MYP Biology

Criterion A - Revision Notes

Ecology

Adaptations, Interdependence and Competition

Communities

An individual is part of a species, but lives in its habitat within a population.
Many different populations interact in the same habitat, creating a community. The populations are often dependent on each other.
An ecosystem is the interaction of a community with non-living (abiotic) parts of the environment. Organisms are adapted to live in the conditions of their environment.

Organisms which need the same resources compete for it.

- There can be competition within a species or between different species.
- Plants may compete for light, space, water and mineral ions.
- Animals may compete for space, food, water and mating partners.

Interdependence describes how organisms in a community depend on other organisms for vital services.

- These include for food, shelter and reproduction (pollination, seed dispersal), e.g. birds take shelter in trees, flowers are pollinated with the help of bees.
- The removal or addition of a species to the community can affect the populations of others greatly, as it changes prey or predator numbers
- A stable community is one where all the biotic (living) and abiotic (non-living) factors are in balance.
    - As a result the population sizes remain roughly constant.
    - When they are lost it is very difficult to replace them.
    - Examples include tropical rainforests, oak woodlands and coral reefs.

Abiotic Factors

An abiotic factor is a non-living factor. You need to be able to explain the effect of a change in an abiotic factor.

Abiotic factors which can affect a community:

1. Light intensity
    - Light is required for photosynthesis.
    - The rate of photosynthesis affects the rate at which the plant grows.
    - Plants can be food sources or shelter for many organisms.
2. Temperature
    - Temperature affects the rate of photosynthesis.
2. Moisture levels
    - Both plants and animals need water to survive.
2. Soil pH and mineral content
    - Soil pH affects the rate of decay and therefore how fast mineral ions return to soil (which are then taken up by other plants).
    - Different species of plants thrive in different nutrient concentration levels.

2. Wind intensity and direction
    - Wind affects the rate of transpiration (movement of water from root to leaves) in plants.
    - Transpiration affects the temperature of the plant, and the rate of photosynthesis because it transports water and mineral ions to the leaves.
2. Carbon dioxide levels
    - CO_2 affects the rate of photosynthesis in plants.
    - It also affects the distribution of organisms as some thrive in high CO_2 environments.
2. Oxygen levels for aquatic animals

- Levels in water vary greatly, unlike oxygen levels in air.
- Most fish need a high concentration of oxygen to survive.

Biotic Factors

A biotic factor is a living factor. You need to be able to explain the effect of a change in a biotic factor.
Biotic factors that can affect a community:

1. Food availability: more food means organisms can breed more successfully and therefore the population can increase in numbers
2. New predators
3. New pathogens: when a new pathogen arises the population has no resistance to it so they can be wiped out quickly
4. Competition: if one species is better adapted to the environment than another, then it will outcompete it until the numbers of the lesser adapted species are insufficient to breed.

Adaptations

Organisms have adaptations that allow them to survive in the conditions where they live.

1. Structural: shape or colour of a part of an organism, e.g.
    - Sharp teeth of a carnivore to tear meat apart
    - Camouflage, such as the tan/brown colour of a lionesses coat, to avoid prey from spotting her
    - Species in cold environments may have a thick layer of fat for insulation
2. Behavioural: the way an organism behaves, e.g.
    - Individuals may play dead to avoid predators
    - Basking in the sun to absorb heat
    - Courting behaviour to attract a mate
2. Functional: involved in processes such as reproduction and metabolism
    - Late implantation of embryos
    - Conservation of water through producing little sweat

Extremophiles live in environments which have extreme conditions. These include high temperatures, pressures or salt concentrations. An example is bacteria which live in deep sea vents where there pressure is very high.

Examples of adaptations for different scenarios

1. Cold climates: Smaller surface area to volume ratio to reduce heat loss, lots of insulation (blubber, fur coat)
2. Dry climates: Adaptations to kidneys so they can retain lots of water producing very concentrated urine, being active in the early morning and evenings when it is cooler, resting in shady areas, larger surface area ratio to increase heat loss
3. Examples of plant adaptations: Curled leaves to reduce water loss, extensive root systems to take in as much water as possible, waxy cuticle to stop water evaporating, water storing tissue in stem

Organisation of an Ecosystem

Levels of Organisation

Feeding relationships are shown by food chains.

1. They begin with a producer.
    - These are always photosynthetic organisms (usually a green plant or algae)
    - Through photosynthesis they make glucose
    - Glucose is used to make other biological molecules in the plant, which make up the biomass
2. Producers are eaten by primary consumers – energy is transferred through organisms in an ecosystem when one is eaten by another.
3. Primary consumers are eaten by secondary consumers – The animals eaten are called the prey and the consumers that kill and eat them are predators.
4. Secondary consumers are eaten by tertiary consumers.

A stable community will show population cycles between the predators and prey.

- If the population of prey increases, the population of predators will also increase.
- This will result in the number of prey decreasing after some time as more would be consumed by the increased number of predators.
- When there isn't enough prey to feed all the predators, the population of predators will decrease, which will allow the population of prey to increase again.

How Materials are Cycled

re cycled through ecosystem.

s are vital for life on Earth.

The Carbon Cycle

- CO_2 is REMOVED from the air in photosynthesis by green plants and algae – they use the carbon to make carbohydrates, proteins and fats. They are eaten and the carbon moves up the food chain.

- CO_2 is RETURNED to the air when plants, algae and animals respire. Decomposers (a group of microorganisms that break down dead organisms and waste) respire while they return mineral ions to the soil.
- CO_2 is RETURNED to the air when wood and fossil fuels are burnt (called combustion) as they contain carbon from photosynthesis.

The Water Cycle

- The sun's energy causes water to evaporate from the sea and lakes, forming water vapour.
- Water vapour is also formed as a result of transpiration in plants.
- Water vapour rises and then condenses to form clouds.
- Water is returned to the land by precipitation (rain, snow or hail), and this runs into lakes to provide water for plants and animals.

- This then runs into seas and the cycle begins again.

Impact of Environmental Change

Environmental changes affect the distribution of species in an ecosystem:

- Temperature: Climate change may lead to insects migrating to places in the world which are becoming hotter
- Water availability: Populations will migrate to find water
- Atmospheric gas composition: Certain pollutants can affect the distribution of organism, e.g lichen cannot grow in places where sulfur dioxide is present.

These changes may be seasonal, geographic or caused by human interaction.

Biodiversity and the Effect of Human Interaction on Ecosystems

Biodiversity: the variety of different species of organisms on Earth or within an ecosystem.

High biodiversity means the ecosystem will be stable.

- Biodiversity means that species are less dependent on each other for things such as food and shelter.

- Many human activities are having a negative effect on biodiversity.

- The future of humans on Earth depends on maintaining biodiversity – for example for food and new medicines.
- The impact of our activities is getting bigger as the population is increasing, as more resources are being used and more waste is being produced.
- More land is being used for houses, farming, shops, roads and factories, which destroys habitats.
- Pollution kills plants and animals.
    - Sewage, fertiliser and toxic chemicals pollute the water.
    - Smoke and acidic gases pollute the air.
    - Landfill and toxic chemicals can result in the pollution of the land.
    - We are using up raw materials quicker than they are being produced. Human have only tried to reduce their impact recently.

Land Use

Humans take up land and therefore reduce the number of habitats for animals and plants by building, quarrying (cutting into ground to obtain stone and other materials), farming and dumping waste

Waste

- Peat is a material that forms when plant material has not fully decayed as there is not enough oxygen.
- It accumulates in bogs that are acidic and waterlogged.
- These bogs are a habitat for many species, in particular for migrating birds
- Peat bogs are being destroyed – they are being drained in order to create space for farming, peat is used as compost, or dried to use as fuel as it contain carbon (releasing CO_2 into the atmosphere).
- It is being used up quicker than it is being formed, as the formation process is slow.

Deforestation

Deforestation: the cutting down of a large number of trees in the same area, in order to use the land for something else.

It happens in tropical areas to:

- Provide land for cattle and rice fields
- To grow crops (e.g. sugarcane, maize) for biofuels which are used to produce energy

The problems caused by deforestation:

1. As trees contain carbon, burning them results in more CO_2 being released into the environment which contributes to global warming. Following deforestation, microorganisms decompose the dead vegetation, producing CO_2 as they respire.

2. Trees take in CO_2 when they photosynthesise, so less trees means less CO_2 is taken in.
3. The number of habitats are reduced, decreasing biodiversity.

Global Warming

The term global warming refers to the fact that the temperature around the world is increasing. This is because we are producing more greenhouse gases (carbon dioxide and methane), resulting in more heat being absorbed and reflected back to Earth, heating it up.

The consequences of this temperature increase are:

- Melting of the ice caps, reducing habitats
- Rising sea levels, reducing habitats as low lying areas will be flooded with salty water
- Temperature and rainfall levels will affect migration and therefore the distribution of different species, as they may no longer be able to survive where they live
- Organisms will become extinct as their habitats are lost, reducing biodiversity

Maintaining Biodiversity

Positive human interactions with ecosystems	**Negative human interactions with ecosystems**
Maintaining rainforests, ensuring habitats here are not destroyed.	Production of greenhouse gases leading to global warming.
Reducing water pollution and monitoring the changes over time.	Producing sulfur dioxide in factories which leads to acid rain – affects habitats.
Preserving areas of scientific interest by stopping humans from going there.	Chemicals used in farming leak into the environment.
Replanting hedgerows and woodlands to provide habitats which were previously destroyed.	Clearing land in order to build on, reducing the number of habitats.

To reduce our negative impact on ecosystems, programs have been put in place to maintain biodiversity.

1. Breeding programs: to stop endangered species from becoming extinct.
2. Protection of rare habitats: to stop the species here from becoming extinct, if damaged they may even be regenerated to encourage populations to live here
3. Reintroduction of hedgerows and field margins around land where only one type of crop is grown: maintains biodiversity as the hedgerows provide a habitat for lots of organisms (because a field of one crop would not be able to support many organisms) and field margins provide areas where wild flowers and grasses can grow.
4. Reduction of deforestation and carbon dioxide production: reduces the rate of global warming, slowing down the rate that habitats are destroyed

5. Recycling rather than dumping waste in landfill: reduce the amount of land taken up for landfills, and slows the rate we are using up natural resources.

Trophic Levels in an Ecosystem

Trophic Levels (7.4.1)

Trophic levels are the different stages in the food chain. They are represented by numbers.

1. Level 1
    - Organisms at the first level are called producers such as plants and algae.
    - They make their own food by photosynthesis.
2. Level 2
    - Organisms at the second level are called primary consumers.
    - These are herbivores, that only eat plants.
2. Level 3
    - Organisms at the third level are called secondary consumers.
    - These are carnivores and they eat herbivores.
2. Level 4
    - Organisms at the fourth level are called tertiary consumers.
    - These are carnivores that eat other carnivores.
    - They have no predators and are at the top of the food chain – called apex predators.

Decomposers break down dead plant and animal matter.

- They do this by secreting enzymes
- The matter is broken down into small soluble food molecules and they move into the microorganism by diffusion.

Pyramids of Biomass
Transfer of Biomass

Pyramids of biomass show the relative biomass at each trophic level.

- It shows the relative weights of material at each level.
- There is less biomass as you move up the trophic levels.
- Not all the food consumed by an animal is converted into biomass – this means the biomass of the organism in the level above another will always be higher, as not all the organism can be consumed and converted into biomass.

Producers (.e.g plants and algae) transfer about 1% of the incident energy from light for photosynthesis, as not all the light lands on the green (photosynthesising) parts of the plant.

Only approximately 10% of the biomass of each trophic level is transferred to the next.

- Not all biomass can be eaten.
    - o Carnivores cannot generally eat bone, hooves, claws and teeth.
- Not all of the biomass eaten is converted into biomass of the animal eating it.

- o Lots of glucose is used in respiration, which produces the waste product carbon dioxide
- o Urea is a waste substance which is released in urine
- o Biomass consumed can be lost as faeces
  - ▪ Herbivores do not have all the enzymes to digest all the material they eat, so it is egested instead

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Food Production

Factors Affecting Food Security

Food security: having sufficient food to feed the population

Factors which affect it:

1. Increasing birth rate means more food is required.
2. Changing diets in developed countries means food resources which are already in low amounts become even more scarce as the demand for them increases.
3. New pests and pathogens can destroy crops.
4. Climate change affects food production (such as no rain resulting in crops failing).
5. Conflicts in some countries can affect the availability of water and food.

To feed everyone on Earth sustainable methods are needed.

Farming Techniques

- Farmers aim to increase the amount of energy (from food) that is converted to biomass in livestock because this is more efficient.
- This is done by reducing the energy transfer from the animals to the environment.
  - o Raising them in small cages so there is less movement and therefore less energy wasted on this
  - o Areas where they are kept have high temperatures so less energy is wasted on controlling body temperature
- To increase growth they are also given high protein foods.

This type of farming has many ethical objections because lots of animals are kept in a small place , causing distress. It also increases the risk of spread of infection. It is carried out to increases profit and efficiency, but the standard of living is very low for the animals.

Sustainable fisheries

The number of fish in the oceans is decreasing.

- This is because humans are fishing at a faster rate than the populations can regenerate.
- To avoid species disappearing in some areas, the populations need stay above a certain level so breeding can continue.
- Some restrictions have been put in place:
  - o There are limits of net sizes (making them bigger) so smaller fish are not caught and can reach breeding age and produce more fish.

- Fishing quotas mean only a certain number of a species of fish can be caught (in an area and over a time period) to prevent overfishing.

Biotechnology

- food production and medicine production

Role of Biotechnology

Biotechnology can be used to help feed the population and potentially provide treatments for a number of diseases.

1. The fungus (the multicellular ones) *Fusarium* can produce mycoprotein. (using fungus to produce protien)
    - Protein-rich food source
    - Suitable for vegetarians
    - Grown on glucose syrup in aerobic conditions
    - The fungus is harvested and purified so it can be consumed
    - disadvantages:
        - People wouldn't like the idea of it
    - Protein without animals
        - Reduces land use, as a lot of land is required to rear animals and also areas to grow crops to feed them.
        - Reduces our methane contribution (because cows produce methane) - global warming reduction

mycelium - hyphne - saprotrophic nutrion
mycelium produces digestive enzymes into the earth which breaks down substances and then absorb it through hyphne

0. Genetically modified bacteria produce insulin
    - The insulin is taken and purified
    - Used to treat people with diabetes

1. Take cells from a healthy person, cut the insulin gene out of the chromosome using restriction enzymes
2. Take a plasmid out from the bacteria and cut a section out of the plasmid using the restriction enzymes.
3. Ligase enzyme would attach the human gene and the plasmid together which would then transfer the information from the gene to the plasmid - ligase enzyme would act as a vector
4. Fermentation in factories to produce insulin.

technology for cutting genetic information = restriction enzymes (specific)

0. Genetically modifying crops to have certain properties can have many advantages
    - Modifying them to be resistant to pests or extreme weather conditions can increase yields
    - Modifying them to increase their nutritional value is beneficial in places where they lack access to certain vitamins (such as 'Golden rice')

- weather resistant
- drought resistant
- wouldnt die in low water conditions
- disease resistance

Take genetic features from one crops and putting it in another

Rice - primary diet in poor countries, lacks vitamin a, people in africa are becoming blind. Scientists genetically modified rice to add vitamin a.

Genetic Engineering

Genetic engineering: Modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic.
Plant cells have been engineered for disease resistance or to have larger fruits
Bacterial cells have been engineered to produce substances useful to humans, such as human insulin to treat diabetes.
The process:

1. Genes from chromosomes are 'cut out' using restriction enzymes leaving 'sticky ends' (short sections of exposed, unpaired bases)

0. A virus or bacterial plasmid is cut using the same restriction enzyme to also create

   sticky ends. This also contains an antibiotic marker gene.

0. The loop and gene sticky ends are then joined together by DNA ligase enzymes
0. The combined loop is placed in a vector, such as a bacterial cell, and then allowed to

   multiply as it will now contain the modified gene. As the bacteria grows we can see which ones are resistant to antibiotics. The colonies that are will be the bacteria that are also producing the modified gene, as they were inserted together.
   In plants the vector is put into meristematic cells (unspecialised cells) which can then produce identical copies of the modified plant.

Genetically modified crops

- They are engineered to be resistant to insects and to herbicides.
- This will result in increased yields as less crops will die.

Genetic modification in medicine
It may be possible to use genetic engineering to cure inherited disorders.

It is called gene therapy and involves transferring normal genes (not faulty) into patients so the correct proteins are produced.

Perceived benefits of genetic engineering	**Perceived risks of genetic engineering**
It can be very useful in medicine to mass produce certain hormones in microorganisms (bacteria and fungi).	GM crops might have an effect on wild flowers and therefore insects. ● ● GM crops are infertile and these genes could spread into wild plants, leading to infertility in other species, which affects the entire environment. ● ● Growing with herbicides and pesticides can kill insects and other plants, which would reduce biodiversity.
In agriculture it can be used to improve yields by: ● Improving growth rates ● Introducing modifications that allow the crops to grow in different conditions, e.g. hotter or drier climates ● Introducing modifications that allow plants to make their own pesticide or herbicide	People are worried that we do not completely understand the effects of GM crops on human health.

Crops with extra vitamins can be produced in areas where they are difficult to obtain.	Genetic engineering in agriculture could lead to genetic engineering in humans. This may result in people using the technology to have designer babies.
Greater yields can help solve world hunger, which is becoming an increasingly bigger issue due to population growth.	They pose a selection pressure, which could lead to increased resistance in other species, creating super weeds and pests.

Cloning

Cloning is creating genetically identical copies of an organism. Methods of plant cloning:

1. Tissue culture: Important to preserve rare plant species or commercially in plant nurseries. ● Plant cells are taken

   ● They are placed in a growth medium with nutrients and hormones
   ● They grow into new plants, and are clones as they are genetically identical to the parent

0. Cuttings: An older, easier method to produce clones
   - ● Cuttings, such as a section of the stem, are taken from a plant with a desirable feature
   - ● They are planted and produce clones as they are genetically identical to the parent

Cloning in animals:

1. Embryo transplants

   o Sperm cells and egg cells from parents with desirable features are obtained.
   o In the lab, they are fertilised to form an embryo.
   o The embryo divides many times and is then inserted into a host mother.
   o The offspring which is eventually born is genetically identical (with the desirable feature) as they have genetic information from the same mother and father.

0. Adult cell cloning

   - The nucleus is removed from an unfertilised egg cell.
   - The nucleus is removed from an adult body cell and placed in the denucleated egg cell.
   - Through the stimulation of an electric shock, the egg cell begins to divide to form an embryo.
   - The embryo is implanted into the womb of a female.
   - The offspring born is a clone of the adult body cell.

Benefits of cloning	**Risks of cloning**

Produces lots of offspring with a specific desirable feature.	The gene pool is reduced through producing clones, meaning it is less likely that the population will survive if a disease arises with low diversity in the population.
The study of clones could help research into embryo development.	Clones have a low survival rate, and tend to have some genetic problems.
Can help extremely endangered species, or even bring back species that have become extinct.	It may lead to human cloning.

Resistant Bacteria

- Bacteria are labelled resistant when they are not killed by antibiotics which previously were used as cures against them.
- Bacteria reproduce at a fast rate.
  Mutations during reproduction can result in new genes, such as the gene for antibiotic resistance.
- This the creation of a new strain.

Exposure to antibiotics creates a selection pressure, as those with antibiotic resistant genes survive and those without die.

As a result those with antibiotic resistance can reproduce and pass on the advantageous gene to their offspring.

This population of antibiotic resistant bacteria increases.

Bacterial diseases spreads rapidly because people are not immune to these new resistant bacteria and there is no treatment for it.
An example is MRSA.

- Called a 'superbug' as it is resistant to many different types of antibiotics
- Common in hospitals: spreads when doctors and nurses move to different patients

How to slow the development of resistance in bacteria:

1. Antibiotics should not be given for viral or non-serious infections
2. Specific antibiotics should be given for specific bacteria
3. Patients should complete their course of antibiotics – if they do not some bacteria may survive and mutate to become antibiotic resistant.
4. Antibiotics should be used less in agriculture – farmers currently use them to prevent their livestock dying from disease, but this overuse leads to antibiotic resistant bacteria which are then transferred to humans when they consume the meat.

How to slow the transmission of the bacteria:

1. Maintain high standards of hygiene in hospitals
2. Medical staff and visitors should wash hands regularly
3. Medical staff should wear disposable clothing or clothing that is regularly sterilised

As the development of antibiotics is expensive and slow, it is difficult to keep up with the development of resistant strains

Photosynthesis

Photosynthesis is the process by which plants make glucose from sunlight. The equation for photosynthesis is:

Light carbon dioxide + water → glucose + oxygen

Each compound has its own chemical symbol:

- Carbon dioxide: CO_2
- Water: H_2O
- Oxygen: O_2
- Glucose: $C_6H_{12}O_6$

The rate of the process is affected by a number of factors.

Rate of Photosynthesis

Factor	Effect
Temperature	With an increase in temperature, the rate of photosynthesis increases. As the reaction is controlled by enzymes, this trend continues up to a certain temperature until the enzymes begin to denature and the rate of reaction decreases.
Light Intensity	For most plants, the higher the light intensity, the faster the rate of the reaction.
Carbon dioxide concentration	Carbon dioxide is also needed to make glucose (see equation). As the concentration of carbon dioxide increases, the rate of reaction increases.
Amount of chlorophyll	Chlorophyll is a pigment in the leaf that converts light energy to food for the plant, and is therefore essential. If, for example, chlorophyll levels are reduced through a magnesium deficiency, then the rate of photosynthesis would decrease.

By carrying out an experiment measuring the oxygen production of a plant, you can calculate the rate of photosynthesis.

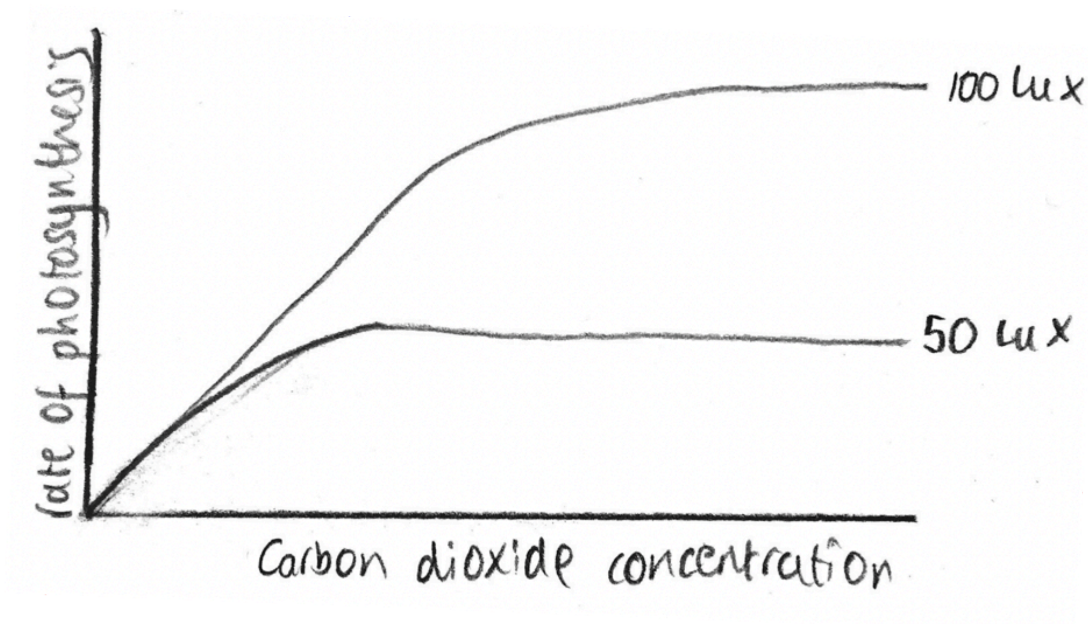
- Pondweed is placed in a test tube full with water. The top is sealed with a bung. A capillary tube also containing water leads into the test tube, and it is attached to a syringe.
- A lamp is placed at a measured distance from the test tube.
- As it photosynthesises, oxygen is produced, forming a gas tube in the capillary tube
- The distance the bubble has moved is measured using a ruler to calculate the volume of oxygen produced.
- Many variables can be changed to observe their effect on photosynthesis: the temperature (using a water bath), time the pondweed is left, the light intensity (varied by the distance the lamp is from the plant).
- It is important to control all factors that may affect photosynthesis except your independent variable (the one you want to change), so it is a valid experiment.
- Any of the factors above may become a limiting factor. This is an environmental condition (such as light intensity) which, in low levels, restricts any increase in the rate of photosynthesis. Despite

increases in other factors (such as temperature or carbon dioxide concentration), the rate of photosynthesis will not increase any more. This can be seen on a graph as the curve levelling off.

A graph involves one limiting factor if it has one line which levels off, with the factor on the horizontal axis and rate of photosynthesis on the vertical axis.

- A graph with two lines represents two limiting factors in two experiments. The investigation involves increasing the factor on the horizontal axis, and is carried out at two different other environmental conditions, such as two different temperatures.

  Light intensity is measured in lux and in this graph we can see that the limiting factor is light intensity. This is because the 50 lux levels limits the rate of photosynthesis compared to the 100 lux experiment, showing that at 50 lux light intensity was the limiting factor - it had the potential to increase the rate of photosynthesis further if it were increased.



A graph involves three limiting factors is similar to the one above, but another factor is stated on each line, which is the same in each
The limiting factor is temperature as light intensity is the same in each and carbon dioxide is increasing.
Farmers can use the knowledge of limiting factors to enhance the conditions in the greenhouse for a greater rate of photosynthesis. This will increase growth leading to increased profits.

Uses of Glucose From Photosynthesis

1. For respiration
2. Converted into insoluble starch for storage (in roots, stems and leaves)
3. To produce fat or oil for storage (in seeds)
4. To produce cellulose to strengthen cell walls
5. Combined with nitrates (absorbed from the soil) to form amino acids which produce proteins

Respiration

Aerobic and Anaerobic Respiration

Respiration occurs in every cell in the body, and it is the process of transferring energy from glucose so living processes can occur. All living things undergo respiration.

- It can take place aerobically (with oxygen) or anaerobically (without oxygen)

Aerobic respiration	Anaerobic respiration
This uses oxygen. It yields the most energy. Most of the reactions that make up aerobic respiration occur in the mitochondria. $C_6H_{12}O_6 + O_2 \text{--->} CO_2 + H_2O$ $C_6H_{12}O_6$ = glucose O_2 = oxygen CO_2 = carbon dioxide H_2O = water	Occurs when there is not enough oxygen. It does not yield as much energy as aerobic respiration. It is only used as a last resort, for example during a sprint where it is difficult to breathe in enough oxygen. The oxidation of glucose is complete. In animals: Glucose ($C_6H_{12}O_6$) ---> Lactic acid In plant and yeast cells it is called fermentation): Glucose ($C_6H_{12}O_6$) ---> Ethanol + Carbon dioxide (CO_2) This reaction is used to make bread and alcoholic drinks.

Response to Exercise

During exercise, more energy is needed in order for the muscles to contract. This means respiration has to occur faster, and therefore more oxygen needs to be supplied to cells (and more CO_2 removed). This is done by:

- Heart rate increasing
- Breathing rate increasing ● Breath volume increasing

If there is not enough oxygen being supplied (for example when you undertake vigorous exercise) anaerobic respiration takes place instead. As lactic acid is a by product of this reaction, it builds up creating an oxygen debt (as oxygen is needed to break lactic acid down).

Oxygen debt is the amount of extra oxygen the body needs after exercise to react with the accumulated lactic acid and remove it from the cells. This results in the muscles tiring and not contracting properly. Blood flowing through the muscles transports the lactic acid to the liver where it is converted back to glucose.

Human Health

Communicable (infectious) diseases

Pathogens, which include viruses, bacteria, protists and fungi, are microorganisms that cause infectious disease. They can infect plants or animals, spreading through either direct contact, by water or by air.

Viruses

- Very small
- They move into cells and use the biochemistry of it to make many copies of itself
- This leads to the cell bursting and releasing all of the copies into the bloodstream

- The damage and the destruction of the cells makes the individual feel ill

Bacteria

- Small
- They multiply very quickly through dividing by a process called binary fission
- They produce toxins that can damage cells

Protists

- Some are parasitic, meaning they use humans and animals as their hosts (live on and inside, causing damage)

Fungi

- They can either be single celled or have a body made of hyphae (thread-like structures)
- They can produce spores which can be spread to other organisms

The ways they are spread:

- Direct contact- touching contaminated surfaces

  Examples: contact with bodily fluids, direct skin to skin, microorganisms from faeces, infected plant material left in field

- By water- drinking or coming into contact with dirty water
- By air- pathogens can be carried in the air and then breathed in (a common example is the droplet infection, which is when sneezing, coughing or talking expels pathogens in droplets which can be breathed in)

The damage that disease causes to populations can be reduced by limiting the spread of the pathogens.

- Improving hygiene: Hand washing, using disinfectants, isolating raw meat, using tissues and handkerchiefs when sneezing
- Reducing contact with infected individuals
- Removing vectors: Using pesticides or insecticides and removing their habitat
- Vaccination: By injecting a small amount of a harmless pathogen into an individual's body, they can become immune to it so it will not infect them. This means they cannot pass it on.

Human Defence System

The non-specific defence system works to prevent pathogens from entering the body.

1. The skin

   - Acts as a physical barrier
   - It produces antimicrobial secretions to kill pathogens
   - Good microorganisms known as skin flora compete with the bad microorganisms for space and nutrients

0. The nose

- Has hairs and mucus (sticky substance) which prevent particles from entering your lungs

0. The trachea and bronchi

   - Secrete mucus in order to trap pathogens
   - Cilia (hair-like structures on cells) beat to waft mucus upwards so it can be swallowed

0. The stomach

   - Produces hydrochloric acid that kills any pathogens in your mucus, or food and drink

The specific immune system acts to destroy any pathogens which pass through the non-specific immune system to the body. A large part of the specific immune system is white blood cells, which can act in three different ways:

Mode of action	How it protects you
Phagocytosis (engulfing and consuming pathogens)	This destroys them, meaning they can no longer make you feel ill.
Producing antibodies	Each pathogen has an antigen on their surface, which is a structure which a specific complementary antibody can bind to. Once antibodies begin to bind to the pathogen, the pathogens start to clump together, resulting in it being easier for white blood cells to find them. If you become infected again with the same pathogen, the specific complementary antibodies will be produced at a faster rate. The individual will not feel the symptoms of the illness. They are said to be immune.
Producing antitoxins	They neutralise the toxins released by the pathogen by binding to them.

Vaccination

Vaccinations involve making an individual immune to a certain disease- they are protected against it before they have been infected. By immunising a large proportion of the population, the spread of the pathogen is reduced as there are less people to catch the disease from (called herd immunity).
Naturally, when you are infected with a pathogen, you feel ill until white blood cells manufacture the correct specific antibody to combat it. Upon a secondary infection, the antibodies can be produced much quicker, so the pathogen can be destroyed and the symptoms are not felt. Vaccinations replicate the first infection so that when the person is exposed to the real disease they do not feel any symptoms, just like in a secondary infection.

- The vaccine contains a dead or inactivated form of the pathogen
- This stimulates white blood cells to produce antibodies complementary to the antigens on the pathogen

Advantages of vaccination	**Disadvantages of vaccination**
They have eradicated many diseases so far (e.g smallpox) and reduced the occurrence of many (e.g rubella).	They are not always effective in providing immunity.
Epidemics (lots of cases in an area) can be prevented through herd immunity.	Bad reactions (such as fevers) can occur in response to vaccines (although very rare).

Antibiotics and Painkillers

Antibiotics are medicines that that kill bacterial pathogens inside the body, without damaging body cells. They cannot kill viruses as they use body cells to reproduce, meaning any drugs that target them would affect body tissue too. Painkillers (such as aspirin) only treat the symptoms of the disease, rather than the cause.

- Antibiotics can be taken as a pill, syrup or directly into the bloodstream
- Different antibiotics are effective against different types of bacteria, so receiving the correct one is important
- Their use has decreased the number of deaths from bacterial diseases
- An example is Penicillin
- The great concern is that bacteria are becoming resistant to antibiotics.
- Mutations can occur during reproduction resulting in certain bacteria no longer being killed by antibiotics
- When these bacteria are exposed to antibiotics, only the non-resistant one die
- The resistant bacteria survive and reproduce, meaning the population of resistant bacteria increases
- This means that antibiotics that were previously effective no longer work

  To prevent the development of these resistant strains we can:

  1. Stop overusing antibiotics- this unnecessarily exposes bacteria to the antibiotics 2. Finishing courses of antibiotics to kill all of the bacteria

Clinical testing: using volunteers and patients

- It is first tested on healthy volunteers with a low dose to ensure there are no harmful side effects
- The drugs are then tested on patients to find the most effective dose
- To test how well it works, patients are split into two groups with one group receiving the drug and one receiving a placebo (appears to look like the drug but has no active ingredient so no effect) so the effect of the new drug can be observed
- These can be single-blind (only the doctor knows whether the patient is receiving the drug) or double blind (neither the patient or doctor knows whether they are receiving the drug, removing any biases the doctor may have when they are recording the results).
- The results then need to be peer reviewed by other scientists to check for repeatability.

Cells

Level of organisation

Organelles: specialised subcellular structures found within living cells (detailed in the next section)
Cells: basic structural unit of a living organism,
Tissues: group of cells with similar structures, working together to perform the same function
Organs: group of tissues, working together to perform specific functions
Organ systems: group of organs with similar functions, working together to perform body functions An example of this would be the respiratory organ system, containing the lungs (organ), which is made up of epithelial tissue consisting of epithelial cells.

Subcellular structures (
Found in plant and animal cells:

Structure	Function
Nucleus	• Contains the genetic material, which codes for a particular protein • Enclosed in a nuclear membrane.
Cytoplasm	• Liquid substance in which chemical reactions occur. • Contains enzymes (biological catalysts, i.e. proteins that speed up the rate of reaction). • Organelles are found in it
Cell membrane	• Contain receptor molecules to identify and selectively control what enters and leaves the cell
Mitochondria	• Where aerobic respiration reactions occur, providing energy for the cell
Ribosomes	• Where protein synthesis occurs. • Found on a structure called the rough endoplasmic reticulum.

Found only in plants:

Structure	Function
Chloroplasts	• Where photosynthesis takes place, providing food for the plant • Contains chlorophyll pigment (which makes it green) which harvests the light needed for photosynthesis.
Permanent vacuole	• Contains cell sap • Found within the cytoplasm • Improves cell's rigidity
Cell wall	• Made from cellulose • Provides strength to the cell

Cell differentiation and specialisation

Specialised cells

- Specialised cells are those which have develop certain characteristics in order to perform particular functions.
- Cells specialise by undergoing differentiation: a process that involves the cell gaining new sub-cellular structures in order for it to be suited to its role.
- Cells can either differentiate once early on or have the ability to differentiate their whole life (these are called stem cells).
- In animals, most cells only differentiate once, but in plants many cells retain the ability.

Examples of specialised cells in animals:

Sperm cells: specialised to carry the male's DNA to the egg cell (ovum) for successful reproduction

- Streamlined head and long tail to aid swimming
- Many mitochondria (where respiration happens) which supply the energy to allow the cell to move
- The acrosome (top of the head) has digestive enzymes which break down the outer layers of membrane of the egg cell

Nerve cells: specialised to transmit electrical signals quickly from one place in the body to another

- The axon is long, enabling the impulses to be carried along long distances
- Having lots of extensions from the cell body (called dendrites) means branched connections can form with other nerve cells
- The nerve endings have many mitochondria which supply the energy to make special transmitter chemicals called neurotransmitters. These allow the impulse to be passed from one cell to another.

Muscle cells: specialised to contract quickly to move bones (striated muscle) or simply to squeeze (smooth muscle, e.g found in blood vessels so blood pressure can be varied), therefore causing movement

- Special proteins (myosin and actin) slide over each other, causing the muscle to contract
- Lots of mitochondria to provide energy from respiration for contraction
- They can store a chemical called glycogen that is used in respiration by mitochondria

Examples of specialised cells in plants

Root hair cells: specialised to take up water by osmosis and mineral ions by active transport from the soil as they are found in the tips of roots.
Have a large surface area due to root hairs, meaning more water can move in

- The large permanent vacuole affects the speed of movement of water from the soil to the cell
- Mitochondria to provide energy from respiration for the active transport of mineral ions into the root hair cell

Xylem cells: specialised to transport water and mineral ions up the plant from the roots to the shoots

- Upon formation, a chemical called lignin is deposited which causes the cells to die. They become hollow and are joined end-to-end to form a continuous tube so water and mineral ions can move through
- Lignin is deposited in spirals which helps the cells withstand the pressure from the movement of water

Phloem cells: specialised to carry the products of photosynthesis (food) to all parts of the plants

- Cell walls of each cell form structures called sieve plates when they break down, allowing the movement of substances from cell to cell
- Despite losing many sub-cellular structures, the energy these cells need to be alive is supplied by the mitochondria of the companion cells.

Stem cells in medicine
Characteristics

- A stem cell is an undifferentiated cell which can undergo division to produce many more similar cells
- Some of these will differentiate to have different functions, such as the specialised cells mentioned above
- They are important in development, growth and repair

Types of stem cells

1. Embryonic stem cells
    - Form when an egg and sperm cell fuse to form a zygote
    - They can differentiate into any type of cell in the body
    - Scientists can clone these cells (though culturing them) and direct them to differentiate into almost any cell in the body
    - These could potentially be used to replace insulin-producing cells in those suffering from diabetes, new neural cells for diseases such as Alzheimer's, or nerve cells for those paralysed with spinal cord injuries
2. Adult stem cells

    - If found in bone marrow they can form many types of cells (not any type, like embryonic stem cells can) including blood cells

0. Meristems in plants

    - Found in root and shoot tips

Stem cells in medicine

Benefits	Risks
Can be used to replace damaged cells, such as in type 1 diabetes, multiple sclerosis and paralysis caused by spinal cord injuries	Ethical issues of destroying unused embryos
Bone marrow transplants for adult stem cells can be used to treat blood cell cancers, such as leukaemia	No guarantee in how successful these therapies will be and if there will be any long term effects
Can grow whole organs for transplants	Mutations could occur in cultured stem cells
No rejection, if it is made from the patient's own cells	Difficult to find suitable stem cell donors
Can allow for the testing of millions of potential drugs without animal testing	

<u>Biological molecules</u>

Carbohydrates

- They are made of carbon, oxygen and hydrogen.
- They are polymers that break down into simple sugars

Proteins

- They are made of carbon, oxygen, hydrogen, sulfur, nitrogen and phosphorous.
- They are polymers that are broken down into its monomers: amino acids

Lipids

- Lipids (fats and oils) are made of carbon, oxygen and hydrogen.
- they are large polymers that are broken down into 3 fatty acids molecules and a glycerol molecule.

Practical: investigate food samples for the presence of glucose, starch, protein and fat

Test for glucose:

1. Add the sample solution into a test tube
2. Add drops of Benedict's solution into the test tube
3. Heat in a water bath at 60-70°C for 5 minutes
4. Take test tube out and record the colour

- If glucose is present the solution will turn brick red
- If glucose is not present that the solution will remain blue

Test for starch

1. 1) Pipette the sample solution into wells or on a tile
2. 2) Add drops of iodine solution and leave for 1 minute
3. 3) Record any colour change
   - If starch is present the solution will turn blue-black
   - If starch is not present the solution will remain brown

Test for protein

1. Add the sample solution into a test tube
2. Add drops of Biuret solution into the test tube
3. Leave for 1 minute and then record the colour
   - If protein is present the solution will turn purple
   - If protein is not present that the solution will remain blue

Test for fat

1. Add $2cm^3$ of ethanol to the test solution
2. Add $2cm^3$ of distilled water

3. Leave for 3 minutes and then record the colour
    - If fat is present a milky white emulsion will form
    - If fat is not present that the solution will remain colourless

Enzymes

Enzymes are biological catalysts (a substance that increases the rate of reaction without being used up). They are protein molecules and the shape of the enzyme is vital to its function. This is because each enzyme has its own uniquely shaped active site where the substrate binds.
A simplified way to look at how they work is the Lock and Key Hypothesis:

- The shape of the substrate is complementary to the shape of the active site (enzyme specificity), so when they bond it forms an enzyme-substrate complex.
- Once bound, the reaction the reaction takes place and the products are released from the surface of the enzyme

Effect of temperature

- The optimum is around 37°C (body temperature)
- The rate of reaction increases with an increase in temperature up to this optimum, but above this temperature it rapidly decreases and eventually the reaction stops.
- When the temperature becomes too hot, the bonds in the structure will break
- This changes the shape of the active site, so the substrate can no longer fit in
- The enzyme is said to be denatured and can no longer work

Practical: investigate how enzyme activity can be affected by changes in temperature

1. Starch solution is heated to set temperature
2. Amylase is added
3. Iodine is added to each well after a minute
4. Measure the time it takes until the iodine stops turning blue-black (this means that starch is not present as amylase has broken the starch down into glucose)
5. Repeat the test with different temperature

Effect of pH

- The optimum pH for most enzymes is 7, but some that are produced in acidic conditions, such as the stomach, have a lower optimum pH
- If the pH is too high or too low, the forces that hold the amino acid chains that make up the protein will be affected
- This will change the shape of the active site, so the substrate can no longer fit in
- The enzyme is said to be denatured and can no longer work

Practical: investigate how enzyme activity can be affected by changes in pH
The enzyme being used is called amylase - which breaks down carbohydrates such as starch into simple sugars such as maltose (see section 1.12 below). We can use iodine (dark orange colour) to check for the presence of starch in the solution at any time. When starch is present, the iodine solution will turn to a blue-black colour.
Amylase has an optimal pH, and we can use this experiment to estimate what it might be.
Materials required:
1% amylase solution, 1% starch solution, iodine solution, labelled buffer solutions of different pH.

Method:

1. Place a beaker of water on a gauze above a Bunsen burner
2. Place single drops of iodine solution on each well of a tray.
3. Add $2cm^3$ of amylase solution, $2cm^3$ of starch solution and $1cm^3$ of pH solution in a test tube and mix the solution.
4. Put this test tube into the water beaker and start a stopwatch. We keep it in this water beaker above a Bunsen Burn to keep it the same temperature so temperature is a controlled variable.
5. Every 10 second use a pipette to place a drop the solution into one of the wells containing iodine solution. The mixture should turn blue-black to indicate that starch is still present and has not yet been broken down.

0. Continue repeating until the solution stops turning black and becomes orange and record the time taken
0. Repeat Steps 1-6 with different pH solutions.
0. Record your results on a graph of pH (on the x-axis) and time taken to complete reaction (on the y-axis).

We can see what the optimum pH of amylase is, as it will be the pH where the reaction is completed the fastest. This should be somewhere around pH 7.0.

Movement in and out of cells

Diffusion

- Diffusion is the spreading out of the particles resulting in a net movement from an area of higher concentration to an area of lower concentration.
- It is a passive process as no energy is required.
- The molecules have to be small in order to be able to move across, for example oxygen, glucose, amino acids and water, but larger molecules such as starch and proteins cannot. Examples in living organisms:
- Single-celled organisms can use diffusion to transport molecules into their body from the air- this is because they have a relatively large surface area to volume ratioDue to their low metabolic demands, diffusion across the surface of the organism is sufficient enough to meet its needs.

- In multicellular organisms the surface area to volume ratio is small so they cannot rely on diffusion alone. Instead, surfaces and organ systems have a number of adaptations that allows molecules to be transported in and out of cells. Examples include alveoli in the lungs, villi in the small intestines and root hair cells in plants.

Many factors affect the rate of movement:

Factor	**Effect**
Concentration gradient	The greater the difference in concentration, the faster the rate of diffusion. This is because more particles are randomly moving down the gradient than are moving against it.
Temperature	The greater the temperature, the greater the movement of particles, resulting in more collisions and therefore a faster rate of diffusion.
Surface area:volume ratio	The greater the surface area, the more space for particles to move through, resulting in a faster rate of diffusion.
Distance	The further the particles have to travel the longer it will take

Osmosis

Osmosis is the movement of water from a less concentrated solution to a more concentrated one through a partially permeable membrane.

- A dilute solution of sugar has a high concentration of water (and therefore a high water potential). A concentrated solution of sugar has a low concentration of water (and therefore a low water potential). Water moves from a dilute solution to a concentrated solution because it moves from an area of high water potential to low water potential- down the concentration gradient.
- It is passive, as it does not use energy.
- If the concentration of sugar in an external solution is the same as the internal, there will be no movement and the solution is said to be isotonic to the cell
- If the concentration of sugar in external solution is higher than the internal, water moves out, and the solution is said to be hypertonic to the cell
- If the concentration of sugar in external solution is lower than the internal, water moves in, and the solution is said to be hypotonic to the cell

Examples in living organisms:

- Osmosis in animals:
    - If the external solution is more dilute (higher water potential), it will move into animal cells causing them to burst.
    - If the external solution is more concentrated (lower water potential), excess water will leave the cell causing it to become shrivelled.
- Osmosis in plants:
    - If the external solution is more dilute, water will move into the cell and into the vacuole, causing it to swell, resulting in pressure called turgor (essential in keeping the leaves and stems of plants rigid).

    - If the external solution is less dilute, water will move out of the cell and they will become soft. Eventually the cell membrane will move away from the cell wall (called plasmolysis) and it will die.

Active transport

- Active transport is the movement of particles from an area of lower concentration to an area of higher concentration, i.e. against the concentration gradient.
- This requires energy from respiration as it is working against the gradient, which is why it is called active.

Examples in living organisms:

- In root hair cells:
    - They take up water and mineral ions (for healthy growth) from the soil
    - Mineral ions are usually in higher concentrations in the cells, meaning diffusion cannot take place
    - This requires energy from respiration to work
- In the gut: Substances such as glucose and amino acids from your food have to move from yorgut into your bloodstream
- Sometimes there can be a lower concentration of sugar molecules in the gut than the blood, meaning diffusion cannot take place
- Active transport is required to move the sugar to the blood against its concentration gradient

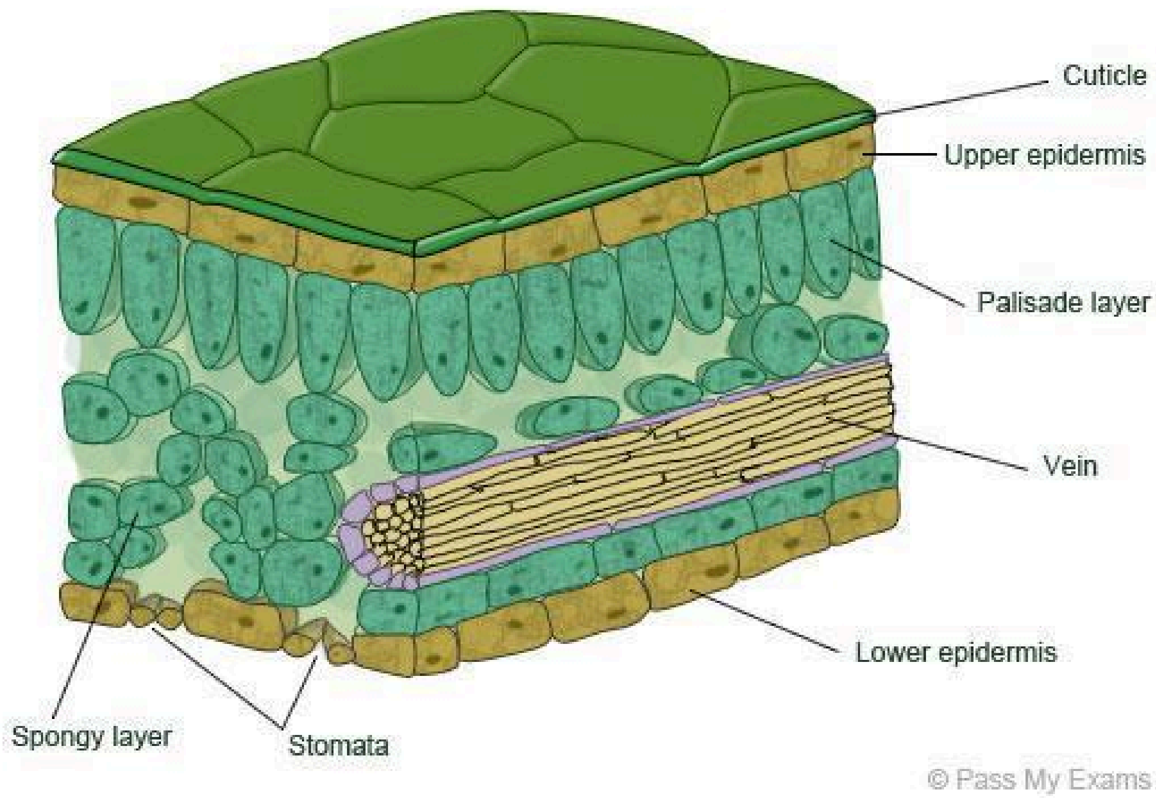
Practical: investigate diffusion in non-living systems

1. Cut a 1cm3 cube of agar made of sodium hydroxide and phenolphthalein indicator
2. Place cube in solution of hydrochloric acid
3. Remove the cube and wash with water to stop further reaction
4. Cut the cube in half and measure the distance that the acid has caused agar to become colourless from outside inwards
5. Repeat the experiment two more times and calculate the mean
6. Repeat with different concentrations of hydrochloric acid

Practical: investigating osmosis in potatoes

1. Place different sucrose solutions including 0% for a control, in different boiling tubes
2. Dry potato strips on a paper towel and measure the masses
3. Place each potato strip into each sucrose solution for 20 minutes and record how the mass changed
4. Repeat tests at each solution several times with potato strips of similar masses

Leaf structures



Structure	Description
Waxy cuticle	Helps to reduce water loss by evaporation and is a protective layer found at the top of the leaf
Upper epidermis	Very thin and transparent in order to let light in to the palisade mesophyll
Palisade mesophyll	Contain lots of chloroplasts so that photosynthesis can happen rapidly
Spongy mesophyll	Have lots of air spaces to allow gases to diffuse in and out of cells faster, as it increases the surface area to volume ratio
Lower epidermis	Contains guard cells and stomata (gaps)
Guard cell	Kidney-shaped cells that open and close the stomata by absorbing or losing water. When lots of water is available, the cells fill and open stomata
Stomata	Where gas exchange and loss of water by evaporation takes place - opens during the day and closes at night

Nutrition in humans

Humans need to eat a balanced diet in order to maintain their health. This should consist of carbohydrates, proteins, lipids, dietary fibre, vitamins, minerals and water.

	Source	Function
Carbohydrates	Bread, cereals, pasta, rice, potatoes	A high energy source
Proteins	Meat, fish, eggs, pulses	For growth and repair
Lipids	Butter, oil, nutes	A high energy source and for insulation
Dietary fibre	Vegetables, bran	To provide roughage to keep food moving

Vitamin A	Carrots, green vegetables	Needed for vision, especially in the dark, and for growth
Vitamin C	Citrus fruits, broccoli, peppers	Helps to absorb iron
Vitamin D	Margarine, oily fish	Helps to absorb calcium
Calcium	Milk	For bone and teeth strength - deficiency can cause rickets (curving of bones)
Iron	Red meat	Needed for haemoglobin - deficiency can cause anaemia
Water	Water, juice, milk	Needed for cell reactions to take place

Factors affecting energy requirements

Age:

- Energy requirements generally increases as we approach adulthood
- Energy needs of adults go down as they age

Activity levels:

- If you are more active then you will need more energy for movement

Pregnancy:

- Energy requirements will increase in order to support growth of the foetus
- Energy needs also increase due to the extra mass of the baby

Human alimentary canal

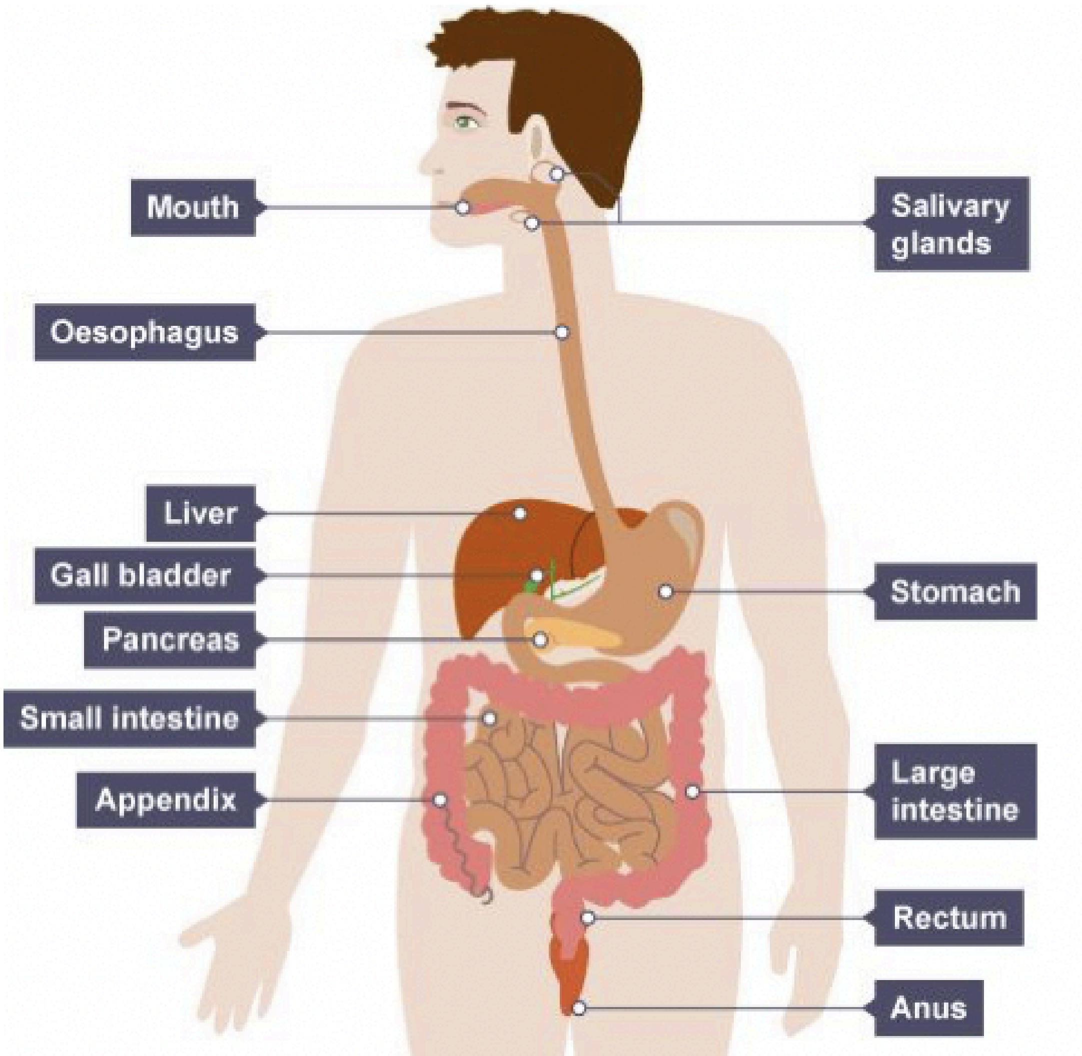
The alimentary canal is the passage food moves through once it has been eaten.

Mouth

- Mechanical digestion: teeth break up large food pieces into smaller pieces with larger surface area to volume ratio (food bolus)
- ● Chemical digestion: amylase breaks down starch into glucose
- ● Salivary glands produce saliva to lubricate the food bolus so it can be swallowed easily

Oesophagus

- Tube from the mouth to the stomach
- Food bolus moves down due to unidirectional wave-like contractions (peristalsis) created by circular muscles and longitudinal muscles that create a squeezing action



Pancreas

- Produces carbohydrase, protease and lipase enzymes
- Secretes enzymes into the stomach and small intestine

Stomach

- Gastric juice is released from stomach lining when it detects food in the stomach
- Gastric juice is made of
    - Pepsin: enzyme breaking down proteins
    - Hydrochloric acid: makes stomach acidic in order for pepsin to work and to kill any ingested bacteria
- Peristalsis also occurs here
- The digested food is now called chyme

Small intestine Duodenum:

- The first part of the small intestine
- Carbohydrases, proteases and lipases digest food here
- Bile is released into the duodenum

Bile is produced in the liver and stored in the gallbladder. It has 2 roles:

1. It is alkaline to neutralise the hydrochloric acid which comes from the stomach.
2. The enzymes in the small intestine have a higher (more alkaline) optimum pH than those in the stomach.
3. It breaks down large drops of fat into smaller ones (emulsifies it). The larger surface

   area allows lipase to chemically break down the lipid into glycerol and fatty acids faster.

- Villi have a thin lining, a large network of capillaries and have a large surface area

Large intestine

- Water is absorbed here, to produce faeces
- Faeces is stored in the rectum and the removed through the anus

Digestive enzymes
Carbohydrates (starch):

- Broken down by carbohydrases
- Starch → maltose by amylase
- Maltose → glucose by maltase

Proteins:

- Broken down by proteases in the stomach and small intestine
- Proteins → amino acids

Lipids:

- Broken down by lipases
- Lipids → glycerol + 3 fatty acids

Gas exchange

In plants

Diffusion has already been described in section 2.15.
Carbon dioxide + water → glucose + oxygen
In order for plants to photosynthesise and respire gas exchange of oxygen and carbon dioxide are needed and this requires diffusion of gases.
Adaptations of leaves for gas exchange

Many of these adaptations have been mentioned before in the photosynthesis section (2as gas exchange is a vital process in photosynthesis.

Spongy mesophyll	Have lots of air spaces to allow gases to diffuse in and out of cells faster, as it increases the surface area to volume ratio
Guard cell	Kidney-shaped cells that open and close the stomata by absorbing or losing water. When lots of water is available, the cells fill and open stomata

Stomata	Where gas exchange and loss of water by evaporation takes place - opens during the day and closes at night
Thin	Short distance of diffusion for carbon dioxide to diffuse into the leaf and oxygen to diffuse out
Flattened shape	Increases surface area for absorption of light and carbon dioxide dioxide

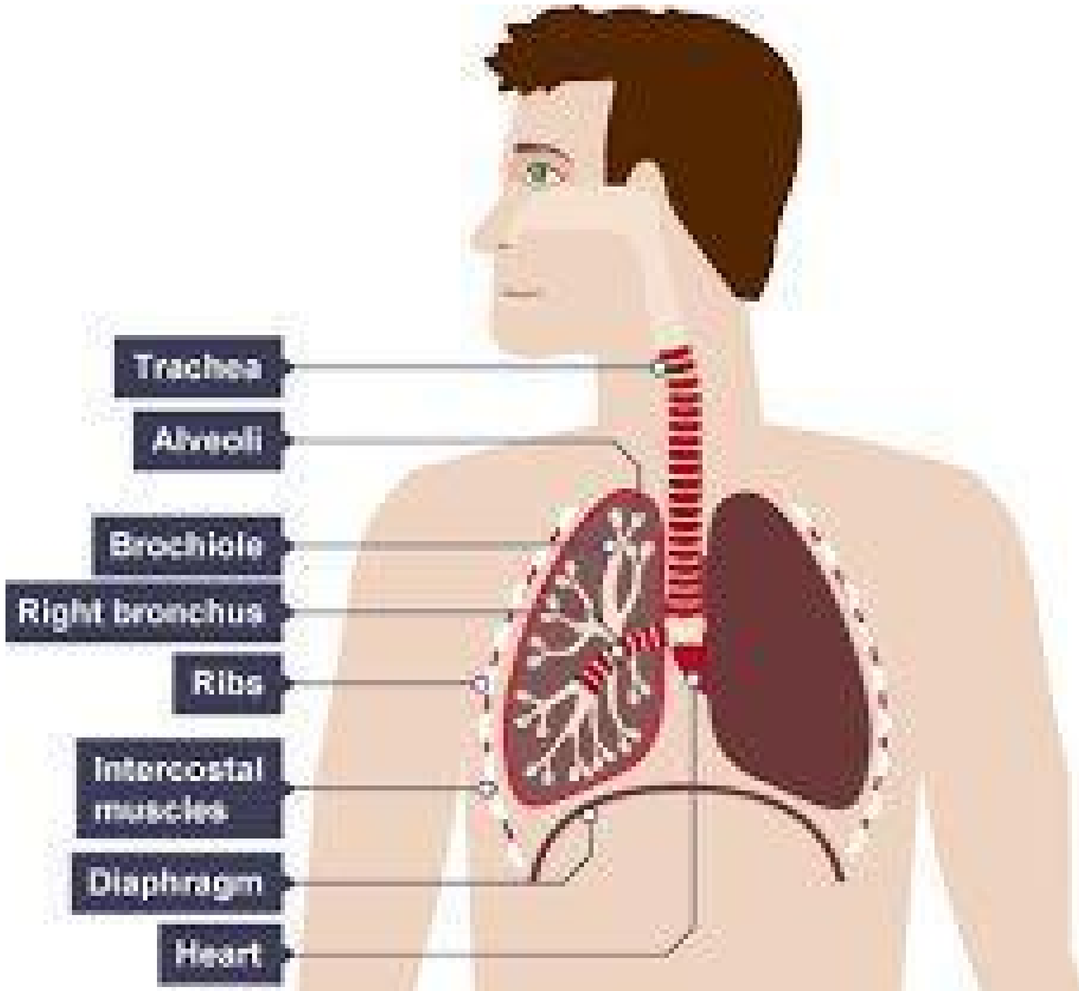
Night vs day

Respiration occurs during night and day, as plants require energy at all times. However, photosynthesis can only occur when light is present (refer to the word equation above) and so cannot occur during the night.

However, during the night there is no photosynthesis so more oxygen is taken into the plants through respiration and more carbon dioxide is released into the atmosphere.

In humans

Structure of thorax



Ribs	Bone 'cage' surrounding the lungs to provide protection of internal organs
Intercostal muscle	Muscles found between the ribs that control inhalation and exhalation

Diaphragm	Muscular dome at the bottom of the thorax that changes the pressure in order to control inhalation and exhalation
Trachea	The windpipe, where air enters the thorax and flows to the lungs
Bronchi	The trachea divides into 2 bronchi - one to each lung
Bronchioles	The bronchi further divide into smaller tubes that connect to the alveoli
Alveoli	Tiny air sacs that are the place of gas exchange
Pleural membranes	Found on the outside of the lungs and inside of chest cavity to lubricate the lungs - reducing friction when breathing

Intercostal muscles and diaphragm in ventilation

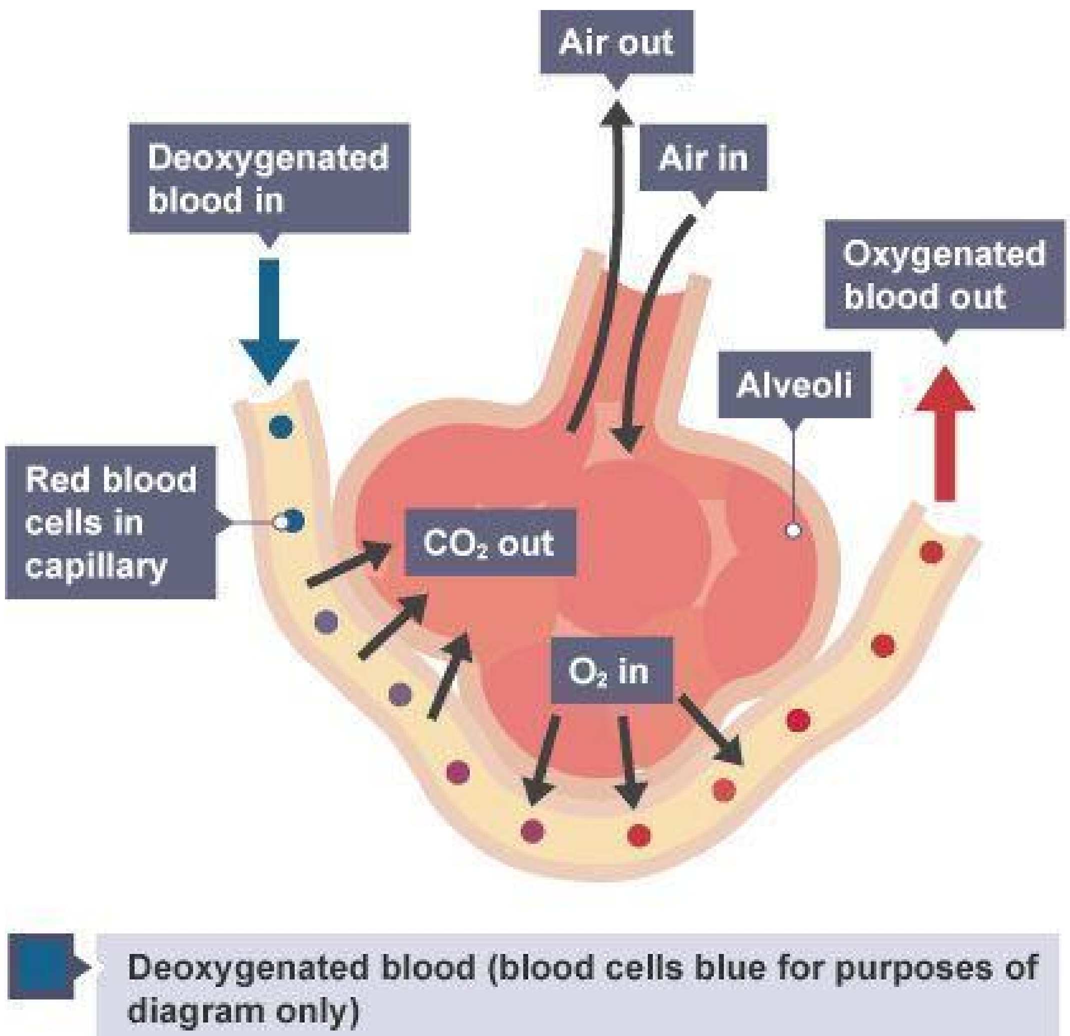
Order of change	**Inhalation**	**Exhalation**
Intercostal muscles	Contract	Relax
Ribcage	Up and out	Down and in

Diaphragm	Contracts downwards	Relaxes upwards
Pressure	Decreases	Increases
Air movement	Moves in	Moves out

Air moves from areas of high pressure to low pressure, so when the thorax pressure decreases (as a result of increased volume created by the intercostal muscles moving the ribcage up and out and the diaphragm flattening) air moves from the higher pressure air down into the lower pressure thorax.

Alveoli adaptations

- **Thin cell walls** - one cell thick so there is a shorter distance of diffusion
- **Folded** - to increase surface area for diffusion
- **Large network of tiny capillaries** - increases concentration gradient between air in alveoli and the blood, as oxygen can move away in the blood and carbon dioxide can be breathed out



Diffusion is a passive process of the spreading out of small particles resulting in a net movement from an area of higher concentration to an area of lower concentration.

In small single-celled organisms can use diffusion to transport molecules into their body from the air- this is because they have a relatively large surface area to volume ratio. Due to their low metabolic demands, diffusion across the surface of the organism is sufficient enough to meet its needs.
However, multicellular organisms have a small surface area to volume ratio so they cannot rely on diffusion alone. Instead, surfaces and organ systems have a number of adaptations that allows molecules to be transported in and out of cells. Examples include alveoli in the lungs, villi in the small intestines and root hair cells in plants.

Transporting substances in plants

Phloem adaptations

● Transport sucrose and amino acids between leaves and other parts of plants (translocation)
○ They can be stored in parts of plants that

- Found in the roots, stems and leaves
- Elongated cells with holes in the cell walls (the end walls are called sieve plates Many organelles from the cells are removed so cell sap can move through.

However, there are many mitochondria in companion cells which provide the energy the cells require
Food substances can be moved in both directions (translocation), from the leaves where they are made for use, or from storage (underground) to parts of the plant that need it.

Xylem adaptations

Water travels up xylem from the roots into the leaves of the plant to replace the water that has been lost due to transpiration. Xylem is adapted in many ways:

- A chemical called lignin is deposited which causes the cells to die.
- These cells then become hollow and join end-to-end to form a continuous tube for water and mineral ions to travel through from the roots
- Water molecules are attracted to each other by hydrogen bonding - creating a continuous column of water up the plant
- The water evaporates from the leaves of the plant, creating the transpiration stream
- Lignin strengthens the plant to help it withstand the pressure of the water movement
- Lignin contains bordered pits, which are holes to allow specific areas for water and therefore minerals to enter the plant

Transpiration

Transpiration and water uptake
Transpiration is the evaporation of water from the surface of a plant. It is a consequence of gaseous exchange, as the stomata are open so that this can occur.

- Water also evaporates at the open stomata
- As water molecules are attracted to each other, when some molecules leave the plant the rest are pulled up through the xylem
- This results in more water being taken up from the soil resulting in a continuous transpiration stream through the plant Factors affecting transpiration**:**

Factor	Effect
Increase in light intensity	This leads to an increased rate of photosynthesis, so more stomata open to allow gaseous exchange to occur. This means more water can evaporate, leading to an increased rate of transpiration.
Increase in temperature	The molecules move faster, resulting in evaporation happening at a faster rate and therefore the rate of transpiration increases. The rate of photosynthesis increases, meaning more stomata are open for gaseous exchange, so more water evaporates and the rate of transpiration increases.
Increased air movement (wind)	If more air is moving away from the leaf due to it being blown away, then the concentration of water vapour surrounding the leaf will be lower. This will mean there will be a steeper concentration gradient resulting in diffusion happening faster. This will increase the rate of transpiration.
Increase in humidity	If the relative humidity is high, then there will be a reduced concentration gradient between the concentrations of water vapour inside and outside the leaf, resulting in a slower rate of diffusion. This will decrease the rate of transpiration.

Practical: investigate the role of environmental factors in determining the rate of transpiration from a leafy shoot
A potometer can be used to investigate how these factors affect water uptake.

1. Set up potometer underwater to remove air bubbles in the xylem so that there is a continuous stream of water and the system is made airtight, apart from a singular bubble of air.
2. Measure the distance this air bubble in the capillary tube moves over time
3. Change an environmental condition, such as light intensity, each time to see how it affects the plant
4. If the air bubbles moves faster then it means that there is a greater rate of water uptake and therefore rate of transpiration.

Transport in humans

Composition of blood

Plasma

- The liquid which carries the components in the blood, e.g. cells, platelets, amino acids, hormones etc.
- Plasma is important for the transport of carbon dioxide, digested food, urea, hormones and heat energy

Red blood cells

- Carry oxygen molecules from the lungs to all the cells in the body
- Contain haemoglobin: a red protein that combines with oxygen to allow for transport
- No nucleus: to create more space for haemoglobin
- Biconcave shape: to maximise surface area for oxygen to be absorbed
- Flexible: so they can fit through very narrow blood vessels

White blood cells

- They are a part of the immune system, which is the body's defence against pathogens
- There are 3 types of WBCs:

1) Phagocytic white blood cells

- One type of white blood cell can do a process called phagocytosis, where the pathogen is engulfed and killed
- As they are able to do this with any type of pathogen it is a non-specific function

2) Producing antibodies (lymphocytes)

- Each pathogen has an antigen on their surface, which is a structure which a specific complementary antibody can bind to.
- Once antibodies begin to bind to the pathogen, the pathogens start to clump together, resulting in it being easier for white blood cells to find them.
- If you become infected again with the same pathogen, the specific complementary antibodies will be produced at a faster rate. The individual will not feel the symptoms of the illness. They are said to be immune.

3) Producing antitoxins
WBCs neutralise the toxins released by the pathogen by binding to them

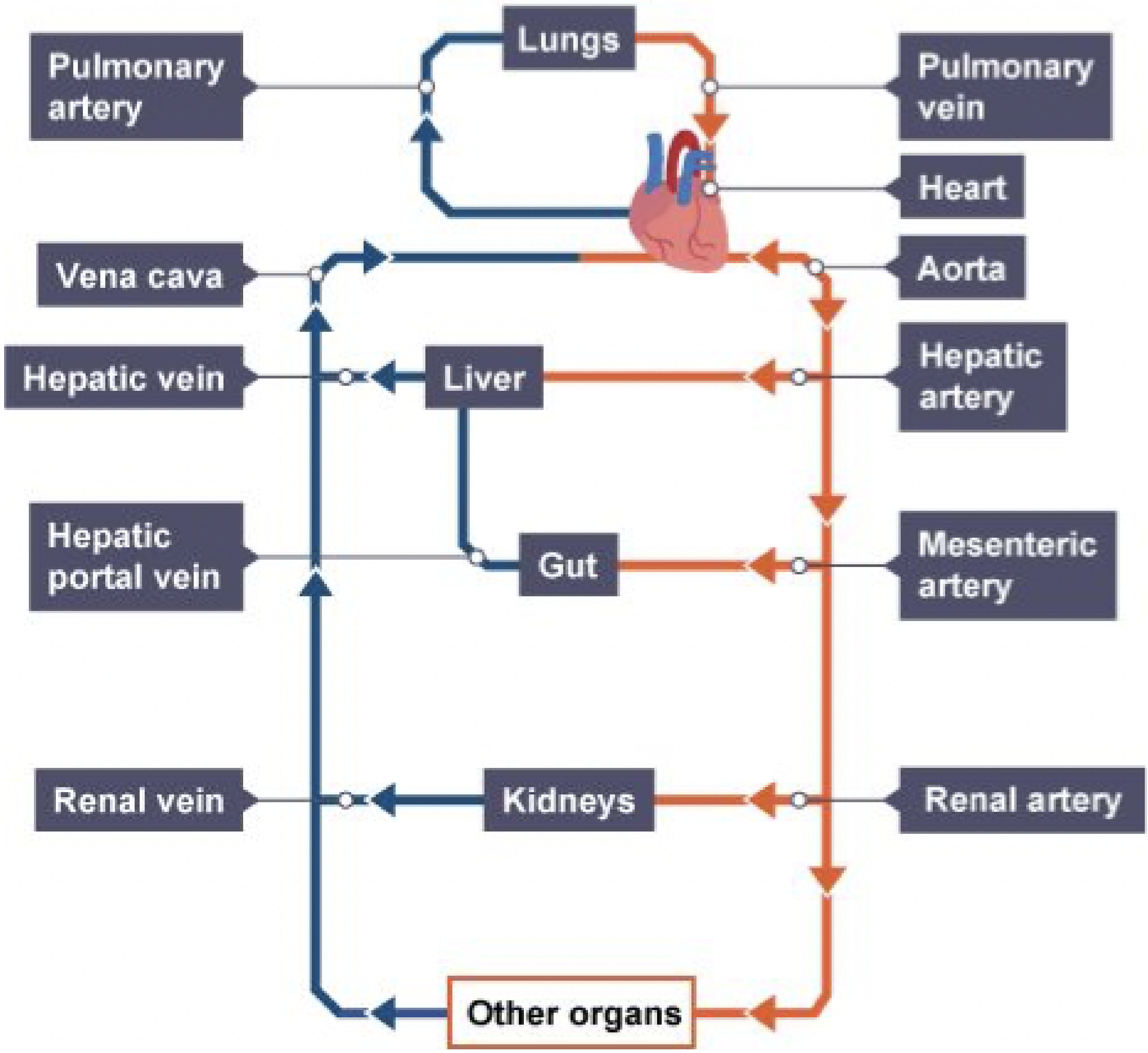
Platelets

1. When the skin is broken (i.e. there is a wound) platelets arrive to stop the bleeding
2. A series of reactions (the clotting cascade) occur within the blood plasma
3. Platelets release chemicals that cause fibrinogen proteins to form a mesh of insoluble fibrin across the wound, trapping red blood cells and therefore forming a clot.
4. The clot eventually develops into a scab to protect the wound from bacteria entering

Human circulatory system

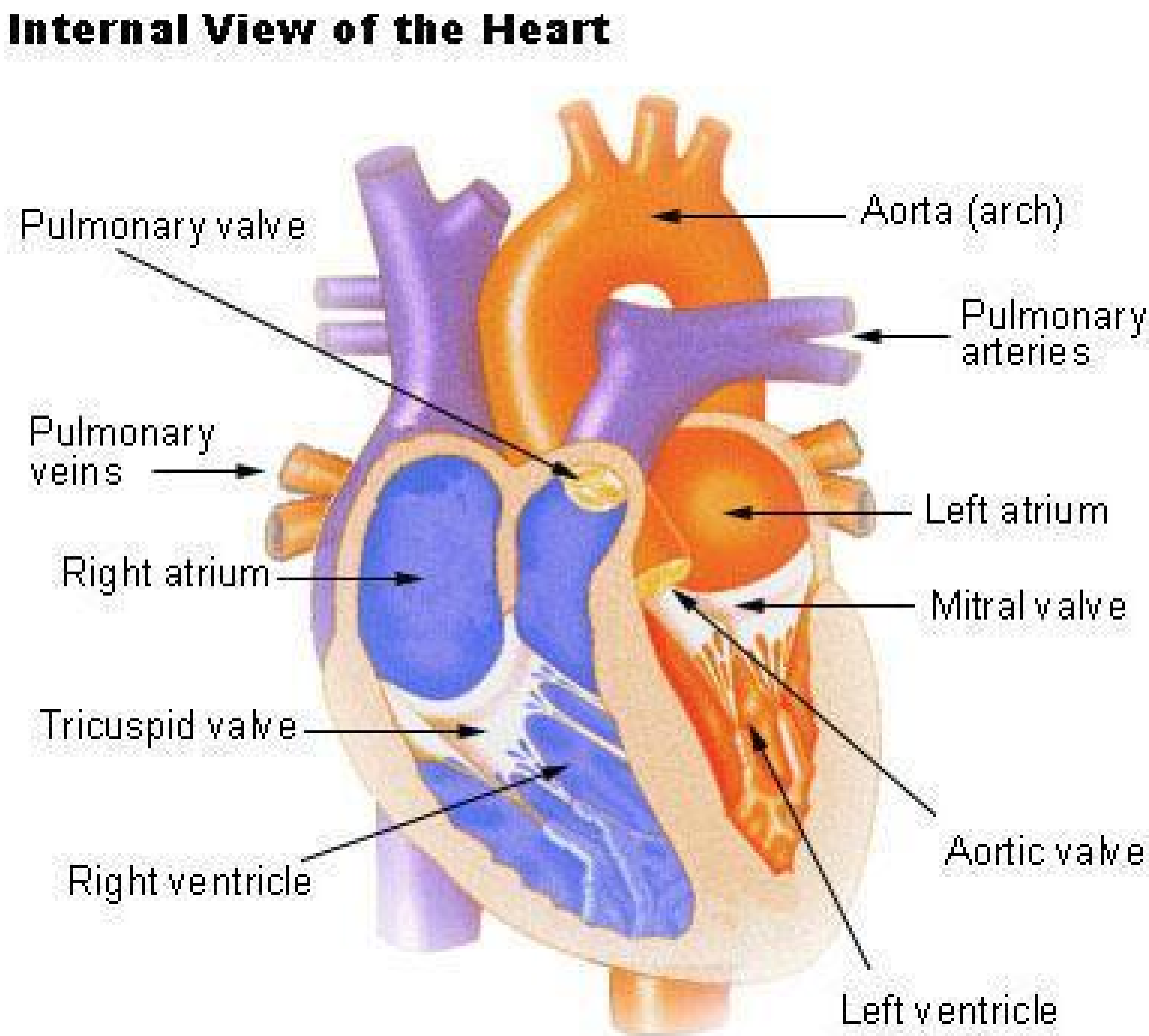
The heart is an organ in the circulatory system. The circulatory system carries oxygen and nutrients to every cell in the body and removes the waste products.
The heart pumps blood around the body in a double circulatory system. This means there are two circuits. Mammals require this double system because the metabolic rate is higher and so need a faster system.

- System 1: Deoxygenated blood flows into the right atrium and then into the right ventricle which pumps it to the lungs to undergo gaseous exchange
- System 2: Oxygenated blood flows into the left atrium and then into the left ventricle which pumps oxygenated blood around the body



You need to know the names of each of the main blood vessels leading to and from the heart, lungs, liver, gut and kidneys.

Structure of the heart



- Muscular walls to provide a strong heartbeat
- The muscular wall of the left ventricle is thicker because blood needs to be pumped all around the body rather than just to the lung like the right ventricle.
- 4 chambers that separate the oxygenated blood from the deoxygenated blood: 2 atria above and 2 ventricles below
- Valves to make sure blood does not flow backwards
- Coronary arteries cover the heart to provide its own oxygenated blood supply

Process:

1. Blood flows into the right atrium through the vena cava, and left atrium through the pulmonary vein.
2. The atria contract forcing the blood into the ventricles.

3. The ventricles then contract, pushing the blood in the right ventricle into the pulmonary artery to be taken to the lungs, and blood in the left ventricle to the aorta to be taken around the body.
4. As this happens, valves close to make sure the blood does not flow backwards.

Structure of blood vessels

Arteries carry blood AWAY from the heart

- Layers of muscle in the walls make them strong
- Elastic fibres allow them to stretch
- This helps the vessels withstand the high pressure created by the pumping of the heart

Veins carry blood TOWARDS the heart

- The lumen (the actual tube in which blood flows through) is wide to allow the low pressure blood to flow through
- They have valves to ensure the blood flows in the right direction

Capillaries allow the blood to flow very close to cells to enable substances to move between them

- One cell thick walls create a short diffusion pathway
- Permeable walls so substances can move across them

Heart rate changes Exercise

- When exercising, muscles require energy and so will be respiring at a higher rate
- This means that the heart rate will increase in order for the heart to pump more oxygen and nutrients around the body and to remove the waste carbon dioxide from respiring muscles
- Stroke volume will also increase, meaning that the heart will pump more powerfully as well as faster

Coronary heart disease (CHD)

The coronary arteries supply blood to the heart and in CHD these arteries become blocked, due to a build-up of fatty plaques (atherosclerosis). This can cause ischaemia (lack of blood and oxygen) which can eventually lead to a muscle death and therefore a heart attack.

Causes of CHD:

- Poor diet
  - A diet rich in saturated fat increases cholesterol levels, which can increase the chance of fatty plaques building up
  - High levels of salt can increase blood pressure which damages the blood vessels and increases the chances of fatty deposits building up
- Smoking
  - Nicotine causes narrowing of blood pressure and increases blood pressure, which can increase the chance of a blockage in the coronary arteries

Stress

- Hormones produced in times of stress can increase blood pressure which can damage the vessel walls

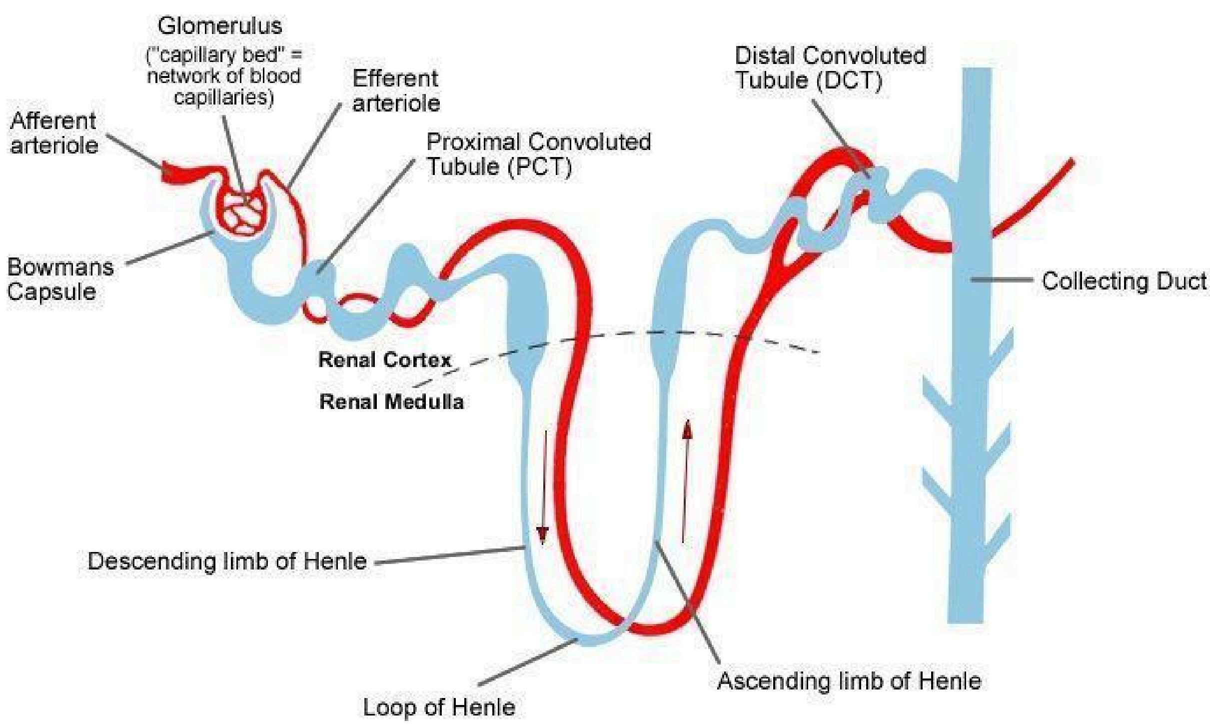
Excretion

Roles of the kidney

The kidneys are very important in maintaining the balance of water and other substances in the body.

- Filtration: filters out the waste products, such as water, ions and urea (from amino acids), at high pressures to form urea
- Selective reabsorption: useful substances such as glucose, ions and water are reabsorbed
- Osmoregulation: controlling water content in the body
- Excretion: removal of waste products from metabolism

The nephron



1. The renal artery transports oxygenated blood to the Bowman's capsule under high pressure
2. In the glomerulus (ball of capillaries within the capsule) the pressure increases even further as the capillaries leaving (efferent arteriole = exiting to renal vein) is narrower than the capillary entering (afferent arteriole)
3. This pressure leads to ultrafiltration- water, salts, glucose and urea pass out of the capillary and into the Bowman's capsule and into the tubules
4. Proteins and blood cells are too big to leave the capillaries and so stay within the blood

5. All glucose is reabsorbed at the proximal convoluted tubule by active transport, whilst the rest of the filtrate continues through the tubules. There are many mitochondria here to provide the energy for active transport.
6. Salts are reabsorbed by the loop of Henle
7. Water is reabsorbed into the blood at the collecting ducts, depending on the levels of water levels in the body (and therefore ADH produced - more on ADH below)
8. The remaining filtrate (water, salts and urea) in the collecting duct will form urine
9. This is transported through the ureters to be stored in the bladder and then through the urethra to leave the body

ADH

Anti-diuretic hormone (ADH) is a hormone involved in the control of the loss of water as urine.
It is released into the pancreas by the pituitary gland when a receptor in the brain detects that the blood is too concentrated.

- It travels in the bloodstream to the kidney tubules
- An increased amount of ADH reaching the tubules increases their permeability to water, so more moves out of the tubule and back into the bloodstream
- This results in a smaller volume of more concentrated (yellow) urine and the blood becoming less concentrated as more water moves into it.
  This is an example of a negative feedback loop, because if the concentration of the blood increases/decreases, more/less ADH is secreted to reverse this change.

  In high temperatures, increased sweating can lead to dehydration. This can lead to salt loss in sweat, meaning that the kidneys may try to compensate for the change by increasing salt retention. The brain detects this and makes us feel that we are thirsty so that we drink more water to dilute the salts in our blood.

Coordination and response

Homeostasis and responses

Homeostasis is the maintenance of a constant internal environment, for example, maintaining body temperature or body water content.

Coordinating responses there needs to be a stimulus (such as heat), a receptor which detects the stimulus (such as the skin on the fingertip) and then an effector which produces the response (such as arm muscles moving the hand away)

Tropisms in plants

Plants need hormones to coordinate and control growth. Examples of these include phototropism, the response to light, and gravitropism or geotropism, the response to gravity. Hormones move from the place they are made to where they are needed in order to produce the appropriate response.

Auxins

Most plants show positive phototropism because they grow towards the light source.

- The plant is exposed to light on one side.
- Auxin, a growth hormone, moves to the shaded side of the shoot.
- Auxin stimulates cells to grow more here.
- This means the shoot bends towards the light.
- The plant receives more light, meaning photosynthesis can occur at a faster rate.

Most shoots show negative gravitropism as they grow away from gravity. If a shoot is horizontal:

- Auxin moves to the lower side.
- The cells of the shoot grow more on the side with most auxin, so it stimulates cells to grow more here.
- This makes the shoot bend and grow away from the ground.
- This is beneficial as light levels are likely to be higher further away from the ground. roots show positive gravitropism as they grow towards gravity. If a root is horizontal:
  Auxin moves to the lower side.
- The cells of the root grow more on the side with less auxin, so it stimulates cells to grow on the upper side.
- This makes the root bend and grow downwards.
- This is beneficial as there are more likely to be increased levels of water and nutrients lower down, and it provides stability for the plant.
- When the auxin distribution becomes equal on both sides it grows straight in that directions.

The human nervous system

Nervous vs endocrine system

- The nervous system is made up of nerve cells that carry impulses around the body.
- The endocrine (hormonal) system is made up of glands that produce hormones that stimulate changes in the body.
- Both systems require stimuli, receptors and effectors and chemicals are involved in both, but there are also key differences between them:

	Nervous system	**Endocrine system**
Type of signal	Electrical	Chemical
Transmitter	Nerve cells	Hormones in bloodstream

Speed of response	Very fast	Slower
Duration of response	Short	Long

The CNS
The central nervous system (CNS) consists of the brain and the spinal cord. It allows us to make sense of our surroundings and respond to it in order to survive.

1. Receptor cells in sense organs convert a stimulus (such as a bright light) into an electrical impulse.
2. This electrical impulse travels along cells called sensory neurons to the central nervous system (CNS).
3. Here, the information is processed and the appropriate response is coordinated, resulting in an electrical impulse being sent along motor neurones to effectors.
4. The effectors carry out the response (this may be muscles contracting or glands secreting hormones).

Synapses
A synapse is the gap between two neurons. Transmission of impulses across the synapse is chemical and uses neurotransmitters.
Neurotransmitters are the chemical released at one end of a nerve fibre.
When an electrical impulse is carried along an axon it triggers the nerve-endings to release neurotransmitters. This is because the electrical impulse cannot directly travel across the synapse (gap) and so needs to be converted to a chemical and then back to an electrical impulse. THe neurotransmitter diffuses across the synapse and binds to receptor molecule on the next neuron. This stimulates the second neuron to transmit the electrical impulse.
The reflex arc
The reflex arc is a subconscious response to a dangerous stimuli, such as a hot surface. Sometimes an extremely quick response is needed and there is not enough time for it to go through the conscious portion of brain so the CNS is involved instead.

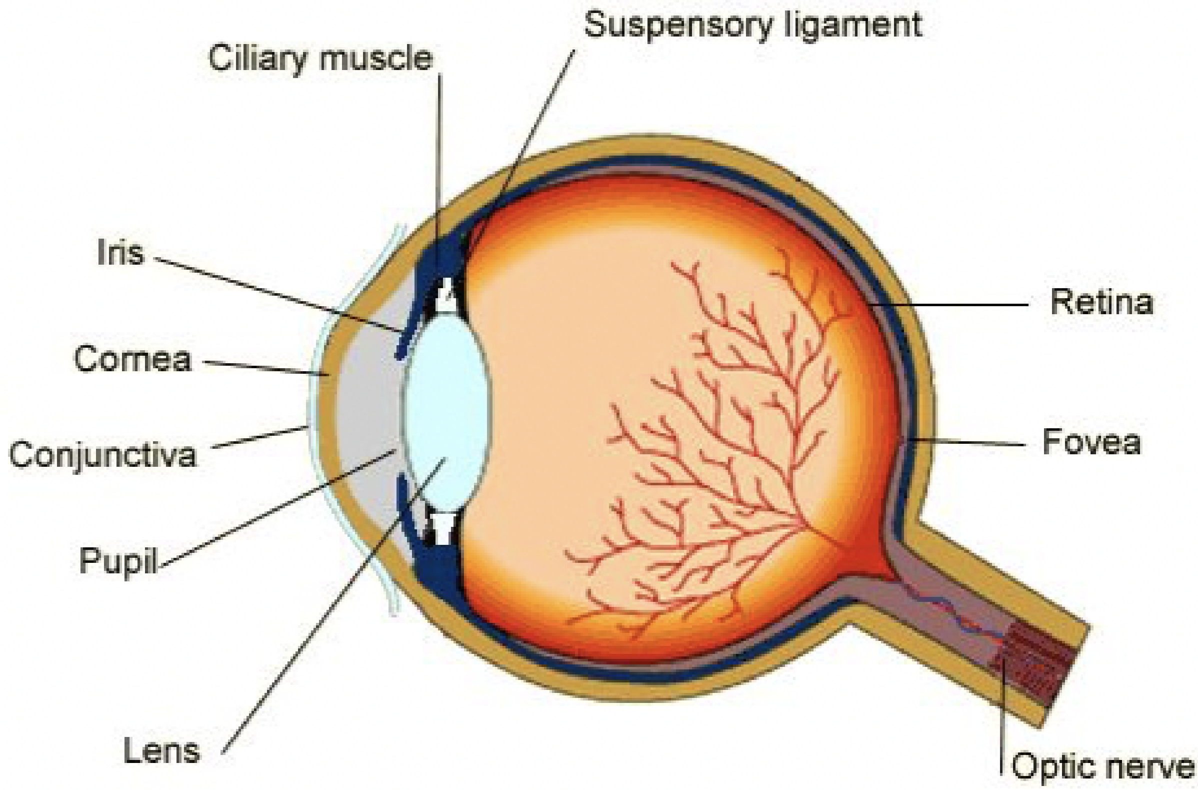
1. A stimulus is detected by receptors, such as thermoreceptors in fingertips detecting heat
2. Impulses are sent along a sensory neuron.
3. In the CNS the impulse passes to a relay neuron.
4. Impulses are sent along a motor neuron
5. The impulse reaches an effector resulting in the appropriate response, such as a contraction of the biceps to move the arm away from the heat source

The eye
● Cornea: the transparent outer part of the eye ○ It refracts light to reach the retina

- Iris: the coloured part of the eye that does not allow light to go through
  - Controls how much light enters eye
  - In bright light, the circular muscles contract and radial muscles relax to make the pupil smaller, avoiding damage to the retina.
  - In dim light, the circular muscles relax and the radial muscles contract to make the pupil larger, so more light can enter to create a better image.
- Lens: transparent, biconvex disc that attaches to ciliary muscles by the suspensory ligaments
  - Focuses light onto the retina
- Retina: contains light receptors

- Contains rods (respond to dim light) and cones (respond to colour)

Optic nerve: carries impulses between the eye and the brain



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Accomodation Near object

- Ciliary muscles contract
- Suspensory ligaments slacken
- This allows the lens to become fatter so the light is refracted more
- Light converges on the retina

Distant object

- Ciliary muscles relax
- Suspensory ligaments stretch
- This allows the lens to become thin so the light is refracted less
- Light converges on the retina

Temperature regulation

Human body temperature is 37.5 degrees celsius. The thermoregulatory centre which monitors and controls body temperature to ensure it remains this temperature is found in the brain.

- Has receptors that monitor the temperature of the blood
- Has receptors in the skin that send impulses to the thermoregulatory centre

When it is hot:

- Sweat (evaporates from skin surface resulting in increased energy transfer away from body) is produced from sweat glands
- Vasodilation means more blood flows closer to the surface of the skin, resulting in increased energy transfer from the body

When it is cold:

- Sweating stops
- Skeletal muscles contract rapidly (shivering) to generate heat from respiration
- Hairs stand on end to create an insulating layer, trapping warm air
- Vasoconstriction means blood does not flow so close to the surface, resulting in less heat lost

Criterion B – Planning an investigation

Criterion B Practice

Example 1:

Energy produced in the body during respiration can be used to keep the body warm. In this task you will DESIGN an investigation to find out if keeping chickens indoors increases their growth.

In your method you should:

1. Formulate a testable hypothesis
2. List the equipment you will use
3. Identify the independent, dependent and control variables
4. Describe how to manipulate and measure variables
5. Describe the method and use of equipment
6. Describe how the data will be collected
7. Explain any safety considerations
8. Outline any ethical concerns about investigations using animals

Example 2:

The student decided to use a spirometer on the group of 10 men smoking outside the mall.
She wanted to find out if smoking affected the respiratory system.
Design a safe investigation to study the effect of smoking on the respiratory system.

In your method you should:

1. Formulate a testable hypothesis
2. List the equipment you will use in addition to the spirometer
3. Identify the independent, dependent and control variables
4. Describe how to manipulate and measure variables
5. Describe the method and use of equipment
6. Describe how the data will be collected
7. Explain any safety considerations
8. Outline any ethical concerns about investigations using human subjects

Remember this Structure!!

Problem:

The effect of ________________ on ___________________
(state the IV) *(state the DV)*

Hypothesis:

If I _____________________________the _____________________
(increase, decrease, or change) *(State the IV)*

then the ___________________will ____
(State the DV) *(increase, decrease, stay the same, or change)*

because ____

____

Describe how to manipulate variables

Independent Variable: _______________________________________

Data Range (Minimum of 5)	
How will you change this?	

Dependent Variable: ____

How will you measure this? (include units)	

Control Variables : ______________________________________
(the group you keep the same.)

Control Variables:

What will be kept the same	How will you keep this the same
1	
2	
3	
4	

5	

Materials List: Be descriptive, such as 10mL graduated cylinder

1. ____

0. ____

0. ____

0. ____

0. ____

0. ____

Method: At least ten steps required, five must have numbers (refer to variables and safety in method)

1. ____

0. ____

0. ____

0. ____

0. ____

0. ____

0. ____

0. ____

0. ____

0. ____

Data Table ____________________ vs. __________________

Independent Variable	Dependent Variable

Criterion C -Processing and Evaluating

Example

In this task you will explore the relationships between enzymes and environmental factors. Scientists investigated the effect of pH on the activity of the enzyme catalase in a fungus. The enzymes have an optimum temperature and pH for it to function effectively. Other factors that affect enzyme activity are substrate and enzyme concentrations
The table below shows the scientists results.

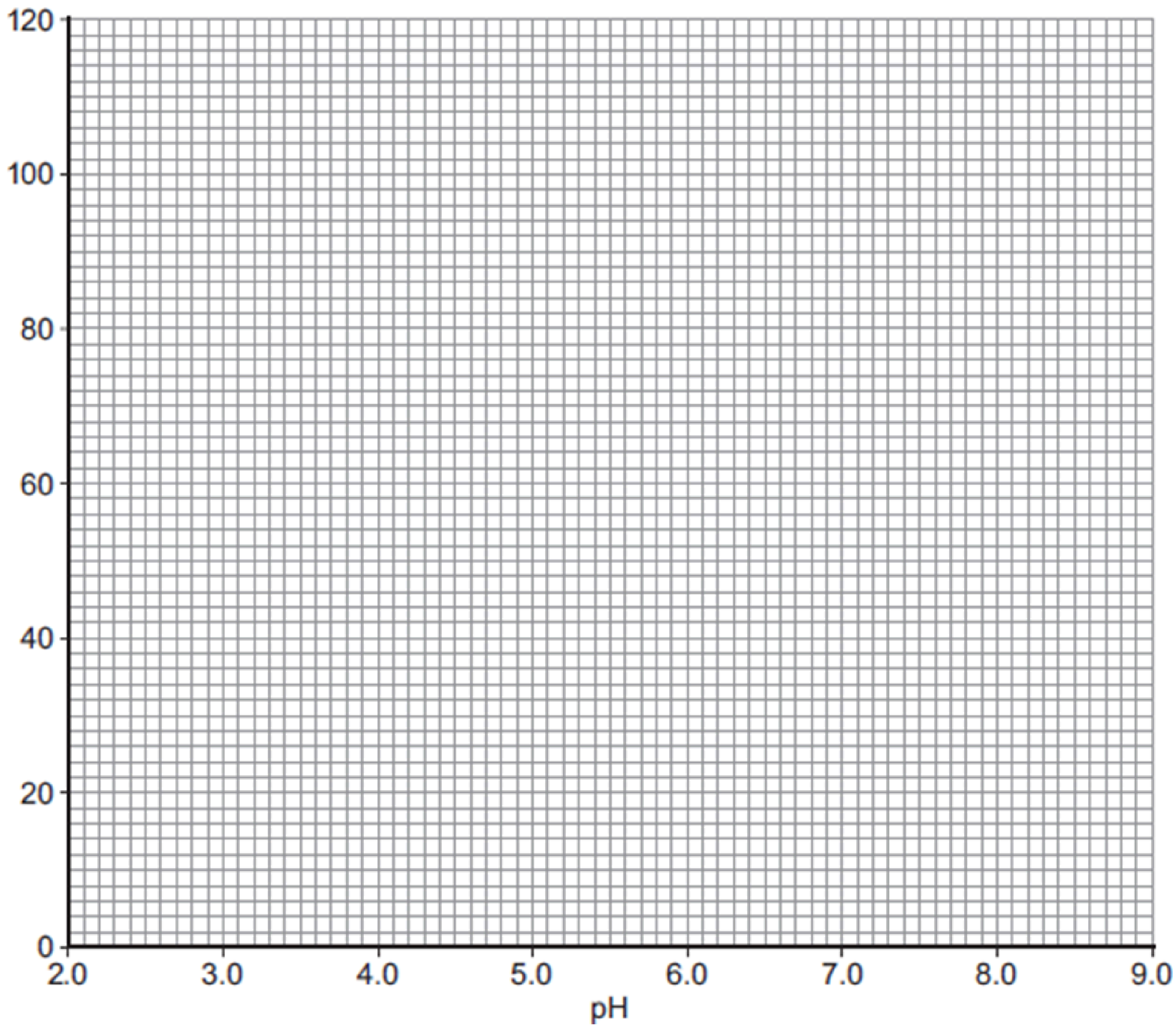
Question 1:
Calculate the mean enzyme activity at pH 5.0.

pH	Enzyme activity in arbitrary units					
	Test 1	Test 2	Test 3	Test 4	Test 5	Mean
3.0	0	0	0	0	0	0
4.0	6	5	8	4	7	6
5.0	38	65	41	42	39	…..
5.5	80	86	82	84	88	84
6.0	100	99	96	103	102	100
6.5	94	92	90	93	91	92
7.0	61	63	61	62	63	62
8.0	22	22	21	24	21	22

.

Question 2:

- **Label** the vertical/Y-axis
- **Plot** the mean values of enzyme activity
- **Draw** a line of best fit.



Question 3:

Describe and **explain** the patterns in these results:

(**NEED TO INCLUDE DATA TO SUPPORT YOUR ANSWER!)**

____
____
____
____
____
_____

Question 4:

Comment on the validity of the hypothesis using the data from the table and the graph.
The scientists hypothesized that "*The fungal enzyme works best between pH 5.5 and 6.5. The optimum pH for this enzyme is 6.0*".

Use the following structure:

The effect of ____________________ on ____________________ is

summarized in the data table and graph. The data ______________________
(doesn't, partially, or completely supports)
the hypothesis that stated ____
(restate entire hypothesis)

Question 5:

Explain what can be concluded from this experiment. Is there any improvements or extensions to this experiment?

Use the following structure:

The purpose of this experiment was to investigate the __________________
(restate title of experiment)

____.

From the data we collected our major finding was ______________________
(state how the IV affected the DV)

____

We did not expect ____ to occur.
(insert and anomaly)

A possible explanation for this anomaly is______________________________

____

Otherwise our data can be explained by ______________________________

____

So our hypothesis was ____
(supported, not supported, partially supported)

A suggestion for improving <u>this</u> experiment is ________________________

____

A suggestion for a <u>related</u> experiment is _____________________________

Criterion D -Reflecting on the impacts of science

Criterion D Structure

Example 1

Researchers from the University of Illinois Chicago are looking for ways to find a solution for climatic change. Use the following videos on the artificial leaf and examine two such possibilities.
Video 1: https://www.youtube.com/watch?v=LHjyGDLiPDI
Video 2: https://www.youtube.com/watch?v=LM_jruaJmNw
One looks at making renewable source of energy from carbon dioxide while the other looks at releasing oxygen into the atmosphere.
This task addresses the key concept of change and focuses on criterion D (reflecting on the impacts of science). In this task you will explore the change that the artificial leaf can bring about in the environment.

Using information from both videos and your wider MYP studies, **discuss** and **evaluate** how the use of artificial leaf will change the environment. In this extended piece of writing, you should use:

- An evaluation of the benefits and limitations of using the artificial leaf
- A discussion of the economic and environmental implications of using the artificial leaf
- A conclusion giving your opinion on the possible success of using the artificial leaf

Example 2

Every year, many patients need to have heart valve replacements. A patient needs a heart valve replacement. A doctor recommends the use of a cow tissue heart valve. The table gives information about two types of heart valve.

Living human heart valve	Cow tissue heart valve
• It has been used for transplants for more than 12 years.	• It has been used since 2011.
• It can take many years to find a suitable human donor.	• It is made from the artery tissue of a cow.
• It is transplanted during an operation after a donor has been found.	• It is attached to a stent and inserted inside the existing faulty valve.
• During the operation, the patient's chest is opened and the old valve is removed before the new valve is transplanted.	• A doctor inserts the stent into a blood vessel in the leg and pushes it through the blood vessel to the heart.

Using information from the table, the video provided and your wider MYP studies, **discuss** and **evaluate** the implications of using a cow tissue heart valve compared with using a living human heart valve.
In this extended piece of writing, you should use:

- An evaluation of the advantages and disadvantages of using a cow tissue heart valve compared with using a living human heart valve
- A discussion of the ethical and environmental implications of using a cow tissue heart valve
- A conclusion giving your opinion on the possible success of using a cow tissue heart valve