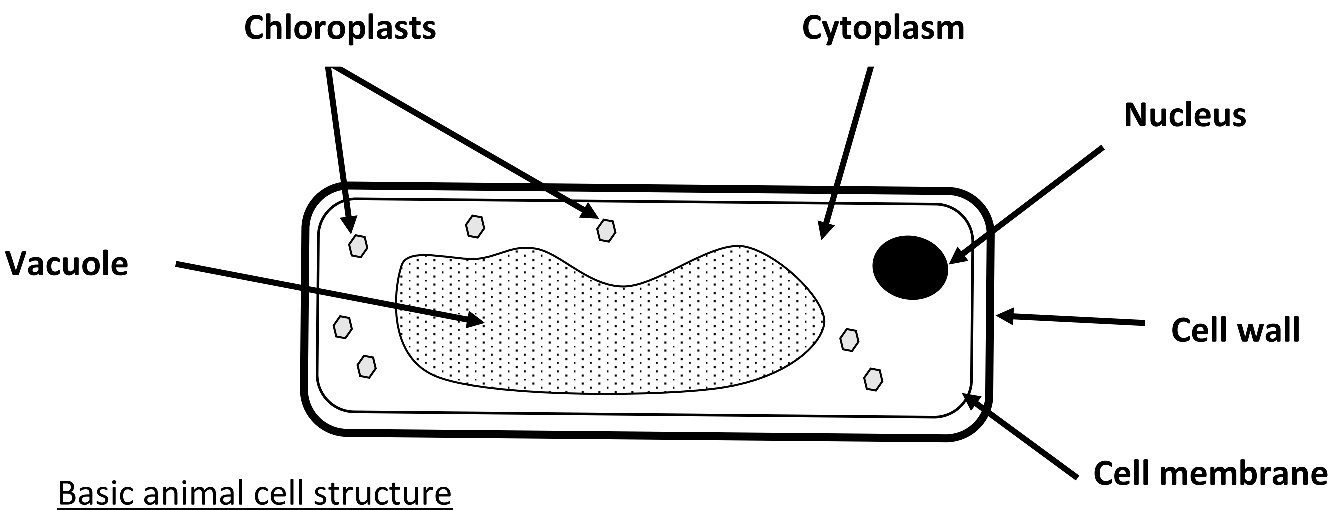
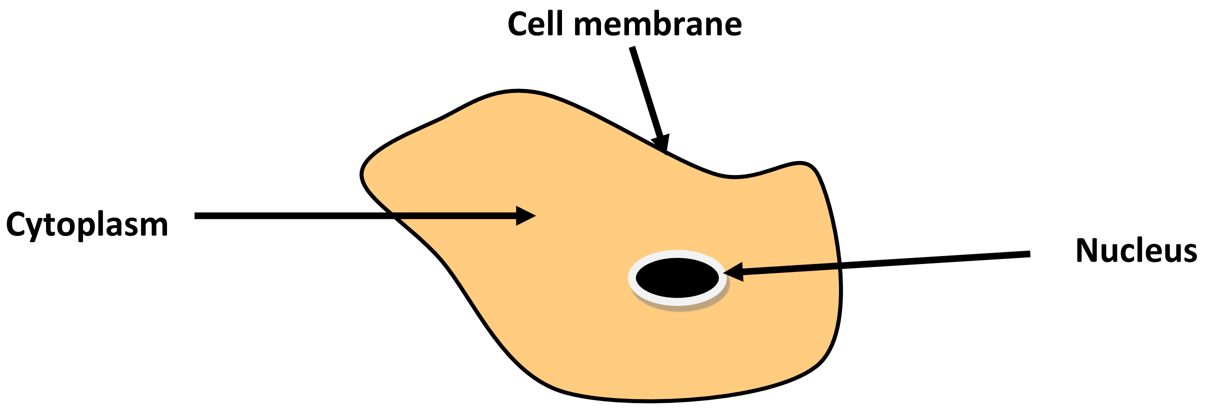
KEY AREA – CELL STRUCTURE & FUNCTION

- Cells are the basic units of all living organisms. Every living thing is made up from cells. Cells can be grouped into two main groups: **Animal cells** and **Plant cells.**

<u>Basic plant cell structure</u>



<u>Basic animal cell structure</u>



Cell Structure	Found in animal cells	Found in plant cells	Found in both animal & plant cell
Cell wall		✓	
Cell membrane	✓	✓	✓
Cytoplasm	✓	✓	✓
Nucleus	✓	✓	✓
Chloroplast		✓	
Vacuole		✓	

<u>Cell structures – What do they do?</u>

Cell Structure	Function (What it does)
Cell wall	Gives plant cells structure. The cell wall prevents plant cells from bursting when water moves into the cell. The cell wall of plant cells is made from a carbohydrate called cellulose.
Cell membrane	Controls the entry and exit of materials from the cell.
Cytoplasm	A 'jelly like' material where most of the cells chemical reactions take place.
Nucleus	The control centre of the cell. It controls all of the cells activities and contains the cells genetic information (DNA).
Chloroplast	The site of photosynthesis. Chloroplasts contain the green pigment chlorophyll.
Vacuole	Contain cell sap which is made up of soluble food and water

- Many cells are transparent and lack colour. This makes their structures difficult to see under the microscope. **Stains** are used when viewing cells under the microscope to make the cell structures stand out. It makes the cell structures easier to see.

- Cells are measured in units called **micrometres (µm)**. There are 1000micrometres in 1 millimetre.

1mm = 1000µm

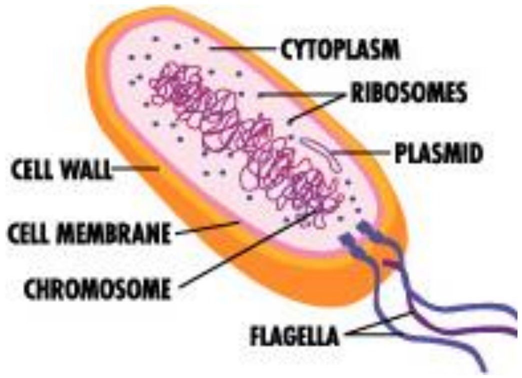
- An **electron microscope** has the ability to magnify an image 500 000 times. This allows many more structures in a cell to be viewed. Many of these specialised structures are called **organelles** and they make up the cell's **ultra structure**.

Other types *of cell*

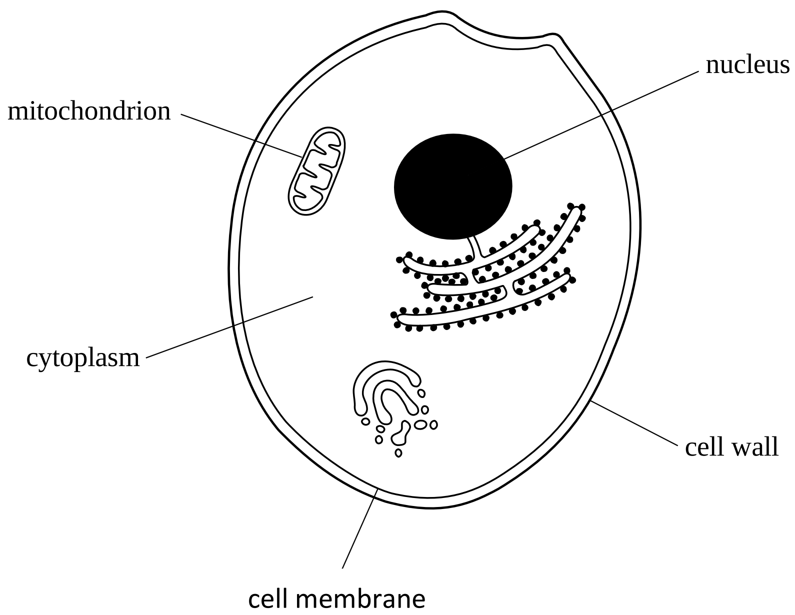
- **Bacteria** are single celled organisms that have a simple structure. Perhaps the most obvious structural characteristic is their small size compared to plant and animal cells. **Bacteria do not contain membrane bound organelles.** For example, the do not have a defined nucleus but instead their genetic material is found in a single chromosome and a circular structure called a **plasmid.**

Bacteria have the following structures in common with plant and animal cells:

- Cell membrane
- Cytoplasm
- Ribosomes

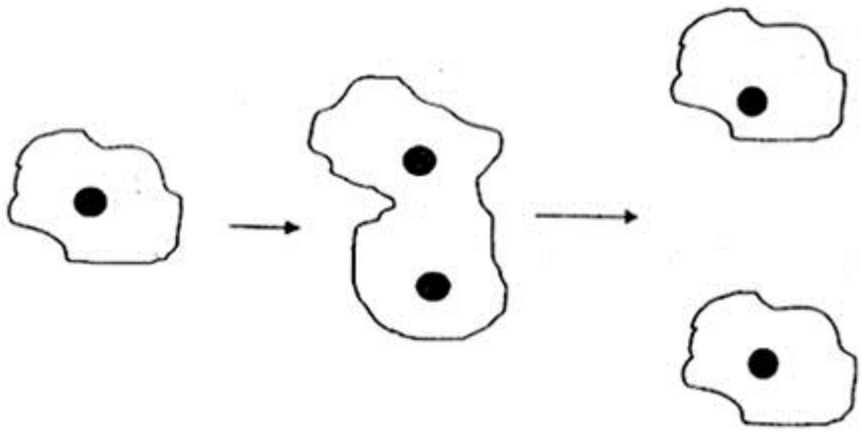


The cells of fungi are similar to plant cells. However they do not contain chloroplasts as fungi do not photosynthesise. Also, the structure of their cell walls is different. The cell walls of fungal cells are composed of a material called **chitin**. **Yeast** is a good example of a fungal cell. **Yeast is a single celled fungus.**

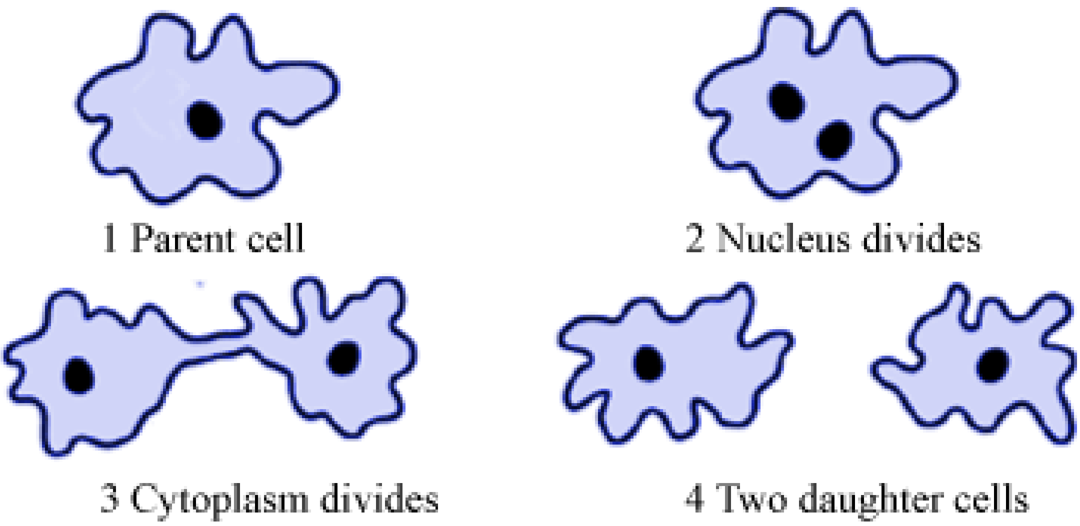


KEY AREA – PRODUCING NEW CELLS

- As organisms grow the number of cells they contain must increase. New cells are produced from existing cells by the process of **cell division**, known as **mitosis.**
- An organism has to produce new cells by cell division for the following reasons:
  - **To grow**
  - **To replace old cells**
  - **To repair damaged cells**
- The **nucleus** of the cell controls all cell activities, **including cell division.**
- Cell division is important for single celled organisms as it is how they reproduce. An amoeba simply divides into two and produces an identical copy of its self.

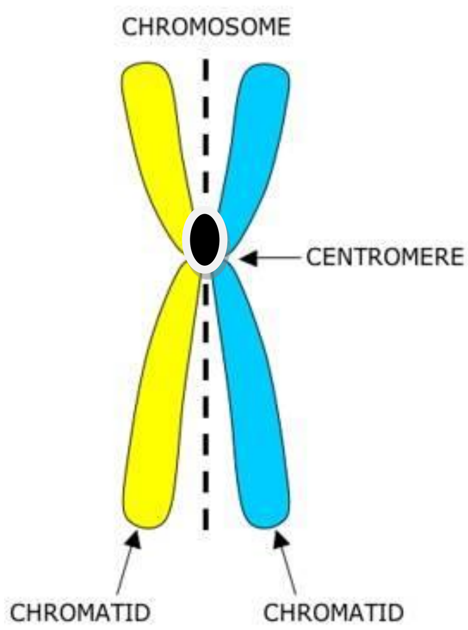


- When any cell undergoes cell division it is the nucleus that must divide first as this contains the cells genetic material (DNA). Once the nucleus has divided then the cytoplasm divides and a new cell membrane is formed around each new cell. In plant cells a new cell wall is formed.



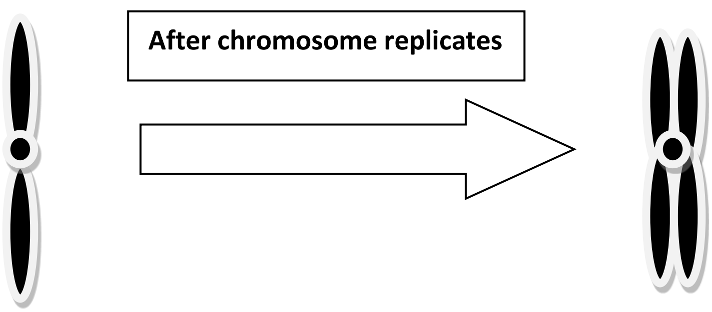
- The cells that are formed at the end of cell division are called **daughter cells** and are identical to the parent cells in every way.

- Information (instructions for the cell) is stored in chromosomes found in the nucleus. Each chromosome is made up of two chromatids which have the same DNA

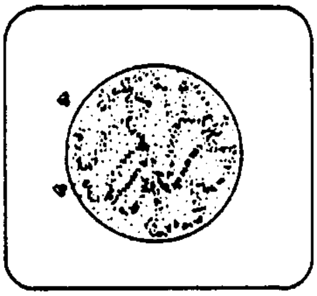


- The new cells produced by mitosis contain the same number of chromosomes and therefore the same genetic information as the original cell.

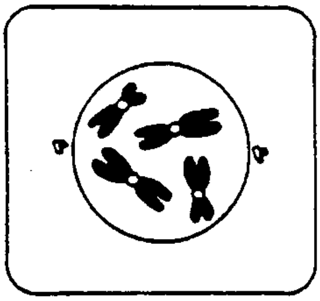
- Before a cell divides each chromosome must make an exact copy of itself.



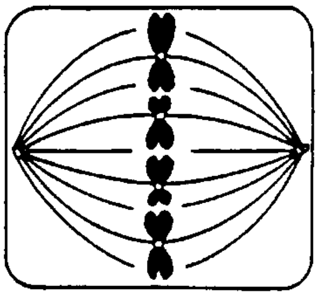
The Stages of Mitosis



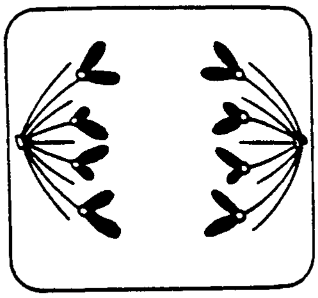
The chromosomes are not yet visible as they are uncoiled. The DNA is replicating preparing for division.



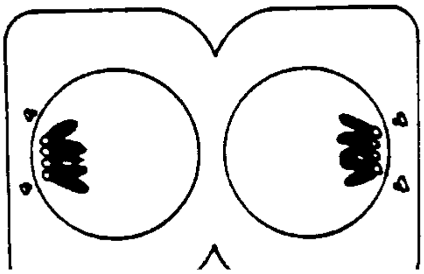
The chromosomes shorten, thicken and are now visible.



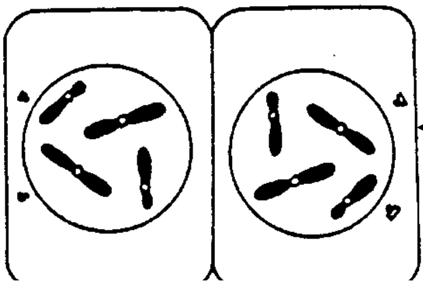
The nuclear membrane is broken down and the chromosomes move to the middle of the cell (equator). The spindle fibres attach to the centromeres.



contract. Chromatids are pulled apart and move to opposite ends (poles) of the cell.



New nuclear membranes form around the chromosomes. The cytoplasm begins to divide to make two identical daughter cells.

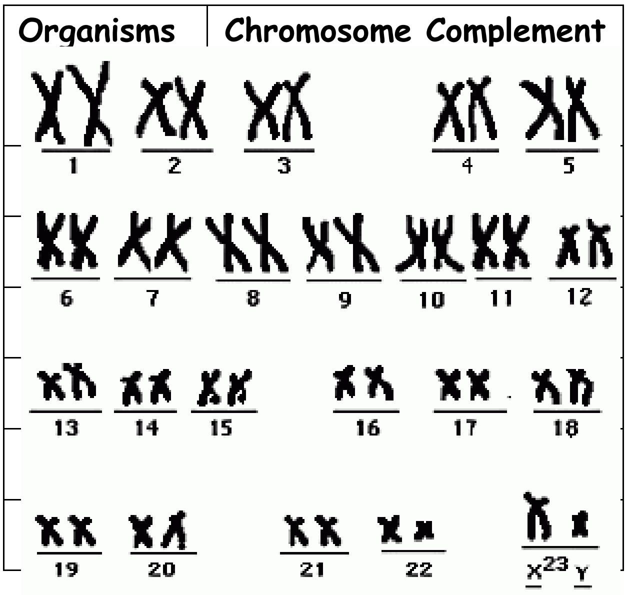


Two new daughter cells are formed containing the same number of chromosomes as the parent cell.

Maintaining Chromosome Number

- Every species has a characteristic number of chromosomes in all body cells. The number of chromosomes an organism has is called their **chromosome complement. (**See table below)

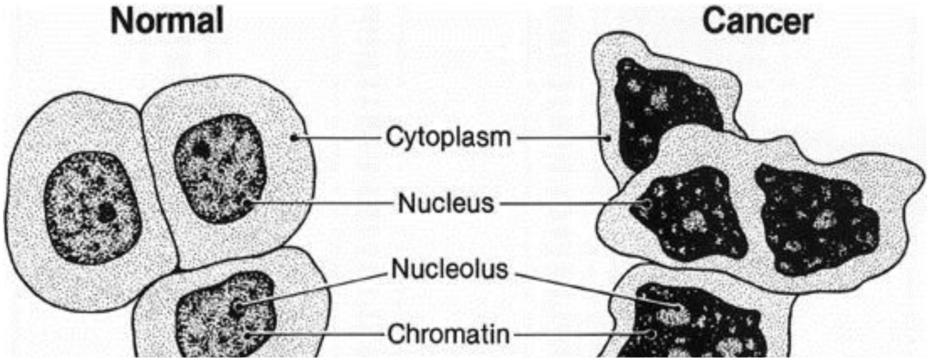
Human Chromosomes



- Each body cell of an organism has a double set of chromosomes. For example, human beings have a chromosome complement of 46 chromes arranged in 23 matching pairs. These double sets of chromosomes make up the organisms **diploid number.**
- Sex cells are the only cells that do not contain a double set of matching chromosomes. They contain only a single set. For example human beings have 23 chromosomes in their sex cells. A single set of chromosomes are the organism's **haploid number.**
- It is essential that the number of chromosomes in the daughter cells (produced by mitosis) is identical to the parent cell. **This ensures that there is no loss of genetic information**.

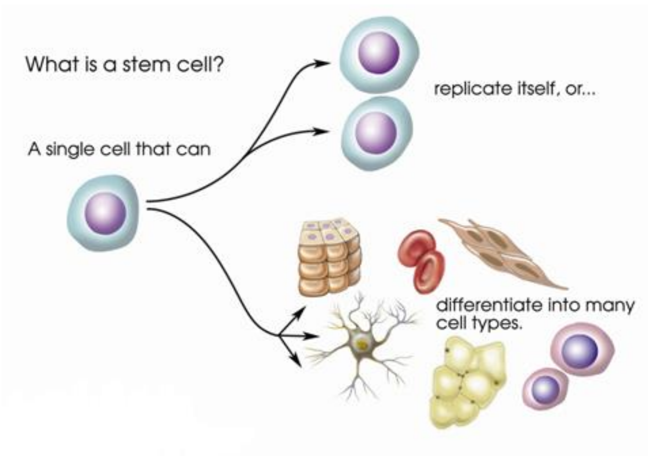
Cancer – When cell division is out of control!

- Cancer is a disease that originates in our own cells. A change in the DNA causes a special gene called an oncogene to be switched on. This leads **to uncontrollable cell reproduction by mitosis**. **This results in cancer**.
- The uncontrollable division of cells can result in a lump made up of a mass of cells called a **tumour**.



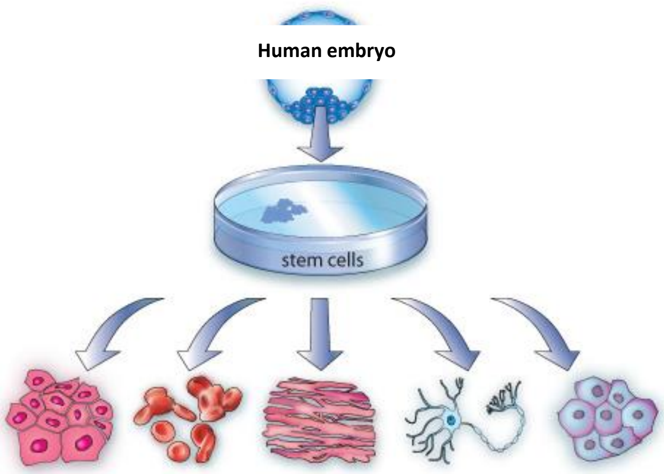
KEY AREA – Stem cells and Meristems

- Stem cells are unspecialised animal cells involved in growth and repair. They are able to:
  - Make copies of themselves
  - Develop into various types of specialised cell



- There are two types of stem cells:

  Embryonic Stem cells – These are capable of developing into **all types** of cell types found in the human body. They even have the potential to regenerate an entire organ from a few cells.



  Adult/tissue stem cells – these cells are found in various tissues in a fully formed human in locations such as the blood, bone marrow and the skin. These cells have a more limited potential than embryonic stem cells, only being able to develop into cells from the tissue they came from.

<u>**Use of stem cells**</u> (you have to be able to describe at least one use of stem cells)

Stem cells can be used to increase understanding of cell development. They can also be used therapeutically.

Research is taking place into the possibility of growing stem cells which are then directed to develop into specific types of cells, providing a source of new cells, tissues and even organs for transplant.

- **Brain diseases** – Embryonic stem cells have been programmed to develop into brain cells to replace damaged ones caused by **Alzheimer's** and **Parkinson's** disease.

- **Heart disease** – this is another area which is being explored for treatment by stem cells. For example, the possibility of growing heart muscle cells from stem cells to treat patients who have damaged heart cells caused by disease.

- **Type 1 diabetes** – this results when the cells of the pancreas which normally produce insulin are destroyed by the person's own immune system. Investigations suggest that embryonic stem cells could be cultured to form insulin-producing cells which could be transplanted into people with diabetes.

Ethical issues with embryonic stem cells

Embryonic stem cell research is considered by some people as controversial as it generates a moral dilemma. It forces a choice between two moral principles:

- To ease suffering by doing all we can to improve medical treatments for illness
- Our responsibility to respect the value of a human life.

In the case of embryonic stem cell research, it is very difficult to respect both of these moral principles. Embryonic stem cell research could lead to new medical treatments, which could save human lives and relieve suffering. The counter point being to obtain embryonic stem cells an early stage embryo has to be destroyed meaning the loss of a potential human life.

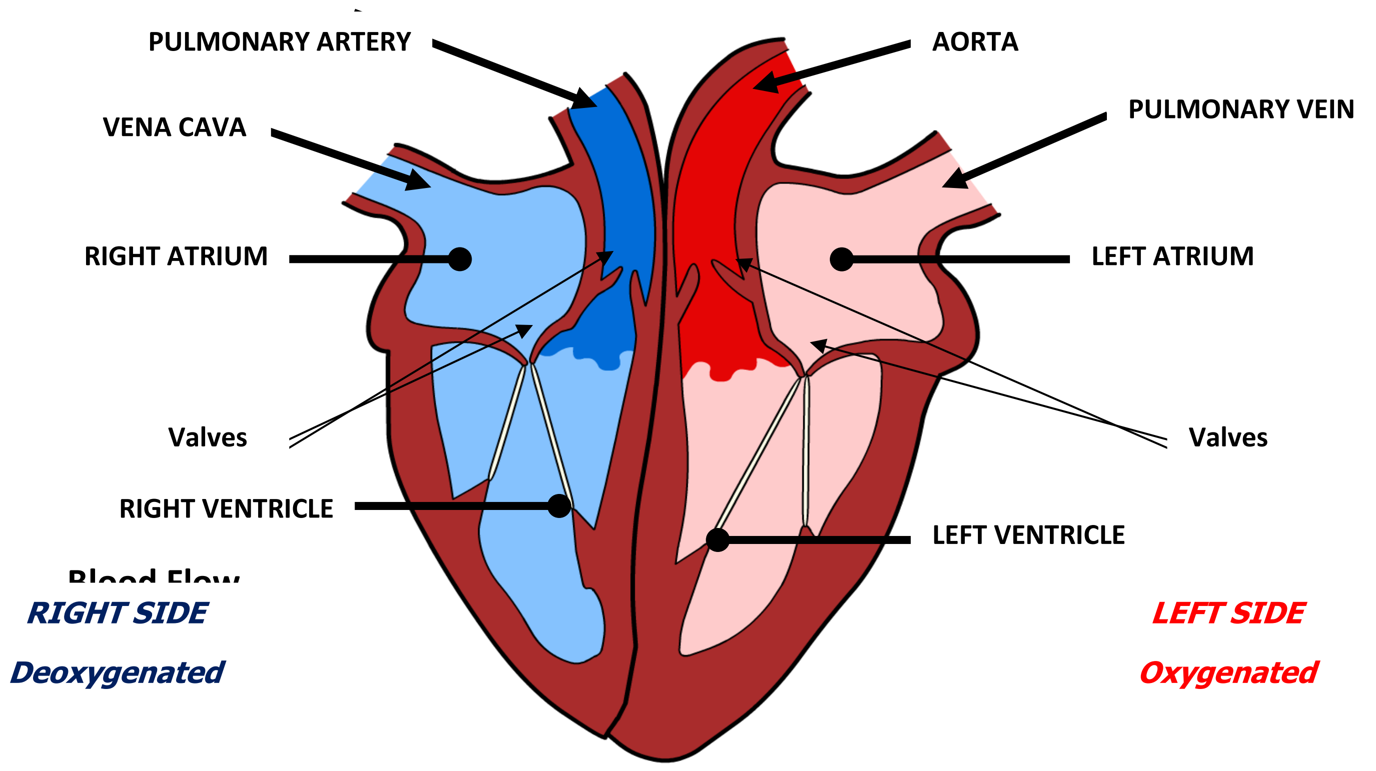
KEY AREA – The need for transport in animals

The heart and circulation

- In mammals, nutrients, glucose, carbon dioxide and other wastes are transported around the body in the blood.
- The heart is a muscular pump which pumps blood around the body. The heart and blood vessels make up the circulatory system.

Heart structure

- The heart has **four chambers**. There are **two atria** (top chambers of the heart),the right atrium and the left atrium and **two ventricles**(bottom chambers of the heart), the right ventricle and left ventricle
- The heart has **four valves** which prevent the backflow of blood, ensuring that blood only flows in one direction
- Blood enters and leaves the heart via major blood vessels. **Veins** transport blood into the heart under low pressure and **arteries** take blood away from the heart under high pressure.
- The **RIGHT** side of the heart contains **DEOXYGENATED** blood. The **LEFT** side of the heart contains **OXYGENATED** blood.



Blood Flow

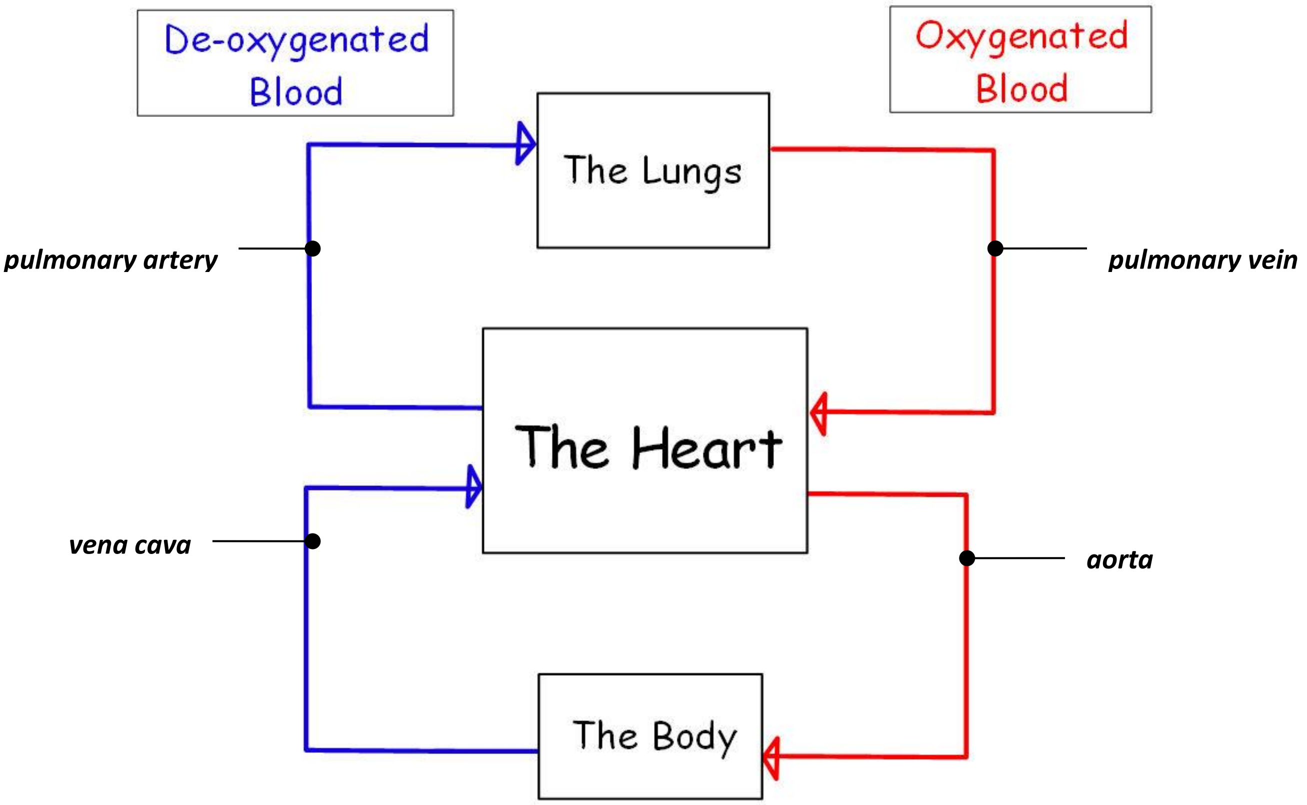
- Deoxygenated blood from the body enters the **right atrium** by the main vein called the **vena cava**. The right atrium contracts, pumping blood into the **right ventricle**. Contraction of the muscular ventricle wall forces blood into the **pulmonary artery**. This vessel carries blood from the heart to the **lungs** where it takes up oxygen. Oxygenated blood from the lungs returns via the **pulmonary vein** to the **left atrium**. The blood is then pumped into the **left ventricle** which contacts forcing blood into the **aorta** which transports blood to all parts of the **body**.

(Deoxygenated blood)

Vena cava (from the body) → right atrium → valve →right ventricle → valve → pulmonary artery →lungs

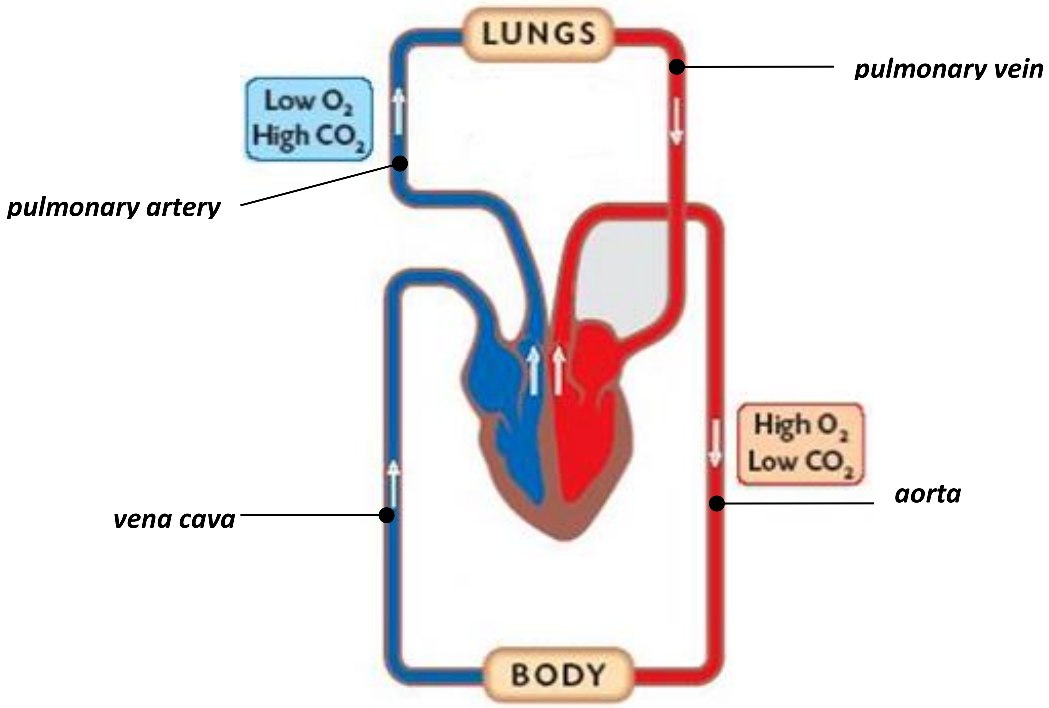
(Oxygenated blood)

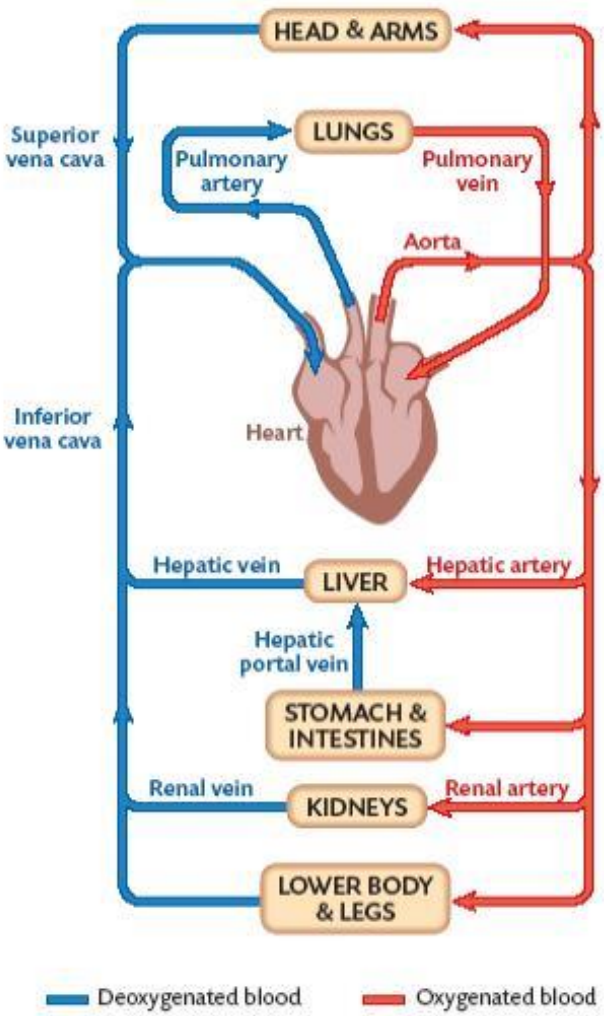
Lungs → pulmonary vein → left atrium → valve → left ventricle → valve → aorta → body



Human circulatory system

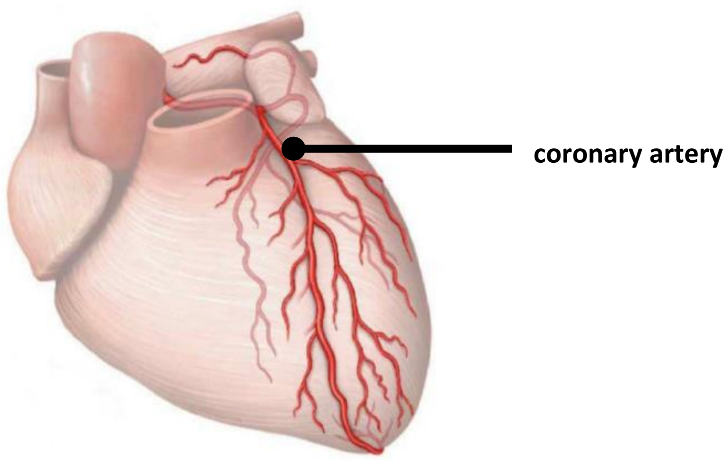
- The human circulatory system is a **double circulation** where the blood flows through the heart **twice** for each complete circuit.





The coronary arteries

- The heart muscle requires its own blood supply to provide it with **oxygen** and **glucose** for respiration. Oxygenated blood is provided by the **coronary arteries**, which can be seen on the outside of the heart.



- **Heart disease** results if the coronary arteries become narrow or blocked. A **heart attack** occurs when a coronary vessel becomes blocked. The region of the heart muscle it supplies is starved of oxygen and dies.

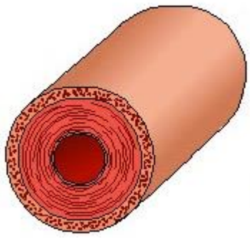
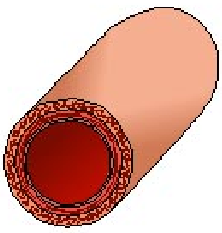
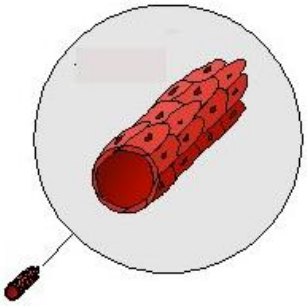
Pulse

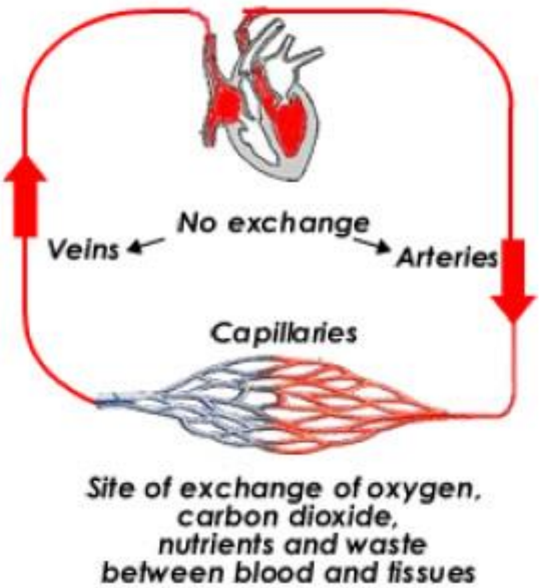
Each time the heart 'beats', blood is pumped into the arteries at high pressure. This produces a wave of pressure that can be felt as a pulse beat in an artery that comes near to the surface of the body.

HEART RATE = PULSE RATE

Blood vessels

- There are three main types of blood vessels: arteries, veins and capillaries. The structure of each type of blood vessel is suited to its specific function.

Blood Vessel	Diagram	Structure/Function
Arteries		• Transport blood (under high pressure) away from the heart • Thick muscular walls to withstand high pressure • Have a pulse
Veins		• Return blood (under low pressure) back to the heart • Thin walls and wider central channels (lumen) • Contain valves to prevent backflow of blood
Capillaries		• Link between arteries and veins • Form networks in body tissues • Exchange of materials occurs between capillaries and respiring cells • Microscopic –their walls are only one cell thick



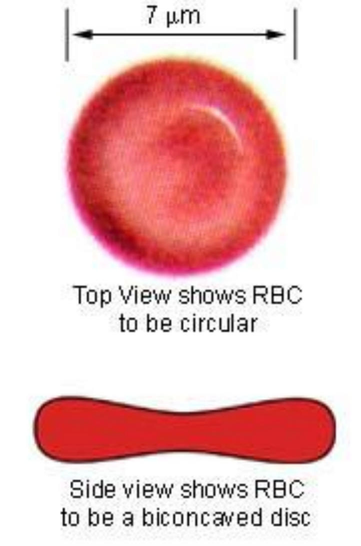
The role of blood in transport

- Blood consists of two parts:
    - **Plasma** – liquid part of blood that contains dissolved materials
    - **Blood cells** – red blood cells for transporting oxygen and white blood cells that are part of the body's immune system
- Blood is used to transport glucose, amino acids, carbon dioxide, oxygen, urea and hormones.

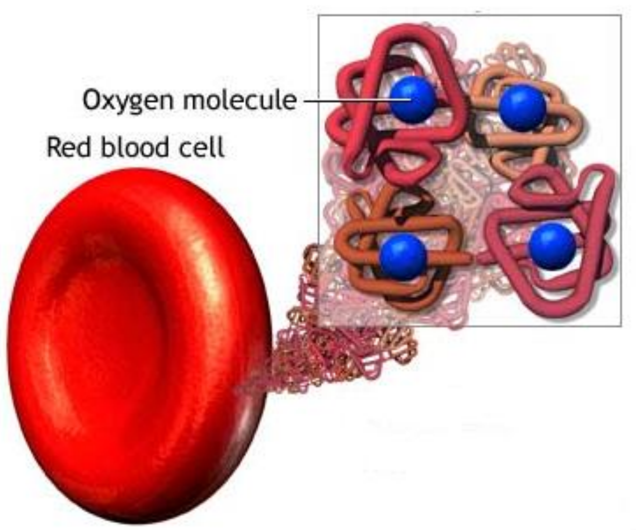
Substance	How it is transported	Use in the body
Oxygen	In the red blood cells	Used in respiration to release energy from glucose
Glucose	Dissolved in the plasma	Used as an energy source in respiration
Carbon dioxide	Most in the plasma and a little in the red blood cells	Waste product produced during respiration
Amino acids	Dissolved in the plasma	Used to make proteins
Urea	Dissolved in the plasma	Waste material produced from the breakdown of excess amino acids
hormones	In the plasma	Chemical messengers produced by glands that bring about different effects throughout the body

Red Blood Cells

******Red blood cells are specialised to carry out their function******



Haemoglobin



Function: *To transport oxygen from the alveoli (air sacs) to all respiring cells*

Shape: *Biconcave, giving an increased surface area for oxygen uptake*

Size: *7um in diameter...their flexibility allows them to fit through capillaries of the same diameter*

Production: *In the red bone marrow from blood stem cells*

Lifespan: *120 days and then they are destroyed in the liver and spleen*

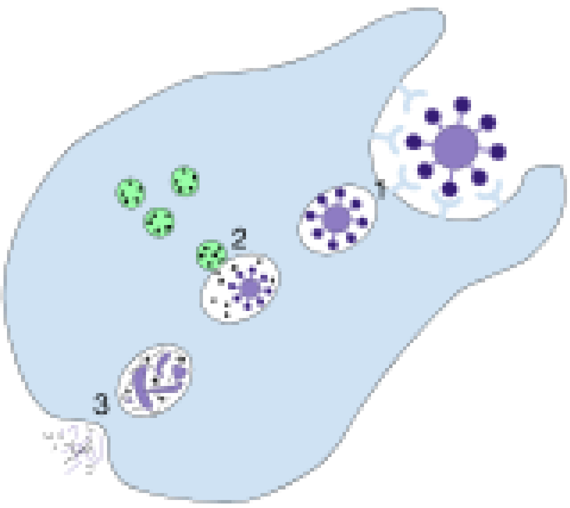
Haemoglobin: *RBC's contain a protein called haemoglobin which combines with oxygen to form oxyhaemoglobin (in the lungs).*
Oxyhaemoglobin then release its oxygen when moving through respiring tissues.

White blood cells

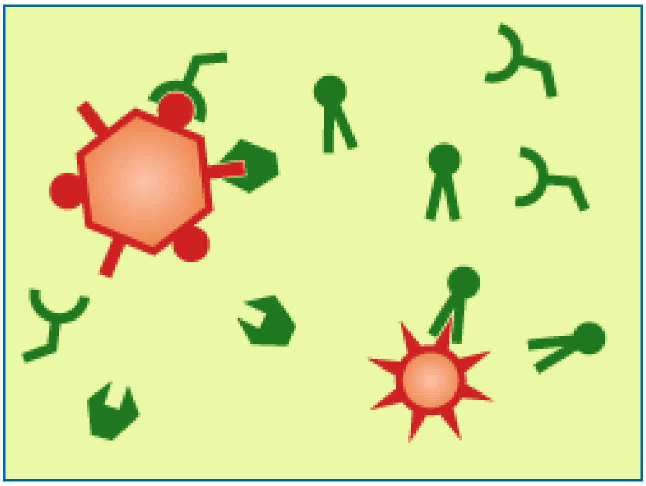
White blood cells are part of the immune system that are involved in destroying pathogens (a bacterium, virus or other microorganism that can cause disease).

There are 2 main types of cells involved: Phagocytes and lymphocytes.

Phagocytes carry out phagocytosis by engulfing pathogens.



Lymphocytes produce antibodies which destroy pathogens. Each antibody is specific to a particular pathogen.



The reaction between haemoglobin and oxygen can be represented below

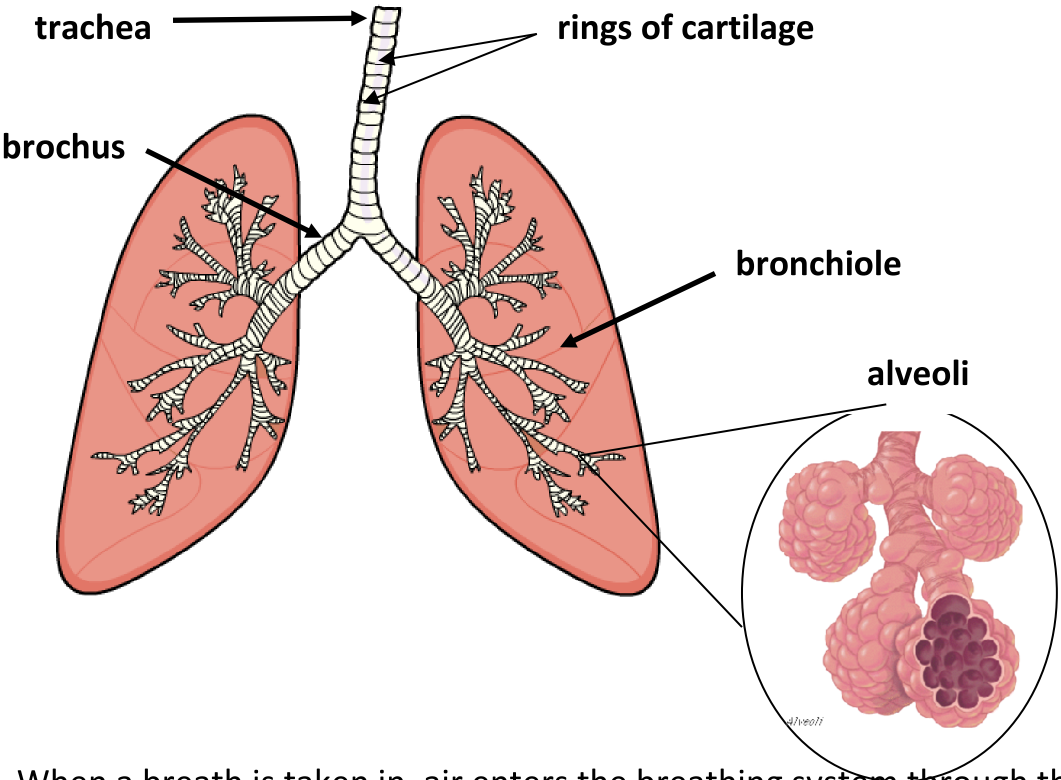
In the blood capillaries of the lungs

OXYGEN + HAEMOGLOBIN ⇌ **OXYHAEMOGLOBIN**

In the blood capillaries of the body tissues

The lungs

- The lungs are where the gases oxygen and carbondioxide are exchanged between the blood and the air.

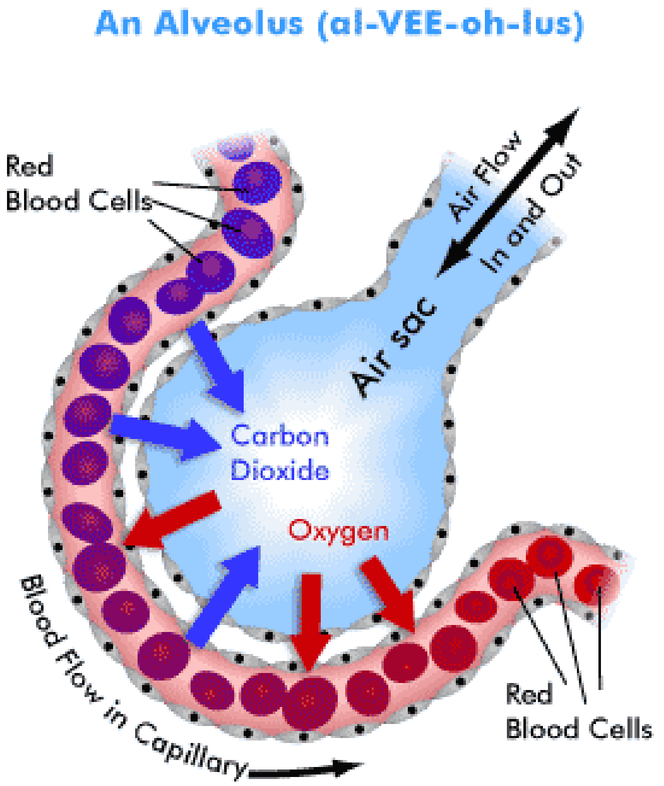


- When a breath is taken in, air enters the breathing system through the nose and mouth. It then passes down the **trachea** to the lungs. As the air moves into the lungs, it travels through a series of smaller branched passages: first the **bronchi** (singular: bronchus) and then the **bronchioles**. At the end of the bronchioles are air sacs known as **alveoli** (singular: alveolus). In the alveoli, oxygen moves into the blood and carbon dioxide moves out of the blood (both by diffusion). This is **gas exchange**. The larger airways (trachea, bronchi) are supported by **rings of cartilage** to ensure the airway is always kept open.

Gas exchange in the alveoli

- The alveoli in the lungs are microscopic. They have a number of features that ensure that gas exchange is efficient:
  - There are millions of alveoli in the lungs, providing a **large surface area** for diffusion to take place.
  - **The walls of the alveoli are only one cell thick**, allowing rapid diffusion as the gases travel short distances.
  - **The lining of the alveoli is moist** to allow gases to dissolve before they diffuse.

- **The alveoli are surrounded by a dense network of capillaries**, giving them a good blood supply.



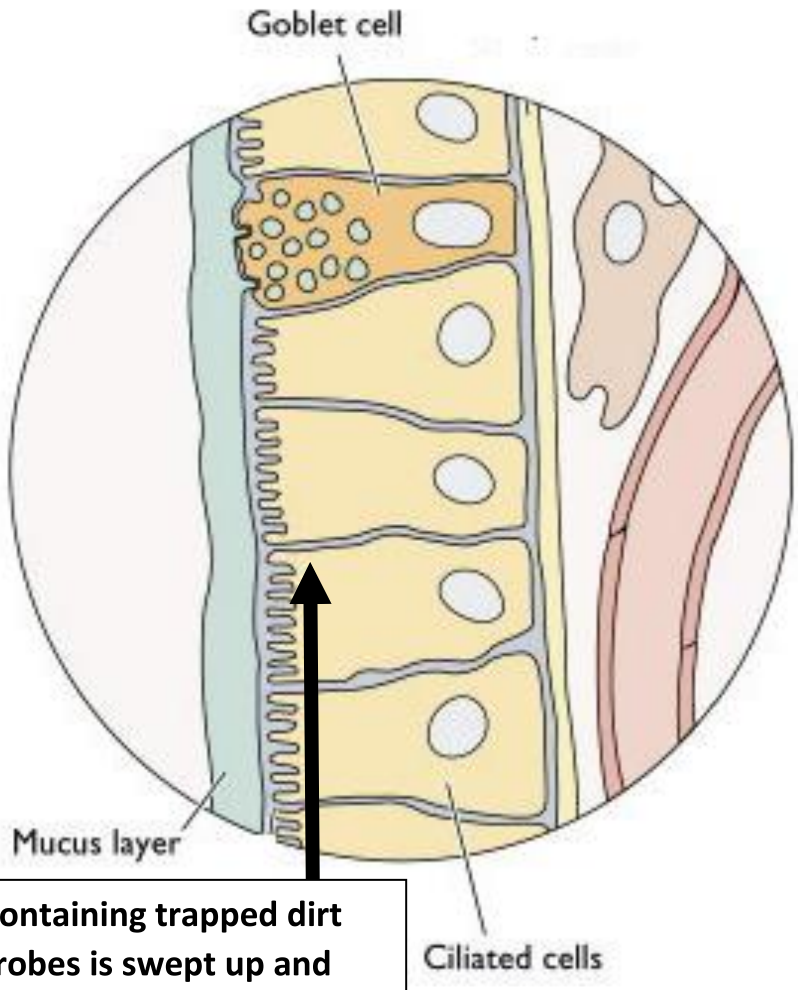
- There is a higher concentration of oxygen in the air within the alveoli than in the blood so oxygen diffuses from the alveoli into the blood. There is a higher concentration of carbon dioxide in the blood than in the alveoli so carbon dioxide moves from the blood into the alveoli.

Keeping the lungs clean

- The trachea, bronchi and bronchioles are lined with two types of specialised cells:

  GOBLET CELLS – These cells produce sticky **mucus** that traps particles of dirt and any microorganisms that are breathed in.

  CILIATED CELLS – These cells have hair like projections called **cilia** which can 'beat' (move). The constant movements of the cilia sweep the mucus and any trapped materials away from the lungs and towards the back of the throat where they can be swallowed and destroyed in the stomach.



Mucus containing trapped dirt and microbes is swept up and away from the lungs by the 'beating' cilia

Digestion

- Digestion is the process in which large insoluble food molecules are broken down into small soluble food molecules by the action of enzymes so that the soluble food can be absorbed into the blood.

Food Groups

- The main food groups in the diet are carbohydrates, fats and proteins.

Food Group	Use	Example of enzyme action	Final product after digestion
CARBOHYDRATE	To provide energy.	Starch —**amylase**→ Maltose	GLUCOSE
PROTEINS	Growth and repair of tissues	Protein —**pepsin**→ Amino Acids	AMINO ACIDS
LIPIDS (FATS)	To provide energy/Thermal insulation/Vitamin transport	Lipids —**lipase**→ Fatty acids + Glycerol	FATTY ACIDS & GLYCEROL

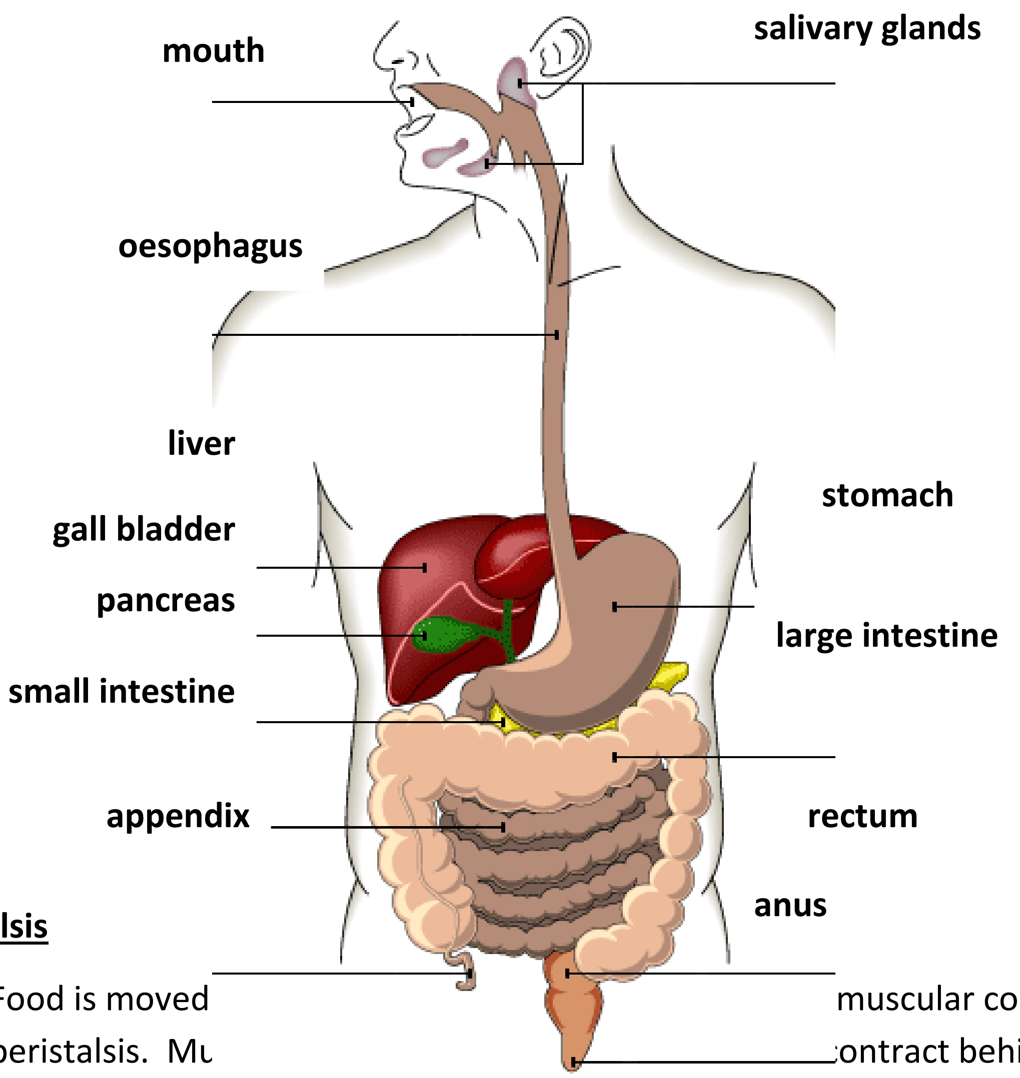
Foods rich in (starch) carbohydrate include bread, potatoes, pasta and rice

Foods rich in protein include meat, cheese, fish and nuts

Foods rich in fats include butter and olive oil

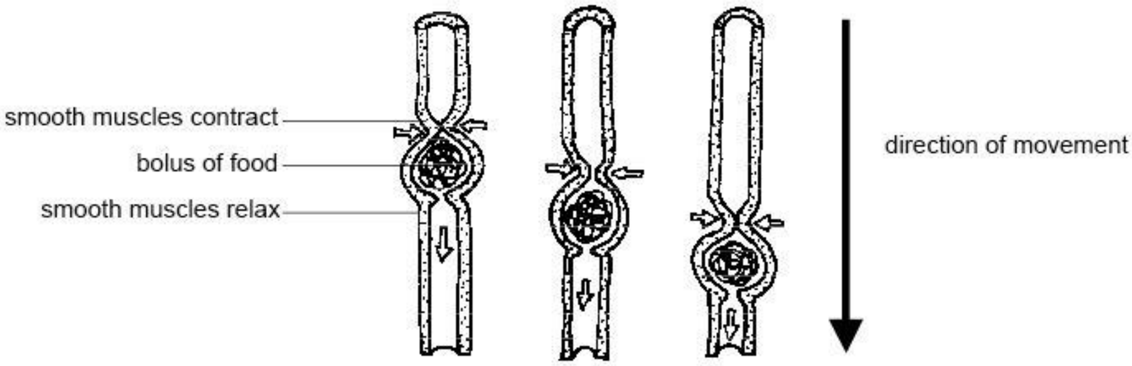
The digestive system

- The alimentary canal is a long, muscular tube that runs from the mouth to the anus. As food travels through the alimentary canal digestion takes place.



Peristalsis

- Food is moved … muscular contractions called peristalsis. Mu… …ontract behind the food where as musc… food to be squeezed along.

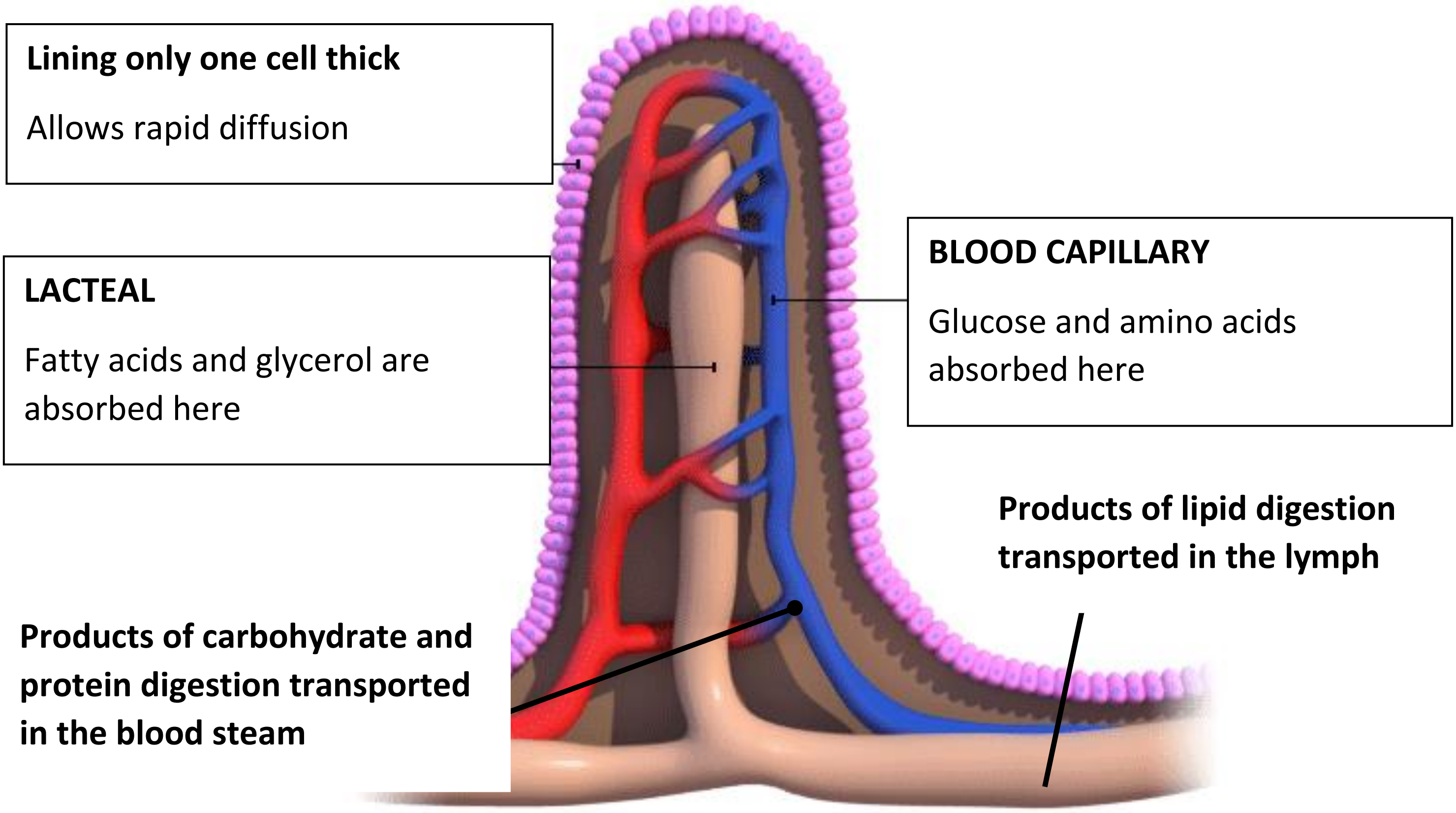


food molecules
lymph system.

- After digestion is complete, the following products of digestion are in the small intestine.
  - Glucose
  - Amino acids
  - Fatty acids and glycerol
- The structure of the small intestine allows very efficient absorption to take place as it is long and the inner lining is folded and has many finger-like projections called villi.
- Villi have the following features that ensure absorption of the products of digestion (soluble foods) are absorbed efficiently

Feature of villi	Benefit
The lining is one cell thick	Allows the rapid diffusion of soluble foods
Large surface area	Increased surface area for increased absorption
Blood capillary present	Ensures a good blood supply is present to receive and transports absorbed glucose and amino acid molecules
Lacteal present	Ensures that products of fat digestion can be absorbed into the lymph system

Internal structure of a villus



KEY AREA – Control and communication

Communication

Internal communication is required for survival of a multicellular organism. Cells in multicellular organisms do not work independently.

Communication occurs through**; Nerve messages** and **Hormones**

Nerve messages

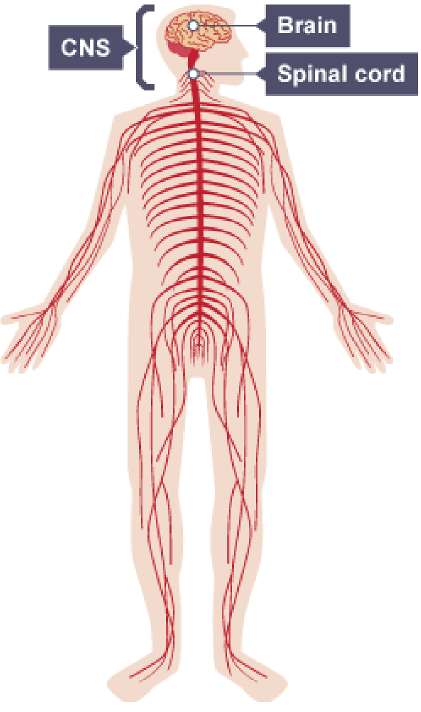
- These are electrical impulses carried in specific nerves
- The messages travel quickly
- Effect of message is short lived

Hormones

- These are chemical messages carried in the blood.
- The blood carries the messages all over the body but they target certain organs.
- The messages travel slowly.
- The effects are longer lasting

The nervous system

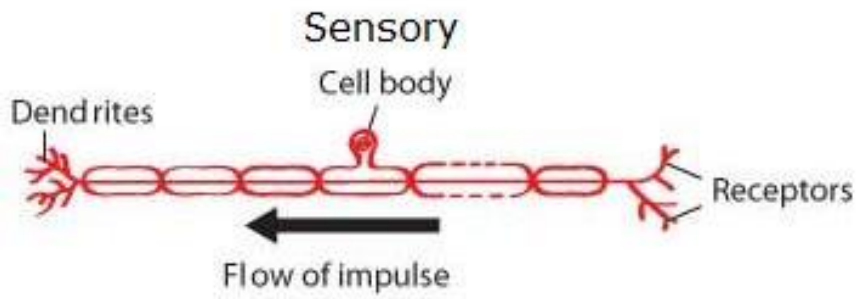
- The nervous system of mammals has two main parts: the central nervous system (CNS), which consists of the brain and spinal cord, and the nerves (neurons), which connect the CNS to all parts of the body.



Types of neurones

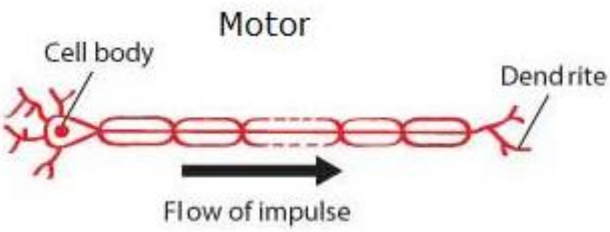
- There are 3 types of neurone (nerve cell).

The **SENSORY** nerve cell or neurone carries electrical impulses from the sensory organ **INTO** the CNS



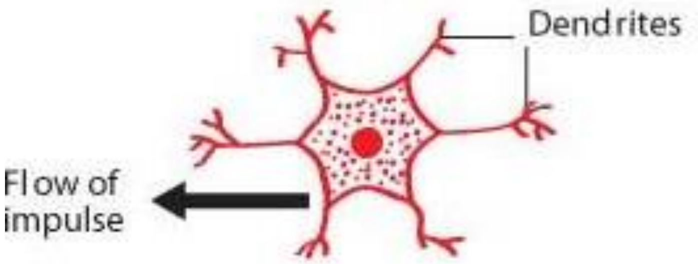
The **MOTOR** neurone carries impulses **FROM** the CNS to a muscle or gland.

The response may be a rapid action from a muscle or a slower response from a gland



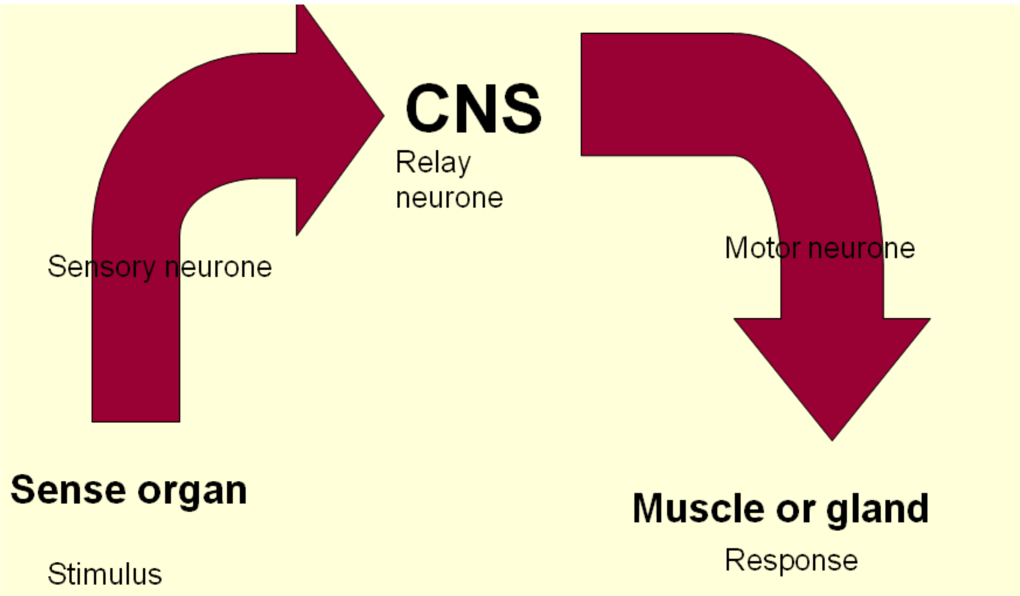
A **INTER** neurone is only found within the CNS. It **TRANSFERS** impulses from sensory neurones to motor neurones

Inter Neurone



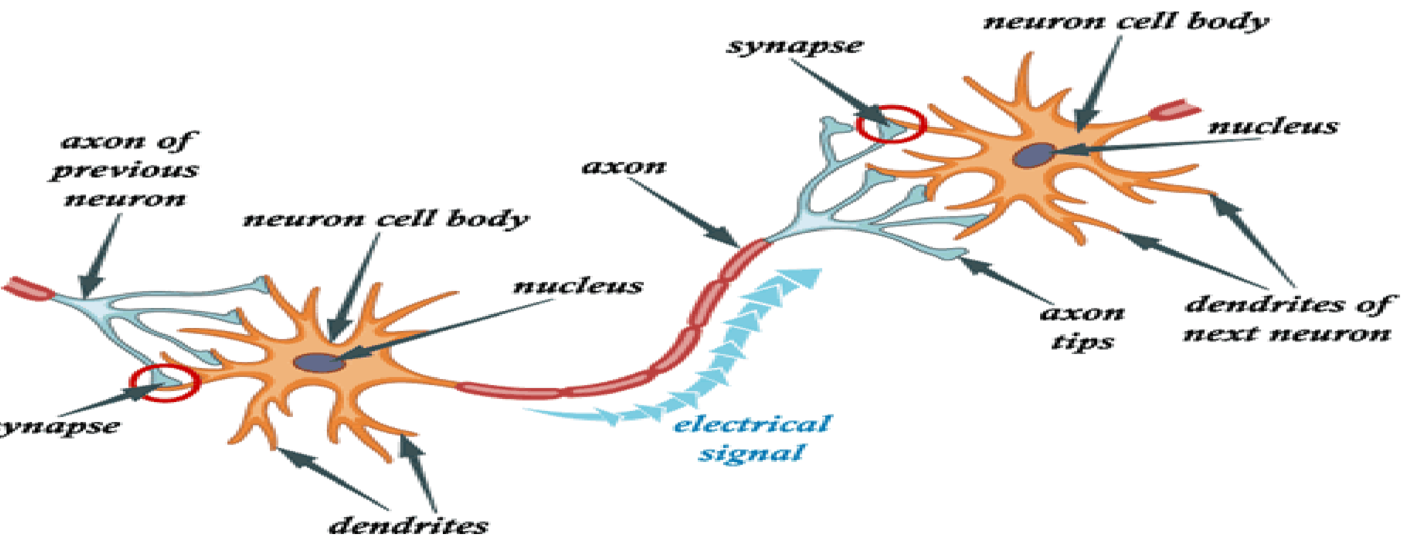
Route travelled by nerve impulses

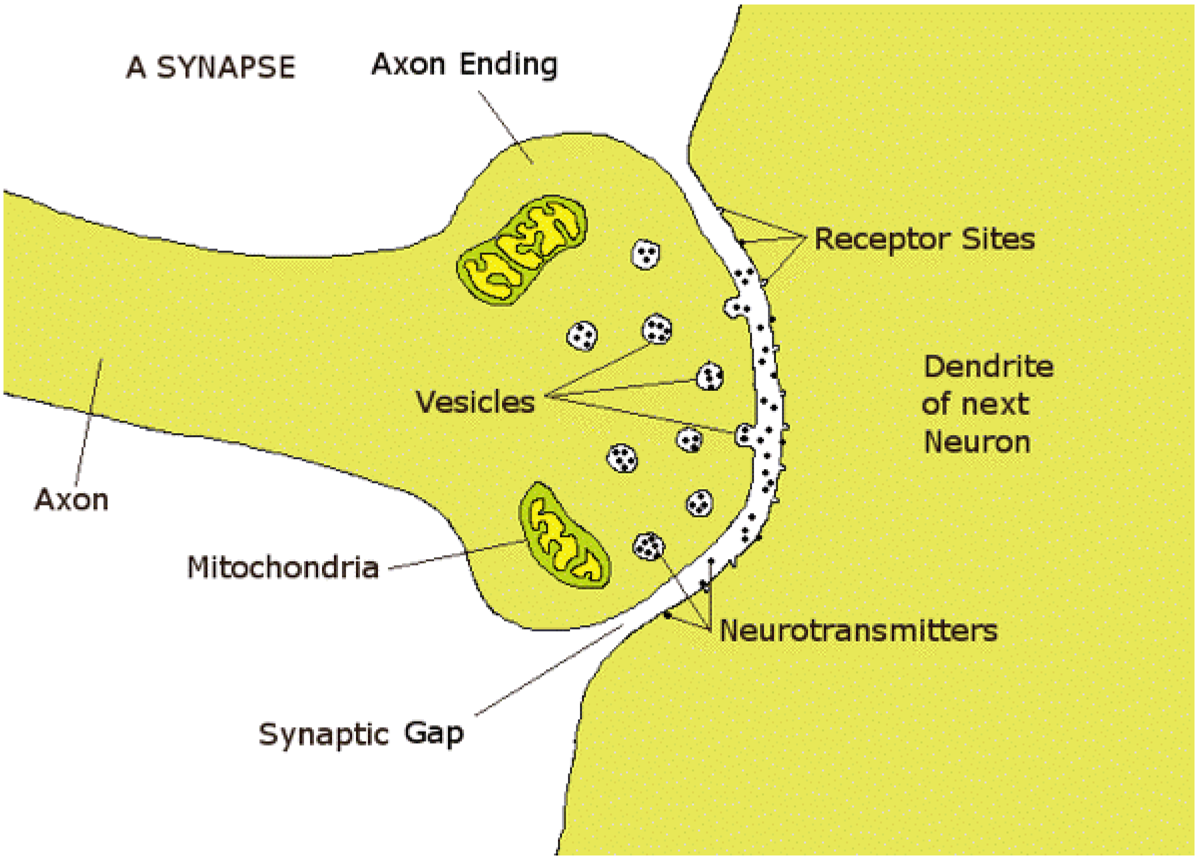
- Electrical impulses travel to the CNS via the sensory neurone. The CNS processes information from our senses which needs a response. The information will pass to the relay neuron within the CNS. Impulses pass to the motor neurone which will carry them to the muscle or gland where action will be taken.



Synapse – tiny gaps

- These are the gaps between neurons where chemicals are released to trigger an impulse in the next neuron.





Reflex actions

- A reflex action is a rapid automatic response to a stimulus (anything an organism can detect). Reflex actions are **involuntary** and **do not necessarily involve the brain.**

- Reflex actions **protect** the body from further damage by allowing it to react quickly to stimuli, such as high temperatures, that may be harmful.

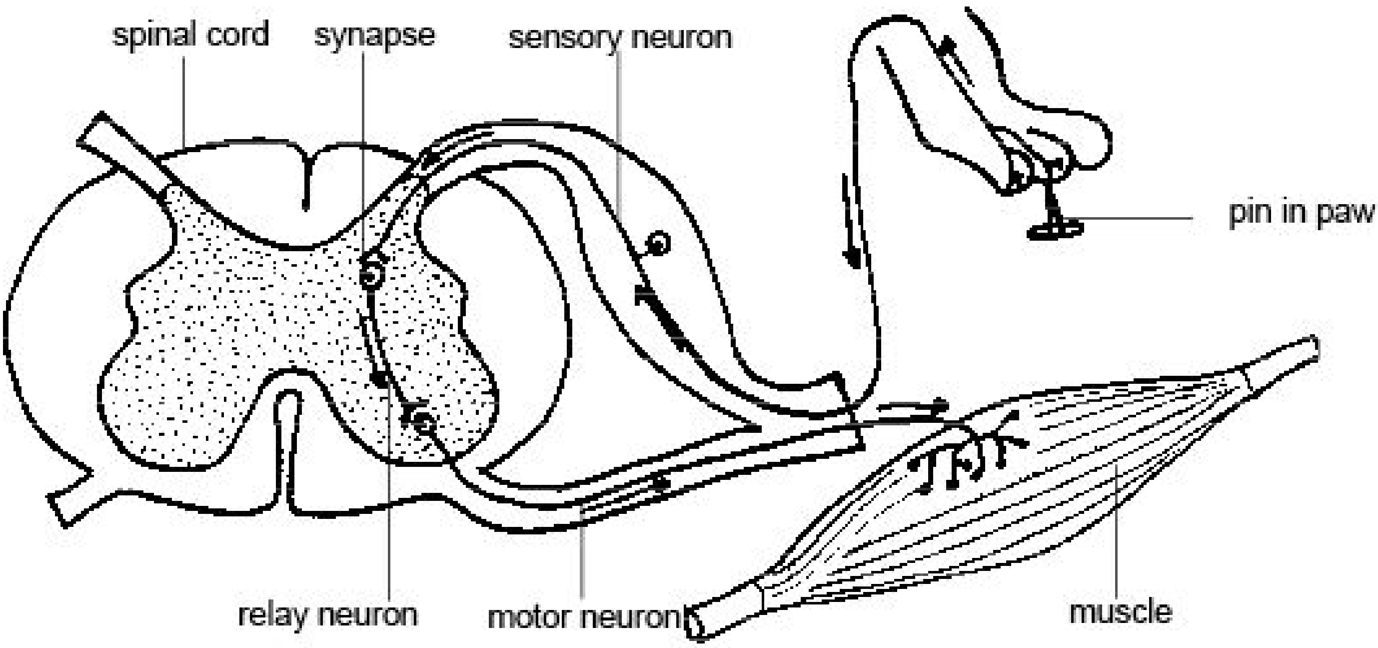
- Reflex actions are quick because there is a direct link in the spinal cord called a relay neuron between the sensory neuron and a motor neuron that causes a muscle to makes the protective response.

- The circuit of the neurons that act to produce the reflex action is called the **reflex arc**.

Reflex arc

- The order of neurons in a reflex arc is:

SENSORY ⟶ RELAY ⟶ MOTOR



Step 1 – Sense organs in the skin detect pain.

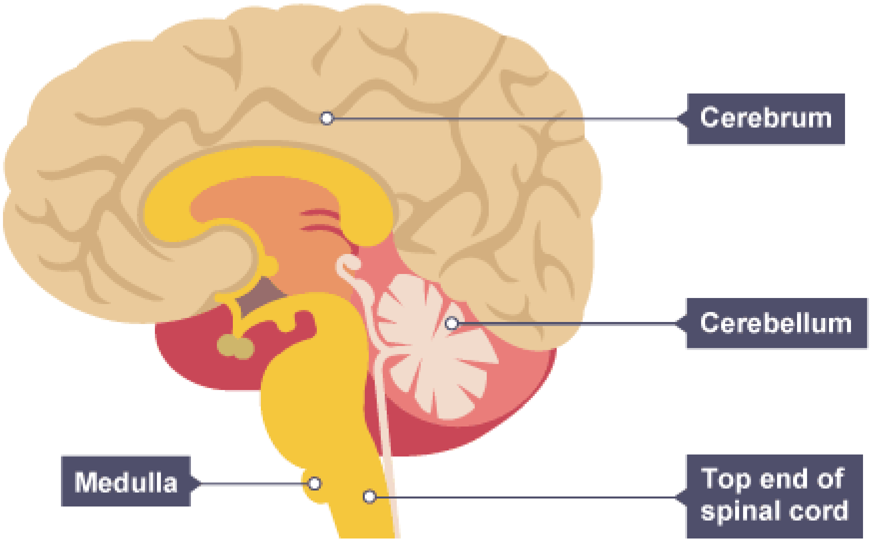
Step 2 – Nerve impulse carried by a sensory neurone into the CNS.

Step 3 – Impulse transferred across a synapse to a relay neurone and then across another synapse to the motor neurone.

Step 4 – Impulse travels along a motor neurone to a muscle.

Step 5 - Muscle contracts and limb is withdrawn (from harmful stimulus)

Structure of the brain

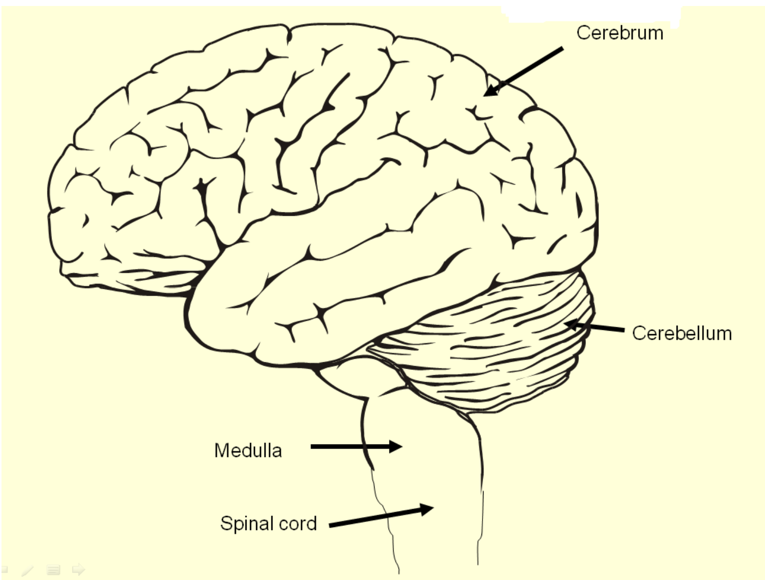


control heart rate,

- The **CEREBRUM** is the large folded area of the brain and is responsible for **conscious thoughts, reasoning, memory and emotions**.

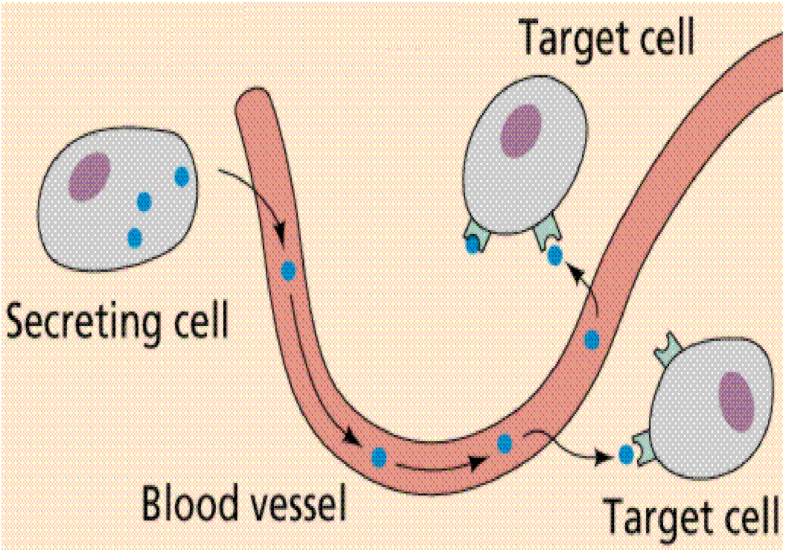
- The **CEREBELLUM** is found at the rear of the brain below the cerebrum and **controls balance and coordinated movement**.

- The **MEDULLA** is found at the top of the spinal cord and contains groups of neurons that transmit electrical impulses to the heart and lungs to **control heart rate, breathing rate and peristalsis**.



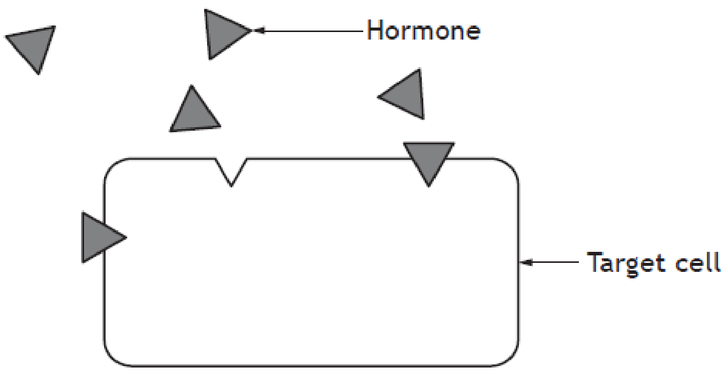
Endocrine System

- In animals, **endocrine glands** produce hormones (chemical messengers) and secrete them directly into the bloodstream. **Hormones travel in the blood** to 'target tissues' where they bring about a response.



- Target tissues have cells with receptors for hormones, so only some tissues are affected by **specific** hormones. The target cell has **specific receptors** and the hormone fits the receptor on the target cell only.

- Since hormones are transported in the blood, hormonal control is slower than nervous control.



Blood Glucose R

- The cor nt.
- If the blood glucose concentration rises too high then the water concentration of the blood will fall and water will diffuse out of cells by osmosis. This may interfere with cell reactions.

- If the blood glucose concentration falls too much, then body cells will not receive as much glucose and so will not be able to release as much energy in respiration.

Two hormones are involved in controlling blood glucose levels.

1. **Insulin**

- This is produced by the **Pancreas**. It is carried in the blood to the target organ - **Liver.**
- Insulin causes the liver to take up glucose from the blood and convert it to a storage carbohydrate called glycogen and therefore reduces the levels of glucose in the blood.

Insulin

Glucose ⟶ **Glycogen**

2. **Glucagon**

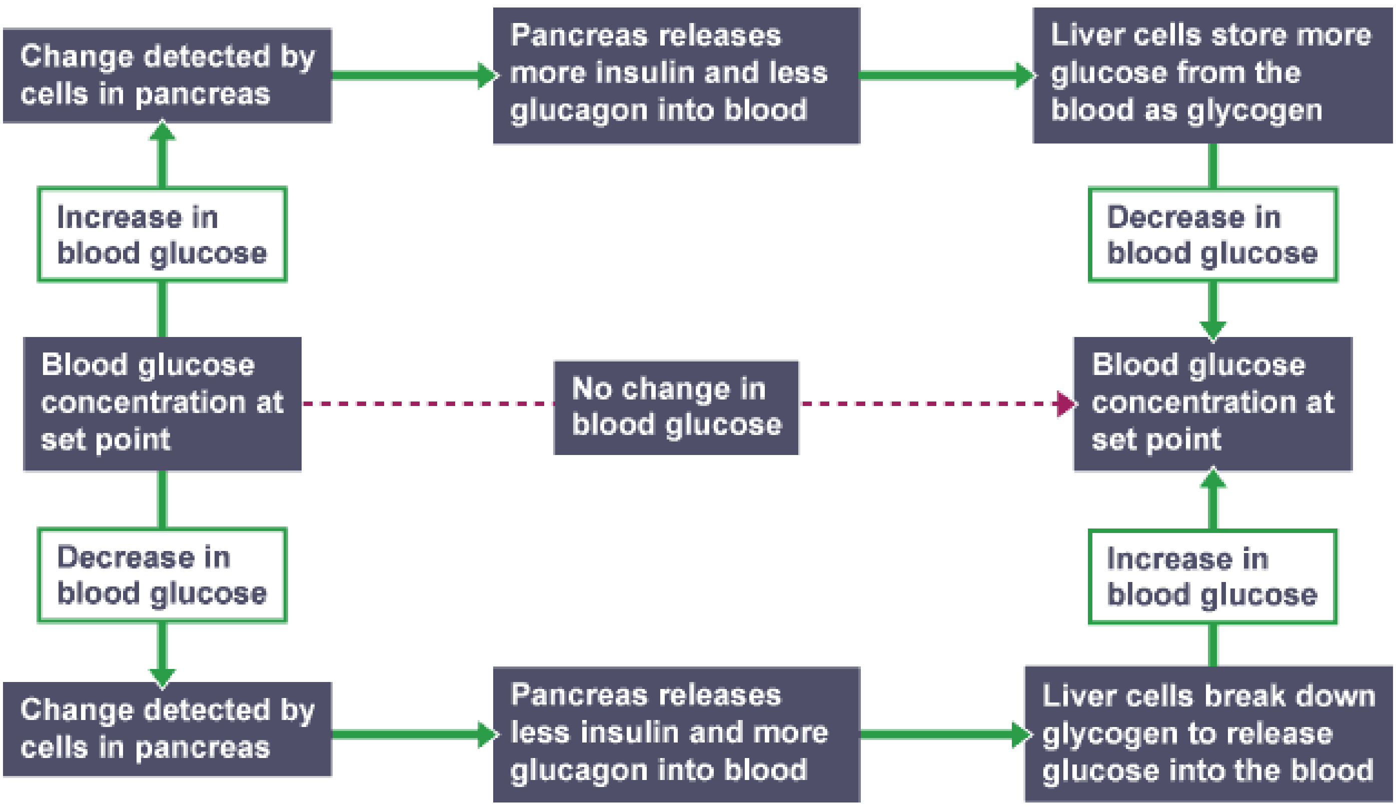
- This is produced by the **Pancreas**. It is carried in the blood to the target organ - **Liver**.
- Glucagon causes the liver to convert the storage carbohydrate glycogen to glucose and therefore increases the levels of glucose in the blood.

Glucagon

Glycogen ⟶ **Glucose**

Blood glucose levels in the body stay at a constant level. Varying levels of insulin and glycogen are produced depending on whether a person has just eaten or has used up lots of energy.

The diagram shows how the concentration of glucose in the blood is regulated.



Diabetes

Diabetes is a condition in which blood sugar regulation fails. This is caused by a communication pathway failure which results in a fault in the release of insulin or in a failure to respond to insulin.

The main symptoms of undiagnosed diabetes can include:

- passing urine more often than usual, especially at night
- increased thirst
- extreme tiredness
- unexplained weight loss
- slow healing of cuts and wounds
- blurred vision

Types of diabetes

Type 1 diabetes

- Type 1 diabetes usually develops early in life and is the most common type of diabetes in children. **It occurs when the body is unable to produce any insulin.**
- Type 1 diabetes is treated with insulin injections, or by using an insulin pump.

Type 2 diabetes

- Type 2 diabetes is the most widespread form of the condition and usually develops later in life. It accounts for 90% of diabetes cases in Scotland and is linked to lifestyle choices involving a diet leading to obesity
- This develops when the body is unable to make enough insulin, or when **the insulin that is produced does not work properly** (known as insulin resistance).
- Type 2 diabetes can be treated with diet and physical activity alone, or combining these with tablets which lower glucose levels in the blood.
- Due to the progressive nature of the condition, insulin treatment may be required later in life.