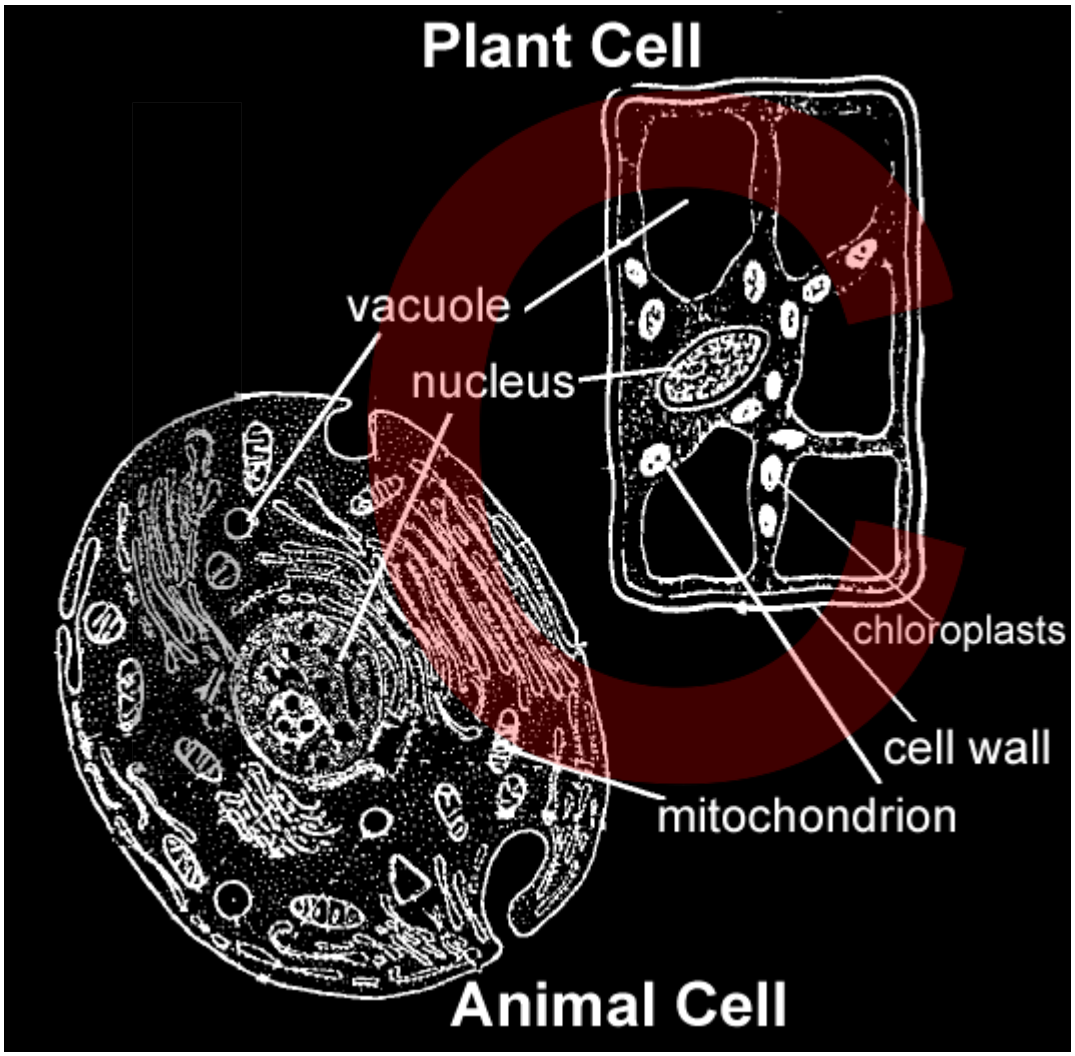
Cell Structure and Organisation

A cell is the smallest unit that can carry on all the processes of life.
All organisms are made of cells, organisms are made of several organ systems, each organ system contains several organs, each organ contains several tissues; each tissue is made of cells.
Cells are very tiny they could be seen only through a microscope. We have two types of cells:

1. Plant Cells
2. Animal Cells



As you can see from the diagram, there are some features found in plant cells but not in animal cells.

Features found in both plant and animal cells:

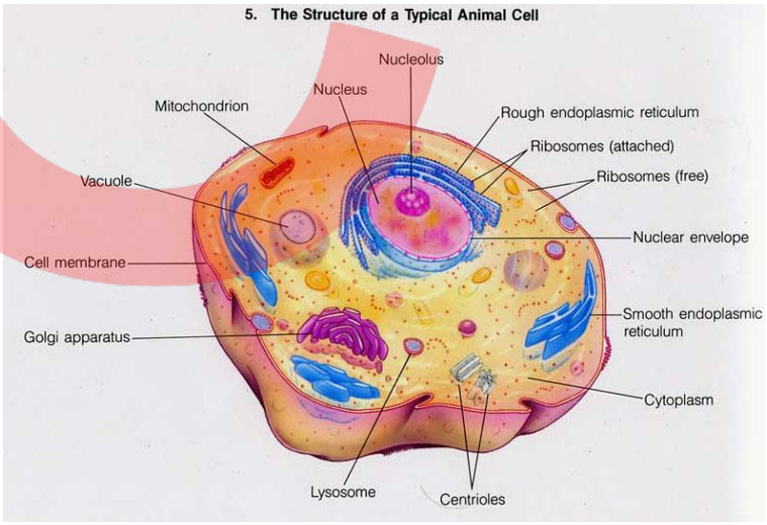
- Cell surface membrane: This is a partially permeable membrane separating the cell from the environment its made of lipid and protein, it controls movement of substances in and out, its strong but flexible.
- Cytoplasm: This is a jelly like substance, its made of mostly water and protein. Metabolic reactions occur in it.
- Nucleus: This determines how the cell behaves and it contains chromosomes made of strings of DNA which also determines which proteins the cell should make etc.

Features found in only plant cells:

- Cell Wall: This is a rigid layer surrounding the cell made of cellulose, it gives the plant its shape and prevents it from bursting.
- Chloroplasts: They are sacs which contain chlorophyll which is a green pigment that traps sunlight for photosynthesis.
- Large central cell sap vacuole: This is a large room in the center of the cell, it stores sugars and salts and controls movement of water in and out of the cell.

Animal cells store sugars in glycogen form but plant cells store it as starch. Animal cells have an irregular shape but plant cells have a regular shape.

When studied at much higher magnifications with the electron microscope, the cytoplasm of animal and plant cells no longer looks like a structureless jellybut appears to be organised into a complex system ofmembranes and vacuoles. Organelles present includethe rough endoplasmic reticulum, a network offlattened cavities surrounded by a membrane, whichlinks with the nuclear membrane. The membrane holds ribosomes, giving its surface a rough appearance.Rough endoplasmic reticulum has the functionof producing, transporting and storing proteins.Ribosomes can also be found free in the cytoplasm. They build up the cell's proteins

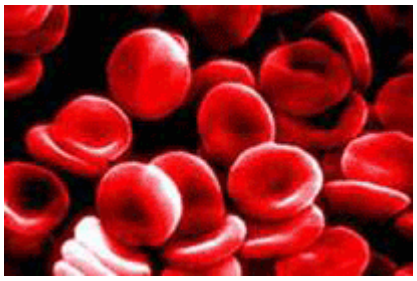


Mitochondria are tiny organelles, which may appear slipper-shaped, circular or oval when viewed in section. In three dimensions, they may be spherical,rod-like or elongated. They have an outer membraneand an inner membrane with many inward-pointingfolds. Mitochondria are most numerous in regionsof rapid chemical activity and are responsible forproducing energy from food substances through the process of aerobic respiration.

Specialised Cells:

Red Blood Cells:

Red blood cells are found in the blood of animals, its function is to transport oxygen from the lungs to all the body cells, and carbon dioxide from the body cells to the lungs.



They are adapted by four ways:

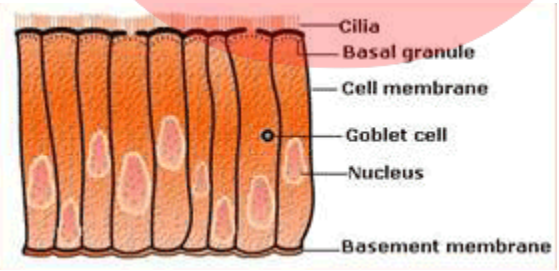
- They have a biconcave disc shape that gives it a large surface area to carry more oxygen.
- They contain a chemical called hemoglobin that combines with oxygen and carbon dioxide.
- They have no nuclease to carry more oxygen and CO2
- They are tiny enough to squeeze through capillaries.
- .

Ciliated Cells:

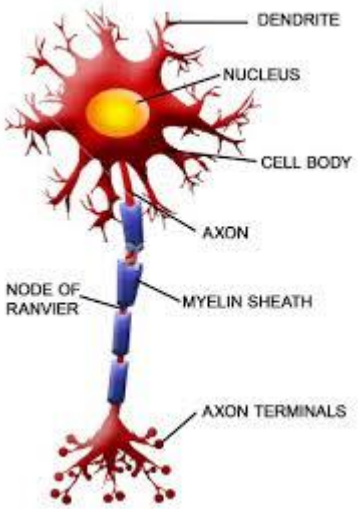
Ciliated cells are present in the trachea and bronchi of out respiratory system.

Their function is to use their cilia to move the mucus up the trachea to the throat. The mucus traps bacteria and dust particles. When it reaches the throat, mucus is swallowed to the stomach where the acid kills the bacteria.

They are adapted by the tiny hair like projections called cilia which sweeps the contaminated mucus upwards.



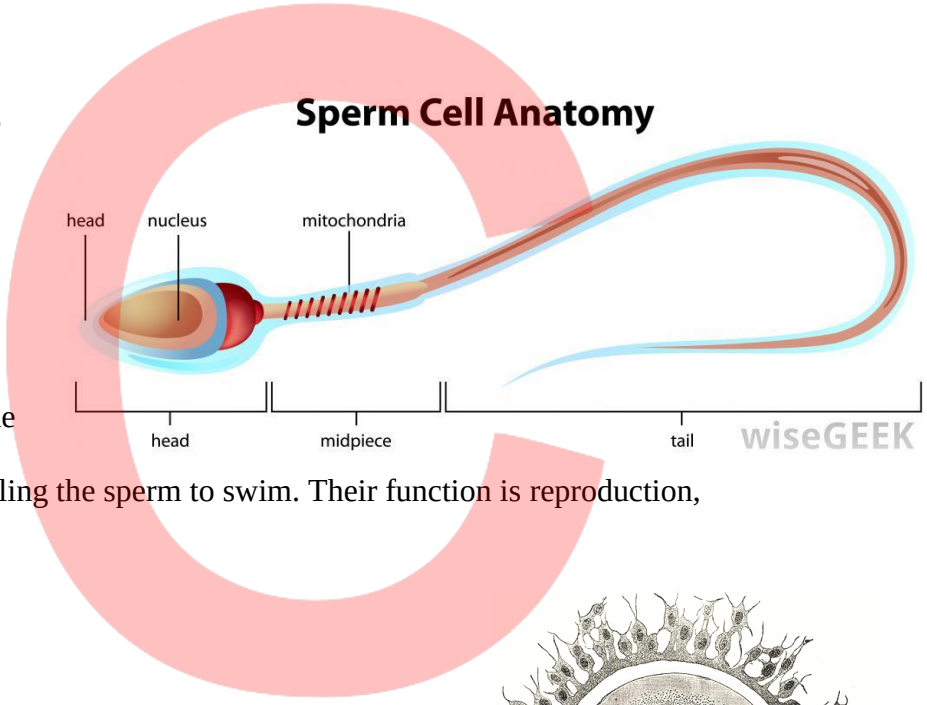
The mucus is secreted by goblet cells which are next to ciliated cells.



Nerve Cells:

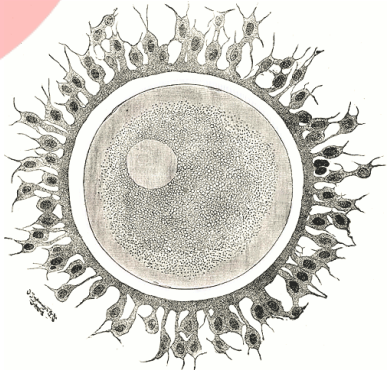
These cells are specialised for conducting electrical impulses along the fibre, to and from the brain and spinal cord. The fibres are often very long and connect distant parts ofthe body to the CNS, e.g. the foot and the spinal cord Chemical reactions cause the impulses to travel along the fibre.

Sperm Cell:



Sperm cells are male sex cells. The front of the cell is oval shaped and contains a nucleus which carries genetic information. There is a tip, called an acrosome, which secretes enzymes to digest the cells around an egg and the egg membrane. Behind this is a mid-piece which is packedwith mitochondria to provide energy for movement. The tail moveswith a whip-like action enabling the sperm to swim. Their function is reproduction, achieved by fertilising an egg cell.

Ovum:

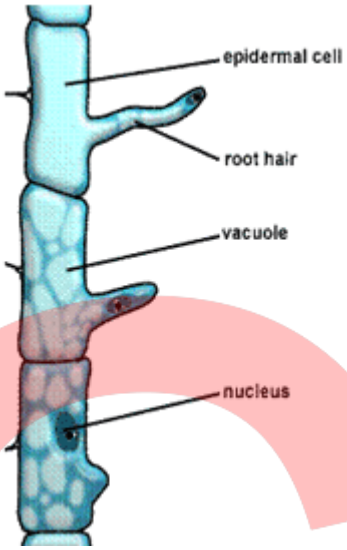


Egg cells (ova, singular: ovum) are larger than sperm cells and are spherical. They have a large amount of cytoplasm, containing yolk droplets made up of protein and fat. The nucleus carries genetic information. The function of the egg cell is reproduction.

Root Hair Cells:

These are cells situated in the roots of plants.
They contain no chloroplasts.

Their function is to absorb water (by osmosis) and minerals (by active transposrt) from the soil. And to anchor the plant in the soil.

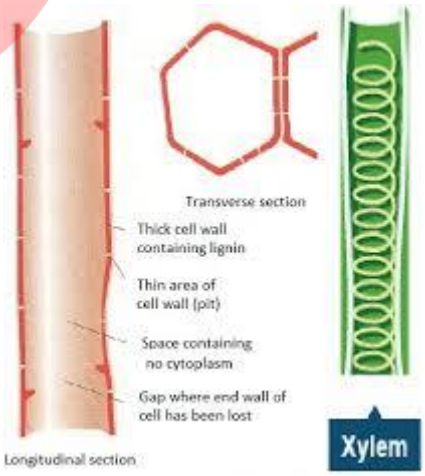


They are adapted by 3 ways.

1) They have an extension that increases the surface area for more water intake.
2) They have a large number of mitochondria for respiration to release energy needed for active transport.
3) They have concentrated vacuoles to help absorbing water by osmosis as the water potential graidient is great.

Xylem Vessels:

These are dead lignified cells that exist in the root, stem and leaves of a plant.
Their function is to transport water and minerals from the roots to the leaves and the rest of the plant through the stem. And to support the plant.



They are adapted by these ways:

They are hollow tubes to allow water and minerals to pass through them with no resistance.

They are strong and have lignified cell walls to support the plant.

Key definitions:

A **tissue** is a group of cells with similar structures, working together to perform a shared function. Examples: such as bone, nerve or muscle in animals, and epidermis and xylem in plants.

An **organ system** is a group of organs with related functions, working together to perform a body function. Examples: The stomach, heart, lungs, intestines, brain and eyes in animals and the root, stem and leaves in plants

An **organism** is formed by the organs and systems working together to produce an independent plant or animal.

Movement In And Out Of Cells

Substance move in and out of cells by three ways:

- Diffusion: The net movement of particles from a region of their higher concentration to a region of their lower concentration down a concentration gradient, as a result of random movement.
- Osmosis: The diffusion of water molecules from a region of their higher concentration (dilute solution) to a region of their lower concentration (concentrated solution) through a partially permeable membrane.
- Active Transport: The movement of ions, in and out of a cell, through a cell membrane, from a region of their lower concentration to a region of their higher concentration, against the concentration gradient, using the energy released by respiration.

Diffusion:

Diffusion is the process by which oxygen enters the blood from the lungs, and by which carbon dioxide enters the leaf from the atmosphere. There are many more examples of diffusion in biology.

Diffusion always takes place down a concentration gradient, that means that the particles that diffuse try to spread evenly in all spaces, so it moves from where it's very concentrated to where it's not concentrated.

There are some factors affecting the rate of diffusion, like the steepness of the concentration gradient. The steeper the gradient the faster the particles diffuse.

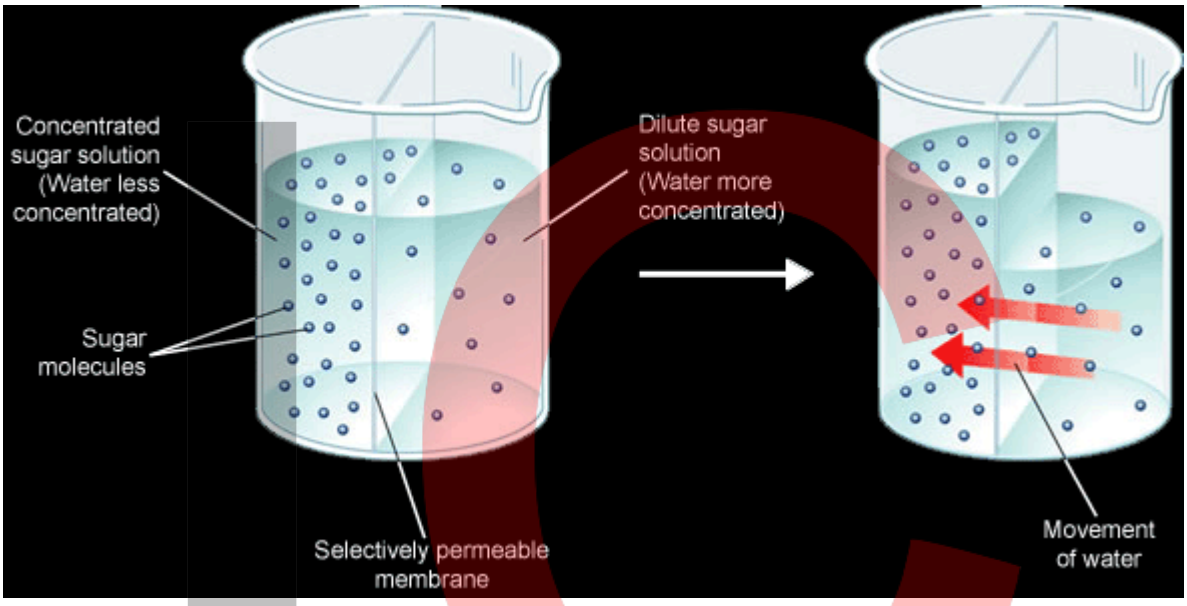
The surface area of the exchange membrane also affects the rate of diffusion. The larger the surface area of the exchange membrane the faster particles diffuse.

Thickness of exchange membrane too determines the diffusion rate, the thinner it is, the easier it will be for particles to go through it, the faster the diffusion rate.

Temperature is another factor affecting the diffusion rate, increasing the temperature will give particles more kinetic energy, making them move faster, thus increasing the rate of diffusion.

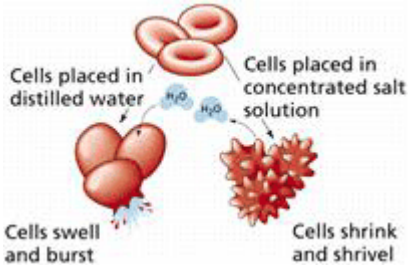
Osmosis:

Osmosis is the diffusion of water molecules. When we speak about osmosis, we don't say water concentration; instead we use the term water potential. A dilute solution means it has lots of water molecules, and a high water potential. A concentrated solution has few water molecules and low water potential. Osmosis has to take place through a partially permeable membrane (or Semi-permeable) this means that the Water molecules move from a place of their high concentration to a place of their low concentration through a membrane with pores in it that lets some molecules through but not others.

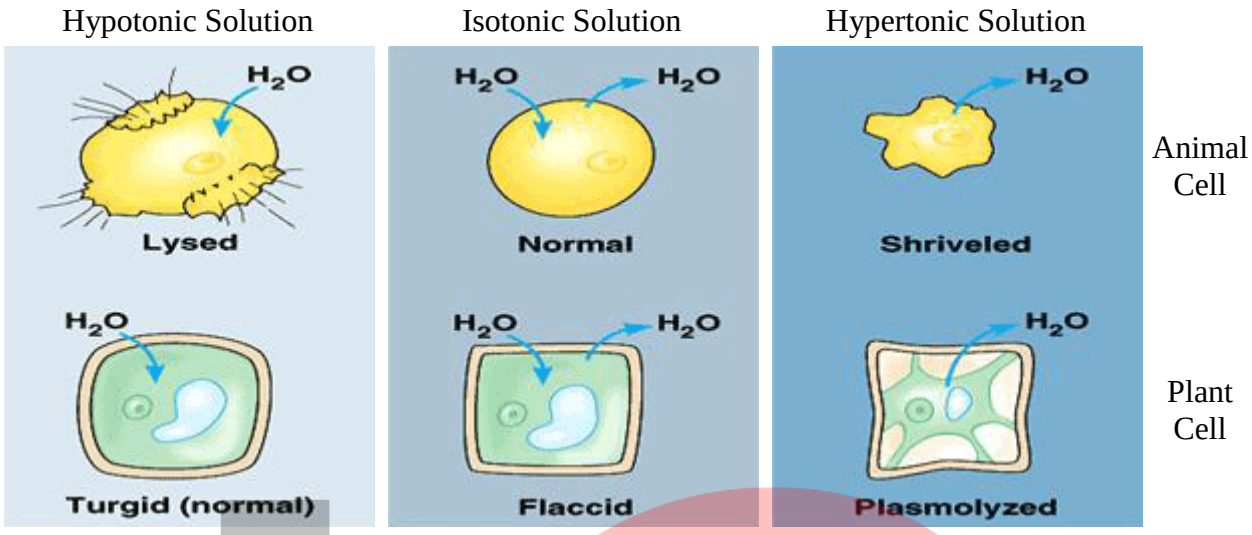


The diagram shows two solutions, one dilute and one concentrated, separated by a semi-permeable membrane. The solution on the right is diluted while the concentration on the left is concentrated. The water molecules will move from the right hand side solution where they are very concentrated to the left hand side solution where they are of a very low concentration, osmosis took place.

Osmosis happens all the time in cells. If you place an animal cell in distilled water. Osmosis will result in the water molecules moving from the distilled water where they are very concentrated to the Cell Where they are of low concentration Through the cell surface membrane. The cell becomes fat. As more Water molecules enter the cell, the cell will eventually burst and die.



If we do the opposite, and place a red blood cell in a concentrated salt solution, the water in the cell has a higher water potential that the concentrated salt solution. Water molecules will move from the cell to the salt solution causing the cell to become shrunken and shrivel as in the diagram.

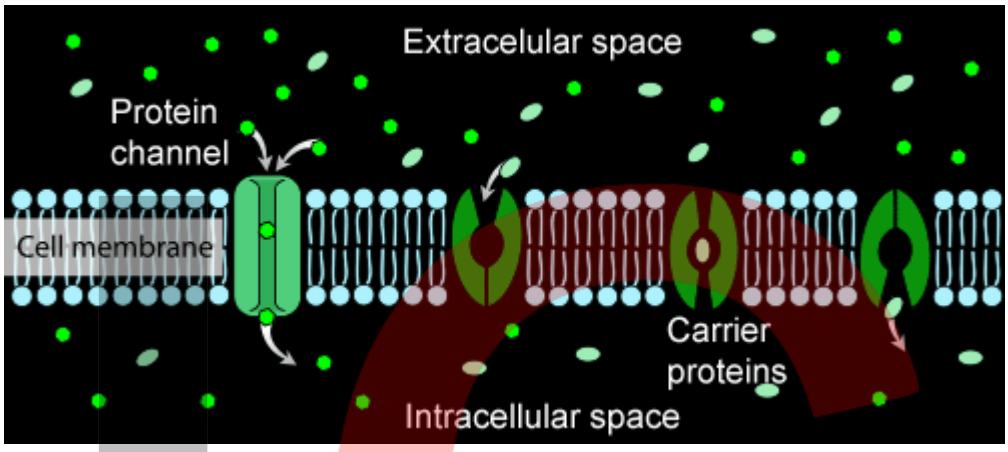


In plant cells, if a plant cell is placed in distilled water, water molecules will move from the distilled water to the cell, the cell swells up and becomes turgid but it will never burst because plant cells are surrounded by cell walls, which are made of cellulose and is elastic, it will stretch but never break, the cell becomes turgid.

If we place a plant cell in a concentrated salt solution with low water potential, water will move from the cell to the solution causing the cell to become plasmolysed as in the diagram.

Active Transport:

Active transport occurs in cells, it is basically the movement of molecules or ions from a region of their low concentration to a region of their high concentration (against the concentration gradient) using energy of respiration. Active transport occurs in living, active cells only because it needs energy, these cells usually have a structure called mitochondria which respires producing energy to be used in active transport.



Active transport happens in roots to absorb mineral salts from the soil. It also occurs in the digestive system of mammals.

If oxygen is absent, respiration won't take place, active transport will stop. Molecules are taken into the cell by protein carriers within the cell membrane.

Enzymes

What are enzymes?

Enzymes are proteins that function as a biological catalyst.
They are proteins in nature.

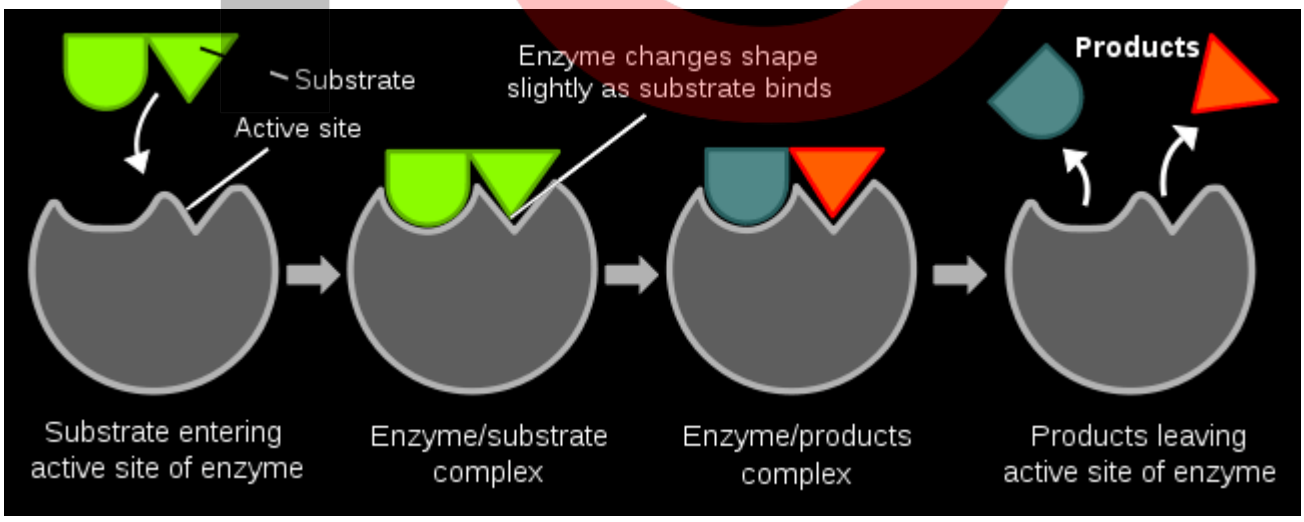
A catalyst is a substance that speeds up a chemical reaction but isn't changed by the reaction.

Hydrogen peroxide (H2O2) is a substance that decomposes into Water (H2O) and Oxygen (O2) if it is left in room temperature for a period of time. This reaction could a long time, but it could be sped up if we add a catalyst. Each catalyst can catalyse a specific substance and nothing but it. The catalyst for Hydrogen peroxide is called Manganese4 oxide. If it is added we will get water and oxygen gas in a very short time, and the manganese4 oxide could be obtained again as it was, it remains unchanged.

How Do Enzymes Work?

Enzymes work the same way as catalysts do, they can work with only one substrate and they can be used more than once.

Enzymes have a structure that is called active site. Only one substance can fit into the active site to be digested, and it is the only substrate that this particular enzyme works with.



The figure above shows the function of enzymes:

- The substrate enters the active site of the enzyme.

- The reaction takes place.
- The substrate exits the enzyme as two simpler products.

You can also think of the way enzymes work as a key and a lock, the key is the substrate and the lock is the enzyme. The key should be exactly the right shape to fit in the lock, so does the substrate to fit in the active site of the enzyme. The key could only open only one lock, and the lock could be unlocked by only that key.

Enzymes are two types, Builders and Breakers. Builder enzymes do the opposite of breaker enzymes. Breakers break large molecules into smaller simpler ones, builders combine smaller ones to make large molecules.

Breaker enzymes are used in the digestive system to break down large insoluble molecules into simpler soluble ones to be used by the body. They are also present in cells that respire to break down sugars and oxygen into carbon dioxide, water and energy. Builder enzymes are present in plants to be used in photosynthesis, the opposite of respiration, in photosynthesis, oxygen and water are combined together to form carbon dioxide and sugars.

Naming enzymes depends on the substrate they work on. For example:
The sucrase enzyme works on sucrose.
The maltase enzyme works on maltose.

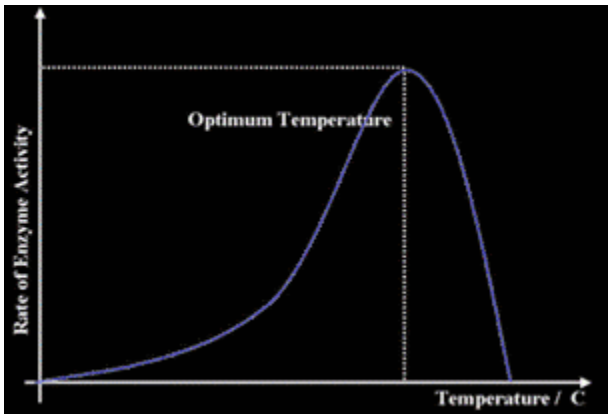
Enzymes are reusable and are only affected by the change in temperature and pH.

Affect of temperature on the enzyme's activity:

Each enzyme has an optimum temperature, this is the temperature at which the enzyme is most active, below this temperature the activity of the enzyme decreases until it becomes inactive at low temperatures, above this optimum temperature the enzyme becomes denatured and can no longer work.

At low temperatures the enzyme is and the substrate are moving very slowly and collide weakly, the enzyme is said to be inactive and doesn't work. As the temperature increases, the enzyme and substrate gain more kinetic energy and move faster colliding more, the enzyme becomes more active and the reaction takes place. When the enzyme reaches it's optimum temperature, it is in its most active mood, if the temperature crosses the optimum the enzyme begins to die and become denatured. The enzymes become denatured when the shape of their active site changes as a result of high temperature, thus the substrate cannot fit into the active site and the enzyme is useless.

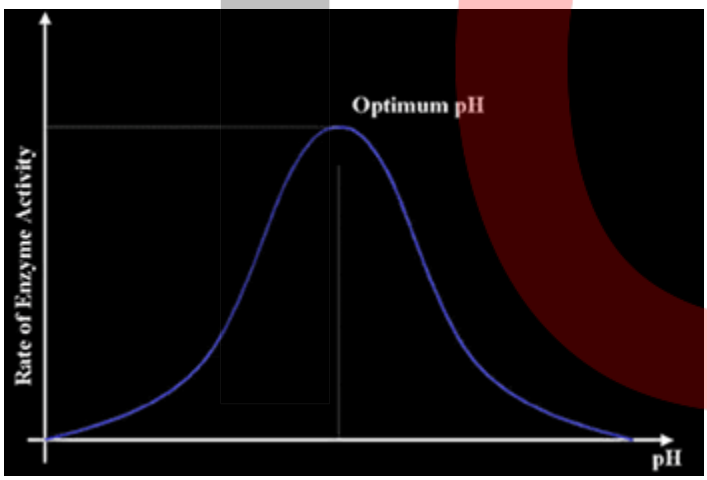
Each enzyme has its own optimum temperature, enzymes in humans have optimum temperatures of around 40 degrees. Plants have enzymes with optimum temperature of about 25 degrees.



The Effect of pH on the enzyme's activity:

As in temperature, enzymes have an optimum pH. The pH is a scale measuring the acidity or alkalinity of a substance or solution. The scale runs from 1 to 14. pH 7 is neutral, below that it is acidic and above that it is alkaline.

Each enzyme has an optimum pH, if this pH changes, the shape of the active site of the enzyme is changed, thus the substrate will not be able to fit in it, and the enzyme becomes useless.



Uses Of Enzymes In Seeds Germination:

Seeds grow into plants by germinating. Seed germination involves enzymes breaking the materials stored in the seed down to be used in growth, energy and building cells. The seed contains stored substances such as:

- Starch: Starch is broken down by amylase enzyme into maltose, maltose is then broken down by maltase enzyme into glucose which is used in respiration.
- Proteins: Proteins are broken down into amino acids by Protease enzyme, amino acids are used in building up cells and growth.
- Fats: Fats are broken down into fatty acids by lipase enzyme, they are used in making cell membranes.

In order for a seed to germinate, some conditions must be present:

- Water: To activate the enzymes.
- Oxygen: To be used for respiration.
- Warm Temperature: For providing the best conditions for enzymes to work and optimum temperature.

Uses Of Enzymes In Biological Washing Powders:

Washing powders contain detergents that help in cleaning clothes by dissolving stains in water. Some stains are made of insoluble substance, these cannot be removed by normal washing powders, instead, a biological washing powder is used.

Biological washing powders contain enzymes that break down the insoluble stain into smaller soluble substances, which are then dissolved in the water.

For example, if your shirt gets stained by egg yolk or blood, there is an enzyme called protease in the washing powder that will break down the insoluble protein into amino acids, which are dissolved in the water and sucked away. Thus the shirt becomes clean.

The best removal of stains is maintained by providing the optimum temperature for enzymes, presoaking to leave time for the enzymes to digest, putting the suitable amount of the powder.

Use Of Enzymes In Food Industry:

Enzymes are often used in the manufacturing of different foods.

Baking – Brewing

In baking, both yeast and sugar are used. Yeast cells contain enzymes that ferment sugar by anaerobic respiration producing carbon dioxide bubbles which causes the dough to rise as in the photo.

Brewing is the process of making wine or beer. In this process fermentation is Involved producing alcohol which and carbon dioxide that gives wine and beer its sparkle.

Making Juices:

In fruits such as apples or oranges, a substance called pectin holds the cells together making it
hard to squeeze them. An enzyme called pectinase digests pectin making it much easier to squeeze the fruit and to make the juice more clear than cloudy.

Enzymes Extraction:

The Enzymes used in the industries are taken from either fungi or bacteria. This takes place in a Fermenter, this is a large sterilized container with a stirrer, a pipe to add feedstock and air pipes. The following steps take place:

Bacteria are put in a fermenter and provided with nutrients that can be wastes of industry or agriculture (a source of carbon such as glucose and a source of nitrogen such as ammonia). Temperature is adjusted to 26C and pH to 6 for optimum enzyme activity for optimum growth and reproduction of bacteria and avoid harming the bacteria. Air is bubbled into the fermenter to provide oxygen for respiration. The contents of the fermenter are stirred.
Then the bacteria are left to reproduce. Then the extracelluar enzymes are obtained by filteration of the contents of fermenter and intracellular enzymes are obtained by crushing the bacteria

Enzymes And Antibiotics:

Antibiotics are powerful medicines that fight bacterial infections. Micro-organisms are used for the production of antibiotics.

Some Antibiotics, like bactericides, fight bacteria by damaging its cell walls causing them to burst and die. Other antibiotics interfere with the protein synthesis and stop the bacteria growing.

Antibiotics have no effect on human cells because human cells have no cell walls and the structures involved in protein production are different than that of bacteria.

Antibiotics are obtained from sources like:

- Fungi (Penecillum fungus): penicillin, the first antibiotic discovered is produced by Pencillium fungus.

Different types of penicillin are produced by different species of the fungus. They are chemically altered in lab to make them more effective and make them able to work with different diseases.

Steps of production:

The Fermenting tank in filled with nutrient solution of sugar (lactose) or corn liquor which contain sugars and amino acids,

1. Nutrients and minerals are added,
2. pH is adjusted around 5 or 6,
3. Temperature is adjusted about 26 degrees,
4. Air is blown through the liquid,
5. The micro-organisms are added and allowed to grow for a day or two in sterile conditions,
6. When the nutrient supply is decreased, micro-organisms secrete their antibiotics,
7. The fluid containing the antibiotic is filtered off and the antibiotic is extracted.

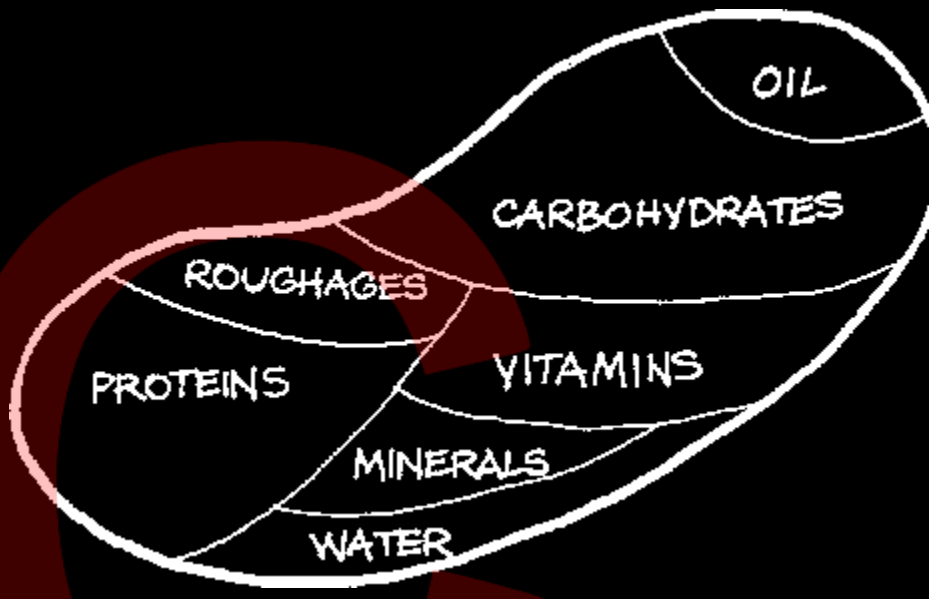
Nutrition

Nutrition is taking in nutrients which are organic substances and mineral ions, containing raw materials and energy for growth and tissue repair, absorbing and assimilating them. Nutrition is one of the characteristics of living organisms. All organisms do it, they do it to obtain energy for vital activities and raw materials needed for growth and repair.

Every Individual needs to take in a certain amount of each nutrient daily, depending on their age, size, sex and activity.

There are 7 Types of nutrients, these are:

- Carbohydrates
- Proteins
- Fats
- Vitamins
- Minerals
- Roughages
- Water



Carbohydrates, proteins, fats and vitamins are all organic substances. This means that they are made by living organisms (plants) and contain carbon atoms in their structures. Plants make organic substances from inorganic materials like carbon dioxide, water and inorganic minerals. Animals are unable to do this.

Carbohydrates:

This nutrient is an organic compound composed of carbon, hydrogen and oxygen.

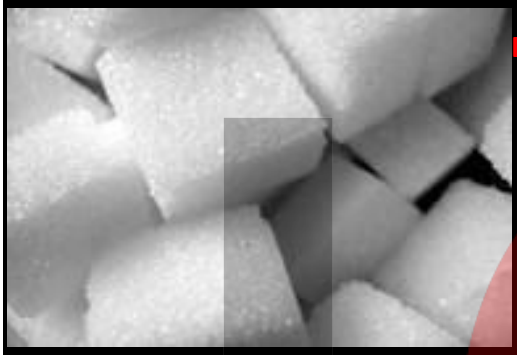
Function:

It is used as an energy resource, essential in respiration to release energy.
It is used in creating the cellulose, the substance forming cell walls of plant cells.

Carbohydrates are 3 types:

Monosaccharides:

- The smallest and simplest form
- Water soluble
- Chemical formula C6H12O6
- Examples: Glucose-Fructose-Galactose
- Sources: Fruits-Honey



Disaccharides:

- Each molecule consists of two Monosaccharide joined together
- Water soluble
- Examples: Lactose-Sucrose-Maltose
- Sources: Table sugar- Milk

Polysaccharides:

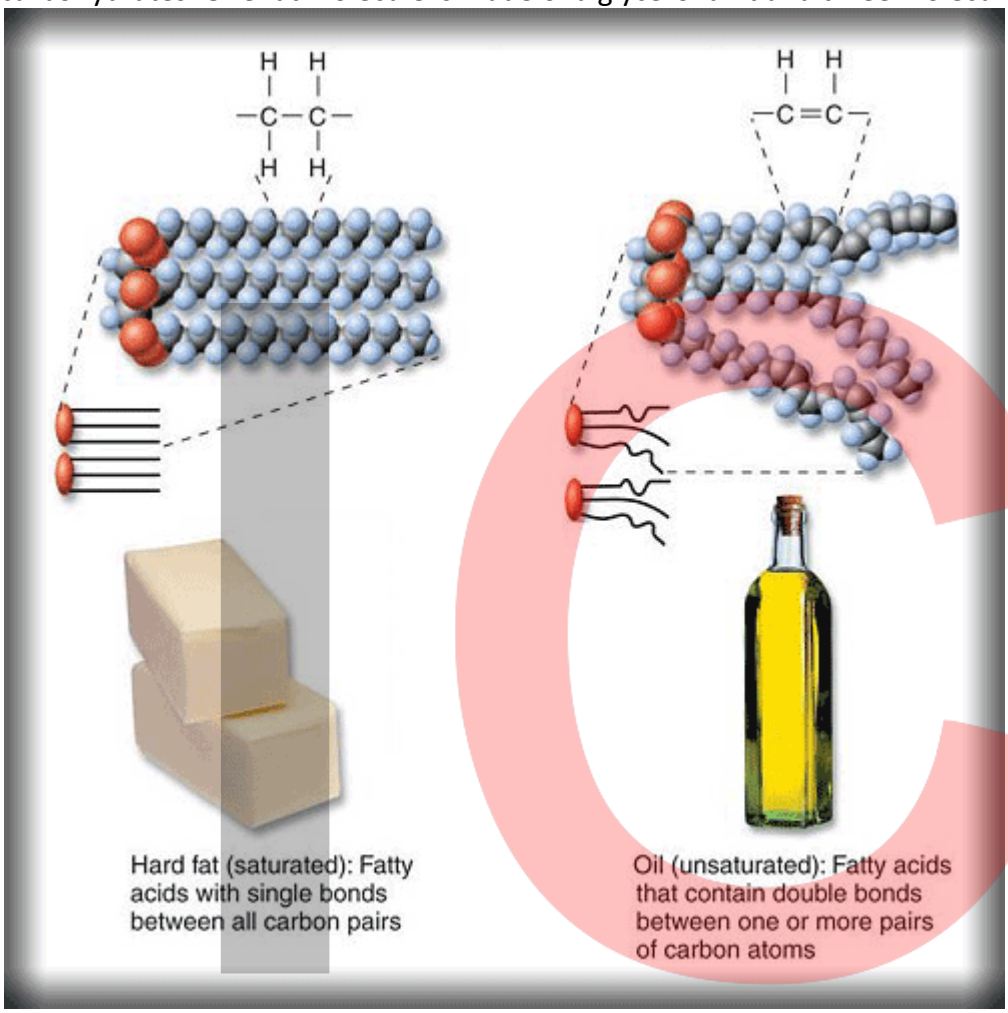
- Each molecule has many joined monosaccharide forming a long chain.
- Insoluble in water
- Examples: Starch-Glycogen-Cellulose
- Sources: Bread-Potatoes-Pasta, Cellulose in plant cells and Glycogen in livers.

Monosaccharide and Disaccharides are **sugars**, they are reducing for Benedict's reagent, except for the disaccharide sucrose, it is non-reducing.

Polysaccharides are not considered as sugars and don't have a sweet taste. Excess polysaccharides are stored in the liver and muscles.

Lipids (Fats):

These are composed of carbon, hydrogen and oxygen. But their ratios are different than that of carbohydrates. One fat molecule is made of a glycerol unit and three molecules of fatty acids.



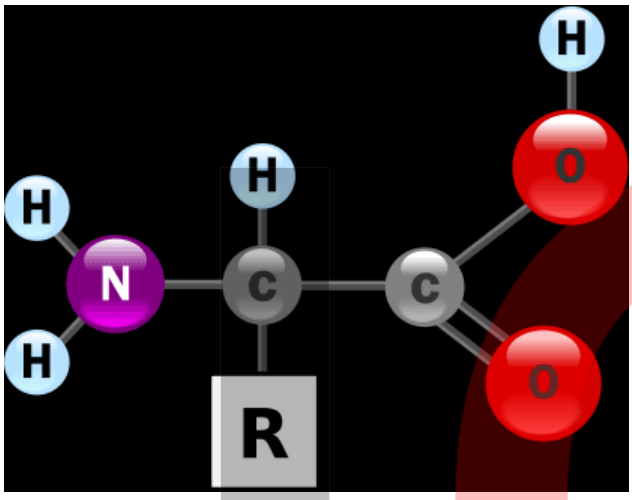
Fats are essential in a diet because they are needed to:

- Release high amounts of energy
- Make cell membranes
- Store them under the skin to insulate heat.
- Forming a layer of fats around organs to protect them from damage
- Storing energy (better than glycogen)

When fats are respired, they produce about twice as much energy as carbohydrates.

Proteins:

These are also organic compounds; they contain the elements Carbon, Hydrogen, Oxygen, Nitrogen and sometimes Phosphorus or Sulfur.
A molecule of protein is a long chain of simpler units called amino acids.



These amino acids are linked together by what's called “peptide bond”.

Types of protein:

- **Animal Protein:** It contains the most biological value because it contains all essential amino acids (Meat, Milk, Fish, Eggs etc).
- **Plant Protein:** It contains a lower biological value to humans because it contains fewer essential amino acids (Cereals, Peas, Beans etc).

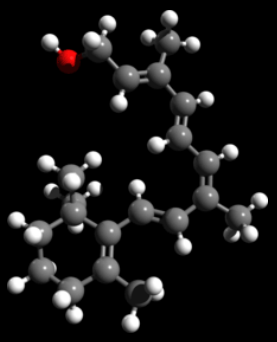
Needs of proteins:

- Making and new body cells
- Growth and repair
- Making enzymes (they are proteins in nature)
- Build up hormones
- Making antibodies

  Although proteins are needed in high amounts, the body will only absorb as much as needed, so excess protein is deaminated in the liver and excreted as urea.

Vitamins:

These are organic, soluble substances that should be present in small amount in our diets, they are very important though.



Most of the amount of vitamins in our bodies was taken in as nutrients, the body its self can only make few Vitamins, so we have to have to get them from organisms that make them, such as plants.

Each type of Vitamin helps in chemical reactions that take place in our cells.

Types Of Vitamins:

Vitamin C: This is present in most fruits and vegetables specially citrus fruits like lemon and oranges, however, it is damaged by heating so it these foods have no value of Vitamin

C if they are eaten cooked.

Vitamin C is essential for the formation of Collagen, a protein that functions as cementing layer between cells, Vitamin C also increases immunity.

Vitamin D: This is present in fish oils, egg yolk, milk and liver. Unlike Vitamin C, Vitamin D is made by animals as well as plants, this occurs when the skin is exposed to the Ultra Violet Rays of the sun. Vitamin D plays a big role in absorbing Calcium from the small intestine and depositing it in bones. So it is responsible for having healthy bones.

Minerals (Inorganic Ions):

These are a lot of types, each needed in small quantities. Iron and Calcium are the most important minerals, and they are needed in higher amounts.

Types Of Minerals:

- **Calcium:** This mineral is needed for the formation of bones and teeth as they are made of calcium salts, it also helps in blood clotting and transmission of nerve impulses. Good sources of the mineral Calcium are milk, dairy products and hard water.

- **Iron:** This mineral is needed for the formation of the red pigment haemoglobin which is essential for the transport of oxygen around the body in red blood cells. Good sources of Iron include red meat specially liver and green leafy vegetables.

Roughages (Fibres):

Although roughages are not even absorbed by the body, they are a very important nutrient in our diet. Roughages are mostly cellulose, which is the substance that makes up the cell walls of plants we eat. We humans, have no enzyme that could digest cellulose, that means that roughages enter the body from the mouth, go through the digestive system, and out through the anus unchanged. But as it goes through the digestive system, roughages take space in the gut to give the gut muscles something to push against, this process of pushing the food through the gut is called peristalsis, without roughages peristalsis is very slow and weak. Quick and strong peristalsis means that food stays in the alimentary canal for a shorter period, this prevents harmful chemicals of certain foods from changing the DNA of cells of the alimentary canal causing cancer, so roughages also helps stay away from cancer. Roughages are found in leafy vegetables.

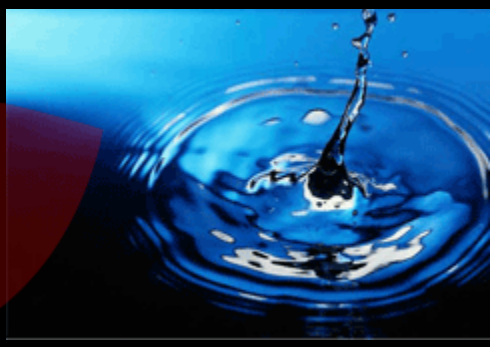
Water:

About 70% of your weight is water. Water is perhaps a very essential nutrient we should take in. The functions of water include:

As a solvent which reactants of metabolic reactions are dissolved in.

It makes up most of the blood plasma which red blood cells, nutrients, hormones and other materials are carried in.

It helps in lowering the body temperature in hot conditions by secreting it as sweat on the skin, the sweat evaporates using heat energy from the body, thus lowering the temperature.



Balanced Diet:

A diet containing all of the 7 classes of nutrients in the right amounts and proportions according to the body needs which are affected by sex, age and activity to maintain health.

Unbalanced Diet (Malnutrition):

Malnutrition is eating inadequate proportions o food. In other words, an unbalanced diet means it is rich in a nutrient and low in another, or even lacking of a substance. There are lots of effects of malnutrition, such as starvation, obesity or deficiency diseases.

Starvation:

Starvationis a severe reduction in vitamin, nutrient and energy intake. It is the most extreme form of malnutrition. In humans, prolonged starvation can cause permanent organ damage and eventually, death. The term inanition refers to the symptoms and effects of starvation. In case of starvation the body tends to feed on its own self. When the glucose level is decreased in the body, the liver breaks down fats to respire for energy, when the body is out of fats, it starts respiring proteins from the muscles to release energy. This leads to loss of weight, muscle wastage, weakness and ultimately **starvation**. Extreme slimming diets, such as those that avoid carbohydrate foods, can result in the disease anorexia nervosa.

Obesity: is the opposite of starvation. It is eating too much of every nutrient, especially carbohydrates and fats. Obesity doesn't strike alone, it brings with it several other diseases such as high blood pressure, cardiac diseases (e.g. coronary heart disease) , diabetes, stress on joints and bones leading to pain as well as other psychological issues like low self esteem and lack of confidence. To prevent obesity, you have to control your carbohydrates and fats intake and exercise regularly.

Coronary heart disease:

It can occur when the diet contains too much fat. Deposits of a fatty substance build up in the arteries, reducing the diameter of these blood vessels, including the coronary artery. Blood clots are then more likely to form. Blood supply to the heart can be reduced resulting in angina (chest pains when exercising or climbing stairs, for example) and eventually a coronary heart attack.

Another consequence of malnutrition is **deficiency diseases**.

These are results of the lack of a certain nutrient in the diet:

Scurvy : Scurvy is caused by a lack of vitamin C (ascorbic acid) in the diet. Vitamin C is present in citrus fruit such as lemons, blackcurrants, tomatoes, fresh green vegetables and potatoes. It is not unusual for people in developed countries who rely on processed food such as tinned products, rather than eating fresh produce, to suffer from scurvy. Symptoms of scurvy include bleeding under the skin, swollen and bleeding gums and poor healing of wounds.

Rickets (bow legs): is the deficiency disease of both Vitamin D and Calcium. Bones are made of calcium which Vitamin D helps in depositing in the bones, if any of both is lacking in the diet, rickets is developed

Anaemia : Lack of iron in the diet can lead to iron-deficiency anaemia, which is a decrease in the number of red blood cells. Red blood cells, when mature, have no nucleus and this limits their life to about 3 months, after which they are broken down in the liver and replaced. Most of the iron is recycled, but some is lost as a chemical called bilirubin in the faeces and needs to be replaced. Adults need to take in about 15 mg each day. Without suffiient iron, your body is unable to produce enough haemoglobin the protein in red blood cells responsible for transporting oxygen to respiring tissues. Iron is also needed by the muscles and for enzyme systems in all the body cells. The symptoms of anaemia are feeling weak, tired and irritable.

Kwashiorkor : Kwashiorkor (roughly = 'deposed child') is an example of protein–energy malnutrition (PEM) in the developing world. When a mother has her second baby, the first baby is weaned on to a starchy diet of yam, cassava or sweet potato, all of which have inadequate protein. The baby then develops symptoms of kwashiorkor (dry skin, pot-belly, changes to hair colour, weakness and irritability). Protein deficiency is not the only cause of kwashiorkor. Infection, plant toxins, digestive failure or even psychological effects may be involved. The good news, however, is that it can often be cured or prevented by an intake of protein in the form of dried skimmed milk.

Marasmus : The term 'marasmus' is derived from a Greek word, meaning decay. It is an acute form of malnutrition. The condition is due to a very poor diet with inadequate carbohydrate intake as well as a lack of protein. The incidence of marasmus increases in babies until they reach the age of 12 months. Sufferers are extremely emaciated with reduced fat and muscle tissue. Their skin is thin and hangs in folds. Marasmus is distinguished from kwashiorkor because kwashiorkor is due to lack of protein intake, while energy intake is adequate. Treatment involves provision of an energy-rich, balanced diet, but the complications of the disorder, which may include infections and dehydration, also need attention to increase chances of survival and recovery.

Special Needs:

There are certain types of people whose diets need to be different to normal ones.
Such as pregnant women, breast-feeding women or children going through puberty.

Pregnant Women:

The diet of a pregnant woman needs to be very rich of certain nutrients because she is not only feeding her self, she is feeding her baby as well. In order for the fetus to develop well, it needs extra Protein, Iron, Calcium and Vitamin D. Proteins are to develop the tissues of the fetus, Iron is to make haemoglobin and to store in the liver, while Calcium and Vitamin D are to develop the baby's bones.

Breast-Feeding Women (Lactation):

Lactation means the production of breast milk. After pregnancy, the mother breast-feeds the baby for about 6 months or more. Breast milk needs to be high in Proteins, Calcium, and Vitamins to guarantee a healthy growth for the infant.

Growing Children (Passing Puberty):

At some point, each child gets a growing spurt. This is a very high growth rate that increases the child's size and mass in a short period of time. A growing child's diet needs extra Proteins to develop cells and enzymes because their metabolic rate is higher, Calcium and Vitamin D to develop bones and Iron to make hemoglobin.

Food Tests:

Starch Test:

- Put sample in a test tube
- Add water to make it a solution
- Add iodine solution
- Is starch is present the solution changes colour from yellowish brown to Blue Black.
- If starch is not present the solution remains yellowish brown.

Reducing sugars test:

Note: This test is only applicable on all sugars (monosaccharide and disaccharide) EXCEPT FOR SUCROSE.

- Add sample to a test tube
- Add Benedict's Reagent
- Put test tube in water bath for heating
- If reducing sugars are present the solution turns from blue to yellow,orange,red (fire colours)
- If reducing sugars are not present the solution remains blue.

Proteins Test:

- Put sample in a test tube
- Add water to make a solution
- Add Buiret Reagents (NaOH and $CuSO_4$)
- If proteins are present in the solution turns Purple
- If proteins are not present the solution remains blue.

Note: Biuret Reagent is blue in colour and made of copper sulphate and a small amount of sodium hydroxide.

Fats Test:

- Add sample to a test tube
- Add ethanol
- Add water and shake well
- If fats are present the solution becomes unclear
- If fats are not present the solution remains clear

Vitamin C Test (DCPIP):

- - Keep adding lemon juice to DCPIP solution
- - Disappearance of blue: vitamin C is present
- - Few drops before blue: high concentration of vitamin C present
- - Many drops before blue: low concentration of vitamin C present

General Table:

Nutrient	Test	Reagent	Colour	Positive	Negative
Starch	Starch test	Iodine solution (a few drops)	Yellow / Brown	Blue / Black	Yellow / Brown
Reducing sugars	Benedict's	Benedict's reagent (equal to sample volume)	Blue	Red (fire)	Blue
Proteins	Biuret	Sodium hydroxide (equal to sample volume) and Copper Sulphate (a few drops)	Blue (NaOH is colourless, $CuSO_4$ is blue)	Purple	Blue
Fats	Emulsion	Ethanol/water	-	Cloudy	Clear
Vitamin C	DCPIP	DCPIP	Blue	Colourless	Blue

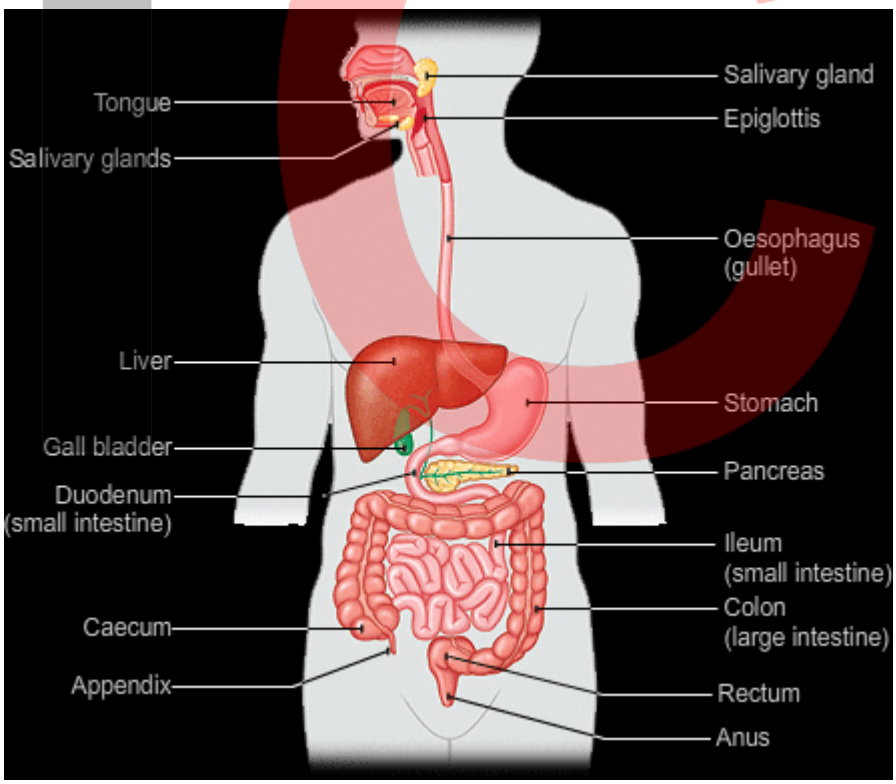
Animal Nutrition

Animals eat to grow, repair etc. They simply eat to live. In this unit we will study how animals make use of what they eat. The journey of the food from the mouth to the anus through the alimentary canal includes 5 steps:

1. Ingestion: Taking in pieces of food into the mouth
2. Digestion: The break down of large, insoluble food molecules into smaller more soluble ones by chemical and mechanical means.
3. Absorption: Taking the digested food molecules into the cells
4. Assimilation: Making use of the digested food molecules for example to release energy or grow etc.
5. Egestion: The elimination of undigested food materials through the anus

*Don't confuse egestion with excretion, excretion is to get rid of waste products of metabolism.

The alimentary canal (gut or digestive tract) is made up of several organs working together to perform all the processes mentioned above. Starting with the mouth and ending with the anus.



The Mouth:

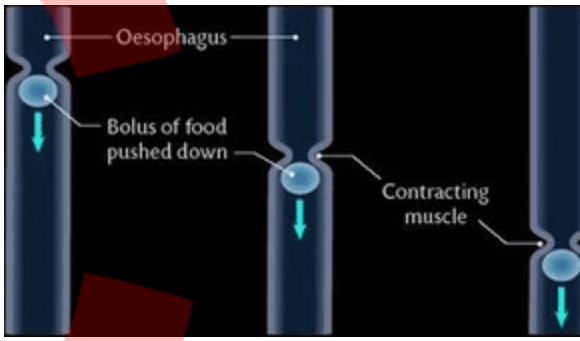
The mouth performs several functions:

Mechanical Digestion: The action of the teeth biting a small piece of food from a large one is considered mechanical digestion, the teeth also tears and grinds the food into a bolus to give it larger surface area for faster chemical digestion.

Chemical Digestion: beneath the tongue lies a salivary gland which secrets saliva into the mouth, this saliva contains water and mucus to lubricate the food bolus and amylase enzyme that breaks down starch in the food into maltose.

After this the tongue pushes the food bolus into the oesophagus.

The Oesophagus:



This is a tube that transports the food from the mouth deep into the body to the stomach.
The food is pushed downwards by the muscles in the walls of the oesophagus, this process is called Peristalsis. Muscles contract and relax creating a wavy motion to push the food down.

The Stomach:

Here the food stays for a while. The stomach is a flexible bag that performs both mechanical and chemical digestion.

Mechanical Digestion: The walls of the stomach contain muscles that contract and relax together mixing the food with the content of the stomach and turning it into liquid chyme, this process is called churning.

Chemical Digestion: The walls of the stomach also secretes a liquid called “Gastric Juice” which contains Hydrochloric acid, Mucus, and pepsin enzyme. The pepsin enzyme digests proteins into simpler polypeptides, while the hydrochloric acid is to provide optimum pH for the enzyme and the mucus is to lubricate the food and protect the walls of the stomach from the acid.

After a few hours, the sphincter which is a muscular valve opens allowing the food into the small intestine.

The Small Intestine:

The small intestine is where most digestion and absorption takes place. It is divided into two sections, duodenum and ileum. The walls of the small intestine contain several types of liquids that help in providing suitable conditions and digest the food. These liquids are:

Bile Juice: it comes from the liver, stored in the gall bladder. It is squirted along the bile duct in the duodenum. The bile works on fats only, fats are very difficult to digest because they are very insoluble, the bile contains bile salts that breaks fats into tiny droplets that float in the content of the small intestine, making it easier for the lipase to digest fats into fatty acids and glycerol, this process is called emulsification.

Pancreatic Juice: it comes from the pancreas and secreted along the pancreatic duct. It contains enzymes and sodium hydrogen carbonate, which neutralises the hydrochloric acid that was added to the food in the stomach, creating better conditions for the enzymes to work. The pancreatic juice contains the following enzymes:

- Amylase to digest starch into Maltose
- Trypsin to digest proteins to polypeptides
- Lipase to digest fats into fatty acids and glycerol

Small intestine liquid: The small intestine itself also secrets a liquid that consists of lots of enzymes to make sure carbohydrates, fats and proteins are digested to their simplest form, these enzymes are:

For carbohydrates:

- Maltase to digest maltose into glucose + glucose
- Sucrase to digest sucrose into glucose + fructose
- Lactase to digest lactose into glucose + galactose

For Fats:

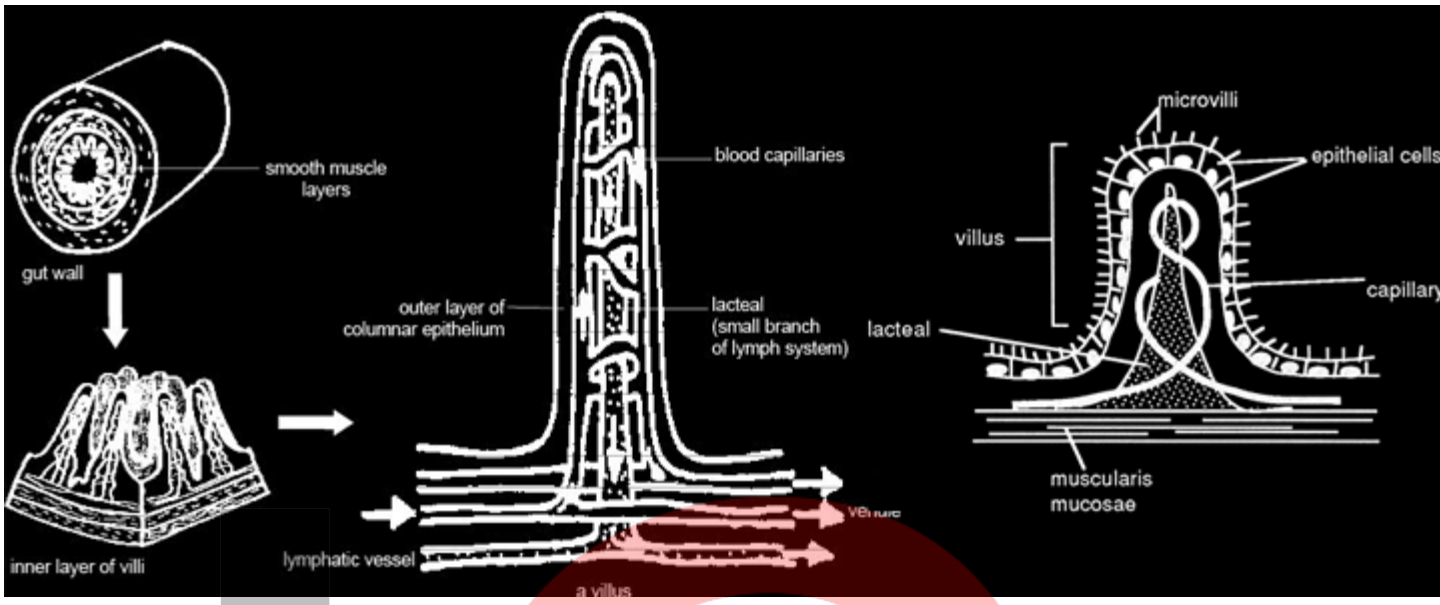
- Lipase to digest fats into fatty acids and glycerol

For proteins:

- Protease for further digestion of polypeptides to amino acids.

Absorption in small intestine:

Absorption in the small intestine takes place in the second section, the ileum. The walls of the ileum are fully adapted for absorption. The interior walls of the ileum is covered with a layer of villi, each villus is covered with another layer of micro villi.



Each villi has a branch of blood capillaries in it as well as a lacteal which is a lymph vessel, the lacteal absorbs fats and lipids with vitamins dissolved in them into The lymphatic system.

Villi and microvilli are adapted to absorption by:

- They give a very large surface area for faster diffusion of food molecules
- Each villus contains a large network of blood capillaries transporting more blood, thus faster diffusion
- Each villis is one cell thick, reducing the diffusion distance and making it faster
- Each villi contains a lacteal which absorbs fats

The Large Intestine:

By the time the food reaches the large intestine, there is not much left of it, only some water, minerals, and fibers. The water and the minerals are absorbed into the blood, while the fibers and dead cells of the alimentary canal are stored in the rectum then excreted through the anus (egestion).

Diarrhoea

Diarrhoea is the loss of watery faeces. It is sometimes caused by bacterial or viral infection, for example from food or water. Once infected, the lining of the digestive system is damaged by the pathogens, resulting in the intestines being unable to absorb fluid from the contents of the colon or too much fluid being secreted into the colon. Undigested food then moves through the large intestine too quickly, resulting in insufficient time to absorb water from it. Unless the condition is treated, dehydration can occur.

Cholera

This disease is caused by the bacterium *Vibrio cholera* which causes acute diarrhoea. Treatment involves rehydration and restoration of the salts lost (administered by injecting a carefully controlled solution into the bloodstream) and use of an antibiotic such as tetracycline to kill the bacteria.The bacteria thrive in dirty water (often that contaminated by sewage) and are transmitted when the water is drunk or used to wash food. Longterm methods of control are to dispose of human sewage safely, ensuring that drinking water is free from bacteria and preventing food from being contaminated.

How cholera causes diarrhoea

When the *Vibrio cholera* bacteria are ingested, they multiply in the small intestine and invade its epithelial cells. As the bacteria become embedded, they release toxins (poisons) which irritate the intestinal lining and lead to the secretion of large amounts of water and salts, including chloride ions. The salts decrease the osmotic potential of the gut contents, drawing more water from surrounding tissues and blood by osmosis. This makes the undigested food much more watery, leading to acute diarrhoea, and the loss of body fl uids and salt leads to dehydration and kidney failure.

Assimilation Of The Absorbed Food Molecules:

After the food molecules are absorbed from the alimentary canal, it is transported to the liver by a special blood vessel called The Hepatic Portal Vein. The liver is an organ that is considered a gland too. It carries out several jobs to “sort out” the food molecules it receives. Each type of nutrient has its own fate in the liver.

Glucose: when the absorbed glucose reaches the liver, the liver allows as much as needed by the body to pass to the circulatory system to by used for respiration or other processes. The excess glucose is converted to glycogen and stored in the liver cells, when the blood is short in glucose, glycogen will be converted back into glucose and secreted to the blood. Some glucose will also be converted to fats as an energy reserve. These functions are controlled by the Insulin and Glucagon hormones which are made in the pancreas.

Amino Acids: some amino acids will be used by the liver cells to make proteins, the rest will be allowed into the blood stream to be absorbed by the body cells which also convert it to proteins. If the body contains enough amino acids, the excess will undergo a process called Deamination, this involves the break down of amino acids into carbohydrates and amino group, which is then converted to ammonia then converted into urea, which is part of the waste product of the body, urine.

A part from sorting out food molecules, the liver performs the following jobs too:

- Dealing with old red blood cells:
  The liver changes dead red blood cells to iron and bile. Iron is stored in the liver, large amounts of iron give it the red colour and used to build up new red blood cells. The bile is stored in the gall bladder to be used in digesting food again.
- Detoxification:
  The liver breaks down toxic materials such as alcohol which damages cells to fats. Alcoholics are known to have liver diseases.
- Helps in generating heat:
  The liver contains a very large number of cells, which means a lot of metabolic reactions take place in it producing lots of energy to warm the blood.
- Making fibrinogen:
  This is a plasma protein which helps in blood clotting when the skin is cut.

Teeth:

Teeth are small, calcified, whitish structures found in the jaws (or mouths) of many vertebrates that are used to break down food.

Types of mammalian teeth:

Incisors:

They are 4 in front of each jaw.
They act like a blade to cut food(eg. To cut a bite of a sandwich) they have a (chisel-like surface).

Canines:

They are two in each jaw.
They are very pointed, in humans they are used for the same purpose as incisors.
However in carnivores they are longer and sharper and used to kill the prey.

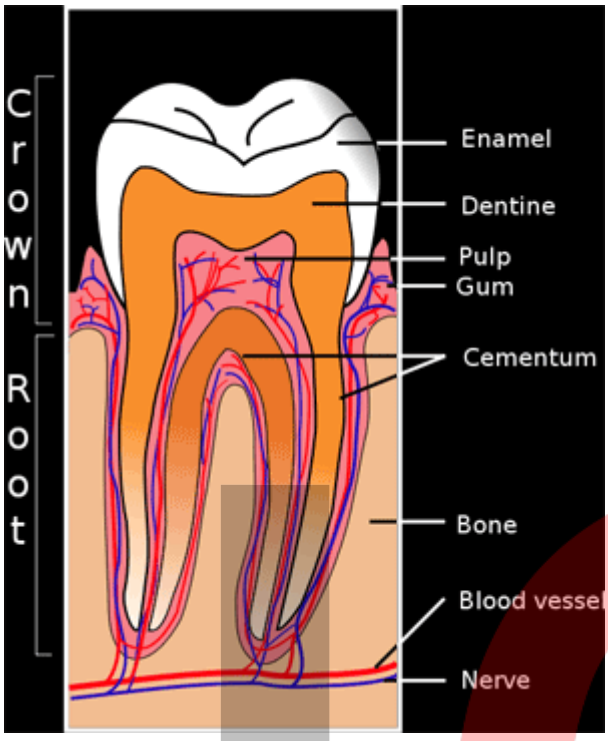
Premolars:

4 on the sides of each jaw
They are used to cut and grind food.

Molars:

They are 6 at the back of
Each jaw, 2 of them are wisdom teeth. They have the same use as Premolars.

Note: remember that we have two jaws, so 4 incisors in each jaw means that we have a total of 8 incisors in our mouth. We have 16 teeth in each jaw, 32 in the whole mouth.



The tooth is divided into two parts, the crown and the root.

Parts of the tooth:

Enamel: Made of calcium salts, it is very strong.

Dentine: It is covered by the enamel and surrounds the pulp cavity.

The pulp cavity: It contains the nerves and blood vessels.

The part of the tooth above the gum is called the crown, the part buried in the jawbone is called the root. The enamel covers the crown, the root is covered by cement. And the tooth is held in place by fibres.

Tooth Decay: when we eat, some food particles stay in our mouth. Bacteria that lives in our mouth feed on these food particles, they respire anaerobically producing lactic acid. Like any acid, lactic acid reacts with the enamel and dissolves it away reaching the dentine, here we feel the toothache.

Methods Of preventing Tooth Decay:

- Reduce sugar intake to prevent bacteria respiring
- Brush teeth to remove the plaque layer of bacteria and saliva on our teeth and neutralise mouth

- Use toothpaste or water containing fluoride because it is absorbed by the teeth and helps stopping the attack by acid
- Pay regular visits to the dentist.

Adding Fluoride To Water

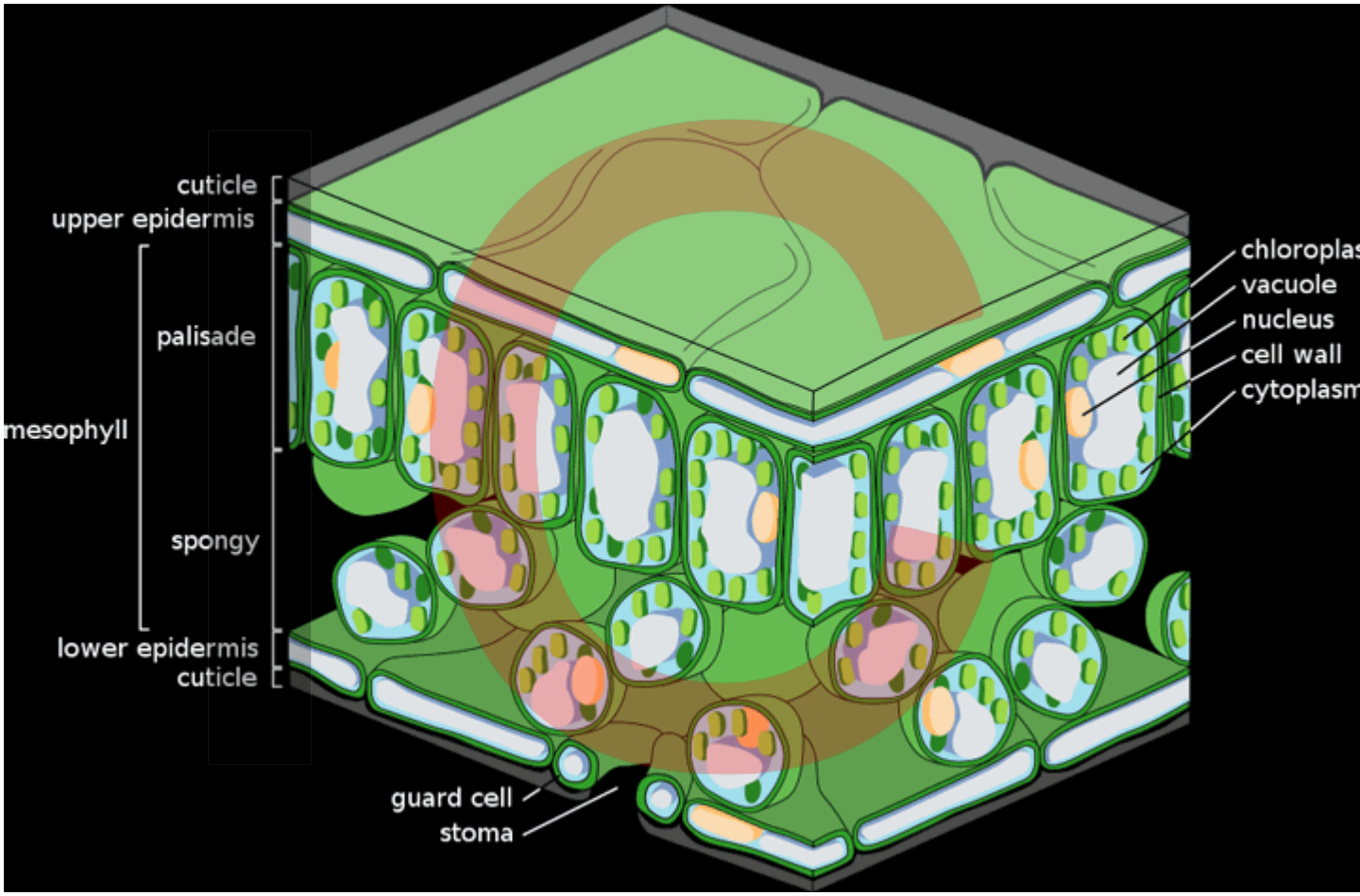
Advantages	Disadvantages
○ Suitable amounts prevent tooth decay ○ It is a cheaper method of teeth caring	• Too much causes teeth molting, illness and abdominal pain • It is expensive

•

Plant Nutrition

Plants are living organisms, they need food in order to keep living. The way they obtain their nutrients however, is completely different than that of ours. Plant make most of their nutrients by themselves, they just need 2 raw materials, these water and carbon dioxide.

The leaf of a plant is considered the kitchen of it. It is where food is made, later on you will see how the leaf is adapted to making food.



Upper Epidermis: it is a layer of cells that cover the leaf and protect it, it is covered by a layer of wax called cuticle.

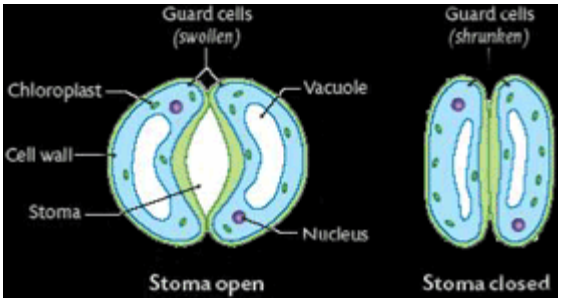
Mesophyll Layer:

- Palisade Mesophyll: a layer of palisade cells which carry out most of photosynthesis
- Spongy Mesophyll: a layer of spongy cells beneath the palisade layer, they carry out photosynthesis and store nutrients.

Vascular Bundle: it is a group of phloem and xylem vessels that transport water and minerals to and from the leaves.

Lower Epidermis:

similar to the upper epidermis, only that it contains a special type of cells called guard cells. Guard cells are a specialised type of cells that control the passage of carbon dioxide into the cell and the passage of oxygen out of the cell by opening and closing the stomata (a hole in the leaf through which gases pass) so guard cells are responsible for the gas exchange.



Photosynthesis:

Photosynthesis means "making with light". It is the process by which plants make useful glucose out of the raw materials water and carbon dioxide, using light energy from the sun.

Water is essential for photosynthesis, it is sucked up from the soil by the roots and transported up the stem to leaves where it is put into use.
Carbon dioxide, just like water is essential for photosynthesis. It moves into the leaf from the air by diffusion, through the stomata (tiny holes in the leaf).

Once carbon dioxide and water are present in the leaf, one condition for photosynthesis is needed, that is light. Palisade cells and spongy mesophyll cells are the cells where photosynthesis take place. They have structures called chloroplasts, these structures contain a green pigment named chlorophyll, this is to trap sunlight to be used in energy, a large number of chloroplasts is required for photosynthesis.

How photosynthesis happen:

- Carbon dioxide and water enter the cell
- The cell traps light energy using chloroplasts
- The energy is used to split water (H2O) into hydrogen and oxygen
- The oxygen is excreted outside the leaf to the atmosphere as a waste product
- The hydrogen reacts with carbon dioxide forming glucose.

Overall equation for the Photosynthesis

Carbon Dioxide Supply:

The carbon dioxide moves to the leaf from the atmosphere by diffusion through tiny holes in the leaf called stomata. Carbon dioxide is not present in a high concentration in air, but compared to its concentration inside the leaf, it is more in the air. This is because the cells inside the leaf are

always doing photosynthesis (at daytime), converting the carbon dioxide into the glucose quickly, thus the concentration of it inside the leaf decreases, making a concentration gradient for diffusion from the atmosphere to the leaf.

Water Supply:

The water is absorbed by the roots of the plants, then they are transported upwards through a hollow tube called the xylem vessel, till it reaches the leaf where photosynthesis takes place, it enters the leaf through holes in the xylem. Excess water leaves the cell through the stomata, this is called "transpiration"

Sunlight Supply:

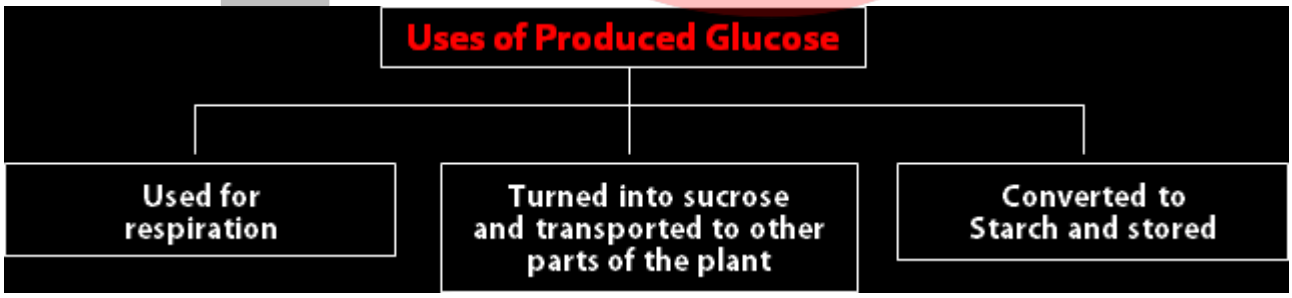
The leaves are always exposed to sunlight at daytime. The sun penetrates the transparent layers on the leaf till it reaches the mesophyll layer, where photosynthesis take place. Palisade cells are nearer to the surface of the leaf than the spongy cells, so they receive more of the light and make more photosynthesis.

Factors Needed For Photosynthesis:

- Water
- Carbon Dioxide
- Light

Factors Affecting The Rate Of Photosynthesis:

- Temperature: As temperature increases while below the optimum photosynthesis increases because enzyme activity increases but as temperature increase above the optimum the rate of photosynthesis decreases due to denaturation of enzymes.
- Concentration of carbon dioxide: the rate increases as it increases
- Light intensity: the rate increases as it increases



Adaptation of leaves for photosynthesis:

When biologists say that something is **adapted**, they mean that its structure is well suited to its function. The detailed structure of the leaf is described in the first section of this chapter and although there are wide variations in leaf shape, the following general statements apply to a great many leaves, and are
• Their broad, flat shape offers a large surface area for absorption of sunlight and carbon dioxide.
• Most leaves are thin and the carbon dioxide only has to diffuse across short distances to reach the inner cells.
• The large spaces between cells inside the leaf provide an easy passage through which carbon dioxide can diffuse.
• There are many stomata (pores) in the lower surface of the leaf. These allow the exchange of carbon dioxide and oxygen with the air outside.
• There are more chloroplasts in the upper (palisade) cells than in the lower (spongy mesophyll) cells. The palisade cells, being on the upper surface, will receive most sunlight and this will reach the chloroplasts without being absorbed by too many cell walls.
• The branching network of veins provides a good water supply to the photosynthesising cells. No cell is very far from a water-conducting vessel in one of these veins.
Although photosynthesis takes place mainly in the leaves, any part of the plant that contains chlorophyll will photosynthesise. Many plants have green stems in which photosynthesis takes place.

Plants at night:

At night, the plant performs several process to convert the stored starch into many useful nutrients like:

- Sugars for respiration
- Cellulose and proteins for making cells
- Vitamins to help in energy action
- Fats as a long term storage material
- Remaining starch is temporarily stored.

Mechanism of Guard Cells:

At daytime, the guard cells open the stomata to allow gaseous exchange, this occurs according to the following steps:

- Sunlight increases the potassium concentration in the vacuoles of the guard cells, the water potential decreases making a gradient between the guard cells and the surround epidermal cells,
- Water moves by osmosis into the guard cells from the epidermal cells,
- The water raises the pressure inside the guard cells,
- The cell wall adjacent to the stomata is thicker and less stretchable then the cell wall on the other side,
- The pressure expand the whole cell except for the inner cell wall (adjacent to the stomata) creating a curve and a pore between the two guard cells,
- The stoma opens.

At night however, the mechanism is opposite:

- Potassium level decreases in the vacuole of the guard cells,
- Water potential increases in the cell and water diffuses out of it,
- The guard cells straighten up because of low pressure closing the stoma.

Mineral Requirements:

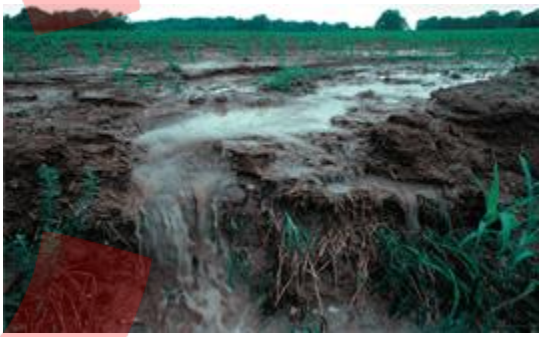
The plant is also in need for mineral ions to control chemical activities, grow, and produce materials. The most important minerals are:

- Mg^{+2} (Magnesium ions): they are important for the production of the green pigment chlorophyll. Lack of it results in lack of photosynthesis and wilting of the leaves,
- Nitrates: these are the sources of nitrogen, they are required to make amino acids and proteins by combining with glucose. Lack of it results in deformation of the plant structure making it small and weak.

Both mineral ions are absorbed from the soil.

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. But there are disadvantages of fertilisers, such as:



- Excess minerals and chemical can enter a nearby river polluting it and creating a layer of green algae on the surface of it, causing lack of light in the river, thus preventing the aqua plants photosynthesizing.
- When living organisms in the river or lake die, decomposers such as bacteria multiply and decay, respire using oxygen. Eutrophication takes place eventually.

Green House:

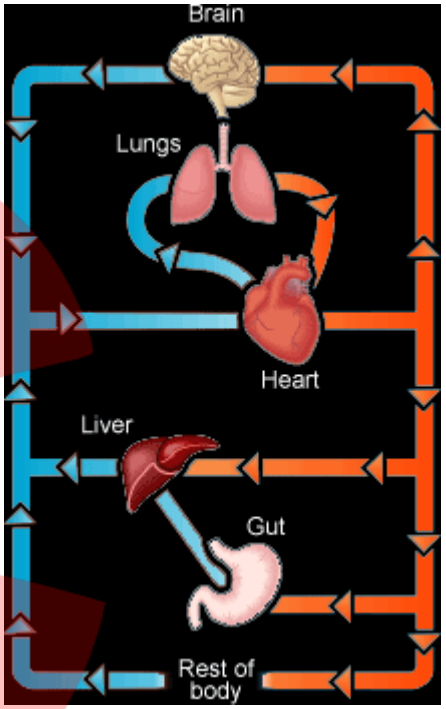
A green house is a placed covered by transparent polythene. In green houses, the limiting factors of photosynthesis are eliminated, and the plants are provided the most suitable conditions for a healthy, rapid growth.

The soil in green houses is fertilised and very rich in mineral ions, assuring healthy, large yields. More carbon dioxide is supplied to the crops for faster photosynthesis. The polythene walls and ceiling allow heat waves and light rays only to enter and prevent harmful waves, thus providing a high light intensity and optimum temperature, sometimes a heating system is used too. A watering system is also present. The disadvantages of green houses are that it is too small to give a large yield and that it is expensive.

Transport In Humans

The human transport system is a system of tubes with a pump and valves to ensure one way blood flow. We need a transport system to deliver oxygen, nutrients and other substances to all our body cells, and take away waste products from them.

The oxygenated blood (high in oxygen, red in color) comes to the heart from the lungs in the pulmonary vein; the heart pumps it to the aorta (an artery) to the rest of the body. The deoxygenated blood returns to the heart from the body in the vena cava (a vein), the heart pumps is to the lungs to get rid of the carbon dioxide.



- Oxygenated Blood: Red color, high oxygen low Carbon dioxide.
- Deoxygenated Blood: Blue color, low oxygen high Carbon dioxide.

Did you notice that during one circulation, the blood went through the heart twice, this is why we call it double circulation.

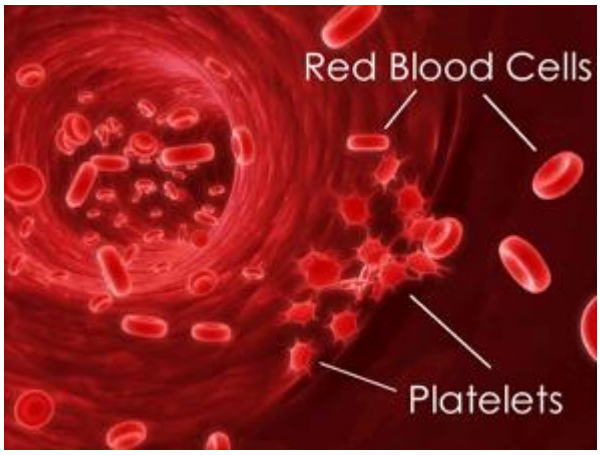
When the blood is flowing away from the heart, it has a very high pressure, when it is flowing towards the heart it has a lower pressure.

Single circulation of fish

Fish have the simplest circulatory system of all the vertebrates. A heart, consisting of one blood collecting chamber (the atrium) and one blood-ejection chamber (the ventricle), sends blood to the gills where it is oxygenated. The blood then flows to all the parts of the body before returning to the heart.This is known as a **single circulation** because the blood goes through the heart once for each complete circulation of the body. However, as the blood passes through capillaries in the gills, blood pressure is lost, but the blood still needs to circulate through other organs of the body before returning to the heart to increase blood pressure. This makes the fish circulatory system inefficient.

The Blood:

The blood is a fluid consisting of several types of cells floating in a liquid called plasma.



Red Blood Cells:

These are one of the smallest cells in your body, they are round with a dent in the middle, we call this shape a Biconcave disc.

The function of the red blood cells is to transport oxygen from the lungs to the body cells. A red protein called Haemoglobin, when the blood reaches the lungs, oxygen diffuses from the alveoli to the red blood cells and combines with haemoglobin forming an unstable compound called oxyhaemoglobin. When the blood reaches the body cells, the oxyhaemoglobin is easily split into oxygen and haemoglobin again, the oxygen diffuses through the blood plasma to the cells.

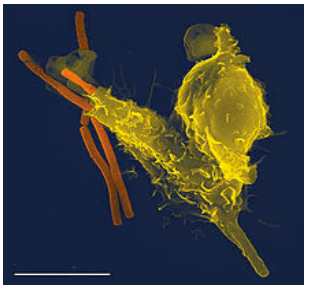
Red blood cells are fully adapted to their function by the following characteristics:

- Biconcave disc shape gives it large surface area to carry more oxygen
- Haemoglobin to combine with oxygen
- No nucleus that takes up space.

White Blood Cells:

White blood cells are one of the substances floating in the blood plasma. They are completely different in function than red blood cells. White blood cells are part of the Immune System, they play a big role in protecting the body by killing bacteria which cause disease, also known as pathogens. White blood cells can be distinguished from red blood cells easily because they are much bigger, with a nucleus, and present in fewer amounts.

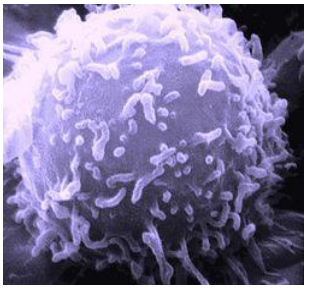
Types Of White Blood Cells:



Phagocytes:

They kill bacteria by engulfing them, taking them in the cell then kill them by digesting them using enzymes, this process is called phagocytosis.
Most white blood cells are the phagocyte type.

Lymphocytes:



Unlike phagocytes, lymphocytes have a large nucleus. They are produced in the lymph nodes (in the lymphatic system). Lymphocytes kill bacteria by secreting antibodies and antitoxins which kill the pathogens directly or make them easier to kill. Each pathogen could be killed by a certain type of antibody

The Platelets:

Platelets are tiny cell fragments that prevent bleeding when the skin is cut, and stops bacteria from entering our systems through the wound. This works by blood clotting, when the skin is cut, some reactions take place that results in platelets producing a protein, this protein will change the fibrinogen (another soluble protein in the plasma) to insoluble fibrin. The fibrin forms long fibres that clot together blocking the cut, thus preventing any bleeding, this is called blood clotting.

Blood Plasma:

This makes up most of the blood. It is mostly water with some substances dissolved in it, these include carbon dioxide, hormones, food nutrients, urea and other waste products. The blood plasma transports substances from one place to another.

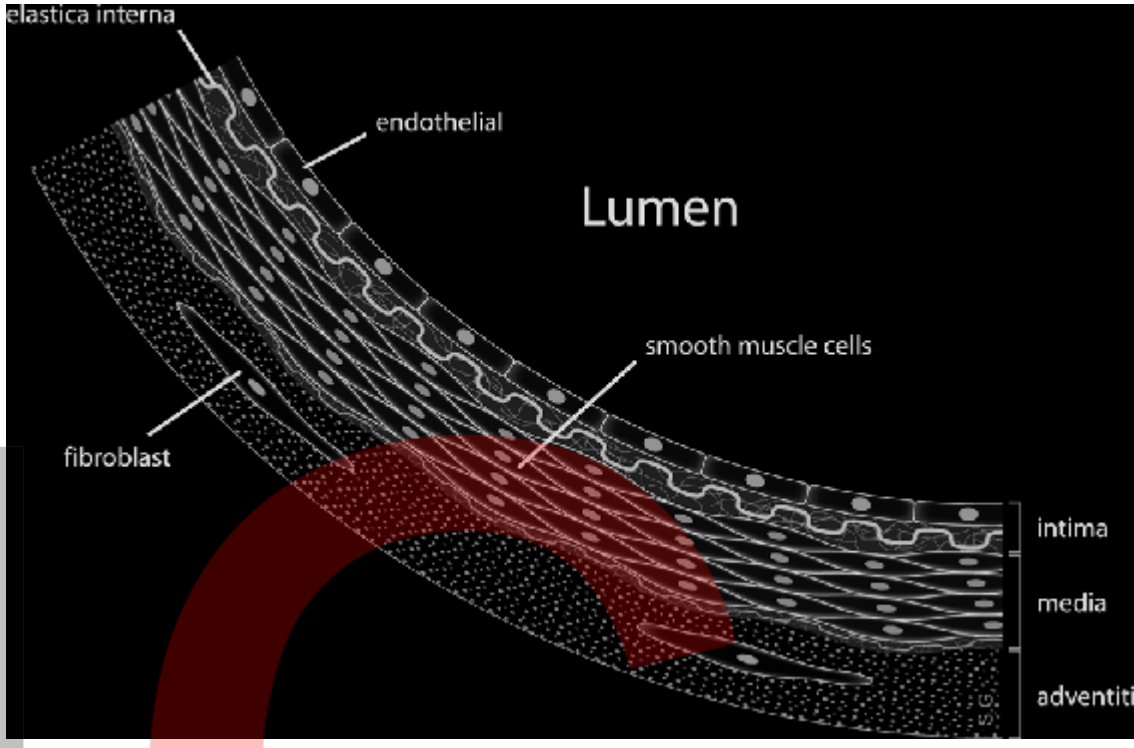
Functions of the blood:

- 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.

Blood Vessels (Vascular System):

This is a number tubes carrying blood away from and to the heart and other organs. The main types are Arteries, Veins and Capillaries.

Arteries:



Their function is to transport blood away from the heart to the lungs or other body organs.

The blood in the arteries always has a high pressure. The heart pumps the blood quickly into the arteries, resulting in the pressure, each time the ventricle of the heart contracts, the pressure in arteries increase, when the ventricle relaxes, the pressure falls. The lumen of arteries is also very narrow, adding to the pressure.

The structure is simple, beside the narrow lumen, the arteries have a strong thick wall to withstand the pressure. Their walls are also elastic and stretchable.

Brief description of characteristics of arteries:

- Transporting blood away from the heart
- Always in a high pressure
- Strong but stretchable walls
- Narrow lumen.

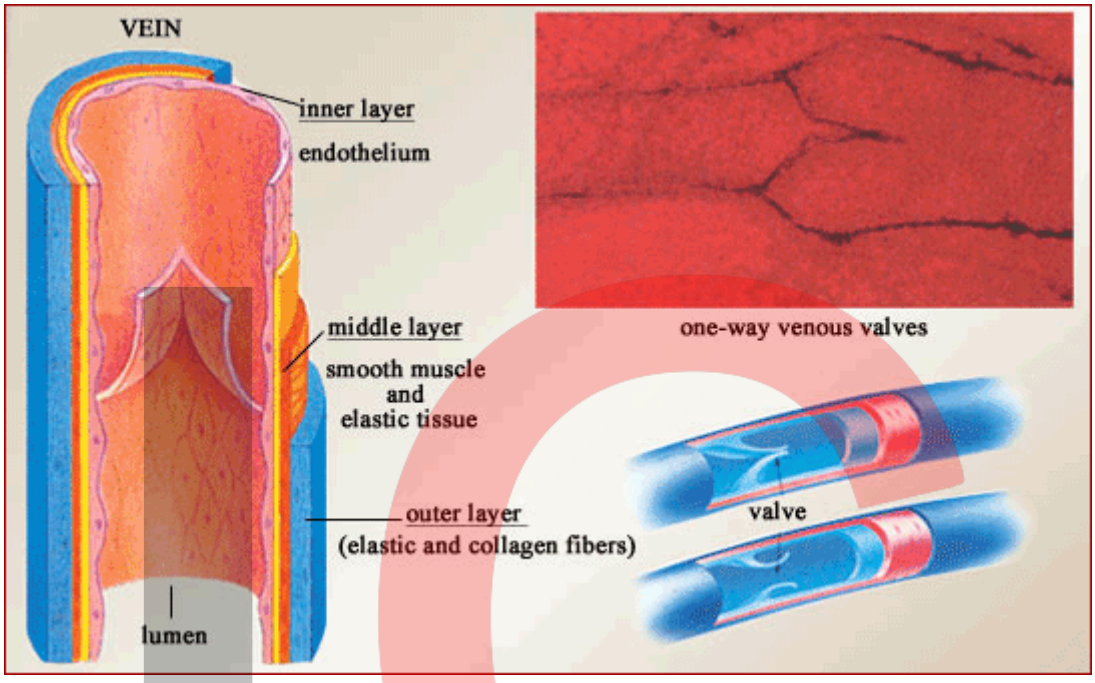
Veins:

Their function is to transport blood to the heart from the body.

The veins always always have a low blood pressure because by the time the blood with high pressure reaches the veins, it loses most of the pressure. This means that blood flows very slowly in veins, to help this, veins lie between muscles so that the blood is squeezed when the muscles contract.

They have a simple structure. Because they have a low pressure, they don't need strong, thick walls like the artery, instead they have thin less elastic walls. Their lumen is much wider too.

Veins have a unique feature, that is valves. Because blood in veins flows slowly with a low pressure, there is a risk of a backflow, specially in veins that move blood upwards against gravity, like the ones in the leg. The valves ensure that the blood is always flowing in the direction of the heart. When the muscles squeeze the blood, the valves are open the let blood through, when muscles relax, valves close to prevent a backflow.



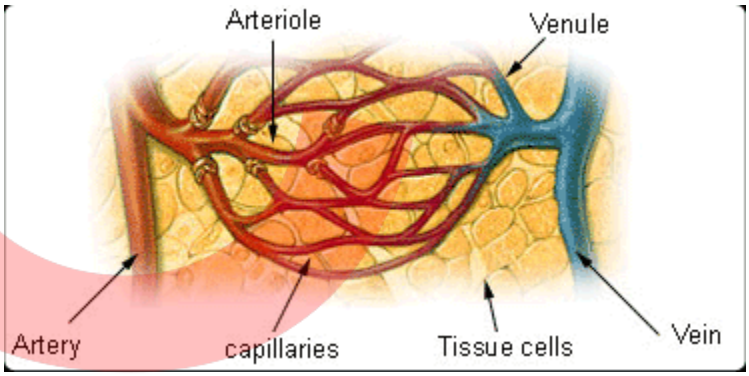
Brief description of characteristics of veins:

- They carry blood to the heart
- Always in a low pressure
- Thin less elastic walls
- Wide lumen
- Valves present.

Arteries	Veins
• blood flows away from the heart	• blood flows towards the heart
• possess thick elastic walls	• possess thin, not very elastic walls
• carry oxygenated blood except pulmonary arteries	• carry deoxygenated blood except pulmonary vein
• do not possess valves except in the aorta	• have valves to prevent back-flow of blood
• arteries are deeper in the flesh than veins	• veins are nearer the surface of the skin than arteries
• pulse is detectable	• pulse is usually not detectable
• have narrow lumen	• have wider lumen

Blood Capillaries:

Blood capillaries are the smallest blood vessels in our systems. Their function is to get blood from the arteries as close as possible to the tissues in order to exchange materials with the cells, and to link arteries with veins.



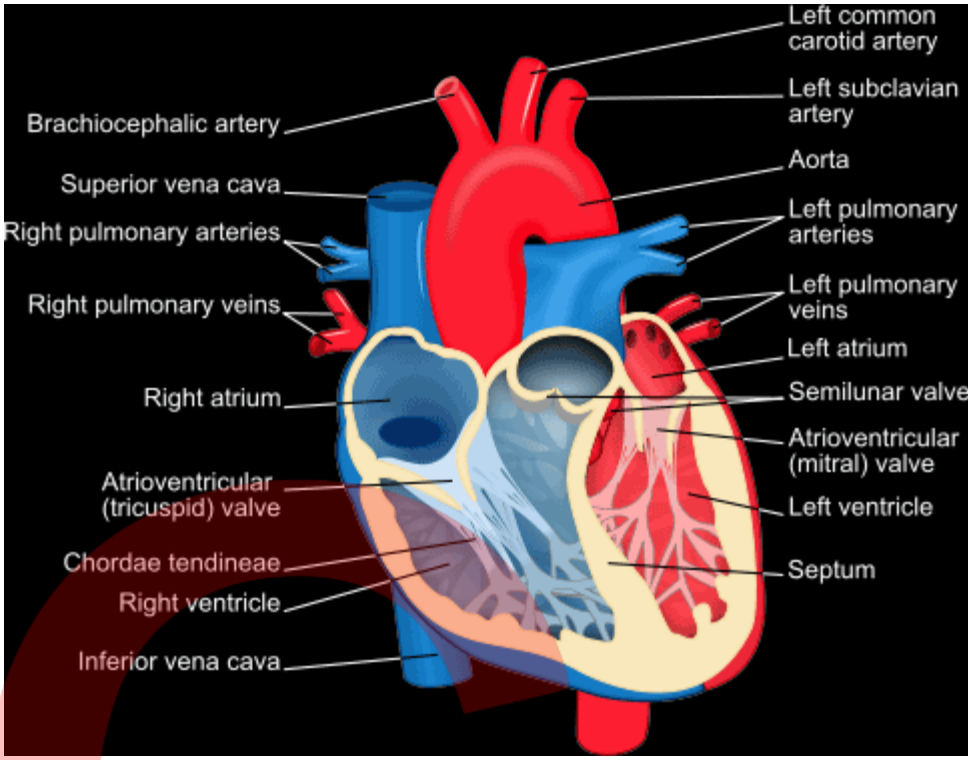
When arteries come near and organ or a tissue, it divides into arterioles, these arterioles divide more into several blood capillaries that go through the tissue, this is when the exchange of oxygen and food nutrients with carbon dioxide and waste products such as urea take place by diffusion.

ll adapted to their jobs. They are one cell thick to reduce the diffusion distance of materials for faster diffusion. They also have pores in their walls between the cells, to allow the plasma to get out of the blood and become tissue fluid.

The Heart:

The heart is a pumping organ that is responsible for the movement of blood around the body. The function of the heart is to give the blood a push, keeping it flowing around the body all the time. That is why the heart is constantly working, if it stops for a minute, the other organs will not receive any oxygen or nutrients, thus the body fails and the person dies. The heart is located in the chest, the thoriac cavity between both lungs.

Structure:



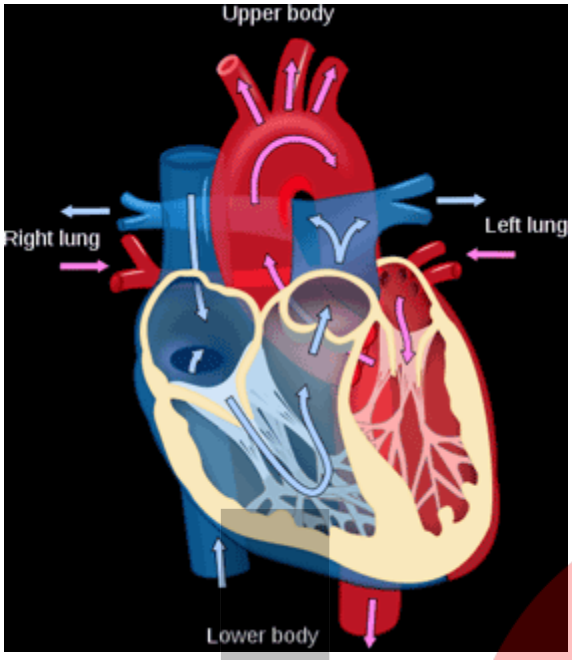
The heart is hollow, it has 4 chambers. Two of them are atria and two are ventricles. One of each of these on each side. When looking at the diagram of a heart, notice that your right is the left side of the heart, and your left is the heart's right, as if you are looking at your own heart on a mirror.

The sides of the heart are separated by a wall called septum. Each side contains an atrium (at the top) and a ventricle (at the bottom), there is a valve between the atrium and the ventricle in each side, it is called bicuspid valve in the left side and tricuspid valve in the right side. There are several blood vessels associated with the heart, these are:

- The Pulmonary vein, it transports oxygenated blood from the lungs to the right atrium.
- The Aorta, which is the biggest artery in the body, it transports oxygenated blood from the heart to the rest of the body.
- The Vena Cava, the biggest vein in the body, it transports deoxygenated blood from the whole body to the heart.
- The pulmonary artery, it transports deoxygenated blood from the heart to the lungs.

Note that blood vessels entering the heart are veins, and the ones leaving the heart are arteries. The left side of the heart always contains oxygenated blood because it receives blood fresh from the lungs and pumps it to the body, the right side always contains deoxygenated blood because it receives is from the body. You can memorise this by the word LORD:

Left Oxygenated – Right Deoxygenated



The heart receives blood from the lungs at the left atrium and pumps it to the body from the left ventricle, then it receives it again from the body at the right atrium and pumps it to the lungs from the right ventricle. The red shows oxygenated blood and the blue shows deoxygenated blood.

Notice that the walls around the left ventricle are much thicker than the ones in the right ventricle. The reason for this is that because the left ventricle pumps blood to the whole body, so blood will travel a long distance, so it needs lots of muscles to contract and pump the blood more strongly.

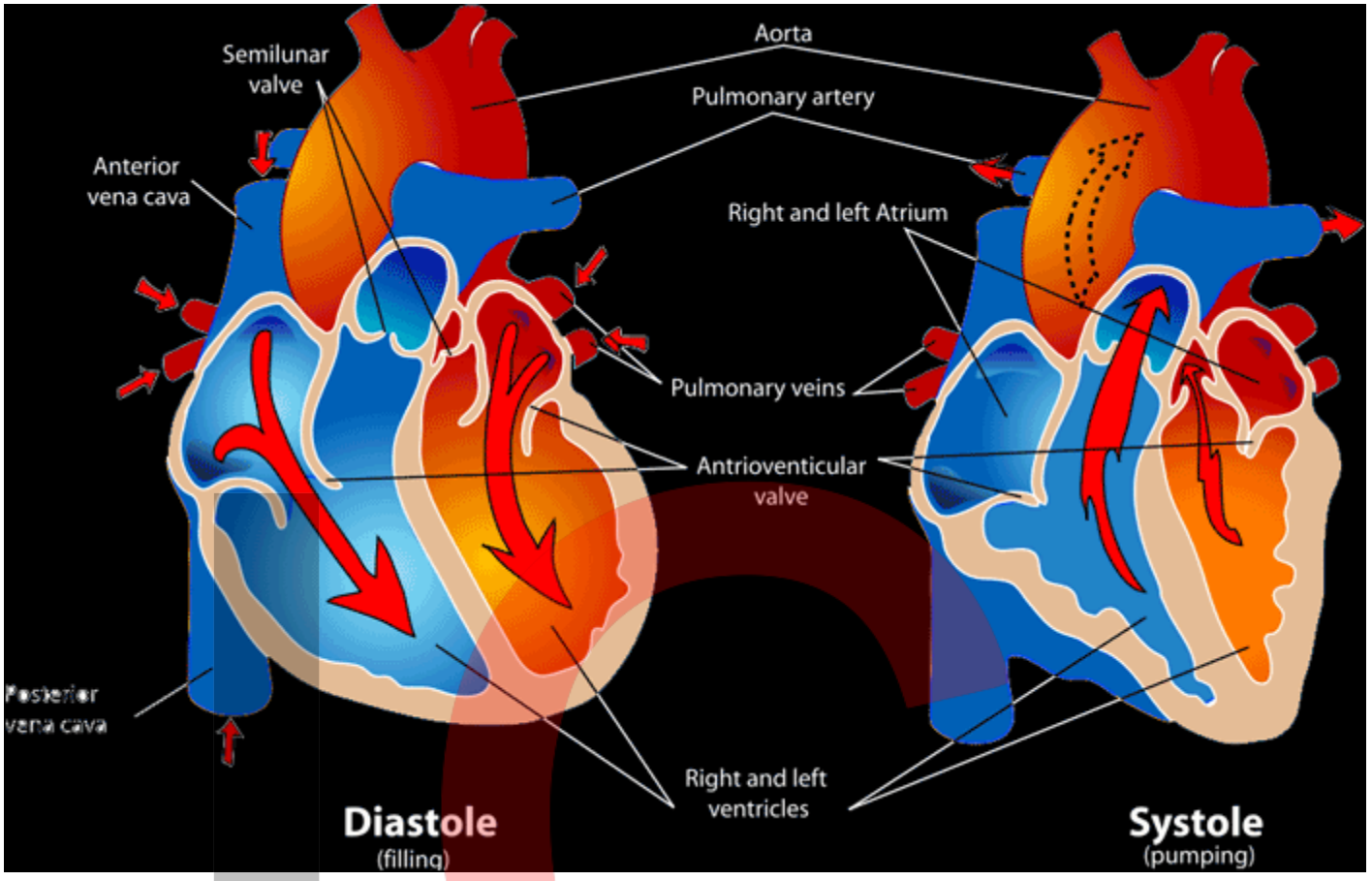
However, the right ventricle pumps blood the lungs which are very close to heart, the blood does not need to be pumped very strongly.

Mechanism of the heart:

When the heart is being filled with blood (whether from the body or the lungs), this is called the diastole. When the heart is pumping the blood out of it (whether to the body or to the lungs), it is called the systole.

During diastole, the heart is getting filled with blood, the blood enters the atria first, the atria contract to force blood into the ventricles, both tricuspid and bicuspid valves are open to allow blood into the ventricles and the semilunar valves are shut. Once the ventricles get filled with blood, it is systole, the bicuspid and tricuspid valves get shut and semilunar valves are open, the ventricles contract strongly forcing the blood into the Aorta or pulmonary artery.

During diastole the semilunar valves are shut to keep the blood out of the arteries. During systole the tricuspid and bicuspid valves are closed, to prevent blood from flowing back into the atria when it is pumped. The tricuspid and bicuspid valves are kept fixed by fibres called tendons, they prevent the valves from opening in the opposite direction, allowing backflow.

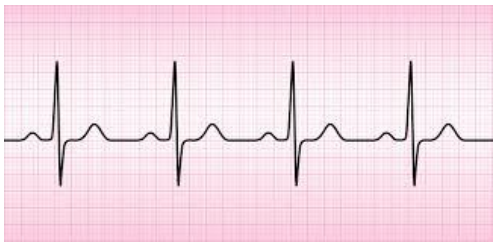


The tendons also control the opening and closing of the cuspid valves, when the tendons are loose, the valves are open. When the tendons are tightened the valves close.

	Diastole	Systole
Ventricles:	Relax	Contract
Atria:	Contract	Relax
Cuspid Valves:	Open	Close
Tendons:	Loose	Tightened
Semilunar Valves:	Close	Open

If you listen to your heartbeat, you will hear two sounds, one low and one high. These are results of the systole and diastole. They are the sounds of the cardiac valves opening and shutting.

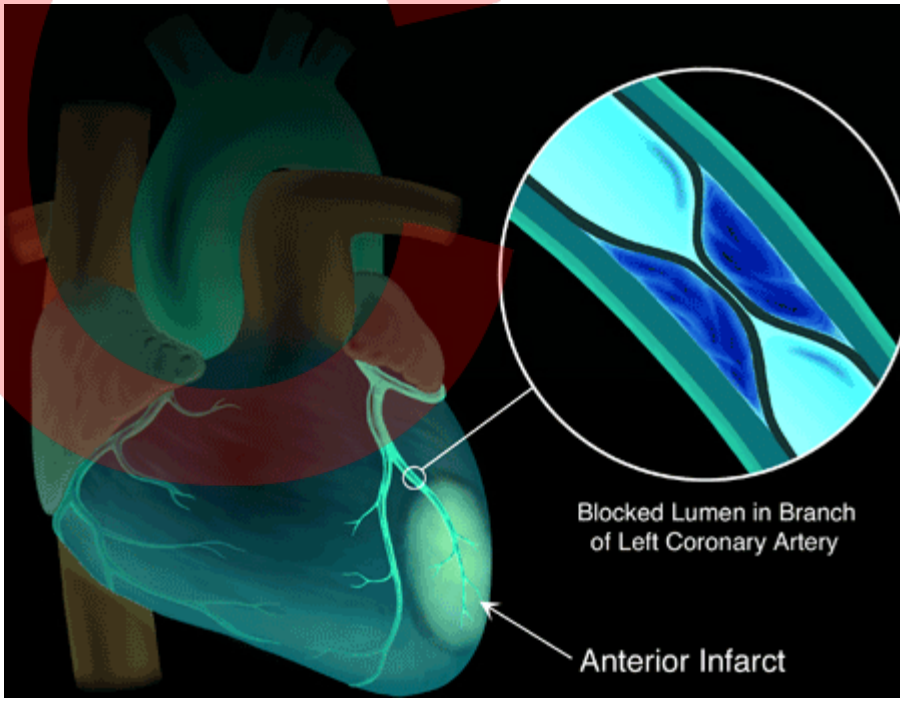
ECGs :



An ECG is an **electrocardiogram**. To obtain an ECG, electrodes, attached to an ECG recording machine, are stuck onto the surface of the skin on the arms, legs and chest . Electrical activity associated with heartbeat is then monitored and viewed on a computer screen or printed out . Any irregularity in the trace can be used to diagnose heart problems.

Coronary Heart Disease (CHD):

The heart, like any other organ, needs a supply of blood containing oxygen and nutrients. In fact, the heart needs a higher amount of blood supply than any other organ because it is working all the time, and contains a lot of muscles. The coronary arteries are those which supply the heart tissues with blood, they branch from the aorta. CHD develops when cholesterol layers build on the walls of the coronary arteries, partially blocking the path of blood, thus this tissue of the heart is not supplied with oxygen nor nutrients, so it stops working properly. If it is not treated at this age, a blood clot may form near the partially blocked area, completely blocking the artery, when this happens, the blood cannot function anymore, a heart attack occurs, which is extremely fatal.



The causes of CHD are mostly in the diet. A diet with lots of fats, increases the chance of cholesterol building up on the walls of the artery, causing CHD, Same thing with salts. Smoking also increases the rate of fat deposition. It was also said that Causes Of CHD are:

- Diet full of fats increases the fats level in blood
- Diet full of salts, salts can be deposited in the artery leading to CHD, same as fats or cholesterol
- Smoking, carbon monoxides increases fat deposition

- Stress was also said to contribute to CHD by raising blood pressure
- Lack of exercise, regular workouts improve the blood flow wearing layers of fats or salts deposited on the walls of arteries away.
- Genetic predisposition Coronary heart disease appears to be passed from one generation to the next in some families. This is not something we have any control over, but we can be aware of this risk and reduce some of the other risk factors to compensate.
- Age and gender As we get older our risk of suffering from coronary heart disease increases. Males are more at risk of a heart attack than females.

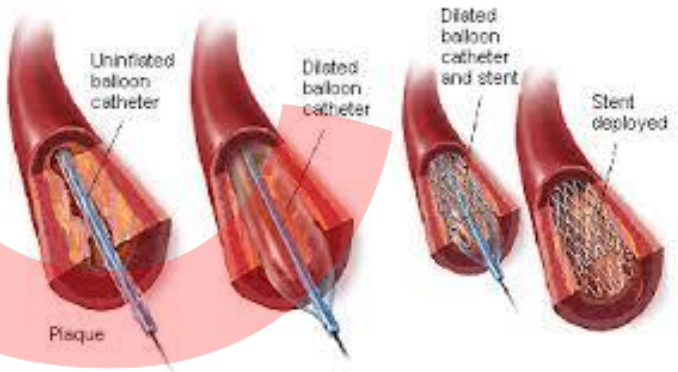
So to protect yourself from CHD you need to avoid diets full of fats and salts, avoid smoking, try to be less stressed out, and exercise regularly.

Treatment of coronary heart disease:

The simplest treatment for a patient who suffers from coronary heart disease is to be given a regular dose of aspirin. Aspirin prevents the formation of blood clots in the arteries, which can lead to a heart attack. It has been found that longterm use of low-dose aspirin also reduces the risk of coronary heart disease.

Methods of removing or treating atheroma and thrombus formations include the use of angioplasty, a stent and, in the most severe cases, by-pass surgery.

Angioplasty involves the insertion of a long, thin tube called a catheter into the blocked or narrowed blood vessel. A wire attached to a deflated balloon is then fed through the catheter to the damaged artery. Once in place, the balloon is inflated to widen the artery wall, effectively freeing the blockage. In some cases a stent is also applied. This is a wire-mesh tube that can be expanded and left in place. It then acts as scaffolding, keeping the blood vessel open and maintaining the free flow of blood. Some stents are designed to give a slow release of chemicals to prevent further blockage of the artery.



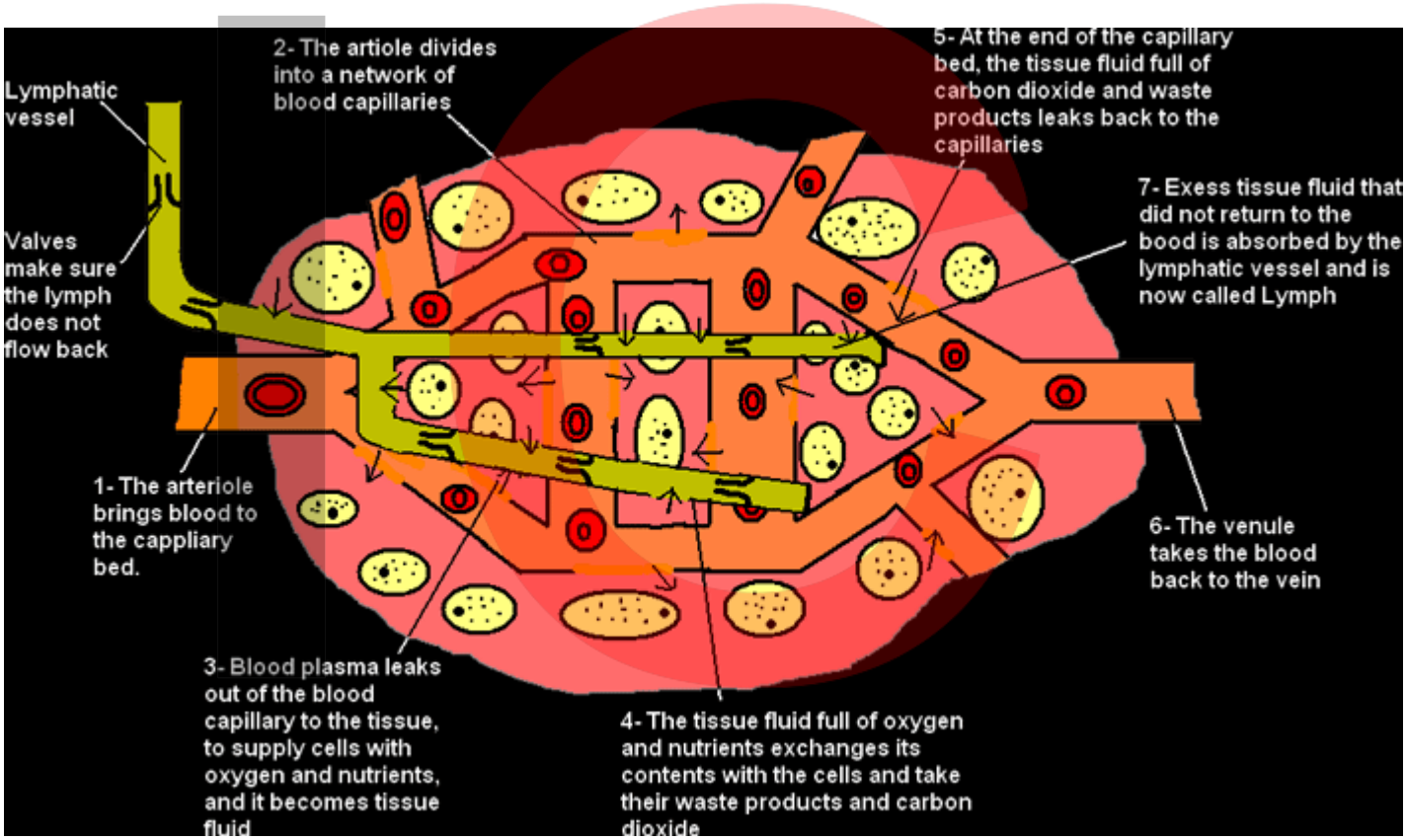
The effect of physical activity on the pulse rate

A heartbeat is a contraction. Each contraction squeezes blood to the lungs and body. The pulse is a pressure wave passing through the arteries as a result of the heartbeat. At rest, the heart beats about 70 times a minute, but this varies according to a person's age, gender and fitness: higher if you are younger, higher if you are female and lower if you are fit. An increase in physical activity increases the pulse rate, which can rise to 200 beats per minute. After exercise has stopped, the pulse rate gradually drops to its resting state. How quickly this happens depends on the fitness of the individual (an unfit person's pulse rate will take longer to return to normal).

Tissue Fluid And Lymph:

Tissue fluid is a fluid surrounding the cells of a tissue. It supplies them with all their needs of oxygen and nutrients, and takes away all their waste products including carbon dioxide. Tissue fluid plays a very big role in substance exchange between blood and cells.

Plasma from the blood capillaries move to the tissue through gaps in the walls. They become tissue fluid. They exchange their content of oxygen and nutrients with the cells and take carbon dioxide and waste products. 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 lymphatic system plays a big role in the protection against disease. It produces the white blood cells lymphocytes. Which kill any cell with a different antigens than the ones in your body cells. So if bacteria get into your body, your lymphocytes quickly recognise them as foreigners and will divide and kill them.

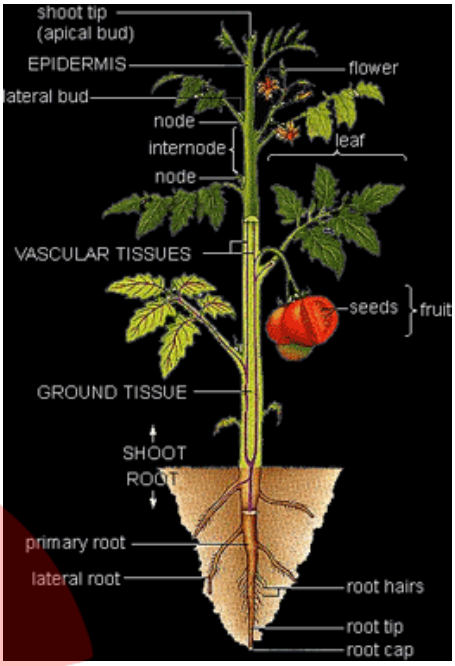
Lymphocytes are considered a problem when it comes to organs transplant. For example if someone (recipient) with renal failure receives a kidney from another person (the donor), the cells of the kidney will have different antigens than the other cells in the patient's body. The lymphocytes will consider the cells of the kidney an enemy and start attacking it, this is called

tissue rejection. Organ transplant is perfect in one case, this is when the donor and the recipient are identical twins, because the antigens of their cells perfectly match. In other cases the recipient is given immunosuppressant drugs to actually weaken their immune system to prevent tissue rejection.

Brief Summary Of Functions Of The Lymphatic System:

- Production of white blood cells lymphocytes
- Transport of digested fats from villi to blood stream
- Transport of lymph from the tissue fluids to the blood stream at the subclavian vein.

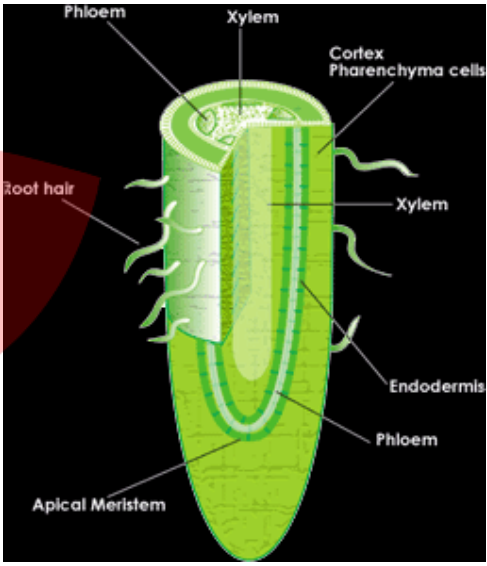
Transport In Plants



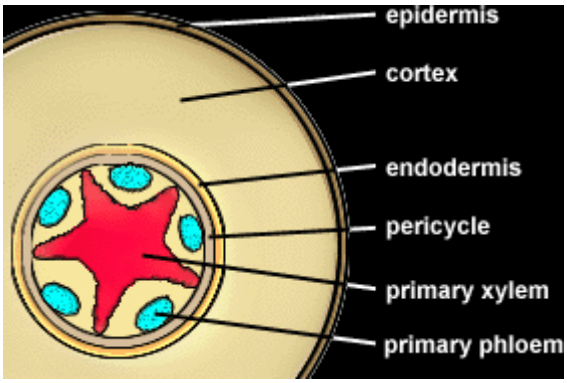
Just like humans, plants have a transport system of vessels and cells that transports water, minerals and other nutrients around the plant.

Structure Of Plants:

A plant is divided into two section, whatever is above the soil, is called the shoot, and whatever is below the soil is called the root. The root is simple, it is usually a main root with extensions of thinner ones. The shoot however, is made of several parts. The roots have the specialised cell, root hair cell, which we looked closely before, the root hair cells absorbs water from the soil and fixes the plant into the ground. In the root also, starts the transports system of the plant which extends all the way from the root up to the tip of the stem. The diagram on the left shows a section through the root. The root hairs of the root hair cells are visible. In the centre of the root, is the beginning of the transport system of the plant, which is made of two main transport tissues, the xylem tissue and the phloem tissue.



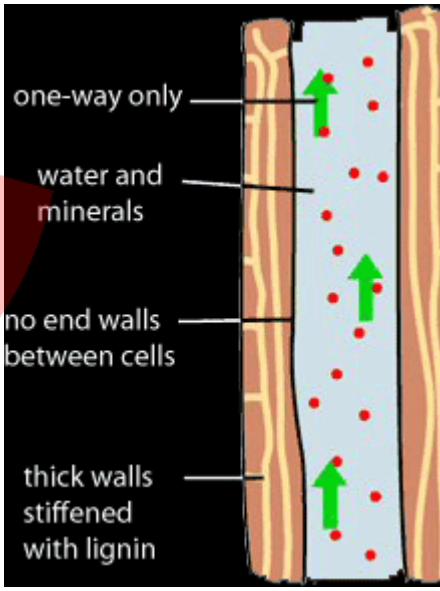
The diagram below shows a transverse section through a root. We can see than there are two types of hollow tubes, the xylem is the one in yellow and the phloem is the one in blue.



Each type of these tissues functions adapts differently to the other.

The diagram on the right shows a transverse section of the stem. We can see that the xylem and phloem are still there, but they are arranged differently, they are both put together in an egg shaped structure separated by a cambium.
Together they are called the vascular bundle, which is surrounded by what is called the cortex.

Structure Of The Xylem Tissue:

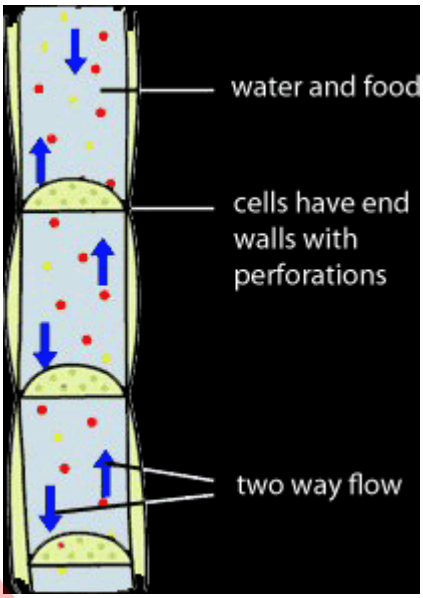


The xylem vessels are long hollow tubes made of dead lignified cells arranged end to end forming a continuous motion.

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. These walls of the xylem vessel contains holes called pits which water enters through.

The xylem tissue is adapted to its functions in different ways. For instance, the cell wall of the dead cells of the walls of it is made of lignin, which makes it stronger to support the stem, the fact that they are dead makes all the water absorbed by the root hair cells get transported to the leaves without being used by the cells of the vessel. The tube is also very narrow, to make it easier for the water to be transported upwards.

Structure Of The Phloem Tissue:

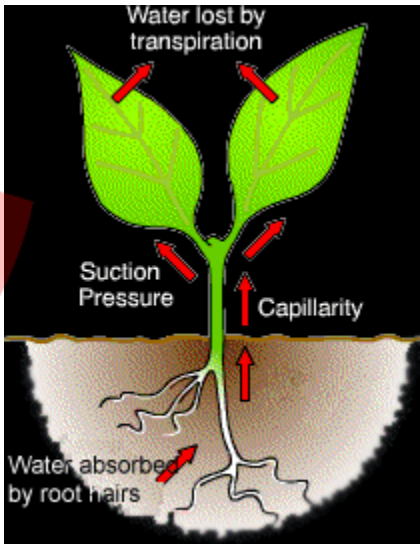


This is a long tube that runs alongside the xylem tissue. They are made of long narrow tubes with perforated sieve plates along the thin length. The function of the phloem tissue is to transport food nutrients such as glucose and amino acids from the leaves and to all other cells of the plant, this is called translocation.

Unlike the xylem, the phloem tissue is made of living cells, because as we will se later, there are several forces causing the transport of water in the xylem, but there are no forces causing the translocation, so substances need to be moved along using active uptake, which needs energy.

The cells of the phloem vessels 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.

Mechanism Of Water Transport:



The water reaches the leaves from the soil by several steps, starting at the root:

- The root hair cells have a concentrated cell sap vacuole which means that the water potential is low in it and high in the soil, osmosis takes place and water enters the cell.
- Minerals are also present in the soil but in low concentration, using active up take, the root hair cells takes the mineral ions in.
- The mixture of mineral and water moves from the root hair cells through the other cells by osmosis active uptake till it reaches the xylem vessel in the root, it enters the xylem through pits.
- The xylem vessel transports the water from the root to the stem (forming the vascular bundle with the phloem) and upwards to the leaves.
- The water and dissolved minerals leave the xylem and get absorbed by the cells in the leaves.

How Water Moves Through The Xylem:

There are three factors affecting the movement of water:

- In root hair cells, the mineral concentration is high, it helps pushing the water towards the xylem and the stem.
- Capillarity is a factor that helps in the movement of water in the xylem vessels. The water molecules are attracted to each other, as one moves upwards it pulls its neighbouring molecule

with it. The molecules are also attracted to the walls of the xylem, the narrower the xylem the easier it is for water to move.

- Transpiration force is the most effective force that causes water movement. In the leaf, the water evaporates and leaves the plant through the stomata, one molecule escapes pulling the other with it, and so on, creating a suction force. You can think of it as using a straw to drink.

Factors Affecting The Transpiration Rate:

- Humidity: humidity means more water vapour in the air, which means water vapour has a higher concentration in the atmosphere than inside the leaf, so transpiration will be much slower because the diffusion of water vapour outside the leaf will be slow. The higher the humidity the slower the transpiration.
- Temperature: when the temperature is high, molecules move faster and evaporate faster, so transpiration rate increases. The higher the temperature the faster the transpiration.
- Wind speed: when the wind is fast, it takes humid air away from around the leaf, making the diffusion rate faster, so the faster the wind the faster the transpiration.
- Light: when light intensity is high, the stomata will open to let Carbon dioxide in for photosynthesis, the water vapour has an easier chance to escape. In the dark the stomata are closed, the transpiration rate is very slow.

Wilting occurs when the transpiration rate is faster than the rate of water absorption. The amount of water in the plant keeps on decreasing. The water content of cells decreases and cells turn from turgid to flaccid. The leaves shrink and the plant will eventually die.

Translocation:

This is the transport of organic food such as sucrose and amino acids in the plant through the phloem vessels.

Glucose, the product of photosynthesis is the most important food of the plant. Because from it, it makes most of its other nutrients. Glucose is converted into an other more complex sugar called sucrose. Sucrose in the leaves enter the phloem vessels. The phloem transports it to every other part of the plant where it is made use of. 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.

Pesticides And Insecticides:

Some insects and pests feed on plants and harm them. A way to prevent this problem is to spray the plant with insecticides and pesticides. But the problem here is that these chemicals also kill insects and pests that are useful to the plant. This is why systemic pesticides are used. When

sprayed, they are absorbed inside the plant and distributed all over the plant. When the harmful insects and pests eat a part of the plant, they eat the poison with it, thus they die and harmless ones are safe.

Adaptation Of Special Plants:

Desert Cactus:

- Leafs are needle like spines to reduce water loss by transpiration. They are covered with a thick cuticle to insulate heat and prevent water escaping. The stomata of the leaves are sunken into the epidermis to be away from external features that increase transpiration.
- The stem is short to prevent wind from blowing it away. It is round to decrease surface area and transpiration rate. Photosynthesis takes place in the stem.
- Roots are very long and deep into the soil to have access to underground water and rain water. Root hair cells have a very concentrated cell vacuole to increase osmosis rate.

Pond Plants:

- Wide, broad leaves on surface of water to exchange gases. Stomata on upper side of the leaf to be in contact with air.

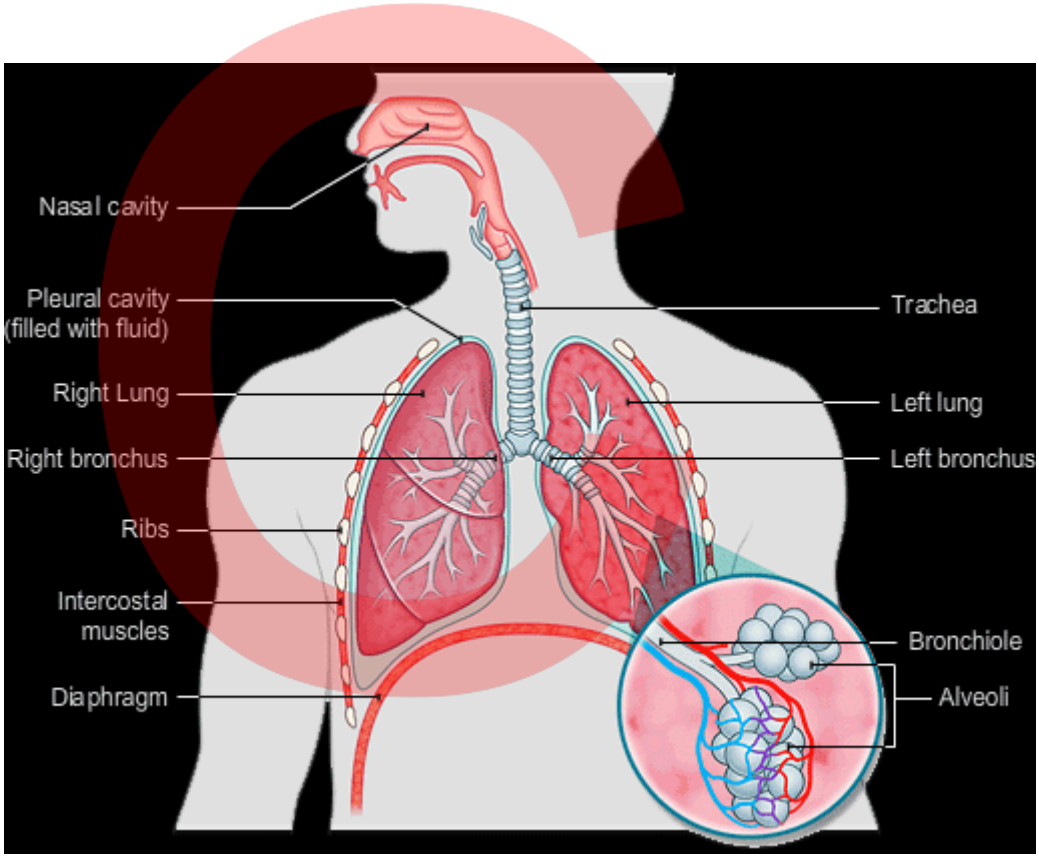
The Respiratory System

We rarely think about breathing unless we're out of breath. The act of breathing is part of the respiratory system, a complex process where air travels into and out of the lungs.

Respiration is slightly different, where exercise causes muscles to release energy in the form of glucose. Both systems are co-dependent, especially when you're playing sport and inhaling greater quantities of oxygen.

Human Respiratory System:

The human respiratory system is made up of air passages, lungs and the respiratory muscles.



Nose: most breathing and gas exchange occur through the nose. It is lined by a layer of mucus and hair to trap the dust and germs in the air. It is also supplied with a dense network of blood capillaries to warm the air entering the body.

Pharynx: Works together with the epiglottis to block the nasal cavity and the trachea during swallowing food, to prevent it from entering the respiratory system.

Trachea (windpipe): this is a tube that connects the nasal cavity and larynx to the lungs.

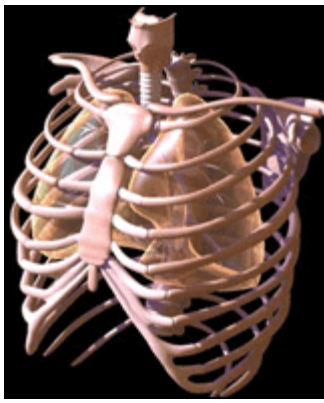
It has C- shaped cartilage rings that keep it open for air to pass and prevents its collapse due to differences in pressure

It is lined with a layer of ciliated epithelium cells and goblet cells which secrete mucus that traps bacteria and dust from inhaled air and gets moved upwards to the larynx by the cilia.

It is then either spit out or swallowed to the stomach where it is eliminated by acid.

Bronchi: when the trachea reaches the lungs, it is divided into two tubes, one goes to the right lung and one goes to the left lung. These are called the bronchi. The bronchi are then divided bronchioles that extended deeper into the lungs.

Alveoli (air sacs): these are tiny bags full of gas; they are present in the lungs in large amounts (several million alveolus in each lung). They give the lungs a much larger surface area (about 70 m2) for faster diffusion of gases between them and the blood.

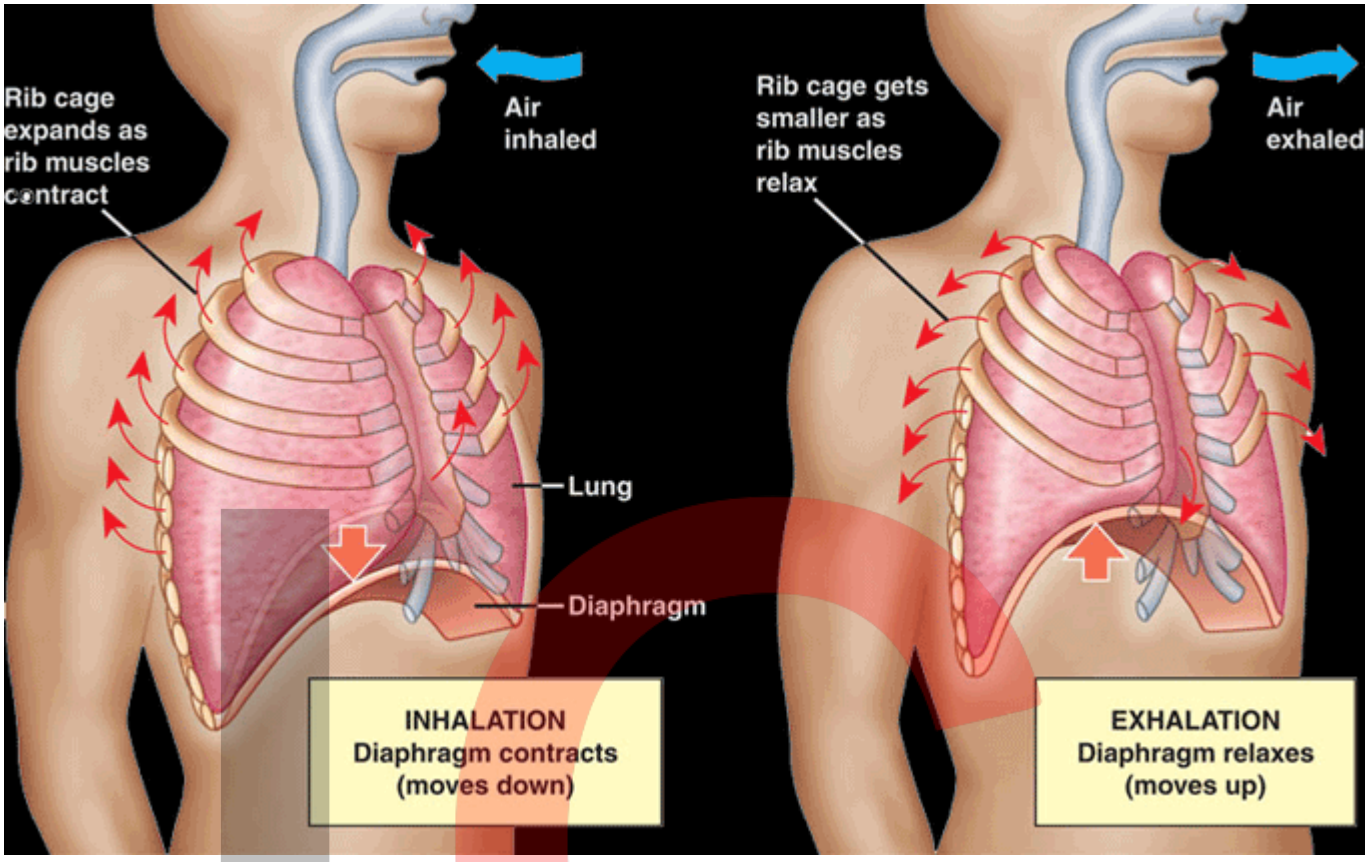


Rib Cage: the lungs are protected by this cage of bones. It surrounds all the thoracic cavity. They are 12 pairs of ribs; one pair extends from one of the first 12 vertebrae of the vertebral column. All of the ribs except for the last two pairs are connected to the sternum, the chest bone. Each pair of ribs is connected to the pairs above it and below it by muscle fibres called inter costal muscles. The rib cage and the lungs are separated by an elastic layer called pleural membrane, or pleura for short. It protects the lungs from damage caused by friction with the rib cage during breathing.

Diaphragm: this is a sheath of muscles that separates the thoracic cavity from the abdominal cavity. Together with the ribs and the inter costal muscles, it plays a big role in breathing and gas exchange.

Gas Exchange (Breathing):

Breathing is different from respiration. Breathing is just the exchange of waste gases from the body with fresh air from the atmosphere. The action of breathing fresh air in is called inhaling; the action of breathing waste gases out is called exhaling.

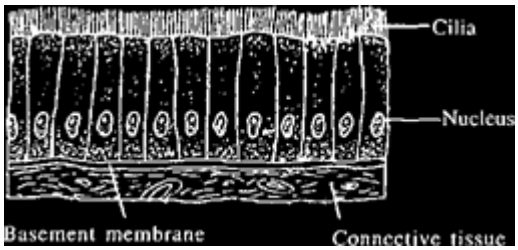


During Inhaling, the brain sends electric impulses by nerves to the diaphragm and the intercostal muscles. The diaphragm contracts becoming flatter. The external intercostal muscles also contract and move the ribs in an outer upwards directions while the internal inetrcostal muscles relax. These actions expand the thoracic cavity making the lungs expand, thus increasing the increasing the volume, with the volume increasing the internal pressure decreases which makes air enter the lungs through the mouth, nose and trachea.

During Exhaling, the diaphragm and the external intercostal muscles relax again and the internal intercostals muscles contract, contracting the thoracic cavity by pulling the ribs downwards and inwards thus squeezing the air out of the lungs to the trachea and mouth and nose to the atmosphere.

Respiratory System in Action:

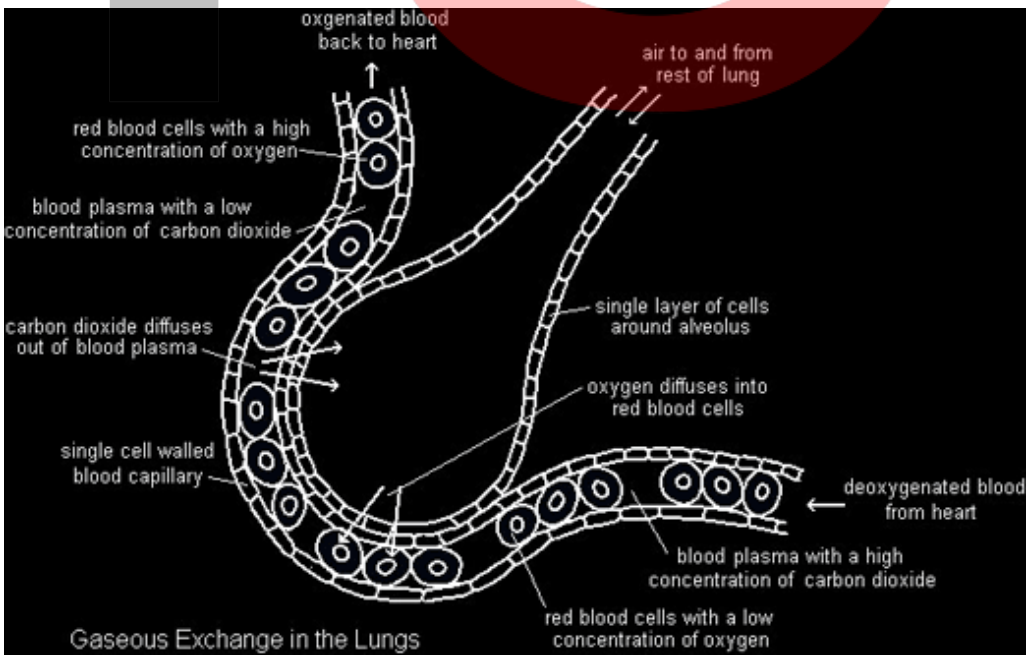
- Inhaling occurs, air is absorbed by lungs, it enters the nose where bacteria and dust in it are trapped by mucus and warmed by blood capillaries. The air enters the trachea where it is cleaned again by cilia.
- The bronchi take the air from the trachea to each lung.
- Bronchi divide into several bronchioles; each one has a group of alveoli at the end of it.
- In the alveoli gas exchange takes place where the oxygen rich air diffuses into the blood capillaries of the pulmonary arteries and the carbon dioxide rich gas diffuses into the alveoli to be exhaled.



- The pulmonary vein carries the oxygenated fresh air to the heart where it is pumped to all the body cells.
- The external intercostal muscles and diaphragm relax and the internal intercostal muscles contract squeezing the waste gases out of the lungs, this is exhalation.

Gas Exchange in Alveoli:

Each alveolus is supplied with blood capillaries. These come from the pulmonary artery and they contain deoxygenated blood rich in carbon dioxide. The concentration of oxygen is very high inside the alveolus and very low in the blood, so oxygen molecules diffuse from the alveolus to the red blood cells and combine with haemoglobin. At the very same time this occurs, carbon dioxide diffuses from the blood to the alveolus because the concentration of it is very high in the blood and low in the alveolus.



Adaptations of Alveoli:

Gas exchange happens because of several factors in the alveolus and the blood capillaries that control the rate of gas exchange:

- Very thin wall of both the alveolus and the capillary, they are one cell thick which makes the diffusion distance shorter, increasing the rate.
- The difference in concentration of gases between the alveolus and the capillary is very large, increasing the diffusion rate of gases.
- The alveolus are balloon shaped which gives it a very large surface area for faster diffusion.
- The walls of the alveolus are lined by a thin film of water in which gases dissolve in during diffusion, this makes it faster.

Composition of Inspired and Expired Air:

Gas	Inspired Air	Expired Air
Oxygen	21%	16%
Carbon Dioxide	0.04%	4%
Nitrogen	79%	79%
Water Vapour	Variable	High

Lung Capacity:

When lungs of an adult are fully inflated they have a volume of about 5 litres.

Tidal Volume: This is the volume of air breathed in and out at rest, this is 0.5 litres.

Vital Volume: The maximum volume of air that can be breathed in and out, at exercise for example is 3 litres.

Residual Volume: The lungs have to have a certain volume of air inside them all the time to keep shape. This is the residual volume and it is 1.5 litres. This air is renewed through breathing.

Breathing rate and exercise:

The increased rate and depth of breathing during exercise allows more oxygen to dissolve in the blood and supply the active muscles. The extra carbon dioxide that the muscles put into the blood is detected by the brain, which instructs the intercostals muscles and diaphragm muscles to contract and relax more rapidly, increasing the breathing rate. Carbon dioxide will be removed by the faster, deeper breathing.

Aerobic Respiration:

A chemical, metabolic reaction catalysed by enzymes that burns down glucose with oxygen producing carbon dioxide, water vapour and lots of energy

Aerobic Respiration: the release of relatively large amounts of energy in cells by the breakdown of food substances in the presence of oxygen.

Anaerobic Respiration:

Some organisms are able to respire and release energy when oxygen is lacking. This is anaerobic respiration. These are like yeast, bacteria and other organisms. Humans can also respire anaerobically for a short period of time. The amount of energy produce is much smaller than that produced during aerobic respiration though.

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

$$C_6H_{12}O_6\ (aq) + 6O_2\ (g) \rightarrow 6\ O_2\ (g) + 6H_2O\ (l)$$

Anaerobic Respiration I Yeast: Yeast is able to respire anaerobically by breaking down glucose molecules into ethanol and carbon dioxide.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 6CO_2$$

Ethanol is produced here, so it is a fermentation reaction. Do remember that glucose is the only reactant.

Anaerobic Respiration in Humans:

When the amount of oxygen received by the muscle cells of the body is not enough to carry out all respiration aerobically, the cells respire anaerobically. But they cannot go like that for a long time. The anaerobic respiration in humans is different than of yeast. Lactic acid is produced instead of ethanol, and no carbon dioxide is produced.

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

The lactic acid produced is very toxic and harmful to the body. That is why it has to be broken down with oxygen as soon as possible. This is called oxygen debt. Breaking down lactic acid releases energy too, if you add up the amount of energy produced during breaking down lactic acid and anaerobic respiration, you will find that it is the same as the amount produced during aerobic respiration.

Effects of Smoking:

Short Term Effects:

- Cilia can't vibrate anymore, the air inhaled isn't clean. Goblet cells release more mucus which makes the trachea narrower.
- Nicotine increases heart beat rate and blood pressure.
- Carbon monoxide combines with haemoglobin instead of oxygen combining with it.
- Carboxyhaemoglobin is formed which is stable.
- Less oxygen transported to cells.

Diseases Caused By Tar:

Chronic Bronchitis:

- Tar makes goblet cells in trachea produce excess mucus
- Mucus falls into lungs
- Bacteria in mucus breed causing infections like bronchitis
- The layer of excess mucus lining the walls of the alveoli increase the diffusion distance of gases making gas exchange slower

Emphysema:

- The excess mucus lining the alveoli irritates it, causing strong coughs which damage the alveoli.
- The alveoli lose its shape and surface area making gas exchange much slower.
- This cause short breathes and sounds while breathing.

Lung Cancer:

- When tar reaches the lungs, it is absorbed by cells of the bronchi, bronchioles and the lungs.
- The tar causes excessive division and reproduction of these cells which develops into cancer
- The cancer can be spread to other organs too.

Diseases Caused By Nicotine:

Coronary Heart Disease:

- Nicotine helps cholesterol deposition on walls of coronary arteries. This causes atheroma.
- Carbon monoxide also increases risk of blood clots forming which might results in blocking the artery.
- Less oxygen is delivered to heart cells, a heart attack or failure can take place leading to death.

Disease and Immunity

●Pathogens and transmission

A pathogen is a disease-causing organism.

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

Pathogens:

Pathogens include many bacteria, viruses and some fungi, as well as a number of protoctista and other organisms. Pathogenic bacteria may cause diseases because of the damage they do to the host's cells, but most bacteria also produce poisonous waste products called toxins. Toxins damage the cells in which the bacteria are growing. They also upset some of the systems in the body. This gives rise to a raised temperature, headache, tiredness and weakness, and sometimes diarrhoea and vomiting. Many viruses cause diseases in plants and animals.

Human virus diseases include the common cold, influenza and AIDS. Some viruses infect plants as well.

While most fungi are saprophytic (feeding on dead organic matter) some are parasitic, obtaining

their nutrients from living organisms. The hyphae of parasitic fungi penetrate the tissues of their host plant and digest the cells and their contents.

Transmission:

Pathogens responsible for transmissible diseases can be spread either through direct contact or indirectly.

Direct contact:

This may involve transfer through blood or other body fluids. HIV is commonly passed on by drug addicts who inject the drug into their bloodstream, sharing needles with other drug users. If one user injects himself, the pathogens in his blood will contaminate the syringe needle. If this is then used by a second drug user, the pathogens are passed on. Anyone cleaning up dirty needles is at risk of infection if they accidently stab themselves. Surgeons carrying out operations have to be especially careful not to be in direct contact with the patient's blood, for example by cutting themselves while conducting an operation. A person with HIV or another sexually transmitted disease who has unprotected sex, can pass on the pathogen to their partner through body fluids.

Indirect contact

This may involve infection from pathogens on contaminated surfaces, for example during food preparation. Raw meat carries bacteria, which are killed if the meat is adequately cooked. However, if the raw meat is prepared on a surface that is then used for other food preparation, such as cutting up fruit or vegetables that are later eaten raw, then the pathogens from meat can be transferred to the fresh food. The person handling the food is also a potential vector of disease if he or she does not wash their hands after using the toilet, moving rubbish or handling raw produce.

One of the commonest causes of food poisoning is the toxin produced by the bacteria *Salmonella typhimurium* and *S. enteritidis*. These bacteria live in the intestines of cattle, chickens and ducks without causing disease symptoms. Humans, however, may develop food poisoning if they drink milk or eat meat or eggs that are contaminated with Salmonella bacteria from the alimentary canal of an infected animal. Intensive methods of animal rearing may contribute to a spread of infection unless care is taken to reduce the exposure of animals to infected faeces.

The symptoms of food poisoning are diarrhoea, vomiting and abdominal pain.

Although these symptoms are unpleasant, the disease is not usually serious and does not need treatment with drugs. Elderly people and very young children, however, may be made very ill by food poisoning. The bacteria are killed when meat is cooked or milk is pasteurised. Infection is most likely if untreated milk is drunk, meat is not properly cooked, or cooked meat is contaminated with bacteria transferred from raw meat. Frozen poultry must be thoroughly defrosted before cooking, otherwise the inside of the bird may not get hot enough during cooking to kill the bacteria. It follows that, to avoid the disease, all milk should be pasteurised and meat should be thoroughly cooked. People such as shop assistants and cooks should not handle cooked food at the same time as they handle raw meat. If they must do so, they should wash their hands thoroughly between the two activities. The liquid that escapes when a frozen chicken is defrosted may contain bacteria. The dishes and utensils used while the bird is defrosting must not be allowed to come into contact with any other food. Uncooked meat or poultry should not be kept alongside any food that is likely to be eaten without cooking. Previously cooked meat should never be warmed up; the raised temperature accelerates the reproduction of any bacteria present. The meat should be eaten cold or cooked at a high temperature.

In the past few years there has been an increase in outbreaks of Salmonella food poisoning in which the bacteria are resistant to antibiotics. The bacteria are present in the faeces of infected people and may reach food from the unwashed hands of the sufferer. People recovering from one of these diseases may feel quite well, but bacteria may still be present in their faeces. If they don’t wash their hands thoroughly after going to the lavatory, they may have small numbers of bacteria on their fingers. If they then handle food, the bacteria may be transferred to the food. When this food is eaten by healthy people, the bacteria will multiply in their bodies and give them the disease.

People working in food shops, kitchens and food-processing factories could infect thousands of other people in this way if they were careless about their personal cleanliness. Some forms of

food poisoning result from poisons (toxins) that are produced by bacteria that get into food. Cooking kills the bacteria in the food but does not destroy the toxins that cause the illness.

In summary, people who handle and prepare food need to be extremely careful about their personal hygiene. It is essential that they wash their hands before touching food, particularly after they have visited the lavatory. Hand-washing is also important after handling raw meat, particularly poultry. Food on display in shops needs to be protected. Some people carry intestinal pathogens without showing any symptoms of disease. These people are called 'carriers'. Once identified, they should not be allowed to work in canteens or food-processing factories.

Contamination of water:

If disease bacteria get into water supplies used for drinking, hundreds of people can become infected. Diseases of the alimentary canal, like typhoid and cholera, are especially dangerous. Millions of bacteria infest the intestinal lining of a sick person. Some of these bacteria will pass out with the faeces. If the faeces get into streams or rivers, the bacteria may be carried into reservoirs of water used for drinking. Even if faeces are left on the soil or buried, rainwater may wash the bacteria into a nearby stream. To prevent this method of infection, drinking water needs to be purified and faeces must be made harmless, a process involving sewage treatment.

Water treatment

On a small scale, simply boiling the water used for drinking will destroy any pathogens. On a large scale, water supplies are protected by (a) ensuring that untreated human sewage cannot reach them and (b) treating the water to make it safe.

The treatment needed to make water safe for drinking depends on the source of the water. Some sources, e.g. mountain streams, may be almost pure; others, e.g. sluggish rivers, may be contaminated. The object of the treatment is to remove all micro-organisms that might cause disease. This is done by filtration and chlorination. The water is passed through beds of sand in which harmless bacteria and protozoa are growing. These produce a gelatinous film which acts as a fine filter and removes pathogens. Finally, chlorine gas is added to the filtered water and remains in contact with it for long enough to kill any bacteria that have passed through the filter. How much chlorine is added and the length of the contact time both depend on how contaminated the water source is likely to be. Most of the chlorine disappears before the water reaches the consumers. The purified water is pumped to a high-level reservoir or water tower. These are enclosed to ensure that no pathogens can get into the water. The height of the reservoir provides the pressure needed to deliver the water to the consumer.

Waste disposal:

Waste from domestic or commercial premises should be stored in dustbins or garbage cans made of galvanised steel or strong plastic, with a closely fitted lid to exclude flies and keep out scavenging animals. If this is not done, pathogens will breed in the waste and become a source of disease organisms. The waste is taken away and disposed of by burning, or burying deep enough to prevent rats using it as food, or (less effectively) tightly packed to keep out flies.

Contamination by houseflies:

Flies walk about on food. They place their mouthparts on it and pump saliva onto the food. Then they suck up the digested food as a liquid. This would not matter much if flies fed only on clean food, but they also visit decaying food or human faeces. Here they may pick up bacteria on their feet or their mouthparts. They then alight on our food and the bacteria on their bodies are transferred to the food. Food poisoning, amoebic dysentery and polio can be spread by houseflies.

Airborne, 'droplet' or aerosol infection:

When we sneeze, cough, laugh, speak or just breathe out, we send a fine spray of liquid drops into the air. These droplets are so tiny that they remain floating in the air for a long time. They may be breathed in by other people or fall on to exposed. If the droplets contain viruses orbacteria, they may cause disease when they are eaten with food or inhaled.

Virus diseases such as colds, 'flu, measles and chickenpox are spread in this way. So are the bacteria that cause sore throats. When the water in the droplets evaporates, the bacteria often die as they dry out. The viruses remain infectious, however, floating in the air for a long time.

In buses, trains and cinemas warm air is moist, and full of floating droplets. These are places where you are likely to pick up one of these infections.

Defences against diseases

The body has three main lines of defence against disease. These involve mechanical barriers, chemical barriers and cells.

Mechanical barriers: Although many bacteria live on the surface of the skin, the outer layer of the epidermis seems to act as a barrier that stops them getting into the body. But if the skin is cut or damaged, the bacteria may get into the deeper tissues and cause infection. Hairs in the nose help to filter out bacteria that are breathed in. However, if air is breathed in through the mouth, this defence is by-passed.

Chemical barriers: The acid conditions in the stomach destroy most of the bacteria that may be taken in with food. The moist lining of the nasal passages traps many bacteria, as does the mucus produced by the lining of the trachea and bronchi.

The ciliated cells of these organs carry the trapped bacteria away from the lungs.

Tears contain an enzyme called lysozyme. This dissolves the cell walls of some bacteria and so protects the eyes from infection.

Cells:

When bacteria get through the mechanical and chemical barriers, the body has two more lines of defence – white blood cells and antibodies, produced by white blood cells. One type of white blood cells fights infection by engulfing bacteria (a process called phagocytosis) and digesting them. Another type produce antibodies that attach themselves to bacteria, making it easier for other white blood cells to engulf them.

Antibodies and immunity

Active immunity is the defence against a pathogen by antibody production in the body.

On the surface of all cells there are chemical substances called antigens. Lymphocytes produce proteins called antibodies which attack the antigens of bacteria or any alien cells or proteins that invade the body. The antibodies may attach to the surface of the bacteria to mark them, making it easier for the phagocytes to find and ingest them, they may clump the bacteria together or they may neutralise the poisonous proteins (toxins) that the bacteria produce.

Each antibody is very specific. This means that an antibody that attacks a typhoid bacterium will not affect a pneumonia bacterium. Some of the lymphocytes that produced the specific antibodies remain in the lymph nodes for some time and divide rapidly and make more antibodies if the same antigen gets into the body again. This means that the body has become immune to the disease caused by the antigen and explains why, once you have recovered from measles or chickenpox, for example, you are very unlikely to catch the same disease again. This is called active immunity. Active immunity can also be gained by vaccination. You may also inherit some forms of immunity or acquire antibodies from your mother's milk. This is innate immunity.

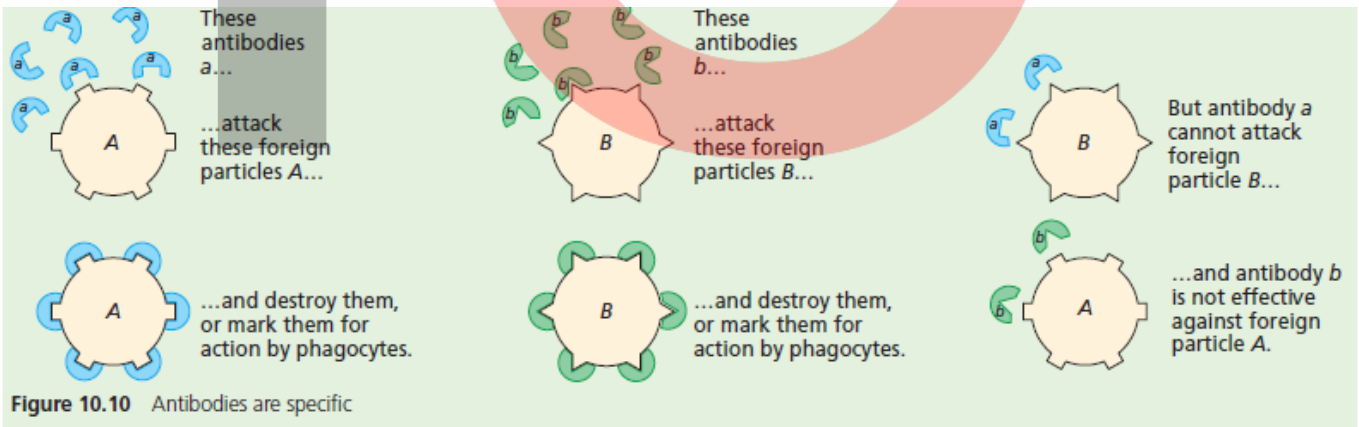


Figure 10.10 Antibodies are specific

Vaccination

When you are inoculated (vaccinated) against a disease, a harmless form of the bacteria or viruses is introduced into your body. The white cells make the correct antibodies, so that if the real micro-organisms get into the blood, the antibody is already present or very quickly made by the blood. The material that is injected or swallowed is called a vaccine and is one of the following:

• a harmless (weakened) form of the micro-organism.

• the killed micro-organisms.

• a toxoid, i.e. the inactivated toxin from the bacteria,

B and T lymphocytes

There are two main types of lymphocyte. Both types undergo rapid cell division in response to the presence of specific antigens but their functions are different (though interdependent). The B cells (from Bone marrow) become short-lived plasma cells and produce antibodies that are released into the blood. These antibodies may attack antigens directly or stick to the surface membrane of infected or alien cells, e.g. cells carrying a virus, bacteria,cancer cells or transplanted cells.

'Killer' T cells (from the Thymus gland) have receptor molecules on their surface, which attach them to these surface antibodies. The T cells then kill the cell by damaging its cell membrane.

'Helper' T cells stimulate the B cells to divide and produce antibodies. They also stimulate the phagocytes to ingest any cells carrying antibodies on their surface.

Some of the B cells remain in the lymph nodes as memory cells. These can reproduce swiftly and produce antibodies in response to any subsequent invasion of the body by the same foreign organism.

Routine vaccination not only protects the individual but also prevents the spread of infectious disease.

Passive immunity

Some diseases can be prevented or cured by injecting the patient with serum from a person who has recovered from the disease. Serum is plasma with fibrinogen removed. A serum is prepared from the plasma given by blood donors. People who have recently received an anti-tetanus inoculation will have made anti-tetanus antibodies in their blood. Some of these people volunteer to donate their blood, but their plasma is separated at once. The anti-tetanus antibodies are then

extracted from the plasma and used to treat patients who are at risk of contracting tetanus, as a result of an accident. The temporary immunity conferred by these methods is called passive immunity because the antibodies have not been produced by the patient.

It is only temporary because it does not result in the formation of memory cells.

When a mother breastfeeds her baby, the milk contains some of the mother's antibodies. These antibodies provide the baby with protection against infection at a vulnerable time: the baby's immune responses are not yet fully developed. However, this is another case of passive immunity as it is only short-term protection: memory cells are not produced.

Type 1 diabetes:

This type of diabetes, also known as juvenileonset diabetes, mainly affects young people. It is due to the inability of islet cells in the pancreas to produce sufficient insulin. There is a slight inherited tendency towards the disease, but it may be triggered by some event, possibly a virus infection, which causes the body's immune system to attack the islet cells that produce insulin. It is therefore classed as an autoimmune disease. The outcome is that the patient's blood is deficient in insulin and he or she needs regular injections of the hormone in order to control blood sugar levels and so lead a normal life. This form of the disease is, therefore, sometimes called 'insulin-dependent' diabetes .