1: Characteristics of living organisms

The 7 characteristics that distinguish living things from non-living objects are: **N**utrition, **E**xcretion, **R**espiration, **S**ensitivity, **R**eproduction, **G**rowth and **M**ovement.

7 characteristics of living organisms

1. Nutrition	**Take in** **Absorb** **Assimilate**	**Nutrients**	**Organic** substances **Mineral** ions containing **raw materials/ energy** for: **Growth + Tissue repair**
Plants make their own food	**Photo-synthesis**	**H_2O CO_2 Light**	
2.Excretion	**Removal**	**Toxic** Materials **Waste** Products of metabolism Substance in **Excess**	By **chemical reactions** in cells (respiration...)
3.Respiration	**Break down**	**Food** in cells	Release **Energy**
4.Sensitivity	**Sense** **Respond**	**Changes** in the environment **(Stimuli)**	
5.Reprodution	**Produce**	**Offspring**	Prevent extinction of species
6.Growth	**Increase**	**Size** **Mass** of an organism	By increasing **cell number** and/or cell **size**
7. Movement	**Change**	**Position** or **Place**	of an **organism** or **part** of an **organism**
Ex: Parts of plants move very slowly to obtain more light for photosynthesis.			

Credit: Painting Above All Else Guard Your Heart
by Carmen Keys

Common misconceptions

- Don't confuse **respiration** with **breathing**.
- Don't use **faeces** or **defecation** as an example of **excretio**n (faeces is indigested food- it has not been formed through metabolic processes).
- Some non-living things, such as a car, may appear to show some of the characteristics – but not all of them.

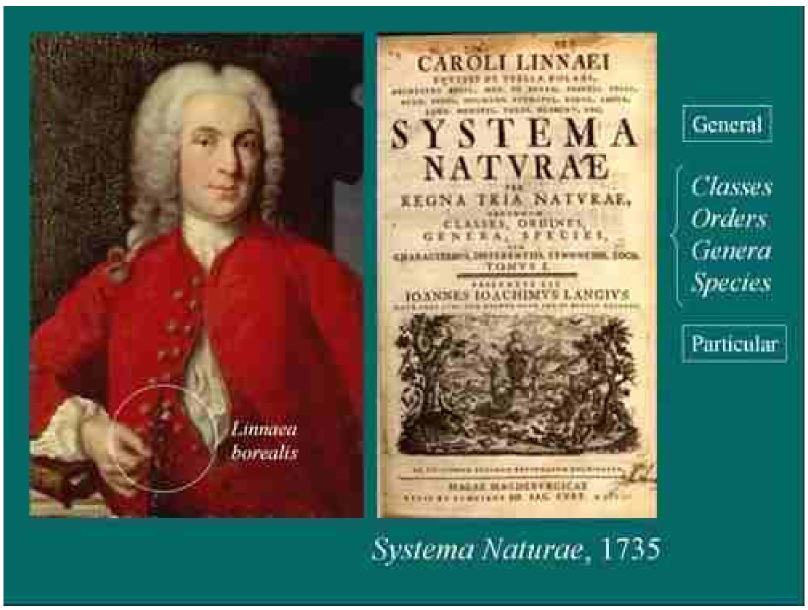
* **Characteristics of living organisms Quiz**

2: Classification of living organisms

Classification: The scientific method of dividing organisms into smaller and larger groups, on basis of their similarities.

Swedish botanist **Carolus Linnaeus** is the Father of Systematic Biology. He believed he could:

- Put every organism into a group (the science of TAXONOMY)
- Give every organism a name (the science of NOMENCLATURE).



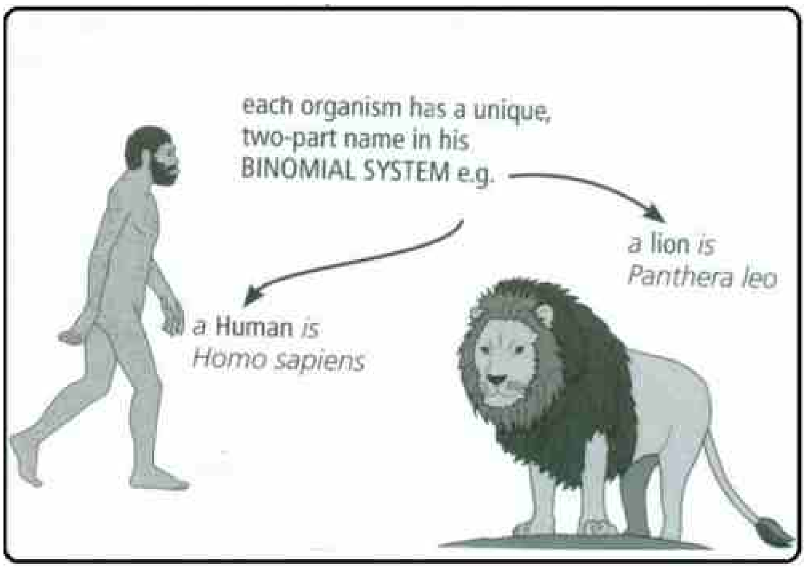
Carolus Linnaeus organized **taxonomy** (1735).

In his **BINOMIAL SYSTEM**, every living organism has a unique, **two-part name**:

- The first name is **Genus,** the second name is **species.**
- Names are written in Latin, printed in *italics*.
- The genus always has a **capital** letter, and the species always has a **small** letter.

For examples:

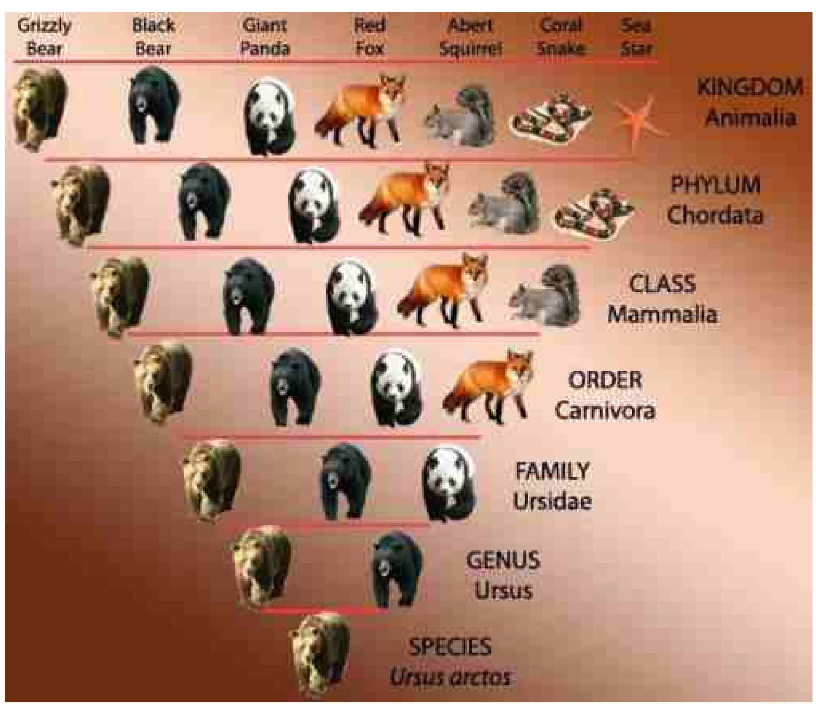
	Genus	Species	Abreviation
Human	***Homo***	***sapiens***	***H. sapiens***
Lion	***Panthera***	***leo***	***P. leo***
Wolf	***Canis***	***lupus***	***C. lupus***



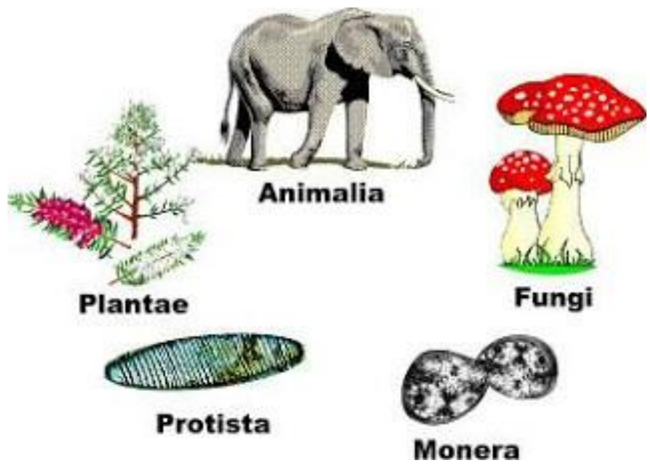
We still use this system today.

All life forms are categorized into a scheme that had 7 categorical terms. The biggest group are **Kingdom,** the smallest one is **Species**.

Each kingdom is divided into smaller group, which include genus and species. Organisms can exist in only one group at each level of classification. For example, an organism can only belong to one kingdom or one genus.

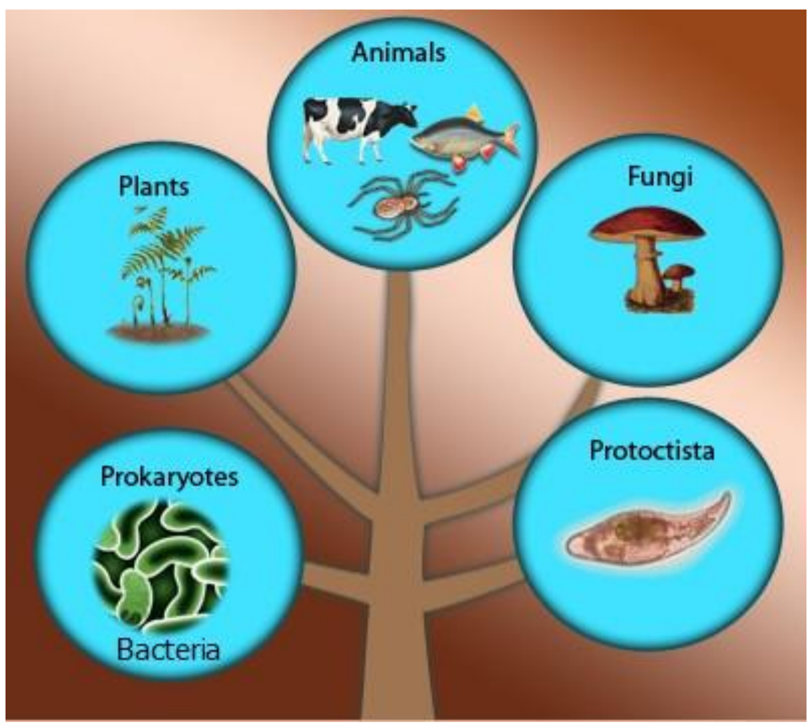


 # 3: Five Kingdoms of living things



All living things are divided into 5 kingdoms. Each kingdom has certain characteristics that all members of that group shared. They are:

Animals, **P**lants, **F**ungi, **P**rotoctists, **B**acteria (Prokaryotes)

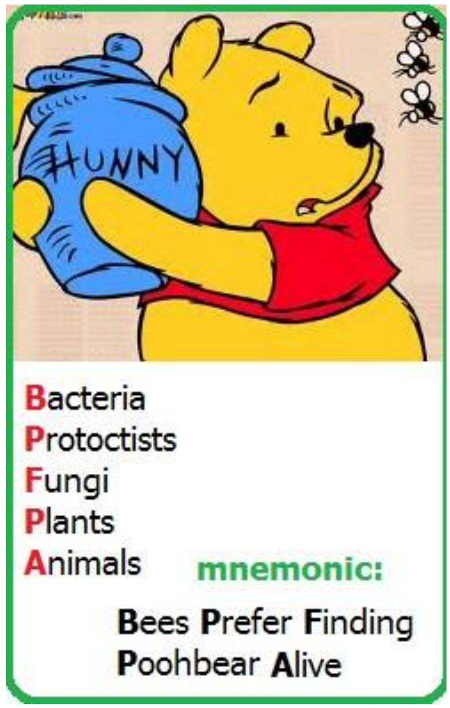


The characteristics that Linnaeus used to divide all organisms into one of the five groups included:

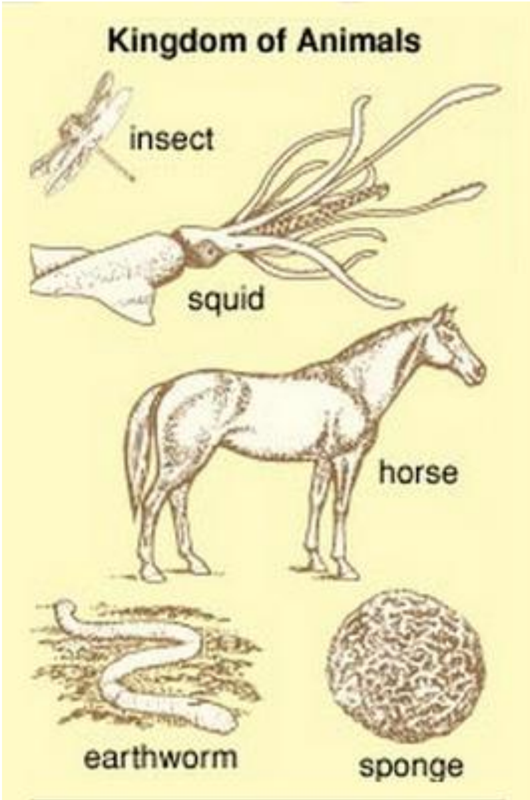
- How many cells made up their bodies, if their cells were very simple or had complex parts

- If they can move on their own
- If they could make their own food, or had to eat other creatures to survive ...

Mnemonic



4: Animal Kingdom – Classification



The animal kingdom contains many phyla. Some of them are:

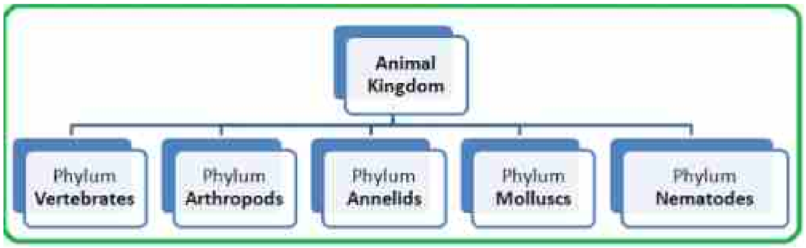
Vertebrates, Arthropods, Annelids, Molluscs, Nematodes.

It is not always easy to recognise an animal. For a very long time, people thought that's sea anemones were plants, because they tend to stay in one place and their tentacles look rather kike petals. Now we know that they are animals.

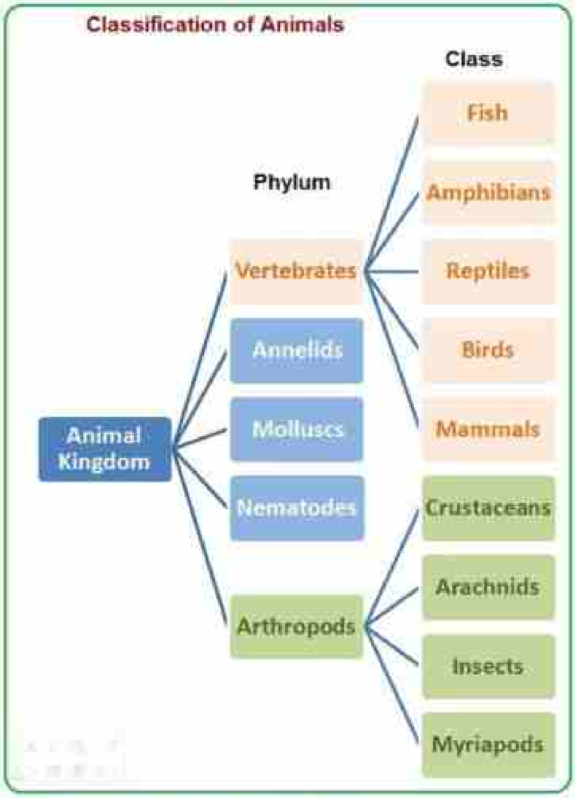
Sea anemones

One of the best way to tell if an organism is an animal is to look at its cells under the microscope. **Animal cells never have cell walls**.

Animals are classified into many phyla. Here are just some of these phyla:

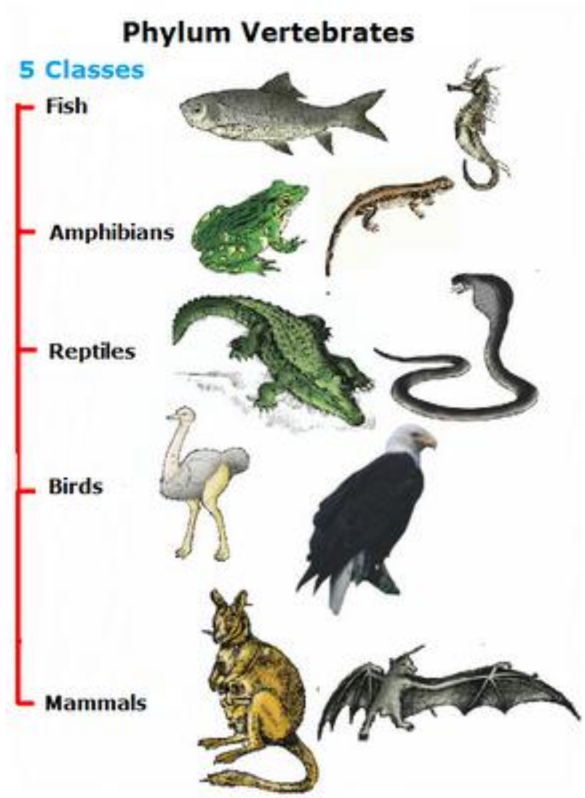


Classes in two of these phyla:



Details of each phylum and class are given in the next topics.

5 Phylum Vertebrates



Vertebrates are animals with backbones. They are divided into 5 groups called classes:

Fish, Amphibians, Reptiles, Birds and Mammals.

Details of each group are given in the table below. You only need to be able to describe visible external features, but other details can be helpful.

VERTEBRATES (ANIMALS WITH BACKBONES)

CLASS	EXTERNAL FEATURES	OTHER FEATURES
Fish (all aquatic)	• Scales • Fins • Eyes and lateral line	• Jelly-covered eggs; usually use external fertilisation • Ectothermic • Gills for gas exchange
Amphibians (always breed in water)	• Moist skin • Four limbs • Eyes and ears	• Jelly-covered eggs; external fertilisation • Ectothermic • Lungs/skin for gas exchange
Reptiles (lay eggs on land)	• Dry, scaly skin • Four limbs (not in snakes) • Eyes and ears	• Soft-shelled eggs; internal fertilisation • Ectothermic • Lungs for gas exchange
Birds (very few are aquatic)	• Feathers (scales on legs) • Two wings, two legs • Eyes and ears	• Hard-shelled eggs; internal fertilisation • Endothermic • Lungs for gas exchange
Mammals (very few are aquatic)	• Fur or hair • Four limbs • Eyes and ears • Nipples	• Live young (a few lay eggs) • Endothermic • Lungs for gas exchange • Feed young with milk from mammary glands

You could be asked to directly describe these in exam questions

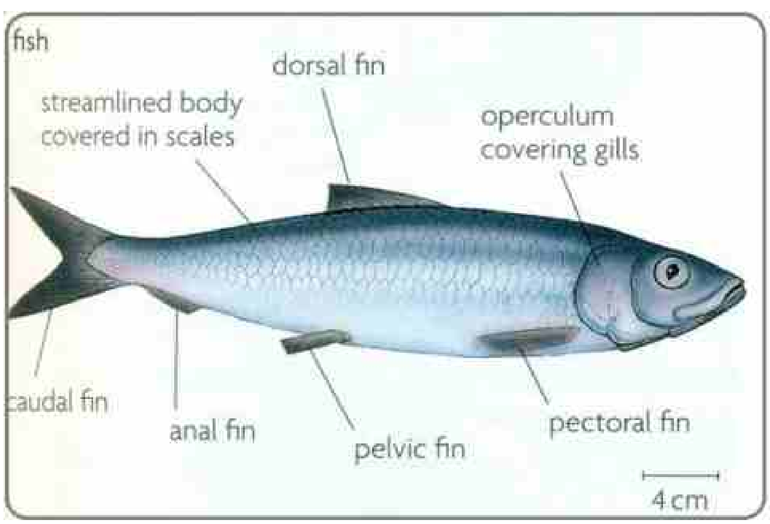
You could use these features in questions on other topics

Classification of vertebrates

Vertebrates are animals with backbones (part of an internal skeleton).
Vertebrates are divided into five groups called classes.
Details of each group are given in the table below.

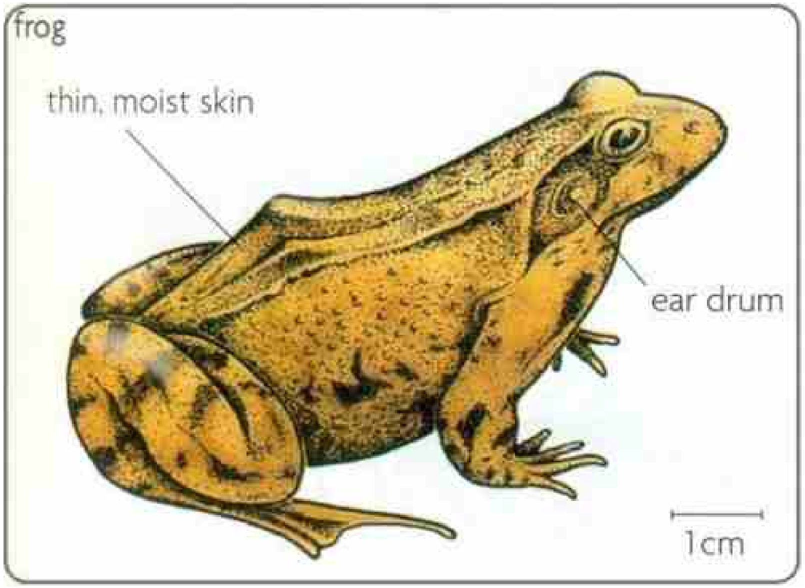
Vertebrate class	Body covering	Movement	Reproduction	Sense organs	Other details	Examples
Fish	Scales	Fins (also used for balance)	Usually produces jelly-covered eggs in water	Eyes but no ears, lateral line along body for detecting vibrations in water	Cold-blooded, gills for breathing	Herring, perch, shark
Amphibians	Moist skin	Four limbs, back feet often webbed to make swimming more efficient	Produces jelly-covered eggs in water	Eyes and ears	Cold-blooded, lungs and skin for breathing	Frog, toad, salamander
Reptiles	Dry, with scales	Four legs (apart from snakes)	Eggs with rubbery, waterproof shell – laid on land	Eyes and ears	Cold-blooded, lungs for breathing	Crocodile, python
Birds	Feathers, scales on legs	Wings, two legs	Eggs with hard shell	Eyes and ears	Warm-blooded, lungs for breathing, beak	Flamingo, pigeon
Mammals	Fur	Four limbs	Live young	Eyes, ears with pinna (external flap)	Warm-blooded, lungs for breathing, females have mammary glands to produce milk to feed young, four types of teeth	Elephant, mouse

1. Fish



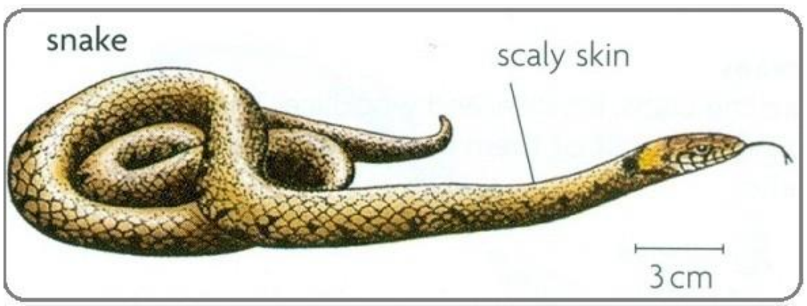
Scales- Fins - Eyes & lateral Lines - Gills.

2. Amphibians



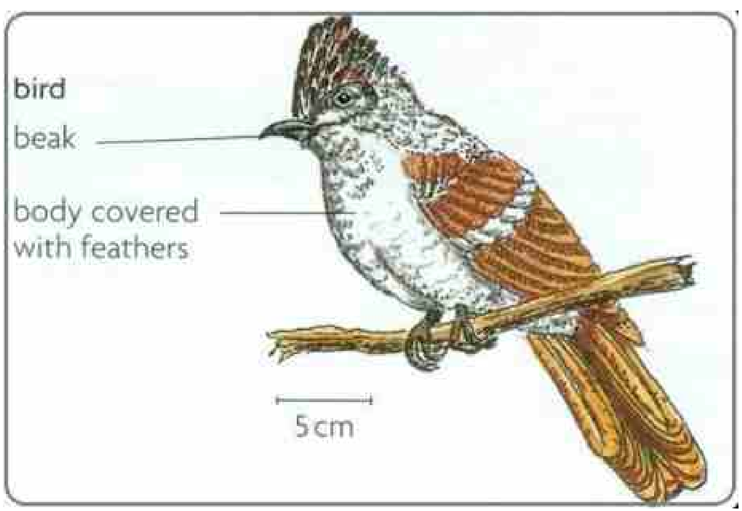
Moist scaleless skin - Eye & Ears - 4 limbs.

3. Reptiles



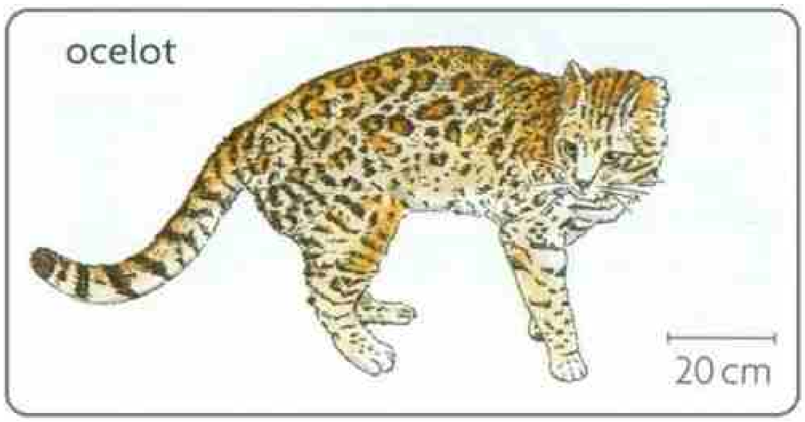
Dry scaly skin - Eyes & Ears - 4 legs (apart from snakes).

4. Birds



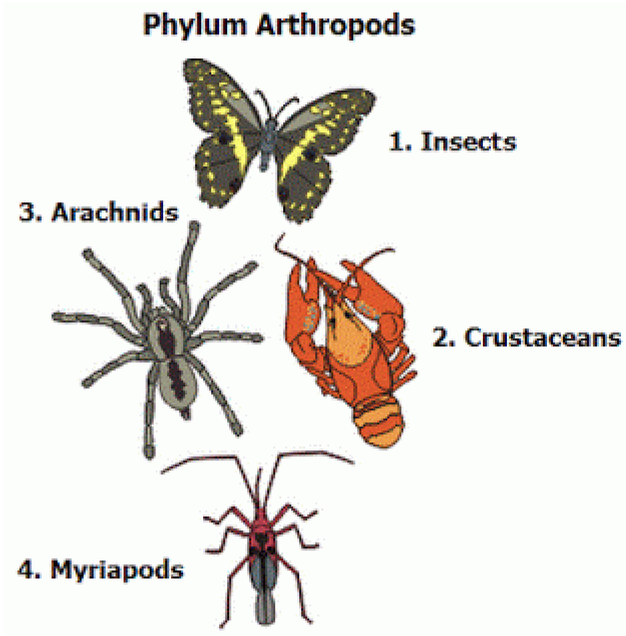
Beak - Feathers - Scales on legs - Wings - 2 legs.

5. Mammals



Fur - 4 limbs.

#6 Phylum Arthropods



There are more arthropods than any other group of animals, so they are divided into classes:

Insects, Crustaceans, Arachnids and Myriapods.

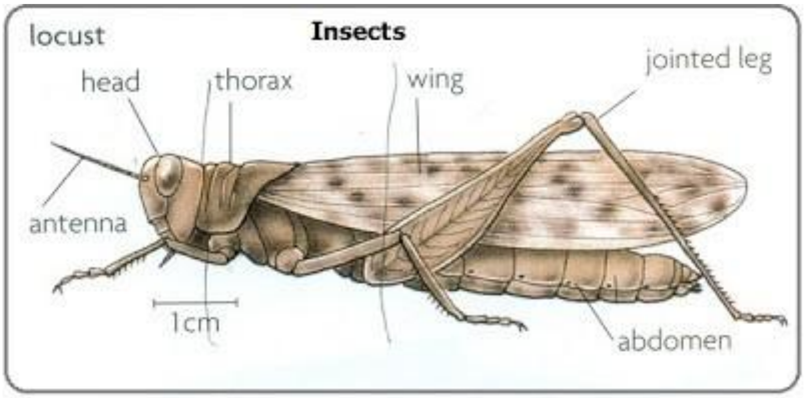
Special features of Arthropods:

- Invertebrates (**no backbone**)
- Waterproof **Exoskeleton** ----> Exist in very dry places, not confined to water or moist places like most invertebrates.
- **Segmented body**
- **Jointed legs** (exoskeleton prevents movement)

4 classes of Arthropods

1. Insects

Insects are a very successful group, due to their exoskeleton and **tracheae**, which are very good at stopping water from evaporating from insects's body, so they can live in **very dry** places.

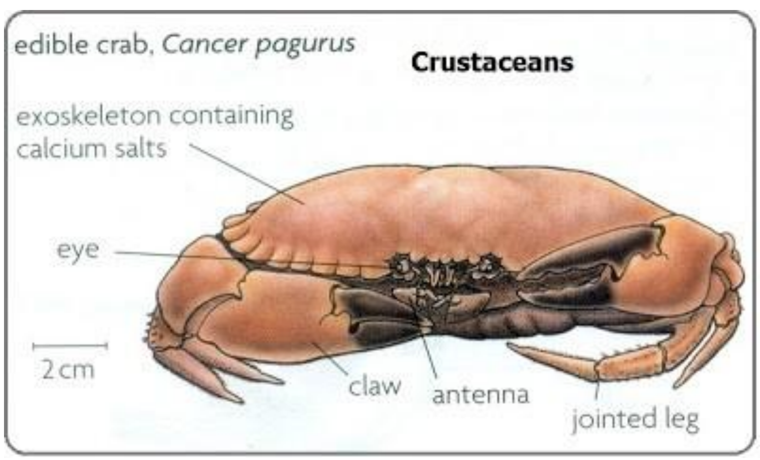


Key features of Insects:

- 3 pairs of **jointed legs**
- 1 or 2 pairs of **wings**
- 1 pair of antennae
- 3 body parts: **Head, Thorax, Abdomen**
- 1 pair of compound **eyes**
- Breath through **tracheae**

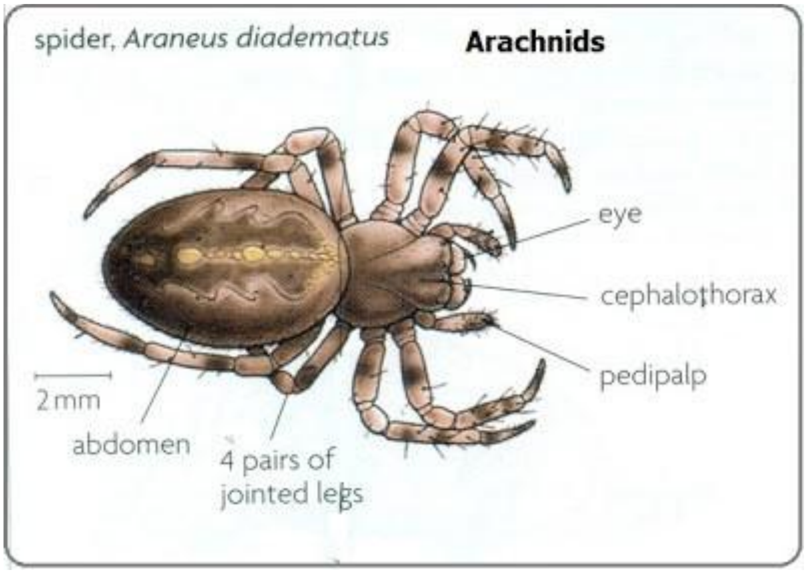
2. Crustaceans

These are the crabs, lobsters and woodlice. They breath through **gills**, so most of them live in **wet places** and many are aquatic.



3. Arachnids

These are spiders, ticks and scorpions. They are **land-dwelling** organisms.

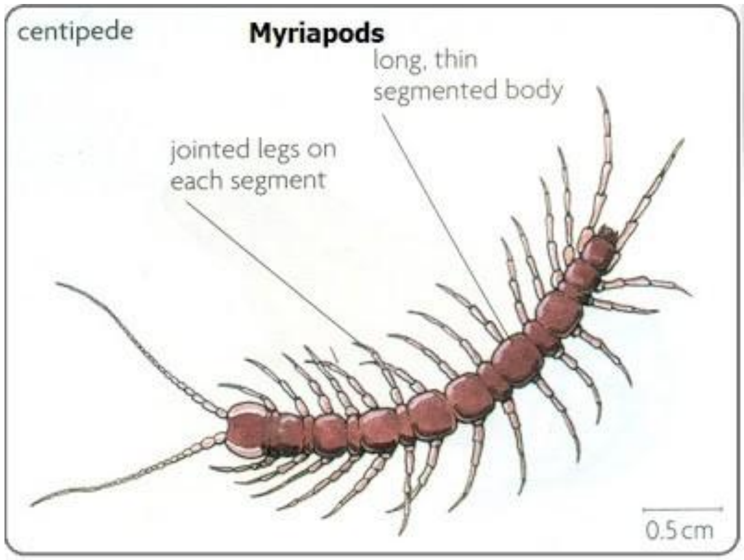


Key features of Arachnids

- 4 pairs of legs
- **no wings**
- 2 pairs of antennae
- 2 body parts: **Cephalothorax, Abdomen**
- several pairs of simple eyes
- all have **piercing jaws** since all are predator
- chelicerae (pointed mouthparts) for biting and poisoning prey

4. Myriapods

These are the centipedes and millipedes.



Key features of Myriapods

- long, thin body with **many segments** for moving easily through soil and leaf litter
- no obvious thorax and abdomen
- **each segment** has **jointed legs** (>9 pairs)
- 1 pair of antennae as sense organs in dark habitats
- simple eyes

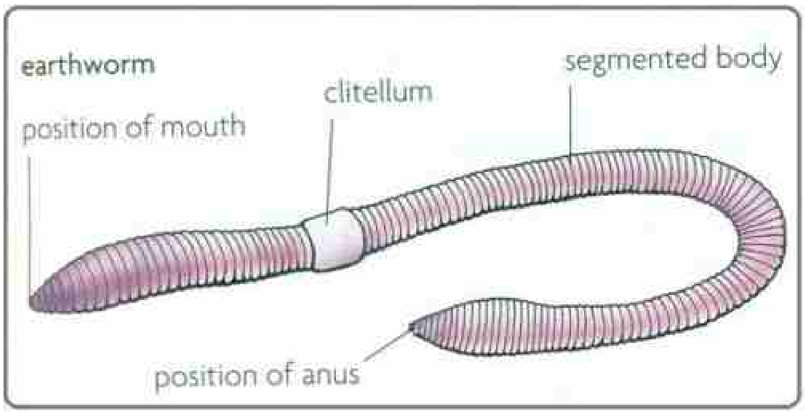
7 Other groups of invertebrates

Details about some more phyla of invertebrates:

Annelids, Nematodes, Molluscs.

1. Phylum Annelids

Annelids are worms, with bodies made up of ring-like segments. Most of them live in water, some like the earthworm live in moist soil.

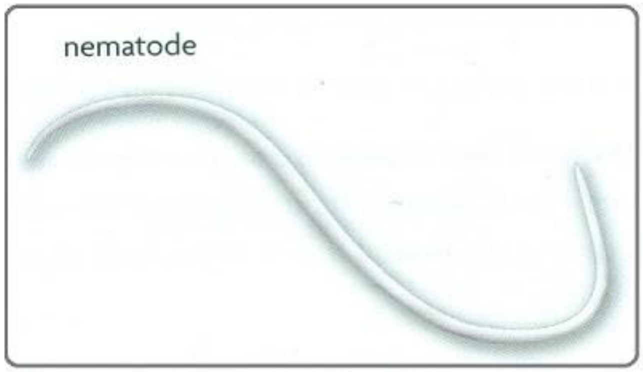


Key features of Annelids

- **many segments** on long body
- body covered with **mucus** to conserve water
- mouth and anus present
- **bristles** (stiff hair) usually present for movement
- many are hermaphrodite (intersex)

2. Phylum Nematodes

Nematodes are worms, but unlike annelids their bodies are not divided into segments. They are usually white, long and thin. They live in many different habitats. Many nematodes live in the soil.

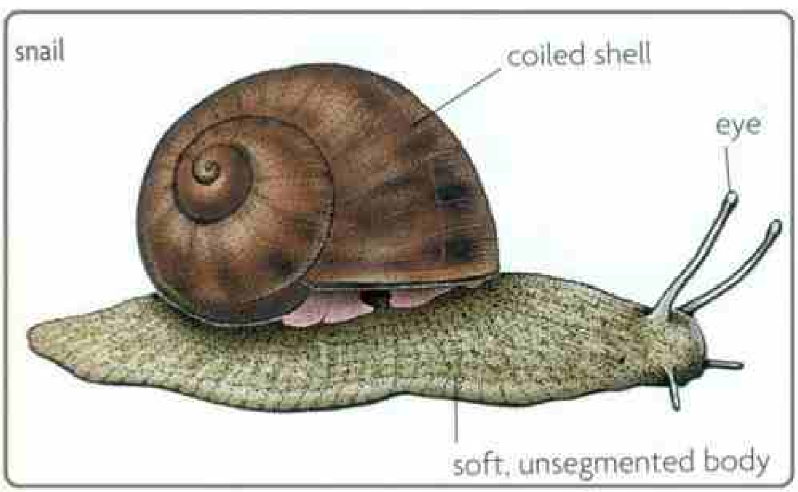


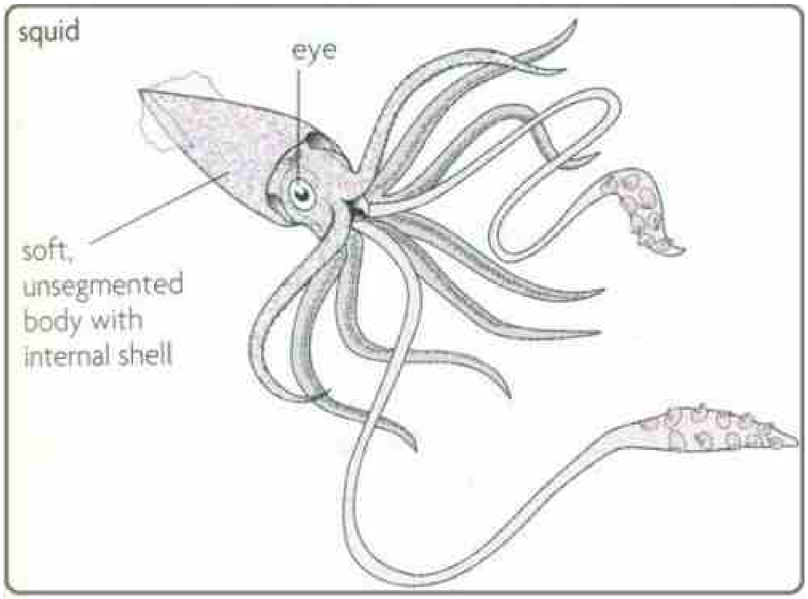
Key features of Nematodes

- **no segments**
- **long cylindrical** body
- body pointed at both ends

3. Phylum Molluscs

Molluscs are soft-bodies animals, sometimes with a shell (snails) or without (slugs).





Key features of Molluscs

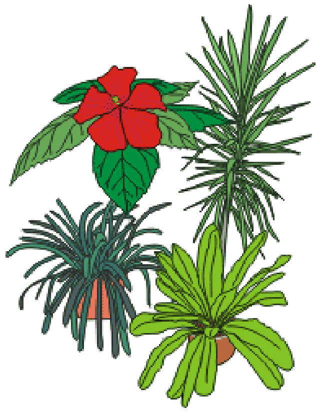
- **soft, unsegmented body**
- **muscular foot** for movement or burrowing
- most have a **shelf** made of calcium carbonate (protection from predators/drying out
- often have **eyes** on retractable tentacles

Common misconceptions

Students are often confused by the different **numbers of legs** in **insects**, **arachnids** and **crustaceans**.

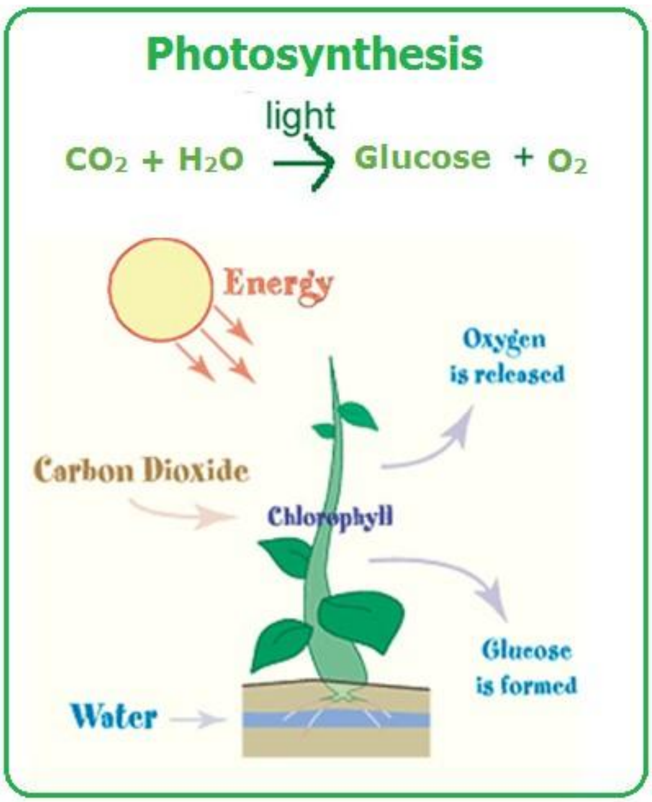
They often loose the mark by stating that insects have **3 legs** instead of **3 pairs** of **legs**.

#8: Plant Kingdom



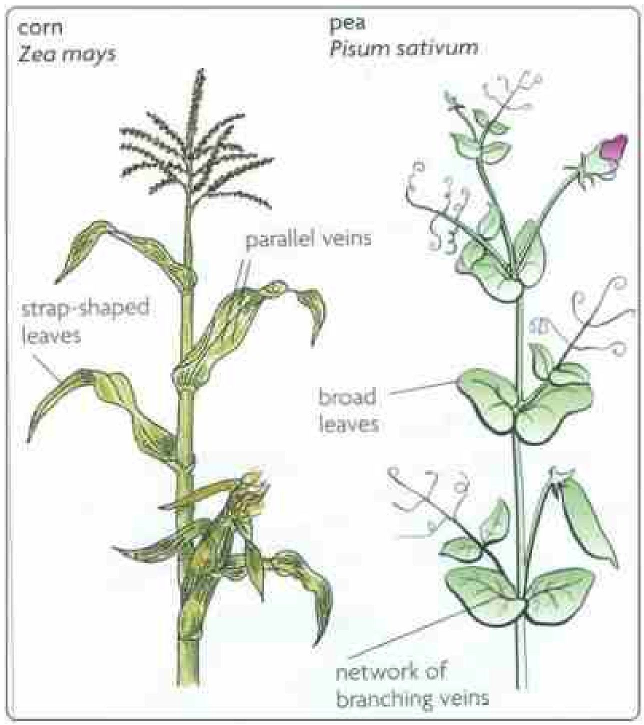
Plants are multicellular organisms, with cell wall made of **cellulose**. They include small organisms such as mosses, ferns and flowering plants.

At least some parts of a plant are green, thanks to pigment **chlorophyll**. Chlorophyll absorbs **energy** from sunlight for plant to make **glucose**, using $\mathbf{CO_2}$ and $\mathbf{H_2O}$ from environment. This is called **photosynthesis**.



Phylum Flowering plants

- have **roots**, **stems** and **leaves**
- have **xylem** and **phloem**
- reproduce by producing **seeds**
- seeds produced inside ovary, inside **flower**
- asexual reproduction is possible



They are divided into 2 groups, depending on number of ***seed leaves*** (***Cotyledon***):

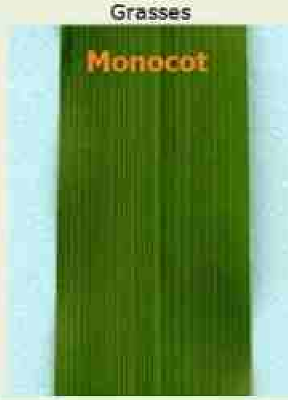
1. **Monocotyledonous** (Monocots)
2. **Dicotyledonous** (Dicots)

MONOCOTYLEDON SEED LEAF

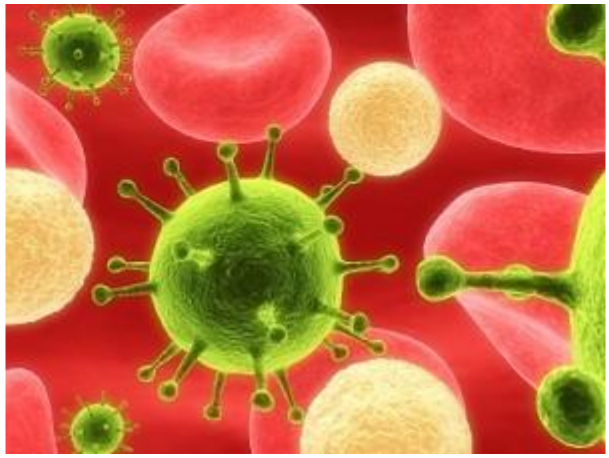
DICOTYLEDON SEED LEAVES

Differences between Monocot and Dicot leaves

Feature	Monocot	Dicot
Leaf shape	long, thin	broad
Leaf veins	parallel	branching (network of veins)
Seed leaf	1	2
Example	Grasses	Trees

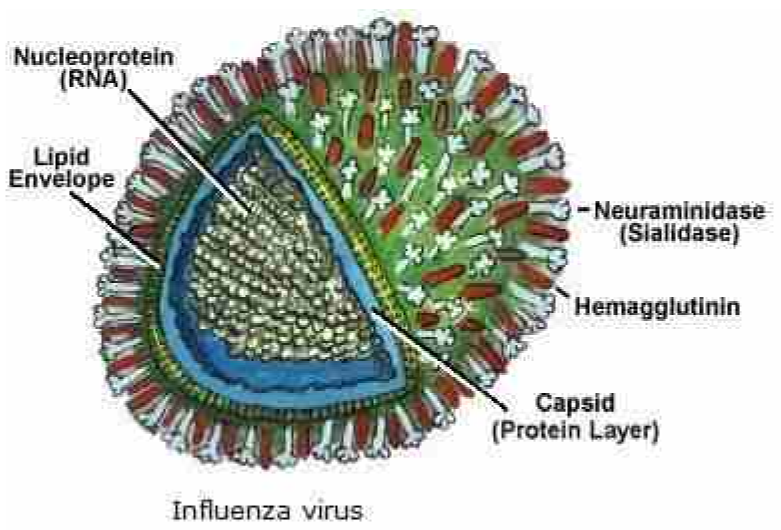


#9: Viruses



Viruses are **not** true **living things**. They are not considered to be alive, because on their own they can do nothing until they enter a living cell.

Viruses are complicated assemblies of molecules including proteins, nucleic acids, lipids, carbohydrates…



When viruses encounter a cell, they take over cell's machinery. A series of chemical reactions occur that lead to the production of new viruses. Theses new viruses burst out of the cell and invade others, where the process is repeated. The host cell is usually killed when this happens.

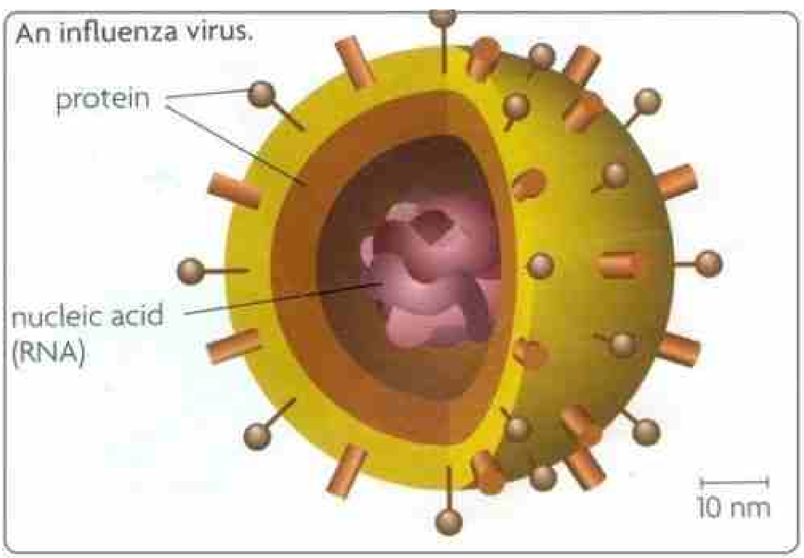
These steps are completely passive, that is, they are predefined by the nature of the molecules that comprise the virus particle. Viruses don't actually 'do' anything. **Without cells, viruses would not be able to multiply.**

Scientists do not classify a virus as a living thing. This is because:

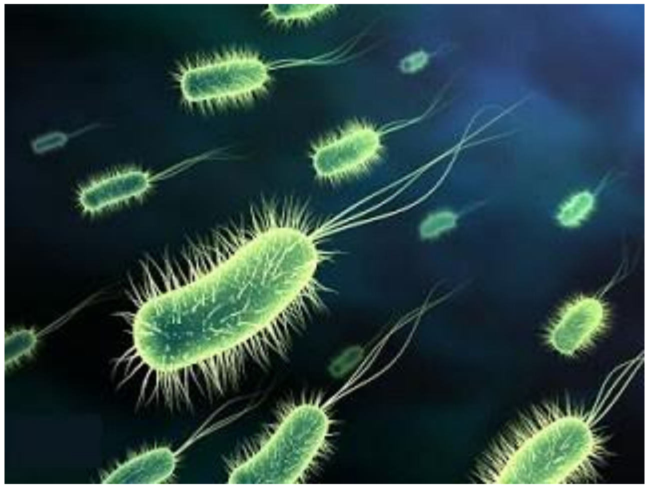
- it does not show all seven processes for life
- when it enters a cell it changes the way a cell works so it can make copies of the virus.

Key features of Viruses

- very **small** (100 times smaller than bacteria)
- **no** typical **cell structure**
- contain a strand of **DNA** or **RNA**
- surrounded by a protein coat called a **capsid**
- the only life process they show is **reproduction** (inside host cell)



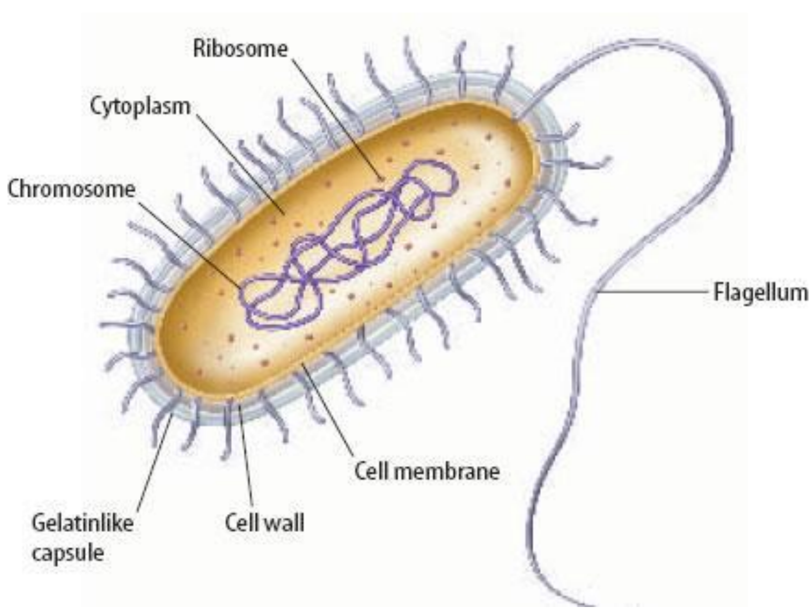
#10: Bacteria Kingdom



Bacteria cells are very different from the cells of all other organisms: they do **not have** a **nucleus.**

Some bacteria can carry out photosynthesis. The oldest fossils belong to this kingdom, so we think that they were the first kinds of organisms to evolve.

Bacterial cell structure



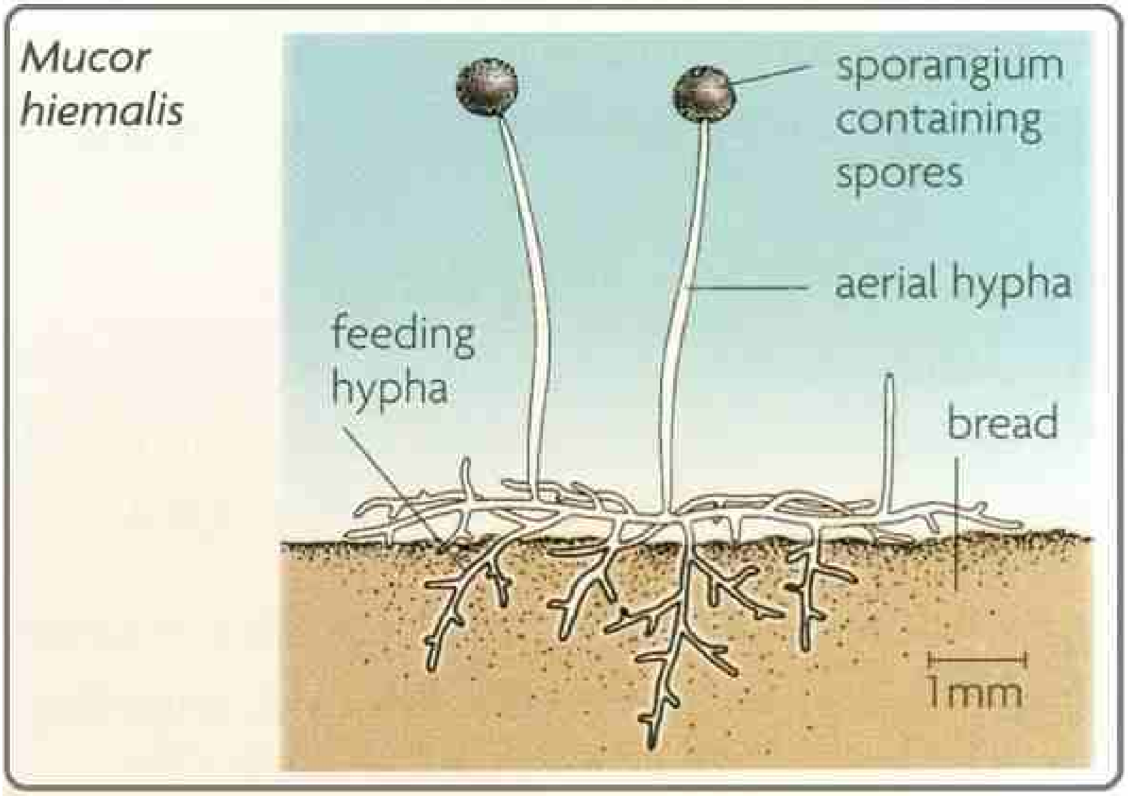
Features of Bacteria

- **small** (1000 times smaller than a plant cell)
- often **unicellular** (single-celled)
- have **cell wall,** which does **not** contain **cellulose** nor **chitin**
- have **cell membrane** and **cytoplasm,** containing **glycogen** granules
- **no nucleus,** only **DNA** int the form of a single, coiled chromosome
- some have a slime capsule
- some have one or more flagella (a lash-like appendage)

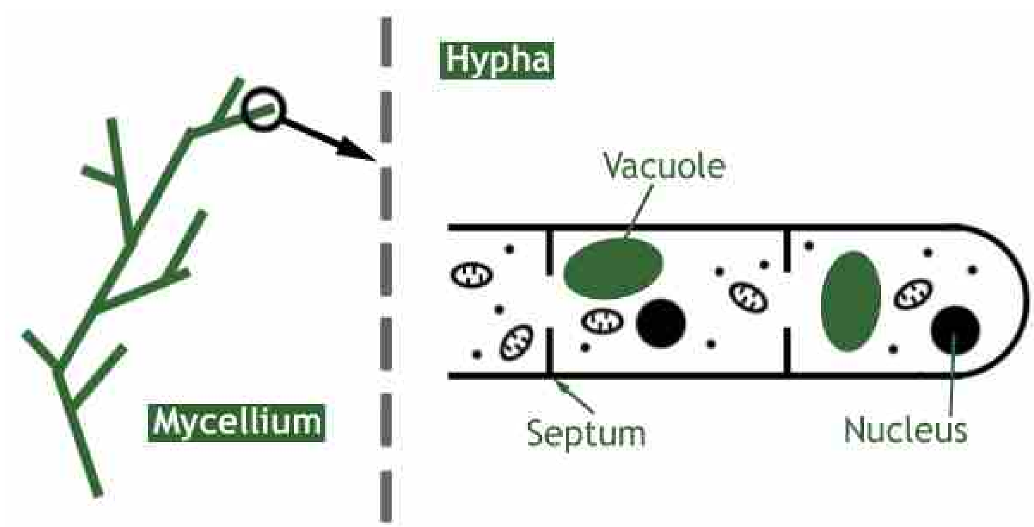
#11: Fungi Kingdom

For a very long time, fungi were classified as plants. However, they are very different from plants and belong to their own kingdom. Fungi **do not have chlorophyll** and do not photosynthesise.

They feed saprophytically, or **parasitically**, on organic material like faeces, human foods and dead plants or animals.

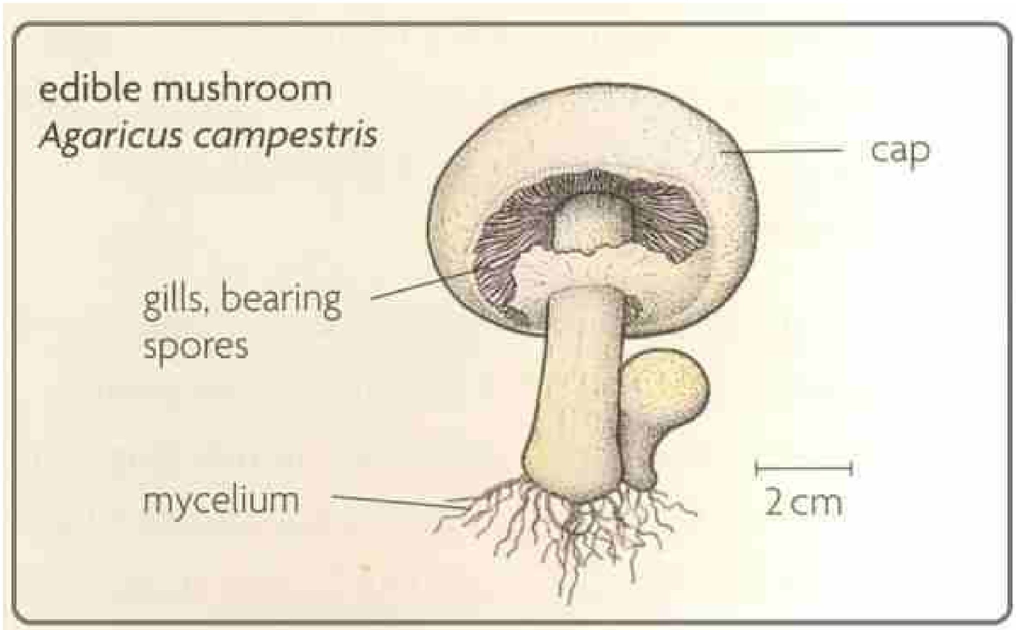


A fungus is made of **hyphae**, which are long tubes, collectively they are called **mycellium** and form branches that can cover many acres.

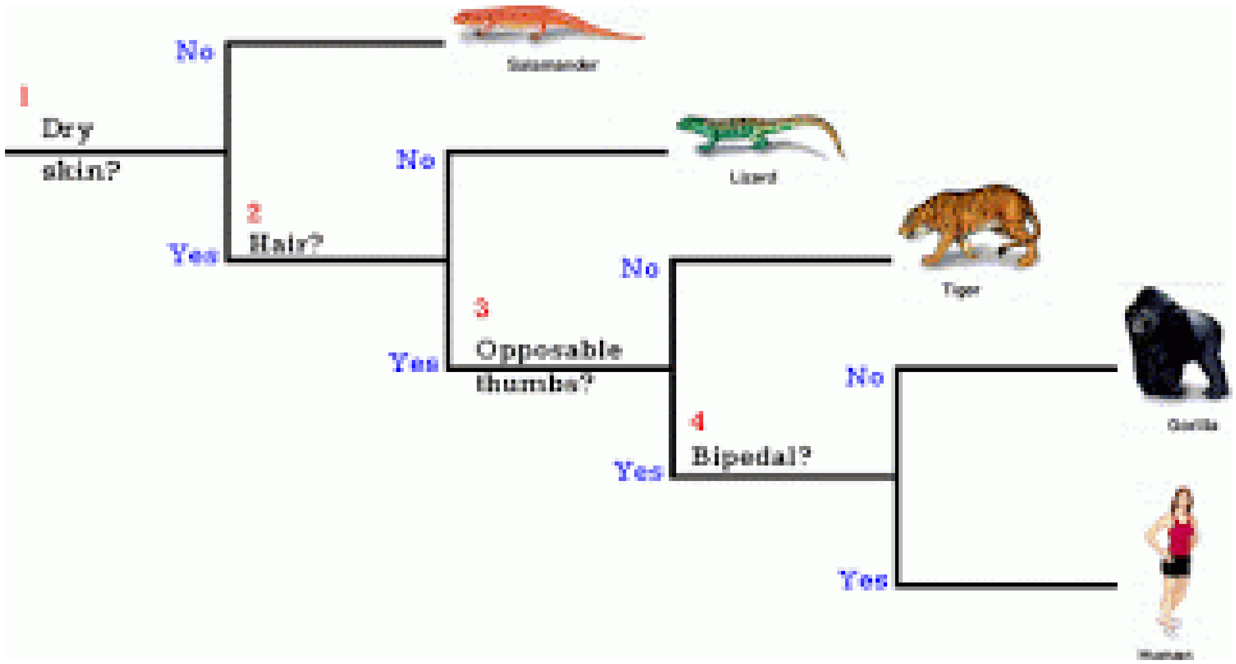


The hypha is a long tube and effectively one cell with many nuclei. It could be divided into comparments by **septa**; The tip is tapered, this is where it is growing outwards and is known as the extension zone.

Fungi grow specialised areas for reproduction called **fruiting bodies**. These can grow very large and be visible to the naked eye where they are known as **mushrooms**. It is from these that spores are produced.

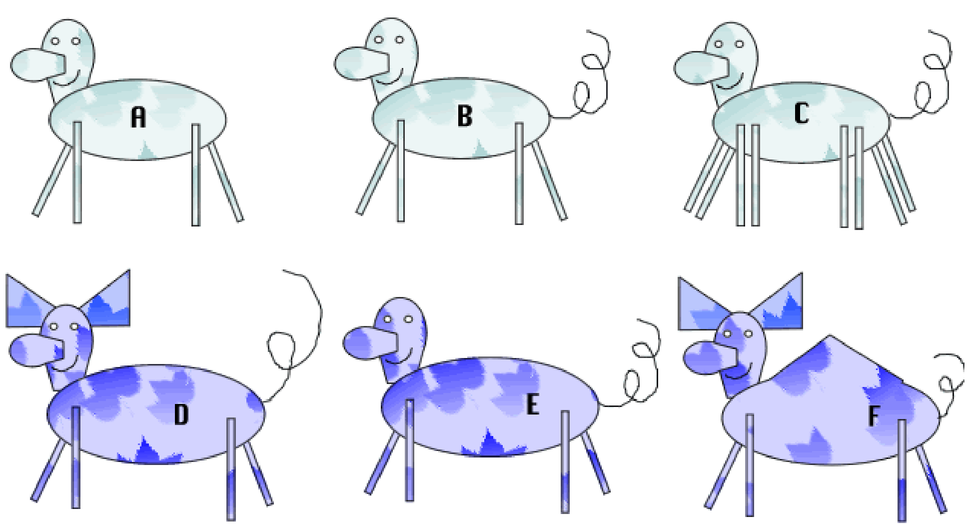


#12: Using simple keys



The identification of biological organisms can be greatly simplified using tools such as **dichotomous keys**. It is a written set of **choices**, each involving **two statements**, that leads to the **name** of an organism. Scientists use these to identify unknown organisms.

Consider the following animals. They are all related, but each is a separate species. Use the dichotomous key below to determine the species of each.



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*

Answers:

***A**: Deerus magnus* ***B**: Deerus pestis* ***C**: Deerus octagis*
***D**: Deerus purplinis* ***E**: Deerus deafus* ***F**: Deerus humpis*

As seen above:

- the keys are **mutually exclusive characteristics** of biological organisms.
- they often begin with **general** characteristics and lead to more **specific** characteristics.
- you simply compare the characteristics of an unknown organism against an appropriate dichotomous key.
- if the organism falls into one category, you go to the next indicated couplet.

By following the key and making the correct choices, you should be able to identify your specimen to the indicated taxonomic level.

Try this

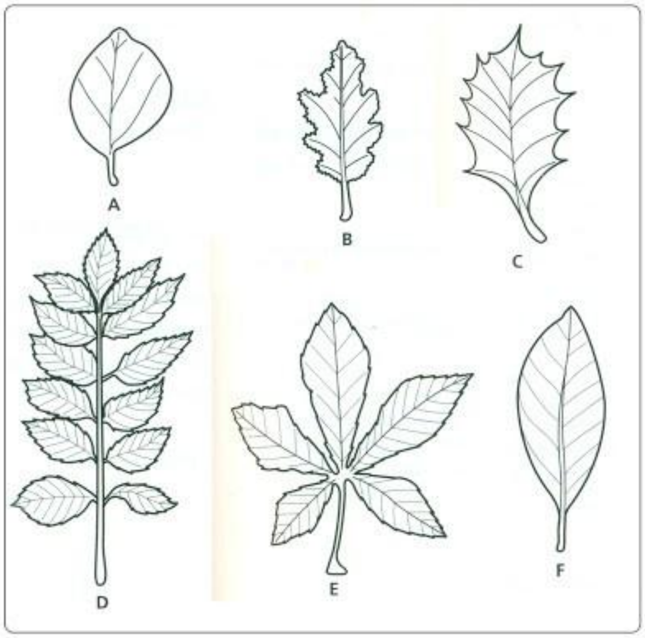


Figure above shows single leaves from six different trees. Use the key below to identify which tree each leaf comes from.

Make a table similar to the one below and put a tick in the correct box to show how you identify each leaf. Give the name of the tree. Leaf A has been identified for you as an example.

1 **a** Leaf with smooth outline	go to 2
b Leaf with jagged outline	go to 3
2 **a** Leaf about the same length as width	*Cydonia*
b Leaf about twice as long as it is wide	*Magnolia*
3 **a** Leaf divided into more than two distinct parts	go to 4
b Leaf not divide into more than two distinct parts	go to 5
4 **a** Leaf divided into five parts	*Aesculus*
b Leaf divided into ten or more parts	*Fraxinus*
5 **a** Leaf with pointed spines along its edge	*Ilex*
B Leaf with rounded lobes along its edge	*Quercus*

[4 marks]

Leaf	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	Name of tree
A	✓		✓								*Cydonia*
B											

Answers

Leaf	1a	1b	2a	2b	3a	3b	4a	4b	5a	5b	Name of tree
B		✓				✓				✓	*Quercus*
C		✓				✓			✓		*Ilex*
D		✓			✓			✓			*Fraxinus*
E		✓			✓		✓				*Aesculus*
F	✓			✓							*Magnolia*

Additional sources:
http://www.biologycorner.com/bio1/notes_taxonomy.html
http://biology.clemson.edu/bpc/bp/Lab/104/Labmanual/LabEx/09Keys.pdf
http://www.biologyjunction.com/dichotomous_keying.htm

#13 Summary of Classification of Living things

- All living things have **7 characteristics**: **Nutrition, Respiration, Growth, Excretion, Movement, Reproduction and Sensitivity.**

- Living organisms are **classified** into groups according to how closely related they are. Each species of organism is given a unique two-word Latin name called a **binomial**. The first word of the binomial is the **genus** and the second word is the **species**.

- **Vertebrates** are classified into **5 classes**: **fish, amphibians, reptiles, birds and mammals.** They each have their own distinctive set of features. E.g. amphibians have a smooth skin, fish and reptiles have scales, birds have feathers and scales, and mammals have hair.

- **Arthropods** are invertebrates with joined legs and segmented bodies. They can be further classified into **insects, arachnids, crustaceans and myriapods.**

- **Annelids** are worm with **segmented** bodies but no legs.

- **Nematodes** are worms with **unsegmented** bodies.

- **Molluscs** have unsegmented bodies, and often have a **shell**.

- **Bacteria** are single-celled organisms whose cells do **not** have **nuclei.**

- **Fungi** include moulds, mushrooms and toadstools. They have cells with **cell walls** but do **not photosynthesise**.

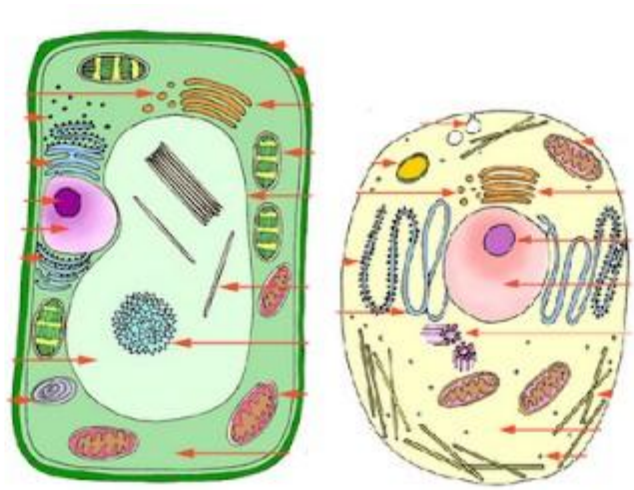
- **Viruses** are **not** generally considered to be **alive** at all. They are not made of cells and cannot carry out any of the characteristics of living things on their own.

- **Flowering plants** can be classified in to **monocotyledonous** plants and **dicotyledonous** plants. **Monocots** have seeds with one cotyledon, and their leaves often have **parallel veins**. **Dicots** have seeds with two cotyledons, and their leaves generally have branching veins.

- A **dichotomous key** is a set of **paired contrasting descriptions** which lead you through to the identification of an unknown organism.

02. Cell

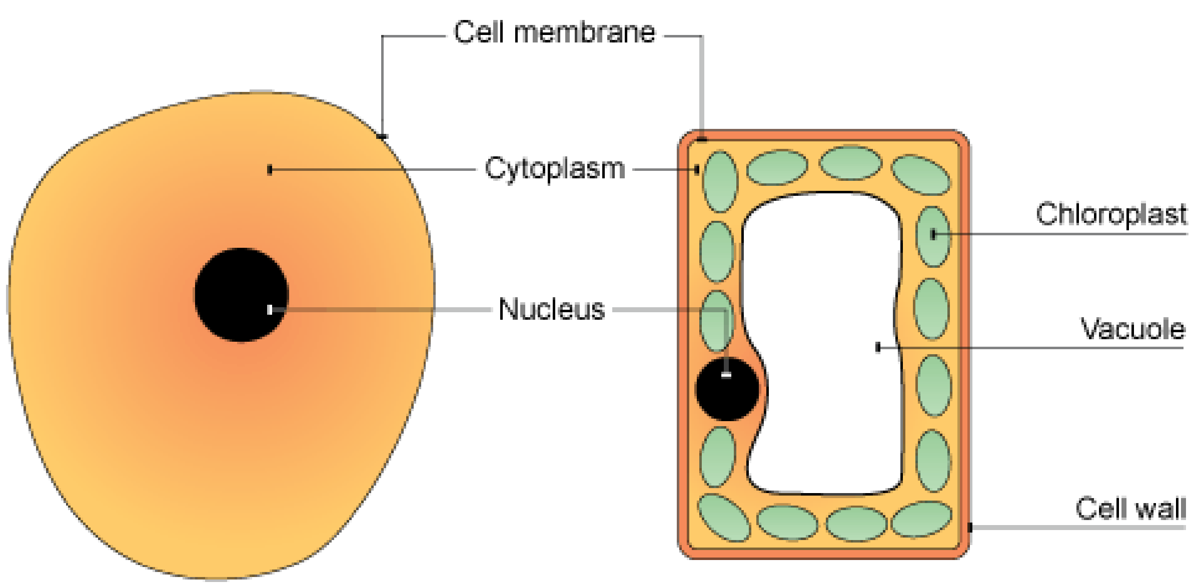
#14: Cell structure



Plant cell Animal cell

Most living things are made of cells. Cell shape varies according to its function. Plant and animal cells differ in size, shape and structure (plants cells are usually larger than animal cells).

Similarities and differences between animal cell and plant cell



Animal cell Plant cell

Tips for drawing

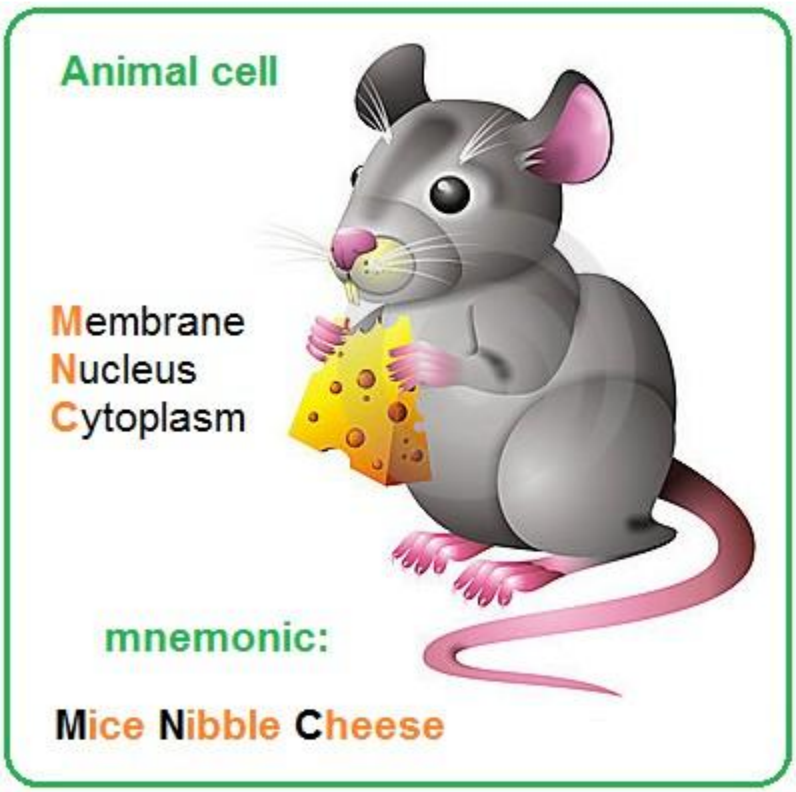
A plant cell

- To **label** parts of a plant cell, start **from** the **outside** and work inwards. The correct order: ***cell wall, membrane, cytoplasm, chloroplast, nucleus, vacuole***.
- Draw the cell wall as a **double line** to show its thickness.
- Make the **cell wall** label line touche the **outer** line, and the **membrane** label line touche the **inner** line.

An animal cell

- Contains only **3** main **parts: Membrane, Nucleus, Cytoplasm.**

Mnemonic



Animal cell features

1. **Irregular** shape as does not have a **rigid cell wall.**

2. **Vacuoles:** may have several **small**, **temporary** vacuoles, for **digestion** or the **excretion** of excess water.

3. **Denser cytoplasm:** contain more **dissolved substances** and **organelles** (e.g. more mitochondria where respiration take place to realease more energy for fast movement).

4. **Store food** (carbohydrates) in the form of **glycogen**

Plant cell features

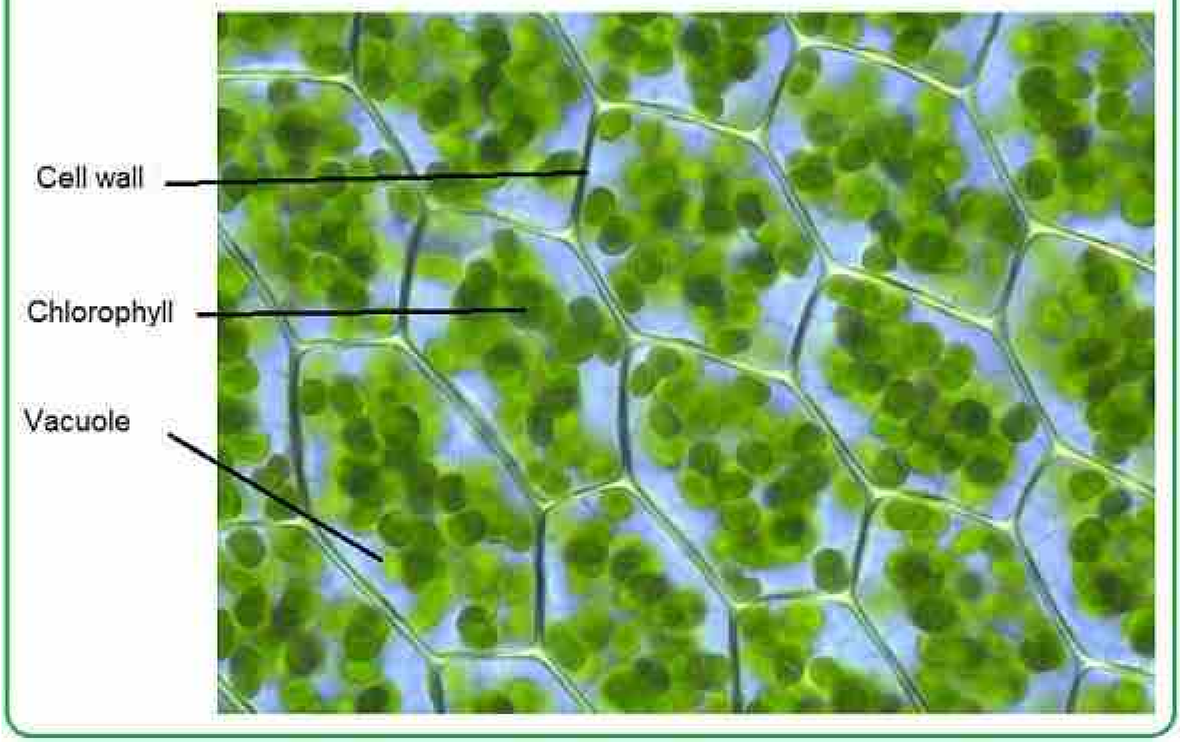
1. **Regular** shape as **cell wall** (made of cellulose) is **rigid** (stiff).

2. **Vacuoles**: **large, permanent** vacuoles, contains H_2O and dissolved substances (**cell sap**). Helps to maintain pressure in the cell.

3. **Chloroplasts:** contain **chlorophyll** and **enzymes** for photosynthesis.

4. **Store food:** Glucose produced by photosynthesis is converted into **starch** and stored in the cytoplasm.

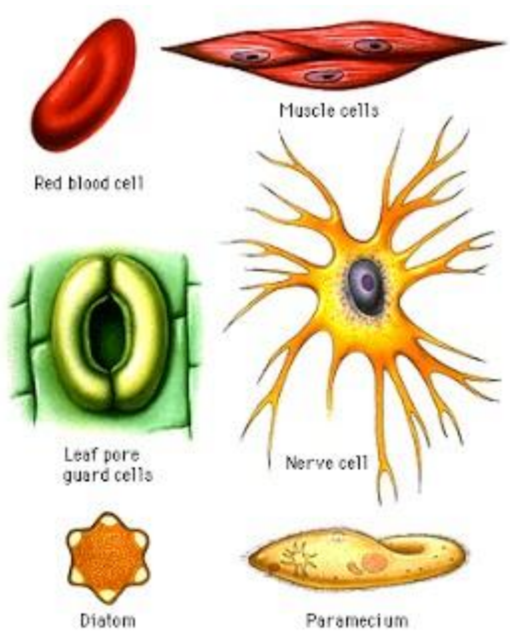
Plant cells



Common misconceptions

- Animal cells **never** have a cell wall, chloroplast or sap vacuole (they may have temporary vacuoles where food is stored.
- **Not all** cells have all cell **parts** when matured, e.g. red blood cell do not have nucleus, xylem cells do not have a nucleus or cytoplasm.
- **Not all** plant cells contain **chloroplasts**, e.g. epidermis cells and root cells do not.
- Chloroplasts (organelle) are **different** from chlorophyll (the chemical found in them)

#15 Cell functions



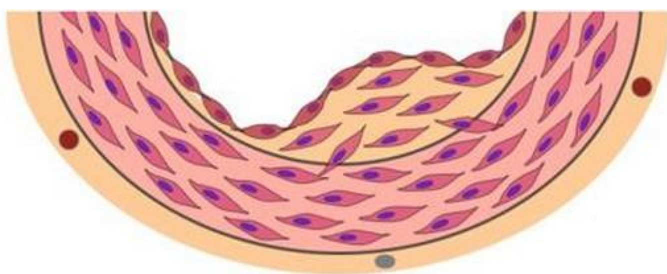
Multicelullar plants and animals contain many different types of cell. Each type of cell is design for a particular function.

Here are examples of cells and their functions in tissues

1. <u>Ciliated cells</u> in **respiratory tract**

F**eatures:** tiny hairs called **cilia** which can move mucus.
Function: waft mucus with bacteria and dust away from the lungs.

2. <u>Muscle cells</u>

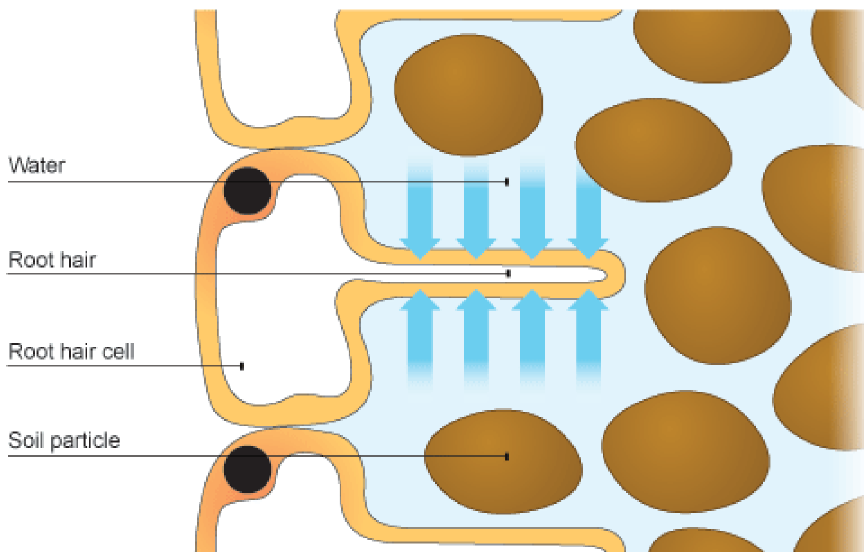


Features: cells merge together to form fibres that can **contract**.
Function: cause movement

3. <u>Red blood cells</u>

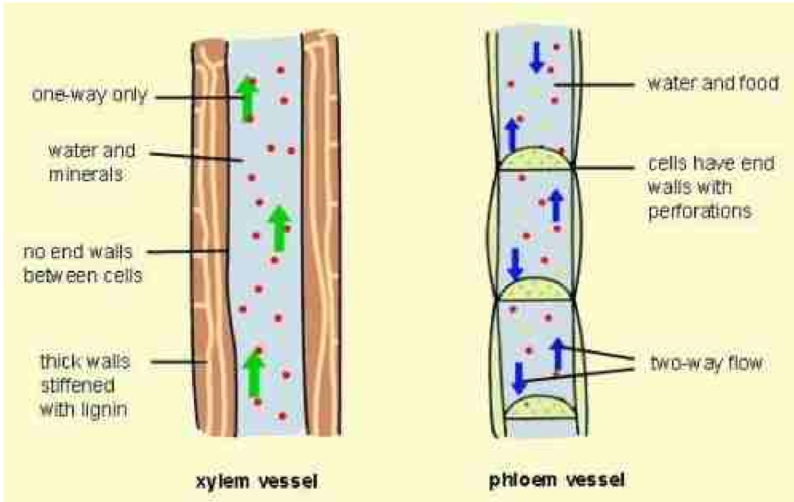
Features: have no nucleus, contain hemoglobin
Function: **transport** oxygen around the body

4. Root hair cell (plants)



Features: the hair gives a large surface area
Function: **absorb** water and mineral ions; anchor the plant firmly in the soil

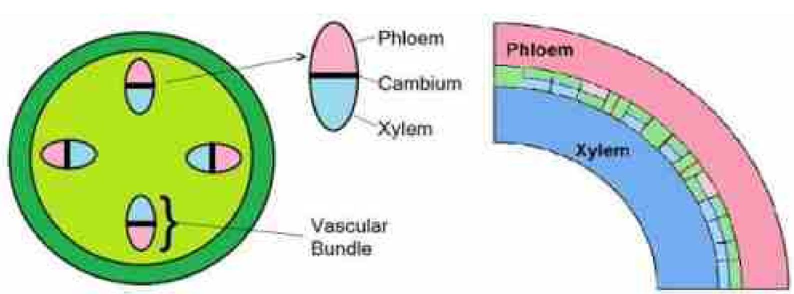
5. Xylem cells

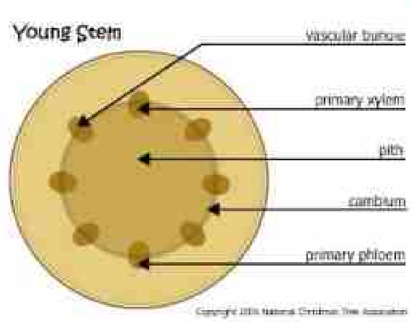


Features: long, thin cells arranged end-to-end to form vessels (tubes). The cells lack end wall and cell contents such as cytolplasm and nucleus. The walls become lignified (woody).
Function: **conduction** (transport water and mineral ions from roots to leaves)
support (Ligmin provides strength for the stem).

Common misconceptions

Xylem and phloem tissue are often confused. **Xylem** carries **water** and **mineral** salts, while **Phloem** transports **sugars** and **amino acids**.
In a vascular bundle in a stem, **Phloem** is on the **outside** and **Xylem** is on the **inside**.



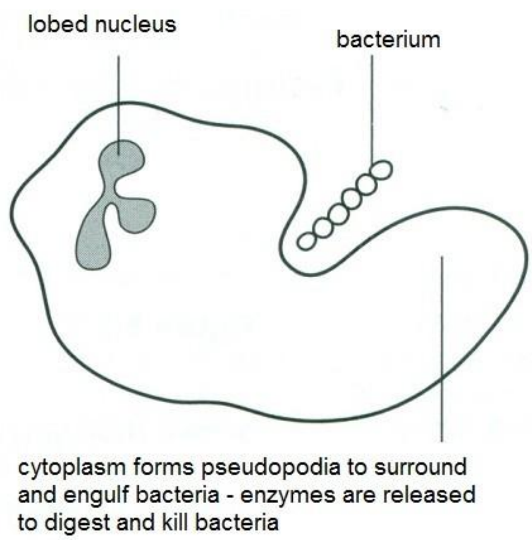


Examiner's tips

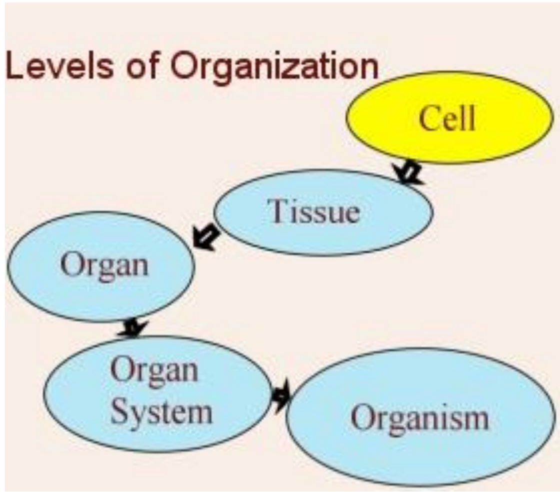
1. You need to be able to give examples of tissues, organs and organ systems in both plants and animals. A leaf is an organ made up of a number of tissues, e.g. upper epidermis, palisade, mesophyll.
2. If you draw a diagram to support an exam answer, make sure you refer to its in your written answer. Annotation is more likely to help you gain extra mark.

Example of annotation

Action of phagocyte



#16: Tissues, Organs and organ Systems



Cells are organized to form tissue, organs, and organ systems. In a healthy organism, all the systems work together.

SPECIALIZED CELLS

- A specialized cell is designed to do a particular job.
- Nerve cells have long fibres to carry massages.
- Muscle cells can contract and relax.
- White blood cells attack bacteria.
- Platelets help clotting.

TISSUES

- Large numbers of specialized cells make up **tissue.**
- Muscles, blood and nerves are all tissues.
- Blood tissue contains red cells for carrying oxygen, white cells for destroying harmful bacteria, and platelets to cause clotting in cuts

ORGANS

- Various tissues together make up an **organ**.
- Each organ has its own specific job.
- The heart, the stomach and the brain are all organs.
- The heart has to pump blood around the body. It is made up of **muscle tissue, blood vessels** and **nerves.**
- Arteries and veins are usually thought of as organ as they consist of several tissue layers.

ORGAN SYSTEMS

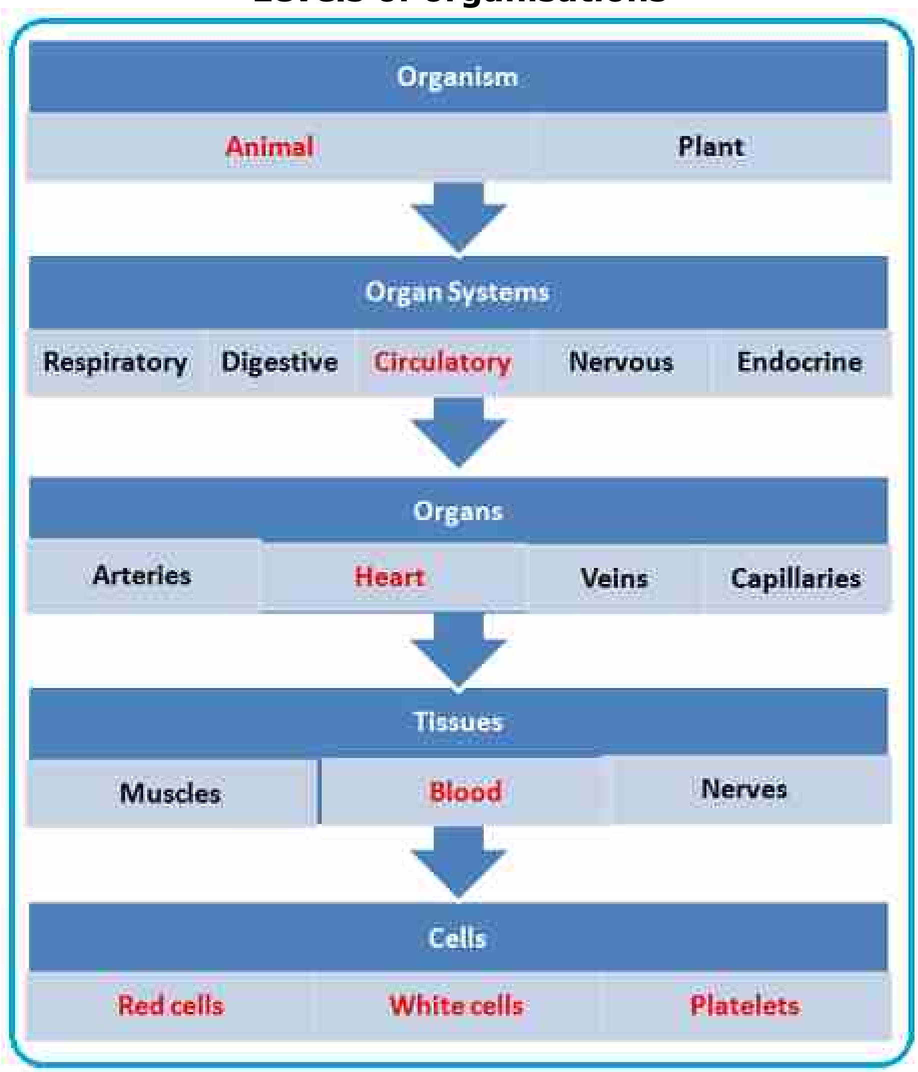
Various organs together make up an **organ system**. E.g. the **circulatory system** carries blood to all parts of the body. It is made up of heart, arteries, veins, capillaries and blood.

ORGANISM

Various organ systems together make up an **organism.**
An human organism has:

- Respiratory system
- Digestive system
- Circulatory system
- Nervous system
- Endocrine system

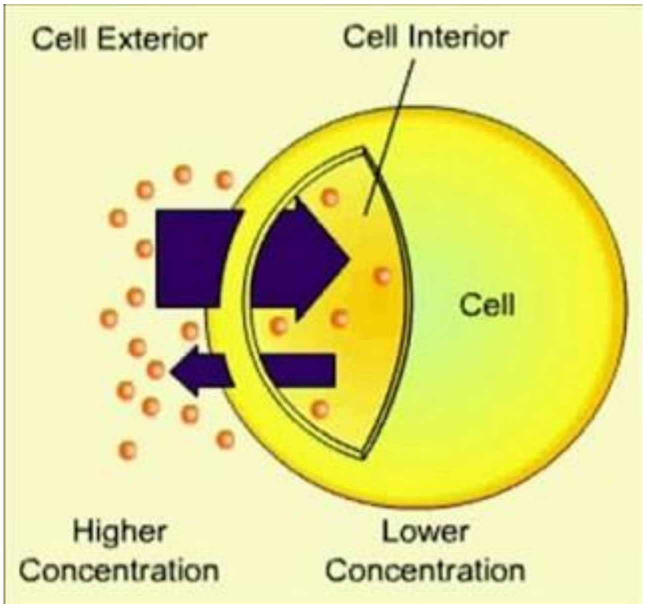
Levels of organisations



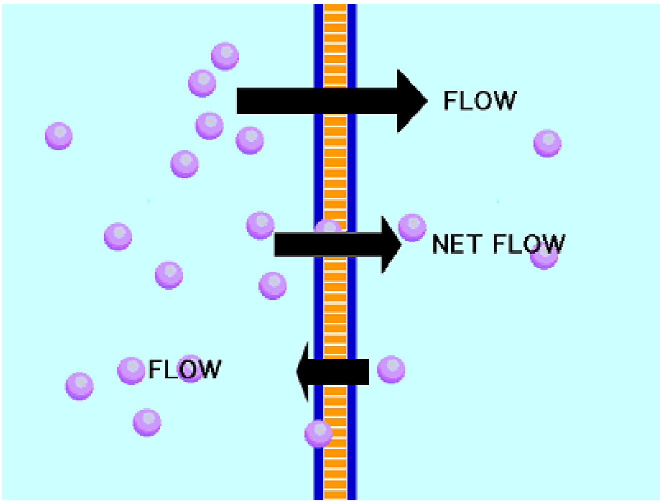
Key definitions

- **Organells**: a structure within a cell (e.g. nucleus, vacuole, cytoplasm and chloroplast are all organelles of a plant cell).
- **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.

#17 Diffusion



Diffusion is the net movement of molecules from a region of its **higher** concentration to a region of its **lower** concentration. Molecules move **down** a **concentration gradient**, as a result of their random movement.



For **living cells**, the principle of the movement down a concentration gradient is the same, but there is one problem:

The cell is surrounded by a **cell membrane**, which can restrict the free movement of the molecules à This is a **selective permeable membrane:** the composition of the membrane (lipid and protein) allows some molecules to cross with ease, but others with difficulty or not at all. The simplest sort of selection is based on the **size** of the molecules.

Importance of gaseous and solute diffusion

Diffusion helps living organisms to:

- **obtain** many of their **requirements**
- **get rid** of many of their **waste products**
- **gas exchange** for respiration

Examples

- CO_2 uses by plants for photosynthesis is diffuses from the air into the leaves, through the stomata (pores at the surface of leaves). There is a lower concentration of CO_2 inside the leaf, as the cells are using it up. O_2 (waste product of photosynthesis diffuses out in the same way).
- Flowering plants use diffusion to attract pollinators like bees.
- Some of the products of digestion are absorbed from the ileum of mammals by diffusion.

Site of diffusion	Substance	Description
Alveoli of lungs	O_2	Alveoli à Blood capillaries
	CO_2	Blood capillaries à Alveoli
Stomata of leaf	O_2	Air spaces of leaf à Atmosphere

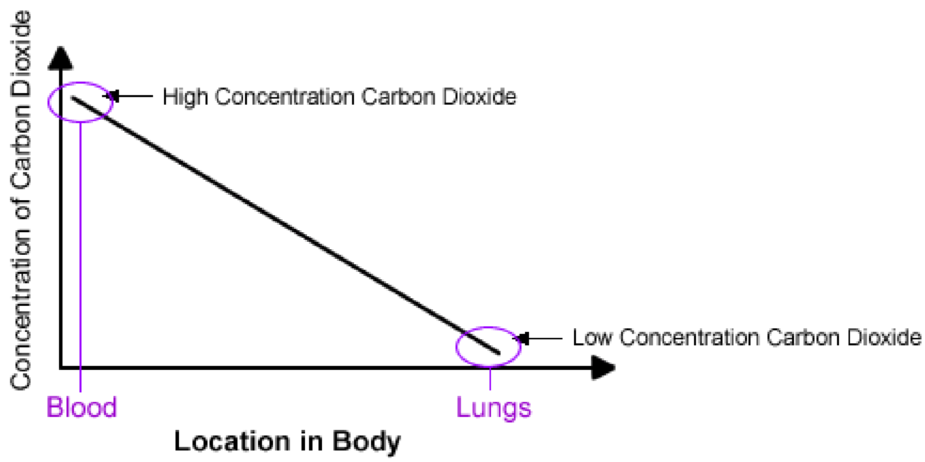
Factors favoring diffusion

- **Distance** (the shorter the better), e.g. thin walls of alveoli and capillaries.
- **Concentration gradient** (the bigger the better). This can be maintained by removing the substance as it passes across the diffusion surface. (Think about oxygenated blood being carried away from the surface of alveoli).
- **Size** of the **molecules** (the smaller the better).
- **Surface area** for diffusion (the larger the better).
- **Temperature** (molecules have more kinetic energy at higher temperature).

Importance of water as a solvent

- Most cells contain about **75%** of **wate.**
- Many **substances** move around a cell **dissolved** in water.
- Many important **reactions** take place in water.

What is a concentration gradient?



The gas particles are more concentrated in the blood than in the lungs. Thus there is a concentration difference between these 2 points. If you join the concentrations in the blood and in the lungs (their points on the graph), you get a straight line which is sloped or has a gradient. This line is the ***concentration gradient*** between the 2 points.

The difference in concentration between 2 regions is known as the concentration gradient.

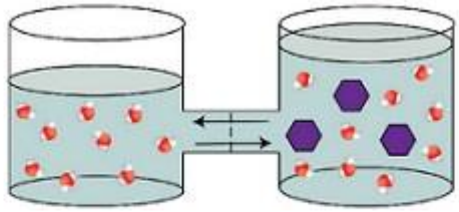
The particles of fluids (liquids and gases) possess kinetic energy. They are continually moving about. As their movement is random, the particles will move (diffuse) down the concentration gradient and become evenly spread out after some time. (So if you spray perfume in one corner of your room, eventually you can smell it from the other side of the room.)

The steeper the concentration gradient, the faster the particles will move. The steeper the concentration gradient for a substance, the faster the rate of diffusion is for that substance!

From http://askmichellebiology.blogspot.com

Additional resource: [*http://askmichellebiology.blogspot.com*](http://askmichellebiology.blogspot.com)

#18 Osmosis



Osmosis is the *diffusion* of **water** molecules from a region of their **higher concentration** to a region of their **lower concentration**, through a *partially* permeable **membrane**.

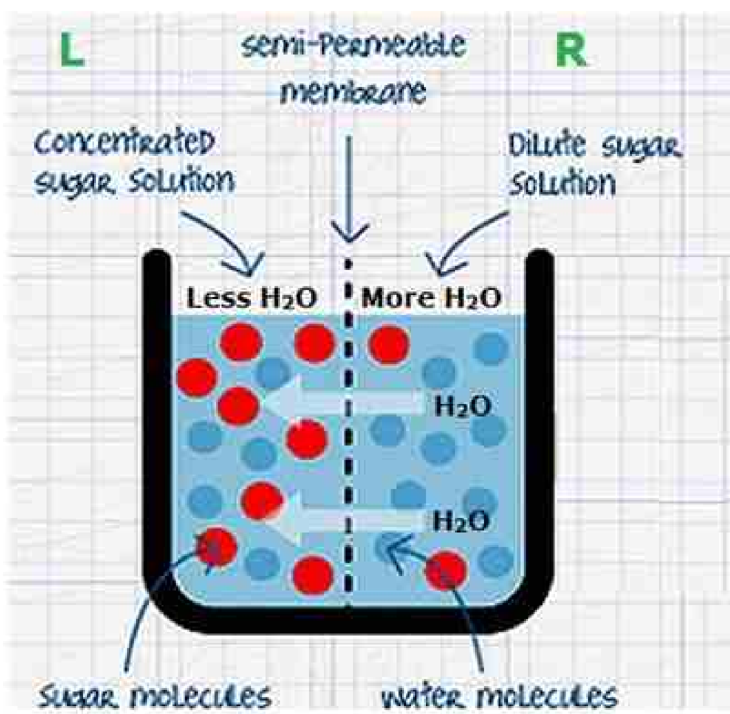
Osmosis is a special form of diffusion and always involves the movement of H_2O across a membrane. Osmosis is:

- the movement of H_2O
- across a selectively permeable membrane
- down a water potential gradient.

In the picture below

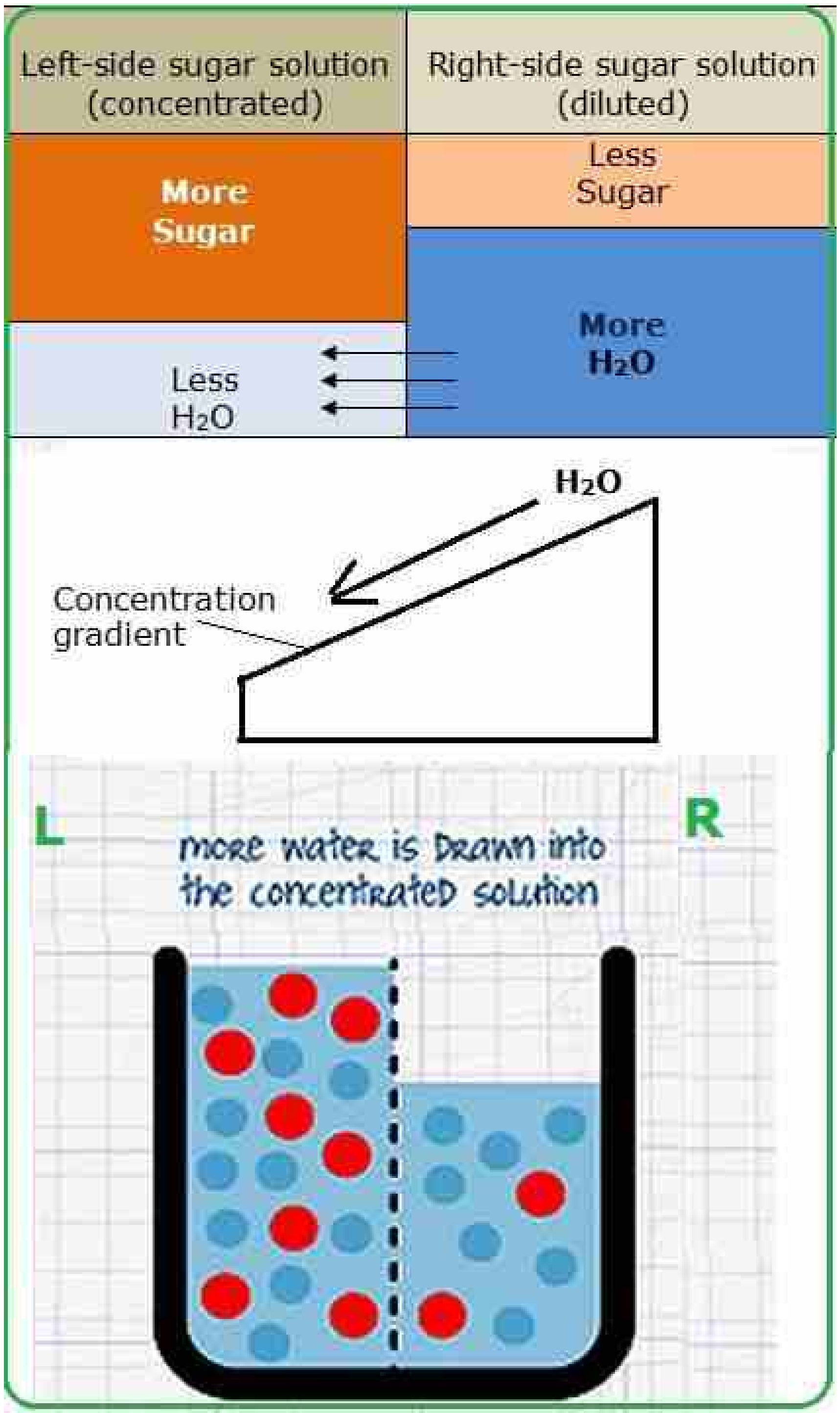
- The concentration of **sugar** molecules is **higher** on the **concentrated** solution **(L)** and lower on the **diluted** one **(R)**.

- The concentration of **wate**r molecules is **higher** on the **(R)** and lower on the **(L)** (a lot of place is taken up by sugar molecules).



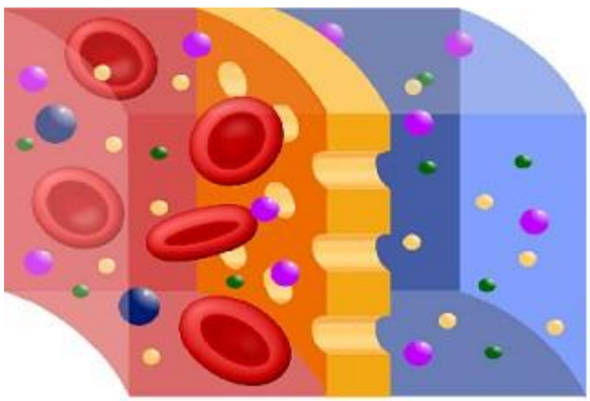
It is confusing to talk about the 'concentration of water', so we can say that a diluted solution (**R**) has a **high water potential** and a concentrated solution (**L**) has a **low water potential**.

There is a water **potential gradient** between the 2 sides. The water molecules diffuse **down** this **gradient**, from a high water potential (R) to a low water potential (L).

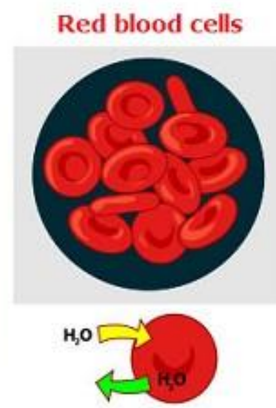


Cell membranes

- partially permeable (let some substances pass through, but not others).
- separate 2 solutions: cytoplasm and solution around the cell.
- If the solutions are of different concentrations, osmosis will occur.



A semi-permeable membrane



Cell membrane lets water go through

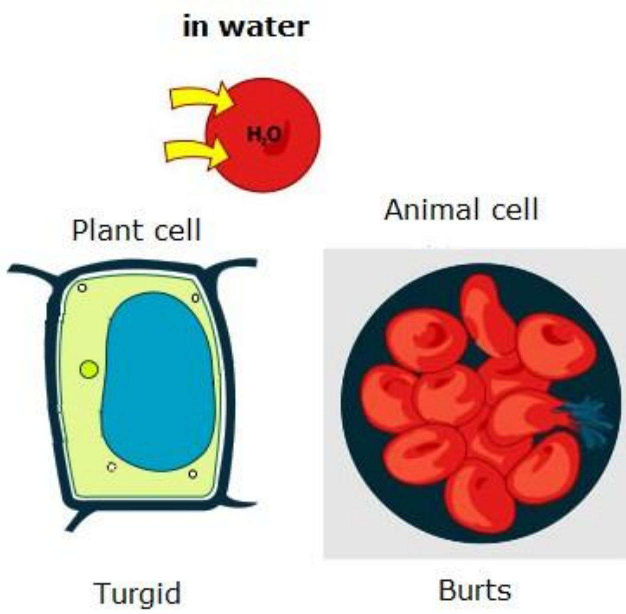
<u>Effect of Osmosis on plant and animal cells</u>

1. <u>When placed **in H_2O:**</u>

Concentration of H_2O **outside** the cell is **higher** than inside it. Cells will **take in** H_2O by osmosis:

- **plant** cells become **turgid** (swollen) but do not burst (have tough **cell wall** which is fully permeable).

- **animal** cells will burst (no cell wall).



2. <u>When placed **in concentrated** sugar or salt **solutions**:</u>

Concentration of H_2O **inside** the cell is **higher** than outside it. H_2O **get out** of the cells by osmosis:

- **plant** cells become **flaccid** (soft and limp), cytoplasm is no longer pressed against the cell wall. The plant loses it firmness and begin to **wilt**.
- **animal** cells shrink, become **crenated.**

Importance of H_2O potential gradient
in the uptake of H_2O by plants:

Enables H_2O movement by **osmosis**

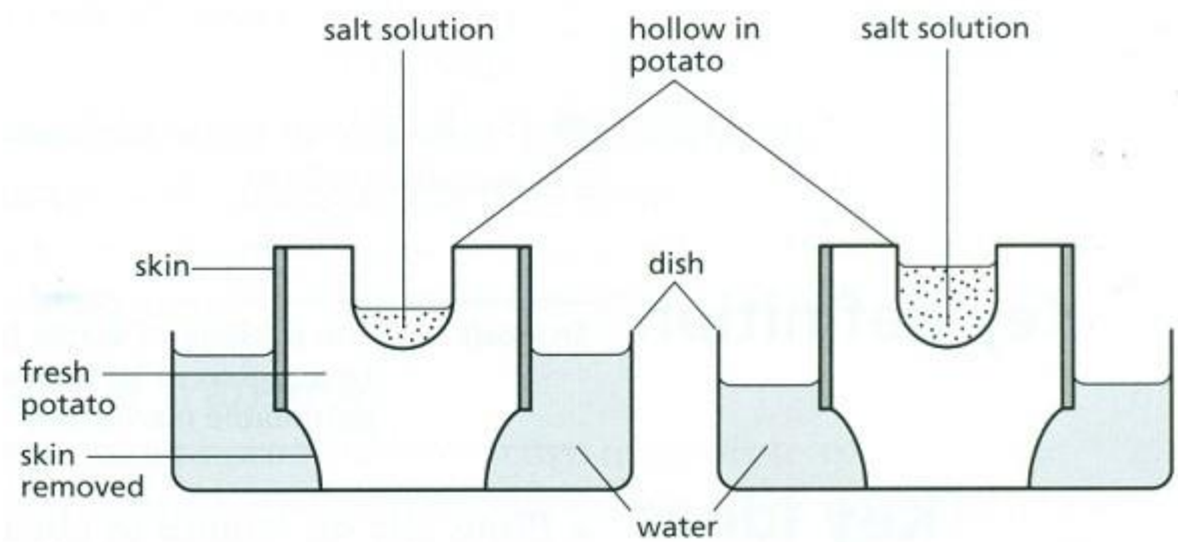
- from **soil** to **root** hairs
- from **tissue** fluid to **cells**
- from **xylem** to leaf **mesophyll** cells.

Common misconceptions

Sugar and salt do **not** move by osmosis. Cell membranes prevent them entering or leaving the cell.

Try this

A potato was set up as shown in the figure below (left-hand side). The investigation was left for several hours. The results are shown on the right-hand side of the figure.



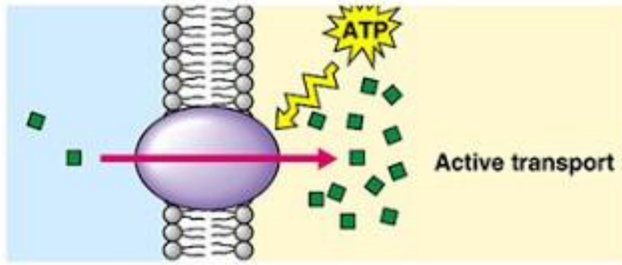
1. Describe what happened to
 a. the water in the disk
 b. the salt solution in the hollow in the potato. [2 marks]

2.
a. Name the process that is responsible for the changes that have occurred. [1 mark]
 b. Explain why these changes have occurred. [3 mark]
 c. Where does this process occur in a plant? [1 mark]
 d. What is the importance to the plant of this process? [1 mark]

Answers

1. *a. The volume of water in the dish decreased.*
b. The volume of salt solution in the potato increased.
2. a. Osmosis
b. 3 points from:
- there was a higher concentration of water in the dish than in the potato
- so water moved into the potato.
- from a high concentration of water to a lower concentration of water
- by osmosis.
c. Root hairs, or in the roots.
d. Osmosis enables the plant to absorb water to maintain cell turgidity (or to replace water lost by transpiration).

#19 Active transport



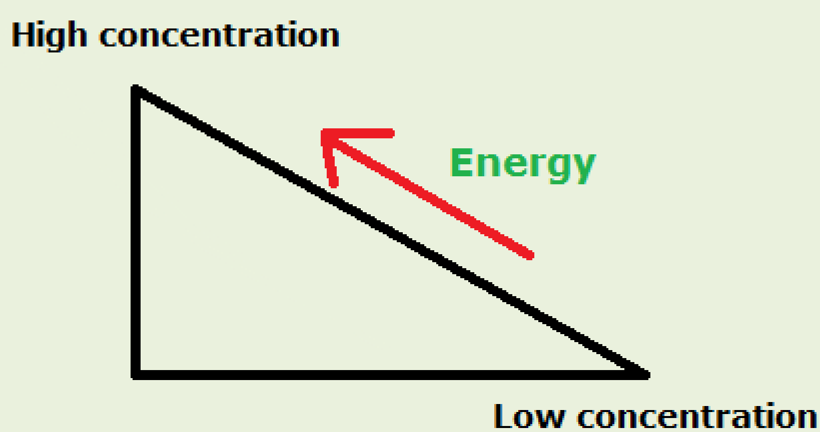
Sometimes substances are required to be move **against** the **Concentration Gradient**, or faster than they would by Passive Transport. In these cases, **Active Processes** are used, which require **energy**.

There are many occasions when cells need to take in **substances** which are only present in **small quantities** around them.

E.g. **root hair** cells in plants take in **nitrate** ions *from* the *soil*. Their concentration are often higher inside the root hair cell than in the soil, so the **diffusion gradient** is from the *root hair* à the *soil*. Despite this, the root hair cells still can take nitrate ions in, by **active transport**.

Active transport

- movement of ions (in or out of a cell through cell membrane) from a region of their **lower** concentration to a region of their **higher** concentration
- **up** a **concentration gradient**
- using **energy** released during *respiration*.



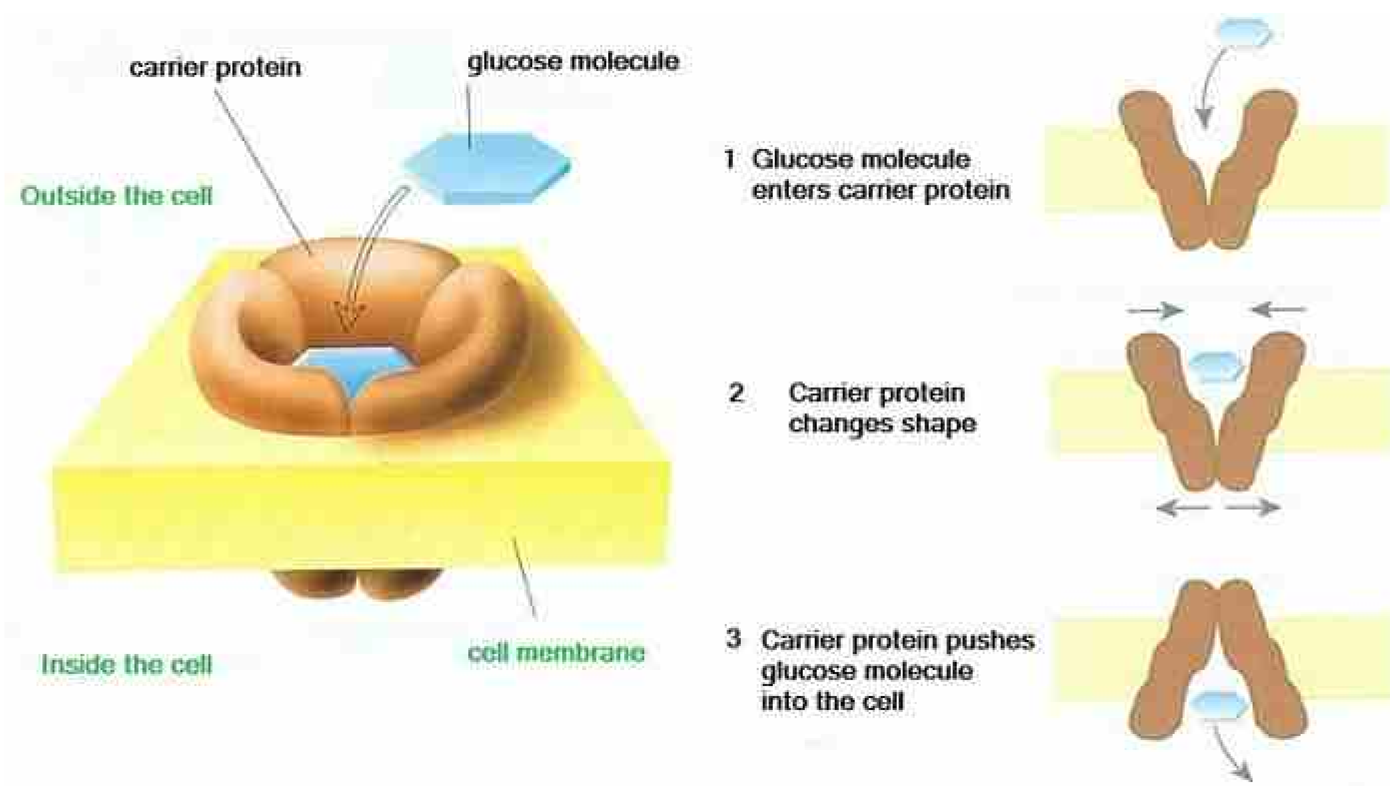
The **importance** of **active transport:** energy-consuming process by which substances are transported against a concentration gradient, e.g. ion uptake by root hairs and glucose uptake by epithelial cells of villi.

Site	Substance	Direction
Root hair cells	Mineral salts (phosphate…)	Soil → roots
Wall of small intestine (villi)	Glucose	Small intestine→ blood plasma

Two big differences between diffusion and active transport:

- **direction** of movement (**down** or **up** a gradient)
- use of **energy** for movement

The active transport is carried out by '**carrier proteins'** in the membrane, which bind to the solute molecule, change shape and carry the molecule across the membrane.



Try this

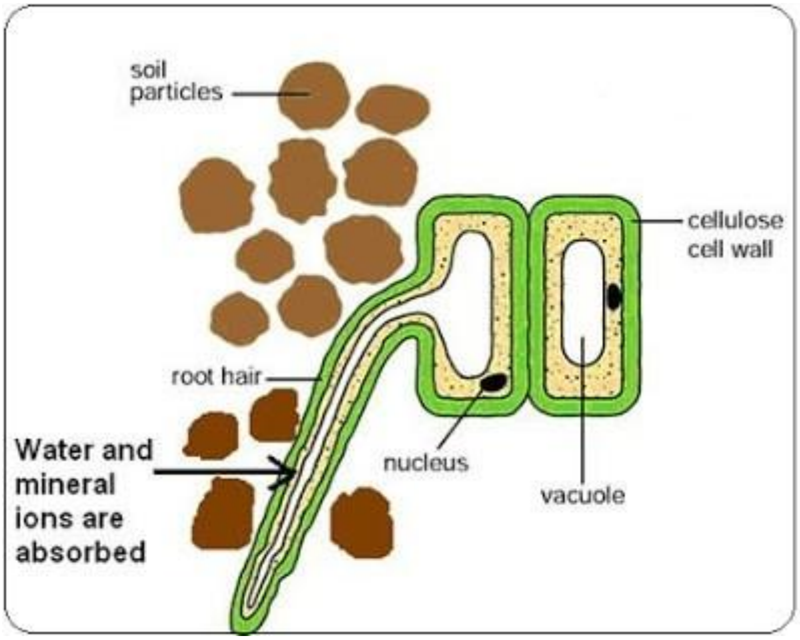


Figure above shows root hair cells.

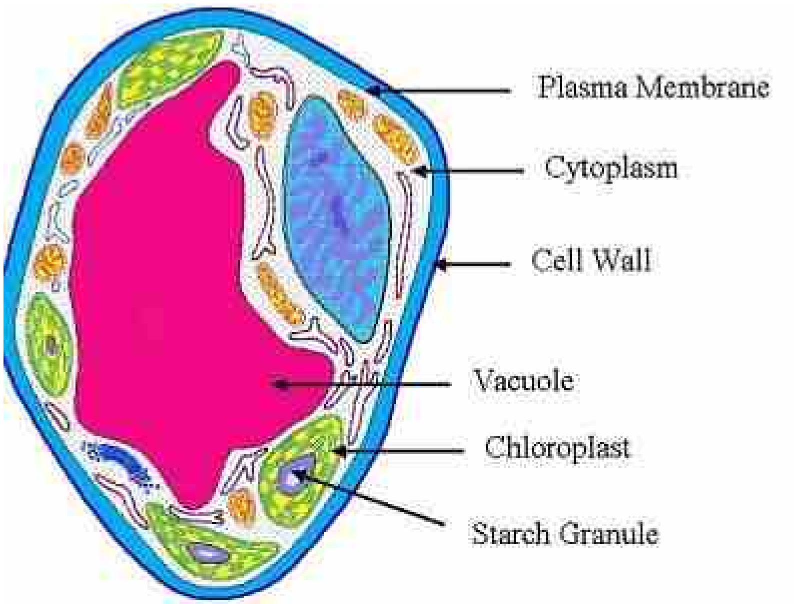
1. Explain how the presence of root hair cells on roots enables the efficient absorption of water and minerals. [*2 marks]*
2. Root hair cells can absorb mineral ions by diffusion and active transport.

 a)Define the term active transport [*2 marks*]
 b)Explain why respiration rates may increase in root hair cells during the uptake of mineral ions [*1 mark*]

Answers

1. - Large number of root hair cells give a large surface area to the root.
- Mitochondria are present to provide energy for active transport.
2. a) active transport is absorption of a substance into a cell or across a membrane
- against (up) a concentration gradient.
- using energy
b) active transport requires energy

20 Summary of Cells



Structure

- **Cells** are the smallest units of living things. They are too **small** to be seen with the naked eye, so we need to use **microscopes** to see their structures.

- Cells have a cell **membrane**, **cytoplasm** and a **nucleus**. Plant cells also have a **cell wall**, and oft en have **chloroplasts** and a large **vacuole** containing cell sap.

- The cell **membrane** is **partially permeable**, and it controls what enters and leaves the cell.

- The **cytoplasm** is a jelly-like solution of many different substances in water. It is the site of many different **metabolic** reactions.

- The **nucleus** contains the **chromosomes**, which are made of **DNA**. This is the genetic information and it controls the activities of the cell.

- The **cell wall** of a plant cell is made of criss-crossing fibres of **cellulose**. It is fully permeable. It helps to **support** the cell, and prevents the cell bursting if it absorbs a lot of water.

- The **vacuole** of a plant cell contains **cell sap**, which is a solution of **sugars** and other substances in water.

- **Chloroplasts** contain the green pigment **chlorophyll**, which absorbs sunlight for **photosynthesis**. There may be **starch grains** inside the chloroplasts, which are the form in which plants store the **food** that they make in photosynthesis.

- A **tissue** is a group of **similar cells** which work together to carry out a particular function. Tissues are grouped into **organs**, and organs are grouped into organ **systems.**

Movement in and out of cells

- Particles in gases, liquids and solutions are in constant random motion. As a result of this, there is a net movement from where they are in a **high concentration** to where they are in a **low concentration**. This is **diffusion**.

- **Diffusion** is important to cells. For example, **oxygen** enters a respiring cell by diffusion, and **carbon dioxide** diffuses out of it.

- Water molecules are small and can diffuse through a **partially permeable membrane**. Larger molecules dissolved in the water cannot do this. The diffusion of water through a partially permeable membrane is called **osmosis**.

- Osmosis is important to cells. In a **dilute solution**, water passes into a cell through its partially permeable cell membrane. The cell gets bigger. **Animal cells** may **burst**, but **plant cells** do not because of their **strong cell wall.**

- In a **concentrated solution**, water passes out of a cell by osmosis through its partially permeable membrane. The cell **shrinks**. Plant cells may become **plasmolysed** – that is, the cell membrane pulls away from the cell wall.

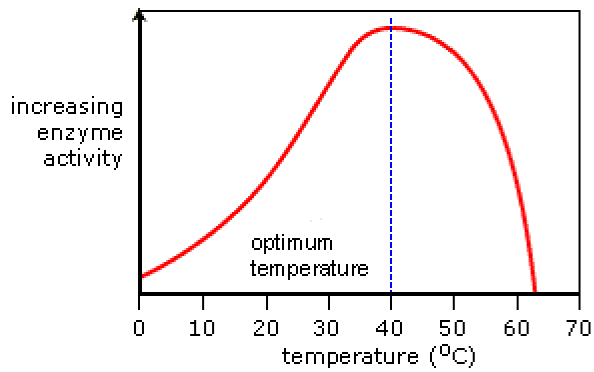
- A solution containing a lot of water is said to have a high water potential. A solution containing only a little water has a low water potential. Water moves by **osmosis** **down** a **water potential gradient**, from a high water potential to a low water potential.

- Cells can use **energy** to move substances **up** their **concentration gradient,** from a low concentration to a high concentration. This is called **active transport**. It uses energy that the cells release by **respiration**.

03 Enzymes

#21 Enzymes and reactions

Many chemical reactions can be speeded up by substances called **catalysts.** Within living organisms, these reactions (metabolic reactions) are controlled by catalysts called **enzymes.** Enzyme molecules are **proteins**.



Key definitions

Catalyst	substance	that **speeds up** a chemical reaction is **not changed** by the reaction
Enzyme	protein	that functions as **biological catalyst**
Substrate	chemical compound	the enzyme work on
End product	result	of the reaction

Enzymes and reactions

Most enzyme names end in –ase, e.g. lipase, protease.

Enzymes

Speed up	or	Slow down	reaction
Build up (synthesise)	or	Breake down	molecules

Enzymes usually speed up reactions, but some slow them down.

Some enzymes help to build up molecules (synthesise them), e.g.

$$\text{Maltose} \xrightarrow{\textbf{starch phosphorylase}} \text{Starch}$$

Others are involved in breaking them down, e.g.

$$\text{Protein} \xrightarrow{\textbf{protease}} \text{Amino Acids}$$

$$\text{Starch} \xrightarrow{\textbf{amylase}} \text{Maltose}$$

Temperature, pH and enzymes

The activity of enzymes is affected by temperature and pH.

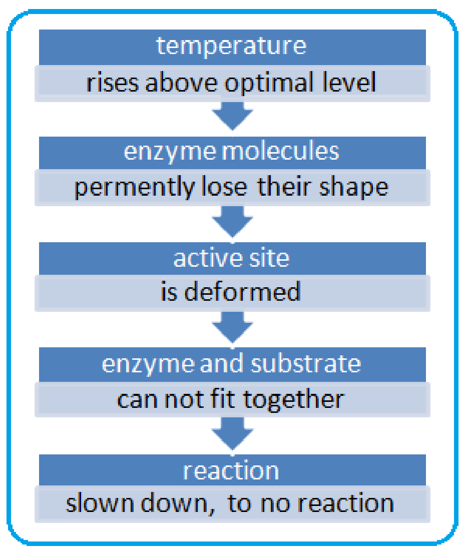
Effect of temperature on enzymes

The **optimum** (best) temperature for enzyme-controlled reactions is 37^0C (body temperature).

As the temperature increases, the rate of reaction increases. But very **high** temperatures **denature** enzymes.

The graph shows the typical change in an enzyme's activity with increasing temperature.

The enzyme activity gradually increases with temperature up to around 37ºC, or body temperature. Then, as the **temperature** continues to **rise**, the rate of reaction falls rapidly as heat energy **denatures** the enzyme. Most enzymes are denatured above 50^0C.



Common misconceptions

- Enzymes are not denatured by low temperatures – they are just slowed down, and will work again when the temperature is suitable.
- Once an enzyme is denatured, the damage is permanent.

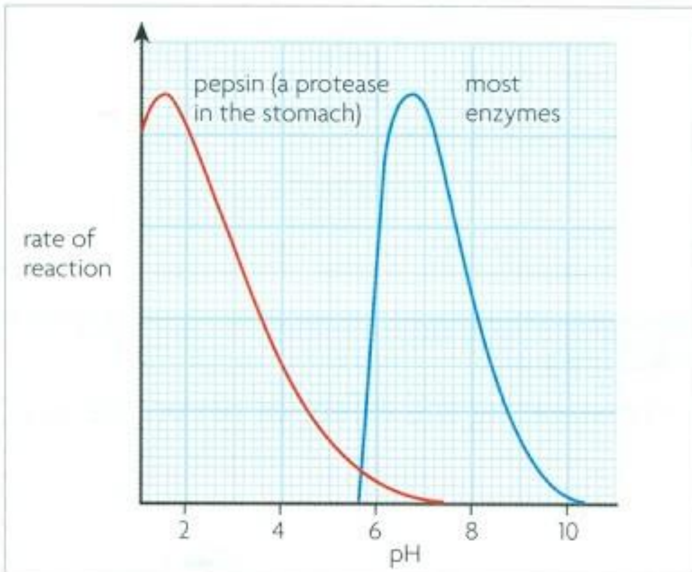
Effect of pH on enzymes

- The pH of a solution is how acidic or alkaline it is.
- Different enzymes work best at different pH values.
- The optimum pH for an enzyme depends on where it normally works.
- It is around neutral (**pH= 7**) for most enzymes but there are some exceptions.

Enzymes	Substrate	End products	Location	pH
Salivary amylase	starch	Maltose Glucose	mouth	6.8
Pancreatic lipase	fat	Fatty acids, Glycerol	duodenum	9.0
Protease	protein	Amino acids	stomach	2.0
			duodenum	9.0

Changes in pH also alter an enzyme's shape and slow down its activity, but this can usually be **reversed** if the optimum pH is restored.

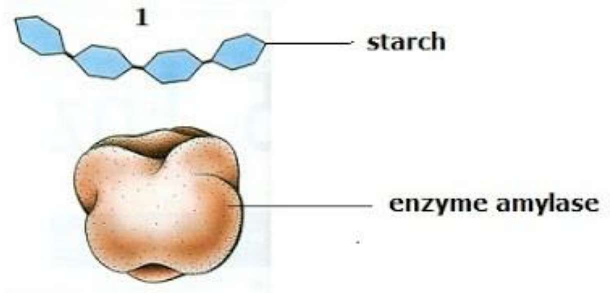
An extreme pH can **denature** enzymes – the active site is deformed permanently.



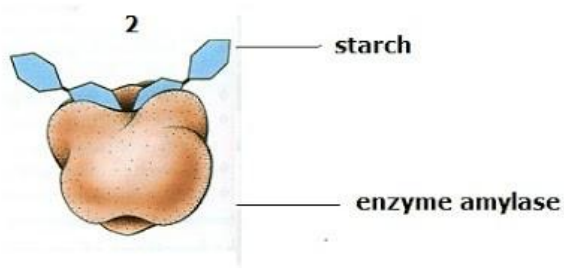
How pH affects enzyme activity.

#22 Enzymes - 'Lock and key' model

Enzymes are very **specific,** each kind of enzyme catalyse one kind of reaction only. To catalyse a reaction, **enzyme** molecule and **substrate** molecule need to meet and **joint** together by a temporary bond.

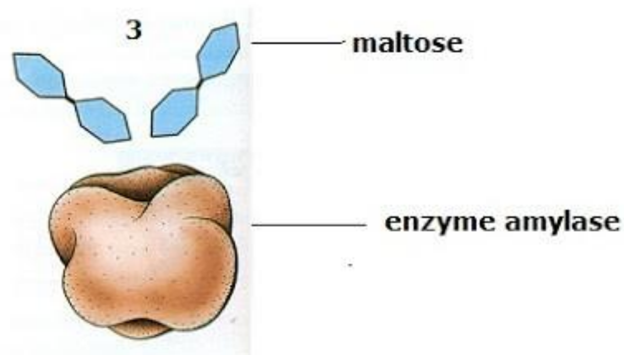


Each molecule has a special shape and an **active site** into which its **substrate** molecule fits exactly.



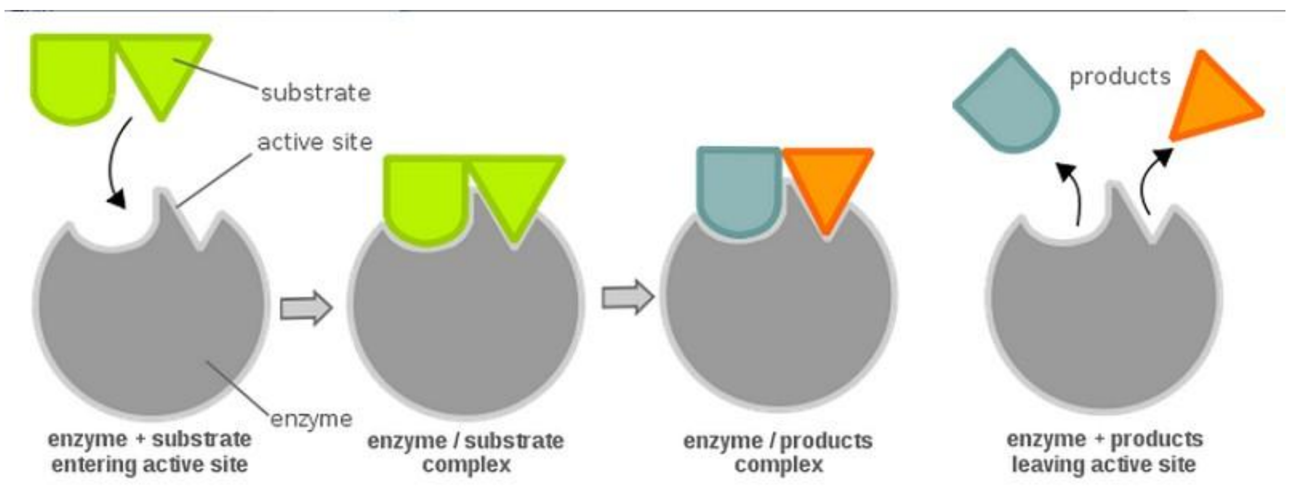
This enzyme is **amylase**, and its **active site** is just the right size and shape for a **substrate** molecule (**starch** in this case).

The starch **slots** into the active site.



The starch is **split** into **maltose** molecules.

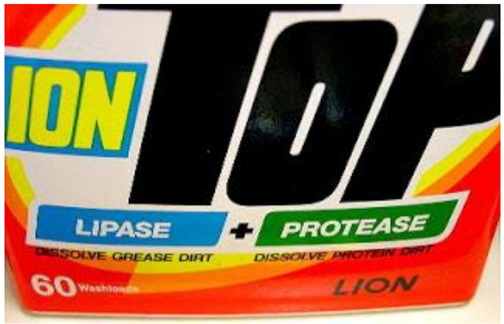
The enzyme is unaltered, and ready to accept another part of the starch molecule



 # 23 Role of enzymes in germinating seeds

- Seeds contain **stored food** in the cotyledons to provide energy and materials for growth. This is usually in the form of **starch** – a large, *insoluble* molecule (long chain of glucose), that keeps the food immobile. The starch needs to be changed into a *soluble* molecule (**sugar**) with help of **enzymes** for the seeds to make use of.
- In the presence of $\mathbf{H_2O}$, **Gibberellin** or **gibberellic acid** (GA) stimulates the production of **amylase**.
- **Amylase** breaks down **starch** to **maltose**, allowing for the formation of ATP (via glucose).
- The **energy** produced in the embryo is used to facilitate germination.
- The **glucose** produced may also be used to synthesis cellulose - for cell wall formation.
- **Warmth** helps speed up the process.

#24 Use of enzyme in biological washing powders



Biological washing powders contain **protease** and **lipase** to remove **protein** stains and **fat**/grease from clothes. The enzymes break down proteins or fats on the fabric, forming water-soluble substances that can be washed away.

Example: Blood contain the red protein Haemoglobin (Hb). The Proteases in biological washing powder break Hb molecules into smaller molecules, which are not coloured and which dissolve in water and can be washed away.

This makes the washing powder more effective than detergent alone, especially at lower temperatures. This save energy (no need to boil water), but if the temperature is too high, the enzyme will be denatured.

The differences between biological and regular washing powders

	Biological washing powder	Regular washing powder
Detergents Mix greasy dirt with H_2O so it can be washed away	(+)	(+)
Enzymes **Braking** down stains and dirt in fabrics	(+) **Proteases** → proteins (blood, egg, gravy*...) **Amylases** → starches **Lipases** → fats and grease **Cellulase** → micro fibrils on cotton, brightening color of washed clothes They work efficiently at 40°C.	(-)
Remove **difficult stains** (blood, gravy, egg yolk, sweat, fats and grease)	**Easily** by decomposing the stains.	**Difficultly**. **Heat** alone makes stains coagulate and attach more firmly to the clothing.

**Gravy: juices that drip from cooking meat.*

Do it your self

Boil two standard eggs together, and push two teaspoons into the yolks so that there is some yolk left on the spoons.

Dissolve equal amounts of **ordinary** and **'biological'** detergents in two separate glasses of water, and leave a yolk-stained spoon in each glass. After some time you will see that the spoon in the ordinary detergent still has **yolk** on, but the yolk on the other spoon has been digested by the 'biological' detergent. This will happen if the 'biological' detergent really contains
enzymes that break down the proteins in egg yolk.

Try this

Figure above shows a box of biological washing powder.

a) Explain why:
i) The presence of protease and lipase would make the washing powder more effective than ordinary detergent [3 marks]

ii) The powder should not be used in boiling water [2 marks]

b) Silk is a material made from protein. Explain why the biological washing powder should not be used to wash silk clothes [2 marks]

Answer:

a) i) Protease and lipase are enzyme
They break down stains better than ordinary detergent
Protease breaks down protein; lipase breaks down fat
ii) Enzymes are denatured at high temperature
b) There is protease in the biological washing powder
This would digest the protein in the silk so the clothes would get spoiled.

Benefit from using enzymes in cleaning products, toothpaste and other products in our home.

Additional resources:

- http://www.saasta.ac.za/biosciences/enzymes.html
- http://isbibbio.wikispaces.com/biological+washing+powders+and+enzymes

#25 Use of enzymes in the food industry

Enzymes are an integral component of modern **fruit juice** manufacturing and are highly suitable for optimising processes. Fruit juices are **extracted** using an enzyme called **pectinase**.

Pectin is a substance which helps to stick plant cells together. Fruits like apple or orange contain a lot of pectin. The braking down of **pectin** makes it much easier to squeeze juice from the fruit.

Pectinase is widely used in order to:

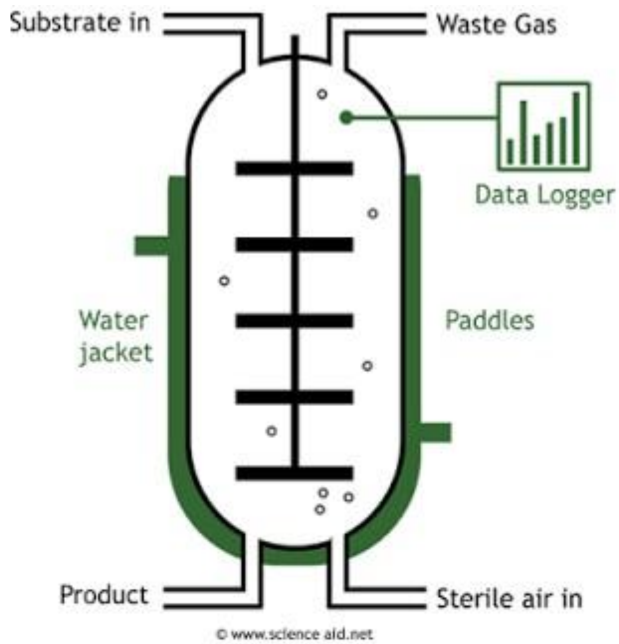
• increase **extraction** of juice from raw material
• increase **processing efficiency** (pressing, solid settling or removal)
• generate a final product that is **clear** and visually attractive

Enzymes are sometimes used when making baby foods. **Proteases** are used to treat some high-protein foods, they break down **proteins** to **polypeptides** and **amino acids** for young baby to **absorb** the food **easier**.

Use of enzymes in the food industry

Process	Use
Baking	Enzymes in yeast convert **sugar** → ethanol and CO_2 $CO2$ makes the bread dough **rise**
Brewing	Enzymes in yeast convert **sugar** → **ethanol** and CO_2 **Ethanol** makes the drink **alcoholic** CO_2 makes the drink **fizzy**
Chees making	Enzyme **rennin,** extracted from cow's stomachs, is used to **clot** milk. Rennin can now be made using genetically engineered bacteria.
Making baby foods	**Trypsin** (a protease) is used to **predigest** baby foods.

#26 Use of microorganisms and fermenter to manufacture enzymes



We obatain many **enzymes** from **microorganisms**. The enzymes that are used in industry are usually obtained from microorganisms. These include **bacteria** and microscopic **fungi**, such as **yeast**. The microorganisms are grown inside large vessels called **fermenters.**

- Inside the **fermenter**, the microorganisms are provided with everything they need to grow and reproduce, e.g.:**O_2**, supply of **nutrients**, a suitable **pH** and **temperature**.
- The microorganisms make the enzymes and release them into the **liquid** in which they are growing.
- The liquid can then be collected from the fermenter, and the enzymes **purified** before use.

Closer look at fermenter

The fermenter is a large, sterile container with a stirrer, a pipe to add feedstock* (molasses* or corn-steep liquor), and air pipes to blow air into the mixture.
The microorganisms are added and the liquid is maintained around 26^0C and a pH of 5-6.

Use of enzymes in the food industry

Process	Use
Baking	Enzymes in yeast convert **sugar** → ethanol and **CO_2** **CO2** makes the bread dough **rise**
Brewing	Enzymes in yeast convert **sugar** → **ethanol** and **CO_2** **Ethanol** makes the drink **alcoholic** **CO_2** makes the drink **fizzy**
Chees making	Enzyme **rennin,** extracted from cow's stomachs, is used to **clot** milk. Rennin can now be made using genetically engineered bacteria.
Making baby foods	**Trypsin** (a protease) is used to **predigest** baby foods.

The enzymes produced by the microorganisms may be extracellular or intracellular:

1. **Extracellular** enzymes are extracted from the feedstock by filtering.
2. To extract **intracellular** enzymes the microorganisms are filtered from the feedstock, then crushed and washed with water. The enzymes are now in solution.

Explain words:

* ***Feedstock***: Raw material (input) fed into a process for conversion into something different (output).

***** Molasses (syrup):*** Thick, dark brown, uncrystallized juice obtained from raw sugar during the refining process.

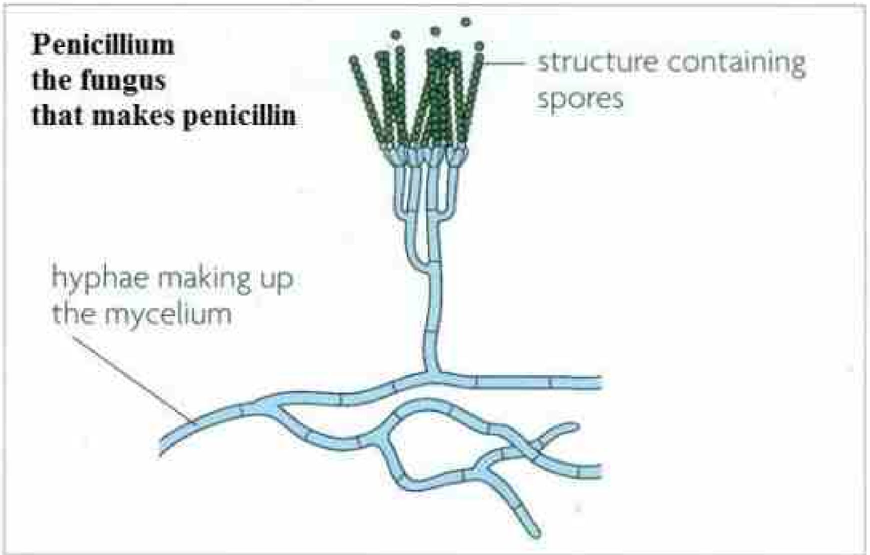
****Corn-steep liquor***: a concentrated fluid obtained by soaking corn grains in water (containing 0,2% SO_2) for 36 — 40 hours at 46 — 50°C.

#27 Use of microorganisms to manufacture antibiotic penicillin

Three colonies of a Penicillium mold growing on an agar medium.

Antibiotics are substances which kill **bacteria** without harming human cells. They help to cure bacterial infections. **Penicillin** is made by growing the fungus ***Penicillium*** in a large **fermenter**.

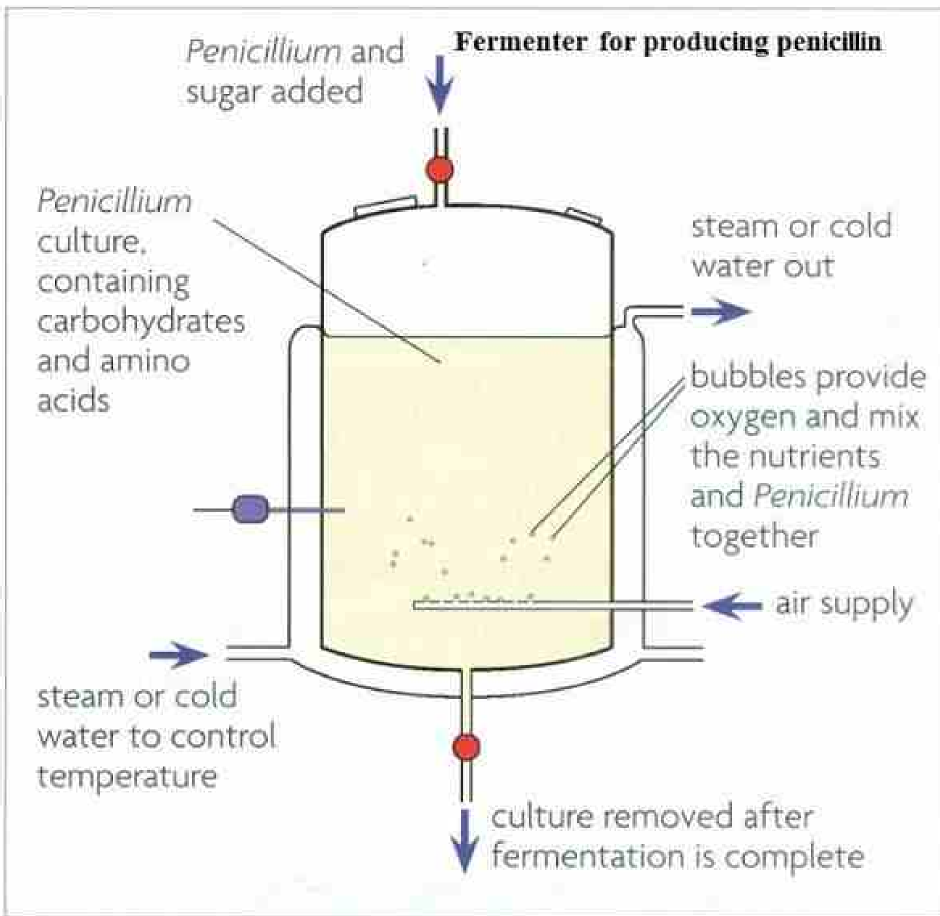
Often, it is easier to use the **whole microorganisms** rather than extract its enzymes from it. The microorganism is grown in a fermenter, its enzymes **convert** a **substrate** to a desired **product**. The production of antibiotic **penicillin** is one example.



Fermenter

The fungus is grown in a **culture** medium containing **carbohydrates** and **amino acid**. This looks like watery porridge and is stirred continuously to:

- Keep the fungus in contact with fresh supplies if nutrients.
- Mix O2 into the culture
- Roll the fungus up into little **pellets** (this facilitates the ***separating*** of the liquid part containing penicillin from the fungus lately).



For first **15-24 h**, the fungus just grows. After that it begins to secret **penicillin**. Rate of production depends on how much sugar is available:

- A lot of sugar à not much penicillin
- No sugar à no penicillin

So **small amount** of sugar have to be fed all the time that the fungus is producing penicillin.

The culture is kept going until the **rate** of production is so **slow** that is not worth waiting more (often after a week). Then it is **filtered**, and the liquid is treated to **concentrate** the **penicillin** in it.

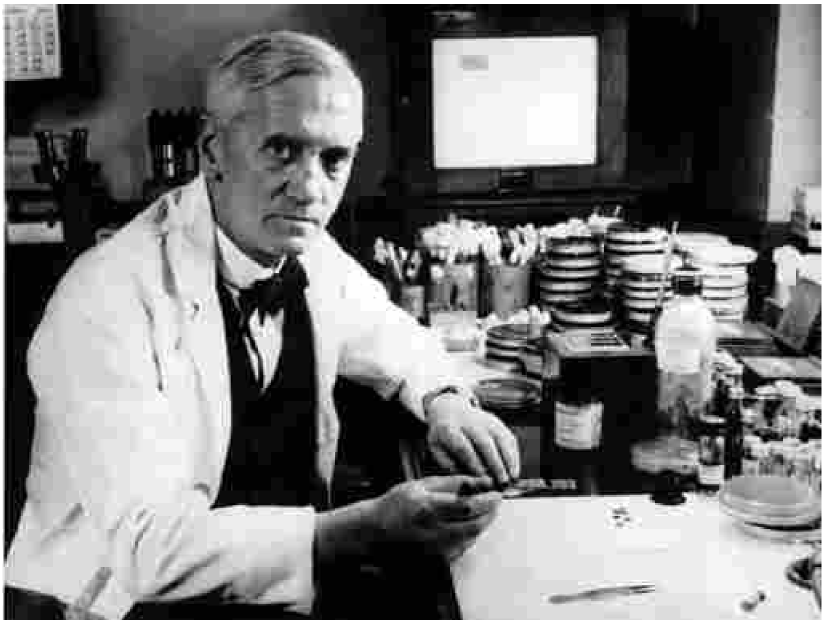
History (not included in the syllabus)

Thousands of glass fermentation vessels like this one were used in Glaxo (now GlaxoSmithKline) laboratories to produce penicillin.

Credits: Science Museum

The penicillium mould was grown on the surface of a liquid filled with all the nutrients it needed. This approach was replaced by the method of growing the mould within large industrial fermenters. The antibiotic was first used in the early 1940s and saved the lives of many soldiers during the Second World War.

Discovering of Penicillin



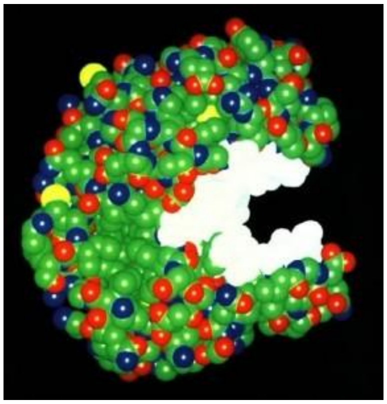
Sir Alexander Fleming, 1952 (photo AP)

Penicillin was discovered **by chance.** **Alexander Fleming -** the Scottish bacteriologist - accidentally left a dish of staphylococcus bacteria uncovered for a few days. He returned to find the dish dotted with bacterial growth, apart from one area where a patch of **mould** (Penicillin notatum) was growing. The mould produced a substance, named **penicillin** by Fleming, which inhibited bacterial growth and was later found to be effective against a wide range of harmful bacteria.

However, it was not until **World War II** that penicillin, the **first antibiotic,** was finally isolated by Howard Florey and Ernst Chain. Fleming, Florey and Chain received a Nobel prize in 1945, for their discovery which revolutionised medicine and led to the development of lifesaving antibiotics.

Additional sources: **Royal Society of Chemistry**
sciencemuseum

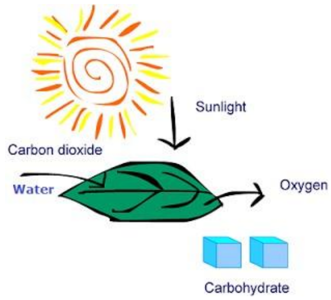
#28 Summary of Enzymes



- **Enzymes** are specialized **protein** molecules facilitating most of the body's **metabolic processes** – such as, supplying energy, digesting foods, purifying your blood, ridding the body of waste products. Enzymes are vital to our health and **change** the **rate** at which **chemical reactions** happen, but without any external **energy** source added or by being changed themselves.
- Enzymes are **proteins** that work as biological **catalysts**.
- Enzymes are named according to the **substrate** on which they act. **Proteases** act on proteins, **carbohydrases** on carbohydrates and **lipases** on fats (lipids). The substance that is produced by the reaction is called the **product**.
- An enzyme molecule has a depression called its **active site**, which is exactly the right shape for the substrate to fit into. The enzyme can be thought of as a **lock**, and the substrate as the **key**.
- **Reactions** catalysed by enzymes work **faster** at **higher temperatures**, up to an optimum that differs for different enzymes. Above the **optimum** temperature, reaction rate rapidly decreases.
- At low **temperatures**, molecules have low kinetic energy, so collisions between enzyme and substrate molecules are infrequent. As temperature rises they collide more frequently, increasing reaction rate.
- **Above** the **optimum temperature**, the vibrations within the enzyme molecule are so great that it begins to lose its shape. The **enzyme** is said to be **denatured**. The substrate no longer fits into the active site and the **reaction stops**.

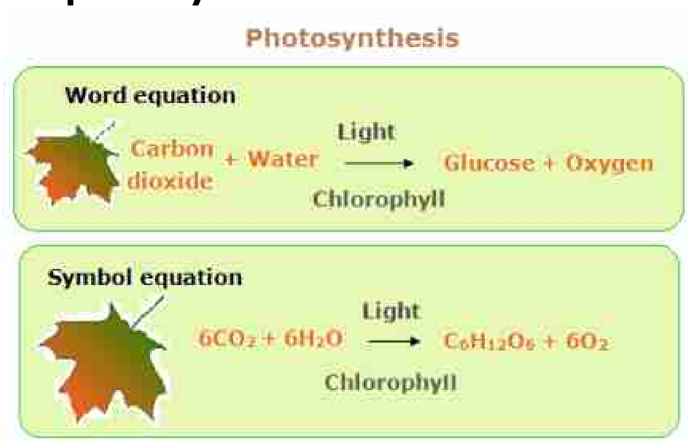
- Reactions catalysed by enzymes work fastest at a particular pH. The **optimum pH** for most enzymes is around **pH7** (neutral), but some have an optimum pH much higher or lower than this.
- **Extremes of pH** cause enzyme molecules to **lose** their **shape**, so they no longer bind with their substrate.
- **Amylase** is found in **seeds**. When the seed begins to **germinate**, the amylase is activated and catalyses the breakdown of **insoluble starch** to **soluble maltose** in the seed. The maltose is used by the growing embryo as an **energy** source and to make **cellulose** for new cell walls.
- **Biological** washing **powders** contain enzymes, often obtained from **microorganisms** such as **bacteria** or **fungi**. The enzymes break down proteins or fats on the fabric, forming watersoluble substances that can be washed away.
- **Pectinase** is used to break down cell walls in **fruits**, making it easier to extract **juice** from them.
- The antibiotic **penicillin** is made by cultivating the fungus **Penicillium** in a fermenter. The fermenter is kept at the correct pH and temperature for the enzymes of the fungus to work well.

04 – Plant nutrition
#38 The equation for photosynthesis



Photosynthesis is the fundamental process by which plants manufacture food molecules (**carbohydrates**) from raw materials **CO_2** and **H_2O)** using **energy** from **light**.

1.The equation for photosynthesis



- The raw materials are CO_2, H_2O and light energy.
- The products are glucose (starch) and O_2

2. The process of photosynthesis

- Green plants take in **CO_2** through their leaves (by **diffusion**).
- **H_2O** is absorbed through plants' roots (by **osmosis**), and transported to the leaf through **xylem** vessels.
- **Chlorophyll** traps **light energy** and absorbs it.
- This energy is used to break up H_2O molecules, than to bond hydrogen and CO_2 to form **glucose**.
- Glucose is usually changed to **sucrose** for transport around the plant, or to **starch** for storage.
- **O_2** is released as a waste product, or used by plant for respiration.
- In this process, **light energy** is converted to **chemical** energy for the formation of glucose and its subsequent storage.

Video: What is photosynthesis?
https://www.youtube.com/watch?v=WHMLq3bqGwk

#39 Photosynthesis investigations - Principles and Starch test

A leaf before (a)
and after (b) starch test.

Experiments can be used to find out what factors (CO_2, light, cholorophyll) are needed for photosynthesis. But first of all you need to **destarch** the plants. To be certain that they are thoroughly destarched, **test** a leaf for **starch** before you begin your investigation.

Principles of investigations

1. Investigations need controls

- **Control** plant (or leave) has all substances it needs.
- **Test** plant lacks one substance (light/chlorophyll/CO_2)

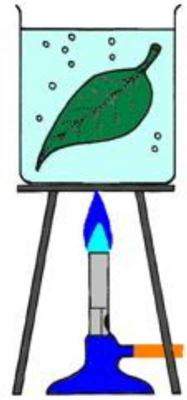
2. Plants must be destarched

- It is very important that the leaves you are testing should **not** have any **starch** in them at the beginning of the experiment.
- So, first of all, you must destarch the plants. Leave them in the **dark** for 48 hours. The plants use up all stores of starch in its leaves.

3. Starch test with Iodine solution

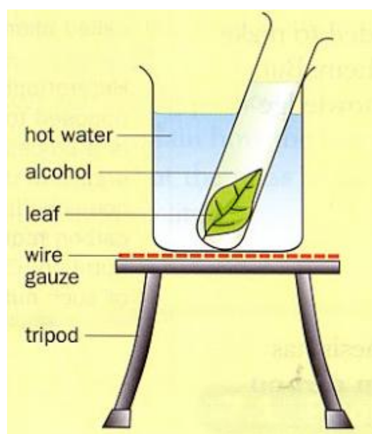
- After a few hours, carry out the starch test on both plants: **Iodine solution** is used; a blue-black colour on the leave is positive.

- **Boil the leaf in water** for 30 second. This kill the cells in the leaf à break down the membrane à iodine solution gets through cell membrane to reach **starch** inside the chloroplasts and react with them.



Boil the leaf in water.

- **Boil the leaf in alcohol** (ethanol) in a water bath: The **green colour** of the leaf and the brown iodine solution can look black together, so you need to remove **chlorophyll** by **dissolving** it out with **alcohol**. Leave it until all the chlorophyll has come out of the leaf.



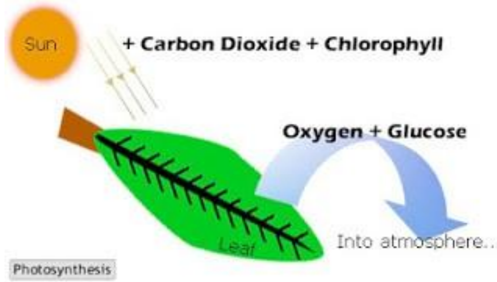
Boil the leaf in alcohol.

- **Rinse the leaf in water**: Boiling the leaf in ethanol makes it brittle, the water softens it.
- Spread the leaf out on a **white** tile à easy to see the result.
- **Add iodine solution** to the leaf à blue- black colour is positive, starch is present.

A leaf before (on the left) and after (on the right) starch test.

Additional resource: sjiiscience.blogspot.com

#40 Photosynthesis investigations – chlorophyll, CO2, light tests



Investigations to see if chlorophyll, light and CO2 are needed for photosynthesis.

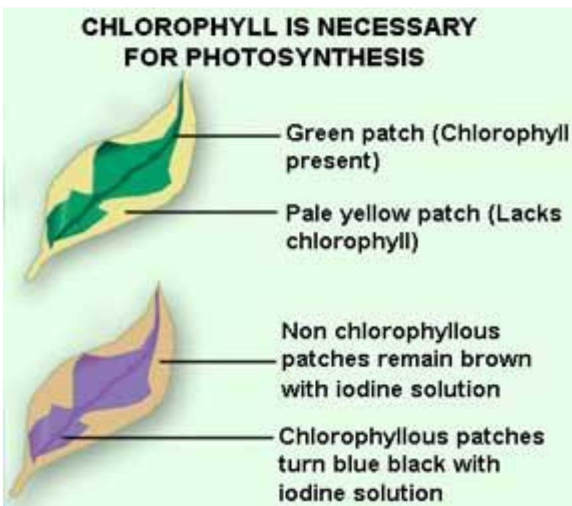
1. Chlorophyll is necessary for photosynthesis

Process

- Take a potted plant with **variegated** (green and white) leaves.
- **Destarch** the plant by keeping it in complete darkness for about 48 hours.
- Expose the plant to the **sunlight** for a few days.
- Test one of the leaves for **starch** with iodine solution.

Observations

- Areas with previously **green** patches test **positive** (turn blue black).
- Areas with previously pale **yellow** patches test **negative** (remain brown).



Conclusion

- Photosynthesis takes place only in green patches because of the presence of **chlorophyll**.
- The pale yellow patches do not perform photosynthesis because of the absence of chlorophyll.

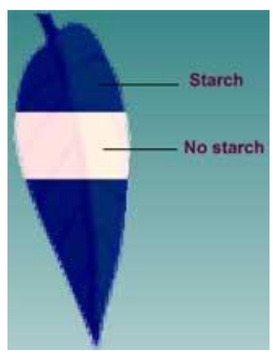
2. Light is essential for photosynthesis

Process

- Take a potted plant.
- **Destarch** the plant by keeping it in complete darkness for about 48 hours.
- Test one of it leaves for starch, to check that is does not contain any.
- Fix a leaf of this plant in between two strips of a thick paper on leaf.
- Place the plant in light for a few days.
- Remove the cover from the leaf and test it for starch.

Observations

Positive starch test will be obtained only in the portion of the leaf exposed to light and negative test in parts with paper strip.

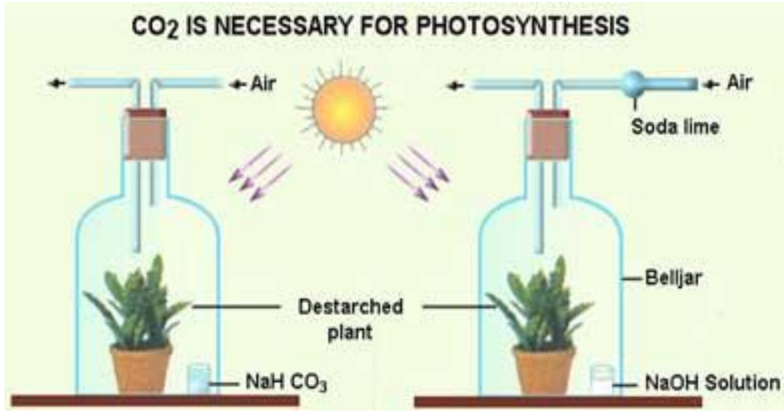


Conclusion
Light is necessary for photosynthesis.

3. Carbon dioxide is essential for photosynthesis

Process

- Take two destarched potted plants.
- Cover both the plants with bell jars and label them as A and B.
- Inside Set-up A, keep **$NaHCO_3$** (sodium bicarbonate). It produces CO_2.
- Inside Set-up B, keep **NaOH** (Sodium hydroxide). It absorbs CO_2.
- Keep both the set-ups in the sunlight at least for 6 hours.
- Perform the starch test on both of the plants.



Observations

Leaf from the plant in which **$NaHCO_3$** has been placed gives **positive** test.
Leaf from the plant in which **NaOH** has been kept give **negatif** test.

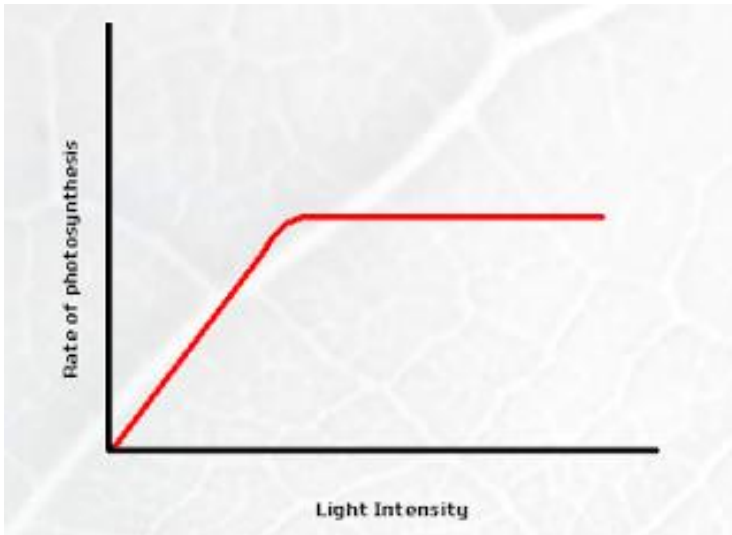
Conclusion

Plant in Set up A gets CO_2 whereas plant in Set-up B does not get CO_2.
It means CO_2 is must for photosynthesis.

Source: **mastermindtutor.com**

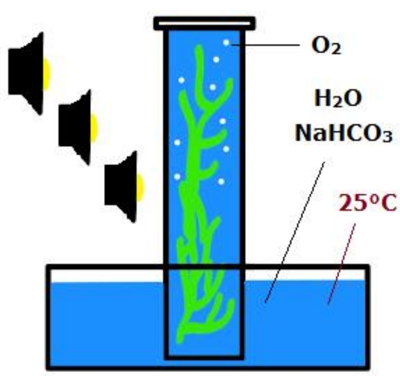
#41 Effect of Light intensity on the rate of Photosynthesis

Plants need light energy to make the chemical energy needed to create carbohydrates. Increasing the light intensity will boost the speed of photosynthesis. However, at high light intensities the rate becomes constant.



Experiment

- Place a pond weed Elodea upside in a test tube containing water.
- Place the tube in a beaker of fresh water at 25°C. This helps to maintain a constant temperature around the pond weed.
- Place excess sodium bicarbonate ($NaHCO_3$) in the water to give a constant saturated solution of CO2.
- Place the lamp (the only light source) at distance from the plant.



- Count the number of oxygen bubbles given off by the plant in 1 minute period. This is the rate of photosynthesis at that particular light intensity.
- The gas should be checked to prove that it is indeed oxygen - relights a glowing splint.

- Repeat at different light intensities by moving the lamp to different distances.

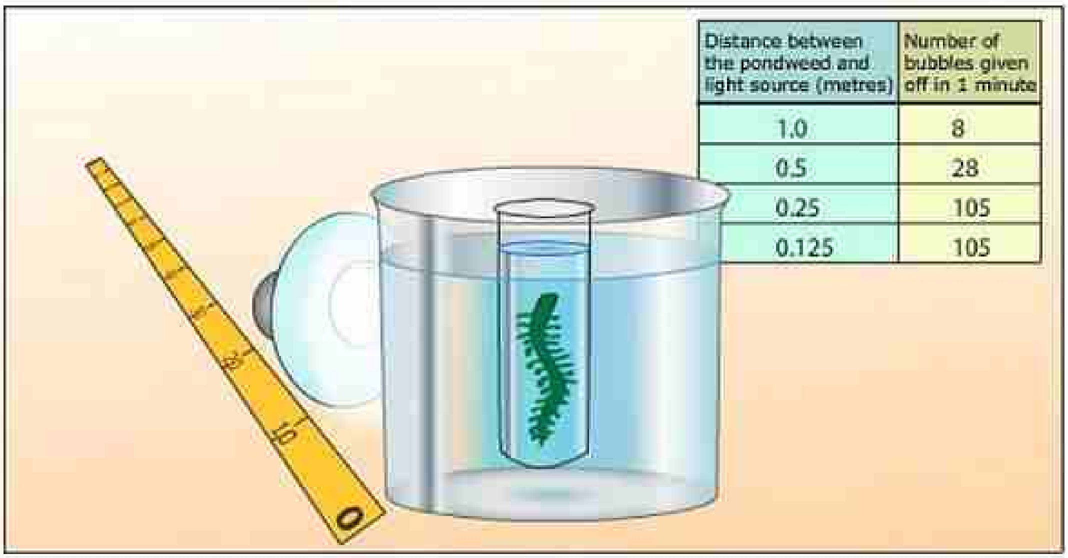
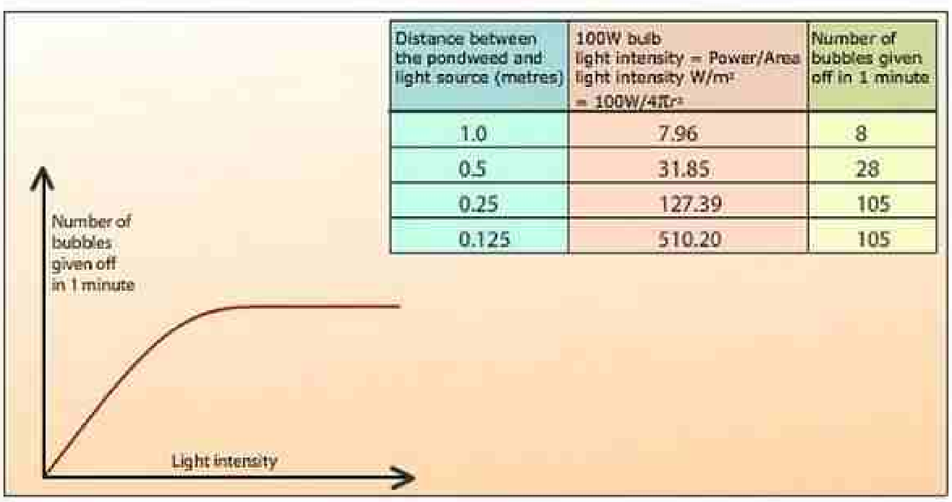


Photo from passmyexams.co.uk

- Graph the results placing light intensity on the x-axis.



Explanation

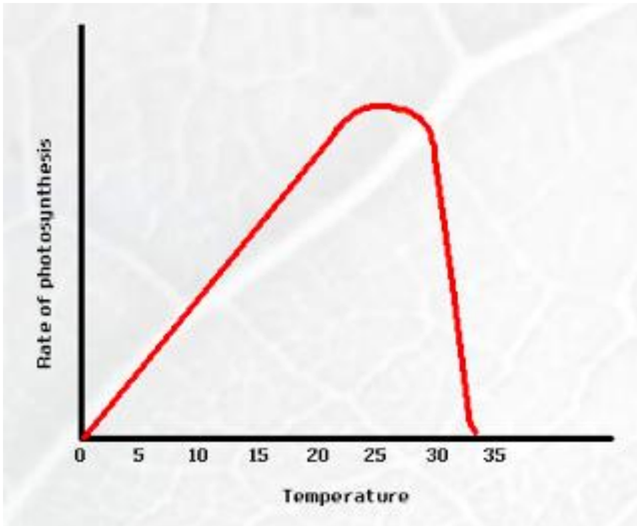
- **Light energy** absorbed by chlorophyll is converted to ATP and H+
- At very low light levels the plant will be respiring only not photosynthesising.
- As the **light intensity increases**, the **rate** of photosynthesis **increases**. However, the rate will not increase beyond a certain level of light intensity.

- At high light intensities the rate becomes **constant**, even with further increases in light intensity, there are no increases in the rate.
- The plant is unable to harvest the light at these high intensities and the chlorophyll system can be damaged by very intense light levels.

Additional sources: **skoool.ie**
passmyexams.co.uk

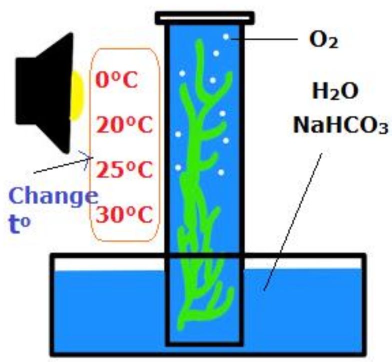
#42 Effect of Temperature on the Rate of Photosynthesis

When the **temperature** rises the rate of photosynthesis rises also. There is an **optimum** temperature at which the rate of photosynthesis is maximum. Beyond this temperature, the reaction quickly comes to a halt.



Experiment

- Place a pond weed Elodea upside in a test tube containing water at 25°C.
- Place the tube in a beaker of fresh water.
- Place excess sodium bicarbonate ($NaHCO_3$) in the water to give a constant saturated solution of CO2.
- Place the lamp (the only light source) at a fixed distance from the plant.
- Maintain the room temperature at 20°C.

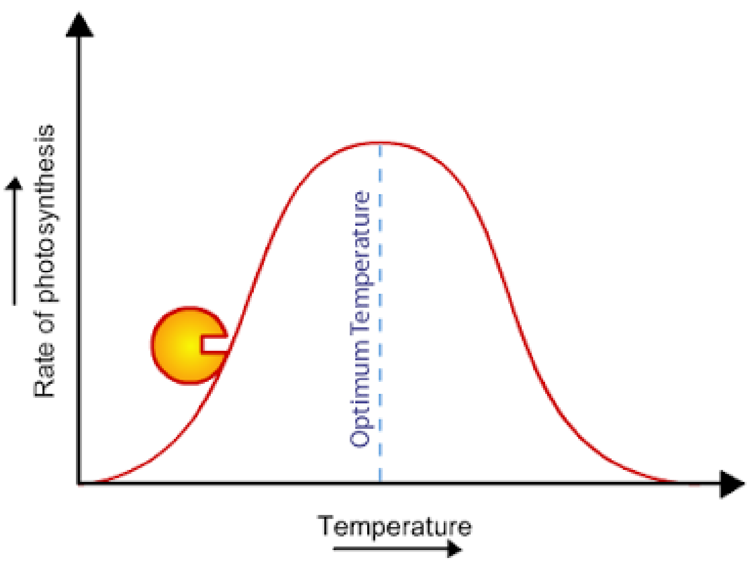


- Count the number of oxygen bubbles given off by the plant in a one - minute period. This is the rate of photosynthesis at that particular temperature.

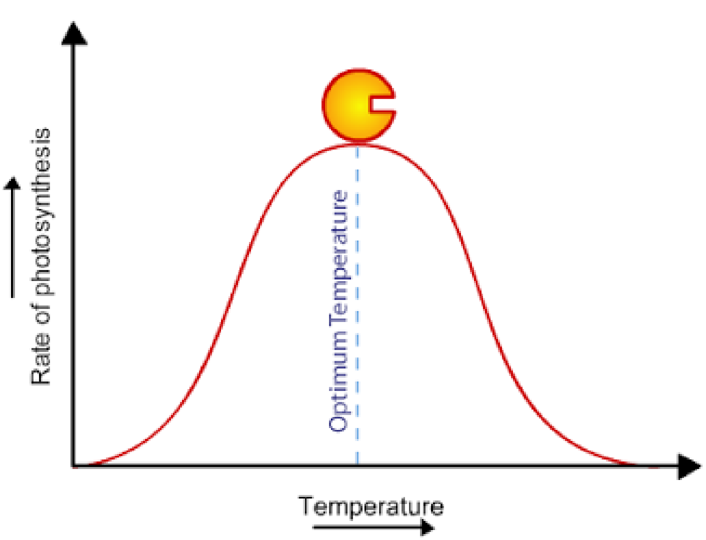
- The gas should be checked to prove that it is indeed oxygen - relights a glowing splint.
- Repeat at different temperatures: 0°C - surround the beaker with an ice jacket; greater than room temperature (25°C, 30°C, 35°C, 40°C, 45°C, etc.,) by using a hot plate.
- Graph the results placing temperature on the x-axis.

Explanation

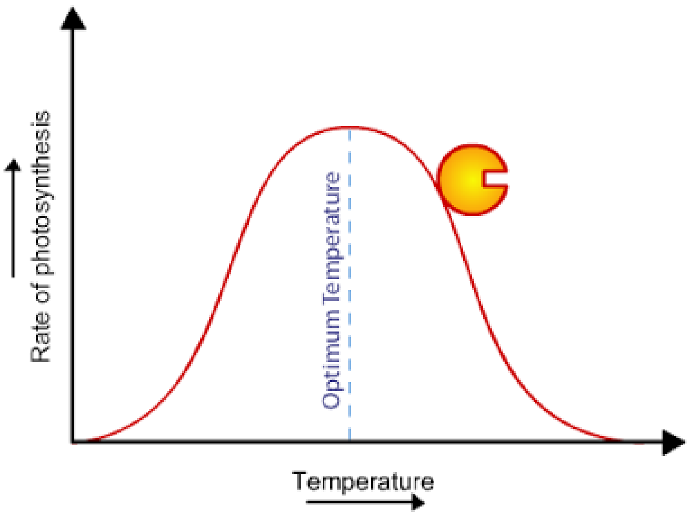
- At low temperature, the enzyme does not have enough energy to meet many substrate molecules, so the reaction is slowed.
- When the temperature rises, the particles in the reaction move quicker and collide more, so the rate of photosynthesis rises also.



- At the optimum temperature, the enzyme is most efficient and the rate if maximum.



- At temperatures above 40°C the rate slows down. This is because the enzymes involved in the chemical reactions of photosynthesis are temperature sensitive and destroyed (denatured) at higher temperatures.



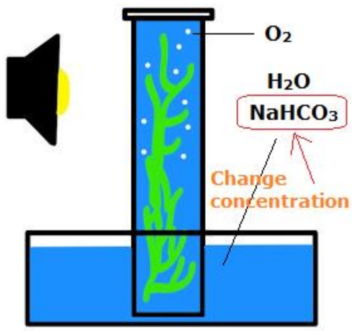
Additional sources : [skoool.ie]
[passmyexams.co.uk]
[woisd.net]

43 Effect of Carbon Dioxide on the Rate of Photosynthesis

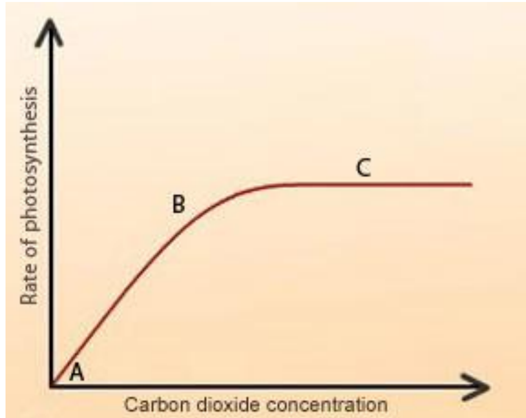
When the concentration of CO_2 is low the rate of photosynthesis is also low. (the plant has to spend time waiting for more CO_2 to arrive). Increasing the concentration of CO_2 increases the rate of photosynthesis.

Experiment

- Place a pond weed Elodea upside in a test tube containing water at 25°C.
- Place the tube in a beaker of fresh water.
- Place excess sodium bicarbonate ($NaHCO_3$) in the water to give a constant saturated solution of CO_2.
- Place the lamp (the only light source) at a fixed distance from the plant.
- Maintain the room temperature at 20°C.



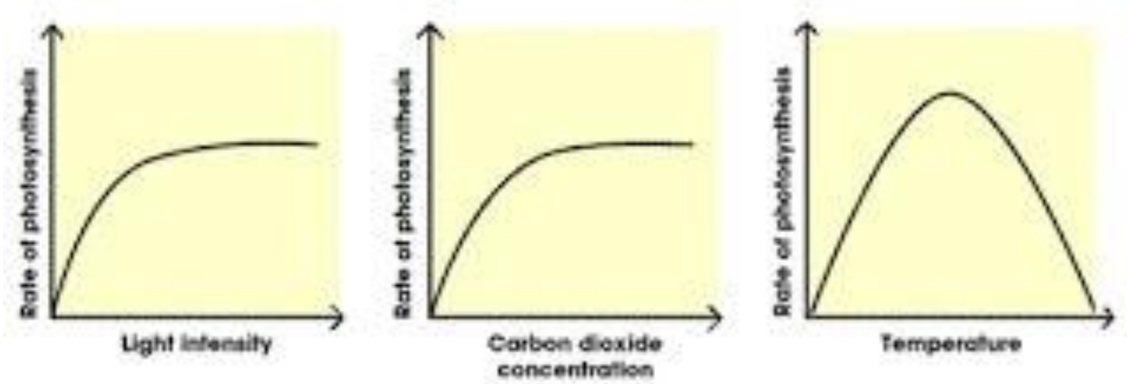
- Count the number of oxygen bubbles given off by the plant in a one - minute period. This is the rate of photosynthesis at that particular concentration of CO_2.
- The gas should be checked to prove that it is indeed oxygen - relights a glowing splint.
- Repeat at different lower CO_2 concentrations by using different dilutions of a saturated solution.
- Graph the results placing CO_2 concentration on the x-axis.



Explanation

- The rate of photosynthesis **increases linearly** with increasing CO_2 concentration (from point A to B).
- The rate falls gradually, and at a certain CO_2 concentration it stays constant (from point B to C). Here a rise in CO_2 levels has **no effect** as the other factors such as light intensity become limiting.

#44 Limiting factors in photosynthesis

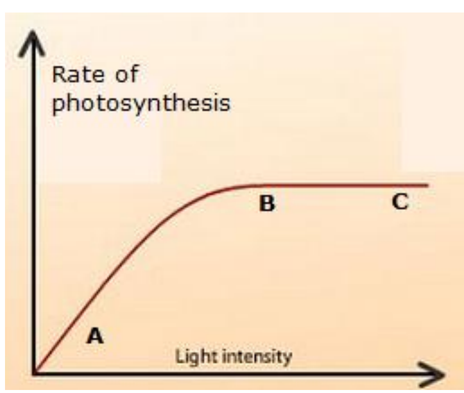


Limiting factor is something present in the environment in such **short supply** that it restricts life processes. Three factors can limit the speed of photosynthesis - **light** intensity, **carbon dioxide** concentration and **temperature**.

If a component is in low supply then productivity is prevented from reaching maximum.

Sunlight

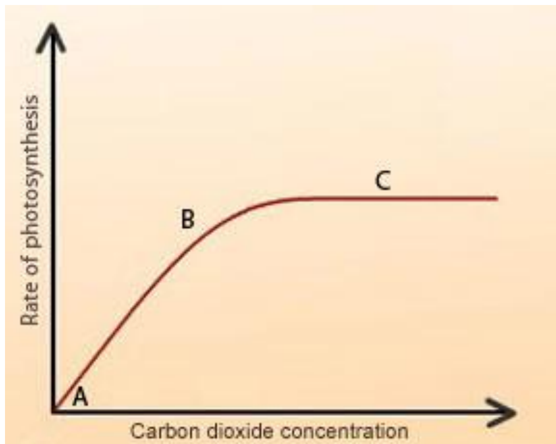
- Light energy is vital to the process of photosynthesis. It is severely limiting at times of partial light conditions, e.g. dawn or dusk.
- As light intensity increases, the rate of photosynthesis will increase, until the plant is photosynthesising **as fast as it can**. At this point, even if light becomes brighter, the plant cannot photosynthesise any faster.



- Over the first part of the curve (**between A and B**), light is a **limiting factor.** The plant is limited in how fast it can photosynthesise because it does not have enough light.
- Between B and C, light is not a limiting factor. Even if more light is shone on the plant, it still cannot photosynthesise any faster.

Carbon dioxide

- In photosynthesis CO_2 is a key limiting factor. The usual atmospheric level of CO_2 is 0.03%. In perfect conditions of water availability, light and temperature this low CO_2 level holds back the photosynthetic potential.
- The more CO_2 a plant is given, the faster it can photosynthesise up to a point, but then a maximum is reach.



Temperature

The chemical reactions of photsynthesis can only take place very slowly at low temperature, so a plant can photosynthesise faster on a warm day than on a cold one.

#45 Optimum conditions for photosynthesis in Green house

When plants are growing outside, we can not do much about changing the conditions that they need for photosynthesis. But if crops are grown in glasshouses, then it is possible to control conditions so that they are photosynthesising as fast as possible.

CO_2 enrichment

CO_2 concentration can be controlled. CO_2 is often a limiting factor for photosynthesis, because its natural concentration in the air is so very low (0.04%). In a closed glasshouse, it is possible to provide extra CO_2 for the plants, e.g. by burning fossil fuels or releasing pure CO_2 from a gas cylinder.

Optimum light

Light also can be controlled. In cloudy or dark conditions, extra artificial lighting can be provided, so that light is not limiting the rate of photosynthesis. The kind of lights that are used can be chosen carefully so that they provide just the right wavelengths that the plants need.

Optimum temperature

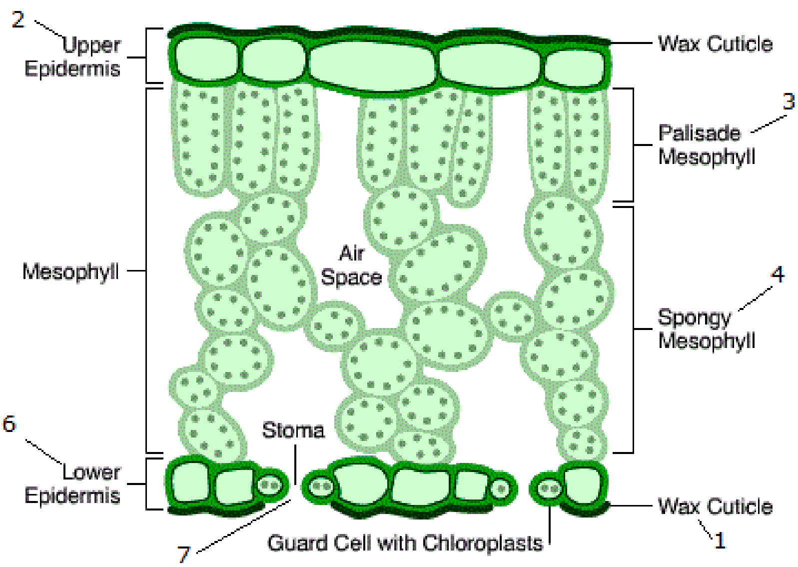
In some countries where it is too cold for good growth of some crop plants, the heated greenhouses can be used. This is done, for example, with tomatoes. The temperature in the glasshouse can be kept at the optimum level to encourage the tomatoes to grow fast and strongly, and to produce a large yield of fruit that ripens quickly.

The temperature can be raised by using a heating system. If fossil fuels are burned, there is also a benefit from the CO_2 produced.

#46 Leaf structure

The leaf consist of a broad, flat part called the **lamina**, which is joined to the rest of the plant by a leaf stalk or **petiole**. Running through the petiole are **vascular bundles**, which then form the **veins** in the leaf.

Although a leaf looks thin, its is made up of **several layers** of cells. You can see these if you look at a transverse section (cross-section) of a leaf under a microscope.



1. Cuticle:

- made of **wax** – waterproofing the leaf
- secreted by cells of the upper epidermis

2. Upper epidermis

- thin and transparent – allows **light** to pass through
- **no chloroplasts** are present
- act as a **barrier** to disease organisms

3. Palisade mesophyll

- main region for **photosynthesis**
- cells are **columnar** (quite long) and packed with **chloroplasts** to trap light energy
- receive CO_2 by diffusion from air spaces in the spongy mesophyll

4. Spongy mesophyll

- cells are more **spherical** and loosely packed
- contain chloroplasts, but not as many as in palisade cells
- **air spaces** between cells allow gaseous exchange – co_2 to the cells, o_2 from the cells during photosynthesis

5. Vascular bundle

- this is a leaf **vein**, made up of xylem and phloem
- **xylem** vessels bring **water** and **minerals** to the leaf
- **phloem** vessels transport **sugars** and **amino acids** away (translocation)

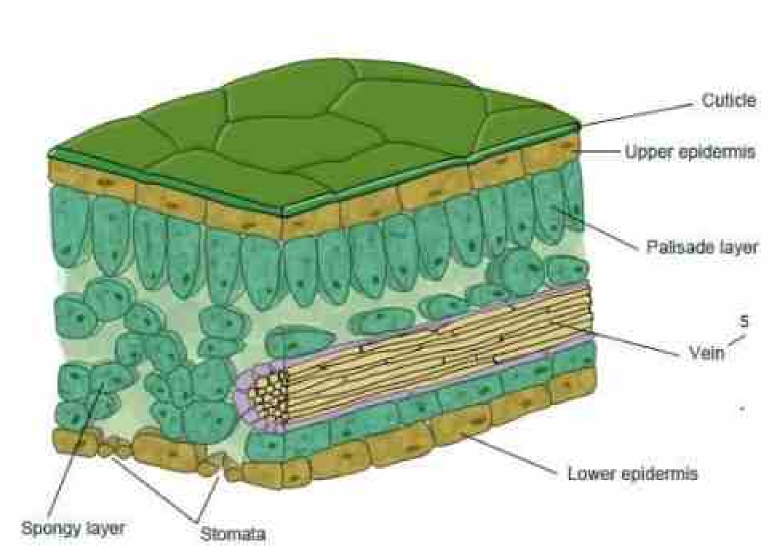


Photo credit: Pass My Exams

6.Lower epidermis

- acts as a **protective** layer
- **stomata** are present to regulate the loss of **water vapour** (transpiration)
- site of **gaseous exchange** into and out of the leaf

7. Stomata

- each stomata is surrounded by a pair of **guard cells**
- guard cells – control whether the stoma is **open** or **closed**
- water vapour passes out during **transpiration**
- CO_2 diffuses in and **O_2** diffuses out during **photosynthesis**

#47 Plant's mineral requirements and fertilisers

Plants need minerals for healthy growth.

Plant is in need for **mineral ions** to control chemical activities, grow, and produce materials. The most important minerals are **Magnesium** ions and **Nitrates**.

1.Importance of nitrate and magnesium ions

	Nitrogen	Magnesium
Mineral salt	Nitrates (NO_3^-) or Ammonium (NH_4^+) ions	Magnesium (Mg^{++}) ions
Why needed	To make proteins	To make chlorophyll
Deficiency	Weak growth, yellow leaves	Yellowing between the veins of leaves

a. Nitrates

- plants absorb nitrate ions from the soil, through their root hairs
- nitrate ions combine with glucose -----> **amino acids**
- amino acids bond together -----> **protein**
- **deficiency** causes poor growth, especially of leaves. The stem becomes weak, lower leaves become yellow and die, while upper leaves turn pale green

Nitrates deficiency: Growth severely restricted, few stems; yellowing of older foliage.

b.Magnesium

- plants absorb magnesium ions from the soil solution
- used for the manufacture of **chlorophyll**
- each chlorophyll contains one magnesium atom
- **deficiency** makes leaves turn yellow from the bottom of the stem upwards and eventually stops photosynthesis

Magnesium deficiency in potato plant.

(Growth fairly normal; foliage slightly pale; older leaflets develop central necrosis, turn yellow or brown and wither prematurely).

Magnesium deficiency: yellowing between the veins of leaves.

2. Nitrogen fertilisers

Sometimes the soil is lacking of the mineral ions needed, this problem can be solved by adding fertilisers to the soil. Fertilisers are chemical compounds rich in the mineral ions needed by the plants. They help the plants grow faster, increase in size and become greener, they simply make them healthier and **increase** the **crop yield**.

Ammonium Nitrate fertiliser

Intensive farming (repeatedly using the same land fro crops) removes nitrates from the soil. These need to be replaced to prevent a drop in yield. Nitrates can be replaced in 3 ways:

- applying animal **manure**
- **crop rotation** – growing leguminous plants such as peas, beans and clover every 2 or 3 years: these plants develop root nodules containing nitrogen-fixing bacteria, and the roots are ploughed into the soil, boosting nitrate levels
- adding artificial **fertilisers** such as ammonium nitrate

Danger of overuse

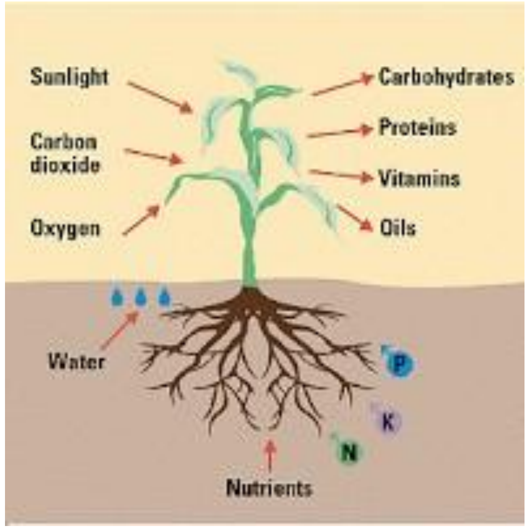
Apply too much nitrogen fertiliser ----> **water** is drawn out of plant roots (osmosis) ----> plant wilt/die.

Eutrophication:
Nitrates can be **leached** out of the soil and enter a nearby **river** polluting it, creating a layer of green **algae** on the **surface** of it causing lack of **light** in the river thus preventing the aqua plants photosynthesising ----> **death** of algae ----> decomposers (**bacteria**) multiply and decay, respire using **O_2** ----> death of **aquatic animals** from lack of O_2 = Eutrophication.

Overuse of nitrogen fertiliser can have nasty environmental consequences.

Additional resource: **xtremepapers.com**

#48 Summary of plant nutrition



- Photosynthesis takes place in chloroplasts in the leaves of plants.
- The word equation for photosynthesis is:

Word equation

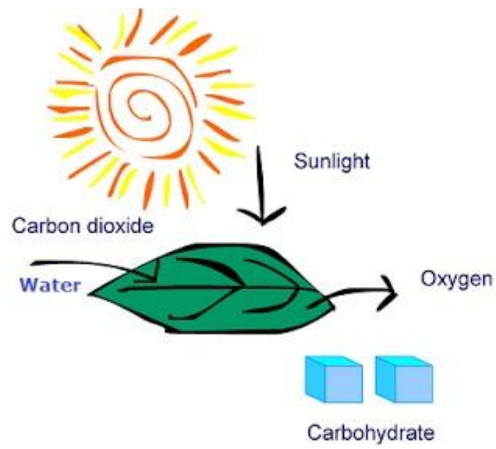
$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Light}} \text{Glucose} + \text{Oxygen}$$

- The balanced equation is:

Symbol equation

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

- Chlorophyll traps energy from light. In photosynthesis, this energy is converted to chemical energy in carbohydrates.



- Photosynthesis takes place in the cells of the mesophyll layer, especially the palisade mesophyll. Leaves are thin and have a large surface area, to speed up the supply of carbon dioxide to the palisade cells and to maximise the amount of sunlight that hits the leaf and can be absorbed by chlorophyll. Stomata and air spaces allow carbon dioxide to diffuse quickly from the air to the chloroplasts. Xylem vessels bring water, and phloem tubes take away the products of photosynthesis.

- Some of the glucose that is made is used in respiration, to provide energy to the plant cells. Some is stored as starch. Some is used to make cellulose for cell walls. Some is transported around the plant in the form of sucrose, in the phloem tubes. Some is combined with nitrate or ammonium ions to make proteins. Some is used to make other substances such as fats. With the addition of magnesium ions, chlorophyll can be made.

- When testing a leaf for starch, it must first be boiled to break down cell membranes and allow iodine solution to make contact with any starch inside the cells. Hot alcohol will remove chlorophyll from the leaf, making it easier to see any colour changes.
- Plants need light and carbon dioxide for photosynthesis.

- If either light or carbon dioxide are in short supply, they limit the rate of photosynthesis and are said to be limiting factors. The rate of photosynthesis is also affected by temperature.

05 Animal Nutrition

#49 Diet

The food an animal eat everyday is called **diet**. Most animals need 7 types of nutrients in their diet: **carbohydrates, proteins, fats** **+** **water, fibre, vitamins, minerals**.

The amount of **energy** needed is provided mainly by our carbohydrate and fat intake. Your dietary requirements depend on your **age**, **sex** and **activit**y.
- Age: The energy demand increases until we stop growing. While children are growing they need more protein per kilogram of body weight than adults do.
- Sex: Generally, males use up more energy than females.
- Pregnant women need extra nutrients for the development of the fetus.

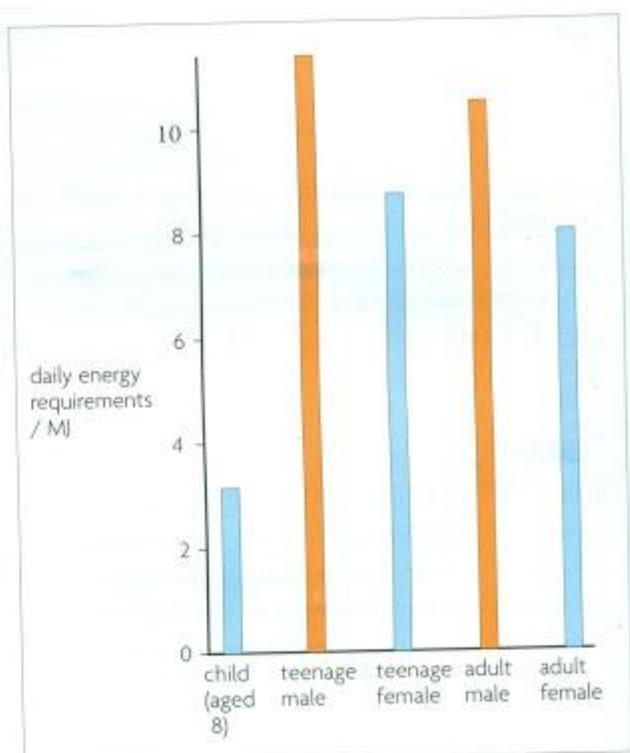


Figure 7.1 Daily energy requirements.

A. A balanced diet is a diet that contains all the **main nutrients** in the correct **amounts** and **proportions** to maintain good health.

B. Malnutrition is the result of not eating a balanced diet. There may be:

- wrong **amount** of food: too little or too much
- incorrect **proportion** of main nutrients
- **lacking** in one or more key nutrients

Effects of malnutrition

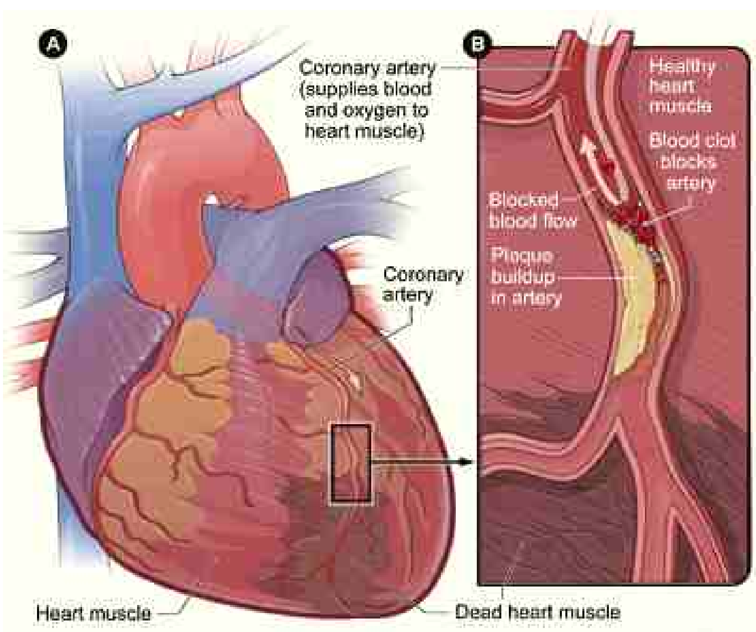
1. Obesity - Too much food (carbohydrate, fat or protein)

too much food → obesity → coronary heart disease

obesity → diabeties → blindness

2. Coronary heart disease

- **Too much** saturated/animal fat in the diet results in high cholesterol levels.
- Cholesterol can stick to the walls of arteries, gradually blocking them.
- If coronary arteries become blocked, the results can be angina and coronary heart disease.



3. Starvation

- **Too little** food can result in starvation.
- Extreme slimming diets, such as those that avoid carbohydrate foods, can result in the disease anorexia nervosa.

Starvation

4. Childhood protein-energy malnutrition (Kwashiakor)

Wrong proportion of nutrients e.g. too much carbohydrates (starchy foods) and a lack of protein can lead to Kwashiakor in young children.

Kwashiakor characterized by edema, anorexia, ulcerating dermatoses.

5. Vitamin, mineral and fiber deficiency diseases - Lacking key nutrients.

Vitamin, minerals, fibre and water

Nutrient	Function	Deficiency	Food sources
Vitamin C	Maintain healthy **skin** and **gums**	**Scurvy**- bleeding under skin, bleeding gums	Citrus fruits, cabbage, blackcurrants, guava, mango, tomato
Vitamin D	-Maintain hard bones -Help to absorb **calcium** from small intestine	**Rickets** - soft bones that become deformed (e.g. bow legs)	-Milk, butter, cheese, egg yolk, fish-liver oil. -Made by **skin** when exposed to sunlight
Calcium	-Formation of healthy **bones** and teeth - Normal **blood clotting**	-Rickets, brittle bones and teeth -Slow blood clotting	Milk, cheese, fish
Iron	-Formation of **haemoglobin** in red blood cells	**Anaemia** (not enough red blood cells → not enough O_2 delivered to tissues): constant tiredness, lack of energy	Red meat, liver, kidney, eggs, vegetables (spinach, cabbage...) , chocolate
Fibre	**Cellulose** adds bulk (mass) to undigested food passing through the intestines, maintaining **peristalsis** (constriction and relaxation)	-**Constipation** -Long-term deficiency leads to **bowel cancer**	Vegetables, fruit, whole meal bread
Water	-Formation of **blood**, **cytoplasm** -Solvent for transport of nutrients and removal of wastes (**urine**) -**Enzymes** only work in solution	**Dehydration**	Drinks, fruit, vegetables

#50 Use of modern technology for increasing food production

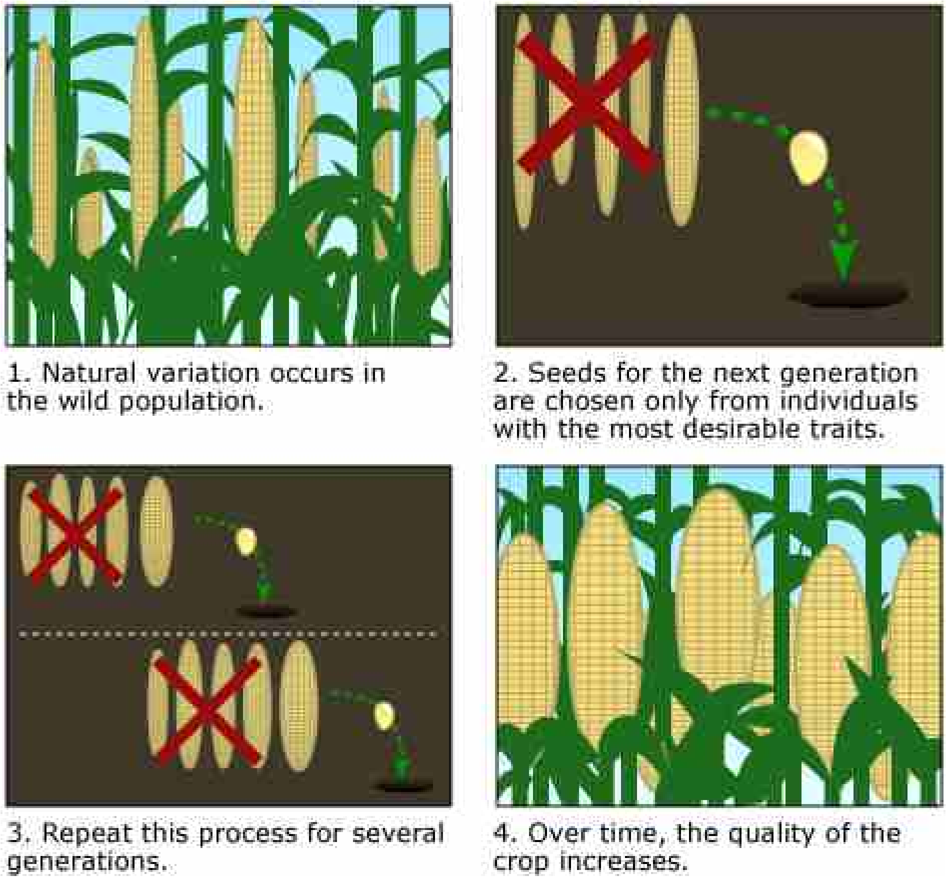
Modern technology such as chemical fertilisers, pesticides, herbicides, modern agricultural machinery, artificial selection... have been used to increase food production.

- Development and use of **chemical fertilisers** on farm land à boots levels of nutrients in the soil, increasing crop yields.
- Development and use of **pesticides** such as insectisides and fungicides à kill pests that feed on ar damage crops à increase crop yields.

- Development and use of **herbicides** à kill weeds that compete with crops for nutrients, light, water and space à increase crop yields.

- Use of **modern machinery**, such as tractors and combine harvesters à enables land and crops to be managed more efficiently.

- **Artificial selection** to produce varieties of plants that are suited to particular climates and soil types, and breeds of animal for specific purpose such as optimum meat, milk, and wool production.



- Development of **biological control** methods for pest control as an alternative to pesticides.

- Use of **yeast and bacteria** in the large-scale production of bread, beer and wine, youghurt and cheese. Single-cell protein and fungi are use to produce meat substitudes.

- Use of **medicines** such as antibiotics, hormones and artificial insemination techniques in intensive animal rearing.

- Use of **plant hormones** in plant growing and fruit production.

- Use of **genetic engineering** and cloning techniques to produce organisms to produce hormones, etc.

- Development of systems to **water plants** in **greenhouses** automatically and to grow plants in nutrient solutions (a process called hydroponics).

- Use of **satellites** to monitor crop development, observe crop diseases and assess the need for additional fertiliser.

- Development of **intensive farming** and automated feeding mechanisms.

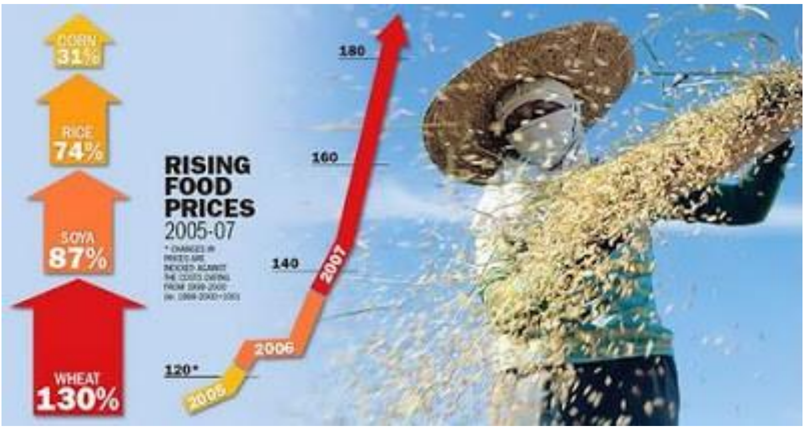
#51 Problems of world food supplies and the causes of famine

There is **not** always **enough food** available in a country to feed the people living there. A severe food shortage can lead to **famine**.

It has been calculated that more than enough food is produced on Earth to provide every single person with more than enough for their needs. Yet many people do not got enough food. Each year, many people die because they have an inadequate diet.

The fundamental problem is that **food is distributed unequally** on our planet: while some parts of the world produce more than enough food for the people that live there, in other part of the world not enough food is produced.

- Although large amounts of food are transported from one area to another, this is still not sufficient to supply enough food to everybody.
- If food prices rise too high, many people may not be able to afford to buy it.

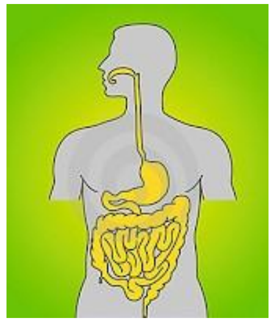


Famine can occur for many different reasons:

- Climate change and natural disaster such as **drought** and **flooding** that prevent crops from growing.

- Increasing **population**: population may grow so large that the land on which they live can no longer provide enough food for them.
- Unequal **distribution** of food.

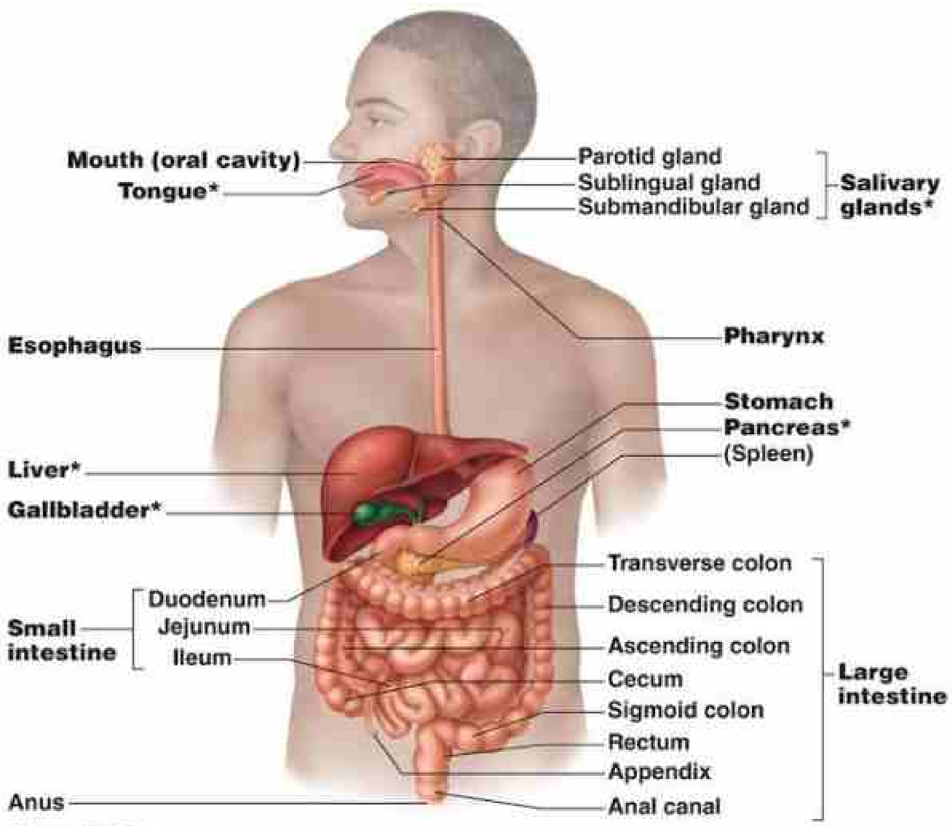
52 Human alimentary canal



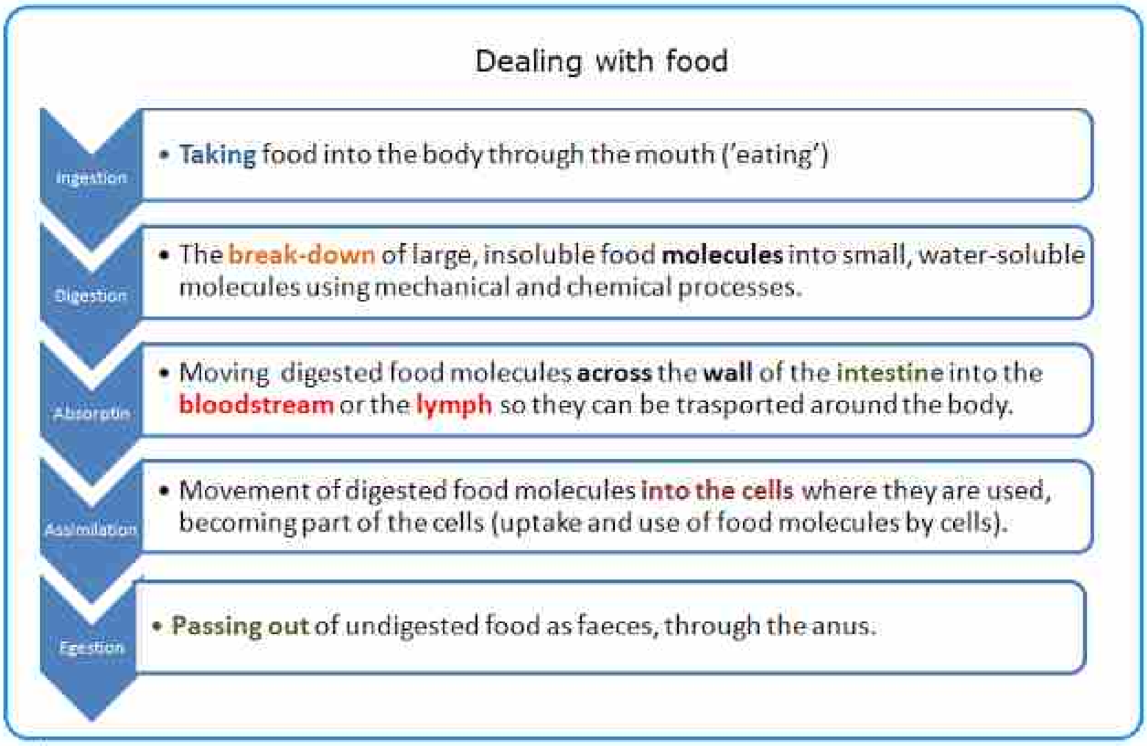
The **alimentary canal** is a long tube which stars at the mouth, runs through the stomach and intestines and finishes at the anus. It is part of the digestive system. The **digestive system** also includes the **accessory organs** (teeth, tongue, gallbladder, salivary glands, liver, the pancreas).

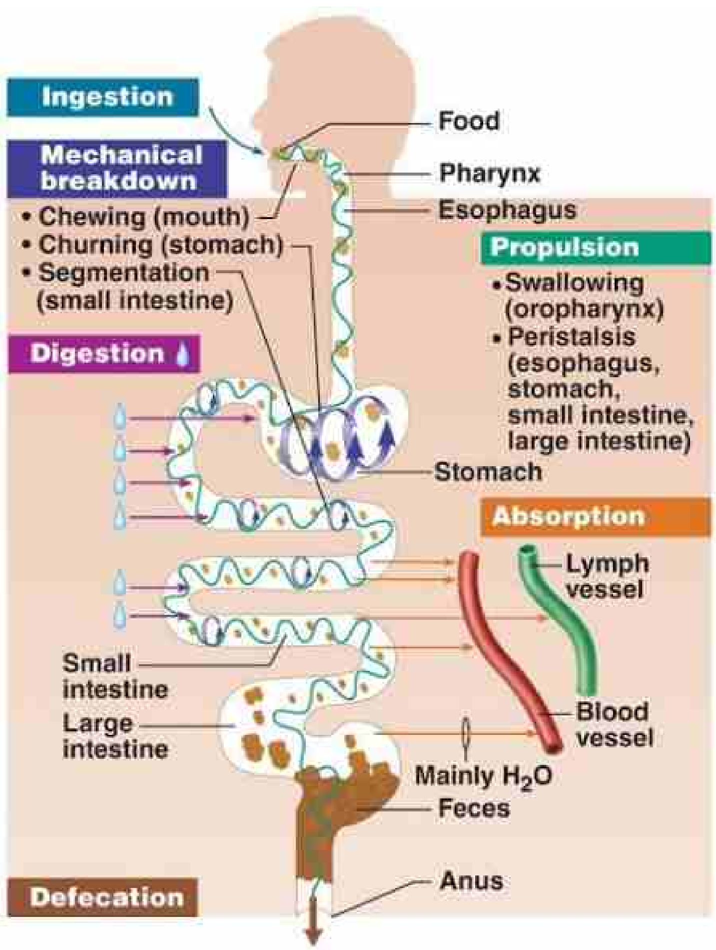
Main regions of the alimentary canal and associated organs are:

- Mouth, salivary glands
- Oesophagus
- Stomach
- Pancreas, liver, gall bladder
- Small intestine (duodenum + ileum)
- Large intestine (colon +rectum)
- Anus.



Food is broken down with the help of digestive juices, which contain special chemicals called enzymes.





Functions of the regions of the digestive system:

Organ	Function
Mouth	**Digestion** starts here! The teeth cut and grind the food, which is mixed with **saliva.** This contains **amylase** to break **starch** down into maltose (sugar).
Oesophagus	Boluses (balls) of food pass through by **peristalsis**, from mouth to stomach.
Stomach	Muscular walls squeeze on food to make it semi-liquid. Gastric juice contains: • **Pepsin** (**a protease**) to break big proteins down into small protein (polypeptides) • Hydrochloric acid (**HCl**) to maintain an optimum pH (1-2,5). The acid also kills bacteria.
Gall bladder	Stores **bile** used to help in the digestion of **fats.**
Pancreas	Secretes **pancreatic juice** into the duodenum, also makes the hormones **insulin** and **glucagon**.
Liver	Makes **bile**, which is stored on the gall bladder. Bile contains **salts** that emulsify **fats**, forming droplets with a large surface area to make digestion by lipase more efficient. Digested foods are **assimilated** here. For example, glucose is stored as glycogen, surplus amino acids are deaminated.
Small intestine	**Duodenum + Ilium**
Duodenum	The first part of the small intestine. It receives pancreatic juice containing **protease, lipase** and **amylase**. Proteins, fats, starches and complex sugars are broken down into small soluble molecules. The juice also contains sodium hydrogen carbonate, which neutralises acid from the stomach, producing a **pH of 7-8**.
Ileum	The second part of the small intestine. Enzymes in the epithelial lining break down **lactose** and **peptides**. Its surface area is increased by the presence of villi which allow the efficient **absorption** of fully digested food molecules into the bloodstream.
Large intestine	**Colon + Rectum** Only undigested food reaches here. Water absorbed.
Rectum	This stores **faeces** until it is egested.
Anus	This has muscles to control when faeces is **egested** from the body.

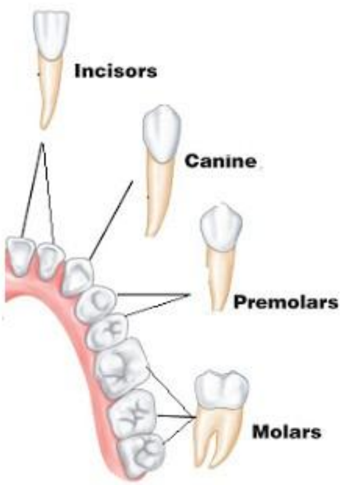
Common misconceptions

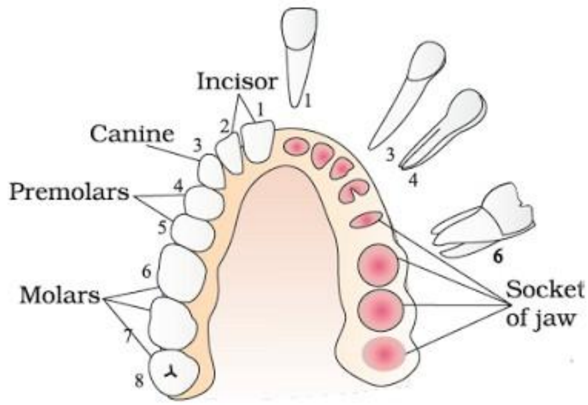
The liver does not make digestive enzymes- bile is not an enzyme. It breaks fat down into smaller droplets, but does not change them chemically.
The fat mollecules stay the same size, it is just the droplet size that changes from large to small due to the action of bile.
Additional resource: classes.midlandstech.com

53 Human teeth and dental decay

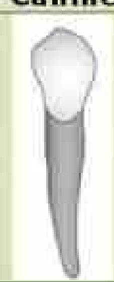
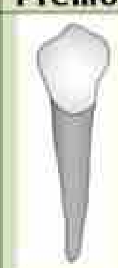
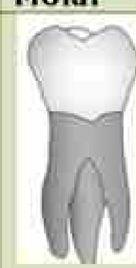
There are four types of teeth in human (incisors, canines, premolars and molars), each specialised for different funtions.

Position of teeth in the mouth

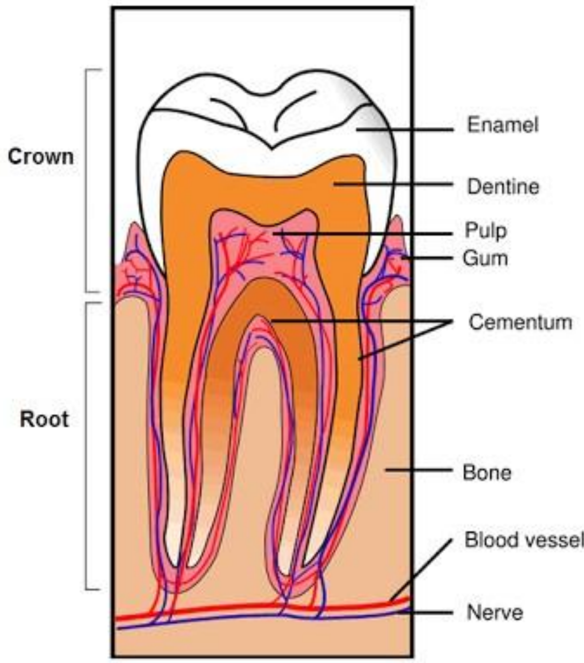




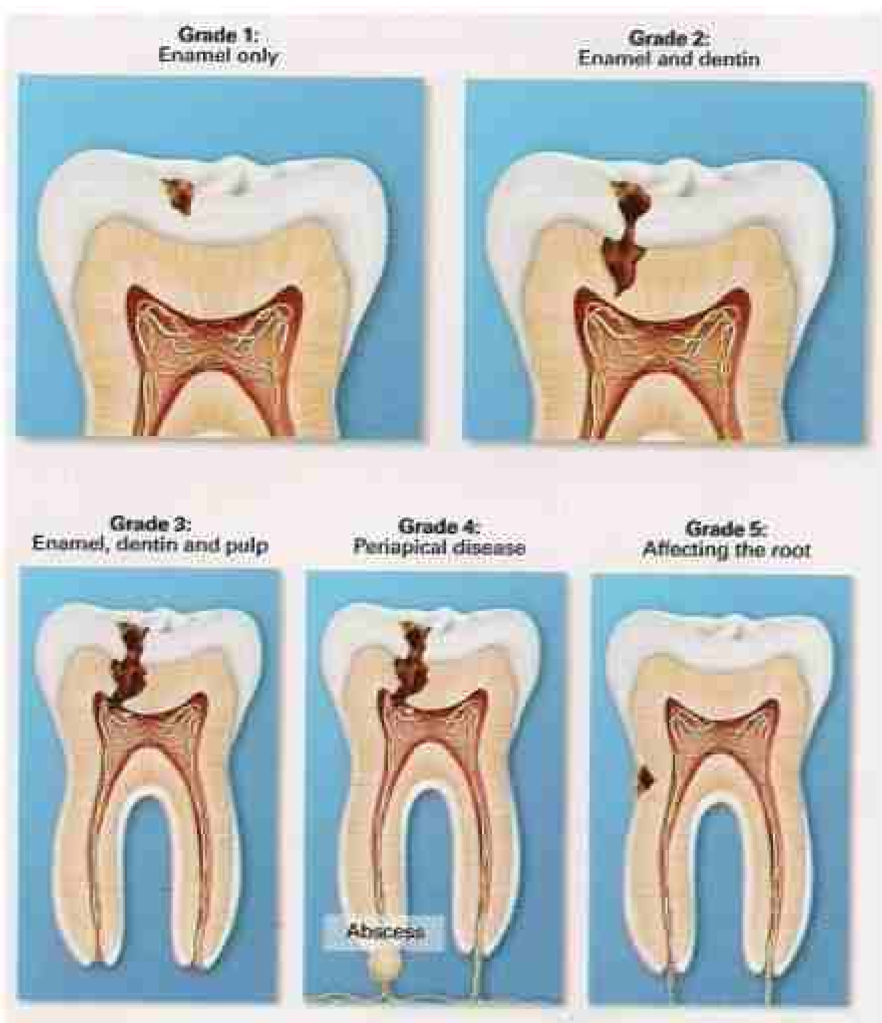
Types of human teeth

	Incisor	**Canine**	**Premolar**	**Molar**
				
Position in mouth	Front	Either side of incisors	Behind canine	Back
Description	Chisel-shaped (sharp edge)	Slightly more pointed than incisors	2 points (cusps), 1 or 2 roots	4 or 5 cusps 2 or 3 roots
Function	Biting of pieces of food	Similar function to incisors	Tearing and grinding food	Chewing and grinding food

Structure of tooth



Causes of dental decay



- Bacteria are present on the surface of our teeth. Food deposits and bacteria form a layer called plaque. Bacteria on the plaque feed on sugars, producing acid. This acid dissolves enamel, forming a hole.

- Dentine underneath the enamel is softer – it dissolves more rapidly.

- If the hole reaches the pulp cavity, bacterial infection can get to the nerve. This results in toothache and possibly, an abscess (an infection in the jaw).

Common misconceptions:

Do not say that sugar causes decay. It only causes problems because of the activity of bacteria feeding on it and producing acids.

Try this

The outer layer of the crown of a tooth is resistant to attack by bacteria

1. Name this outer layer. (1 mark)
2. State the mineral and the vitamin needed in the diet for the healthy development of this layer. (2 mark)
3. Explain how bacteria can gain entry through this layer into the tooth and cause dental decay. (3 mark)

Answers

1. Enamel
2. Mineral: calcium; vitamin: D
3. Three points from:

- bacteria feed on sugar from food left on the teeth
- bacteria produce acid
- acid attacks or dissolves the enamel
- dentine if softer, so it breaks down more quickly
- this results in a hole in the enamel, exposing the pulp cavity.

#54 Adding fluoride to public water supplies

Fluoride helps prevent **destruction** of the tooth surface caused by **acids** produced by bacteria. It forms a **reservoir** on the teeth from which fluoride is released during attack. It reduces the **loss of minerals** from the tooth and promotes **repair** of early tooth decay.

Growing children can absorb fluoride in their diet (from toothpaste of fluoridated water). It becomes part of the enamel of their developing teeth, and the enamel; is then more resistant to tooth decay.

Arguments for and against the addition of fluoride to public water supplies

For:

- Tooth decay in the local population of children decreases.
- There is no need to buy fluoridated toothpaste.

Against:

- It is form of mass medication – people have no choice about whether or not they want the treatment.
- Fluoride is a benefit only to growing children – adults do not benefit.
- If people take proper care of their teeth, fluoridation is unnecessary.
- Fluoride may have side effects, such as an increase in risk of bone cancer (but this is unlikely).

Proper care of teeth

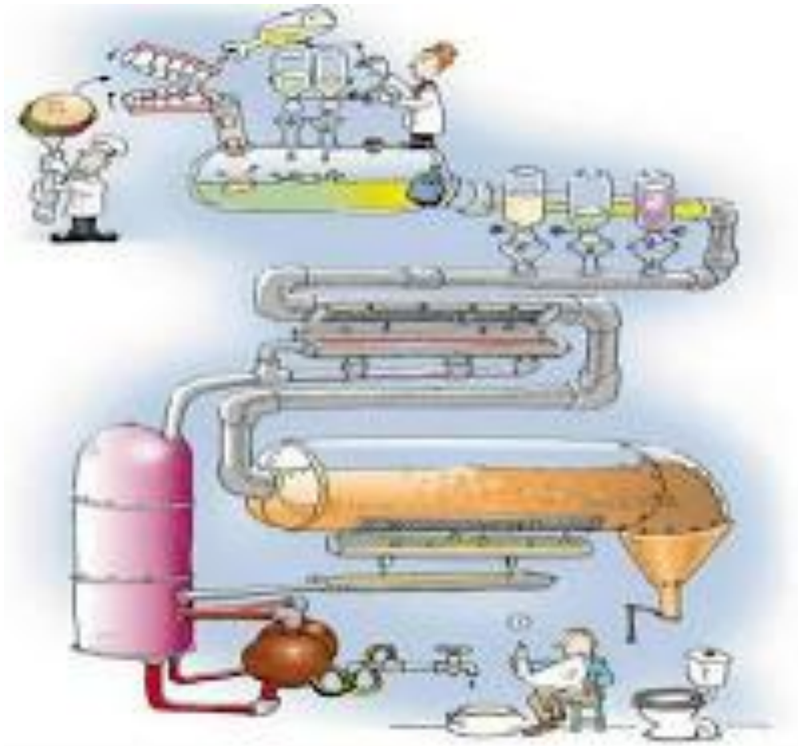
- Avoid sugary food, especially between meals, so bacteria cannot make acid and clean teeth regularly to remove plaque.
- Use dental floss or a toothpick to remove pieces of food and plaque trapped between them.

- Use fluoride toothpaste (or drink fluoridated water) – fluoride hardens tooth enamel.
- Visit a dentist regularly to make sure and tooth decay is reacted early and any stubborn plaque (called calculus) is removed.

Common misconceptions

There is a big difference between **fluoride** and **fluorine**. Fluorine is a very toxic gas, while fluoride is a mineral that helps to strengthen teeth. Make sure do not use the term fluorine in an exam answer about teeth.

55 Mechanical and chemical digestion



Food that we ingest is mainly made up of **large, insoluble molecules** that can not be absorbed through the gut wall. It needs to be changed into **small, soluble** molecules.

1. Mechanical digestion is the physical process of preparing the food for chemical digestion.

- It involves **chewing** (in the mouth), **mixing**, **churning** (in the stomach and intestine) and **segmentation** (in the intestine).
- Large pieces of food are breaking down into smaller pieces à increases the surface **area** of the food.
- **Bile** physically digests **fats** by emulsifying them – turning them into small droplets with a large surface area.

Chewing

Mechanical digestion, performed bye the teeth à pieces of food are mixed with saliva and become smaller à easier to swallow and have a larger surface area.

Peristalsis

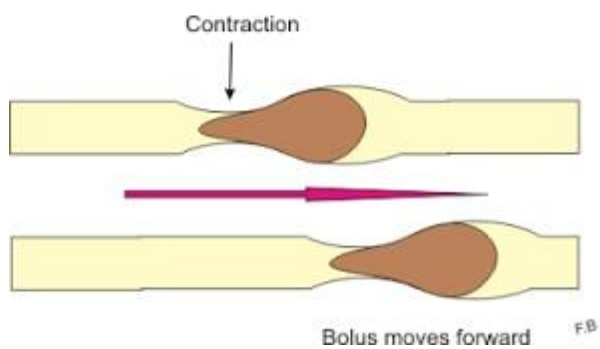
- The walls of the alimentary canal have an **inner**, **circular muscle** fibre coat and an **outer**, **longitudinal muscle** fibre coat.

- As the ball of food (bolus) formed in the mouth enters the pharynx, a reflex action is initiated.

- This produces slow, wave-like contractions in the walls of the esophagus and later along the whole length of the tract (**peristalsis**).

- Peristaltic waves involve the **contraction** of the **circular muscle** fibres **behind** the bolus (A) and their **relaxation in front** of the bolus.

- Longitudinal muscles provide the **wave-like action**. The two functions together push the ball down the tract (B).



Misconceptions: Chewing food does not involve breaking down large molecules into small molecules; it only breaks down large pieces into smaller pieces, giving a larger surface area for enzymes to work on.

Video Peristalsis

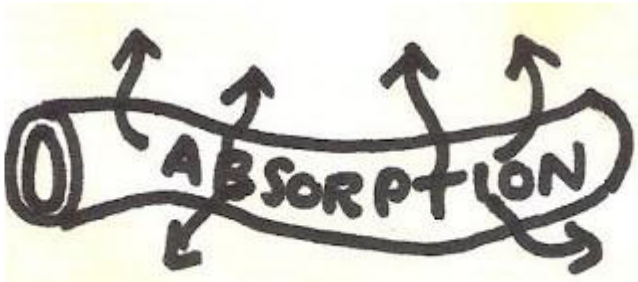
2. Chemical digestion

- Involves breaking down large, insoluble molecules into small, soluble ones.

- Enzymes speed up the process. They work efficiently at body temperature (37^0C) and at suitable pH.

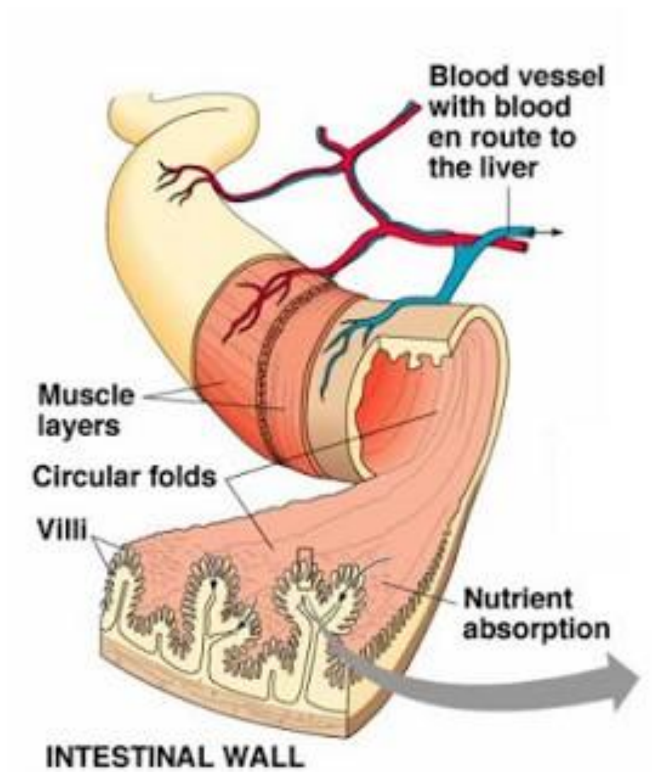
- The main places where chemical digestion happens are the mouth, stomach and small intestine.

56 Absorption – function of small intestine and significance of villi

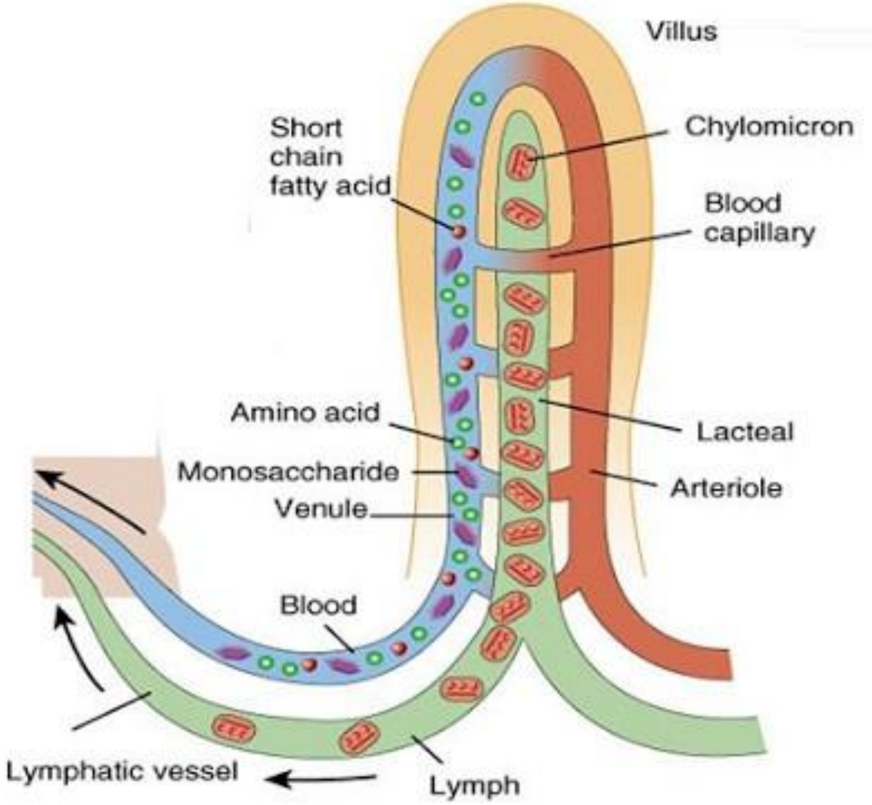


Absorption is the movement of digested food molecules **through the wall** of the intestine into the blood or lymph.

Digestion is completed in the small intestine. By now, most carbohydrates have been broken down to simple **sugar**, proteins to **amino acids**, and fats to **fatty acids** and **glycerol**. These molecules are small enough to **pass through** the wall of the **small intestine** and into the **blood**. This is called **absorption.** The small intestine is especially adapted to allow absorption to take place very efficiently.



It has a very rich blood supply. Digested food molecules are small enough to pass through the wall of the intestine into the bloodstream. **Water, mineral salts** and **vitamins** are also absorbed in the small instestine.
The small intestine absorbs 5-10 dm^3 of **water** each day. How ever, the colon absorbs much less water and salt than the small intestine, generally around 0,3–0,5 dm^3 per day.



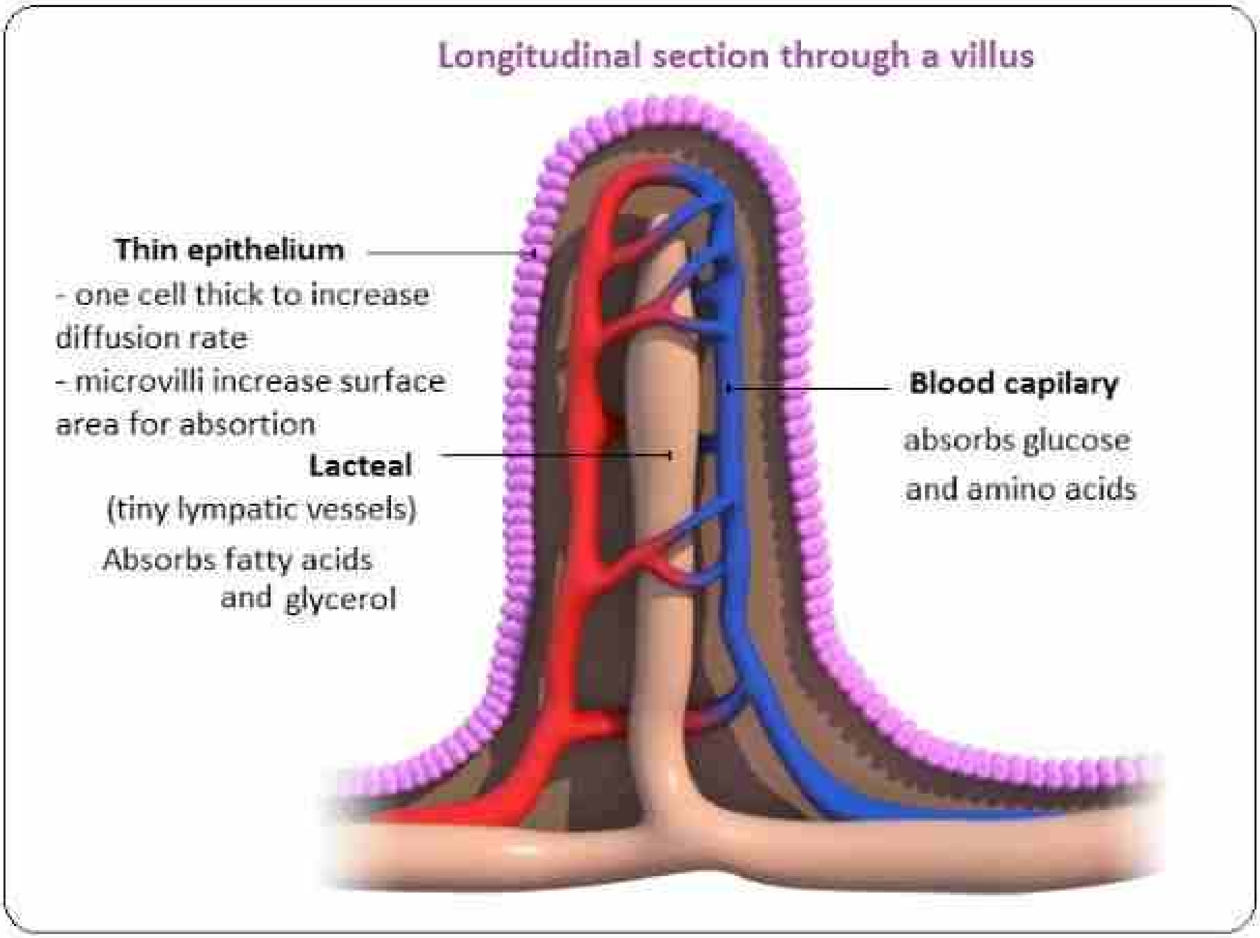
The adaptation of the small intestine for absorbing digested nutrients

Features	How this helps absorption take place
It is very long, about 5 m in an adult human	This gives plenty of time for digestion to be completed, and for digested food to be absorbed as it slowly passes through.
It has villi, each villus is covered with cells which have even smaller projections on them, called microvilli.	This gives the inner surface of the small intestine a very large surface area. The larger the surface area, the faster nutrients can be absorbed.
Villi contain blood capillaries	Monosaccharides, amino acids, water, minerals and vitamins, and some fats, pass into the blood, to be taken to the liver and then round the boy.
Villi contain lacteals, which are part of the lymphatic system.	Fats are absorbed into lacteals.
Villi have walls only one cell thick	The digested nutrients can easily cross the wall to reach the blood capillaries and lacteals.

Significance of Villii

Villi are finger like projections that increase the surface area for absorption. If a section of small intestine was turned inside out, its surface would be kike a carpet. Inside each **villus** are:

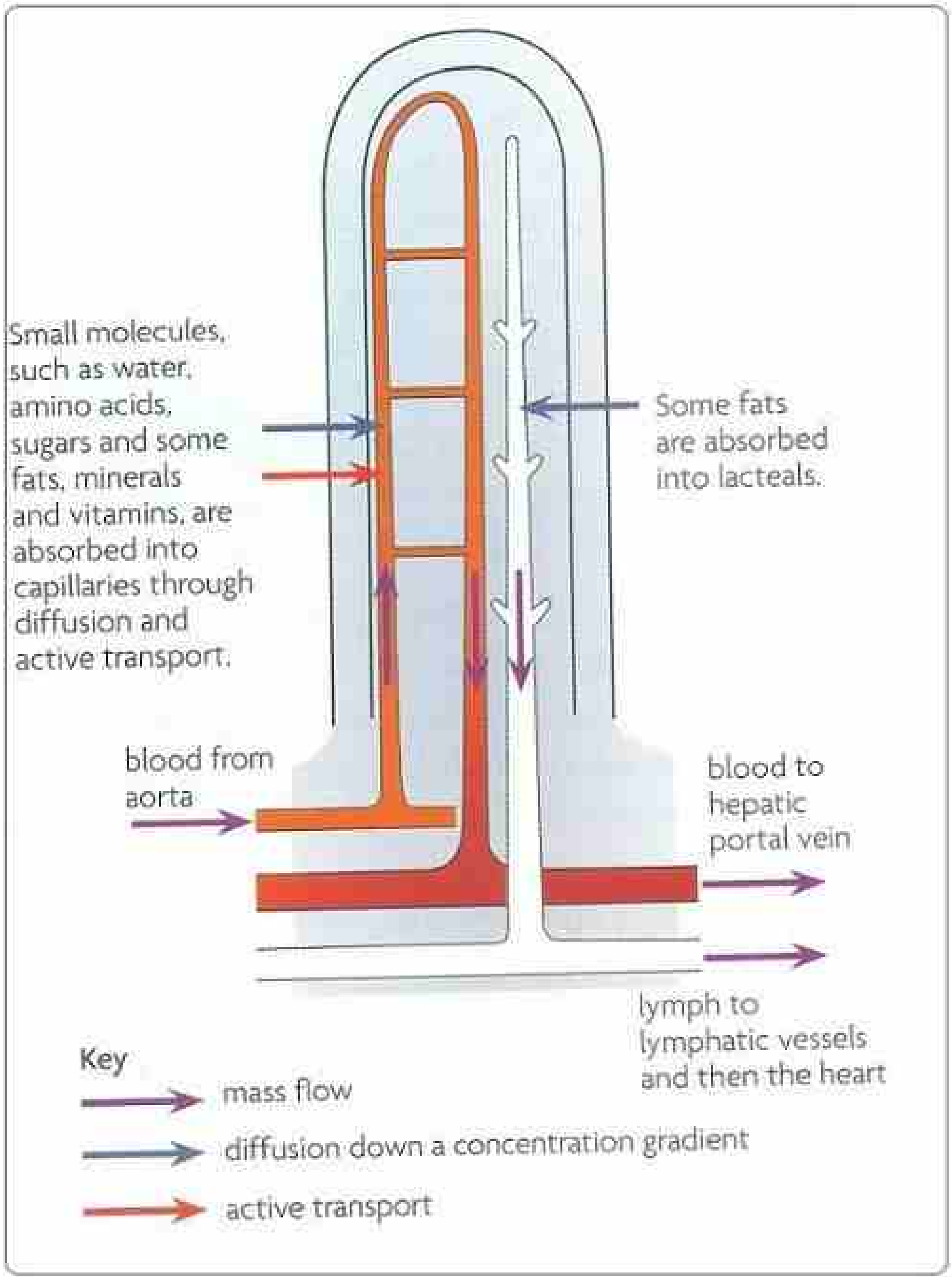
- Blood capillaries: absorb amino acids and glucose.
- Lacteals: absorb fatty acids and glycerol.



Food molecules are absorbed:

- mainly by **diffusion**.
- or by **active transport**.

Epithelial cells contain mitochondria to provide energy for absorption against the concentration gradient.



Role of the hepatic portal vein

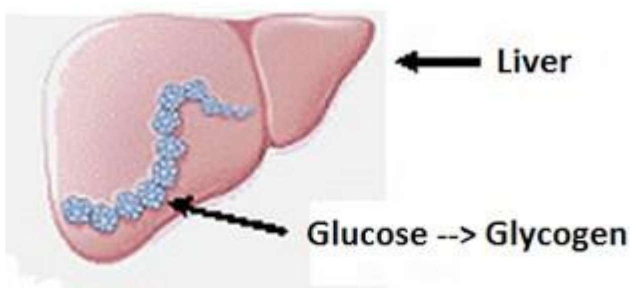
The hepatic portal vein transports absorbed food from the small intestine to the liver. After a meal, the blood in this vein contains very high concentrations of glucose and amino acids, as well as vitamins and minerals. The liver reduces levels backs to normal.

57 Assimilation and role of the liver

Assimilation is the movement of **digested food molecules** into **the cells** of the body where they are used, becoming part of the cells.

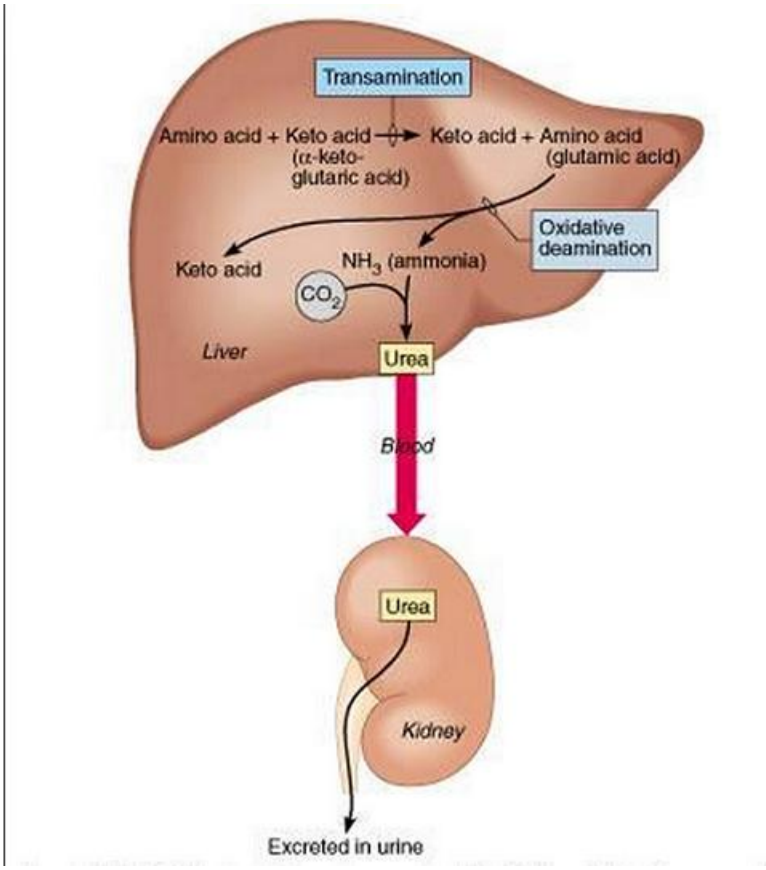
Role of liver in the metabolism of glucose and amino acids

- **Excess glucose** in the blood arriving at the liver is converted into **glycogen** (animal starch) for storage, or broken down through respiration, producing **energy** for other purposes.



- Amino acids cannot be stored in our body, so any that is **excess** has to be dealt with in the liver.
  - Some amino acids are **transaminated** to produce a different amino acid.
  - The rest are **deaminated** to produce **ammonia (NH_3)** and a **keto acid**.

  \+ **NH_3** is converted into **urea,** which is transported to the kidneys and excreted.
  \+ The **keto acid** is used primarily as energy for liver cells



So **Deamination** is the removing of **nitrogen-containing** part of amino acids to form **urea** and using of the remainder of amino acid to provide **energy** to the liver cells.

Role of liver in the breaking down of alcohol and other toxins

- Breaking down any toxins absorbed from the alimentary canal, including drugs such as alcohol. Cells in the liver are able to convert many toxins to harmless substances that can be transported in the blood and excreted from the body.

Role of fat as an energy storage substance

- **Fatty acids** and **glycerol** pass into the lymphatic system and then the bloodstream. Once in the blood nutrients are carried to all cells of the body. Some are oxidised to produce **energy** and others are used to repair the cell, build new cells.

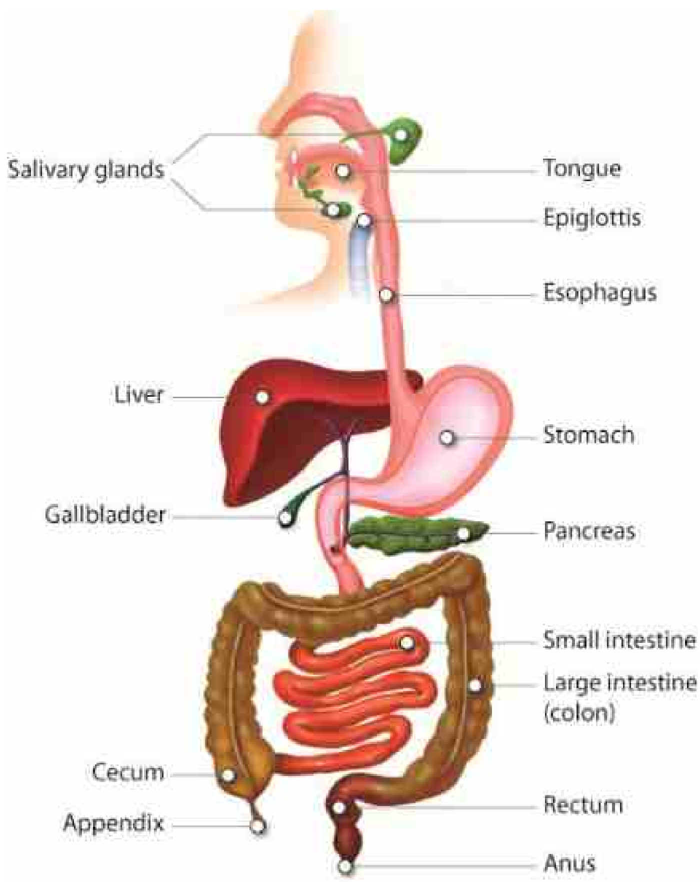
- Fat is a good storage compound – it releases twice as much energy as carbohydrates when respired, and act as insulation in the skin. Some nerve cells form a **myelin sheath** from fat, to prevent electrical impulses from leaking out.

#58 Summary of animal nutrition

A **balanced diet** contains suitable proportions of each group of nutrients – carbohydrates, fats, proteins, minerals, vitamins, water and fibre – and the correct amount of energy.

- Eating food containing more energy than you can use up causes weight increase, which can lead to obesity. Children who do not get enough food may suffer from energy protein malnutrition, in which they do not grow properly and have little energy.

- Digestion is the breakdown of large molecules of food into small ones, so that they can be absorbed through the wall of the alimentary canal.



- Mechanical digestion breaks down large pieces of food to small ones. It is done by the teeth, the muscles in the wall of the alimentary canal and bile salts. Chemical digestion breaks down large molecules to small ones. It is done by enzymes.

- Mammals have four types of teeth – incisors, canines, premolars and molars – each with their own functions.

- Digestion begins in the mouth, as teeth grind food into smaller pieces, and amylase digests starch to maltose.

- Protein digestion begins in the stomach, where pepsin digests proteins to polypeptides. Rennin is present in young mammals, and clots milk protein. Hydrochloric acid kills bacteria and provides a low pH for the action of pepsin.

- Pancreatic juice flows into the duodenum. It contains enzymes that digest starch, proteins and lipids, and also sodium hydrogencarbonate to partly neutralise the acidity of food coming from the stomach.

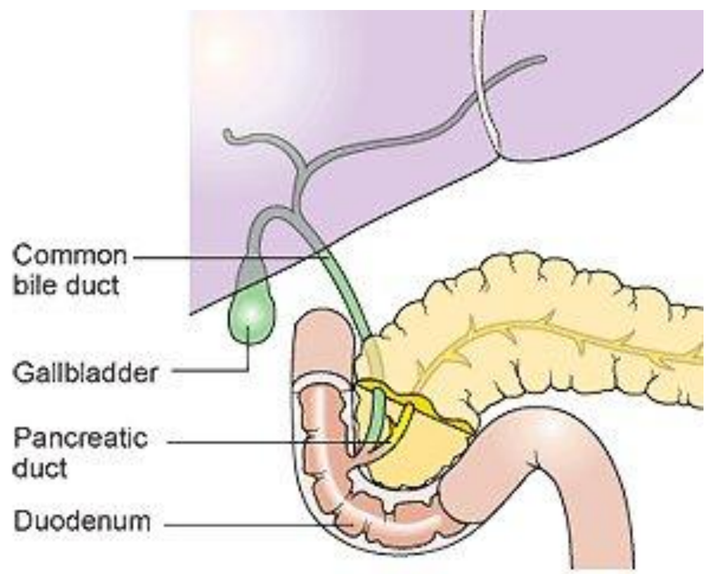
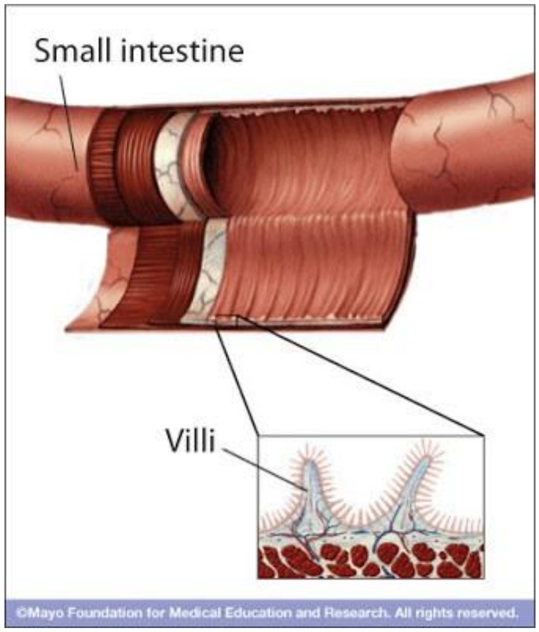


Diagram showing the bile ducts in the pancreas
© CancerHelp UK

- Bile also flows into the duodenum. It contains bile salts, which emulsify fats, making it easier for lipase to digest them.

- The lining of the small intestine is covered with villi, giving it a very large surface area, which helps to speed up absorption. Cells on the surface of the villi make enzymes, which complete the digestion of food. The villi contain blood capillaries to absorb glucose, amino acids, water, vitamins and minerals, and lacteals to absorb fatty acids and glycerol.

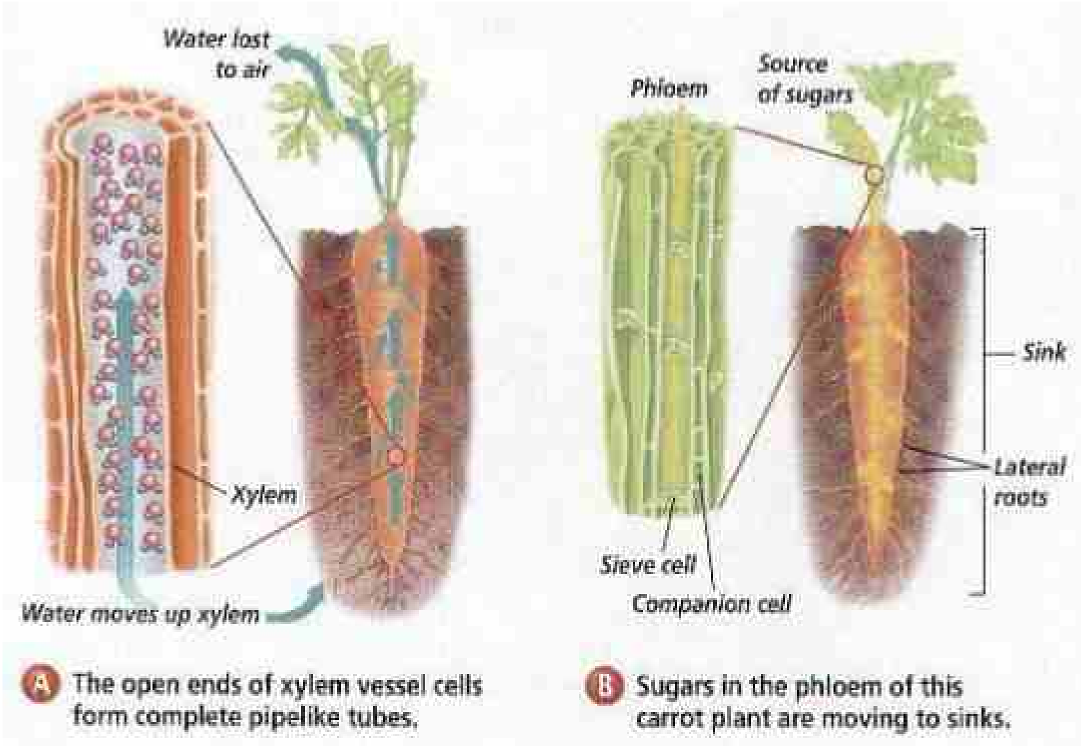


- The absorbed nutrients are carried to the liver in the hepatic portal vein. Some are used in the liver, some are stored, and some are sent on in the blood to be delivered to cells all over the body.

- The colon absorbs more water from the food. In the rectum, the undigested food is formed into faeces, which are eventually egested through the anus.

06- Plant transport

#59 Transport in plants - functions of xylem and phloem

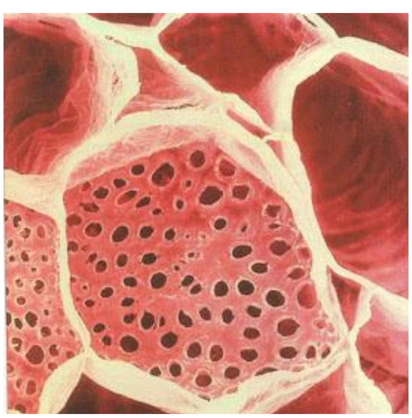


Plants have transport systems to move food, water and minerals around. These systems use continuous tubes called xylem and phloem:

- **Xylem vessels** carry **water** and minerals from the **roots** to the leaves.
- **Phloem** tubes carry **sugar** & other organic **nutrients** made by plant from the **leaves** to the rest of the plant.

Structure of the phloem tissue

This is a long tube that runs alongside the xylem tissue. They are made of long narrow tubes with **perforated sieve plates** along the thin length.

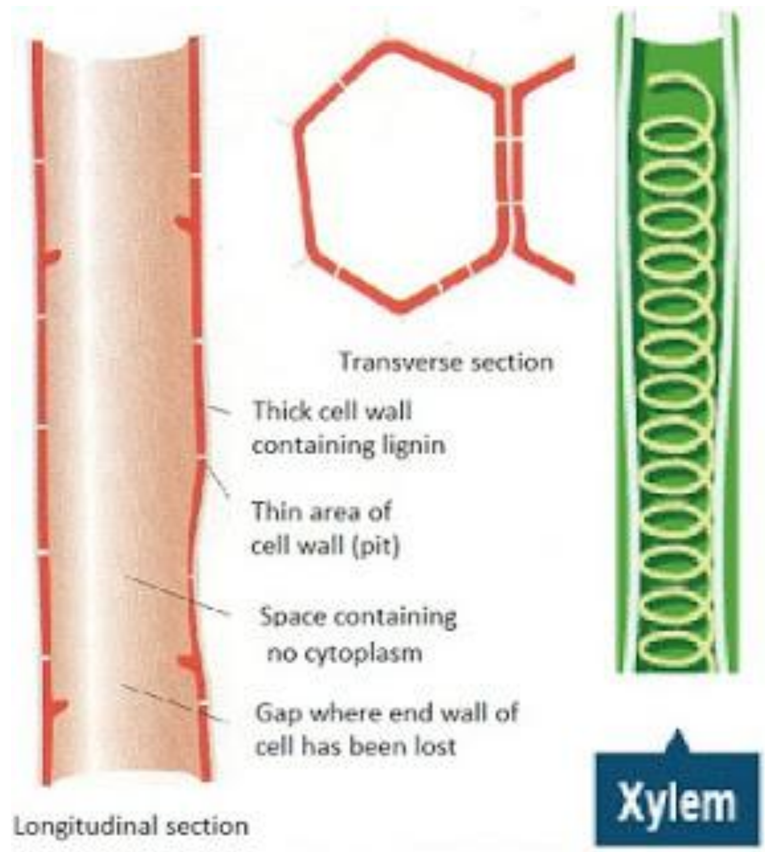


Scanning electron micrograph of a sieve plate in a phloem tube (x1300)

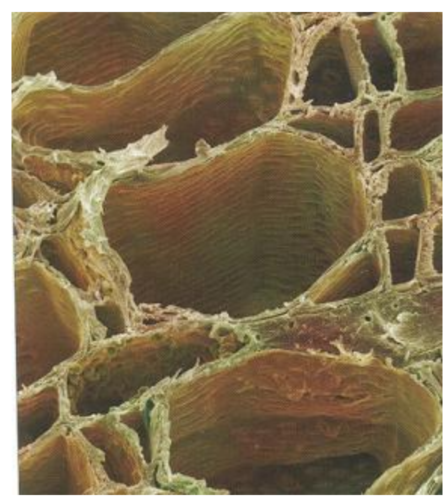
The function of the phloem tissue is to **transport** food nutrients such as **glucose** and **amino acids** from the leaves and to all other cells of the plant, this is called translocation.

Unlike the xylem, the phloem tissue is made of columns of **living cells,** swhich contains a cytoplasm but no nucleus, and its activities are controlled by a **companion** cell next to it which has a nucleus, but companion cells have no function in translocation.

Structure of the xylem tissue

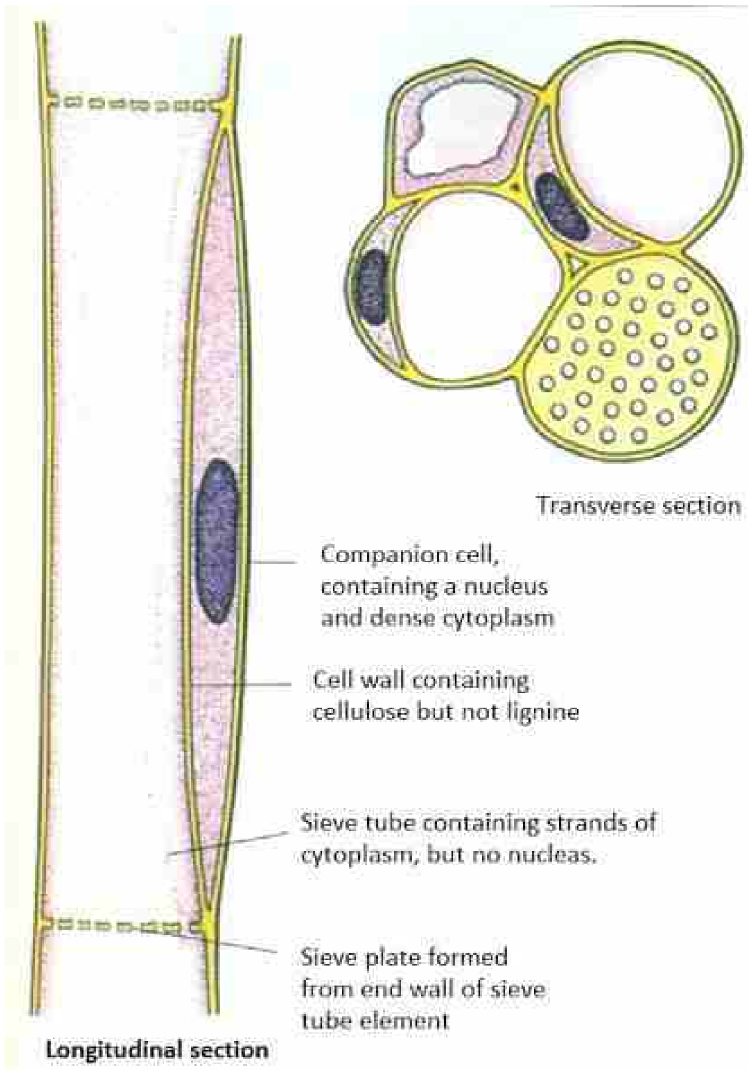


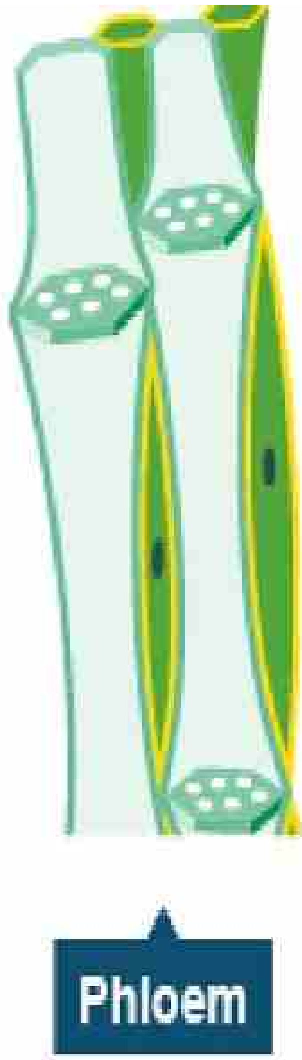
Xylem vessels consist of **dead cells**. They have a thick, strengthened cellulose cell wall with a hollow lumen. The end walls of the cells have disappeared, so a long, open tube is formed. The walls of the xylem vessel contains holes called **pits** which water enters through.



Scanning electron micrograph of xylem vessels (x1800)

The xylem vessel is specialised to **transport** **water** and dissolved **minerals** from the root up to all the other parts of the plant, and also to helps **supporting** the stem and strengthening it.

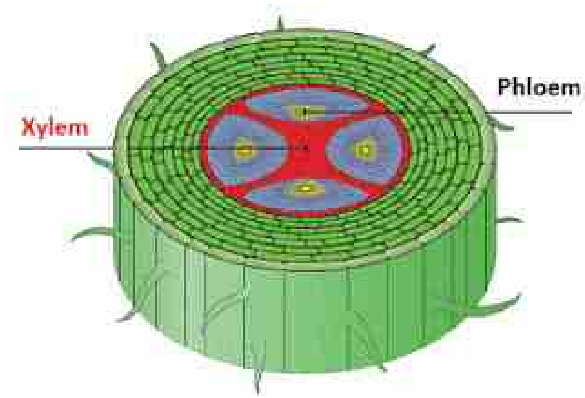




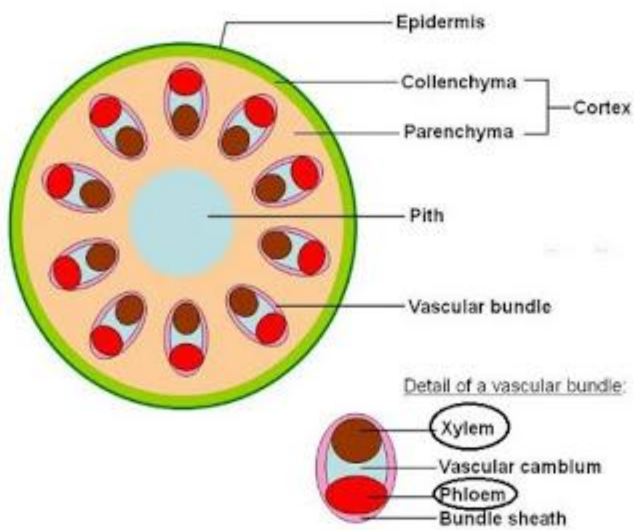
Additional resource: xtremepapers.com
acceleratedstudynotes.com

Related post: [**Cell functions**]()

#60 Distribution of Xylem and Phloem in roots, stems and leaves

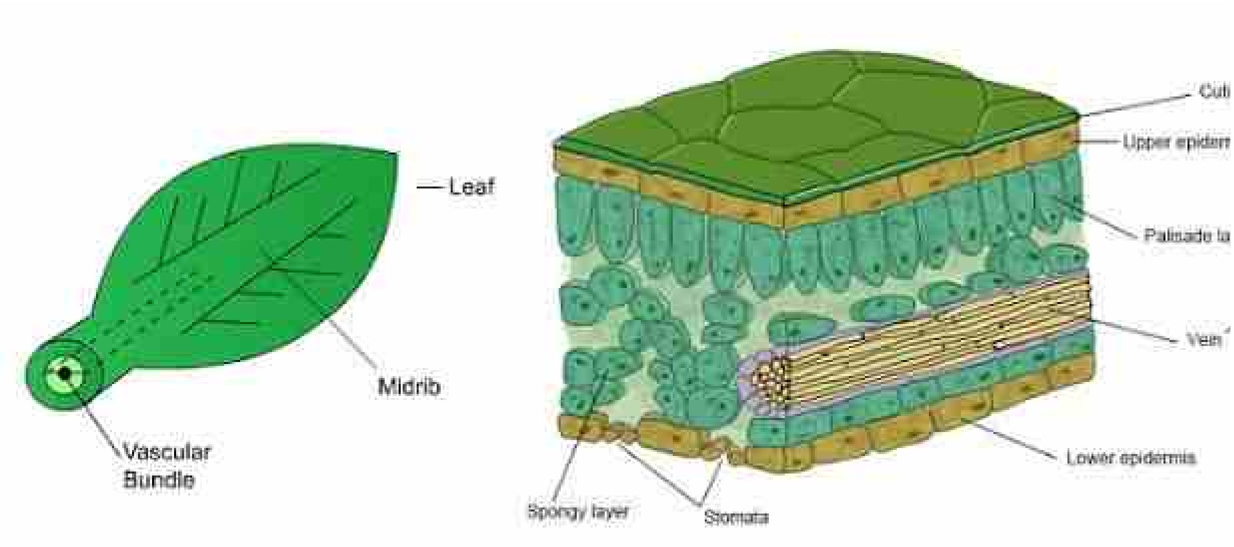


In the **roots** xylem and phloem are in the **centre** to withstand stretching forces.



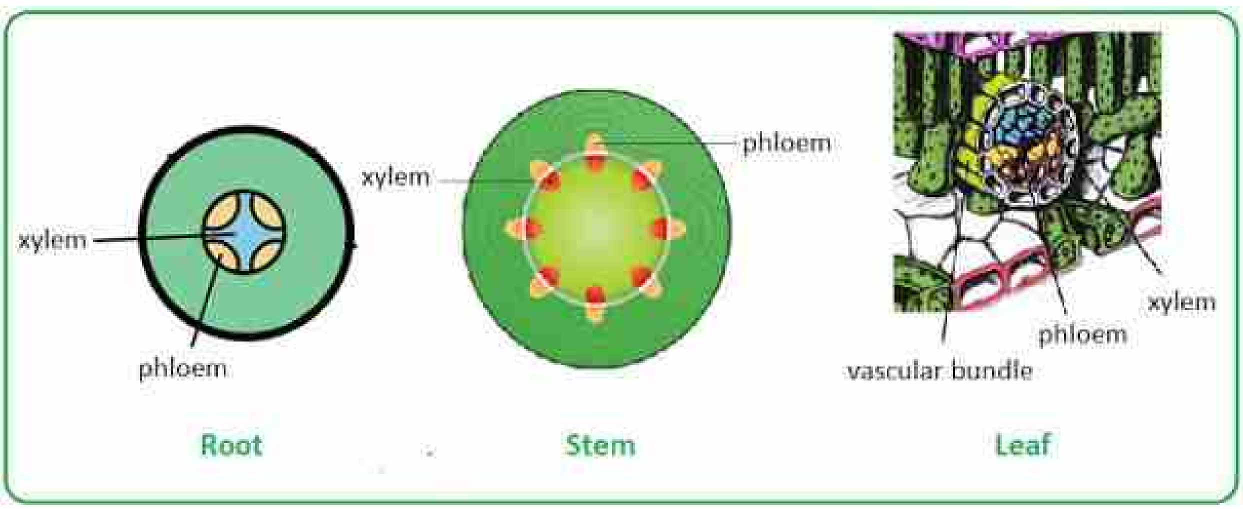
In the **stems**, they are arranged in bundles near the **edge** to resist compression and bending.

They are grouped together into **veins** and **vascular bundles** as they pass through **leaves**.

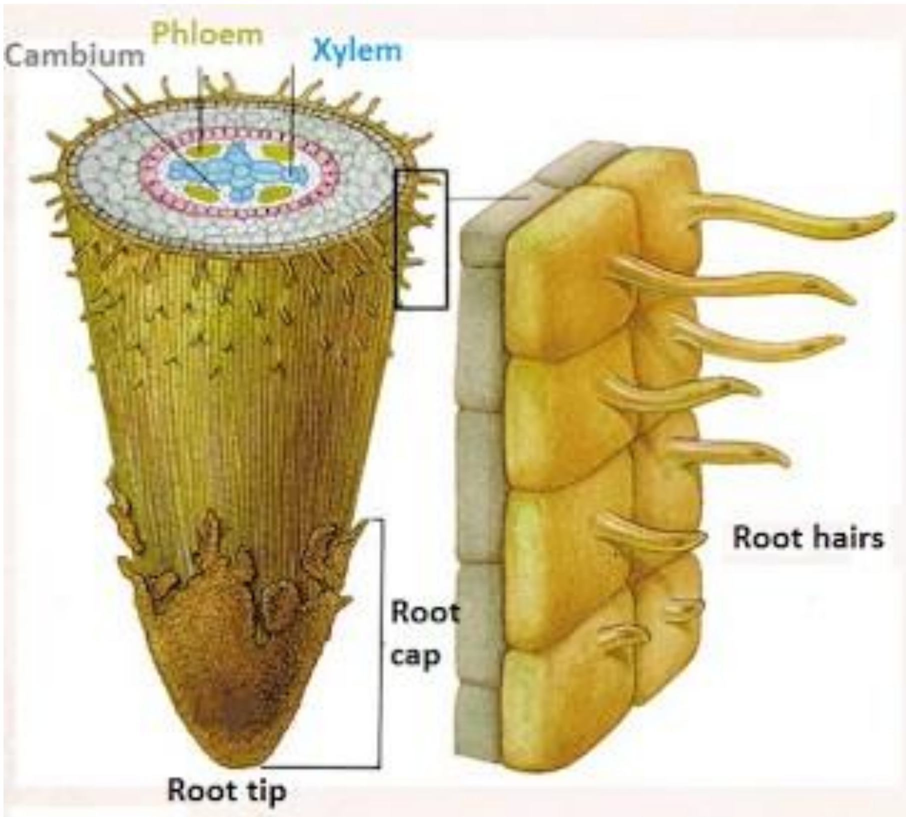


Leaf

The positions of xylem and phloem tissues as seen in transverse sections of unthickened, herbaceous, dicotyledonous roots, stems and leaves:



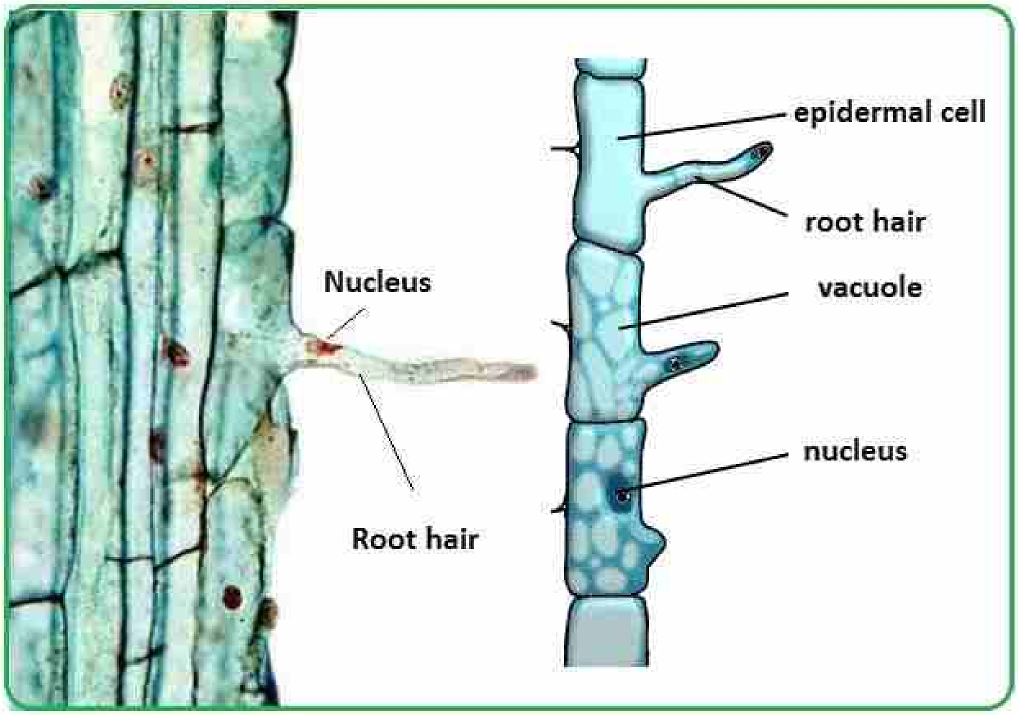
61 Root hairs and water uptake by plants



Plants take in **water** from the soil, through their **root hairs:**

- At the very tip is a **root cap**. This is a layer of cells which protects the root as it grows through the soil.
- The rest of the root is covered by a layer of cells called the **epidermis**.
- The **root hairs** are a little way up from the root tip. Each root hair is a **long epidermal cell**. Root hairs do not live for very long. As the root grows, they are replaced by new ones.

Root hair cells, as seen under the light microscope:



*The **hair** is an **extension** of the cell and not a separate cellular structure.*

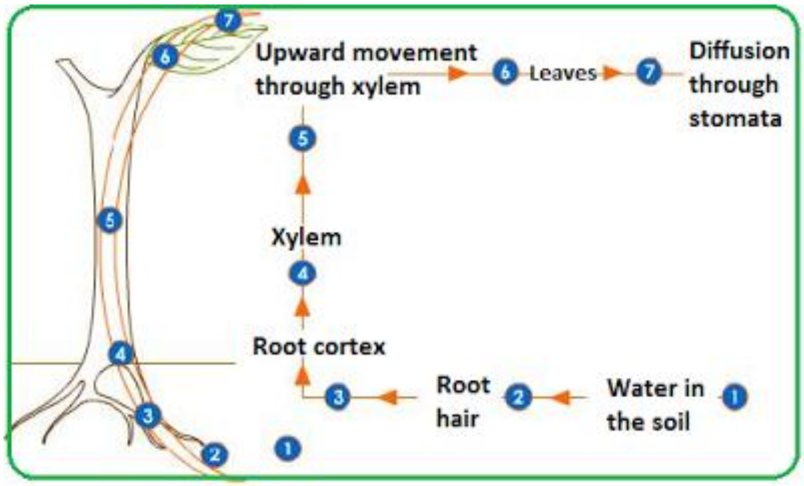
Functions of root hair cells

- **Increase** the external **surface area** of the root for **absorption** of **water** and **mineral ions** (the hair increases the surface area of the cell to make it more efficient in absorbing materials).
- Provide **anchorage** for the plant.

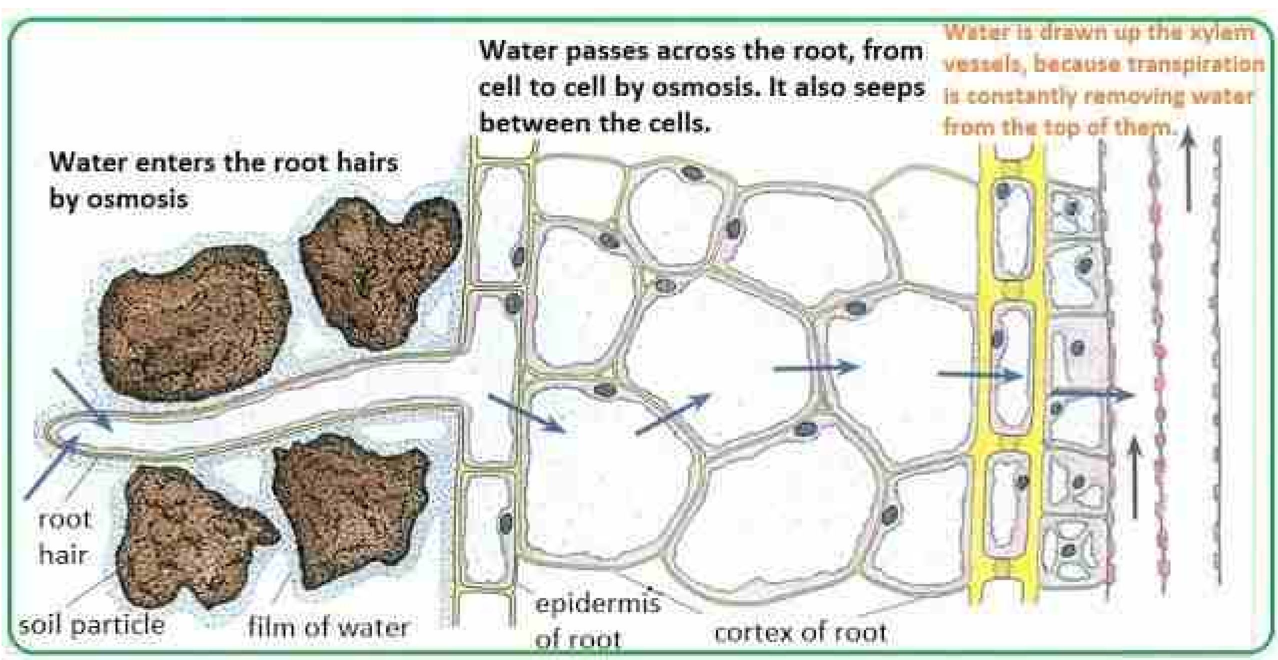
Video

#62 Passage of water through root, stem and leaf

Water enters **root hair** cells by **osmosis**. This happens when the water potential in the **soil** surrounding the root is higher than in the cell à water diffuses from the soil into the root hair, **down** its **concentration gradient.**



- As the water enters the cell, its water potential becomes higher than in the cell next to it, e.g. in the **cortex**. So water moves, by **osmosis**, into the next cell. Some of water may also just **seep** through the spaces between the cells, or through the cell walls, never actually entering a cell.



- Water vapour evaporating from a leaf crates a kind of **suction**, its pressure at the top of the vessels is lower than that at the bottom à water move up the **stem** in the xylem, more water is drawn into the leaf from the xylem. This creates a **traspiration stream**, pulling water up from the root. Mature xylems cells have no cell contents, so they act like open-ended tubes allowing free movement of water through them. Roots also produce a root pressure, forcing water up xylem vessels.

- Water moves from xylem to enter **leaf** tissues **down** water **potential gradient**. In the leaves, water passes out of the xylem vessels into the surrounding cells.

Common misconceptions

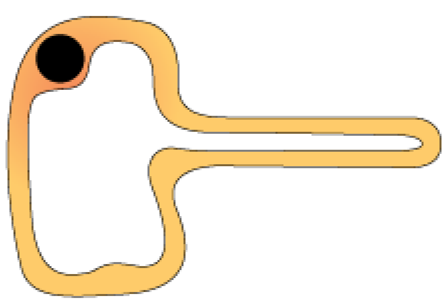
Water does not travel through xylem vessels by osmosis. Osmosis involves the movement of water across cell membranes – xylem cells do not have living contents when mature, so there will be no membranes.

Try this

Describe how the structure of xylem tissue is adapted to its functions.
The cells join together to make a long tubular structure.
There are no cross-wall and no living contents so the water and mineral salts can pass through freely.

Describe the mechanism of water movement through the xylem.
Water moves by the pull from the leaves caused by the transpiration.
Xylem vessels are very thin, so they act like a capillary tube helping to withdraw water upward.

1. a) Labell all parts of the root hair cell (5 mark)



b) Which plant cell part is missing from this cell? (1 mark)

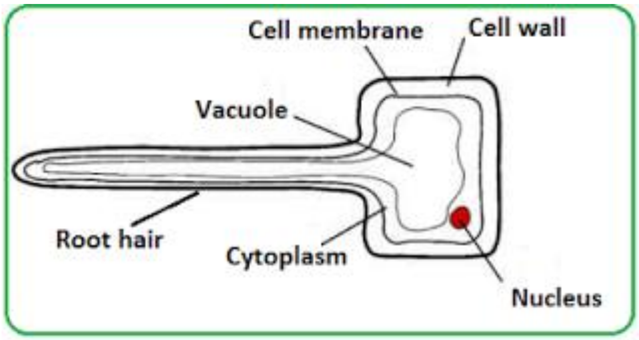
c) Name the process by which the cell absorbs:

i)Water (1 mark)

ii)Minerals (1 mark)

Answer:

a)

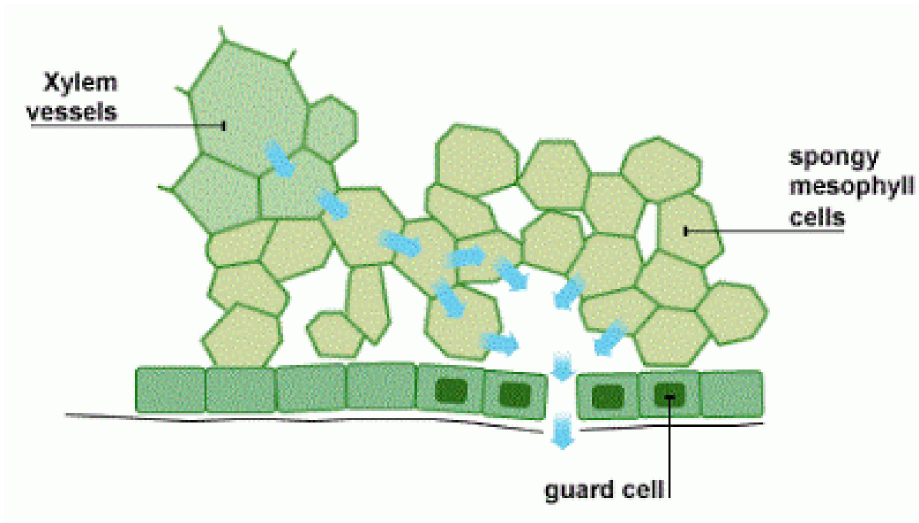


b) Chloroplast

c) i) [osmosis]

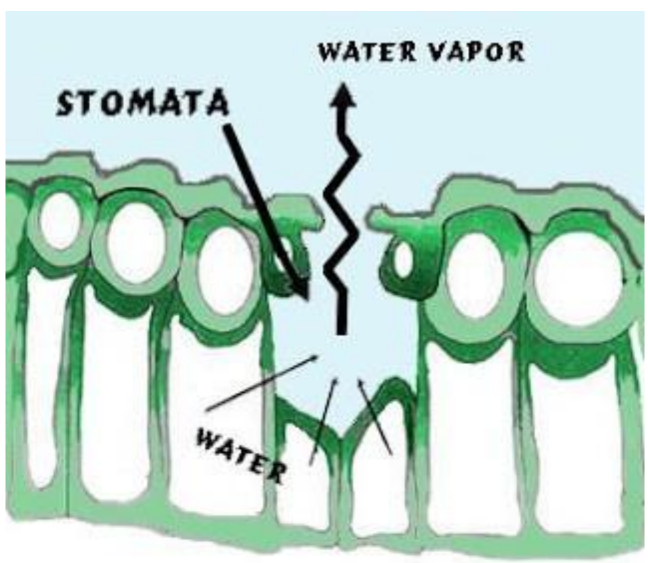
ii) [diffusion] or [active transport] (or active uptake)

 # 63 Transpiration in plants and factors affecting transpiration rate



In the leaves, **water** molecules leave the **xylem vessels** and move from cell to cell. They move through the **spongy mesophyll** layer by **osmosis** along a concentration gradient. Water then **evaporates** into **spaces** behind the stomata and diffuses through the **stomata** into the surrounding air.

Transpiration is the **evaporation** of **water** at the surfaces of the **mesophyll** cells, followed by loss of water vapour from plant leaves, through the **stomata.**



Water in the leaf cells forms a thin layer on their **surface**. The water evaporates into the **air spaces** in the spongy **mesophyll**. This creates a **high** concentration of water molecules. They diffuse out of the leaf into the surrounding air, through the **stomata**, by **diffusion**.

Mechanism of water movement through a plant

Water molecules are attracted to each other (cohesion) à water vapour evaporating from a leaf crates a kind of suction, pressure of water at the top of the vessels is lower than that of the bottom à water move up the **stem** in the xylem, more water is drawn into the leaf from the xylem. This creates a **traspiration stream**, pulling water up from the root.

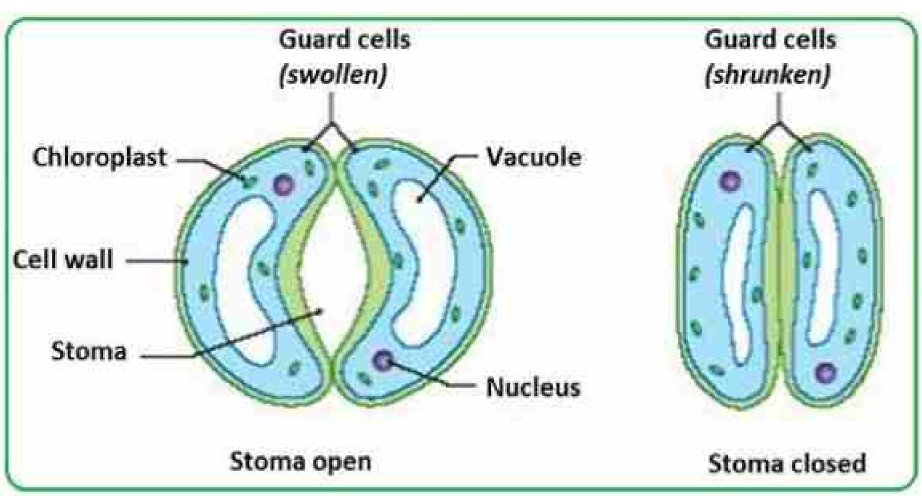
The rate of transpiration can be affected by several factors:

Factors affecting transpiration rate

Factor	Explanation
↑ temperature	↑ the kinetic (movement) energy of water molecules → they **diffuse** faster.
↑ air movement (wind...)	Removes water molecules as they pass out of the leaf → maintaining a steep concentration gradient for **diffusion**.
↓ humidity	↓ the concentration of water molecules outside the leaf → steeper concentration gradient for **diffusion**.
↑ light intensity	Stomata open to allow gas exchange for photosynthesis → water vapour can **diffuse** out of the leaf.

The opening and closing of the **stomata** is controlled by the **guard cells**.

- In **light**, guard cells **take up** water by osmosis and become **turgid**. Because their inner walls are rigid they are pulled apart, **opening** the pore.
- In **darkness** water is **lost** and the inner walls move together **closing** the pore.

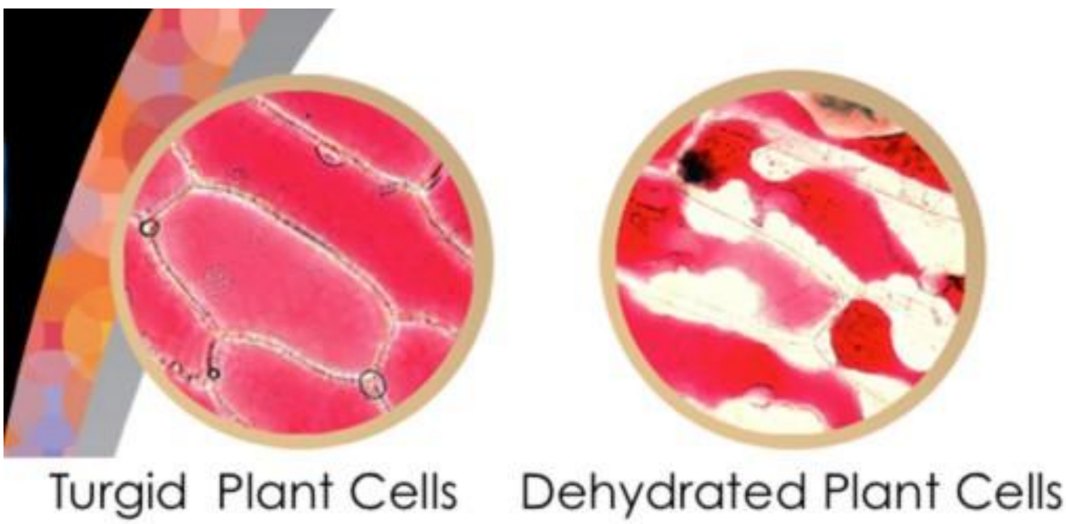


Because of this, the transpiration rate is increased by an increase in light intensity.

* Most of the factors that result in a change in transpiration rate are linked to **diffusion**. When writing explanation, try to include references to the **concentration gradient** caused by a change in the factor.

How wilting occurs

Young plant stems and leaves rely on their cells being **turgid** to keep them rigid. If the amount of **water lost** from the leaves of a plant is > than the amount **taken** into the roots à the plant will have a **water shortage** à cells become **flaccid** (soft) and will no longer press against each other à Stems and leaves lose their rigidity, and **wilt**.



#64 Adaptations of the leaf, stem and root to different environments

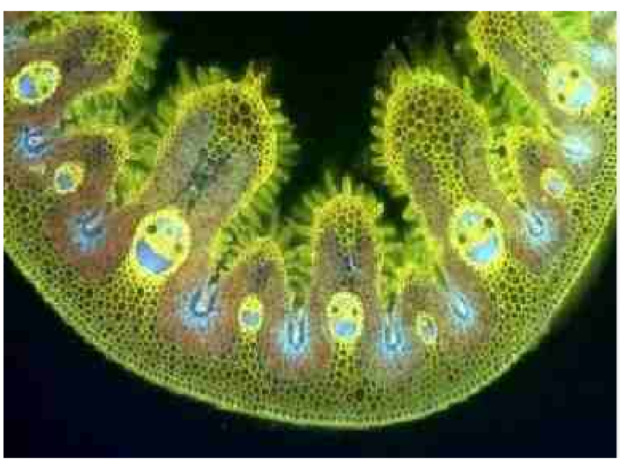
Plants which live in extreme environments have **adaptations** to control their transpiration rate. Most modifications are adaptations to very **dry** (arid) **environments.**

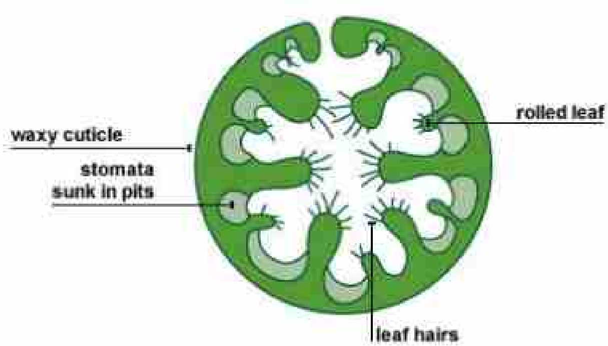
Water plants have no problems of water shortage. They do not need adaptations to conserve water as desert plants.

Plants modified to cope with a lack of water are called **xerophytes**. Living in **deserts** where water is scarce and evaporation is rapid, or in **windy** habitats where evaporation can also be rapid, they have to **cut down water loss.**

1. Marram grass (Ammophila)

- Very **long roots** to search for water deep down in sand dunes.
- **Leaves** that **roll up** in dry weather to increase humidity around stomata, reducing transpiration.
- **Sunken stomata** to create high humidity and reduce transpiration.
- **Fine hairs** around stomata, reducing air movement so humidity builds up and transpiration is reduced.



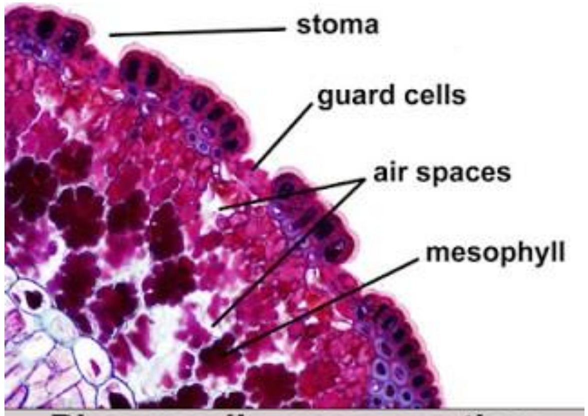


2. Prickly pear cactus (Opuntia)

- **Leaves** reduced to **spines** – this reduces the surface area for transpiration and also acts as a defence against herbivores.
- **Reduces** number of **stomata**.
- Stomata **cloesed** during the **day**- when conditions for transpiration are most favourable.
- **Fleshy stem** - to store water.

3. **Pine tree** (Pinus)

- **Leaves needles-shaped** to reduce surface area for transpiration and to resist wind damage.
- **Sunken stomata** to create high humidity and reduce transpiration.
- **Thicsk waxy cuticle** on the epidermis to prevent evaporation from leaf surface.



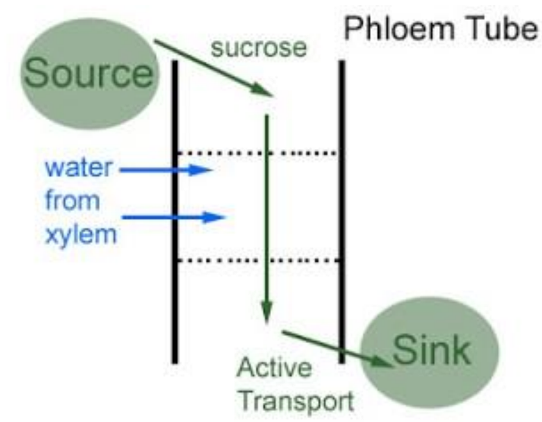
Pine needle cross section

Water plants may have stomata on the tops of their leaves

Water hyacinth (Ecichhornia csassipes)

- **Roots** do not attach to to the bed of the river or pond where they grow, but just float freely in the water.
- The **stems** and **leaf stalks** have hollow spaces in them, filled with air à help to float on the top of the water where they can get plenty of light for photosynthesis.
- **Leaves** and **stomata** are on **both surfaces**, not just on the underside as in most plant à allow to absorb CO_2 from the air, for photosynthesis.
- The **cuticle** on the upper and lower surfaces of the leaves is much **thinner** than in plants that don't live in water, there is no need to prevent water loss from the leaves.

65 Translocation of organic foods in plants



Translocation is the movement of organic food such **sucrose** and **amino acids** in **phloem**; from regions of production to regions of storage OR regions of utilisation in respiration or growth.

1. Glucose the product of **photosynthesis** is very important as it makes many other important nutrients, e.g. **sucrose**.

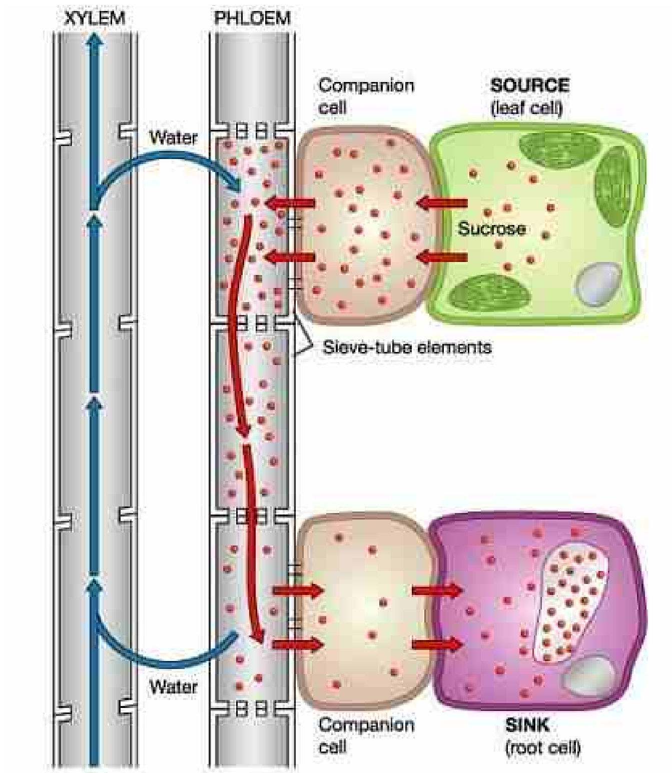
- Sucrose in the leaves then enters the **phloem** vessels.
- The phloem transports the sucrose all **across the leaf** where it can be made used of.

2. Amino acids are also transported in the phloem.

Sucrose and amino acids are transported to every tissue of the plant, each cell use it in a different way.

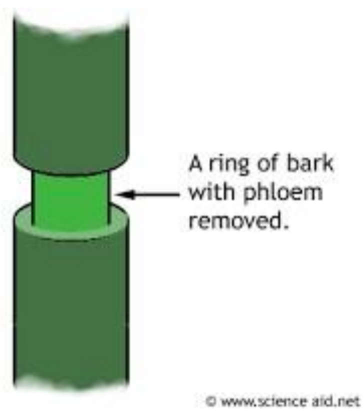
- **Root cells** convert sucrose into glucose for **respiration** and **store** it.
- **Growing cells** make cellulose for **cell walls** from sucrose and use the amino acids to make **proteins** for growth.
- And **fruits** use the sucrose to make the attractive **scent** and **tasty nectar** to attract insects.

The areas of the plant where sucrose is made, are called **sources**, and where they are delivered to and made use of are called **sinks**.



Ringing Experiment

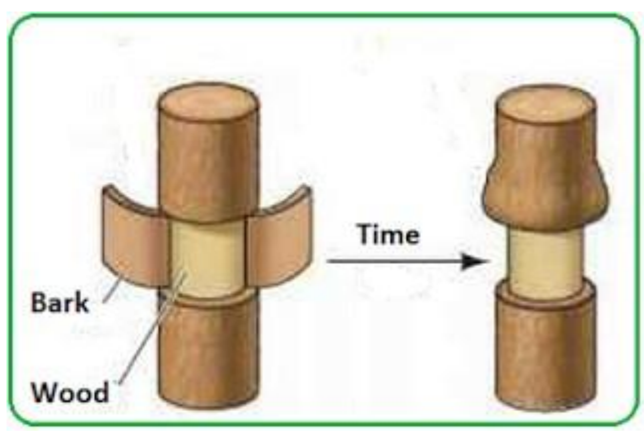
The **phloem** vessels are situated nearer to the bark in comparison with xylem à they can be selectively removed by cutting a **ring** in a stem just deep enough to cut the phloem but not the xylem.



After a week there is:

- a **swelling above** the ring
- **reduced growth below** the ring
- the **leaves** are unaffected.

This was early evidence that **sugars** were transported downwards in the phloem.



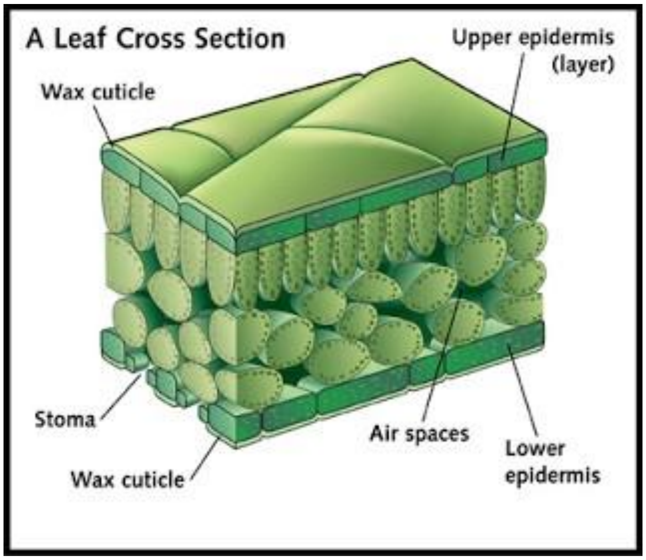
Grey squirrels and other small mammals gnaw the bark and destroy the phloem that is in the inner bark region.

#66 Translocation of applied chemicals (pesticides) throughout the plant

People who grow crops for food sometimes need to use chemicals called **pesticides**. Pets such as **insects** that eat the crop plants, or **fungi** that grow on them, can greatly reduce the yield of the crop. Pesticides are use to kill the insects or fungi.

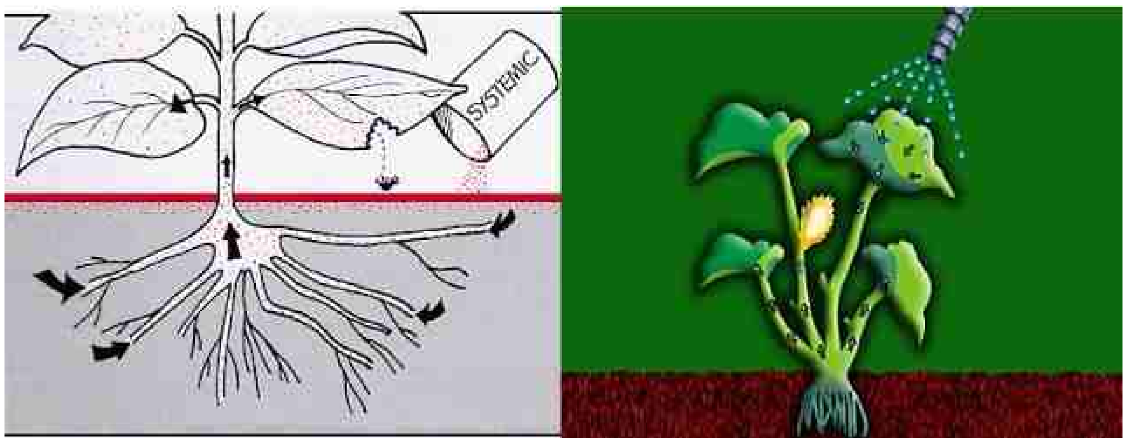
Some pesticides kill only the insects or fungus that the spray touches. They are called **contact pesticides**. They can be very effective if they are applied properly, but they also kill insects and pests that are useful to the plant.

Systemic pesticides are more effective because when sprayed onto the leaves of the plant, they are **absorbed** by it through the **cuticle** or **stomata** and into the phloem tubes. They move through the plant in the **phloem** (**translocation**) and are taken in by any insect eating the plant or sucking up phloem sap.



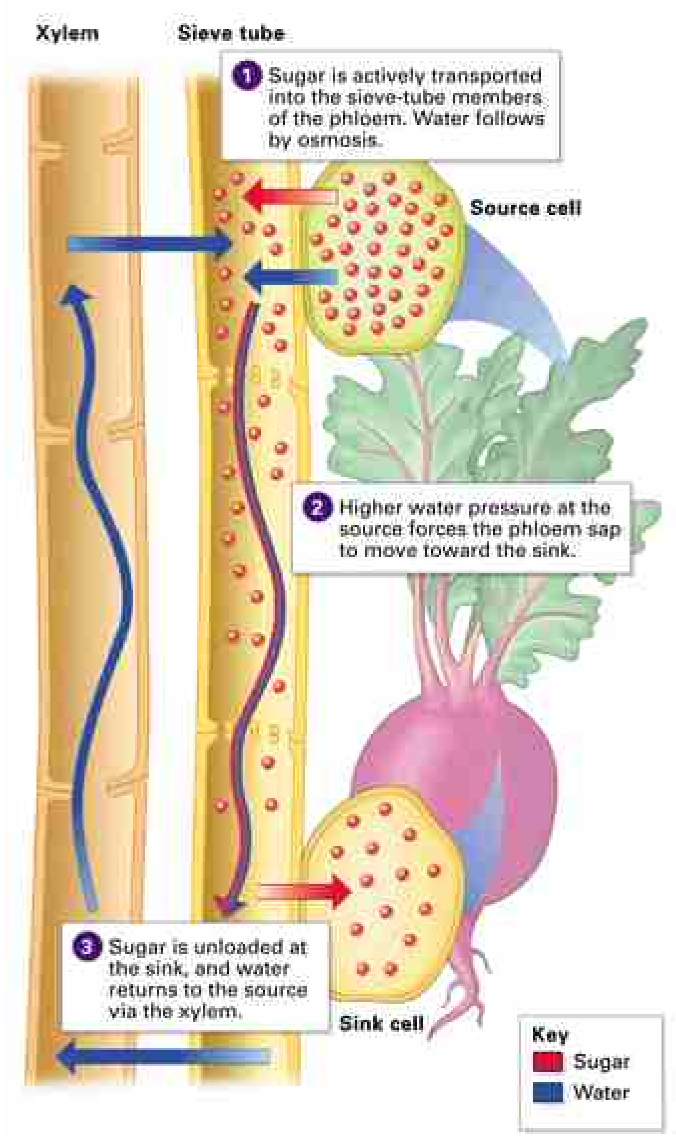
So any insect feeding on the plant, even if it was hidden under the leaf where the spray could not reach it, will eventually end up feeding on pesticide. The same is true for fungi; no matter where they are growing on the plant, the pesticide will eventually reach them. Once an insect has ingested enough pesticide it will die, meanwhile the harmless insects remain safe.

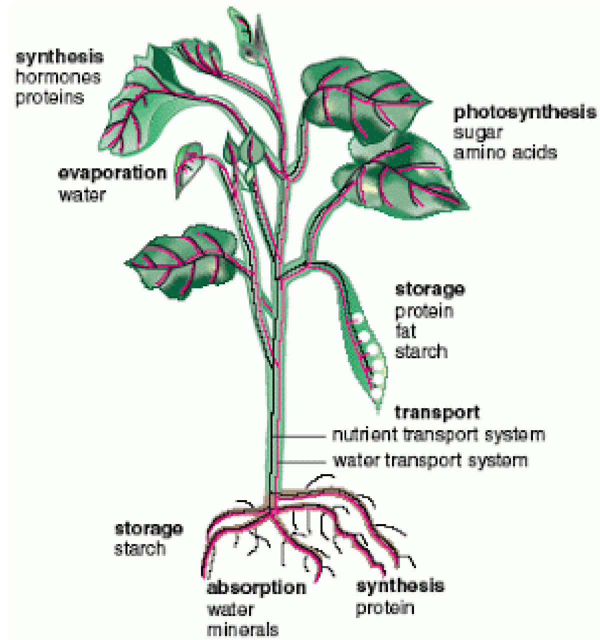
The disadvantages of systemic pesticides are that they may accumulate in the food chain.



Systemic pesticides may need to be taken up by roots or through the leaves.

#67 Transport of materials from sources to sinks at different seasons





'**Source**' is the part of a plant where substances are **produced** (e.g. leaves for sucrose, amino acids) or **enter the plant**.

'**Sink**' refers to the part of the plant where the substrate can be **stored** (e.g. roots or stem for starch).

Examples:
Sources:
Leaves - sucrose is produced here.
Root hairs - Nitrates are absorbed here.

Sinks:
Roots/Stems - starch is stored here.
Root tips - amino acids are stored here.

When a plant is actively photosynthesising and growing, the **leaves** are generally the major **sources** of translocated materials. They are constantly **producing sucrose**, which is carried in the phloem to all other parts of the plant.

These parts - the **sinks** - include the **roots,** the **flowers** and the **fruits**:

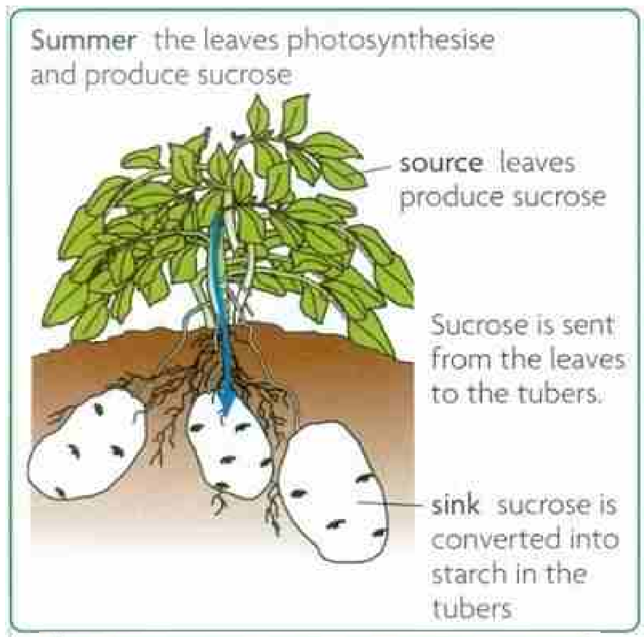
- The **roots** may change some of the sucrose to starch and store it.
- The **flowers** use the sucrose to make fructose.
- Later, when the **fruits** are developing, quite large amounts of sucrose may be used to produce sweet, juicy fruit ready to attract animals.

But many plants have a time of year when they become **dormant**. During this stage, they wait out harsh conditions in a state of reduced activity.

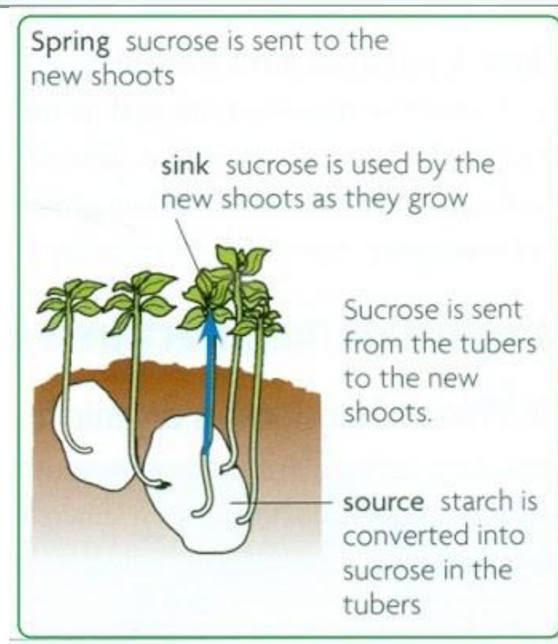
Dormant plants do not photosynthesise, but survive on their stored starch, oils and other materials. When the seasons change, they begin to grow again. Now the stored materials are converted to sucrose and transported to the growing region.

For example, potato plants are not able to survive the cold frost of winter.

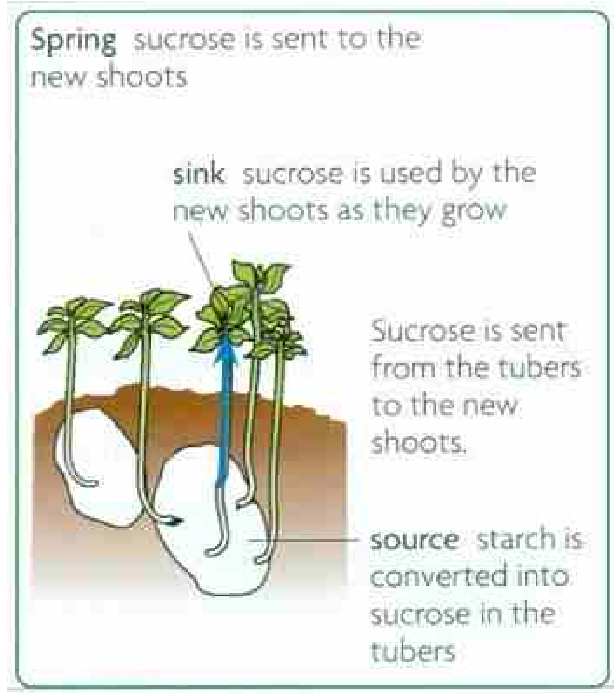
- During the **summer**, the leaves photosynthesise and send sucrose down into underground stems. Here, swellings called **tubers** develop. The cells in the root tubers change the **sucrose to starch** and store it.



- In **winter**, the leaves die. Nothing is left of the potato plant above ground - just the stem tubers beneath the soil.



- In **spring**, they begin to grow new shoots and leaves. The **starch** in the tubers is changed back to the **sucrose**, and transported in the phloem to the growing **stems and leaves**. This will continue until the leaves are above ground and photosynthesise.



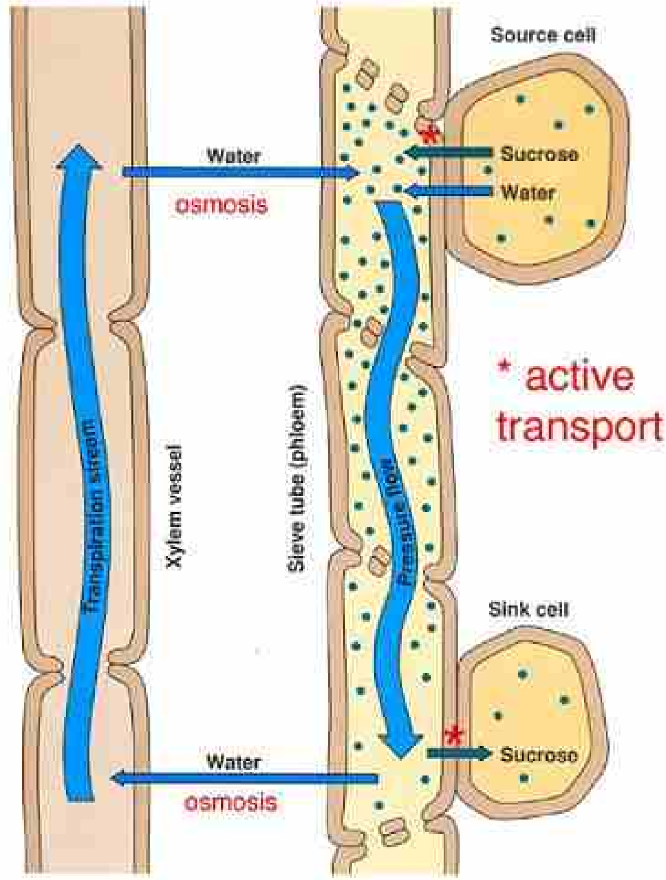
So in **summer**, the **leaves** are **sources** and the growing stem **tubers** are **sinks**. In **spring**, the stem **tubers** are **sources** and the growing **leaves** are **sinks**.

Conclusion:

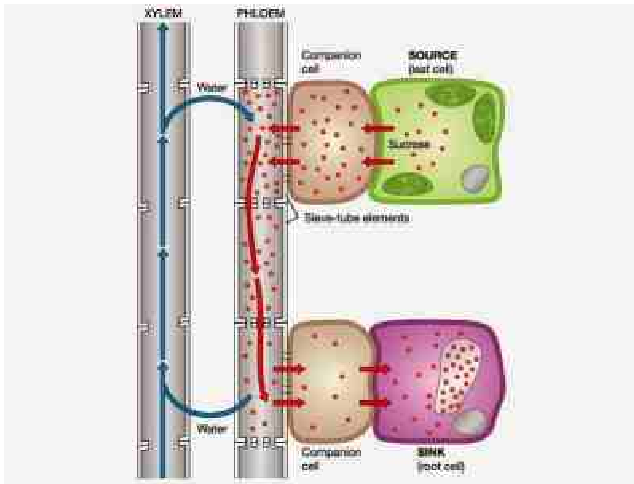
Phloem can transfer sucrose in **either direction** - up or down the plant. This isn't true for the transport of water in the **xylem** vessels. That can only go **upwards**, because transpiration always happens at the leaf surface, and it is this that provides the 'pull' to draw water up the plant.

Comparison of transpiration and translocation

	Transport	From	To	Mechanism	High rate
Transpiration	H_2O, Mineral irons	Soil	Leaves, Flowers Fruits	**Passive** process using a **tension** in the xylem produce by **evaporation** of water.	on **hot**, **sunny**, **windy** and **dry** days
Translocation	Sucrose, Amino acids	Leaves	Shoot,root tips, root cortex, seeds, flowers, fruits	**Active** process, the **water** enters the tubes to build up a head of pressure that forces the phloem sap to the **sinks**.	on warm, **sunny** days when plants are producing more sugar


Source cell
Water
osmosis
Sucrose
Water
* active transport
Transpiration stream
Xylem vessel
Sieve tube (phloem)
Pressure flow
Sink cell
Water
osmosis
Sucrose

#68 Summary of plant transport



- In plants, **xylem** vessels transport **water** and **mineral** ions from the roots upwards to the leaves. **Phloem** tubes transport **sucrose** and other organic nutrients, from the leaves where they are made to all parts of the plant. This is called **translocation**.

- **Xylem** vessels are made of **dead**, empty **cells** with strong lignin in their walls. As well as transporting water, they help to **support** the plant.

- Water is drawn up xylem vessels by the evaporation of water from the leaves, called **transpiration**. Transpiration happens fastest when it is hot, dry, windy and sunny.

- Water enters root hairs by **osmosis**, and then moves across the cortex of the root into the xylem.

- Root hairs take up mineral ions by **active transport**, using energy supplied by respiration to move them against their concentration gradient.

- **Phloem** is made of **living cells** with sieve plates at their ends. A companion cell is associated with each phloem sieve tube element.

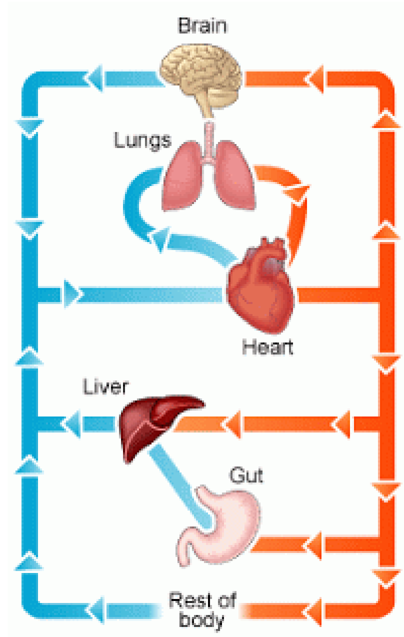
- Systemic **pesticides** are translocated in phloem.

- **Sucrose** is translocated from sources to sinks. Different parts of a plant may become sources and sinks in different seasons.

07 – Human transport Biology Notes IGCSE Cambridge 2014

69 Transport in humans - the circulatory system

The main transport system of human is the **circulatory system**, a system of tubes (**blood vessels**) with a pump (the **heart**) and **valves** to ensure **one-way** flow of blood.

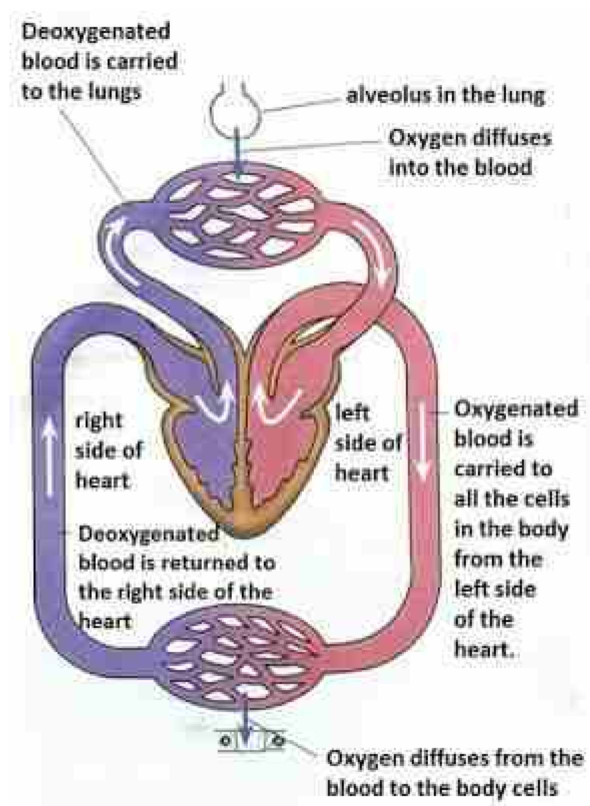


Its functions:

- To transport **nutrients** and **oxygen** to the cells.
- To remove **waste** and **carbon dioxide** from the cells.
- To provide for efficient **gas exchange**.

The **right** side of the heart collects **deoxygenated** blood form the body and pumps it to the **lungs**.

The **left** side collects **oxygenated** blood from the lungs and pumps it to the **body**.

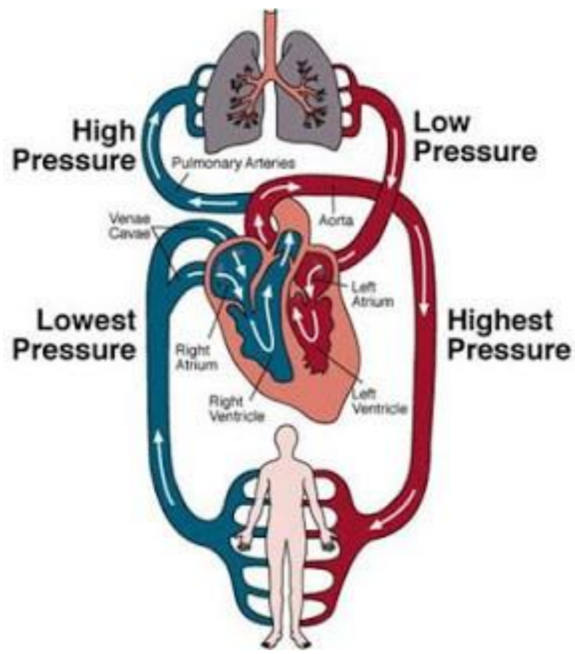


The double circulation

Beginning at the lungs, blood flows into the left-hand side of the heart, and then out to the rest of the body. It is brought back to the right-side of the heart, before going back to the lungs again.

This is call a **double circulation system**, because the blood travels through the heart twice on one complete journey around the body:

- one circuit links the **heart** and **lungs** (low pressure circulation)
- the other circuit links the **heart** with the rest of the **body** (high pressure circulation).



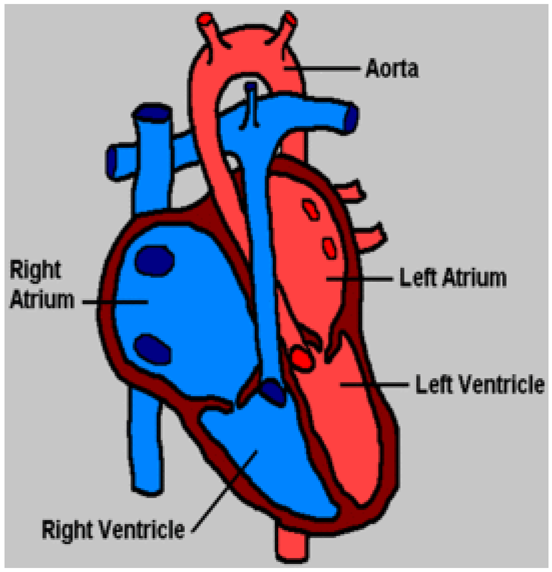
The importance of a double circulation

- **Oxygenated** blood is kept separate from **deoxygenated** blood. The septum in the heart ensures this complete separation. Oxygenated blood flows through the left side of the heart while deoxygenated blood flows through the right.

- The **blood pressure** in the **systemic circulation** is kept **higher** than that in the pulmonary circulation. The left ventricle, with a thicker wall, pumps blood under higher pressure to the body and delivers oxygenated blood effectively to all parts of the body. The right ventricle has a thinner wall and pumps blood to the lungs under lower pressure, thereby avoiding any lung damage.

Video

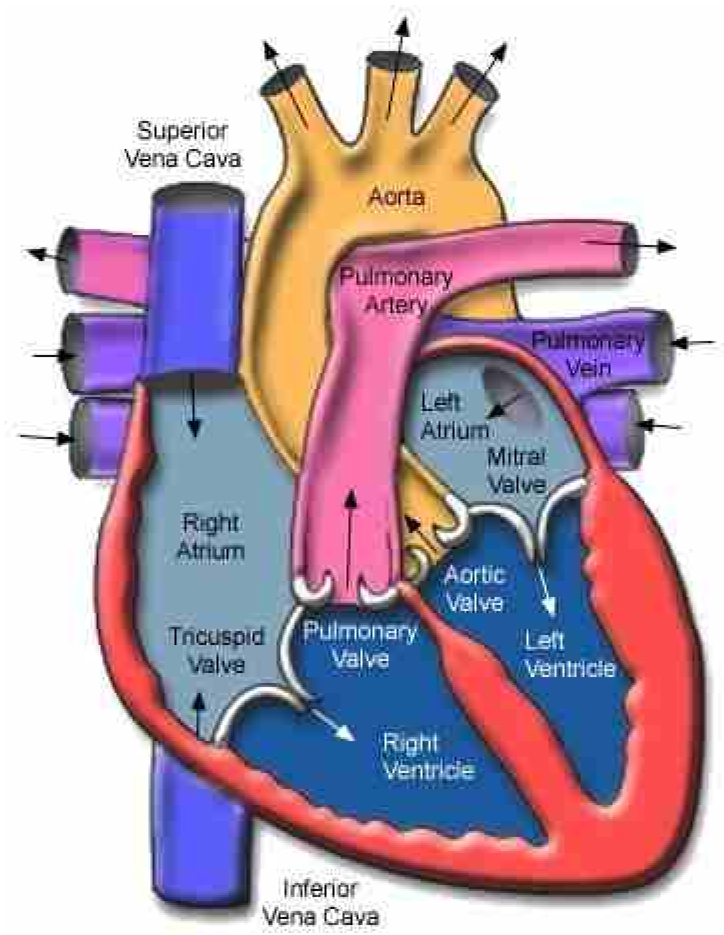
70 Structure and function of the heart



The function of the **heart** is to pump blood around the body. The **right** side pumps blood to the **lungs** and the **left** side pumps blood to the rest of the **body**.

Structure of the heart

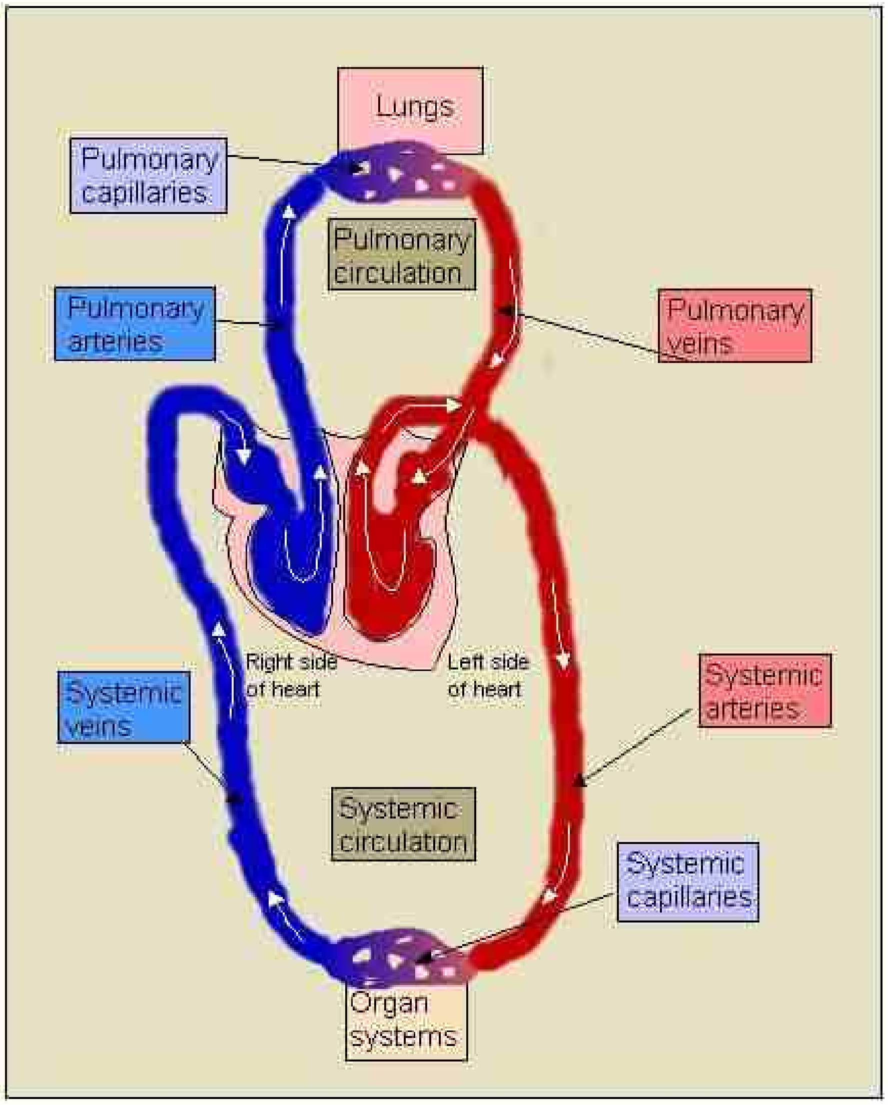
Muscular wall	Septum	Chambers	Valves	Associated blood vessels
The wall of the LV is much thicker than the RV because it needs to build up enough pressure to move the blood to all the main organs.	Completely separated the chambers on the left-hand side and the ones on the right-hand side.	2 atria: **right atrium** (RA) and **left atrium** (LA), receiving blood from veins and squeeze it into the ventricles. 2 ventricles: **right ventricle** (RV) and **left ventricle** (LV), receiving blood from the atria and squeeze it into arteries.	Semilunar Tricuspid Bicuspid	Vena cava Pulmonary artery Pulmonary Aorta



Heart's function

- **Blood circulation**

1. Blood in the **right ventricle** (RV) is pump to the **lungs**
2. Blood from the **lungs** flows back into the **left atrium** (LA) and then into the **left ventricle** (LV).
3. Blood in the LV is pumped through the **body** (except for the lungs)
4. Blood returns to the heart where it enters the **right atrium** (RA).



- ***Muscular contraction***

The heart is made of a special type of muscle called **cardiac muscle** which contracts and relaxes regularly, throughout life.

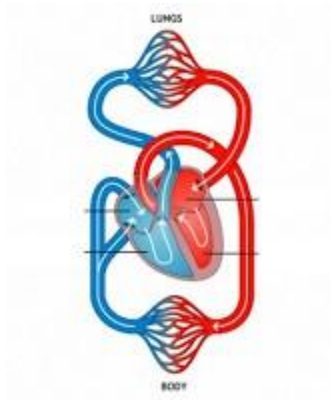
The heart's muscle is constantly active, so it needs its own blood supply, through the **coronary artery**, to provide it with **oxygen** and **glucose**.

- ***Working of the valves***

Valves in the heart prevent blood from being pushed backwards up into the atria when the heart 'beats'.

Animation: **Heart Contraction and Blood Flow**
How the heart pumps blood

Try this



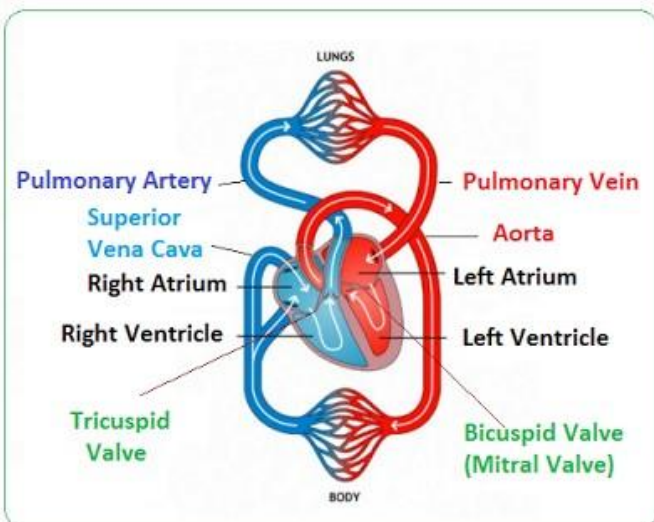
1.On a copy of the diagram of the double circulatory system, labell:

i) The 4 main blood vessels (4 marks)
ii) The chambers of the heart (4 marks)
iii) The 2 valves shown (2 marks)

2.State 2 differences in composition between blood leaving the right ventricle and blood entering the left atrium. (2 marks)

Answers:

1.



2.Blood leaving the right ventricle has more CO_2 and less O_2 than blood entering the left atrium.

Common misconceptions

Remember that blood passing through the chambers of the heart does **not** supply the heart muscle with oxygen or glucose. The heart muscles has its own blood supply - via the coronary arteries - to do this.

#71 Effect of exercise on heartbeat and causes of coronary heart disease

A heartbeat is a contraction. Each contraction squeezes blood to the lungs and body. The heart beats about **70 times** a minute, more if you are younger, and the rate becomes lower the fitter you are.

- During exercise the **heart rate increases** to supply the muscles with more oxygen and glucose à allow the muscles to respire aerobically à they have sufficient energy to contract.

- **Regular exercise** is important to keep the heart muscle in good tone à heart is more efficient in maintaining blood pressure and↓risk of coronary heart disease and stroke.

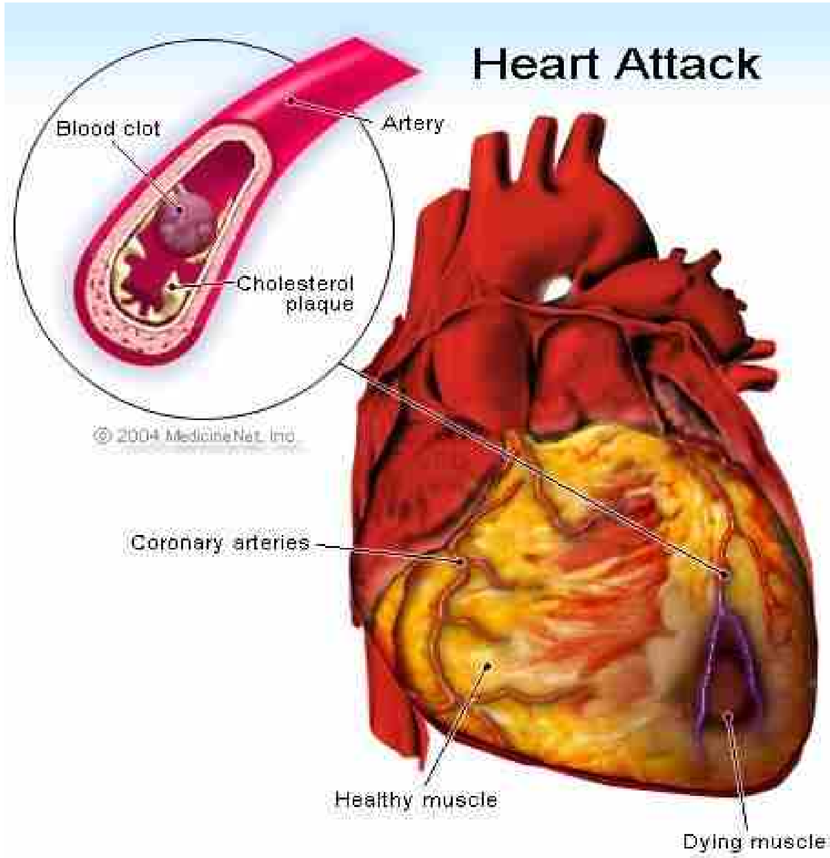
Coronary arteries

The muscles of the heart are so thick that the nutrients and oxygen in the blood inside the heart would not be able to diffuse to all the muscles quickly enough. The heart muscles needs a constant supply of nutrients so that it can keep contracting and relaxing. The **coronary arteries** supply this.

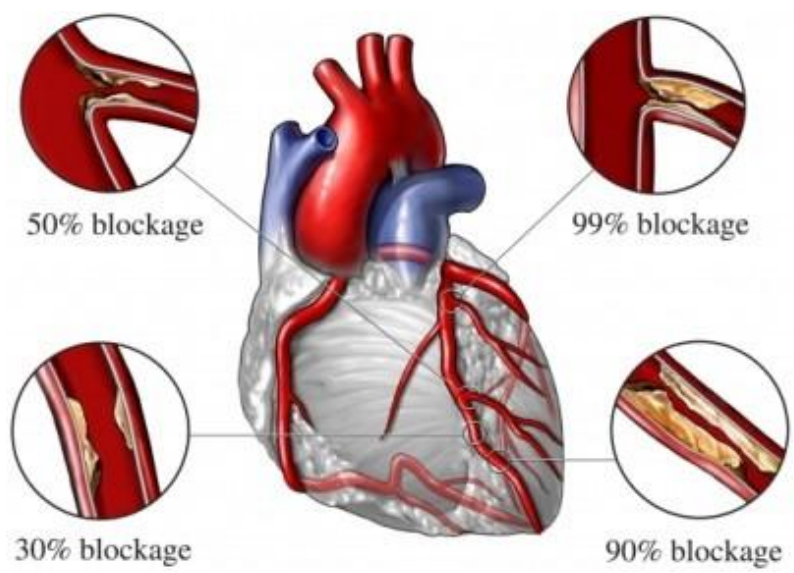
If a coronary artery gets **blocked** – e.g. by a blood clot – the cardiac muscles run **short of oxygen** à they can not respire à can not obtain energy to contract à **heart stops** beating. This is called a **heart attack** or **cardiac arrest**.

Main causes of a coronary heart disease and preventive measures

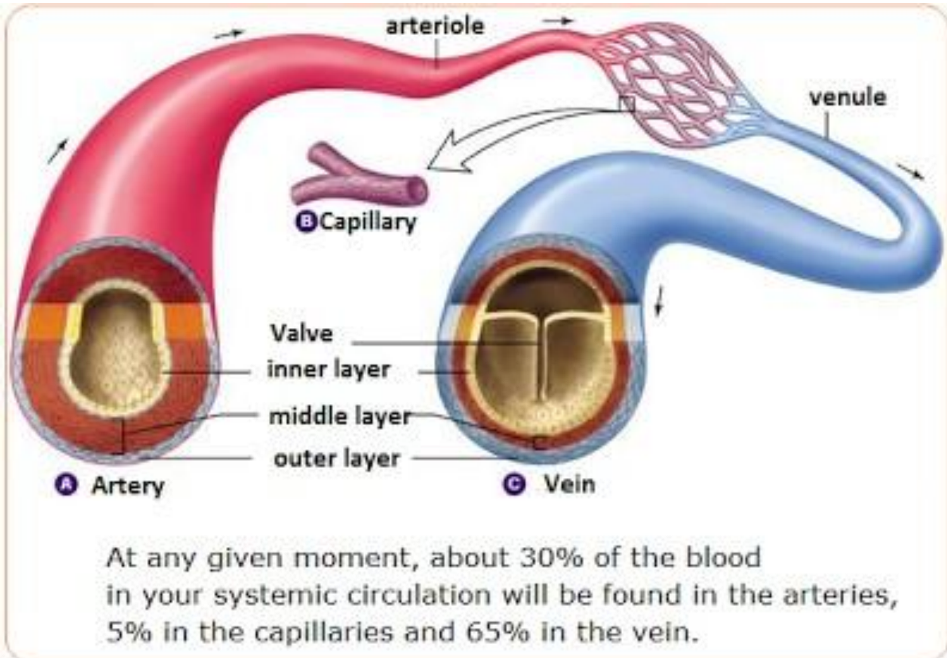
Cause	Explanation	Preventive measures
Poor diet with too much saturated (animal) fat	→ Cholesterol building up in arteries → block the blood vessels/form a blood clot.	Cholesterol - free diet
Smoking	Nicotine damages the heart and blood vessels	Stop smoking
Stress	Tends to ↑ blood pressure →collect fatty materials in the arteries.	Relaxing Avoid the causes of stress
Obesity	→ put extra strain on the heart, makes it more difficult for the person to exercise.	Controlled diet Regular exercise
Lack of exercise	The heart muscle loses its tone and becomes less efficient in pumping blood.	Regular exercise
Inherited factors	Heart disease can pass from one generation to the next in some families.	Reduce the other risk factors by a healthy life-style.



Blockage of the coronary arteries is called **coronary heart disease**.



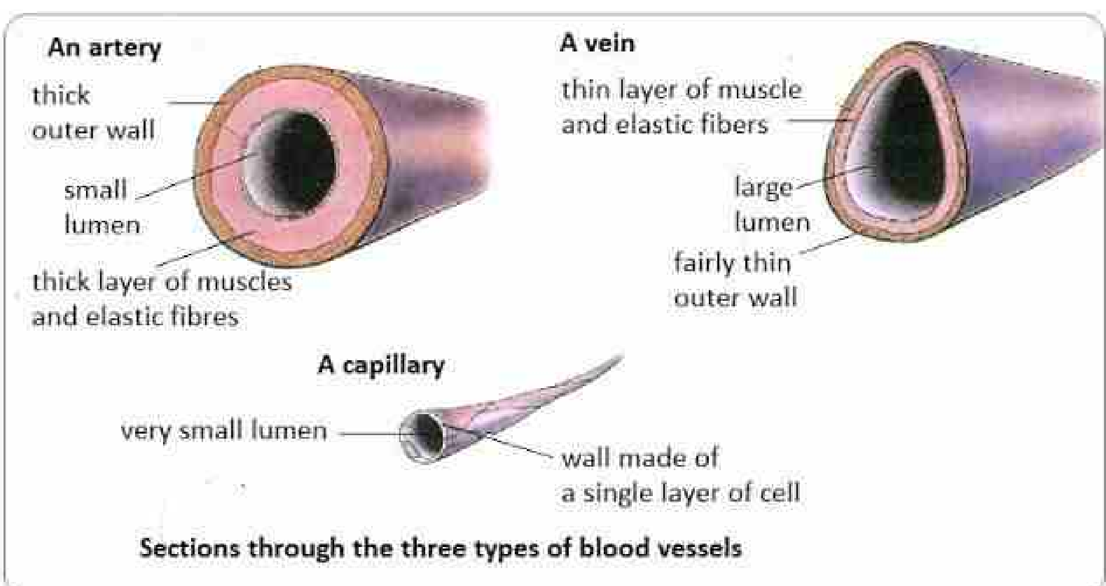
72 Arteries, veins and capillaries - structure and functions



There are 3 main kinds of blood vessels – arteries, veins and capillaries.

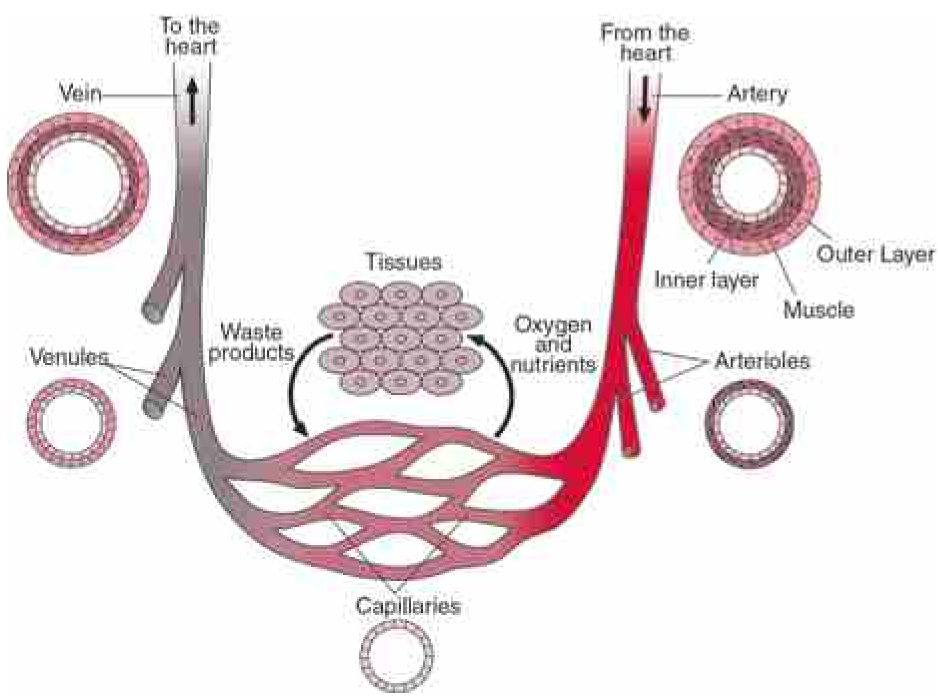
- **Arteries** carry blood away from the heart. They divide again and again, and eventually form very tiny vessels called capillaries.
- The **capillaries** gradually join up with one another to form large vessels called veins.
- **Veins** carry blood towards the heart.

The comparison of blood vessels structure and functions



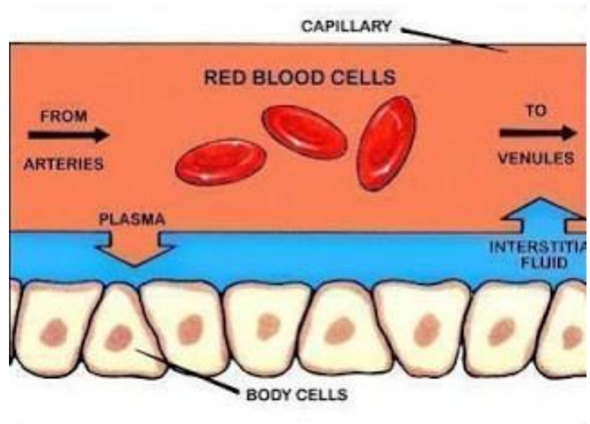
	Arteries	Capillaries	Veins
Function	Carry blood **away** from the heart at **high** pressure	-Supply all cells with their **requirements** -Take away **waste** products	**Return** blood to the heart at **low** pressure
Structure of wall	-**Thick**, strong -Contain **muscles**, **elastic** fibres and **fibrous** tissue	**Very thin**, only one cell thick	-**Thin** -Mainly **fibrous** tissue -Contain far **less muscle** and **elastic** tissue than arteries
Lumen	-**Narrow** -Varies with heartbeat (increases as a pulse of blood passes through)	-**Very narrow** -Just wide enough for a red blood cell to pass through	**Wide**
Valves	(-)	(-)	(+) Prevent backflow
How structure fits function	-Strength and elasticity needed to withstand the pulsing of the blood, prevent bursting and maintain pressure wave -Helps to maintain **high blood pressure**, preventing blood flowing backwards	- No need for strong walls, as most of the blood pressure has been lost -Thin walls and narrow lumen bring blood into close contact with body tissue, allowing **diffusion** of materials between capillary and surrounding tissues. -White blood cells can squeeze between cells of the wall	- No need for strong walls, as most of the blood pressure has been lost - Wide lumen offers **less resistance** to blood flow

The transfer of materials between capillaries and tissue fluid



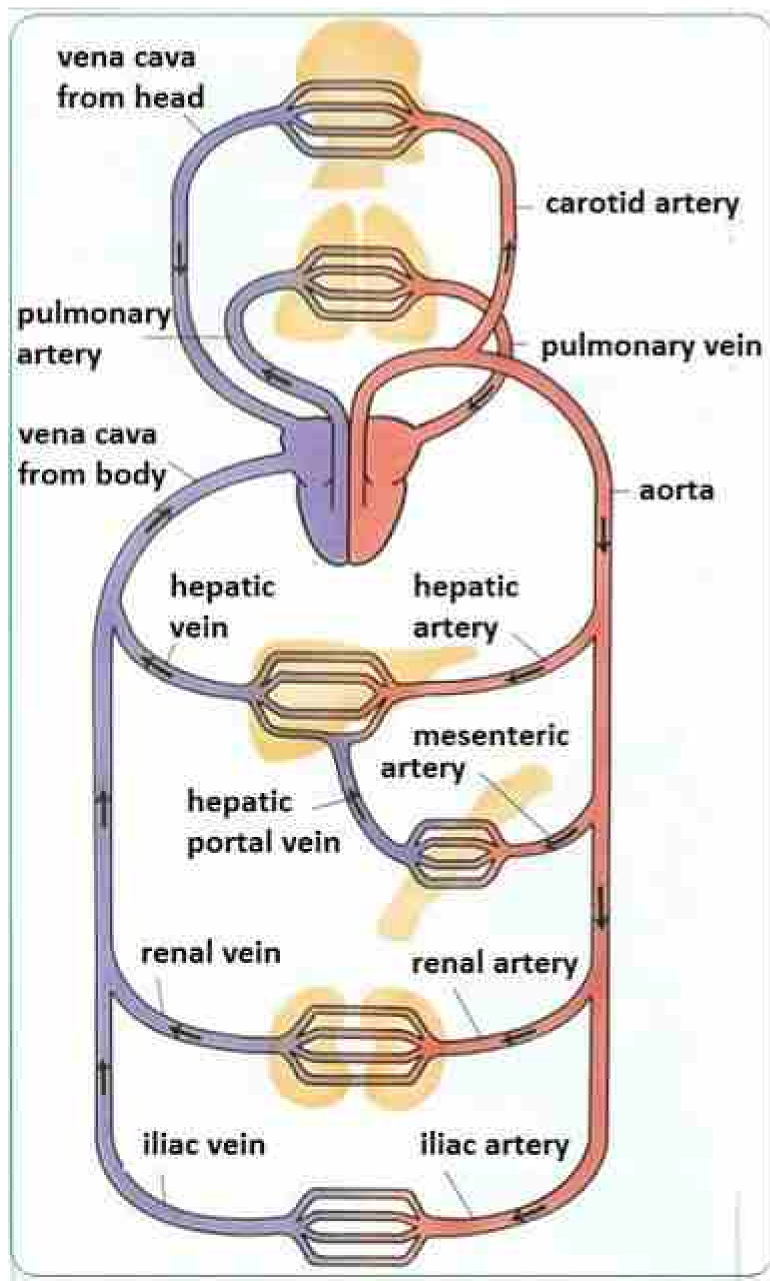
As blood enters capillaries from arterioles (small arteries), it slows down. This allows **substances** in the plasma, as well as **O_2** from red blood cells, to **diffuse** through the capillary wall into the surrounding tissues (the capillary wall is thin and permeable).

Liquid in the **plasma** also passes out. This forms **tissue fluid,** bathing the cells. **Waste products** from the cells, e.g. CO_2, **diffuse** back through the capillary walls into the plasma. Some of the tissue fluid also passes back.



Diffusion is responsible for the transfer of materials between capillaries and tissue fluid.

Plan of the main blood vessels in the human body



Sample questions

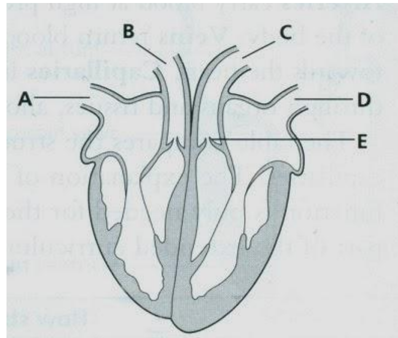


Figure above shows a section through the heart

i) Name the two blood vessels **A** and **B** [2 marks]
ii) Which of blood vessels **A, B, C** or **D** carry oxygenated blood [1 mark]
iii) Name valve **E** and state its function [3 marks]

Student's answer

i) A, vena cava (✓) B, pulmonary vein (✗)
ii) C (✗)

iii) name: semilunar valve (✓) function: to stop blood going backwards (✓)

Examiner's comments

*Blood vessels **B** is the pulmonary artery. Arteries of the heart always carry blood from a ventricle.*

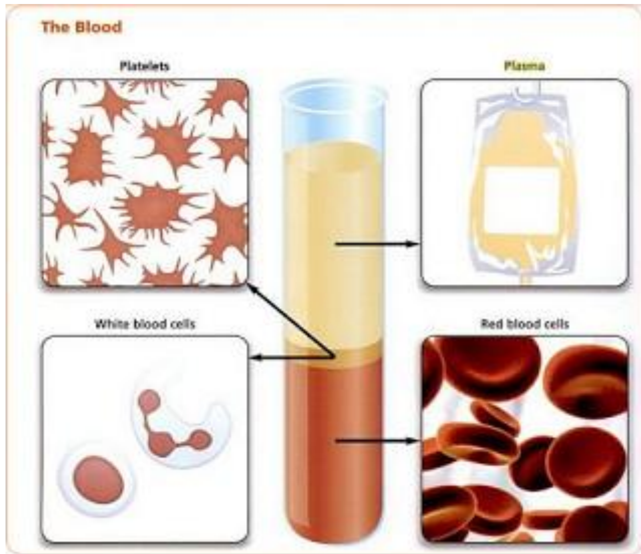
*Part ii) needs two answers (blood vessels **C** and **D**) to gain the mark.*

***D** is the pulmonary vein, which carries oxygenated blood to the heart from the lung.*

***C** is the aorta, which carries oxygenated blood from the heart to the body.*

In part iii) the name of the valve is correct, but there are two marks for its functions. This candidate has given only one statement: a second mark was available for stating that the valve prevents blood from going back into the left ventricle.

73 Blood composition and Plasma

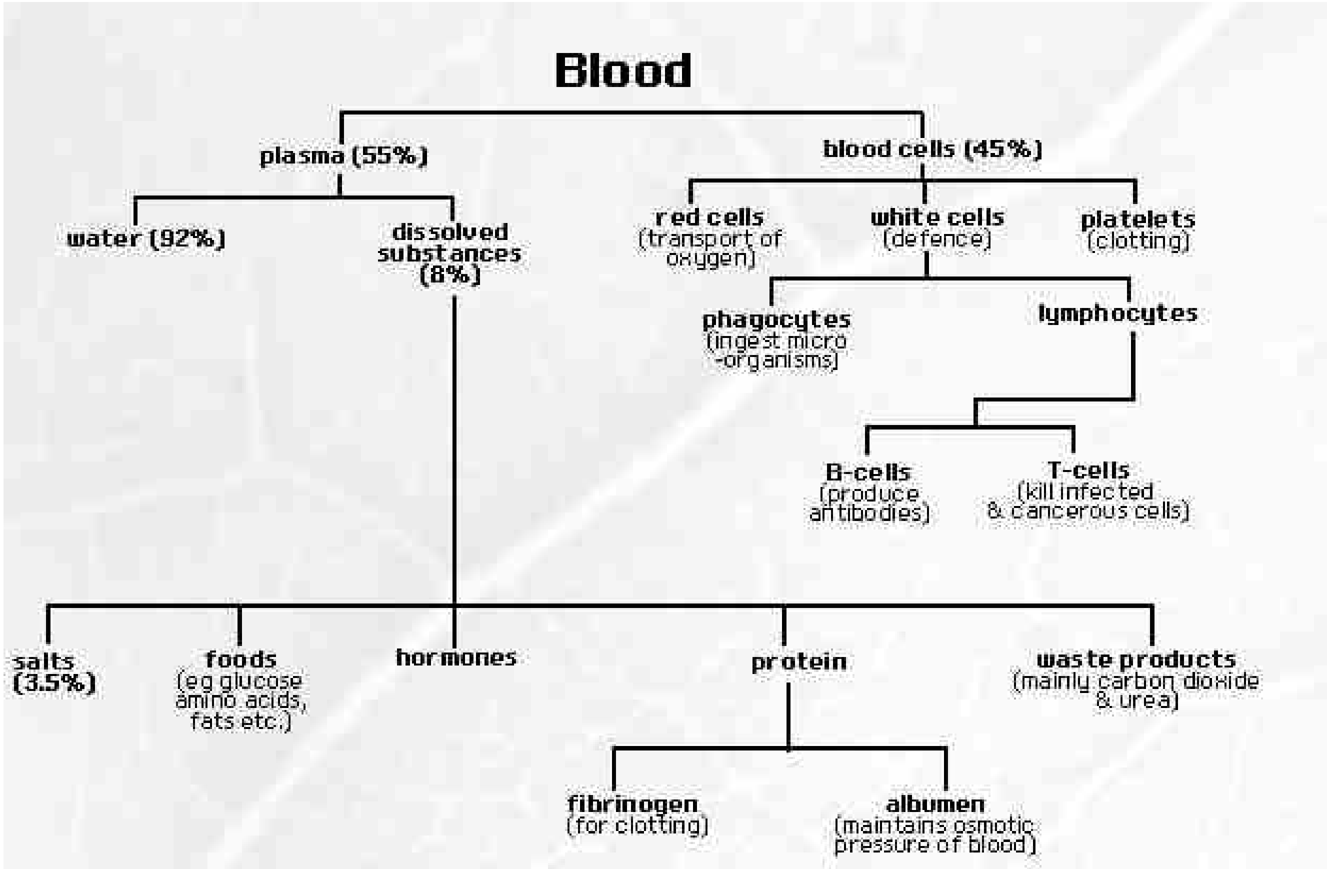


If blood is allowed to stand without clotting, it separates out into 4 components: **plasma**, **red blood cells,** **white blood cells** and **platelets.**

The **plasma** and **red** blood cells play an important role in the **transportation** of substances, around the body.

White blood cells and **platelets** are part of the body's **immune system**.

55% of the blood is plasma. This straw-coloured liquid contain water with many important **dissolved** substances which must be carried around the body. **Most materials** are **carried** by the blood plasma, **except** for **oxygen**.



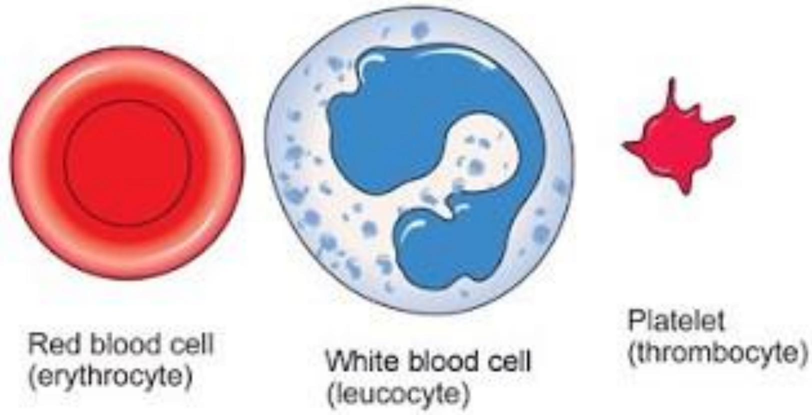
Credit: [moodle]()

Plasma transports:

- blood **cells**
- soluble **nutrients** e.g. **glucose** (products of digestion) from the small intestine to the organs
- **amino acids** (plasma acts as a pool for amino acids for these cannot be stored in the body)
- **plasma proteins** that are important in blood **clotting** (e.g. fibrinogen).
- **CO_2** (waste gas produced by respiration in cells) from the organs to lungs
- Other wastes of digestion (e.g. **urea**) from the liver to the kidneys.
- **Antibodies** and **antitoxins**
- **Hormones**
- **Ions**
- **Heat** from the liver and muscles to all parts of the body.

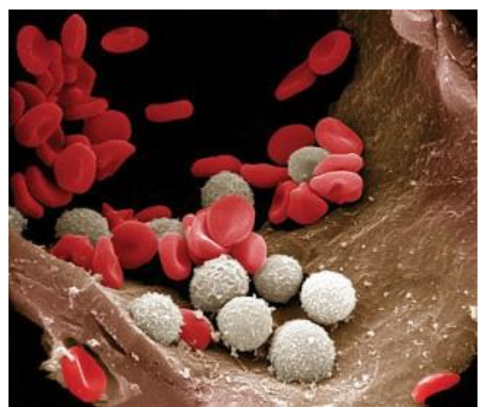
Video

74 Blood cells - structure and functions



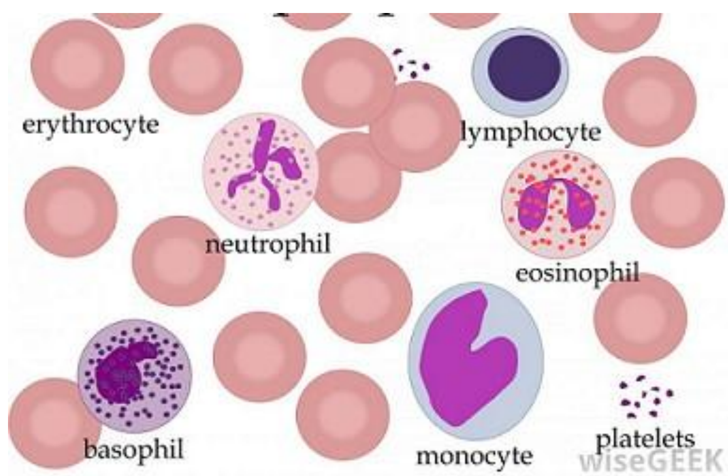
Blood consists of **cells** floating in **plasma.**
Most of the cells are **red blood cells**.
A much smaller number are **white blood cells**.
There are also fragments formed from special cells in the bone marrow, called **platelets**.

Red and **white** blood cells as seen under a light microscope.



Blood as seen through a microscope:

- The largest cells are **white cells**.
- The others are all **red cells**.
- There are also a few **platelets**.



Functions of blood cells

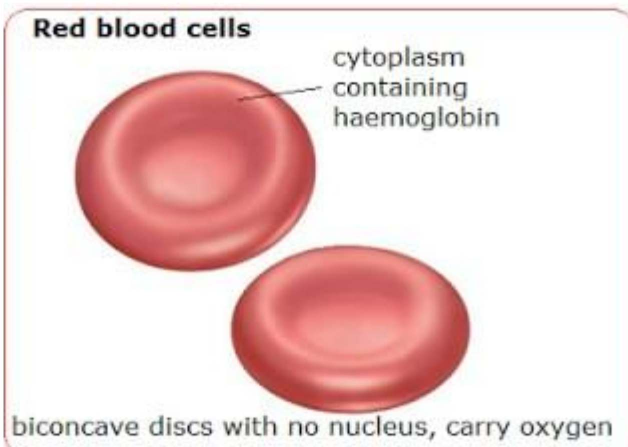
- Red blood cells transport **oxygen**.
- White blood cells protect against **disease**.
- Blood platelets help the blood to **clot**.

1.Red blood cells (erythrocytes)

- Made in the **bone marrow** of some bones, including ribs, vertebrae and some limb bones. Produced at a very fast rate – about 9000 million per hour!

- **Transport O_2** from lungs to all respiring tissues. Prepare **CO_2** for transport from all rerspiring tissues to lungs.

- Contain **haemoglobin (Hb)**, a red iron-containing pigment which can **carry O_2**. In the lungs, Hb combines with O_2 to form oxyhaemoglobin. In other organs, oxyhaemoglobin splits up into Hb and O_2



- Have **no nucleus** à can fit more Hb inside the cytoplasm, but can **lives** only for about **4 months**.

- Have a special **biconcave disc** shape à increases the surface area and makes the diffusion of oxygen into & out of the cell easier.

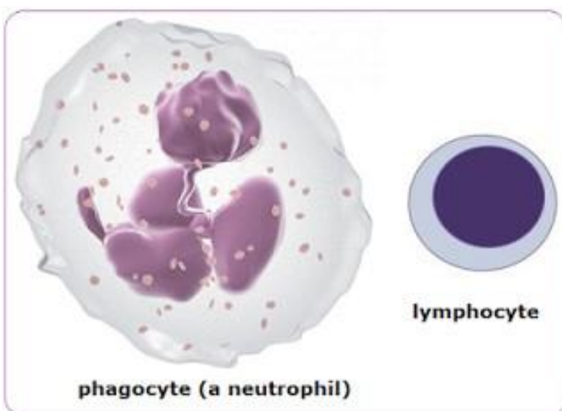
- Old red blood cells are broken down in the liver, spleen and bone marrow. Some of the **iron** from the Hb is stored, and used for making new Hb, some of it is turned into bile pigment and excreted.

2. White blood cells (leukocytes)

- Made in the **bone marrow** and in the **lymph nodes**.
- Have a **nucleus**, often large and **lobed**.
- Can **move around** and squeeze out through the walls of blood capillaries into all parts of the body.
- There are many different kinds of white blood cells. They all have the function of **fighting pathogens** (disease-causing bacteria and viruses) and to clear up any dead body cells in your body:

a.Phagocytes:

- Have **lobed nuclei** and **granular cytoplasm**.
- Can move out of capillaries to the site of an infection.
- Remove any microorganisms that invade the body and might cause infection, **engulf** (ingest) and kill them by **digesting** them.



b. Lymphocytes: produce antibodies to fight bacteria and foreign materials.

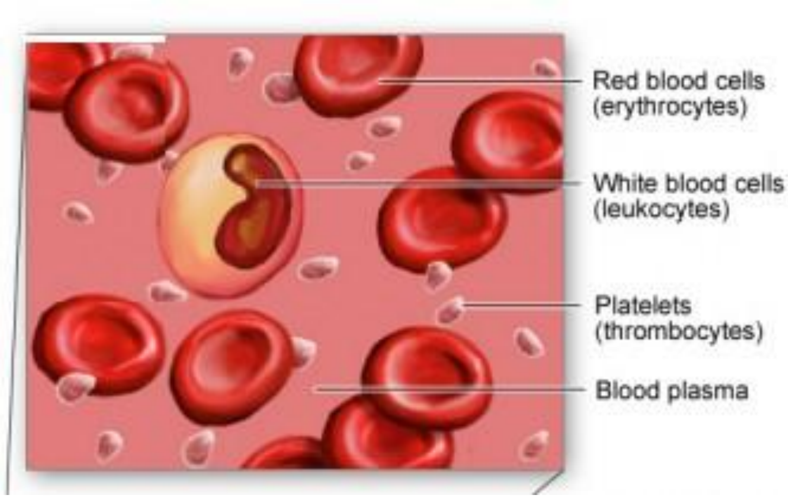
- **Have large nuclei**
- Responsible for **immunity**
- There are two different types of lymphocytes:

B-lymphocytes: secrete special **proteins** called **antibodies** in response to contact with their particular **antigen,** which may be an invading **pathogen** or a **foreign tissue** that has been transplanted.

T-lymphocytes attack **foreign** or **infected** cells and kill them.

3. Platelets (thrombocytes)

- Small fragments of cells, with **no nucleus**.
- Made in the red **bone marrow.**
- Involve in **blood clotting**: form blood clot, which **stop blood loss** at a wound and **prevent** the entry of **germs** into the body.



Functions of the blood

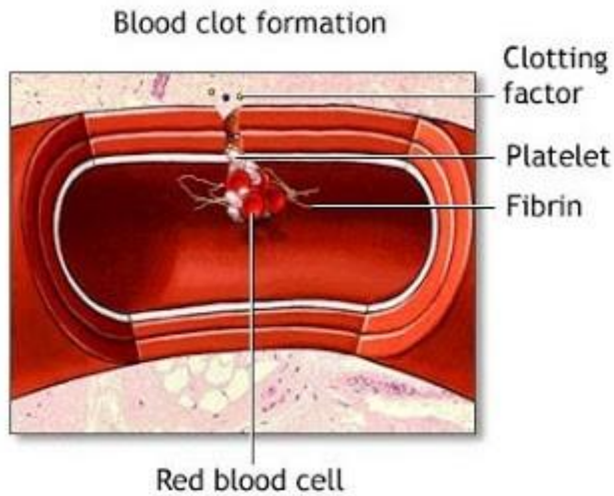
- Transportation of R.B.C's, W.B.C's, oxygen, food nutrients, hormones, and waste products.
- Defence against disease, by white blood cells phagocytosis and production of antibodies.
- Supplying cells with glucose to respire and keep a constant temperature.

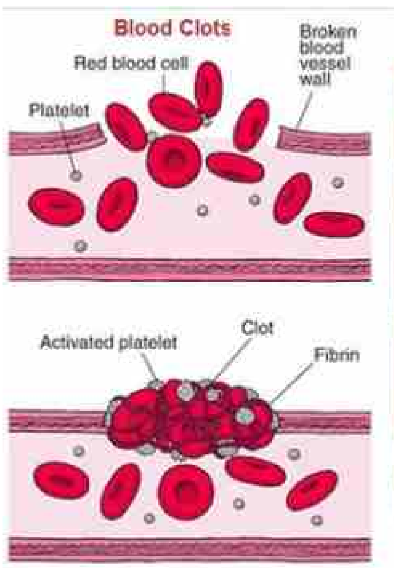
#75 Blood clotting

When an injury causes a blood vessel wall to break, platelets are **activated**. They change shape from round to **spiny**, stick to the broken vessel wall and each other, and begin to **plug** the break.

The platelets also interact with **fibrinogen**, a **soluble** plasma **protein**, to form **insoluble fibrin**. **Calcium** is required for that.

Fibrin strands form a **net** that entraps more platelets and other blood cells (red cells and white cells), producing a **clot** that plugs the break.





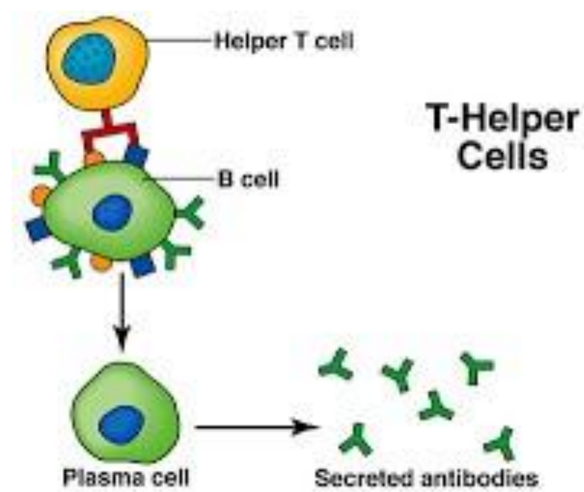
Necessity for blood clotting

- Prevent excessive blood loss from the body when there is a damage of the blood vessel.
- Maintain the blood pressure.
- Prevent the entry of microorganism and foreign particles into the body.
- Promote wound healing.

Video

#76 Immune system - antibody production,
tissue rejection & phagocytosis

The **immune system** is the body's defence against disease and foreign bodies, under the form of **antibody production**, **tissue rejection** and **phagocytosis.**



Antibody production

Antibodies are produced by **lymphocytes**, which are formed in lymph nodes. Lymphocytes produced **antibodies** in response to the presence of **pathogens** such as bacteria. This is because **alien cells** have chemicals called **antigen** on their surface**.** A different antibody is produced for each antigen.

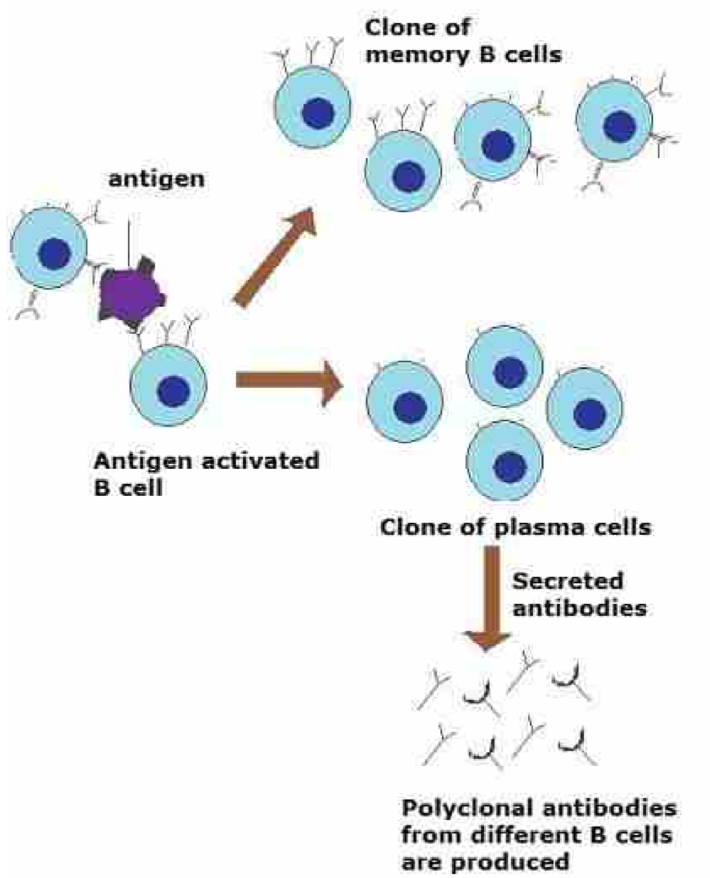
The antibodies make bacteria **clump** together in preparation for action by **phagocytes**, or neutralise **toxins** produced by the bacteria. Once antibodies have been made, they remain in the blood to provide long-term protection.

Some lymphocytes **memorise** the antigens the body has been exposed to. They can rapidly reproduce and produce antibodies to respond to further infections by the same pathogen (disease-causing organism).

Tissue rejection

Transplants involve **replacing** a damaged organ with a donor organ. Unfortunately, lymphocytes and phagocytes will respond to any foreign cells in your body, even if they are not pathogens.

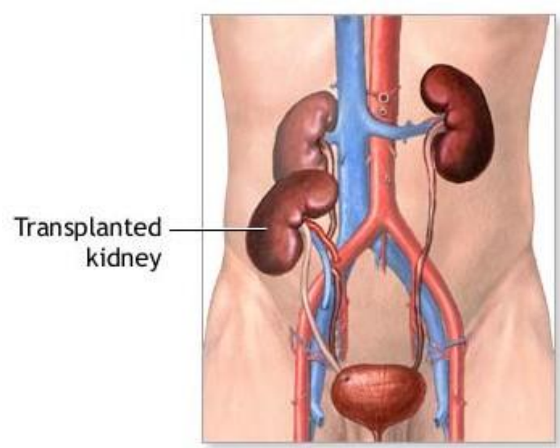
If a person's **kidneys** fail, they can be given a new kidney taken from another person. However the recipient's immune system will recognise the cells in the new kidney as '**foreign**', and will attack and destroy them.
The transplanted organ triggers an immune response, **antibodies** are secreted and the organ may be rejected. This is called **tissue rejection.**



To prevent this happening:

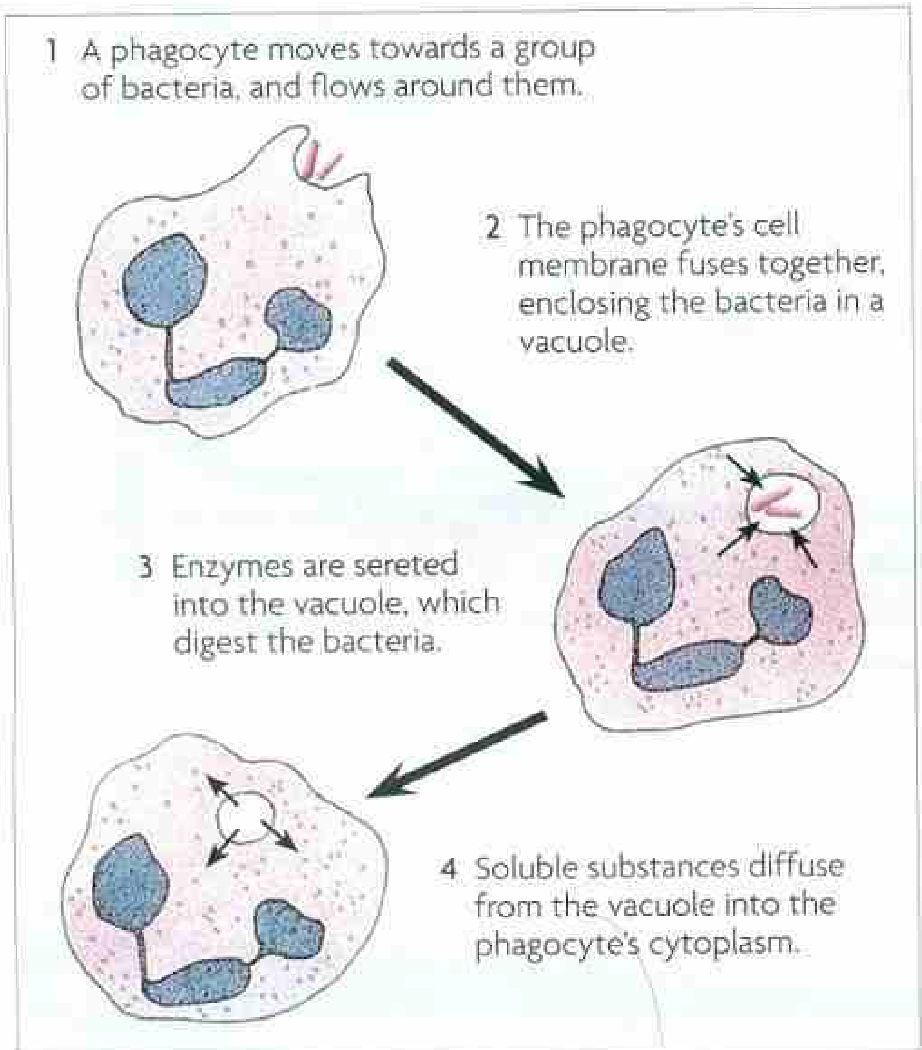
- The donor organ needs to be a **similar** tissue type to that of the patient e.g. from a close **relative**.

- **Immunosuppressive** drugs are uses, which switch off the body's immune response. While recovering, transplant patients are at risk of dying from any disease they are exposed to, so they need to be kept in **isolation**.



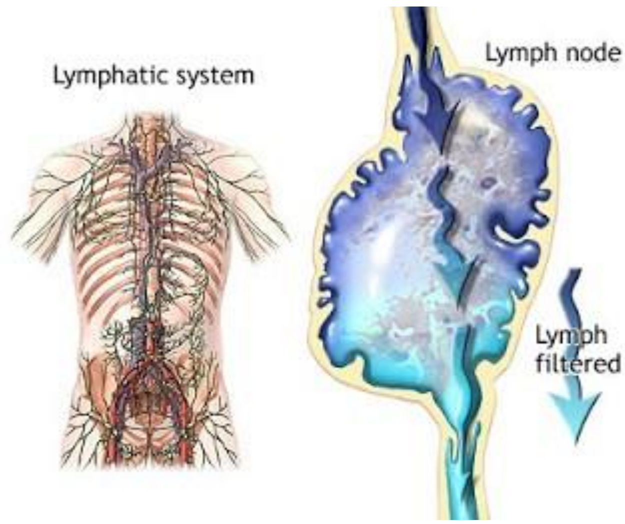
Phagocytosis

Phagocytes have the ability to move out of capillaries to the site of an infection. They then engulf (ingest) the infecting pathogens and kill them by digesting them.



Video: Phagocytosis of a Paramecium (unicellular ciliate protozoa)

77 Functions of lymphatic system

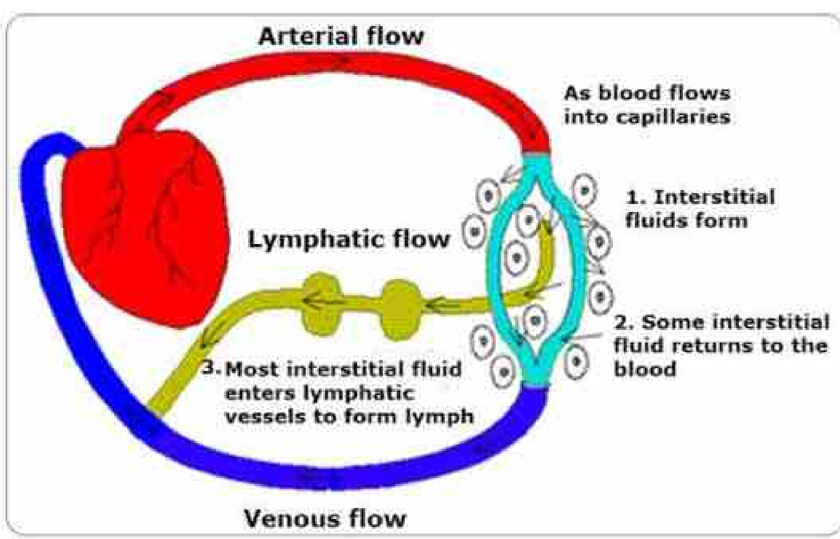


The **lymphatic system** is a collection of lymph **vessels** and **glands**. It has 3 main roles:

- **Fluid balance**: return **tissue fluid** to the blood
- **Protection from infection**: produce white blood cells **lymphocytes**
- **Absorption of fats**: transport digested **fats** from **villi** to blood stream

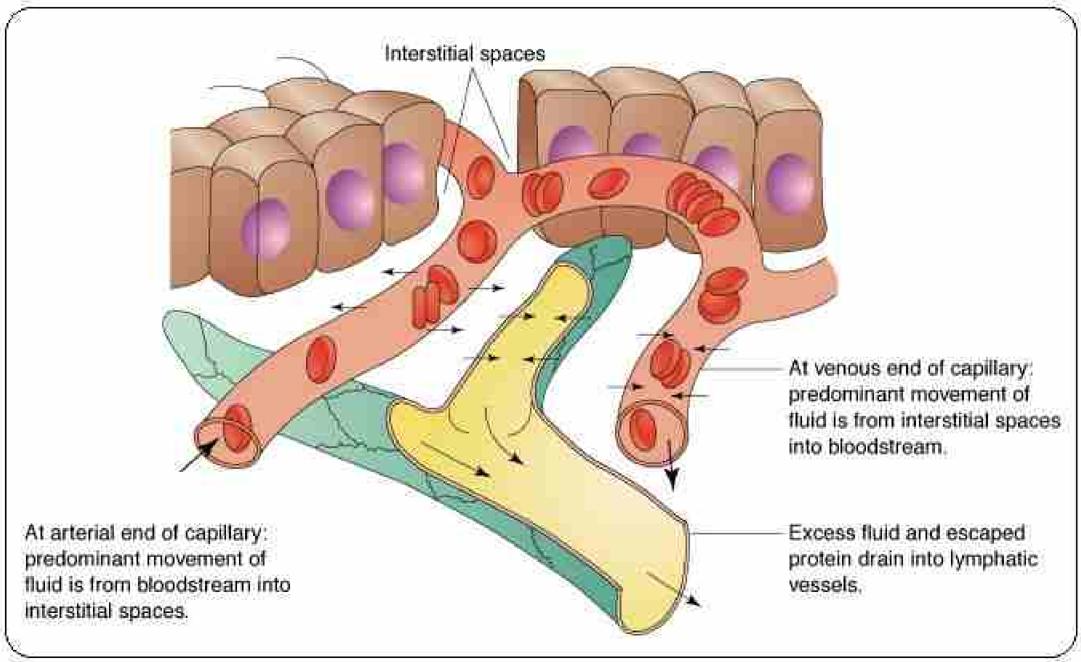
1. Lymph and Tissue Fluid

Tissue fluid is a fluid surrounding the cells of a tissue. It is **leaked plasma** - Plasma from the blood capillaries move to the tissue through gaps in the walls and become tissue fluid.



Tissue fluid play an important role in **substance exchange** between blood and cells. It supplies cells with **O_2** and **nutrients** and takes away **waste** products including **CO_2**.

At the end of the capillary bed, the tissue fluid leaks back into the blood, and becomes plasma again, but not all of it. A little of it is absorbed by the lymphatic vessel and becomes **lymph**.



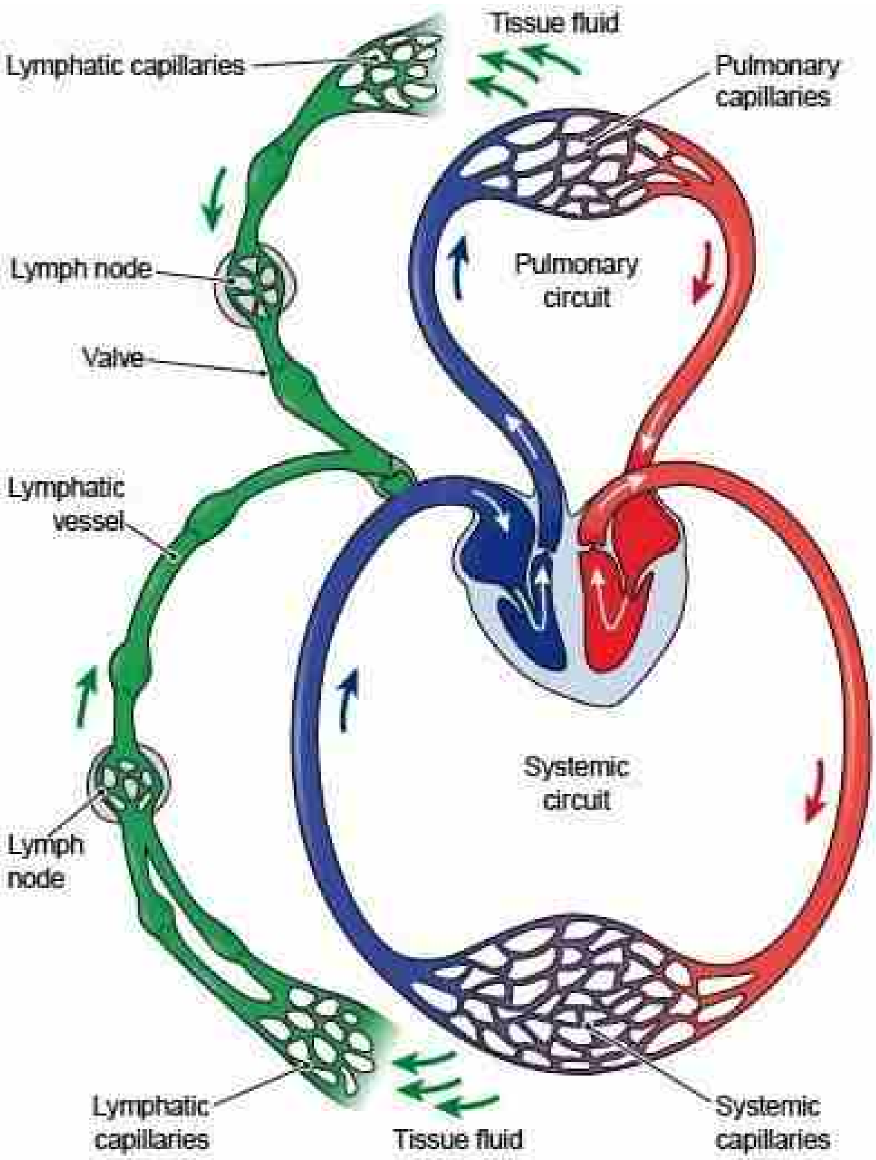
The lymphatic vessel takes the lymph to the blood stream by secreting them in a vein near the heart, called **subclavian vein**. The lymph in the lymphatic vessels are moved along by the squeeze of muscles against the vessel, just like some veins.

The return of tissue fluid to the blood in the form of lymph fluid prevents fluid built up in the tissue.

2. Production of lymphocytes

The lymphatic system is an important component of the **immune system**, which fights infection. One group of white blood cells, the lymphocytes, are made in **lymph glands** such as the **tonsils**, **adenoids** and **spleen**. The glands become more active during an infection because they are producing and releasing large numbers of lymphocytes.

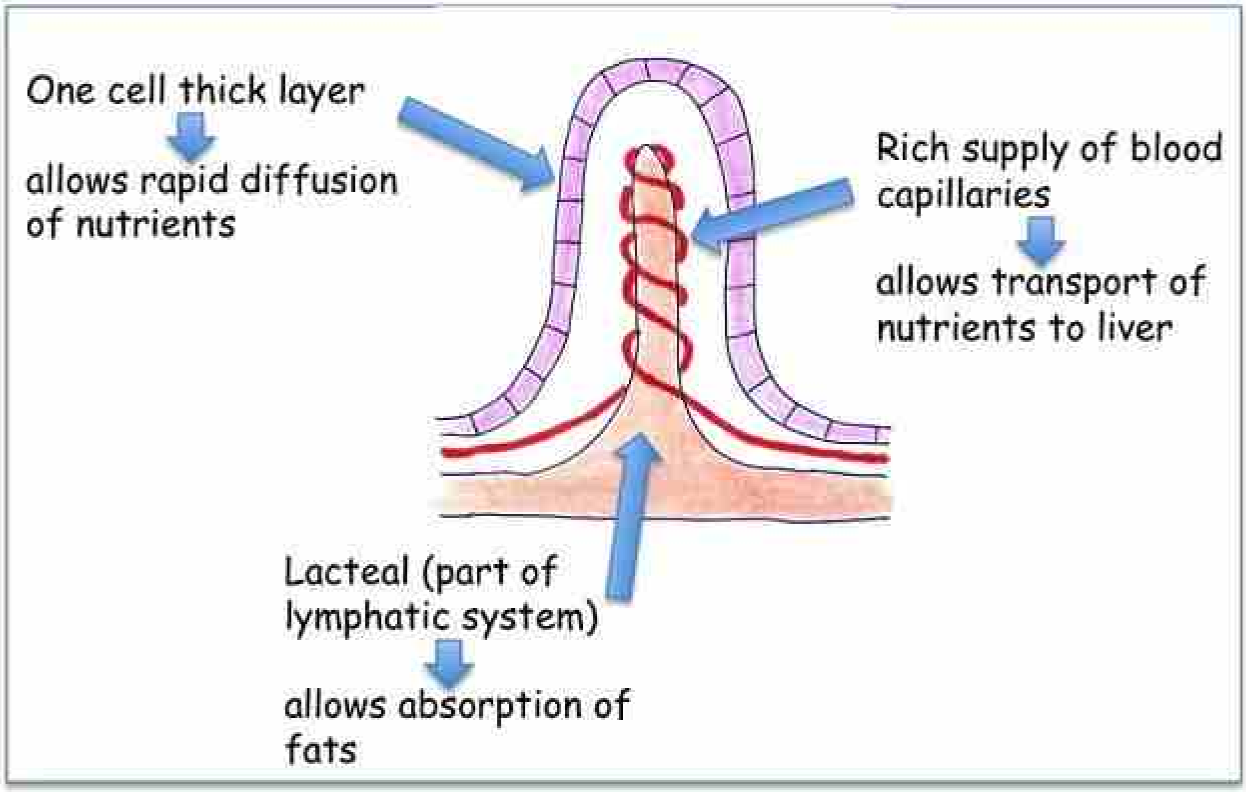
The lymphocytes can live and **multiply** in the lymphatic system, where they attack and destroy **foreign organisms**. Lymphoid tissue scattered throughout the body filters out pathogens, other foreign matter and cellular debris in body fluids.



Tissue fluid
Lymphatic capillaries
Pulmonary capillaries
Lymph node
Pulmonary circuit
Valve
Lymphatic vessel
Systemic circuit
Lymph node
Lymphatic capillaries
Tissue fluid
Systemic capillaries

3. The absorption of fatty acids and glycerol from the small intestine

Following the chemical and mechanical breakdown of food in the digestive tract, most nutrients are absorbed into the blood through **intestinal capillaries**. Many digested **fats**, however, are **too large** to enter the blood capillaries and are instead absorbed into **lymphatic capillaries** by **intestinal lacteals.** Fats are added to the blood when lymph joins the bloodstream.

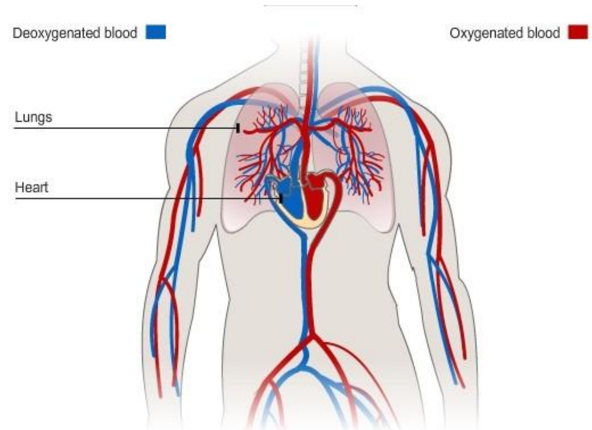


Each villus contains a lacteal - a blind ending lymph vessel.

Additional source: **lubopitko-bg**
Xtremepapers
Related topic: Absorbtion – function of the small intestine and significance of villi

Video

#78 Summary of human transport



- Mammals have a double circulatory system, in which blood is moved through vessels by the regular contraction and relaxation of cardiac muscles in the wall or the heart.

- Blood enters the atria of the heart, flows through open vales into the ventricles, and is then forced out into the arteries during systole.

- The ventricles have thicker walls than the atria, and the left ventricle has a thicker wall than the right ventricle, to allow them to produce a greater force when the muscles contract, necessary so that they can push the blood further.

- In coronary heart disease, the coronary arteries become blocked, so oxygen is not delivered to the heart muscles and they stop contracting. Smoking, stress and a diet high in saturated fats increase the risk.

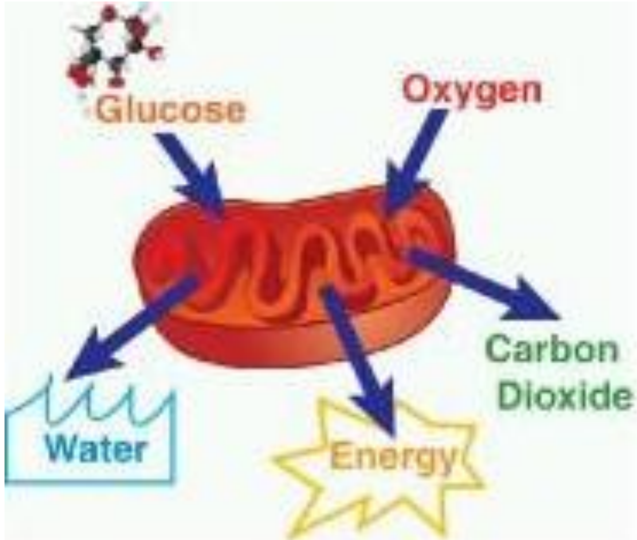
- Arteries are thick-walled, elastic vessels that carry pulsing, high-pressure blood away from the heart. They split into capillaries, which are tiny vessels with walls only one cell thick. Capillaries take blood close to every cell to the body, so that the cells are supplied with oxygen and nutrients and have their waste products removed. Capillaries join up to form veins. Veins are thin-walled vessels with valves, which carry low-pressure blood back to the heart.

- Blood contains red cells, white cells and platelets floating in plasma. Plasma transports many different substances in solution. Red cells contain the iron-containing protein haemoglobin, which transports oxygen. White cells fight against bacteria and viruses. Platelets help the blood to clot.

- Fluid leaks out of capillaries to fill the spaces between all the body cells, where it is called tissue fluid. It is collected into lymph vessels which carry it back to the bloodstream.

08 Respiration

 # 79 Respiration realeases energy from food



Respiration is the **chemical reactions** that **break down nutrient molecules** in living cells to **release energy**.

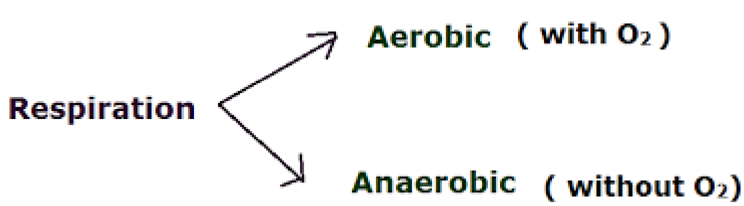
In humans, our cells need energy (ATP) for:

- muscle contraction
- making protein molecules: linking together amino acids into long chains
- cell division: to repair damaged tissues and so that we can grow
- active transport
- transmitting nerve impulses
- maintenance of constant body *t*°

All this energy comes from the food we eat. Water soluble molecules are absorbed from the intestine into the blood.

The main energy–providing nutrient: **glucose** (contains a lot of chemical energy).

There are 2 types of respiration:



Video

#80. Aerobic and anaerobic respiration

Respiration releases energy from food.

There are 2 kinds of respiration: **Aerobic** and **Anearobic**. The main difference between them is that aerobic respiration involves **oxygen** and anaerobic respiration does not!

A. Aerobic respiration

The release of a relatively **large amount of energy** in cells by the breakdown of food substances in the **presence of O_2**.

glucose + oxygen ⟶ carbon dioxide + water

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

B. Anaerobic respiration

Anaerobic respiration: the release of a relatively **small amount of energy** by the breakdown of food substances in the **absence of O_2**.

Anaerobic respiration in muscles during exercise:

glucose ⟶ lactic acid + energy

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + \text{energy}$$

Anaerobic respiration in yeast:

glucose ⟶ ethanol + carbon dioxide + energy

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{energy}$$

Muscles respire anaerobically when exercising vigorously, because the blood cannot supply enough oxygen to maintain aerobic respiration. Howerver, the formation and build-up of lactic acid in muscles causes cramp (muscle fatigue).

The lactic acid that is made is transported to the liver, and later is broken down by combining it with O_2. This extra O_2 is breathed in after the exercise has stopped, and it is known as the **oxygen debt**.

Bread making

- yeast is mixed with water to activate it then added to flour to make dough

- mixture -----> warm place ------> rise

- yeast releases CO_2 ------> dough rises
* a warm t^o is important because fermentation is controlled by enzymes

- when dough is cooked, high t^o kills yeast and evaporates any formed ethanol
- air spaces are left where CO_2 was trapped

Brewing

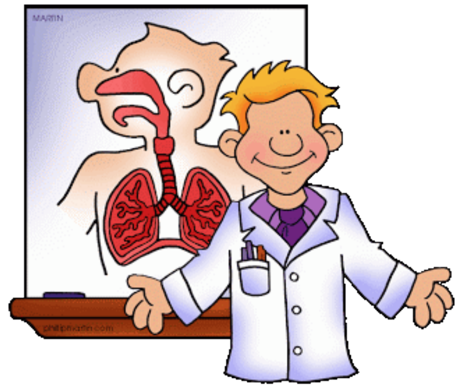
- yeast is added to a source of sugar (fruit juice or germinated barley grains) and kept in warm conditions

- fermentation (yeast respires the sugar) occurs ------> ethanol is formed making the drink alcoholic

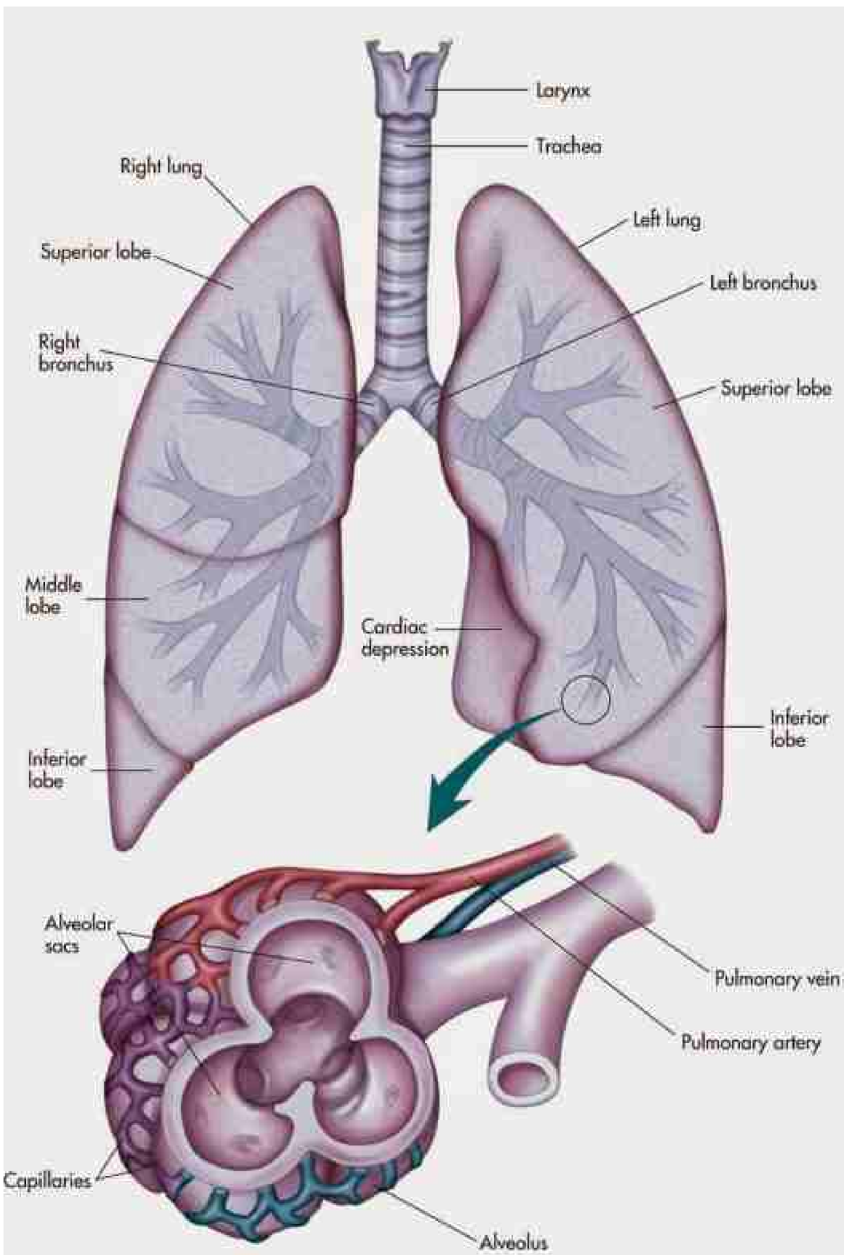
- CO_2 makes the drink fizzy + sharp flavour

#81. Gaseous exchange, role of mucus and cilia

Gas exchange usually involves **2 or more gases** transferred in **opposite** directions across a **respiratory surface**.



1. Structure of the breathing system: the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries.

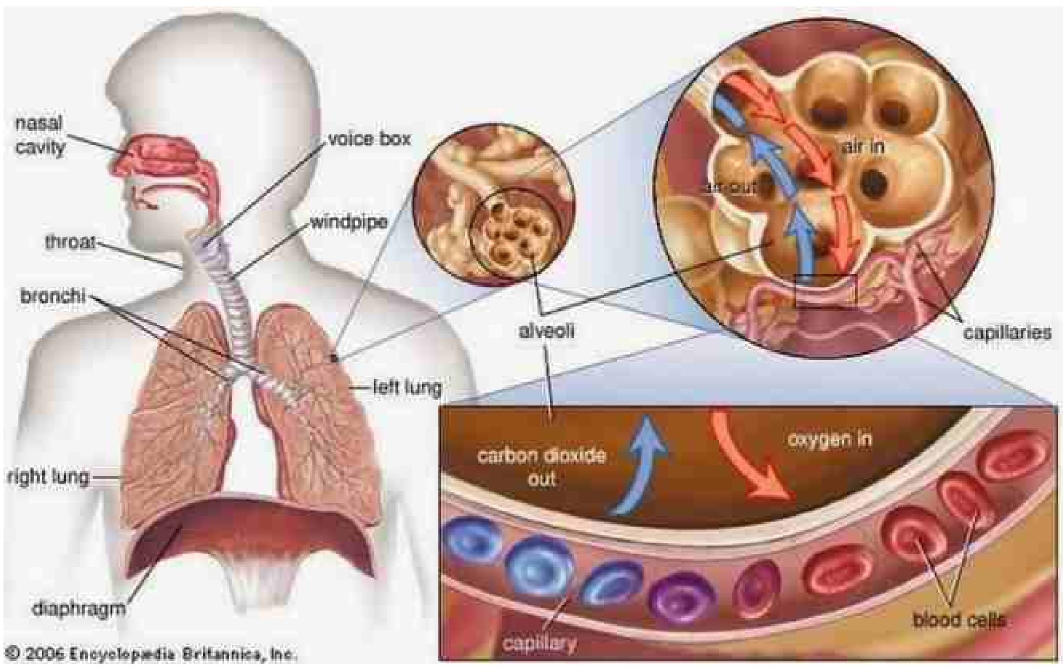


Credit: biology-forums.com

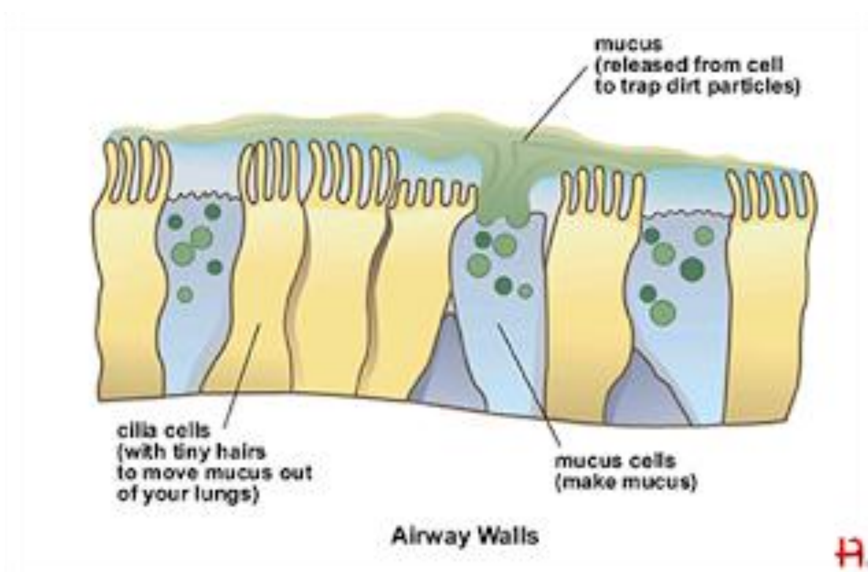
2. Gaseous exchange relies on diffusion. To be efficient, the **gaseous exchange surface** must:

- **thin** – shorter distance to diffuse
- **moist** – allow gases to dissolve
- **large surface area**
- have a **concentration gradient** across surface – maintained by movement of air and transport/ use of gas.

These features are present in gills (fish) and alveoli (lungs).



3. The role of mucus and cilia



- Inside the nose, thin turbinal bones are covered with a layer of cells. Some of which are **goblet cells**.

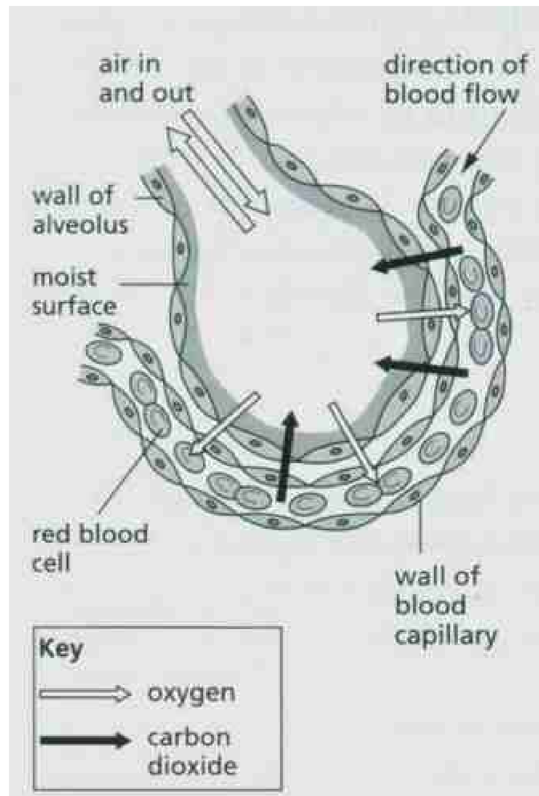
- Goblet cells produce a **liquid** (water + **mucus**) ---> evaporate ---> moisten nose.

- Cilia: tiny hair-like projections; constantly moving

- Bacteria + dust particles are **trapped** by cilia and mucus as to not move further inside the gas exchange system.

Try this

State how each feature labeled on the diagram of an alveolus makes the process of gaseous exchange efficient. [5 marks]



Answer

Wall of alveolus – one cell thick (or very thin) so that diffusion happens quickly.

Moist surface- allow O_2 to dissolve making diffusion faster.

Blood is moving – so that's concentration gradient is maintained for O_2 and CO_2

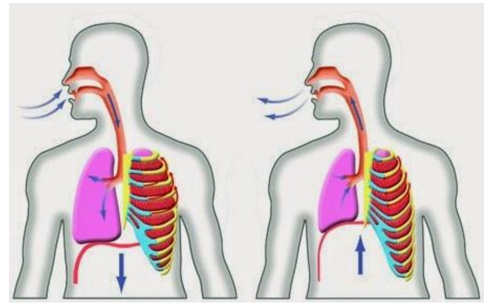
Wall of capillary – one cell thick (or very thin) so that's diffusion happens quickly.

Red blood cells – contain haemoglobin to transport O_2 away from the lungs.

Video: Gas exchange

Video: Functions of Cilia and Goblet Cells

#81 Inspired and expired air, blood pH and breath rate



* inspired air: air we breath in
* expired air: air we breath out

The composition of inspired and expired air

Testing for CO_2

To investigate the differences in composition between inspired and expired air, we use **limewater** because **it change colour** when the gas is bubbled through, from colourless to **milky**.

There is more CO_2 present in **expired air**
---> it makes limewater change colour more **quickly** (than inspired air).

Effects of physical activity on breathing

** tidal volume: amount of air during normal, relaxed breathing*
vital capacity; maximum amount of air breathed in or out in one breath

During normal breathing:
- depth (tidal volume) : ≈ 0.5ℓ
- rate: 12 breaths/ minute

During exercise:
- depth: ≈ 5ℓ (depending on age, sex, size & fitness of person)
- rate: over 20 breaths/ minute

The total lung volume is greater than vital capacity (some air always remains in the lungs). If not, alveoli walls would stick together, the lung would collapse.

Link between physical activity and rate and depth of breathing

- when you run, muscles in your legs use up a lot of energy.
- cells in the muscles need a lot of O_2 very quickly.
- they combine **O_2 + glucose** as fast as they can, to **release energy** for muscle construction ---> a lot of O_2 is needed
- you breath **deeper** and **faster** to get **more O_2** into your blood.
- your heart beast faster to get O_2 to the leg muscles as quickly as possible.
- a **limit** is reached - the heart and the lung can not supply O_2 to the muscles any faster.
- some extra energy (not much) is produced by **anaerobic respiration:** some glucose is broken down without combing with O_2:

Glucose ---> lactic acid + energy.

- **CO2** and **lactic acid** concentration in tissue and in the blood ↑ ---> blood **pH** ↓
- Brain sens the change ---> nerve impulses sent to the diaphragm and the intercostal **muscles**, stimulating them to **contract harder** and **more often** ---> **faster** and **deeper** breathing.

Try this

a) The composition of the air inside the lungs changes during breathing.
i) State **three** differences between inspired and expired air. [3 marks]
ii) Gaseous exchange in the alveoli causes some of the changes to the inspired air. Describe **three** features of the alveoli which assist gaseous exchange. [3 marks]

b) i) State what is meant by anaerobic respiration [2 marks]
ii)Where does anaerobic respiration occur in human? [1mark]

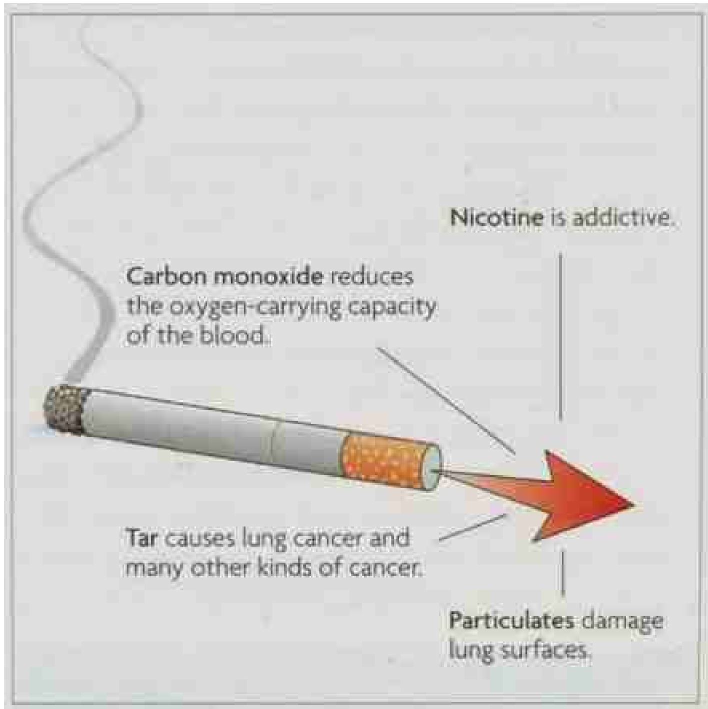
Answer
a) i) Inspired air contains more O_2, less CO_2, and less water vapor then expired air.
ii) **Three** features from:

- the wall of the alveolus is one cell thick (or very thin)
- there is a moist surface to the alveoli
- there are large number of alveoli
- the air in the alveoli is constantly being replaced.

b) i) The release of energy by cells without the use of oxygen.
ii) In muscle cells.

#82 Effects of tobacco smoke on the respiratory system

Tobacco smoke contains **irritants** and **carcinogens**.
Its 4 main toxic chemicals: **carbon monoxide, nicotine, smoke particles** and **tar.**



Carbon monoxide:
- combines with haemoglobin in RBC ---> prevents them transporting O_2.

Nicotine:
- addictive ---> continual smoking

Smoke particles:
- irritate air passages ---> inflammation + increase mucus production ---> chronic bronchitis.
- presence of smoke particles in alveoli + coughing = emphysema (breathlessness)

Tar:
- a carcinogen: increase risk of lung cancer (cell division out of control)
- lines air passages:
    - increase mucus production
    - paralysing + damaging cilia
    ---> bronchitis

Common misconceptions

Remember that only nicotine and carbon monoxide enter the blood. Tar and smoke particles do not – they stay in the lungs.

Sample question

The table shows the percentage of haemoglobin which is inactivated by CO present in the blood of taxi drivers in a city.

City taxi drivers	Percentage of Hb inactivated by CO	
Daytime drivers	Non-smokers	2.3
	Smokers	5.8
Night-time drivers	Non-smokers	1.0
	Smokers	4.4

i) Suggest two sources of the CO inhaled by these taxidrivers [2marks]

ii) Some daytime drivers have 5.8% of their Hb affected. Using information from the table, explain which source contributes most to this effect. [2 makrs]

iii) Suggest a reason for the differences, shown in the table, between daytime and night-time drivers. [1 mark]

Studen's answer

i) 1. cigarette smoke ✓
2. breathing by passengers ✗

ii) It must be cigarette smoking because non-smokers have less of their Hb affected. ✓

iii)Therer could be less car exhaust fumes, containing CO, at night. ✓

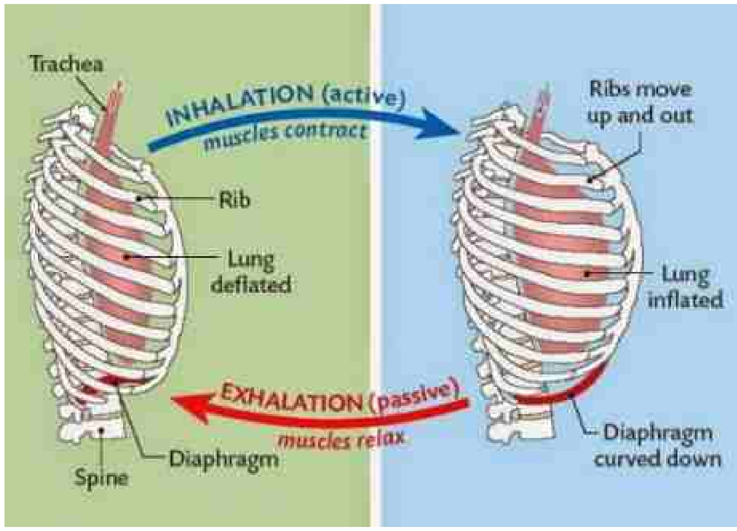
Examiner's comments

In part (i), the second answer if biologically incorrect (we breath out CO_2, not CO. The other correct answer was car exhaust gases.

In part (ii), the answer and the explanation were correct.

Part (iii) war a good answer.

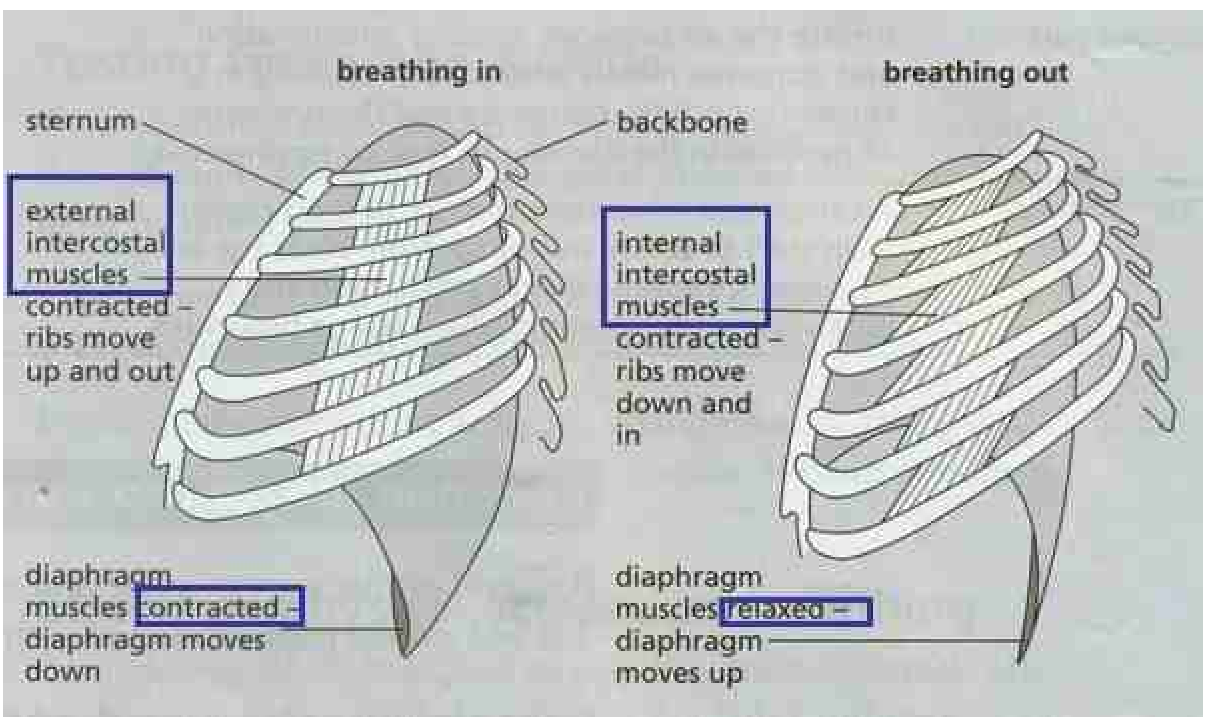
#83 Ventilation, role of intercostal muscles and diaphragm



There are 2 sets of muscles which help you to breath:
- **intercostal**: between the ribs

- **diaphragm**: a large sheet of muscle and elastic tissue, underneath the lungs and heart.

Figure below shows the relationship between intercostal muscles, diaphragm and ribcage to achieve ventilation of the lungs.



Two set of intercostal muscles are attached to the ribes. They are antogonistic.

1. Breathing in (inhaling)

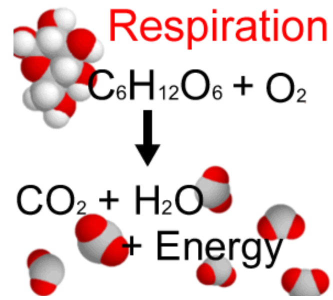
- The **external intercostal muscles** contract, they move the ribcage upward and outward ---> ↑ volume of the thorax.
- The diaphragm muscles **contracts** ---> diaphragm moves **down**
- ↑ volume of the thorax
- ↓ air pressure in the thoracic cavity
- air rush **into** the lungs through the mouth or nose.

2. Breathing out (exhaling)
The opposite happens:

- The **internal intercostal muscles** contract
- The diaphragm muscles **relax** ---> diaphragm moves **up**
- ↓ volume of the thorax
- ↑ air pressure in the thoracic cavity
- air rush **out** of the lungs.

Features	**Inspiration**	**Expiration**
Intercostal muscles	**external** muscles contract	**internal** muscles contract
Ribcage moving	**upward** outward	**downward**
Diaphragm muscles	**contract**	**relax**
Diaphragm	move ↓	move ↑
Thorax volume	↑	↓
Air pressure in thorax cavity	↓ lower than air pressure outside	↑ higher than air pressure outside
air rushes	**into** the lungs	**out** of the lungs

#84 Summary of Respiration



- **Respiration** is a series of metabolic reactions that takes place in every living cell. The purpose of respiration is to **release energy** from **glucose**, so that the cell can make use of the energy.

- In **aerobic** respiration, the glucose is combined with O_2, forming CO_2 and H_2O.

- In **anaerobic** respiration, the glucose is broken down without being combined with O2. In plants and fungi, this produces alcohol and CO_2.

- In animals (including human) it produces lactic acid.

- Muscles respire aerobically when they are working so fast that they cannot be supplied with O_2 quickly enough. The lactic acid that is made is transported to the liver, and later is broken down by combining it with O_2. This extra O_2 is breathed in after the exercise has stopped, and it is known as the **oxygen debt**.

- All gas exchange **surfaces** need to be thin, have a large surface area, be kept moist, and have a good supply of O_2. In larger animals, a transport system is needed to carry away the CO_2 and bring O_2.

- The air we breath in travels down the **trachea** and **bronchi**, through the **bronchioles** and into the **alveoli**.

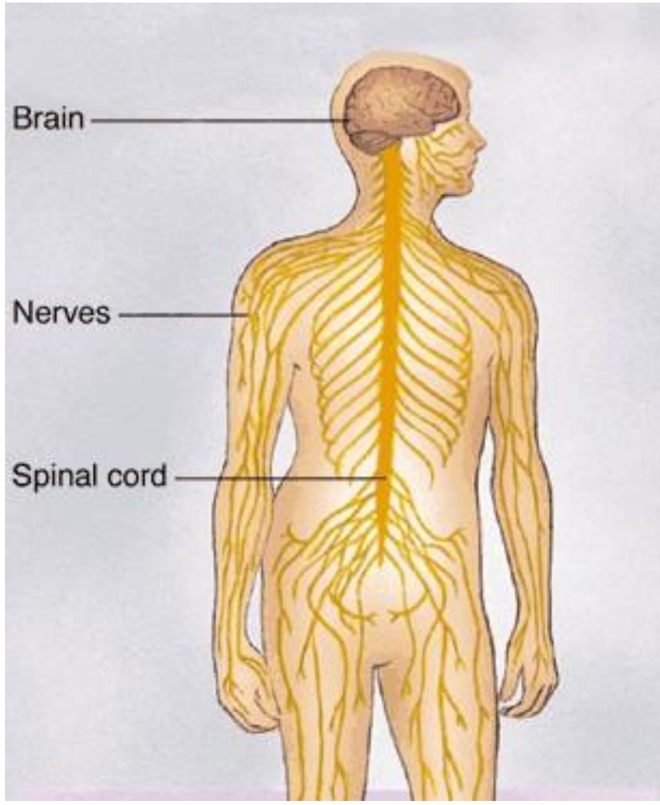
- Some of these tubes are lined with **goblet cells** which make mucus, and **ciliated** cells. The mucus traps dirt, bacteria and other particles and the cilia sweep the mucus up and away from the lungs.

- Air is drawn into the lungs by the contraction of the **external intercostal muscles** and the muscles in the **diaphragm**. These muscle contractions increase the volume of the thorax, which decreases the pressure. Air flows down the pressure gradient and into the lungs.

- **Tobacco smoke** contains many different substances that harm health. **Nicotine** is an addictive stimulant, and its intake increases the risk of developing heart diseases. **Tar** causes lungs and other cancers. **CO_2** reduces the ability of red blood cells to transport O_2. Smoke particles irritate the lungs and can contribute to the development of emphysema.

09. Coordination and response

85 The human nervous system



The human nervous system is made up of two parts:

- ***Central*** *nervous system* (CNS) - **brain** and **spinal cord**: role of coordination
- ***Peripheral*** *nervous system* - **nerves**: connect all parts of the body to the CNS.

Together, they coordinate and regulate body functions.

Sense organs are linked to the peripheral nervous system. They are groups of receptor cells responding to specific stimuli: light, sound, touch, temperature and chemicals. When exposed to a stimulus they generate an electrical impulse which passes along peripheral nerves to the CNS, triggering a response.

Peripheral nerves contain **sensory** and **motor** neurones (nerve cells).

	transmit nerve impules
Sensory neurone	sense organs →·CNS
Motor neurone	CNS → effectors (muscles or glands)

Motor and sensory neurones are covered with a **myelin sheath**, which insulates the neurone to make transmission of the impulse more efficient.

The cytoplasm (mainly **axon** and **dendron**) is elongated to transmit the impulse for long distances.

Structure	Sensory neurone	Motor neurone
Cell body	Near end of neurone, in a ganglion (swelling) just outside the spinal cord	At start of neurone, indise the grey matter of the spinal cord
Dendrites	Present at end of neurone	Attached to cell body
Axon	Very short	Very long
Dendron	Very long	None

Fun fact: The human nervous system runs on electrical impulses that travel close to the speed of light.

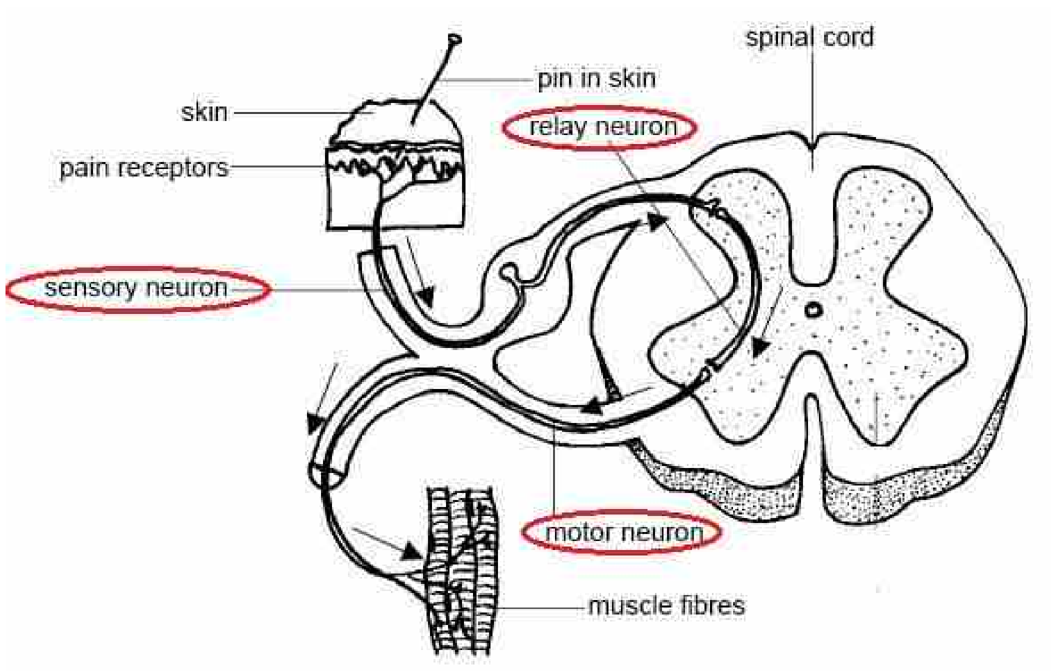
Sample question and answer

Question Figure above shows a type of neurone. Name this type of neurone and state a reason for your choice. [2 marks]

Answer Name: *motor neurone.*
Reason: *It has a cell body, the cell body is at the and of the cell.*

Video: The Human Nervous System
Video: The Spinal Cord
Video: Human Body Nervous System

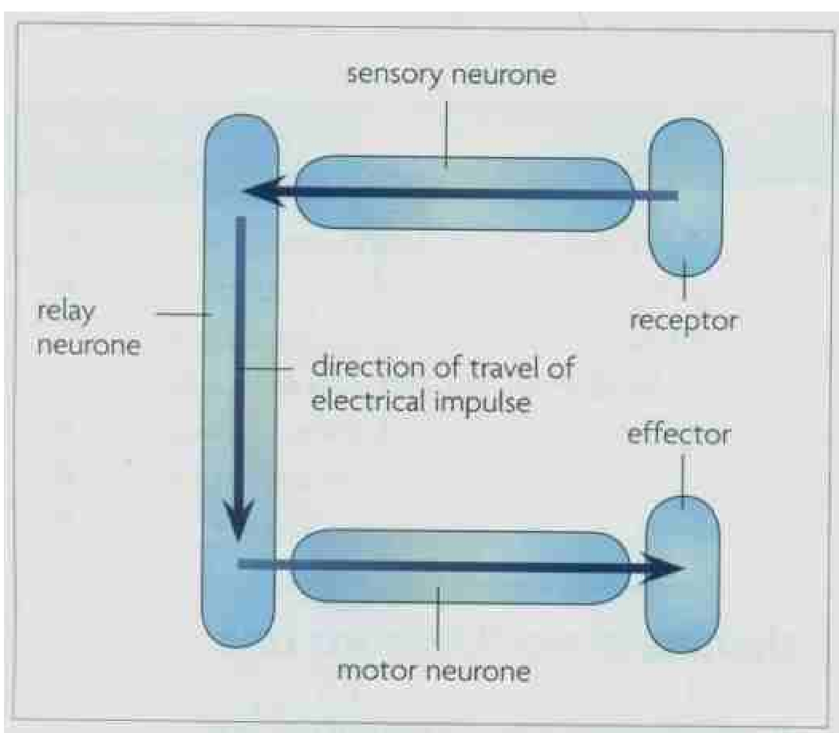
#86 Simple reflex arc



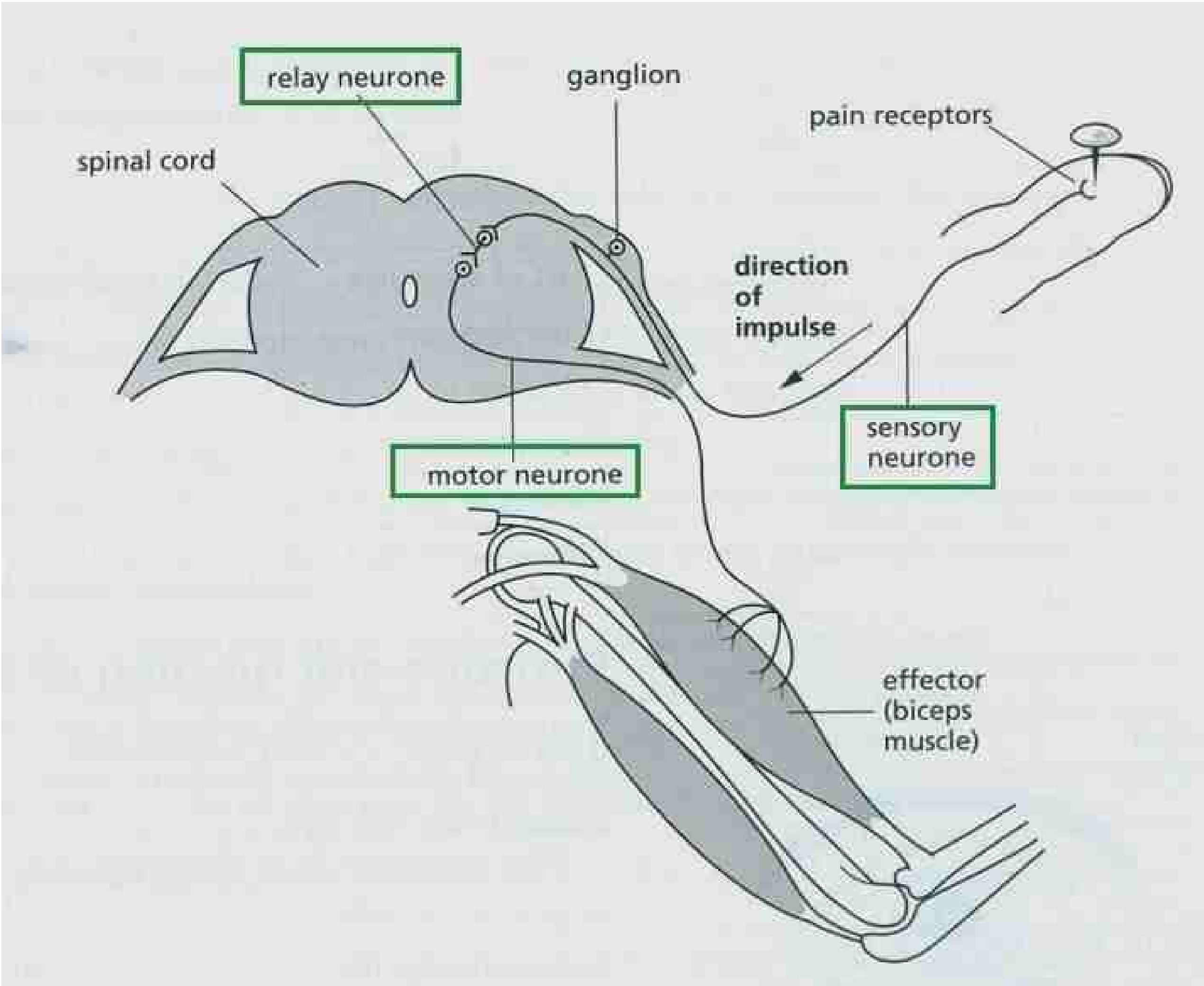
A **reflex** action is an **automatic response** to a stimulus.

A **reflex arc** describes the **pathway** of an **electrical impulse** in response to a stimulus.

Relay neurones are found in the spinal cord, connecting **sensosy** neurones to **motor** neurones.



On the picture below, the stimulus is a drawing-pin sticking in the finger.
The response is the withdrawal of the arm due to contraction of the biceps.



The sequence of events is:

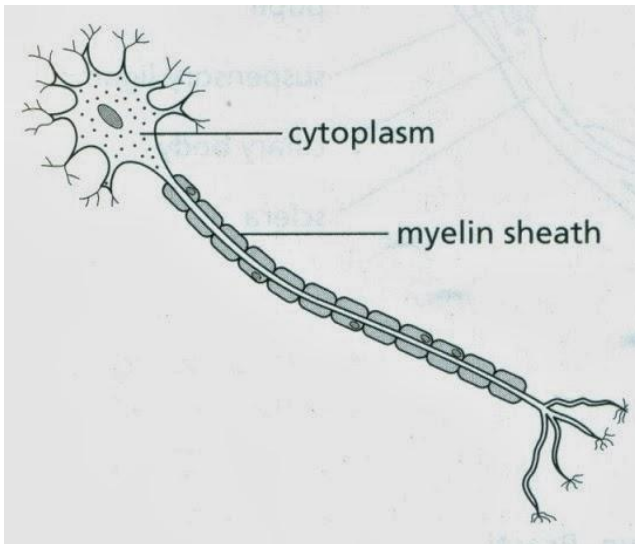
- **Stimulus** (sharp pin in the finger)
- **Receptor** (pain receptor in skin)
- **Coordinator** (spinal cord)
- **Effector** (biceps muscle)

Reflex: automatically and rapidly integrating and coordinating stimuli with responses

Neurones do not connect directly with each other: there is a gap called a synapse. The impulse is 'transmitted' across the synapse by means of a chemical called acetylcholine.

Try this

Figure below shows a nerve cell.



a. i) Name the type of nerve cell shown in the figure [1 mark]

ii) State two features that distinguish it from other types of nerve cell [2 mark]

iii) Where, in the nervous system, is this cell located? [1 mark]

b. Nerve cells are specialised cells. Suggest how the following parts of the nerve cell, labelled in the figure, enable the nerve cell to function successfully:
cytoplasm; myelin sheath. [4 mark]

c. Reflex involve a response to a stimulus.

i) Copy and completes the flowchart by putting the following terms in the boxes to show the correct sequence in a reflex. [2 marks]

ii) For the pupil reflex , identify each of the parts of the sequence by copying and completing the table below. The first has been done for you. [4 marks]

Part of sequence	Part in pupil reflex
Coordinator	Brain
Effector	
Receptor	
Response	
Stimulus	

Answer

a. i) Motor neurone
ii) Two features from:
- presence of motor end plates
- the cell body is at the beginning of the cell
- the cell body has dendrites on
- there is no dendron (only on axon).

iii) Peripheral nervous system.

b. Cytoplasm: two suggestions from:
- is elongated
- passes electrical signals along
- connects different parts of the body
- is modified to form dendrites.

Myelin sheath: two suggestions from:
- acts as insulating material
- so prevents leakage of electrical signal from axon
- allows faster transmission of impulses.

c. i) flowchart

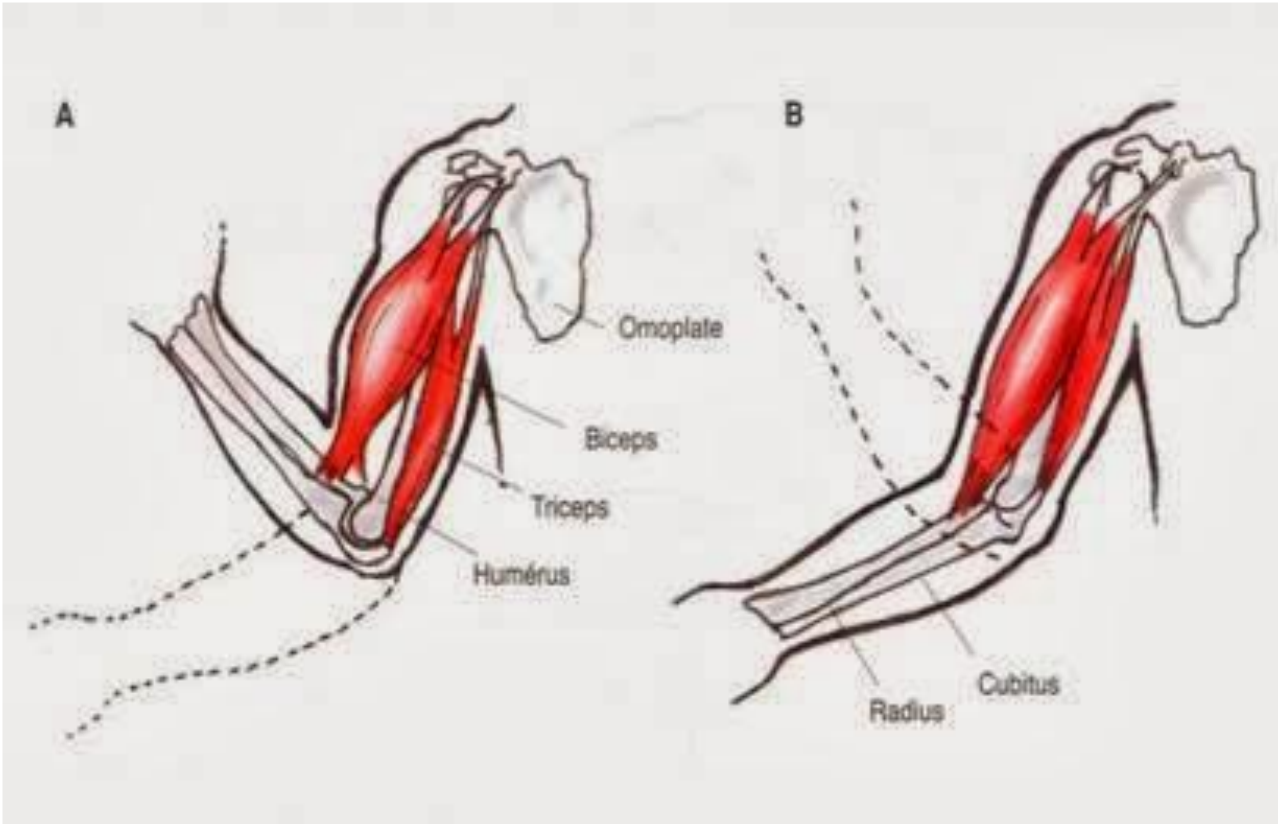
Stimulus ⇨ receptor ⇨ coordinator ⇨ effector ⇨ respons

ii)

Part of sequence	Part in pupil reflex
Coordinator	Brain
Effector	Iris (muscle)
Receptor	Retina or rods or cones
Response	Pupil changes diameter or iris muscles contract
Stimulus	Bright light or change in light intensity

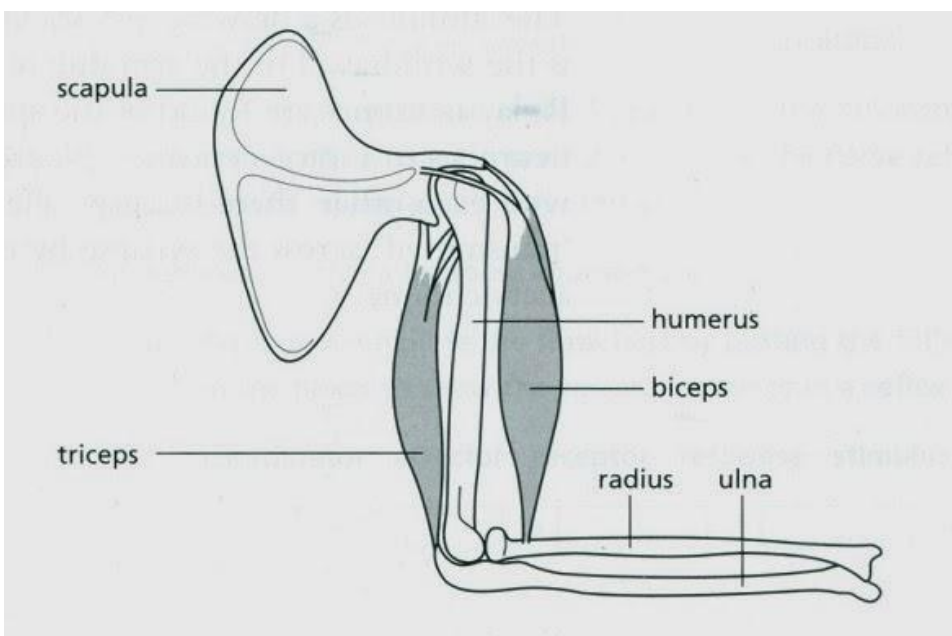
Video: Reflex Arc

#87 Effectors, biceps and triceps



Effectors are muscles or glands which respond when they receive impulses from motor neurones. Examples of effectors are the biceps and triceps muscles in the arm.

Structure of the human arm



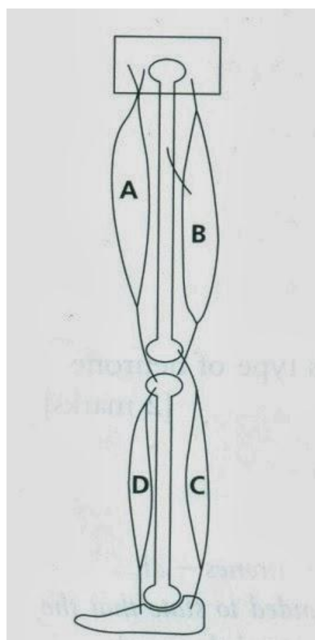
When stimulated, muscles contract get shorter). The biceps and triceps are antagonistic muscles - they have opposite effects when they contract.

The biceps is attached to the scapula (shoulder blade) and the radius. Contraction of the biceps pulls on the radius, moving the lower arm toward the scapula. This results in the arm bending (flexing) at the below - the arm is raised.

The triceps is attached to the scapula, humerus and ulna.
Contractions of the triceps pulls on the ulna, straightening (extending) the arm. In doing so, the triceps pulls the biceps back to its original lengths.

Try this

Figure below is a simplified diagram of the muscles and bones of the human leg.



a) Complete the following sentences.

Muscles are formed from cells which have special property of being able to _____ . Because of this, muscles can not push, they can only ____. [2 marks]

b) Muscles operate as antagonistic pairs. With reference to figure above, explain what is mean by this statement. [2 marks]

c) i) Which muscles **A, B, C** or **D**, must contraction in order to raise the heel to stand on tiptoe? [1 mark]

ii) Which muscles **A, B, C** or **D**, must contract to bend the leg at the knee? [1 mark]

d) When running very quickly, the muscles of the leg may not receive sufficient oxygen to supply all their energy requirements.

i) Name the type of respiration these muscle cells carry out to release additional energy. [1 mark]

ii) Name the waste product produced by this process. [1 mark]

Answer

a) Contract; pull

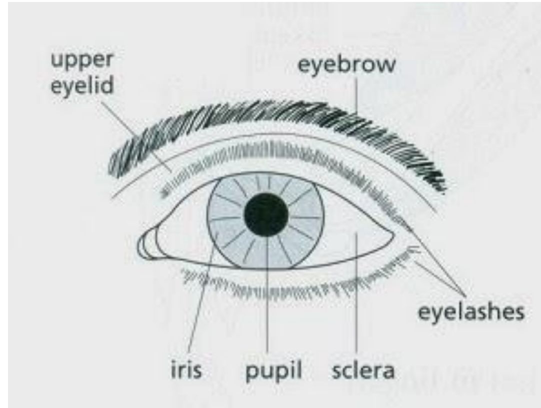
b) Muscles **A** and **B**; and **C** and **D** are antagonistic pairs. They have opposite effects when they contract.

c) i) **C**
ii) **B**

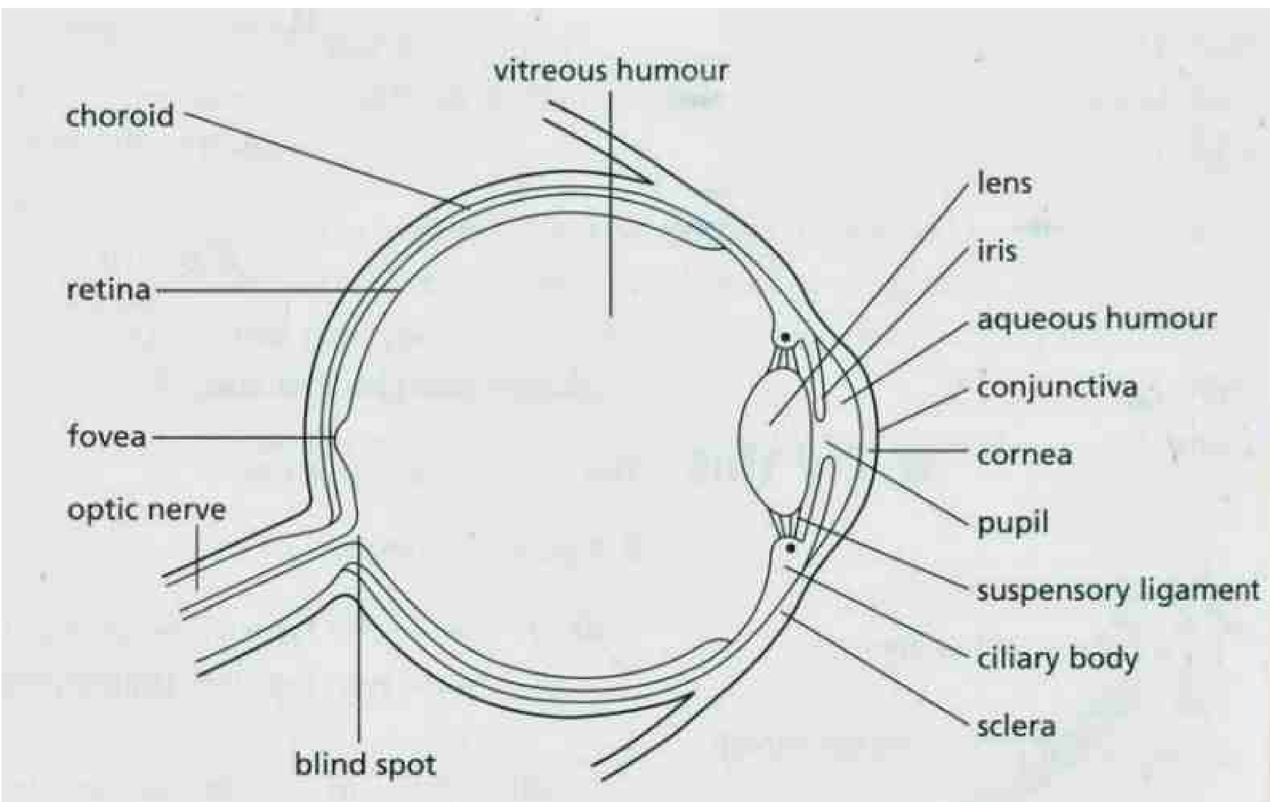
d) i) Anaerobic respiration.
ii) Lactic acid (or lactate).

#88 Structure and function of the eye, rods and cones

You need to be able to label parts of the eye on diagrams.



- The eyebrow stops sweat running down into the eye.
- Eyelashes help to stop dust blowing on to the eye.
- Eyelids can close automatically (blinking is a reflex) to prevent dust and other particles getting ton to the surface of the cornea.
- Blinking also helps to keep the surface moist by moving liquid secretions (tears) over the exposed surface. Tears also contain enzymes that have an antibacterial function.

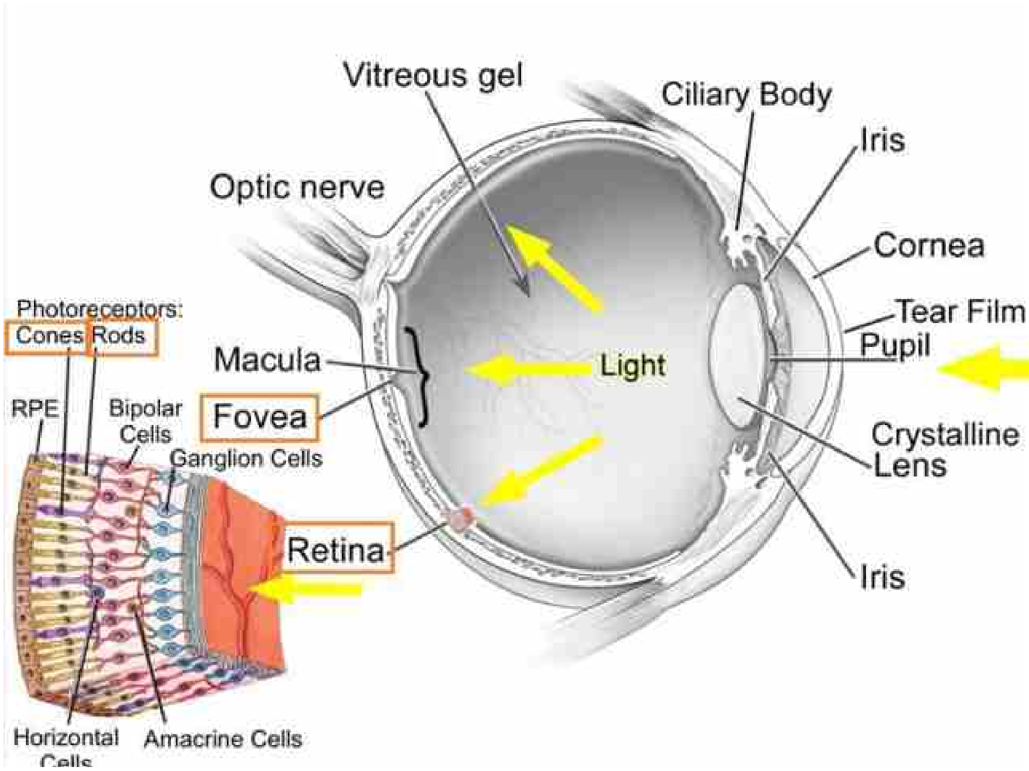


*** Try this**

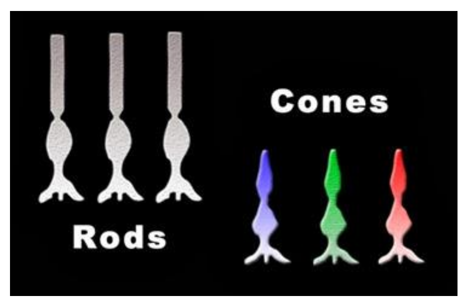
Trace or copy both diagrams of the eyes. Practice adding the labels. [8 marks]

Distinguishing between rods and cones

Rods and cones are light-sensitive cells in the retina. When stimulated they generate electrical impulses, which pass to the brain along the optic nerve.

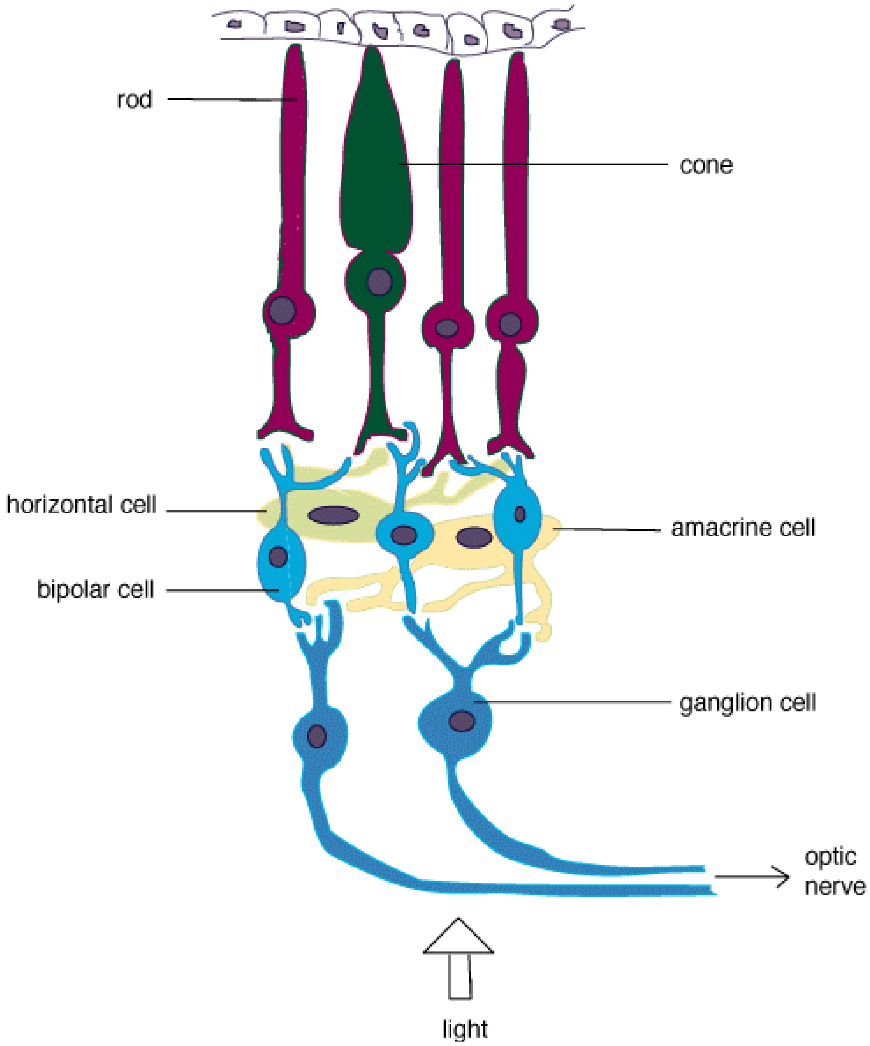


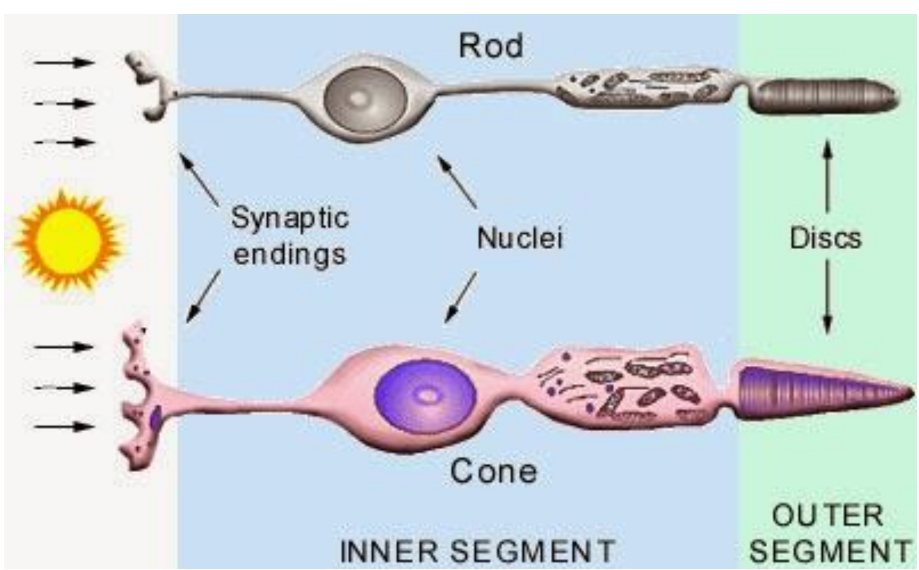
The normal retina has rods that see only black, white, and shades of grey and tones and three forms of color cones, red, green, and blue.



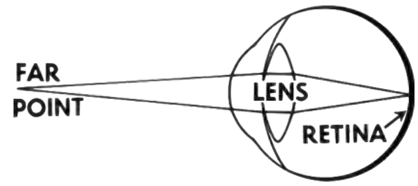
	Function	Distribution	Comments
Rods	Sensitive to low light intensity. Detect shades of grey	Found throught the retina, but none in the centrer of the fovea or in the blind spot	Provide us with night vision, when we can recognise shapes but not colours
Cones	Sensitive only to high light intensity. Detect colour (don't operate in poor light)	Concentrated in the fovea	There are three types, sensitive to red, green and blue light

Photos of rods and cones.

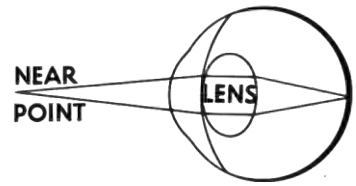




89 Accommodation - focusing on objects far and near



The amount of focusing needed by the lens depends on the distance of the object being viewed – light from near objects requires a more convex lens than light from a distant objects.



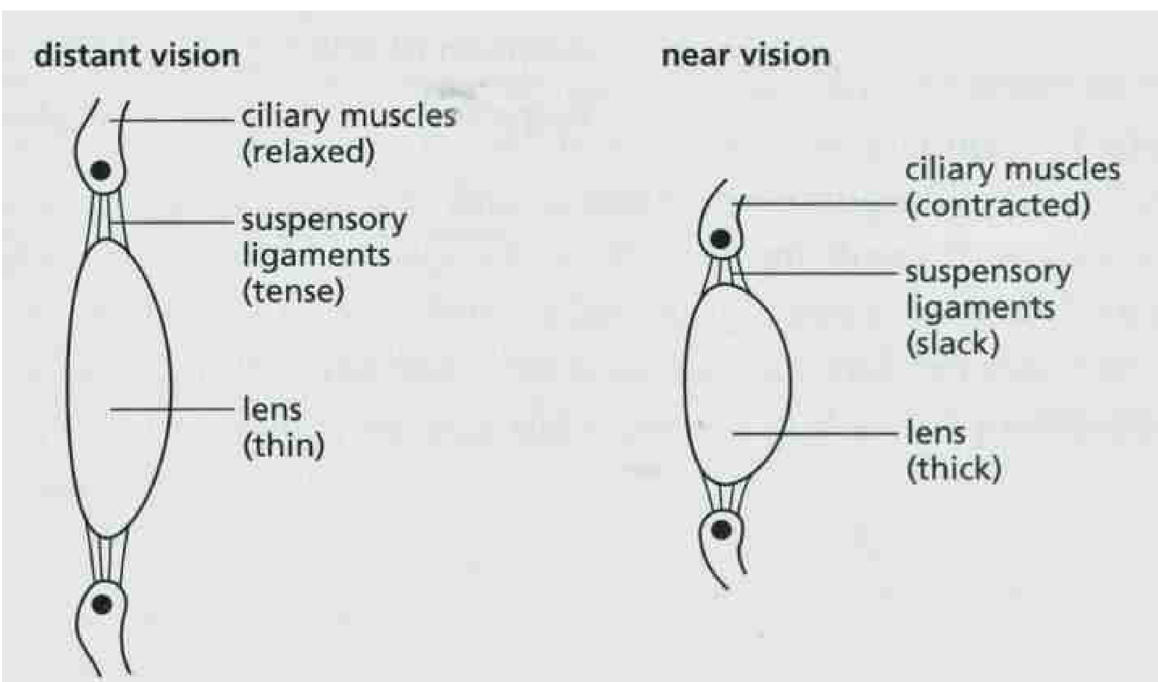
The shape of the lens needed to accommodate the image is controlled by the ciliary body - this contains a ring of muscle around the lens.

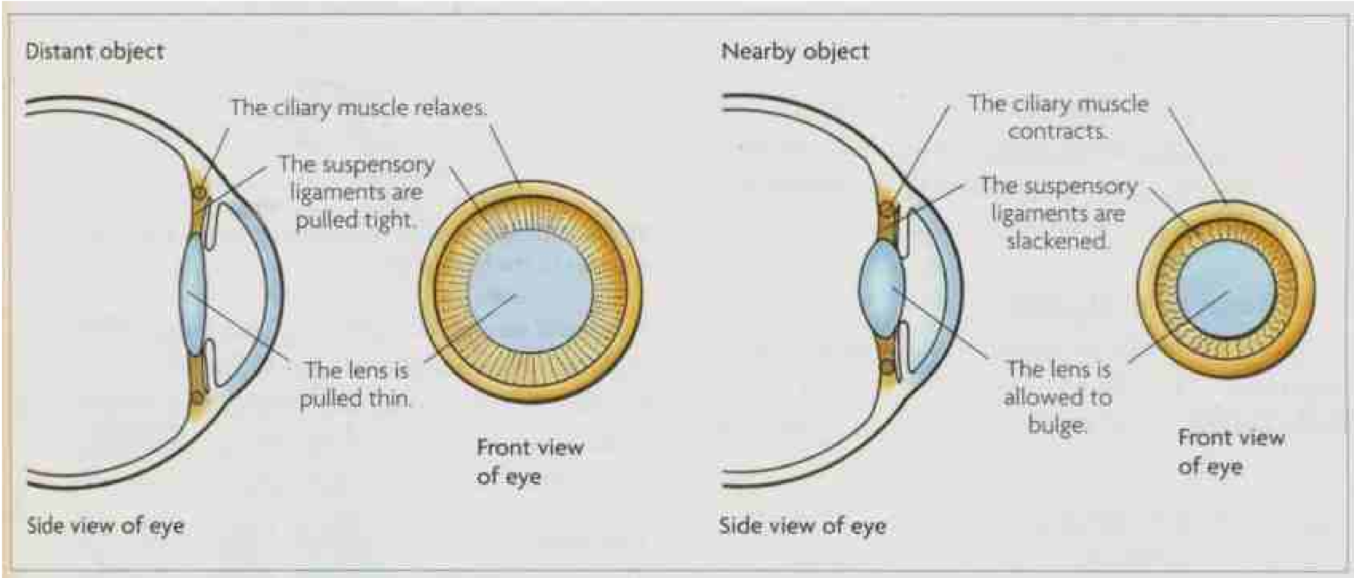
Distance objects

The ciliary muscles relax, giving them a larger diameter. This pulls on the suspensory ligaments which, in turn, pull on the lens. This makes the lens thinner (less convex). As the ciliary muscles are relaxed, there is no strain on the eye.

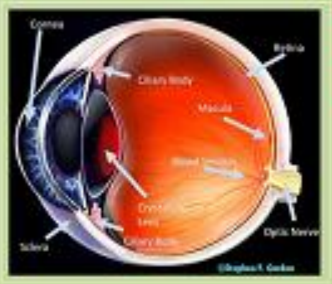
Near objects

The ciliary muscles contract, giving them a smaller diameter. This removes the tenssion on the suspensory ligaments which , in turn, stop pulling on the lens. The lens becomes thicker (more convex). As the ciliary muscles are contracted, there is strain on the eye, which can cause a headache if a near object (book, microscope, computer screen etc.) is viewed for too long.



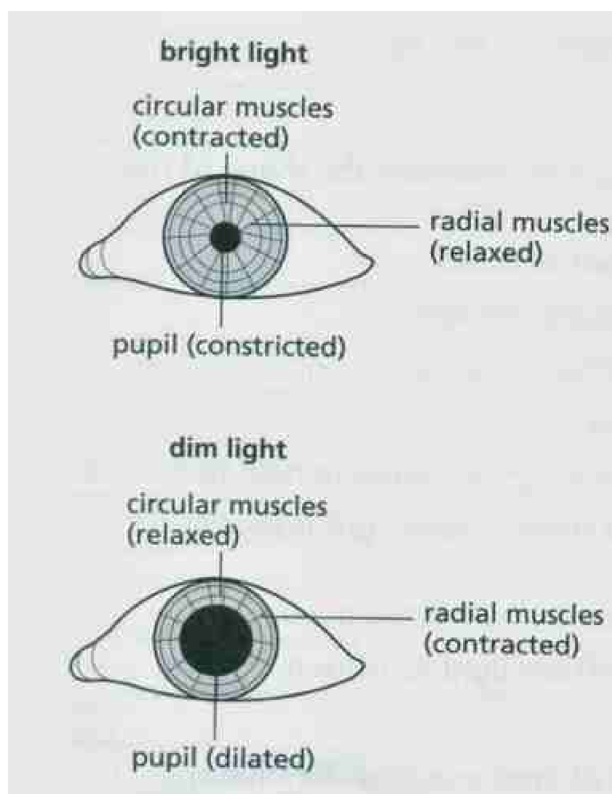


Mnemonic **CCC**



Ciliary muscles
Contracts for
Close vision

Pupil reflex



The reflex changes the size of the pupil to control the amount of light entering the eye. In bright light, pupil size is reduced as too much light falling on the retina could damage it. In dim light, pupil size is increased to allow as much light as possible to enter the eye.

The retina detects the brightness of light entering the eye. An impulse passes to the brain along sensory neurones and travels back to the muscles of the iris along motor neurones, triggering a response - the change in size of the pupil due to contraction of radial or circular muscles.

Video: BBC Eye pupil reflex

Common misconceptions

Students often confuse circular muscles and ciliary mucles. Remember that **circular** muscles affect the size of the **iris**, **ciliary** muscles affect the shape of the **lens**.

Try this

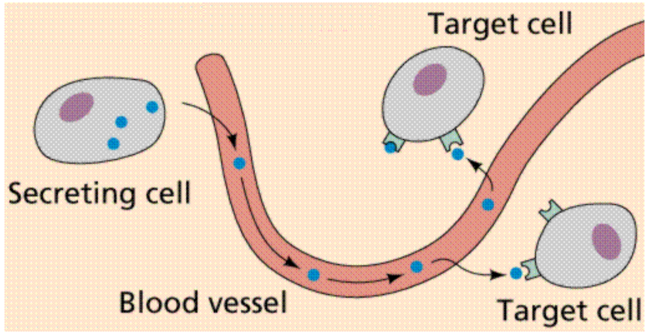
Describe and explain how the eye changes its focus from a distant object to a near object.

Answer

- ciliary muscle contract
- the suspensory ligaments become relaxed
- so tension is removed from the lens
- the lens becomes more convex
- so light is focused more strongly.

Video: Human eye structure, accomodation

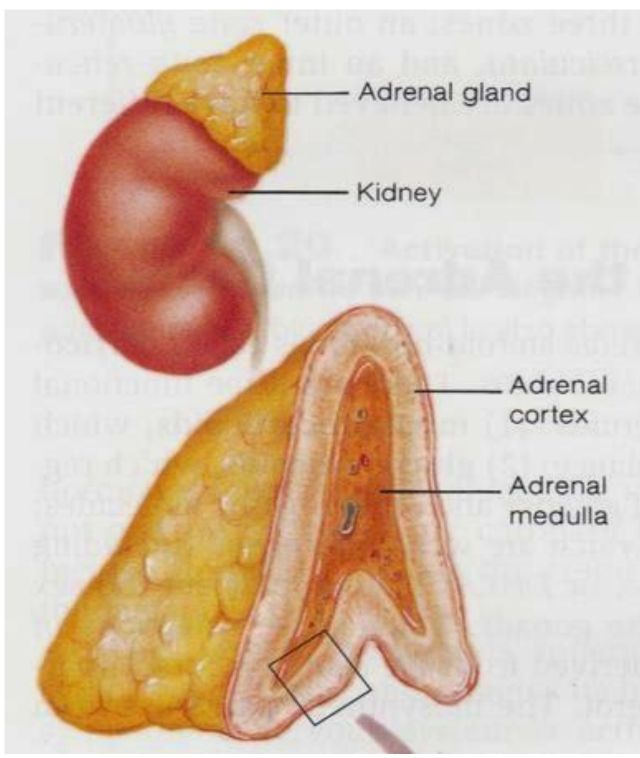
#90 Hormones, role of adrenaline



Hormone is a **chemical** substance, secreted by **endocrine gland,** carried by the **blood**, which alters the activity of one or more specific **target organs** and is then destroyed by the **liver**.

1. Chemical control of metabolic activity by adrenaline

Adrenaline is a hormone secreted by **adrenal glands**. When you are frightened, excited, your brain sends impulses along a verve to your adrenal glands. This makes them secrete adrenaline into the blood.



Adrenal gland is situated above each kidney.

Adrenaline helps you to cope with danger:

1. ↑ **heart rate** → supply **O_2** to brain and muscle more **quickly** →↑ energy for action (fighting, running…).

Contract blood vessels in skin and digestive system → they carry very little blood → supplies blood back to vital organs (brain and muscles).

2. Stimulate **liver** to convert glycogen to glucose, ↑ **glucose** release into the blood by liver → extra glucose for muscle →help muscle to contract.

Examples of situations in which adrenaline secretion increases

Adrenaline is needed and secreted in a "fright, fight or flight" situation.

E.g.: When you are facing danger, for example, a masked man with a gun is approaching you.

- Your brain sends a signal to the adrenal glands, to start secreting and pumping adrenaline into the bloodstream.

- the actions of the adrenaline is listed above

- this gets you ready to either stand and fight or run away from the man.

2. Comparison of nervous and hormonal control systems

Comparison of nervous and hormonal control systems

Feature	Nervous	Hormonal (endocrine)
Made up of	Neurones	Secretory cells
Form of transmission	Electrical impulses	Chemical (hormones0
Transmission pathway	Nerves fibres (axons and dendrons)	Blood plasma
Speed of transmission	Fast	Slow
Duration of effect	Short term	Long term
Response	Localised	Widespread (although there may be a specific target organ)

#91 Use of hormones in food production

Farmer sometimes use **hormones** to make their animals **grow faster**, or to produce **more** of a particular **product**. One hormone used in this way is called **bovine somatotropin**, or **BST.**

BST is a hormone which is naturally produced by cattle. However, if cows are given extra BS, they make more milk. Some people think it would be a good idea to give cow BST, to get higher milk yields. You would need fewer cows to get the same amount of milk.

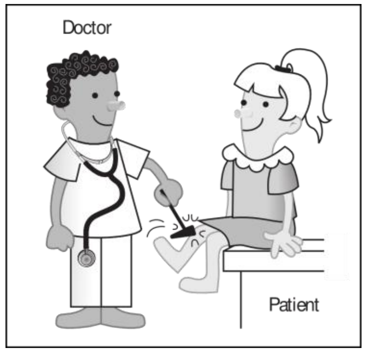
Here are arguments against it.

- Some people are worried about drinking milk form cows treated with BST. They think BST might damage their health. This is very unlikely, because the hormone does not get into the milk in any significant quantity.
- It is difficult to see why we need BST. For example, the European Union already produces more milk than it needs, so milk quotas have to be imposed, to stop farmer from producing too much milk.
- There are concerns that the BST might harm the cows. Cows treated with BST make very large amounts of milk, far beyond the 'natural' levels which they produce. This make them more likely to get infections of their udders (breast), and may make them feel less comfortable.

Mammary infections in BST treated cows require treatment with antibiotics.

Read more on this topic:
[Recombinant bovine somatotropin]

#92 Voluntary and involuntary actions



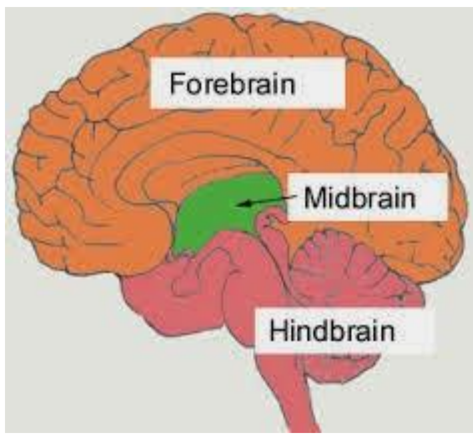
Knee jerk is an involuntary reflex

Two types of action controlled by the human nervous system are: **voluntary** and **involuntary** actions. The peripheral nerves transmit both of them.

Comparison of voluntary and involuntary ations

Feature	Voluntary action	Involuntary action
Nature	- Conscious thought (make decision about making action). - Free will - Consciously control skeletal muscles	- Does not involve thought - Not under the control of the will - Cannot control the activities.
Examples	If we want to ask question, we raise our hands	Involving - skeletal muscle (e.g. knee jerk) - smooth muscles (e.g. peristalsis) - cardiac muscles (e.g. pumping of the heart)
Role	Respond with the benefit of experience	Respond quickly to avoid danger
Controlled by	Forebrain (Cerebrum): - coordinates incoming information, initiates impulses sent to the effectors. - may spontaneously initiates actions without any sensory stimulation.	- Hind-brain (cranial reflex action) - Spinal cord (spinal reflex action), e.g. blinking of the eyes

Speed of action	Slow response, as the cerebrum needs time to "think" before an action is carried out.	Rapid response, as the cerebrum is not involved.
Response to the same stimulus	The same stimulus may produce various responses. E.g. when you are hungry, you may decide to eat or not to eat, or just need to drink water.	The same stimulus always results in the same response (stereotyped response), e.g. the knee jerk reflex.



Forebrain is responsible for voluntary actions, hindbrain is responsible for involuntary actions

Source: [Voluntary and Involuntary Actions]

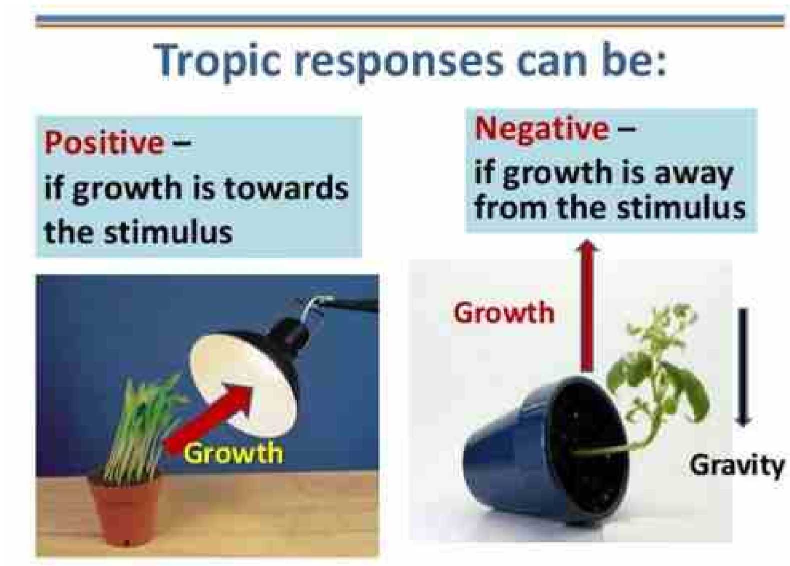
#93 Coordination in plants – tropism

Tropism are responses by part of a plant **toward** of **away** from a **stimulus** coming from one direction.

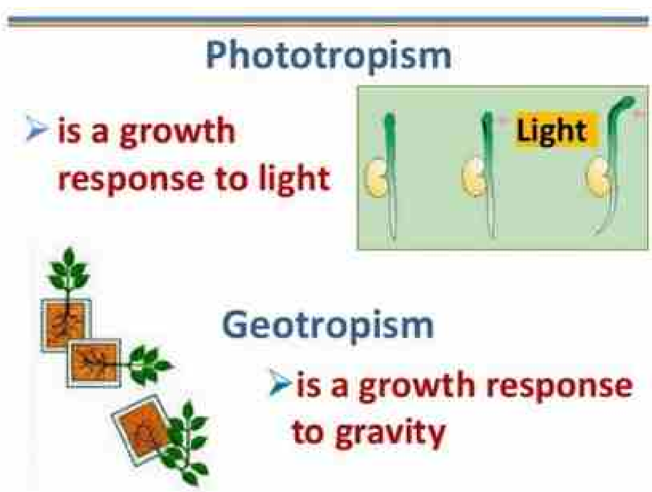
The movement is always a **growth movement**.

Like animals, plants are able to response to their environment, although usually with much **slower** responses than those of animals.

In general, plants respond to stimuli by changing their rate or direction of growth. They may grow either **towards** or **away** from a stimulus. These responses are called **tropisms**.



Two important stimuli for plants are **light** and **gravity**.



Shoots normally grow towards light. Roots do not usually respond to light, but a few grow away from it.

Shoots tend to grow away from the pull of gravity, while roots normally grow towards it.

Plant tropism

	Stimulus	
	Light	Gravity
Shoot	(+)	(-)
Root	(-)	(+)

(+) Grow towards the stimulus

(-) Grow away from the stimulus

A shoot is:

NEGATIVELY GEOTROPIC

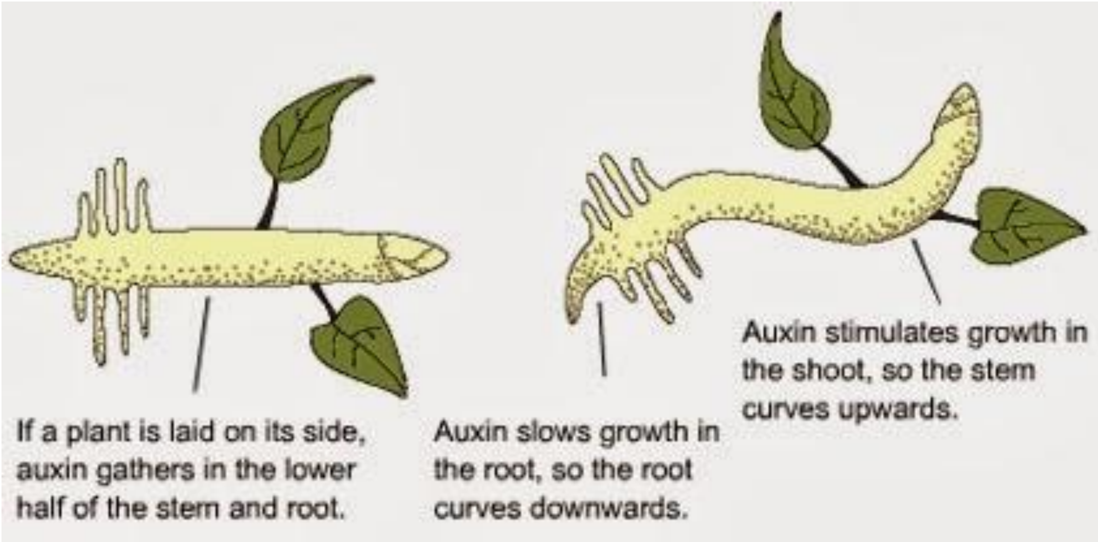
POSITIVELY PHOTOTROPIC

A root is:

- **POSITIVELY GEOTROPIC**
- **NEGATIVELY PHOTOTROPIC**

Pictures are taken from: **Tropism slideshow**

#94 Control of plant growth by auxins, weedkillers



Auxins are plant **growth substances**, produced by the shoot and root tips of growing plants.

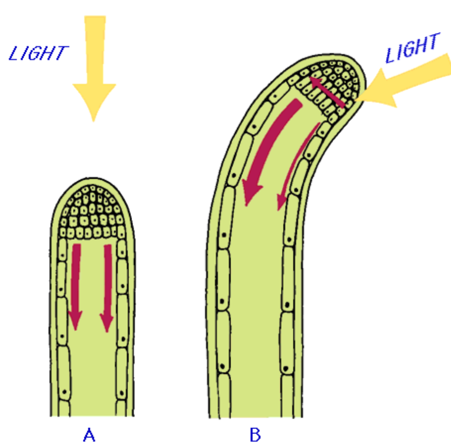
- Auxins in the **shoot** → **stimulate** cell growth, by the absorption of water.

- Auxins in the **root** → **slow down** the cell growth.

Auxin in phototropism

*1. If a **shoot** is exposed to light from one side*

- More auxins are moving in the **shaded** side (from the tip of the shoot)
- On this side, cells are stimulated to absorb **more** water, plant grows more
- Shoot bends **toward** the light.
- This is called **positive phototropism.**



*2. If a **root** is exposed to light in the absence of gravity*

- More auxins are moving in the **shaded** side (from the tip of the root) →
- On this side, cells are stimulated to absorb **less** water, plant grows less
- Root bends **away** from the light.
- This is called **negative phototropism.**

When exposed to light from one side

Fetures	Shoot	Root
More auxins are moving in the **shaded** side	(+)	(+)
Cell are stimulated to absorb (on the shaded side)	**more** water	**less** water
Stem bends	**toward** the light	**away** from the light
Process	Positive phototropism	Negative phototropism.

Auxin in geotropism

1. If a shoot is placed horizontally in the absence of light:

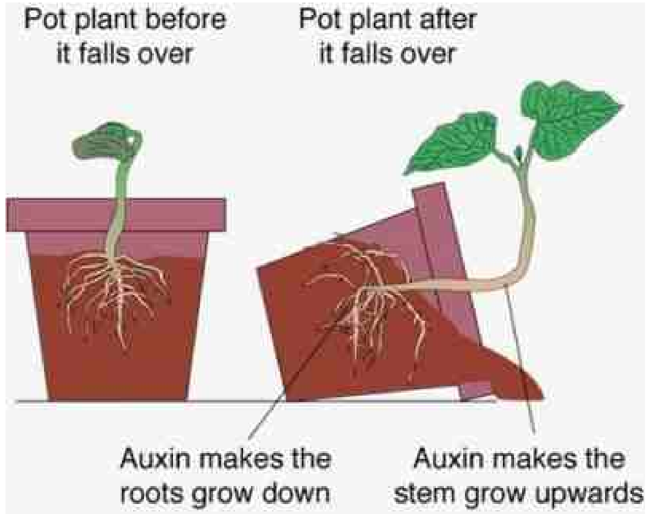
- Auxins accumulate on the lower side of the shoot, due to gravity.
- Cells on the lower side grow more **quickly**
- The shoot bends **upwards**.
- This is called **negative geotropism.**

2. If a root is placed horizontally in the absence of light:

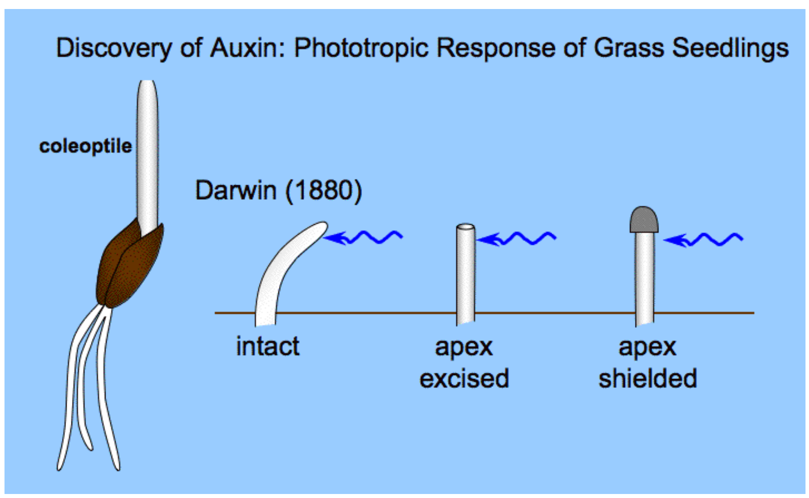
- Auxins accumulate on the lower side of the shoot, due to gravity.
- Cells on the lower side grow more **slowly**
- The shoot bends **downwards**.
- This is called **positive geotropism.**

When is placed horizontally in the absence of light

Fetures	Shoot	Root
More auxins are moving in the **lower side**	(+)	(+)
Cell growth (on the lower side)	more **quickly**	more **slowly**
Bending	**upwards**	**downwards**
Process	Negative geotropism	Positive phototropism.



Darwin did the first experiments to study the effects of Auxin



Credit: plantphys.info

- Shoots and roots that have their **tips removed** will not respond to light or gravity because the part that produces auxins has been cut off.
- Shoots that have their tips covered with **opaque material** grow **straight** upwards when exposed to one-sided light, because the auxin distribution is not influenced by the light.

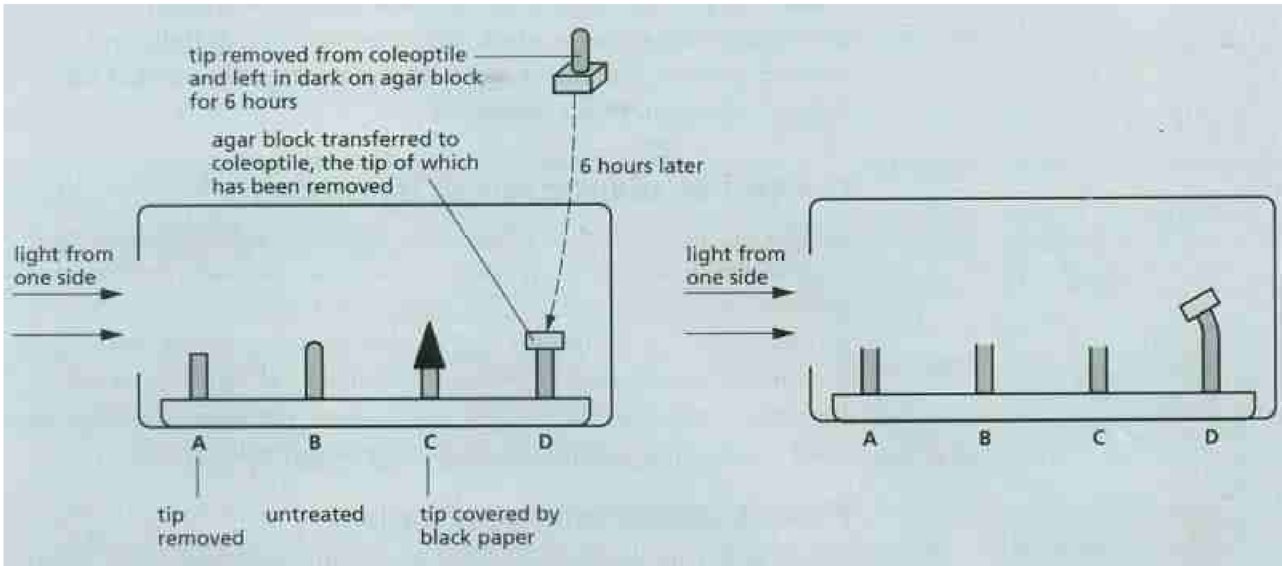
Effects of weedkillers

Weedkillers (herbicide) are synthetic plant hormones, similar to auxins. If these chemicals are sprayed on to plants they can cause rapid, uncontrolled growth and respiration, resulting in the death of the plant.

Some plant species are more sensitive than others to synthetic plant hormones, so weedkillers can be selective.

Many weedkillers kill only broad-leaved plants (dicotyledons), leaving grasses (moncotyledons) unharmed.

Try this



In figure above, the left-hand side shows an experiment in which the coleoptiles (shoots) of similar seedlings have been treated in different ways, and the right-hand side shows the result in shoot D 24 hours later.

a) i) Name the response shown by shoot D. [2 marks]
ii) Explain what has caused this response. [3 marks]
b) Copy and complete the right-hand side figure to show the likely results for shoots A, B and C. [3 marks]

Answer

a) i) Positive phototropism
ii) Three points from:
- the coleoptiles have been exposed to one-sided light
- auxins have been produced by the tip
- and have passed into the block
- auxins have passed from the block to the cut coleoptile
- more auxins accumulates on the shaded side of the coleoptile
- causing more growth on the shaded side.

b)**A,** taller and growing vertically upwards;
B, taller and bending towards the light;
C, taller and growing vertically upwards.

#95 Summary of coordination and response

- All organisms are able to sense changes in their environment, called **stimuli**, and respond to them. The part of the body that senses the stimulus is a **receptor**, and the part that responds is an **effector**.

- The **human nervous system** contains specialized cells called neurons. The brain and spinal cord make up the central nervous system (CNS), which coordinates responses to stimuli.

- **Reflex actions** are fast, automatic responses to a stimulus. They involve a series of neurons making up a reflex arc. A sensory neurone takes the impulse to the CNS and a motor neurone takes it from the CNS to an effector.

- Receptors are generally found within **sense organs**.

- The receptors in the eye are **rod** and **cone cells**, found in the retina. Rods respond to dim light and cones to bright light. Cones give colour vision.

- The cornea and lens focus light rays onto the **fovea**, the part of the eye where cone cells are most densely packed.

- The shape of the lens is changed by the contraction or relaxation of the **ciliary muscle**. When focusing on a distance subject , the muscle relaxes so that the suspensory ligament are pulled taut and the lens is pulled into a thin shape. When focusing on a near object, the muscle contracts and the lens falls into its natural, more rounded shape.

- Muscles can pull when they contracts, but they cannot push. A pair of muscles is therefore needed to pull in different directions, e.g. at the elbow joint. They are **antagonistic muscles**.

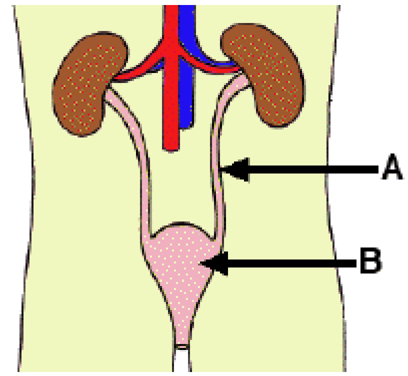
- **Hormones** are chemicals made in endocrine glands and carried in the blood plasma. **Adrenaline** is secreted by the adrenal glands, and bring about changes that supply the muscles with extra glucose. This gives the energy for contraction for ‘fight or flight’.

- Plant response to some stimuli by growing towards or away from them. These responses are **tropism**.

- **Auxins** are mostly made in the tips of the shoots and roots, and can diffuse to other parts of the shoots or roots. It collects in the shady side of the shoot, making the side grow faster so the shoot bends towards the light. Auxins are used as selective weedkillers.

10. Excretion

#96 Structure of the kidney, the nephron

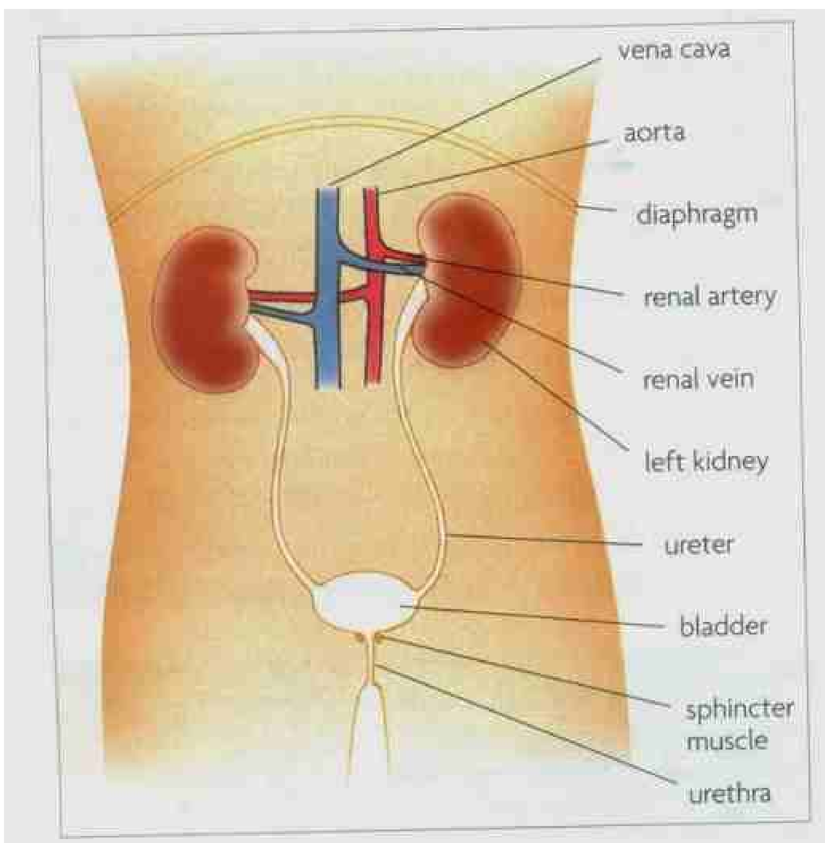


Excretion is the removal from organisms of **toxic materials**, the **waste products** of metabolism and **substances in excess** of requirements (**carbon dioxide**, **urea, salts**…).

Common misconceptions

*Remember that faeces is **not** an example of excretion – it is mainly undigested material that has passed through the gut, but which has not been made in the body. The only excretory materials in it are bile pigments.*

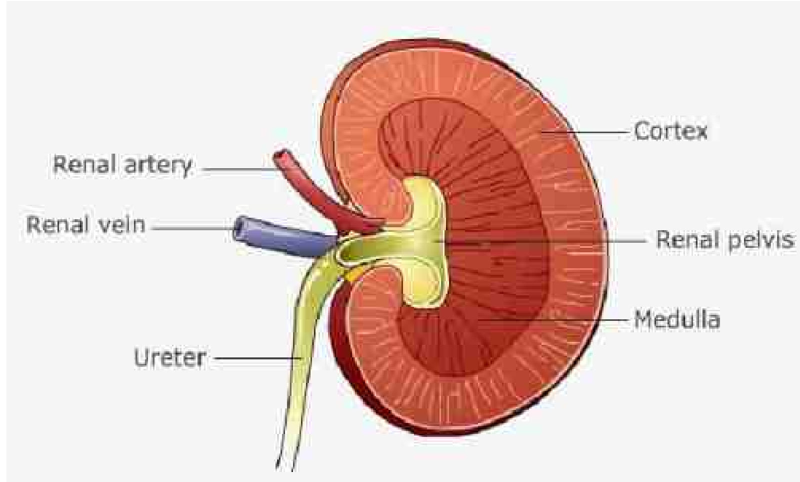
The relative position of the ureters, bladder and urethra in the body



Examiner's tip

*Make sure you can label the diagram showing the relative positions of the kidneys, ureters, bladder and urethra. The spellings of the **ureter** and **urethra** are really important.*

Structure of a kidney

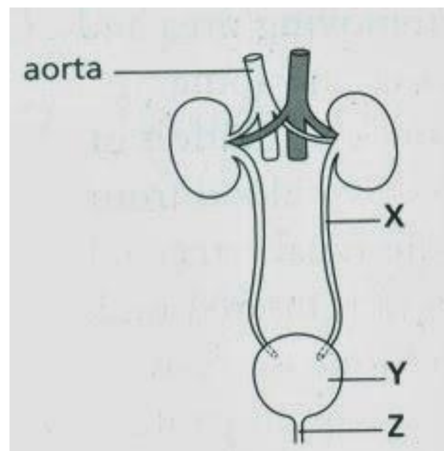


The kidney has 3 main parts: the **cortex, medulla,** and **pelvis**. Leading form the pelvis is a tube, called the **ureter**. The ureter carries urine that the kidney has made to the **bladder**.

Kidneys are made up of thousands of tiny tubules, or **nephrons**. Each nephron begins in the cortex, loops down into the medulla, back into the cortex, and then goes down again through the medulla to the pelvis. In the pelvis, the nephrons join up with the ureter.

Sample question and answer

Figure on the right shows the human urinary system



a) Name parts **X,Y** and Z. [3 marks]

b) Name the blood vessel that carries blood from the aorta to the kidneys. [1 mark]

c) Suggest two differences between the composition of the blood flowing to the kidneys and the blood flowing away from the kidneys. [2 marks]

Student's answer

a) **X** ureta ✗ **Y** Bladder ✓ **Z** vagina ✗
b) renal artery
c)1. Blood going to the kidneys contains more urea.
2. Blood going to the kidney contains oxygen.

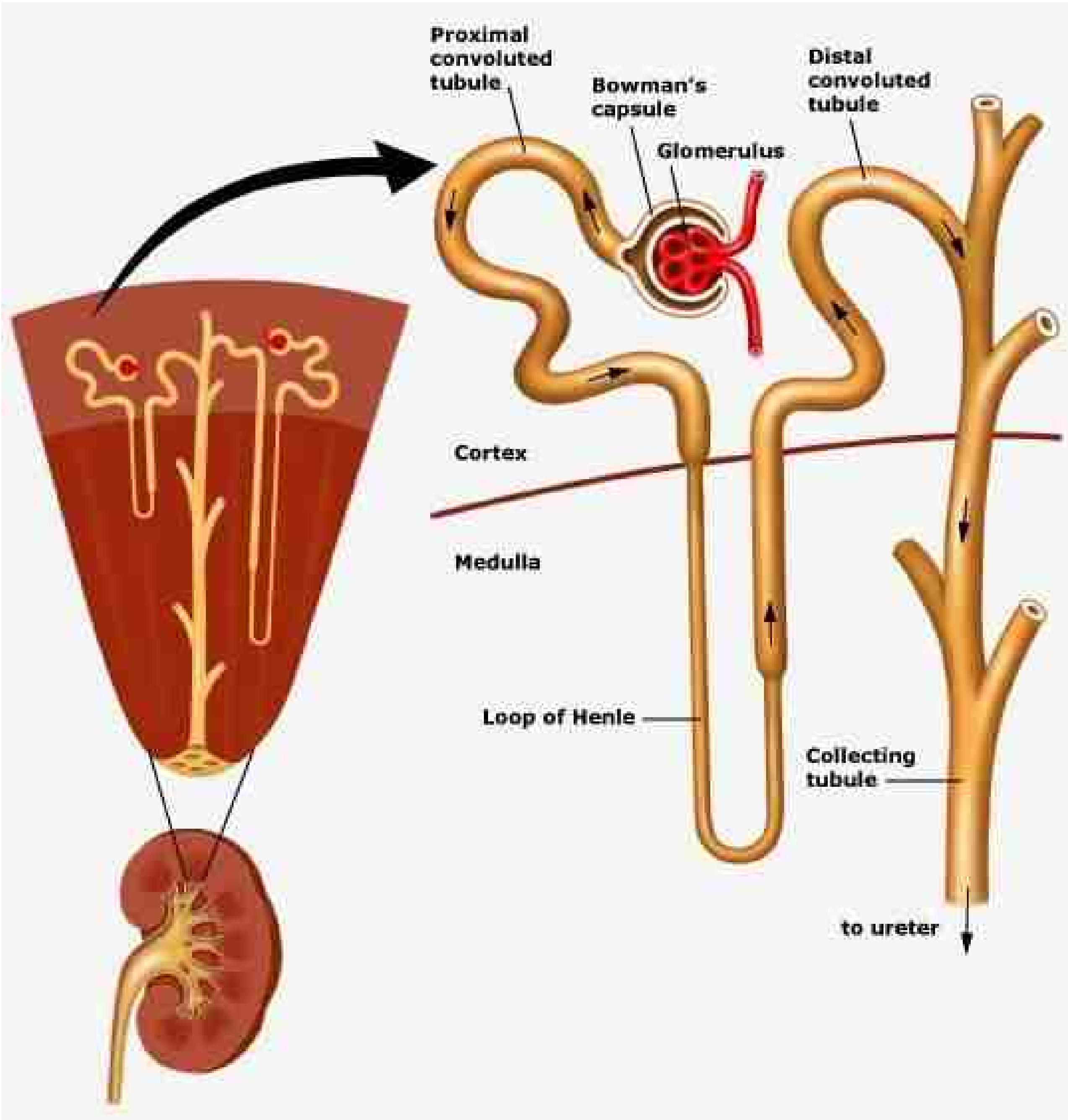
Examiner's comments

The spelling of **X** (ureter) must be accurate because this name is so similar to urethra.

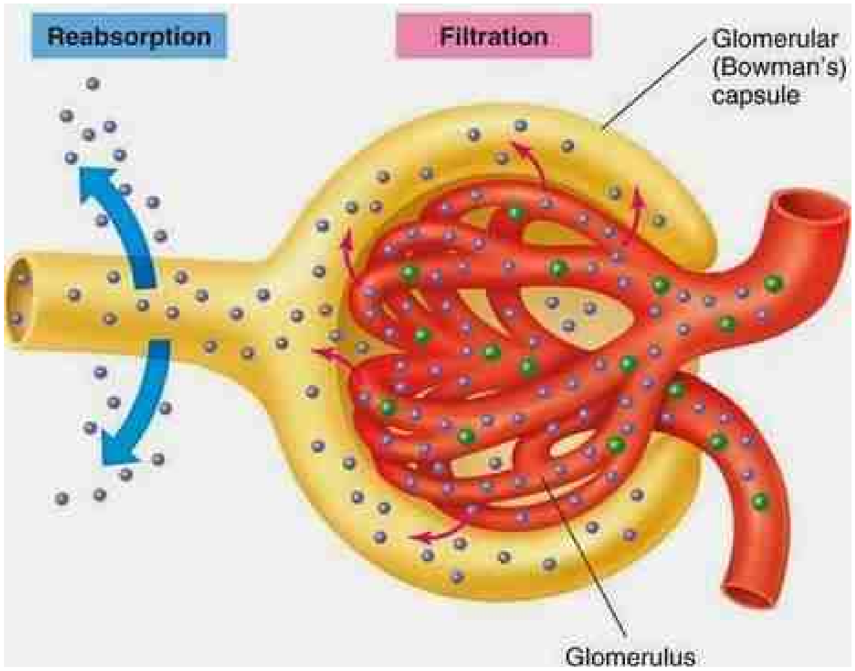
Part **Z** is the urethra, not the vagina (the vagina is attached to the uterus, not the bladder).

In part (c) the second answer given does not make a comparison. If the candidate had stated 'blood going to the kidney contains more oxygen', this would have gained the mark.

Video: Urinary system The nephron



97 Function of the kidney - filtration and reabsorption



The function of the kidney is to filter blood, **removing** urea and excess H_2O, **reabsorbing** glucose, some H_2O and some mineral salts.

Urine is made by filtration and selective reabsorption

- As blood passes through the kidneys, it is filtered. This **removes** most of the **urea** from it, and also excess **H_2O** and **salts**.
- As this liquid moves through the kidneys, any **glucose** in it is **reabsorbed** back into the blood. Most of the **H_2O** is also reabsorbed along with some of the **salts**.

Remove from blood	Reabsorb into the blood
• most **urea** • excess **H_2O** • excess **salts**	• all **glucose** • most **H_2O** • some **salts**

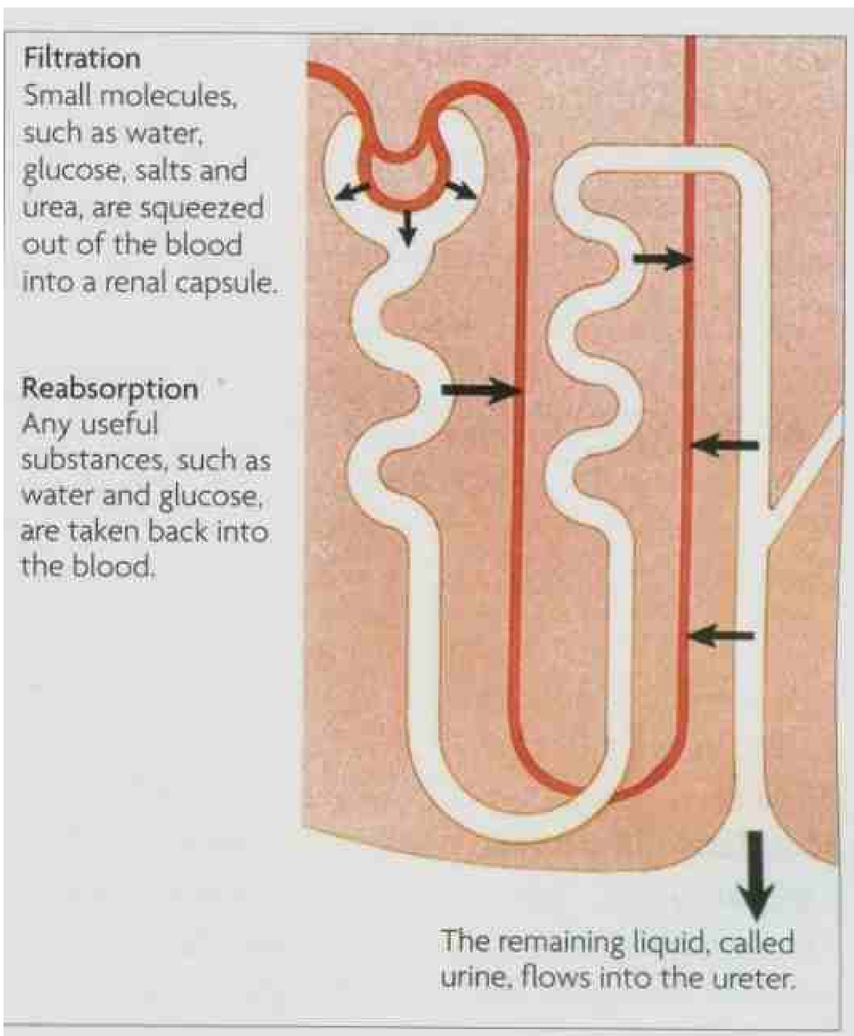
The final liquid produced by the kidneys is a solution of **urea** and **salts** in **water.** It is called **urine,** and it flows out of the kidneys, along the ureters and into the bladder. It is stored in the bladder for a while, before being released from the body through the **urethra.**

Filtration happens in renal capsules

Blood is brought to the **renal capsule** in a branch of the renal artery. Small molecules, including water and most of the things dissolved in its, are squeezed out of the blood into the renal capsule.

There are thousands of renal capsules in the cortex of each kidney. Each one is shaped like a cup. It has a tangle of blood capillaries, called a **glomerulus**, in the middle. The blood vessels bringing blood to each glomerulus is quite wide, but the one taking blood away is narrow. This means that the blood in the glomerulus cannot get away easily. Quite a high pressure builds up, squeezing the blood in the glomerulus against the capillary walls.

These walls have small holes in them. So do the walls of the renal capsules. Any molecules small enough to go through these holes will be squeezed through, into the space in the renal capsule.
Only small molecules can go through. These include water, salt, glucose and urea. Most protein molecules are too big, so they stay in the blood, along with the blood cells.



Useful substances are reabsorbed

The fluid in the renal capsule is a solution of **glucose, salts** and **urea** dissolved in water. Some of the substances in this fluid are needed by the body. All of the **glucose**, some of the **water** ans some of the **salts** need to be kept in the blood.

Wrapped around each kidney tubule are blood capillaries. Useful substances from the fluid in the kidney tubule are reabsorbed, and pass back into the blood in these capillaries.

The remaining fluid continues on its way along the tubule. By the time it gets to the collecting duct, it is mostly water, with urea and salts dissolved in its. It is called urine. The kidneys are extremely efficient at reabsorbing water. Over 99% of the water entering the tubules is reabsorbed.

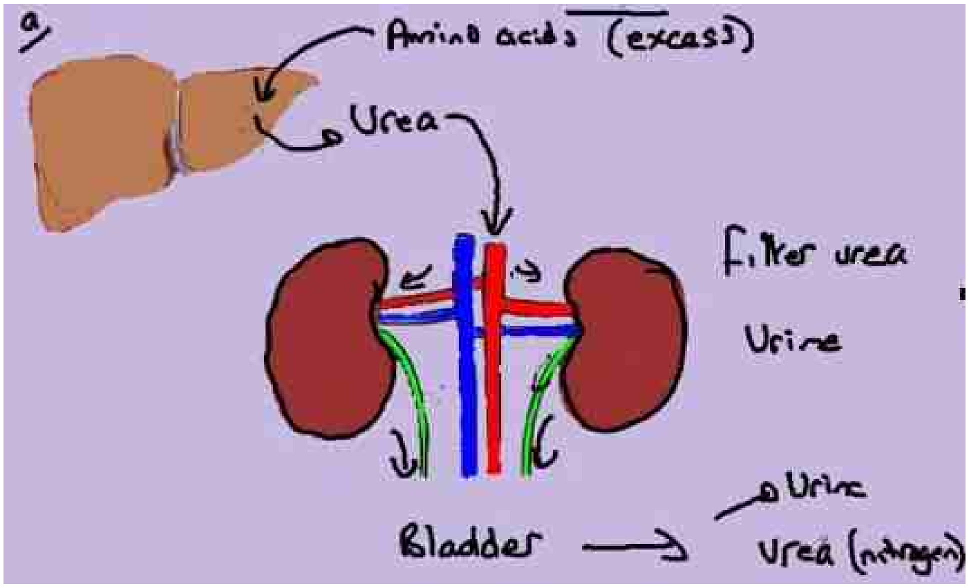
The relative amount of water reabsorbed depends on the state of hydration of the body (how much water is in the blood), and is controlled by secretion of the hormone ADH.

- On a hot day: we sweat more to cool down à the body needs to conserve water à produce a small amount of concentrated urine.
- On a cold day: little sweat is being produced à we tend to produce a larger volume of dilute urine.

Filtered blood returns to the vena cava (main vein) via a renal vein. The urine formed in the kidney passes down a ureter into the bladder, where it is stored. A sphincter muscle controls the release of urine through urethra.

Video: Nephron function

98 Urea formation, breakdown of alcohol & drugs in liver



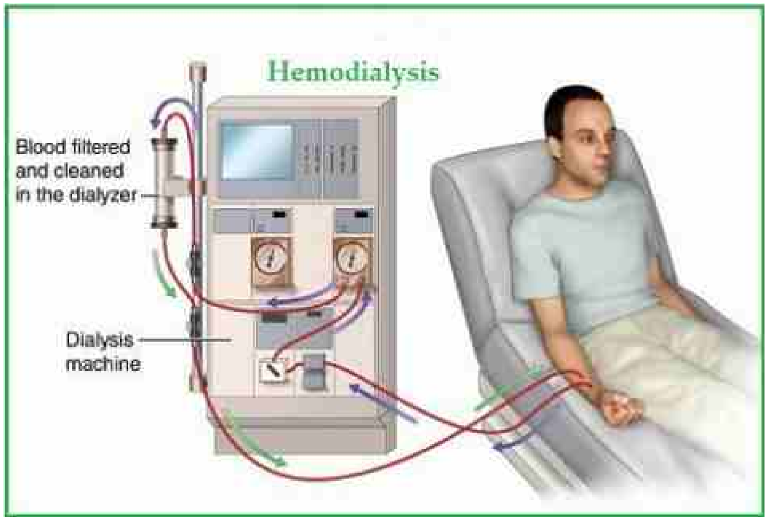
Surplus **amino acids** in the bloodstream cannot be stored. They are removed by the liver and broken down into the **urea** (which is the nitrogen-containing part of the amino acid) and a **sugar** residue, which can be respired to release energy. The breakdown of amino acids is called **deamination**.

Urea is returned to the bloodstream (into the hepatic vein) and filtered out when it reaches the kidneys.

The body treats alcohol as a poison. The liver removes poisons, such as **alcohol** and **drugs**, from the blood and breaks them down. Prolonged and excessive use of alcohol damages the liver and may cause it to fail. An overdose of **drugs**, such as **paracetamol**, can result in death due to liver failure, because the liver cannot cope with breaking down such a high concentration of the chemical.

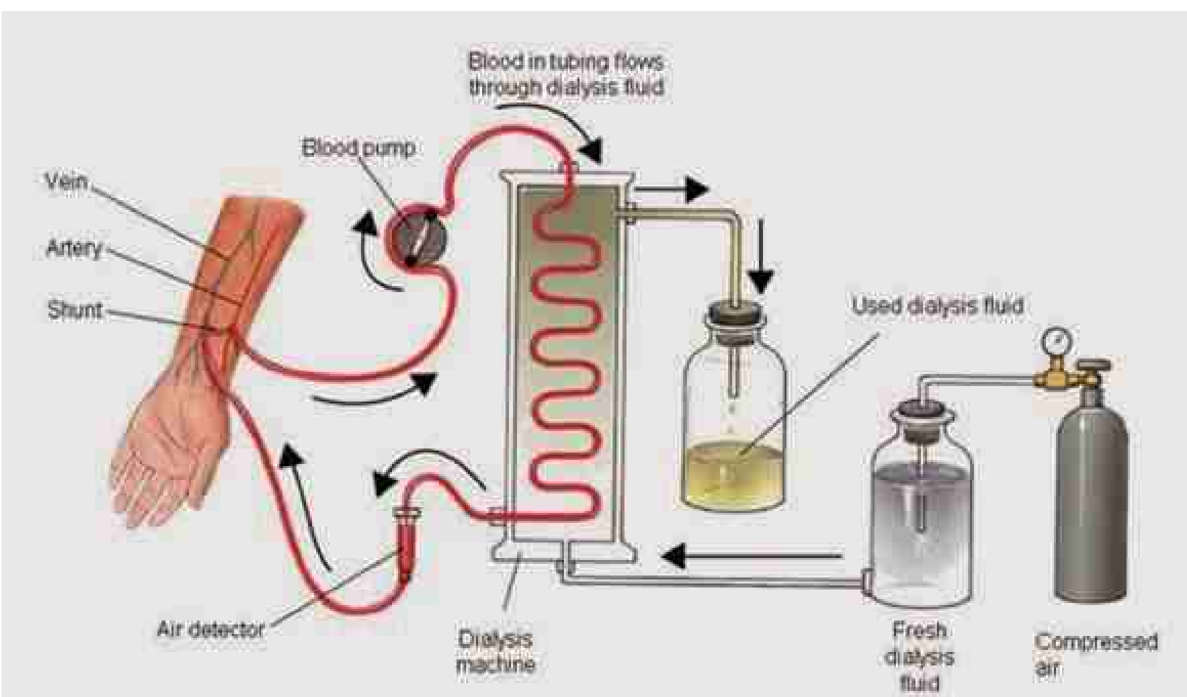
The liver also converts **hormones** into inactive compounds. These are filterd out of the blood by the kidneys.

99 Dialysis and its application in kidney machines



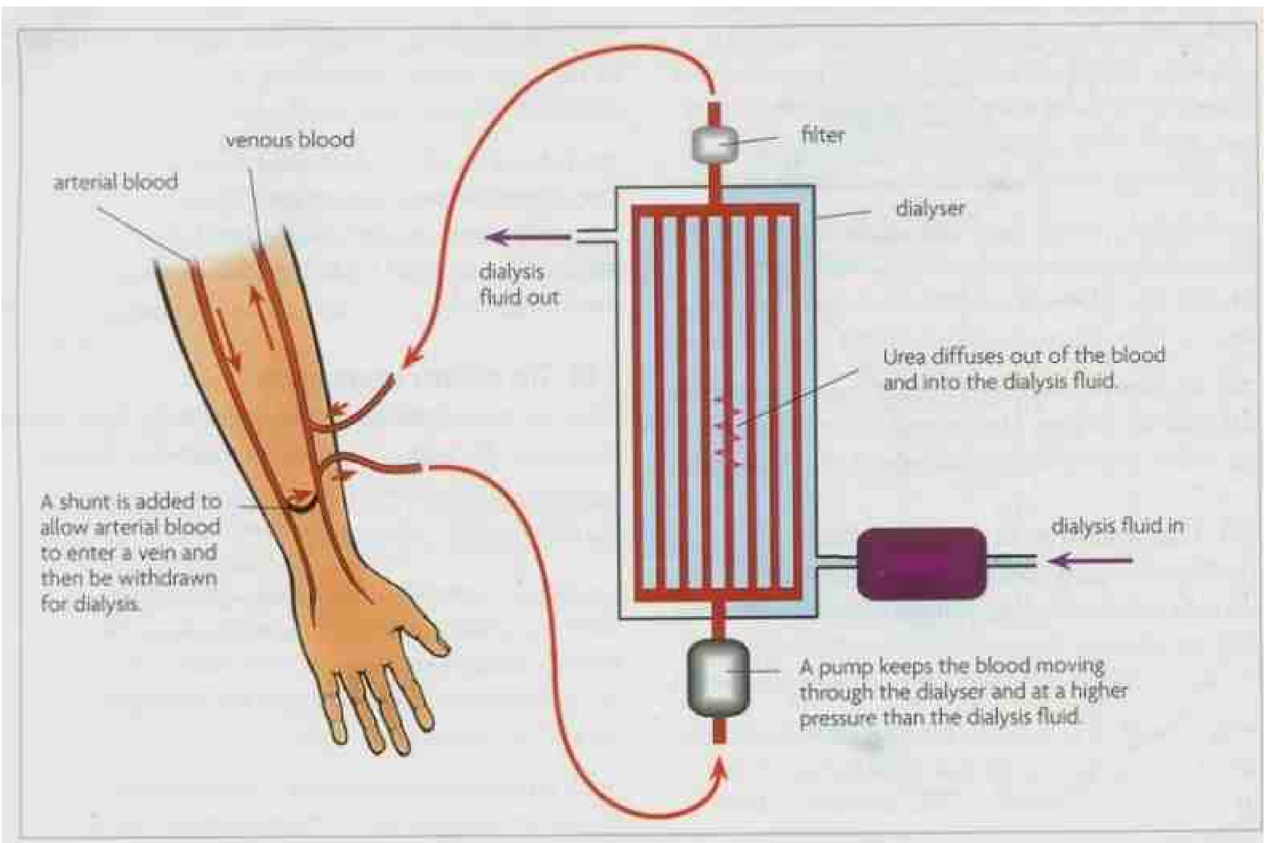
The usual treatment for a person with kidney failure is to have several sessions a week using a **dialysis unit** (a kidney machine), to maintain the glucose and protein concentration in blood diffusion of urea from blood to dialysis fluid.

Dialysis is a method of removing one or more components from a solution using the process of diffusion. The solution is separated from a bathing liquid contains none of the components that need to be removed from the solution, so these pass from the solution, through the membrane, into the bathing dilution by diffusion. The bathing solution needs to be changed regularly to maintain a concentration gradient.



Kidney dialysis.

A patient with kidney failure needs to have toxic chemicals removed from the blood to stay alive. Blood is removed from a vein in the arm, and is kept moving through dialysis tubing in the dialysis machine using a pump. The tubing is very long to provide a large surface area. The dialysis fluid has a composition similar to blood plasma, but with no urea or uric acid. **Urea** or **uric acid** and excess **mineral salts** are **removed** from the blood, by **diffusion**, into the dialysis fluid. The cleaned blood is then passed through a bubble trap to remove any air bubbles, before being returned to the patient's vein.



How kidney dialysis works.

Advantages and disadvantages of kidney transplants compared with dialysis.

Advantages

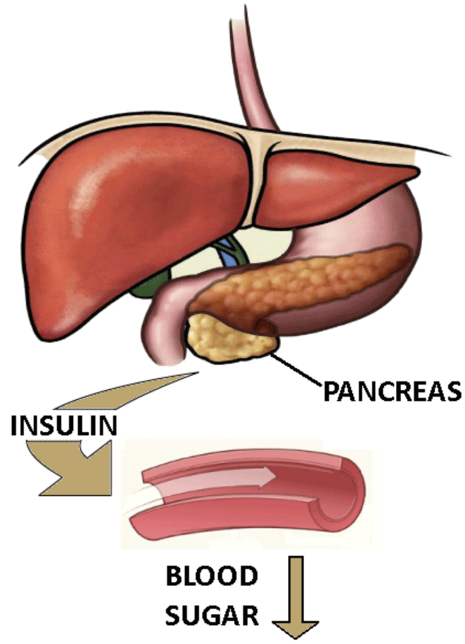
- The patients can return to a normal lifestyle – dialysis may require a lengthy session in hospital, 3 times a week, leaving the patient very tired after each session.
- A dialysis machine will be available for other patients to use.
- Dialysis machines are expensive to buy and maintain.

Disadvantages

- Transplants require a suitable donor – with a good tissue match. The donor may be a dead person, or a close living relative who is prepared to donate a healthy kidney (we can survive with one kidney_.
- The operation is very expensive.
- There is a risk of rejection of the donate kidney – immunosuppressive drugs have to be used.
- Transplantation is not accepted by some religions.

Video: Hemodialysis and how it works

100 Summary of homeostasis, excretion, drugs



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- Organisms that can control their internal body temperature are called **homeotherms**. Mammals and birds are homeotherms. All other animals are **poikilotherms**, meaning that they have only limited ways of controlling their temperature.

- The control of body temperature in humans involves the **hypothalamus**, the **skin** and **muscles**. When the body becomes too hot, **sweating** and **vasodilatation** increase the rate of heat loss from the skin. When the body becomes too cold, **shivering** increases heat production, and **vasoconstriction** reduces the rate of heat loss from the skin.

- The **pancreas**, working in conjunction with the **liver**, controls blood **glucose** concentration. When this rises too high, the pancreas secretes **insulin** which causes the liver to remove glucose from the blood and convert it to **glycogen**. When blood glucose concentration falls to low, the pancreas secretes **glucagon** which causes the liver to convert glycogen to glucose.

- **Excretion** is the removal from the body of waste products of metabolism. The main excretory products of mammals are **CO_2**, **urea, salts** and excess **H_2O**.

- Mammals excrete CO_2 from the **lungs** and urea from their **kidneys**.

- **Urea** is produced in the **liver** from excess amino acids. It is transported in solution in blood plasma to the kidneys, where it is excreted in **urine**.

- **Urine** is made in the **nephrons** of each kidney. First, blood is filtered. Then any substances to be retained in the blood are reabsorbed. The fluid that is left in the nephron flows into the **ureters** and then to the **bladder**, before leaving the body as urine through the **urethra**.

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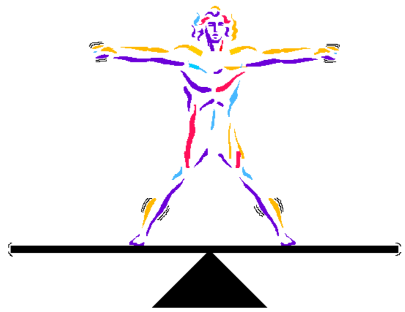
- **Alcohol** is also a depressant. Drinking alcohol lengthens reaction time, reduced self-control and may cause aggression, causing serious problems for friends and family. Some people become addicted to alcohol. Over time, the liver is damaged by excessive alcohol intake.

11. Homeostasis, Drugs

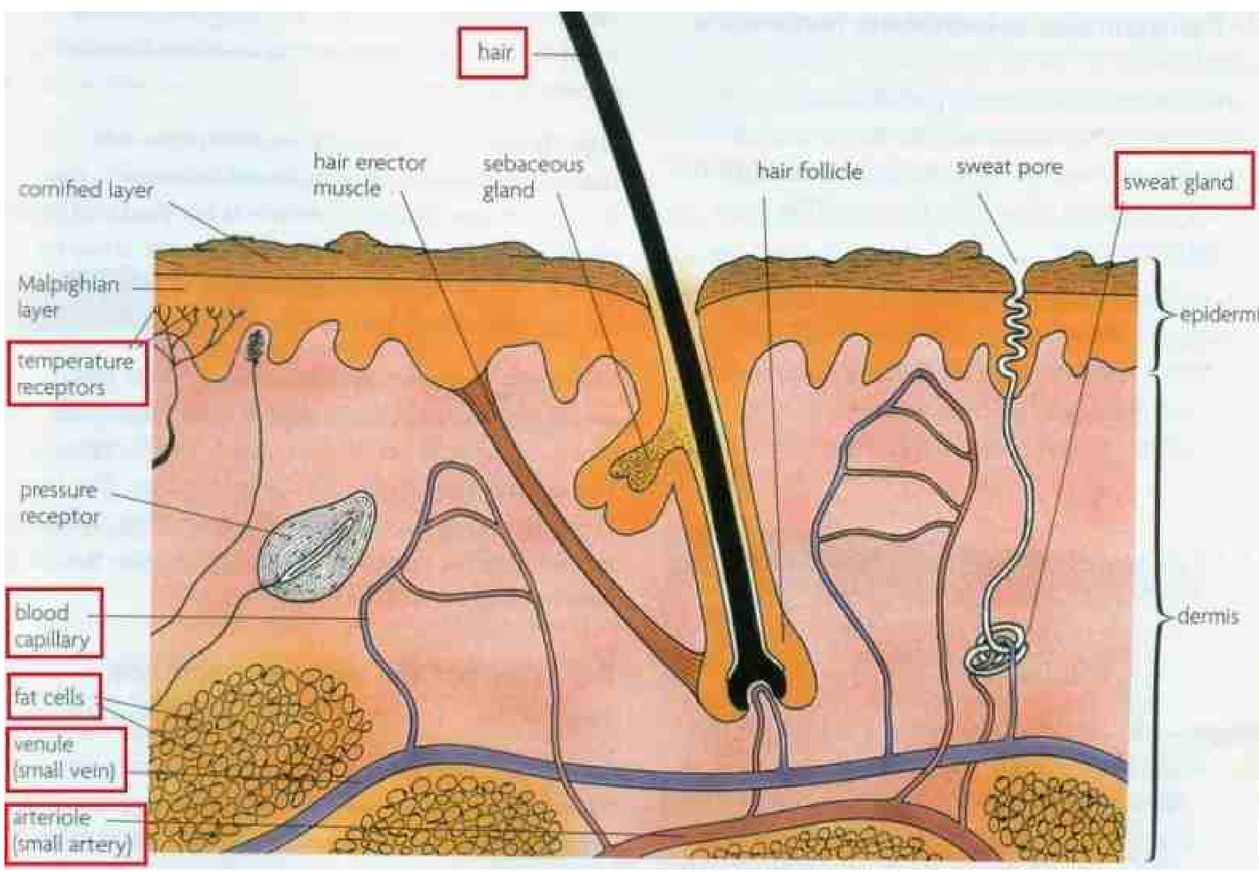
#101 Homeostasis



Homeostasis is the maintenance of a **constant internal environment**, which is vital for an organism to stay healthy. Fluctuations in temperature, water levels and nutrient concentrations … could lead to death.

Temperature regulation is one homeostatic function. Mammals and birds are warm-blooded – they maintain a constant body temperature despite external environment changes.

Human maintain a body temperature of 37^0C – we have mechanisms to lose heat when we get too hot, and ways of retaining heat when we get too cold.

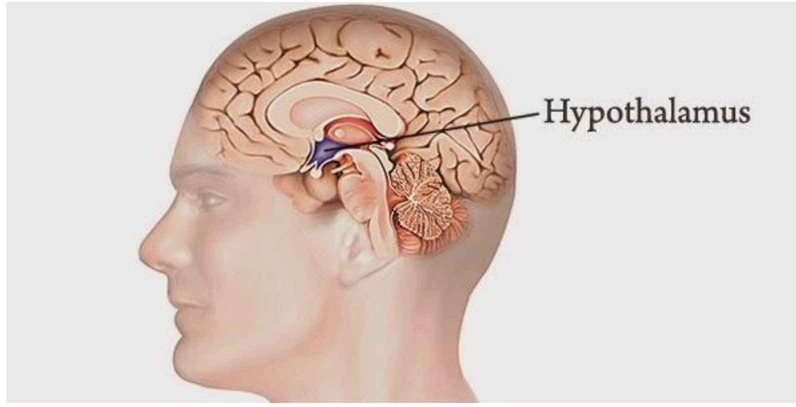


A section through human skin.

The hypothalamus coordinates temperature control

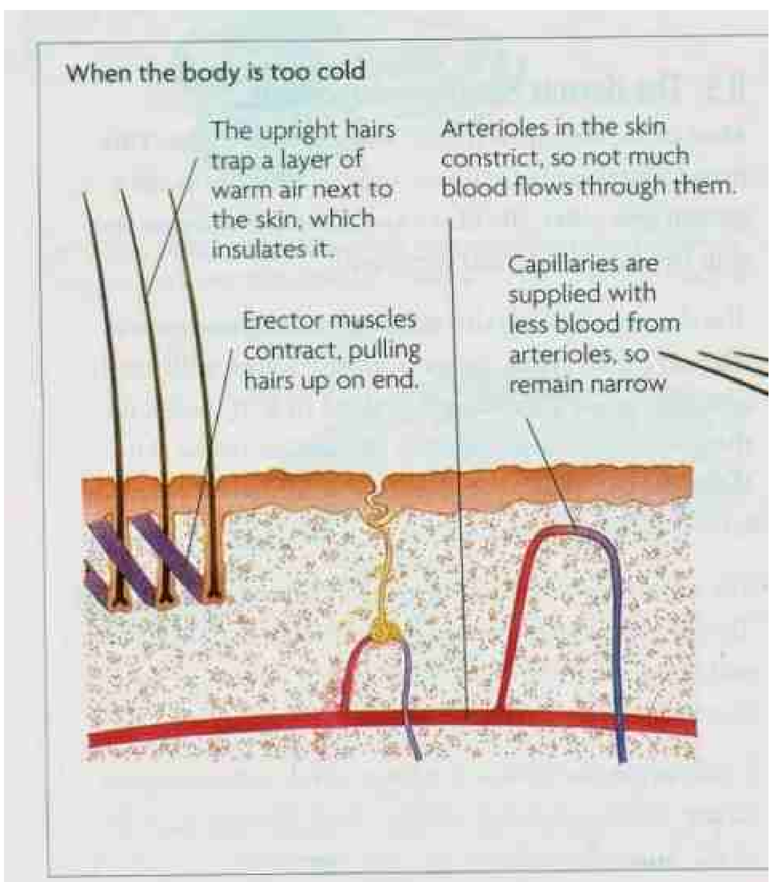
The **hypothalamus** (part of brain) acts like a thermostat. It detects t° of the blood running through it.

If t° > or < 37^0C, it sends electrical impulses, along nerves, to parts of the body which function in regulating body t°.



When you are cold, body produces and saves heat

- *shivering*: muscles contract and relax spontaneously ---> produces heat ---> warms blood
- *vasoconstriction*: arterioles near skin become narrower so little blood can flow through them (the blood flows through the deep-lying capillaries instead)---> conserve heat
- *metabolism may increase* ---> release energy
- *hair stands up.* In human, it just produces 'goose pimples'. But in hair animals (cat), it acts as an *insulator*: trap a thicker layer of warm air next to the skin, prevent skin from loosing more warmth.

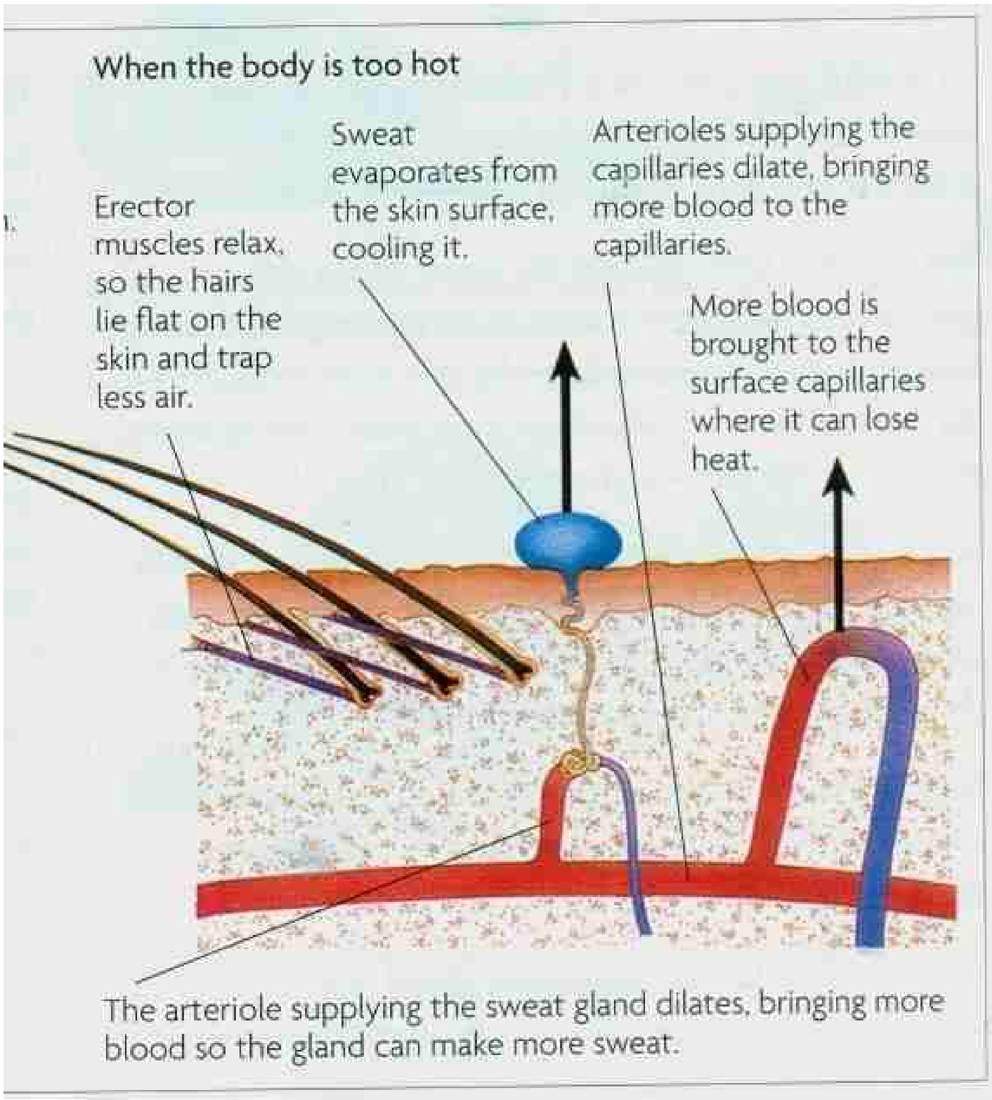


When you are hot, the body loses more heat:

- *sweating*: droplets of sweat evaporate, cooling the body

- *vasodilation*: more blood flows near skin surface ---> lose heat

- *hair lies flat.*



Common misconceptions

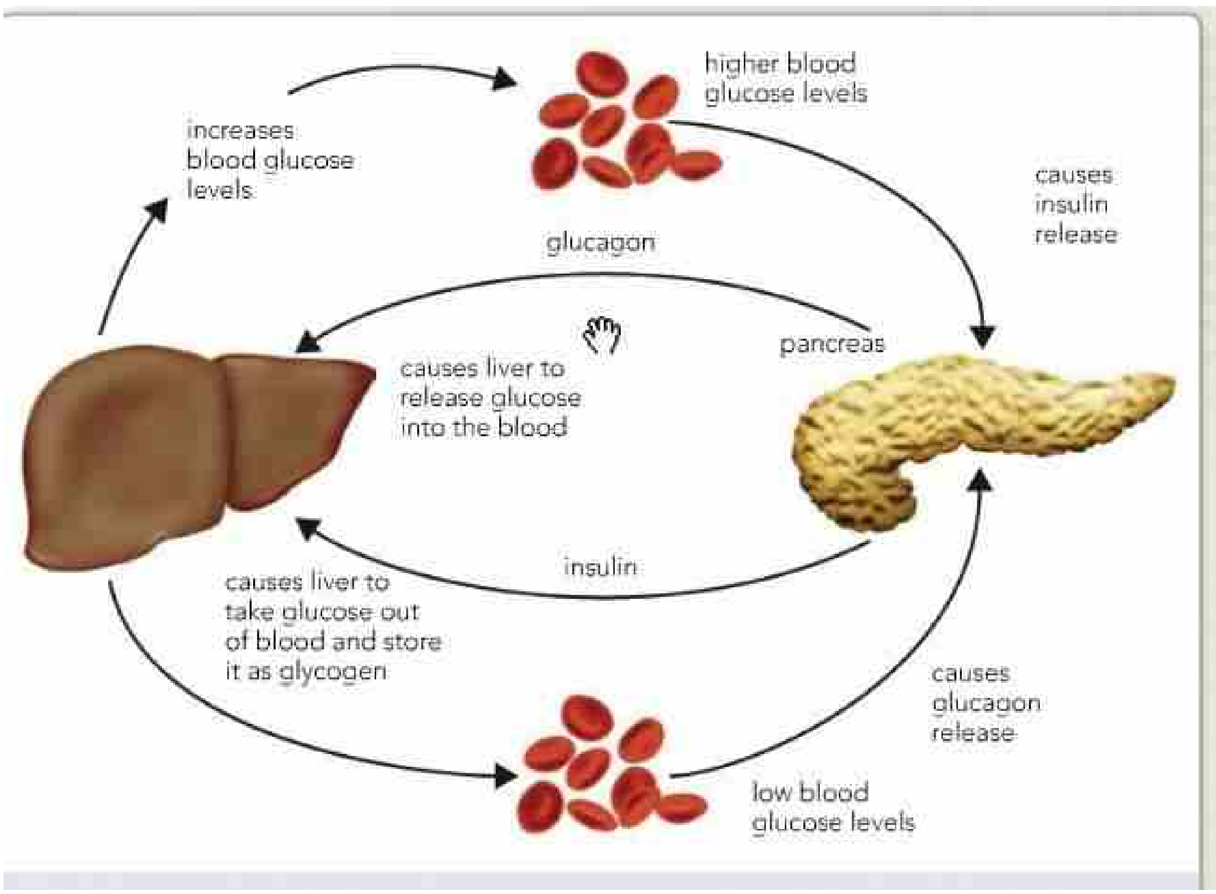
*Remember that the process of vasodilatation and vasoconstriction happen only in arterioles – the do **not** happen in capillaries or veins. When writing about the process, make sure you refer to arterioles.*

#102 Control of blood glucose content

The control of **glucose** concentration in the blood is a very important part of homeostasis.

Two hormones **insulin** and **glucagon)** control blood **glucose** levels.

Both hormones are secreted by the **pancreas** and are transported to the **liver** in the bloodstream.



When blood glucose levels get too high or too low, a person may:

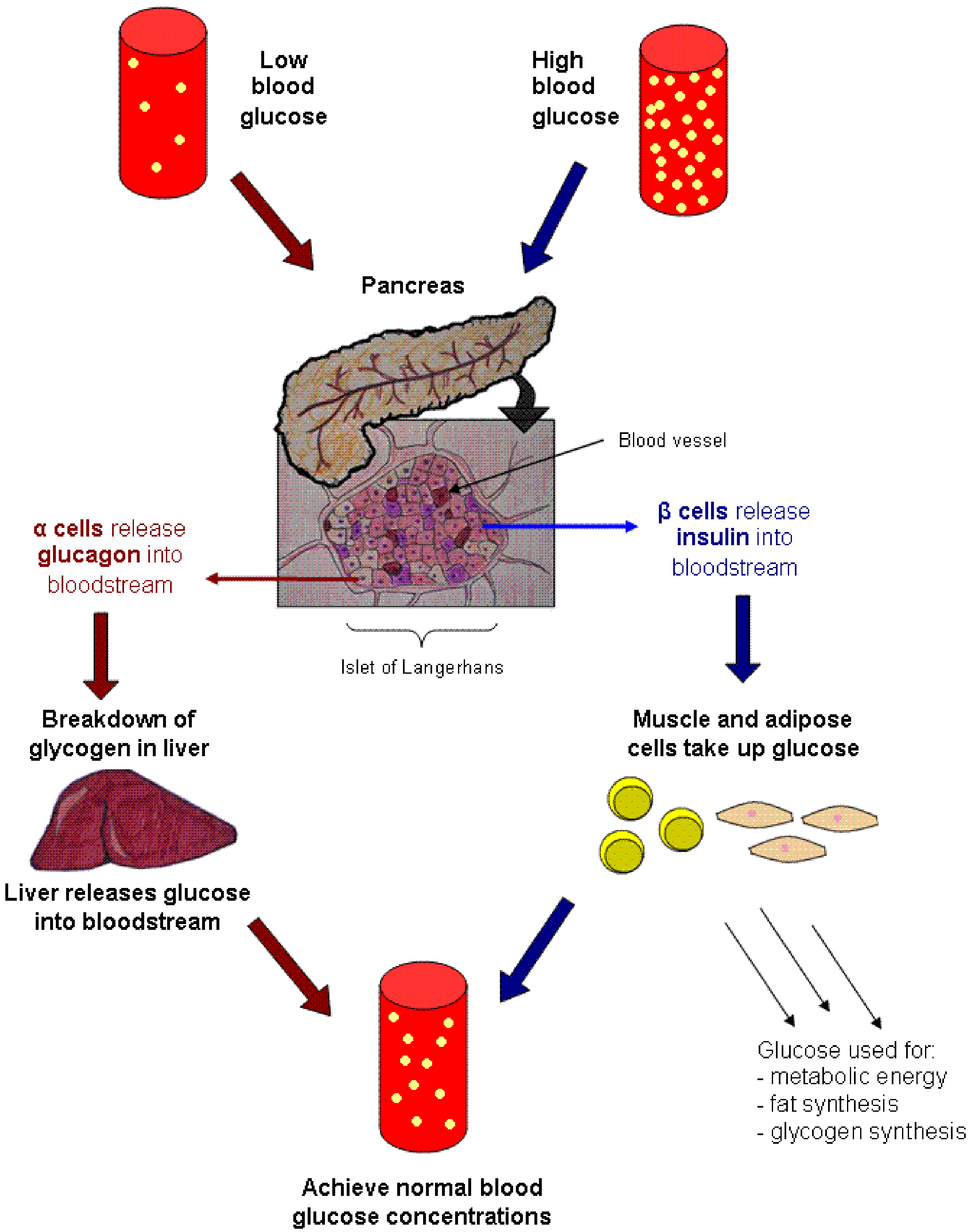
- lose consciousness
- fall into a coma
- die

Too little glucose ---> Cells can not release enough energy they need. Brain cells are especially dependent on glucose for respiration, and die quite quickly if they are deprived of it.

Too much glucose in the blood ---> water moves out of cells and into the blood by osmosis ---> Cell has too little water to carry out normal metabolic process.

The control of blood glucose concentration is carried out by the pancreas and the liver.

Pancreas secretes **insulin** and **glucagon**: 2 hormones that work side-by-side.

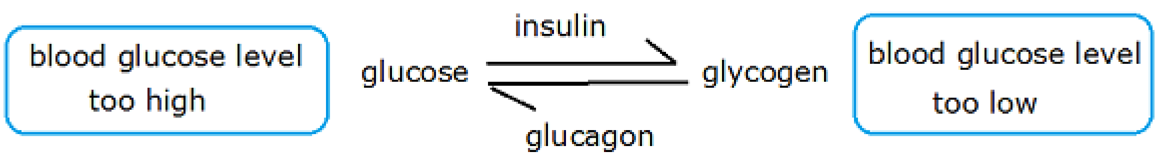


Left-side: When glucose levels drop below normal, glycogen is broken down to glucose, which is released into the bloodstream.

glucagon: glycogen ---> glucose

Right-side: Excess glucose is stored in the liver and muscles as the polysaccharide glycogen (animal starch).

insulin: glucose ---> glycogen
↑ respiration rates ---> cells consume more glucose



Try this

Copy and complete the paragraph using some of the words in the list below.

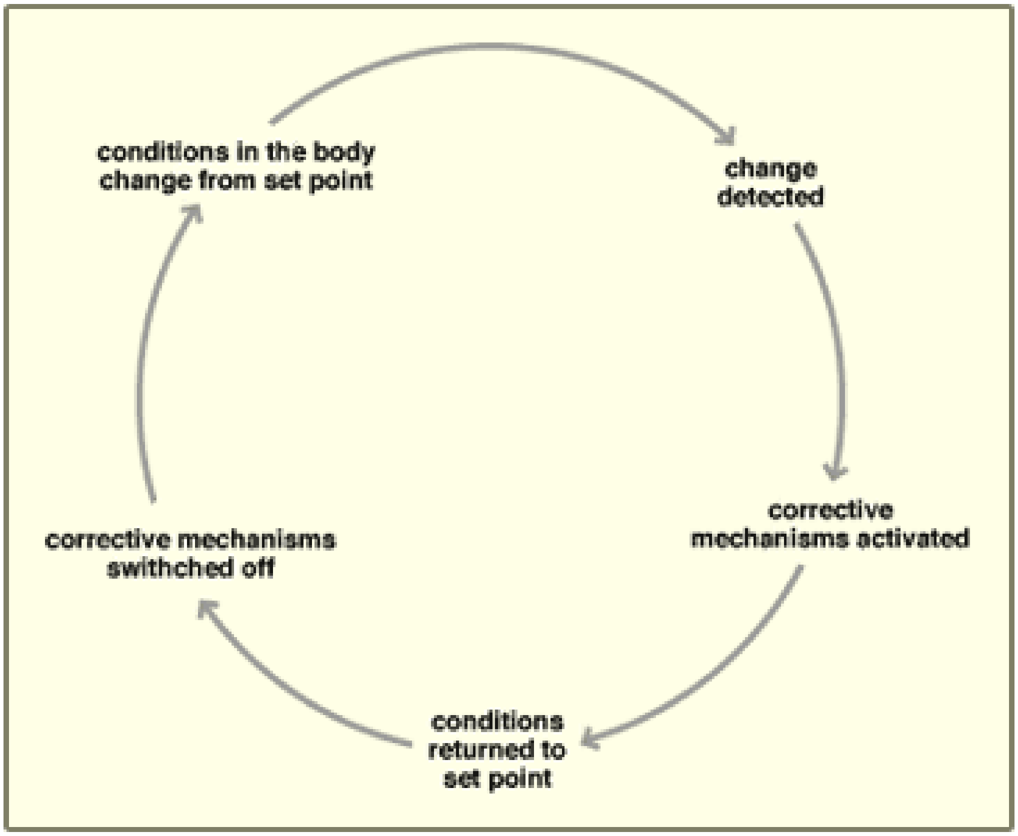
excretion glucose glycogen insulin liver oestrogen pancreas secretion starch stomach sucrose

The bloodstream transports a sugar called ___________ . The blood sugar level has to be kept constant in the body. If this level falls below normal, a hormone called glucagon is released into the blood by an endocrine organ called the _______ . The release of a substance from a gland is called _____. Glucagon promotes the breakdown of ________ to increase the blood sugar level. If the blood sugar level gets too high, the endocrine organ secretes another hormone called ___________ into the blood. This hormone promotes the removal of sugar from the blood and its conversion to glycogen in the _________ [6 marks].

Answer

glucose , pancreas, secretion, glycogen, insulin, liver.

#103 Negative feed back in homeostasis



Temperature and glucose blood levels regulation involve **negative feedback**:

- a **change** from normal conditions (body temperature, blood glucose levels…)

- triggers a **sensor**,

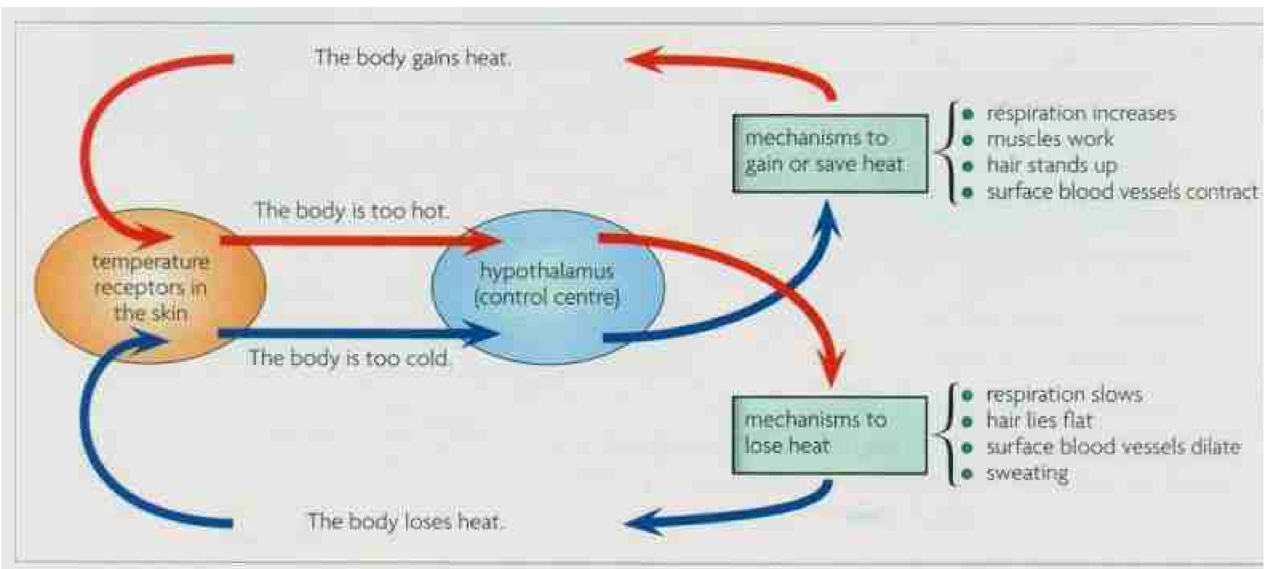
- stimulates a **response** in an **effector**.

Glucose blood levels regulation

- If **glucose** levels rise, the sensor will instruct an effector (the **pancreas**) to secret **insulin** ---> glucose levels drop below normal.
- If glucose levels drop, the sensor will instruct the pancreas to stop secreting insulin ---> glucose levels rise.
- This is negative **feedback** – the change is fed back to the effector.

Temperature regulation

- All the time, the hypothalamus is monitoring small changes in the temperature of your blood.
- If temperature rise above normal, actions take place that help to **reduce** it.
- If temperature is lower than normal, the hypothalamus stops these actions and start actions that help to **raise** the blood temperature.
- This is **negative** feedback - the information that the blood has cool down **stop** the hypothalamus making your skin to increase heat loss.



Maintaining temperature in steady state.

#104 Drugs: antibiotics, heroin, alcohol

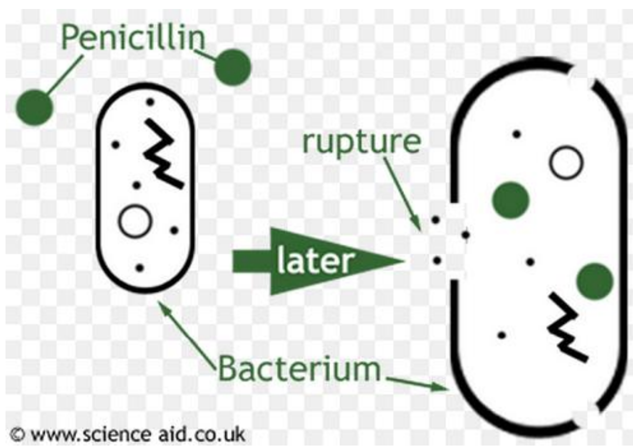
Drug is any substance taken into the body that modifies or affects **chemical reactions** in the body. Drug used in **medical care**, or to relieve mild pain, are very helpful to us. However, some people **misuse drugs**, so that they cause harm to themselves and to others around them.

1. Antibiotics kill bacteria in the body

Antibiotics are substances that **kill bacteria** or prevent their growth, but do not harm other living cells. Most of them are made by **fungi**. It is thought that the fungi make antibiotics to kill bacteria living near them – bacteria and fungi are both decomposers, so they might compete for food.

The first antibiotic to be discovered was **penicillin**. It is made by the fungus *Penicillium.* Penicillin kills bacteria by:

preventing the production of peptidoglycan that form the **cell wall**:
---> the cell continue to grow without dividing or developing new cell wall
--->the wall gets weaker ---> ruptures (lysis).

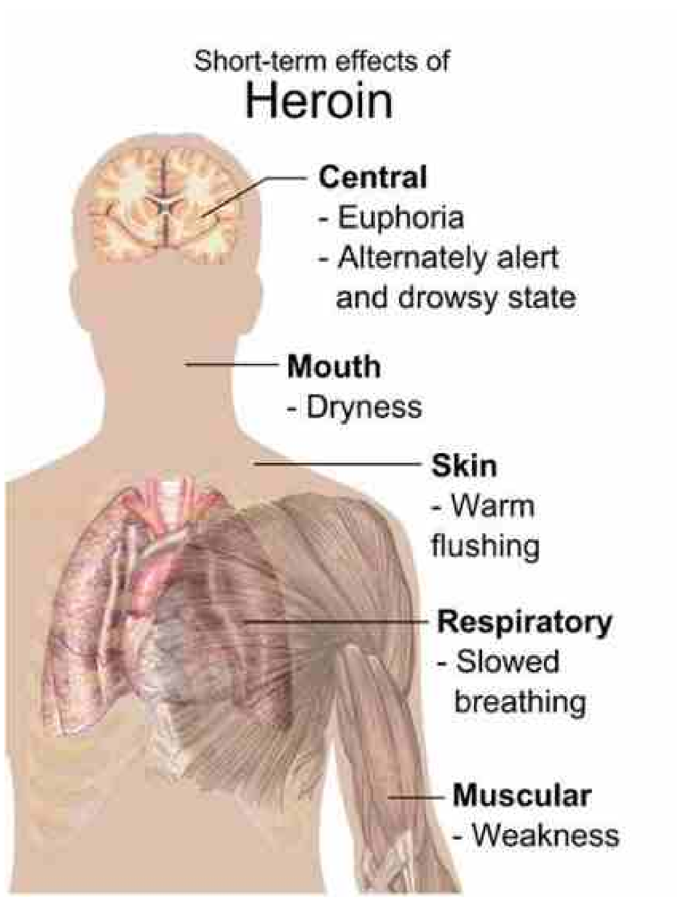


Since the **discovery** of penicillin in 1928, many more antibiotics have been developed and used to treat bacterial infections. Some bacteria have mutated and become resistant to antibiotics, but new drugs are constantly being developed and tested.

Antibiotics do **not** work **against viruses**. Many antibiotics kill bacteria by damaging their cell walls. Viruses do not have **cell walls**, so they are unharmed by antibiotics. It is difficult to develop drugs that kill viruses without damaging the body's tissues.

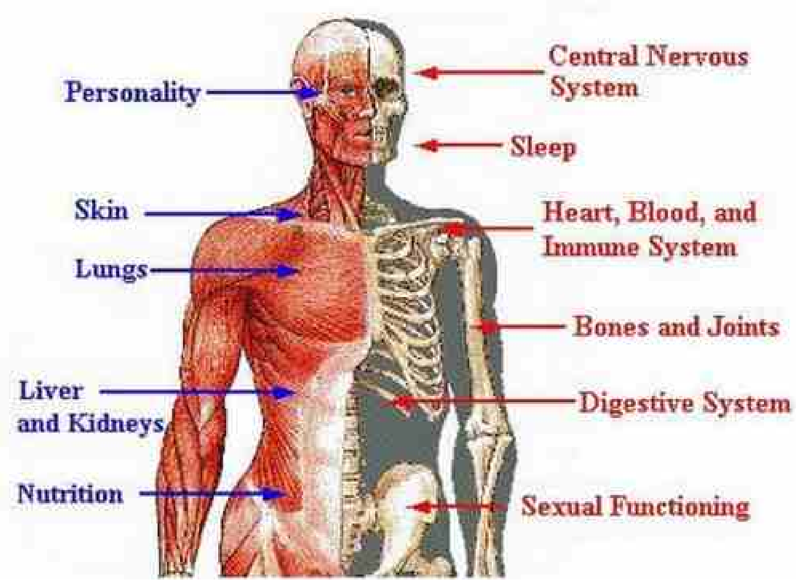
2. Effects of heroin abuse

- **Heroin** is a powerful **depressant**.
- It is a narcotic, producing a dream-like feeling of relaxation and reducing severe pain.
- It is very **addictive**, leading to dependency (addiction).
- **Withdrawal** symptoms can be very unpleasant – involving cramp, sleeplessness, violent vomiting, sweating and hallucinations.
- The body develops a tolerance to the drug, so an addict needs to take increasing amount to achieve the same feeling. This leas t the risk of **overdosing** on the drug.
- When injected using unsterilized and shared needles, there is a risk of infections such as **hepatitis** and **HIV.**
- Addiction creates **financial problems** leading to family breakdown, **criminal activity** and sexual promiscuity.



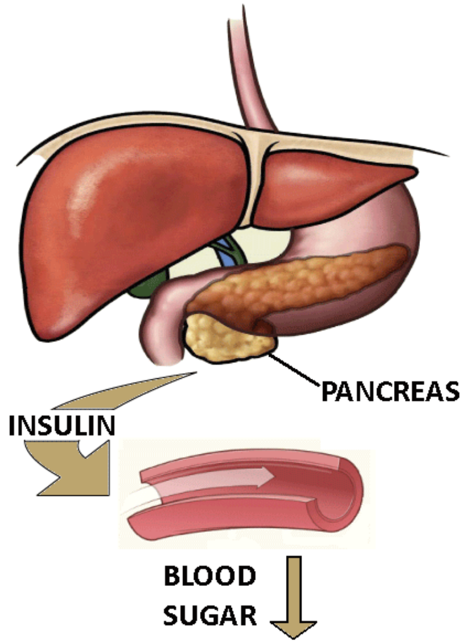
3. Effects of excessive consumption of alcohol

- Small amounts – alcohol can relax the body and create a sense of wellbeing.
- Alcohol is a **depressant**: larger amounts slow down the transmission of electrical impulses in the brain, so reactions are depressed, coordination is impaired and reasoned judgments become difficult. Mood swings involving violence can result.
- Increase **reaction time** makes driving and handling machinery dangerous.
- Poor judgments may leads to criminal activity and sexual promiscuity.
- Long-term excessive drinking can lead to **addiction** (alcoholism).
- This can lead to **financial** difficulties and family problems.
- As the liver removes alcohol from the blood, heavy drinking can leas to **liver damage** such as cirrhosis.
- Drinking can cause **brain damage**, peptic ulcers in the stomach and obesity.
- Drinking during **pregnancy** can damage the fetus, increase the risk of miscarriage or premature birth, and reduce the average birth weight.



Alcoholism Health Issues.

105 Summary of homeostasis, excretion, drugs



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12 Reproduction

#106. Types of reproduction

Reproduction is the process that makes more of the same kind of an organism.

There are 2 types of reproduction: **asexual** and **sexual**.

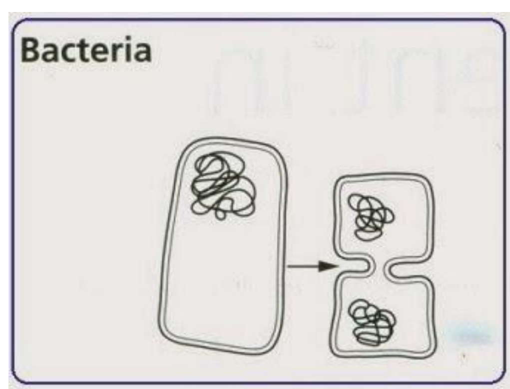
1. Asexual reproduction:

- the process resulting in the production of ***genetically indentical offspring*** from one parent.
- formation of a new organism, ***without involvement of gametes or fertilisation***.

Examples

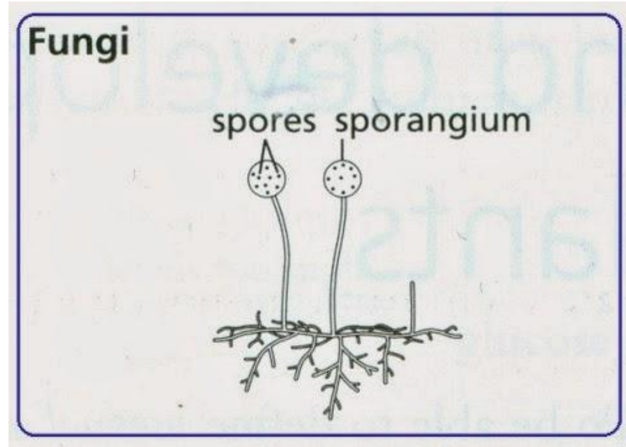
Bacteria

Bacteria reproduce asexually by binary fission. Inside an individual bacterium, the DNA replictates. Then the cell divides into two, with each daughter cell containing a copy of the parental DNA. Once the daughter cells have grown, they can also reproduce.



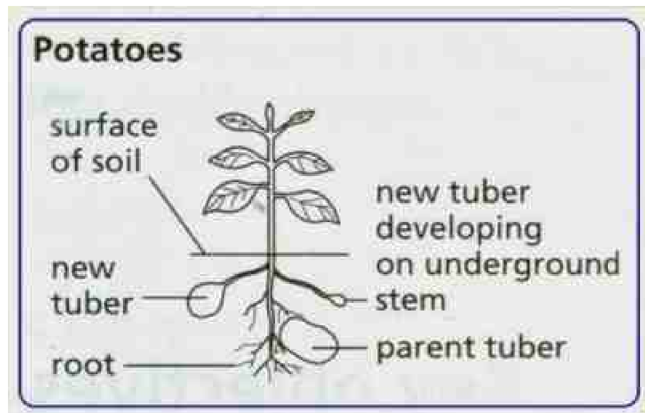
Fungi

Fungi can reproduce asexually by producing spores, which may be formed inside a structure called a sporangium. When ripe, the sporangium bursts open allowing the spores to be dispersed. In suitable conditions the spores germinate and grow to form new individuals.



Potatoes

Potatoes are stem tubers. The parent plant photosynthesises and stores the food produced in underground stems, which swell to form tubers. Each tuber contains stored starch, and there are buds in depressions in the surface known as eyes. In suitable conditions the buds use the stored food to form shoots, form which roots also develop. Each tuber can form a new plant.



Advantages and disadvantages

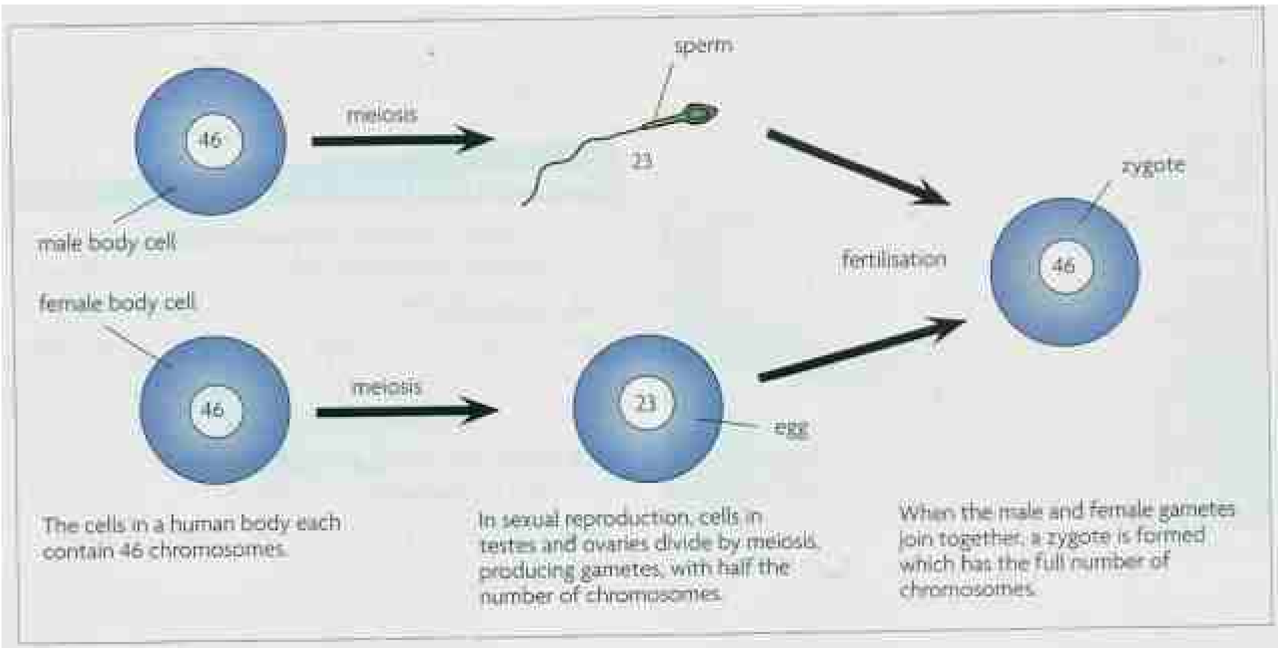
Advantages	Disadvantages
- quick - only one parent needed - no gametes needed - all good characteristics passed on - no dispersal (potato tubers) --> grow in same favourable environment as parent - store large amounts of food ---> rapid growth	- little variation ---> adaptation to environment is unlikely - offsprings inherit bad characteristics (e.g.: resistance from a disease) - lack of dispersal ---> competition (nutrients, water, light)

2. Sexual reproduction:

- the process involving the ***fusion of haploid nuclei*** to form a ***diploid zygote*** and the production of ***genetically dissimilar offspring***.

OR

- formation of a new organism by the fusion of gametes (fertilisation)



- Advantages	- Disadvantages
- variation in offspring ---> adaptation to environment - new varieties created ---> disease resistance	- 2 parents needed - Growth (of plant) is slow

Video: Asexual Reproduction
https://www.youtube.com/watch?v=jk2RJm5RBEk

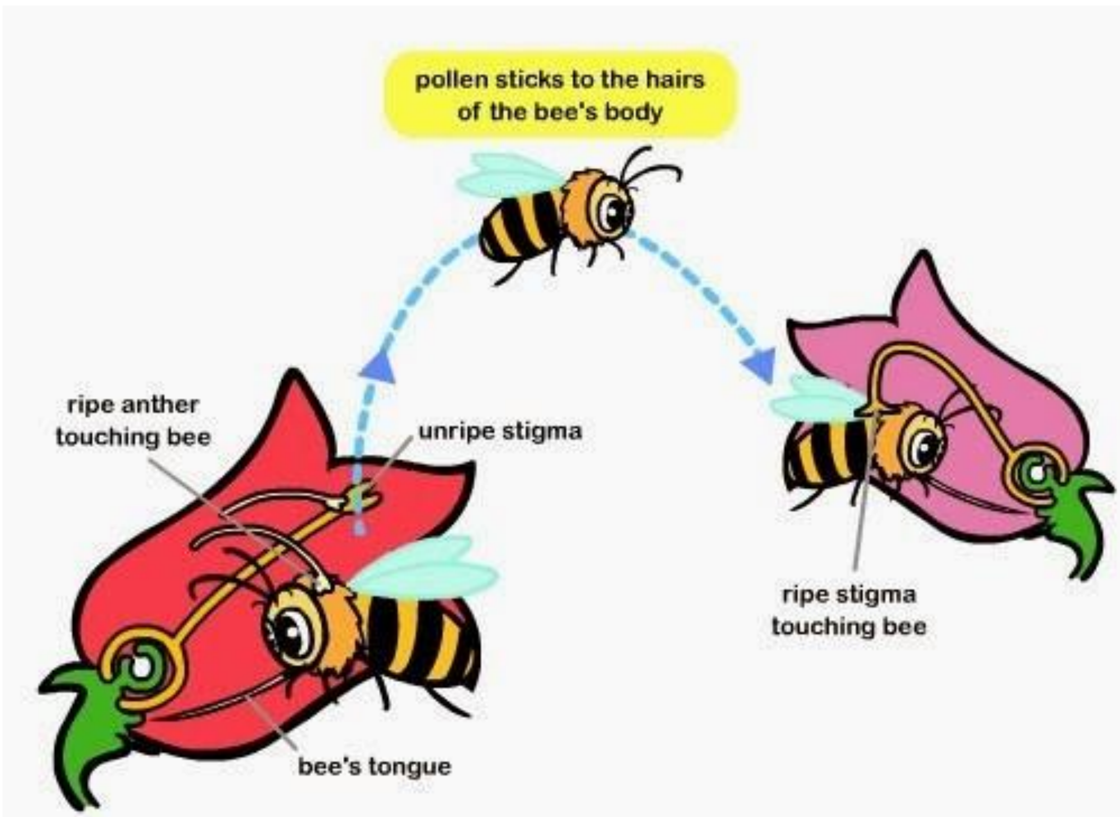
Video: Sexual Reproduction
https://www.youtube.com/watch?v=tFZeyFbBLXE

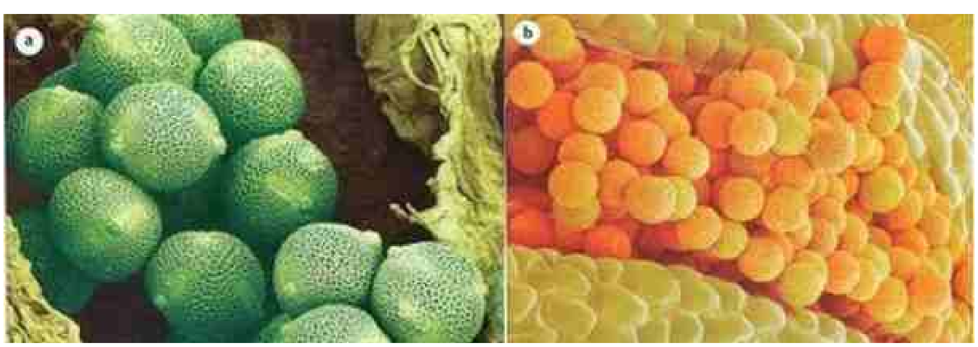
#107 Reproduction in plants - agents of pollination

Reproduction in flowering plants may occur both sexually or asexually.

Pollination can take place with the help of **agents**: **wind** or **insects.**

Pollination: transfer of **pollen grains from** the male part of the plant **(anther) to** the female part **(stigma).**





Pollen grains.

Structural adaptations

Features of wind- and insect-pollinated flowers

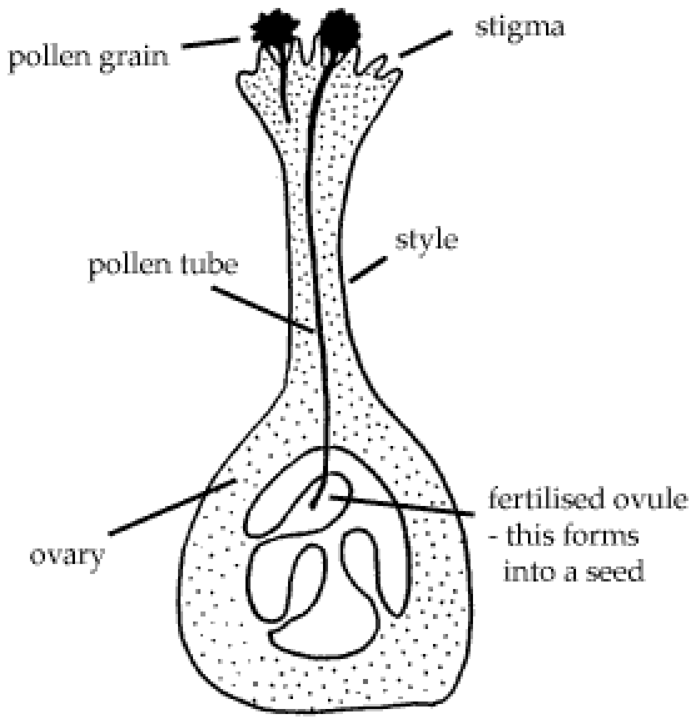
Feature	Insect-pollinated	Wind-pollinated
Petals	- large, coloured, scented - guidelines for insects into flower	- absent/small
Nectar	- produce by nectarines - attract insects	- absent/small and green
Stament	- inside flower	- long filaments: anther hang freely outside flower → pollen exposed to wind
Stigme	- small, sticky - inside flower → insects rub against	- large, feathery - hang outside flower → catch pollen
Pollen	- smaller amount - grain round and sticky or covered in spikes to attact to insects	- larger amount - grain smooth, light, easily carried by wind
Bracts (modified leaves)	- Absent	- Sometime present

Common misconceptions

Students often get confused between pollination and seed dispersal. When animals such as insects carry pollen, they aid pollination. When animal carry seeds, they aid seed dispersal.

Growth of pollen tube and the process of fertilization

Figure below shows a section through a single carpel.



If pollen grains are of the same species as the flower they land on, they may germinate. Germination is triggered by a sugary solution on the stigma, an involves the growth of a pollen tube from the pollen grain.

The pollen tube contains the male nucleus, which is needed to fertilise the ovule inside the ovary. The pollen tube grows down the style, through the ovary wall, and through the micropyle of the ovule.

Fertilisation is the fusion of the male nucleus with the female nucleus. If the ovary contains a lot of ovules, each will need to be fertilised by a different pollen nucleus.

Video: Flower Reproduction

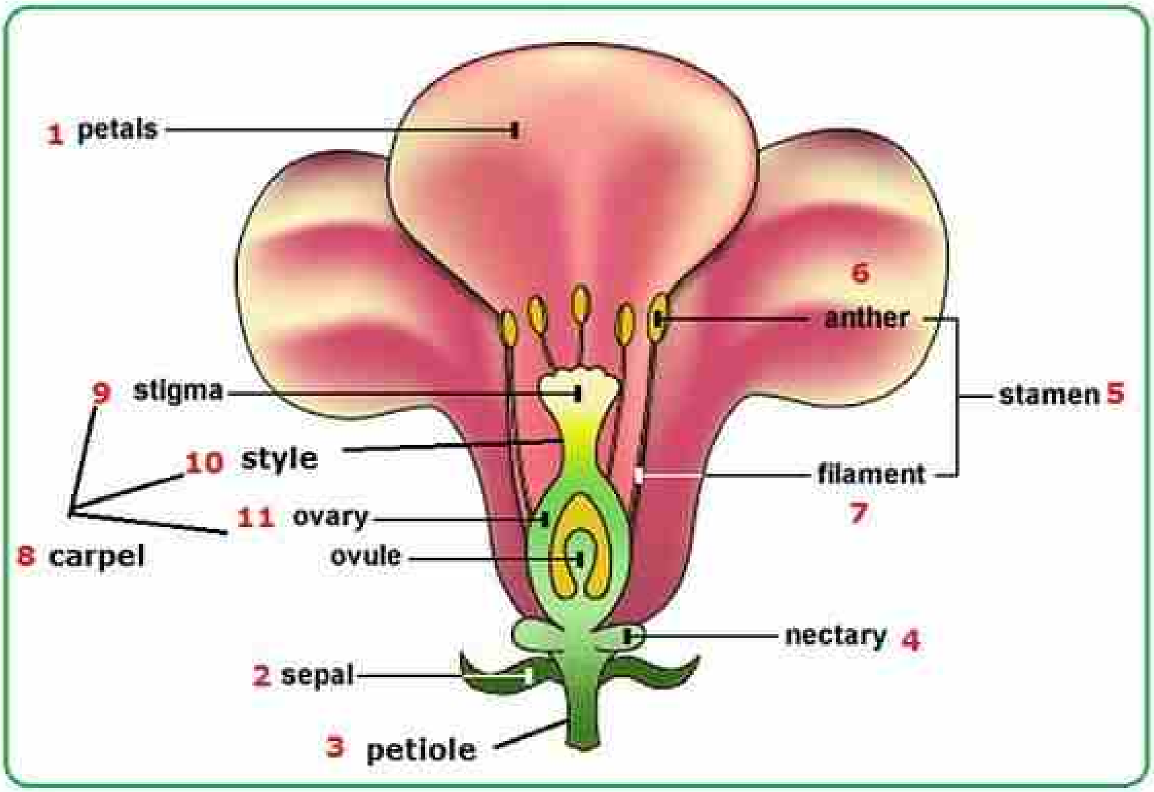
https://www.youtube.com/watch?v=YqM6rgB_l_o

Video: Sexual Reproduction in Flowering Plants

https://www.youtube.com/watch?v=CkBNEM2mD30

#108 Structure and functions of a flower

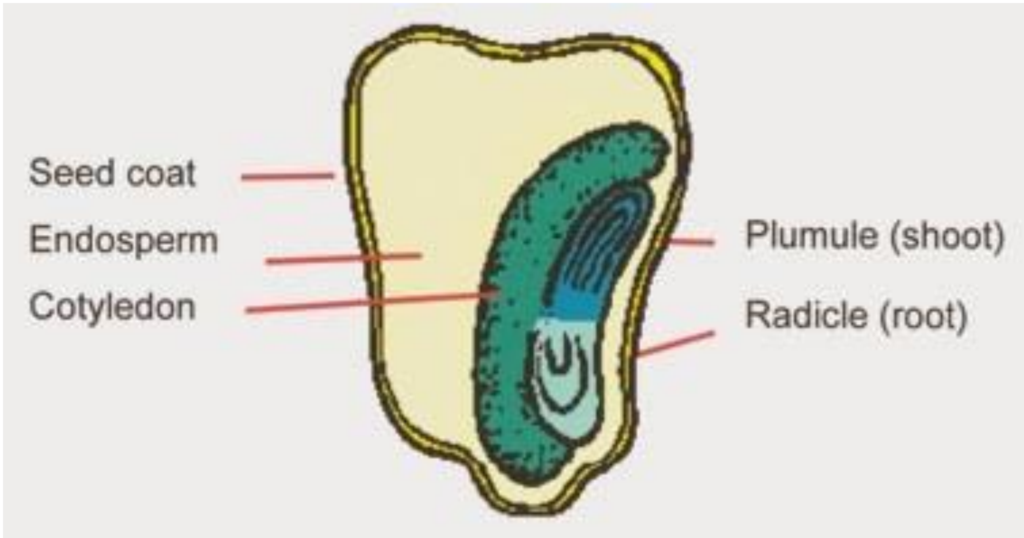
You need to be able to describe the **structure** and **functions** of a named **dicotyledonous** (two seed leaves) flower.



Functions of parts of a flower

	Part	Function
1	Petal	Often large and coloured, to attract insects
2	Sepal	Protects the flower while in bud
3	Petiole (stalk)	Supports the flower to make it easily seen by insects, and to be able to withstand wind
4	Nectary	Produces nectar, to attract insects
5	Stamen	The male reproductive part of the flower, made up of anther and filament
6	Anther	Contains pollen sacs, in which pollen grains are formed. Pollen contains male sex cells.
7	Filamen	Support the anther
8	Carpel	The female reproductive part of the flower, made up of stigma, style and ovary
9	Stigma	A sticky surface to the ovary, through which pollen tubes grow
10	Style	Links the stigma to the ovary, through which pollen tubes grow
11	Ovary	Contains ovules, which develop into seeds when fertilised.

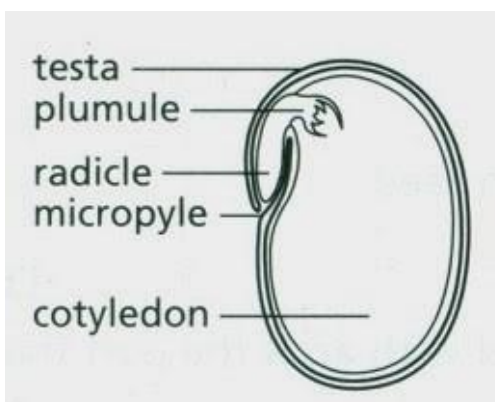
#109 Formation of seed, conditions affecting germination



The fertilised **ovule** divides by mitosis to form a **seed** containing the embryo plant and food stores called **cotyledons**.

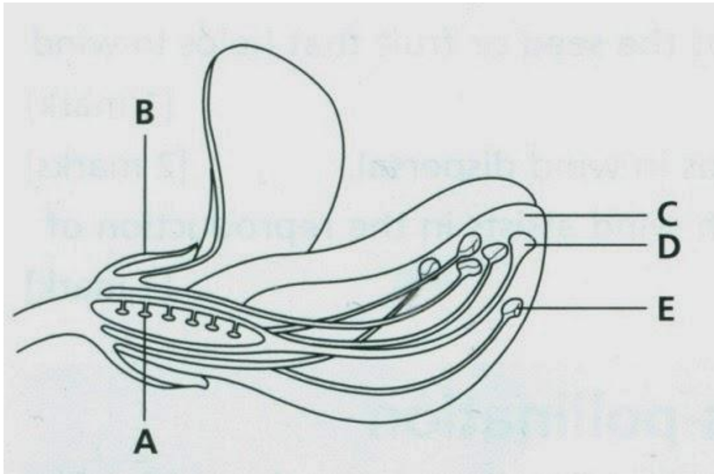
- The wall of the ovule forms the seed testa (coat).
- The ovary wall develops into a fruit, which may be fleshy (e.g. plum) or a dry pod (e.g. lupin or pea).

Structure of a non-endospermic seed



Try this

Figure below shows a section through a bean flower.



a) Name the parts labeled **A** and **B** [2 marks]

b) This flower is insect-pollinated. Suggest how parts **C, D** and **E** help in pollination of this flower. [3 marks]

c) After pollination, the ovules develop into seeds. Describe the events which occur after pollination and which result in the formation of seeds [4 marks]

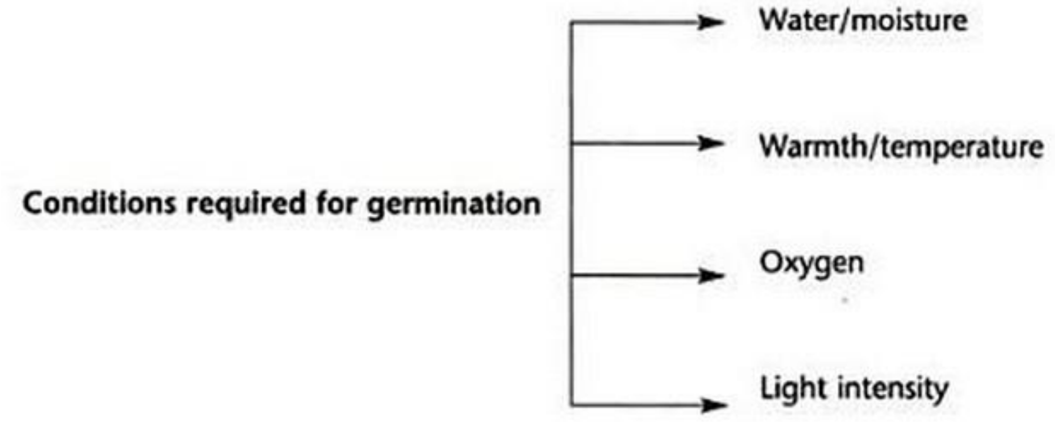
Answer

a) **A**: ovule, **B**:sepal

b) **C** (petal) are large and colourful to attract insects
D (stigma) is sticky and lies in the way of the insects to cllect pollen
E (anther) produces pollen and lies in the way of the insects to transfer pollen on to their bodies.

c) **Four** points form:
- pollen grains germinate
- pollen tube grows down the style
- through the micropyle
- into the ovule
- the male nucleus fuses with the female nucleus
- reference to fertilisation

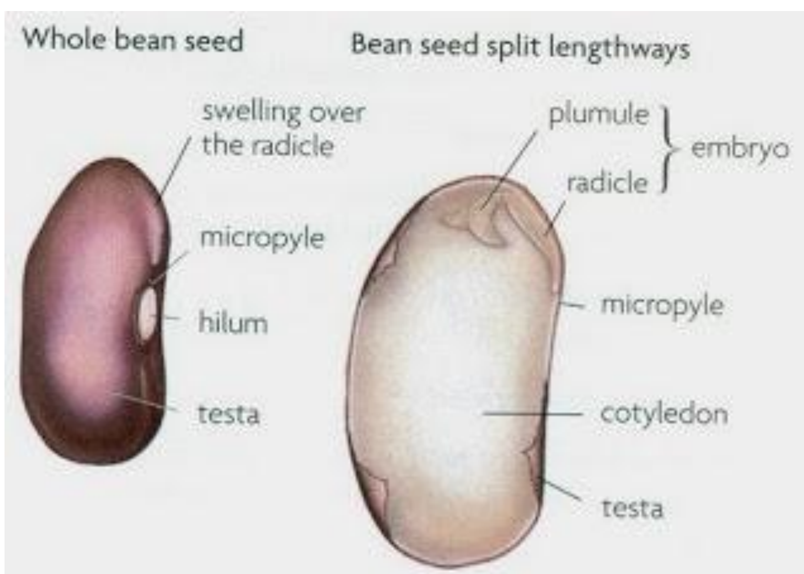
Environmental conditions affecting germination



1.Water:

- absorbed through **microphyle** until **radicle** is forced out of **testa**
- **activate enzymes** for converting soluble food stores in the cotyledons down to **soluble food** ---> for growth + energy production of baby plant.

2.Oxygen: respiration ---> release energy ---> growth



3.Warmth/temperature: enzymes present in the seed get activated and work best at optimum temperature (20-40^{0}C) which trigger growth in the baby plant.

4. Light intensity: high or very low light intensity does not allow enzymes to function normally.

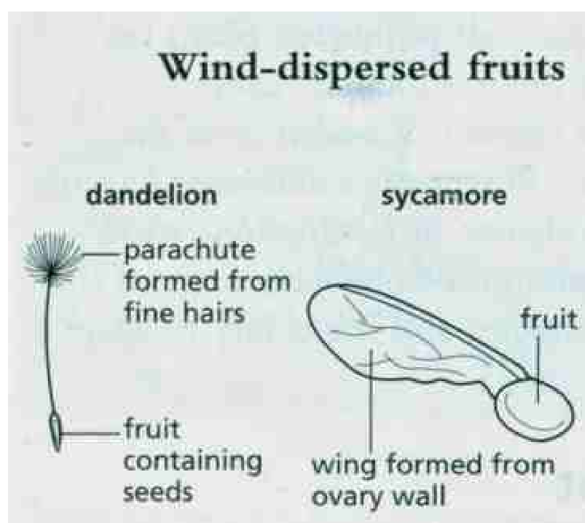
#110 Seed dispersal

The flowers produce seeds which can be **dispersed** by the **wind** or other **animals,** providing a means of **colonising new areas**.

Nutmeg is dispersed by birds.
Photo credit: russolab.unl.edu

1. Wind-dispersed seeds

- Fruits contain seeds, and usually have a **parachute** or a **wing** to help them be carried away from the parent plant by the wind.
- Examples: dandelion, sycamore



The **dandelion** fruit has a group of fine hairs called a pappus, which catches the wind and acts like a **parachute**. The fruit counterbalances the pappus.

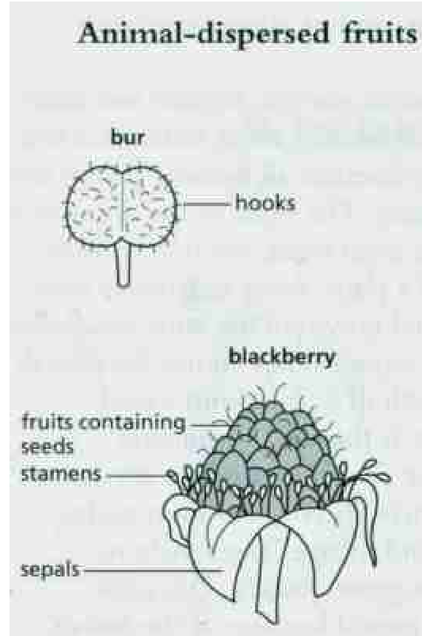
The **sycamore** has a **wing** with a large surface area. When the fruit drops off the tree it spins, slowing down in descent. If caught by the wind the seed will be carried away from the parent plant, reducing competition for nutrients, water and light.

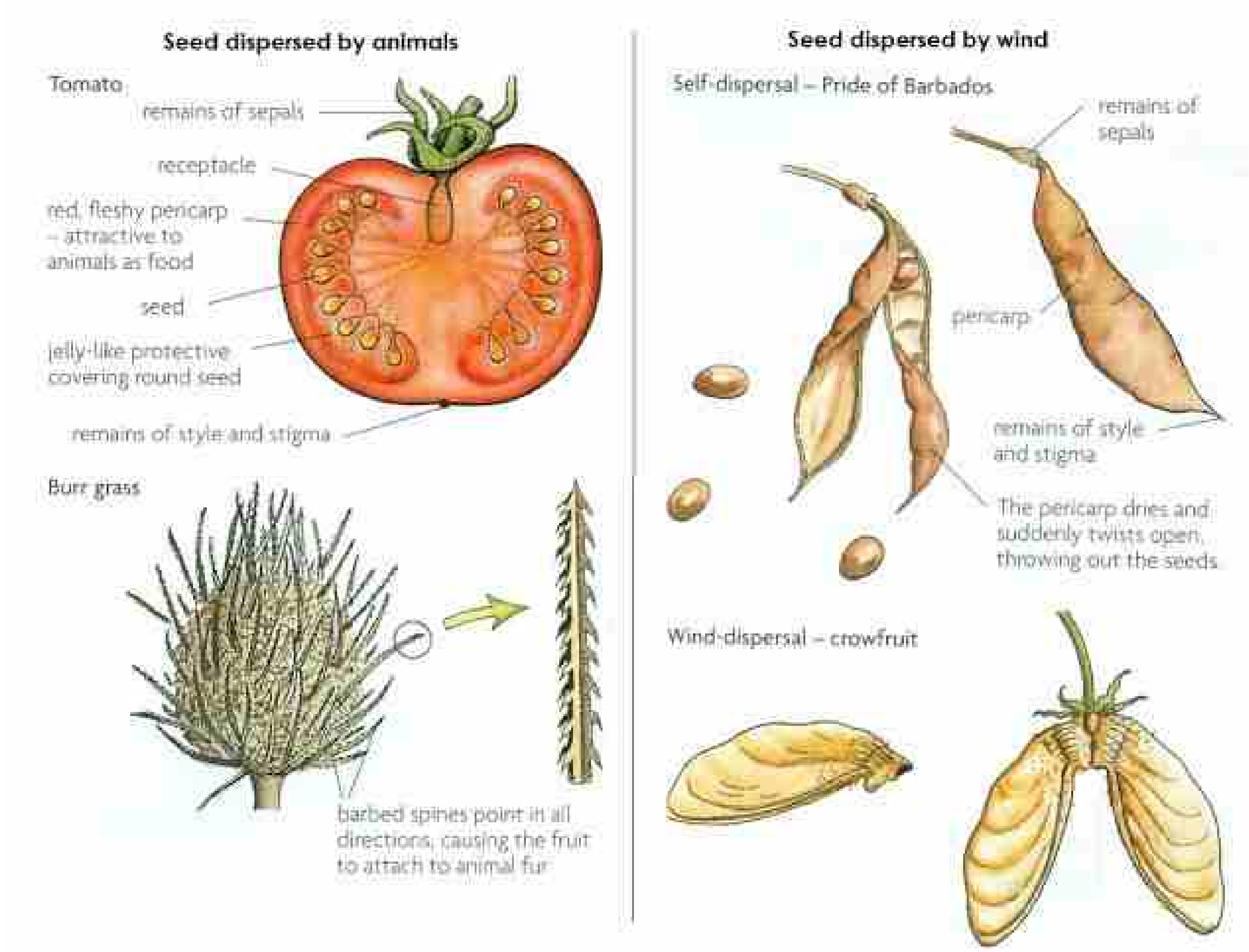
2. Animal-dispersed seeds

There are 2 main modification of fruits for animal dispersal: **succulent** fruits and **hooked** fruits.

Succulent fruits attract animals because they are brightly coloured, juicy and nutritious.
When **eaten**, the seed pass through animal's **faeces**, which may be a long way from the parent plant. The faeces provides nutrients when the seeds germinate.

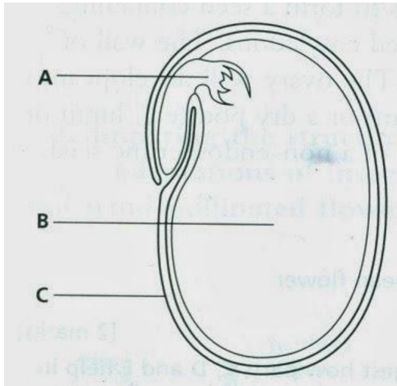
Hooked fruits catch on to an **animal's fur** as it brushes past the parent plant. Eventually the seeds drops off, or the animal grooms itself to remove them. This disperses the seeds away from the parent plant.





Try this

Figure below shows a section through a bean seed.



1. i) Name the parts labeled **A**, **B** and **C**. [3 marks]
   ii) Copy the diagram and label with an **X** the part that contains the seed's food reserves. [1 mark]

2. Seeds and fruits are dispersed away from the parents plant.
   i)Sketch a seed or fruit that is adapted for dispersal by wind. Label with a **Y** the special feature of the seed or fruit that helps in wind dispersal. [1 mark]
   ii) Suggest how this feature helps in wind dispersal. [2 marks]

   iii) Suggest another way in which wind assist in the reproduction of plants. [1 mark]

Answer

1. i) **A** plumule; **B** cotyledon, **C** testa (seed coat)
   ii) **X** on any part of the cotyledon.

2. i) Sketch of dandelion, sycamore…
   Y on the part that catches the wind (parachute, wing…).

ii) **Two** points from:
- description of how the feature catches the wind
- and slows down the descent of the seed or fruit
- so the seed or fruit is carried away from the parent plant.

iii) Wind pollination

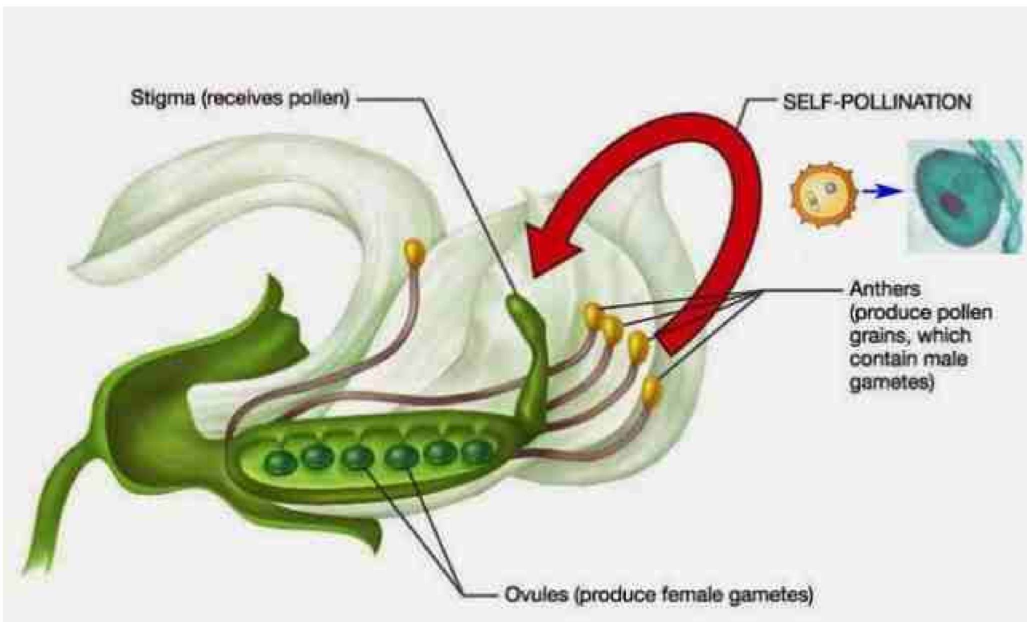
Video: Seeds - An amazing video taken from BBC's The Private Life of Plants documentary series (MUST SEE).
https://www.youtube.com/watch?v=buZV0h4vfmQ

#111 Self-pollination and cross-pollination

Self-pollination - transfer of pollen from the anther to the stigma of the same flower, or to another flower of the same plant.
Cross-pollination - transfer of pollen from the anther of a flower to the stigma of a flower on a different plant of the same species.

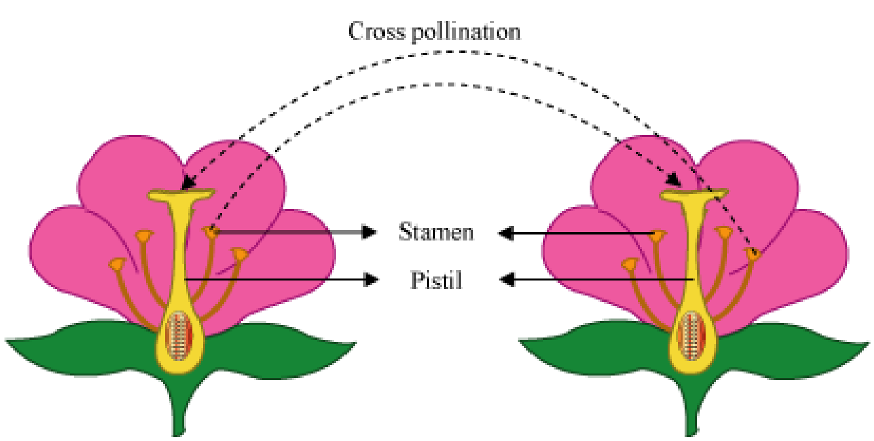
Self-pollination

- ↑ chance of successful pollination à smaller numbers of pollen
- ↑ chance of fertilisation and seed formation
- ↓variation in the offspring.
- ↓ ability to adapt to environmental change.



Cross-pollination

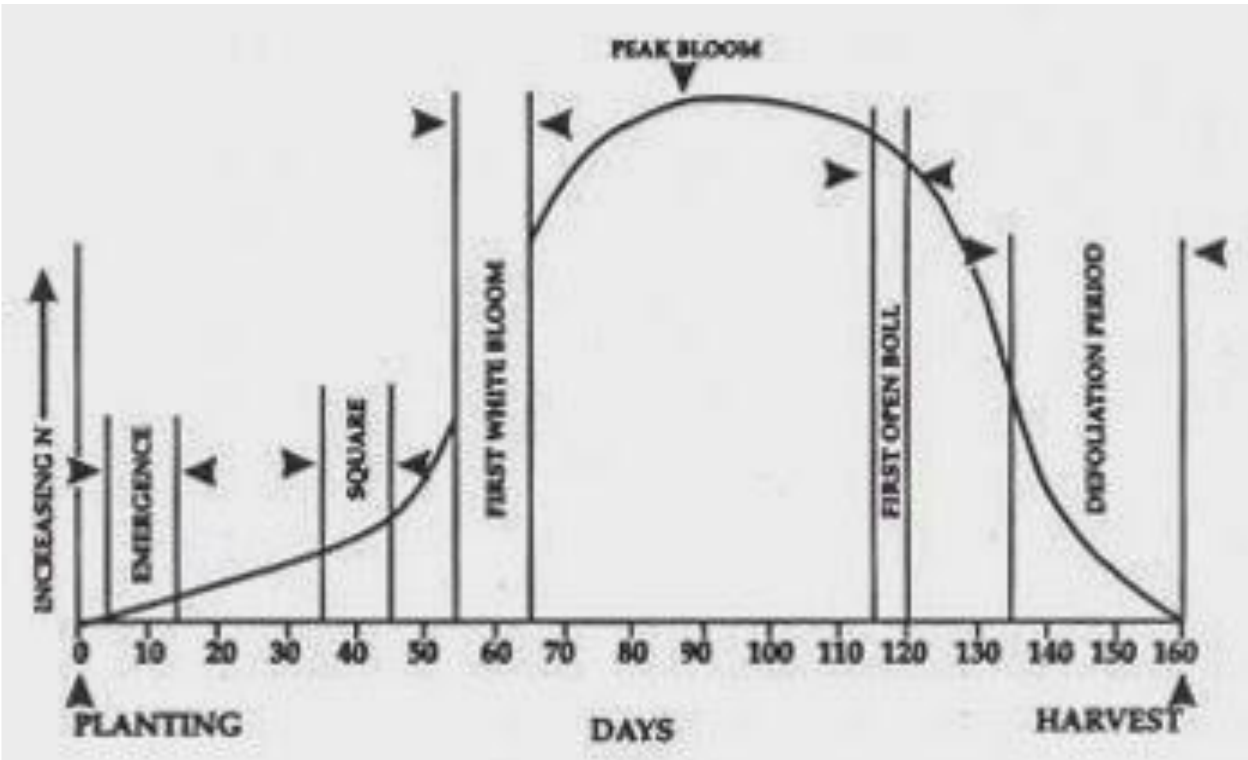
- ↓ chance of successful pollination à large amounts of pollen
- ↓ chance of fertilisation
- ↑ variation
- ↑ ability to adapt to environmental change.



#112 Growth and development

Growth - permanent **increase** in **size** and **dry mass**, by an increase in cell number or cell size or both.

Development - increase in **complexity**



1. Development

- increase in complexity of an organism as it grows. As the number of cells increases, they become differentiated (specialized for different tasks).

- change in shape to adapt for a specific function.

Examples:

- nerve cells are very elongated and can transmit electrical impulses

- xylem cells are elongated and lose their cell contents, with the cell walls becoming lignified so the cells conduct water efficiently.

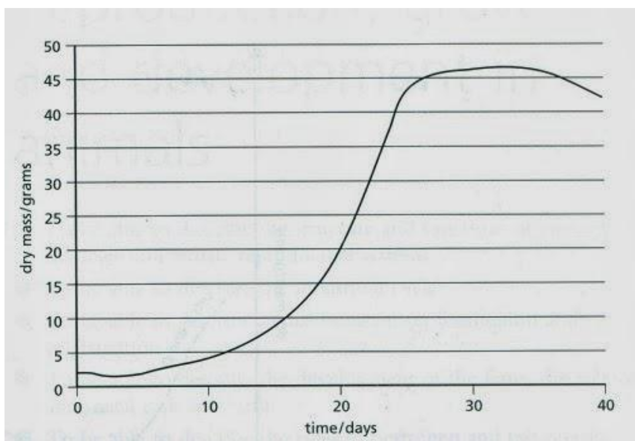
2. Growth

- due to an increase in cells, produced by mitosis.
- controlled by hormones (in animals) and growth substance like auxins (in plants).

Dry mass

- Often used as a measure of growth, because wet mass varies from day to day (e.g. plant will take up more water on a wet day than on a dry day, but the water does not all become part of the biomass – living material of the plant).
- Obtained by drying out the organism in an oven (killing it).
- Many individual have to be germinated at the same time and grown in the same conditions.
- Samples are dried at various times during the growth period.

Example: Changes of dry mass during the growth of a plant from a seed.



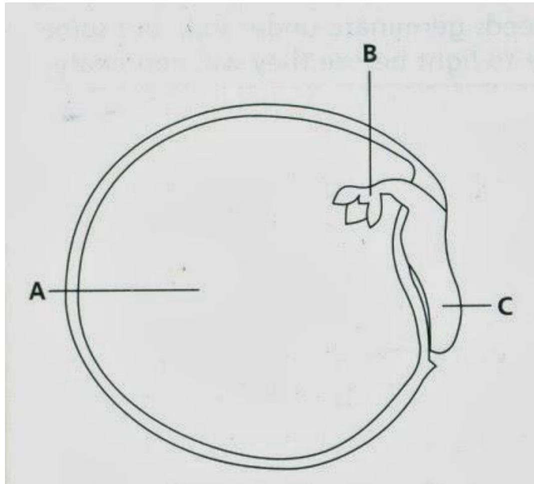
- ↓ slightly when the seed germinates, at day 2 (some of the stores in the cotyledon are being used in respiration).

- ↑ when the plumule stars to photosynthesise, and foliage leaves form to continue the process.

- ↓ at the end of the growth period (loss of seeds and fruits; leaves die).

Try this

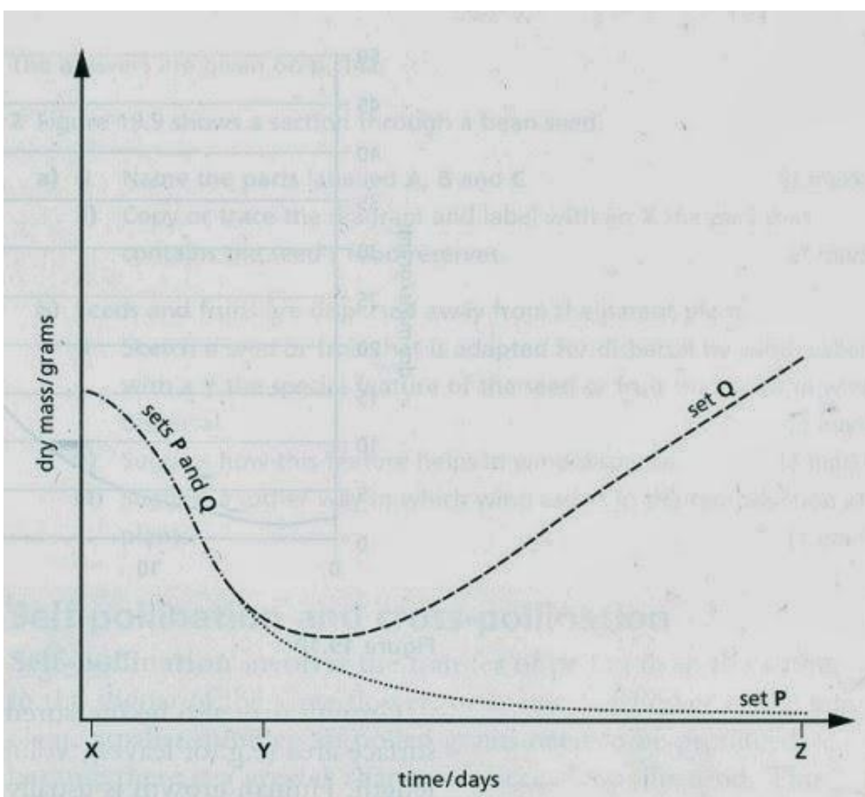
1. Figure below shoes a section through a seed of a dicotyledon.



i) What is the role of part **A**? [1 mark]

ii) What do parts **B** and **C** of the seed develop into after germination? [2 marks]

2. Figure below shows changes in mass of sets of pea seeds as they germinate and grow into seedlings, after germination set **B** was grown in the dark and set **Q** in the light.



i) Why is mass measured as dry mass? [1 mark]

ii) Explain the changes in dry mass between days **X** and **Y** in both sets of seedling. [4 marks]

iii) Explain why there is a difference in the dry mass of set **P** and **Q** between day **Y** and **Z**. [4 marks]

Answer

1. i) Stored food.
   ii) **B** develops into the shoot (or leaves)
   C develops into the root.

2. i) Wet mass varies according to the amount of water absorbed of lost from the plant, or dry mass represents the amount of cytoplasm.

   ii) **Four** points from:
   - the dry mass drops between days **X** and **Y** for both sets of seedlings
   - food stored in the cotyledons
   - is used to supply energy
   - through respiration
   - some food is converted into other materials
   - for growth of the radical and plumule.

   iii) **Four** points from:
   - set Q increases in dry mass and st P decreases in mass
   - set Q is in the light and can photosynthesise
   - to make new cytoplasm
   - set P is in the dark and can not photosynthesise
   - set P uses up remaining food stores through respiration.

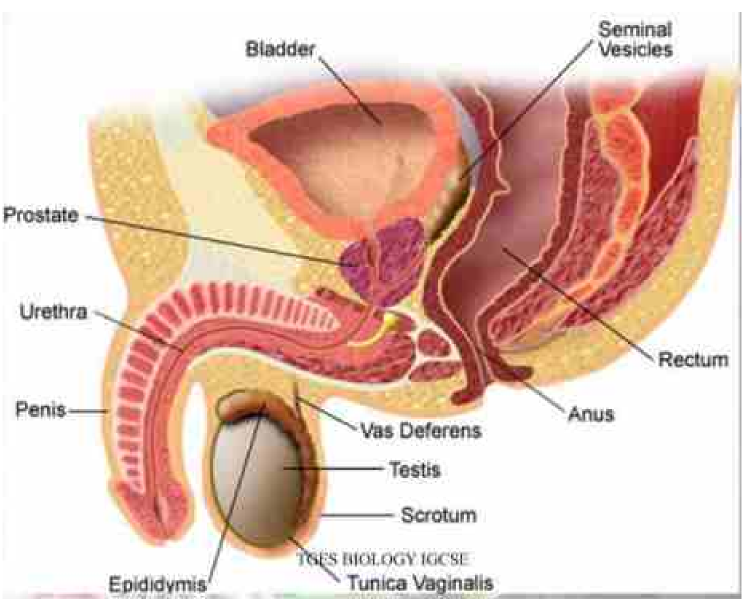
#113 Reproduction in humans - Reproductive system

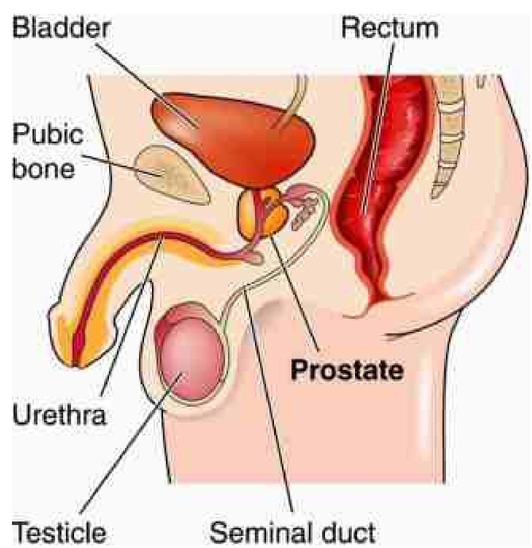
Reproduction in humans is when the male gamete (**sperm**) **fuses** together with the female gamete (**ovum/egg**).

At first, it is just one single cell, which **duplicates** over and over until after 9 months…… TA-Dahh! - A baby is born!

Male reproductive system

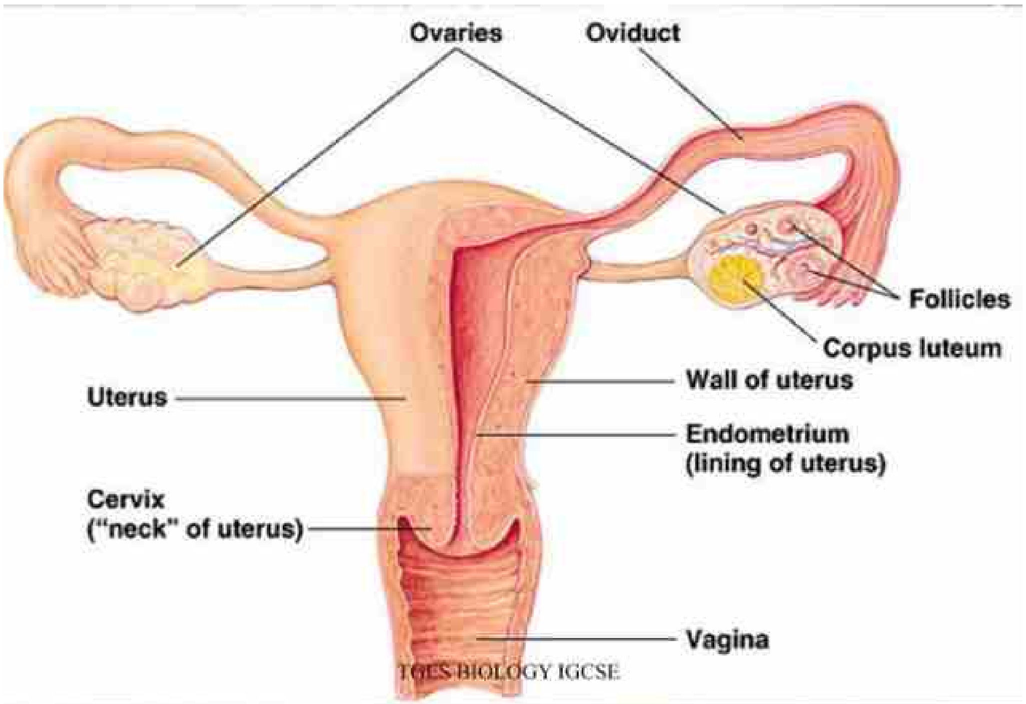
- **Testes**: produce **sperm** and **testosterone**
- **Scrotum**: a **sac** that keeps testes cool (outside body)
- **Sperm ducts**: **link testis to urethra:** allow passage of semen containing sperm
- **Prostate gland**: produce **alkaline fluid** ---> semen
- **Urethra**: urinate; pass semen (+sperm) through penis
- **Penis:** become firm, **inserted into vagina** during sexual intercourse ---> transfer sperm





Female reproductive system

- **Ovaries:** contains follicles, produce and stores **eggs,** produce **oestrogen**
- **Oviducts**: carries ovum to uterus; Fallopian tubes = site of fertilisation
- **Uterus** – where fetus develops
- **Cervix-** a ring of muscles that separate the vagina from the uterus
- **Vagina: receives sperm from erect penis** during intercourse



Comparing male and female gametes

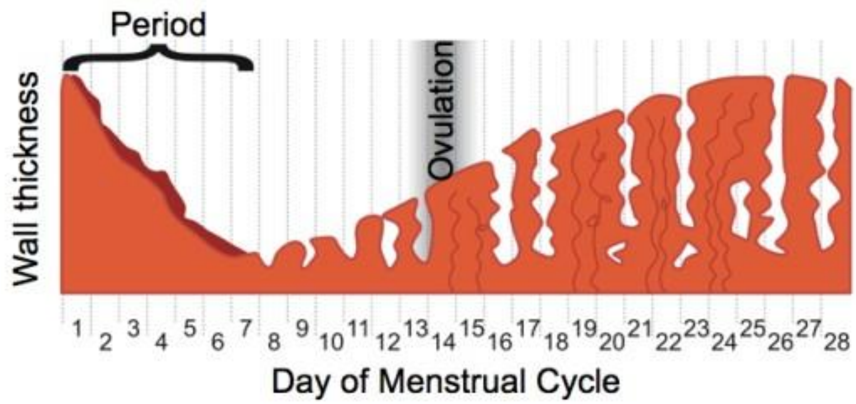
Feauture	Sperm cell	Egg cell
size	small	Larger than sperm
movement	Tail lashes from side to side	Doesn't move by itself – cilia and peristalsis in oviduct
Number produced	Millions constantly produced	Once a month (puberty ---> menopause)

Slide Show: Reproduction from TGES Biology
http://tgesbiology.weebly.com/uploads/9/0/8/0/9080078/reproduction.swf

Video: Human Body Systems - Reproductive System https://www.youtube.com/watch?v=GArALyhGtfQ

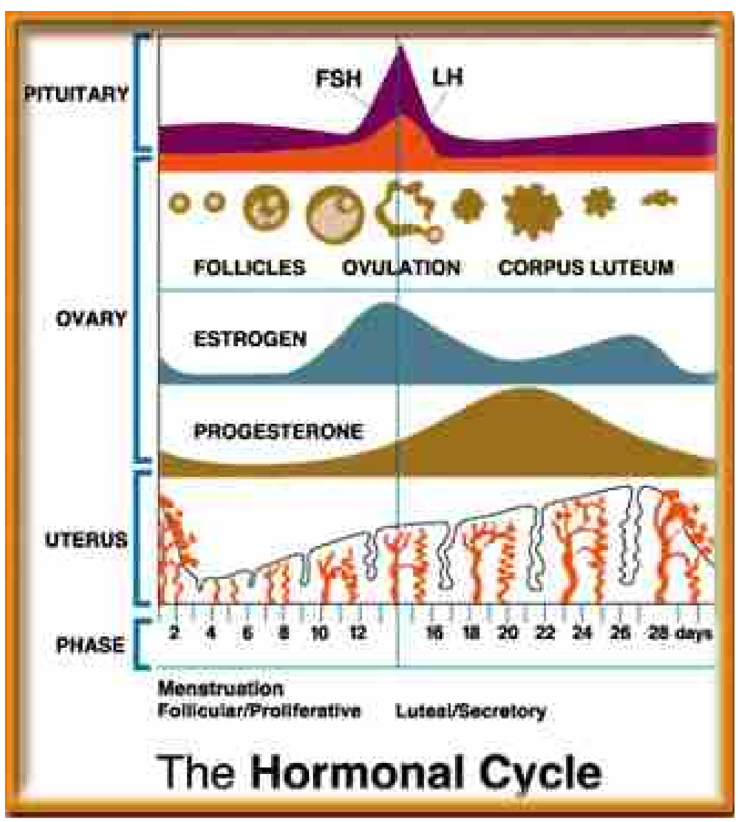
#114 Menstrual cycle

The **menstrual cycle** in women is a recurring process in which the **lining** of the uterus is prepared for pregnancy, and if pregnancy does not happen, the lining is shed at **menstruation**. The cycle lasts about 28 days.



Several **hormones** control this cycle:

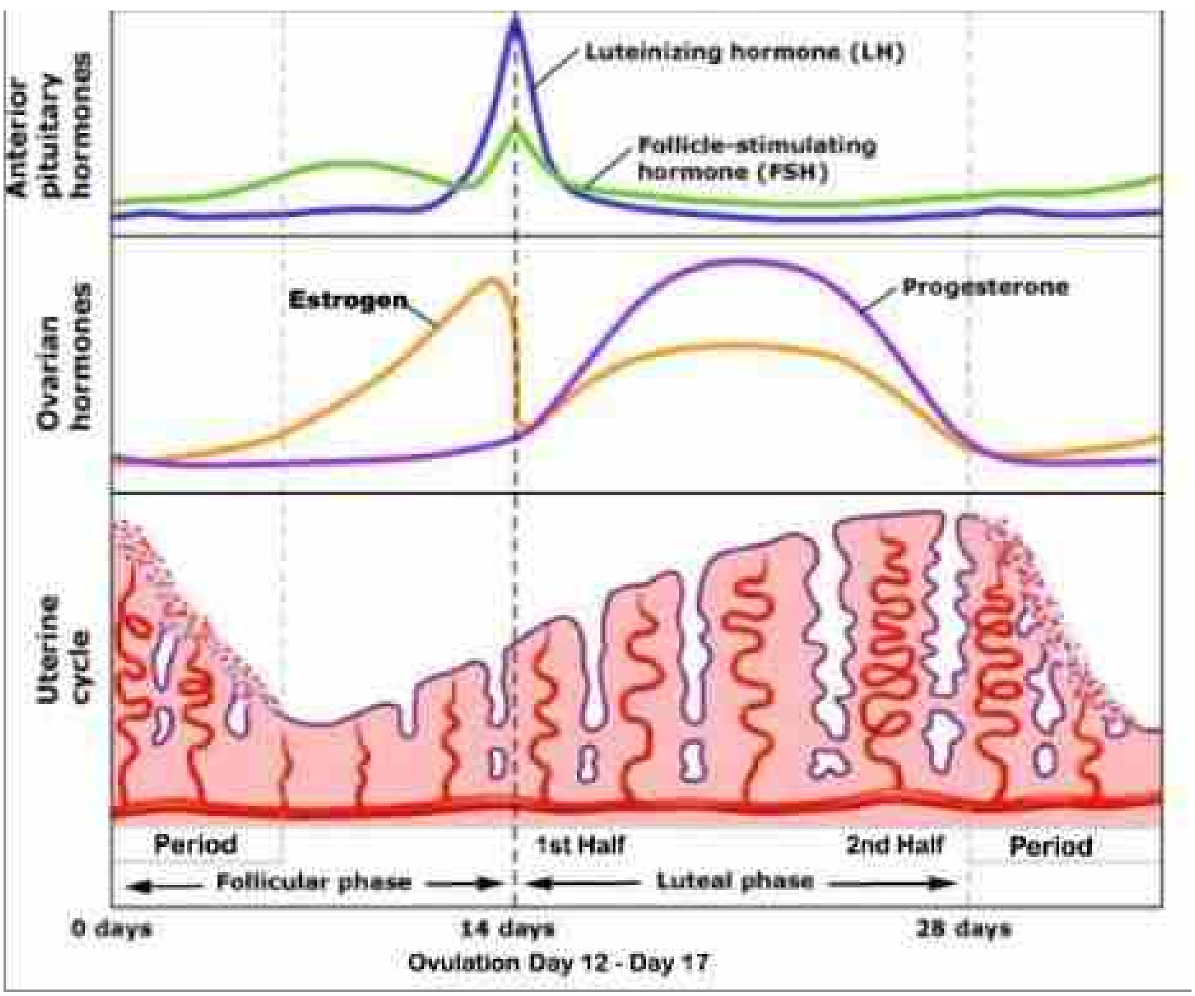
	FSH **LH**	**Oestrogen,** **Progesterone**
Secreted by	Pituitary gland (at the base of the brain)	Ovaries
Function	Control the release of egg from ovary	Change the thickness of uterus lining



1. Menstruation

- Usually, one egg is released from an ovary every month. Before the egg is released, the **lining** of the uterus becomes thick and spongy to prepares for a fertilised egg. It is full of tiny blood vessels, ready to supply the embryo with food and oxygen if it should arrive.
- If the egg is not fertilised, it is dead by the time it reaches the uterus.
- Is does not sink into the spongy wall, but continues onwards, down through the vagina.
- As the spongy lining is not needed now ---> it gradually disintegrates and is slowly lost through the vagina.
- This is called menstruation, or period and it last for about 5 days.

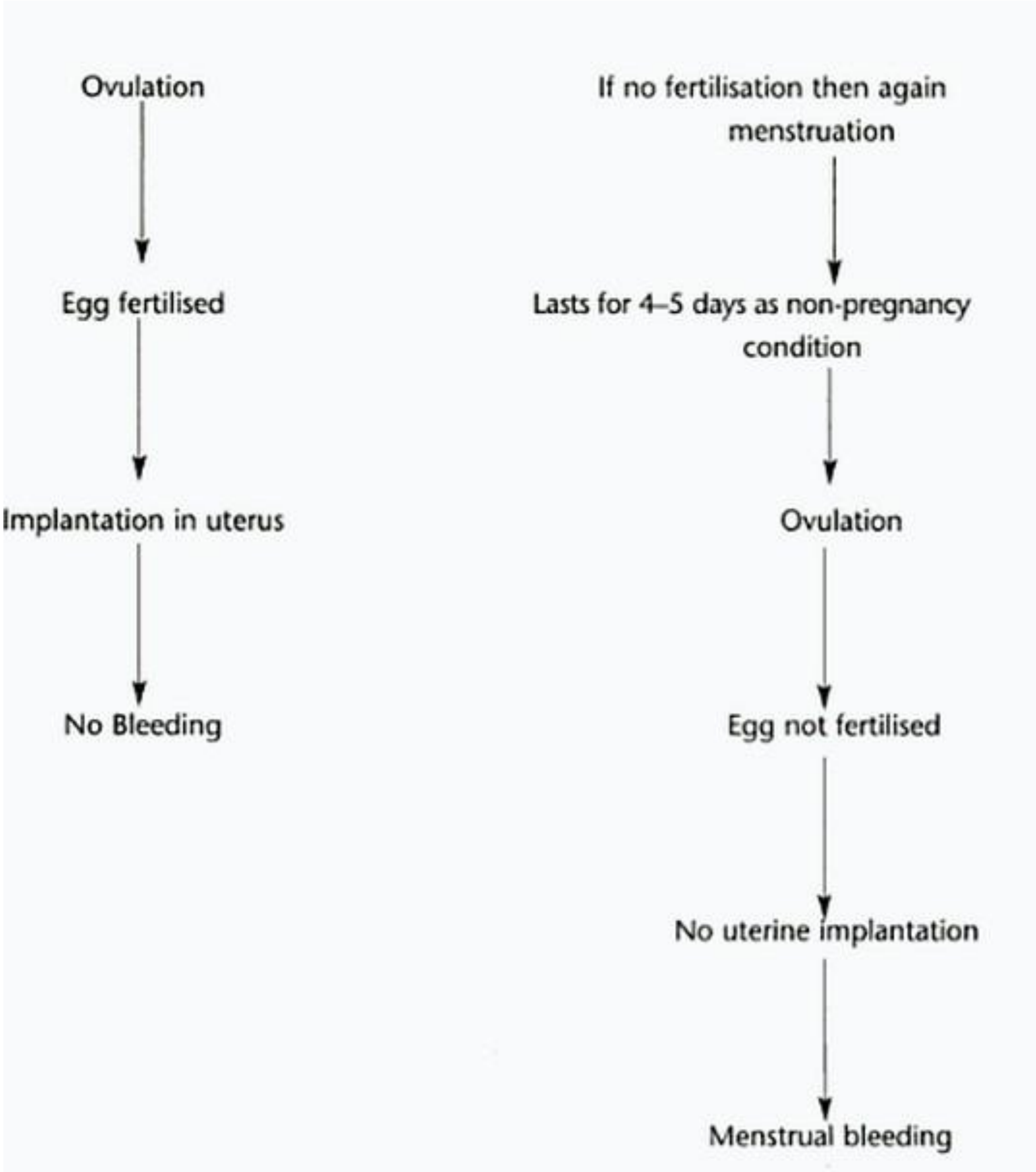
2. Ovulation



Ovary	Pituitary gland
• a **follicle** develops • secretes **oestrogen** • ↑↑ oestrogen in the blood. • lining of the uterus grows thick, spongy	• secretes **LH, FSH** • stimulates follicle to secrete oestrogen.
When the **follicle** is **fully developed** ---> **LH** ↑↑↑↑ and **FSH** ↑↑	
• follicles rupture and **release** fully developed **ovarian cells** (**ovulation**)	
• empty follicle stops secreting oestrogen • becomes a **corpus luteum** • secretes **progesterone** • uterus lining thick, spongy, well supplied with blood in case a egg is fertilised.	• ↓↓ **LH, FSH**

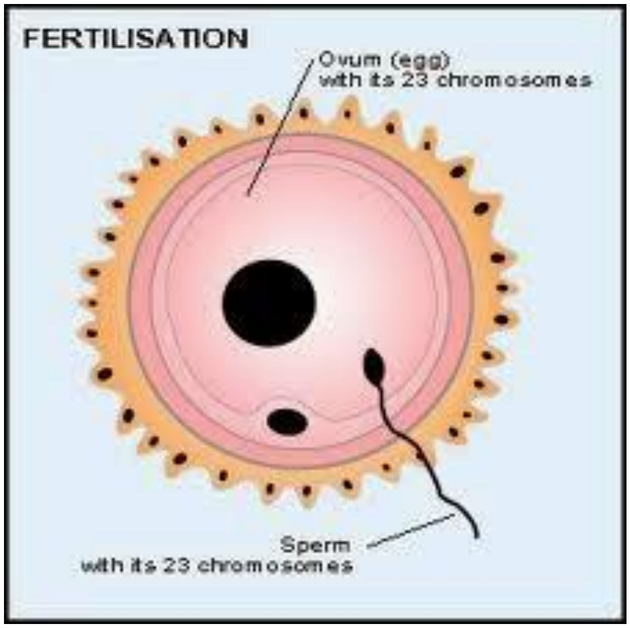
If the egg is not fertilized
• corpus luteum gradually disappears • no more progesterone secreted • uterus lining breaks down
Menstruation
• a new **follicle** develops

If the egg is fertilized
• corpus luteum does not degenerate so quickly • secretes progesterone until the embryo sinks into uterus wall and a placenta develops
Placenta secretes progesterone through pregnancy
• it maintains the uterus lining so that the menstruation does not happen during pregnancy

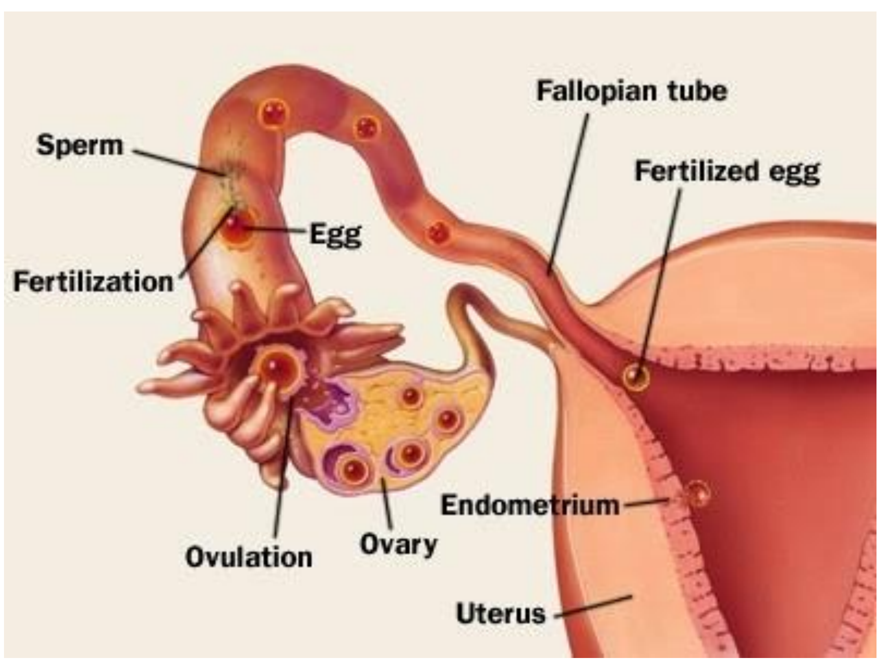

Ovulation
Egg fertilised
Implantation in uterus
No Bleeding
If no fertilisation then again menstruation
Lasts for 4–5 days as non-pregnancy condition
Ovulation
Egg not fertilised
No uterine implantation
Menstrual bleeding

#115 Formation of the fetus - fertilisation, implantation

After sexual intercourse, sperms swim through the cervix and the uterus into the oviducts, where they meet an egg. One **sperm** may **fertilise** the **egg** to produce a **zygote**.



After ovulation, the egg is caught in the funnel of the oviduct. Very slowly, the egg travels towards the uterus. If the egg is not fertilised by a sperm within 8-24 hours after ovulation, it will die. By this time, it has only traveled a short way along the oviduct. So a sperm must reach an egg while it is quite near the top of the oviduct if fertilization is to be successful.

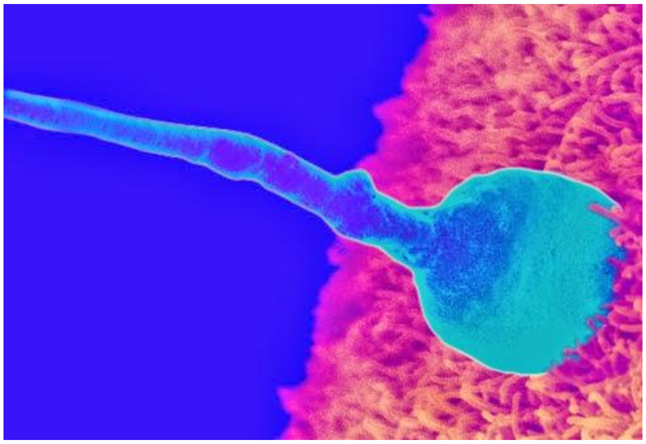


1. Sexual intercourse involves inserting the erect penis into the vagina.

- When stimulated, spongy tissue in the penis filled with blood and becomes erect.
- At the climax, semen is ejaculated from the penis into the neck of the vagina.
- Muscles in the wall of the sperm duct help to propel the semen forward
- The sperms with their tails swim from the vagina, through the cervix and uterus, into an oviduct.

2. Fertilisation happens in the oviduct

- ovum/egg pass down in oviduct
- a single **sperm penetrates the membrane of ovum** by secreting a protease enzyme; only the head of the sperm goes in, the tail is left outside.



Credit: Web MD

- the sperm nucleus and the egg nucleus **fuse** to form a **diploid zygote** = **fertilization**

- sperm can remain active in the oviduct for at least 2 days and the ovum may take a day to pass from the ovary to the uterus, so there is a fertile period of 3 to 4 days around ovulation when fertilization can happen.

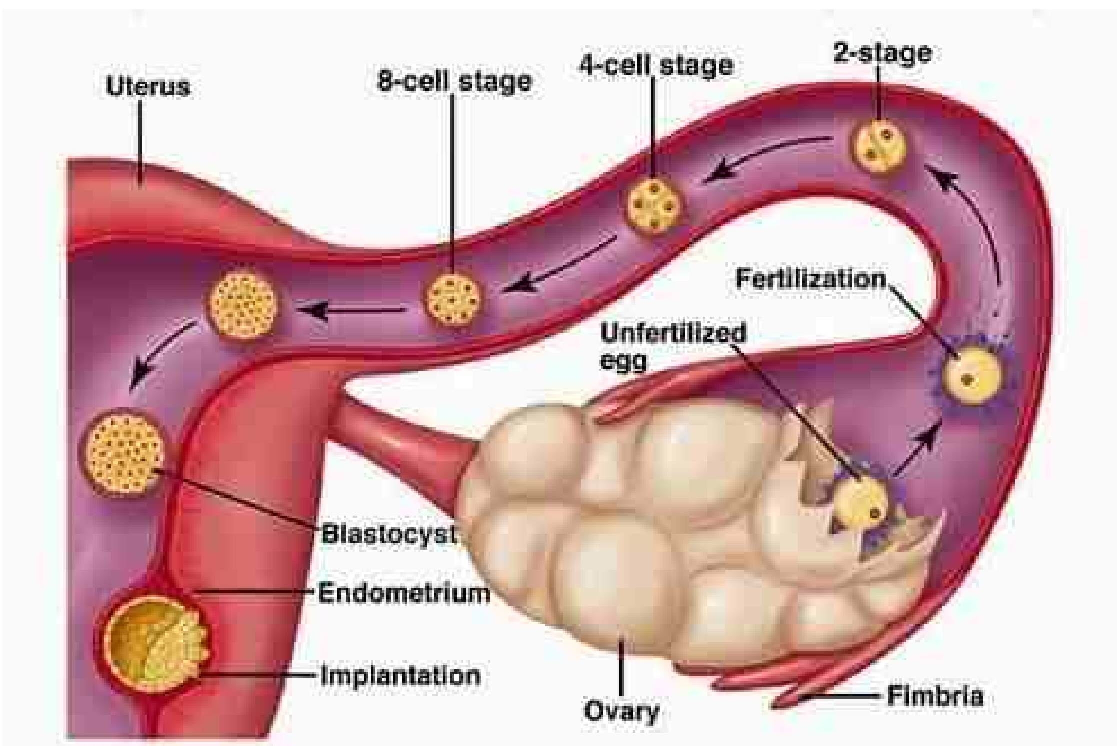
3. The zygote implants in the uterus wall

- the zygote moves slowly down the oviduct. As it goes, it **divides** by mitosis.

- it takes several hours for the embryo to reach the uterus, and by this time it is a ball of 16 or 32 cells (a **blastocyst**).

Egg implanting in uterus. Credit: Web MD

- the uterus has a thin, spongy lining, and the embryo sinks into it = **implantation**.

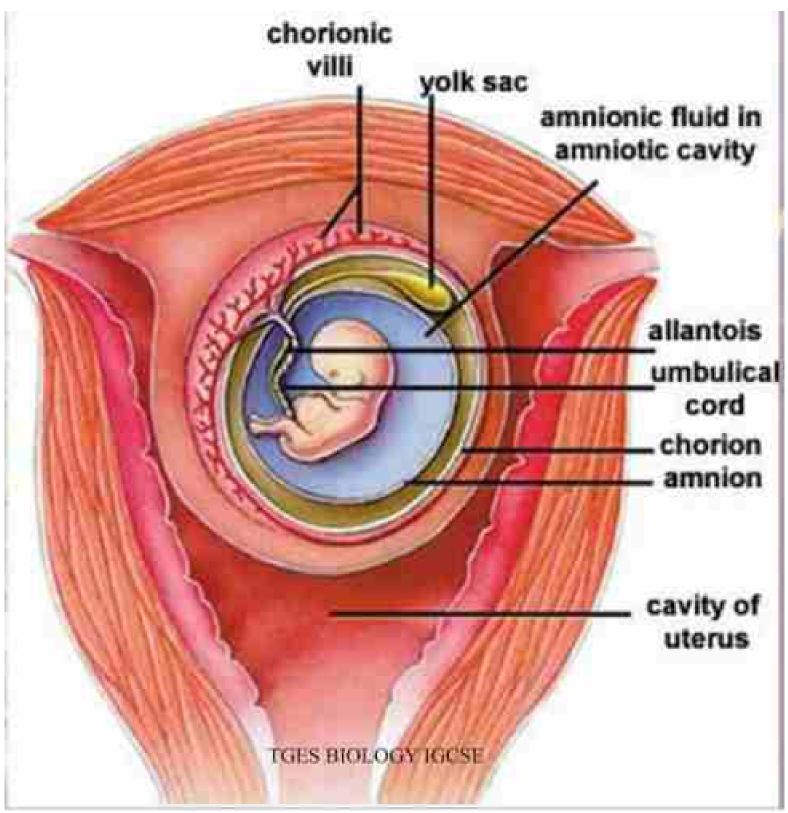


Credit: soc.hawaii.edu

#116 The development of the fetus

The **blastula** develops into an **embryo** and some of the cells form a **placenta**, linking the embryo with the uterus lining. Organs such as the heart develops and, after **8 weeks**, the embryo is called a **fetus**.

Growth of the fetus requires a good supply of nutrients and O_2. This is achieved through the link between the **placenta** and the mother's blood supply in the uterus lining. The placenta is soft and dark res, and has finger-like projections called **villi**. The villi fit closely into the uterus wall.

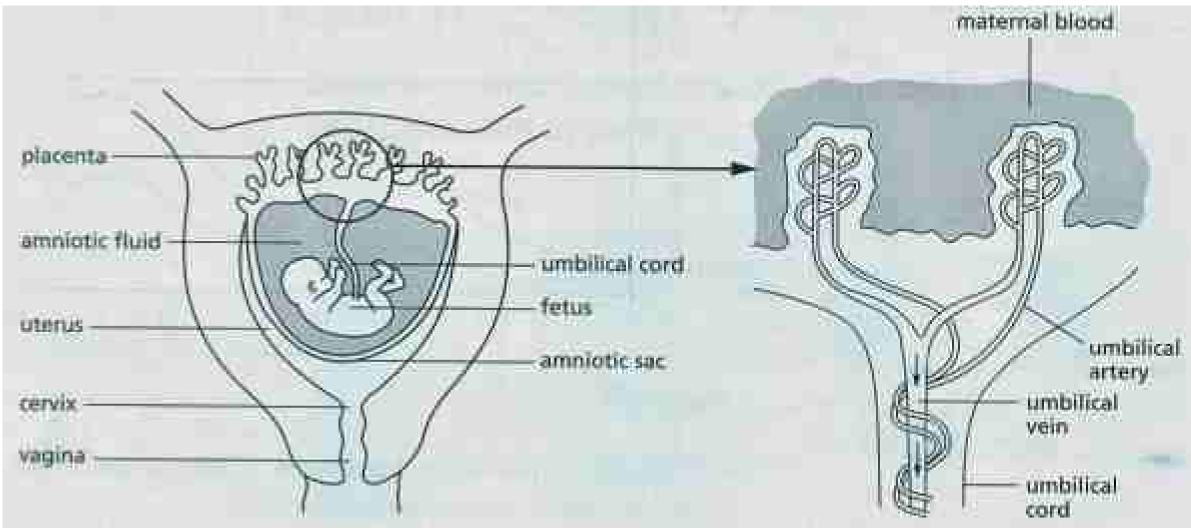


1. Umbilical cord

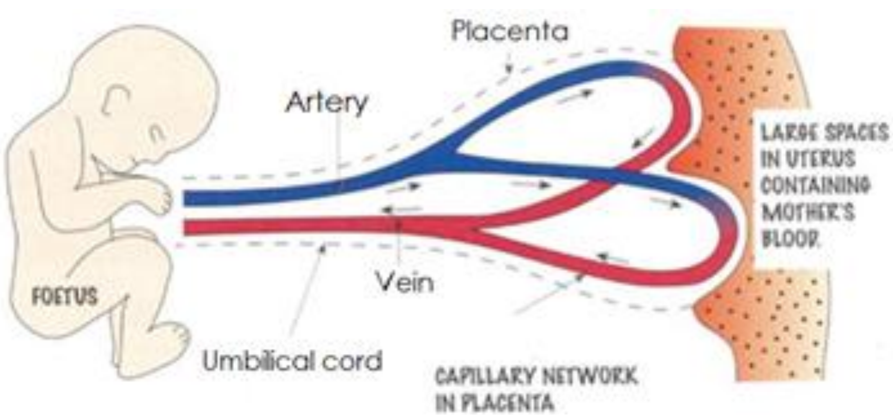
- joins fetus to placenta; contains:
- 2 arteries: blood from fetus ---> placenta
- 1 vein: returns blood ---> fetus

2. Placenta

Brings blood supply of fetus close to mother's



- Blood from the fetus passes through the **umbilical cord** in the **umbilical artery** to the placenta.
- Here it comes close to the mother's blood.
- transport O_2 + nutrients (amino acids, glucose…) from mother ---> fetus
- transport CO_2 + wastes (urea…) from fetus --->mother (through umbilical vein).



Prevents mixing

This is really important because the fetus and mother may have different blood groups - any mixing could result in **blood clotting**, which could be fatal to both mother and fetus.

3. An amnion protects the fetus

The fetus is surrounded by a strong membrane, called amnion. Inside the amnion is a liquid called amniotic fluid.

The fetus in the amniotic sac. Credit: preventdisease.com

Amniotic sac: **membrane** from embryo cells: encloses fetus, prevents entry of bacteria

Amniotic fluid: supports, protects fetus from **mechanical damage**; **absorbs urine** released by fetus.

Try this

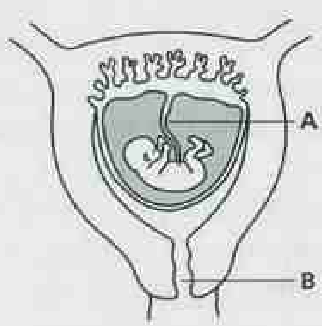


Figure 20.5

1 Figure 20.5 shows a fetus developing in the uterus.

a) i) Copy the figure, and label parts **A** and **B**. [2 marks]

ii) Outline **three** functions of the placenta. [3 marks]

iii) The blood of the fetus and that of the mother flow close to each other in the placenta, but do not mix. State **two** advantages to the fetus of having a separate blood system from that of the mother. [2 marks]

Answer

a) i) **A,** umbilical cord ; **B,** vagina

ii) **Tree** functions from:

- transfers O_2 from mother to fetus
- transfers nutrients (of named nutrients) from mother to fetus
- transfers CO_2 from fetus to mother
- transfers wastes (or named wastes) from fetus to mother
- allows the transfer of antibodies from mother to fetus
- prevents mixing of the blood of mother and fetus.

iii) Helps prevent bacteria passing from mother to fetus, the blood group of mother and fetus may be different.

Sample question and answer

Sample question

Figure 20.6 shows a fetus developing in the uterus. Copy and complete the table below by identifying the parts labelled **A**, **B** and **C** and stating a function of each one.

Figure 20.6

Part	Name	Function
A		
B		
C		

[6 marks]

Student's answer

Part	Name	Function
A	placenta ✓	provides the fetus with blood containing oxygen from the mother ✗
B	amniotic fluid ✓	protects the fetus ✗
C	uterus ✗	contains the fetus during pregnancy ✗

Examiner's comments

The description of the function of the placenta is very badly worded: the placenta prevents the blood of the mother and fetus from mixing. Answers containing biologically incorrect information are penalised.

Details about the amniotic fluid are too vague to gain the mark for the function. The correct answer was 'to protect the fetus from physical damage'.

*Part **C** is the amniotic sac, which contains the amniotic fluid.*

#117 Antenatal care

Ante-natal (before birth) **care** is a routine care for the healthy pregnant woman.

Dietary needs

Before the baby is born, it obtains all its dietary requirements from its mother through the placenta. The mother's **diet** needs to be **balanced** so that's the fetus receives all the materials needed for healthy growth and development.

If the mother's diet is deficient in any nutrients, the bay may not develop properly. So her diet should contain plenty of:

- amino acids ---> healthy grow and development
- calcium ---> development of the skeleton
- iron ---> red blood cell formation
- energy (carbohydrates/ fats) – help to move mother's heavier body.

Exercise

- gentle exercise (swimming, walking…)
- special exercises

Things to avoid

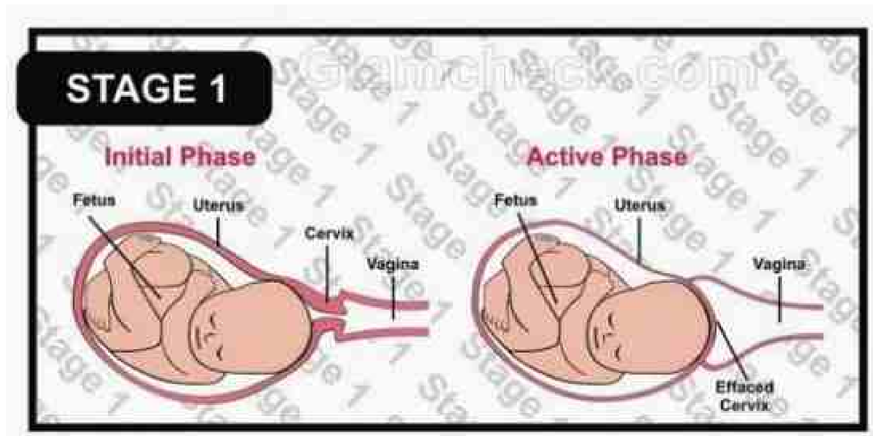
- drugs: aspirin, heroin
- smoking: nicotine and CO
- alcohol drinking
- viruses: HIV, rubella (can pass across the placenta, risking the fetus health).

#118 Process of birth

Birth begins when the strong **muscles** in the wall of the uterus start to **contract**. This first stage of birth (called **labour**) is triggered by the hormone oxytocin.

Stages of birth

Stage 1

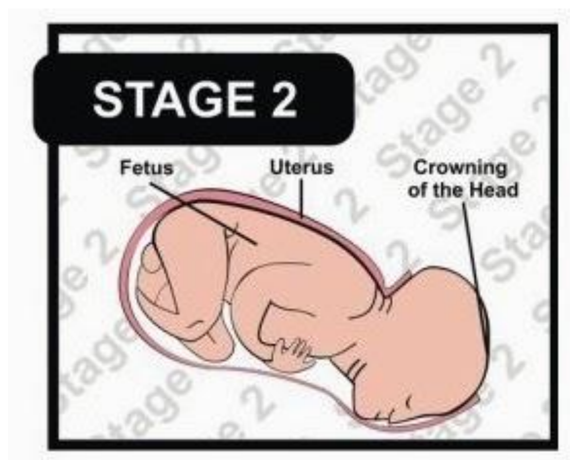


The muscular walls of the uterus start to contract, slowly stretch the opening of the cervix.

The pressure breaks the amniotic sac, releasing the **amniotic fluid**.

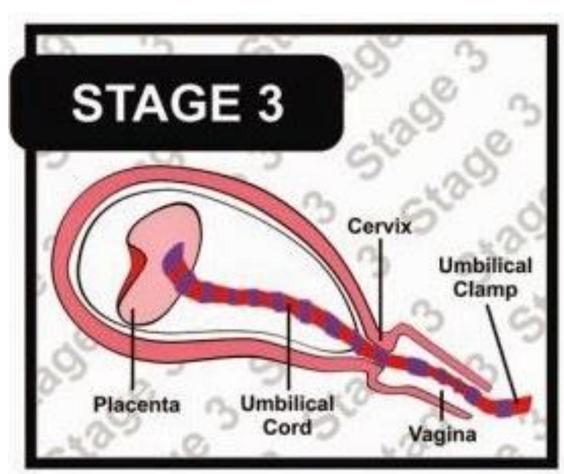
Contraction gradually become more frequent, pushing the baby down towards the **cervix**, which become **dilated** to allow baby to pass through.

Stage 2

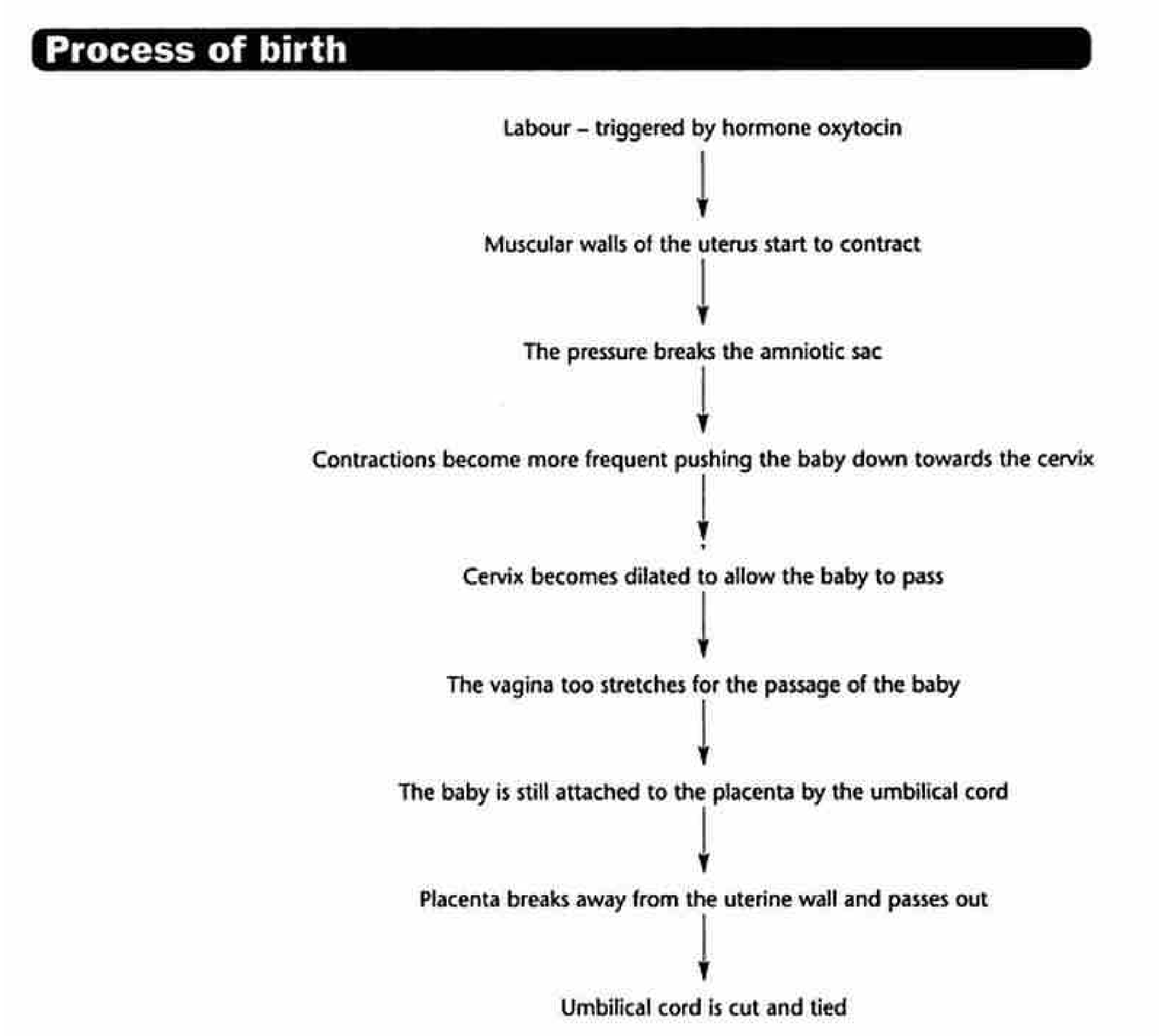


The **vagina** stretches to allow the baby to be born.

Stage 3



The baby is still attached to the placenta by the umbilical cord, so this is cut and tied. The **placenta** breaks away form the wall of the uterus and passed out (**afterbirth**).



Try this

Describe, in sequence the main events which occur during birth. [3 marks]

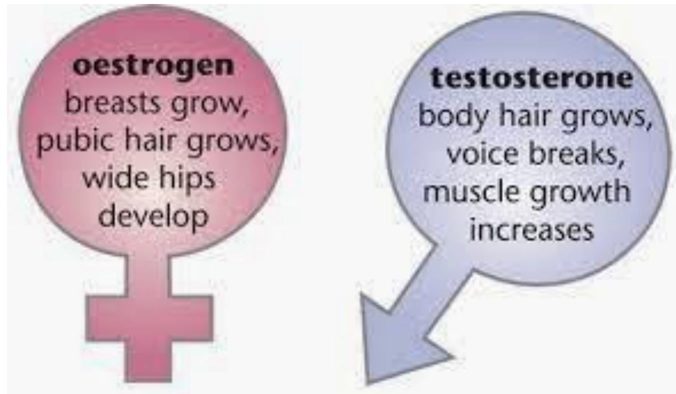
Answer

Three points from**:**

- the wall of the uterus contracts
- the amniotic sac bursts
- amniotic fluid passes out though the vagina
- the cervix dilates
- the baby passes out through the cervix and vagina.

#119 Sex hormones

Sex hormones (testosterone in boys and oestrogen in girls) are responsible for the development of **secondary sexual characteristics** at puberty.



Sex hormones

	Testosterone	Oestrogen
Secreted by	testes	ovaries
Make changes	in boys	in girls

Puberty

- the **sex organs** (ovaries in girls, testes in boys) become **mature** and start to secret hormones, making gametes (ova and sperms)

- happens at about **10-14 years.**

Secondary sexual characteristics at puberty

Male	Female
Voice becomes much lower (breaks)	Breasts grow, nipples enlarge
Hair start to grow on chest, face, under arms and in pubic area	Hair develops under arms and in pubic area
Body becomes more muscular	Hip become wider
Penis becomes larger	Uterus and vagina become larger
Testers start to produce sperm	Ovaries start to release eggs and period begin (menstruation)

Sites of production of **oestrogen** and **progesterone** in the menstrual cycle and in pregnancy

Hormones	Site of production	
	In the menstrual cycle	**In pregnancy**
Oestrogen	Ovaries	Placenta
Progesterone	Corpus luteum (remains of follicle in ovary after ovulation)	Placenta

Try this

Try this

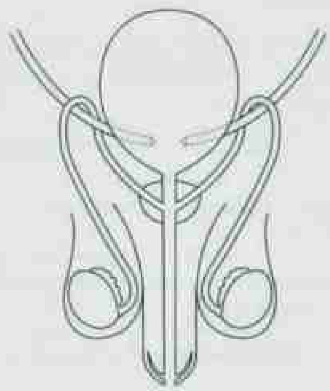


Figure 20.7

3 Figure 20.7 represents part of the male reproductive system, together with parts of the urinary system.

a) Copy or trace the figure and label:

i) the sperm duct (vas deferens) [1 mark]

ii) the urethra. [1 mark]

b) What is the difference in function of the urethra in males and females? [2 marks]

c) i) The hormone testosterone controls the development of secondary sexual characteristics in males. State **two** of these characteristics which develop at puberty. [2 marks]

ii) On your drawing label clearly where this hormone is produced. [1 mark]

iii) Some international athletes, female as well as male, have taken testosterone, illegally, as a drug. Suggest why these athletes might have done this. [2 marks]

Answer

a) i) Sperm duct labeled correctly between the testes and urethra.

ii) Urethra labeled correctly between bladder and tip of penis.

b) In males the urethra carries urine and semen at different times; in females the urethra only carries urine.

c) i) **Two** male secondary sexual characteristics from:
- voice becomes much lower (breaks)
- hair starts to grow on chest, face, under arms and pubic area
- body becomes more muscular
- penis becomes larger
- testes start to produce sperm.

ii) Testis (or testes) labeled correctly.

iii) testosterone makes muscles grow, so the athletes can run faster or perform better.

#120 Method of birth control

There are 4 main groups of **birth control** methods:
natural, **chemical**, **mechanical** and **surgical.**

1. Natural methods

Natural methods

- Withdrawl
- Withdrawl of penis before ejaculation
- Not very reliable

- Abstinence
- No sexual intercourse
- Most reliable

- Rhythm method
- Intercourse is avoided at the ovulation period
- Cannot be exactly predicted

2. Chemical methods

Chemical methods

- Contraception pill
- Contains progesterone and oestrogen which prevent ovulation
- Progesterone only prevents implantation of blastula

- Spermicidal
- Kills sperm in the vagina
- Should only be used with condom/diaphragm

3. Mechanical methods

Mechanical methods

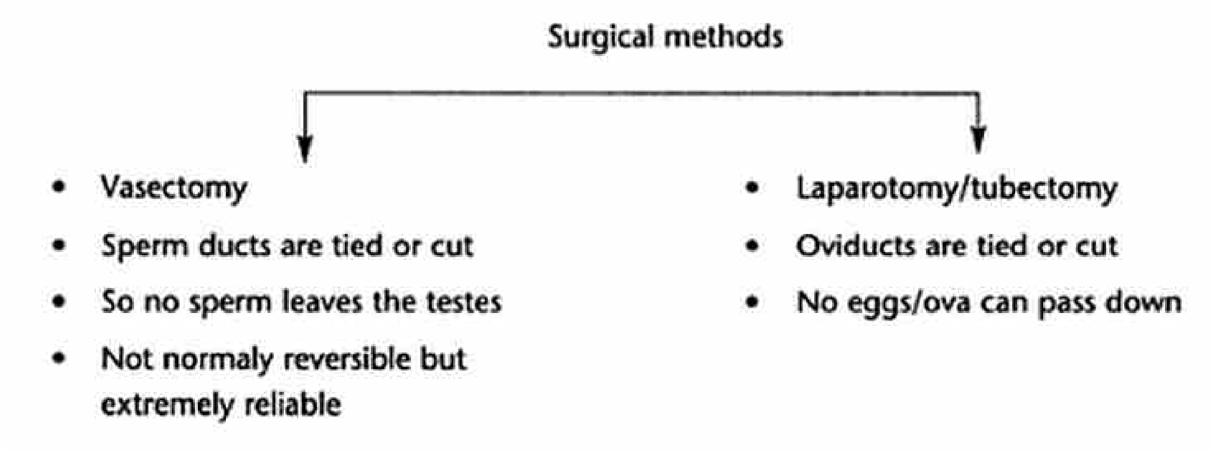
- Use of condom
- A rubber sheath placed to stop sperm entering the vagina
- Also prevents veneral diseases spreading

- Femidom
- A plastic sheath placed inside the vagina
- Prevents entry of sperm
- Prevents sexually transmitted diseases

- Diaphragm
- Dome shaped rubber barrier fitted in the cervix by a doctor
- Prevents the entry of sperm into the cervix

- IUD/Intrauterine device
- Plastic-coated copper coil is surgically inserted into the wall of the uterus
- Prevents implantation of blastula

4. Surgical methods



Photos from WebMD:

Chemical methods

Birth Control Pill

The most common type of birth control pill uses the hormones estrogen and progestin to prevent ovulation. When taken on schedule, the pill is highly effective.

About 8% of typical users get pregnant, including those who miss doses. Like all hormonal contraceptives, the pill requires a prescription.

Spermicide

Spermicide contains a chemical that kills sperm.

It comes in the form of foam, jelly, cream, or film that is placed inside the vagina before sex.

Mechanical methods

Male Condom

The latex condom is the classic barrier method. It prevents sperm from entering the woman’s body, protecting against pregnancy and STDs.

Of couples who rely only on male condoms, 15% get pregnant in a year.

Female Condom

The female condom is a thin plastic pouch that lines the vagina and can be put in place up to 8 hours before sex.

Users grasp a flexible, plastic ring at the closed end to guide it into position.

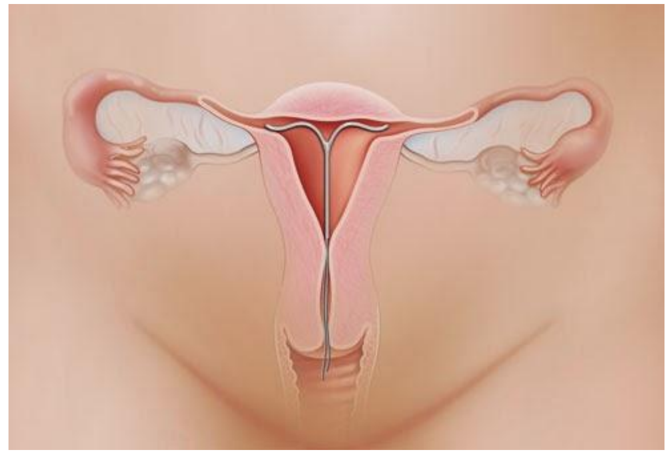
It's somewhat less effective than the male condom.

Diaphragm

The diaphragm is a rubber dome that is placed over the cervix before sex.

IUD

IUD stands for intrauterine device, a T-shaped piece of plastic that is placed inside the uterus by a doctor.

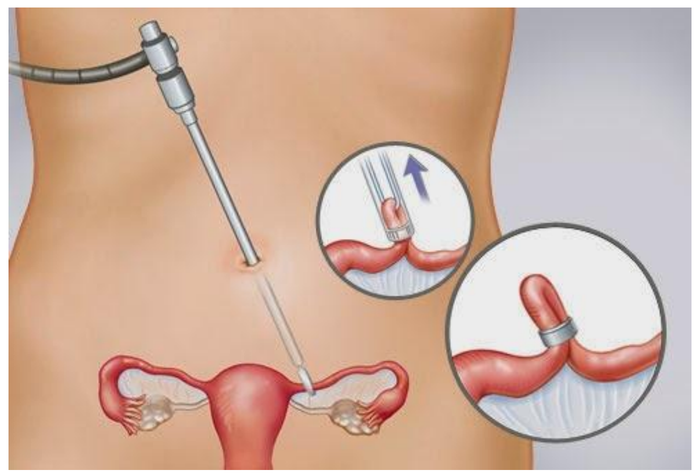


The copper IUD, ParaGard, works for as long as 12 years. The hormonal IUD, Mirena, must be replaced after 5 years. Both types make it more difficult for sperm to fertilize the egg.

Fewer than eight in 1,000 women get pregnant.

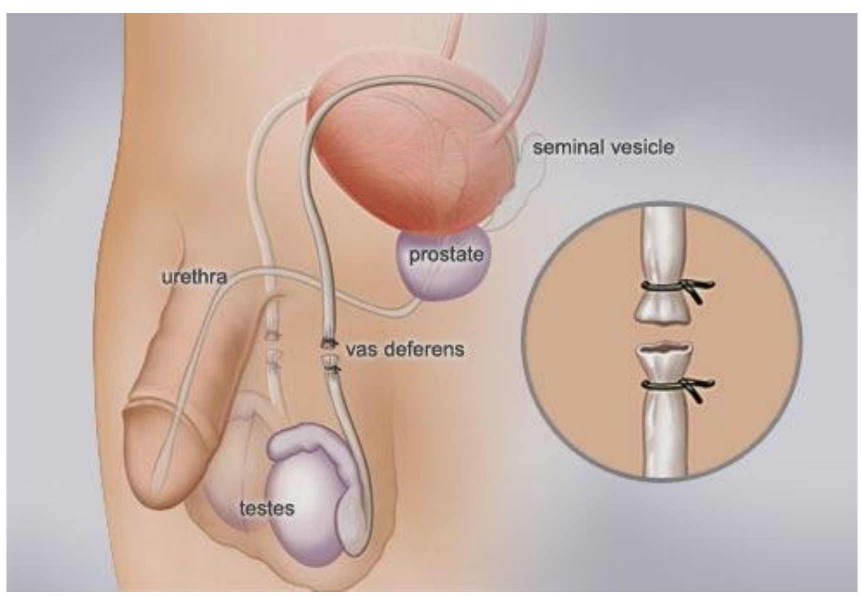
Surgical methods

Tubal Ligation
A surgeon closes off the fallopian tubes, preventing eggs
from making their journey out of the ovaries.



Vasectomy

Besides condoms, a vasectomy is the only birth control option available to men. It involves surgically closing the vas deferens – the tubes that
carry sperm from the testes, through the reproductive system.
This prevents the release of sperm but doesn't interfere with ejaculation.



Least Effective Methods

Without using any form of birth control,
85% of sexually active couples will get pregnant within a year.
Even the least effective birth control options
reduce that number considerably.

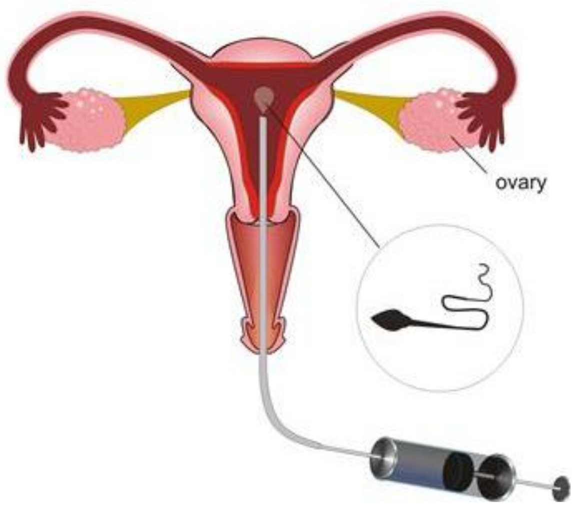
Source: Letts Revise IGCSE - Biology:Complete Study and Revision Guide

Slide Show: Birth control Options from WebMD

http://www.webmd.com/sex/birth-control/ss/slideshow-birth-control-options

#121 Artificial insemination, hormones in fertility drugs

An **artificial insemination** procedure uses a thin, flexible tube (catheter) to put **sperm** into the woman's **reproductive tract** (vagina, cervix, uterus) around the time of ovulation. For some couples with infertility problems, insemination can improve the chances of pregnancy.



Artificial insemination

If the problem causing the couple's infertility is in the man (he may not be producing healthy sperms), then **sperms** from a **donor** is collected in a clinic, and can be **stored** at a low temperature for many months or even years. The woman can then attend the clinic, and some of the sperms can be placed into her reproductive tract.

Prior to insemination, the sperm usually are washed and concentrated (placing unwashed sperm directly into the uterus can cause severe cramps). Concentration is accomplished by selectively choosing highly active, healthy sperm that are more capable of fertilizing an egg.

The artificial insemination may be a real help to a couple, as it allows them to have a child that they could not otherwise have.

Problems:

- The man has to be able to accept that the child is not biologically his.

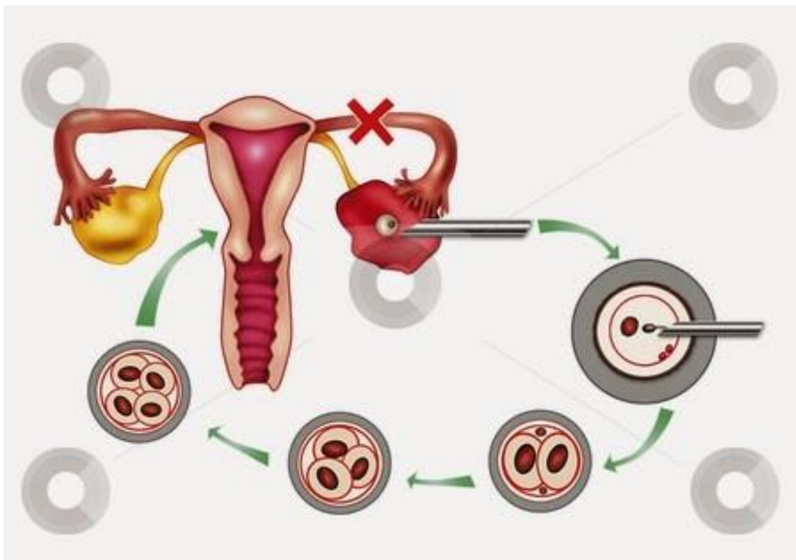
- When the child grows up, he may wants to know who his biological father is. Some people think that the identity of the sperm donor should be given to the child. However, this may cause more problems than it solves. Many sperm donors wish to remain anonymous.

Use of hormones in fertility drugs

Fertility drugs are used when the woman is not producing enough eggs. She is given hormones, including FSH and LH, that cause multiple release of eggs.

- The eggs can be allowed to be released into the oviduct in the normal way.

- If the woman has a problem with **blocked oviducts**, the **eggs** are removed from her ovaries just before they are due to be released, and placed in a warm liquid in a **Petri dish**. Some of her partner **sperms** are added, and fertilization takes place in the dish. 2 or 3 of the resulting **zygotes** are placed into her **uterus**, where they develop in the usual way. This is called ***In vitro* fertilization** (**IVF**).



IVF

Problems:

- The treatment is quite expensive, and not always successful. Some argue that the it should not be freely available to anyone who wants it. Other think that the inability to have children can be so devastating to a couple that they should receive the treatment free of charge.

- Sometimes 2 or 3 embryos develop, so the couple might have twins or triplets when they really only wanted one child.

#122 Breast feeding vs formula milk?

This has been a tough question for many years: Which is better - **breast milk** or **fomula milk?** While breast milk is nutritious, it has its inconveniences. Formula milk is convenient but expensive. What to choose?

	Breast feeding	Formula milk
Advantages	- has antibodies; no bacteria - foodstuffs in correct proportions - no risk of allergic reaction - correct t° - no additives/ preservatives - builds mother - child bond - no cost; no preparation - breast-feeding triggers reduction of uterus size	- less painful - other people can feed baby - may contain supplement vitamins, minerals
Disadvantages	- may be painful - mother needs to be present - damage beauty	- more likely to develop illness (diarrhoea, urine infection...) - risks of wrong mixture - expensive

Fun fact! Breast milk can naturally and easily remove eye make-up! Plus, it can cure certain eye diseases!

There are several other things you could do with breast-milk :) Find out more, just for fun, at:

http://www.breastfeeding-problems.com/using-breast-milk.html

I swear, some of these facts can blow your mind!

Video: Breastfeeding vs bottle feeding - DrTummmy.com

https://www.youtube.com/watch?v=XPi0odcvegM

#123 HIV/ AIDS - transmission and prevention methods

AIDS (Acquired Immune Deficiency Syndrome) is a disease caused by the HIV.
HIV can not live outside the human body. It is an especially **fragile** virus - much less tough than the cold virus.
It is **transported** in **body fluids**. You can only become infected with HIV through direct contact of your body fluid with those of someone with the virus.

How HIV affects the immune system

- The HIV virus **attacks** some types of **lymphocyte** (white blood cells) in the blood stream.
- Lymphocytes produce **antibodies** ---> attack the **antigens** on invading microbes.
- Some lymphocytes are **stored** in lympho nodes ---> protection against **future infection**.
- **HIV prevents** this immunity being retained, so the AIDS sufferer has no protection against diseases such as tuberculosis (TB) and pneumonia.

Methods of transmission:

- unprotected sexual intercourse with infected person
- drug use involving sharing needle used by infected person
- transfusion of infected blood
- infected mother to fetus
- feeding a baby with milk from an infected mother
- unsterilised surgical instruments

Prevention methods

- condom for sexual intercourse
- refuse sexual intercourse
- screen blood (for transfusion)
- use sterilized needles
- feed baby with bottled powdered milk (if mom has HIV)
- use sterilised surgical instruments.

Video: How is HIV Transmitted?

https://www.youtube.com/watch?v=z8BwYFlTAGY

Video: How to prevent HIV transmission?

https://www.youtube.com/watch?v=NXnvP_sKS9k

#124 Gonorrhoea

Gonorrhoea bacteria, Credit: Science photo library

Gonorrhoea is caused by bacteria that can be **passed** from one person to another during **sexual intercourse.** ***Neisseria bacterium*** is a small, round cell. It can only survive in moist places, such as tissues lining the tubes in the **productive systems** of a man and a woman.

Symptoms

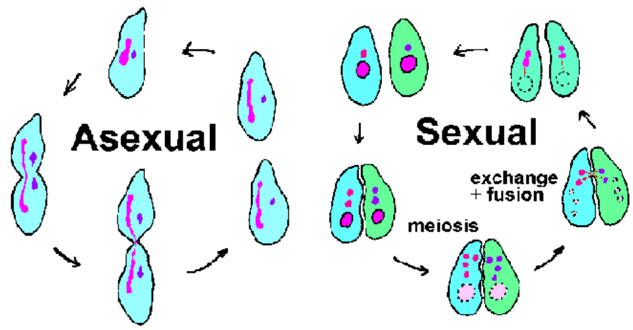
- If gonorrhoea bacteria are living in a woman's vagina or a man's urethra, the infection can be passed during sexual intercourse.
- The first symptoms occurs 2-7 days after infection.
- Man: the bacteria reproduce inside the urethra ---> unpleasant discharge and pain when urinating.
- Woman: the bacteria reproduce mostly in the cervix, although they can also do so in the vagina ---> many woman do not notice discharge or suffer a pain as men do.
- Most men with gonorrhoea know that they have it, many women are unaware that they have the infection.

	Signs and symptoms	Effects	Treatment
Male	- **Sores** on penis - **Discharge** of pus from penis - **Pain** when urinating	- Damage to urinary and reproductive organs - Sterility - Blindness in a baby born to a mother with the disease.	Antibiotic, e.g. penicillin
Female	- Discharge of pus from vagina, but not always obvious - Often **no symptoms**		

Severe eye pathology in a baby born to a mother with gonorrhoea: eyelids swollen, profuse purulent discharge. If untreated blindness may result.
Credit: cehjournal.org

#125 Summary of Reproduction

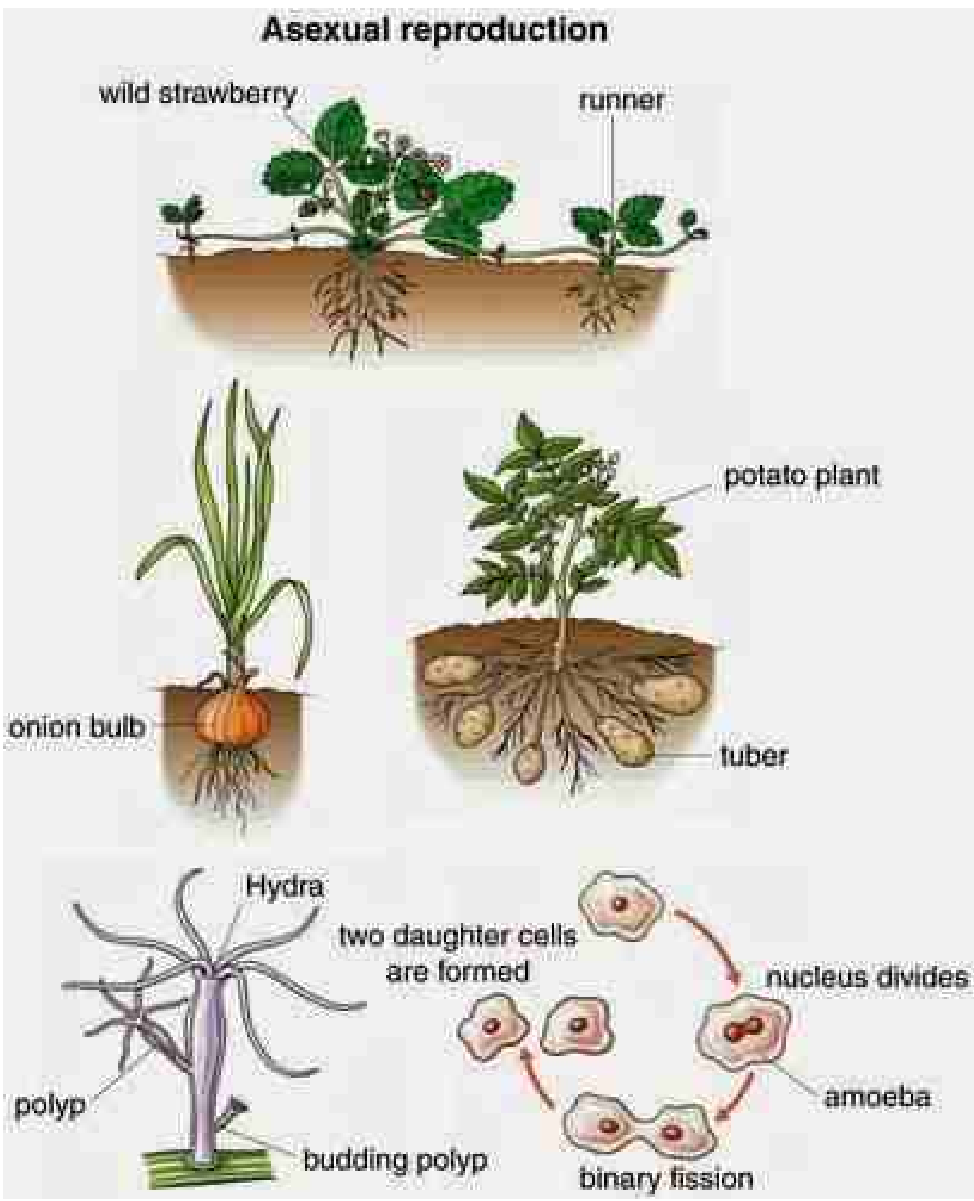
Reproduction is the biological process by which new "**offspring**" individual organisms are produced from their "**parents**". It is a fundamental feature of all known life.



Two types of reproduction:
sexual and **asexual.**

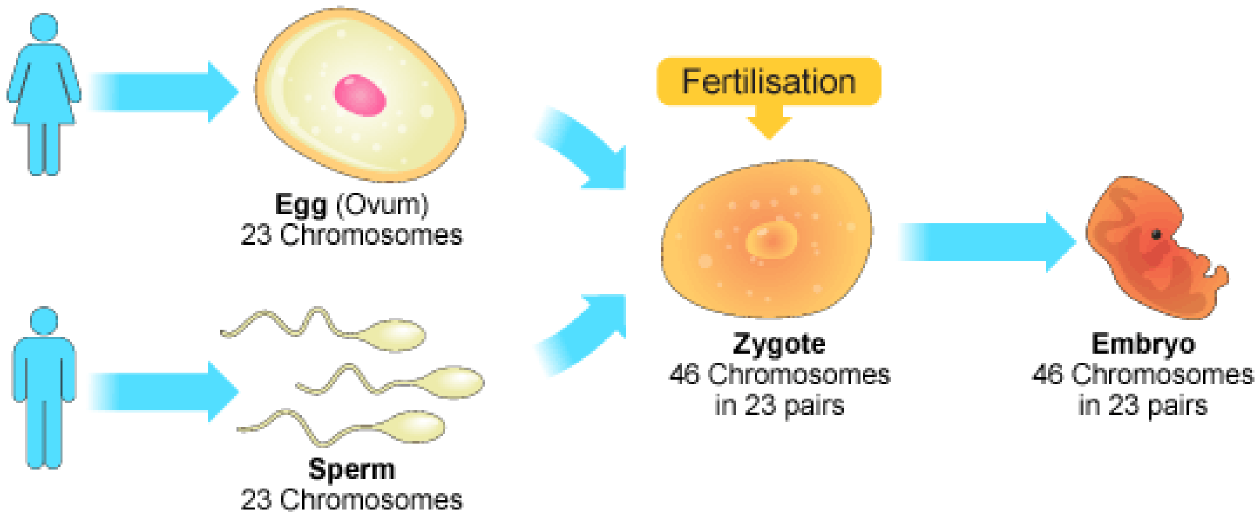
Asexual reproduction

It involves cell division by **mitosis,** producing a group of genetically identical individuals called a clone. Bacteria, fungi and potatoes can reproduce asexually.



Sexual reproduction

Sexual reproduction involves the production of genetically different gametes by **meiosis**. A male gamete fertilises a female gamete, producing a zygote which is genetically different from its parents.



In human

- The male gametes are **sperms**, they are made in the **testes**. During sexual intercourse, semen containing sperms passes out to the penis and into a woman's vagina.

- The female gametes are **eggs** and are made in the **ovaries**. After sexual intercourse, sperm swim through the cervix and uterus into the **oviducts**, where they may meet an egg. One sperm may fertilise the egg to produce a **zygote**.

- The **zygote** travels to the uterus and **implants** into the lining, growing into an **embryo** attached t the uterus wall via an umbilical cord and **placenta**. The placenta brings the growing embryo' blood very close to the mother's blood, so that's nutrients and waist products can diffuse between them.

- The growing embryo is protected by **amniotic fluid** produced by the amnion.

- After birth, a young mammal is fed on **milk** from its mother. This provides it with exactly the correct balance of nutrients, as well as antibodies which protect it from infectious diseases.

- An egg is releases from an ovary about one a moth. If it is not feritlised, the thick lining of the uterus breaks down, in **menstruation**.

- The menstrual cycle is controlled by the **hormones** oestrogen, progesterone, FSH and LH.

- **Birth control** helps a couple t avoid having unwanted children. There are natural, surgical, mechanical and chemical methods.

- Hormones can be used to increase fertility.

- **Gonorrhoea** and **HIV/AIDS** are infectious diseases that can be transmitted by sexual contact.

In plants

- The **flowers** are the reproductive organs. Male gametes are make inside pollen grains, produced by anthers. Female gametes are make inside ovules produced by ovaries.

- The movement of pollen from an anther to a stigma is called **pollination**, and may be brought about by insects of the wind.

- After landing on a suitable stigma, a pollen grain **germinates** and the gametes travel down the style to the ovules. Here, **fertilisation** takes place and a **zygote** is produced. The zygote develops into an **embryo**, and the ovule develops into a **seed**. The ovary develops into the **fruit**, containing the seeds which contain the embryos.

- Fruits are adapted to **disperse seeds**, using animals or the wind.

- Seeds require certain condition before they will germinate.

13 Inheritance

126 Inheritance - key definitions

Inheritance is the **transmission** of **genetic information** from one generation to the next, leading to continuity of the species and variation within it.

Key definitions

Chromosome	A thread of DNA, made up of genes.
Allele	An alternative form of a gene. Pairs of alleles occupy the same relative positions on chromosome pairs.
Gene	A section of DNA, which codes for the formation of a protein controlling a specific characteristic of the organism.
Haploid nucleus	A nucleus containing a single set of unpaired chromosomes, e.g. in sperm and ova (eggs). In humans, the haploid number is 23.
Diploid nucleus	A nucleus containing pairs of chromosomes, e.g. in somatic (body) cells, In humans the diploid number is 46.
Genotype	The genetic make-up of an organism, e.g. Tt, where T and t are alleles of a gene.
Phenotype	The characteristics visible in an organism, controlled by the genotype, e.g. a tall plant or a dwarf plant.
Homozygous	Having a pair of identical alleles controlling the same characteristics, e.g. TT, where T=tall. The organism will be pure-breeding for that characteristics.
Heterozygous	Having a pair of dissimilar alleles for a characteristic, e.g. Tt.
Dominant	A gene, e.g. T, that always shows in the phenotype of an organism whether the organism is heterozygous (Tt) or homozygous (TT).
Recessive	A gene, e.g. t, that only has an effect on the phenotype when the organism is homozygous (tt)

Video: The Human Genome Project, 3D Animation
https://www.youtube.com/watch?v=VJycRYBNtwY

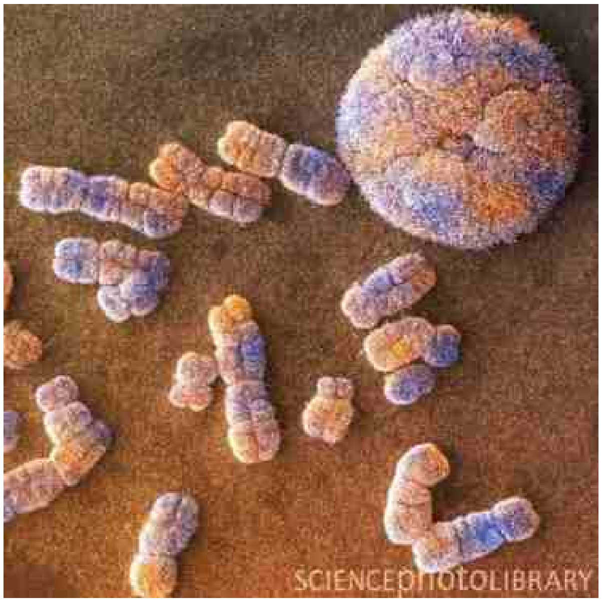
#127 Chromosomes, DNA, genes and alleles

In the nucleus of every cell there are a number of long threads called **chromosomes**.

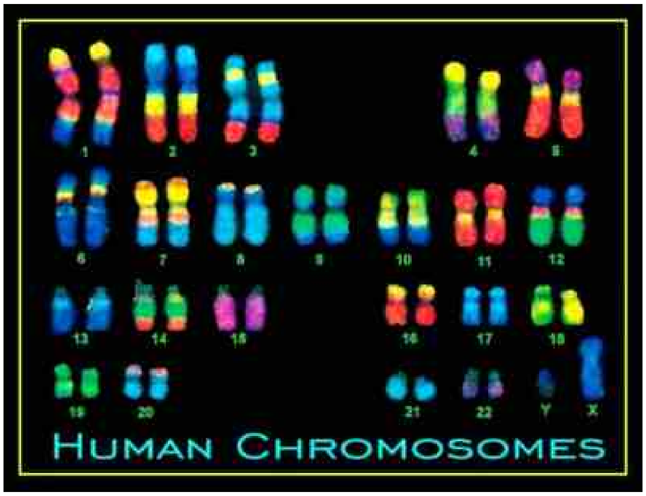
Chromosomes

Most of the time, the chromosomes are too thin to be seen except with an electron microscope. But when a cell is dividing, they get shorter and fatter so they can be seen with a light microscope.

Human chromosomes and nucleus. Chromosomes are a packaged form of DNA. The DNA normally exists in a non-condensed form in the cell nucleus (upper right). It condenses into chromosomes (centre and lower left) during cell replication.



Human cells contain 46 chromosomes, which are in pairs. Sex cells (sperm and ova) contain only 23 chromosomes. The 23 chromosomes comprise one from each pair.

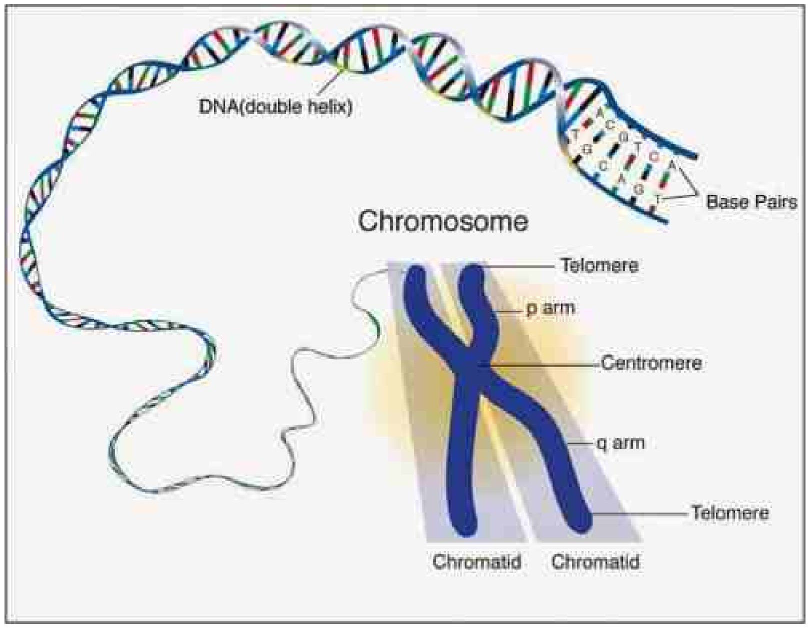


Inheritance of sex in humans

Of the 23 pairs of chromosomes present is each human cell, one pair is the sex chromosomes. These determine the sex of the individual. Male have XY, female have XX. So the presence of a Y chromosome results in male features developing.

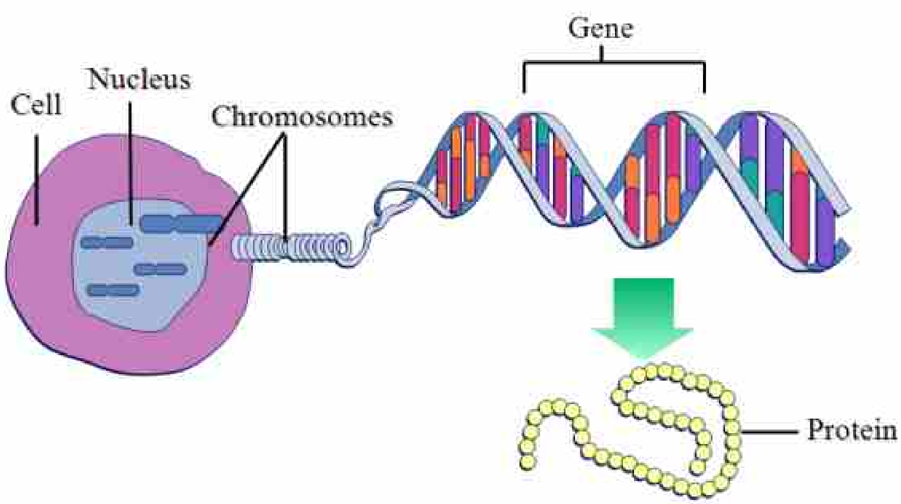
DNA

Each chromosome contains one very long molecule of DNA. The DNA molecule carries a code that instructs the cell about which kind of **proteins** it should make. Each chromosome carries instructions for making many different proteins.



Gene

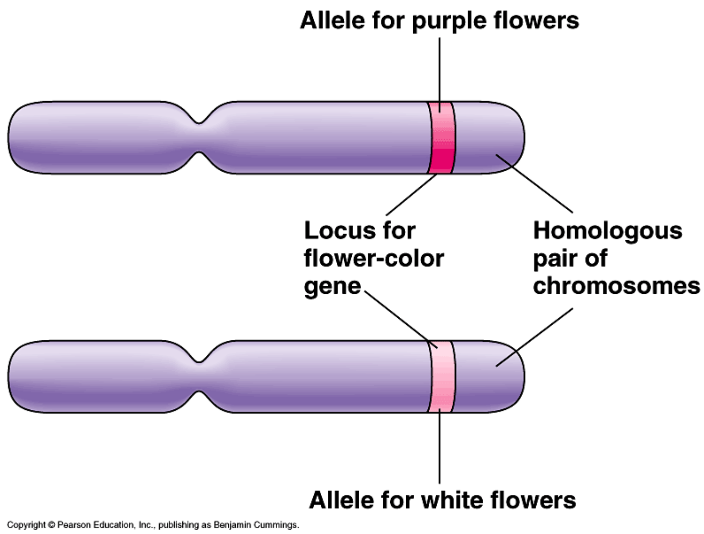
Each chromosome is made up of a large number of **genes** coding for the formation of different proteins which give us our characteristics. The gene responsible for a particular characteristic is always on the same relative position on the chromosome.

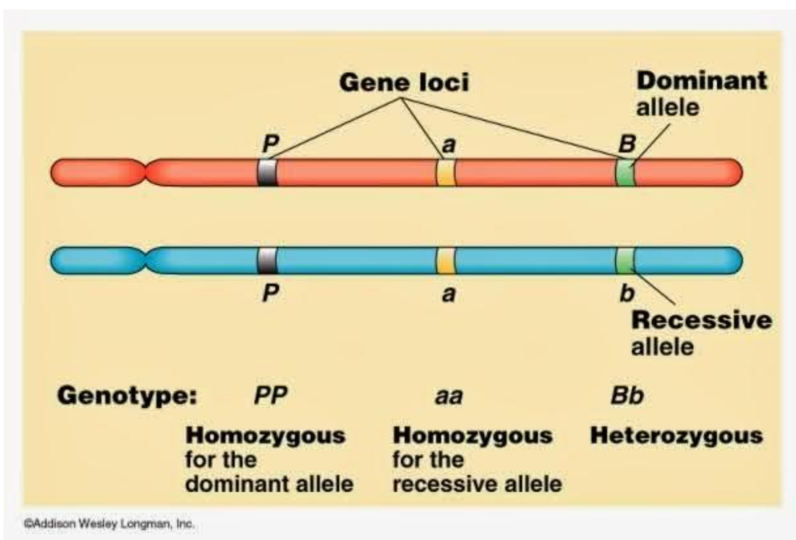


A part of a DNA molecule coding for one protein is called a gene.

Alleles

When the chromosomes are in pairs, there may be a different form (allele) of the gene on each chromosome.





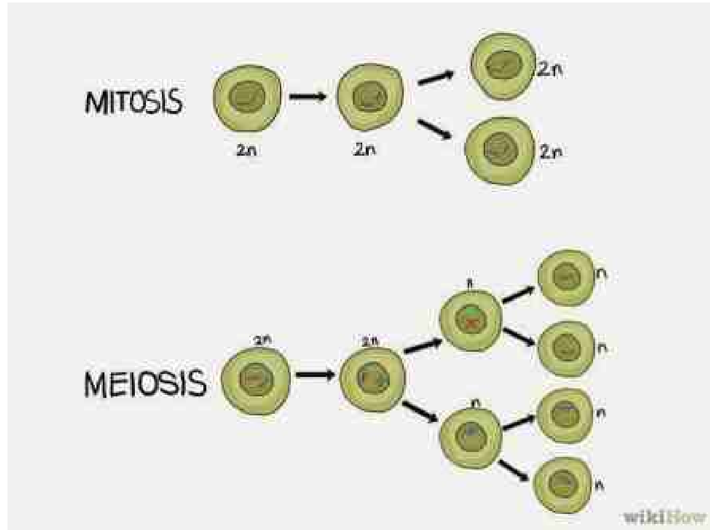
Video: What is a Chromosome?

https://www.youtube.com/watch?v=xUrlreMaUrs

Video: What is DNA?

https://www.youtube.com/watch?v=zwibgNGe4aY

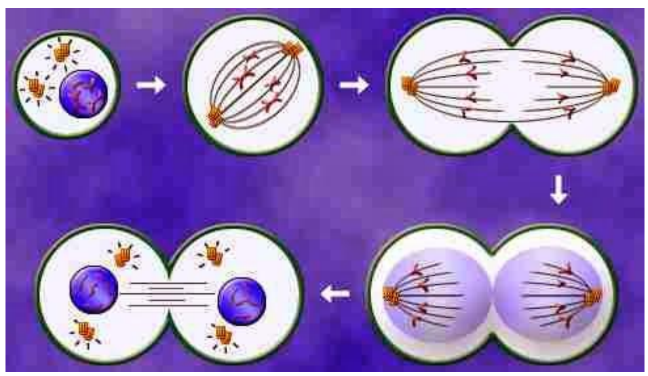
128 Cell division – Mitosis and Meiosis



Mitosis is a nuclear division giving rise to genetically **identical** cells in which the chromosome number is maintained by the exact duplication of chromosome.

Meiosis is a reduction division in which the chromosome number is **halved** from diploid to haploid.

Mitosis

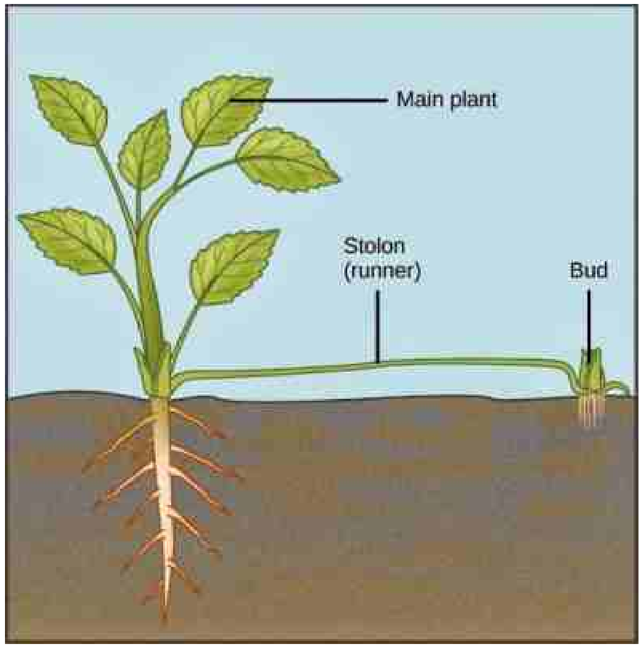


Mitosis is the way in which **any cell** (plant or animal) divides when an organism is:

- **growing**
- **repairing** a damaged part of its body
- **replacing** worn out cells

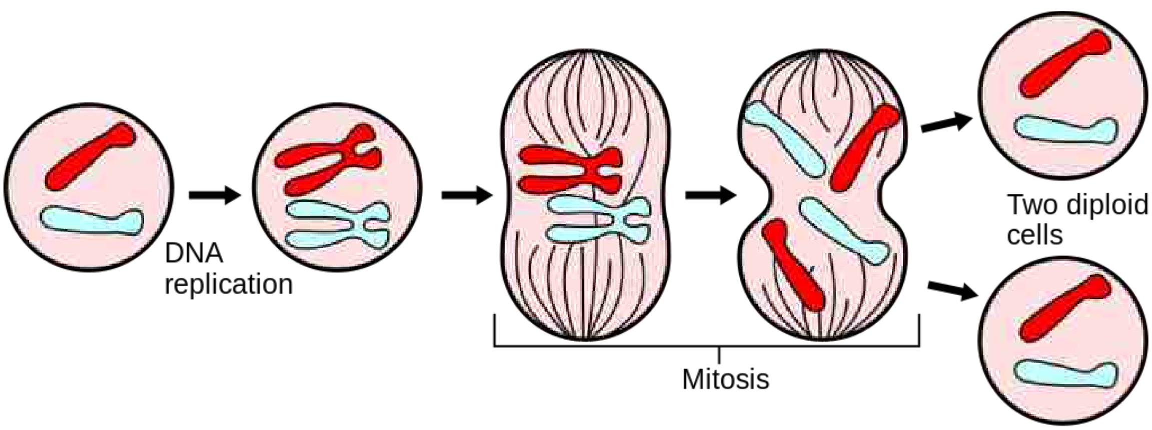
Growth means getting bigger. An individual cell can grow a certain amount, but not indefinitely. Once a cell gets to a certain size, it becomes difficult for all parts of the cell to obtain oxygen and nutrients by division. In order to grow any more, the cell divides to form two smaller cells, each of which can then grow and divide again.

Mitosis is also used in **asexual reproduction**. For example, sweet potato plant can reproduce by growing adventitious roots or runners which eventually produce new plants.



Process of mitosis

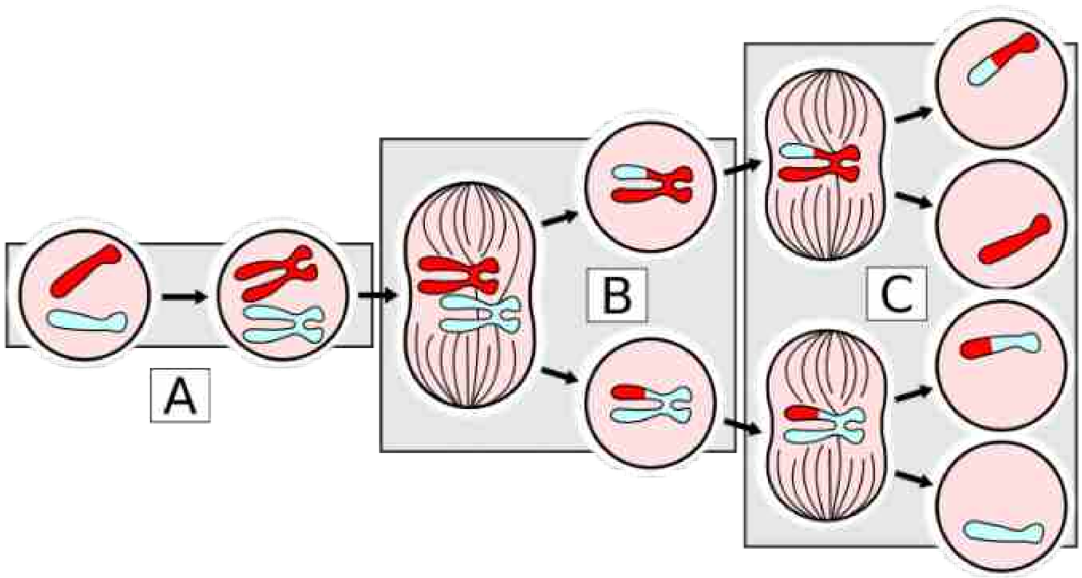
- During the process, all the **chromosomes** in the parent cell are **copied**.
- Each copy remains attached to the original one --> each chromosome is made up of 2 identical threads joined together.
- The parent cell (with 4 chromosomes) **split** to form 2 nuclei each with 2 chromosomes as the parent nucleus cell.
- At the end of a mitotic cell division, the number of cells is doubled and the **daughter cells** produced are genetically **identical** to the **parent.**



Meiosis

Meiosis is the way in which **gametes** (sex cells) are produced. Gametes have only **half** the number of chromosome of a normal body cell. They have 1 set of chromosome instead of 2. When they fuse together, the zygote formed has 2 sets.

- Human gametes are formed by the division of cells in the ovaries and testes
- The gametes produced are haploid, but they are formed from diploid cells, so meiosis involves **halving** the normal chromosome number - the pairs of chromosomes are separated.
- During meiosis, the new cells get a mixture of homologous chromosomes from father and mother --> A sperm cell could contain a chromosome 1 from father and a chromosome 2 from mother.
- There are all sorts of combinations --> gametes are **genetically different** form the parent cells. Meiosis produces genetic variation.
- When ova are formed in a woman, all the ova will carry an X chromosome. When sperm are formed in a man, half the sperm will carry an X chromosome, half will carry a Y chromosome.



Sample question

Complete the following passage, using only words form the list below.
diploid   gametes   haploid   meiosis   mitosis   red blood cells

The transfer of inherited characteristics to new cells and new individuals depends on two types of cell division. During ____________, the chromosomes are duplicated exactly and __________ cells are produced.

However, during _______________, the chromosome sets are first duplicated and then halved, producing cells. These cells will become __________ .   [4 marks]

Student's answer

During **meiotosis** û , the chromosomes are duplicated exactly
and **identical** û cells are produced.

However, during **meiosis** ü, the chromosome sets are first duplicated and then halved, producing cells. These cells will become **gametes.** ü

Examiner's comments

The first answer is not clear – it mixes up the terms 'mitosis' and 'meiosis'. Sometimes candidates do this deliberately when they are not sure of the answer, hoping that the examiner will give them the benefit of the doubt. (We don't!). This candidate has not followed the rubric (instructions) in the question for the second answer: the term 'identical' does not appear in the word list. The correct answers are 'mitosis' and 'diploid'.

Try this

1) The nuclei of human liver cells contain 46 chromosomes. Complete the table below to show how many chromosomes would be present in the cells listed. [3 marks]

Type of cell	Number of chromosomes
Ciliated cell in windpipe	
Red blood cell	
Ovum	

2) Describe 2 differences, other than the number of chromosomes, between nuclei produced by mitosis and those produced by meiosis. [2 marks].

Answer:

1) Ciliated cell: 46
Red blood cell: 0 (this cell has no nucleus)
Ovum: 23

2) Two differences from:

- chromosomes in daughter mitotic cells will be identical to parental chromosomes (or there is no variation).
- genes in daughter mitotic cells will be identical to parental genes.
- chromosomes in daughter mitotic cells will be in homologous pairs, but they will be single in meiotic nuclei.

Video: Mitosis
https://www.youtube.com/watch?v=VlN7K1-9QB0

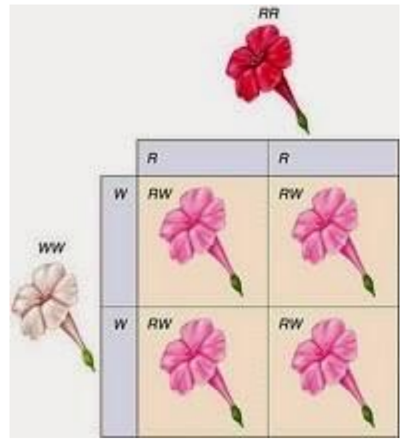
Video: Meiosis
https://www.youtube.com/watch?v=D1_-mQS_FZ0

Video: Difference between mitosis and meiosis
https://www.youtube.com/watch?v=Ba9LXKH2ztU

129 Monohybrid cross and the punnett square

A **monohybrid cross** involves the crossing of individuals and the examination of **one** (*mono*) **character** (flower colour, pod shape...) and **different** (*hybrid*) **traits** (red colour, white colour) in their offspring.

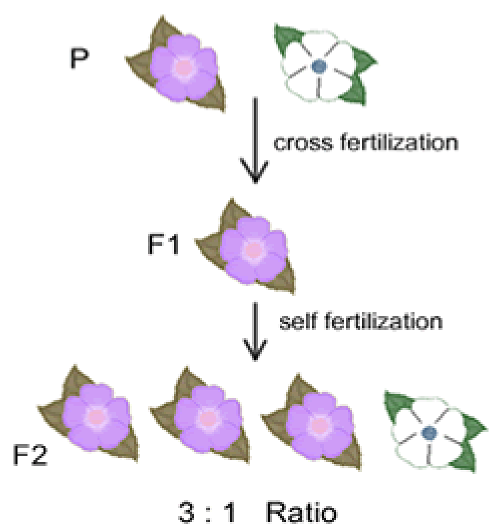
The **Punnett square** is a useful tool for predicting the genotypes and phenotypes of offspring in a genetic cross involving Mendelian traits.



Mendel crossed true-breeding plants that differed for a given character. Pollen from true-breeding pea plants with **purple** flowers (one trait) was placed on stigmas of true-breeding plants with **white** flowers (another trait).

The **F1** seeds were **all purple**; the white flower trait failed to appear at all. Because the purple flower trait completely masks the white flower trait when true-breeding plants are crossed, the purple flower trait is called **dominant**, and the white flower trait is called **recessive**.

The F1 plants were allowed to self-pollinate. This step was the monohybrid cross. (or the F1 cross). The progeny, called **F2**, were examined: roughly **1/4** were white, and **3/4** were purple.



All the genetic crosses shown below will involve examples using pea plants, which can be tall (T) of dwarf (t) – tall is dominant to dwarf.

Examiner's tips

- *When you rite out a genetic cross, make sure you state what the symbols represents, e.g. T=tall, t=dwarf.*
- *Make sure you label each line in the cross (phenotype, genotype…).*
- *It's a good idea to circle gametes to show that meiosis has happened.*
- *Read the question really carefully – are you asked to state the outcome in terms of the genotype or the phenotype?*

Punnett square

*1. A cross between a pure-breeding **tall** pea plant and a pure-breeding **dwarf** pea plant.*

As tall is dominant to dwarf, and both plants are pure-breeding, their genotypes must be **TT** and **tt**.

phenotypes of parents	tall		dwarf
genotypes of parents	TT	×	tt
gametes	T T	×	t t

punnett square

	T	T
t	Tt	Tt
t	Tt	Tt

F_1 genotypes	all Tt
F_1 phenotypes	all tall

*2. A cross between two **heterozygous tall** pea plant.*

The genotype of both plants must be **Tt**.

phenotypes of parents	tall		dwarf
genotypes of parents	Tt	×	Tt
gametes	T t	×	T t

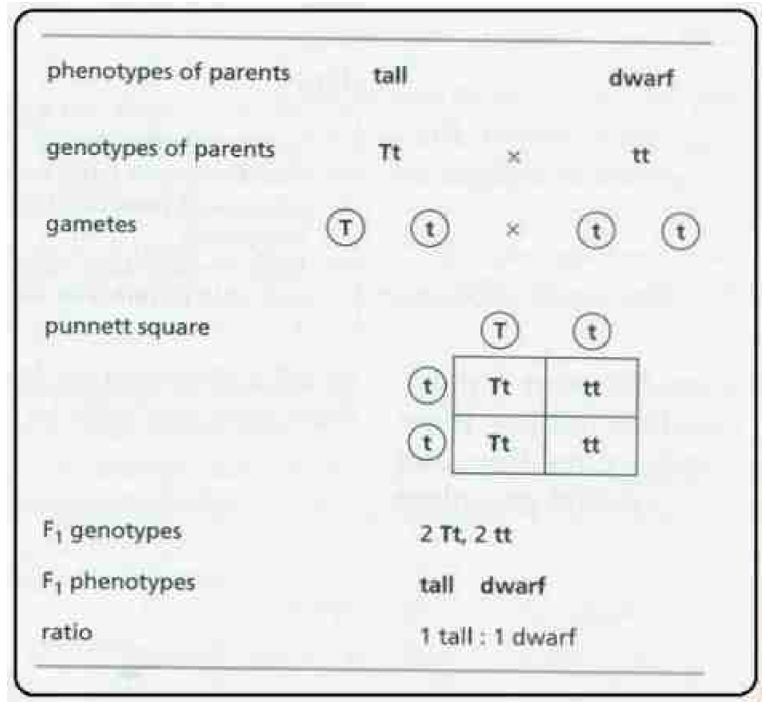
punnett square

	T	t
T	TT	Tt
t	Tt	tt

F_1 genotypes	1 TT, 2 Tt, 1 tt
F_1 phenotypes	tall tall dwarf
ratio	3 tall : 1 dwarf

*3. A cross between two **heterozygous tall** pea plant.*

The hetetozygous tall pea plants must be **Tt**.
The dwarf pea plants must be **tt**.



Common misconceptions

Some students ignore the letters for alleles given in genetic questions and make up their own, without stating a key. This usually results in a number of marks being lost through errors that could easily have been avoided.

Try this

1. In exam questions involving genetic crosses, you often need to predict the genotypes of the parents form descriptions of them. Work out the following genotypes, based on peas that can be round or wrinkled, with round being dominate to wrinkled. Remember that the dominant allele normally takes the capital letter or the characteristic is represents

a) A heterozygous round pea [1 mark]
b) A wrinkled pea [1 mark]
c) A pure-breeding round pea [1 mark]

Answer

a) Rr
b) rr
c) RR

2. Complete the passage by writing the most appropriate word from the list in each space.

chromosome diploid gene heterozygous meiosis mutation phenotype recessive dominant

Petal colour in pea plants is controlled by a single ___which has two forms, red and white. The pollen grains are produced by ______. After pollination, fertilization occurs and the gametes join to form a _____ zygote.

When two red-flowered pea plants were crossed with each other, some of the offspring were white-flowered. The _____ of the rest of the offspring was red-flowered. The white-flowered form is_____ to the red-flowered form and each of the parent plants was therefore______. [6 marks]

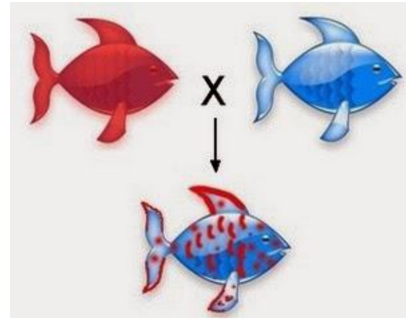
Answer

gene meiosis diploid phenotype recessive heterozygous

Video: Punnett squares

https://www.youtube.com/watch?v=_ksIajiPUAU

130 Codominance and inheritance of blood group



Sometimes, neither of a pair of **alleles** is completely dominant or completely recessive. Instead of one of them completely hiding the effect of the other in a heterozygote, they **both have an effect on the phenotype**. This is called **codominance.**

The result is that there can be three different phenotypes. When writing the genotypes of codominant alleles, the common convention is to use a capital letter to represent the gene involved, and a small raised letter for each phenotype.

Imagine a kind of flower which has two alleles for flower colour. The allele C^w produces white flowers, while the allele C^R produces red ones. If these alleles show codominance, then the genotypes and phenotypes are:

genotype	**phenotype**
C^w C^w	white flowers
C^w C^R	pink flowers
C^R C^R	red flowers

Common misconceptions

When factors are codominant, students often think this will result in different proportions of offspring having the parents' features. However, codominance results in the appearance of a new characteristic, which is intermediate to the parents features. For example, if the parents are pure-breeding for long fur and short fur, the offspring will all have medium-length fur.

Inheritance of A, B, AB and O blood group - an example of codominance

- In humans, there are 4 blood types (phenotypes): A, B, AB, and O
- Blood type is controlled by **3 alleles**: I^A, I^B, I^O (the base letter = I stands for immunoglobulin)
- I^O is **recessive**, two I^O alleles must be present for the person to have type O blood
- I^A and I^B are **codominant** but both are dominant to I^o. If a person receives an I^A allele and a I^B allele, their blood type is type AB, in which characteristics of both A and B antigens are expressed.

Because I^O is dominated by both I^A and I^B alleles, a person with blood group A could have the genotype I^A I^O or I^A I^A. This has implication when having children because, if both parents carry the I^O allele, a child could be born with the genotype I^OI^O (blood group O), even though neither of the parents have this phonotype.

Blood type	Genotype	
A	I^A, I^O I^A, I^A	AO AA
B	I^B, I^O I^B, I^B	BO BB
AB	I^A, I^B	AB
O	I^O I^O	OO

Video: Codominance and the inheritance of blood type

https://www.youtube.com/watch?v=nykVH9Z7Gw8

131 Variation continuous and discontinous

Variation is all the **differences** which exist between members of the same species. It is caused by a combination f **genetic** and **environmental** factors.

There are two kinds of variation:
continuous and **discontinuous**.

Continuous variation

- shows a complete range of the characteristic within a population.

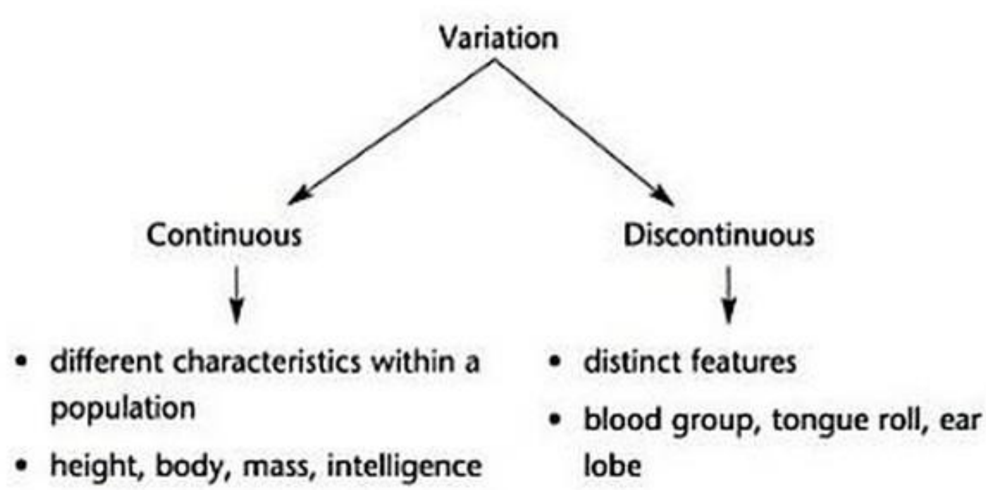
- caused both by both **gens** (often a number of different genes) and **environment**:

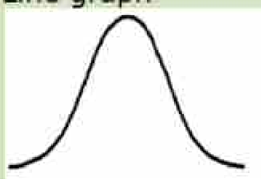
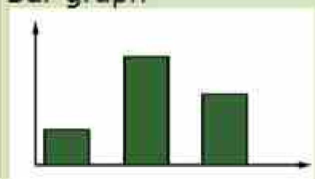
- Plants: availability of/competition for: nutrients, light, water; exposure to disease…

- Animals: availability of food/balanced diet; exposure to disease (or the availability of health serviced for humans).

Discontinuous variation

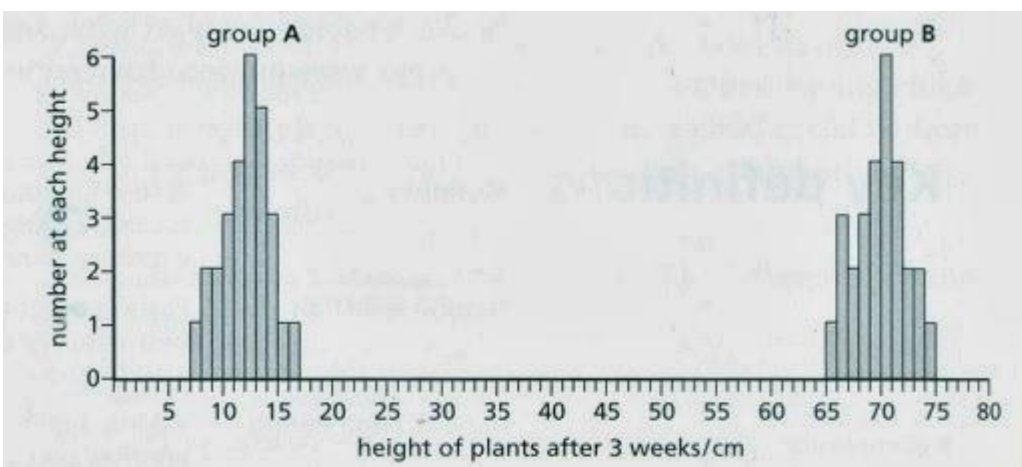
- seen where there are obvious, distinct categories for a feature.
- no intermediates between categories, the feature cannot usually change during life.
- caused by a single gen/a small number of **genes**, with **no environmental** influence.



	Continuous variation	Discontinuous variation
Properties	- No distinct categories - No limit on the value - Tends to be quantitative	- Distinct categories. - No in-between categories - Tends to be qualitative
Examples	• height • weight • heart rate • finger length • leaf length	• tongue rolling • finger prints • eye colour • blood groups
Representation	Line graph 	Bar graph 
Controlled by	A lot of Gene and environment → range of phenotypes between 2 extremes, e.g. height in humans.	A few genes → limited number of phenotypes with no intermediates e.g. A, B, AB and O blood groups in humans

Try this

Seventy seeds were collected from a cross between two plants of the same species. The seeds were sown at the same time and, after 3 weeks, the heights of the plants which grew were measured and found to fall in to two groups, A and B, as shown in figure below.



a) Calculate the percentage of seeds which germinated. Show your working. [2 marks]

b) i) Name the type of variation shown within each group [1 mark]

ii) State three factors which might have caused this variation. [3 marks]

Answer

a) 56/70x100=80%

b) i) continuous variation.

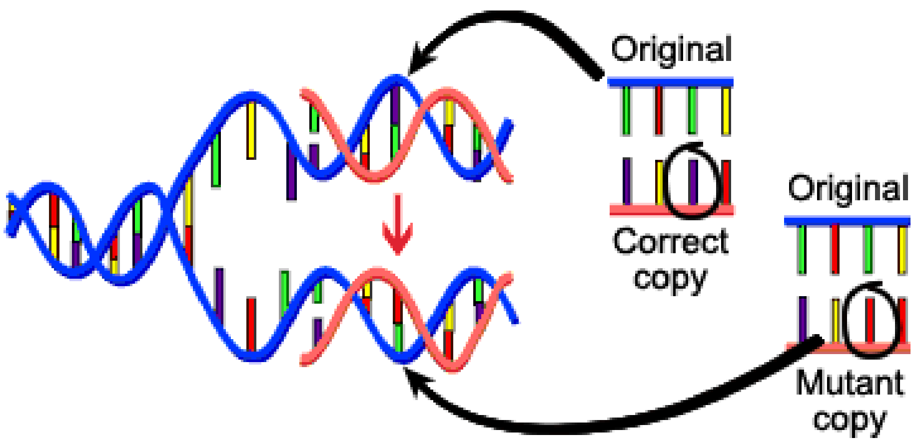
ii) Any 3 factors from: genes, temperature, disease, seed size, light, O_2, CO_2, H_2O, minerals, mutation, trampling by animals.

Video: What is meant by genetic difference?

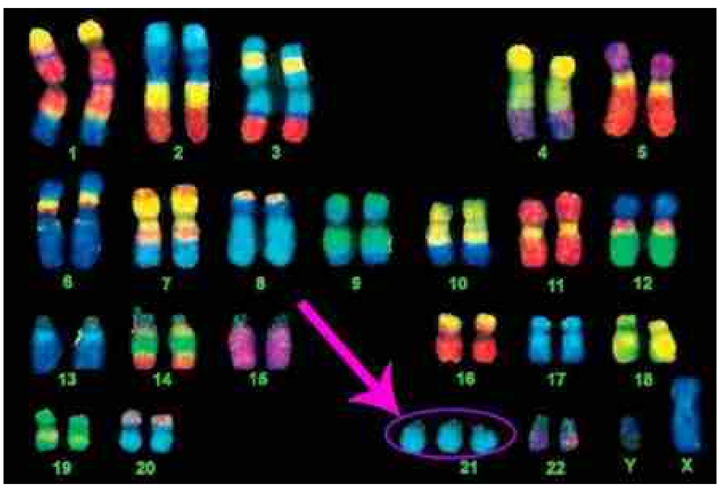
https://www.youtube.com/watch?v=a5yzRRvROpE

132 Mutation, Down syndrome, effect of radiation

Mutation is a unpredictable **change** in the **genes** or **chromosome** number, as a result of fault copying when DNA is replicated, faulty separation of chromosomes during cell division, or exposure to radiation or some chemicals.



Down's syndrome is caused by a mutation. When ova are formed in the ovaries, the chromosome number is halve. During this division process (meiosis), one of the chromosome (number 23) sticks to its partner. This results in one ovum with 24 chromosomes and one with only 22, and the ovum with 24 chromosomes is still viable. If it is fertilized, the fetus formed will have 47 chromosomes instead of 46.



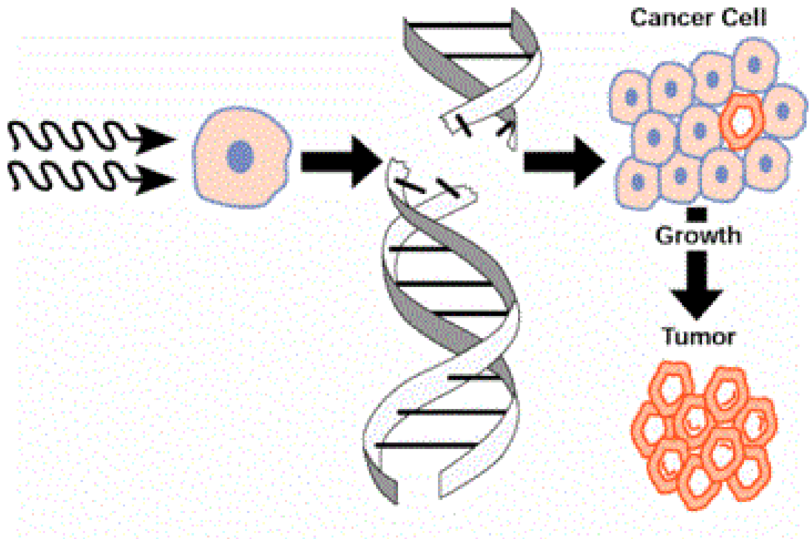
3 chromosome 21 in Down syndrome.

The presence of the extra chromosome causes unusual characteristics in the baby. These usually include lowered life expectancy, mental retardation (although some Down's children are very intelligent), early puberty, and a distinctive round face and short neck.

A child with Down syndrome.

Effects of ionising radiation and chemicals on the rate of mutation

- Mutation are normally very rare. However, exposure to radiation and some chemicals, such as tar in tobacco smoke, **increases** the **rate of mutation**.
- Exposure can cause uncontrolled cell division, leading to the formation of tumours (cancer).



The development of cancer from mutated cells.

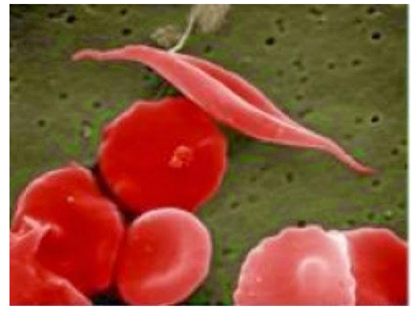
- Exposure of gonads (testes and ovaries) to radiation can lead to sterility or to damage to genes in sex cells that can be passed on to children.
- Some scientists argue that there is a higher incidence of leukaemia (a form a white blood cells cancer) in the children of workers at nuclear power stations.

Video: DNA mutation, effect of radiation and chemicals on mutation

https://www.youtube.com/watch?v=efstlgoynlk

#133 Sickle cell anaemia and its incidence to that of malaria

Sickle cell anaemia is caused by a **mutation** in the blood pigment **haemoglobin**. When the faulty haemoglobin is present in a red blood cell, it causes the cell to deform and become **sickle-shaped**, especially when oxygen levels in the blood become low.



Normal and sickle red blood cells

In this state the sickled red blood cells are less efficient at transporting oxygen and more likely to become stuck in a capillary, preventing blood flow.

The faulty allele is dominated by the allele for normal haemoglobin, but still has some effect in a heterozygous genotype.

The possible genotypes are:

- $\mathbf{H^NH^N}$ normal haemoglobin, no anaemia
- $\mathbf{H^NH^n}$ some abnormal haemoglobin, sickle cells trait (not life-threatening)
- $\mathbf{H^nH^n}$ abnormal haemoglobin, sickle cells anaemia (life-threatening)

Malaria is a life-threatening disease caused by a parasite that invades red blood cells. The parasite is carried by some species of mosquito.

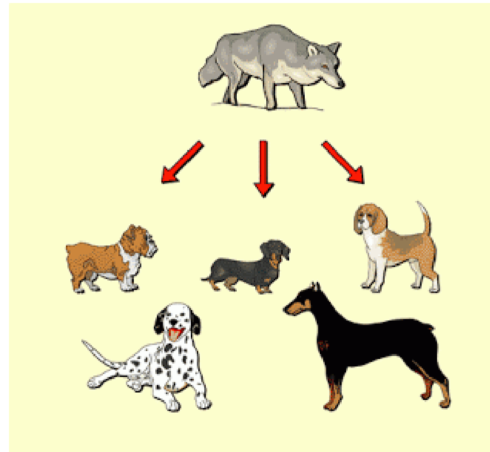
- A person who is heterozygous ($\mathbf{H^NH^n}$) for sickle cell anaemia has **protection** from malaria, because the malaria parasite is unable to invade an reproduce in the sickle cells.
- A person who is homozygous for sickle cell anaemia ($\mathbf{H^nH^n}$**)** also has **protection**, but is at high risk of dying form sickle cell anaemia.
- A person with normal haemoglobin ($\mathbf{H^NH^N}$) in a malarial country is at **high risk** of contracting malaria.

When the distributions of malaria and sickle cell anaemia are shown on a map of the work, it is found that the two coincide in tropical areas because of the selective advantage of the H^n allele in providing protection against malaria.

Video: Sickle cell
disease https://www.youtube.com/watch?v=9AHFHleYwdU
Video: What is Sickle cell anaemia
https://www.youtube.com/watch?v=Qd0HrY2NlwY
Video: Evolution of sickle cell malaria
https://www.youtube.com/watch?v=1fN7rOwDyMQ

#134 Artificial and natural selection

Artificial selection is a method used by humans to produce varieties of animals and plants which have an increased economic importance. People use **selective breeding** to produce new varieties of a species, so that certain **desirable traits** are represented in successive generations.



A variety is a type of a particular species that is different in some clear way from other varieties of that species. The different breeds of domestic dogs and large ears of maize corn are products of artificial selection.

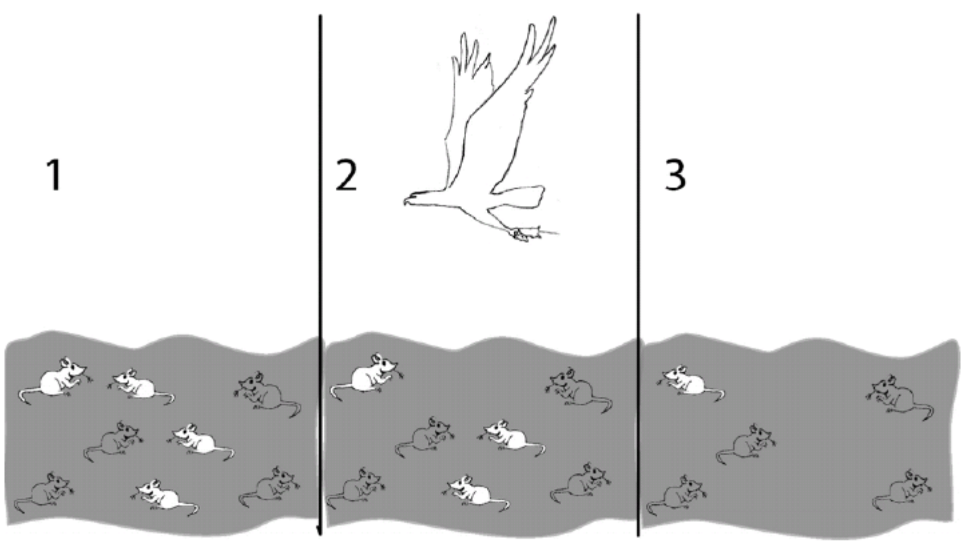
These common vegetables were cultivated from forms of wild mustard. This is evolution through artificial selection.

Selective breeding of cows

Suppose you wanted a variety of cow that produced a lot of milk. This is what you could do:

- choose or select the cows in your herd that produce the most milk
- let only these cows reproduce
- select the offspring that produce the most milk
- let only these offspring reproduce
- keep repeating the process of selection and breeding until you achieve your goal.

Natural selection is the process by which plants and animals that **can adapt** to changes in their environment are able to **survive** and reproduce while those that cannot adapt do not survive. It gives the greater chance of **passing** on of **genes** by the **best adapted organisms**.



Try this

Farmers have carried out artificial selection to improve the breeds of some animals. Some of the original breeds have become very rare and are in danger of becoming extinct.

a) Explain what is meant by artificial selection [2 marks]

b) i) Name one species which is in danger of extinction. [1 mark]
ii) Biologists are concerned that species of animals and plants should not become extinct. Why is it important to prevent the extinction of plant and animal species? [2 marks]

Answer

a) A method used by humans to produce varieties of animals and plants which have an increased economic importance.

b) i) Any endangered species, such as panda, tiger, elephant, named whales species, named tuna species.

ii) Two point from:

- to maintain the gene pool
- to provide chemicals that may be useful in development of medicines
- the species may be an important part of a food chain
- rare species may provide tourism to supply poor communities with money.

Additional source: **BBC Bitesize**

Video: What is Natural Selection?

https://www.youtube.com/watch?v=0SCjhI86grU&list=PLfHpBjIQ933u6AuVr6y78X5rd-AFr0aq8

SlideShow

http://learn.genetics.utah.edu/content/selection/artificial/

#135 Variation and antibiotic-resistance strains of bacteria

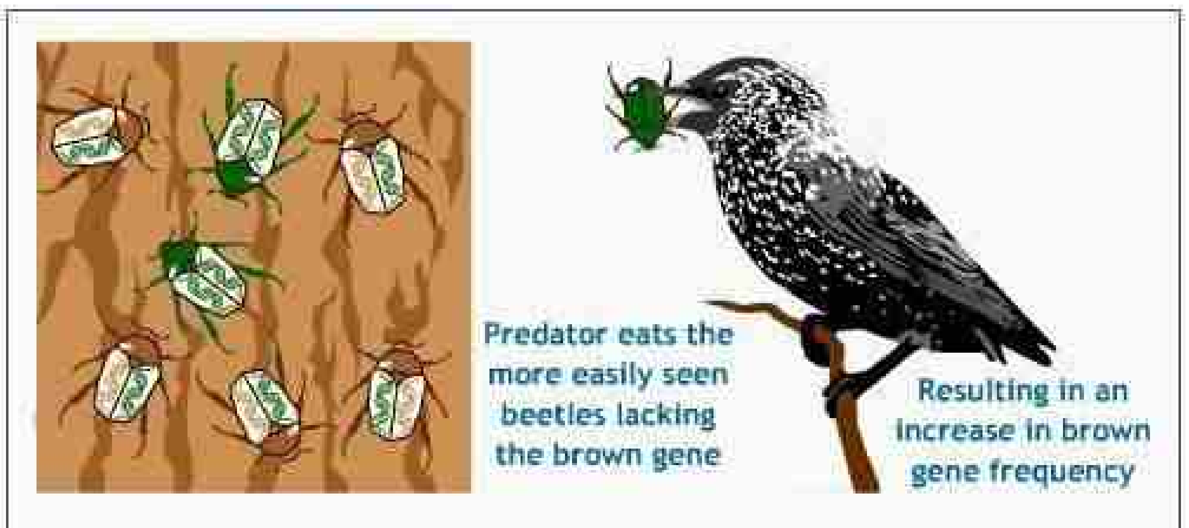
Variation is the slight individual **differences** within populations. All living things change and evolve from one generation to the next. As they do so, more variation is produced.

Some variations is **inherited** (passed on from parents) and some is **acquired** (developed during life).

Animals and plants produced by sexual reproduction will show variation from their parents, for example in the size of the muscles in the legs of lions.

When new organisms are produced, not all of them are likely to survive because of competition for resources such as food, water and shelter. The same is true for plants (they compete for resources such as nutrients, light, water and space).

The individuals with the most favourable characteristics are most likely to survive.



Variations in a Population

The process of natural selection follows a sequence, as listed below.

- Some of the variations within a population may give some individuals an advantage over others in the population. Bigger muscles in the legs of a lion would enable it to run more quickly and get food more successfully.
- In an environment where there is food shortage, the lion with the biggest leg muscles is most likely to survive to adulthood.

- The weaker individuals die before having the chance to breed, but the surviving adults breed and pass on the advantageous genes to their offspring.
- More of the next generation carry the advantageous genes, resulting in a stronger population, better adapted to a changing environment.

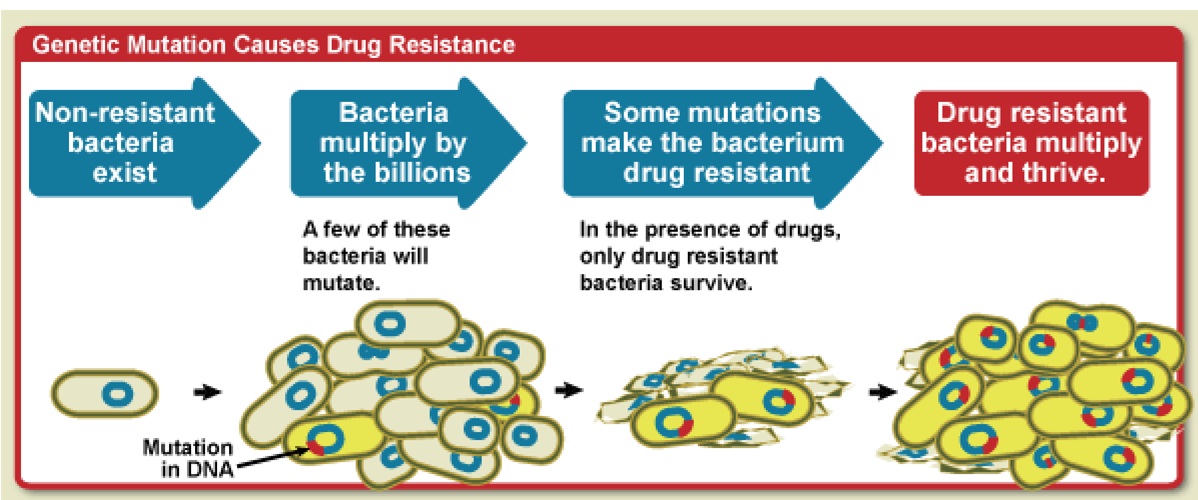
Slow changes in the environment results in adaptation in a population to cope with the change. Failure to adapt could result in the species becoming extinct. This gradual change in the species through natural selection over time, in response to changes in the environment, is a possible **mechanism for evolution.**

Examples: antibiotic-resistance strains of bacteria
Bacteria reproduced rapidly - a new generation can be produced every 20 minutes by binary fission. Antibiotics are used to treat bacterial infections: an antibiotic is a chemical that kills bacteria by preventing bacterial cell wall formation.

Mutations occur during reproduction, which produce some variation in the population of bacteria.

Individual bacteria with the most favourable features are most likely to survive and reproduce.

A mutation may occur that enables a bacterium to resist being killed by antibiotic treatment, while the rest of the populating is killed when treated. This bacterium would survive the treatment and breed, passing on the antibiotic - resistant gene to its offspring. Future treatment of this population of bacteria using the antibiotic would be ineffective.

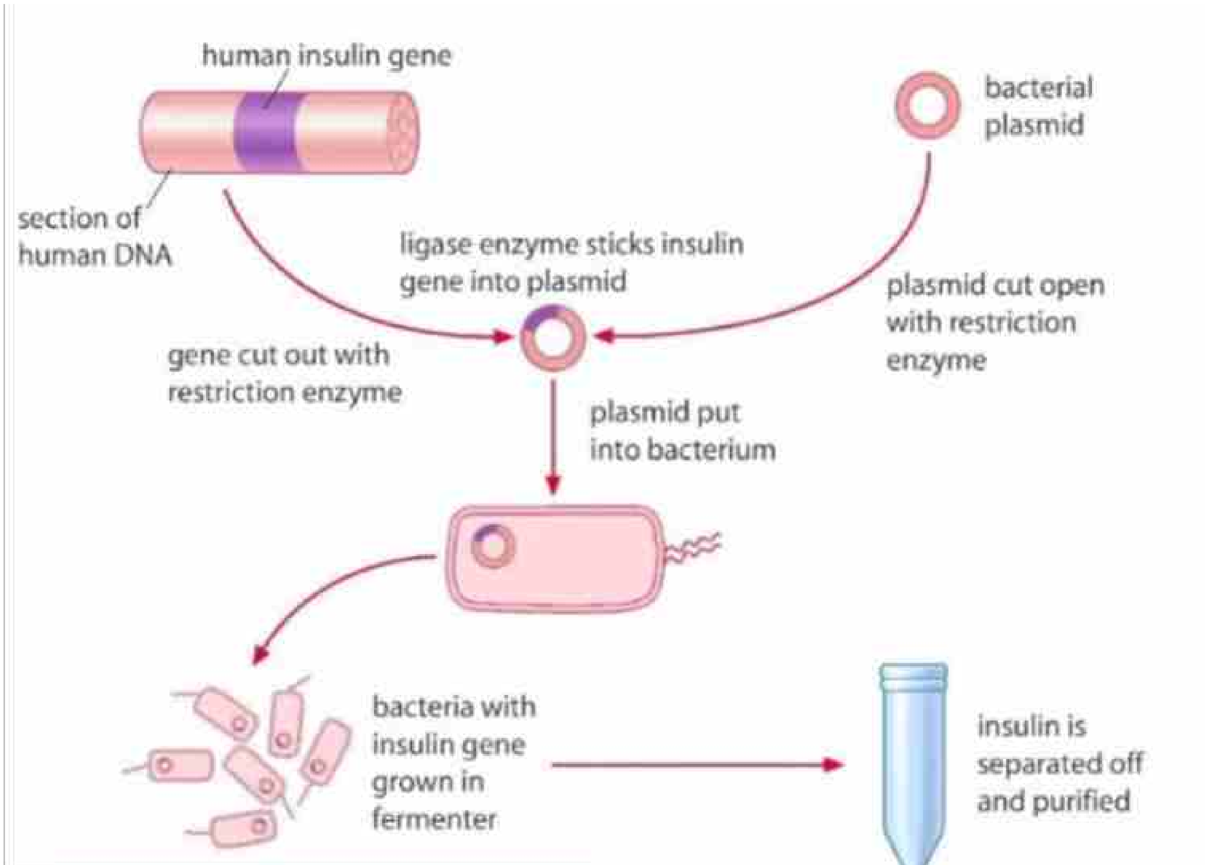


Video GCSE BBC Science Bitesize - Variation, Inheritance and Evolution: https://www.youtube.com/watch?v=1m_m18UaxUs

Video The Animation of Antimicrobial Resistance
https://www.youtube.com/watch?v=AYvX8tnCM9s

136 Genetic engineering, putting human insulin genes into bacteria

Genetic engineering is a process of **taking a gene** from one **species** and **putting** it into another species.



B Making genetically engineered insulin.

The control of all the normal activities of a bacterium depends upon its single **chromosome** and small rings of genes called **plasmids**. In genetic engineering pieces of chromosome from a different organism can be inserted into a plasmid. This allows the bacteria to make a new substance.

The ethics of genetic engineering

Benefits:

- cures for diseases, such as cystic fibrosis and cancer
- food which is healthier, stays fresh for longer periods and tastes better.

Risks:

- unknown effects of moving genes from one organism to the other
- new dangerous diseases being created
- against God and nature.

Using genetic engineering to put human insulin genes into bacteria

1. Human cells with genes for healthy insulin are selected.
2. A chromosome (a length of DNA) is removed from the cell.
3. The insulin gene is cut from the chromosome using restriction endonuclease enzyme.
4. A suitable bacterial cell is selected. Some of its DNA is in the form of circular plasmids.
5. All the plasmids are removed from the bacterial cell.
6. The plasmids are cut open using the same restriction endonuclease enzyme.
7. The human insulin gene is inserted into the plasmids using ligase enzyme.
8. The plasmid are returned to the bacterial cell (only one is shone in the diagram).
9. The bacterial cell is allowed to reproduce in a fermenter. All the cells produced contain plasmids with the human insulin gene.

The importance of this process

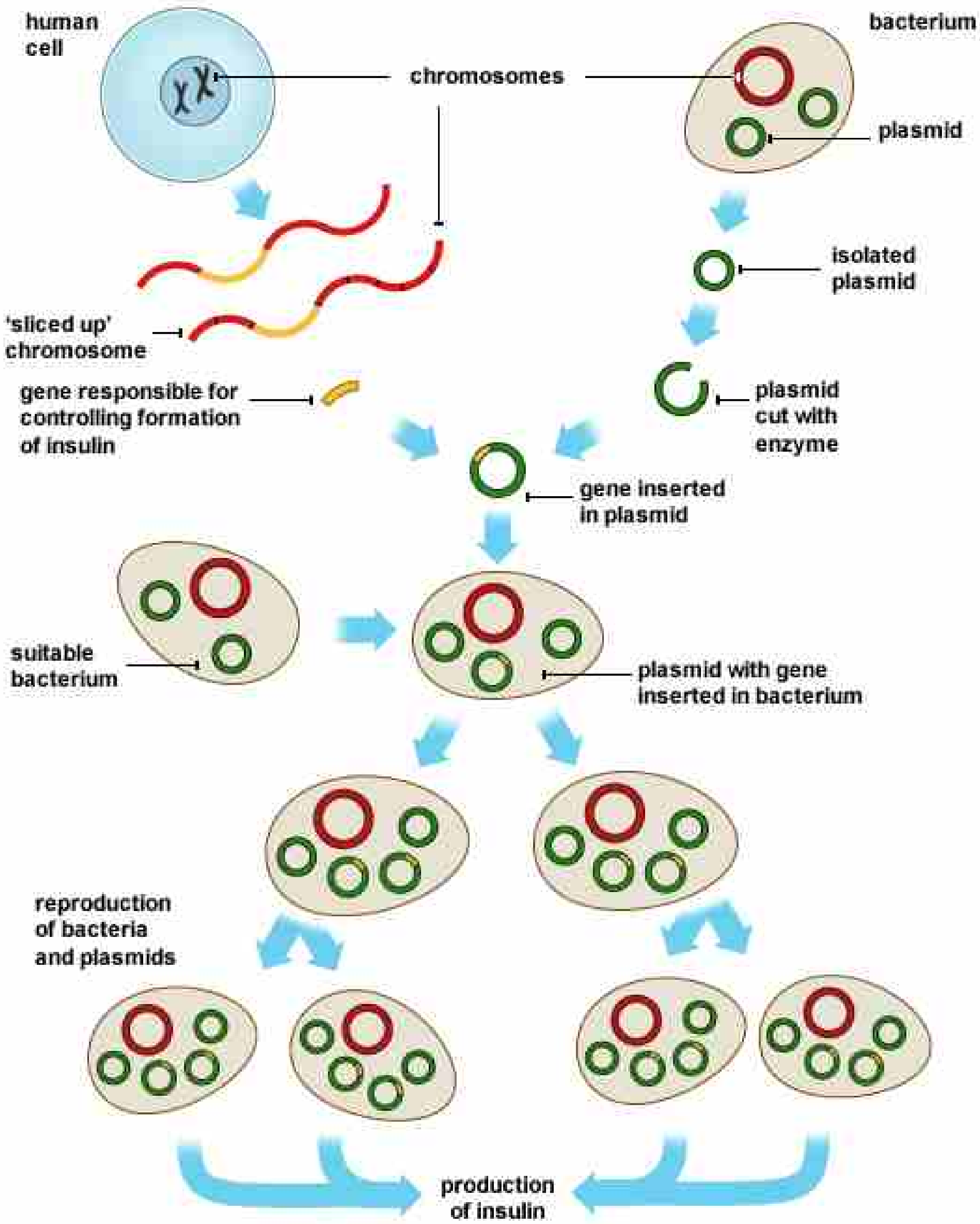
- Diabetics need a source of insulin to control their blood sugar level. In the past cow insulin has been used, but some people are allergic to it. Human insulin produced from genetically engineered bacteria will not trigger an allergic reaction.
- The insulin is acceptable to people with a range of religious belief who may not be allowed to use insulin form animals such as cows or pigs.
- The product is very pure.
- Human insulin can be made on a commercial scale, reducing costs.

Video Genetic Engineering

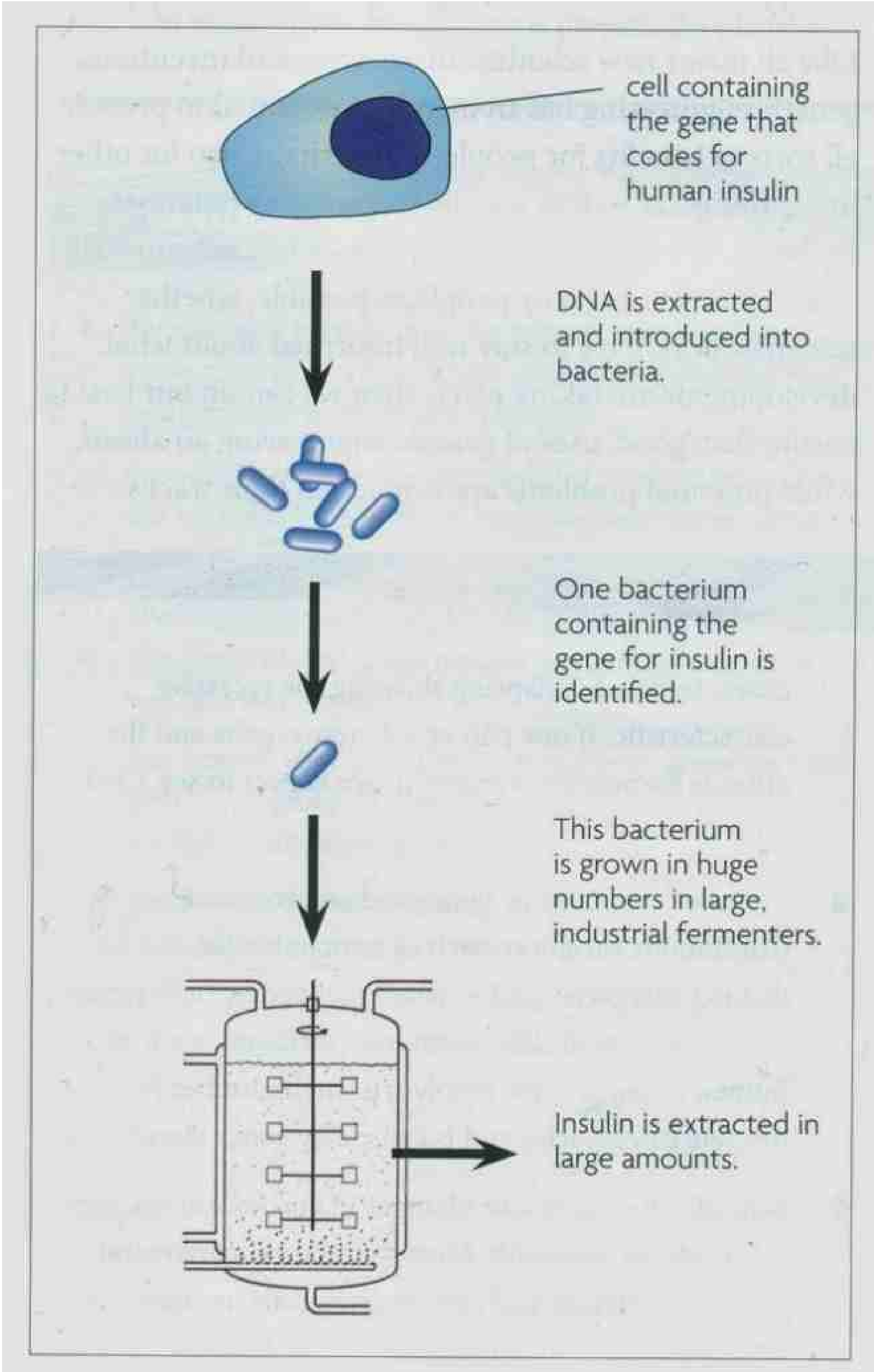
https://www.youtube.com/watch?v=zlqD4UWCuws

Video Genetically Engineered Insulin

https://www.youtube.com/watch?v=MJ_6oXaLRj4

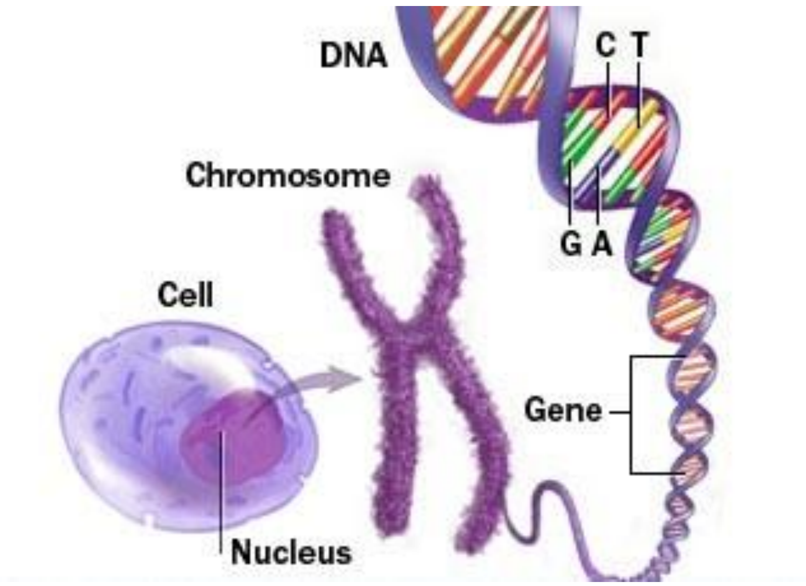


human cell
chromosomes
bacterium
plasmid
isolated plasmid
'sliced up' chromosome
gene responsible for controlling formation of insulin
plasmid cut with enzyme
gene inserted in plasmid
suitable bacterium
plasmid with gene inserted in bacterium
reproduction of bacteria and plasmids
production of insulin



Using genetic engineering to produce bacteria that make human insulin.

#137 Summary of inheritance



- **Chromosomes** are long thread of **DNA** made up of strings of **genes**. In a diploid cell, each of a pair of homologous chromosomes carries the same genes in the same position. A diploid cell therefore has 2 copies of each gene.

- **Gametes** have only one set of chromosomes , and so they have only one copy of each gene.

- Different forms of a particular gene are called **alleles**. They may be **dominant** of **recessive**. The genotype of an organism tells us the alleles of genes that it carries. If the 2 alleles of a gene are the same in the organism, then it is **homozygous**. If they are different, it is **heterozygous**.

- If **2 heterozygous** organisms breed together, we expect a **3:1 ratio** of offspring showing the dominant characteristic to offspring showing the recessive characteristic. If one parent is **heterozygous** and the other is **homozygous** recessive, we expect to see a **1:1 ratio** in the offspring.

- **Variations** is caused by genes and environment. **Continuous** variation, such as human height, has no distinct categories and is usually caused by both genes and environment. **Discontinuous** variation, such as human blood groups, involves a small number of discrete categories and is caused by genes alone.

- New alleles of genes, or changes in categories chromosomes, can be caused by **mutation**. Most mutations are harmful. Ionising radiation and certain chemicals increase the risk of mutation happening.

- In a population of organisms, those with the characteristics best adapted to the environment are most likely to survive and reproduce. This is called **natural selection**.

- It the environment changes, or if a new advantageous allele appears, natural selection can leas to change over many generations. This is called **evolution**.

- **Sickle cells anaemia** is caused by recessive allele of the gene for haemoglobin. People who are homozygous recessive often die before they can reproduce. People who are homozygous dominant have a greater chance of getting **malaria** if they live in places where this disease is present. People who are heterozygous have a selective advantage, because they are less likely to get malaria. Natural selection therefore maintains this allele in the population in parts of the world where people may be killed by malaria.

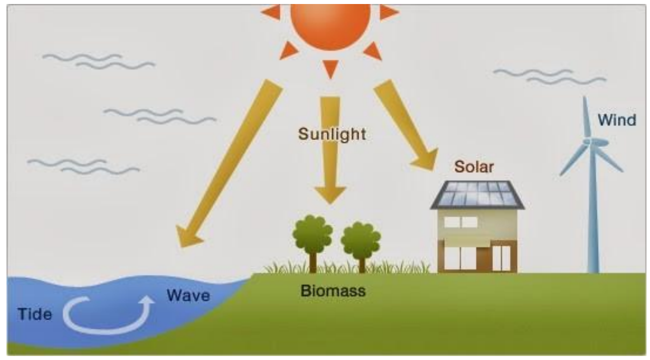
- Human select plants and animals with desirable characteristics and breed from them. Over many generations, this produces new strain of plants or animals with features that's we require. This is called **artificial selection**.

- **Genetic engineering** involves taking a **gene** from one species and inserting it into another. This has been done with the human insulin gene, to give bacteria that produce **insulin** for harvest an sale, for use by people with diabetes.

14 Ecosystem

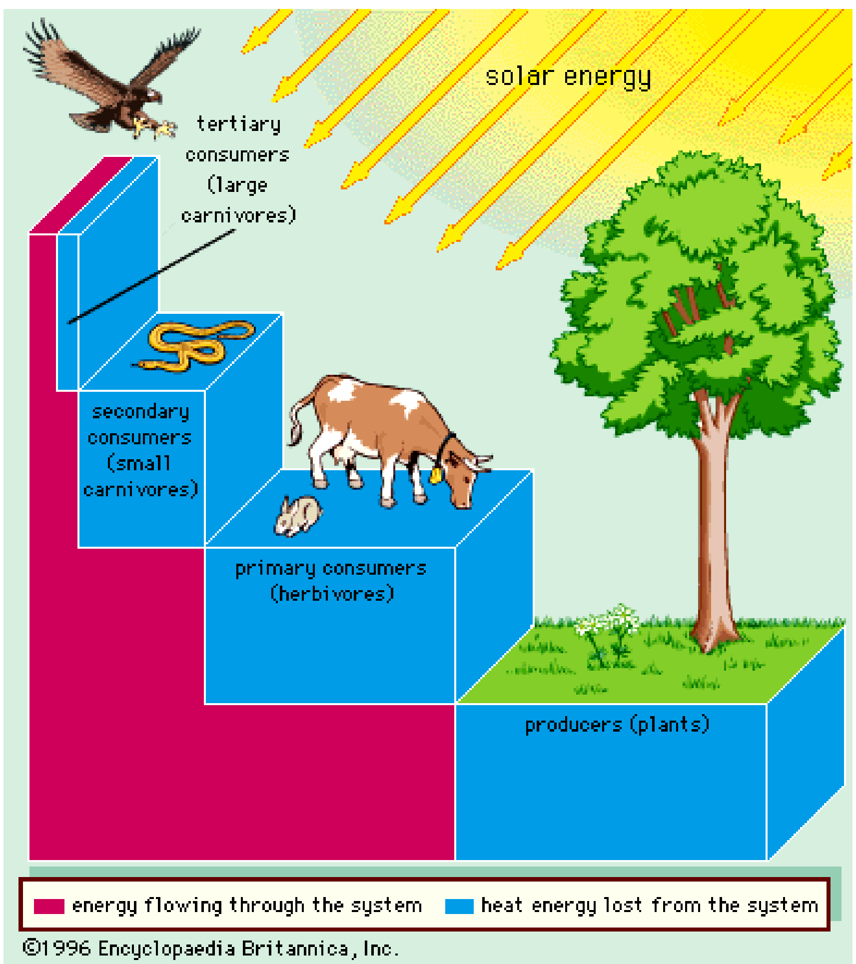
#138 Energy flow, energy loss

The **Sun** is the principal source of energy input to biological systems. The Earth receives 2 main types of energy from the Sun: **light** (solar) and **heat**. Photosynthetic plants and some bacteria can trap light energy and convert it into **chemical energy**.



Non-cyclical nature of energy flow

Heterotrophic organisms obtain their energy by eating plants or animals that have eaten plants. So all organisms, directly or indirectly, get their energy from the Sun. The energy is passed from one organism to another in a food chain but, unlike water and elements such as carbon and nitrogen, **energy does not return in a cycle**. Energy give out by organisms is **lost to the environment**.



Energy is **lost** at each level in the food chain, as in the examples below.

- Energy lost through the process of **respiration** (as heat)
- Energy used up for **movement** (to search for food, find a mate, escape from predators…).
- Warm-blood animals (birds and mammals) maintain a standard **blood temperature** – they lose heat to the environment.
- Warm-blood animals lose heat energy in **faeces** and **urine**.
- Some of the **material** in the organism being eaten is **not used** by the consumer, for example a locust does not eat the roots of maize, and some of the parts eaten are not digestible.

Even plants do not make use of all the light energy available to them. This is because some light:

- is reflected off shiny leaves
- is the wrong wavelength for chlorophyll to trap
- passes through the leaves without passing through any chloroplasts
- does not fall on the leaves.

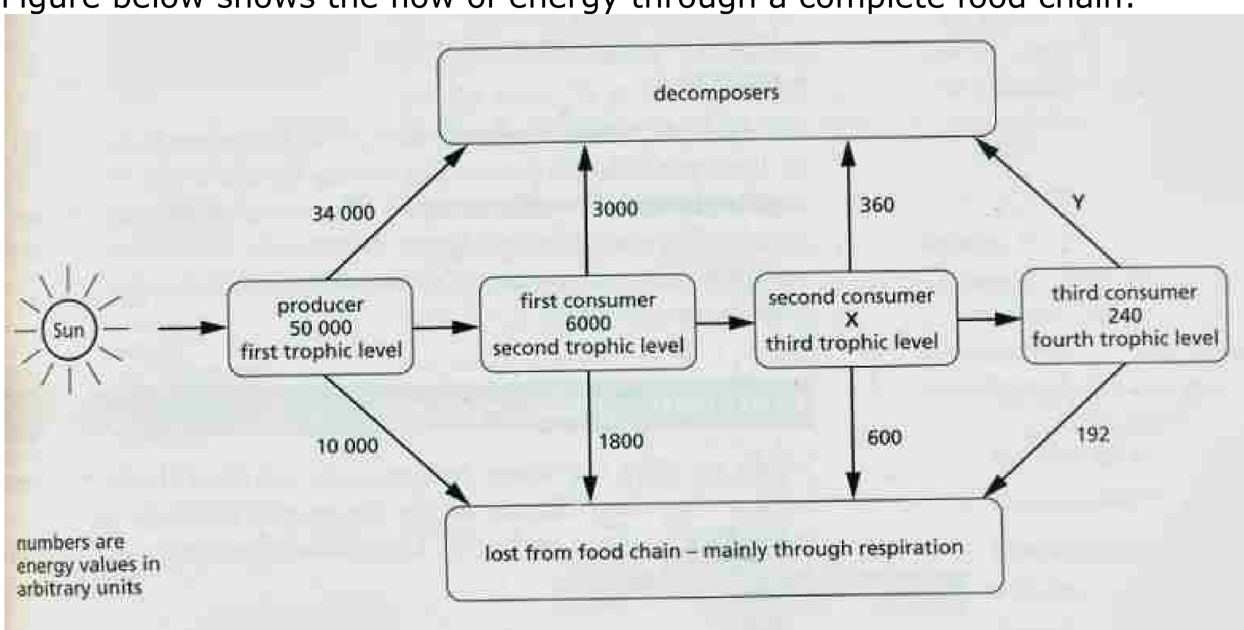
On average, about **90%** of the **energy** is **lost** at **each level** in a food chain. This means that in long food chains, very little of the energy entering the chain through the producer is available to the top carnivore. So there tend to be small numbers of top carnivores. The food chain below shows how energy reduces through the chain. It is based on maize obtaining 100 units of energy.

maize	→	locust	→	lizard	→	snake
100 units		10 units		1 unit		0.1 unit

On shorter food chains, less energy is lost.

Try this

Figure below shows the flow of energy through a complete food chain:



1. a) Which form of the Sun’s energy is trapped by the producer? [1 mark]

b) Into which energy form is the Sun’s energy converted when it is trapped by the producer? [1 mark]

2. a)The first consumer has received 6000 units of energy. How many units of energy (X on the figure) have been passed to the second consumer? [1 mark]

b) How many units of energy (Y on the figure) are lost from the third consumer to the decomposers. [1 marks]

3. a) Suggest why the proportion of the energy intake which a producer loses to the environment (20%) is smaller than that lost to the environment by a first consumer (30%). [2 marks]

b) Many countries have difficulty in producing enough food for their population. How might it help to overcome this problem if humans were always fed as first consumers, rather than second or third consumers? [3 marks]

Answer

1. a) Light (or solar) energy

b) Chemical energy

2. a) 1200 units

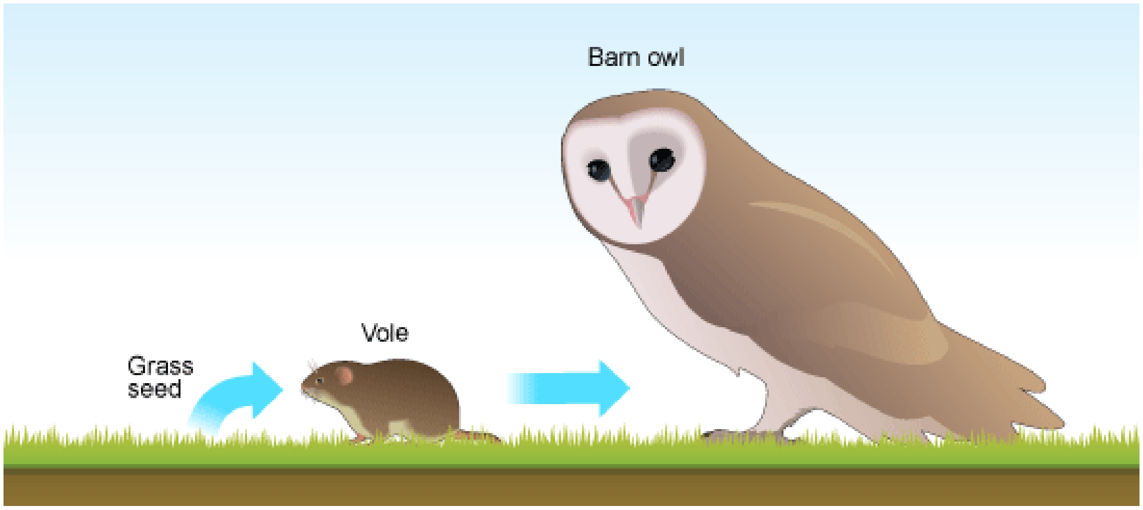
b) 48 units

3. a) The consumer may be warm-blooded, so some energy is lost as heat. Consumers usually move around to find food, a mate, or escape from predators, which uses up energy, but producers do not move.

b) Feeding as a first consumer involves eating plants. Less energy is lost to the environment when feeding at this level, so food production is more efficient in terms of energy conservation.

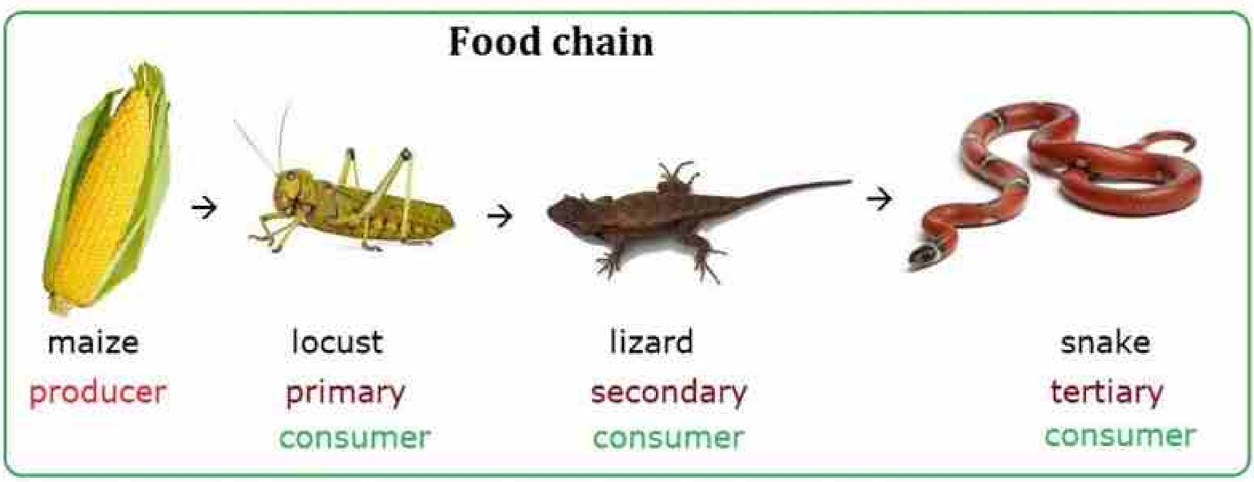
#139 Food chain

Food chain is a chart showing the **flow of energy** (food) from one organism to the next beginning with a **producer**.



Examples:

- **mahogany tree → caterpillar → song bird → hawk**
- **maize → locust → lizard → snake**



- A food chain usually starts with a **photosynthetic plant**, which gains its energy from the Sun.
- The **arrows** used to link each organism to the next represent the direction of energy flow. They always points towards the 'eater', and away from the plant.
- The feeding level is known as the **trophic level**.
- Plant are **producers** (they make/produce food for other organisms).
- Animals that eat plants are primary **consumers** (a consumer is an 'eater'). They are also called carnivores.

Examiner's tips

- *Make sure you can write a food chain involving 3 consumers, with the arrows in the correct direction.*
- *Don't include the Sun (it is not an organism).*
- *Always start with the producer on the left of diagram.*
- *Practice labeling each trophic level in your food chain under the organisms (producer, primary consumer, etc.).*
- *Don't waste time drawing plants and animals: this will not get you any extra marks.*

Common misconceptions

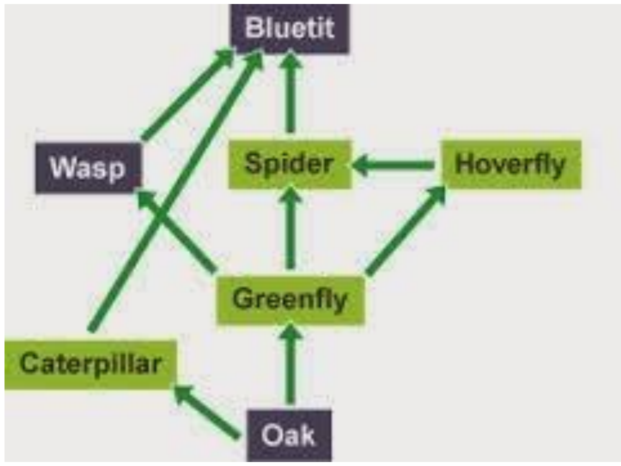
Marks are often lost when students write out food chains and webs because they draw the arrows the wrong way round or put the chain back-to-front (or both). The following example was seen in a recent paper:

jackal → sheep → grass

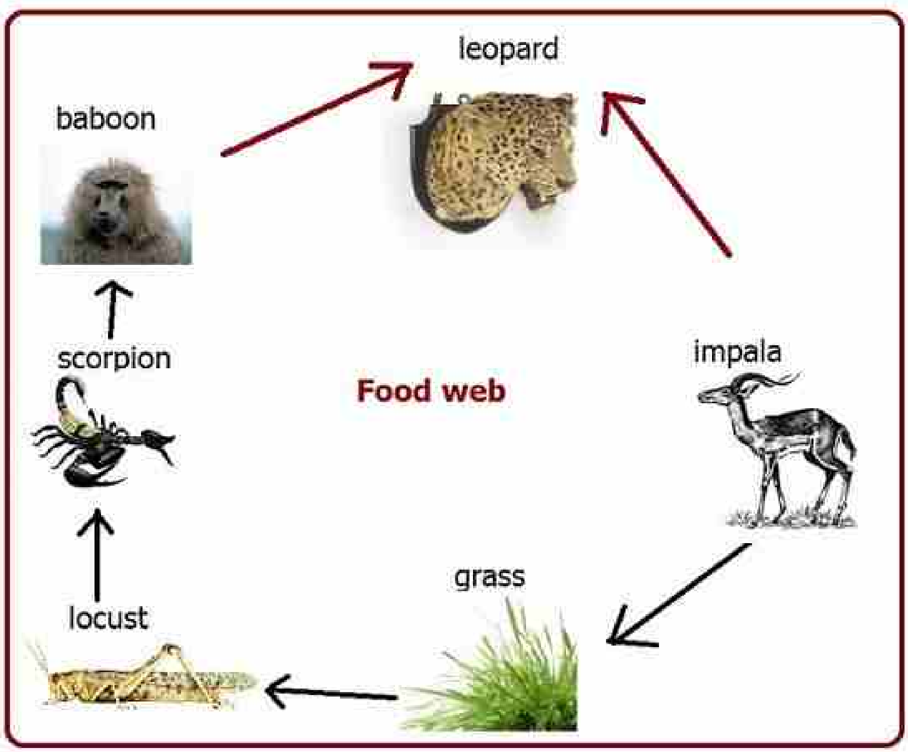
This student is suggesting that grass eats sheep and sheep eat jackals!

140 Food web

Food web is a network of interconnected food chains showing the energy flow through part of an ecosystem.



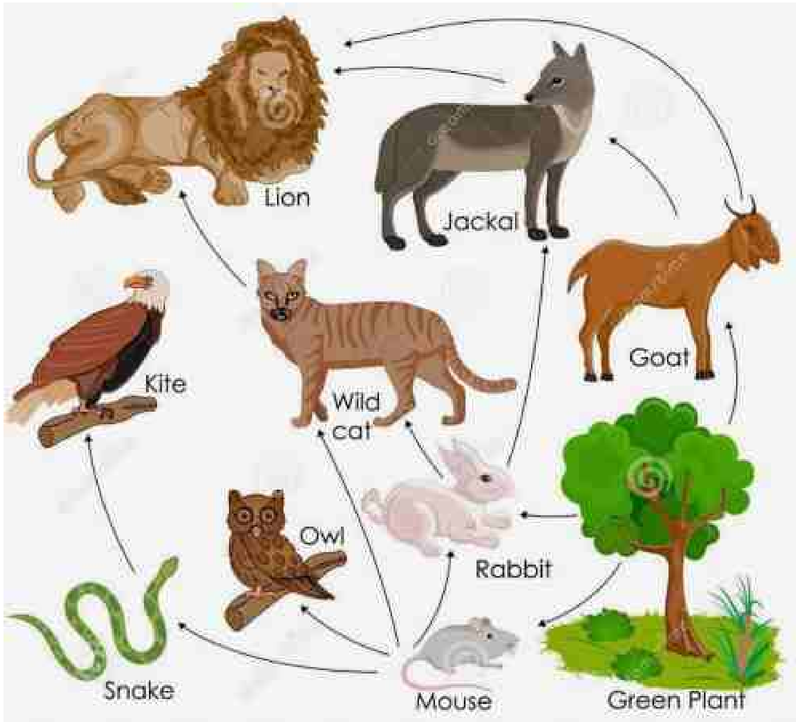
These are a more accurate way of showing feeding relationships than food chains, because most animals have more than one food source. For example, in the food webs in figure below, the leopard feeds on baboons and impala.



The leopard can be placed at 2 different trophic levels:

- secondary consumer (feeding on imlala)
- quaternary or fourth level consumer (feeding on baboons).

Another example of food web.



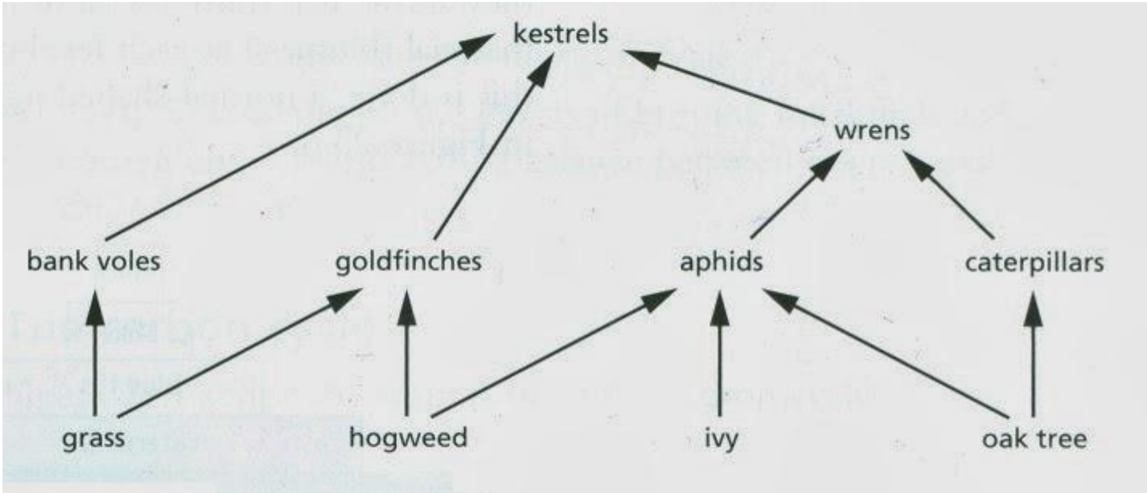
Food webs are easily **unbalanced**, especially if one population of organisms in the web dies or disappears. This may happen for a number of reasons, including:

- over–predation or hunting
- disease
- pollution
- use of pesticides
- lack of food (or other resources)
- emigration.

For example, in the food web here, if all the baboons were killed by hunters the leopard would have only impala to eat. So the impala population would decrease. The scorpion population may increase because of less predation by baboons, but if there are more scorpions they will eat more locusts, reducing the locust population, and so on.

Try this

Figure below shows a food web:



1. Select appropriate organisms form the food web to complete each column in the table below. [4 marks]

	Consumer	Producer	Carnivore	Herbivore
Organism 1				
Organism 2				

2. Ladybirds eat aphids. A very large number of ladybirds arrive in the habita where these organisms live. Predict some of the possible effects this could have on the organisms in the above food web.
[6 marks]

Answer

a)

	Consumer	Producer	Carnivore	Herbivore
2 organisms from	Bank voles Goldfinches Aphids Caterpillar Wrens Kestrels	Grass Hogweed Ivy Oak tree	Wrens Kestrels	Bank voles Goldfinches Aphids Caterpillars

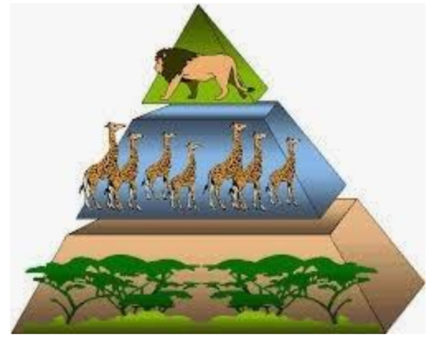
b) 6 suggestion such as:

- decrease in aphids because ladybirds eat aphids
- increase in ivy because there will be fewer aphids feeding
- decrease in wrens because there are fewer aphids to eat
- decrease in caterpillars because the wrens now have only caterpillars for food
- increase in oak trees because there will be fewer aphids feeding
- increase in hogweed because there will be fewer aphids feeding
- increase in goldfinches because there is more hogweed to eat.

There are other possible suggestions.

#141 Food pyramids of numbers, biomass and energy

A **food pyramid** shows the relative sizes of different components at the various trophic levels of a food chain. There are three types of ecological pyramid we use: **numbers**, **biomass** and **energy**.



In a food pyramid, each trophic level in a food chain is represented by a horizontal bar, with the width of the bar representing the **number** of organisms, the amount of **biomass** or the amount of **energy** available at that level. The base of the pyramid represents the producer; the second level is the primary consumer; and so non.

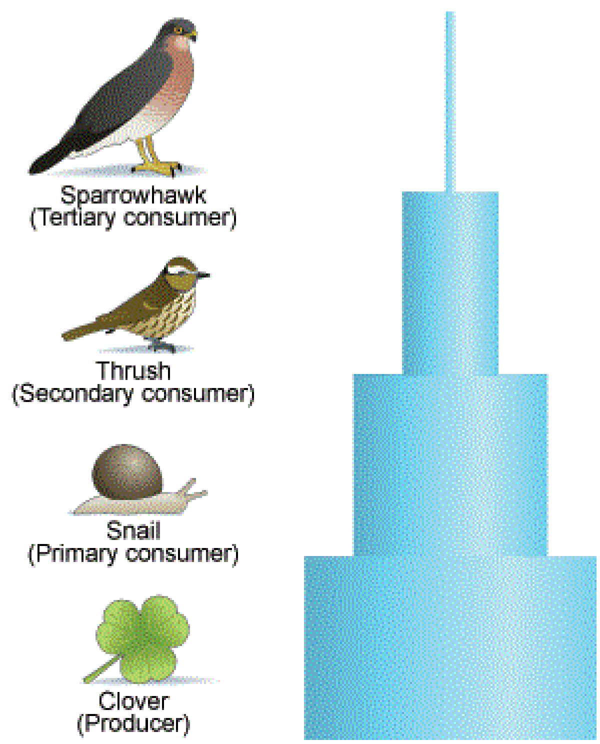
1. Pyramids of numbers

A pyramid of numbers shows the ***relative number of organisms at each stage of a food chain.***

Example 1: **clover → snail → thrush → hawk**

Clover is a plant and it is the producer in this food chain. Its bar goes at the bottom of the pyramid.

Energy is lost to the surroundings as we go from one level to the next, so there are fewer organisms at each level in this food chain. A lot of clover is needed to support the snail population. A thrush eats lots of snails, and a hawk eats lots of thrushes, so the population of hawks is very small.



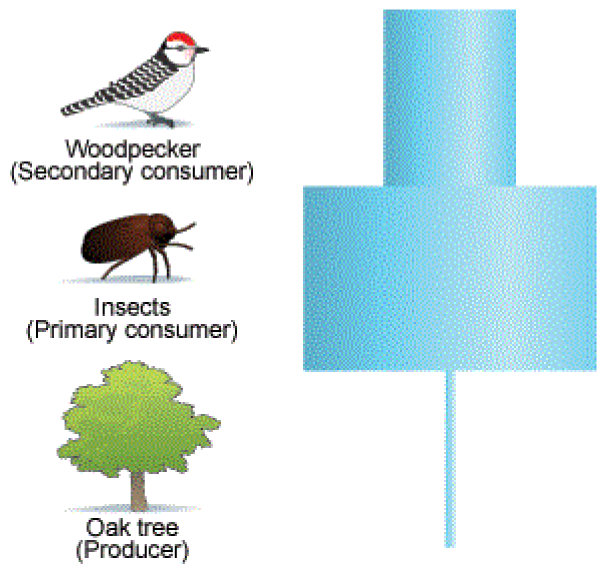
Other pyramid shapes

Sometimes the pyramid of numbers doesn't look like a pyramid at all. This could happen if the producer is a large plant such as a tree, or if one of the animals is very small. Remember, though, that whatever the situation, the producer still goes at the bottom of the pyramid.

Here are two examples like this:

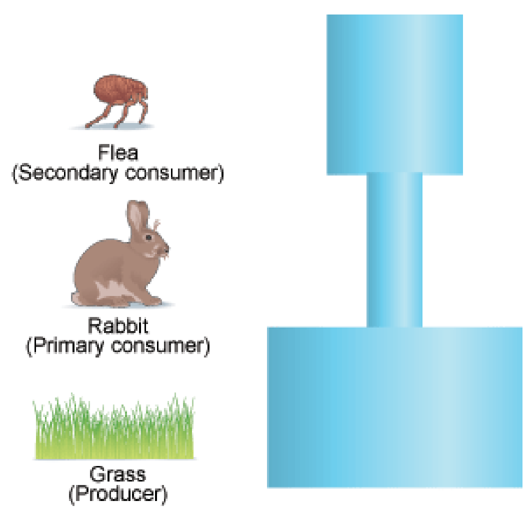
Example 2:* *Oak tree → Insects → Woodpecker

An oak tree is very large so many insects can feed on it.



Example 3:* *Grass → Rabbit → Flea

Fleas are very small and lots of them can feed on a rabbit.

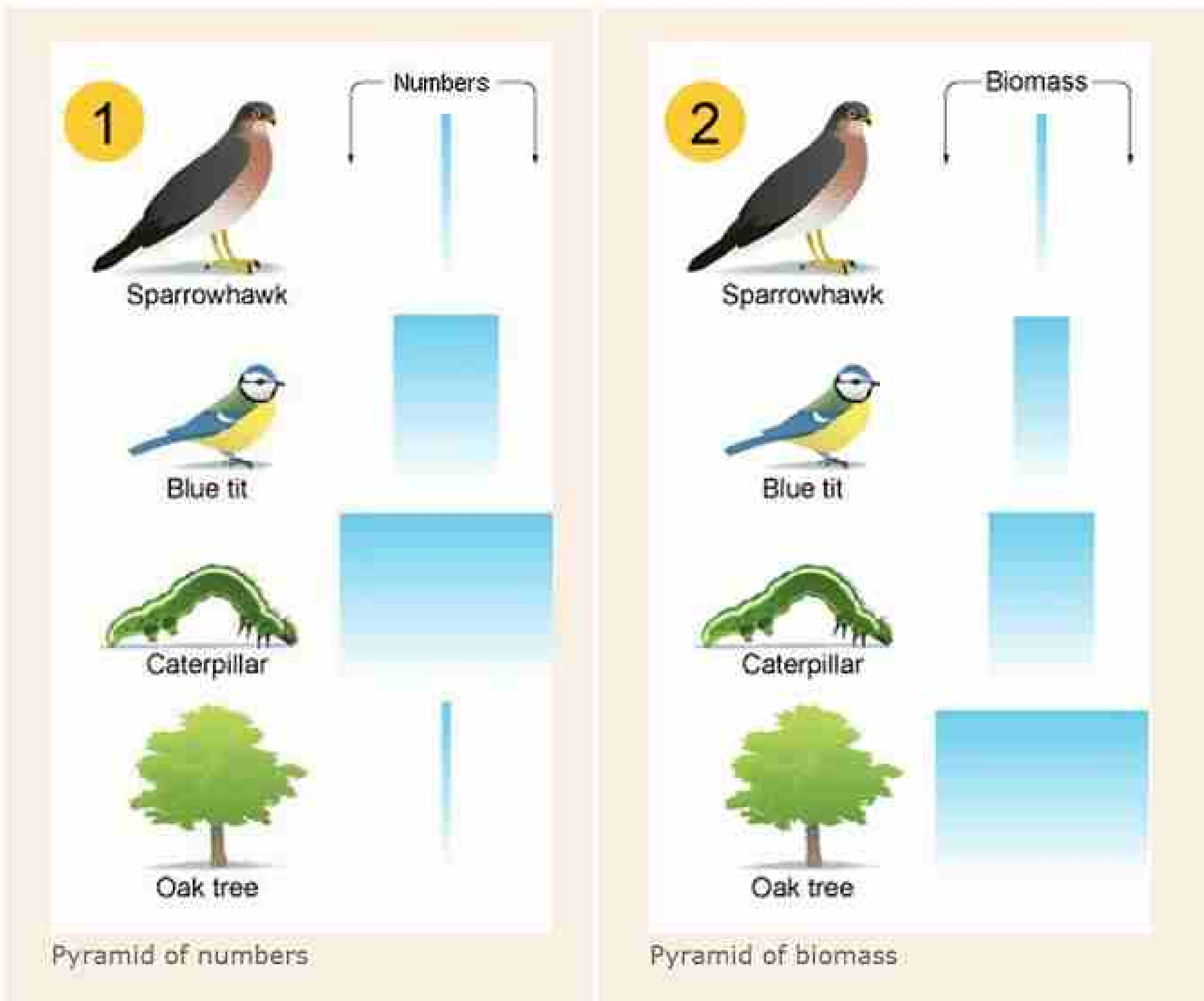


2. Pyramids of biomass

Sometimes a pyramid of numbers is not the best way to represent a food chain. In this case a pyramid of **biomass** (the dry mass of an organism) is a better diagram to use. It shows the ***total mass of organisms at each stage of a food chain.***

In general, all producers have a higher biomass than the primary consumer, so a pyramid will always be produced.

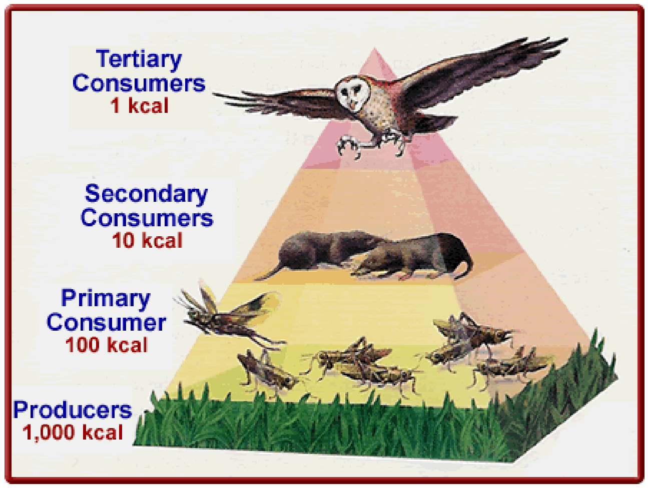
The total energy (and biomass) present at a lower tier of the pyramid, must be greater than the higher tiers in order to support the energy requirements of the subsequent organisms.



Pyramid of numbers and pyramid of biomass

3. Pyramids of energy

Pyramid of energy shows *amount of* ***energy*** trapped per unit ***time*** and ***area*** at each ***stage*** of a ***food chain.***

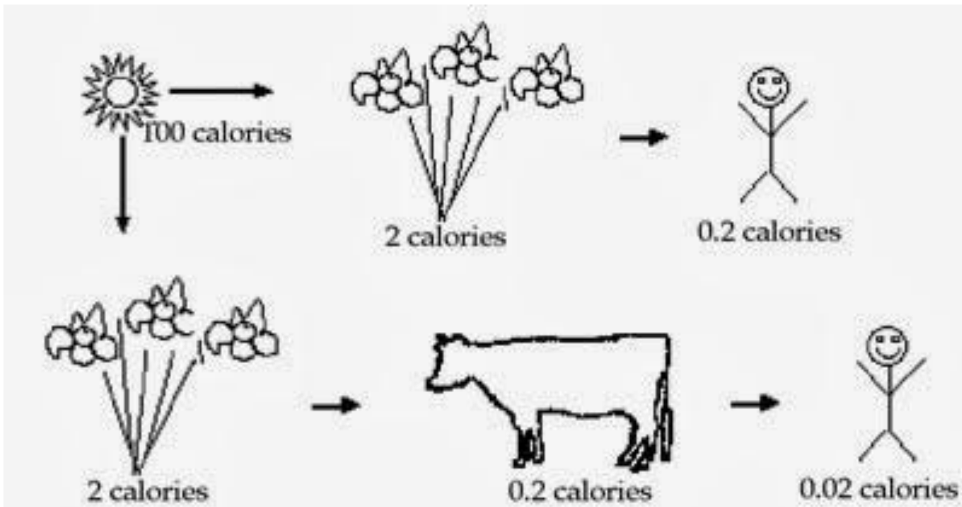


A normal-shaped pyramid is always produced because there is a reduced amount of energy at each successive level.

** Most of information in this post is taken from* **BBCBitesize**

#142 Food chain and energy efficiency

In term of conversations of energy, there is an increased efficiency in supplying green plants as human food and a relative inefficiency in feeding crop plants to animals.

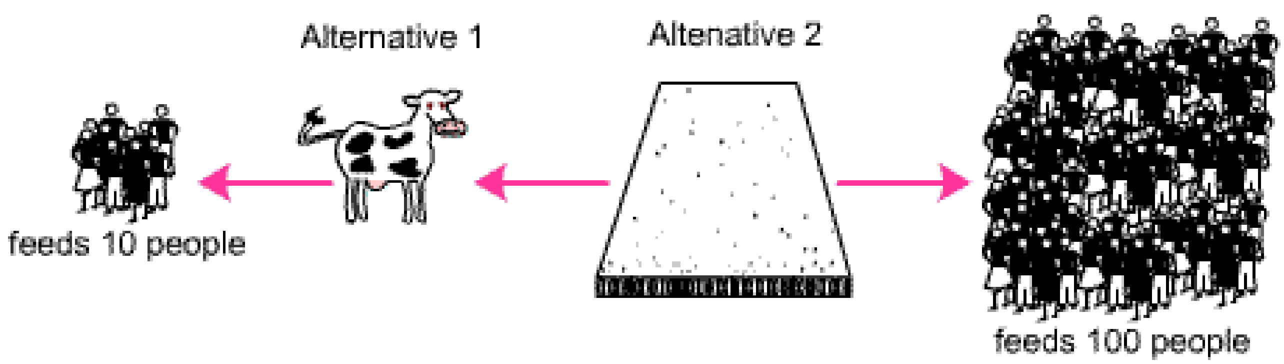


Short food chains are more efficient than long ones in providing energy to the top consumer. Below are two food chains and energy values for each level in them. Both food chains have a human being as the top consumer.

	maize →	cow →	human
unit of energy	100	10	1

	maize →	human
unit of energy	100	10

Ten times more energy is available to the human in the second food chain than in the first. In the second food chain, the human is a herbivore (vegetarian). But eating parts of a cow provide humans with other nutrients, as well as those we gain energy from – it would be very difficult to persuade everyone to become vegetarian for the sake of energy efficiency.

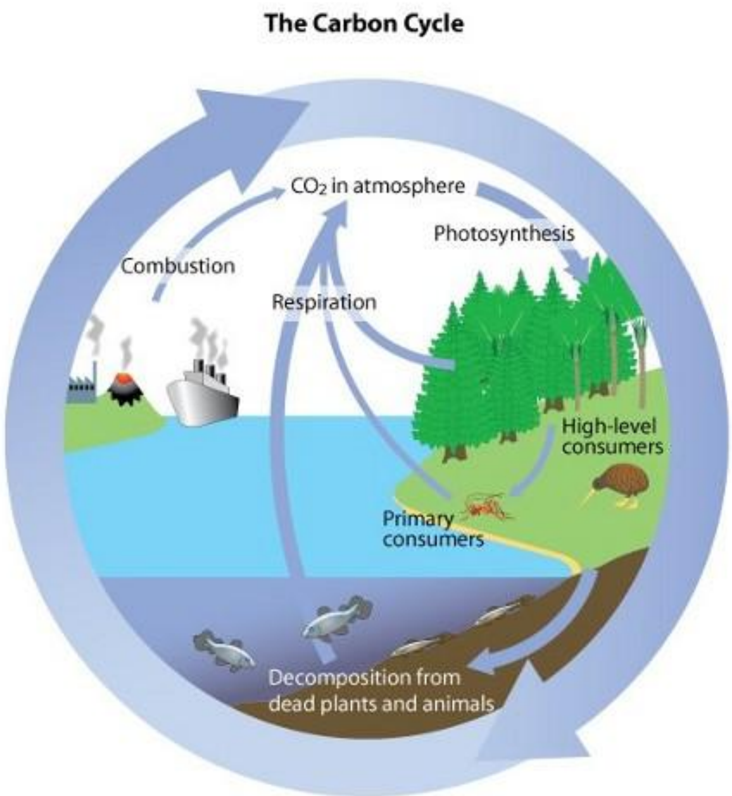


Some farmers try to maximize meat production by reducing movement of their animals (keeping them in pens or cages with a food supply) and keeping them warm in winter. This means less stored energy is wasted by the animals.

Why food chains usually have fewer than 5 trophic levels?

As the energy is passed along the chain, each organism uses some of it. So the further along the chain you go, the less energy there is. The loose of energy along the food chain limits the length of it. There rarely more than 5 links in a chain, because there is not enough energy left to supply the next link. Many food chains only have 3 links.

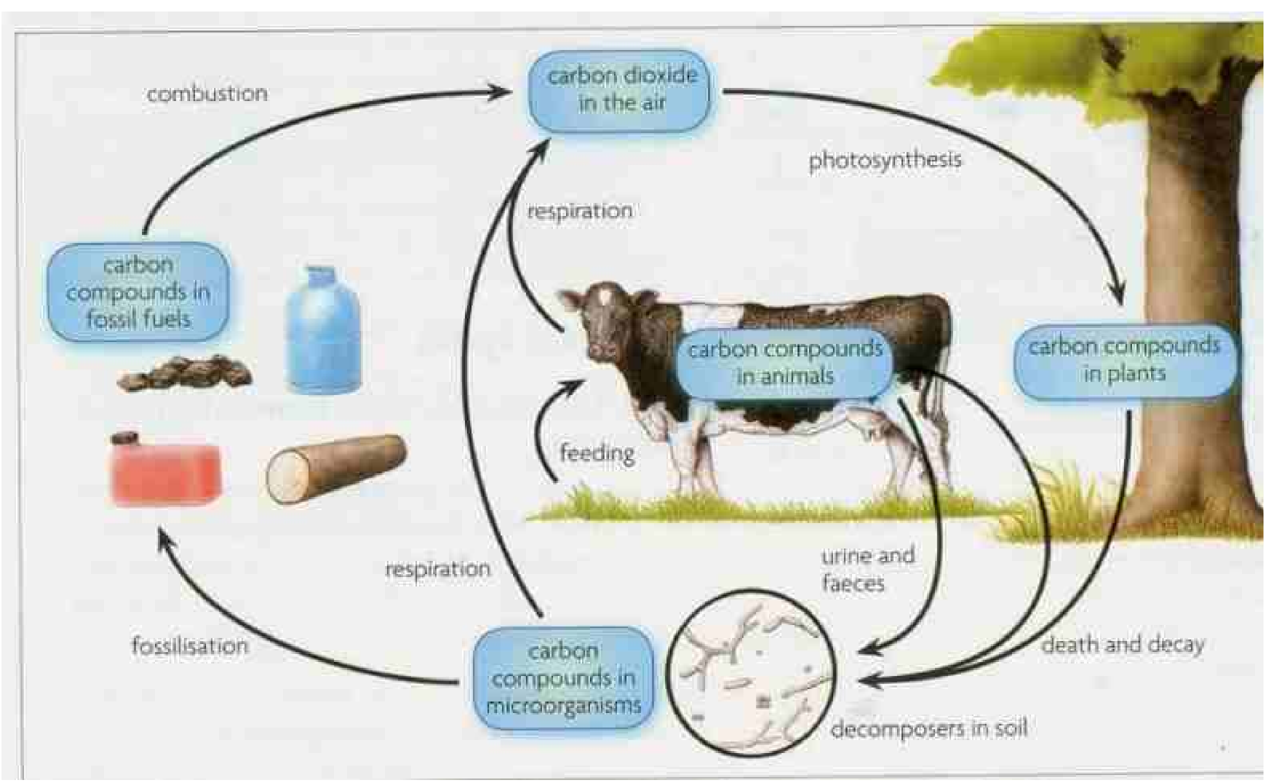
#143 Nutrient cycles - Carbon and water cycles



Most of the chemicals that make up living tissue contain **carbon**. When organisms die the carbon is **recycled** so that it can be used by future generations.

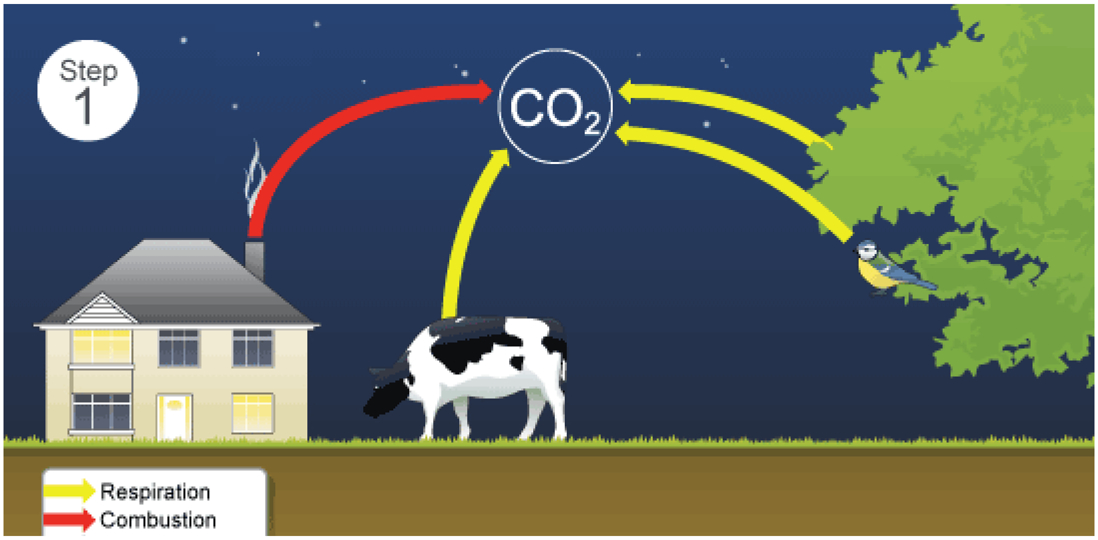
Four main processes are involved:
photosynthesis,
respiration,
decomposition
combustion.

A. Carbon cycle



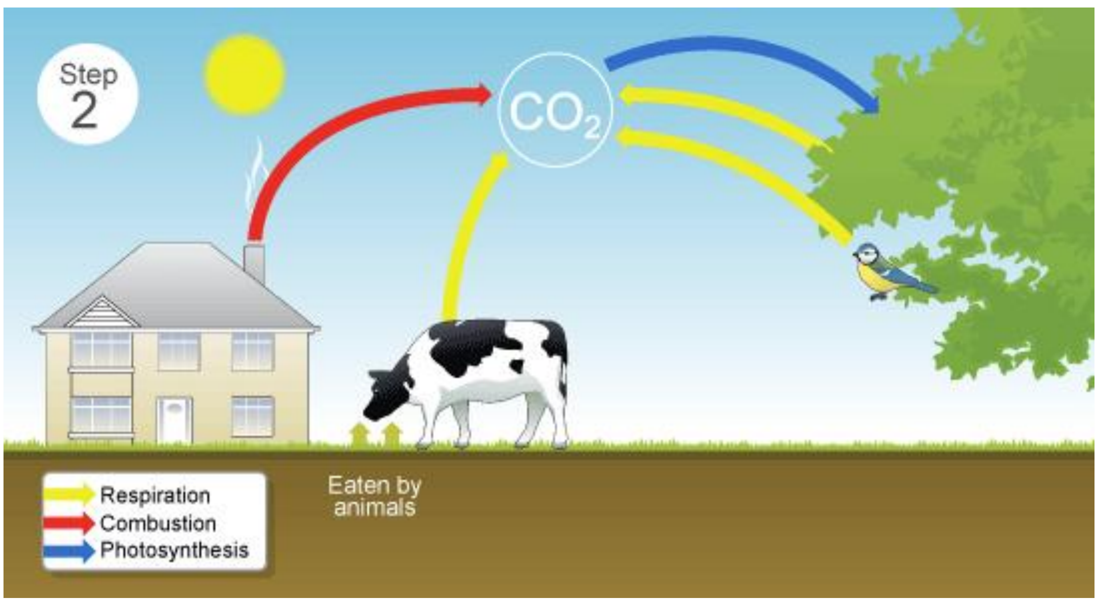
Carbon cycle

1. Carbon enters the atmosphere as **CO_2** from **respiration** and **combustion**.

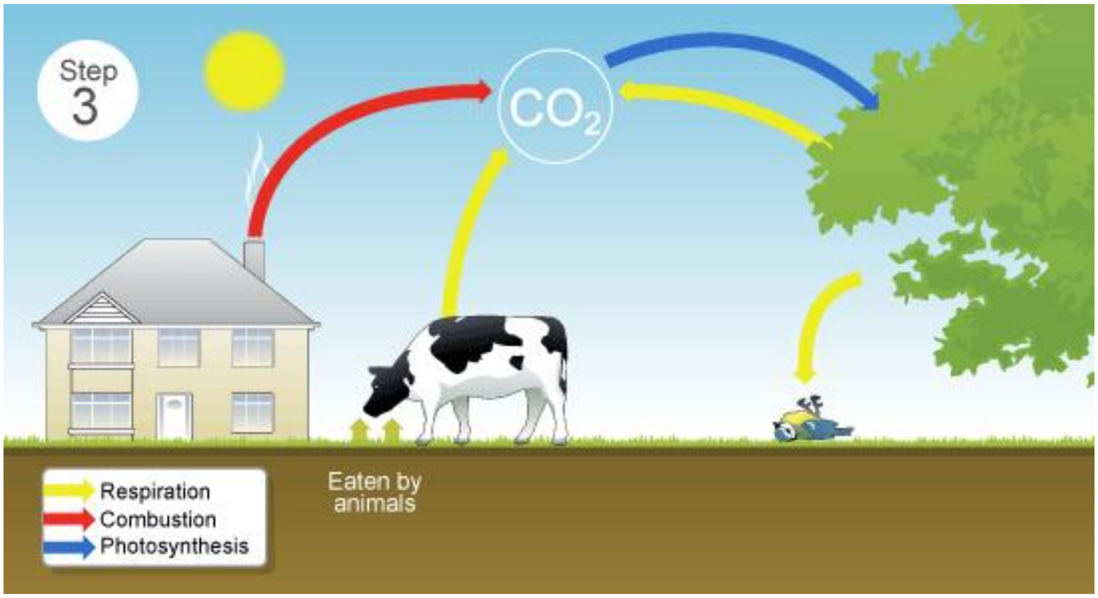


Credit: BBC Bitesize

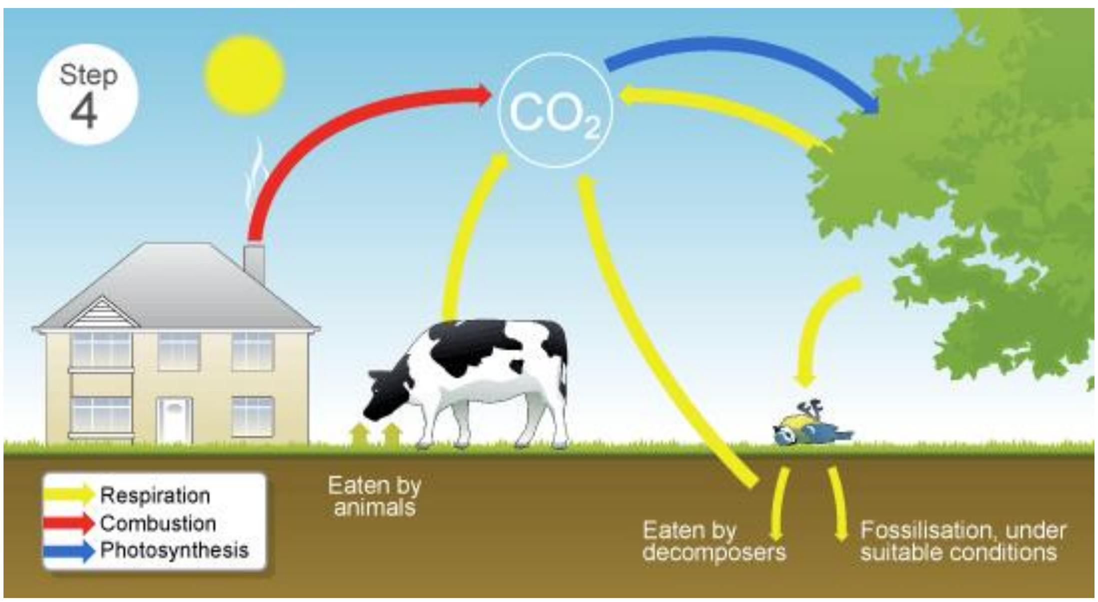
2. **CO_2** is absorbed by producers to make **carbohydrates** in **photosynthesis**.



3. **Animals** feed on the plant passing the carbon compounds along the food chain. Most of the carbon they consume is exhaled as **CO_2** formed during respiration. The animals and plants eventually **die**.



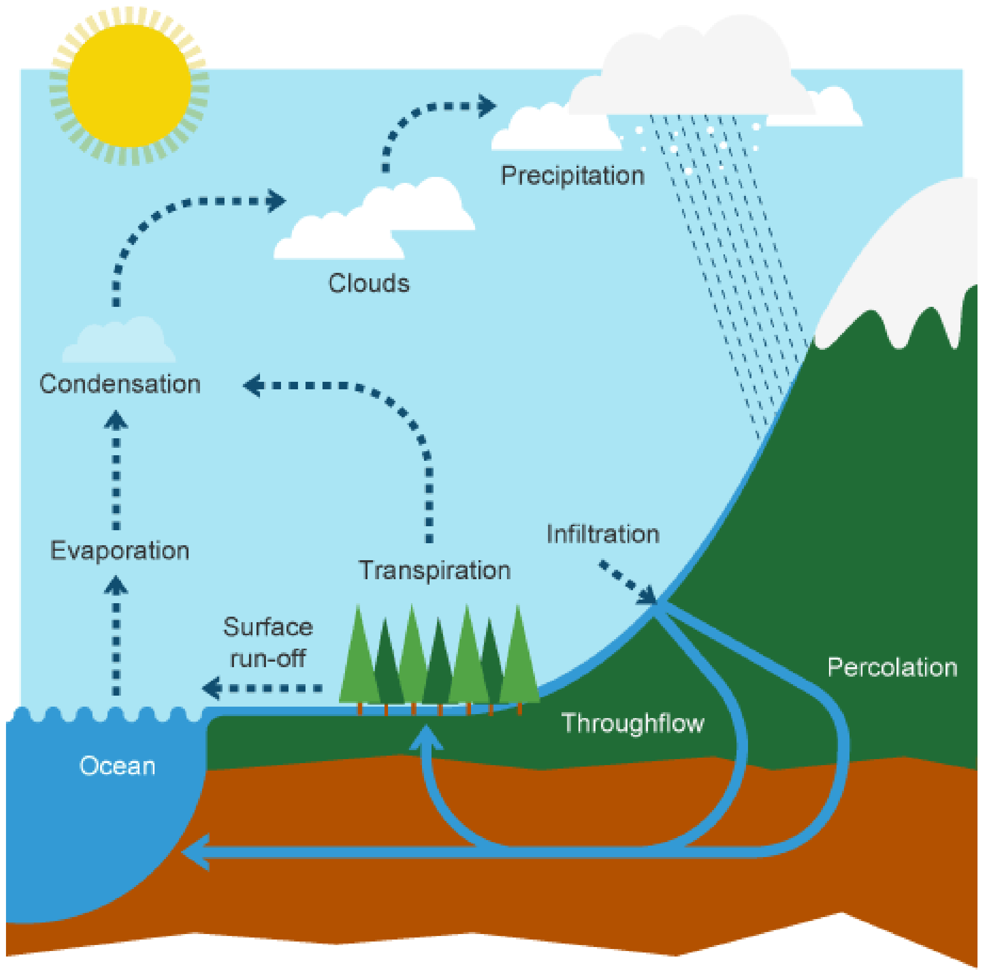
4. The dead organisms are eaten by **decomposers** and the carbon in their bodies is returned to the atmosphere as **CO_2**. In some conditions **decomposition** is blocked. The plant and animal material may then be available as **fossil fuel** in the future for combustion.



Common misconception

Plants do not start respiring when they stop photosynthesizing (at night) – they respire all the time, but during the day there is usually a net intake of CO_2 ant out put of O_2.

B. Water cycle

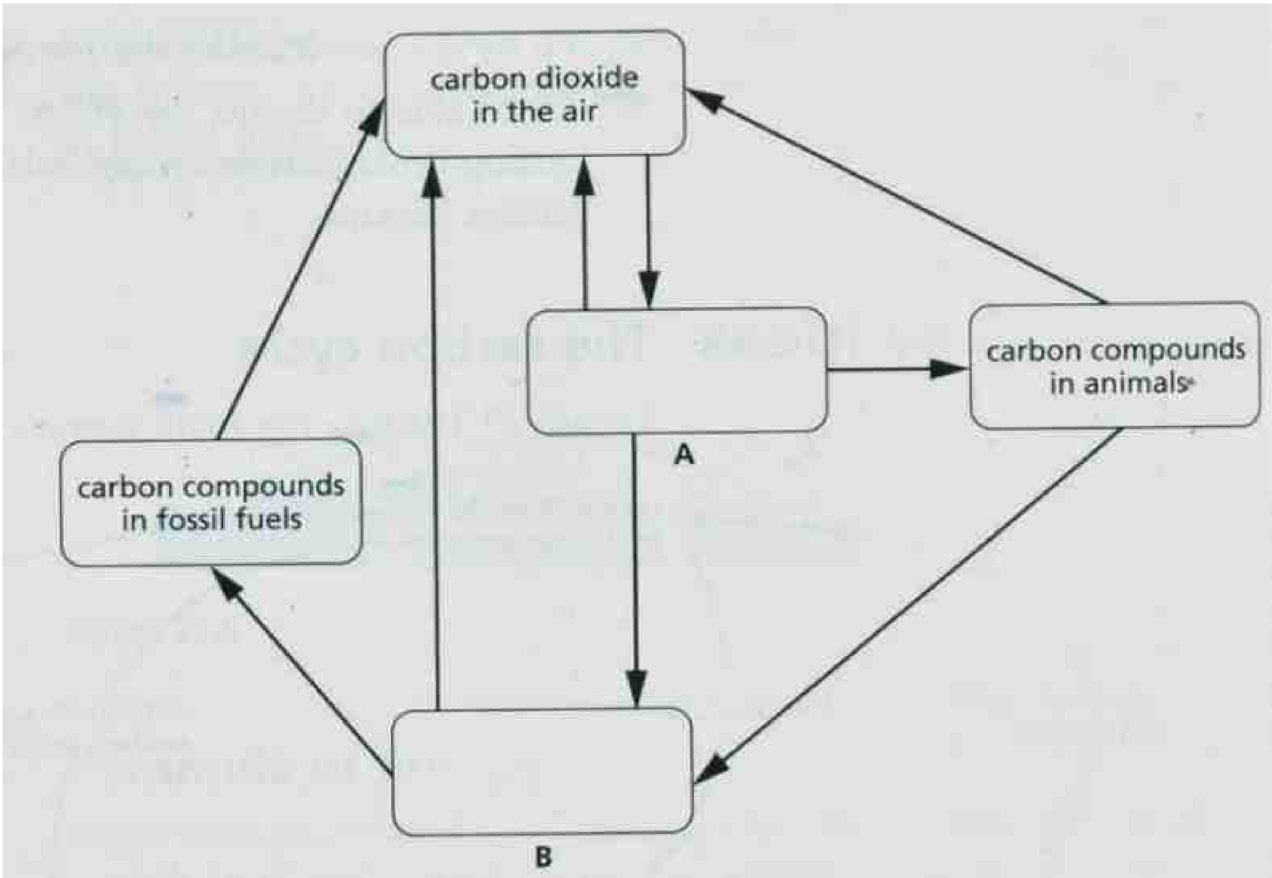


Water cycle (credit: BBC Bitesize)

- Energy from the Sun heats the surface of the Earth.
- Plants release water vapour into the air through **transpiration**.
- Water **evaporates** from oceans, rivers, lakes and soil.
- The warm, moist air rises because it is less **dense**.
- Water vapour **condenses** into water droplets as it cools down, forming clouds.
- Water droplets get bigger and heavier they begin to fall as rain, snow and sleet (**precipitation),** draining into streams, rivers, lakes and sea.
- Plant root take up water by **osmosis**.
- In addition, animals lose water to the environment through exhaling and sweating, and in urine and faeces.

Try this

Figure below shows a diagram of the carbon cycle.



a) Copy and complete the cycle by filling in boxes **A** and **B**. [2 marks]

b) On your diagram, label with the letter indicated an arrow that represents the process of:

i) combustion – **C** [1 mark]
ii) decomposition – **D** [1 mark]
iii) photosynthesis – **P** [1 mark]
iv) respiration – **R** [1 mark]

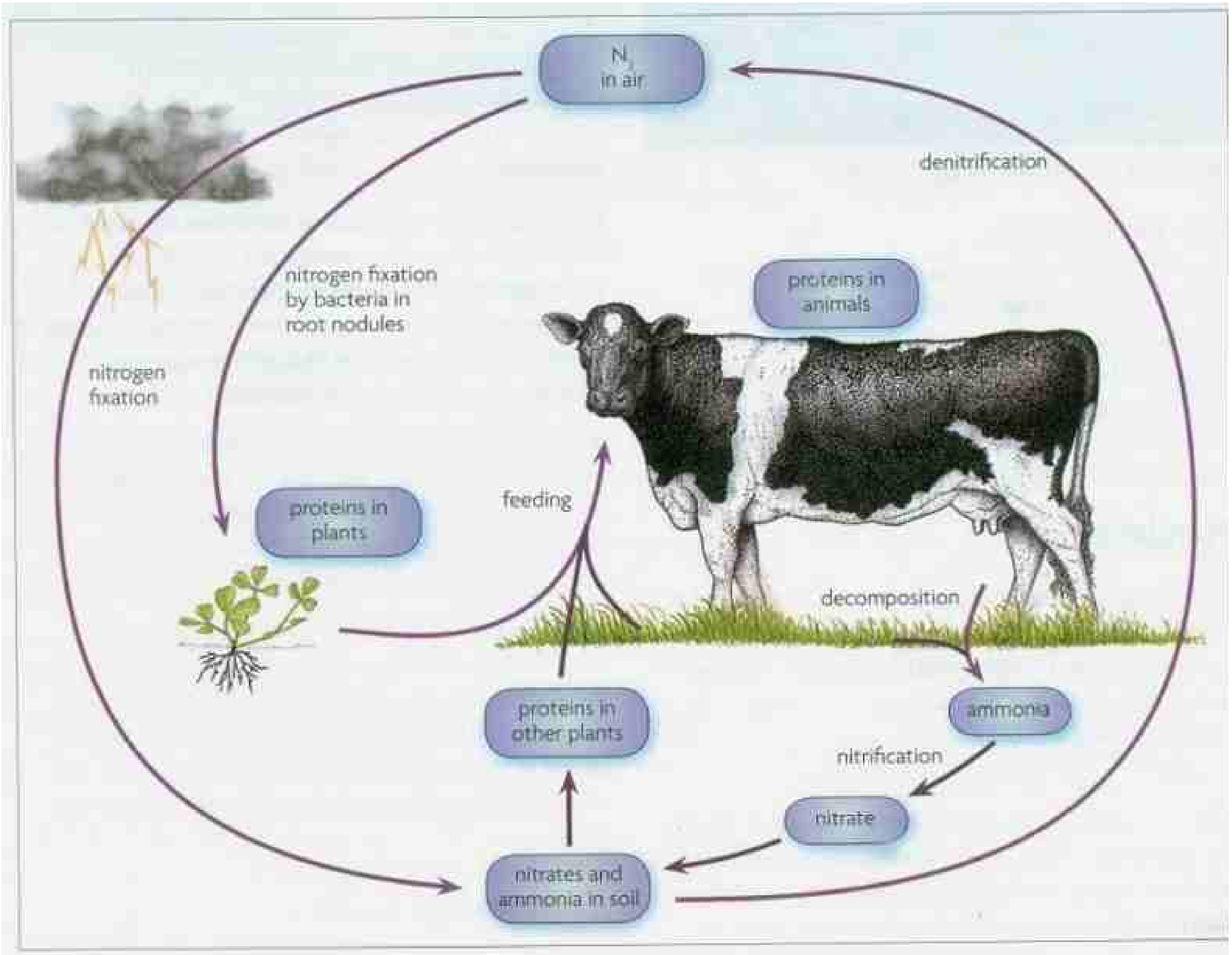
Answer

a) **A,** carbon compounds in plants.
B, carbon compounds in dead plants and animals.

b) i) **C** on arrow between fossil duels and CO_2 in the air.
ii) **D** on arrow between box B and CO_2 in the air.
iii) **P** on arrow between CO_2 in the air and box A.
iv) **R** on arrow between carbon compounds in animals (or box A) and CO_2 in the air.

#144 Nitrogen cycle

Nitrogen is essential for the formation of amino acids to make **proteins**. The **nitrogen cycle** describes the ways in which nitrogen is recycled.



Nitrogen cycle

The element nitrogen is a very unreactive gas. Plants are not able to change it into nitrogen compounds, but it is needed to form proteins. Nitrogen compounds become available for plants in the **soil** in a number of ways, including:

- **nitrogen-fixing bacteria** (some plants – legumes such as peas, beans and clover – have roots with nodules that contain these bacteria, so the plant receives a direct source of nitrates)
- breakdown of dead plants and animals by **decomposers** (bacteria, fungi and invertebrates)
- the addition of **artificial fertilizers**, **compost** (decaying plant material) and **manure** (decaying animal waste – urine and faeces)
- **lightning** – its energy causes nitrogen to react with oxygen.

Plants absorb nitrates into their roots by active uptake. The nitrates are combined with glucose (from photosynthesis) to form **protein**. Proteins are passed through the food chain as animals eat the plants. When animals digest proteins the amino acids released can be reorganized to form different proteins.

Some soil bacteria - **denitrifying bacteria**- break down nitrogen compounds and release nitrogen back into the atmosphere. This is a destructive process, commonly occurring in **waterlogged soil**. Farmers try to keep soil well drained to prevent this happening – a shortage of nitrates in the soil stunts the growth of crop plants.

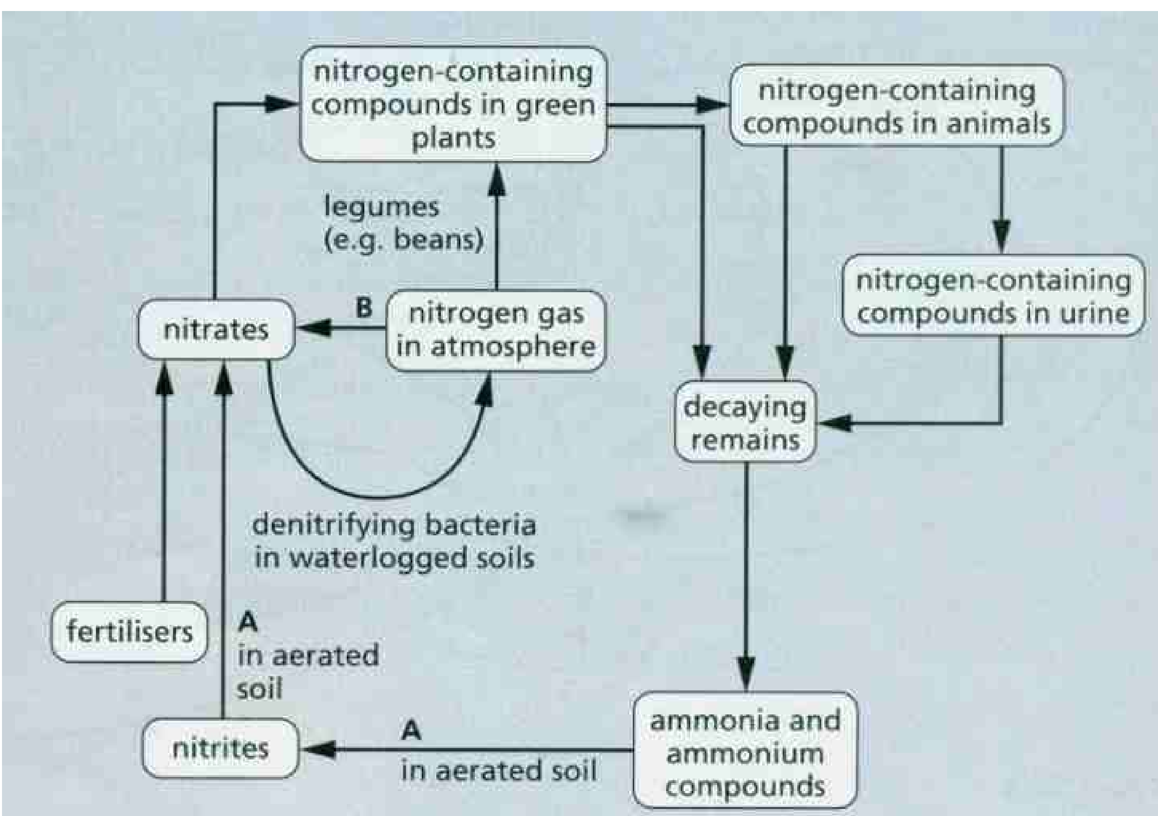
Nitrates and other ammonium compounds are very **soluble**, so they are easy leaches out of the soil and can cause pollution.

Farmer can increase the fertility (nitrogen compound concentration) of their soil by:

- adding artificial fertilisers
- adding manure or compost
- growing leguminous plants, then digging the roots (with their nodules) into the soil.

Try this

The figure below shows the nitrogen cycle.



1. i) Name the main nitrogen-containing compound found both in plants and in animals. [1 mark]

ii) Name one nitrogen-containing compound that is present in urine. [1 mark]

iii) Name the type of organism that causes the changes at A. [1 mark]

iv) What atmospheric conditions bring about the change at B? [1 mark]

2. Using the figure, explain why it is an advantage to have good drainage in most agricultural land. [4 marks]

Answer

1. i) Proteins (or amino acids)

ii) Urea or ammonia or uric acid.

iii) Bacteria

iv) Lightning or electrical storms.

2. Four points from:

- aerated soils allow the activity of useful bacteria
- to convert ammonium compounds in to nitrites
- and to convert nitrites into nitrates
- nitrates can be absorbed by plants
- to allow growth or formation of protein
- waterlogged soils encourage denitrifying bacteria
- which break down nitrates into nitrogen
- so there would be a shortage of nitrates for plants to absorb
- leading to poor growth.

#145 Effects of combustion of fossil fuels on CO2 level

Photosynthesis takes CO_2 out of the atmosphere and replaces it with O_2. **Respiration** and **combustion** both do the opposite: they use up O_2 and replace it with CO_2.

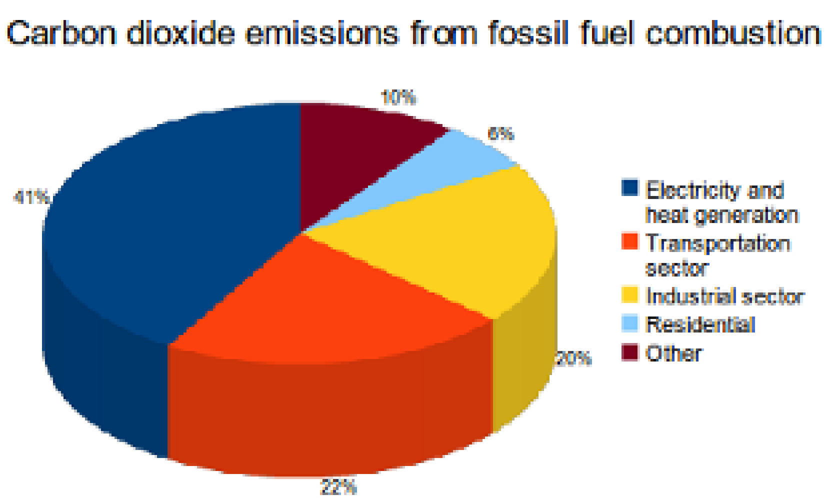
The equations are essentially the same, but reversed:

$$\mathbf{CO_2 + H_2O} \underset{\text{respiration, combustion}}{\overset{\text{photosynthesis}}{\rightleftharpoons}} \mathbf{glucose + O2}$$

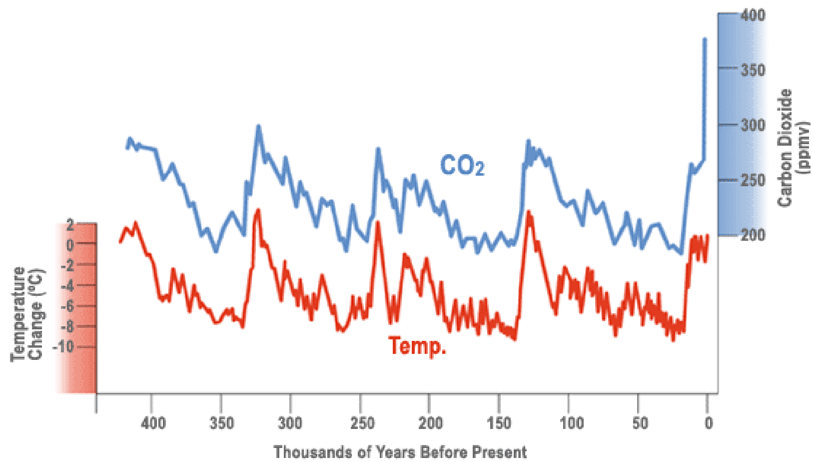
In order for the amount of CO2 in the atmosphere to remain stable, the rates of these processes need to be balanced.

Processes that change the equilibrium (balance) include:

- cutting down forests (deforestation) – less photosynthesis
- combustion of fossil fuel (coal, oil and gas)
- increasing numbers of animals (including humans) – they all respire.



An increase in CO_2 levels in the atmosphere is thought to contribute to global warming.

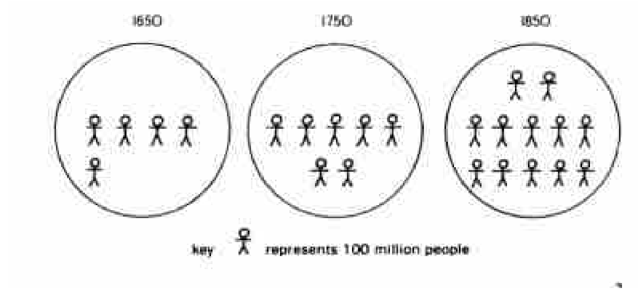


CO_2 forms a layer in the atmosphere, which traps heat radiation from the Sun. This causes a gradual increase in the atmospheric temperature which can:

- melt polar ice caps, causing flooding of low-lying land
- change weather conditions in some countries, increasing flooding or reducing rainfall and changing arable (farm) land to desert
- cause the extinction of some species that cannot survive at higher temperatures.

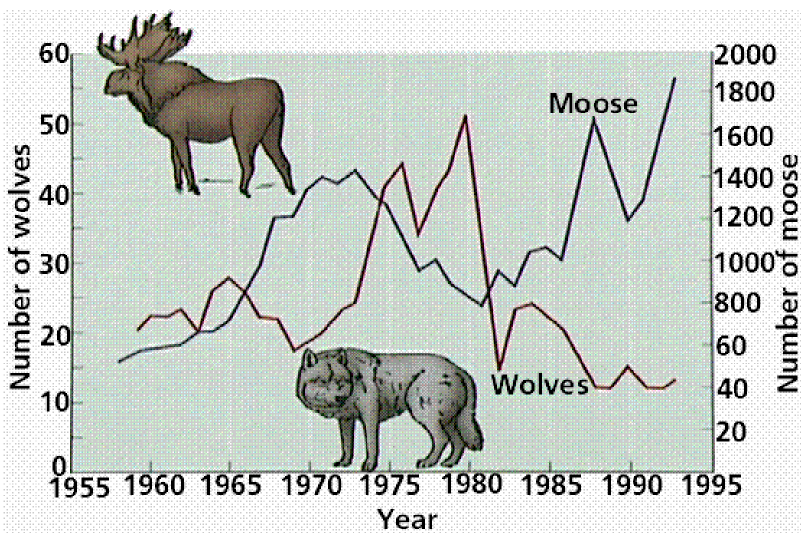
#146 Population size, factors affecting the rate of growth

A **population** is a group of organisms of one species, living in the same area at the same time. Factors affecting the rate of population growth include **food supply, predation** and **disease.**



1. The rate of growth of a population depends on:

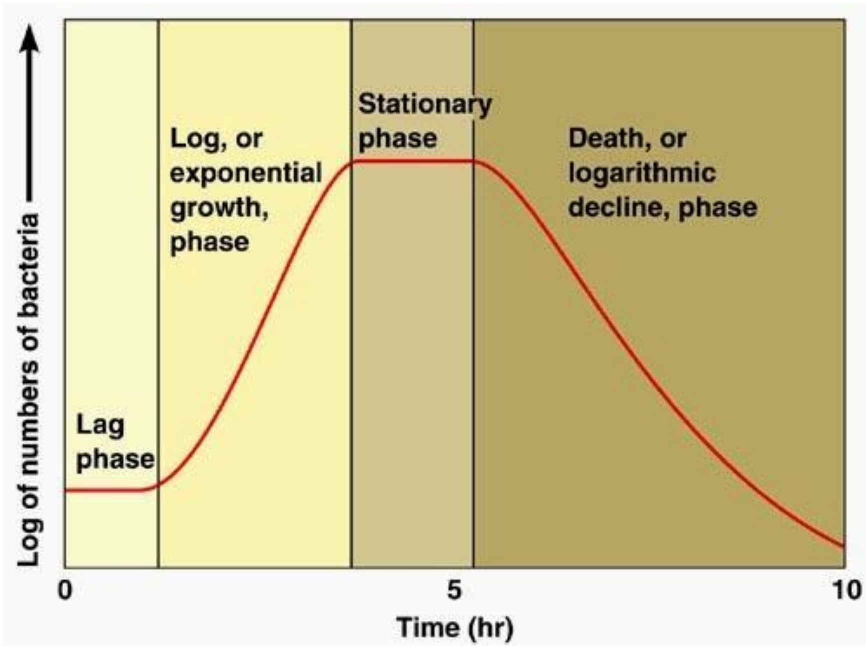
- **Food supply** – abundant food will enable organisms to breed more successfully to produce more offspring; shortage of food can result in death or force emigration, reducing the population.
- **Predation**- if there is heavy predation of a population, the breeding rate may not be sufficient to produce enough organisms to replace those eaten, so the population will drop in numbers. There tends to be a time lag in population size change for predators and their pray: as predator numbers increase, prey number drops; and as predator numbers drop, prey numbers rise again (unless there are other limiting factors).



- **Disease** – this is a particular problem in large populations, because disease can spread easily from one individual to another. Epidemics can reduce population sizes very rapidly.
- Use of **contraceptives** (for humans).

2. Population growth in an environment with limited resources

When a limiting factor influences population growth, a sigmoid (S-shaped) curve is created. You need to be able to place the terms **lag, log, stationary** and **death phase** on a graph of population growth.



Lag phase – the new population takes time to settle and mature before breeding begins. When this happens, a doubling of small numbers does not have a big impact on the total populations size, so the line of the graph rises only slowly with time.

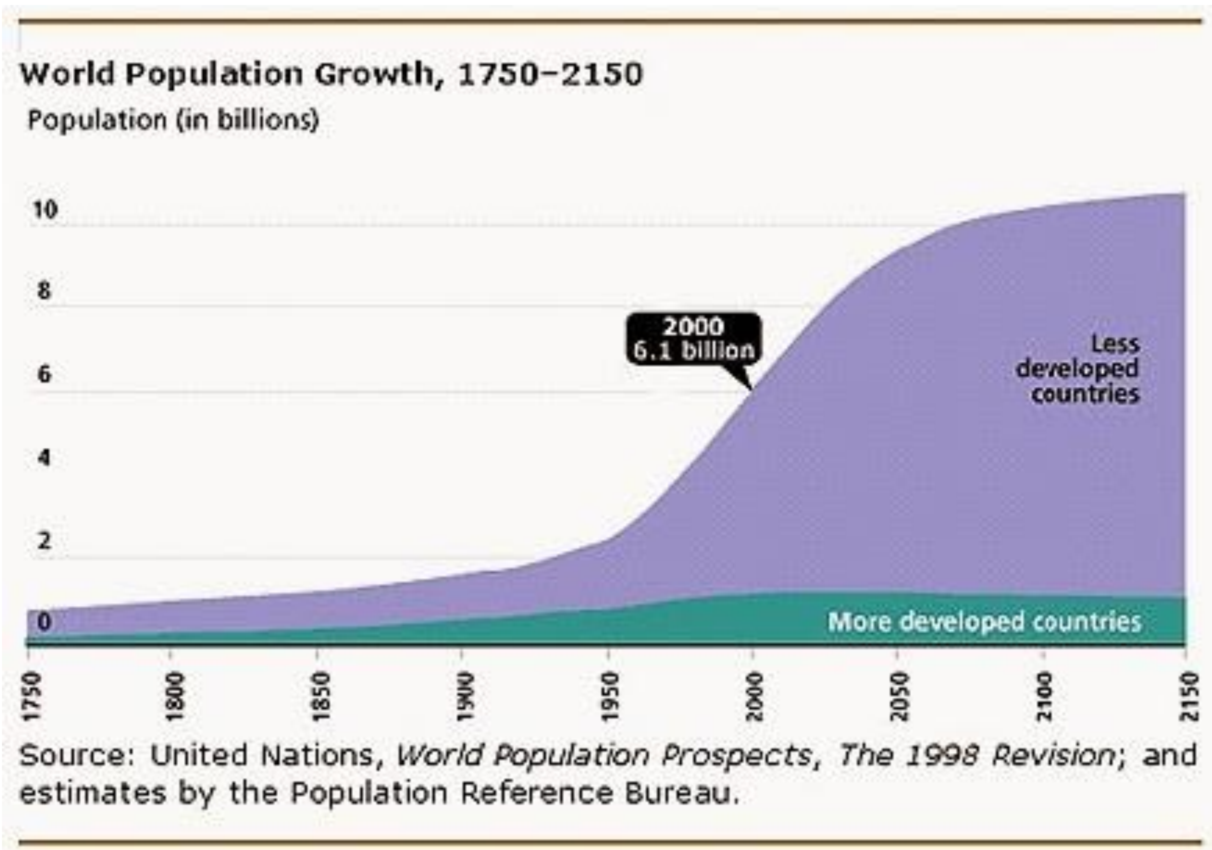
Log (exponential) phase – there are no limiting factors. Rapid breeding in an increasing population causes a significant in numbers. A steady doubling in numbers per unit of time produces a straight line.

Stationary phase – limiting factors, such as shortage of food, cause the rate of reproduction to slow down and there are more deaths in the population. When the birth rate and death rate are equal, the line of the graph becomes horizontal.

Death phase - as food runs out, more organisms die than are born, so the number in the population drops.

3. Population growth in the absence of limiting factors

If there is no limiting factors , there will be **no stationary or death phase** – the log phase will continue upwards, instead of the line leveling off. This has happened with human population growth. Human population size has increased exponentially because of improvements on food supply and the development of medicine to control diseases. Infant mortality has decreased, while lifer expectancy has increased.



Population growth in developed and developing countries.

Such a **rapid increase in population size** has **social implications**:

- increase demand for basic resources (food, water, space, medical care, fossil fuels).
- increase pressures on the environment (more land needed for housing, growing crops, road buildings, more wood for fuel and housing) and more pollution.
- larger population of young people --> greater demands on education.
- more old people --> greater demands on healthcare.

Abundant food supplies can leads to more people becoming obese --> greater demands on healthcare (heart disease, diabetes, blindness…). In the long term ---> reduce average life expectant, as poor health becomes a limiting factor.

147 Summary of Ecosystem

- **Energy** enters ecosystems in sunlight. **Producers** (photosynthetic plants) capture some of this energy and transfer it to organic substances such as carbohydrates. **Consumers** (animals and fungi) gets their energy by eating producers or other consumers.

- **Food chains** and **food webs** show how energy flows through an ecosystem. The level at which an organism feeds in a food chain is its trophic level.

- Energy is lost as it passed along food chains.

- The **energy losses** in food chains limit the length of the chain, so few food chains have more than five trophic levels.

- It would be more energy-efficient for humans to harvest and eat plant crops, rather than feeding the crops to animals and then eating those.

- **Pyramids of numbers** and pyramids of **biomass** are ways of showing the relative numbers or biomass at different trophic level in a food chain.

- The **carbon cycle** shows how CO_2 from the air is used in **photosynthesis** to make organic compounds in plants, which are then eaten by animals. **Decomposers** obtain their carbon by feeding on dead plants or animals, or on their waist materials. **Respiration** by all organisms returns CO_2 to the air.

- **Nitrogen** gas is very inert, and must be fixed (to produce ammonium ions or nitrate ions) before it can be used by living organisms. Some plants have **nitrogen-fixing bacteria** in their roots, and other nitrogen-fixing bacteria live freely in the soil. Plants absorb ammonium or nitrate ions and use them to make proteins, which can then be eaten by animals. Decomposers and **nitrifying bacteria** convert proteins to ammonia and nitrates, which can be re-used by plants. Denitrifying bacteria convert nitrates to nitrogen gas which is returned to the air.

- The **size of a population** of organisms is affected by environmental factors such as food **supply**, **predation** and **disease**.

- When a resource is in **limited** supply, the growth of a population often shows a **lag** phase, **exponential** phase, **stationary** phase and **death** phase.

- Age pyramids show the structure of a population at one moment in time, and can be used to predict how the population is likely to change in the future. The global **human population** is increasing, but there is hope that by the end of this century the growth will have slowed significantly.

15 Human and Ecosystem

#148 The human influences on the ecosystem

- Increasing use of **pesticides**, **fertilizers** and **herbicides** à ↑ levels of nutrients in the soil, kill insect pests, kill weeds à ↑ crop yields.

- Use of modern **machinery** (tractors, combined harvesters) à manage land and crop more efficiently.

- **Artificial selection** to produce varieties of plants suited to particular climates and soil types, and breeds of animal for specific purposes (optimum meat, milk, wool production).

- Use of **yeast** and **bacteria** in the large-scale production of breads, beer and wine, yoghurt and cheese. Single-cell protein and fungi are used to produce meat substitutes.

- Use of **medicines** such as antibiotics, hormones and artificial insemination techniques in intensive **animal rearing**.

- Use of **plant hormones** in plant growing and fruit production.

- Use of **genetic engineering** and **cloning** techniques to produce organisms to produce hormones…

- Development of systems to water plants in **greenhouses** automatically and to grow plants in nutrient solutions (hydroponics).

- Use of **satellites** to monitor crop development, observe crop diseases and assess the need for additional fertilizer.

- Development of intensive farming and automated feeding mechanisms.

149 Undesirable effects of deforestation

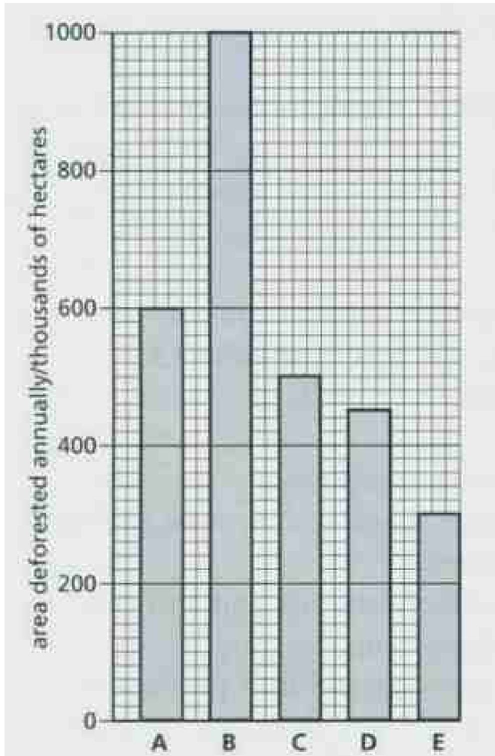
Deforestation is the removal of large areas of forest to provide **land** for farming and roads, and to provide **timber** (wood) for building, furniture and fuel. Deforestation has a number of **undesirable effects** on the environment.

Deforestation:

- Reduction of habitats or food sources for animals, which can result in their **extinction.** Animal and plant diversity is reduced, and food chains are disrupted.
- **Loss of plant species** and their genes which may be important for medical use or genetic engineering in the future.
- Removal of trees means there are no roots to hold soil, which can result in **soil erosion** and leaching of minerals. Desertification can eventually occur.
- Lack of roots and soil à **flooding** and mudslides. Lakes can become silted up.
- Leaching of nutrients into lakes and rivers à eutrophication.
- Less CO_2 is absorbed from the atmosphere, more CO_2 build up à increase the **greenhouse effect**.
- Less O_2 is produced à atmospheric O_2 level can drop.
- Less transpiration à reduced rainfall.

Try this

Figure below show the area of tropical rainforest deforested annually in five different countries, labeled **A** to **E**.



1. i) Which of the countries shown has the largest area deforested annually? [1 mark]

ii) Which of the countries shown has 600 000 hectares of rainforest removed each year? [1 mark]

iii) In another country, **F**, 550 000 hectares are deforested annually. Plot this on a copy of the figure. [1 mark]

2. i) Country **E** has a total of 9 000 000 hectares of tropical rainforest remaining. How long will it be before it is all destroyed, if the present rate of deforestation continues? [1 mark]

ii) Stat 2 reasons why tropical rainforests are being destroyed by humans. [2 marks]

iii) After deforestation has taken place, soil erosion often occurs rapidly. Suggest 2 ways in which this may occur. [2 marks]

3. Tropical rainforests reduce the amount of CO_2 and increase the amount of O_2 in the atmosphere. Explain why both these occurrences are important to living organisms. [2 marks]

Answer

1. i) **B**

ii) **A**

iii) Column for **F** drawn to 550. Column shaded in the same way as the others, and labeled. Column drawn an equal width and distance from the others.

2. i) 30 years

ii) **2** reasons from:

- to clear land for agriculture, housing, industry or roads.
- to collect timber for housing
- to collect timber for fuel.

iii) **2** suggestions from:

- plants have gone so there are no roots to bind the soil.
- wind blows soil away
- rain washes soil away.

3. Increased CO_2 can lead to global warming, or flooding, or desertification.
O_2: organisms need O_2 for respiration to release energy.

#150 Overuse of fertilisers, water pollution by sewage

It is very tempting for farmers to increase the amount of fertilisers applied to crops to try and increase crop yields. However, this can lead to the **eutrophication** of **rivers** and **lakes** and the sequence occurs.

1. Overuse of fertilisers

- fertilisers (very soluble) are easily leached out of the soil
- fertilisers are washed into a water system (river or lake)
- **algae** absorb fertiliser and grow rapidly (algal bloom)
- algae form a blanket on the surface of the water, blocking light from algae below
- algae die without light
- bacteria decompose dead algae, using up O_2 in the water for respiration
- animals in water die through lack of O_2.

Fishermen row a boat in a algae-filled lake in China.
Credit: Totallycoolpix.com

A second effect of overuse of fertilisers can be the **death** of the **plants**. High concentrations of the fertilizer around plant roots can cause the roots to lose water by osmosis. The plant then wilts and dies.

2. Sewage

Sewage can result in eutrophication in a similar way to overuse of fertilisers. This is because sewage contains high levels of nutrients such as phosphates, organic matter and bacteria. The **phosphates** act as fertilisers for algae, while the **bacteria** feed on the **organic matter** and reproduce rapidly, using up O_2 in respiration.

If sewage is untreated before disposal it can lead to **disease organisms** such as cholera and typhoid being transmitted in the water.

3. Chemical waste

Chemical waste such as **heavy metal** (mercury, nickel…) and **oil** can cause serious pollution. Some chemicals may be dumped (or enter water systems through leaching) in low concentrations, at which levels they are not toxics. However, bioaccumulation occurs if they enter a food chain. **Plankton** absorb the chemical and has no mechanism for excreting it. Animals such as small **fish,** feeding on large number of plankton, build up the chemical because, again, they have no means of excreting it.

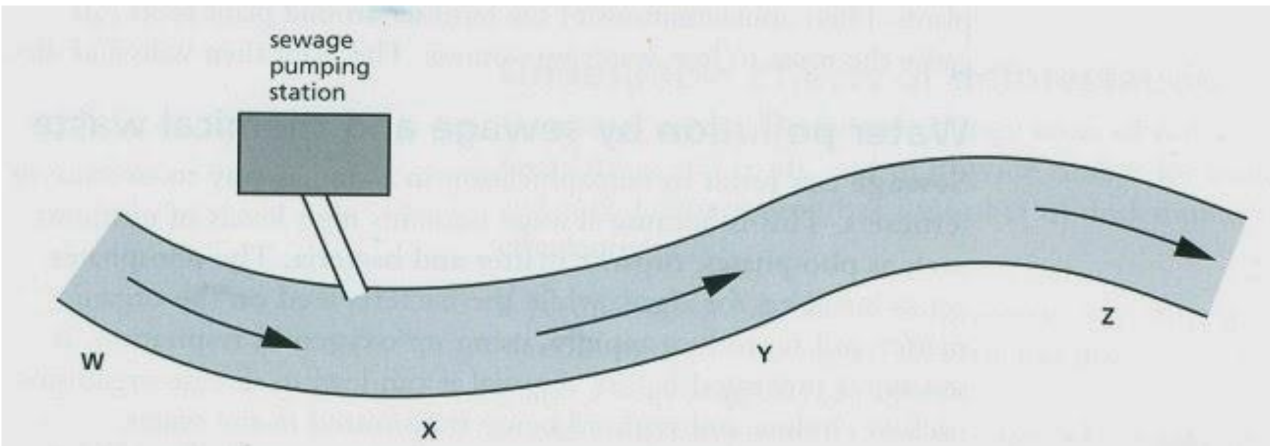
Animals, including **humans**, at the top of the food chain, eat many fish and accumulate high concentration of the chemical, which is now **toxic**. Poisons such as **mercury** damage the central nervous system and can lead to death.

Seabirds are severely affected by oil spills.

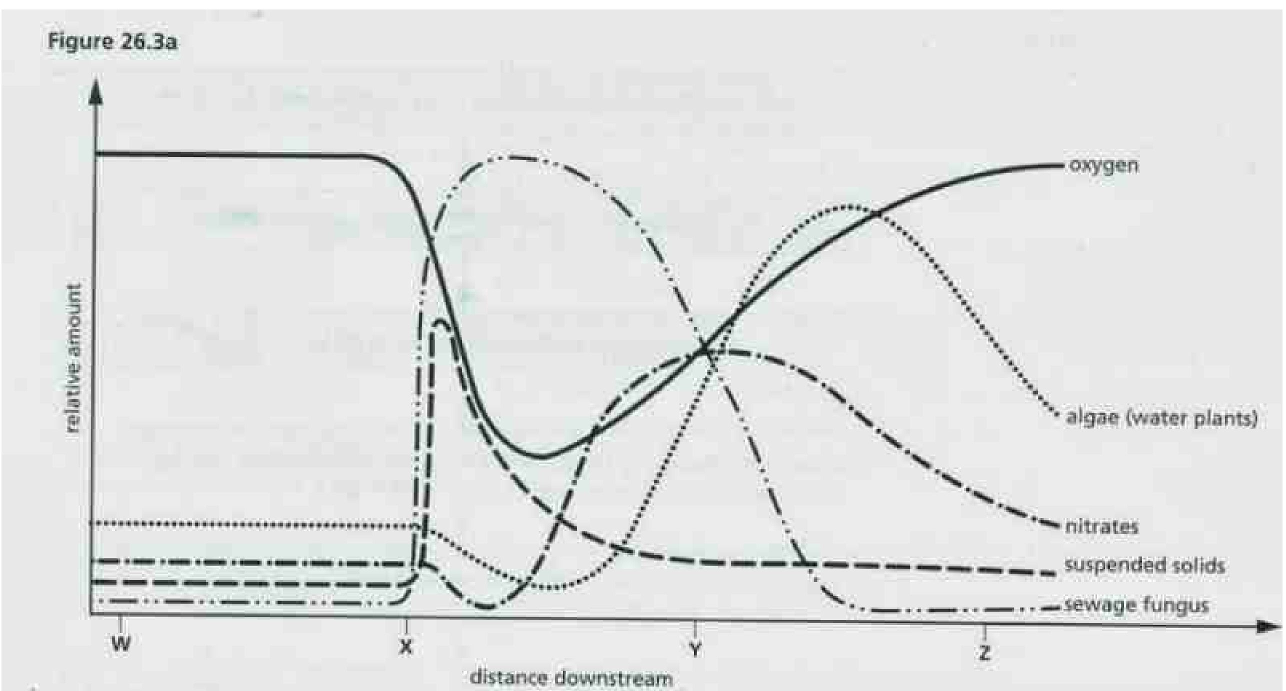
When **oil** is dumped into water it can form a surface layer, coating animals such as birds that feed in the water. When the birds try to clean their feathers they swallow the oil, which poisons them. Oil also disrupts food chains.

Try this

Figure below shows part of a river into which sewage is pumped. The river water flows form **W** to **Z**, with the sewage being added at **X**.



Some of the effects of adding sewage to the river are shown in picture below.



Try this

1. Describe the changes in the levels from **W** to **Z** of:

i) nitrates [2 marks]
ii) suspended solid [2 marks]

2. Suggest why the level of O2:

i) drops at **X** [1 mark]
ii) increase again toward **Z** [1 mark]

3. Suggest 2 reasons why levels of algae drop:
i) when sewage is added to the river [2 marks]
ii) towards **Z** [2 marks]

4. A farm at **Z** used herbicides on the field next to the river. Suggest why this could cause further problems in the river. [1 mark]

Answer

1. **i)** Constant level between W and X, or starts off quite low, or at point X it start to drop then increases toward Y before dropping again toward Z.

ii) Level starts off quite low, then at point X it increases sharply; level returns nearly to original level between Y and Z.

2. **i) One** suggestion from:
- aerobic respiration by sewage fungus
- lack of algae to produce O_2

ii) One suggestion from:
- lack of sewage fungus
- photosynthesis by alge.

3. **i) Two** suggestions from:
- presence of suspended solids blocks ligh for algae
- lack of nitrate in the water
- possible presence of toxins in sewage
- possible increase in temperature or unsuitable temperature.

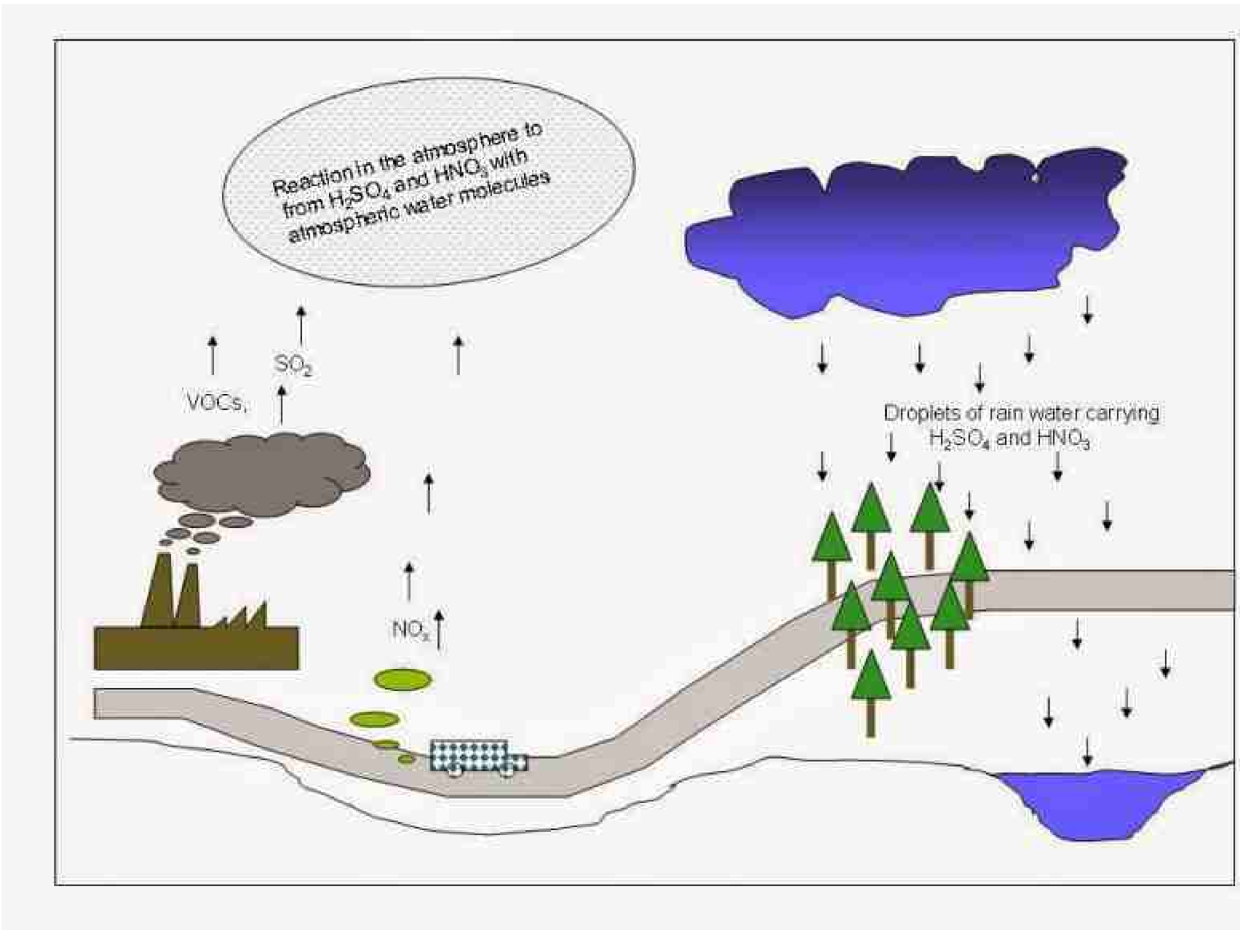
ii) Two suggestions from:
- shortage of nitrates
- grazing by aquatic herbivores
- possible drop in temperature , or unsuitable temperature.

4. **One** suggestion from:
- herbicides could leach into river and kill algae
- herbicides will kill algae and disrupt food chain
- herbicides may be toxic to other organisms in the river.

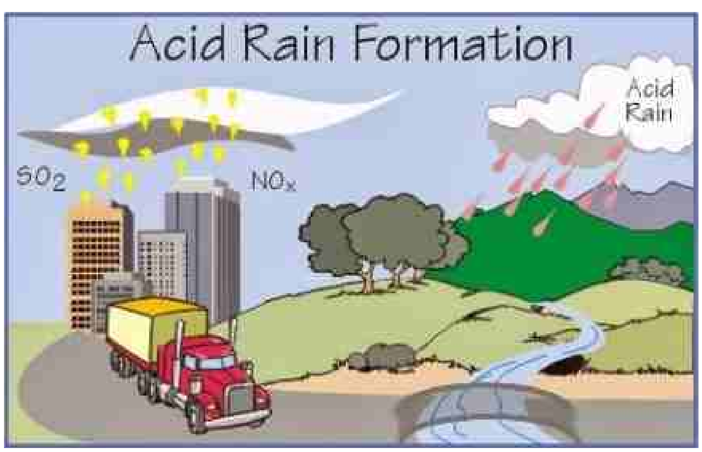
#151 Air pollution by sulfur dioxide (SO2), acid rain

SO_2 released into the air when **coal** and **oil** are **burned**. Power stations burn large amounts of these fossil fuels. SO_2 dissolves in the water vapour in clouds, forming **sulphuric acid** (H_2SO_4). When it rains, the **rain** is **acidic**.

The **combustion** of petrol in car engines also contributes to acid rain, but this is mainly due to the production of oxides of nitrogen in the exhaust fumes, rather than SO_2.



Acid rain



The main causes of acid rain are process that release **SO_2** and **oxides of nitrogen** into the atmosphere. These include:

- burning of **fossil fuels**, such as coal and gas, by power stations
- combustion of petrol in **car engines**.

Problems caused by acid rain include:

- **Damage** to **plant leaves**, eventually killing the plants. Whole forests of pine trees have been destroyed by acid rain.

Plant leaves damaged by acid rain.

- **Acidification of lakes**: as the water become more acidic, some animals such as fish cannot survive and fish stocks are destroyed.
- Increased risk of **asthma attacks** and bronchitis in humans.
- **Corrosion** of stonework on buildings.
- Release into soil of soluble **aluminium ions** that are toxic to fish when washed into lakes.

Ways of **reducing the incidence** of acid rain:

- changing the types of power stations that generate electricity from coal and oil to **gas** or **nuclear power**, or using more renewable energy sources such as wind
- using **'scrubbers'** in power station chimneys – these remove most of the **SO_2** present in the waste gases
- using catalytic **converters** in car exhausts – these convert oxides of nitrogen to harmless nitrogen.

Common misconceptions

*Remember that car engines do **not** make large amount of SO_2 – but they are responsible for producing large amount of oxides of nitrogen, CO_2 and CO.*

Examiner's tip

When describing the effects of car exhaust fumes on the environment, don't make a list of the chemicals and then link them all to acid rain or global warming. Be specific:

- *oxides of nitrogen leas to acid rain;*
- *CO can reduce the ability of haemoglobin to carry O_2;*
- *CO_2 increases can lead to global warming.*

Try this

1. SO_2 is a major pollutant of the air. Which process is mainly responsible for the release of SO_2 into the air? [1 mark]

2. SO_2 is one of the gases which contributes to acid rain. Acid rain can affect trees and their surrounding soil in a variety of ways. Figure below shows where these effects can occur.

Suggest how each of the following affects the tree and explain how it can lead to its death.

i) Damage of the leaves [2 marks]
ii) Damage of the fine roots [2 marks]
iii) Death of the soil microorganisms [2 marks]

Answer

1. Combustion of fossil fuels.

2. **i)** The leaves are unable to photosynthesise, so it cannot make food.

ii) One suggestion and explanation from:

- the roots are unable to absorb water, so cells will become flaccid, or the tree will wilt, or transport of materials will not happen

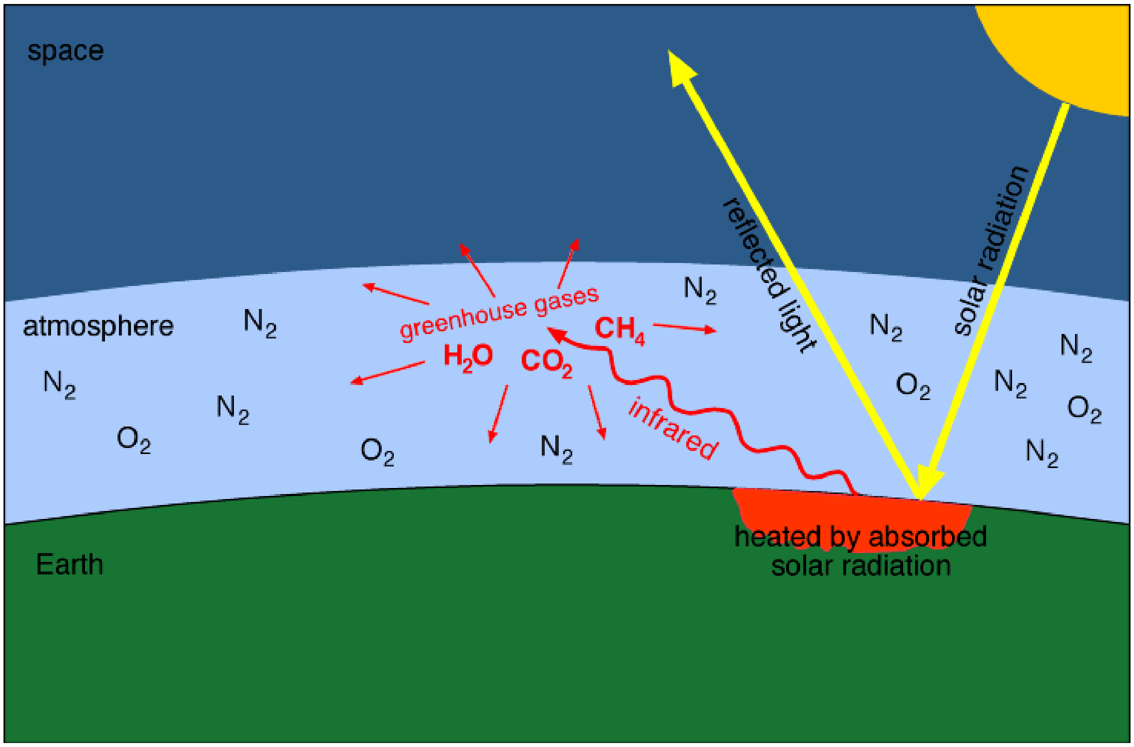
- the roots are unable to absorb mineral salts which are needed, e.g. for formation of chlorophyll, or for growth.

iii) One suggestion and explanation from:

- less decomposition will occur, so there will be less minerals available to the plant, e.g. magnesium ions for formation of chlorophyll.

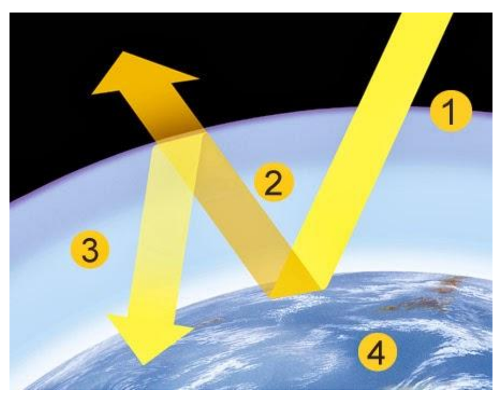
- there will be no nitrogen-fixing bacteria, so there will be less nitrates for the roots to take up, which are needed for protein formation.

#152 Greenhouse gases and global warming



Some gases in the Earth's atmosphere stop heat radiating into space from the Earth. This is called the **greenhouse effect** and the gases involved are called greenhouse gases. They include: **methane**, **CO_2** and **water vapour.** An increased greenhouse effect can lead to global warming and climate change.

The diagram shows how the greenhouse effect works.



1. Electromagnetic radiation at most wavelengths from the Sun passes through the Earth's atmosphere.

2. The Earth absorbs electromagnetic radiation with short wavelengths and so warms up. Heat is radiated from the Earth as longer wavelength infrared radiation.

3. Some of this infrared radiation is absorbed by greenhouse gases in the atmosphere.

4. The atmosphere warms up.

Source: [BBC Bytesize]

#153 Pesticides, herbicides, nuclear fallout and non-biodegradable plastics

Some **pesticides** are **non-biodegradable** and stay in the environment for a long time. For example, **DDT** has been a very effective insecticide, used to kill mosquitoes to reduce the spread of malaria. However, because it does not break down, it enters water systems such as lakes, where it is absorbed into plankton.

DDT spraying.

They are unable to excrete DDT. In a similar way to heavy metal, it is passed up the **food chain** and bioaccumulation occurs: the top carnivores suffer from it toxicity. For example, when fish eagles are exposed to DDT passed through the food chain, they produce eggs with very thin shells. When the adult birds sit on the nest, the eggs break, so they are unable to produce offspring.

Some **insecticides** are **non-specific**: when applied to kill an insect pest, they also kill all the other insects that are exposed to it. This may include useful insects, such as bees that are needed to pollinate crops. Food webs can be affected, threatening the extinction of top carnivores such as birds of prey.

Herbicides are used to kill weeds in a crop, to reduce competition to increase crop yield. However, herbicides may also kill rare plants species near the field being sprayed.

Nuclear fallout can be the result of a leak from a nuclear power station, or from a nuclear explosion. **Radioactive particles** are carried by the wind or water and gradually settle in the environment. If the radiation has a long half-life, it remains in the environment and is absorbed by living organisms. The radio active material bioaccumulates in food chains and can cause **cancer** in top carnivores.

Effects of non-biodegradable plastics in the environment

Plastics that are **non-biodegradable** are not broken down by decomposers when dumped in landfill sites or left as litter. This means they remain in the environment, taking up valuable space or causing visual pollution. Discarded plastic bottles cant trap small animals; nylon fishing line and nets can trap birds and mammals such as seals and dolphins. When plastic is burned it can release toxic gases.

Plastic bottles can not be broken down by decomposers.

#154 Conservation of species, recycling sewage and paper

Koala is an endangered animal

Conservation is the process of looking after the natural environment. Conservation attempts to maintain or increase the range of different **species** living in an area, known as **biodiversity**.

The need for conservation of species

- Many species of animals and plants are in danger of extinction, due to factors such as habitat destruction, the introduction of other species, international trade and pollution.

- Loss of a species also means that its genes are lost: these may be important in the future for genetic engineering (e.g. to improve crops) and the production of useful chemicals such as medicines.

- The presence of rare species can be an important source of money for poor communities, through tourism.

- The species may play an important role in a food chain: its loss could endanger other species.

The need for conservation of habitats

- If habitat is lost, so are the species that live in them, so habitat destruction poses the greatest threat to the survival of species.

- A habitat maybe conserved by:

- using laws to protect the habitat
- using wardens to protect the habitat
- reducing or controlling public access to the habitat
- controlling factors, such as water drainage and grazing, that may otherwise contribute to destruction of the habitat

The need for conservation of natural resources

Some natural resources (the material we take from Earth) are not replaceable (renewable). For example, **fossil fuels** such as coal took millions of years to form. Increasing demands for energy are depleting these resources.

Ways of conserving natural resources:

- Increase the use of renewable energy (wind farms, solar power, hydroelectric power…).

- Improve the efficiency of energy use (better insulation, smaller car engines, more public transports…).

- Grow tree specifically for fuel, then replant as they are cut down --> the greenhouse effect is not increased, and habitats can be maintained when trees felling is carefully managed.

The principle of recycling sewage (water) and paper

Sewage is mainly water, contaminated with organic material, solids, bacteria and minerals such as phosphates. In places where water is in short supply, the sewage is treated to provide water that is clean enough to drink. Any treated effluent that is returned to water system such as a river will not cause problems such as eutrophication.

Treatment of sewage:

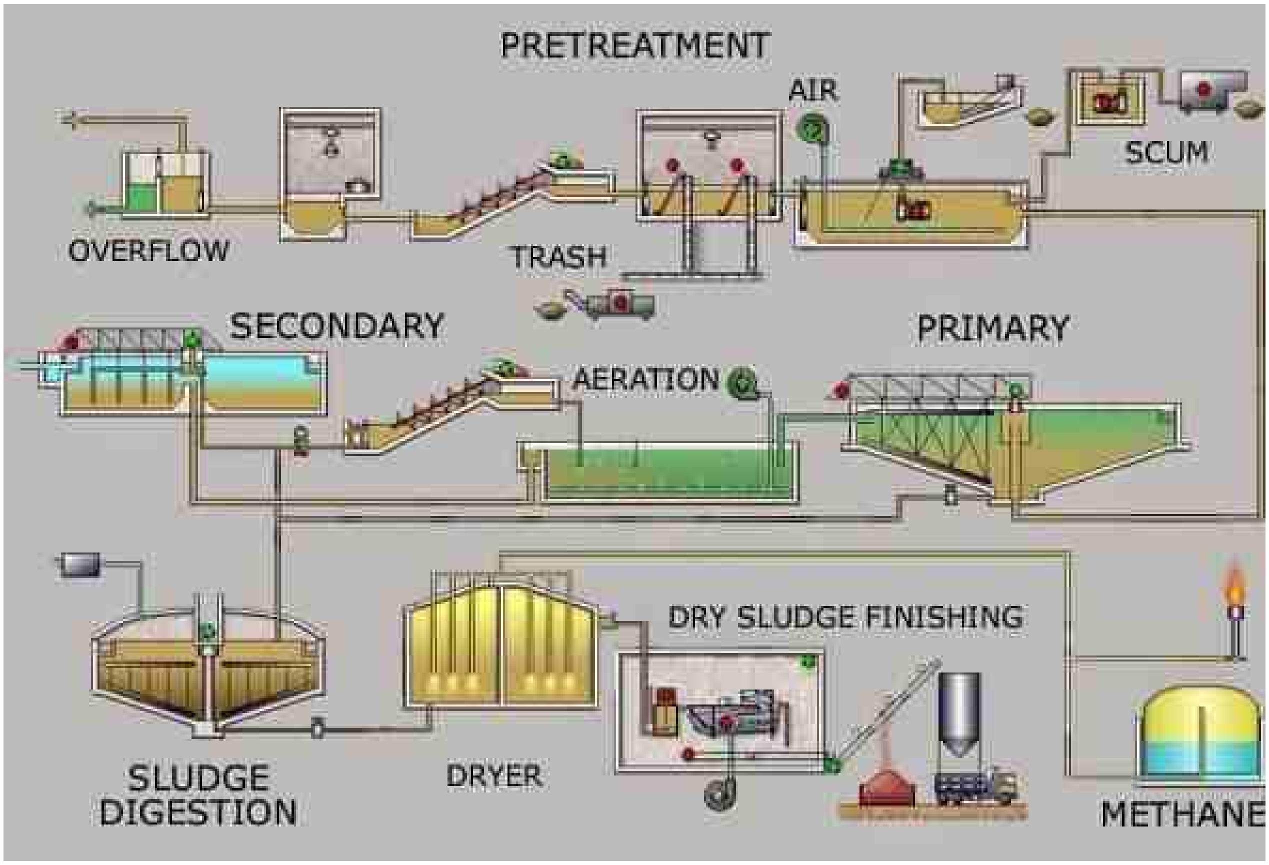
1. Large object such as sticks **screened** out of raw sewage.

2. Suspended grit allowed to settle out by gravity in **grit settling tank**.

3. Organic matter allowed to settle out by gravity in **sludge-settling tank** – after digestion in a **sludge digester**, sludge can be used as fertiliser on farmland – methane gas can also be generated for use as a fuel.

4. Remaining liquid sprinkled on to the top of an **aeration tank** containing stone – microorganisms (protoctists and aerobic bacteria) on surface of stones digest any remaining organic mater.

5. Water passing out may be **chlorinated** to kill any bacteria, so it is safe to drink.



Typical large-scale sewage treatment plant. Credit:Wikipedia.

Paper is made from wood (trees). If the paper is recycled after use, fewer trees need to be cut down. The used paper is turned into a pulp and any dyes such as printing ink are removed. The pulp is then rolled into sheets and dried to produce recycled paper that can be used for newspapers, toilet paper, hand towels…

155 Summary of Human and Ecosystem

- **CO_2** and **methane** are **greenhouse gases**, trapping outgoing long wavelength radiation in the atmosphere and warming the Earth. Increased concentrations of these gases are causing **global warming**.

- **SO_2** is produced when **coal** and other **fossil fuels** burn.

- **SO_2** and **nitrogen oxides** dissolves and react in water droplets in the atmosphere, and fall to the ground as **acid rain**. This leaches aluminum ions from soils, and kills plants and aquatic organisms.

- Fall-out from accidents at **nuclear reactions** emits ionising radiation, which damages DNA and can cause mutations, cancer and radiation burns.

- **Deforestation** reduces the amount of CO_2 that is taken out of the atmosphere for photosynthesis, and so may increase global warming. **Combustion** of the felled trees releases CO_2 into the atmosphere. Deforestation also destroys habitats for animals, possibly leading to their extinction. It increases soil erosion and flooding.

- **Water pollution** by fertilisers or raw sewage can cause eutrophication, in which large populations of aerobic bacteria form, reducing the amount of dissolved O_2 in the water and making it impossible for most animals to live there. Other chemical wastes, such as heavy metals, can also cause water pollution.