IGCSE Biology Study Guide

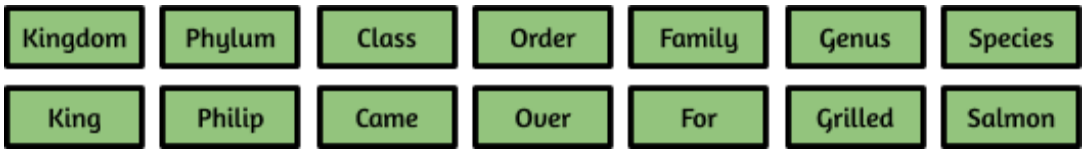
By Aditya Ghosh

1.1 Characteristics of living organisms

There are seven characteristics of living organisms :

MOVEMENT	Movement is an action by an organism or part of an organism that causes a change of position or place.
RESPIRATION	Respiration is the term used for 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 make appropriate responses.
GROWTH	Growth is a permanent increase in size and dry mass by an increase in cell size, cell number, or both.
REPRODUCTION	The processes that make more of the same kind of organism.
EXCRETION	Excretion is the removal from an organism of the waste products of metabolism, toxic substances, and substances in excess of requirement.
NUTRITION	Nutrition is the taking in of materials for energy, growth, and development; plants require light, CO_2, water, and ions; animals require organic compounds, ions and usually need water.

1.2 Concept and use of a classification system

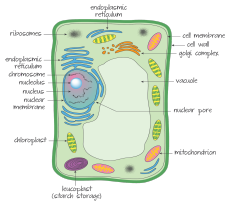
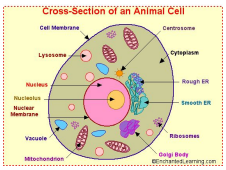
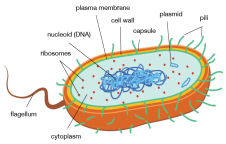
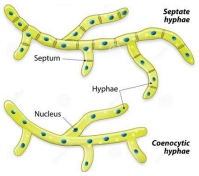
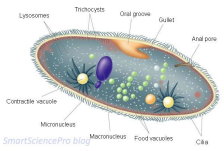


A SPECIES is a group of organisms that reproduce to produce fertile offspring. It is thus the ultimate stage of classifying living organisms. BINOMIAL NOMENCLATURE is an internationally agreed system in which the scientific name of an organism is made up of two parts showing the genus and species. Eg name: *Panthera leo* (Genus capital, species small) (Italicised - typing, underline - writing)

Classification: Traditional methods include studying morphology (Outward appearance of an organism) and anatomy of a living organism. However modern-day technology allows us to compare organisms by comparing their DNA. We can compare sequences of amino acids in the DNA from different organisms. Organisms with similar sequences would be more closely related

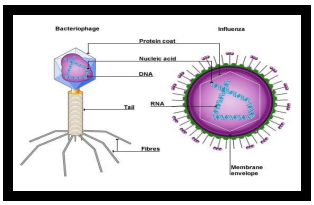
1.3 Features of organisms.

The cells of all living organisms are made up of a cell membrane, cytoplasm, and DNA. They also contain ribosomes in the cytoplasm that carry out protein synthesis and enzymes that are involved in processes such as respiration. Living organisms are broken into 5 Kingdoms:

Plant	Animal	Prokaryote	Fungi	Protoctist
				
• Multicellular • Cellulose wall • Large vacuole • Eg: Hydrilla	• Multicellular • No wall • No vacuole • Eg: Muscle	• Peptidoglycan • No nucleus • Plasmids • Eg: Cholerae	• Chitin wall • Hyphae from mycelium • Eg: Yeast	• Do not belong anywhere else • Eg: Paramecium

<u>Viruses (Not living thus not one of the kingdoms)</u>

- Made of genetic material enclosed in a protein coat
- Viruses are parasitic. They enter a host cell in another organism to multiply.



<u>Vertebrates</u> (animals with a vertebral column and an internal skeleton (Phylum - CHORDATA)

Fish Eg: tuna, cod	• Streamlined bodies to swim through water. • Fins for swimming and balance. • Lateral line allows them to detect pressure changes in water • They use gills to breathe O2 that is dissolved in the water
Amphibians Eg: frogs	• Smooth and moist skin (no scales) • They have lungs as well as gills • Fertilization and development is external - gametes released directly into H_2O
Reptiles Eg: lizards	• Dry, scaly skin to cut down water loss • Fertilization is internal; it takes place inside the female's body. Development however is external. Reptiles lay eggs which are leathery and waterproof
Birds Eg: Hawks	• Feathers instead of hair as it makes the total weight lighter - easier to fly • Front limbs are modified to wings • No teeth but species have beaks adapted to deal with different types of food • Fertilization is internal but development is external, birds lay eggs
Mammals Eg: Humans	• Mammals have either hair or fur • Fertilization and development are both internal - they give birth to live young • Females suckle their young on milk from mammary glands. • Use lungs for breathing

Invertebrates

Invertebrates are animals that do not have a vertebral column

Arthropod is the largest group in the animal kingdom as it contains the largest number of species, All arthropods have: **a segmented body, an exoskeleton and jointed legs**

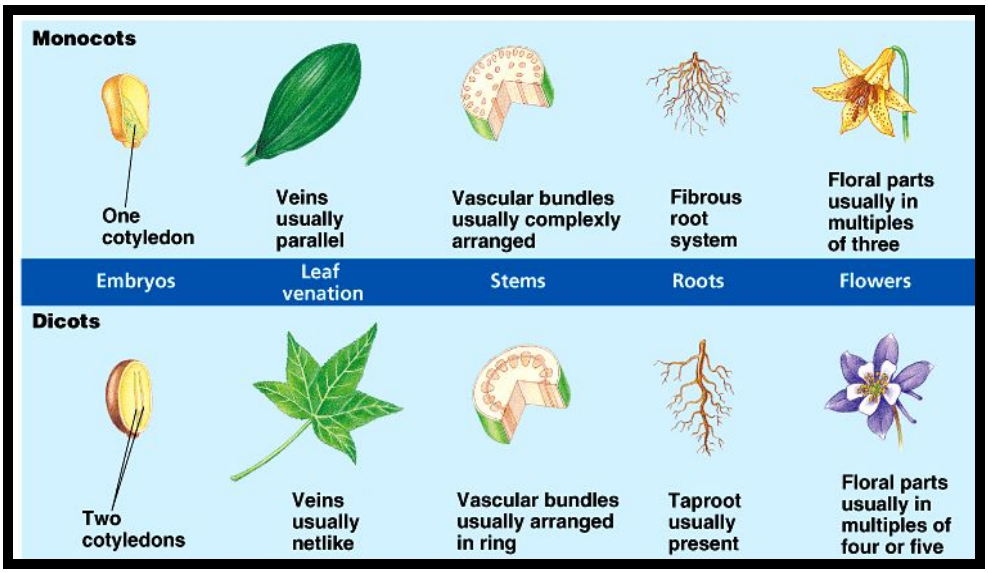
Crustaceans Eg: crabs	• Chalky exoskeleton for hard and effective protection against predators • Two pairs of antennae and compound eyes • 5-20 pairs of legs • Front legs are modified into pincers and back legs are specialized to swim
Myriapods Eg: Centipedes	• These consist of the centipedes and millipedes • Long bodies with many segments • Centipedes have one pair of legs to each body segment whereas millipedes have two pairs to each segment • Centipedes are fast-moving carnivores and can paralyze their prey whereas millipedes are slow-moving herbivores that feed on leaf litter.
Insects Eg: Beetles	• Three pairs of legs on the thorax and may have few pairs of wings • One pair of antennae on the head • Compound eyes made of many individual components • Breathe through holes on the sides of their lower body called spiracles • A waterproof cuticle enables them to not lose water
Arachnids Eg: Spiders	• Bodies are divided into two parts - cephalothorax and abdomen • Four pairs of legs • Poison fangs to paralyze enemy or prey • Weave webs with their spinnerets.

Ferns and flowering plants

Most plants are green in color as they contain a green pigment in their leaves called chlorophyll. This is stored in chloroplast. Chlorophyll absorbs light for photosynthesis. All plant cells are surrounded by a cell wall made of cellulose. Ferns and flowering plants both have transport systems. Xylem vessels transport water and ions, phloem vessels transport sucrose and amino acids

Ferns	• Strong stems, roots, and leaves • Ferns grow from a thick underground stem called a rhizome • Ferns do not produce seeds, they release microscopic pores that are carried by wind - this is the method ferns use to pollinate
Flowering plants	• The apical bud is where the stem grows new leaves • The stem supports the plant and allows for pollination and transport • They anchor the plant to the ground • They also absorb water and mineral ions for the plant from the soil

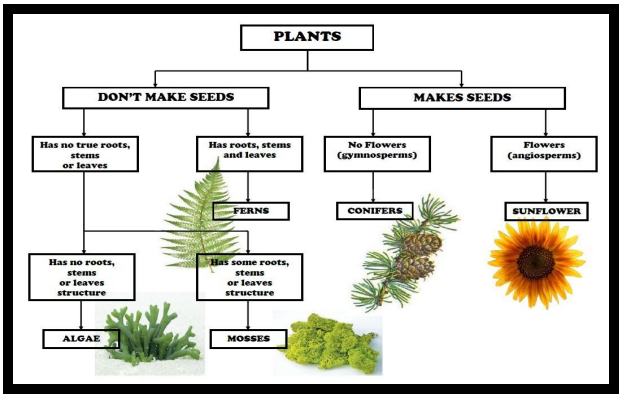
DICOTYLEDONS AND MONOCOTYLEDONS



1.4 Dichotomous Keys

Dichotomous keys are used by scientists to identify living things. There are 2 types:

1.	Has green colored body .....go to 2
	Has purple colored body ..... go to 4
2.	Has 4 legs .....go to 3
	Has 8 legs ..... *Deerus octagis*
3.	Has a tail ..... *Deerus pestis*
	Does not have a tail ..... *Deerus magnus*
4.	Has a pointy hump ..... *Deerus humpis*
	Does not have a pointy hump.....go to 5
5.	Has ears .....*Deerus purplinis*
	Does not have ears .....*Deerus deafus*



2.1 Cell structure and organization

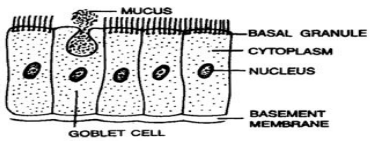
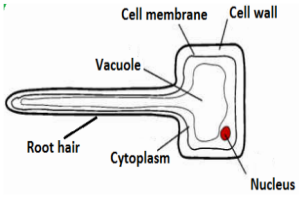
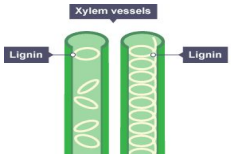
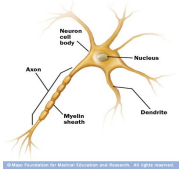
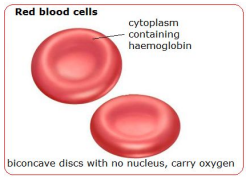
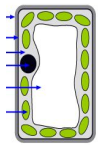
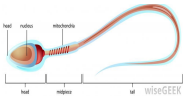
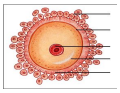
Cells are the small building blocks that make up all living organisms.
Differences between a plant and animal cell :

Feature	Plant cell	Animal cell
Cell wall	present	absent
Cell membrane	Present - surrounded by cell wall	present
Shape	Permanent shape	Varies as there is no cell wall
Chloroplast	Present where photosynthesis occurs	absent
Vacuole	Large permanent vacuole	Small vacuoles in cytoplasm
Nucleus	Present (side of the cell)	Present (anywhere in the cell)
Cytoplasm	present	present

Functions of cell organelles

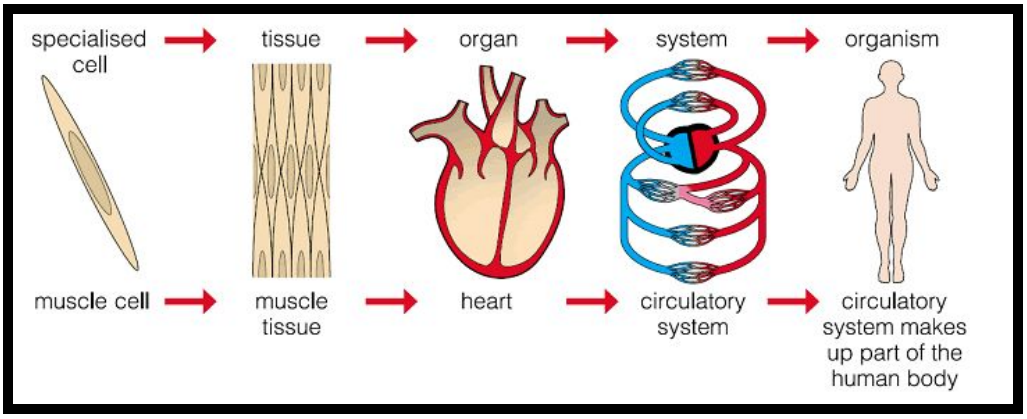
Cell organelle	Functions
Cell membrane	• Keeps contents of cell inside • Partially permeable (controls movement of substances in and out)
Nucleus	• Controls all the activities of the cell • Controls how cells develop • Contains genetic info
Cytoplasm	• Site for chemical reactions such as respiration and protein synthesis
Chloroplast	• Contains chlorophyll, which absorbs light for photosynthesis • Stores starch
Cell wall	• Prevents the cell from expanding too much when it is filled with water • Gives the cell its shape • It is almost completely permeable
Sap vacuole	• Filled with water, sugar, and salt to help maintain the shape of the cell
Rough ER	• Small ends of the rough ER are pinched off to form vesicles where protein can be stored or transported (not found in prokaryotes)
Ribosomes	• Small organelles that carry out protein synthesis (make proteins)
Mitochondria	• Almost all cells, except prokaryotes, have mitochondria • The outer membrane controls the entry and exit of substances • Aerobic respiration takes place on the inner membrane

2.2 Levels of organization

Cell	Found?	Features	Function	Image
Ciliated epithelial cells	Trachea Bronchi Oviduct	These cells have small hairs called cilia on their surfaces	Cilia beat back and forth to create a current in the fluid. In the trachea, mucus is swept into the gullet. In the oviduct, the egg is moved	
Root hair cells	These cells are extensions from the roots of a plant	Long extensions Thin cell wall Xylem vessels close to the wall	Large surface area for absorption Quick diffusion Quick diffusion	
Xylem vessels	Plant stems	Cells surrounded by lignin Hollow	Support prevents water leakage Allows water to pass through	
Nerve cells	Found in the nerves of organisms with nervous systems	Thin extensions of cytoplasm like wire These are linked in a chain	Allows nerve cells to link together in a chain Impulses can be transferred very quickly in this way	
Red blood cells	Found in the blood of organisms	Hemoglobin Biconcave disc No nucleus	Binds to O_2 Increases the surface area for the absorption of O2 More hemoglobin, so more O_2 carried	
Palisade mesophyll cells	Found in a plant's leaves	Lots of chloroplasts Cellulose cell wall	Increases rate of photosynthesis Strengthens the cell and gives it shape	
Sperm cells	Male's testes	Acrosome Flagellum	Enzymes help to penetrate the egg cell Allows sperm to swim through fluids	
Egg cells	Female's ovary	Yolk Jelly coating	A store of energy for zygote Changes composition to allow 1 sperm	

Levels of organization

Cell - the building block for all living organisms.
Tissue - a group of cells with similar structures, working together to perform a shared function
Organ - a structure made up of a group of tissues, working together to perform specific functions.
Organ System - A group of organs with related functions, working together to perform body functions



2.3 Size of specimens

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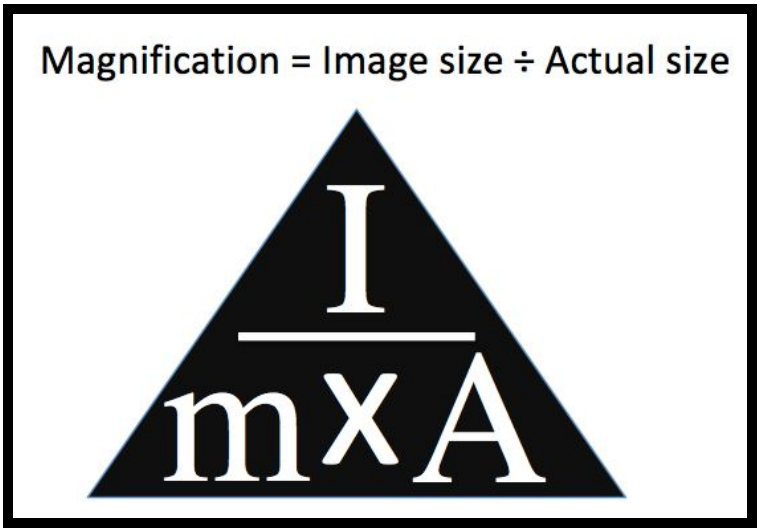


3.1 Diffusion

Diffusion is the net movement of particles from a region of higher concentration to a region of lower concentration down a concentration gradient, as a result of their random movement.

Diffusion is an example of passive transport as it doesn't require any energy. Diffusion takes place because molecules contain kinetic energy which causes them to bounce around. They collide with other particles and spread out in the fluid in this way.

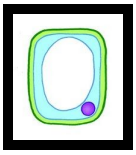
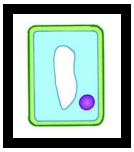
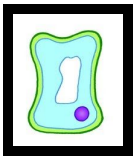
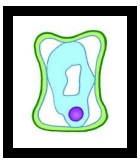
The diffusion of gases and solutes is important as without it, molecules which are needed for life, for example, glucose and oxygen for respiration, would not be able to get to the places they are needed. Water is needed as a solvent

Factors that affect diffusion

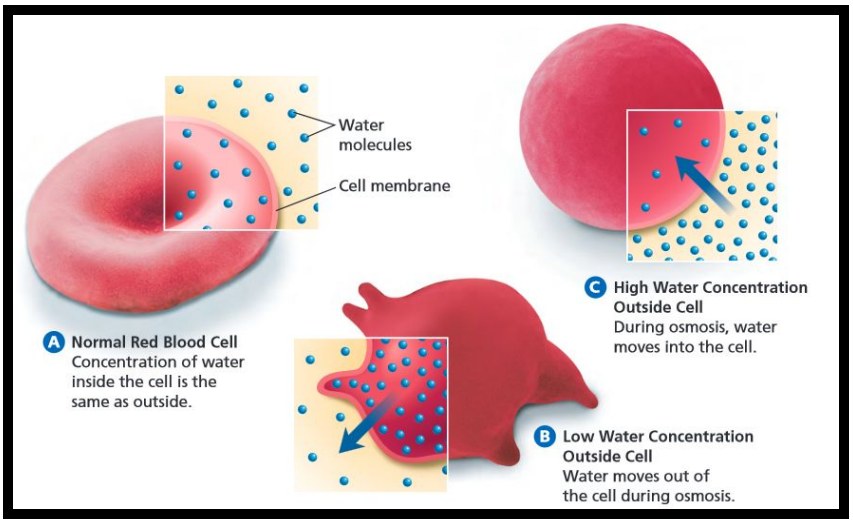
- Distance - the smaller the distance, the quicker the diffusion
- Concentration gradient - The greater the concentration gradient, the quicker the diffusion
- Surface area - If diffusion takes place over a larger surface area, it is quicker
- Temperature - when hotter, particles have more KE, so Brownian motion is faster

3.2 Osmosis

Osmosis is the net movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane

Condition	Image
When a plant cell is placed in a **hypotonic solution** as compared to inside the cell, water from the solution moves into the cell, creating **turgor pressure** on the wall**.** This makes the cell **turgid**, therefore supporting the plant, and giving it its shape. The cell wall is inelastic, so doesn't burst	
In **isotonic solutions** there is no concentration gradient, so the cell doesn't change	
In a **hypertonic solution** as compared to inside the cell, water leaves the cell as the solution inside the cell has higher water potential. The cell shrivels and becomes **flaccid**	
When too much water is lost from the cell by osmosis, the cell membrane is pulled away from the cell wall and the cell undergoes **plasmolysis**.	

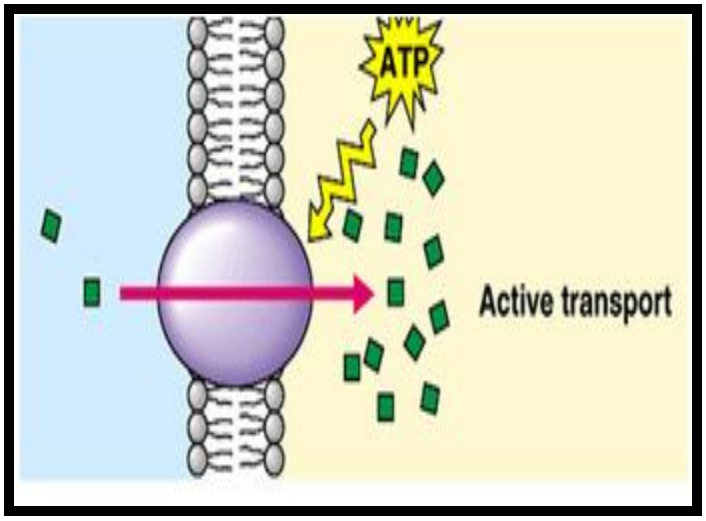
Osmosis in Animals

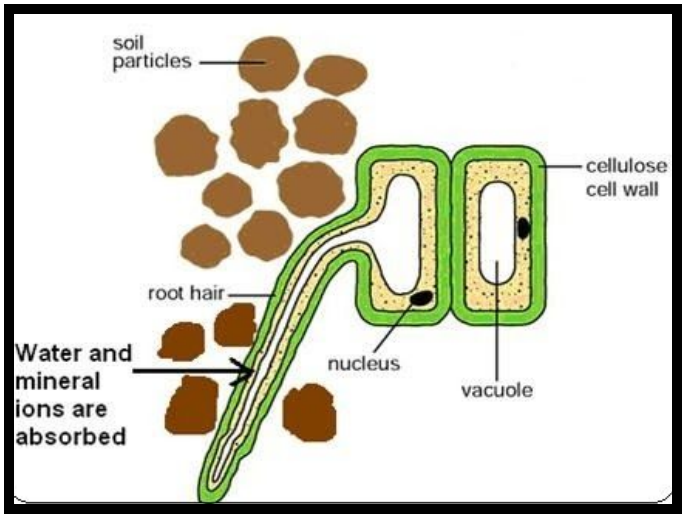


3.3 Active transport

Active transport is the movement of particles through a cell membrane from a region of lower concentration to a region of higher concentration using energy from respiration and the aid of protein carriers.

Active transport needs carrier proteins. First, the molecule being transported combines with a carrier protein. Energy from respiration enables the carrier protein to change its shape to carry the ion or molecule to the inside of the membrane. After the ion or molecule is in the membrane, the carrier protein reverts to its original shape.





Active transport is needed when an organism wants to optimize the number of nutrients it can take up - ion uptake by root hairs and uptake of glucose by epithelial cells of villi.

Biological Molecules

Carbohydrates

These are compounds of (C, H, O)

They are either starches or sugars. There are six main types of sugars. The Monosaccharides are:

- GLUCOSE
- GALACTOSE
- FRUCTOSE

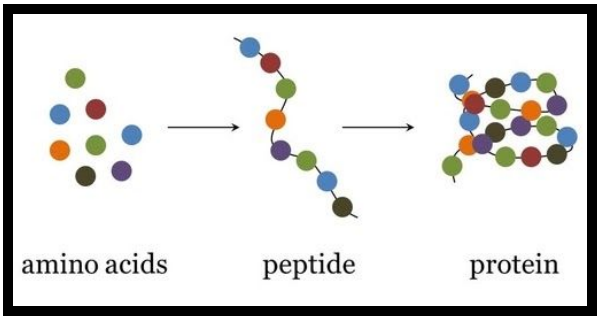
The Disaccharides (2 sugar units) are:

- MALTOSE (GLUCOSE + GLUCOSE)
- LACTOSE (GLUCOSE + GALACTOSE)
- SUCROSE(GLUCOSE + FRUCTOSE)

There is also Starch which is made of many units of sugars. Starch (Plants store energy as starch), Glycogen (in liver and muscles of animals (animal fats) and cellulose (molecules are linked by fibers - thus very strong and rigid) are examples of polysaccharides.

Proteins

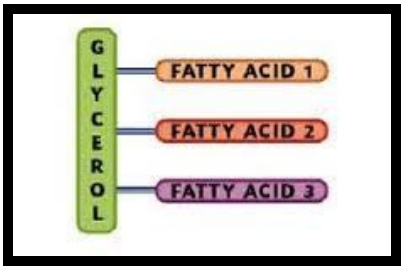
Proteins are complex molecules made up of (C, H, O, N,(S)) Proteins are made of long strands of amino acids. Different proteins end up in different shapes because of their amino acid sequence. The shape and structure of proteins determine their function. For example, enzymes have a specially designed active site where a particular substrate is broken down. Similarly, antibodies have a specific antigen that they can bind to on the pathogen body



Lipids

Lipids are fats and oils. Lipids are large molecules made from small fatty acids and glycerol.

Each fat molecule is made of one glycerol molecule attached to three fatty acids. Made with Carbon, Hydrogen, Oxygen, and Phosphorus (C, H, O,(P))



Chemical tests for biological molecules.

Simple tests can be used to identify starch, sugar, proteins, fats, and Vit C.

To test a substance for any of these substances, an extract needs to be made. To make the extract simply grind the substance being tested with a mortar and pestle with some water. Wear eye protection as some chemicals in these tests are corrosive.

Test for starch
Extract containing starch will turn a few drops of yellow iodine solution blue-black

Test for reducing sugar
Extract containing reducing sugar will turn blue Benedict's solution brick red when placed in a test tube in a water bath at 80°C

Test for protein
Extract containing protein would turn a few drops of blue biuret solution lilac

Test for fats
When shaken with ethanol, and some distilled water in a test tube, an extract containing fat creates a white emulsion

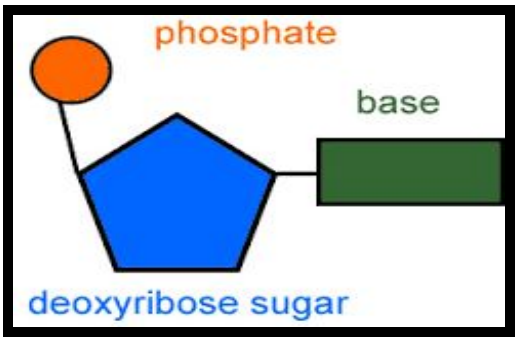
Test for Vitamin C
A titration of Vitamin C and DCPIP solution makes the blue color of DCPIP disappear

DNA

Chromosomes in nuclei are made of one long thread of a chemical called DNA DNA is made up of (C, H, O, P,(N)). DNA is made up of units called nucleotides. A nucleotide is made up of :

- A phosphate
- A sugar
- A base

The molecule is twisted into a double helix



Base pairing:
THYMINE(T) PAIRS WITH ADENINE(A) (2 H Bonds)
CYTOSINE(C) PAIRS WITH GUANINE(G) (3 H Bonds)

Water

Water is an important solvent. It is very necessary in digestion, excretion, and transport

Enzymes

A catalyst is a substance that increases the rate of a chemical reaction and is not changed by the reaction. Enzymes are proteins that function as biological catalysts.

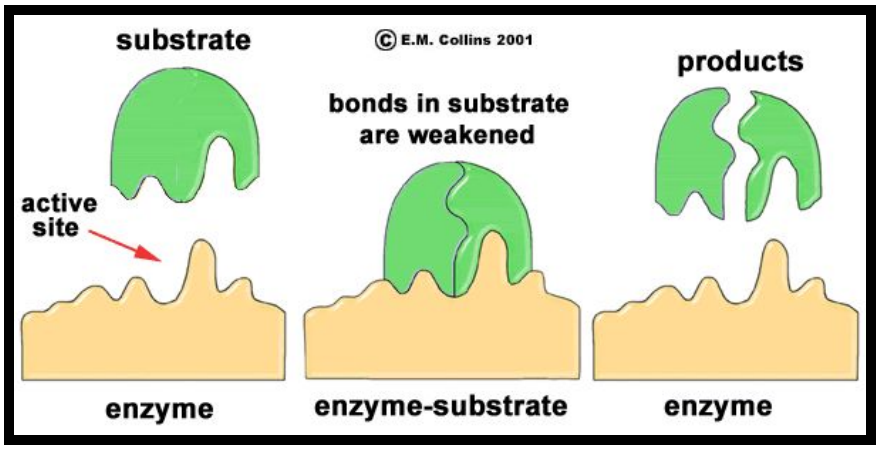
Enzymes either :

- ❖ Break large molecules into smaller ones
- ❖ Build large molecules from smaller ones
- ❖ Convert one small molecule to another

An enzyme is a biological catalyst

- They speed up reaction
- They are proteins
- The are reusable
- Can be denatured
- They are influenced by pH and temperature.

Lock and key hypothesis



Starch is chemically digested by amylase - the product is maltose (two glucose molecules) The maltose is further broken down by maltase to get two single units of glucose.

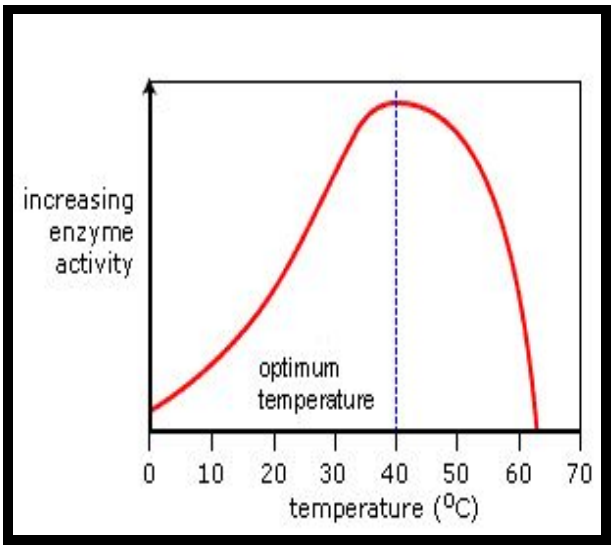
Fat is chemically digested by lipase. The products are fatty acids and glycerol

Proteins are chemically digested in the stomach by pepsin into peptides and is then digested by trypsin to get amino acids.

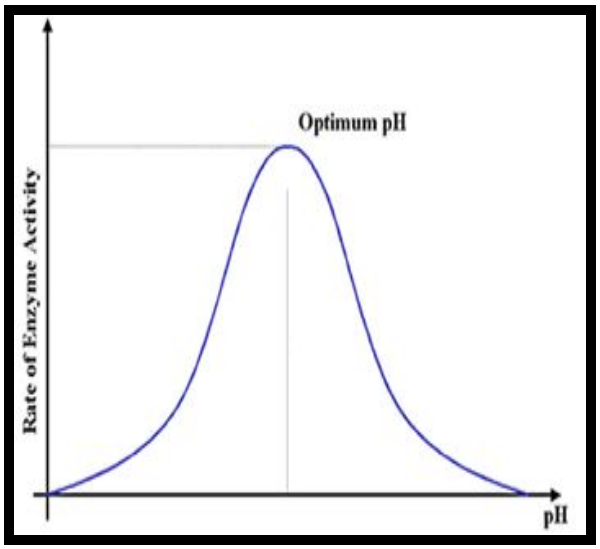
A successful reaction between a substrate and an enzyme depends on :

- Optimal pH - some enzymes work best in acidic conditions and some in basic conditions and some in neutral conditions. Wrong pH damages enzymes
- Optimum temperature - for human enzymes is 37 -40* C - lower than this, enzymes are inactivated. Higher than this enzymes start to denature
    - Enzymes are folded into a shape that accepts the substrate molecule. This is determined by the sequence of amino acids that form it
    - As you approach the optimum temp, enzymes gain kinetic energy, and so collisions with substrates are more frequent. As a result, the rate of reaction is highest
    - As you go beyond the optimum temp, bonds holding enzymes break down, the shape of the active site changes. So it is **denatured**
- Orientation of the enzyme and the substrate

Denaturing is the structural change in a protein that results in a loss (usually permanent) of its biological properties.



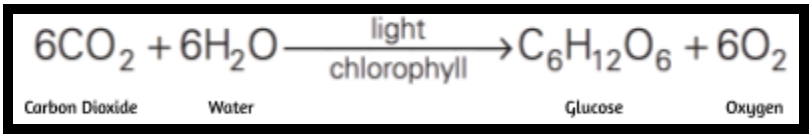
Temperature Graph



pH Graph

6.1 Photosynthesis

Photosynthesis is the process by which plants manufacture carbohydrates from raw materials using energy from light.



Light energy is absorbed by chlorophyll (found in chloroplasts). The energy from light is transferred by chlorophyll into chemical energy to drive the reactions that form carbohydrates from water and carbon dioxide. **Energy is used to split water into hydrogen ions and oxygen. The H ions are used to reduce CO_2 to $C_6H_{12}O_6$** so light energy absorbed by chlorophyll becomes the chemical bond energy in the simple sugars that are produced, and O_2 is released as a byproduct.

Requirements for photosynthesis

- **Light** - provides energy for the process
- **Chlorophyll** - traps light energy
- **Carbon dioxide** - diffuses into leaves from the air
- **Water** - absorbed by roots of the plant

Investigations

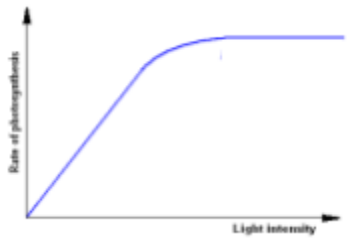
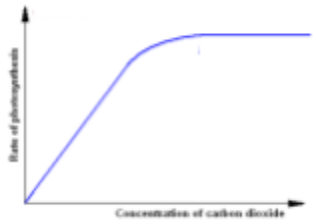
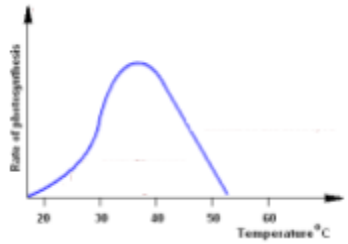
TESTING A LEAF FOR STARCH ● Place in boiling water ● Place in ethanol ● Place in a water bath ● Remove and wash in cold water ● Spread leaf on a tile and starch test it	**IMPORTANCE OF CO_2** ● Leave a destarched plant in a bag with soda lime under sunlight for few hours ● Test for starch - should be a negative test
IMPORTANCE OF CHLOROPHYLL ● Starch test one normal leaf, and one variegated leaf ● Normal leaf - fully positive ● Variegated leaf - negative where white	**IMPORTANCE OF LIGHT** ● Cover a destarched leaf with a stencil and leaf in light for a few hours ● Test for starch - covered part should be -ve

The general idea is that **photosynthesis is not successful in the absence of any of these.**

Uses of glucose as a product of photosynthesis

- Respiration
- Changed into starch and stored in stem tubers and chloroplasts
- Converted to cellulose which makes up cell walls
- Converted to sucrose for translocation
- Glucose forms proteins along with amino acids - growth and repair
- Sugars converted to oils - efficient way of storage in seeds

Rate of photosynthesis and limiting factors: A **limiting factor** is something present in the environment in such short supply that it restricts life processes

	LIGHT With increasing light intensity, the rate of photosynthesis rises to a point where it becomes constant as other limiting factors such as CO2 and temperature are stalling a quicker rate of photosynthesis. As the light intensity increases, stomata open wider, allowing more light to enter the plant
	CARBON DIOXIDE CONCENTRATION With increasing carbon dioxide concentration, the rate of photosynthesis rises to a point where it becomes constant as other limiting factors such as light intensity and temperature are stalling a quicker rate of photosynthesis
	TEMPERATURE Up to an optimum temperature for enzyme activity, the rate of photosynthesis rises. However, after this temperature, enzymes denature and the rate of photosynthesis falls quickly. To explain refer to enzymes, and how optimum temperature affects their activity. Greater kinetic energy increases the rate of reaction.

The optimum conditions for plant survival can be provided in a glasshouse.

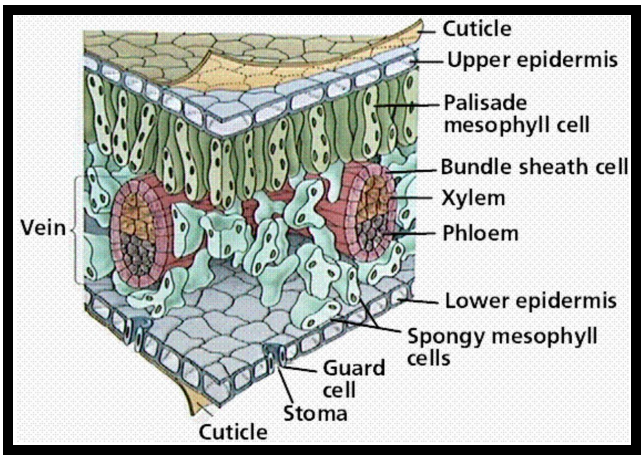
Hydrogencarbonate indicator

Plant/Animal/Both (Dark)	**(Plant + Animal)(Normal)**	**Plant (normal conditions)**
Only respiration - CO_2 which reacts with water to form carbonic acid, indicator goes yellow	Both plant and animal respire and release CO_2, but some taken by the plant, so orange.	CO_2 taken out of the water, less carbonic acid, indicator goes purple

6.2 Leaf structure

Functions of various leaf parts

Cuticle	Waterproof layer that also cuts down the water lost by evaporation
Upper epidermis	A single layer of cells with no chloroplasts. Light goes straight through
Palisade mesophyll	• Contain lots of chloroplasts - most photosynthesis occurs here • Packed very close together to maximize light absorption
Spongy mesophyll	Many air spaces (makes it easier for CO2 to diffuse) in between
Vascular bundle	Xylem and phloem transport respective substances around the plant
Lower epidermis	No thick cuticle. Lots of stomata on surface - allow gases in and out



Role of stomata and guard cells

Stomata allow three substances to move in and/or out of the leaf

- O_2
- CO_2
- H_2O vapor

Guard cells open in the morning for CO_2 to diffuse into the plant. They close at night to minimize water loss. In the morning water moves by osmosis into guard cells forcing them open. This water moves out at night and so the guard cells close.

6.3 Mineral requirements

The plant uses nitrates for the production of amino acids that are built into proteins. Proteins are used for the growth and repair of cells. A deficiency of nitrate ions results in stunted growth, weak stems, yellow dying lower leaves and upper leaves turn pale green

The plant requires magnesium to make chlorophyll. A lack of chlorophyll results in leaves turning yellow due to a lack of chlorophyll. Also as no photosynthesis takes place, plant growth is harmed.

7.1 Diet

Balanced diet - A **balanced diet** is a diet containing **nutrients** such as carbohydrates, proteins, fats, vitamins, and minerals along with water in the appropriate proportions and ensures good health and growth.

Functions of nutrients:

- **Provision of energy**
- **To allow growth and repair**
- **To regulate the body's metabolism**

Sources of nutrients

Name	Source	Use	Deficiency disease
Carbs	Rice	Simple sugars provide quick energy Starch releases much more energy after digestion	Kwashiorkor
Proteins	Meat	Broken down to amino acids, before being changed to various proteins for growth and repair	PEM
Fats	Butter	Long term energy and insulation under heart and skin	
Water		Most of body mass/ metabolism / blood / excretion	
Vit C	Citrus	Tissue repair/disease resistance/muscles and bones	Scurvy
Vit D	Milk	Strengthens bones and teeth	Rickets
Iron	Liver	Formation of hemoglobin in RBCs	Anemia
Calcium	Milk	Strengthens bones and teeth	Rickets
Fiber	Cereal	Prevents constipation / lowers blood cholesterol	CHD/Bowel cancer
Vit A	Carrots	Vision, healthy skin, immunity	Night blindness

Factors that affect nutritional requirements

AGE ● More calcium for youngsters and elderly for strengthening of bones ● More energy for children - more active	**PREGNANCY** ● Greater supply of all nutrients ● More iron is required for the formation of hemoglobin in the fetus' blood
GENDER ● Boys - more active - more energy ● Girls require more iron than boys	**BREAST-FEEDING WOMAN** ● Greater supply of calcium, vitamins, and minerals required to produce breast milk

Why can fat be bad for us?

OBESITY: The main causes of obesity include :

- High intake of fatty food and refined foods containing excess added sugar
- Little exercise
- Social and emotional stress - leads to "comfort" eating

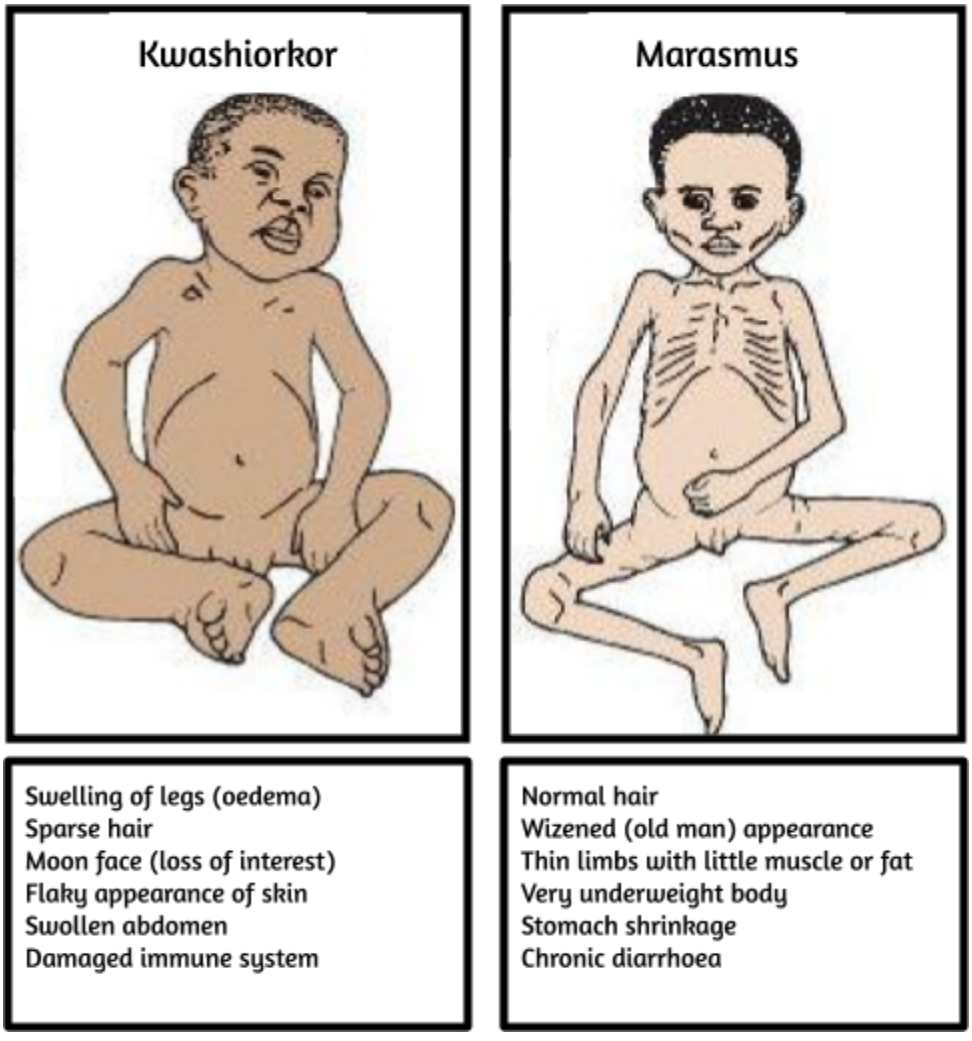
Obesity could cause multiple problems such as CHD, high BP, and diabetes

CONSTIPATION :

- Fiber adds bulk to food and allows the food to move smoothly down the alimentary canal.
- If there is too little or no fiber in the diet, food moves slowly causing constipation

Starvation and nutrient deficiency

Starvation is a period when there is no or not enough nutrient intake into the body.
The most common form of malnutrition is protein-energy malnutrition (PEM)
Its worst forms are kwashiorkor and marasmus.



7.2 Alimentary canal

INGESTION : the taking in of substances eg: food and drink, into the body through the mouth.

MECHANICAL DIGESTION : the breakdown of food into smaller pieces with no chemical change to the food molecules.

CHEMICAL DIGESTION : the breakdown of large insoluble molecules into small soluble molecules

ABSORPTION : the movement of food molecules and ions through the wall of the intestine into the blood.

ASSIMILATION: the movement of digested food molecules into the cells of the body where they are used, becoming part of the cells

EGESTION : the passing out of food that has not been digested or absorbed as faeces through the anus.

Cholera and Diarrhoea

Cholera is a waterborne disease caused by the bacterium *Vibrio cholerae*. Some of the pathogens survive and make it to the small intestine where they burrow in the wall of the small intestine and start to produce a toxin, which enters the epithelial cells and disrupts the functioning of their membranes, releasing chloride ions into the lumen of the small intestine. This creates a water potential gradient. Through osmotic movement, water moves from a region of its higher water potential in the epithelial cells to a region of its lower potential in the intestine. This causes diarrhea, which is the loss of watery feces. The loss of water and ions causes dehydration.

Oral rehydration therapy (ORT)

People suffering from cholera need to be given a dose of ORT solution to replenish the lost water and salts. An ORT contains :

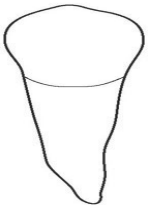
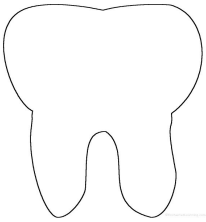
- Water to rehydrate blood and other tissues
- Sodium ions to replace the ions lost from the blood and tissue fluid
- Glucose to provide energy for the active uptake of sodium ions from the intestine
- Ions of potassium and chloride to replace ions lost in diarrhea

Parts of the alimentary canal and their functions

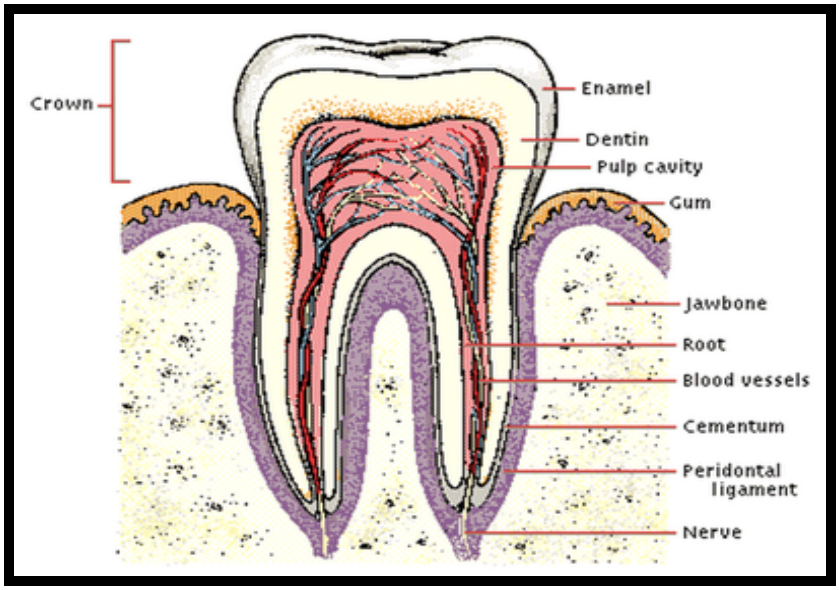
PART OF THE CANAL	FUNCTIONS
MOUTH	- To ingest food - To mix food with saliva to form bolus
SALIVARY GLANDS	- Produces and secretes saliva to the mouth. Saliva contains water, mucus, and salivary amylase
OESOPHAGUS	- Peristalsis - Behind the bolus, Circular muscles around the esophagus contract and longitudinal muscles relax to push the food down - In front of the bolus, the circular muscles relax and the longitudinal muscles contract to widen the esophagus to move the bolus down
STOMACH	- Muscle bag that mixes food with HCl and pepsin to form chyme - Acid has 2 roles = optimum pH for pepsin, and kills pathogens
DUODENUM	- Chyme passes through the pyloric sphincter into the first part of the small intestine - the duodenum, a little bit at a time - Pancreatic juice from the pancreas and bile from the liver is added here
ILEUM	- Most of the chemical digestion and absorption happens here - Maltase enzymes on the wall digest maltose to glucose
PANCREAS	- Produces pancreatic juice which contains amylase, trypsin (a protease), and lipase and transports it to the duodenum via the pancreatic duct
LIVER	- Does about 200 functions - Produces bile - Breaks down excess amino acids (Deamination) - The blood takes food from the small intestine to the liver via the hepatic portal vein.
GALLBLADDER	- Stores bile and transports it to the small intestine via the bile duct
COLON	- Absorbs any excess water from undigested and unabsorbed food
RECTUM	- Holds the feces until ready for egestion
ANUS	- Muscular sphincter to hold the feces in the rectum

7.3 Mechanical digestion

There are four types of teeth in humans - incisors, canines, premolars, and molars

Teeth type	INCISOR	CANINE	PREMOLAR	MOLAR
				
Shape	Chisel	Pointed	Uneven cusps	Like premolars
No. in humans	8	4	8	12
Position	Centrally located	After incisors	After canines	At the back
Description	1 ROOT	1 SHARP ROOT	1 ROOT	2 ROOTS
Function	Biting	Tearing	Grinding	Chewing

Structure of human teeth



Causes of dental decay and dental care

Causes of dental decay	Proper care of teeth
• Not brushing/flossing regularly • Coating of bacteria and food on teeth - the bacteria respires sugars in the food, producing acid which dissolves the enamel	• Brush teeth after meals • Avoid sugary foods between meals • Use a fluoride toothpaste/water dispenser • Visit dentist regularly for checkups

7.4 Chemical digestion

Chemical digestion is important to break down large insoluble molecules into small, soluble ones.

Functions of enzymes

Amylase in the **Mouth and the Duodenum** breaks down **Starch** to **Maltose**

Maltase attached to the **Ileum wall** breaks down **Maltose** to **Glucose**

Pepsin in the **Stomach** breaks down **Protein** to **Polypeptides**

Trypsin in the **Duodenum** breaks down **Polypeptides** to **Amino acids**

Lipase in the **Duodenum** breaks down **Fats** to **Fatty acids and Glycerol**

Amylase, Lipase, and Trypsin are made in the Pancreas and move to the intestine in the pancreatic duct

Function of Hydrochloric acid in the stomach

- Denature enzymes in bacteria in food
- Give optimum pH for pepsin activity

Bile

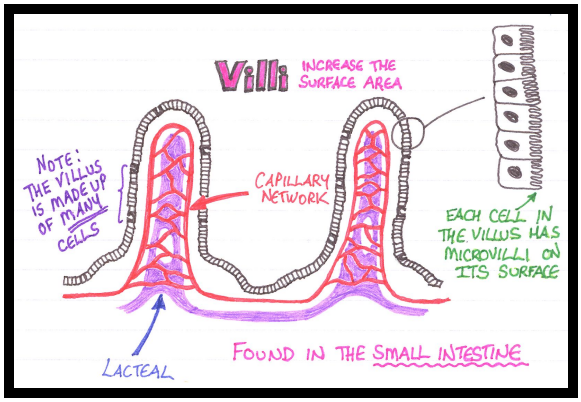
- Neutralizes the acidic mixture entering the duodenum to provide optimum pH for enzymes
- Emulsifies fat to increase the surface area for the chemical digestion of fat by lipase

7.5 Absorption

Digested food is absorbed in the small intestine. Most water is absorbed in the small intestine. Any excess is absorbed in the large intestine. The inner wall of the small intestine form folds that are called villi. Behind these villi are blood capillaries and the lacteal (part of the lymphatic system)

Adaptations

- A large number of villi and microvilli increase the surface area for absorption
- One-cell thin wall speeds up diffusion
- Blood capillaries are very close to the wall of the villi to speed up diffusion
- Lacteals branches of the lymph system that absorb and transport digested fat
    - Gut movements empty the lacteal and lymph moves slowly through lymphatic vessels and enter the blood near the heart.

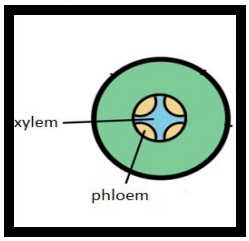
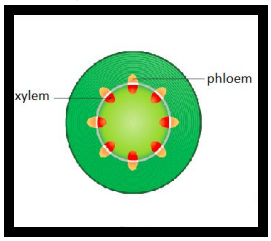
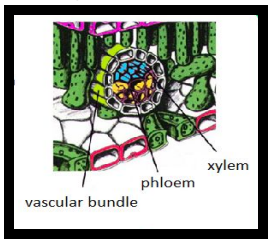


8.1 Transport in plants

The xylem and phloem vessels in plants have different structures and functions:

XYLEM	PHLOEM
Transports water and mineral ions	Transports sucrose and amino acids from sources to sinks
Unidirectional transport	Bidirectional transport
At the center of the vascular bundle in roots	Located on the outer side of the vascular bundle
Consist of tracheids and vessel elements	Consist of sieve tubes and companion cells
Tubular shape with no cross walls	Elongated tubular shape with thin-walled sieve tubes
Dead tissue at maturity so it is hollow with no cell contents	Living tissue with little cytoplasm but no nucleus/ tonoplast
Waterproof gives strength and support to the plant due to the presence of lignin	Sieve tubes have pores at each end in the cross walls
BOTH ARE PRESENT IN ROOTS, STEMS, AND LEAVES.	

Positions of xylem and phloem in different parts of the plant

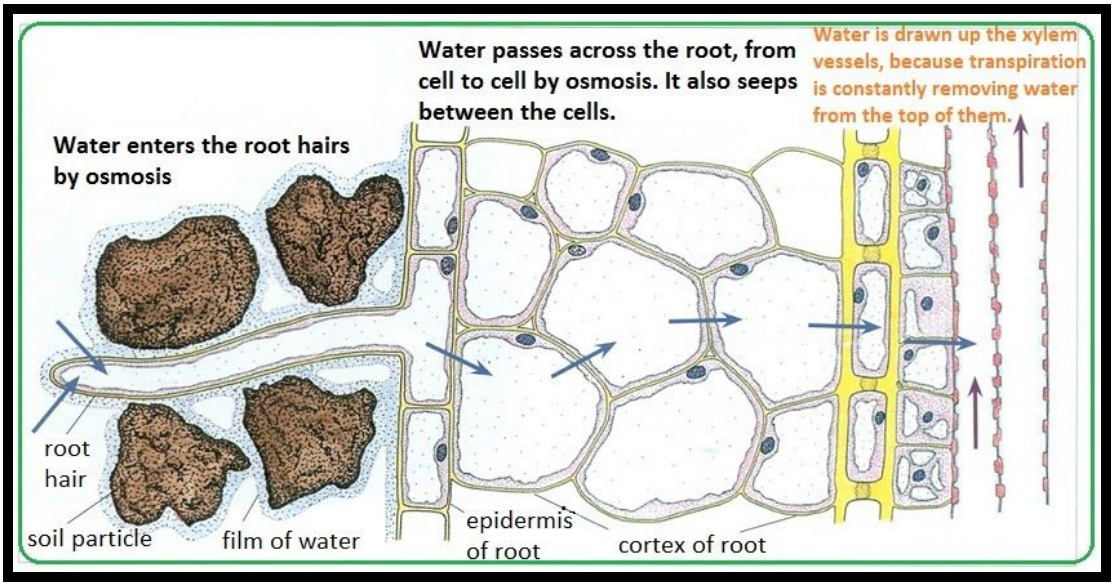
Arrangement in roots	Arrangement in stems	Arrangement in leaves
		

8.2 Water uptake

Root hairs have numerous smaller hairs and themselves are finger-like extensions of the cytoplasm, greatly increasing the surface area for the absorption of substances. Mineral ions enter the root hairs by active transport. As the water potential now in the roots is lower than in the soil water, water enters the root hair by osmosis down its potential gradient. Placing a celery stalk in a solution of red food coloring, and then cutting it in half allows us to observe the path of water above the roots - a red stain is visible along the xylem.

8.3 Transpiration

Transpiration is the loss of water vapor from plant leaves by evaporation of water at the surfaces of mesophyll cells followed by diffusion of water vapor through the stomata



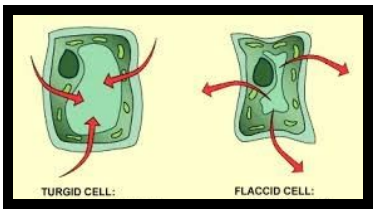
Water isn't pushed up the xylem, it is pulled by the evaporation of water. Water is pulled up the xylem from the roots to the leaves by **transpiration pull.** This pull is caused due to the constant loss of water from the leaves. The continuous flow of water is known as a **transpiration stream**.

Transpiration depends on 2 properties of water:
COHESION - water molecules tend to attract each other, sticking together in a chain
ADHESION - the water molecules tend to stick to the inside of the xylem vessel.

Wilting

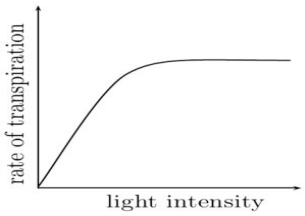
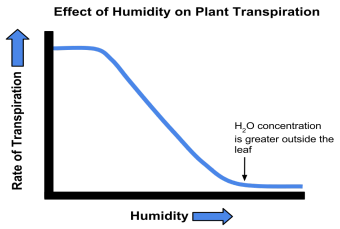
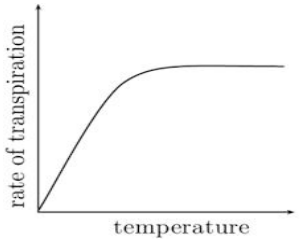
Rate of transpiration in the morning > night - stomata open only in the morning in the presence of light and to allow CO_2 to diffuse into the plant. At night the stomata are closed to reduce transpiration. They also close in hot, dry conditions when water loss is not being replenished from the roots.

When the stomata have closed and the leaves still don't get water, the plant wilts. Cells lose their turgidity and become flaccid - the plant becomes soft and weak. Stem cannot remain upright and leaves droop



Wilting can be a good thing. Plants do not get too hot as leaves droop, reducing the number of rays of sunlight that fall on them. When the temperature drops, later on, the lost water can quickly be replenished

Factors that affect the rate of transpiration (measured with a potometer - refer to P6 doc)

Light 	The rate of transpiration increases with increasing light intensity up to a certain maximum point (this varies and depends on other limiting factors - humidity, temperature). Stomata open wider as light increases therefore allowing more water vapor to leave the plant.
Humidity 	This is the measure of water vapor in the air. If the humidity of the air is high, the rate of transpiration is low due to the greater concentration in the air. If the humidity of the air is low, the rate of transpiration is high due to the greater concentration in the leaves. Therefore the water vapor leaves the leaf by diffusion from higher to lower concentration
Temperature 	In higher temperatures, the rate of transpiration is higher as water vapor molecules have more kinetic energy. This increases the rate of evaporation from the surface of the mesophyll cells

8.4 Translocation

TRANSLOCATION: The movement of sucrose and amino acids in phloem vessels from regions of production (sources) to regions where they are stored or to regions where they are used in respiration or growth (sinks)

Uses of sucrose

- Broken down into simple sugars used in respiration
- Changed to starch for storage in cortex or seeds
- Used to make cellulose for cell walls of new cells made at the root tip
- Stored in some fruits to sweeten and attract animals.

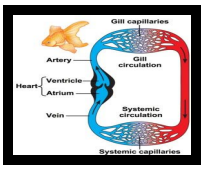
Translocation is an active process - the different parts of a plant may act as a source or a sink at different times of the life of a plant.

9.1 Circulation

The circulatory system is a system of blood vessels with a pump (the heart) and valves that ensure the one-way flow of blood.

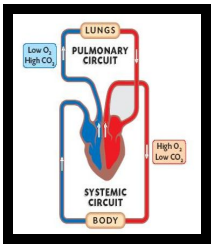
Single Circulation

Fish have single circulatory systems. In such systems, blood passes through the heart only once in one complete circulation.



Double circulation

Mammals have a double circulatory system. **This means that blood flows through the heart twice in one complete circulation.** Deoxygenated blood enters the right and is then pumped to the lungs, where it is oxygenated. It then returns to the left and is then pumped around the body. Double circulatory systems transport substances faster than single ones. Also, oxygenated and deoxygenated blood is separated by the **septum**, so they cannot mix.



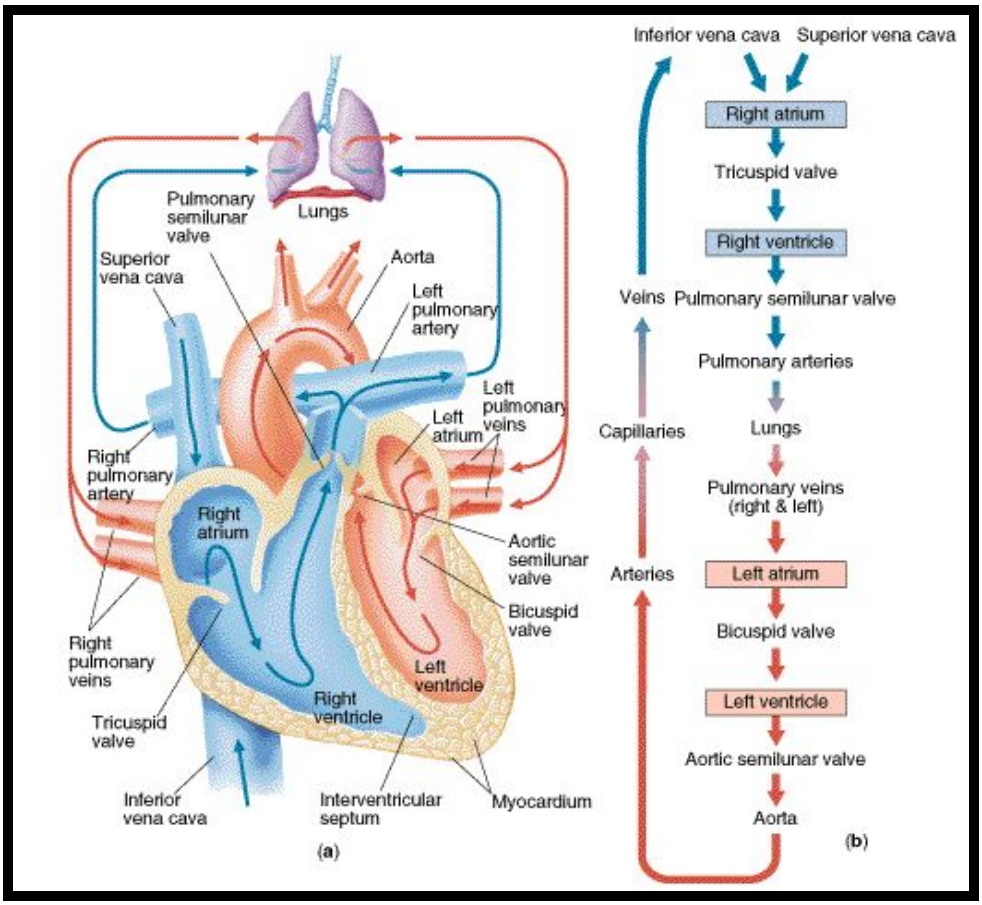
9.2 Heart

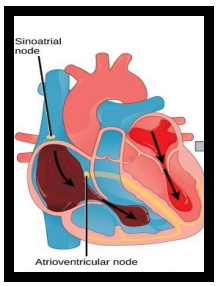
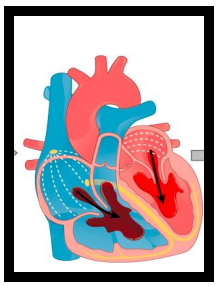
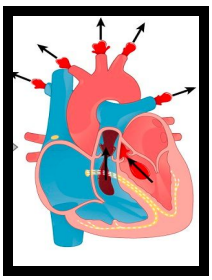
Order of thickness
Left ventricle
Right ventricle
Atria

The left ventricle pumps blood the furthest (all around the body), so thickest walls.

The right ventricle pumps to the lungs, closer to the heart.

Atria pump only within the heart, so the wall is least thickest



		
All chambers of the heart relax, and blood flows into the heart.	Atria contract and ventricles are relaxed, blood moves into ventricles Atrioventricular valves close, preventing backflow into the atria	After the atria relax, the ventricles contract pumping blood into arteries Semilunar valves then close, preventing backflow into the ventricles

Heart rate can be monitored using an electrocardiogram (ECG), pulse rate, and hearing the sound of the valves opening and closing During exercise, muscles require more energy from respiration to contract. Therefore the heart beats faster. As a result, arteries dilate (widen), increasing blood flow.
This results in:

- Increase in supplies of O_2 and glucose
- Increase in the removal of CO_2

The number of heartbeats in a minute is called pulse rate. Resting pulse rate gives an idea of a person's fitness. Always link to oxygen debt, lactic acid and anaerobic respiration (T12)

Coronary heart disease (CHD)

Coronary arteries transport blood to these heart muscles, which require O_2 and glucose for respiration. The narrowing of coronary arteries as a result of excess cholesterol sticking to the wall is known as **atherosclerosis.** Artery walls become rough and platelets in blood clot and block the vessel, forming a thrombosis. A total thrombosis of the coronary artery means that no oxygen gets to the heart muscles, and the heart stops beating altogether. This is known as cardiac arrest. A pain caused in the chest area due to thrombosis is called **angina**. This should act as a warning for a **heart attack**

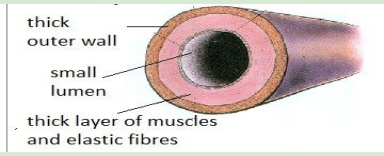
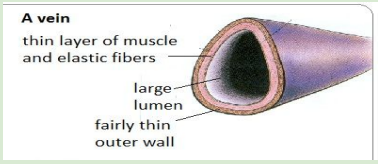
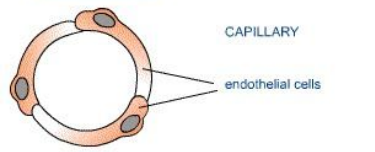
Risk factors for CHD include a high cholesterol diet, a lack of exercise, smoking, and stress. Some factors such as a genetic predisposition, age, and gender cannot be avoided

CHD Treatment

- **Coronary artery bypass**
  - An artery from another part of the body (arms or legs) is taken and attached above and below the blocked area. Several grafts may be required if it is a serious case.
- **Angioplasty -** A balloon is inflated to widen the artery, and a stent holds it in place
- **Aspirin -** thins the blood

9.3 Blood and lymphatic vessels

ORGAN	IMPORTANT ARTERIES AND VEINS
HEART	Heart - Coronary artery - heart muscles - coronary vein - heart
LUNG	Heart - pulmonary artery - lungs - pulmonary vein - heart
LIVER	Heart - aorta - hepatic artery - liver - hepatic vein - vena cava - heart
KIDNEY	Heart - aorta - renal artery - kidneys - renal vein - vena cava heart
SMALL INTESTINE	Heart - aorta - mesenteric artery - small intestine - hepatic portal vein - liver - hepatic vein - vena cava - heart

BLOOD VESSEL	IMAGE	STRUCTURE	FUNCTION
ARTERIES		• Thick, muscular wall consisting of elastic and fibrous tissue • Narrow lumen, which can vary according to heartbeat	• To withstand blood pressure, preventing bursting of the blood vessel • Ensuring the one-way flow of blood
VEINS		• Thin walls with little fibrous and muscular tissue • Large lumen • Contain valves	• Necessity for a thick wall is gone as blood pressure has been lost • Less resistance to blood flow • Valves prevent backflow
CAPILLARIES		• One cell thick walls • Narrow enough for one RBC to get through only	• Reduce substances' diffusion distance • Vessels can squeeze around every cell in the body

Arterioles are branches of arteries, which allows the transport of blood to all parts of the body
Venules are the branches that connect to veins, which receive 'used' blood from all parts of the body
Shunt vessels are vessels that direct blood directly from an artery to a vein

Lymphatic system

When blood reaches tissues, some of the blood plasma moves into small gaps between cells, forming tissue fluid. WBCs can change shape and enter tissue fluid, however, RBCs cannot. Cells are 'bathed' in tissue fluid, making it easier for oxygen and glucose to diffuse into cells and wastes like carbon dioxide and urea to diffuse out into tissue fluid

These wastes cannot remain amongst the cells. Most of the tissue fluid enters lymphatic vessels and is converted into the lymph. Lymph vessels are similar to veins and the lymph is slowly moved by the

contraction of surrounding muscles. Small lymph vessels join into two large ones and the lymph is emptied into the **subclavian veins** under the collar bone. The lymph mixes with blood in the vena cava before it enters the heart.

The lymphatic system:

- Filters bacteria, foreign materials, toxins and any harmful materials.
- Drains away excess fluid to prevent water clogging of the tissues and cells.
- Transports proteins back into the blood supply.
- Produces lymphocytes which protect and defend the body against infection.
- Produces antibodies to fight bacteria.
- Absorbs fat from the intestine and transport it to the liver.

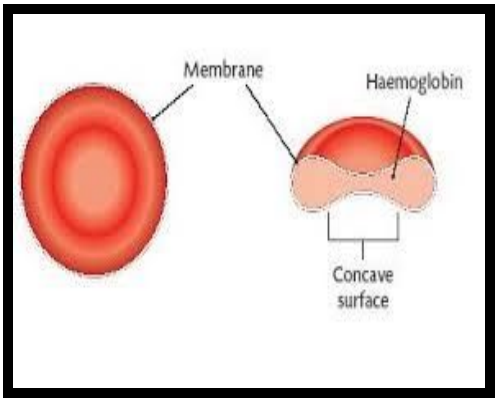
9.4 Blood

Blood is made of cell fragments suspended in a yellow liquid called plasma, which consists of many nutrients, wastes, blood proteins, and hormones dissolved in water. The red color of blood is due to the presence of hemoglobin in RBCs. There are three main types of cells in blood:

- Red blood cells: have no nucleus and have cytoplasm that is full of hemoglobin - traps oxygen for transport around the body
- White blood cells: contain nuclei and responsible for disease prevention
- Platelets: tiny cell fragments that cause blood to clot. Transport ions, nutrients (glucose and amino acids), CO_2, and hormones

The main function of RBCs is the transport of oxygen. Hemoglobin is made of iron. Hemoglobin combines with oxygen to make oxyhemoglobin

Cell Structure	Adaptation to Function
Contains haemoglobin	Haemoglobin transports oxygen from the lungs to all parts of the body.
No nucleus	Carry more haemoglobin which leads to increased transport of oxygen.
Circular biconcave shape	Increased surface area to volume ratio of the cell. Hence, increased transport of oxygen.



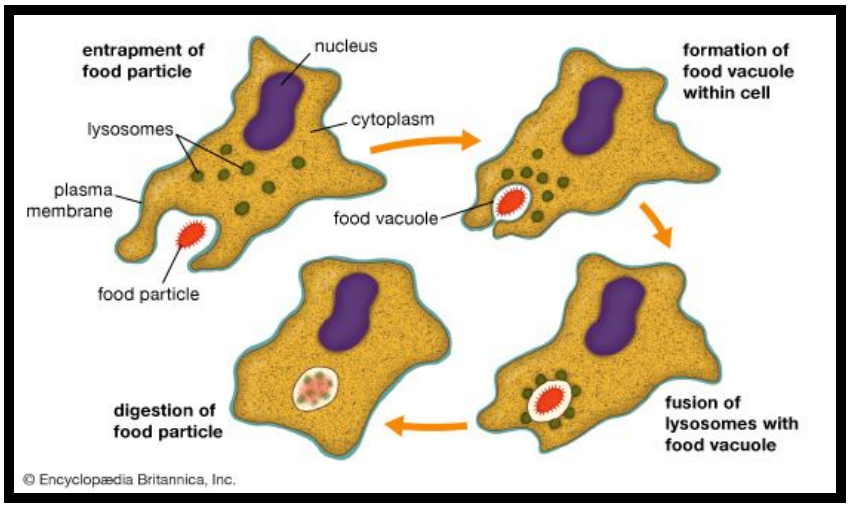
White blood cells

There are two types of WBCs:

- Phagocytes
- Lymphocytes

Phagocytes

These WBCs ingest pathogens such as bacteria. They surround the pathogen and take them into food vacuoles. This process is known as phagocytosis.



Lymphocytes

Each lymphocyte is specifically made for a certain pathogen. Lymphocytes produce antibodies that have unique cell surface receptors. The receptors only bind to a certain antigen (antigens are small extensions of the pathogen)

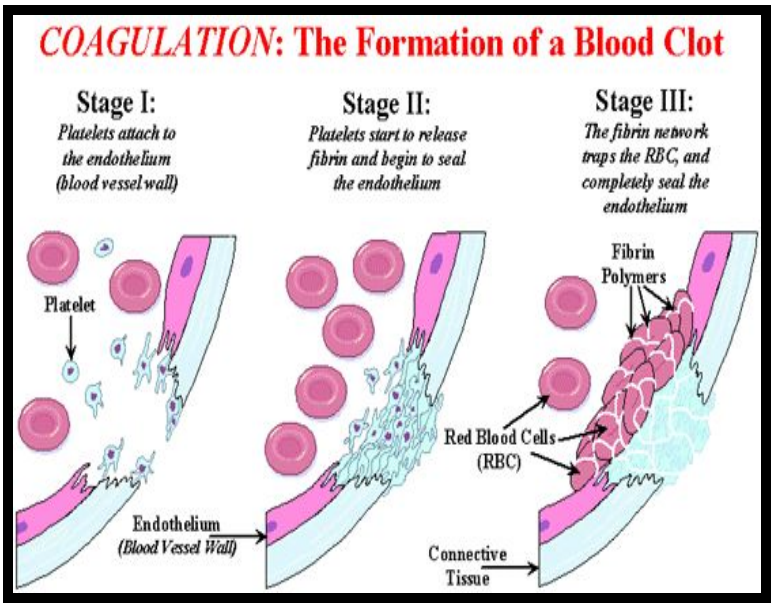
Antibodies have three ways of attacking a pathogen:

- They make them stick together - makes them immobile (agglutinate)
- They dissolve their cell membranes - water enters the cell and they burst
- Antitoxins (a type of antibody) neutralize pathogenic toxins.

While referring to WBCs, never say 'WBCs'. Instead, refer to them as lymphocytes or phagocytes

Blood clotting

When a blood vessel is damaged, platelets release substances that change the soluble substance in the blood called fibrinogen into insoluble fibrin. Fibrin is a thread-like substance that forms a mesh over the damaged area. RBCs get trapped in the mesh, forming a clot. The clot hardens forming a scab that falls off over time. This process prevents excessive blood loss and pathogens entering the body



Diseases and immunity

A **pathogen** is a disease-causing organism

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

These diseases may be transmitted directly through **blood** or **other body fluids**, or indirectly through **contaminated food and drink, animals, and the air**

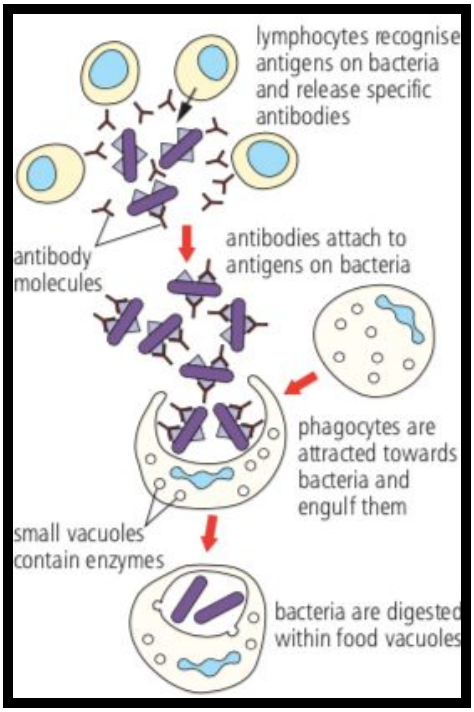
Body's defense to disease

Mechanical barriers such as ● Skin ● Hair in the nose	**Chemical barriers** such as: ● Stomach HCl ● Mucus in the trachea
Cells ● Phagocytosis ● Antibody production by lymphocytes	The body's defenses can be enhanced by **vaccinations**

White blood cells

Lymphocytes

Lymphocytes produce antibodies that have unique cell surface receptors. The receptors only bind to a certain **antigen** (antigens are small extensions of the pathogen). The activation of lymphocytes is called an **immune response**



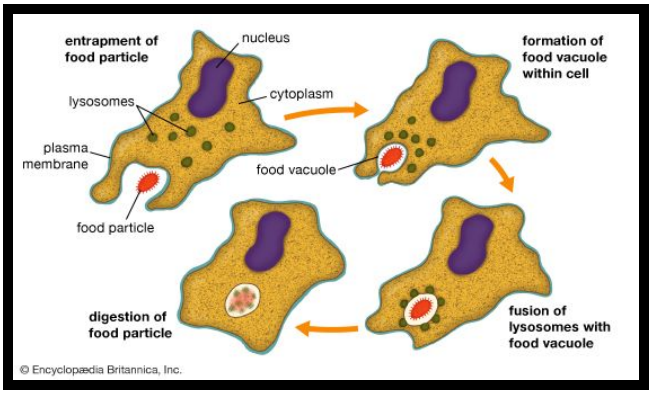
Antibodies have three ways of attacking a pathogen:

- They make them stick together (agglutinate) - makes them immobile
- Prevent flagella from moving - also makes them immobile
- They dissolve their cell membranes - water enters the cell and they burst
- Antitoxins (a type of antibody) neutralize pathogenic toxins.
- Marking their positions for phagocytes to destroy

Active immunity is a defense against a pathogen by antibody production in the body. This is gained after an infection from a pathogen or after a vaccination.

Phagocytes

These WBCs ingest pathogens such as bacteria. They surround the pathogen and take them into food vacuoles. This process is known as **phagocytosis**



Vaccination

- The patient is given a dose of **dead or inactive pathogen**, which contain antigens
- Antigens trigger an **immune response**, causing lymphocytes to produce antibodies
- Weak pathogen is easily defeated
- **Memory cells** remain in the body, so the next time a pathogen attacks, the body is prepared
- The vaccinated individual now has active immunity
- Vaccination reduces the number of people that can catch a disease and spread it to others.

Passive immunity is a short-term defense against a pathogen by antibodies acquired from another individual, e.g. mother to infant. If protection is required in a hurry, antibodies can be given through an injection. In passive immunity, memory cells are not created as lymphocytes are not triggered

When an infant is growing in a mother's womb, antibodies pass through the placenta into the baby's body. The immunity is only **short term** though as the baby's body soon treats the antibodies as foreign and kills them

Malfunction of the immune system

Sometimes, the immune system treats our antigens as foreign and prompts an immune response. As a result, healthy tissues are destroyed. This can cause a variety of diseases known as autoimmune diseases. Eg: rheumatoid arthritis, multiple sclerosis, and Type 1 diabetes.

Type 1 Diabetes

This occurs when the immune system attacks and destroys pancreatic cells that make insulin. Insulin is responsible for controlling the glucose concentration in the blood. When food is consumed, insulin stimulates the absorption of food and instructs the liver to store glucose as glycogen.

The symptoms of Type 1 Diabetes are:

- Weight loss - cells use protein and fat instead of glucose as sources of energy
- Thirst - due to increased concentration of glucose in the blood (decreased water potential)
- Tiredness - due to lack of glycogen that can be converted to glucose

Disease prevention

- Personal hygiene
- Hygienic food preparation
- Proper waste disposal
- Sewage treatment

Gas Exchange in Humans

Features and functions of the breathing system

Feature	Function
Bronchioles split to form many alveoli	Large surface area for gas exchange
Alveolar surface is moist	Allows gases to dissolve in water for diffusion
Wall of alveoli and capillaries are one cell thick	Allows for efficient diffusion of gases
Network of blood capillaries	Quick diffusion of gases
Quick ventilation process	O_2 inhaled quickly, CO_2 exhaled quickly

Function of cartilage in the trachea:

In the **trachea,** there is **tracheal cartilage**. **Cartilage** is a strong but flexible tissue. The tracheal cartilages help support the **trachea** while still allowing it to move and flex during breathing.

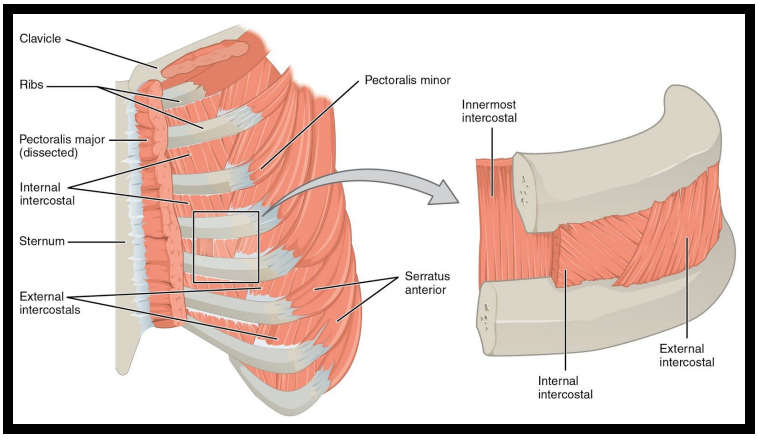
Ventilation process

Inspiration

1. External intercostal muscles contract and internal intercostal muscles relax
2. This raises the ribs upwards and outwards
3. At the same time, the diaphragm contracts and flattens
4. Both these movements increase the volume in the thorax, decreasing the pressure
5. Since atmospheric pressure is greater, air moves into the lungs and they inflate

Expiration

1. The internal intercostal muscles contract and the external intercostal muscles relax
2. This lowers the ribs downwards and inwards
3. At the same time, the diaphragm relaxes and bulges upwards
4. These actions decrease the volume in the thorax, increase pressure in the thorax
5. Since atmospheric pressure is lower, air moves out of the lungs

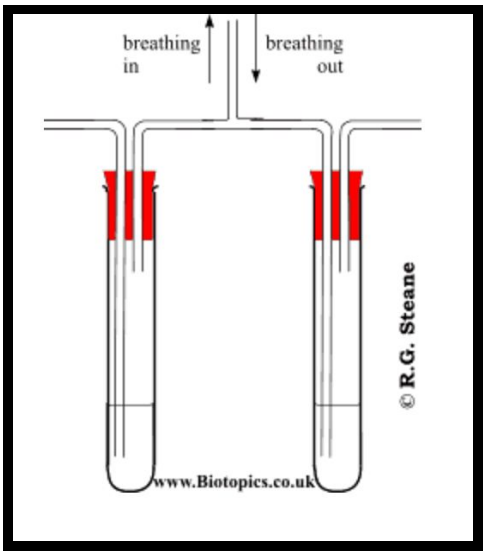


The two types of intercostal muscles contract and expand accordingly to allow inspiration and expiration

Compositions of inspired and expired air

Constituent	Inhaled air	Exhaled air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	78%	78%
Water vapor	Variable	Variable but more saturated than inspired air

Experiment to test for the differences in the volume of CO2 between inspired and expired air:



The test tubes are both filled with lime water which turns cloudy when CO2 is present.

The test tube on the right will turn cloudy because the air we breathe in contains about 0.04% carbon dioxide while the air we breathe out contains about 4% carbon dioxide.

Hence the air we exhale contains about 100 times the concentration of CO2 compared to the air we inhale.

Rate and depth of breathing :

Increases with exercise. On working, muscles require more oxygen for respiration. They also need to expel more carbon dioxide. The maximum amount of air that can be inhaled is known as vital capacity.

Control of breathing

When you respire more, the increase in the production of CO_2 reduces the pH in the tissues and the blood. They may also make lactic acid from anaerobic respiration which has the same effect. The brain detects this drop in pH and sends nerve impulses to the diaphragm and intercostal muscles to contract faster and increase the rate and depth of breathing. By breathing deeper and more rapidly, more O_2 is supplied to cells for respiration, and more CO_2 is removed from the body, reducing the pH. This is an example of **homeostasis**.

Cleaning air

Goblet cells in the trachea release mucus that traps any dirt, dust, or pathogens. This is then swept by ciliated epithelial cells into the gullet to be swallowed.

12.1 Respiration

There are various uses of energy in the human body. Some of these are:

- Muscle contraction
- Protein synthesis
- Cell division
- Active transport during absorption in the villi
- Growth
- Sending impulses along nerves
- Maintaining the body temperature

Respiration involves the action of enzymes in cells

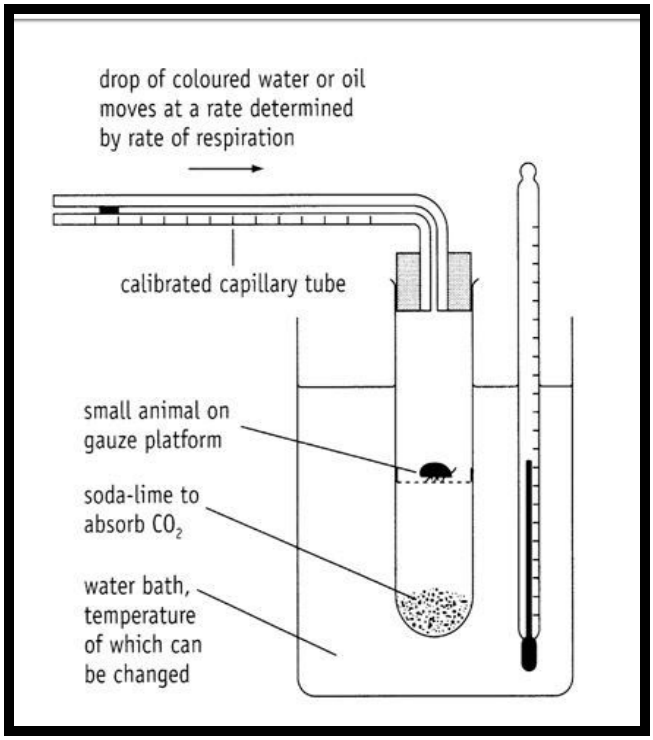
12.2 Aerobic respiration

Aerobic respiration involves the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy

AEROBIC RESPIRATION FORMULA

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

Glucose Oxygen Carbon Dioxide Water Energy



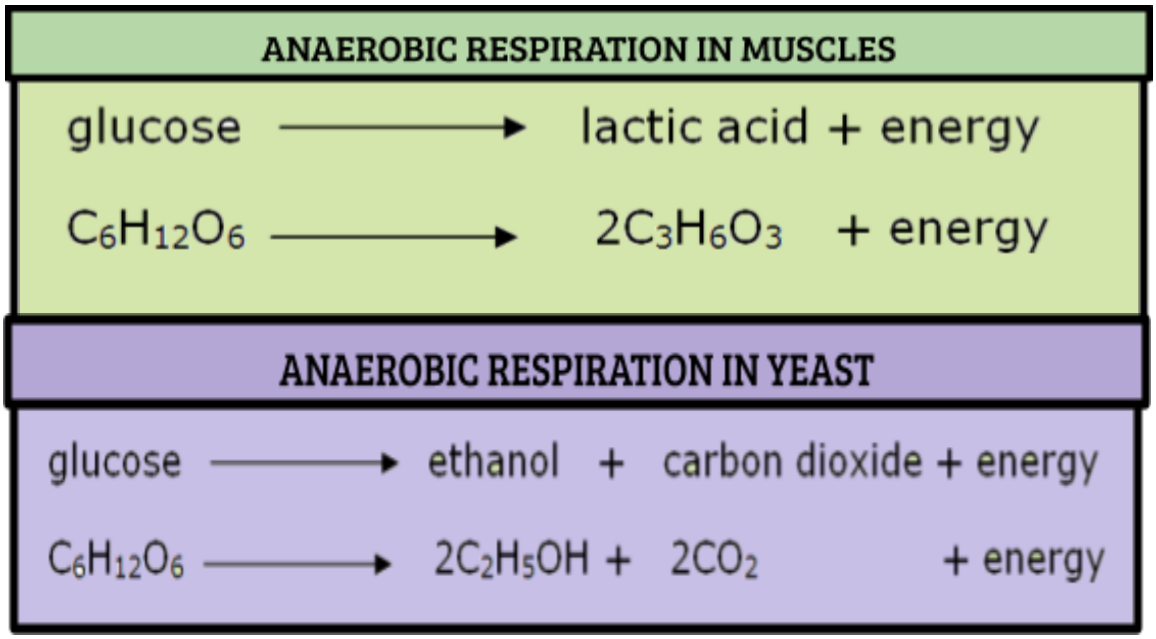
This apparatus can be used to measure rates of respiration at different temperatures (which is varied by placing different temperatures of water in the beaker)

If only respiration is being observed with no independent variable involved, the beaker setup with water is not required.

In both cases, the organism would respire taking in oxygen and releasing CO_2 which is absorbed by the soda lime. Since the air absorbed is not being replaced, the drop of colored water moves along the capillary tube. In the case of measuring how temp. affects respiration, the faster the drop moves, the higher the rate of respiration. The same experiment can be used with a germinating seed

12.3 Anaerobic respiration

Anaerobic respiration involves the chemical reactions in cells that break down nutrient molecules to release energy without using oxygen



Anaerobic respiration releases much less energy per glucose molecule than aerobic respiration

	Energy released (kJ/g^{-1} glucose)
Aerobic respiration	16.1
Fermentation by yeast	1.2
Anaerobic in muscles	0.8

Lactic acid and oxygen debt

During vigorous exercise, the muscles of the body perform anaerobic respiration releasing lactic acid. Lactic acid can slowly poison muscles and cause cramps, so it must be removed from the body. The buildup of lactic acid in the body causes **oxygen debt**. This is the amount of oxygen required after exercise **to facilitate the breakdown of lactic acid** in the body.

After vigorous exercise, lactic acid is rapidly transported to the liver to be broken down. The heart continues to pump blood faster after exercise to quickly transport lactic acid to the liver. We carry on breathing faster and deeper to supply more oxygen for aerobic respiration to break down the lactic acid in the liver even after completing the exercise.

Excretion is the removal from the body of the waste products of metabolism, toxic substances, and substances over the requirement. These are removed by the lungs, liver, and kidneys - the excretory organs. Excretion is important, as urea and CO_2 are toxic materials, and must be expelled.

Excretory products

- **Carbon dioxide** - is made during respiration. It is transported to the lungs in the blood plasma. Here, it diffuses out of the blood into the air in the alveoli and is breathed out
- **Urea** is made in the liver from excess amino acids. It is carried to the kidneys in the plasma where it is filtered out and leaves the body dissolved in urine.

Urea, excess water, and salts make up **urine**, which is excreted by the **kidneys**. The volume and concentration of urine is affected by: Water intake, Temperature, Exercise

Assimilation

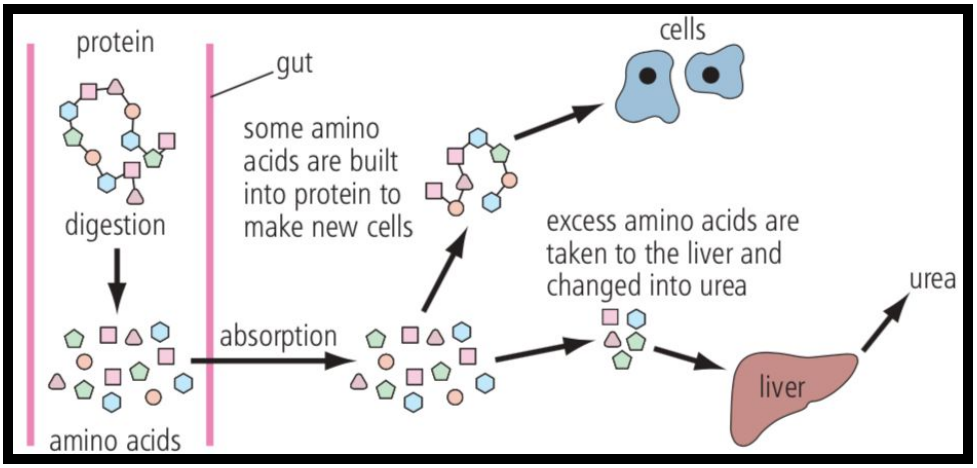
Assimilation is the process by which digested food molecules move into cells where they are used, becoming part of the cells. The liver carries out several functions as part of assimilation:

- Stores glycogen (polysaccharide of glucose)
- Uses amino acids to make proteins, such as plasma proteins, e.g. fibrinogen
- Breaks down excess amino acids to urea (deamination)
- Converts fatty acids and glycerol into fat which is stored around the body
- Produces cholesterol from fats

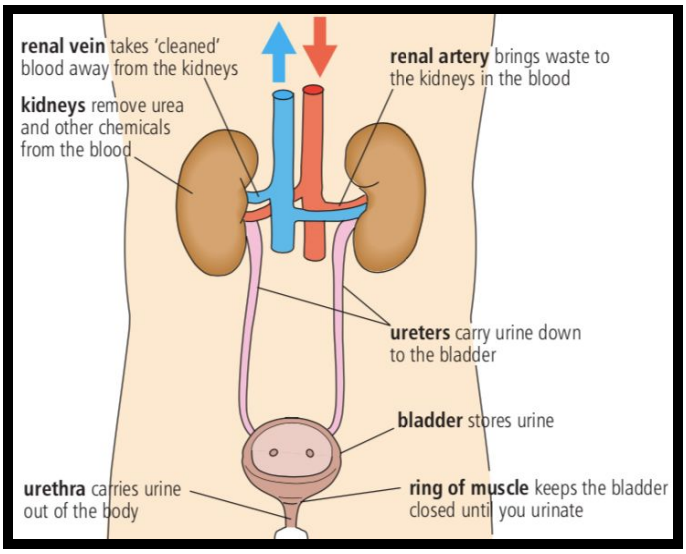
Roles of the liver

- Everything under assimilation
- Making bile
- Breaks down hormones after use
- Breaks down harmful substances such as alcohol

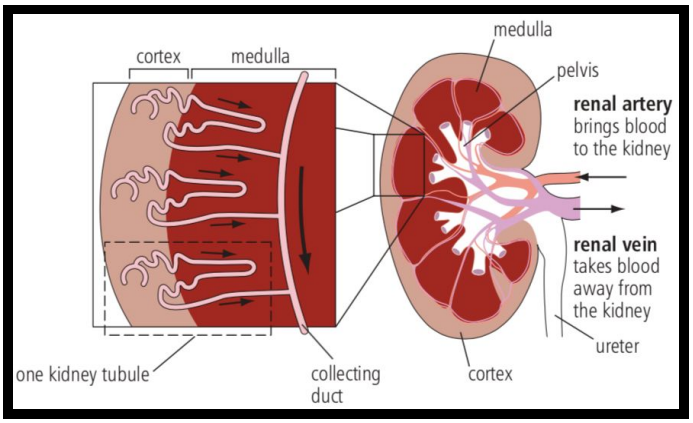
Amino acids that cannot be used in the body undergo **deamination**. Deamination is the removal of the nitrogen-containing part of amino acids to form urea



The kidneys

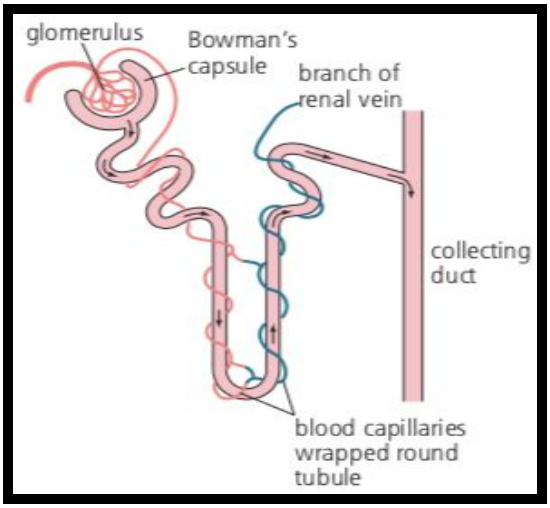


The kidneys are part of the **urinary system**. Blood enters the kidneys through the **renal arteries**. Inside each kidney is a complex network of filtering units called **kidney tubules**.



Inside the kidney

The function of the **kidney tubules** is to filter the blood, remove waste chemicals, and determine how much water is excreted. The filtering is carried out in the **cortex**. The waste chemicals and excess water are removed from the body in the urine which flows from the kidneys down the **ureter** and is stored in the **bladder**.

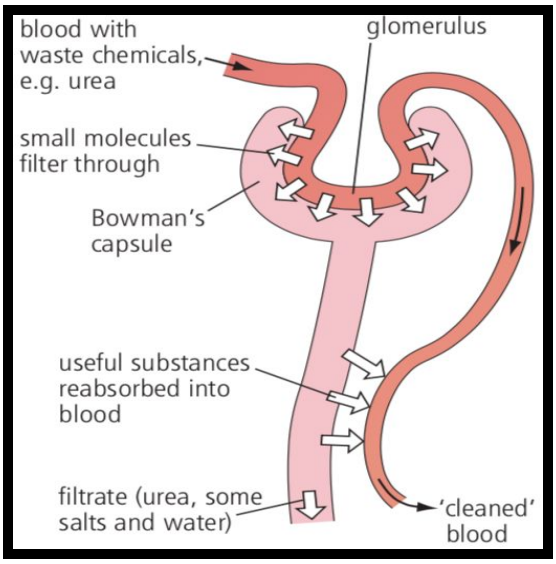


Structure and functioning of a kidney tubule

Once inside the kidney, the renal artery branches many times to give arterioles. Each of these arterioles supplies blood to a closely packed group of capillaries called a **glomerulus**. After filtration, blood flows out of the glomerulus, eventually ending up in the renal vein. The glomerulus is found inside the Bowman's capsule. The end of the kidney tubule drains into a **collecting duct** that goes through the medulla and empties urine in the pelvis, which then flows into the ureter.

Filtration

The blood vessel entering the glomerulus is wider than the one leaving it, so there must be more blood entering the glomerulus than there is leaving it. This causes pressure to increase inside the glomerulus. It is this pressure that causes the blood to be filtered.



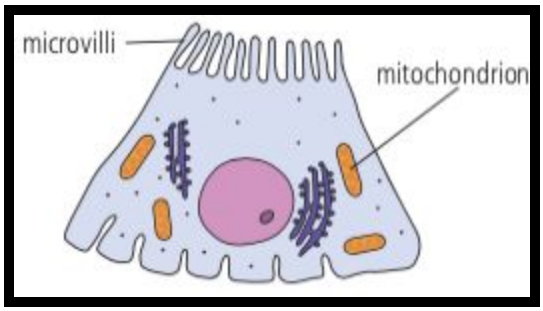
The lining of the capillaries is like a net. Blood cells and large molecules, like blood proteins, are too big to pass through the capillary lining and so stay in the blood. Small molecules, like urea, glucose, salts, and water, pass out of the glomerulus and into the Bowman's capsule. It is in this space that the filtrate collects.

Reabsorption

All of the glucose, some salts, and much of the water is needed by the body. They are **reabsorbed** back into the blood from the kidney tubule. This reabsorption involves **active transport**

Adaptations of cells in the wall of the tubule include:

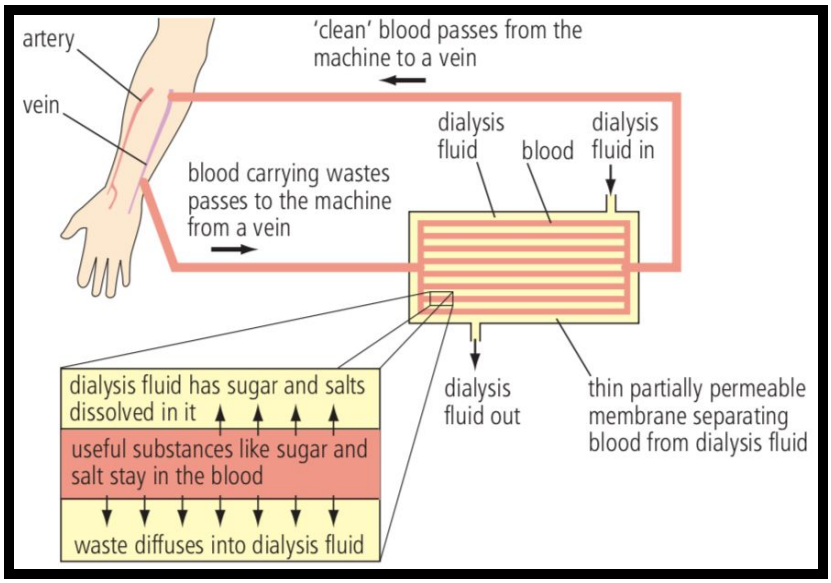
- **Microvilli** that increase S.A for absorption
- Plenty of **mitochondria** provide energy for active transport



After the process of reabsorption, what is left is urea and excess salts dissolved in water. As this fluid flows through the tubule, some water may be reabsorbed if the body is low in the water. The fluid that enters the collecting ducts is urine

Kidney dialysis

This procedure is required when both kidneys are damaged. An indicator for the requirement of dialysis is the presence of protein in the urine, as a result of a damaged glomerulus.



Explanation of dialysis treatment

- A tube is connected to the patient's veins so blood flows into the machine.
- Inside the machine, the blood is pumped over the surface of a dialysis membrane, which separates the patient's blood and the dialysis fluid.
- Urea diffuses out of the blood (NOT present in dialysate), across the **dialysis membrane,** and into the dialysis fluid, from higher to lower concentration
- The dialysis fluid already has glucose and salts in it, so there will be no overall loss of glucose and salts from the blood by diffusion into the fluid. (**Dialysate** has the same concentration of salts, glucose and same water potential as blood)
- Urea and other waste chemicals leave the machine in the dialysis fluid
- The patient's 'cleaner' blood passes back into the vein.

This process must be done for at least 15 hours a week (3 5-hour sessions). Patients must have a restricted diet with minimal protein and salt intake between treatments.

Advantages and disadvantages of kidney transplant compared to kidney dialysis

Advantages	**Disadvantages**
• No regular treatments at dialysis center • No restricted diet • No periods of feeling unwell	• Require immunosuppressant • Risk of infection during/after operation • Rejection of kidney (donor compatibility)

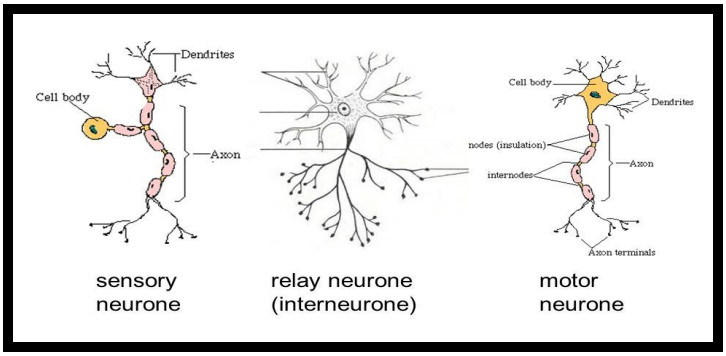
14.1 Nervous control in humans

A nerve impulse is an electrical signal that passes along nerve cells called **neurons**.
The human nervous system consists of two parts:

1. Central Nervous System
    a. Brain (protected by skull)
    b. Spinal Cord (protected by vertebral column)
2. Peripheral Nervous System: consists of the neurons

Receptors: are parts of the body that detect stimuli (Eg: Pain sensors in the skin)
Coordinators: are parts of the body that pass on info about stimuli to the effector
Effectors: are parts of the body that make a respond to the stimuli (Eg: muscles)

There are three types of neurons:

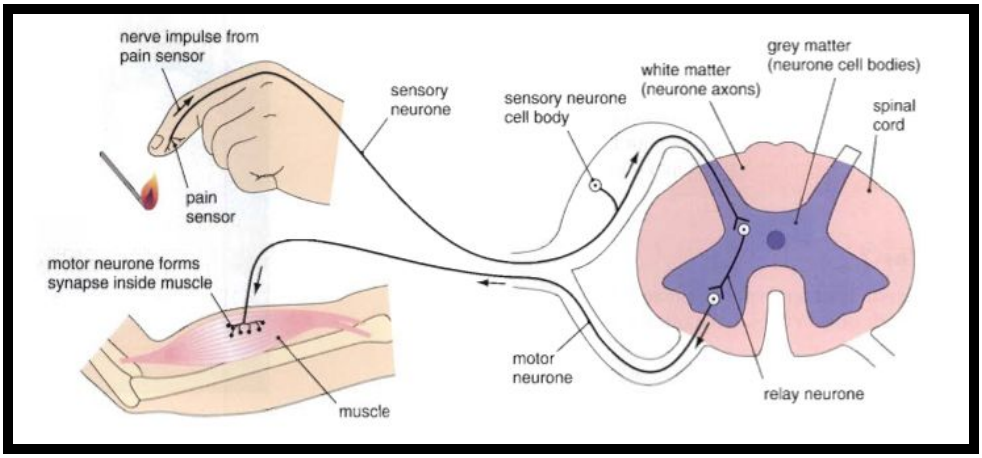


Voluntary and involuntary actions

Voluntary actions are those we choose to make and the decisions to make them occur in our brains. These are also known as cranial reflexes as impulses are sent to the brain before a decision is made. Involuntary actions that occur unconsciously. They are also known as spinal reflexes, as impulses don't reach the brain.

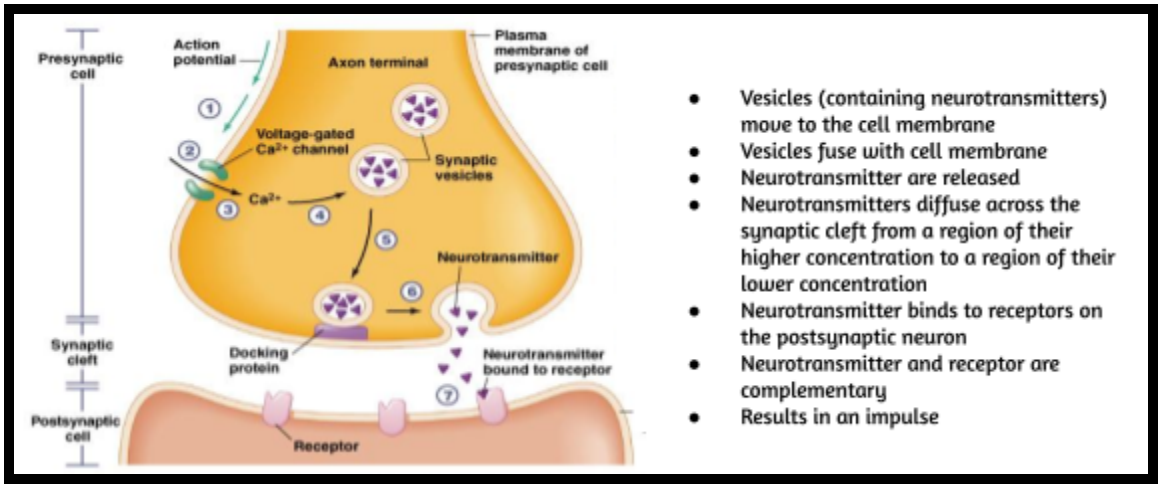
Reflex Arcs

Reflex reactions are a means of automatically and rapidly integrating and coordinating stimuli with the responses of effectors (muscles and glands)



Synapses

The junction between 2 neurons is known as a synapse. The signal that travels through nerves to a target (axons) is called an action potential. Below are a diagram and the process of passing impulses from one neuron to another. In a reflex arc, synapses ensure unidirectional travel of impulses



The effect of drugs on synaptic transmission

Drugs influence the transmission of impulses by influencing the release of neurotransmitters by interacting with receptors either by stimulating them or by inhibiting them.

Amphetamines and other excitatory drugs stimulate the release of neurotransmitters in the brain, which makes the person more alert. This may also suppress appetite.

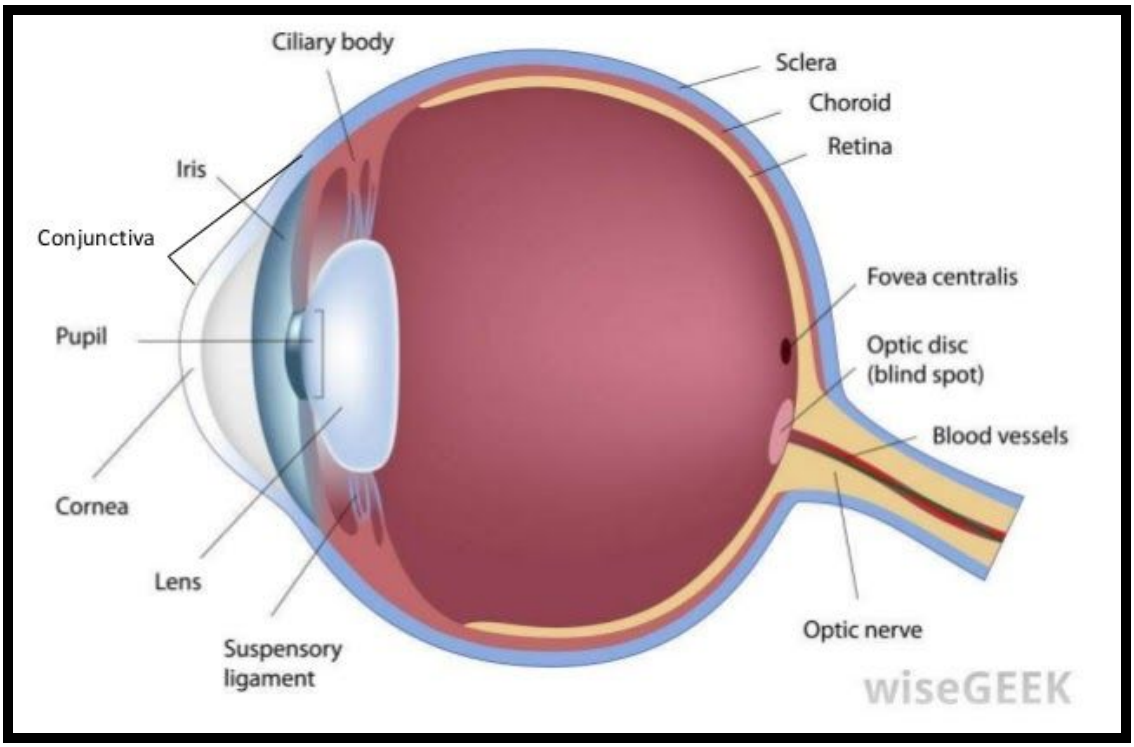
Heroin and beta-blockers are inhibitory drugs. These drugs reduce the release of neurotransmitters by acting on neuron membranes. **Heroin acts on the postsynaptic neuron to reduce the transmission of neurotransmitters, and this reduces the sensation of pain and creates a feeling of euphoria**.

- Heroin diffuses into synapse
- Heroin is similar to endorphin - used for pain and stress relief
- Heroin binds to receptors (for neurotransmitter)
- Blocks neurotransmitter entering receptor site
- Feeling of euphoria

Beta-blockers are taken to reduce BP and heart rate. Beta-blockers lodge themselves in the receptors of postsynaptic neurons, preventing impulses from flowing.

14.2 Sense organs

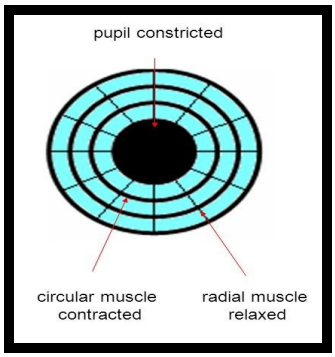
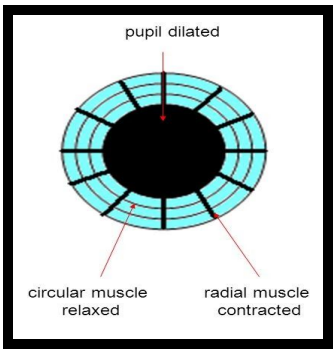
The sense organs are a group of receptor cells that respond to specific stimuli: light, sound, touch, temperature, and chemicals.



STRUCTURE	DESCRIPTION	FUNCTION
Cornea	The front part of the sclera. Is convex and transparent	Protects the front of the eye and refracts light
Iris	Pigmented so light cannot pass through. Muscles contract and relax to control the size of the pupil.	Protects the photoreceptors in the retina from being damaged by too much light.
Lens	Transparent, biconvex, flexible disc behind the iris attached by the suspensory ligaments to the ciliary muscles	Brings light entering through the pupil to a focus on the retina
Retina	Lining of the back of the eye containing rods and cones	Screen on which images are formed as a result of light being focused onto it by the cornea and lens
Optic nerve	Bundle of sensory neurons at the back of the eye	Carries signals from the photoreceptors to the brain

Pupil reflex

Radial and circular muscles are an antagonistic pair. This means they work together, but their effects are produced by contrasting actions.

In bright light, Radial muscles relax, and circular muscles contract causing the pupil to constrict. This reduces the amount of light entering the eye, protecting the retina.	In the dim light, radial muscles contract and circular muscles relax causing the pupil to dilate. This increases the amount of light entering the eye
	

Accommodation

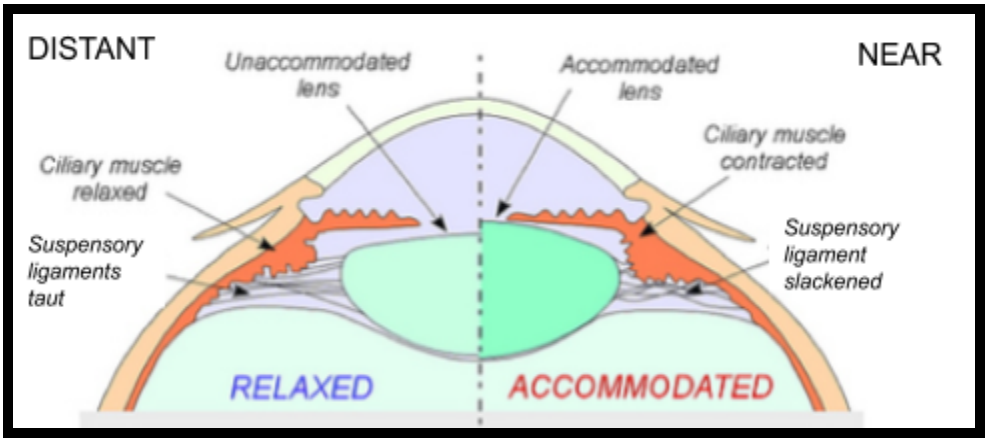
Accommodation is the term used to describe the changes that occur in the eye when focusing on far and near objects. As light enters the eye, it must be bent so that the image can be seen clearly. Most of the refraction is done by the cornea and some by the lens. The shape of the lens is controlled by the antagonistic muscle pair consisting of the ciliary muscle and the suspensory ligaments.

For a distant object:

- Ciliary muscles relax
- The pressure inside the eye pulls the suspensory ligaments tight, pulling the lens into an elliptical shape.

For a near object:

- Ciliary muscles contract to counteract the pressure in the eye
- Suspensory ligaments become slackened and the lens has a more circular shape



Rods and cones

There are two types of photoreceptors in the eye:

- Rods
  - Sensitive to levels of low light and send impulses when it is dark.
  - Black and white
- Cones
  - Sensitive to light of high intensity
  - Three types (Red, Blue and Green) (Mixtures of these are also found)

The fovea is the center of the retina contains cones and no rods. Each cone has its neuron to the brain so this area in the middle of our visual field gives us a very detailed image. The rest of the retina contains rods and few cones. This area gives us our peripheral vision which is not as detailed.

Hormones in humans

A **hormone** is a chemical substance produced by an **endocrine gland** (release hormones directly into the blood) and carried by the blood, which alters the activity of one or more of the specific target organs. **Exocrine glands** carry out chemical secretions. (Eg: Saliva glands)

Endocrine gland	Hormone(s)	Effect
Pituitary gland	FSH, LH	Controls growth, sperm and egg production
Adrenal glands	Adrenaline	Released in fight or flight situations
Pancreas	Insulin, glucagon	Insulin lowers blood glucose, glucagon increases it
Testes (Males)	Testosterone	Stimulates development during puberty
Ovaries (Females)	Oestrogen	Control menstrual cycle and stimulate development

Adrenaline

Responses necessary to survive in 'fight or flight' situations are coordinated by **adrenaline** which gets you ready for action by increasing breathing rate, increased heart rate, widening the pupils so more light enters the eye, converting glycogen in the liver to glucose, coordinates increased uptake of O_2 and changing blood distribution so O_2 and glucose get to muscles.

- Air passages widen to allow more air into the body
- Arterioles in the brain and muscles dilate
- Arterioles in other parts of the body constrict

Adrenaline secretion can increase as a result of fear or stress

Nervous system VS Endocrine system

FEATURE	NERVOUS SYSTEM	ENDOCRINE SYSTEM
Structures	Nerves	Secretory glands in cell
Form of info	Electrical impulses	Hormones
Pathways	Along neurons	In the blood
Speed of info transfer	Fast	Slow
Longevity of responses	Short-lived	Slow and longer-lasting
Target area	Specific effector	Whole tissue or organ
Response examples	Muscle contraction or secretion by glands	Conversion of glycogen to glucose, protein synthesis, rate of respiration

14.4 Homeostasis

Homeostasis is the maintenance of a constant internal environment. It is the control of internal conditions within set limits.

Negative feedback

In negative feedback, a change sets off a response that cancels out the change to restore conditions to their normal levels.

Glucose concentration in blood

When carbs are eaten, the amount of glucose in the blood increases. The **pancreas** secretes **insulin** into the blood which stimulates liver cells to convert glucose into glycogen. This reduces the concentration of glucose in the blood.

When glucose levels in the blood are low, for example after exercise, the pancreas secretes **glucagon** which stimulates liver cells to break down glycogen into glucose and increase glucose concentration levels in the blood.

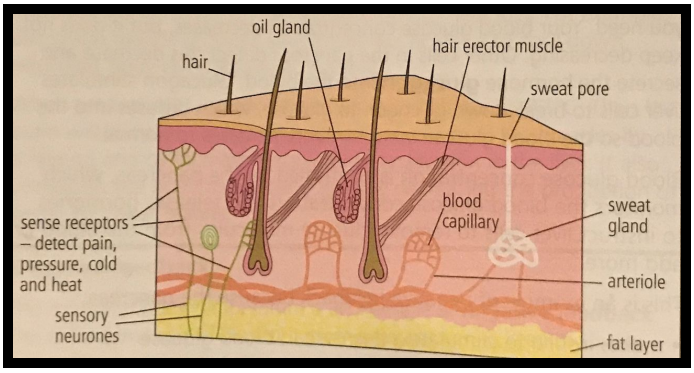
Type I diabetes

The pancreas cannot produce sufficient insulin
Symptoms: tiredness, thirst, unexplained weight loss, blurred vision, frequent urination
Treatment: Insulin doses to be taken before meals

The skin

The skin is the largest organ in the body. It has several important functions:

- Protects the body from damage
- Stops pathogens from entering
- Prevents too much water loss
- Detects temp. changes
- Detects pressure changes (pain)



Controlling body temperature

In the heat: the brain detects an increase in blood temp. The brain sends impulses to increase the rate of sweating so that more heat is lost by evaporation. Hair erector muscles contract to allow hairs to lie flat. No shivering.

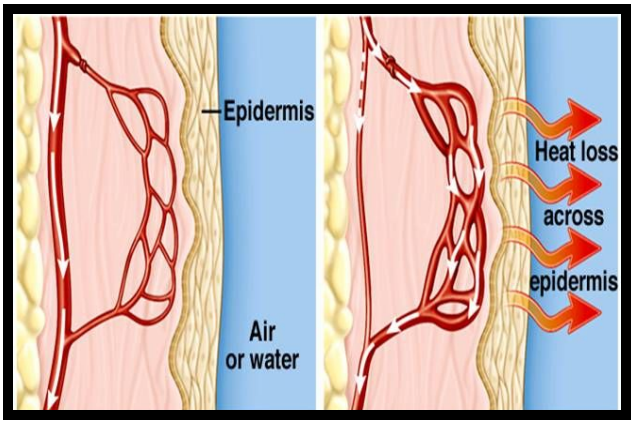
In the cold: the brain detects a decrease in blood temp. Sweat glands stop producing sweat, hair erector muscles relax to raise the hairs which trap air, providing insulation. Body shivers to generate heat from respiration.

Vasodilation and Vasoconstriction

In hotter weather, muscles of arteriole walls relax causing them to dilate/widen. There is now an increased flow of blood to capillaries which means more heat is lost to the surroundings by convection and radiation. This is known as **vasodilation.**

In cooler weather, the muscles of the arteriole walls contract and make the artery narrower. Blood may also be redirected to veins via shunt vessels, under the fat layer of the skin. There is now a decreased flow of blood to capillaries which reduces the amount of heat lost by convection and radiation. This is known as **vasoconstriction.**

VASOCONSTRICTION



VASODILATION

14.5 Plant tropism

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

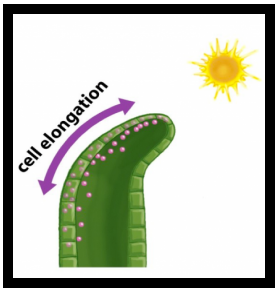
- Roots are **positively gravitropic** as they grow in the direction of gravity
- Shoots are **negatively gravitropic** as they grow upwards, away from gravity

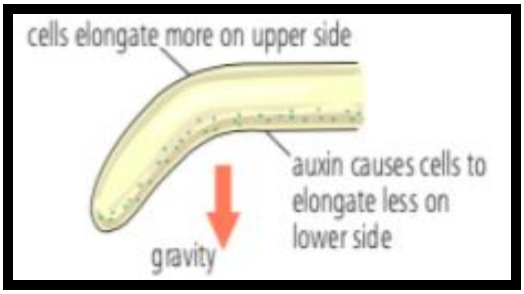
Phototropism is a response in which parts of a plant grow towards or away from light

- Shoots are **positively phototropic** as they grow towards light
- Roots are **negatively phototropic** as they grow away from light. Either ways, they are not sensitive to light

The role of auxins

- Auxin is made solely on the shoot and root tips
- It then spreads throughout the plant from the tips
- Distributed unequally in response to light and gravity
- Stimulate cell elongation - eventually growth
- A high concentration of auxins promotes growth in the shoot but inhibits growth in the root
- In shoots, auxins move to the side away from light, in roots auxins move to the lower side





Response	Where?	Direction of growth	Advantage
Positive phototropism	Stem tip	Growth towards light	Maximum light for photosynthesis
Negative phototropism	Root tip	Growth away from light	Less chance of drying out
Positive geotropism	Root tip	Towards gravity	More chance of finding moisture
Negative geotropism	Shoot tip	Away from gravity	More chance of finding light

Synthetic auxins are very effective as **Selective Weedkillers**. Herbicides like 2.4-D are sprayed on the broad-leaved weeds as it tends to run off thinner leaves.

Auxins increase the growth rate of weeds, possibly by increasing the rate of cell division. Weeds cannot produce enough food to sustain the growth and eventually die.

15.1 Drugs

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

15.2 Medicinal drugs

Use of antibiotics

Antibiotics are a group of chemicals made by microorganisms that are used to kill pathogens or stop their growth. These are prescribed by doctors or vets to cure human and animal diseases caused by bacteria or fungi. Every antibiotic works in one of these two ways:

- A bactericidal antibiotic kills the bacteria by inhibiting the production of **peptidoglycan**.
    - The cell walls are now weak and burst due to osmotic pressure
- A bacteriostatic stops the bacteria from **multiplying**

Resistance

Some bacteria have developed **resistance** against antibiotics (eg: MRSA). This is formed by **natural selection** over time as these bacteria develop a **mutation**. The development of resistant bacteria can be minimized by:

- Prescribing antibiotics **only when necessary**
- Ensuring that people **complete their courses**
- **Not overusing with animals**

Viruses

Antibiotics **do not** work against viruses. Viruses are not cells, which means they do not carry out their metabolism but rely entirely on the cells of their host. To control viruses we would have to inhibit our metabolism, and this is not possible.

15.3 Misused drugs

Alcohol and Heroin

Heroin and Alcohol are examples of powerful depressant drugs. The drugs greatly reduce one's reaction time and self-control. When someone is **addicted** to the drug, the body gets used to the drug, and it causes pain. Addicts have to take more to reduce the pain. This is how **tolerance** is developed, and more needs to be taken each time to reduce the pain. The **sharing** of needles is a mode of transmission for HIV and Hepatitis. Social implications once addicted:

- The addict only thinks about his/her next dose
- Becomes difficult to keep a job
- Addicts shun friends and family and hang out only with other addicts
- Crime
- Road accidents

A user who stops taking heroin experiences **withdrawal symptoms**, which include sleeplessness, hallucinations, cramps, sweating, vomiting, and nausea. Many drug addicts go through **rehabilitation** which is often the only way to overcome the habit.

Effect of heroin on synapses: done in T14

Liver

The liver is the organ that breaks down alcohol and other toxic substances. Excessive alcohol consumption can cause liver damage such as :

- **Cirrhosis** - the permanent scarring of liver tissue
- **Alcoholic hepatitis -** inflammation
- Stomach ulcers
- Heart disease
- Brain damage

Smoking and health

Nicotine is a drug that reacts with nerve cells at synapses. It is a **stimulant**. Nicotine makes the heart beat faster and narrows the arterioles, which increases blood pressure.

Tar is the sticky black material that collects in the lung as smoke cools. It irritates the airways and stimulates them to produce more mucus. **Cilia** are damaged, and mucus remains in the airways, therefore narrowing them. Chemicals in tar are carcinogenic

Carbon monoxide (CO) is a poisonous gas which combines with hemoglobin, reducing the volume of oxygen that blood can carry by around 10%.

Diseases caused by smoking

Chronic obstructive pulmonary disease (COPD) is the term given for several lung diseases such as bronchitis and emphysema.

Bronchitis

Accumulation of mucus, which contains dust and dirt (including pathogens) in the bronchi allows bacteria to replicate. The body sends phagocytes to the bronchi. Large amounts of phlegm are produced which people attempt to cough up. This condition is known as **chronic bronchitis**.

Emphysema

When bacteria, tar, and particles reach the alveoli, phagocytic WBCs digest a pathway through the walls to get them. Eventually, the walls of the alveoli are weakened so they break down and burst. This reduces the surface area for gas exchange. This condition is known as **emphysema**

Lung cancer

Carcinogens in tar promote changes in DNA cells on the lining of the airways. The cells grow and divide uncontrollably, eventually becoming a **tumor**. If undiscovered, it may occupy a large area of the lung, blocking airways and blood vessels. The tumor may break off and spread to other organs. Graphs that show deaths from lung diseases show that the increased popularity of smoking has lead to lung cancer, while other diseases have reduced due to improvements in medical care.

Heart disease

Tobacco smoke increases the chances of fat build-up in the arteries of the heart. The chances of **CHD** are also increased.

Misuse of drugs in sport

Anabolic steroids are similar to the male sex hormone **testosterone**. The work by mimicking the protein-building effects of the hormone. They cause:

- Muscle growth
- Increased strength
- Increases endurance

Long-term effects include:

- In men
    - Aggression
    - Impotence
    - Baldness
    - Kidney and liver damage
    - Development of breasts
- In women
    - Male features
    - Facial and body hair
    - Irregular periods

16.1 Asexual Reproduction

Asexual reproduction is a process resulting in the production of genetically identical offspring from one parent. For eg:

- Bacteria reproduce by **binary fission** - one cell divides into 2
- Fungi reproduce with spores (except yeast)

Advantages and disadvantages of asexual reproduction to a wild population and crops:

- Advantages
  - It is fast - organisms can reproduce rapidly
  - No mates required
  - Good characteristics are passed on
- Disadvantages
  - If they grow near each other there is competition for resources
  - Very little variation - all genetically identical, so a genetic disease could wipe out all organisms
  - Harmful characteristics are retained

16.2 Sexual reproduction

Sexual reproduction is a process involving the fusion of the nuclei of two gametes (sex cells) to form a zygote and the production of offspring that are genetically different from each other. **Fertilization** is the fusion of gamete nuclei. The nuclei of gametes are haploid. The nucleus of a zygote is diploid.

Advantages and disadvantages of sexual reproduction to a wild population and crops:

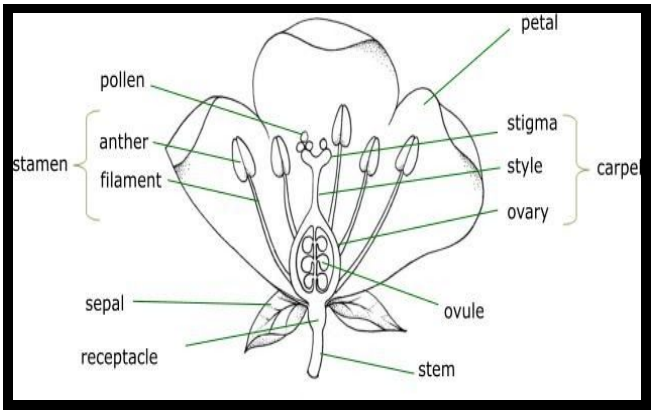
- Advantages
  - More variation assists with survival. It increases the chance that at least some offspring of a parent will survive.
  - Unique individuals
  - Natural selection gets rid of unfavorable genes
- Disadvantages
  - It is a very long process
  - Requires two parents, which is why reproduction is slower

Differences and similarities between sexual and asexual reproduction

	Sexual reproduction	Asexual reproduction
Differences	- 2 parents - Cells divide by meiosis - Variation and diversity	- 1 parent - Cells divide by fission or budding - Little variation
Similarities	Both processes are types of reproduction and both produce offspring	

16.3 Sexual reproduction in plants

Structures and functions of the parts of a plant



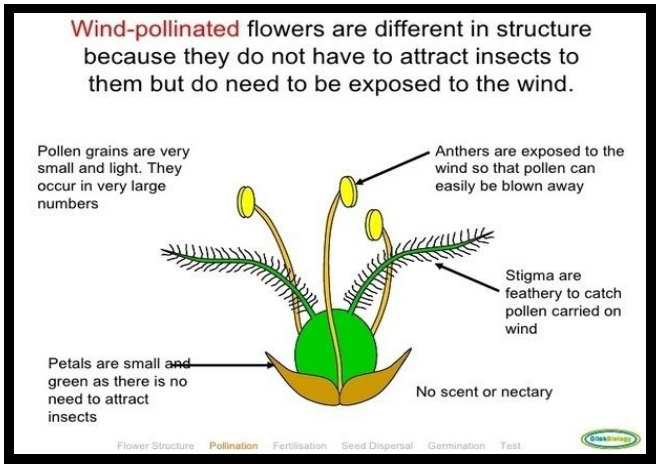
Part of the plant	Insect-pollinated flower	Wind-pollinated flower
PERIANTH		
Sepal	Leaf-like structures that protect the flower when it is a bud	
Petals	Usually brightly colored and scented. Many have a nectary at the base	Absent or modified to bracts which are difficult to see
STAMEN (Male sex organs)		
Anther	Firmly to filaments. Pollen is made here. Also, they are inside the flower for insects to rub against	Anthers hang outside the flower as they are loosely attached to the filaments. Pollen can be easily blown away.
Filament	A short stalk which holds the anther.	Long filaments allow anthers to hang outside the flower
CARPEL/PISTIL (Female sex organs)		
Stigma	They are sticky and small for insects to rub against	They are feathery and large to increase surface area to catch pollen
Style	The path below the stigma, through which pollen tubes pass and gain nutrition as they move towards the ovule	
Ovary	Produces the females sex cells	
Ovule	Contains female sex cells	

Structure of an insect-pollinated plant (Same as picture on prev page)

Insect-pollinated flowers have bright, colored, and sweet smelling petals. Their stigmas are sticky, so pollen can stick to them. The pollen grains of insect-pollinated flowers are often spiky and sticky. They are adapted to attach to hairs on surfaces of insect bodies. They are produced in small quantities as not many are wasted

Structure of wind-pollinated flowers

Anthers hang outside the flower so that the wind can blow them away. The feathery stigmas are also positioned outside the flower. They act a net, providing a large surface area for catching pollen grains that get blown into them. The pollen grains of wind-pollinated flowers are small, smooth, and light so that they are easily carried by the wind. The flowers make huge numbers, as the chances of the grains landing on a stigma are very small as



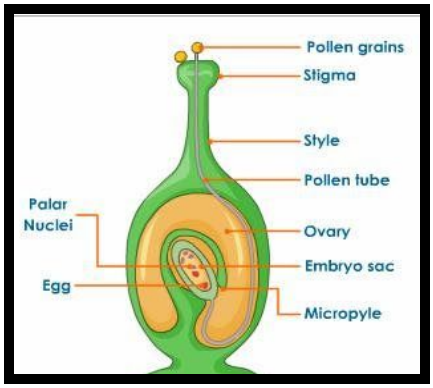
Types of pollination

Self-pollination is the transfer of pollen grains from the anther of a flower to the stigma of the same flower or a different flower on the same plant. Genetic info is not exchanged, so less variation

Cross-pollination is the transfer of pollen grains from the anther of a flower to the stigma of a flower on a different plant of the same species. Genetic info is exchanged with greater variation.

Process of fertilisation

When a pollen grain lands on a stigma, it starts to grow a **pollen tube** to take the male nucleus to a female nucleus in an ovule. As the tube grows, it gains nutrition from the tissues of the style and carries the male nucleus with it. When the first tube reaches the ovary, it enters the ovule through a small hole called the **micropyle**. Fertilization then occurs to form a zygote.



Seed formation

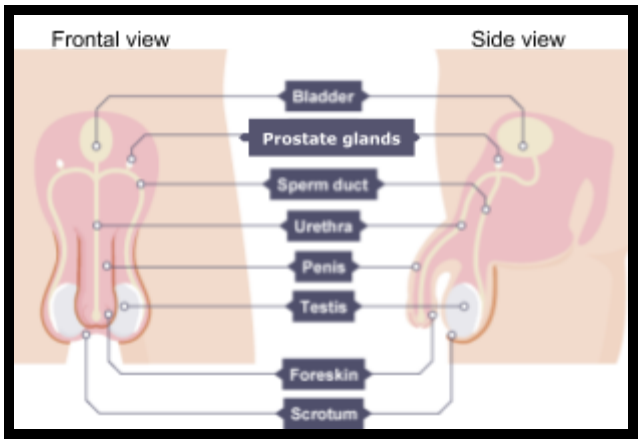
The ovary forms the **fruit.** The ovule is the **seed**.

Conditions for germination

- Water is needed for the seeds to swell, and to activate enzymes for growth reactions
- Oxygen is needed for aerobic respiration to provide the embryo with energy
- A warm temperature is needed so that enzymes can work efficiently

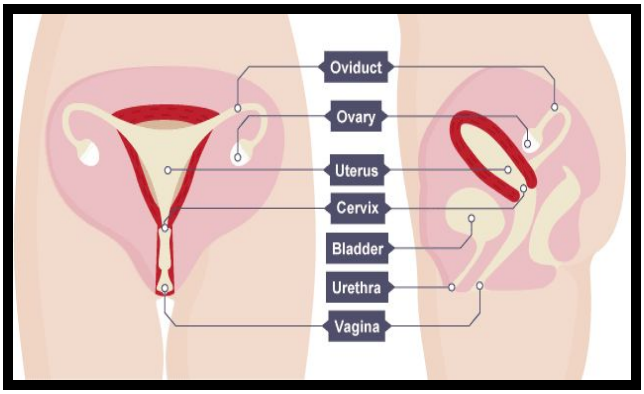
16.4 Sexual reproduction in humans

The male reproductive system



- **Testes** produce **sperm** and **testosterone**
- **Scrotum** keeps sperm at lower than 37°C
- **Sperm ducts** move sperm to the urethra
- The **prostate gland** produces fluids
- **Urethra** moves sperm to the penis tip
- **Penis** transfers sperm to the female body

The female reproductive system



- **Ovaries** produce **eggs** and **estrogen**
- **Oviducts** moves the egg to the uterus
- **Uterus** is where a zygote implants itself
- **Cervix** is a muscular ring that can dilate
- **The vagina** is the opening of the system

Comparison of male and female gametes

Feature	Sperm cell	Egg cell
Size	Small	Much larger than sperm cell
Motility	Flagellum swings back and forth	Peristaltic movement in the oviduct
Energy store	Little - uses sugar in semen	Enough to last until implantation
No. produced	Millions throughout lifetime	Once a month until menopause

Adaptive features of sperm and egg cells

Sperm	**Egg**
• A **flagellum** allows it to swim to the egg cell • **Many mitochondria** release energy for movement • **Acrosome** contains enzymes that digest egg jelly coat	• **Jelly coating** composition changes after fertilization so that only one sperm enters • **Energy store** provides energy until implantation

Fertilisation and implantation

If there is an egg in the oviduct, a sperm may succeed in penetrating it. Enzymes released by the **acrosome** digest the **jelly coat** of the egg. A zygote is formed, and no more sperms can now enter.

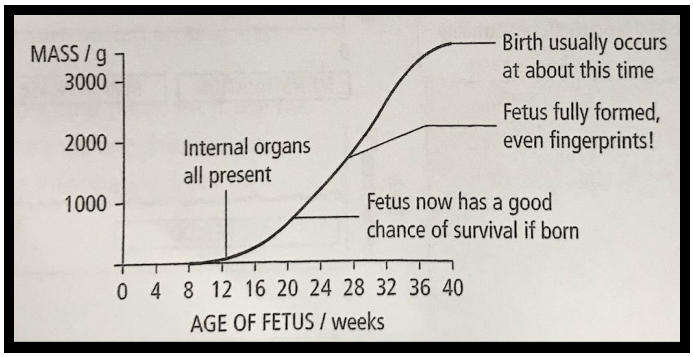
After a few hours, the **embryo** is a hollow ball of cells. Ciliated epithelial cells in the oviduct beat the embryo, and peristalsis moves it towards the uterus. The embedding of the embryo into the soft lining of the uterus is known as **implantation**.

Pregnancy

This time between fertilization and birth (9 months in humans), is called the **gestation period**. After the embryo has been implanted onto the lining of the uterus, an **umbilical cord** grows to attach the fetus to the **placenta**. The embryo remains in an **amniotic sac.**

The main stages of pregnancy are:

- 1 month - the heart is beating
- 2 months - Most organs are formed
- 3 months - the fetus develops nerves and muscles
- 5 months - the baby develops fine details. The mother may have felt movements
- 7 months - Almost complete



Antenatal care (Before birth)

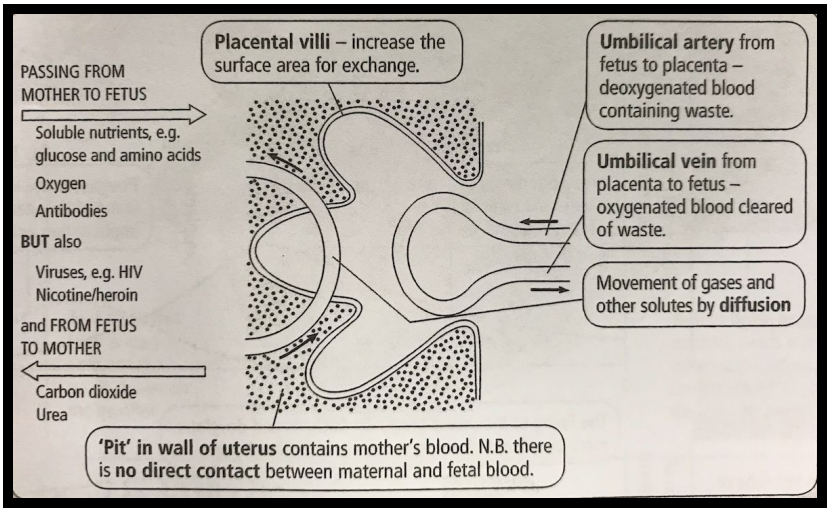
A pregnant woman must ensure she receives adequate quantities of :

- Calcium - Bones are growing
- Iron - Extra blood cells are required to be made which contain hemoglobin
- Carbs - So mother has enough energy to move her heavier body around
- Protein - To provide amino acids that both require to make new tissues

Toxic substances and substances (must be avoided)

Alcohol → baby is underweight or brain-damaged
Drugs → Blood vessels and heart may be damaged. Baby is small, born early, or even dead
Smoking → Oxygen supply is reduced by nicotine and carbon monoxide
HIV → Fetus may be infected with life-threatening diseases before birth
Rubella → Embryo is infected and cannot develop properly. May be born blind or deaf

Functions of different parts

Part	Function
Placenta	The site of exchange of oxygen and nutrients such as glucose, amino acids, fats, mineral ions, vitamins, and water for carbon dioxide and other wastes (excretory waste); they diffuse between the fetal blood and the maternal blood. It also provides a barrier to toxins and pathogens. However, the fetus is still susceptible to disease. Some toxins, e.g. nicotine, and pathogens, e.g. rubella virus, HIV can pass across the placenta and affect the fetus. Large surface area and thin capillaries increase the rate of diffusion 
Umbilical cord	Attaches the fetus to the placenta and contains blood vessels
Amniotic sac	Makes **amniotic fluid** to surround and protect the fetus against mechanical damage (Eg: when the mother moves), maintain a suitable temperature

<u>Labour and Birth</u>

- A few weeks before birth, the fetus positions its head above the cervix.
- **Oxytocin** released from the **pituitary gland** stimulates the muscles of the uterus to contract. These contractions become stronger and more frequent. Stronger contractions break the **amnion** due to high pressure, allowing the **amniotic fluid** to escape.
- Next, the muscles in the uterus wall contract strongly, and push the baby towards the cervix, the **cervix dilates**, and then the **baby's head is pushed through the vagina.**
- The **umbilical cord** is cut and tied above the point where it attaches to the baby. The remains of the cord from the baby's **navel**.
- After a few minutes, the placenta comes away from the uterus wall. It is pushed out of the vagina as the **afterbirth**.

Breastfeeding vs Bottle feeding

Breastfeeding	Bottle feeding
Contains antibodies	Less difficult or embarrassing
Passive immunity	More convenient - only need to mix powder with water in sterile conditions
Forms close bond between mother and child	Increased risk of infection from non-sterile water
Less likely to develop diseases such as cancers or diabetes	
No cost	Expensive

16.5 Sex hormones in humans

Sex organs become active between the ages of 10-14. During **puberty**, the testes start to make sperm, and follicles start to develop in the ovaries. Girls develop earlier than boys.

The changes that take place are controlled by **hormones**. At the beginning of puberty, the pituitary gland in the brain produces hormones that stimulate the testes and the ovaries. These make the sex organs active, and the organs produce **sex hormones** that develop our **secondary sexual characteristics.**

Puberty in boys

The testes start making **testosterone**, which stimulates:

- The growth of the sex organs
- The testes to make sperm cells
- Growth of hair on the face and other parts of the body
- The deepening of the voice
- Development of muscles in the body
- Broadening shoulders

Puberty in girls

The ovaries start making **estrogen** and **progesterone**, which stimulates:

- The growth of the sex organs
- The start of the menstrual cycle
- Growth of hair in parts of the body
- Growth and development of breasts
- Widening of the hips

This period is known as **adolescence**. The hormones produced can bring about mood changes and sexual urges

The menstrual cycle

HORMONES AND STAGES

1. Menstruation (DAYS 1-5)
2. Pituitary gland at the base of the brain secretes FSH (Follicle stimulating Hormone)
3. FSH "travels" to the ovary - through the bloodstream
4. Causes a follicle in the ovary to nature
5. This means an ovum starts to develop in it
6. Follicle then produces oestrogen
7. Oestrogen repairs and develops the lining of the uterus (Endometrium)
8. High levels of oestrogen cause pituitary gland to release LH (Luteinising Hormone)

DAYS 6-13

9. LH causes follicle to release ovum into the oviduct (DAY 14)
10. Follicle then gets called the yellow body (CORPUS LUTEUM) - now produces progesterone
11. Progesterone maintains the lining of the uterus, and inhibits production of FSH and LH
12. Implantation of zygote (If ovum is fertilised) - yellow body continues to produce progesterone for up to three months.
13. If no implantation, the yellow body breaks down

DAYS 15-28

16.6 Methods of birth control in humans

METHOD	To prevent pregnancy, the method of birth control must either: ● Stop the sperm from reaching the egg ● Stop the eggs from being made ● Stop the fertilized egg from implanting and developing in the uterus
BARRIER	❖ Diaphragm - a dome placed into a woman's cervix ❖ Condom - most commonly used - thin rubber tube ❖ Femidom - female equivalent of a condom ❖ IUD (Intrauterine device) - small plastic device wrapped in copper and hormones, that is placed in the uterus - prevents sperm from entering - can prevent implantation even fertilization occurs ❖ IUS (Intrauterine system) - T-shaped plastic device with progesterone - uterus
CHEMICAL	❖ Contraceptive pill - oral pill containing progesterone - comes with side effects ❖ Contraceptive implant - a rod placed under the arm that releases progesterone ❖ Contraceptive injections - contain progesterone ❖ Spermicides - kill sperm when used in conjunction with a barrier method
NATURAL	Some couples may not be comfortable with contraception, so they use the **rhythm method**. This involves having sex when there is very little chance of fertilization. Alternatively, individuals could **abstain** from sex
SURGICAL	❖ Vasectomy - cutting and tying the sperm ducts ❖ Sterilization - cutting and tying the oviducts

Control of fertility

Some couples want to have children but cannot because the man or woman is **infertile**. Often the cause of infertility is the inability of the ovaries to produce eggs. This may be due to a lack of FSH production. Treatments for this include:

- **Fertility drugs** - Contains FSH that stimulates the ovaries to release eggs
- **Artificial insemination (AI)** - semen may be collected from the man (who probs have a low sperm count) or another donor, and then placed with a fine tube in the woman's uterus
- **In vitro fertilization (IVF)** - Eggs and sperms are collected from the potential parents and mixed in a lab dish. Then they are placed in a carrier uterus

Use of hormones in contraception and fertility treatments

Human **fertility** is controlled by **hormones**, so fertility can be controlled using hormonal forms of contraception. The oral contraceptive, which is known as the pill, implants, IUDs, and IUSs contain **estrogen** or **progesterone**. These hormones inhibit the production of **FSH**, and eggs cannot mature.

Fertility drugs however have FSH, which stimulates the ovaries to release eggs.

Social implications of contraception and fertility treatments

- Easier for couples to plan their families and decide when to have children
- Women have more control over their fertility even though some procedures are expensive
- Birth rates are falling
- Women can make choices about education and careers

16.7 Sexually Transmitted Infections/Diseases (STI/STD)

A **sexually transmitted infection** is an infection that is transmitted via body fluids through sexual contact. An example is HIV.

The **Human Immunodeficiency Virus (HIV)** is a human pathogen. The main type of cells it affects is the lymphocytes. HIV infection may lead to the development of **Acquired Immunodeficiency Syndrome (AIDS).** AIDS is the name given to a collection of diseases brought on by the weakening of the body's immune system.

How HIV affects the body

1) The virus enters the bloodstream and then cells, which it uses as hosts to multiply
2) It attacks and destroys an important type of lymphocyte called the T lymphocyte that coordinates the immune system
3) These T lymphocytes would normally stimulate other lymphocytes to produce antibodies
4) But with fewer T lymphocytes, fewer antibodies are produced every time there is another infection
5) A person will succumb to any number of other infections because of their weakened immune system

Modes of HIV transmission

- Unprotected sexual intercourse
  - Transmitted in blood, semen, or vaginal fluid
- Hypodermic needles contaminated with infected blood
- Unborn babies
  - Virus can pass across the placenta to the fetus
  - Mother's blood to baby's blood at birth, as the two bloodstreams are in close contact
  - Breast milk
- Transfusions

Measures taken for the prevention of HIV/AIDS

- Antiviral drugs - prevent the virus from multiplying in the body cells Eg: Zidovudine (AZT)
- Contact tracing
  - Controls spread of virus
  - Any person diagnosed is asked to identify people he/she could have passed it onto
- Methods to reduce spread include
  - Use of condoms during intercourse
  - Setting up free needle exchange schemes for those people who inject drugs
  - Screening donated blood for HIV - before transfusion
  - Education programs that raise awareness

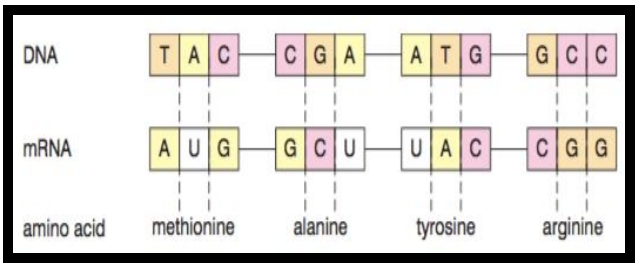
17.1 Inheritance

Inheritance is the transmission of genetic information from generation to generation

17.2 Chromosomes, genes, and proteins

A **chromosome** is a thread-like structure of DNA, carrying genetic information in the form of genes. A **gene** is a length of DNA that codes for a protein An **allele** is a version of a gene. In humans, if 23rd pairing of chromosomes decides gender. XX = ♀, XY = ♂

Proteins and the genetic code



DNA controls cell function by controlling the production of proteins (some of which are enzymes), antibodies, and receptors for neurotransmitters. There are 4 bases in DNA - Adenine(A), Thymine(T) (Uracil (U) in mRNA), Cytosine(C), Guanine(G). Each amino acid is coded by a sequence of 3 bases on DNA. There are about 20 such amino acids.

Protein synthesis is described below:

- Gene coding remains in the nucleus
- A copy of the DNA is made by transcription
- mRNA molecules carry a copy of the gene to the cytoplasm
- mRNA passes through ribosomes
- **Ribosomes** assemble amino acids into protein molecules by translation
- The specific order of amino acids is determined by the sequence of bases in the mRNA. Each amino acid is joined to the other by a **peptide bond**

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. A **haploid nucleus** is a nucleus containing a single set of unpaired chromosomes, e.g. in gametes. A **diploid nucleus** is a nucleus containing two sets of chromosomes, e.g. in body cells (23 pairs in humans)

17.3 Mitosis

Mitosis is nuclear division giving rise to genetically identical cells. This process is used in the growth, repair of damaged tissues, replacement of cells, and asexual reproduction. Mitosis involves:

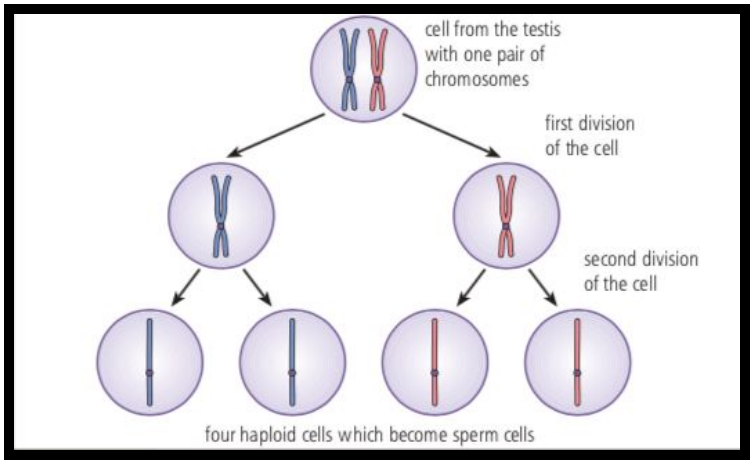
- DNA replication in the cell
- The 2 copies separate so each new cell gets a copy of each chromosome
- As a result of **mitosis**, each daughter cell has the same chromosome number as the original parent cell.

Stem cells

During the development of an embryo, most cells become specialized cells. But embryos contain a special type of cell called **stem cells**. These can grow into any type of cell found in the body. Stem cells divide by mitosis to produce daughter cells that can become specialized for specific functions.

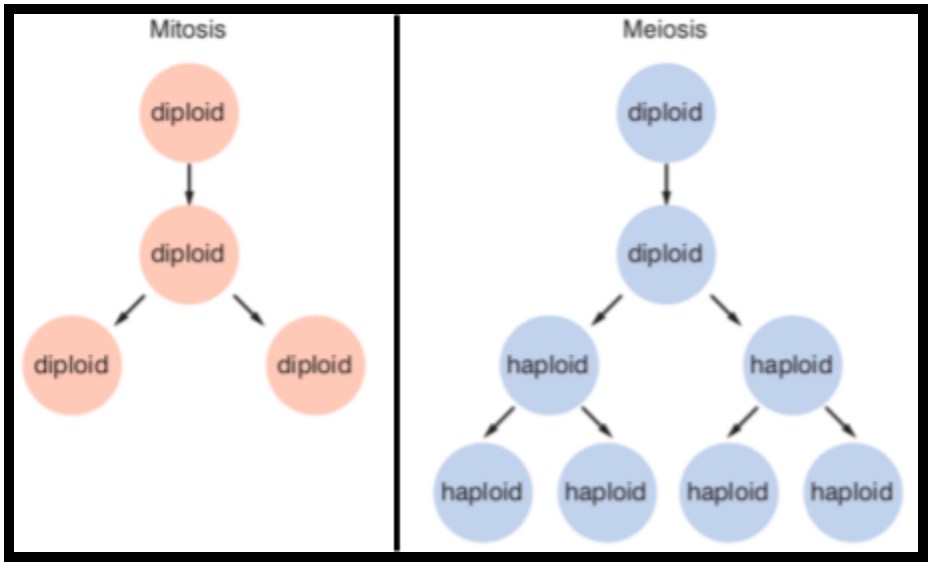
17.4 Meiosis

Meiosis is the reduction division in which the chromosome number is halved from diploid to haploid resulting in genetically different cells. This process is used in the production of **gametes**. Meiosis produces **variation** amongst individuals by forming new combinations of maternal and paternal chromosomes.



Differences between mitosis and meiosis

Mitosis	Meiosis
One division	Two divisions
The number of chromosomes remains the same	The number of chromosomes is halved
The daughter cells are genetically identical	The daughter cells are genetically different
Two daughter cells are formed	Four daughter cells are formed



17.5 Monohybrid inheritance

Genotype is the genetic makeup 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. In pure breeding, both parents are homozygous individuals. **Heterozygous** is having two different alleles of a particular gene. A heterozygous can not take part in pure-breeding, as there is the likelihood of the offspring gaining a new phenotype. **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 present.

Pedigree diagrams

Symbols:

- ➔ Square = male
- ➔ Circle = female
- ➔ Shaded circle or square = individual has the condition
- ➔ Unshaded circle or square = individual not showing the condition

For questions about pedigree diagrams, draw a Punnett square consisting of parent phenotypes (parental cross), to obtain a ratio, and compare with the proportions of children in the next generation (F_1 generation).

Parental combinations for 2:2, 3:1 and 4:0 ratios (Example: T - Dominant, t - recessive)

4:0

	t	t
t	tt	tt
t	tt	tt

The phenotypes of the parents are both homozygous recessive, so all 4 possibilities show the recessive trait and are also homozygous recessive

	T	t
T	TT	Tt
T	TT	Tt

The phenotypes of the parents are Homozygous and heterozygous dominant. Two possibilities are homozygous dominant. The other two end up heterozygous dominant

	T	T
T	TT	TT
T	TT	TT

The phenotypes of the parents are both homozygous dominant, so all 4 possibilities show the dominant trait and are also homozygous dominant

2:2

	T	t
t	Tt	tt
t	Tt	tt

In this case, there is a 50% chance of either combination

3:1

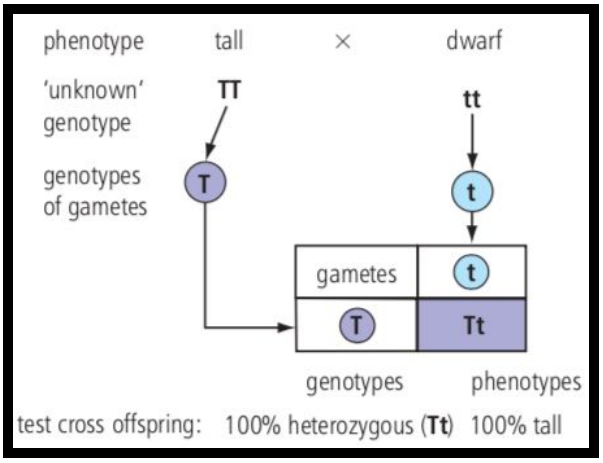
	T	t
T	TT	Tt
t	Tt	tt

In this case, there is a 75% chance of one characteristic and 25% for the other

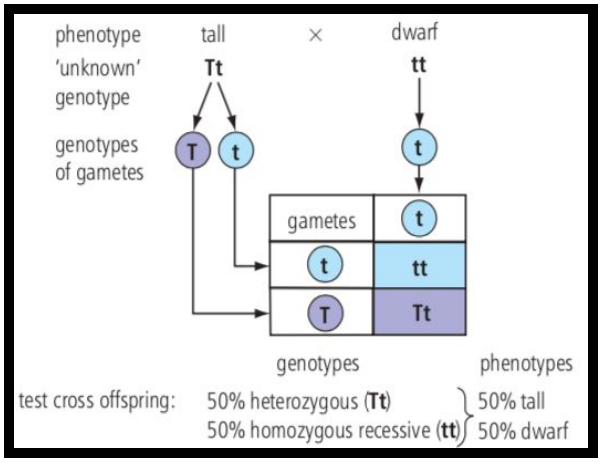
Test crosses

A **test cross** is used to determine the genotype of an individual to find out whether it is homozygous or heterozygous dominant. We do not need to do this for organisms with recessive traits as the only possible genotype is homozygous recessive. The results from a test cross show the ratios expected in the offspring, not the actual numbers.

If the unknown tall plant is homozygous (TT):



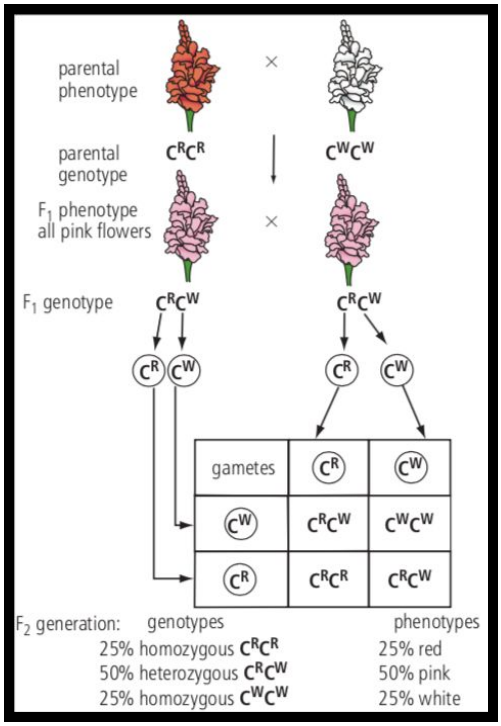
If the unknown tall plant is heterozygous (Tt):



Codominance

Sometimes, both alleles are expressed and neither is dominant. This is known as **codominance**.

For example, if a red flower $\mathbf{C^RC^R}$ is crossed with a white flower $\mathbf{C^WC^W}$, where both C^R and C^W are codominant, 100% of the F1 are $\mathbf{C^RC^W}$, which gives the flowers a **pink** color. If these pink flowers are then bred, a 1:1:2 ratio is obtained in the F2, where 25% are red, 25% are white, and 50% are pink.



Multiple alleles

In the case of human blood groups, the four different blood groups are determined by the gene **I**, with three different alleles **I^A, I^B, and I^O.** I^A and I^B are codominant, and code for different molecules on the surface of RBCs. I^O is recessive and doesn't code for these molecules.

The table below shows the genotypes for different blood groups:

Genotype	Blood group
I^AI^A	A
I^AI^O	A
I^BI^B	B
I^BI^O	B
I^AI^B	AB
I^OI^O	O

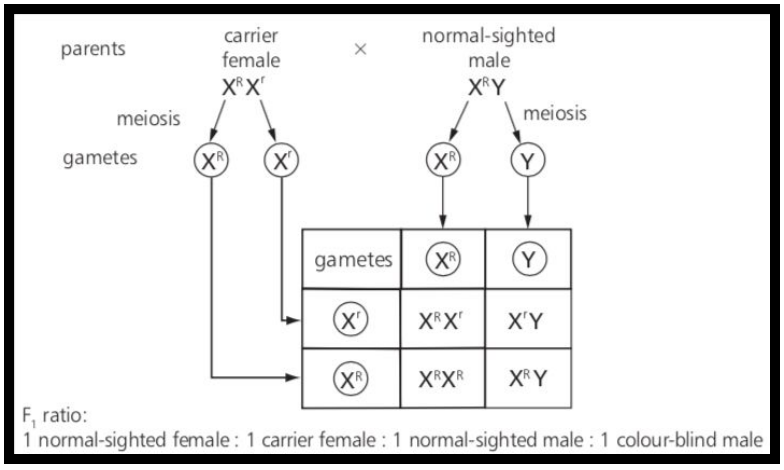
Sex linkage

A **sex-linked characteristic** is a characteristic in which the gene responsible is located on a sex chromosome and that this makes it more common in one sex than in the other.

The genes located on the X chromosome are described as sex-linked. Among these genes are genes involved in controlling vision and blood clotting. Males have an X and a Y chromosome, and if the X they possess is recessive, they will have the diseases. The disease is less common in females as they have another X chromosome which may still be dominant. However, in rare cases, a female may get two recessive X chromosome and have the disease.

Colour blindness

A gene on the X chromosome controls the ability of the cones in the retina to see red and green. There is a recessive allele that doesn't produce the protein necessary for color vision. If a male gets the recessive X with the Y, he will have the disease. **Males cannot be carriers**.



18.1 Variation

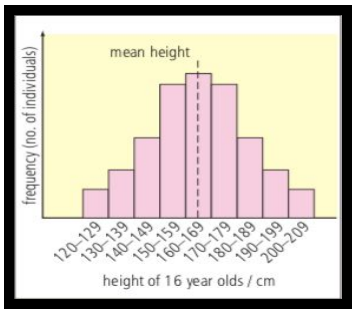
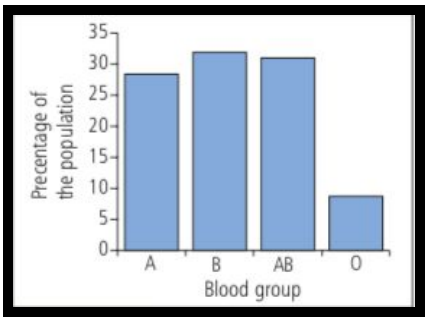
Variation is the differences between individuals of the same species.

Phenotypic and Genotypic variation

Variation in morphology or anatomy is known as **phenotypic variation**. These features can be influenced by both genetic and environmental factors. **Genetic variation** is the differences between the genotypes of individuals. This means genotype or alleles of the genes inherited are different.

Continuous and Discontinuous variation

There are two types of phenotypic variation within a species:

Continuous variation: In this type of variation, there is a range along which individuals can be placed in terms of how they display a trait. For eg: height of 16 years olds: Ranges from 120-210cm. Height is affected not only by genes but also by the food consumed, exercise done, and growth spurt times. Therefore this type of variation can be shown on a frequency histogram.	**Discontinuous variation:** In this type of variation, there are a few possible phenotypes and no intermediates. Discontinuous variation is caused by genes alone and the environment does not affect them. For eg: Blood group - everyone is A, B, AB, or O and there are no intermediates. Therefore this type of variation can be shown on a bar chart.
 A histogram showing the number of people at each height **range**	 A bar chart showing the number of people with each **type** of blood group

Mutations

A **mutation** is a genetic change. A **gene mutation** is a change in the base sequence of DNA. A gene mutation is the only way new alleles are formed.

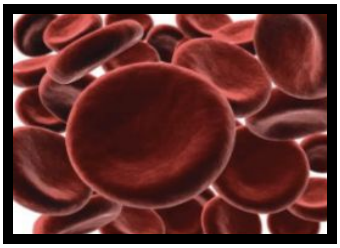
Mutations are caused by damage to DNA or a failure in the copying process that occurs before nuclear division. The rate at which they occur can be increased by:

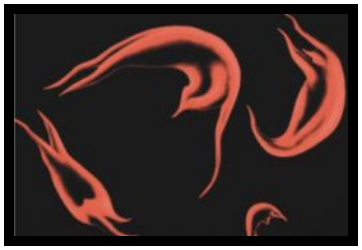
- Exposure to ionizing radiation - UV, X-rays, ɣ
- Chemicals

A greater dose means a greater chance of mutation.

Sickle-cell anemia

As a result of **sickle-cell anemia**, RBCs in the blood are in the shape of a sickle. These cells have abnormal hemoglobin which makes it difficult for the RBCs to carry oxygen. SCA can prove fatal if the distorted cells block blood vessels, or if the **spleen** destroys the abnormal sickle cells at a greater rate than normal, causing anemia. The disease is most common in Africa.





The disease results from a **gene mutation**. The normal allele H^A codes for normal hemoglobin, and the mutant allele H^S codes for an abnormal form. The alleles are **codominant**. Those who are heterozygous have a much milder form of the disease called **sickle cell trait**.

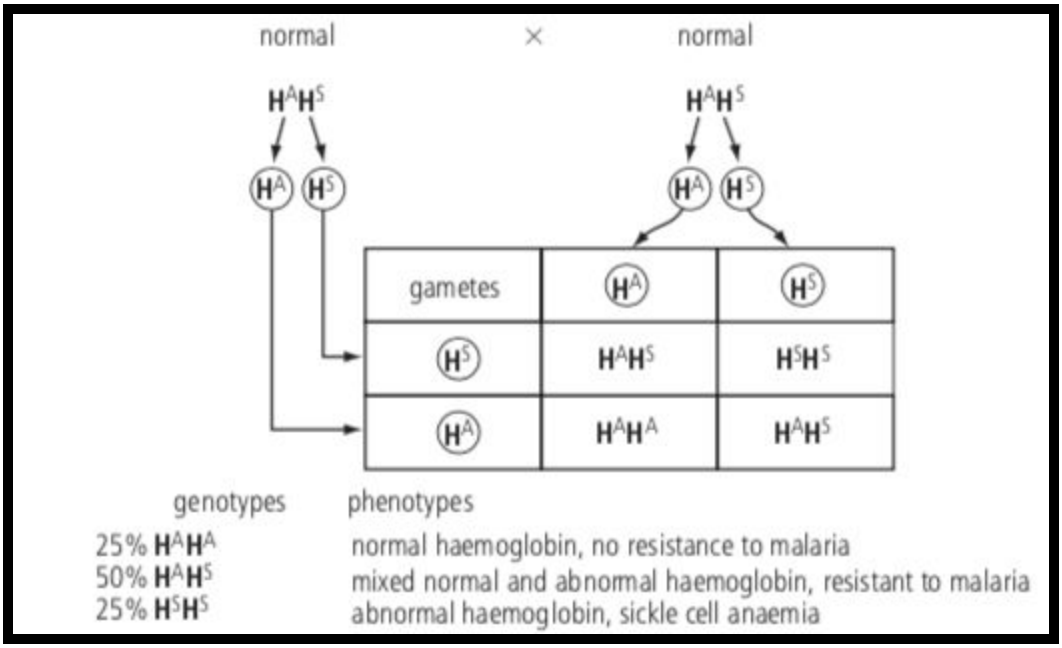
SCA and Malaria

SCA allele is common among people from areas where malaria is common. The malarial parasite cannot choose abnormal RBCs as hosts, so those with a mutant allele (hetero or homo) are protected from malaria

The link between SCA heterozygotes and resistance to malaria is an example of natural selection:

- There a selection pressure against individuals who are homozygous for SCA H^SH^S, because they could die from anemia
- There a selection pressure against individuals who are homozygous for the normal allele H^AH^A, because they could die from malaria

Therefore there is a selective advantage for heterozygous individuals H^AH^S, as they do not suffer badly from anemia and are protected from malaria. The SCA remains in the population in areas where malaria is an important **selective agent**



18.2 Adaptive features

Adaptive features are inherited functional features of an organism that increase its fitness
Fitness is the probability of an organism surviving and reproducing in the environment in which it is found.

Adaptive features of:

Hydrophytes: plants that grow submerged or partially submerged in water. Eg: water lilies, hydra

- These plants are buoyed up in the water, so plant cells save energy as they don't produce xylem cells.
- **No root hair**: easy absorption when in water
- **No cuticle on leave**: no need to conserve water
- CO_2 and O_2 diffuse slowly in water, so an **extensive system of air spaces in the stem and leaves** allow gases to diffuse
    - Provide buoyancy to keep the plant afloat
- **Wide flat leaves** to absorb as much light as possible
- Many stomata always open on the upper surface

Xerophytes: plants which can exist in conditions where water is scarce. Eg: Cactus

- **Leaves reduced to spines and round, compact shape**
    - Reduces surface area exposed
    - Less water lost
- **Waxy cuticle**
    - Reduced transpiration
- **Swollen stems with water storage tissue**
- **Shallow, root spreading system**
    - Quick absorption of water from rain and overnight condensation
- **Shiny surfaces**
    - Reflect heat and light
- **Stomata closed during the day**
    - Reduced water loss
    - CO_2 for photosynthesis collected and stored at night

18.3 Selection

When asked to describe natural selection:
Within all populations there exists variation, which is a result of **gene mutations, meiosis, and thus fertilization**. Organisms of the same species reproduce, and there is an **overpopulation** as a result of a large number of offspring being born. Predators eat seeds and eggs, and disease and starvation can kill the young. Therefore, populations remain stable. In the **competition for resources,** the organisms with helpful mutations can survive the struggle for survival. The organisms best adapted to survive to emerge on top and then **reproduce, passing on their favorable alleles to future generations. (KEYWORDS IN BOLD REQUIRED)**

Evolution

All species tend to evolve. **Evolution** is the change in adaptive features of a population over time as the result of natural selection.

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

Antibiotic resistance

Antibiotics are chemicals that kill bacteria or inhibit their growth. Some bacteria have developed a resistance to their effects.

When bacteria are exposed to an antibiotic, most are killed. However, some bacteria with a **mutation** can resist the antibiotic. For eg: it may be able to produce an enzyme that breaks it down.

As the non-resistant bacteria die, the resistant bacteria start replicating, leading to a new strain of antibiotic-resistant bacteria. (Natural selection eg.)

Selective breeding

- Humans choose desirable features of an organism to improve. Eg: Fast growth, high yield etc
- Organisms that show these features are bred to produce the next generation
- The offspring are checked to find those that show an improvement in the desired features
- These are kept for breeding the next generation
- This process continues for many generations

There are 2 main methods of carrying out selective breeding:
Outbreeding involves the breeding of unrelated organisms. This may be used to combine the good characteristics of separate individuals. Outbreeding results in tougher individuals with a better chance of survival. This is called **hybrid vigor**.

Inbreeding involves breeding close relatives in an attempt to retain desirable characteristics. However, the offspring may have a loss of vigor, with the population weakened by a lack of gene diversity and reduced fertility. There is also a higher disease susceptibility.

Artificial selection vs Natural selection

Artificial selection	Natural selection
Selection due to human influences	Selection due to environmental factors
Does not result in new species	May result to new species
Inbreeding is common, leading to loss of vigor in the offspring	Outbreeding is common, leading to hybrid vigor
A relatively fast process	A slow process taking many years
Proportion of heterozygous individuals reduces	Proportion of heterozygous individuals is high

19.1 Energy flow

The Sun is the principal source of energy input to biological systems. Plants use light energy from the sun to **photosynthesize** and make glucose - a form of chemical energy. Herbivores and omnivores are consumers that consume plants for energy. Omnivores and carnivores can also consume other animals for their energy. Energy is passed on in this way from organism to organism through **ingestion** until it eventually ends up as **heat in the environment.**

19.2 Food chains and Food webs

Food chains show the transfer of energy from one organism to the next, beginning with a producer - the first trophic level. A **trophic level** is the position of an organism in a food chain, a food web, a pyramid of numbers, or a pyramid of biomass. The transfer of energy in this way is **inefficient**. 90% of energy in an organism is lost in the form of wastes, through respiration and undigested material, and the ingesting organism can only obtain 10% of the energy. For this reason, food chains usually consist of a maximum of 5 trophic levels, as there wouldn't be enough energy for any organisms after.

Efficiency of having vegetarian diets

There is greater efficiency in supplying plants as human food than livestock. A vegetarian diet can support far more people. If we cut down the number of links in the food chain, more individuals at the end of the food chain can be fed. This is because we are cutting down the 90% 'wastage' of energy that occurs at each trophic level.

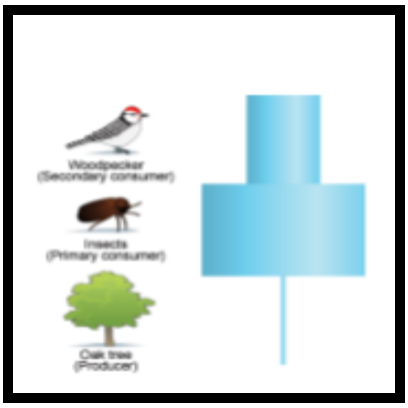
Food webs

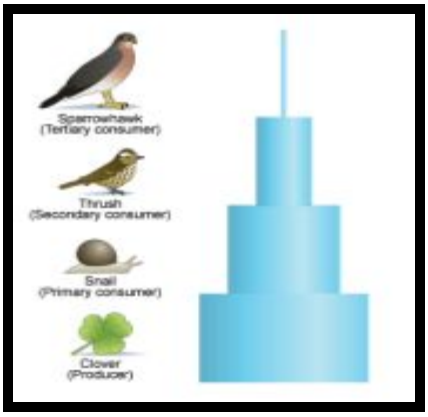
Food webs are a network of interconnected food chains. Food webs consist of:

- **Producers** - organisms that make their organic nutrients, usually using energy from sunlight, through photosynthesis. Eg: Apple tree
- **Consumers** - organisms that get their energy by feeding on other organisms. These may be classified as primary, secondary, tertiary, or quaternary depending on their trophic level
- **Herbivores** - animals that get their energy by feeding on plants
- **Carnivores** - animals that get their energy by feeding on other animals
- **Decomposers** - organisms that get their energy from dead or waste organic material

Pyramid of numbers

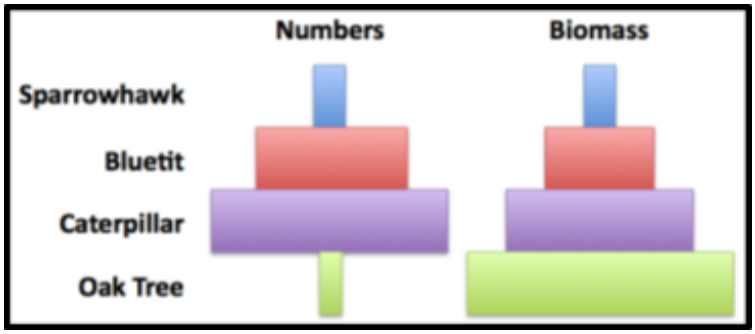
Pyramids of numbers allow us to see how many organisms are involved, but a problem with pyramids of numbers is that they do not take into account the **size** of organisms at each trophic level. Therefore they may be shaped irregularly





Pyramid of biomass

One way to overcome the problem of irregularity is to measure **biomass** instead of numbers. A biomass pyramid shows the actual weight of living things at each trophic level. Biomass pyramids however don't take into account the rate at which organisms grow



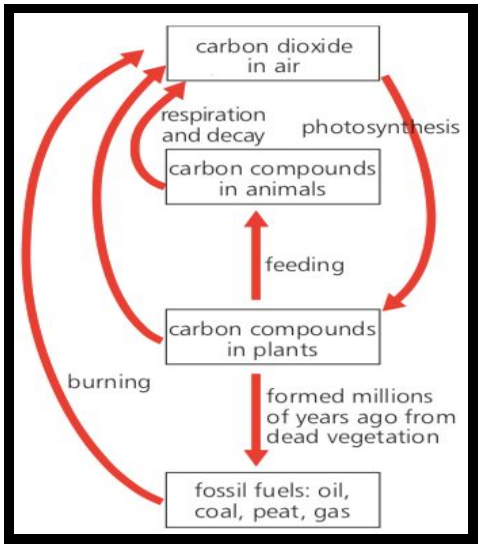
19.3 Nutrient cycles

CARBON CYCLE

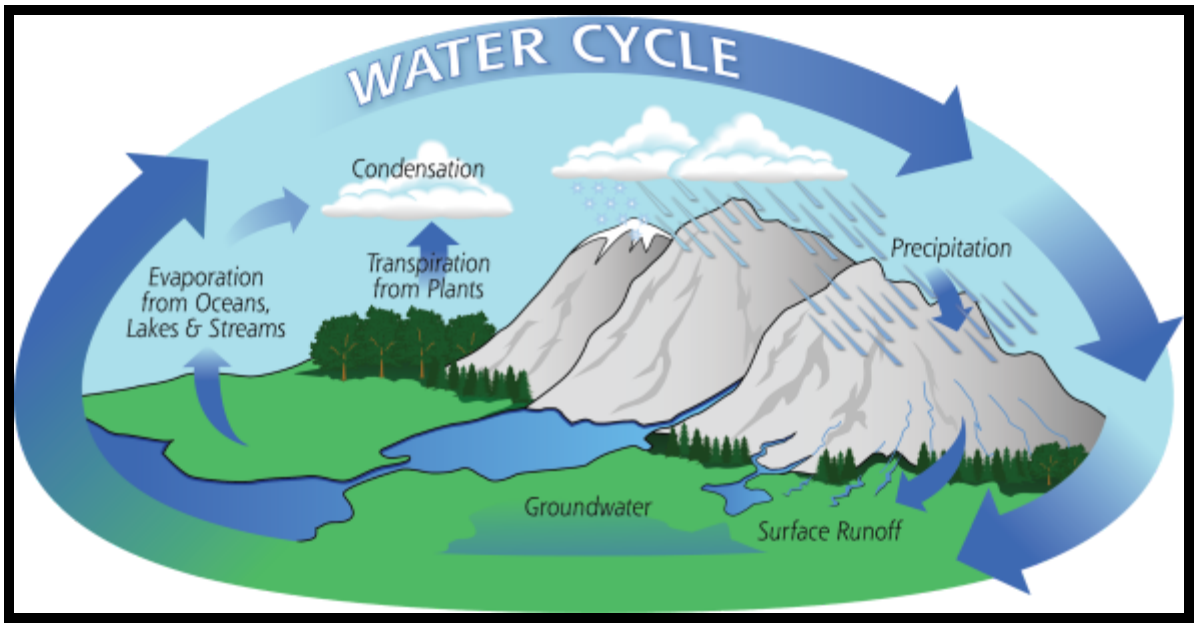
Effect of combustion and deforestation on CO_2 concentrations

Combustion: burning fossil fuels releases lots of CO_2 which collects in the earth's atmosphere

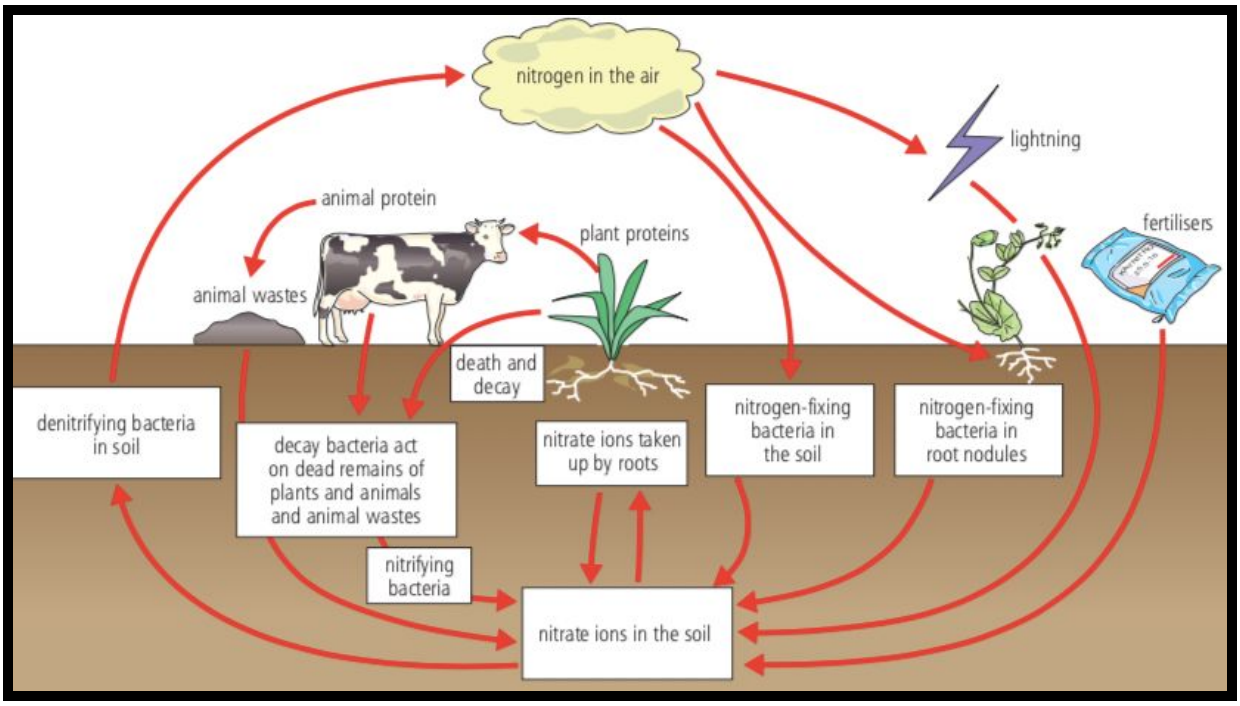
Deforestation: There are fewer trees that take in CO_2 for photosynthesis



WATER CYCLE



NITROGEN CYCLE



The nitrogen cycle involves:

- Decomposition of plant and animal protein first to amino acids and then ammonium ions (NH_4^+) by decomposers through **ammonification**
- **Nitrification** - conversion of ammonium first to nitrites (NO_2^-) and then to nitrates (NO_3^-) by nitrifying bacteria
- **Nitrogen fixation** by lightning and nitrogen-fixing bacteria **Rhizobium**
- **Absorption** of nitrate ions by plants to convert to amino acids - protein - for growth and development
- Feeding and digestion of proteins by animals
- **Denitrification** - conversion of nitrates to nitrogen gas that is released into the atmosphere by denitrifying bacteria
- **Leaching** - Nitrate ions are lost from the soil before plants can absorb them as they can be washed out of the soil by rainwater.

Numerous **microorganisms** are involved in these processes

19.4 Population size

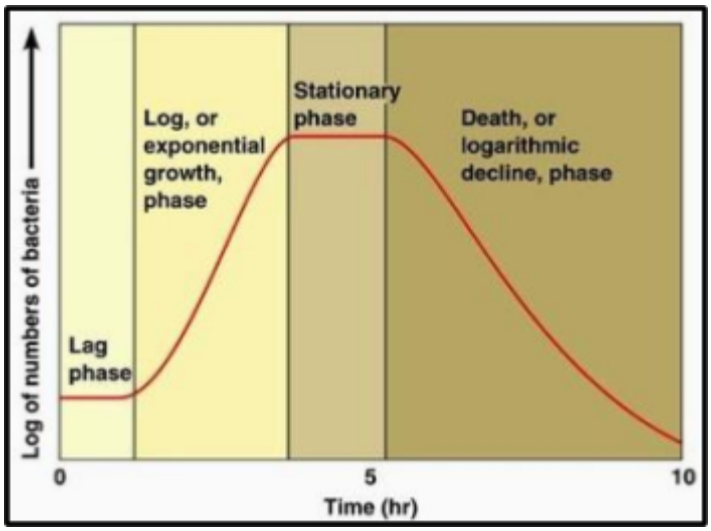
A **population** is a group of organisms of one species, living in the same area, at the same time. A **community** is all of the populations of different species in an ecosystem. An **ecosystem** is a unit containing the community of organisms and their environment, interacting together

Factors affecting population size

- **Competition for resources** - if there is limited food, only the best competitors survive
- **Predation** - numbers of predators and numbers of prey affect the population of both species
- **Disease** - when organisms live close to each other, disease can stunt population growth

Sigmoid population growth curve - curve showing bacterial growth (a good model for all species)

Phases in bacterial growth



- **Lag phase** - replication has little effect, as their numbers are so small.
- **Exponential phase** - The population increases by doubling. After a while, however, the lack of food and the buildup of wastes limit population growth, which then slows down
- **Stationary phase** - bacterial cells are dying at the same rate as they are being produced. This may because of food shortage or waste buildup
- **Death phase** - When more cells are dying than are being produced, so the population declines. This could be because of food shortage, oxygen deficit, toxic wastes.

Human populations

For the past 300 years, human populations have increased exponentially for the following reasons:

- Improved agriculture means more people are better fed, better nutrition means better protection against disease - decrease in deaths from starvation and malnutrition
- Public health has improved - decrease in child mortality rates
- Medical care has improved - increase in life expectancy, fall in birth rates

Currently, we are in the exponential phase of our species, approaching the stationary phase

20.1 Biotechnology and Genetic engineering

Bacteria are useful in biotechnology and genetic engineering due to:

- Their rapid reproduction rate
- Their ability to make complex molecules
- The lack of ethical concerns over their manipulation and growth
- The genetic code they share with all other organisms
- The presence of plasmids

20.2 Biotechnology

Biofuels and breadmaking

When yeast respires without oxygen (anaerobically) it is called fermentation:

Glucose → ethanol + carbon dioxide + energy released

Biofuels

Sugar-rich products from sugarcane and maize can be fermented anaerobically with yeast to produce ethanol. Ethanol is removed from the mixture by **fractional distillation**

Breadmaking

Bread is made from **dough**, a mixture of flour, water, salt, sugar, and yeast. This mixture is kept at a warm temperature. The yeast starts to ferment the sugar, producing carbon dioxide gas and alcohol. **Bubbles of carbon dioxide are trapped inside the dough and make it rise.** The ethanol evaporates

Fruit juice extraction

Pectinases are enzymes that break down pectins, which are molecules that act as a 'glue' in plant cell walls. Pectinases are used for extracting fruit juices and for softening vegetables.

Washing powders

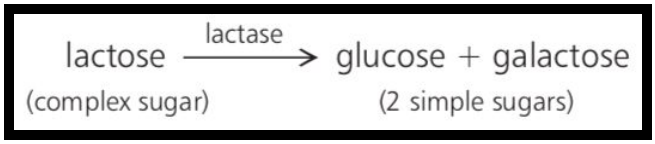
Biological washing powders in the modern-day contain enzymes that breakdown food stains on clothes. Some of these are:

- **Proteases** - Break down protein stains (Eg: blood, egg)
- **Lipase** - breaks down fats in greasy stains (Eg: butter, lipstick)
- **Amylase** - breaks down starch
- **Cellulase** - breaks down cellulose fibers on cotton fabrics

The enzymes listed above are modified so that they withstand the high temperatures and alkaline conditions required for some washing powders. During a washing cycle, the enzymes break down stains; the unwanted products of the reactions are removed when the washing machine empties.

Use of lactase in making lactose-free milk

Some people are lactose-intolerant. There the enzyme lactase is required to break down the lactose found in milk. The lactase enzyme is attached to **alginate beads** which ensures that the enzyme does not mix with the final product. You can investigate the effect of lactase in breaking down lactose by using test strips that detect the concentration of glucose.

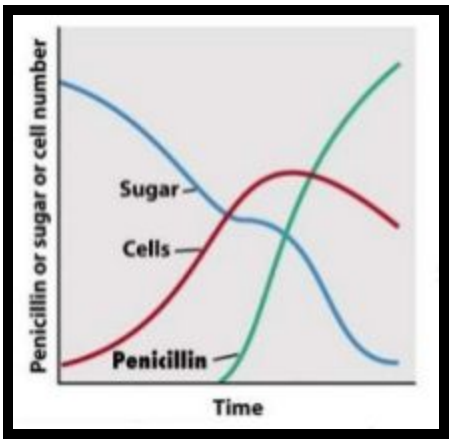


Fermenters and penicillin

Industrial production of penicillin

The fermenter is inoculated with a culture of *Penicillium chrysogenum*. This then proceeds to grow under the conditions maintained inside the fermenter. These conditions should include:

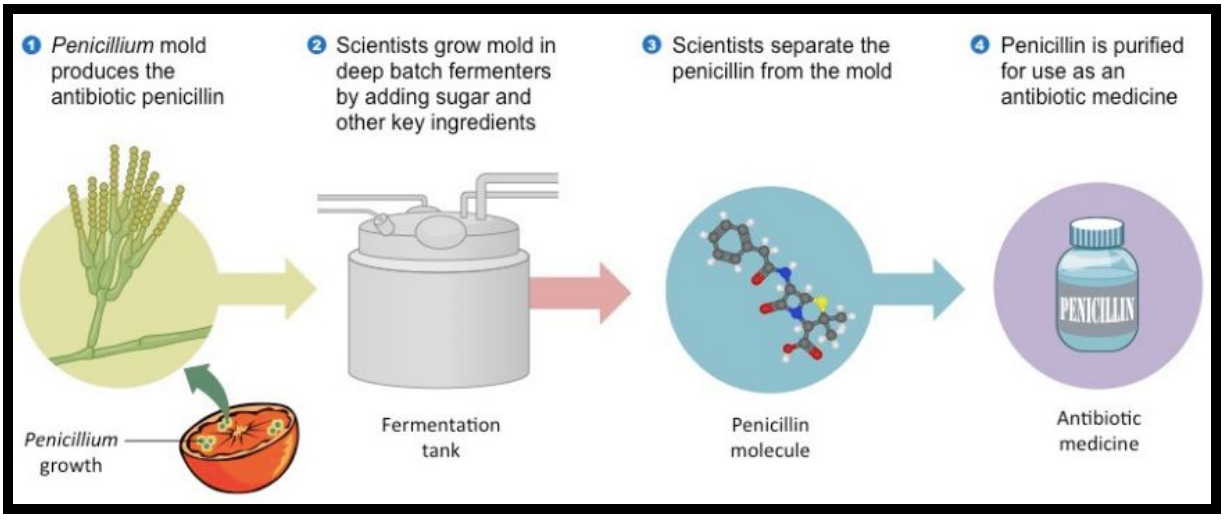
- Adding nutrients such as sugar or starch for respiration
- Ammonia or urea as a source of nitrogen for protein synthesis
- Vit B for respiration
- Constant temp. of 24°C
- Constant pH of 6.5



It takes about 30 hours for penicillin production to start. Penicillin is secreted into the surrounding liquid by the fungus.

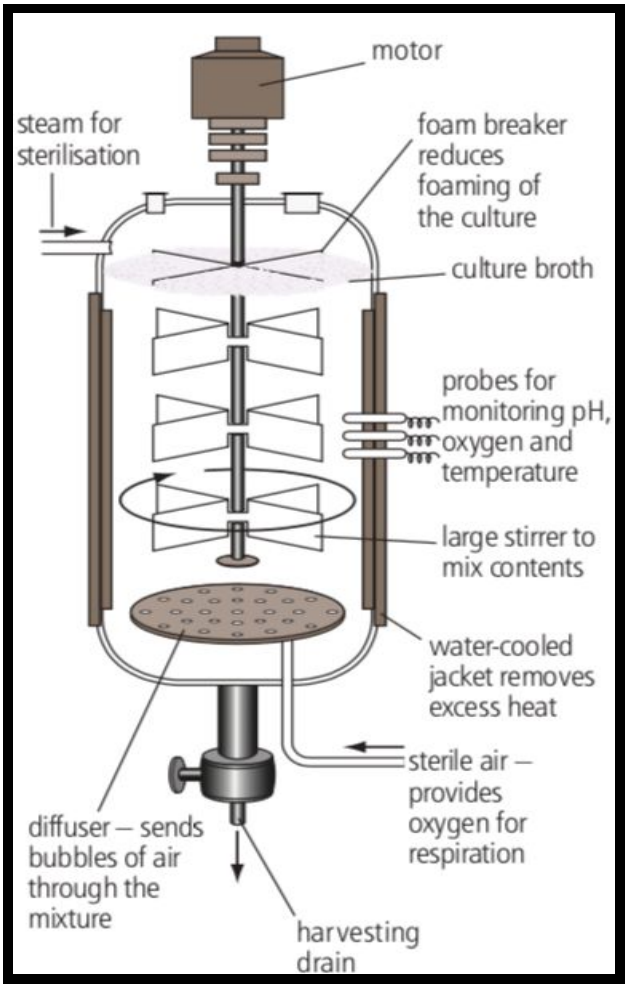
There is a delay in production. This is because penicillin is a **secondary metabolite**, a substance which is not necessary for the growth of the fungus. These are only produced when resources are low and the organisms must produce these compounds to kill off their competitors to allow it to survive. After the penicillium has replicated, sugar and ammonia is removed, so the bacterium are **under stress**, and therefore produce penicillin

Penicillin production starts after the exponential growth phase in response to one or more limiting factors. After about 6 days, the mixture in the fermenter is filtered, the penicillin is extracted using a solvent and is then purified into a crystalline salt. These crystals are used to form capsules.



The fermenter

- The **fermentation vessel** is made of stainless steel and is filled with a medium containing sugars and ammonium salts. The fungus *Penicillium* is added.
- Sugars provide energy for respiration and ammonium salts are used by the fungus to carry out protein synthesis.
- A **stirrer** keeps the microorganisms suspended so they always have access to nutrients and oxygen. Stirring also helps to maintain an even temperature throughout the fermenter.
- An **air supply** provides oxygen for the aerobic respiration of the fungus.
- A **water-cooled jacket** removes the heat produced by fermentation to give a constant temperature of 24°C.
- **Probes** monitor the temperature to maintain a constant pH of 6.5 by adding alkalis if necessary.



Remember **PAWS** (**P**robes **A**ir supply **W**ater-cooled jacket **S**tirrer)

20.3 Genetic engineering

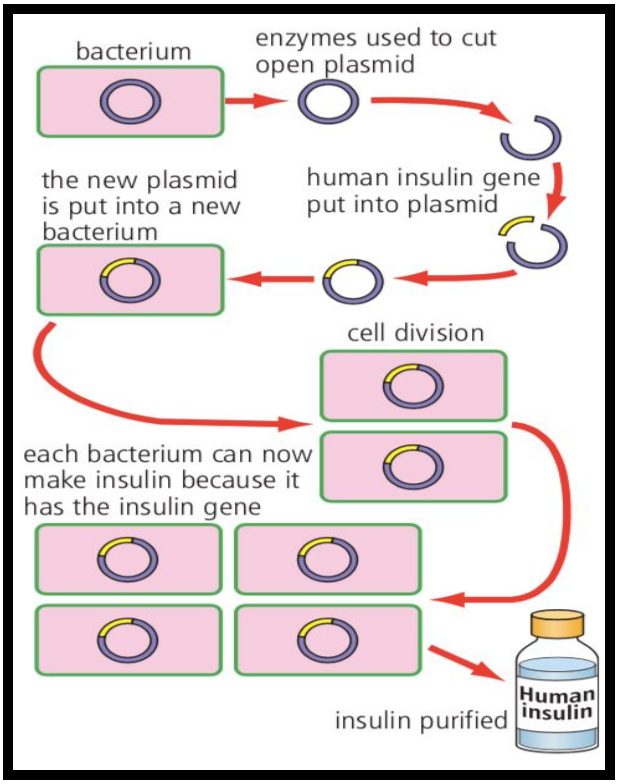
Genetic engineering is changing the genetic material of an organism by removing, changing or inserting individual genes

Examples of genetic engineering:

- Insertion of human genes into bacteria to make human insulin
- Insertion of genes into crops to
    - Offer resistance to herbicides
    - Offer resistance to pesticides
    - Provide additional vitamins

Genetic engineering using bacterial production involves:

- Isolation of DNA making up a human gene using **restriction enzymes**, forming sticky ends
- Cutting of bacterial plasmid DNA with these enzymes, forming **complementary sticky ends**
- Insertion of human DNA into bacterial plasmid DNA using **DNA ligase** to form a **recombinant plasmid**
- Insertion of plasmid into bacteria
- Replication of bacteria containing recombinant plasmids which make human protein as they express the gene



Advantages and disadvantages of genetically modifying crops

Advantages	Disadvantages

• Solving global hunger
  ○ More food available
  ○ Crops survive extreme conditions
• Environmentally friendly
  ○ GM crops have resistance
  ○ Less use of chemicals
• Consumer benefits
  ○ Better quality and fewer additives
	• Environmental safety
	  ○ GM crops may become successful weeds
	• Food safety
	  ○ New gene combinations may be harmful
	• Biodiversity
	  ○ Reduces variety

21.1 Food supply

The availability of modern technology has resulted in increased food production as:

- **Agricultural machinery** - increased efficiency
- **Chemical fertilizers**- better yield and quality
- **Pesticides** - better yield and quality
- **Herbicides** - reduce competition with weeds
- **Selective breeding** - retains best traits

A **monoculture** is growing the same specific crop in large areas, year after year.:

- **Herbicides and Pesticides** kill some species that are harmless/ perhaps helpful
- Constant use of these chemicals leads to the **evolution of resistance**
- Use of fertilizer damages the soil, which no longer supports the **biodiversity of organisms**
- **Continual drain** of the same nutrients

Intensive farming is using modern technology to achieve high yields of crop plants and livestock.

- Animals, especially cattle, generate a lot of **methane** (greenhouse gas)
- **Urine and feces** pollute waterways which leads to eutrophication
- Waste food from large fish farms can have a serious effect on surrounding waters
- The high density of fish **eases the spread of pathogens**

Social, environmental and economic implications

- Food production requires a large area of land - residents displaced
- Land clearance for plantations and ranching - damages the environment
- Farming has become increasingly mechanized - leads to unemployment
- Intensive agriculture requires large energy inputs
    - Fossil fuels need to be burned
    - Requires investments from large corporations - These steal all profits

Problems that contribute to world famine

- Unequal distribution of food
- Increasing Population
- Poverty
- Drought
- Flooding

21.2 Habitat destruction

Some of the reasons for habitat destruction are:

- Clearance of land for crop growth, livestock production, and housing
- Extraction of natural resources - digging in mines and quarries
- Marine pollution

Human influences on food chains and webs

If we haven't completely cleared areas of the natural environment or destroyed them by pollution, we have removed organisms directly or indirectly. For example:

- Large predators have been killed as they were dangerous
- Large herbivores have been killed for food
- Overfishing has had significant effects

Undesirable effects of deforestation

The cutting down of trees by humans for various purposes has resulted in several environmental problems including:

- **The extinction of species**
  - Habitats destroyed - animals cannot adapt
- **The loss of soil (erosion)**
  - Nothing to bind the soil, so running water washes it away, along with nutrients
- **Increased flooding**
  - Water runs off land much quicker, as it is not absorbed by plants
- **Increase in CO_2 in the atmosphere**
  - CO_2 is not replaced by O_2

21.3 Pollution

Pollution is the release of harmful substances from human activities that are harmful to the environment. A **pollutant** is anything released as a result of human activity that has the potential to cause harm.

Sources and effects of land and water pollution

Pollutant	Sources	Undesirable effects on the environment
CO_2	Burning fossil fuels	Enhances greenhouse effect
CH_4	Cattle, paddy fields	Enhances greenhouse effect
Sewage	Wastes	Reduces O_2 concentration in rivers
Industrial waste	Factories	Can be fatal - they accumulate in organisms
Fertilizers (N and P)	Agriculture	Eutrophication in freshwater
Herbicides	Agriculture	Spray drift kills harmless plants
Pesticides	Agriculture and livestock	Accumulates in and kills harmless species
Solid waste/Rubbish	Domestic/industrial waste	Buried in landfills, toxic, visual pollutant
Nuclear fall-out	Bombs, Reactor accidents	Death (high exposure), cancer, mutations

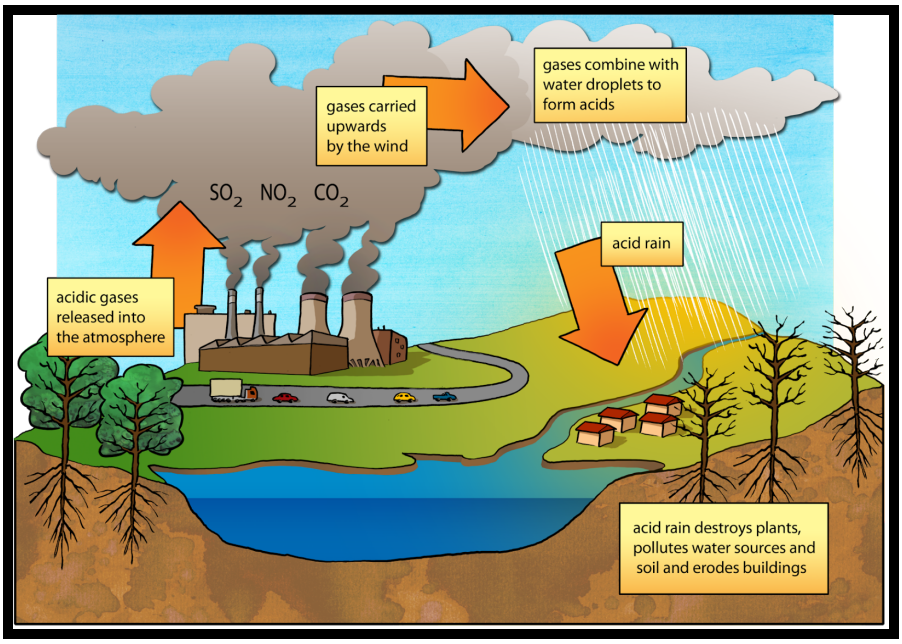
Eutrophication

I. Excess use of fertilizer is washed away into water bodies - this is known as **leaching**
II. Algal growth is stimulated with the increased availability of NPK
III. Animals that eat the algae do not multiply fast enough to control their growth
IV. **Algal bloom** - algae covers the surface of the water - blocking light
V. Plants and algae below the surface cannot photosynthesize and therefore die
VI. **Decomposers** such as bacteria feed on dead plants and algae
VII. They respire **aerobically**, multiply rapidly and **reduce the concentration of dissolved O_2**
VIII. The reduction in O_2 concentration kills fish and other invertebrates

Waste plastics

Materials that are broken down in the environment by decomposers are **biodegradable**
However, some are not and these are **non-biodegradable**. Disposing of these is the problem - they have to be thrown into landfills and remain in them for thousands of years. Aquatic life is also affected eg: Turtles think plastic bags are jellyfish

Causes, Effects, and Measures to reduce acid rain



Causes :
SO_2 released on burning sulfur compounds and NO and NO_2 from car exhausts are carried upwards by wind. These gases react with water droplets to form sulfuric acid (H_2SO_4) and nitric acid (HNO_3). These makeup acid rain

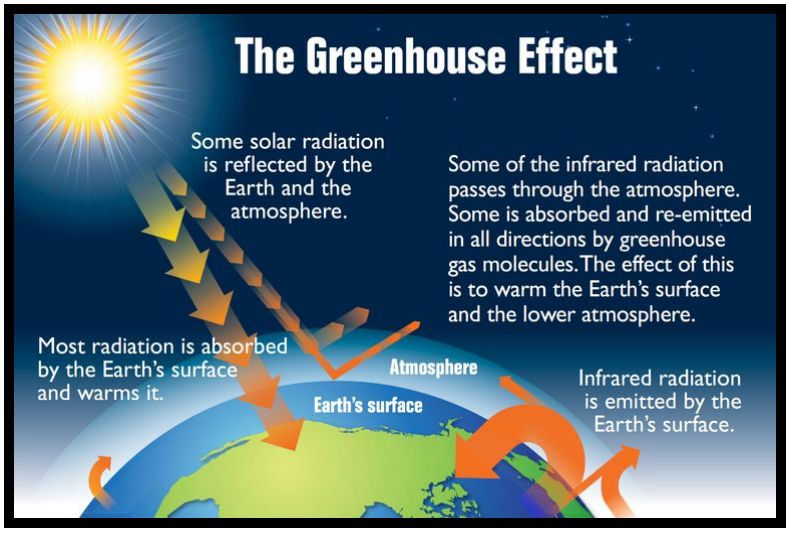
Effects: Destroys plants, pollutes water sources and soil, erodes buildings and monuments

Measures to reduce: Burning of low sulfur fuels, flue gas desulfurization (treating gases with wet powdered limestone - neutralizes acidic gases), catalytic converters - reduce nitrogen oxides

Negative impacts of female contraceptive hormones in watercourses

When females take contraceptive pills, the hormone estrogen is excreted in urine and is washed into water bodies. This can lead to **reduced sperm count** in men and **intersex** (change of gender) in fish leading to gender imbalance

The greenhouse effect



Greenhouse gases include CO_2, H_2O vapor, CH_4, and CFCs. Light and heat energy enters the earth's atmosphere as **Ultraviolet radiation (shortwave)**, to which greenhouse gases are not sensitive. Once the light and heat are reflected, they become **infrared radiation (longwave)**, to which greenhouse gases are sensitive. The greenhouse gases trap heat and release it back towards the earth's surface. The greenhouse effect is a **natural process** and without it, Earth's temperature would be too low for survival. The **enhanced greenhouse effect** is leading to **climate change**, as the excess buildup of gases traps too much heat. This could mean that:

- Sea levels rise if temperature in the poles goes above 0°C - ice would melt - flooding
- Change in wind patterns
- Change in distribution of rainfall

21.4 Conservation

A **sustainable resource** is one that is produced as rapidly as it is removed from the environment so that it does not run out. **Sustainable development** is development providing for the needs of an increasing human population without harming the environment. Sustainable development requires the management of conflicting demands, as well as planning and cooperation at local, national, and international levels.

The need to conserve fossil fuels

The world's energy demands are constantly increasing. We must sustainably use non-renewable sources so that future generations can also survive. This can be done by:

- Reducing energy wastage - improving efficiency
- Reducing demand for petrol/gasoline
- Recycling materials

Sustainable timber production and fishing

Some resources such as forests and fish stocks can be maintained through **educating** people about the damage caused by overuse, employment of **legal quotas** that limit the number of trees or the number of fish that can be removed from their environments, or **Restocking**.

Sewage treatment

There are three main stages of sewage treatment:

- **Primary treatment**
  - Involves the filtration of large particles such as twigs
- **Secondary treatment**
  - Involves adding microbes that decompose material in the sewage. 2 methods:
    - Activated sludge process - Air is pumped through sewage which is full of microbes that break down nutrients in aerobic conditions into CO_2. Urea is converted to ammonia and then nitrate ions
    - Trickle filters - These are beds of gravel covered with microbes. The liquid from primary treatment is pumped through these beds and microbes decompose the material.
- **Tertiary treatment**
  - Involves a period of settling in large tanks
  - Microbes and organic material settle at the bottom to form sludge
  - The sludge maybe
    - Sent back to the second stage to increase microbe population
    - Sent to an anaerobic stage in which bacteria break down waste matter to CH_4 - The methane is burned to provide energy for the sewage works
    - Dumped into sea or spread on land as a soil conditioner

Extinction and endangered species

A species becomes **extinct** if there are no individuals left alive anywhere in the world. When the numbers of a species decrease to such a level that it is at risk of becoming extinct the species is described as **endangered**

Threats to the survival of species

- Climate change - As the world gets warmer, species become less adapted to survive
- Habitat destruction - Species die as they cannot adapt as easily to a new environment
- Pollution - The effects of pollution take a toll on other species as well
- Introduced species - competition increases, and balance of organisms changes
- Hunting - Excessive hunting has led to several extinctions

A **small population** of a species means that there is **very little genetic variation**, so this makes endangered species at risk of becoming extinct. With few individuals, many of the **alleles of the genes are lost**. This reduces the chance of the population **evolving** in response to changes in the environment

Conservation of species

This can be done through:

- Monitoring and protecting species and habitats
  - National parks
  - Marine parks
  - Reducing habitat destruction
  - Preventing trade in endangered animal and plant goods
  - Encouraging sustainable management of ecosystems
- Education
- Captive breeding programs
- Seed banks
- Botanical gardens

Reasons for conservation

We should conserve ecosystems, habitats, and species because:

- Ecosystems provide us with several services
  - Food
  - Fuels
  - Area for recreation
  - Medicine
- Ecosystems maintain biodiversity
- Habitats support a wide variety of organisms
- Preventing extinction