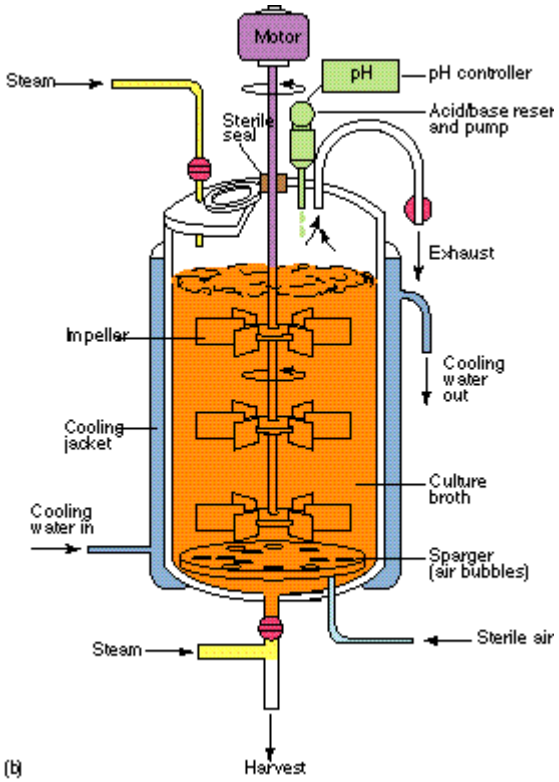
Nutrients => allow microorganism to grow

Optimum Temperature => catalyse growth

pH => keep microorganism alive

Oxygenation => respiration

Agitation => homogeneous mixture



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Fish farming:

These are fish that are bred to be used as both human and animal food as a source of protein

In order to maximise the yield, must control:

- **Water quality**
  - Prevent the build-up of faecal matter which can cause the spread of disease
  - Also need to provide the right temperature and oxygen levels
- **Interspecific predation**
  - Controlled by having netting over the tanks fish inhabit to prevent predation
  - Younger fish are also separated from older fish to prevent intraspecific predation
- **Disease**
  - Controlled by removing faecal matter, introducing pesticides to kill bacteria and supplying ill fish with antibiotics
- **Diet**
  - Fed regularly so they are not hungry and do not feed on each other
  - Also have a tailored diet
- **Selective Breeding**
  - To make fish: bigger, mature faster, taste batter, more placid etc

b) Selective breeding

10-11

Selective breeding allows us to pick desirable characteristics to increase throughout a population

Used for plants and animals to make them:

- Bigger
- Grow faster
- Fatter
- Tougher
- Friendlier
- etc

c) Genetic modification (genetic engineering)

12-16

A gene is a section of one strand of DNA that codes for the production of a protein

Humans are trying to produce recombinant DNA – this is DNA from two organisms that has been 'recombined'

The organism that receives this DNA is a transgenic organism.

The breakthrough was the discovery that bacteria were capable of swapping parts of DNA called **plasmids**

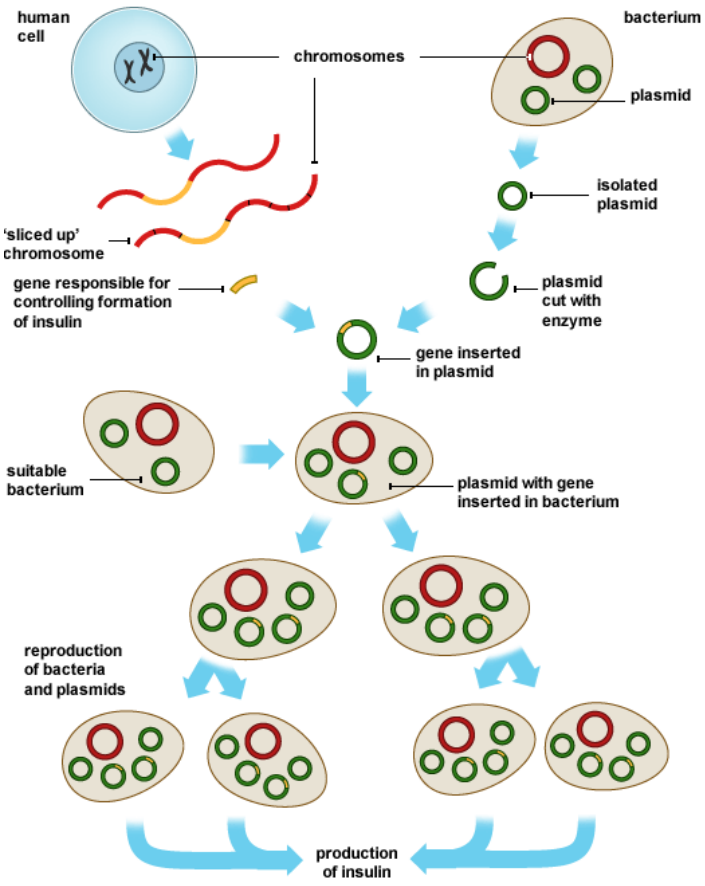
Scientists managed artificially do this

In order to create recombinant DNA:

- Plasmids from bacteria are isolated
- They are used as the vector
- The DNA loop is cut using restriction enzymes
- The desired gene is removed from the donor using restriction enzymes and inserted into the plasmid
- The plasmid is then reconnected with the new DNA using DNA ligase which fuses the DNA together at the complementary sticky ends
- These plasmids are then reinserted into the bacteria cell with the new gene

Vectors – A means of transferring DNA between cells. Can be either a plasmid or a virus

Vast quantities of human insulin are made in this way by bacteria within a fermenter



Genetically modified plants

There is great potential for plants which are genetically modified

e.g. 'Golden Rice' has been produced which has three genes added to allow the rice to make beta-carotene that is an important vitamin A source that prevents blindness and would save the eyes of millions of children in less developed countries.

Other advantages that can be bred in plants are:

- Increased resistance
- Increased heat and drought tolerance
- Increased salt tolerance
- A better balance of proteins carbohydrates, lipids, vitamins and minerals

Transgenic: This refers to genetic material that has been transferred from one species to a different species

d) Cloning

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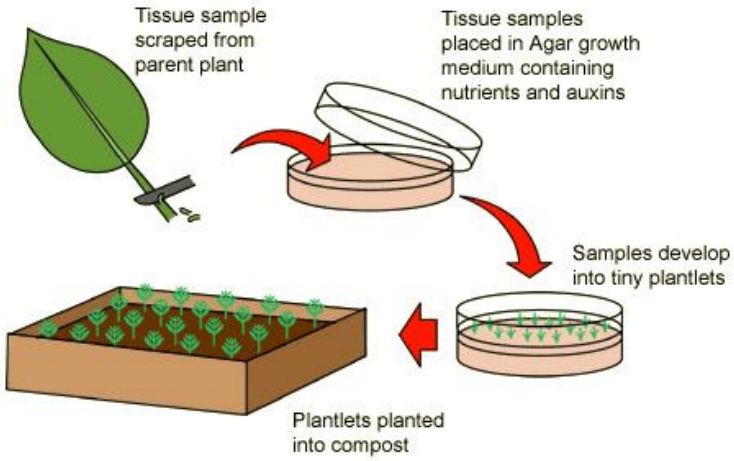
Micropropagation (Tissue Culture)

This involves:

1. Small amounts of parent tissue or a number of cells are taken
2. The plant material is transferred to plates containing sterile nutrient agar jelly
3. Plant hormones are added to stimulate the cells to divide
4. Cells grow rapidly into small masses of tissue
5. More growth hormones are added to stimulate the growth of roots and stems
6. The tiny plantlets are transferred into potting trays where they develop into plants



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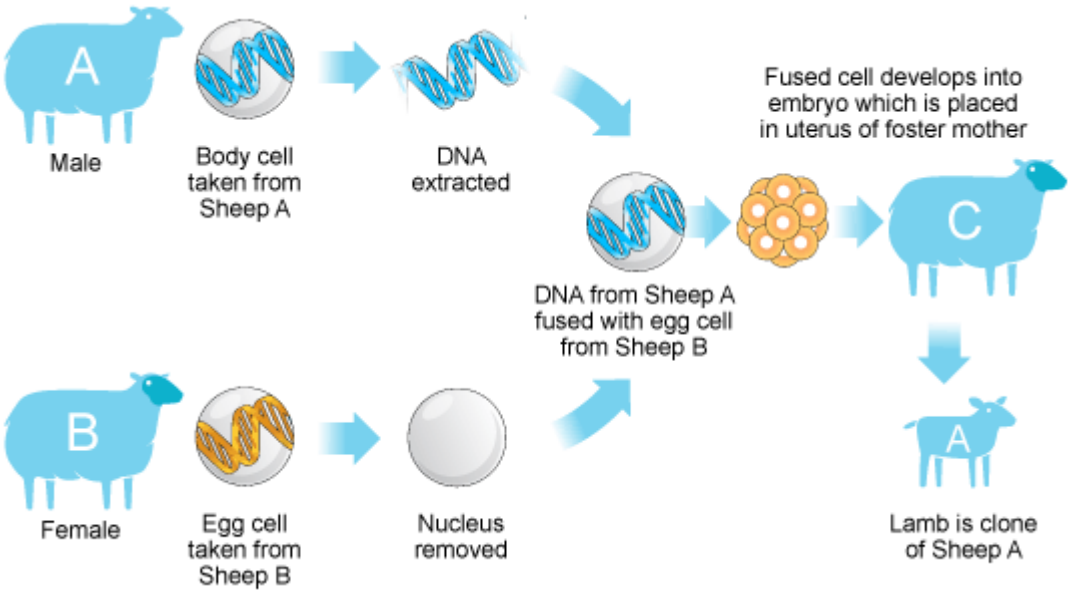
This process produces genetically identical plants => used when trying to make plants with desirable characteristics on an industrial scale

Animal Cloning

19

Dolly the sheep was the first mammal to be cloned using adult cell cloning:

1. An egg cell is removed from the *ovary* of an adult female
2. Its nucleus is removed
3. The nucleus from any cell of a donor is inserted into the empty egg cell
4. The fused cell begins to develop normally, using genetic information from the donated DNA.
5. The embryo was implanted into the uterus of a foster mother
6. Normal gestation occurs
7. Offspring is genetically identical to the donor



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There is great potential for cloned, transgenic animals

e.g growing human organs inside animals for human transplants

BUT there are risks

- Greater risk of immune rejection with xenotransplants (animals to humans)
- The transplanted organ may carry pathogens that do not affect the donor but are harmful to humans
- Some viruses may be 'hidden' in the DNA of the transplanted organ
- Ethics