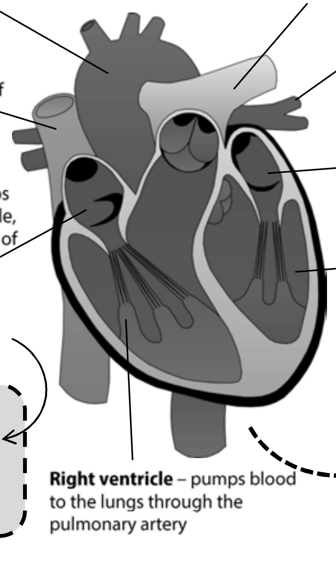
HEART, LUNGS AND BLOOD

The heart

Inner structure



Aorta – carries blood to the body

Vena cava – carries deoxygenated blood from the lower part of the body to the heart's right atrium

Right atrium – pumps blood to right ventricle, and contains a group of cells that act as a pacemaker for the natural resting heart rate

Artificial pacemakers can be used to regulate heart rate if the natural pacemaker fails.

Right ventricle – pumps blood to the lungs through the pulmonary artery

Pulmonary artery – carries deoxygenated blood from right ventricle to lungs

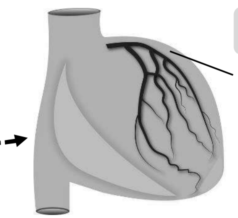
Pulmonary vein – carries oxygenated blood from lungs to left atrium

Left atrium – pumps blood to left ventricle

Left ventricle – pumps blood to the body through the aorta

The human body uses a **double circulatory system** – blood passes through the heart twice: once to pump oxygenated blood to the body, and once to pump deoxygenated blood to the lungs.

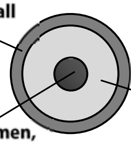
Outer structure



Coronary arteries – carry blood to the left and right sides of the heart to supply the heart muscle with oxygen and nutrients

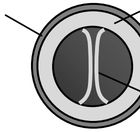
Blood vessels

Arteries



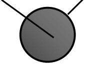
- **Carry blood away from the heart** to the organs of the body
- Blood delivers necessary substances such as oxygen and glucose to cells
- **Artery walls stretch with each heartbeat** then return to normal, pushing blood along at high pressure – this is why artery walls have thick elastic fibres and muscles

Veins



- **Carry blood back to the heart** from the body's organs
- **Blood is at low pressure** so walls are thin and valves are present to stop blood flowing backwards
- **Movement of skeletal muscles** pushes blood in veins back to heart
- **Wide lumen** means there is less resistance to blood flow

Capillaries

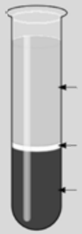


- **Network of fine blood vessels that connect arteries and veins**
- **Thin, porous walls** so that small molecules such as oxygen can diffuse from blood to cells, and small waste molecules can diffuse back into the blood from cells
- **Small lumen** just wide enough for one red blood cell enables efficient transfer of oxygen to cells

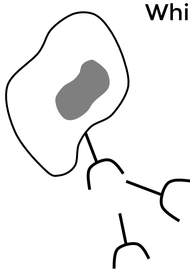
Blood components

Plasma

- Blood is both a **tissue** and a body fluid made of **plasma**, which carries red blood cells, white blood cells and platelets in suspension
- Transports blood cells, soluble molecules from digestion, carbon dioxide and urea



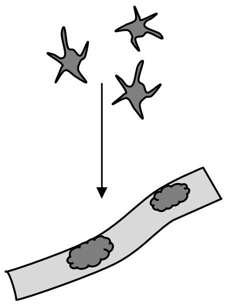
White blood cells



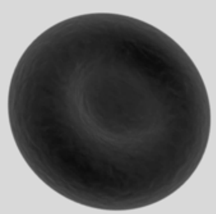
- Part of the **immune system** to defend against pathogens
- Produce **antibodies** against pathogens
- Produce **antitoxins** against toxins produced by pathogens
- Engulf and digest pathogens

Platelets

- Pieces of cells that come together to produce **blood clots**
- Clotting creates **scabs** to stop bleeding and prevent bacteria entering the body through wounds



Red blood cells



- Carry **oxygen** (in haemoglobin) to cells
- Have a **biconcave disc** shape to increase the surface area for diffusion of oxygen
- Have **no nucleus** to make room for haemoglobin to carry the maximum amount of oxygen

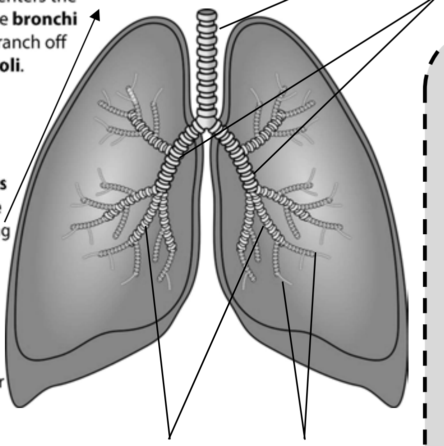
Lungs

Gas exchange

As you breathe in, oxygen-rich air enters the lungs through the **trachea**, into the **bronchi** (and smaller **bronchioles**) that branch off from it, and finally into **alveoli**.

Air in the alveoli has a higher O_2 concentration than blood in capillaries, **so O_2 diffuses down its concentration gradient into the blood** in the capillaries surrounding the alveoli.

Blood that has travelled around the body has a higher concentration of CO_2 than the air in the alveoli, so **CO_2 diffuses from the capillaries into the alveoli** and is breathed out.



Trachea – the main airway, supported and protected by cartilage rings

Bronchi – branch off from the trachea

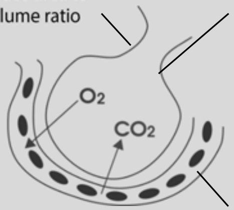
Bronchioles – branch off from bronchi

Alveoli – tiny sacs at the end of the airways of the lung

Alveolar adaptations for gas exchange

Alveoli are small and spherical – high surface area to volume ratio

Thin membrane of alveoli – short diffusion distance



Alveoli are surrounded by a capillary network, and lungs are ventilated. Therefore, concentration gradients of oxygen and carbon dioxide remain high, ensuring a high rate of gas exchange.

DIGESTION

Digestive system

Organisation in living organisms

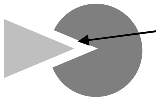
Cells The basic building blocks of organisms →	**Tissues** Groups of similar cells ↓
Organ systems Groups of organs working together to form organisms	← **Organs** Groups of different tissues performing a function

The **digestive system** is an organ system responsible for digesting and absorbing food, and excreting waste products.

How does digestion occur?

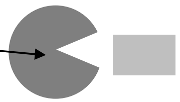
Enzymes catalyse reactions throughout the **digestive system** to **break down food** (carbohydrates, lipids and proteins) into **smaller soluble molecules** that can be absorbed into the **blood** for transport around the body. The resultant molecules can be used to **make new carbohydrates, lipids and proteins**, and some glucose is used in cellular **respiration**.

Enzyme-catalysed reactions



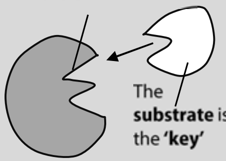
The specific reaction an enzyme catalyses depends on the shape of its **active site**, an area that binds to complementary substrate molecules during reactions.

This enzyme will not catalyse a reaction involving this substrate because the substrate is not complementary to its active site.

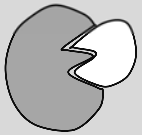


Lock and key model

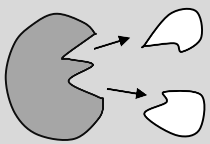
The enzyme's **active site** is the **'lock'**



1) The substrate fits perfectly into the active site – they are specific to each other (like a key in a lock).



2) The enzyme and substrate bind together.



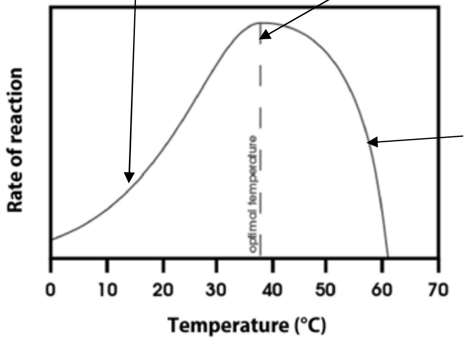
3) The enzyme catalyses the reaction; in this case, the breakdown of a food particle into smaller soluble molecules.

Rate of reaction

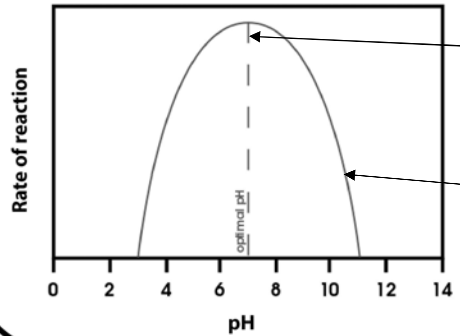
Factors that affect the rate of enzyme-catalysed reactions

As temperature increases, particles have more kinetic energy and move around more. Enzyme and substrate are more likely to collide, so **reaction rate increases.**

Most digestive enzymes in the human body work best at **37 °C**, because this is the temperature of the human body.



If the temperature becomes too high, the enzyme **denatures** (the active site changes shape so that the substrate no longer fits).



Different enzymes work best at different **pH** values.

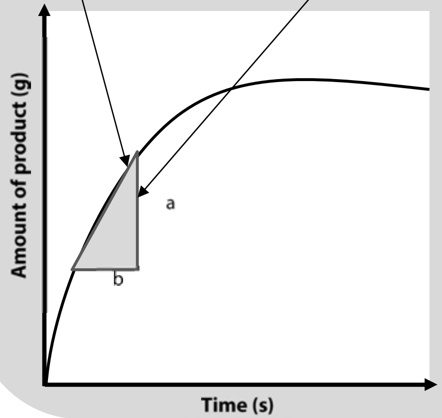
At certain pH values, **bonds in the enzyme break down**, causing the active site to change shape so that the substrate no longer fits inside it.

Practical: investigating effect of pH on rate of reaction of amylase enzyme

Procedure

1) Place test tubes of **starch solutions** in a water bath at 37 °C.
2) Add a **buffer** with a different pH value to each test tube of starch solution.
3) Set up **spotting tiles** with drops of iodine in rows.
4) Add **amylase** into one of the test tubes and start the **stopwatch**.
5) Every 20 seconds, use a pipette to **take a sample** from the test tube and add it to a drop of iodine on the spotting tile.
6) If the reaction has taken place, **iodine** will turn from yellow-red to blue-black.
7) **Repeat** this for each of the test tubes. Record the time it takes for the reaction to take place at each pH in a table.

1. Draw a **straight line** on the curve of the graph to represent the gradient at this point – this is the **tangent**.
2. Draw a **horizontal and vertical line** from the tangent to form a right-angled triangle.
3. Measure the **change in product** from the vertical line of the triangle (a) and the **change in time** from the horizontal line of the triangle (b).
4. **Divide (a) by (b)** to find the **gradient**, which is the **rate of reaction**.
5. **Units** for rate of reaction come from the graph. For example, y is in grams (g) and x is in seconds (s), so units for rate are **g/s**.

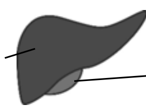


Digestion of food

Food type	Enzyme(s) that break(s) it down	Reaction (breaking down substances)	Where the enzyme is produced	Food test
Carbohydrate	Amylase, a carbohydrase	Starch → Sugars, e.g. maltose	Small intestine, pancreas, salivary glands	**Iodine solution** turns from yellow-red to blue-black if starch is present. **Benedict's solution** turns from blue to brick-red/orange if reducing sugars are present.
Lipid	Lipases	Lipids → Fatty acids and glycerol	Small intestine, pancreas	Dissolve in **ethanol**, then add to distilled water. A cloudy emulsion is produced if lipids are present.
Protein	Proteases	Proteins → Amino acids	Small intestine, pancreas, stomach	**Biuret reagent** (corrosive) turns from blue to purple if protein is present.

Role of bile

Bile is made in the liver.



It is stored in the gall bladder.

Bile is secreted into the small intestine, where it **emulsifies fat into smaller droplets**, increasing the surface area of the lipid.

It also **neutralises hydrochloric acid** from the stomach to make conditions in the small intestine more alkaline.

Overall, the action of bile **speeds up the breakdown of fat** into glycerol and fatty acids by lipases.

HEALTH PROBLEMS AND LIFESTYLE

Health issues

Good health
State of complete physical, mental and social well-being.

Diseases cause poor health
- They can be **communicable** or **non-communicable**
- Can be caused by / made worse by lifestyle factors, e.g. stress, poor diet and lack of exercise

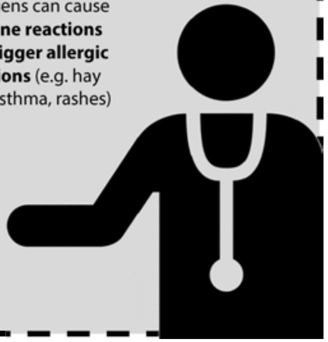
Interactions between disease factors

Viruses can cause **cancers** (e.g. HPV can lead to cervical cancer)

Pathogens can cause **immune reactions that trigger allergic reactions** (e.g. hay fever, asthma, rashes)

Immune system problems (e.g. AIDS) can increase likelihood of **infectious disease**

Poor **physical health** can result in **mental illness** e.g. depression

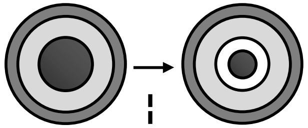


Coronary heart disease (CVD)

Factors that increase the likelihood of **coronary heart disease (CVD)** include a high-fat diet, smoking and lack of exercise. Each of these increases the level of cholesterol in the blood, causing fatty deposits.

Cause 1 of CVD: fatty deposits

Fatty deposits build up in **coronary arteries** so that they become narrow (**atherosclerosis**)



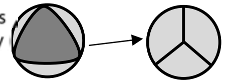
Less **oxygen** reaches the heart muscle **so heart muscle cells start to die**

Heart pain / heart attack

Treatment: Statins are drugs that reduce blood cholesterol, reducing fatty deposits. They can have side effects such as nausea, muscle pain, memory loss and liver/kidney damage.

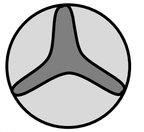
Treatment: Stents can be used to keep arteries open to maintain blood flow.

Normal heart valves open and shut fully



Cause 2 of CVD: faulty valves

Faulty valves do not open or close fully and may lose function

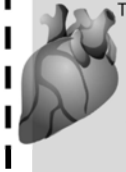


Heart failure
Heart **loses efficiency**, leading to breathlessness and even death

Treatment: Replacement valves
1) **Mechanical valves** – these are long-lasting but patients must take drugs to stop their body rejecting the valve.
2) **Biological valves** (from pigs, cattle, humans, etc.) – these don't require drugs but must be replaced every 12 years or so.

Other CVD treatments

Heart transplant
Replacing a damaged heart with a healthy one.



The patient may die waiting for a new heart because of **long waiting lists.**

Temporary hearts can be given while the patient waits for transplant, or to rest the heart. This is expensive.

Transplants can be **rejected** by the patient's immune system.

Artificial pacemaker
Correcting abnormal heart rate.

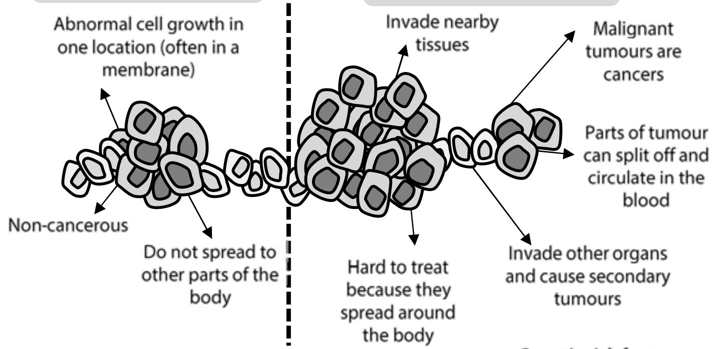
Increases **quality and length of life** but **medical check-ups** required for the rest of the patient's life.

Cancer

Cancer = an uncontrolled division of abnormal cells, resulting in disease

Benign tumours

Malignant tumours



Risk factors / causes of cancer

Viral infections (e.g. HPV causing cervical cancer)

Genetic risk factors (e.g. an allele of the BRCA1 gene predisposes breast cancer)

Chemicals (e.g. tar from smoking) – called carcinogens

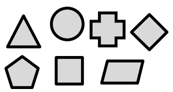
Mutations

Ionising radiation (e.g. UV, X-rays causing melanomas)

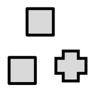
Type 2 diabetes

Risk factors
- A factor that **increases the likelihood of developing a disease**
- Can be an aspect of a person's lifestyle, a genetic factor, or a substance in a person's environment / in a person's body
- Obesity and lack of exercise are risk factors for type 2 diabetes

Sampling
To determine whether something is a risk factor for a disease, scientific research must be done on **samples** of human populations.



Good samples are large and varied to represent the whole population.

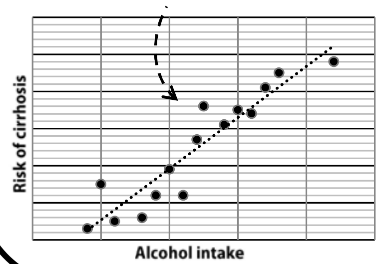


Poor samples are small and not representative.

Alcohol and smoking

Heavy alcohol consumption can lead to damage of the liver and brain tissues:
1) Alcohol is a **carcinogen**, so increases the risk of liver cancer in heavy drinkers.
2) Long-term heavy drinking can cause **brain tissue to become soft** and lose its structure and function, and **cause liver cirrhosis** (destruction of liver tissue).
3) Smoking can cause lung cancer (tar is a carcinogen) and lung disease.

This graph shows a **correlation** (a suggested link) between alcohol consumption and liver cirrhosis. A correlation does not prove that a factor causes a disease.



More scientific data has been collected to show that there is a **causal mechanism** explaining how alcohol causes liver cirrhosis.

Birth defects

Smoking during pregnancy leads to **carbon monoxide** being carried in the blood, which prevents the **fetus** from having **enough oxygen** to develop normally.

This can cause **birth defects** such as low weight, brain damage, or even stillbirth.

Alcohol can pass from the mother's blood into the baby via the placenta.

Because the **fetus's liver cannot process the alcohol,** it can cause damage to its organs, brain damage and facial deformities.

PLANT ORGANISATION

Plant tissues

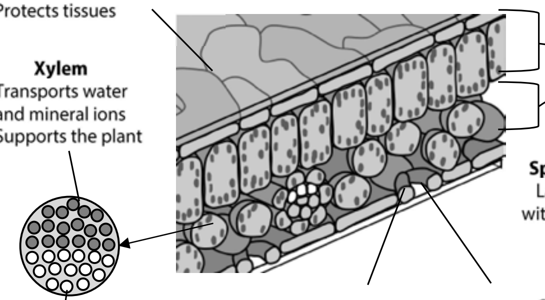
Tissues of the leaf

The leaf is an organ made up of several different tissues.

Epidermis
- Covers surfaces of tissues
- Secretes protective waxy cuticle over leaf surface
- Protects tissues

Palisade mesophyll
Have many chloroplasts for photosynthesis

Xylem
- Transports water and mineral ions
- Supports the plant



Spongy mesophyll
Large surface area with big air spaces for gas diffusion

Guard cells
Close and open stomata

Stomata
Pores that allow water loss and gas exchange when open. They close to limit water loss by evaporation.

Phloem
For translocation

Transpiration

What is transpiration?

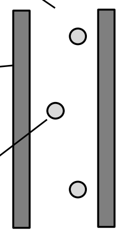
Transport of **water and mineral ions** from roots to stem and leaves of plant via the **xylem**. Water is needed in the stems and leaves of the plant for **photosynthesis** and for **structural support**.

Adaptations of xylem vessels for transpiration

Dead cells form a **continuous tube** without cell wall ends

Walls are strengthened by **lignin**

Water and mineral ions can travel easily up the stem to the leaves in a **continuous stream**



Process of transpiration

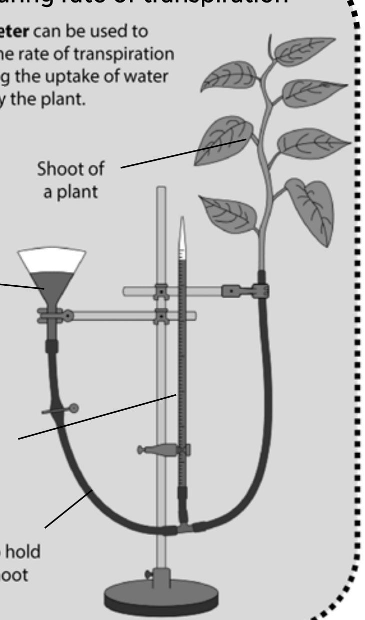
1) Water vapour is lost from the air spaces of the leaf through diffusion out of open stomata. This is **evaporation**.

2) Loss of water from the leaves pulls more water up the stem through the xylem from the roots, to replace what has been lost. This is **transpiration**.

3) Water enters the roots from the soil by **osmosis** to replace the water constantly moving away from the roots to travel up the stem.

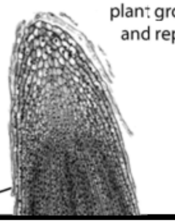
Measuring rate of transpiration

A **potometer** can be used to investigate the rate of transpiration by measuring the uptake of water by the plant.



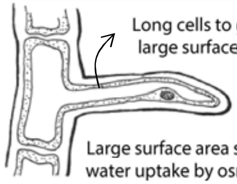
Meristem

Undifferentiated cells with the ability to divide quickly and differentiate into any specialised plant cell type



Responsible for plant growth and repair

Root hair cells



Long cells to give a large surface area

Large surface area speeds up water uptake by osmosis and mineral ion uptake by active transport from the soil

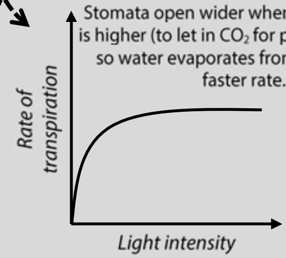
The stem, roots and leaves form a **plant organ system**: organs working together to enable transport of substances (water, mineral ions and sugars) around the plant.

Investigate the distribution of stomata and guard cells.
1) Coat a section of a leaf with clear nail varnish.
2) Peel off the varnish and place on a microscope slide.
3) Count the number of stomata under the microscope in randomly sampled squares of the leaf and take the mean value.

Factors affecting transpiration rate

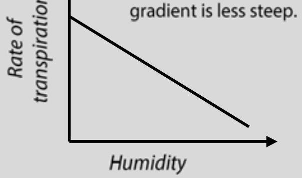
Light intensity

Stomata open wider when light intensity is higher (to let in CO_2 for photosynthesis), so water evaporates from the leaf at a faster rate.



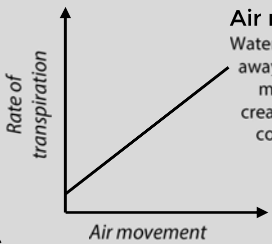
Humidity

If there is a lot of water in the air, water will leave the leaf more slowly because the concentration gradient is less steep.



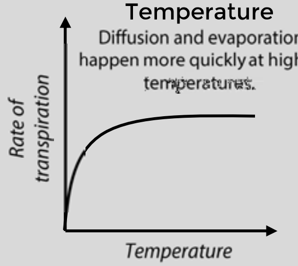
Air movement

Water vapour moves away from the leaf more quickly, creating a steeper concentration gradient.



Temperature

Diffusion and evaporation happen more quickly at higher temperatures.

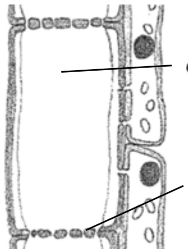


Translocation

What is translocation?

Transport of **sugars** (products of photosynthesis) dissolved in sap from leaves to other plant tissues via the **phloem**.

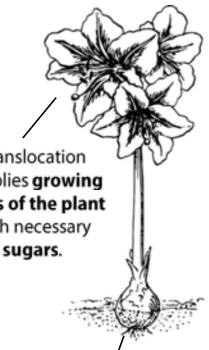
Adaptations of phloem tissue for translocation



Live, elongated cells form tubes

End walls of cells have **pores** for sap to move through the vessel

Importance of translocation



Translocation supplies **growing parts of the plant** with necessary **sugars**.

Sugars can also be transported to other plant organs where they will be **stored** for later use.