# Mass Transport

## THE NEED FOR TRANSPORT

Transport is needed to move substances from one place to another. Diffusion is one way this is done.
Diffusion is the movement of particles in a liquid or gas from an area of high particle concentration to an area of low particle concentration (down the concentration gradient)

In single celled organisms and very small multicellular organisms, diffusion can be used alone for transport:

- The distance required for oxygen and nutrients to diffuse in and waste to diffuse out is very short
- It has a large surface area to volume ratio (SA:V), meaning there is a large area surface area for substances to diffuse into
- They have low metabolic demands

For large multicellular organisms, every cell requires oxygen and glucose to carry out respiration in order to carry out all life processes. Respiration produces the waste product carbon dioxide in addition to the other waste products that need to be removed from the cells before they damage.
Since diffusion alone would be too slow, large multicellular organisms have a mass transport system as well - series of structures that allow substances to be moved systematically through an organism.
This mass transport system consists of the heart, circulatory system and the blood. This system allows nutrients and waste to be transported around the body and then into the cells using osmosis, active transport and diffusion, allowing the cells to carry out functions efficiently.

## FEATURES OF A MASS TRANSPORT SYSTEM

- Exchange surfaces to allow nutrients in and waste out
- A system of vessels (capillaries, veins, arteries) that either branch out or a follow a singular route.
- A way of moving materials fast enough e.g. heart pumping
- Way of making sure materials are going in the right direction e.g. valves
- A transport medium
- Way of adapting the rate for the organisms needs e.g. HR



## CIRCULATION SYSTEMS

Plants have a open circulatory system however most animals have a closed circulatory system, the advantages of this are:

- The pressure can be increased to increase the flow of blood
- The flow can be directed towards the organs that are in the most need of oxygen and nutrients

Animals like fish have a single circulation system; this is where the heart pumps the blood to the organs of gas exchange and the blood travels around the body before returning to the heart. However birds and mammals require more oxygen and nutrients, so they have a double circulation system. They move more when away from water and produce more waste that needs to be removed quickly, therefore they require a faster supply of oxygen and nutrients.

The double circulation system has two separate circulation systems; the pulmonary circulation and the systemic circulation.

- The systemic circulation carries oxygenated blood from the heart to the cells of the body and deoxygenated blood back to the heart.
- The pulmonary circulation carries the deoxygenated blood to the lungs to be oxygenated and then carries the oxygenated blood to the heart.

This helps ensure that oxygenated and deoxygenated blood do not mix. The fully oxygenated blood is delivered quickly at a high pressure when the heart pumps, supplying cells with oxygen.
Deoxygenated blood travels in small vessels in the lungs to allow gas exchange to take place, this happens at a low pressure to prevent the vessels from bursting. This would be too slow when it reaches the large vessels, so the heart is needed to increase the pressure/speed that the blood flows at.

# Blood and Blood vessels

## Arteries

Arteries carry blood away from the heart to cells in the body. The blood is usually oxygenated apart from the pulmonary artery that carries deoxygenated blood from the heart to lungs and the umbilical artery that carries deoxygenated blood from the fetus to placenta.
The arteries branch out when leaving the heart - as they get further away from the heart the lumen becomes smaller. The smallest arteries furthest from the heart are the arterioles.
Blood is pumped out of the heart regularly and with every pump there is a high pressure of blood in the arteries, the arteries closest to the heart have to withstand the pressure:

- Their walls have a lot of elastic fibers so they can stretch and recoil depending on the volume of the blood without causing damage and also a lot of collagen that increases the strength to help withstand pressure.
- Those further from the heart(peripheral arteries) have a lot of smooth muscle so they can contract and relax to change the size of the lumen according to the current volume of blood.

## Capillaries

Capillaries are very small vessels that branch throughout the tissues of the body forming capillary beds. They connect the arterioles to the venules.
There is a capillary close to every cell therefore substances easily diffuse between cells and the blood, blood also flows relatively slow therefore giving more time for diffusion to occur.
Capillaries have a structure that is one cell thick(endothelial cells). This helps them fit In tissues and allows rapid diffusion to occur. When blood enters a capillary it is oxygenated but as it leaves it is less oxygenated as the oxygen diffuses out into cells and carbon dioxide diffuses in.

## Veins

Veins carry blood towards the heart, the blood is usually deoxygenated apart from the pulmonary vein - that carries highly oxygenated blood from the lungs to the heart and the umbilical vein that carries oxygenated blood from the placenta to the fetus.
Venules drain blood from capillary beds and feed it back into veins, they contain smooth muscle that allow them to constrict so they can control blood flow through capillaries.
Tiny venules leave from the capillaries and they keep combining till they form only two large veins that carry the blood from the tissues back to the heart :

- Inferior vena cava : blood from the lower parts of the body
- Superior vena cava : blood from the upper part of the body

Veins hold a large volume of blood - more than half of the body's volume of blood is in the veins at once.
Veins have a low blood pressure as the pressure decreases by the time it gets through the capillaries to the venules. The low pressure blood then returns to the heart and lungs to get oxygenated again before recirculating.
Veins have valves as the blood returning to the heart is moving with muscle pressure, so valves are needed to stop blood flowing backwards.:

- Larger veins contract when physical activity takes place allowing the blood to get back to heart, valves aid in stopping the blood flowing backwards.
- One way valves are in veins at intervals, these are called semi-lunar valves - they develop from infoldings of the inner wall of the vein.



## Cardiac Cycle

### THE HEART

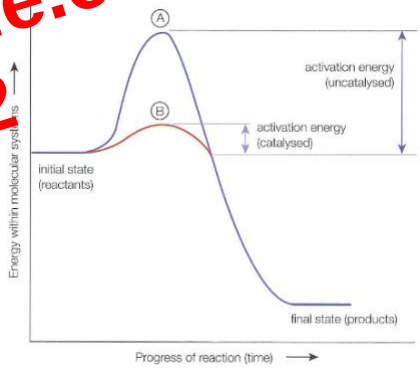
The heart is made of cardiac muscle(intrinsic rhythm and does not fatigue) The right side of the heart receives blood from the body and pumps it to the lungs. The left side of the heart receives blood form the lungs and pumps it to the body. The two sides are split by the septum to stop the blood from either side mixing.
Inferior vena cava - collects deoxygenated blood from the lower parts of the body
Superior vena cava - receives deoxygenated blood from the head, neck, arms and chest

- The carboxyl and amino ends, give them ionic properties, the molecules are very large, so they form a colloid. This is when microscopic particles of one substance are suspended throughout another substance e.g. protein in water.
- They do not settle and can't be easily separated, important as they hold molecules in position in the cytoplasm.
- Haemoglobin is a globular protein made of four polypeptide chains connected by disulfide bonds, it carries oxygen and is easily soluble, so it can be transported in the blood.
- Each polypeptide chain surrounds an iron containing haem group. The iron allows the haemoglobin to bind and release oxygen molecules and the arrangement of the polypeptide chains, determines how easily this is done.

- Enzymes are large so globular proteins that are biological catalysts – soluble due to many hydrophilic side groups
- A catalyst is a substance that changes the rate of reaction by lowering activation energy and providing an alternative pathway without changing the substance produced. The catalyst is unaffected at the end of the reaction and can be used again.
- Enzymes can affect structures and functions in an organism
- They can be intracellular – catalyze reactions inside cells e.g. DNA polymerase or extracellular – catalyze reactions outside of cells e.g. lysosome – enzyme in your tears.
- They catalyze both anabolic and catabolic reactions. Anabolic – reactions that build up new chemicals, catabolic – reactions that break down substances. The two reactions together is metabolism.
- Enzymes have an active site which has a very specific shape, so enzymes are said to show great specificity, this allows them to catalyze one specific reaction.
- Temperature and pH affect how efficient enzymes are as they affect the intermolecular bonds that form the shape of the enzyme.

## LOWERING ACTIVATION ENERGY

- In a chemical reaction, chemicals require a certain amount of energy(heat) before the reactions starts; activation energy
- Enzymes lower the amount of energy required allowing reactions to happen at a lower temperature, speeding up the rate of reaction.
- When a substrate fits into the enzyme's active site and forms an enzyme-substrate complex this lowers the activation energy
- In an anabolic reaction, two substrate molecules need to join, being attached to the enzyme holds them closer together, reducing any repulsion so they can bond more easily
- In a catabolic reaction, fitting a substrate into the active site puts a strain on the substrate, causing it to breakdown more easily.






## HOW ENZYMES WORK

### Induced fit hypothesis

- Substrate and enzyme form an enzyme-substrate complex, then after the enzyme breaks/joins substrates, once the reaction is complete, the products are not in the right shape to stay in the active site and the complex breaks up, this releases the products and allows the enzyme to form new complexes.
- The lock and key hypothesis claimed that the active site had the perfect shape for the substrate to fit into, however the active site actually has a similar shape and it is flexible allowing it to modify around the substrate to form the complex.
- Therefore the enzyme needs to be specific in the way it changes shape as well(due to its tertiary structure), once the products are released, the enzyme changes back to its inactive form.

## ENZYME AND SUBSTRATE CONCENTRATION

Increasing the concentration of enzymes, increases the rate of reaction – more active sites present that the substrates can collide with to form a complex,
However this is only up until a certain point as the number of substrates is limited, so when the amount of enzymes exceeds the amount of substrates, it no longer has an affect on the rate of reaction.