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Organisation

GCSE AQA BIOLOGY: TOPIC 2

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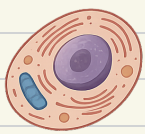
Cell organisation

Cell organisation → the way the cells are structured and arranged to form tissues, organs, and organ systems that carry out specific functions in a multicellular organism.

Levels of organisation

Biological structures are organised in the following order:

1. **Cells** - basic building blocks, make up all living organisms (e.g. muscle cell)
2. **Tissues** - a group of similar cells working together to perform a function (e.g. muscular tissue)
3. **Organs** - a group of different tissues working together to perform a specific function (e.g. Stomach)
4. **Organ systems** - a group of organs working together to carry out body functions (e.g. digestive system)
5. **Organism** - a whole living being made of systems working together. (e.g human)



Cell

↓

Tissue

↓

Organ

↓

Organ System

↓

Organism

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Enzymes

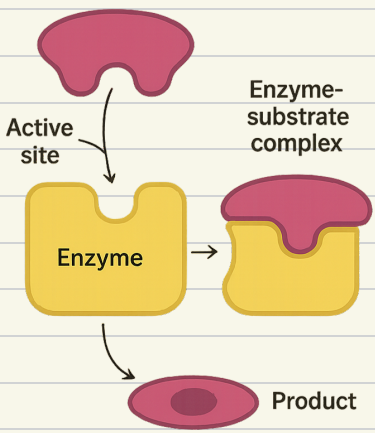
Enzymes → biological catalysts - they speed up chemical reactions in living organisms without being used up. They are proteins made from chains of amino acids folded into specific shapes.

Key feature of enzymes:

Specific - each enzyme only works with one substrate (like a key fitting in a lock)
Reusable - enzymes are not used up in the reaction
Affected by temperature and pH - they work best in certain temperatures and pH

Lock and key model:

Enzyme has an active site and that's where the reaction takes place.
The substrate fits into the enzyme with the exact shape. This gets called enzyme - substrate complex.
Then the enzyme breaks the substrate down.



Enzyme's actions are affected by the following factors:

- Enzyme activity can be affect the reaction rate depending on the temperature, hot temperatures help the rate of reaction increase, however if it gets too hot the bonds can break.
- depending on the organism, all enzymes have an optimum temperature (for example human body's is around 37°C -this is the temperature that they work best at.
- pH is another factor impacting enzyme rates, each enzyme has an optimum pH.
- if the temperatures and pH are too high or low, the shape of the enzyme's active site changes shape resulting in the substrate to not fit in. This is when the enzyme has denatured.

Practical

pH effect on enzymes

Investigate how pH affects the breakdown of starch:

1. Place a drop of iodine solution (helps detect starch - if starch is present, iodine solution turns from orange to blue/black) into each well of the spotting tile.
2. In a test tube, add 2cm³ of buffer solution (set pH), 2cm³ of amylase and 2cm³ of starch. Mix gently and start the stopwatch immediately.
3. Every 10 seconds, take a drop of the reaction mixture and add it to a new iodine well.
4. Continue until the iodine no longer turns blue-black and remains orange - this means starch is broken down.
5. Record the time taken for the starch to be broken down.
6. Repeat the whole experiment with buffer solutions at different pH values to see how pH affects enzyme activity.

Variables:

- Independent - pH (different buffer solutions)
- dependent- time taken for starch to be broken down
- control - temperature, concentration and volume of amylase and starch

Analysis:

The shortest time means it is the fastest reaction, so it's the optimum pH.

Equation to calculate the rate of reaction:

$$\text{Rate} = 1000/\text{time}$$

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Digestive enzymes

Digestive enzyme → break down insoluble molecules. Food that we eat is made of large molecules, for example fats, protein and starch. Those molecules are too big to pass through the walls of the digestive system. The role of the digestive enzyme is to break big molecules into smaller molecules, that can then be sent in the bloodstream and be used by the body.

The enzyme amylase breaks down starch (carbohydrate) into glucose (sugar)	The enzyme protease breaks down proteins into amino acids	The enzyme lipase breaks down fats (lipids) into glycerol and fatty acids
Amylase is made in: salivary glands, pancreas and small intestine	Protease is made in: stomach (pepsin), the pancreas and small intestine	Lipase is made in: pancreas and small intestine
Starch (Type of carbohydrate) ⇨ Glucose (Type of sugar)	Proteins ⇨ Amino acids	Fats (type of lipids) ⇨ Glycerol, fatty acids

What are these products used for:

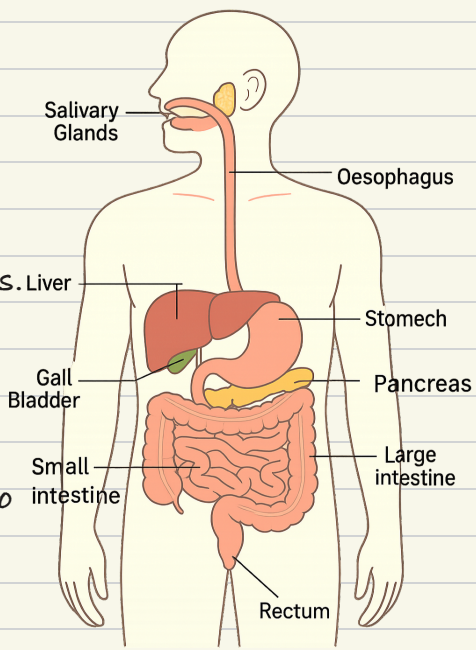
Sugars → used for and energy respiration

Amino acids → used to build proteins in the body

Fatty acids and glycerol → used to make cell membrane and store energy

Bile → yellow fluid made by the liver and stored in the gall bladder. It is released into the small intestine.
The purpose of bile is to neutralise hydrochloric acid in the stomach which makes the contents very acidic for enzymes as they work best in alkaline conditions. Bile is alkaline so it neutralises the acid, creating the right pH for enzyme. Bile also emulsifies fats - It breaks large fat droplets that are insoluble into smaller ones. This increases the surface area for lipase to work on, making digestion more efficient.

Organs in the digestive system:



- mouth/ salivary glands: releases amylase in saliva to begin breaking down starch.
- oesophagus: pushes food to the stomach.
- stomach: mixes food using muscles.
  Produces protease (pepsin) to digest proteins.
  Releases hydrochloric acid to kill bacteria and give enzymes an acidic environment.
- liver: makes bile to help digest fats by emulsification.
- gall bladder: stores bile, then releases it into small intestine.
- pancreas: produces the 3 key enzymes and sends them into the small intestine.
- small intestine: produces the 3 enzymes. Digests food and absorbs small molecules into the bloodstream.
- large intestine: absorbs water from undigested material.
- rectum: stores faeces (indigestible remains) before the exit through the anus.

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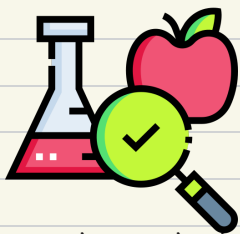
Food tests

Food tests aims to identify which food molecules (carbohydrates, proteins, or lipids) a good sample contains using simple chemical tests.

Preparing the food sample- for all tests



1. Get a small sample of the food you want to test
2. Break it up using a mortar and pestle
3. Add distilled water to the food in a beaker
4. Stir or mix well to dissolve some of the food
5. Filter the mixture using a funnel and filter paper to get a clear solution for testing

Test for sugars - Benedict's test

- prepare food sample
- Use Benedict's solution (blue) to your food sample in test tubes
- leave the tube in the water bath at about 75°c for 5 mins
- if sugar is present, the solution will turn from blue → green→ yellow → brick red, depending on how much sugar is present

Test for starch- iodine solution

- Prepare food sample
- add a few drops of iodine solution to your food sample
- if starch is present, it will turn from orange-brown → blue-black

Test for proteins- biuret test

- Prepare food sample
- add a few drops of sodium biuret solution to the sample
- If proteins are present, it will turn blue to purple or lilac

Test for lipids - Sudan III test

- prepare the food sample
- add Sudan III stain to the sample (no filtering needed)
- shake the test tube gently
- if lipids are present, a red layer will form on top of the liquid

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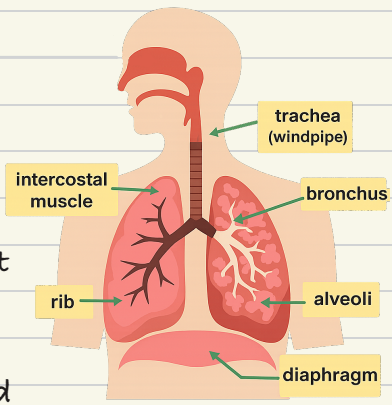
Lungs

Function → lungs are organs of the respiratory system. The main function is gas exchange - taking in oxygen from the air and removing Carbon dioxide from the blood.

Structure of lungs

Lungs are found in the thorax, thorax is the top part of the body, above the diaphragm, below the neck. Lungs are protected by the ribcage, intercostal muscles and the diaphragm. The air we breathe enters the body through the nose or mouth. It then passes down into the trachea/ windpipe (tube supported by rings of cartilage, preventing it from collapsing). The trachea splits into two bronchi - one leading to each lung. Inside the lungs, the bronchi branch into smaller tubes called bronchioles. At the end of the bronchioles are tiny air sacs called alveoli, where gas exchange occurs.



Alveoli and gas exchange

Alveoli are little air sacs that are found in the lungs and are adapted to gas exchange. They are surrounded by a network of blood capillaries. There are millions of alveoli in each lung, giving a huge surface area for gas exchange.

Gas exchange is the diffusion of gases between the alveoli and the blood. Oxygen from the air diffuses from the alveoli into the blood in the capillaries. Carbon dioxide in the blood diffuses from the capillaries into the alveoli to be breathed out. This happens because of the concentration gradient; oxygen is high in the alveoli and low in the blood while Carbon dioxide is high in he blood and low in the alveoli.

To calculate breathing rate= number of breaths/ number of minutes

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Heart

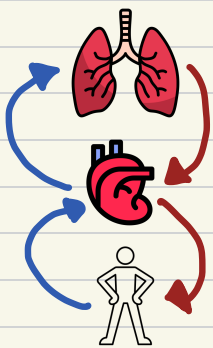
Function → the heart is a muscular organ that pumps blood around the body.

It is part of the circulatory system, which includes: heart, blood, blood vessels.

Double circulatory system

Humans have double circulatory system:

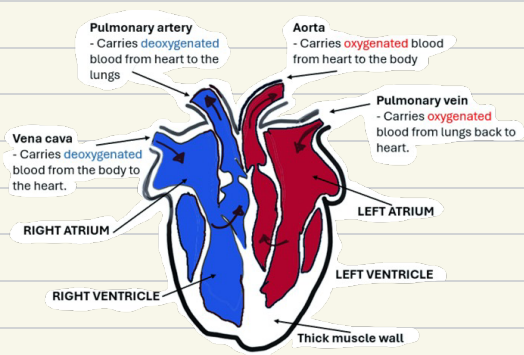
- on the right side the right ventricle - pumps deoxygenated blood to the lungs to pick up oxygen. The blood then returns to the heart.
- on the left side the left ventricle pumps oxygenated blood to the rest of the body. The blood gives up oxygen at the body cells and the deoxygenated blood returns to the heart, and this process keeps repeating.



Structure of the heart

The heart pumps blood around the body and its walls are made of muscle tissue. The heart has 2 valves and they prevent back flow of blood.
The heart has four chambers - right atrium, right ventricle, left atrium, left ventricle. Movement of the blood:

1. Deoxygenated blood from the body enters the right atrium through the vena cava
2. it then moves into the right ventricle, which pumps it to the lungs through the pulmonary artery
3. in the lungs, blood collects oxygen and becomes oxygenated
4. This oxygenated blood returns to the left atrium via the pulmonary vein
5. it flows into the left ventricle, which has a thicker wall so it can pump the blood around the body



The heart also has coronary arteries that branch off the aorta. These supply the heart with its own oxygenated blood.

Pacemaker

The natural pacemaker is a group of cells in the right atrium wall. It controls the heartbeat rhythm by producing electrical impulses. These cells produce a small electric impulse that spreads to the surrounding muscle cells, causing them to contract. If it fails, an artificial pacemaker can be fitted (small electric device under the skin)

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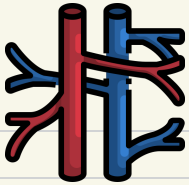
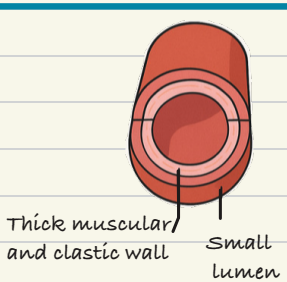
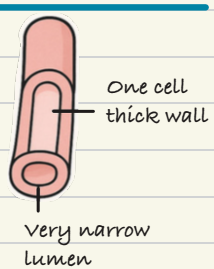
Blood vessels



Function → blood vessels transport blood around the body. They are part of the circulatory system and connect the heart to organs and tissues.

There one three main types of vessels:

- arteries
- veins
- capillaries

Features	Arteries	Veins	Capillaries
Function	Carry blood away from the heart	Carry blood to the heart	Allow exchange of substances
Wall-thickness	Thick	Thin	Very thin - 1 cell thick
Lumen (the hole in the vein) size	Small	Large	Very narrow
Pressure	High	Low	Low but allows diffusion
Valves	No	Yes (to prevent backflow)	No
Diagram			

To calculate the rate of blood flow = $\frac{\text{Volume of blood}}{\text{Number of minutes}}$

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Blood

Blood → tissue made up of different cells suspended in a liquid called plasma.
Blood is important as it's role is transportation, protection, and regulation.

Red blood cells

Red blood cell's function is to carry oxygen from lungs to the cells, helps maintain aerobic respiration in body tissues and supports homeostasis by delivering oxygen and removing carbon dioxide.
They have a biconcave disc shape, which increases the surface area for gas exchange. They contain haemoglobin, a red pigment, which binds to oxygen.
They have no nucleus to carry oxygen.

White blood cells

White blood cell's function is to defend against infection. They can change shape, taking part in phagocytosis (covered more in topic 3)
They have a nucleus. Some produce antibodies, some produce antitoxins and some carry out phagocytosis.

Plasma

Plasma is the liquid part of blood. It is a yellow fluid. It carries cells, waste, and useful substances around the body: red, white cells, glucose, carbon dioxide, urea, hormones, proteins, antibodies and antitoxins.

Platelets

Platelets are tiny fragments of cells. They have no nucleus. Its function is to help blood clot at a wound to prevent blood loss and stop entry of micro organisms.

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Cardiovascular disease

Cardiovascular disease - condition that affects the heart or blood vessels.

One of the cardiovascular diseases you need to know about is coronary heart disease. This is when coronary arteries (they supply blood to the heart) become narrowed or blocked due to the build up of fatty material in the artery walls. This reduces blood flow, causing a lack of oxygen to the heart, which can lead to a heart attack.

Treatment of coronary heart disease (CHD)

Stents

- Mesh tubes inserted into arteries to keep them open, allowing blood to flow through.
- advantages: effective long-term, quick recovery, quickly open blocked arteries.
- disadvantages: risk of infection, clotting after procedure.

Statins

- drugs that reduce cholesterol (too much cholesterol causes fatty deposits, leading to CHD)
- advantages: reduce risk of heart attack, help prevent other disease, easy to take.
- disadvantages: negative side effects, must be taken regularly, effect takes time

In some severe cases, other treatments may be needed:

Artificial blood:

Used when a person loses a lot of blood.

- acts as a blood substitute
- used to replace lost volume and carry oxygen temporarily
- gives doctors time to find a blood donor match or stimulate red blood cell production

Adv: can save lives in emergencies and no need for blood type matching and reduces infection list

Disadv: doesn't replace the function of real blood cells long-term and only temporary as patient still needs real blood eventually

Artificial heart:

Used when a patient's heart fails completely.

- Artificial heart is a machine that pumps blood around the body temporarily, until a real heart is available
- keeps patient alive while waiting for a donor heart

Adv: saves lives when no donor is available and prevents organ failure due to lack of blood flow.

Disadv: can lead to blood clotting or infection and not as affective as natural heart and parent may need to take blood thinners.

Valve replacement:

Used when heart valves become stiff or leaky, which effects blood how direction and pressure

- Repaired or replaced using biological valves (from humans or animals) or mechanical valves (made from metal/plastic)

Adv: fixes blood flow and reduces strain on the heart and it can improve quality of life.

Disadv: require lifelong medication to prevent blood clots and surgery has risks of infection and bleeding.

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Health and disease

Health → state of physical and mental wellbeing. Health can be affected by disease, diet, stress, and life situation.

Type of diseases:

- Communicable - can be spread from person to person. (E.g. Covid 19)
- Non - communicable - cannot be spread between people. Often long-lasting. (E.g. Cancer)

Interactions between diseases

Diseases can interact in the body, making them more vulnerable to other disease or worsening their heath overall:

- some infectious diseases can trigger or increase the risk of non-communicable diseases; for example, HPV (virus) can cause cervical cancer.
- if a disease weakens your immune system, you're less able to fight off other infections.
- having a long-term physical disease can lead to mental health problems, like depression or anxiety.

Factors affecting health:

- stress - leads to mental health issues
- poor diet - leads to obesity, malnutrition, diabetes
- environmental and social factors

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Non-communicable diseases risk factors

Risk factors → something that increases the chance of developing a disease, for example lifestyle - related, environmental and inherited genetically.

Risk factors	How it affects the body	Linked diseases
Smoking	• Damages lungs • narrows arteries • increases blood pressure	• Lung cancer • CHD • stroke
Lack of exercise	• Lowers cardiovascular fitness • contributes to obesity	• CHD • type 2 diabetes
Obesity	• Increases blood pressure • causes insulin resistance	• Type 2 diabetes • CHD • some cancers
Excess alcohol	Damages liver and brain cells	• Brain damage • cancer and liver disease
Unbalanced diet	• lead to obesity	• Type 2 diabetes • heart disease
Exposure to carcinogens	Substances that cause mutations in DNA	Cancers

Multiple risk factors can combine, increasing the overall Chance of disease. For example, a person who is overweight, smokes and eats poorly is at much higher risk of cardiovascular disease. Non - communicable disease cause many deaths worldwide. They place a huge financial burden on NHS, families, and workplaces due to treatment cost and loss of income.

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Cancer

Cancer → uncontrolled cell growth and division that results in the formation of a tumour (lump of abnormal cells)

Types of tumour:

Benign

- The tumour grows in one place until there's no more room
- does not invade other tissues
- not cancerous
- normally not dangerous unless it puts pressure on organs (eg. Benign brain tumour)

Malignant

- The tumour invades nearby tissues
- can spread to other parts of the body via the bloodstream
- cancerous
- cells from the tumour may break off and form secondary tumours elsewhere

Risk factors for cancer:

- Smoking- strongly linked to lung cancer and others
- UV exposure - increases risk of skin cancer (e.g. From sun)
- alcohol - linked to bowel, liver and kidney cancer
- genetic factors- some people inherit faulty genes that increase cancer risk

Treating cancer:

- Surgery - removing the tumour from the body
- radiotherapy - using targeted radiation to kill cancer cells
- chemotherapy - using drugs to kill fast-diving cells (Can affect heathy cells too)

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Plant cell organisation

Plant cell organisation → like humans, plants are made of organ systems that work together to carry out life processes. In plants this includes transporting water, minerals, and food, as well as photosynthesis.

Plant tissues and their functions

Epidermal tissue → covers and protects the surface of the plant. It is found in the outer layer of leaves and stems.

Palisade mesophyll tissue → main site of photosynthesis -lots of chloroplasts. Found in the upper layer of the leaf.

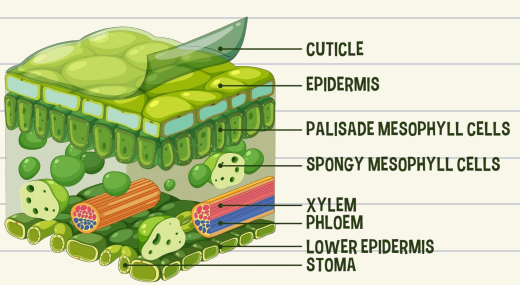
Spongy mesophyll tissue → air spaces for gas exchange. Found beneath palisade layer in leaf.

Xylem, phloem → transports water and mineral ions from roots to leaves. Found throughout the plant.

Meristem tissue → where growth occurs and contains stem cells. Found in the tips of roots and shoots.

Structure of a leaf

1. Waxy cuticle → a thin, waterproof layer on the surface, it reduces water loss by evaporation.
2. Upper epidermis → thin and transparent. Allows light to pass through to the palisade layer below, also protects the leaf.
3. Spongy mesophyll layer -loosely packed with air spaces, allows gas exchange.
4. Xylem and phloem- (inside the spongy layer) - transport water, sugars and minerals.
5. Lower epidermis - contains stomata (tiny pores) allows gas exchange



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Transpiration & translocation

Transpiration → The loss of water vapour from the leaves and stems of a plant. Transpiration occurs in xylem.

How transpiration happens:

- Water evaporates from cell surfaces inside the leaf.
- it diffuses out through the stomata into the air.
- more water is pulled up through the xylem from the roots - this is called the transpiration stream.

Transpiration is important as it draws up water and minerals from the soil.

Factors affecting transpiration rate:

- Light intensity → brighter light, high transportation rate (more stomata open)
- temperature → The higher the temperature, higher transpiration rate
- wind speed → high wind speed, removes humid air leading to high transpiration
- humidity → more humidity, transportation rate will be lower (less evaporation gradient)

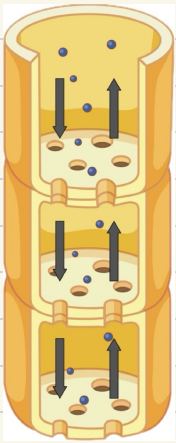
Translocation → The movement of dissolved sugars through the phloem from sources (where sugars are made) to sinks (whore sugars are used/stored)

How translocation happens:

- Sugars move up or down the plant depending on demand
- requires energy from respiration (so phloem cells are alive)

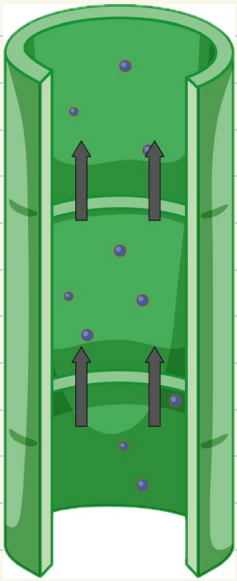
Phloem

- transports food substances (mainly dissolved sugars) from leaves to the rest of the plant for usage or storage
- made of columns of living cells with small pores in the end walls to allow cell sap to flow through
- has sieve plates between cells for flow
- movement is two way
- companion cells provide energy for transport
- carry out translocation



Xylem

- Transports water and mineral ions from roots to leaves and stem
- made of dead cells joined end to end with no end walls between them.
- strengthened with lignin
- movement is one way only
- carry out transpiration



Stomata and guard cells:

Stomata are small pores on the leaf. Their function is to let carbon dioxide in for photosynthesis and let oxygen and water vapour out. Guard cells control the opening and closing of stomata. If the water level is high, guard cells become swollen and stomata opens; if water level is low, guard cells shrink, and stomata closes (to prevent further loss).