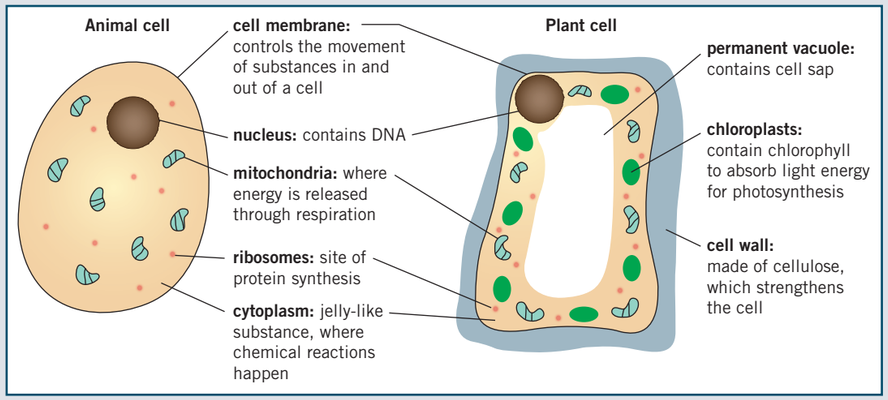
Chapter 1: Cell biology and transport

Knowledge organiser

Eukaryotic cells

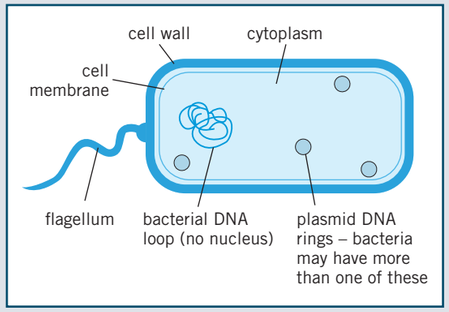
Animal and plant cells are eukaryotic. They have genetic material (DNA) that forms **chromosomes** and is contained in a **nucleus**.



Prokaryotic cells

Bacteria have the following characteristics:

- single-celled
- no nucleus – have a single loop of DNA
- have small rings of DNA called **plasmids**
- smaller than eukaryotic cells.



Microscopes

Light microscope	Electron microscope
uses light to form images	uses a beam of electrons to form images
living samples can be viewed	samples cannot be living
relatively cheap	expensive
low magnification	high magnification
low resolution	high resolution

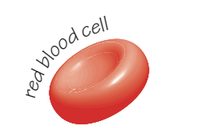
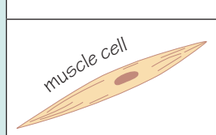
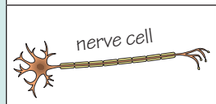
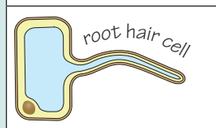
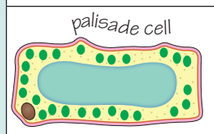
Electron microscopes allow you to see sub-cellular structures, such as ribosomes, that are too small to be seen with a light microscope.

L To calculate the **magnification** of an image:

$$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$$

Specialised cells

Cells in animals and plants differentiate to form different types of cells. Most animal cells differentiate at an early stage of development, whereas a plant's cells differentiate throughout its lifetime.

Specialised cell	Function	Adaptations
	fertilise an ovum (egg)	• tail to swim to the ovum and fertilise it • lots of mitochondria to release energy from respiration, enabling the sperm to swim to the ovum
	transport oxygen around the body	• no nucleus so more room to carry oxygen • contains a red pigment called haemoglobin that binds to oxygen molecules • flat bi-concave disc shape to increase surface area-to- volume ratio
	contract and relax to allow movement	• contains protein fibres, which can contract to make the cells shorter • contains lots of mitochondria to release energy from respiration, allowing the muscles to contract
	carry electrical impulses around the body	• branched endings, called dendrites, to make connections with other neurones or effectors • myelin sheath insulates the axon to increase the transmission speed of the electrical impulses
	absorb mineral ions and water from the soil	• long projection speeds up the absorption of water and mineral ions by increasing the surface area of the cell • lots of mitochondria to release energy for the active transport of mineral ions from the soil
	enable photosynthesis in the leaf	• lots of chloroplasts containing chlorophyll to absorb light energy • located at the top surface of the leaf where it can absorb the most light energy

Comparing diffusion, osmosis, and active transport

	Diffusion	Osmosis	Active transport
Definition	The spreading out of particles, resulting in a net movement from an area of higher **concentration** to an area of lower concentration. Factors which affect the rate of diffusion: difference in concentration, temperature, and surface area of the membrane.	The diffusion of water from a **dilute** solution to a concentrated solution through a **partially permeable membrane**.	The movement of particles from a more dilute solution to a more concentrated solution using energy from respiration.
Movement of particles	Particles move down the concentration **gradient** – from an area of *high* concentration to an area of *low* concentration.	Water moves from an area of *lower* solute concentration to an area of *higher* solute concentration.	Particles move against the concentration gradient – from an area of *low* concentration to an area of *high* concentration.
Energy required?	no – passive process	no – passive process	yes – energy released by respiration
Examples	**Humans** • Nutrients in the small intestine diffuse into the **capillaries** through the **villi**. • Oxygen diffuses from the air in the **alveoli** into the blood in the capillaries. Carbon dioxide diffuses from the blood in the capillaries into the air in the alveoli. • **Urea** diffuses from cells into the blood for excretion in the kidney. **Fish** • Oxygen from water passing over the gills diffuses into the blood in the **gill filaments**. • Carbon dioxide diffuses from the blood in the gill filaments into the water. **Plants** • Carbon dioxide used for photosynthesis diffuses into leaves through the **stomata**. • Oxygen produced during photosynthesis diffuses out of the leaves through the stomata.	**Plants** • Water moves by osmosis from a dilute solution in the soil to a concentrated solution in the **root hair cell**.	**Humans** • Active transport allows sugar molecules to be absorbed from the small intestine when the sugar concentration is higher in the blood than in the small intestine. **Plants** • Active transport is used to absorb mineral ions into the root hair cells from more dilute solutions in the soil.

Key terms

Make sure you can write a definition for these key terms.

cell membrane, cell wall, chloroplast, chromosome, concentration, cytoplasm, dilute, DNA, eukaryotic, gill filaments, gradient, magnification, mitochondria, nucleus, partially permeable membrane, passive process, permanent vacuole, plasmid, prokaryotic, resolution, ribosome, root hair cell, stomata

Chapter 1: Cell biology and transport

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

B1 questions	Answers
1 What are two types of eukaryotic cell?	animal and plant
2 What type of cell are bacteria?	prokaryotic
3 Where is DNA found in animal and plant cells?	in the nucleus
4 What is the function of the cell membrane?	controls movement of substances in and out of the cell
5 What is the function of mitochondria?	site of respiration to transfer energy for the cell
6 What is the function of chloroplasts?	contain chlorophyll to absorb light energy for photosynthesis
7 What is the function of ribosomes?	enable production of proteins (protein synthesis)
8 What is the function of the cell wall?	strengthens and supports the cell
9 What is the structure of the main genetic material in a prokaryotic cell?	single loop of DNA
10 How are electron microscopes different to light microscopes?	electron microscopes use beams of electrons instead of light, cannot be used to view living samples, are much more expensive, and have a much higher magnification and resolution
11 What is the function of a red blood cell?	carries oxygen around the body
12 Give three adaptations of a red blood cell.	no nucleus, contains a red pigment called haemoglobin, and has a bi-concave disc shape
13 What is the function of a nerve cell?	carries electrical impulses around the body
14 Give two adaptations of a nerve cell.	branched endings, myelin sheath insulates the axon
15 What is the function of a sperm cell?	fertilises an ovum (egg)
16 Give two adaptations of a sperm cell.	tail, contains lots of mitochondria
17 What is the function of a palisade cell?	carries out photosynthesis in a leaf
18 Give two adaptations of a palisade cell.	lots of chloroplasts, located at the top surface of the leaf
19 What is the function of a root hair cell?	absorbs minerals and water from the soil
20 Give two adaptations of a root hair cell.	long projection, lots of mitochondria
21 What is diffusion?	net movement of particles from an area of high concentration to an area of low concentration along a concentration gradient – this is a passive process (does not require energy from respiration)
22 Name three factors that affect the rate of diffusion.	concentration gradient, temperature, membrane surface area
23 How are villi adapted for exchanging substances?	• long and thin – increases surface area • one-cell-thick membrane – short diffusion pathway • good blood supply – maintains a steep concentration gradient
24 How are the lungs adapted for efficient gas exchange?	• alveoli – large surface area • moist membranes – increases rate of diffusion • one-cell-thick membranes – short diffusion pathway • good blood supply – maintains a steep concentration gradient
25 How are fish gills adapted for efficient gas exchange?	• large surface area for gases to diffuse across • thin layer of cells – short diffusion pathway • good blood supply – maintains a steep concentration gradient
26 What is osmosis?	diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane
27 Give one example of osmosis in a plant.	water moves from the soil into the root hair cell
28 What is active transport?	movement of particles against a concentration gradient – from a dilute solution to a more concentrated solution – using energy from respiration
29 Why is active transport needed in plant roots?	concentration of mineral ions in the soil is lower than inside the root hair cells – the mineral ions must move against the concentration gradient to enter the root hair cells
30 What is the purpose of active transport in the small intestine?	sugars can be absorbed when the concentration of sugar in the small intestine is lower than the concentration of sugar in the blood

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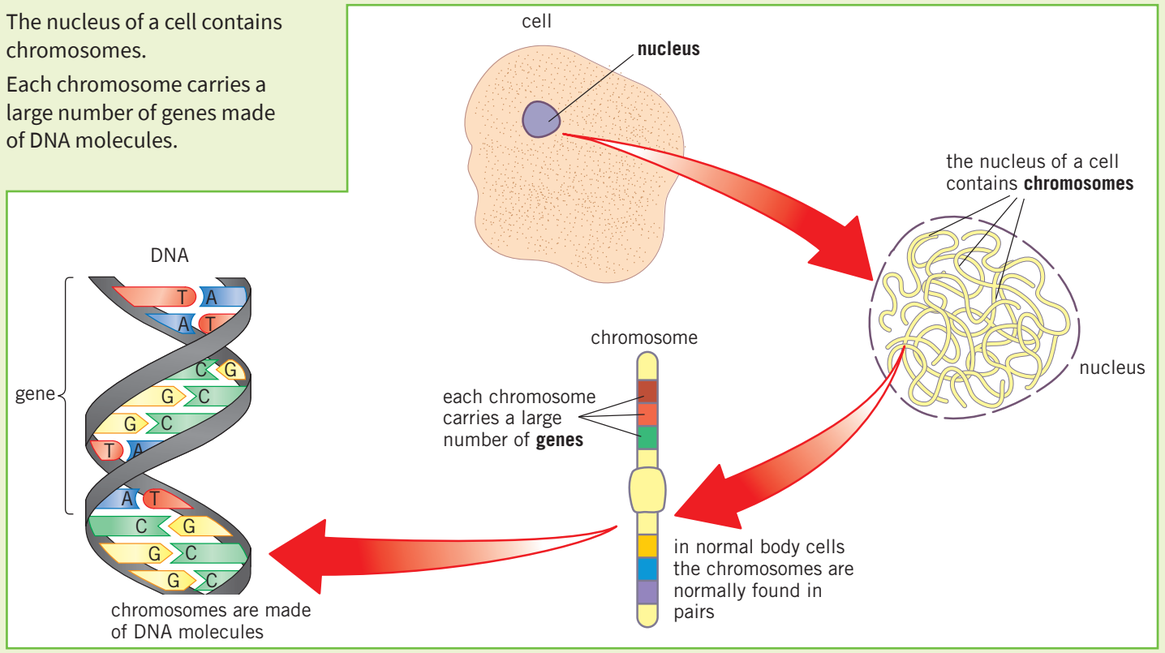
Chapter 2: Cell division

Knowledge organiser

Chromosomes

The nucleus of a cell contains chromosomes.

Each chromosome carries a large number of genes made of DNA molecules.

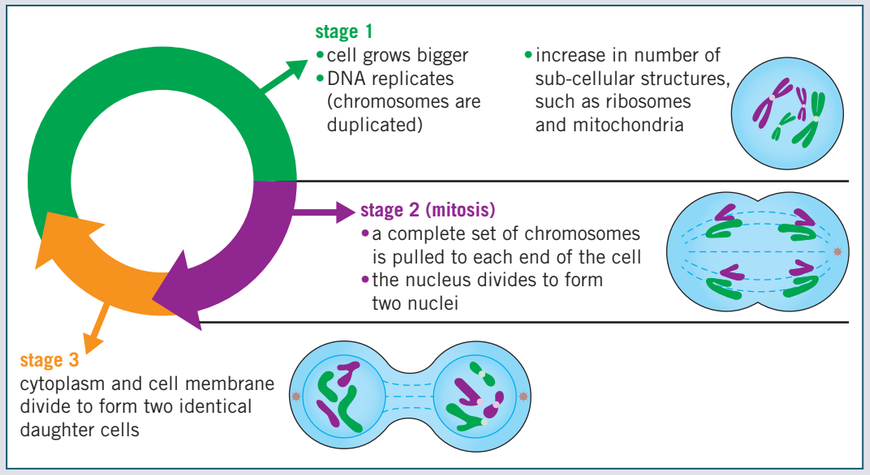


The cell cycle

Body cells divide to form two identical **daughter cells** by going through a series of stages known as the **cell cycle**.

Cell division by **mitosis** is important for the growth and repair of cells, for example, the replacement of skin cells. Mitosis is also used for asexual reproduction.

There are *three* main stages in the cell cycle:



Stem cells in medicine

A stem cell is an undifferentiated cell that can develop into one or more types of specialised cell.

There are two types of stem cell in mammals: **adult stem cells** and **embryonic stem cells**.

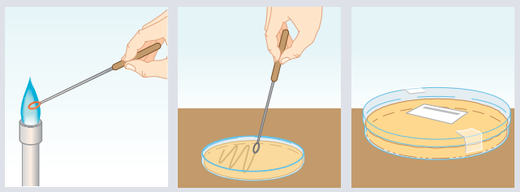
Stem cells can be **cloned** to produce large numbers of identical cells.

Type of stem cell	Where are they found?	What can they differentiate into?	Advantages	Disadvantages
adult stem cells	specific parts of the body in adults and children – for example, bone marrow	can only differentiate to form certain types of cells – for example, stem cells in bone marrow can only differentiate into types of blood cell	• fewer ethical issues – adults can consent to have their stem cells removed and used • an already established technique for treating diseases such as leukaemia • relatively safe to use as a treatment and donors recover quickly	• requires a donor, potentially meaning a long wait time to find someone suitable • can only differentiate into certain types of specialised cells, so can be used to treat fewer diseases
embryonic stem cells	early human embryos (often taken from spare embryos from fertility clinics)	can differentiate into any type of specialised cell in the body – for example, a nerve cell or a muscle cell	• can treat a wide range of diseases as can form any specialised cell • may be possible to grow whole replacement organs • usually no donor needed as they are obtained from spare embryos from fertility clinics	• ethical issues as the embryo is destroyed and each embryo is a potential human life • risk of transferring viral infections to the patient • newer treatment so relatively under-researched – not yet clear if they can cure as many diseases as thought
plant meristem	meristem regions in the roots and shoots of plants	can differentiate into all cell types – they can be used to create clones of whole plants	• rare species of plants can be cloned to prevent extinction • plants with desirable traits, such as disease resistance, can be cloned to produce large numbers of identical plants • fast and low-cost production of large numbers of plants	• cloned plants are genetically identical, so a whole crop is at risk of being destroyed by a single disease or genetic defect

Binary fission

Cell division in bacteria is called binary fission. In optimum temperature and nutrients, bacteria can multiply as often as every 20 minutes. In a lab, bacteria can be grown in sterile conditions on an agar gel plate or in a nutrient broth.

The lid of the petri dish must be sealed but not all the way so that oxygen can still get in. This is so that harmful bacteria that do not need oxygen aren't able to grow.



Therapeutic cloning

In **therapeutic cloning**

- cells from a patient's own body are used to create a cloned early embryo of themselves
- stem cells from this embryo can be used for medical treatments and growing new organs
- these stem cells have the same genes as the patient, so are less likely to be rejected when transplanted.

Key terms

Make sure you can write a definition for these key terms.

adult stem cell, binary fission, cell cycle, chromosome, clone, daughter cells, embryonic stem cell, gene, meristem, mitosis, nucleus, therapeutic cloning

Chapter 2: Cell division

Retrieval questions

Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B2 questions	Answers
1	What is a stem cell?	undifferentiated cell that can differentiate into one or more specialised cell types
2	What are adult stem cells?	stem cells from adults that can only differentiate into certain specialised cells
3	Where can adult stem cells be found?	bone marrow
4	What are embryonic stem cells?	stem cells from embryos that can differentiate into any specialised cell
5	Where are embryonic stem cells found?	early human embryos (usually from spare embryos from fertility clinics)
6	What is therapeutic cloning?	patient's cells are used to create an early embryo clone of themselves – stem cells from the embryo can then be used to treat the patient's medical conditions
7	Give one advantage of using therapeutic cloning.	stem cells from the embryo are not rejected when transplanted because they have the same genes as the patient
8	Give one advantage of using adult stem cells.	fewer ethical issues as obtained from adults who can consent to their use
9	Give two disadvantages of using adult stem cells.	can take a long time for a suitable donor to be found • can only differentiate into some specialised cell types, so treat fewer diseases
10	Give two advantages of using embryonic stem cells.	• can differentiate into any specialised cell, so can be used to treat many diseases • easier to obtain as they are found in spare embryos from fertility clinics
11	Give two disadvantages of using embryonic stem cells.	• ethical issues surrounding their use, as every embryo is a potential life • potential risks involved with treatments, such as transfer of viral infections
12	What are plant meristems?	area where rapid cell division occurs in the tips of roots and shoots
13	Give two advantages of using plant meristems to clone plants.	• rare species can be cloned to protect them from extinction • plants with special features (e.g., disease resistance) can be cloned to produce many copies
14	Give one disadvantage of using plant meristems to clone plants.	no genetic variation, so, for example, an entire cloned crop could be destroyed by a disease
15	What is cell division by mitosis?	body cells divide to form two identical daughter cells
16	What is the purpose of mitosis?	growth and repair of cells, asexual reproduction
17	What happens during the first stage of the cell cycle?	cell grows bigger, chromosomes duplicate, number of subcellular structures (e.g., ribosomes and mitochondria) increases
18	What happens during mitosis?	one set of chromosomes is pulled to each end of the cell and the nucleus divides
19	What happens during the third stage of the cell cycle?	the cytoplasm and cell membrane divide, forming two identical daughter cells
20	What is the term for cell division in bacteria?	Binary fission

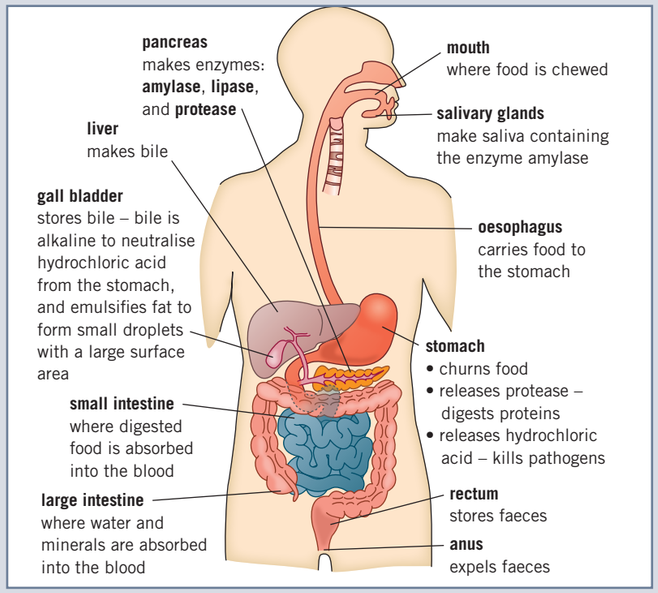
Chapter 3: Organisation and the digestive system

Knowledge organiser

There are five **levels of organisation** in living organisms:

- **cells** – basic building blocks
- **tissues** – groups of cells that have similar structures and functions
- **organs** – groups of tissues working together to perform a specific function
- **organ systems** – groups of organs working together
- **organisms** – organ systems work together, forming an organism

Digestive system



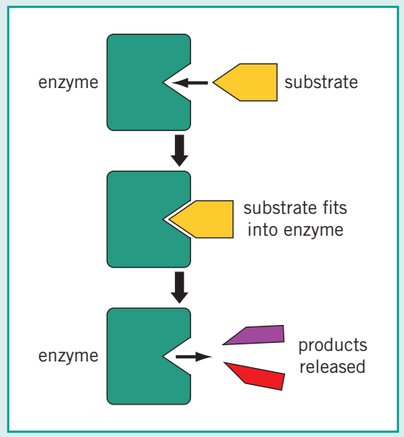
Digestive enzymes

Digestive enzymes convert food into small, soluble molecules that can then be absorbed into the bloodstream. For example, carbohydrases break down carbohydrates into simple sugars.

Enzyme	Sites of production	Reaction catalysed
amylase	salivary glands pancreas small intestine	starch → glucose
proteases	stomach pancreas small intestine	proteins → amino acids
lipases	pancreas small intestine	lipids → fatty acids and glycerol

Enzymes

Enzymes are large proteins that **catalyse** (speed up) reactions. Enzymes are not changed in the reactions they catalyse.



Lock and key theory

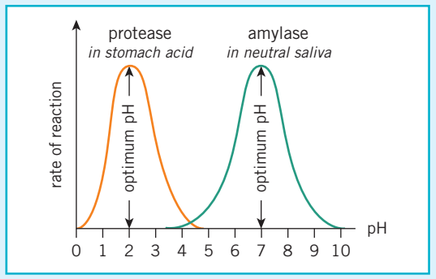
This is a simple model of how enzymes work:

1. The enzyme's **active site** (where the reaction occurs) is a specific shape.
2. The enzyme (the lock) will only catalyse a specific reaction because the **substrate** (the key) fits into its active site.
3. At the active site, enzymes can break molecules down into smaller ones or bind small molecules together to form larger ones.
4. When the products have been released, the enzyme's active site can accept another substrate molecule.

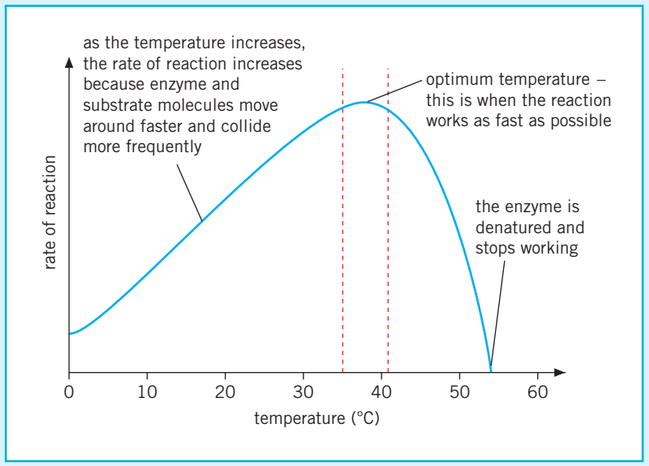
The effect of pH on enzymes

Different enzymes have different **optimum** pH values.

This allows enzymes to be adapted to work well in environments with different pH values. For example, parts of the digestive system greatly differ in pH.

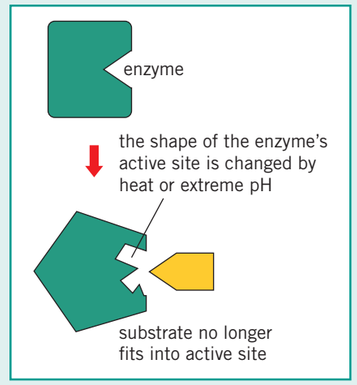


The effect of temperature on enzymes



Denaturation

At extremes of pH or at very high temperatures, the shape of an enzyme's active site can change.



The substrate can no longer bind to the active site, so the enzyme cannot catalyse the reaction – the enzyme has been **denatured**.

Key terms

Make sure you can write a definition for these key terms.

active site *amylase* *catalyse* *denatured* *enzyme* *lipase* *optimum* *organ* *organ system* *pH* *protease* *substrate* *temperature* *tissue*

Chapter 3: Organisation and digestive system

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B3 questions	Answers
1	Name the five levels of organisation.	cells → tissues → organs → organ systems → organisms
2	What is a tissue?	group of cells with similar structures and functions
3	What is an organ?	group of tissues working together to perform a specific function
4	What is the function of the liver in digestion?	produces bile, which neutralises hydrochloric acid from the stomach and emulsifies fat to form small droplets with a large surface area
5	What is the function of saliva in digestion?	lubrication to help swallowing – contains amylase to break down starch
6	Name three enzymes produced in the pancreas.	amylase, protease, lipase
7	What are enzymes?	protein molecules that catalyse specific reactions in organisms
8	Why are enzymes described as specific?	each enzyme only catalyses a specific reaction, because the active site only fits together with certain substrates (like a lock and key)
9	Describe the function of amylase.	to break down starch into glucose
10	Where is amylase produced?	salivary glands, pancreas, and small intestine
11	Describe the function of proteases.	to break down proteins into amino acids
12	Where are proteases produced?	stomach, pancreas, and small intestine
13	Describe the function of lipases.	to break down lipids into fatty acids and glycerol
14	Where are lipases produced?	pancreas and small intestine
15	What are two factors that affect the rate of activity of an enzyme?	temperature and pH
16	What does denatured mean?	shape of an enzyme's active site is changed by high temperatures or an extreme pH, so it can no longer bind with the substrate
17	Describe the effect of temperature on enzyme activity.	as temperature increases, rate of reaction increases until it reaches the optimum for enzyme activity – above this temperature enzyme activity decreases and eventually stops
18	Describe the effect of pH on enzyme activity.	different enzymes have a different optimum pH at which their activity is greatest – a pH much lower or higher than this enzyme activity decreases and stops
19	Why do different digestive enzymes have different optimum pHs?	different parts of the digestive system have very different pHs – the stomach is strongly acidic, and the pH in the small intestine is close to neutral
20	What is an organ system?	a group of organs working together to perform a specific function

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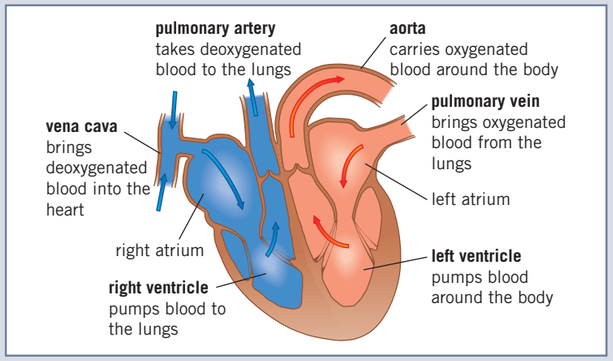
Chapter 4: Organising animals and plants 1

Knowledge organiser

The heart

The heart is the organ that pumps blood around your body. It is made from **cardiac** muscle tissue, which is supplied with oxygen by the **coronary artery**.



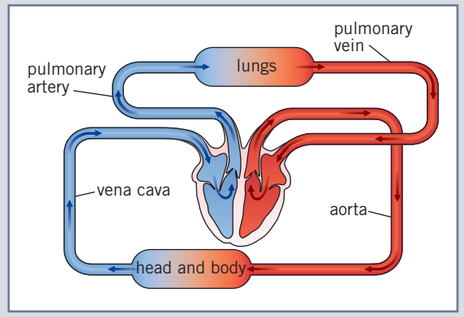
Heart rate is controlled by a group of cells in the right atrium that generate electrical impulses, acting as a pacemaker.

Artificial pacemakers can be used to control irregular heartbeats.

Double circulatory system

The human circulatory system is described as a **double circulatory system** because blood passes through the heart twice for every circuit around the body:

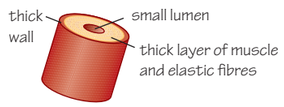
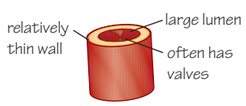
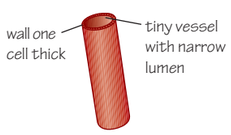
- the right ventricle pumps blood to the lungs where gas exchange takes place
- the left ventricle pumps blood around the rest of the body.



blood is a tissue made up of four main components

- red blood cells – bind to oxygen and transport it around the body
- plasma – transports substances and blood cells around the body
- platelets – form blood clots to create barriers to infections
- white blood cells – part of the immune system to defend the body against pathogens

Blood vessels

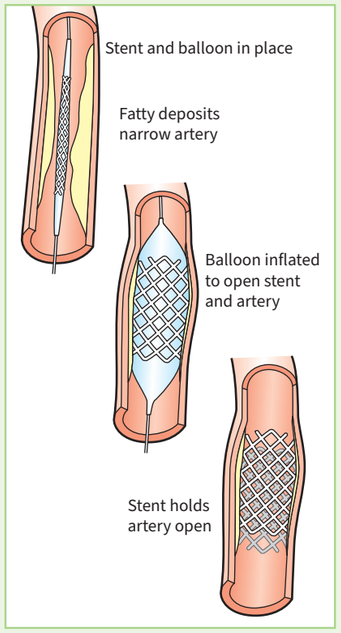
Vessel	Function	Structure	Diagram
artery	carries blood *away from* the heart (high pressure)	• thick, muscular, and elastic walls • the walls can stretch and withstand high pressure • small lumen	
vein	carries blood *to* the heart (low pressure)	• have valves to stop blood flowing the wrong way • thin walls • large lumen	
capillary	• carries blood to tissues and cells • connects arteries and veins	• one cell thick – short diffusion distance for substances to move between the blood and tissues (e.g., oxygen into cells and carbon dioxide out) • very narrow lumen	

Heart issues

Coronary heart disease is caused by a build up of fatty material in the coronary arteries, making them narrow, and reducing blood flow. Stents can be used to help keep the coronary arteries open.

Patients with heart failure often have to use artificial hearts before a donor heart becomes available for a heart transplant.

People with faulty heart **valves** may feel symptoms of breathlessness as valves do not fully open, making the heart less efficient. These can be replaced with biological valves (from animals), or mechanical valves (made from titanium and polymers).

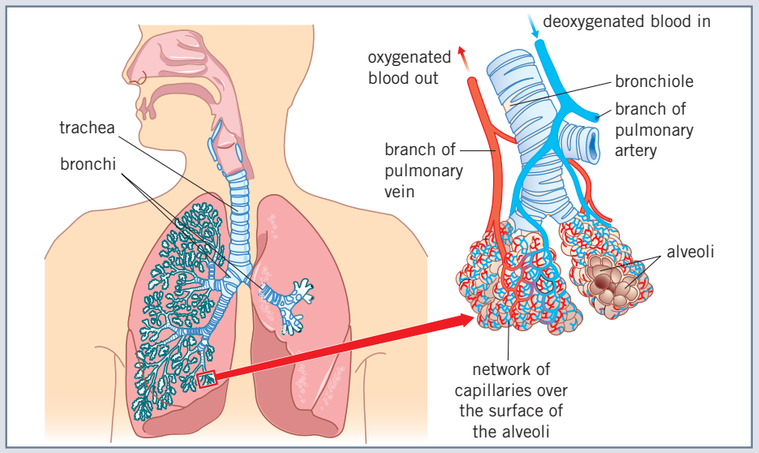


Lungs

When breathing in, air moves

1. into the body through the mouth and nose
2. down the trachea
3. into the **bronchi**
4. through the **bronchioles**
5. into the **alveoli** (air sacs).

Oxygen then diffuses into the blood in the network of **capillaries** over the surface of the alveoli.



Key terms

Make sure you can write a definition for these key terms.

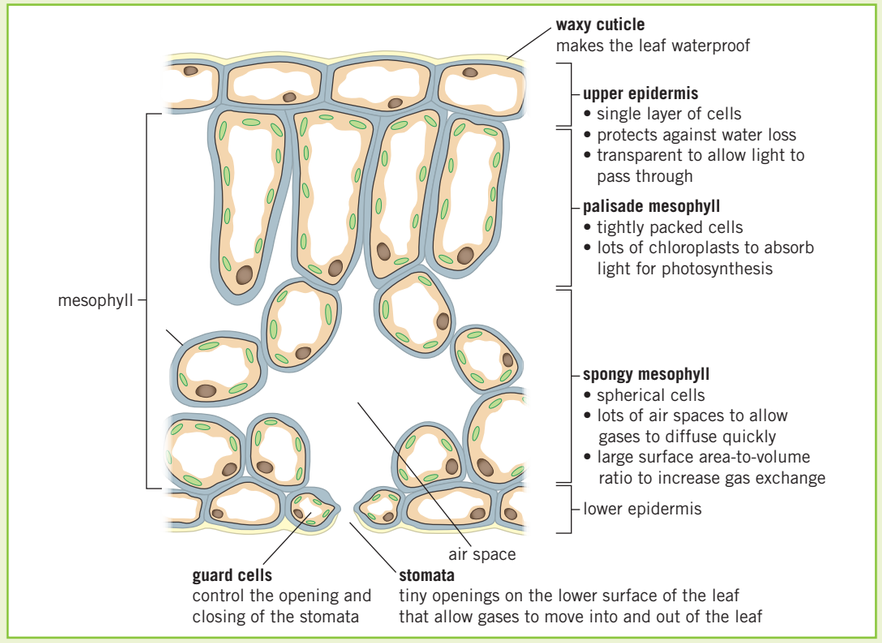
alveoli *aorta* *artery* *atrium* *bronchi* *bronchiole* *capillary* *cardiac* *coronary* *double circulatory system* *plasma* *platelet* *pulmonary* *valve* *vein* *vena cava* *ventricle*

Chapter 4: Organising animals and plants 2

Knowledge organiser

Tissues in leaves

Leaves are organs because they contain many tissues that work together to perform photosynthesis.



Stomata

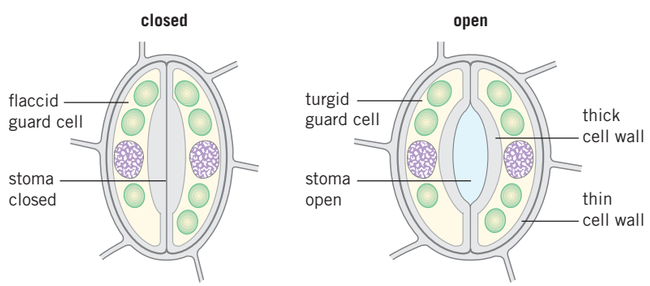
Stomata are tiny openings in the undersides of leaves – this placement reduces water loss through evaporation.

They control gas exchange and water loss from leaves by:

- allowing diffusion of carbon dioxide into the plant for photosynthesis
- allowing diffusion of oxygen out of the plant.

Guard cells are used to open and close the stomata.

When a plant has plenty of water, the guard cells become turgid. The cell wall on the inner surface is very thick, so it cannot stretch as much as the outer surface. So as the guard cells swell up, they curve away from each other, opening the stoma.



Transpiration

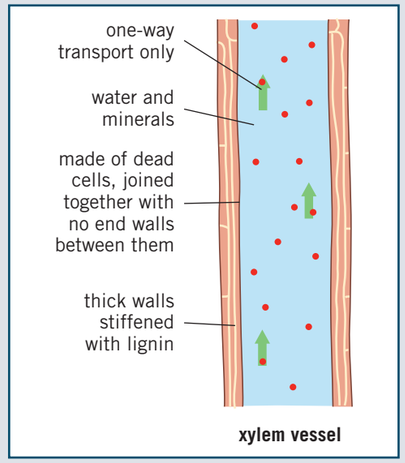
Description

Water is lost through the stomata by evaporation. This pulls water up from the roots through the **xylem** and is called transpiration. The constant movement of water up the plant is called the **transpiration stream**.

Importance

- provides water to cells to keep them **turgid**
- provides water to cells for photosynthesis
- transports mineral ions to leaves

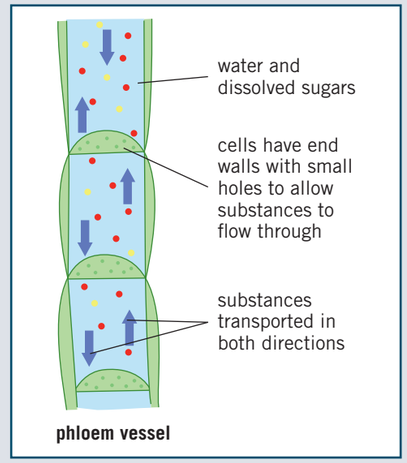
Specialised tissues



Translocation

The movement of dissolved sugars from the leaves to the rest of the plant through the **phloem**.

- moves dissolved sugars made in the leaves during photosynthesis to other parts of the plant
- this allows for respiration, growth, and glucose storage



Factors affecting the rate of transpiration

Factor	Effect on transpiration	Because...
temperature	higher temperatures *increase* the rate of transpiration	water evaporates faster in higher temperatures
humidity	lower humidity *increases* the rate of transpiration	the drier the air, the steeper the concentration gradient of water molecules between the air and leaf
wind speed	more wind *increases* the rate of transpiration	wind removes the water vapour quickly, maintaining a steeper concentration gradient
light intensity	higher light intensity *increases* the rate of transpiration	stomata open wider to let more carbon dioxide into the leaf for photosynthesis

Key terms

Make sure you can write a definition for these key terms.

photosynthesis stomata guard cells transpiration translocation
light intensity temperature humidity wind speed phloem xylem

Chapter 4: Organising animals and plants

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

B4 questions	Answers
1 Name the four main components of blood.	red blood cells, white blood cells, plasma, platelets
2 What is the function of platelets?	form blood clots – prevent the loss of blood and stop wounds becoming infected
3 Why is the human circulatory system a double circulatory system?	blood passes through the heart twice for every circuit around the body – deoxygenated blood is pumped from the right side of the heart to the lungs, and the oxygenated blood that returns is pumped from the left side of the heart to the body
4 How does the structure of an artery relate to its function?	carries blood away from the heart under high pressure – has a small lumen and thick, elasticated walls that can stretch
5 How does the structure of a vein relate to its function?	carries blood back to the heart at low pressure –doesn't need thick, elasticated walls, but has valves to prevent blood flowing the wrong way
6 How does the structure of a capillary relate to its function?	carries blood to cells and tissues – has a one-cell-thick wall to provide a short diffusion distance
7 List the structures air passes through when breathing in.	mouth/nose → trachea → bronchi → bronchioles → alveoli
8 What is the function of the red blood cells?	Bind to oxygen and transport it around the body
9 What is the function of the white blood cells?	Defend the body against pathogens
10 What is the function of the plasma?	Transports blood cells and substances around the body
11 Why is a leaf an organ?	there are many tissues inside the leaf that work together to perform photosynthesis
12 How is the upper epidermis adapted for its function?	• single layer of transparent cells allow light to pass through • cells secrete a waxy substance that makes leaves waterproof
13 How is the palisade mesophyll adapted for its function?	tightly packed cells with lots of chloroplasts to absorb as much light as possible for photosynthesis
14 How is the spongy mesophyll adapted for its function?	air spaces increase the surface area and allow gases to diffuse quickly
15 What is the function of the guard cells?	control the opening and closing of the stomata
16 What is the function of the xylem?	transport water and mineral ions from the roots to the rest of the plant
17 Give three adaptations of the xylem.	• made of dead cells • no end wall between cells • walls strengthened by a chemical called lignin to withstand the pressure of the water
18 What is the function of the phloem?	transport dissolved sugars from the leaves to the rest of the plant
19 What is the purpose of translocation?	transport dissolved sugars from the leaves to other parts of the plant for respiration, growth, and storage
20 Define the term transpiration.	movement of water from the roots to the leaves through the xylem
21 What is the purpose of transpiration?	• provide water to keep cells turgid • provide water to cells for photosynthesis • transport mineral ions to leaves
22 Name four factors that affect the rate of transpiration.	temperature, light intensity, humidity, and wind speed
23 What effect does temperature have on the rate of transpiration?	higher temperatures increase the rate of transpiration
24 What effect does humidity have on the rate of transpiration?	higher levels of humidity decrease the rate of transpiration
25 Why does increased light intensity increase the rate of transpiration?	stomata open wider to let more carbon dioxide into the leaf for photosynthesis
26 What is the function of the stomata?	allow diffusion of gases into and out of the plant
27 Where are most stomata found?	underside of leaves
28 What is the advantage to the plant of having a high number of stomata at this location?	reduces the amount of water loss through evaporation

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Chapter 5: Communicable diseases

Knowledge organiser

Communicable diseases

Communicable diseases can be spread from one organism to another.

Viruses live and reproduce rapidly inside an organism's cells. This can damage or destroy the cells.

Viruses

	Spread by	Symptoms
measles	inhalation of droplets produced by infected people when sneezing and coughing	• fever • red skin rash • complications can be fatal – young children are vaccinated to immunise them against measles
HIV (human immunodeficiency virus)	• sexual contact • exchange of body fluids (e.g., blood when drug users share needles)	• flu-like symptoms at first • virus attacks the body's immune cells, which can lead to AIDS – where the immune system is so damaged that it cannot fight off infections or cancers
TMV (tobacco mosaic virus – plants)	• direct contact of plants with infected plant material • animal and plant vectors • soil: the pathogen can remain in soil for decades	• mosaic pattern of discolouration on the leaves – where chlorophyll is destroyed • reduces plant's ability to photosynthesise, affecting growth

Bacteria reproduce rapidly inside organisms and may produce **toxins** that damage tissues and cause illness.

Bacteria

	Spread by	Symptoms	Prevention and treatment
Salmonella	bacteria in or on food that is being ingested	*Salmonella* bacteria and the toxins they produce cause • fever • abdominal cramps • vomiting • diarrhoea	poultry are vaccinated against *Salmonella* bacteria to control spread
gonorrhoea	direct sexual contact – gonorrhoea is a **sexually transmitted disease** (STD)	• thick yellow or green discharge from the vagina or penis • pain when urinating	• treatment with antibiotics (many antibiotic-resistant strains have appeared) • barrier methods of contraception, such as condoms

Fungi

	Spread by	Symptoms	Prevention and treatment
rose black spot	water and wind	• purple or black spots on leaves, which turn yellow and drop early • reduces plant's ability to photosynthesise, affecting growth	• **fungicides** • affected leaves removed and destroyed

Protists

	Spread by	Symptoms	Prevention and treatment
malaria	mosquitos feed on the blood of infected people and spread the protist pathogen when they feed on another person – organisms that spread disease by carrying pathogens between people are called **vectors**	• recurrent episodes of fever • can be fatal	• prevent mosquito vectors breeding • mosquito nets to prevent bites • anti-malarial medicine

Detection and identification of plant diseases

Signs that a plant is diseased

- stunted growth
- spots on leaves
- areas of rot or decay
- growths
- malformed stems or leaves
- discolouration
- pest infestation

Ways of identifying plant diseases

- gardening manuals and websites
- laboratory testing of infected plants
- testing kits containing monoclonal antibodies (Chapter 9 *Monoclonal antibodies*)

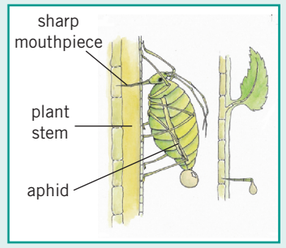
Plant diseases and insects

Plant diseases can also be directly caused by insects.

Aphids are insects that suck sap from the stems of plants. This results in

- reduced rate of growth
- wilting
- discolouration of leaves.

Ladybirds can be used to control aphid infestations as ladybird larvae eat aphids.



Plant defences

Physical barriers

- cellulose cell walls – provide a barrier to infection
- tough waxy cuticle on leaves
- bark on trees – a layer of dead cells that can fall off

Chemical barriers

- many plants produce antibacterial chemicals
- poison production stops animals eating plants

Mechanical adaptations

- thorns and hairs stop animals eating plants
- leaves that droop or curl when touched to scare herbivores or dislodge insects
- some plants **mimic** the appearance of unhealthy or poisonous plants to deter insects or herbivores

Controlling the spread of communicable disease

There are a number of ways to help prevent the spread of communicable diseases from one organism to another.

Hygiene

Hand washing, disinfecting surfaces and machinery, keeping raw meat separate, covering mouth when coughing/sneezing, etc.

Isolation

Isolation of infected individuals – people, animals, and plants can be isolated to stop the spread of disease.

Controlling vectors

If a vector spreads a disease destroying or controlling the population of the vector can limit the spread of disease.

Vaccination

Vaccination can protect large numbers of individuals against diseases.

Key terms

Make sure you can write a definition for these key terms.

aphid, bacterium, communicable disease, fungicide, fungus, isolation, mimic, pathogen, protist, sexually transmitted disease (STD), toxin, vaccination, vector, virus

Chapter 5: Communicable diseases

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B5 questions	Answers
1	What is a communicable disease?	a disease that can be transmitted from one organism to another
2	What is a pathogen?	a microorganism that causes disease
3	Name four types of pathogen.	bacteria, fungi, protists, viruses
4	How can pathogens spread?	air, water, direct contact
5	How do bacteria make you ill?	produce toxins that damage tissues
6	How do viruses make you ill?	reproduce rapidly inside cells, damaging or destroying them
7	Name three examples of viral diseases.	measles, HIV, tobacco mosaic virus
8	Name two examples of bacterial diseases.	*Salmonella*, gonorrhoea
9	Name four methods of controlling the spread of communicable disease.	good hygiene, isolating infected individuals, controlling vectors, vaccination
10	Describe an example of a protist disease.	malaria – caused by a protist pathogen that is spread from person to person by mosquito bites, and causes recurrent fevers
11	Describe an example of a fungal disease in plants.	rose black spot – spread by water and wind, and affects plant growth by reducing a plant's ability to photosynthesise
12	How can the cause of a plant disease be identified?	gardening manuals and websites, laboratory testing, monoclonal antibody kits
13	What are three mechanical defences that protect plants?	thorns and hairs, leaves that droop or curl, mimicry to trick animals
14	Give three physical defences of plants.	cellulose cell walls, tough waxy cuticles, bark on trees
15	How can aphids be controlled by gardeners?	introduce ladybirds to eat the aphids
16	How can plant diseases be detected?	areas of decay, discolouration, growths, malformed stems or leaves, presence of pests, spots on leaves, and stunted growth

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Chapter 6: Preventing and treating disease

Knowledge organiser

Non-specific defences

Non-specific defences of the human body against all pathogens include:

Skin

- physical barrier to infection
- produces antimicrobial secretions
- microorganisms that normally live on the skin prevent pathogens growing

Nose

Cilia and **mucus** trap particles in the air, preventing them from entering the lungs.

Trachea and bronchi produce mucus, which is moved away from the lungs to the back of the throat by cilia, where it is expelled.

Stomach

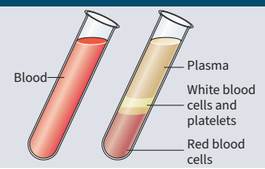
Produces strong acid (pH 2) that destroys pathogens in mucus, food, and drinks.

White blood cells

If a pathogen enters the body, the immune system tries to destroy the pathogen.

The function of **white blood cells** is to fight pathogens.

There are two main types of white blood cell – lymphocytes and phagocytes.



Lymphocytes

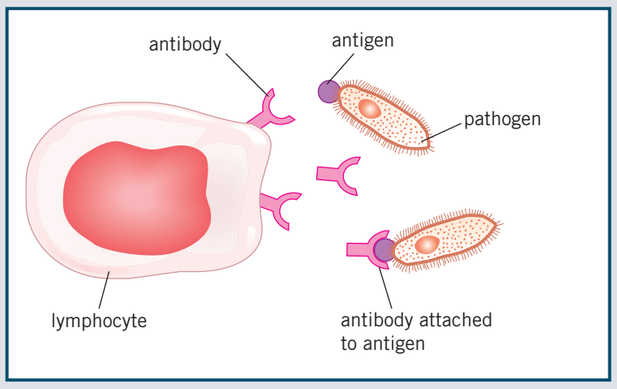
Lymphocytes fight pathogens in two ways:

Antitoxins

Lymphocytes produce **antitoxins** that bind to the toxins produced by some pathogens (usually bacteria). This *neutralises* the toxins.

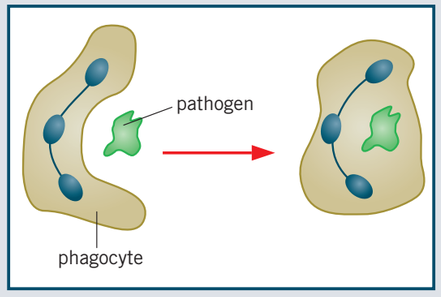
Antibodies

Lymphocytes produce **antibodies** that target and help to destroy specific pathogens by binding to **antigens** (proteins) on the pathogens' surfaces.



Phagocytes

1. Phagocytes are attracted to areas of infection.
2. The phagocyte surrounds the pathogen and engulfs it.
3. Enzymes that digest and destroy the pathogen are released.



Monoclonal antibodies (HT only)

Monoclonal antibodies are produced by mouse lymphocytes which are combined with a tumour cell to make a hybridoma cell. These can divide to make an antibody which can later be cloned and used to treat diseases such as cancer or used in pregnancy tests.

Key terms

Make sure you can write a definition for these key terms.

antibiotic *antibody* *antigen* *antitoxin* *dose* *double-blind trial* *efficacy* *Herd immunity* *monoclonal antibodies* *mucus* *peer review* *placebo* *toxicity* *vaccination* *white blood cell*

Treating diseases

Antibiotics

- **Antibiotics** are medicines that can kill *bacteria* in the body.
- Specific bacteria need to be treated by specific antibiotics.
- Antibiotics have greatly reduced deaths from infectious bacterial diseases, but antibiotic-resistant strains of bacteria are emerging.

Treating viral diseases

- Antibiotics *do not* affect viruses.
- Drugs that kill viruses often damage the body's tissues.
- Painkillers treat the symptoms of viral diseases but do not kill pathogens.

Discovering and developing new drugs

Drugs were traditionally extracted from plants and microorganisms, for example

- the heart drug digitalis comes from foxglove plants
- the painkiller aspirin originates from willow trees
- penicillin was discovered by Alexander Fleming from *Penicillium* mould.

Most modern drugs are now synthesised by chemists in laboratories.

New drugs are extensively tested and trialled for

- **toxicity** – is it harmful?
- **efficacy** – does it work?
- **dose** – what amount is safe and effective to give?

Stages of clinical trials

Pre-clinical trials

Drug is tested in cells, tissues, and live animals.

Clinical trials

1. Healthy volunteers receive very low doses to test whether the drug is safe and effective.
2. If safe, larger numbers of healthy volunteers and patients receive the drug to find the optimum dose.

Peer review

Before being published, the results of clinical trials will be tested and checked by independent researchers. This is called **peer review**.

Double-blind trials

Some clinical trials give some of their patients a **placebo** drug – one that is known to have no effect.

Double-blind trials are when neither the patients nor the doctors know who has been given the real drug and who has been given the placebo. This reduces biases in the trial.

Vaccinations

Vaccinations involve injecting small quantities of dead or inactive forms of a pathogen into the body. This stimulates lymphocytes to produce the correct antibodies for that pathogen. If the same pathogen re-enters the body, the correct antibodies can be produced quickly to prevent infection. If a large proportion of the population is vaccinated against a disease, it is less likely to spread. This is called **herd immunity**.

Chapter 6: Preventing and treating disease

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B6 questions	Answers
1	What non-specific systems does the body use to prevent pathogens getting into it?	• skin • cilia and mucus in the nose, trachea, and bronchi • stomach acid
2	What three functions do white blood cells have?	phagocytosis, producing antibodies, producing antitoxins
3	What happens during phagocytosis?	phagocyte is attracted to the area of infection, engulfs a pathogen, and releases enzymes to digest the pathogen
4	What are antigens?	proteins on the surface of a pathogen
5	Why are antibodies a specific defence?	antibodies have to be the right shape for a pathogen's unique antigens, so they target a specific pathogen
6	What is the function of an antitoxin?	neutralise toxins produced by pathogens by binding to them
7	What does a vaccine contain?	small quantities of a dead or inactive form of a pathogen
8	How does vaccination protect against a specific pathogen?	vaccination stimulates the body to produce antibodies against a specific pathogen – if the same pathogen reenters the body, white blood cells rapidly produce the correct antibodies
9	What is herd immunity?	when most of a population is vaccinated against a disease, meaning it is less likely to spread
10	What is an antibiotic?	a drug that kills bacteria but not viruses
11	What do painkillers do?	treat some symptoms of diseases and relieve pain
12	What properties of new drugs are clinical trials designed to test?	toxicity, efficacy, and optimum dose
13	What happens in the pre-clinical stage of a drug trial?	drug is tested on cells, tissues, and live animals
14	What is a placebo?	medicine with no effect that is given to patients instead of the real drug in a trial
15	What is a double-blind trial?	a trial where neither patients nor doctors know who receives the real drug and who receives the placebo
16	What is a monoclonal antibody?	A monoclonal antibody is an antibody produced by a single clone of cells.
17	Give two examples in which monoclonal antibodies can be used for.	Treating cancer, in pregnancy tests

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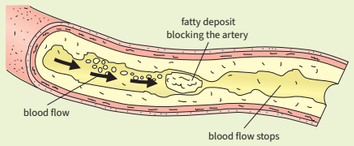
Chapter 7: Non-communicable diseases

Knowledge organiser

Coronary heart disease

Coronary heart disease (CHD) occurs when the coronary arteries become narrowed by the build-up of layers of fatty material within them.

This reduces the flow of blood, resulting in less oxygen for the heart muscle, which can lead to heart attacks.



Health issues

Health is the state of physical and mental well-being.

The following factors can affect health:

- communicable and non-communicable diseases
- diet
- stress
- exercise
- life situations.

Different types of disease may interact, for example:

- defects in the immune system make an individual more likely to suffer from infectious diseases
- viral infection can trigger cancers
- immune reactions initially caused by a pathogen can trigger allergies, for example skin rashes and asthma
- severe physical ill health can lead to depression and other mental illnesses.

Treating cardiovascular diseases

Treatment	Description	Advantages	Disadvantages
stent	inserted into blocked coronary arteries to keep them open	• widens the artery – allows more blood to flow, so more oxygen is supplied to the heart • less serious surgery	• can involve major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery
statins	drugs that reduce blood **cholesterol** levels, slowing down the deposit of fatty material in the arteries	• effective • no need for surgery • can prevent CHD from developing	• possible side effects such as muscle pain, headaches, and sickness • cannot cure CHD, so patient will have to take tablets for many years
replace faulty heart valves	heart valves that leak or do not open fully, preventing control of blood flow through the heart, can be replaced with biological or mechanical valves	• allows control of blood flow through the heart • long-term cure for faulty heart valves	• can involve major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery
transplants	if the heart fails a donor heart, or heart and lungs, can be transplanted **artificial hearts** can be used to keep patients alive whilst waiting for a heart transplant, or to allow the heart to rest during recovery	• long-term cure for the most serious heart conditions • treats problems that cannot be treated in other ways	• transplant may be rejected if there is not a match between donor and patient • lengthy process • major surgery – risk of infection, blood loss, blood clots, and damage to blood vessels • risks from anaesthetic used during surgery

Risk factors and non-communicable diseases

A **risk factor** is any aspect of your lifestyle or substance in your body that can increase the risk of a disease developing.

Some risk factors cause specific diseases. Other diseases are caused by factors interacting.

Risk factor	Disease	Effects of risk factor
diet (obesity) and amount of exercise	Type 2 diabetes	body does not respond properly to the production of insulin, so blood glucose levels cannot be controlled
	cardiovascular diseases	increased blood cholesterol can lead to CHD
alcohol	impaired liver function	long-term alcohol use causes liver cirrhosis (scarring), meaning the liver cannot remove toxins from the body or produce sufficient bile
	impaired brain function	damages the brain and can cause anxiety and depression
	affected development of unborn babies	alcohol can pass through the placenta, risking miscarriages, premature births, and birth defects
smoking	lung disease and cancers	cigarettes contain carcinogens, which can cause cancers
	affected development of unborn babies	chemicals can pass through the placenta, risking premature births and birth defects
carcinogens, such as ionising radiation, and genetic risk factors	cancers	for example, tar in cigarettes and ultraviolet rays from the Sun can cause cancers
		some genetic factors make an individual more likely to develop certain cancers

Cancer

Cancer is the result of changes in cells that lead to uncontrolled growth and division by mitosis.

Rapid division of abnormal cells can form a **tumour**.

Malignant tumours are cancerous tumours that invade neighbouring tissues and spread to other parts of the body in the blood, forming secondary tumours.

Benign tumours are non-cancerous tumours that do not spread in the body.

Treatment

Treatment of non-communicable diseases linked to lifestyle risk factors – such as poor diet, drinking alcohol, and smoking – can be very costly, both to individuals and to the Government.

A high incidence of these lifestyle risk factors can cause high rates of non-communicable diseases in a population.

Key terms

Make sure you can write a definition for these key terms.

artificial heart, benign, carcinogen, cholesterol, coronary heart disease, health, malignant, risk factor, statin, stent, transplant, tumour

Chapter 7: Non-communicable diseases

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B7 questions	Answers
1	What is coronary heart disease?	layers of fatty material that build up inside the coronary arteries, narrowing them – resulting in a lack of oxygen for the heart
2	What is a stent?	a device inserted into a blocked artery to keep it open, allowing more blood and oxygen to the heart
3	What are statins?	drugs that reduce blood cholesterol levels, slowing the rate of fatty material deposit
4	What is a faulty heart valve?	heart valve that doesn't open properly or leaks
5	How can a faulty heart valve be treated?	replace with a biological or mechanical valve
6	When do heart transplants take place?	in cases of heart failure
7	What are artificial hearts used for?	keep patients alive whilst waiting for a transplant, or allow the heart to rest for recovery
8	Define health.	state of physical and mental well-being
9	What factors can affect health?	disease, diet, stress, exercise, life situations
10	What is a risk factor?	aspect of lifestyle or substance in the body that can increase the risk of a disease developing
11	Give five risk factors.	poor diet, smoking, lack of exercise, alcohol, carcinogens
12	What is cancer?	a result of changes in cells that lead to uncontrolled growth and cell division by mitosis
13	What are malignant tumours?	cancerous tumours that can spread to neighbouring tissues and other parts of the body in the blood, forming secondary tumours
14	What are benign tumours?	non-cancerous tumours that do not spread in the body
15	What two types of risk factor affect the development of cancers?	lifestyle and genetic risk factors
16	What is a carcinogen?	a substance that can cause cancers to develop

Chapter 8: Photosynthesis

Knowledge organiser

Photosynthetic reaction

Photosynthesis is a chemical reaction in which energy is transferred from the environment as light from the Sun to the leaves of a plant. This is an **endothermic** reaction.

Chlorophyll, the green pigment in **chloroplasts** in the leaves, absorbs the light energy. Leaves are well-adapted to increase the rate of photosynthesis when needed.

L

carbon dioxide + water $\xrightarrow{\text{light}}$ **glucose** + oxygen

$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$

Rate of photosynthesis

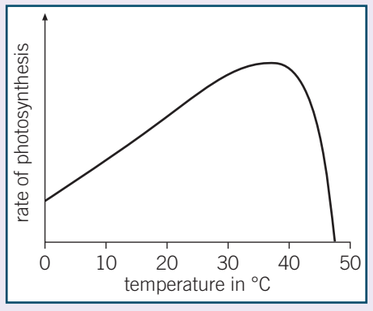
A **limiting factor** is anything that limits the rate of a reaction when it is in short supply.

The limiting factors for photosynthesis are

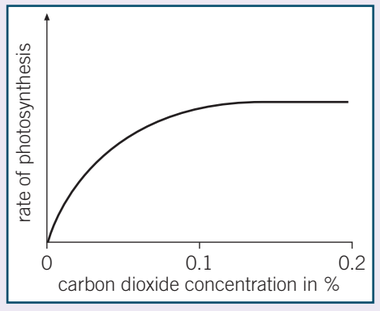
- temperature
- carbon dioxide concentration
- light intensity
- amount of chlorophyll.

Less chlorophyll in the leaves reduces the rate of photosynthesis. More chlorophyll may be produced by plants in well-lit areas to increase the photosynthesis rate.

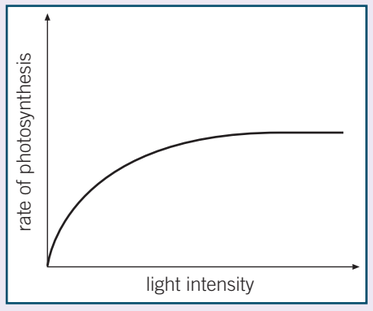
Limiting factors and photosynthesis rate (HT only)



- At low temperatures the rate of photosynthesis is low because the reactant molecules have less kinetic energy.
- Photosynthesis is an enzyme-controlled reaction, so at high temperatures the enzymes are denatured and the rate quickly decreases.



- Carbon dioxide is used up in photosynthesis, so increasing carbon dioxide concentration increases the rate of photosynthesis.
- At a certain point, another factor becomes limiting.
- Carbon dioxide is often the limiting factor for photosynthesis.

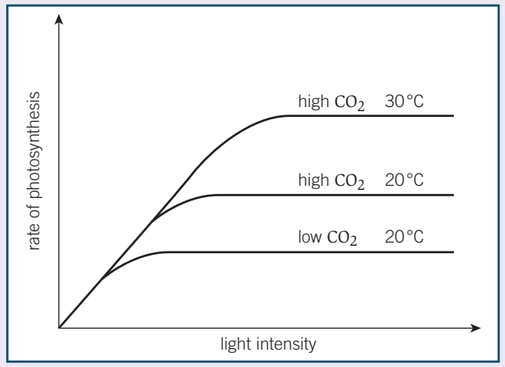


- Light energy is needed for photosynthesis, so increasing light intensity increases the rate of photosynthesis.
- At a certain point, another factor becomes limiting.
- Photosynthesis will stop if there is little or no light.

Interaction of limiting factors (HT only)

Limiting factors often interact, and any one may be limiting photosynthesis.

For example, on the graph the lowest curve has both carbon dioxide and temperature limiting photosynthesis. Temperature is limiting for the middle curve, and the highest curve shows photosynthesis rate increases when both temperature and carbon dioxide are increased until another factor becomes limiting.



Inverse square law (HT only)

As the distance of a light source from a plant increases, the light intensity decreases – this is called an inverse relationship. This relationship is not linear, as light intensity varies in inverse proportion to the square of the distance:

L

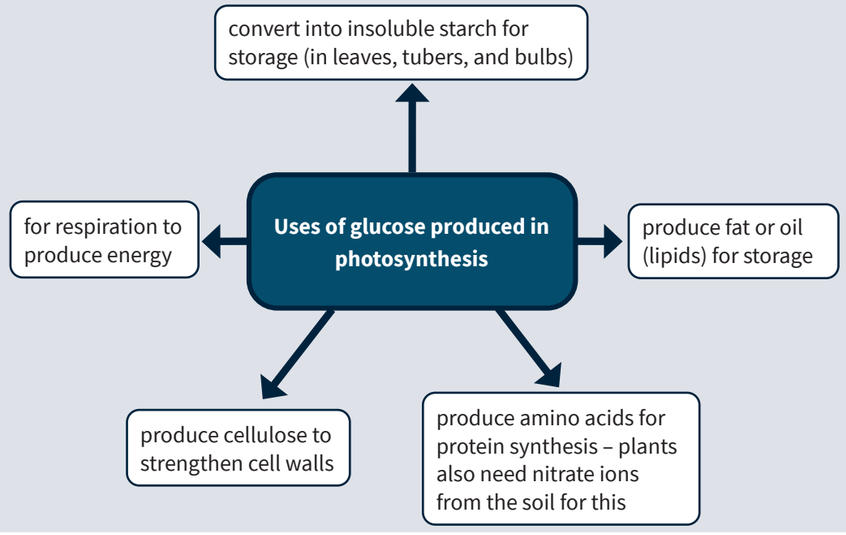
$$\text{light intensity} \propto \frac{1}{\text{distance}^2}$$

For example, if you double the distance between a light source and a plant, light intensity falls by three-quarters.

Greenhouse economics

Commercial greenhouses control limiting factors to get the highest possible rates of photosynthesis so they can grow plants as quickly as possible or produce the highest yields, whilst still making a profit.

Uses of glucose



Key terms

Make sure you can write a definition for these key terms.

carbon dioxide *chlorophyll* *chloroplast* *concentration* *endothermic* *glucose* *greenhouse gases* *light intensity* *inverse square law* *limiting factor* *photosynthesis* *protein synthesis*

Chapter 8: Photosynthesis

Retrieval questions

Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B8 questions	Answers
1	Where does photosynthesis occur?	chloroplasts in the leaves of a plant
2	What is the name of the green pigment in the leaves?	chlorophyll
3	What type of reaction is photosynthesis?	endothermic
4	What type of energy is used in photosynthesis?	light energy
5	Give the word equation for photosynthesis.	carbon dioxide + water → glucose + oxygen
6	Give the balanced symbol equation for photosynthesis.	$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
7	Define the term limiting factor.	anything that limits the rate of a reaction when it is in short supply
8	Give the limiting factors of photosynthesis.	• temperature • carbon dioxide concentration • light intensity • amount of chlorophyll
9	Describe how light intensity affects the rate of photosynthesis.	increasing light intensity increases the rate of photosynthesis until another factor becomes limiting
10	Describe how carbon dioxide concentration affects the rate of photosynthesis.	increasing carbon dioxide concentration increases the rate of photosynthesis until another factor becomes limiting
11	Describe how temperature affects the rate of photosynthesis.	increasing temperature increases the rate of photosynthesis as the reaction rate increases – at high temperatures enzymes are denatured so the rate of photosynthesis quickly decreases
12	Give the equation for the inverse square law for light intensity.	light intensity $\propto \frac{1}{\text{distance}^2}$
13	Why are limiting factors important in the economics of growing plants in greenhouses?	greenhouses need to produce the maximum rate of photosynthesis whilst making profit
14	How do plants use the glucose produced in photosynthesis?	• respiration • convert it into insoluble starch for storage • produce fat or oil for storage • produce cellulose to strengthen cell walls • produce amino acids for protein synthesis

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Chapter 9: Respiration

Knowledge organiser

Cellular respiration

Cellular **respiration** is an **exothermic** reaction that occurs continuously in the **mitochondria** of living cells to supply the cells with energy.

The energy released during respiration is needed for all living processes, including

- chemical reactions to build larger molecules, for example, making proteins from amino acids
- muscle contraction for movement
- keeping warm.

Respiration in cells can take place aerobically (using oxygen) or anaerobically (without oxygen).

Type of respiration	Oxygen required?	Relative amount of energy transferred
aerobic	✓	complete **oxidation** of glucose – large amount of energy is released
anaerobic	✗	incomplete oxidation of glucose – much less energy is released per glucose molecule than in aerobic respiration

Aerobic respiration

glucose + oxygen → carbon dioxide + water

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Anaerobic respiration in muscles

glucose → lactic acid

$C_6H_{12}O_6 \rightarrow 2C_3H_6O_3$

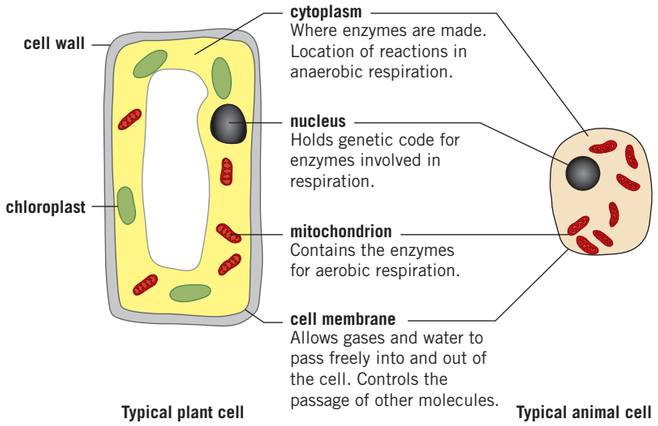
Fermentation

Anaerobic respiration in plant and yeast cells is represented by the equation

glucose → ethanol + carbon dioxide

Anaerobic respiration in yeast cells is called **fermentation**.

The products of fermentation are important in the manufacturing of bread and alcoholic drinks.



Key terms

Make sure you can write a definition for these key terms.

aerobic *amino acids* *anaerobic* *carbohydrates* *cellulose* *exothermic* *fermentation* *fatty acid* *glycerol* *glycogen* *lactic acid* *lipids* *metabolism* *mitochondria* *oxidation* *oxygen debt* *proteins* *respiration* *starch*

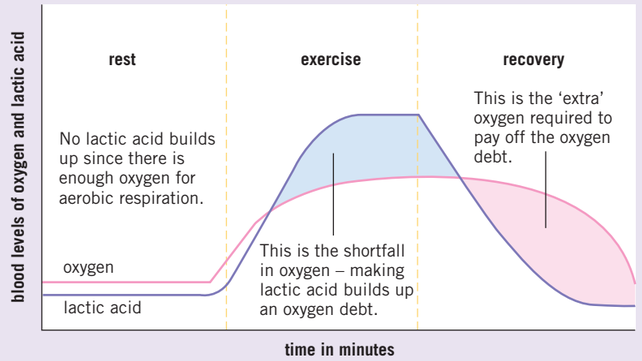
Response to exercise

During exercise the human body reacts to the increased demand for energy.

To supply the muscles with more oxygenated blood, heart rate, breathing rate, and breath volume all increase.

If insufficient oxygen is supplied, anaerobic respiration takes place instead, leading to the build-up of **lactic acid**.

During long periods of vigorous exercise, muscles become fatigued and stop contracting efficiently.



Oxygen debt (HT only)

After exercise, the lactic acid accumulated during anaerobic respiration needs to be removed. **Oxygen debt** is the amount of oxygen needed to react with the lactic acid to remove it from cells.

Removal of lactic acid

lactic acid in the muscles

↓

transported to the liver in the blood

↓

lactic acid is converted back to glucose

Metabolism

Metabolism is the sum of all the reactions in a cell or the body.

The energy released by respiration in cells is used for the continual enzyme-controlled processes of metabolism that produce new molecules.

Metabolic processes include the synthesis and breakdown of:

Carbohydrates

- synthesis of larger carbohydrates from sugars (starch, glycogen, and cellulose)
- breakdown of glucose in respiration to release energy

Lipids

- synthesis of lipids from one molecule of glycerol and three molecules of fatty acid

Proteins

- synthesis of amino acids from glucose and nitrate ions
- amino acids used to form proteins
- excess proteins broken down to form urea for excretion

Chapter 9: Respiration

Retrieval questions

Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

B9 questions	Answers
1 Define the term cellular respiration.	an exothermic reaction that occurs continuously in the mitochondria of living cells to release energy from glucose
2 What do organisms need energy for?	• chemical reactions to build larger molecules • muscle contraction for movement • keeping warm
3 What is the difference between aerobic and anaerobic respiration?	aerobic respiration uses oxygen, anaerobic respiration does not
4 Write the word equation for aerobic respiration.	glucose + oxygen → carbon dioxide + water
5 Write the word equation for anaerobic respiration in muscles.	glucose → lactic acid
6 Write the balanced symbol equation for aerobic respiration.	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
7 Why does aerobic respiration release more energy per glucose molecule than anaerobic respiration?	oxidation of glucose is complete in aerobic respiration and incomplete in anaerobic respiration
8 What is anaerobic respiration in yeast cells called?	fermentation
9 Write the word equation for anaerobic respiration in plant and yeast cells.	glucose → ethanol + carbon dioxide
10 How does the body supply the muscles with more oxygenated blood during exercise?	heart rate, breathing rate, and breath volume increase
11 What substance builds up in the muscles during anaerobic respiration?	lactic acid
12 What happens to muscles during long periods of activity?	muscles become fatigued and stop contracting efficiently
13 What is oxygen debt?	amount of oxygen the body needs after exercise to react with the accumulated lactic acid and remove it from cells
14 How is lactic acid removed from the body?	lactic acid in muscles → blood transports to the liver → lactic acid converted back to glucose
15 What is metabolism?	sum of all the reactions in a cell or the body

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Chapter 10: The human nervous system

Knowledge organiser

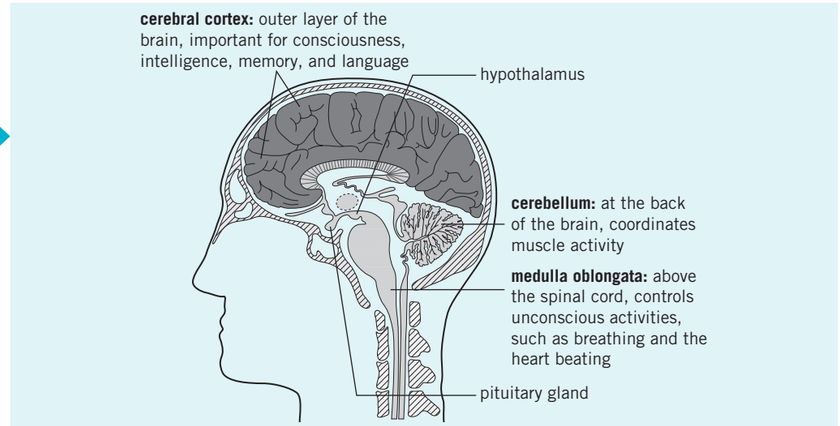
Nervous system responses

Stimulus	Receptor	Coordinator	Effector	Response
a change in the environment (**stimulus**) is detected by **receptors**	information from receptors passes along cells (**neurones**) to the CNS as electrical impulses	the CNS coordinates the body's response to the stimulus	effectors bring about a response, such as glands secreting hormones or muscles contracting	the body responds to the stimulus

The brain

The brain controls complex behaviour.

It is made of billions of interconnected neurones, with different regions that carry out different functions.



Accommodation

Accommodation is the process of changing the shape of the lens to focus on near or distant objects.

To focus on a *near* object

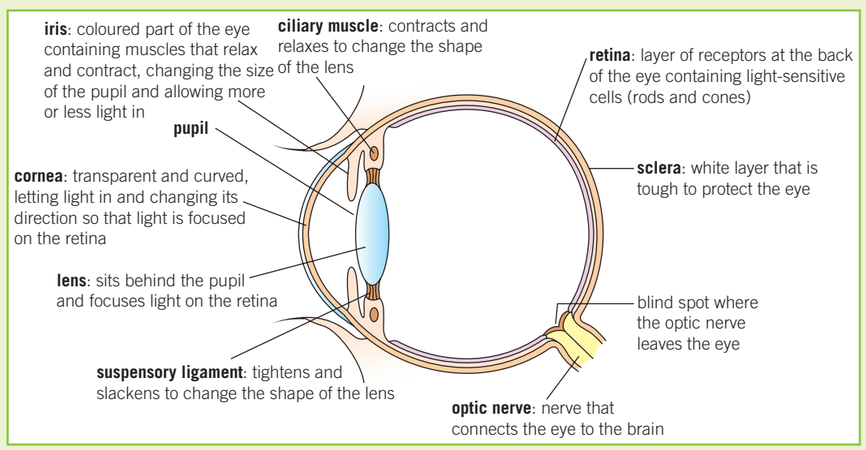
- ciliary muscles *contract*
- suspensory ligaments are slack
- so lens is thicker and more curved, and refracts light rays more strongly.

To focus on a *distant* object

- ciliary muscles relax
- suspensory ligaments are pulled tight
- so lens is thinner and flatter, and only refracts light rays slightly.

Structure of the eye

The eye is a **sense organ** containing **receptors** sensitive to light intensity and colour.

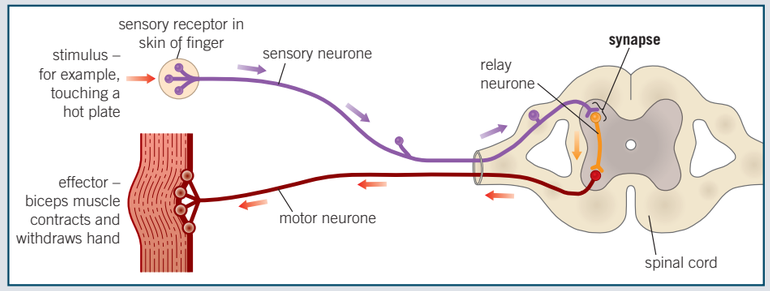


Reflex arcs

The nervous system is made up of the **central nervous system** (CNS) and a network of nerves. The CNS comprises the brain and spinal cord.

Reflex actions of the nervous system are automatic and rapid – they do not involve the conscious part of the brain.

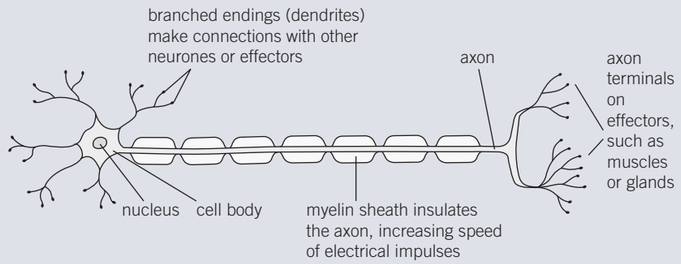
Reflex actions are important for survival because they help prevent damage to the body.



Reflex arc structures

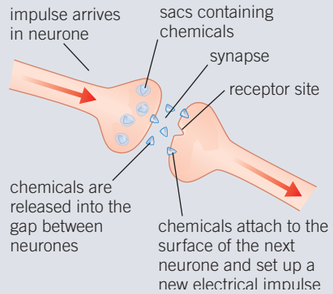
Neurones

Neurones carry electrical impulses around the body – relay neurones connect sensory neurones to motor neurones



Synapses

Synapses are gaps between neurones, which allow electrical impulses in the nervous system to cross between neurones



Research on the brain (HT only)

Neuroscientists have mapped the regions of the brain to particular functions by studying patients with brain damage, using MRI scanning techniques, and electrically stimulating parts of the brain.

The brain is very complex and delicate, making investigating and treating brain disorders difficult.

Brain damage and diseases can involve many different neurones, chemicals, and areas of the brain. Treatment is difficult because

- it is not fully understood what each area of the brain does
- drugs do not always reach the brain through its membranes
- surgery can easily cause unintended damage.

Common defects of the eyes

Myopia

Short-sightedness, when distant objects look blurred because rays of light focus in front of the retina.

This is corrected using **concave** spectacle lenses.

Hyperopia

Long-sightedness, when near objects look blurred because rays of light focus behind the retina.

This is corrected using **convex** spectacle lenses.

Treatment of eye defects

- spectacle lenses to refract light rays to focus on the retina
- hard and soft contact lenses – like traditional glasses, but on the surface of the eye
- laser eye surgery – to change the shape of the cornea
- replacement lenses – adding another lens inside the eye to correct defects permanently.

Key terms

Make sure you can write a definition for these key terms.

brain, central nervous system, concave, convex, effectors, hyperopia, involuntary, myopia, neurones, receptors, reflex action, spinal cord, stimulus, synapse

Chapter 10: The human nervous system

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

B10 questions	Answers
1 What is the function of the nervous system?	it enables organisms to react to their surroundings and coordinates behaviour
2 What are the two parts of the central nervous system?	brain and spinal cord
3 Why are reflex actions described as rapid and automatic?	they do not involve the conscious part of the brain
4 Why are reflex actions important?	for survival and to prevent damage to the body
5 Give the pathway of a nervous response.	stimulus → receptor → coordinator → effector → response
6 Give the function of the cerebral cortex.	outer layer of the brain playing an important role in consciousness
7 Give the function of the medulla oblongata.	part of the brain above the spinal cord that controls breathing and heart rate
8 Give the function of the cerebellum.	part at the back of the brain involved in coordinating muscle activity
9 Why is it difficult to treat brain disorders?	brain is very complex and delicate
10 What is a synapse?	gap between two neurones, allowing impulses to cross
11 What is the function of neurones?	carry electrical impulses around the body
12 What is accommodation?	process of changing the shape of the lens to focus on near/distant objects
13 Give two common defects of the eyes.	myopia (short-sightedness) and hyperopia (long-sightedness)
14 How can eye defects be treated?	spectacle lenses, contact lenses, laser surgery, and replacement lenses in the eye

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Chapter 11: Hormonal coordination 1

Knowledge organiser

Human endocrine system

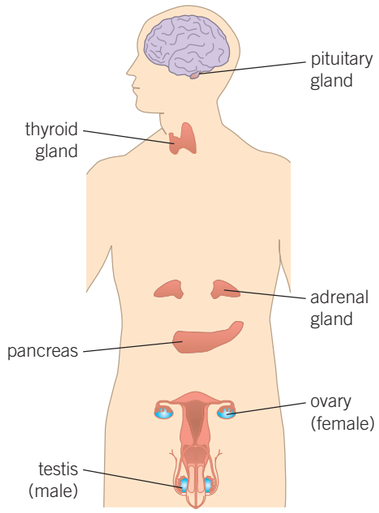
The **endocrine system** is composed of glands that secrete chemicals called **hormones** into the bloodstream.

The blood carries hormones to a target organ, where an effect is produced.

Compared to the nervous system, the effects caused by the endocrine system are slower but act for longer.

The **pituitary gland**, located in the brain, is known as a 'master gland', because it secretes several hormones into the blood.

These hormones then act on other glands to stimulate the release of other hormones, and bring about effects.



Endocrine gland	Role of the hormones
Pituitary	• controls growth in children • stimulates the thyroid gland to make thyroxine to control the rate of metabolism • in females – stimulates the ovaries to produce and release eggs, and make oestrogen • in males – stimulates the testes to make sperm and testosterone
Thyroid	• controls the rate of metabolism in the body
Pancreas	• controls blood glucose levels
Adrenal	• prepares the body for stress • involved in the 'fight or flight' response
Ovaries	• controls the development of female secondary sexual characteristics • controls the menstrual cycle
Testes	• controls the development of male secondary sexual characteristics • involved in the production of sperm

Negative feedback (HT only)

Negative feedback systems work to maintain a steady state. For example, blood glucose, water, and **thyroxine** levels are all controlled in the body by negative feedback.

Adrenaline

- produced by **adrenal glands** in times of fear or stress
- increases heart rate
- boosts delivery of oxygen and glucose to brain and muscles
- prepares the body for 'fight or flight' response
- does not involve negative feedback, as adrenal glands stop producing **adrenaline**

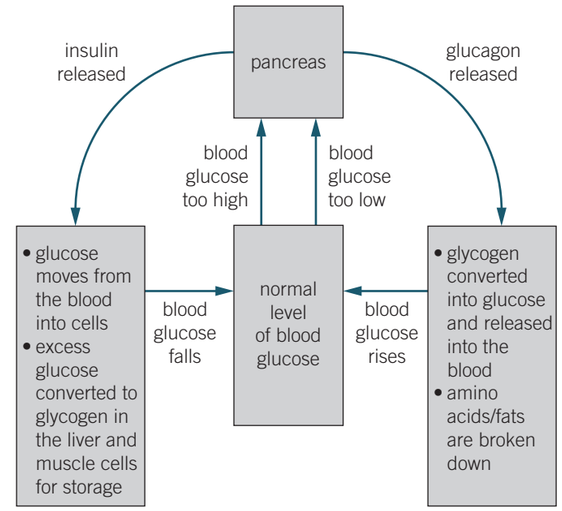
Thyroxine

- produced by the **thyroid gland**
- regulates how quickly your body uses energy and makes proteins (**metabolic rate**)
- important for growth and development
- levels controlled by negative feedback

Control of blood glucose levels

Blood glucose (sugar) concentration is monitored and controlled by the **pancreas**.

This is an example of negative feedback control, as the pancreas switches production between the hormones **insulin** and **glucagon** to control blood glucose levels.



Diabetes

Diabetes is a non-communicable disease where the body either cannot produce or cannot respond to insulin, leading to uncontrolled blood glucose concentrations.

Type 1 diabetes	Type 2 diabetes
early onset	usually later onset, obesity is a risk factor
pancreas stops producing sufficient insulin	body doesn't respond to the insulin produced
commonly treated through insulin injections, also diet control and exercise	commonly treated through a carbohydrate-controlled diet and exercise

Key terms

Make sure you can write a definition for these key terms.

adrenal gland | adrenaline | diabetes | endocrine system | glucagon | hormone | insulin | metabolic rate | negative feedback | pancreas | pituitary gland | thyroid gland | thyroxine

Chapter 11: Hormonal coordination 2

Knowledge organiser

Hormones in human reproduction

During puberty, reproductive hormones cause the secondary sex characteristics to develop:

Oestrogen

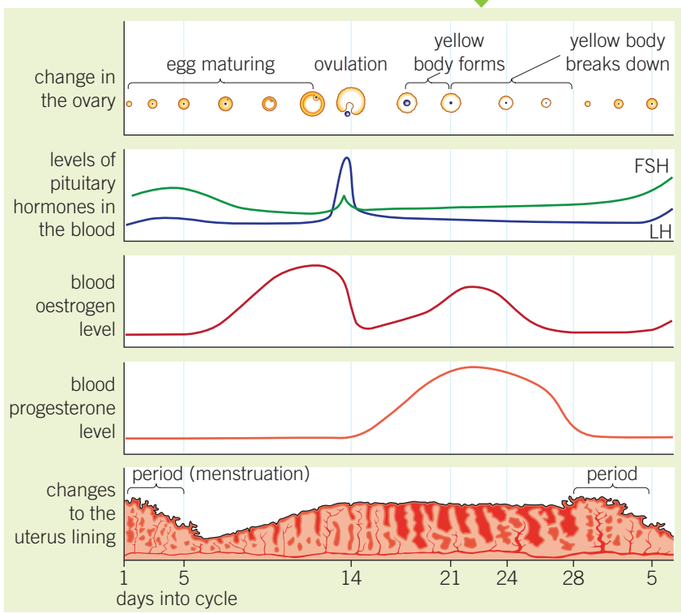
- main female reproductive hormone
- produced in the **ovary**
- at puberty, eggs begin to mature and one is released every ~28 days

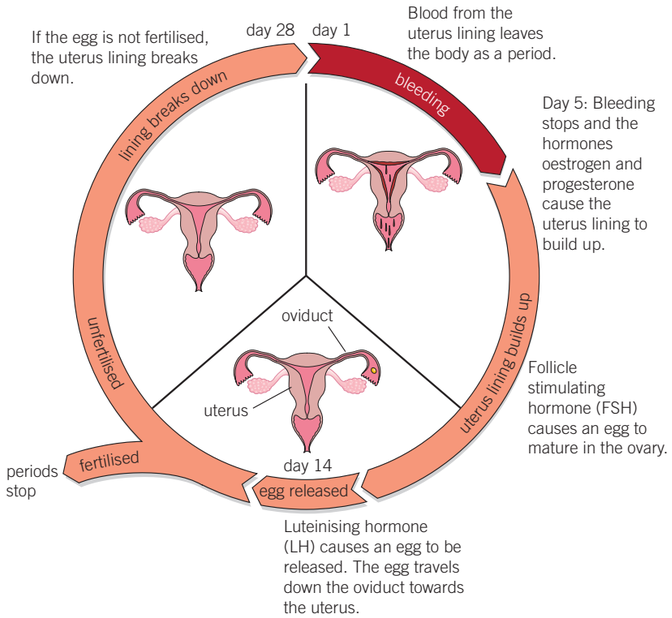
Testosterone

- main male reproductive hormone
- produced by the **testes**
- stimulates sperm production

The menstrual cycle

Hormone	Released by	Function
follicle stimulating hormone (FSH)	pituitary gland	• causes eggs to mature in the ovaries • stimulates ovaries to produce oestrogen
luteinising hormone (LH)	pituitary gland	• stimulates the release of mature eggs from the ovaries (**ovulation**)
oestrogen	ovaries	• causes lining of uterus wall to thicken • inhibits release of FSH • stimulates release of LH
progesterone	ovaries	• maintains thick uterus lining • inhibits release of FSH and LH





Treating infertility with hormones (HT only)

Hormones are used in modern reproductive technologies to treat **infertility**.

FSH and LH can be given as a drug to treat infertility, or **in vitro fertilisation** (IVF) treatment may be used.

IVF treatment

1. mother given FSH and LH to stimulate the maturation of several eggs
2. eggs collected from the mother and fertilised by sperm from the father in a laboratory
3. fertilised eggs develop into embryos
4. one or two embryos are inserted into the mother's **uterus** (womb) when the embryos are still tiny balls of cells

Fertility treatment has some disadvantages:

- it is emotionally and physically stressful
- it has a low success rate
- it can lead to multiple births, which are a risk to both the babies and the mother.

Contraception

Fertility can be controlled by a variety of hormonal and non-hormonal methods of **contraception**.

Hormonal contraception

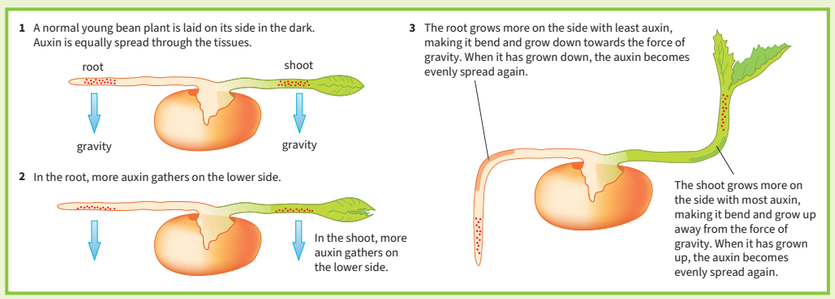
- oral contraceptives – contain hormones to inhibit FSH production so no eggs mature
- injection, implant, skin patch, or intrauterine devices (IUD) – slowly release progesterone to inhibit maturation and release of eggs; can last months or years

Non-hormonal contraception

- barrier methods, for example, condoms and diaphragms – prevent sperm reaching the egg
- copper IUD – prevents the implantation of an embryo
- surgical methods of male and female sterilisation
- spermicidal agents – kill or disable sperm
- abstaining from intercourse when an egg may be in the oviduct

Plant hormones

A plant's response can be known as **phototropism**, when the shoots bend towards light, and **gravitropism** when the root moves towards gravity. The responses are controlled by the hormone **auxin**. In phototropism, auxin moves from the side of the shoot with light to the unlit side, meaning the cells on that side will grow more. In gravitropism, high levels of auxin means that the growth of root cells in inhibited. (HT only) **Gibberellins** are also plant hormones which begin the process of seed germination by breaking down the food stores in the seeds and stimulate the growth of stems. Ethene is another hormone which controls cell division.



Key terms

Make sure you can write a definition for these key terms.

auxin · contraception · follicle stimulating hormone · gravitropism · infertility · in vitro fertilisation · oestrogen · ovary · luteinising hormone · menstrual cycle · ovulation · phototropism · progesterone · testes · uterus

Chapter 11: Hormonal coordination

Retrieval questions

Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B11 questions	Answers
1	What is the endocrine system?	system of glands that secrete hormones into the bloodstream
2	How do the effects of the endocrine system compare to those of the nervous system?	endocrine system effects are slower but act for longer
3	Where is the pituitary gland located?	brain
4	Which organ monitors and controls blood glucose concentration?	pancreas
5	Which hormones interact to regulate blood glucose levels?	insulin and glucagon
6	What is the cause of Type 1 diabetes?	pancreas produces insufficient insulin
7	What is the cause of Type 2 diabetes?	body cells no longer respond to insulin
8	What is the function of FSH?	causes eggs to mature in the ovaries, and stimulates ovaries to produce oestrogen
9	What is the function of LH?	stimulates the release of an egg
10	What is the function of oestrogen?	causes lining of uterus wall to thicken
11	What are the methods of hormonal contraception?	oral contraceptives, injection, implant, skin patch, IUD
12	What are the methods of non-hormonal contraception?	barrier methods, copper IUD, spermicidal agents, sterilisation, abstinence
13	State the disadvantages of IVF treatment.	• emotionally and physically stressful • low success rate • can lead to risky multiple births
14	What is the function of adrenaline in the body?	increases heart rate and boosts delivery of oxygen and glucose to brain and muscles to prepare the body for 'fight or flight'
15	What is the function of thyroxine in the body?	stimulates basal metabolic rate, so is important for growth and development
16	Name one hormone controlled by negative feedback.	thyroxine
17	Which endocrine glands control secondary sexual characteristics?	ovaries in females, testes in males

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Chapter 12: Homeostasis in action

Knowledge organiser

Homeostasis

Homeostasis is the regulation of internal conditions (of a cell or whole organism) in response to internal and external changes, to constantly maintain optimum conditions for functioning.

This maintains optimum conditions for all cell functions and enzyme action.

In the human body, this includes control of

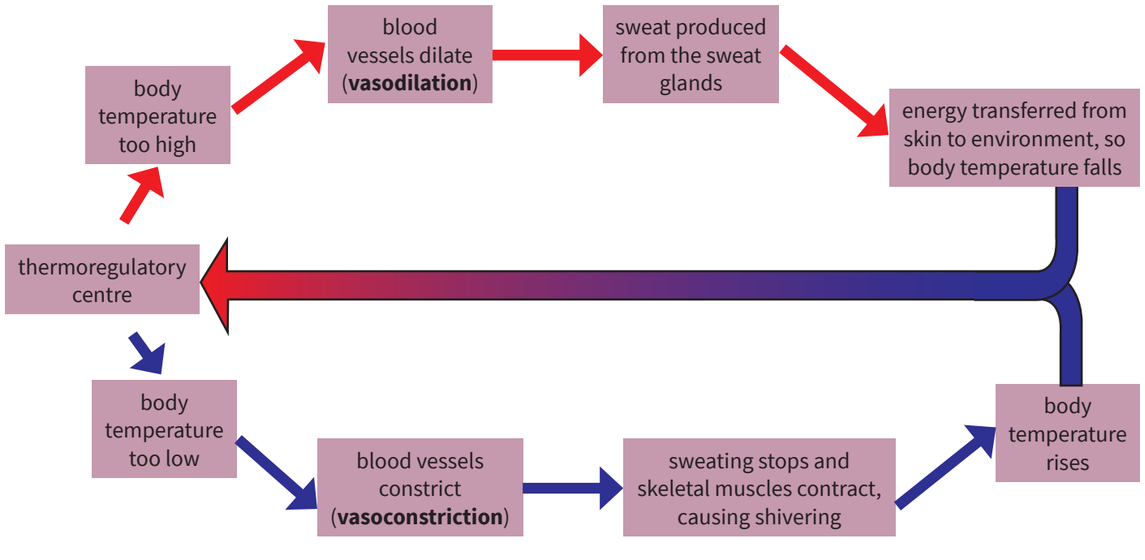
- blood glucose concentration
- body temperature
- water levels.

The automatic control systems of homeostasis may involve nervous responses or chemical responses.

All control systems involve

- receptor cells, which detect **stimuli** (changes in the environment)
- **coordination centres** (such as the brain, spinal cord, and pancreas), which receive and process information from receptors
- **effectors** (muscles or glands), which produce responses to restore optimum conditions.

Control of body temperature



Body temperature is monitored and controlled by the **thermoregulatory centre** in the brain. The centre contains receptors sensitive to the blood temperature.

The skin also contains temperature receptors and sends nervous impulses to the thermoregulatory centre.

Maintaining water and nitrogen balance

Water leaves the body through the lungs during exhalation, and water, ions, and **urea** are lost from the skin in sweat. The body has no control over these losses.

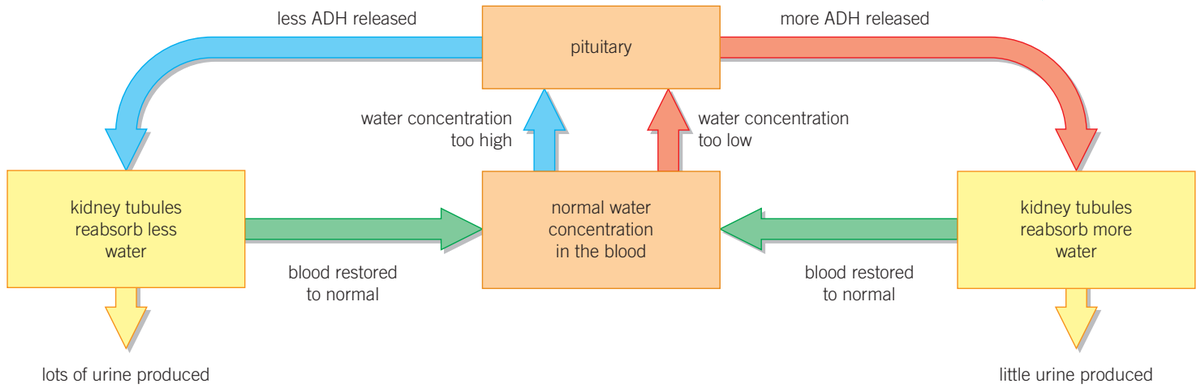
Excess water, ions, and urea are removed by the kidneys in **urine**.

Levels of water in the body must be balanced because cells do not function efficiently if they lose or gain too much water.

The kidneys produce urine by filtration of the blood and selective reabsorption of useful substances such as water, glucose, and some ions.

The water level in the blood is controlled through this process by the hormone **ADH**, which affects the amount of water absorbed by the **kidney tubules**.

This is a **negative feedback cycle**.



People who suffer from kidney failure may be treated by organ transplants or kidney **dialysis**.

Process of kidney dialysis

- blood temporarily removed from patient's body
- filtered through a dialysis machine
- patient's blood passes over dialysis fluid
- dialysis fluid has no urea
- urea and waste products diffuse from high concentration in patient's blood to low concentration in dialysis fluid
- patient's blood then returned to their body

Waste products

The digestion of proteins from food results in excess amino acids, which need to be excreted safely.

These amino acids are deaminated in the liver to form ammonia.

Ammonia is toxic, so it is immediately converted to urea for safe excretion.

Key terms

Make sure you can write a definition for these key terms.

ADH | adrenal gland | adrenaline | coordination centres | dialysis | effectors | endocrine system | homeostasis | hormone | kidney tubule | metabolic rate | negative feedback | stimuli | thermoregulatory centre | urea | urine | vasoconstriction | vasodilation

Chapter 12: Homeostasis in action

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B12 questions	Answers
1	What is homeostasis?	maintenance of a constant internal environment
2	Give three internal conditions controlled in homeostasis.	body temperature, blood glucose concentration, and water levels
3	Give three things all control systems include.	receptors, coordination centres, and effectors
4	Where is body temperature monitored and controlled?	thermoregulatory centre in the brain
5	What happens if body temperature is too high?	blood vessels dilate (vasodilation) and sweat is produced
6	What happens if body temperature is too low?	blood vessels constrict (vasoconstriction), sweating stops, and shivering takes place
7	What is the function of the kidneys?	filter and reabsorb useful substances from the blood, and produce urine to excrete excess water, ions, and urea
8	How are excess amino acids excreted from the body?	deaminated to form ammonia in the liver, ammonia is converted to urea and excreted
9	Which hormone controls the water level in the body?	ADH
10	How is kidney failure treated?	organ transplant or kidney dialysis
11	In kidney dialysis, what fluid is temporarily removed from the patients body?	Blood
12	In kidney dialysis, name one substance that diffuses from the patients blood into the dialysis fluid.	Urea or waste products
13	Define diffusion.	The movement of particles from an area of higher concentration to an area of lower concentration.
14	What are proteins broken down into?	Amino acids
15	Amino acids are de-aminated to form ammonia in what organ of the body?	The liver
16	Why does ammonia need to be excreted safely?	Ammonia is toxic
17	State two things controlled by negative feedback in the body.	Blood glucose, water, thyroxine
18	Where is the hormone adrenaline produced?	Adrenal glands
19	What is the function of adrenaline?	Prepares the body for fight or flight, increases heart rate
20	Where is the hormone thyroxine produced?	Thyroid gland
21	What is the function of thyroxine?	Regulates how quickly the body produces energy, makes proteins

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Chapter 13: Reproduction

Knowledge organiser

Types of reproduction

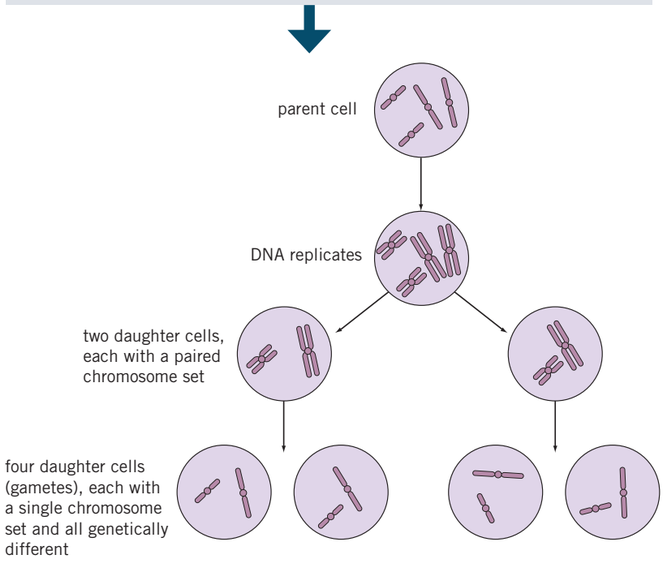
Sexual reproduction	Asexual reproduction
two parents	one parent
cell division through **meiosis**	cell division through **mitosis**
joining (fusion) of male and female sex cells (**gametes**) – sperm and egg in animals, pollen and ovule in plants	no fusion of gametes
produces non-identical offspring that are genetically different to parents	produces offspring that are genetically identical to parent (**clones**)
results in wide variation within offspring and species	no mixing of genetic information

Meiosis

Meiosis is a type of cell division that makes gametes in the reproductive organs.

Meiosis halves the number of chromosomes in gametes, and **fertilisation** (joining of two gametes) restores the full number of chromosomes.

The fertilised cell divides by mitosis, producing more cells. As the embryo develops, the cells differentiate.



DNA and the genome

Genetic material in the nucleus of a cell is composed of **DNA**.

DNA is made up of two strands forming a **double helix**.

DNA is contained in structures called **chromosomes**.

A **gene** is a small section of DNA on a chromosome that codes for a specific sequence of amino acids, to produce a specific protein.

The **genome** of an organism is the entire genetic material of that organism.

The whole human genome has been studied, and this has allowed scientists to

- search for genes linked to different diseases
- understand and treat inherited disorders
- trace human migration patterns from the past.

Inherited disorders

Some disorders are due to the inheritance of certain alleles:

- Polydactyly (extra fingers or toes) is caused by a **dominant** allele.
- Cystic fibrosis (a disorder of cell membranes) is caused by a **recessive** allele.

Embryo screening and gene therapy may alleviate suffering from these disorders, but there are ethical issues surrounding their use.

Genetic inheritance

gamete	specialised sex cell formed by meiosis
chromosome	long molecule made from DNA found in the nucleus of cells
gene	sequence of DNA that codes for a protein – some characteristics are controlled by a single gene (e.g., fur colour in mice and red-green colour-blindness in humans), but most are controlled by multiple genes interacting
allele	different forms of the same gene
dominant	allele that only needs one copy present to be expressed (it is always expressed)
recessive	allele that needs two copies present to be expressed
homozygous	when an individual carries two copies of the same allele for a trait
heterozygous	when an individual carries two different alleles for a trait
genotype	combination of alleles an individual has
phenotype	physical expression of the genotype – the characteristic shown

Genetic crosses

A **genetic cross** is when you consider the offspring that might result from two known parents. **Punnett squares** can be used to predict the outcome of a genetic cross, for both the genotypes the offspring might have and their phenotypes.

For example, the cross bb (brown fur) × BB (black fur) in mice:

		mother	
		B	**B**
father	**b**	Bb	Bb
	b	Bb	Bb

offspring genotype: 100 % Bb

offspring phenotype: all black fur (B is dominant)

Sex determination

Normal human body cells contain 23 pairs of chromosomes – one of these pairs determines the sex of the offspring.

In human females the sex chromosomes are the same (XX, homozygous), and in males they are different (XY, heterozygous).

A Punnett square can be used to determine the probability of offspring being male or female. The probability is always 50 % in humans as there are two XX outcomes and two XY outcomes.

		mother	
		X	**X**
father	**X**	XX	XX
	Y	XY	XY

Key terms

Make sure you can write a definition for these key terms.

allele *chromosome* *clone* *DNA* *dominant* *double helix* *fertilisation* *gamete* *gene* *genetic cross* *genome* *genotype* *heterozygous* *homozygous* *meiosis* *mitosis* *phenotype* *Punnett square* *recessive*

Chapter 13: Reproduction

Retrieval questions

Learn the answers to the questions below, then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B13 questions	Answers
1	What is sexual reproduction?	joining (fusion) of male and female gametes
2	What type of cell division is involved in sexual reproduction?	meiosis
3	What type of cell division is involved in asexual reproduction?	mitosis
4	What is meiosis?	cell division that produces four daughter cells (gametes), each with a single set of chromosomes
5	What are the male and female sex chromosomes in humans?	• XX – female • XY – male
6	What are the male and female gametes in flowering plants?	• pollen – male gamete • ovule – female gamete
7	What is the genetic material in cells called?	DNA
8	What is the structure of DNA?	two complementary strands forming a double helix
9	What is a gene?	small section of DNA that codes for a particular amino acid sequence, to make a specific protein
10	What are alleles?	different forms of the same gene
11	What is a recessive allele?	allele that needs to be present twice to be expressed
12	What is a dominant allele?	allele that is always expressed, even if only one copy is present
13	What is a genome?	the entire genetic material of an organism
14	Define the term homozygous.	two of the same alleles present in an organism
15	Define the term heterozygous.	two different alleles present in an organism
16	What type of allele causes polydactyly?	dominant allele
17	What type of allele causes cystic fibrosis?	recessive allele
18	How many chromosomes do normal human body cells have?	23 pairs (46)
19	Why is studying the human genome important?	• search for genes linked to certain diseases • understanding and treatment of inherited disorders • tracing past human migration

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Chapter 14: Variation and evolution

Knowledge organiser

Variation in populations

Differences in the characteristics of individuals in a population are called **variation**.

Variation may be due to differences in

- the genes they have inherited, for example, eye colour.
- the environment in which they have developed, for example, language.
- a combination of genes and the environment.

Mutation

There is usually a lot of genetic variation within a population of a species – this variation arises from **mutations**.

A mutation is a change in a DNA sequence:

- mutations occur continuously
- very rarely a mutation will lead to a new phenotype, but some may change an existing phenotype and most have no effect
- if a new phenotype is suited to an environmental change, it can lead to a relatively rapid change in the species.

Selective breeding

Selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics.

Process of selective breeding:

1. choose parents with the desired characteristic from a mixed population
2. breed them together
3. choose offspring with the desired characteristic and breed them
4. continue over many generations until all offspring show the desired characteristic

The characteristic targeted in selective breeding can be chosen for usefulness or appearance, for example:

- disease resistance in food crops
- animals that produce more meat or milk
- domestic dogs with a gentle nature
- larger or unusual flowers.

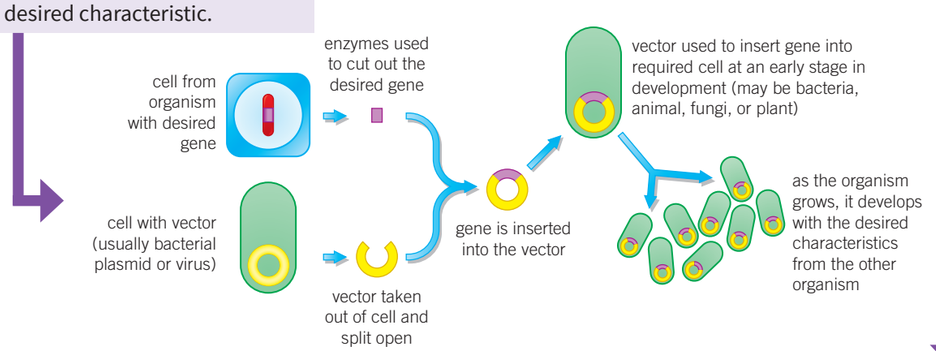
Disadvantages of selective breeding:

- can lead to **inbreeding**, where some breeds are particularly prone to inherited defects or diseases
- reduces variation, meaning all of a species could be susceptible to certain diseases

Genetic engineering (HT only)

Genetic engineering is a process that involves changing the genome of an organism by introducing a gene from another organism, to produce a desired characteristic.

- Bacterial cells have been genetically engineered to produce useful substances, such as human insulin to treat diabetes.
- Plant crops have been genetically engineered to be resistant to diseases, insects, or herbicides, or to produce bigger and better fruits and higher yields. Crops that have undergone genetic engineering are called **genetically modified** (GM).

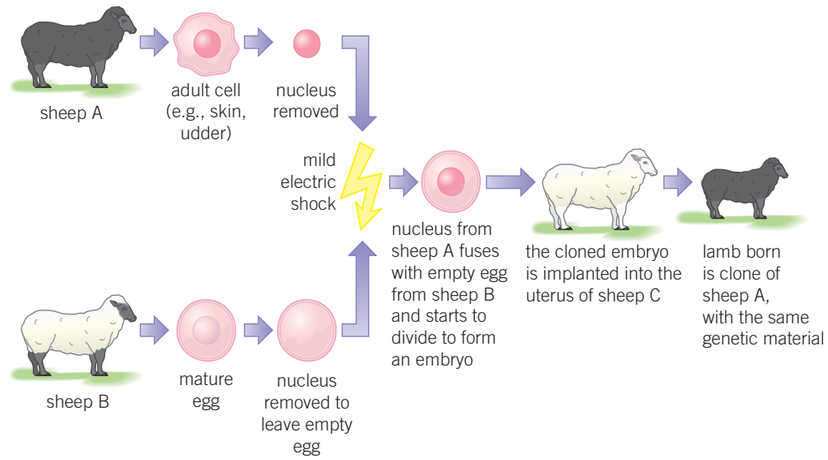


Benefits	Risks
• potential to overcome some inherited human diseases • can lead to higher value of crops as GM crops have bigger yields than normal • crops can be engineered to be resistant to herbicides, make their own pesticides, or be more resistant to environmental conditions	• genes from GM plants and animals may spread to other wildlife, which could have devastating effects on ecosystems • potential negative impacts on populations of wild flowers and insects • ethical concerns, for example, in the future people could manipulate the genes of children to ensure certain characteristics • some believe the long-term effects on health of eating GM crops have not been fully explored

Cloning

A **clone** is an individual that has been produced **asexually** and is genetically identical to its parent.

Adult cell cloning



Methods of cloning

Tissue culture

Small groups of cells from part of a plant are used to grow identical new plants. This is important for preserving rare plant species and growing plants commercially in nurseries.

Cutting

An older, simple method used by gardeners to produce many identical plants from a parent plant.

Embryo transplant

Cells are split apart from a developing animal embryo before they become specialised, then the identical embryos are transplanted into host mothers.

Benefits	Risks
• large number of identical offspring produced • quick and economical • desired characteristics guaranteed	• limits variation and causes reduction in gene pool • clones may be vulnerable to diseases/ changes in the environment • ethical considerations around cloning living organisms

Key terms

Make sure you can write a definition for these key terms.

asexual *clone* *cutting* *embryo transplant* *genetically modified* *genetic engineering* *inbreeding* *mutation* *selective breeding* *tissue culture* *variation*

Chapter 14: Variation and evolution

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

B14 questions	Answers
1 What is variation?	differences in the characteristics of individuals in a population
2 What can cause variation?	genetic causes, environmental causes, and a combination of genes and the environment
3 How do new phenotype variants occur?	mutations
4 What is selective breeding?	breeding plants and animals for particular characteristics
5 Describe the process of selective breeding.	**1** choose parents with the desired characteristic **2** breed them together **3** choose offspring with the desired characteristic and breed again **4** continue over many generations until all offspring show the desired characteristic
6 What are the consequences of inbreeding?	inherited defects and disease
7 What is genetic engineering?	modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic
8 How have plant crops been genetically engineered?	to be resistant to diseases/herbicides/pesticides, to produce bigger fruits, to give higher yields
9 How have bacteria been genetically engineered?	to produce useful substances, such as human insulin to treat diabetes
10 What are enzymes used for in genetic engineering?	cut out the required gene
11 What is used to transfer the required gene into the new cell in genetic engineering?	vector (e.g., bacterial plasmid or virus)
12 Describe the steps involved in adult cell cloning.	**1** nucleus removed from unfertilised egg cell **2** nucleus from adult body cell inserted into egg cell **3** electric shock stimulates egg cell to divide to form an embryo **4** embryo develops and is inserted into the womb of an adult female
13 What is tissue culture cloning?	using small groups of cells from plants to grow identical new plants
14 Why is tissue culture cloning of plants important?	preserve rare species and for growing plants commercially in nurseries
15 What is cutting as a cloning method?	simple method used by gardeners to produce many identical plants from a parent plant
16 Describe cloning through using embryo transplants.	cells split apart from a developing animal embryo before they are specialised, then the identical embryos are transplanted into host mothers

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Chapter 15: Genetics and evolution

Knowledge organiser

Theory of evolution

Evolution is the gradual change in the inherited characteristics of a population over time.

Evolution occurs through the process of **natural selection** and may result in the formation of new species.

Darwin published this theory in *On the Origin of Species* (1859). His ideas were considered controversial and only gradually accepted because

- they challenged the idea that God made all of the Earth's animals and plants
- there was insufficient evidence at the time the theory was published, although much more evidence has been gathered since
- mechanisms of inheritance and variation were not known at the time
- other theories, such as that of Jean-Baptiste Lamarck, were based on the idea that the changes that occur in an organism over its lifetime could be passed on to its offspring. We now know that in the majority of cases this type of inheritance cannot occur.

Process of natural selection

The theory of evolution by natural selection states that

- organisms within species show a wide range of variation in phenotype
- individuals with characteristics most suited to the environment are more likely to survive and breed successfully
- these characteristics are then passed on to their offspring.

Evidence for evolution

The theory of evolution by natural selection is now widely accepted because there are lots of data to support it, such as

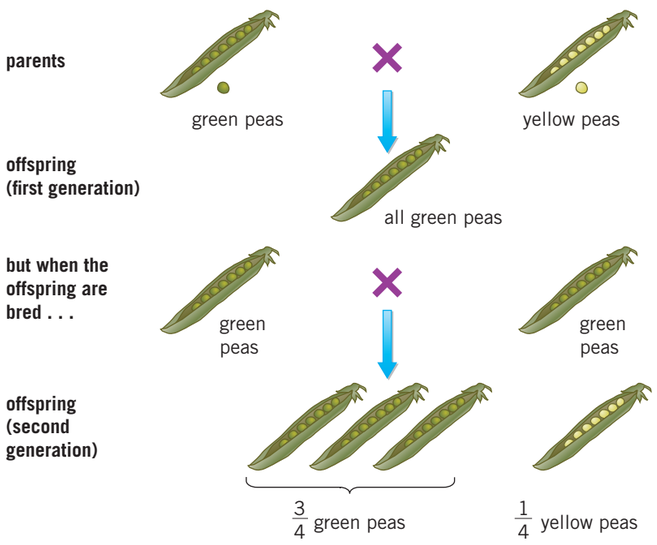
- it has been shown that characteristics are passed on to offspring in genes
- evidence from the **fossil record**
- the evolution of antibiotic resistance in bacteria.

Extinction

Extinction is when there are no remaining individuals of a species still alive.

Factors that may contribute to a species' extinction include

- new predators
- new diseases or pathogens
- increased competition for resources or mates
- catastrophic events (e.g., asteroid impacts, volcanic eruptions, earthquakes)
- changes to the environment (climate change, destruction of habitats).



Development of gene theory

Further work by many scientists led to the development of **gene theory**.

In the late nineteenth century the behaviour of chromosomes during cell division was observed.

↓

In the early twentieth century genes and chromosomes were observed to behave similarly, leading to the idea that genes were located on chromosomes.

↓

In the mid-twentieth century the structure of DNA and mechanism of gene function were determined.

Key terms

Make sure you can write a definition for these key terms.

evolution *extinction* *fossil record* *natural selection* *speciation* *antibiotic-resistance* *gene theory*

Speciation

Alfred Wallace worked with Darwin to propose the theory of evolution by natural selection. He is also known for his work on the theory of **speciation**.

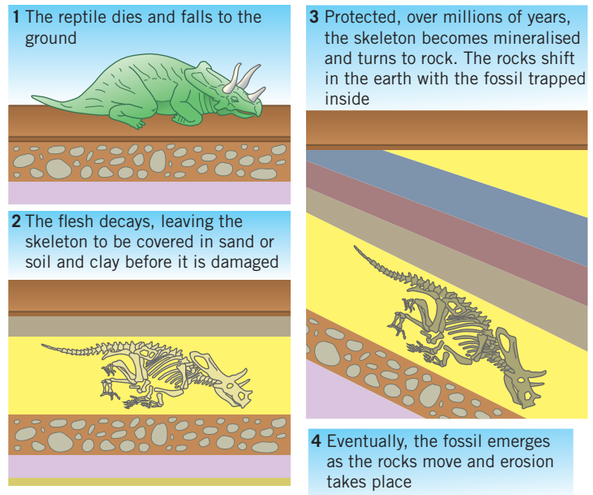
Speciation is the gradual formation of a new species as a result of evolution. More evidence and work from scientists over time have led to our current understanding of the theory of speciation.

Process of speciation

1. two populations of one species are isolated (e.g., by a river or mountain range)
2. natural selection occurs so that the better-adapted individuals reproduce and pass on these different characteristics
3. the populations have an increasing number of genetic mutations as they adapt to their different environments
4. eventually the two populations are so genetically different they cannot breed to produce fertile offspring

Fossils

Benefits of the fossil record	Problems with the fossil record
• can tell scientists how individual species have changed over time • fossils allow us to understand how life developed over Earth's history • fossils can be used to track the movement of a species or its ancestors across the world	• many early organisms were soft-bodied, so most decayed before producing fossils • there are gaps in the fossil record as not all fossils have been found and others have been destroyed by geological or human activity – this means scientists cannot be certain about how life began on Earth

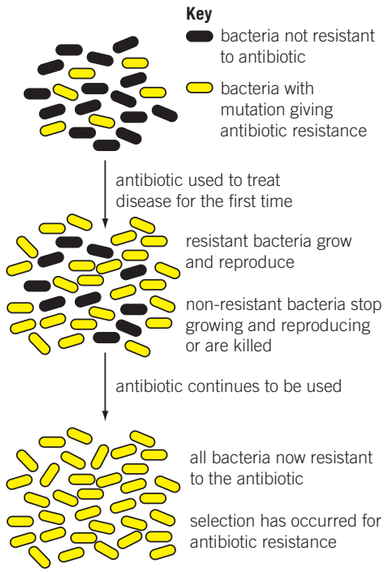


Emergence of antibiotic resistance

The development of new antibiotics is expensive and slow, so is unlikely to keep up with the emergence of new antibiotic-resistant bacteria strains.

To reduce the rise of antibiotic-resistant strains

- doctors should only prescribe antibiotics for serious bacterial infections
- patients should complete their courses of antibiotics so all bacteria are killed and none survive to form resistant strains
- the use of antibiotics in farming and agriculture should be restricted.



Chapter 15: Genetics and evolution

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B15 questions	Answers
1	What is evolution?	change in the inherited characteristics of a population over time through natural selection, which may result in a new species
2	Who first proposed the theory of evolution by natural selection?	Charles Darwin
3	What is the theory of evolution by natural selection?	all species of living things evolved from a common ancestor that developed billions of years ago
4	Describe Lamarck's idea of inheritance.	organisms change over their lifetimes and these characteristics can be inherited
5	Why was the theory of evolution by natural selection controversial?	• challenged the idea that God made all of Earth's animals and plants • insufficient evidence at the time • genes, inheritance, and variation were not understood
6	What is speciation?	gradual formation of a new species as a result of evolution
7	What evidence supports the theory of evolution?	• parents pass on their characteristics to offspring in genes • fossil record evidence • evolution of antibiotic-resistant bacteria
8	What did Mendel discover through breeding experiments on plants?	inheritance of characteristics is determined by units (genes) passed on unchanged to offspring
9	What are fossils?	remains of organisms from millions of years ago, found in rocks
10	How might fossils be formed?	• parts of an organism do not decay because the conditions needed for decay are absent • traces of organisms are preserved • parts of an organism are replaced by minerals
11	What are the benefits of the fossil record?	can learn how species changed and life developed on Earth, and can track the movement of species across the world
12	What are the problems with the fossil record?	• many early organisms were soft-bodied so left few fossils • gaps in the fossil record as not all fossils have been found and some have been destroyed
13	What is extinction?	no individuals of a species are still alive
14	What is the binomial system?	naming of organisms by their genus and species
15	What classification system did Carl Woese introduce?	three-domain system of Archaea, Bacteria, and Eukaryota
16	Why can bacteria evolve rapidly?	they reproduce at a fast rate
17	How do antibiotic-resistant strains of bacteria develop?	mutations that allow the strain to survive and reproduce

Chapter 16: Adaptations and interdependence

Knowledge organiser

Ecosystem organisation

Individual organisms

↓

Population
the total number of organisms of the same species that live in one specific geographical area

↓

Community
group of two or more populations of different species living in one specific geographical area

↓

Ecosystem
the interaction of a community of living organisms with the non-living parts of their environment

A stable community is one where all the species and environmental factors are in balance so that population sizes remain fairly constant.

An example of this is the interaction between predator and prey species, which rise and fall in a constant cycle so that each remains within a stable range.

Competition

To survive and reproduce, organisms require a supply of resources from their surroundings and from the other living organisms there.

This can create competition, where organisms within a community compete for resources.

There are two types of competition – **interspecific competition** is between organisms of different species and **intraspecific competition** is between organisms of the same species.

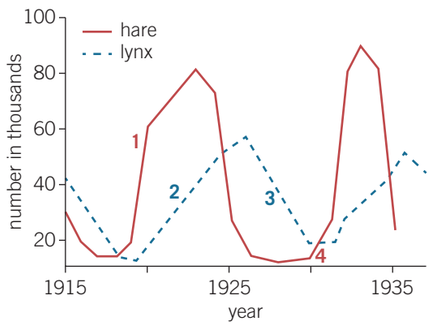
Animals often compete for:
- food
- mates
- territory.

Plants often compete for:
- light
- space
- water and mineral ions from the soil.

Interdependence

Within a community each species **interacts** with many others and may depend on other species for things like food, shelter, pollination, and seed dispersal.

If one species is removed it can affect the whole community – this is called **interdependence**.



1 If the population of hares increases there is a larger food supply for the lynx.

2 This can therefore support more lynx, so more offspring survive.

3 The growing numbers of lynx eventually reduce the food supply. The number of predators starts to decrease.

4 The prey population starts to increase once more – the cycle then begins again.

Abiotic factors

Abiotic factors are non-living factors in the ecosystem that can affect a community.

Too much or too little of the following abiotic factors can negatively affect the community in an ecosystem:
- carbon dioxide levels for plants
- light intensity
- moisture levels
- oxygen levels for animals that live in water
- soil pH and mineral content
- temperature
- wind intensity and direction.

Biotic factors

Biotic factors are living factors in the ecosystem that can affect a community.

For example, the following biotic factors would all negatively affect populations in a community:
- decreased availability of food
- new predators arriving
- new pathogens
- competition between species, for example, one species outcompeting another for food or shelter, causing a decline in the other species' population.

Adaptations of organisms

Organisms have features – **adaptations** – that enable them to survive in the conditions in which they live. The adaptations of an organism may allow it to outcompete others, and provide it with an evolutionary advantage.

Structural adaptations

The physical features that allow an organism to successfully compete:
- sharp teeth to hunt prey
- colouring that may provide camouflage to hide from predators or hunt prey
- a large or small body-surface-area-to-volume ratio.

Behavioural adaptations

The behaviour of an organism that gives it an advantage:
- making nests to attract a mate
- courtship dances to attract a mate
- use of tools to obtain food
- working together in packs.

Functional adaptations

Adaptations related to processes that allow an organism to survive:
- photosynthesis in plants
- production of poisons or venom to deter predators and kill prey
- changes in reproduction timings.

You can work out how an organism is adapted to where it lives when given information on its environment and what it looks like.

For example, without the following adaptations the organisms below would be at a disadvantage in their environment.

Organism	Example adaptations
	• white fur for camouflage when hunting prey • feet with large surface area to distribute weight on snow • small ears to reduce heat loss • thick fur for insulation
	• feet with large surface area to distribute weight on sand • hump stores fat to provide energy when food is scarce • tough mouth and tongue to allow camel to eat cacti • long eyelashes to keep sand out of eyes
	• spines instead of leaves to reduce surface area and therefore water loss, and to deter predators • long roots to reach water underground • large, fleshy stem to store water

Some organisms are **extremophiles**, which means they live in environments that are very extreme where most other organisms could not survive. For example, areas with:
- very high or low temperatures
- extreme pressures
- high salt concentrations
- highly acidic or alkaline conditions
- low levels of oxygen or water.

Bacteria that live in deep sea vents are extremophiles.

Deep sea vents are formed when seawater circulates through hot volcanic rocks on the seafloor. These environments have very high pressures and temperatures, no sunlight, and are strongly acidic.

Key terms

Make sure you can write a definition for these key terms.

abiotic factor *adaptation* *biotic factor* *community* *ecosystem* *extremophile* *interaction* *interdependence* *interspecific competition* *intraspecific competition* *population*

Chapter 16: Adaptations and interdependence

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B16 questions	Answers
1	What is a population?	total number of organisms of the same species that live in a specific geographical area
2	What is a community?	group of two or more populations of different species living in a specific geographical area
3	What is an ecosystem?	the interaction of a community of living organisms with the non-living parts of their environment
4	What is competition?	contest between organisms within a community for resources
5	What is interdependence?	when species in a community depend on others for resources and shelter
6	What do animals often compete for?	food, mates, and territory
7	What do plants often compete for?	light, space, water, and mineral ions
8	What is an abiotic factor?	non-living factor that can affect a community
9	List the abiotic factors that can affect a community.	• carbon dioxide levels for plants • light intensity • moisture levels • oxygen levels for animals that live in water • soil pH and mineral content • temperature • wind intensity and direction
10	What is a biotic factor?	living factor that can affect a community
11	List the biotic factors that can affect a community.	• availability of food • new predators • new pathogens • competition between species
12	What is a stable community?	when all species and environmental factors are in balance, so population sizes remain fairly constant
13	How do adaptations help an organism?	they enable the organism to survive in the conditions in which it lives
14	What are the three types of adaptations?	structural, behavioural, and functional
15	What is an extremophile?	an organism that lives in a very extreme environment
16	What makes an environment extreme?	• very high or low temperatures • extreme pressures • high salt concentrations • highly acidic or alkaline conditions • lack of oxygen or water

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Chapter 17: Organising an ecosystem

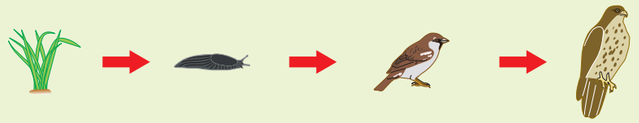
Knowledge organiser

Levels of organisation

Feeding relationships within a community can be represented by **food chains**.

Photosynthetic organisms that synthesise molecules are the producers of all **biomass** for life on Earth, and so are the first step in all food chains.

A range of experimental methods using transects and quadrats are used by ecologists to determine the distributions and abundances of different species in an ecosystem.



all food chains begin with a **producer**, for example, a green plant or alga producing glucose through photosynthesis

slugs are **primary consumers** – they are **herbivores** that eat producers

sparrows are **secondary consumers** – they are **carnivores** that eat primary consumers

hawks are **tertiary consumers** – they are carnivores that eat secondary consumers

Consumers that kill and eat other animals are predators, and those that are eaten are **prey**.

Apex **predators** are carnivores with no predators.

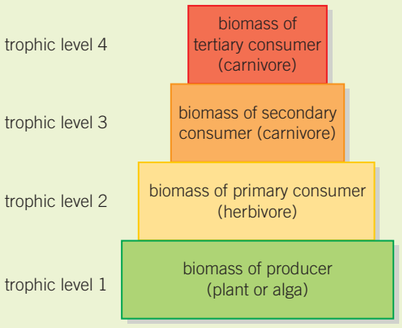
Organisms usually have more complex feeding relationships, with more than one predator or more than one food source. These can be shown in a **food web**.

Pyramids of biomass

The **trophic level** of an organism is the number of steps it is from the start of its food chain.

Pyramids of biomass represent the relative amount of biomass at each trophic level of a food chain.

Biomass is the amount of living or recently dead biological matter in an area. Biomass is transferred from each trophic level to the level above it in the food chain.



Producers transfer about 1% of the incident light energy used for photosynthesis to produce biomass.

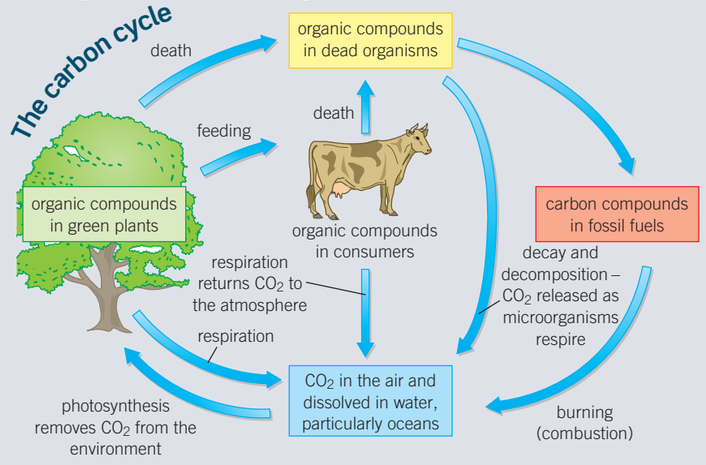
Approximately 10% of the biomass from each trophic level is transferred to the level above it.

This loss of biomass moving up the food chain is due to several factors:

- use in life processes, such as respiration
- not all of the matter eaten is digested, some is egested as waste products
- some absorbed material is lost as waste
- energy is used in movement and to keep animals warm.

How materials are cycled

All materials in the living world are recycled, which provides the building materials for future organisms.

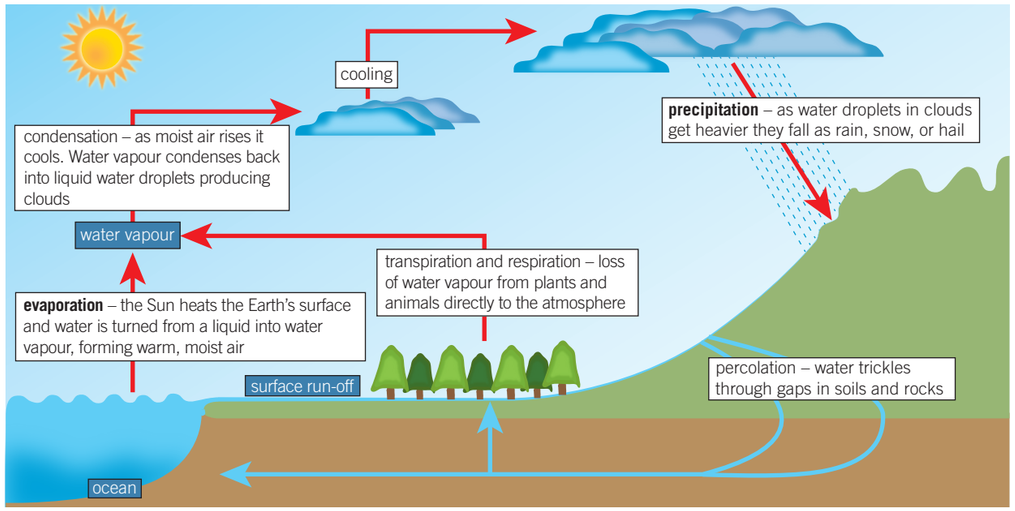


Key terms

Make sure you can write a definition for these key terms.

biomass carbon cycle carnivore consumer decomposer evaporation fertiliser food chain food web herbivore precipitation predator prey producer trophic level water cycle

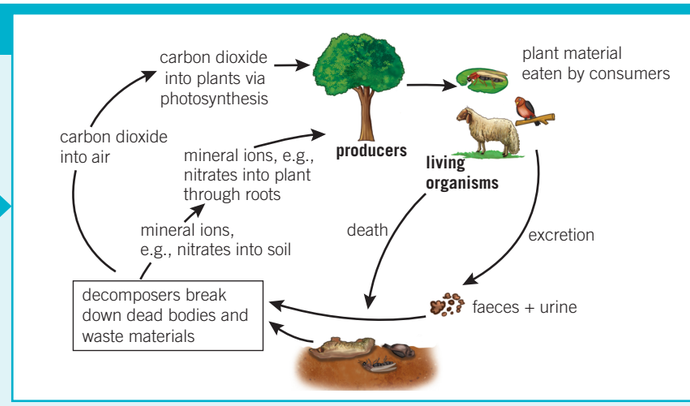
The water cycle



Decomposition

Decomposers, such as bacteria and fungi, break down dead plant and animal matter by secreting enzymes into the environment. The small soluble food molecules produced then diffuse into the decomposer.

These materials are cycled through an ecosystem by decomposers returning carbon to the atmosphere as carbon dioxide and mineral ions to the soil.



Gardeners and farmers try to provide optimum conditions for the rapid decay of waste material by decomposers.

Decomposition will occur faster in warm temperatures, when oxygen and moisture levels are high, and there is a neutral pH.

The compost produced from this decay is then added to soil as a natural **fertiliser** for growing garden plants and crops.

When there is a lack of oxygen, waste is decomposed anaerobically.

Anaerobic decay produces methane gas. Biogas generators use anaerobic decay to produce methane for use as a fuel.

Impacts of environmental change

Environmental changes affect the distribution of species in ecosystems.

These changes may be seasonal, geographic, or caused by humans, and include:

- temperature – varies greatly between locations and seasons, and warming temperatures have contributed to species migrating away from the Equator
- availability of water – during droughts animals have to move away from their usual habitats to areas with more water, and cannot survive if this is not possible
- composition of atmospheric gases – human activities release greenhouse gases and pollutants, which cause harmful effects like climate change and acid rain.

Chapter 17: Organising an ecosystem

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B17 questions	Answers
1	What is a producer?	organism that makes its own food, usually by photosynthesis
2	What is a food chain?	representation of the feeding relationships within a community
3	What is a consumer?	organism that eats other organisms for food
4	What is a herbivore?	organism that only eats producers (plants/algae)
5	What is a predator?	organism that kills and eats other organisms
6	What is a prey organism?	organism that is killed and eaten by another organism
7	What is an apex predator?	carnivore with no predators
8	What proportion of biomass is transferred from each trophic level to the one above?	approximately 10%
9	Why is biomass lost between trophic levels?	• some ingested material is egested • some material is lost as waste (carbon dioxide and water in respiration, water and urea in urine) • used in life processes, such as respiration • energy is used in movement and to keep animals warm
10	What is the carbon cycle?	process that returns carbon from organisms to the atmosphere as carbon dioxide, which can then be used by plants
11	What is the water cycle?	process that provides fresh water for plants and animals on land before draining into seas and rivers
12	What is a decomposer?	organism that breaks down dead plant and animal matter
13	What is the role of decomposition?	returns carbon to the atmosphere and mineral ions to the soil from dead matter
14	What factors affect the rate of decay by decomposers?	oxygen levels, moisture levels, temperature, and pH
15	What gas does anaerobic decay produce?	methane gas
16	How can this gas be used?	as a fuel
17	Give the environmental changes that can affect the distribution of organisms.	temperature, availability of water, and composition of atmospheric gases

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Chapter 18: Biodiversity and ecosystems

Knowledge organiser

Biodiversity

Biodiversity is the variety of all the different species of organisms (plant, animal, and microorganism) on Earth, or within a specific ecosystem.

High biodiversity ensures the stability of an ecosystem, because it reduces the dependence of one species on another in the ecosystem for food or habitat maintenance.

The future of the human species depends on us maintaining a good level of biodiversity. Many human activities, such as **deforestation**, are reducing biodiversity, but only recently have measures been taken to try to prevent this.

Global warming

Levels of carbon dioxide and methane in the atmosphere are increasing due to human activity, contributing to global warming and climate change. Global warming is the gradual increase in the average temperature of the Earth.

This scientific consensus is based on systematic reviews of thousands of peer-reviewed publications.

Global warming has resulted in

- large-scale habitat change and reduction, causing decreases in biodiversity
- extreme weather and sea level changes
- migration of species to different parts of the world, affecting ecosystems
- threats to the security and availability of food.

Waste management

Rapid growth of the human population and increases in the standard of living mean humans are using more resources and producing more waste.

Waste and chemical materials need to be properly handled in order to reduce the amount of **pollution** they cause. Pollution kills plants and animals, and can accumulate in food chains, reducing biodiversity.

Pollution can occur

- in water, from sewage, fertiliser run-off, or toxic chemicals (e.g., from factories)
- in air, from smoke and acidic gases
- on land, from landfill and toxic chemicals.

Land use

Rapid population growth has led to humans using much more land for building, quarrying, farming, and dumping waste. This reduces the area in which animals can live and can further destroy habitats through pollution.

For example, the destruction of **peat bogs** (areas of partially decayed vegetation) to produce garden compost has decreased the amount of this important habitat, and the biodiversity it supports. The decay or burning of peat for energy also releases carbon dioxide into the atmosphere, contributing to **global warming**.

Deforestation

Large-scale deforestation in tropical areas has been carried out to provide land for cattle and rice fields, and to grow crops for **biofuels**.

This has resulted in

- large amounts of carbon dioxide being released into the atmosphere due to burning of trees
- extinctions and reductions in biodiversity as habitats are destroyed
- climate changes, as trees absorb carbon dioxide and release water vapour.

Farming techniques

Sustainable methods of food production need to be developed if we are going to feed the Earth's human population.

Intensive farming techniques make food production more efficient by restricting energy transfer from food animals to their environment.

This can be done by:

- limiting the movement of the animals
- controlling the temperature of their surroundings.

In order to also maximise yield from animals and crops, farmers also:

- feed animals high-protein foods to increase growth
- give animals antibiotics to prevent or treat disease
- regularly use fertilisers, herbicides, and pesticides on crops.

Sustainable fisheries

Fish stocks in the oceans are declining. It is important to maintain fish stocks to ensure breeding continues, or certain species may disappear altogether in some areas.

To avoid this happening, net sizes (bigger holes to stop young fish being caught) and fishing quotas (how many fish can be caught) are controlled in many places.

Food security

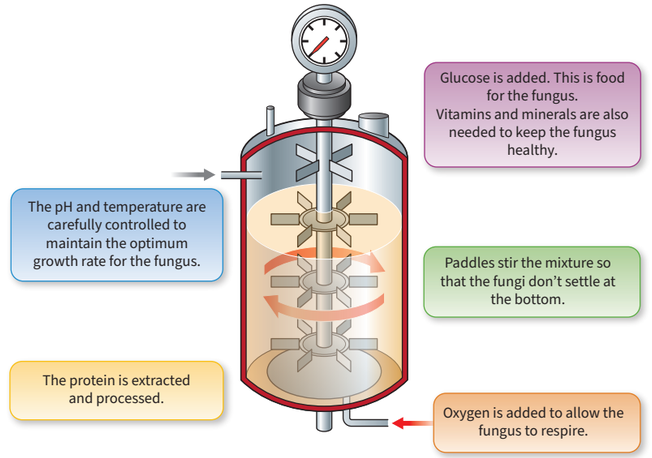
Food security is having enough food to feed a population.

Biological factors threatening human food security include:

- rapid population growth and increasing birth rate in some countries
- changing diets in developed countries, requiring scarce food resources to be transported globally
- new pests and pathogens impacting farming of vast amounts of crops
- environmental changes, such as drought, affecting food production
- increasing cost of agricultural inputs, like fertilisers
- conflicts in some parts of the world, which affect the availability of water or food.

The role of biotechnology

Scientists can use new technologies to solve the problem around food production for a growing population. The fungus *Fusarium* is used to make mycoprotein, a protein-rich alternative to meat. *Fusarium* is cultured in aerobic conditions in fermenters.



Advantages of intensive farming	Disadvantages of intensive farming
• high yield and quicker growth of crops and animals • efficient use of food, with less waste produced • can meet demand for food from a rapidly increasing population	• increased risk of antibiotic-resistant bacteria strains • pesticides and herbicides may kill beneficial organisms and reduce biodiversity • ethical issues about animal welfare and quality of life • large carbon dioxide and methane emissions

Key terms

Make sure you can write a definition for these key terms.

biodiversity *biofuel* *deforestation* *food security*
global warming *intensive farming* *peat bog* *pollution*

Chapter 18: Biodiversity and ecosystems

Retrieval questions

Learn the answers to the questions below then cover the answers column with a piece of paper and write as many as you can. Check and repeat.

	B18 questions	Answers
1	What is biodiversity?	the variety of all the different species of organisms on Earth, or within an ecosystem
2	What is the advantage of high biodiversity?	ensures stability of ecosystems by reducing the dependence of one species on another
3	How are humans trying to maintain biodiversity?	• breeding programmes • protection of rare habitats • reintroduction of hedgerows • reduction of deforestation and carbon dioxide emissions • recycling resources
4	Why are more resources being used, and more waste produced, by humans?	rapid growth in human population, and increase in the standard of living
5	Where does pollution occur?	water, air, and land
6	How are humans reducing the land available for other organisms?	building, quarrying, farming, and dumping waste
7	What are the negative impacts of the destruction of peat bogs?	• reduces amount of available habitat, causing decreases in biodiversity • burning or decay of peat releases carbon dioxide into the atmosphere
8	Why have humans carried out large-scale deforestation in tropical areas?	• provide land for cattle and rice fields • grow crops for biofuels
9	What is food security?	having enough food to feed a population
10	What are the biological factors threatening human food security?	• rapid population growth and increasing birth rate • new pests and pathogens • changing diets in developed countries • environmental changes • conflicts • costs of agricultural inputs
11	How can the efficiency of food production in farming be increased?	• limit movement of animals • control temperature of surroundings • feed animals high-protein foods • give animals antibiotics • regularly use fertilisers, herbicides, and pesticides
12	What gases are increasing in atmospheric levels and contributing to global warming?	carbon dioxide and methane
13	How can fish stocks be maintained at a sustainable level?	controlling net sizes and introducing fishing quotas
14	How is biotechnology used to maintain the growing human population?	• large quantities of microorganisms cultured for food, such as mycoprotein from *Fusarium* • GM bacteria producing treatments like human insulin • GM crops providing higher yields or improved nutritional values

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