CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

YOUR NOTES

CONTENTS:

1.1 CHARACTERISTICS

Characteristics of Living Organisms: Basics

- **Movement:** an action by an organism causing a change of position or place
- **Respiration:** the chemical reactions that break down nutrient molecules in living cells to release energy
- **Sensitivity:** the ability to detect and respond to changes in the environment
- **Growth**: a permanent increase in size
- **Reproduction:** the processes that make more of the same kind of organism
- **Excretion:** the removal from organisms of toxic materials and substances in excess of requirements
- **Nutrition:** the taking in of materials for energy, growth and development

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.1 CHARACTERISTICS cont...

YOUR NOTES

EXTENDED ONLY

Characteristics of Living Organisms

- **Movement:** an action by an organism or part of an organism causing a change of position or place
- **Respiration:** the chemical reactions that break down nutrient molecules in living cells to release energy for metabolism
- **Sensitivity:** the ability to detect or sense stimuli in the internal or external environment and to make appropriate responses
- **Growth:** a permanent increase in size and dry mass by an increase in cell number or cell size or both
- **Reproduction:** the processes that make more of the same kind of organism.
- **Excretion:** the removal from organisms of toxic materials, the waste products of metabolism (chemical reactions in cells including respiration) and substances in excess of requirements
- **Nutrition:** the taking in of materials for energy, growth and development; plants require light, carbon dioxide, water and ions; animals need organic compounds, ions and usually need water

EXAM TIP

Use this mnemonic to help you remember these processes:

MRS. H. GREN

Movement **R**espiration **S**ensitivity
Homeostasis
Growth and development **R**eproduction **E**xcretion **N**utrition

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.2 CLASSIFICATION

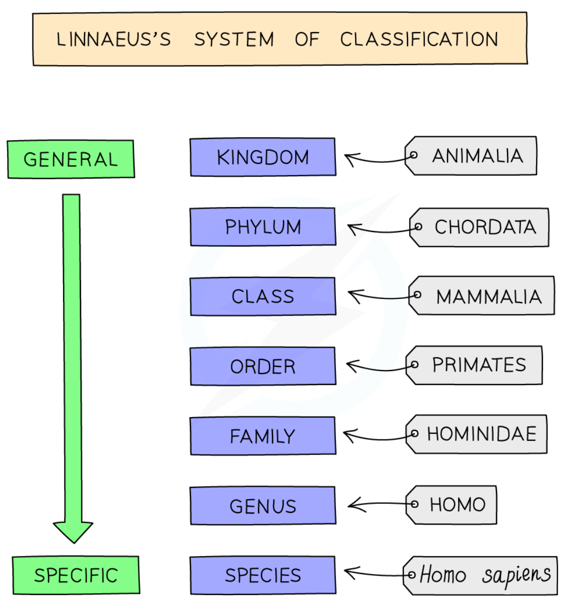
YOUR NOTES

How Organisms are Classified: Basics

- There are millions of species of organisms on Earth
- A species is defined as a group of organisms that can **reproduce to produce fertile offspring**
- These species can be classified into groups by the **features that they share** e.g. all mammals have bodies covered in hair, feed young from mammary glands and have external ears (pinnas)

The Binomial System

- Organisms were first classified by a Swedish naturalist called **Linnaeus** in a way that allows the subdivision of living organisms into smaller and more specialised groups
- The species in these groups have more and more features in common the more subdivided they get
- He named organisms in Latin using the **binomial system** where the scientific name of an organism is made up of two parts starting with:
    - the **genus** (always given a **capital letter**)
    - and followed by the **species** (starting with a **lower case letter**)
- When typed, binomial names are always in italics (which indicates they are Latin) e.g. Homo sapiens
- The sequence of classification is: **Kingdom, Phylum, Class, Order, Family, Genus, Species**



Linnaeus's system of classification

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.2 CLASSIFICATION cont...

YOUR NOTES

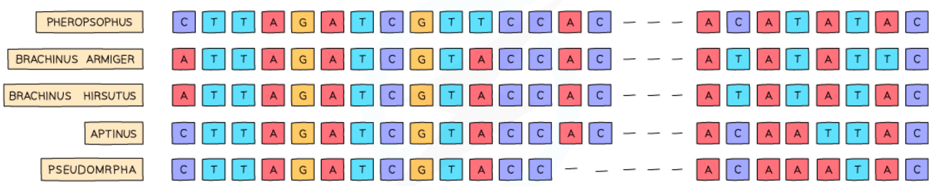
EXAM TIP

The order of classification can be remembered by using this mnemonic:
King Philip Came Over For Gran's Spaghetti

EXTENDED ONLY

How Organisms are Classified

- Organisms share features because they originally descend from a **common ancestor**
- Example: all mammals have bodies covered in hair, feed young from mammary glands and have external ears (pinnas)
- Originally, organisms were classified using **morphology** (the overall form and shape of the organism, e.g. whether it had wings or legs) and **anatomy** (the detailed body structure as determined by dissection)
- As technology advanced, **microscopes**, knowledge of **biochemistry** and eventually **DNA sequencing** allowed us to classify organisms using a more scientific approach
- Studies of DNA sequences of different species show that the **more similar the base sequences in the DNA of two species, the more closely related those two species are** (and the more recent in time their common ancestor is)
- This means that the **base sequences in a mammal's DNA are more closely related to all other mammals** than to any other vertebrate groups



DNA sequences can show how closely related different species are

- The sequences above show that Brachinus armiger and Brachinus hirsutus are **more closely related** than any other species in the list as their DNA sequences are identical except for the last-but-one base (B.armiger has a T in that position whereas B.hirsutus has an A)
- As DNA base sequences are used to code for **amino acid sequences in proteins**, the similarities in amino acid sequences can also be used to determine how closely related organisms are

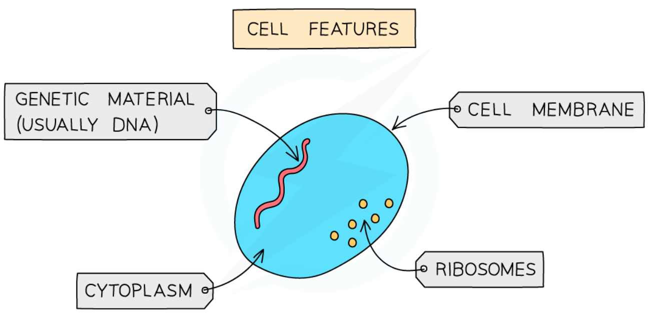
CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.3 FEATURES OF ORGANISMS

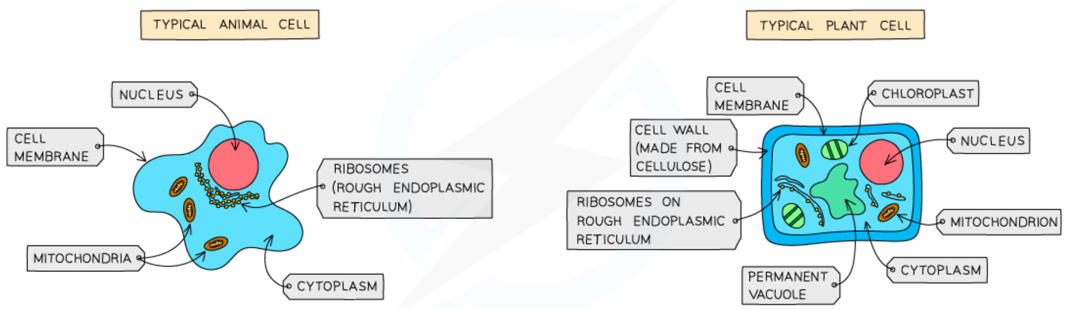
YOUR NOTES

Common Cell Structures

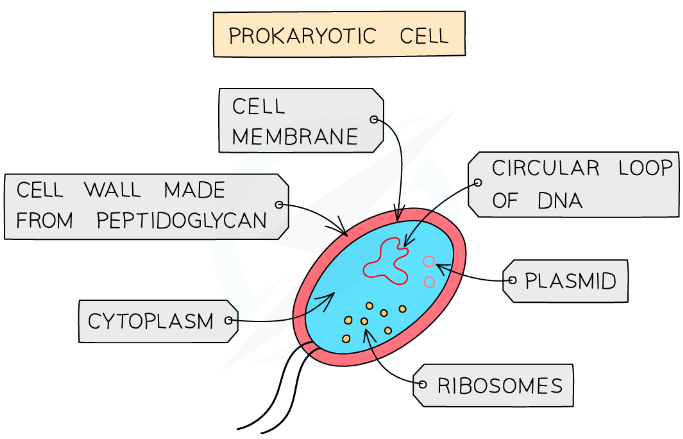
- The cells of all living organisms contain the following:
  - **Cytoplasm**
  - **Cell membrane**
  - **DNA as genetic material** (either found in the nucleus or free in the cytoplasm)



General cell features



A typical animal cell and plant cell



A typical prokaryotic cell

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.3 FEATURES OF ORGANISMS cont...

YOUR NOTES

EXTENDED ONLY

Cell Composition & Structure

When viewed under an electron microscope (at a much higher magnification), all cells also contain the following:

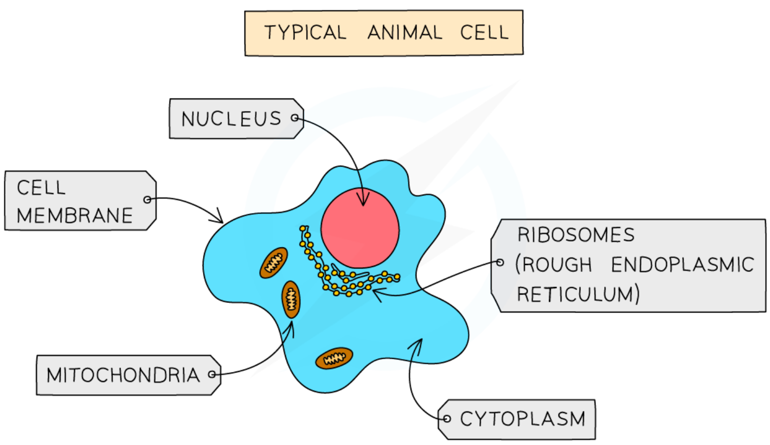
- **Ribosomes** for protein synthesis
- **Enzymes** for respiration (in many, but not all types of cells, found in mitochondria)

The Five Kingdoms

- **Animals**
- **Plants**
- **Fungi**
- **Protoctists**
- **Prokaryotes**

Main features of all animals:

- They are **multicellular**
- Their cells contain a **nucleus** but **no cell walls** or **chloroplasts**
- They feed on organic substances **made by other living things**



A typical animal cell

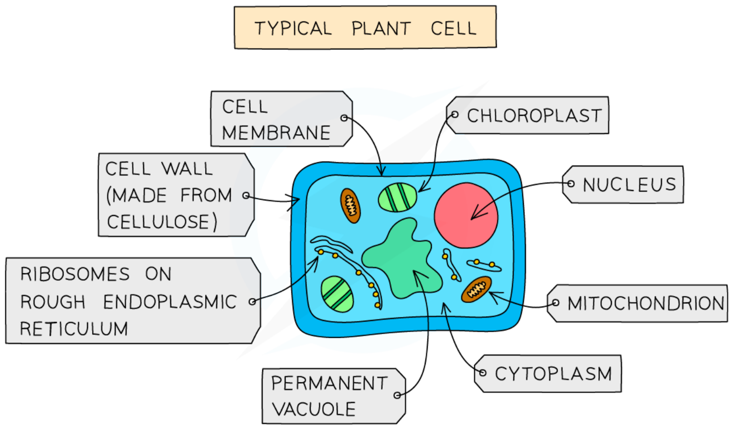
CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.3 FEATURES OF ORGANISMS cont...

YOUR NOTES

Main features of all plants:

- They are **multicellular**
- Their cells contain a **nucleus**, **chloroplasts** and **cellulose cell walls**
- They all feed by **photosynthesis**



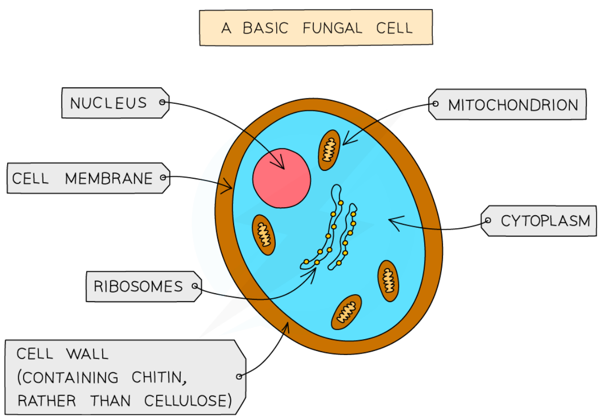
A typical plant cell

EXTENDED ONLY

Fungi, Protoctists & Prokaryotes

Main features of all fungi (e.g. moulds, mushrooms, yeast)

- usually **multicellular**
- cells have **nuclei** and **cell walls** not made from cellulose
- do not photosynthesize but **feed by saprophytic** (on dead or decaying material) **or parasitic** (on live material) **nutrition**



A typical fungal cell

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

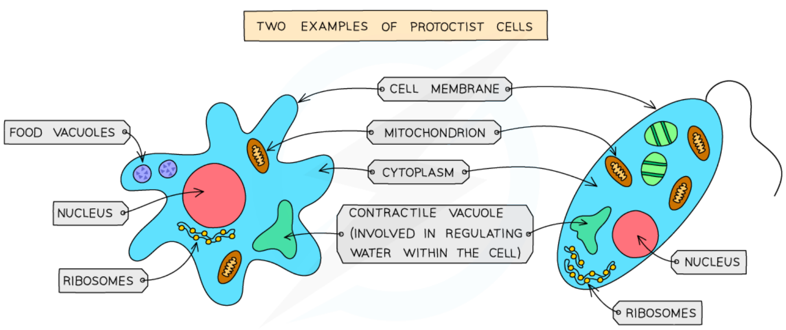
1.3 FEATURES OF ORGANISMS cont...

YOUR NOTES

EXTENDED ONLY cont...

Main features of all Protoctists (e.g. Amoeba, Paramecium, Plasmodium)

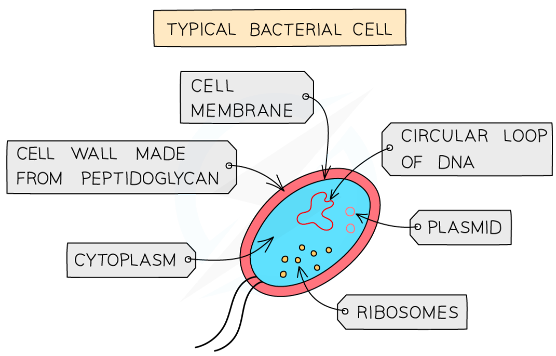
- **Most are unicellular** but some are multicellular
- All have a **nucleus**, some may have cell walls and chloroplasts
- This means that **some protoctists photosynthesise and some feed on organic substances** made by other living things



Two examples of protoctist cells

Main features of all Prokaryotes (bacteria, blue-green algae)

- They are often **unicellular**
- Their cells have **cell walls** (not made of cellulose) and **cytoplasm** but **no nucleus or mitochondria**



A typical bacterial cell

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

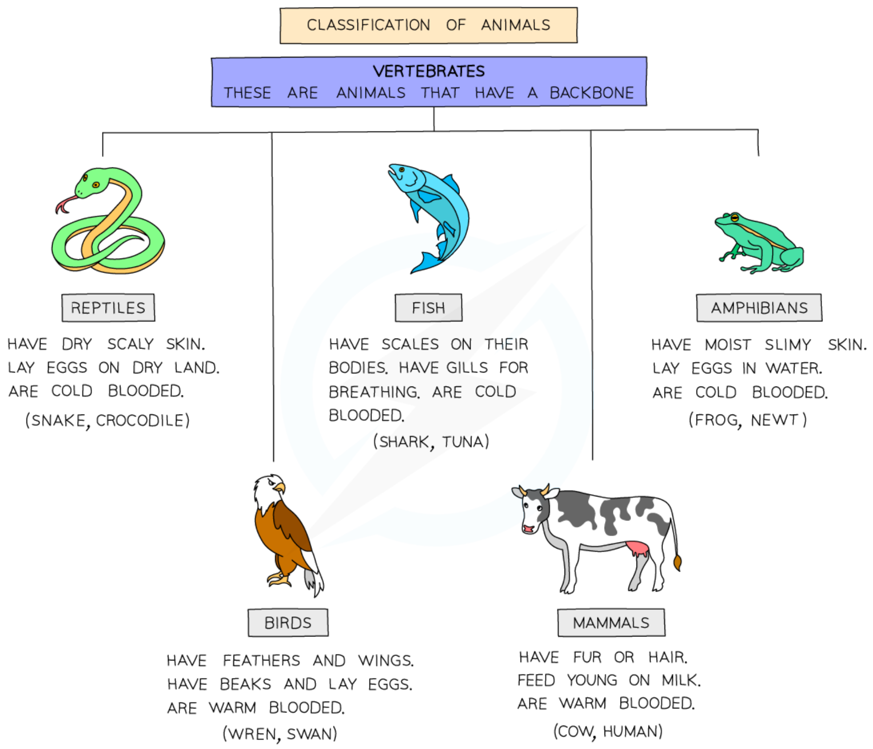
YOUR NOTES

1.4 CLASSIFYING ANIMALS

Vertebrates

All vertebrates have a backbone. There are 5 classes of vertebrates:

CLASS	MAIN FEATURES	EXAMPLES
MAMMALS	– FUR/HAIR ON SKIN – HAVE A PLACENTA – YOUNG FEED ON MILK FROM MAMMARY GLANDS – EXTERNAL EARS (PINNA) VISIBLE – ENDOTHERMIC	HORSE, DOG, SQUIRREL, HUMAN
BIRDS	– SKIN COVERED IN FEATHERS – HAVE 2 LEGS AND 2 WINGS INSTEAD OF FORELIMBS – LAY EGGS WITH HARD SHELLS ON LAND – HAVE A BEAK – ENDOTHERMIC	PARROT, BLUE TIT, EAGLE
REPTILES	– DRY, FIXED SCALES ON SKIN – LAY EGGS WITH RUBBERY SHELLS ON LAND	SNAKE, TURTLE, IGUANA
AMPHIBIANS	– SMOOTH, MOIST SKIN – ADULTS USUALLY LIVE ON LAND (SO HAVE LUNGS), LARVAE LIVE IN WATER (SO HAVE GILLS) – LAY EGGS WITHOUT SHELLS IN WATER	FROG, TOAD, NEWT
FISH	– LOOSE, WET SCALES ON SKIN – GILLS TO BREATHE – LAY EGGS WITHOUT SHELLS IN WATER	FLOUNDER, GROUPER



Vertebrate classification

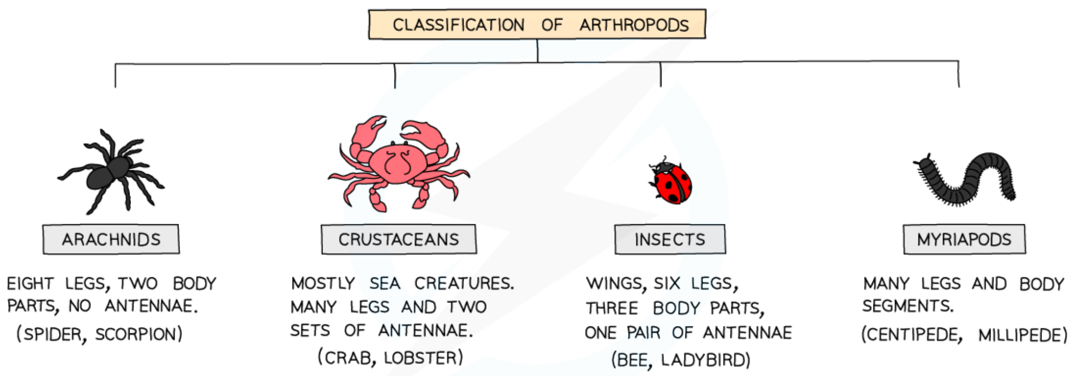
CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.4 CLASSIFYING ANIMALS cont...

Invertebrates

- One of the morphological characteristics used to classify invertebrates is **whether they have legs or not**
- All invertebrates with **jointed legs** are part of the phylum **Arthropods**
- They are classified further into the following classes:

CLASS	MAIN FEATURES	EXAMPLES
MYRIAPODS	– BODY CONSISTS OF **MANY SEGMENTS** – EACH SEGMENT CONTAINS AT LEAST **1 PAIR OF JOINTED LEGS** – 1 PAIR OF ANTENNAE	CENTIPEDE
INSECTS	– **3 PART BODY** – HEAD, THORAX AND ABDOMEN – **3 PAIRS** OF JOINTED **LEGS** – **2 PAIRS OF WINGS** (1 OR BOTH PAIRS MAY BE VESTIGIAL – MEANING NON–FUNCTIONAL AND UNDEVELOPED) – 1 PAIR OF ANTENNAE	BUTTERFLY
ARACHNIDS	– **2 PART BODY** – CEPHALOTHORAX AND ABDOMEN – **4 PAIRS** OF JOINTED **LEGS** – NO ANTENNAE	SPIDER
CRUSTACEANS	– **MORE THAN 4 PAIRS** OF JOINTED **LEGS** – **CHALKY EXOSKELETON** FORMED FROM CALCIUM – BREATHE THROUGH GILLS – **2 PAIRS OF ANTENNAE**	CRAB



Arthropod classification

YOUR NOTES

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.5 CLASSIFYING PLANTS

YOUR NOTES

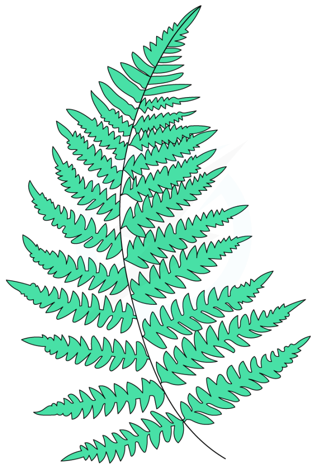
EXTENDED ONLY

Ferns & Flowering Plants

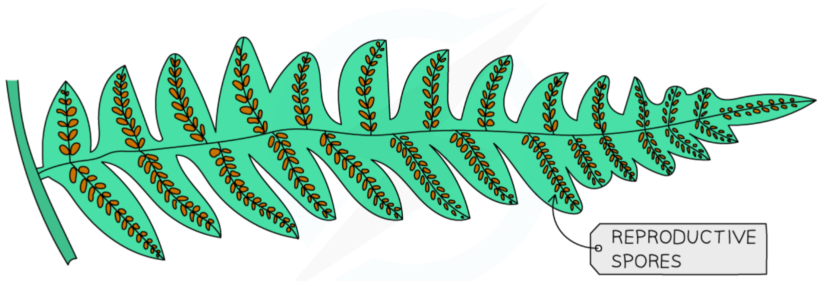
- At least some parts of any plant are green, caused by the presence of the pigment **chlorophyll** which absorbs energy from sunlight for the process of **photosynthesis**
- The plant kingdom includes organisms such as **ferns and flowering plants**

Ferns:

- Have leaves called **fronds**
- Do not produce flowers but instead **reproduce by spores** produced on the underside of fronds



Ferns



Ferns reproduce by spores found in the underside of their fronds

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

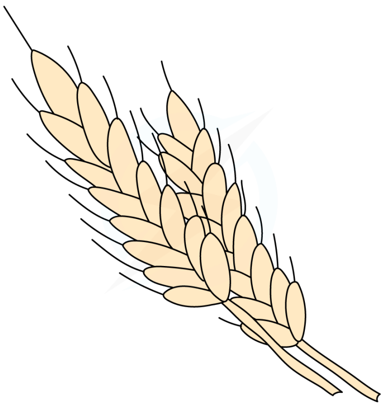
1.5 CLASSIFYING PLANTS cont...

YOUR NOTES

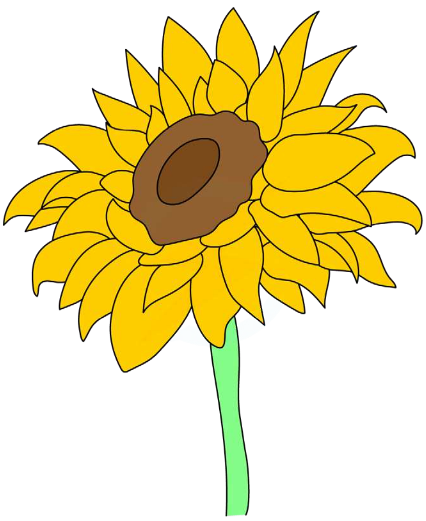
EXTENDED ONLY cont...

Flowering plants:

- Reproduce sexually by means of **flowers and seeds**
- Seeds are produced inside the ovary found at the base of the flower
- Can be divided into two groups – **monocotyledons** and **dicotyledons**



Wheat plants are monocotyledons



Sunflowers are dicotyledons

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

YOUR NOTES

1.5 CLASSIFYING PLANTS cont...

EXTENDED ONLY cont...

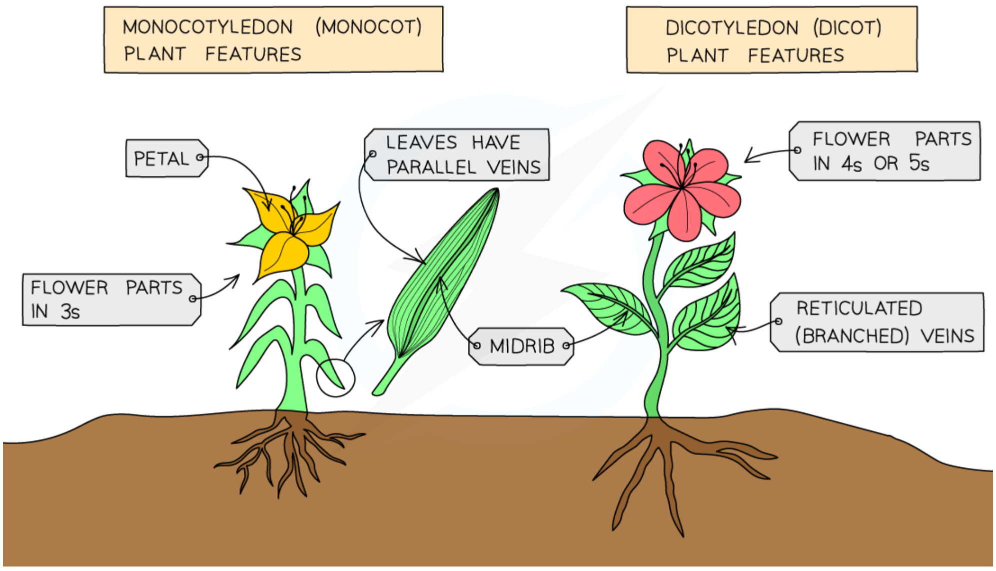
How to distinguish between monocotyledons and dicotyledons:

1. FLOWERS

- Flowers from **monocotyledons** contain petals in **multiples of 3**
- Flowers from **dicotyledons** contain petals in **multiples of 4 or 5**

2. LEAVES

- Leaves from **monocotyledons** have **parallel leaf veins**
- Leaves from **dicotyledons** have **reticulated leaf veins** (meaning that they are all interconnected and form a web like network throughout the leaf)



Comparing Monocots and Dicots

EXAM TIP

Identification of monocotyledons and dicotyledons comes up fairly frequently in the multiple choice paper.

So it is worth learning the two differences between their flowers and leaves.

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

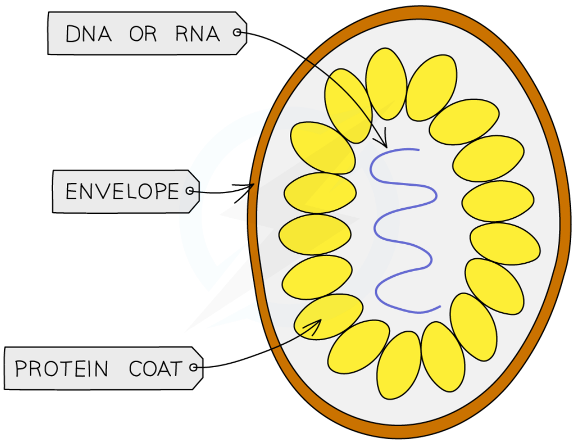
YOUR NOTES

1.6 VIRUSES

EXTENDED ONLY

Features of Viruses

- Viruses are not part of any classification system as they are not **considered living things**
- They **do not carry out the seven life processes** for themselves, instead they **take over a host cell's metabolic pathways** in order to make multiple copies of themselves
- Virus structure is simply **genetic material** (RNA or DNA) inside a **protein coat**



Structure of a typical virus

1.7 DICHOTOMOUS KEYS

Constructing & Using a Key

- Keys are used to identify organisms based on a **series of questions about their features**
- Dichotomous means 'branching into two' and it leads the user through to the name of the organism by giving **two descriptions at a time** and asking them to choose
- Each choice leads the user onto another two descriptions
- In order to successfully navigate a key, you need to pick a single organism to start with and **follow the statements from the beginning until you find the name**
- You then pick another organism and **start at the beginning of the key again**, repeating until all organisms are named

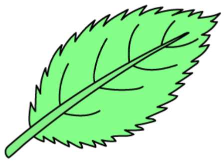
CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.7 DICHOTOMOUS KEYS cont...

YOUR NOTES

THE DIAGRAM SHOWS A LEAF

USE THE KEY TO IDENTIFY THE LEAF

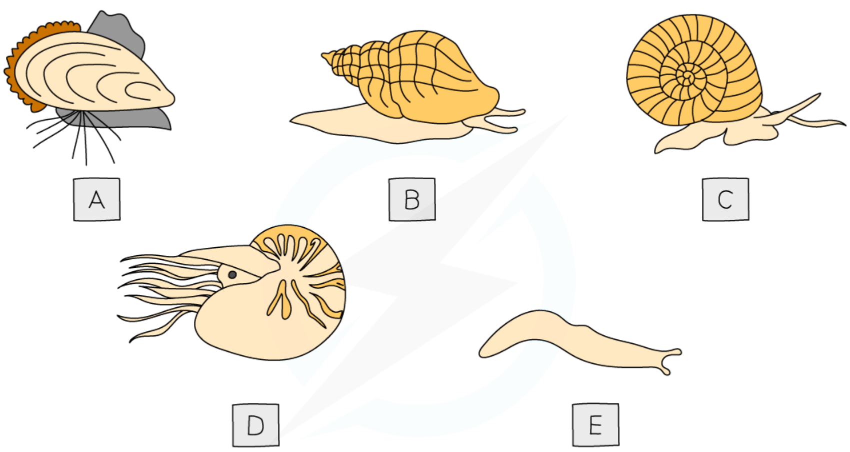


1 LEAF WITH SEVERAL SMALL LEAFLETS............GO TO 2
LEAF WITH ONE LARGE LEAF BLADE...............GO TO 3

2 LEAFLETS ARE BROAD AND FLAT...................A
LEAFLETS ARE NARROW AND HAIR-LIKE......B

3 LEAF WITH A SMOOTH EDGE............................C
LEAF WITH A TOOTHED EDGE..........................D

Example of a dichotomous key *1



USE THE KEY TO IDENTIFY EACH SPECIES. WRITE THE LETTER OF EACH SPECIES (A TO E) IN THE CORRECT BOX BESIDE THE KEY.

Example of a Dichotomous Key *2

CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

1.7 DICHOTOMOUS KEYS cont...

YOUR NOTES

KEY		
1 (a)	BODY IS COMPLETELY OR PARTLY COVERED IN A SHELL	GO TO 2
(b)	BODY IS NOT COMPLETELY OR PARTLY COVERED IN A SHELL	LIMAX FLAVUS
2 (a)	SHELL IS ATTACHED TO ROCKS BY THIN THREADS	MYTILUS EDULIS
(b)	SHELL IS NOT ATTACHED TO ROCKS BY THIN THREADS	GO TO 3
3 (a)	SHELL IS A SPIRE THAT COMES TO A POINT	BUCCINUM UNDATUM
(b)	SHELL IS NOT A SPIRE THAT COMES TO A POINT	GO TO 4
4 (a)	ANIMAL HAS TENTACLES	NAUTILUS POMPILIUS
(b)	ANIMAL HAS 2 TENTACLES	PLANORBIS PLANORBIS

EXAM TIP

- Simple dichotomous keys almost always come up in the multiple choice paper, so make sure you can use one.
- Very occasionally they show up in the theory paper
- When they do you almost always have to use one instead of constructing one: so focus on this rather than spending hours learning to construct them yourself!

> NOW TRY SOME EXAM QUESTIONS

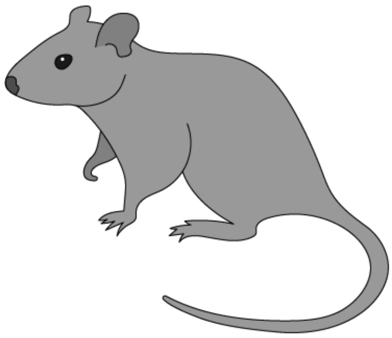
CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The image below shows a house mouse, whose scientific name is Mus musculus.



Which genus does it belong to?

A Mammal

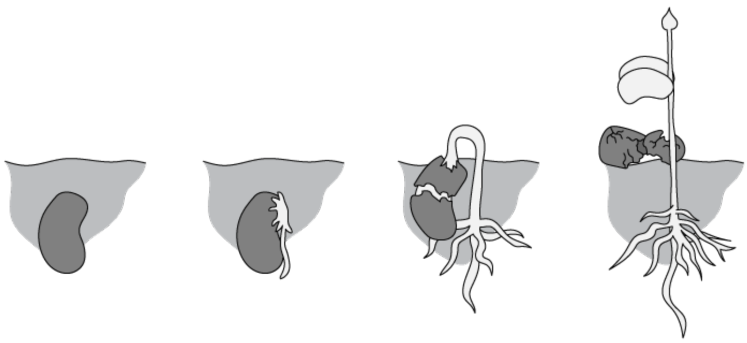
B musculus

C Mus

D Vertebrate

QUESTION 2

The image below shows what occurs to a seed during and after germination, the seed has been planted in well-watered soil.



Which characteristics of living things are demonstrated by this sequence?

A Nutrition and reproduction

B Reproduction and growth

C Nutrition and sensitivity

D Sensitivity and growth

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

Which of the following would not be a characteristic seen in all living organisms?

A Reproduction

B Respiration

C Excretion

D Photosynthesis

QUESTION 4

Four different descriptions about plants are given below.

Which statement would apply to a plant that is a dicotyledon?

A The veins in the leaf are reticulated.

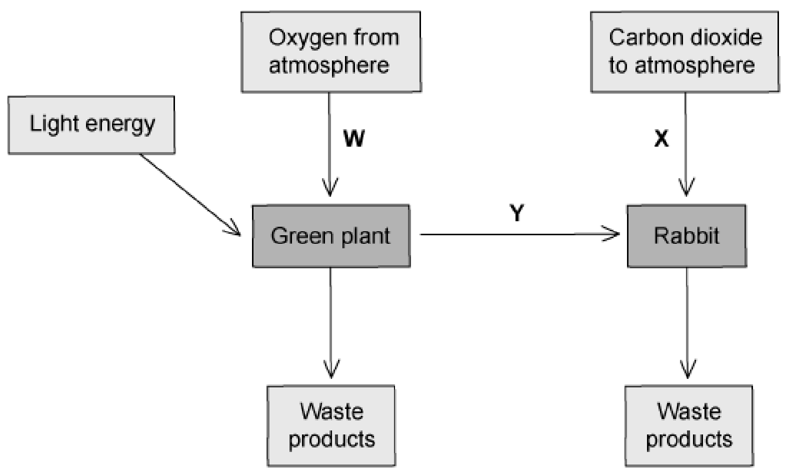
B Each flower has six petals.

C The flowers are all wind-pollinated.

D The leaves have parallel veins.

QUESTION 5

Some of the processes carried out by living organisms are illustrated in the diagram below.



CHARACTERISTICS & CLASSIFICATION OF LIVING ORGANISMS

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5 cont...

Which row of the following table correctly describes the characteristics shown by living organisms in the diagram above?

	W	X	Y
A	respiration	photosynthesis	respiration
B	respiration	respiration	nutrition
C	photosynthesis	respiration	excretion
D	respiration	excretion	nutrition

> CHECK YOUR ANSWERS AT SAVEMY EXAMS.CO.UK

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for more questions and revision notes

2 ORGANISATION OF THE ORGANISM

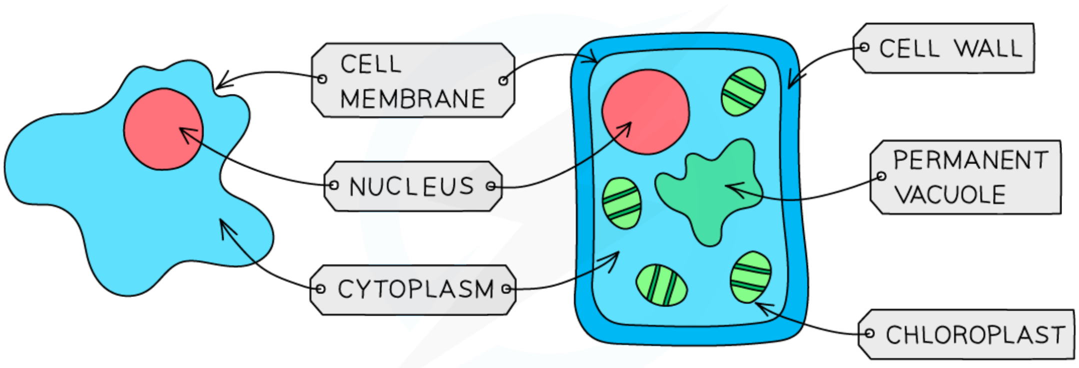
YOUR NOTES

CONTENTS:

2.1 CELL STRUCTURE & ORGANISATION

Structures: Basics

- **Cytoplasm** is found inside the cell and contains all the other cell structures
- The large **nucleus** is surrounded by a nuclear membrane to separate it from the cytoplasm
- The **cell membrane** surrounds the cell
- The **cell wall** is made of cellulose and surrounds the cell membrane in plant cells
- **Chloroplasts** are organelles found in the cytoplasm that are packed with the pigment **chlorophyll** and so are green in colour
- **Vacuoles** are large vesicles that take up a large part of the interior of plant cells



An animal and plant cell as seen under a light microscope

2 ORGANISATION OF THE ORGANISM

2.1 CELL STRUCTURE & ORGANISATION cont...

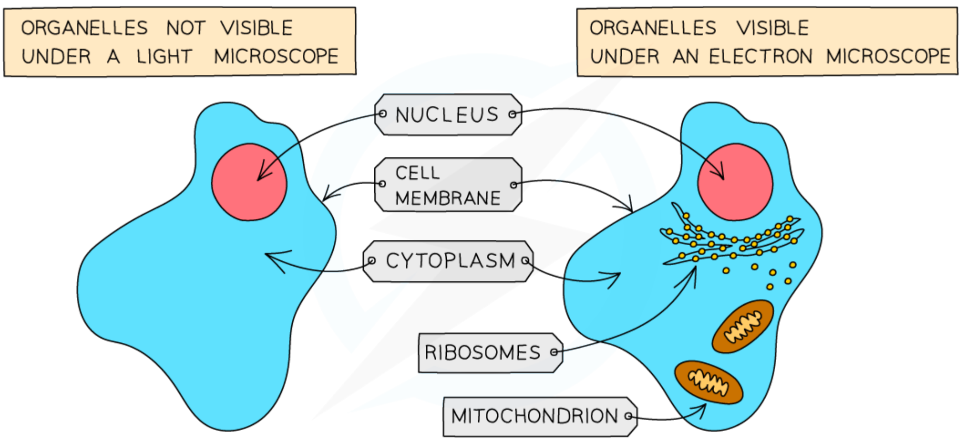
YOUR NOTES

EXTENDED ONLY

Structures

Within the cytoplasm, the following organelles are visible in **almost all cells except prokaryotes** when looking at **higher magnification** (ie using an **electron microscope**):

- **Mitochondria** (singular: mitochondrion) are organelles found throughout the cytoplasm
- **Ribosomes** are tiny structures that can be free within the cytoplasm or attached to a system of membranes within the cell known as **Endoplasmic Reticulum**
- Endoplasmic reticulum studded with ribosomes looks **rough** under the microscope; this gives rise to its name of **Rough Endoplasmic Reticulum** (often shortened to **R.E.R.**)
- **Vesicles** can also be seen using a higher magnification – these are small circular structures found moving throughout the cytoplasm



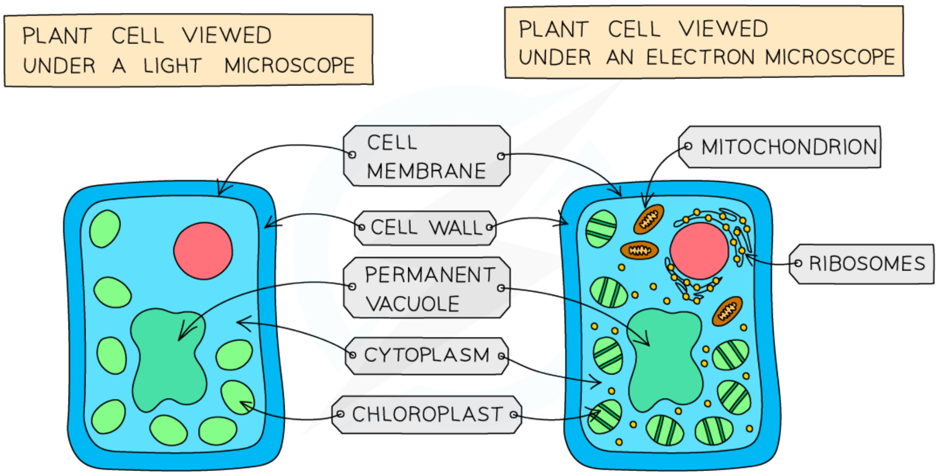
Structures in an animal cell visible under a light microscope and an electron microscope

2 ORGANISATION OF THE ORGANISM

2.1 CELL STRUCTURE & ORGANISATION cont...

YOUR NOTES

EXTENDED ONLY cont...



Structures in a plant cell visible under a light microscope and an electron microscope

Functions: Basics

STRUCTURE	FUNCTION
NUCLEUS	– CONTAINS GENETIC MATERIAL IN CHROMOSOMES WHICH CONTROL HOW CELLS GROW AND WORK – CONTROLS CELL DIVISION
CYTOPLASM	– SUPPORTS CELL STRUCTURES – SITE OF MANY CHEMICAL REACTIONS – CONTAINS WATER AND MANY SOLUTES
CELL MEMBRANE	– HOLDS THE CELL TOGETHER – CONTROLS SUBSTANCES ENTERING AND LEAVING THE CELL
CELL WALL	– GIVES THE CELL EXTRA SUPPORT AND DEFINES ITS SHAPE
CHLOROPLASTS	– SITE OF PHOTOSYNTHESIS, PROVIDING FOOD FOR PLANTS – THE CHLOROPHYLL PIGMENTS ABSORB LIGHT ENERGY NEEDED FOR THE REACTION TO OCCUR
VACUOLE	– CONTAINS CELL SAP – USED FOR STORAGE OF CERTAIN MATERIALS – ALSO HELPS SUPPORT THE SHAPE OF THE CELL

2 ORGANISATION OF THE ORGANISM

2.1 CELL STRUCTURE & ORGANISATION cont...

YOUR NOTES

EXTENDED ONLY

Functions

STRUCTURE	FUNCTION
MITOCHONDRIA	– SITE OF AEROBIC RESPIRATION, PROVIDING ENERGY FOR THE CELL – CELLS WITH HIGH RATES OF METABOLISM (CARRYING OUT MANY DIFFERENT CELL REACTIONS) WILL HAVE SIGNIFICANTLY HIGHER NUMBERS OF MITOCHONDRIA THAN CELLS WITH LOWER NUMBERS OF REACTIONS TAKING PLACE IN THEM
RIBOSOMES	– SITE OF PROTEIN PRODUCTION IN PROTEIN SYNTHESIS
VESICLES	– USED TO SAFELY TRANSPORT SUBSTANCES FROM ONE PART OF THE CELL TO ANOTHER

2.2 SPECIALISED CELLS

Adaptations of Specialised Cells

- Specialised cells are those which have **developed certain characteristics** in order to **perform particular functions**. These differences are controlled by genes in the nucleus
- Cells specialise by undergoing **differentiation**: this is a process by which cells develop the structure and characteristics needed to be able to carry out their functions

2 ORGANISATION OF THE ORGANISM

2.2 SPECIALISED CELLS cont...

YOUR NOTES

Examples of specialised cells in animals:

CELL	FUNCTION	ADAPTATIONS
CILIATED CELL	MOVEMENT OF MUCUS IN THE TRACHEA AND BRONCHI	– EXTENSIONS OF THE CYTOPLASM AT THE SURFACE OF THE CELL FORM HAIR–LIKE STRUCTURES CALLED **CILIA** WHICH **BEAT TO MOVE MUCUS** AND TRAPPED PARTICLES UP TO THE THROAT
NERVE CELL	CONDUCTION OF IMPULSES	– **LONG** SO THAT NERVES CAN RUN TO AND FROM **DIFFERENT PARTS OF THE BODY** TO THE CENTRAL NERVOUS SYSTEM – THE CELL HAS **EXTENSIONS AND BRANCHES**, SO THAT IT CAN **COMMUNICATE** WITH OTHER NERVE CELLS, MUSCLES AND GLANDS – THE AXON (EXTENSION OF CYTOPLASM AWAY FROM THE CELL BODY) IS COVERED WITH A **FATTY SHEATH**, WHICH **INSULATES** THE NERVE CELL AND **SPEEDS UP** THE NERVE IMPULSE
RED BLOOD CELL	TRANSPORT OF OXYGEN	– **BICONCAVE DISC** SHAPE **INCREASES SURFACE AREA** FOR MORE EFFICIENT DIFFUSION OF OXYGEN – CONTAINS **HAEMOGLOBIN** WHICH **JOINS WITH OXYGEN** TO TRANSPORT IT – CONTAINS **NO NUCLEUS** TO **INCREASE AMOUNT OF SPACE** AVAILABLE FOR HAEMOGLOBIN INSIDE CELL
SPERM CELL	REPRODUCTION	– THE HEAD CONTAINS THE GENETIC MATERIAL FOR FERTILISATION IN A **HAPLOID NUCLEUS** (CONTAINING HALF THE NORMAL NUMBER OF CHROMOSOMES) – THE **ACROSOME** IN THE HEAD CONTAINS **DIGESTIVE ENZYMES** SO THAT A SPERM CAN PENETRATE AN EGG – THE MID–PIECE IS PACKED WITH **MITOCHONDRIA** TO RELEASE **ENERGY** NEEDED TO SWIM AND FERTILISE THE EGG – THE **TAIL** ENABLES THE SPERM TO **SWIM**
EGG CELL (OVUM)	REPRODUCTION	– CONTAINS A **LOT OF CYTOPLASM** WHICH HAS **NUTRIENTS** FOR THE GROWTH OF THE EARLY EMBRYO – **HAPLOID NUCLEUS** CONTAINS THE GENETIC MATERIAL FOR FERTILISATION – CELL MEMBRANE **CHANGES AFTER FERTILISATION** BY A SINGLE SPERM SO THAT **NO MORE SPERM** CAN ENTER

2 ORGANISATION OF THE ORGANISM

2.2 SPECIALISED CELLS cont...

YOUR NOTES

Examples of specialised cells in plants:

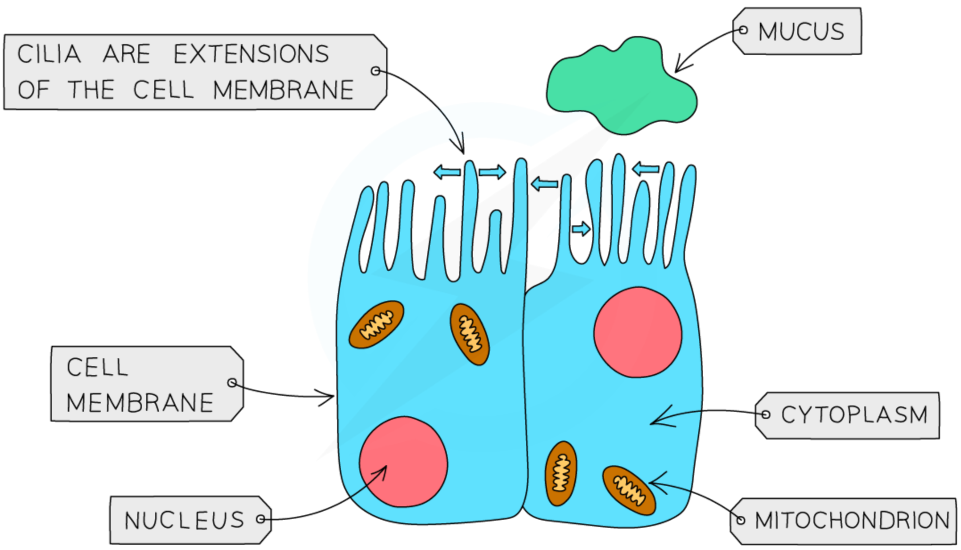
ROOT HAIR CELL	ABSORPTION OF WATER AND MINERAL IONS FROM SOIL	– **ROOT HAIR** INCREASES **SURFACE AREA** OF CELL TO ENSURE **MAXIMUM ABSORPTION** OF WATER AND MINERAL IONS – WALLS ARE **THIN** TO ENSURE WATER MOVES THROUGH **QUICKLY** – NO CHLOROPLASTS PRESENT
XYLEM VESSEL	CONDUCTION OF WATER THROUGH THE PLANT; SUPPORT OF THE PLANT	– **NO TOP AND BOTTOM WALLS** BETWEEN XYLEM VESSELS, SO THERE IS A **CONTINUOUS COLUMN OF WATER** RUNNING THROUGH THEM – CELLS ARE **DEAD** WITHOUT ORGANELLES OR CYTOPLASM TO ALLOW **FREE PASSAGE OF WATER** – THEIR WALLS BECOME **THICKENED** WITH A SUBSTANCE CALLED **LIGNIN** WHICH MEANS THEY ARE ABLE TO HELP **SUPPORT** THE PLANT
PALISADE MESOPHYLL CELL	PHOTOSYNTHESIS	– **COLUMN SHAPED** TO MAXIMIZE ABSORPTION OF SUNLIGHT AND **FIT AS MANY IN A LAYER** UNDER THE UPPER EPIDERMIS OF THE LEAF AS POSSIBLE – CONTAINS **MANY CHLOROPLASTS** FOR MAXIMUM **PHOTOSYNTHESIS**

2 ORGANISATION OF THE ORGANISM

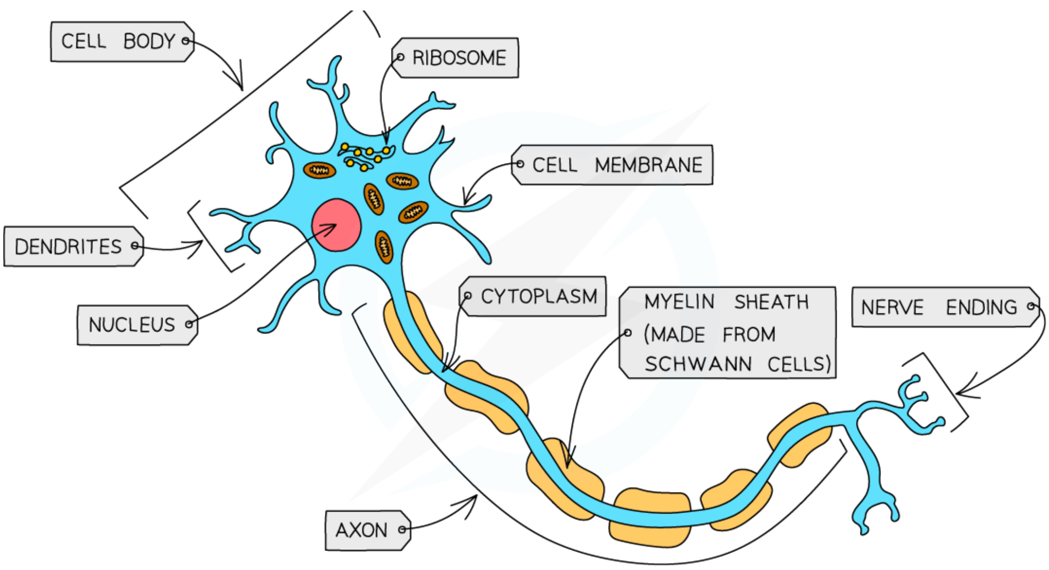
2.2 SPECIALISED CELLS cont...

YOUR NOTES

Diagrams of specialised cells in animals:



Ciliated cell

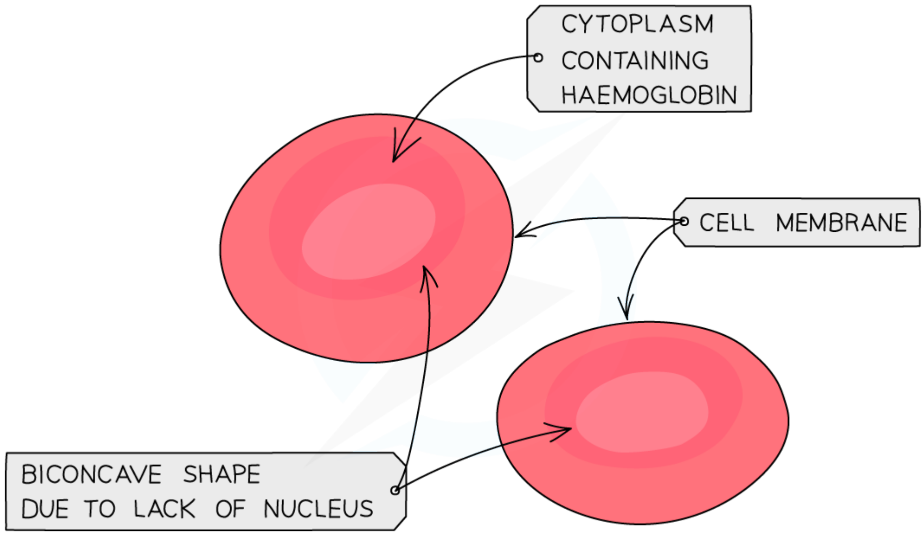


Nerve cell

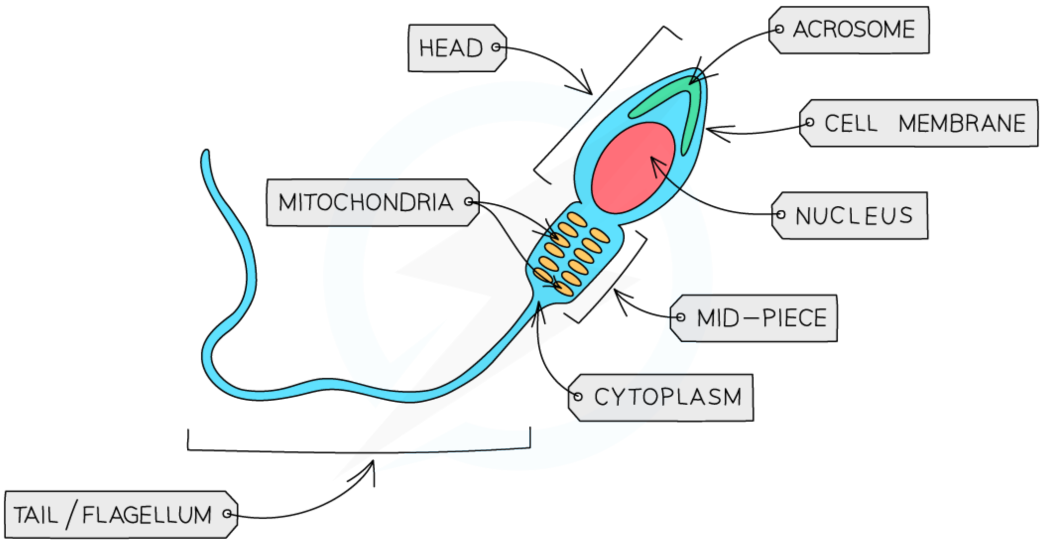
2 ORGANISATION OF THE ORGANISM

YOUR NOTES

2.2 SPECIALISED CELLS cont...



Red blood cell

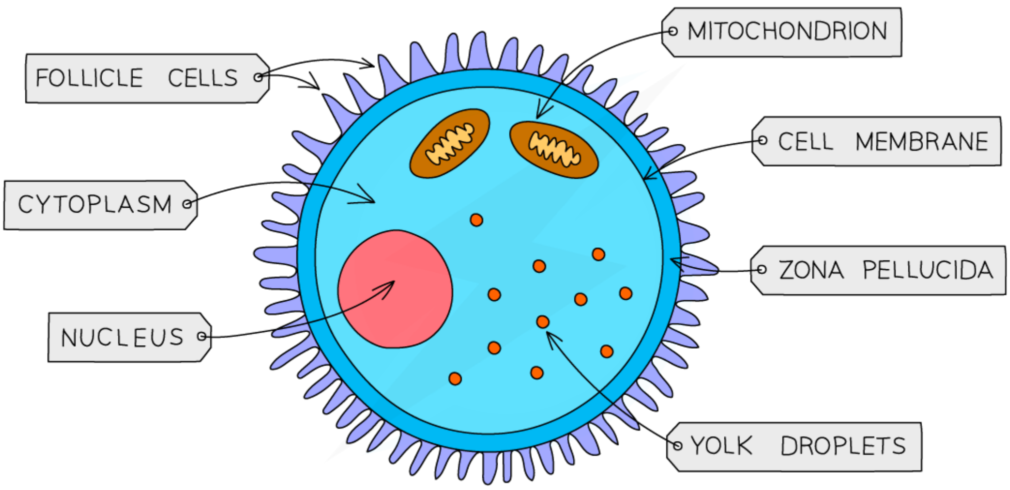


Sperm cell

2 ORGANISATION OF THE ORGANISM

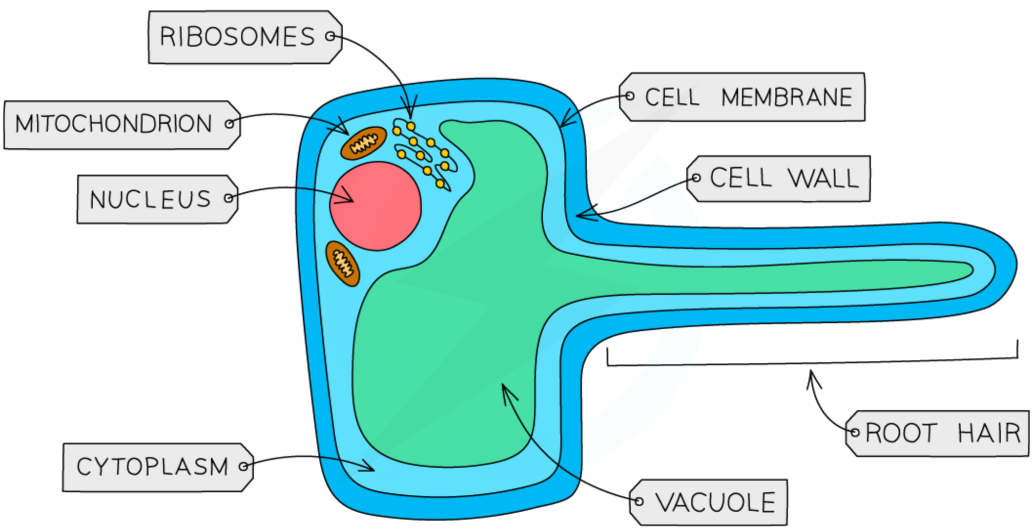
2.2 SPECIALISED CELLS cont...

YOUR NOTES



Egg cell

Diagrams of specialised cells in plants:

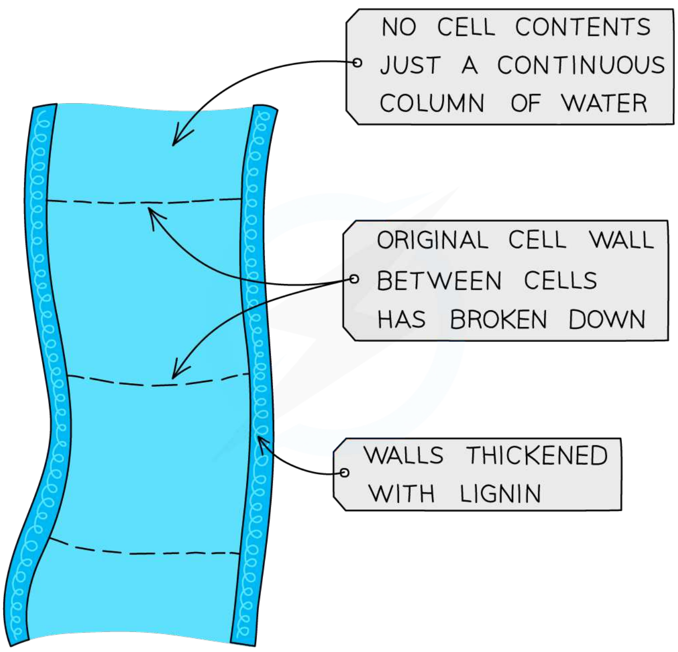


Root hair cell

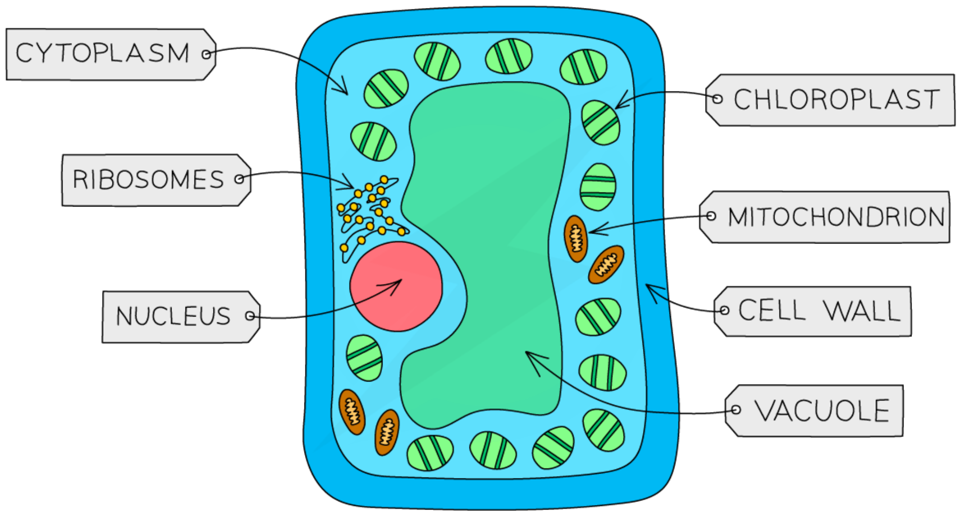
2 ORGANISATION OF THE ORGANISM

2.2 SPECIALISED CELLS cont...

YOUR NOTES



Xylem structure



Palisade mesophyll cell

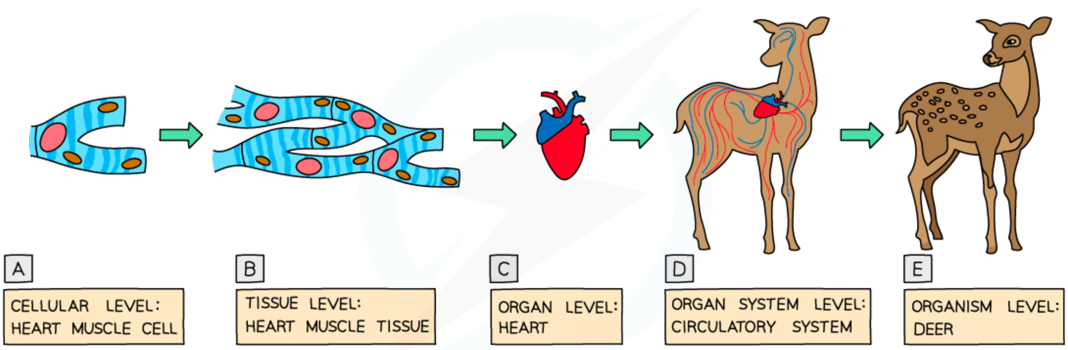
2 ORGANISATION OF THE ORGANISM

2.3 LEVELS OF ORGANISATION

YOUR NOTES

Cells, Tissues, Organs & Organ Systems

LEVEL	DESCRIPTION
CELLS	BASIC FUNCTIONAL AND STRUCTURAL UNITS IN A LIVING ORGANISM
TISSUES	GROUPS OF CELLS OF SIMILAR STRUCTURE WORKING TOGETHER TO PERFORM THE SAME FUNCTION
ORGANS	MADE FROM DIFFERENT TISSUES WORKING TOGETHER TO PERFORM SPECIFIC FUNCTIONS
ORGAN SYSTEMS	GROUPS OF ORGANS WITH RELATED FUNCTIONS, WORKING TOGETHER TO PERFORM BODY FUNCTIONS



Levels of organisation

EXAM TIP

Most incorrect answers here come from not being able to identify a tissue, so it's worth making sure you understand and remember that **tissues are always made up of only one type of cell**.

2 ORGANISATION OF THE ORGANISM

2.3 LEVELS OF ORGANISATION cont...

YOUR NOTES

ORGAN SYSTEM	ORGANS	TISSUE EXAMPLES
SHOOT SYSTEM	LEAF, STEM, FLOWER, FRUIT	– EPIDERMIS MESOPHYLL – XYLEM – PHLOEM
ROOT SYSTEM	ROOT, TUBER	– XYLEM – PHLOEM – GROUND TISSUE
DIGESTIVE SYSTEM	OESOPHAGUS, STOMACH, SMALL INTESTINE, LARGE INTESTINE	– MUSCLE – CONNECTIVE – NERVE – EPITHELIAL
CIRCULATORY SYSTEM	HEART, VEINS, ARTERIES	– MUSCLE – CONNECTIVE – NERVE – EPITHELIAL
IMMUNE SYSTEM	THYMUS, SPLEEN	– BONE MARROW
RESPIRATORY SYSTEM	TRACHEA, BRONCHI, LUNGS	– CONNECTIVE – MUSCLE – EPITHELIAL
EXCRETORY SYSTEM	LIVER, KIDNEY, SKIN, LUNGS	– MUSCLE – CONNECTIVE – EPITHELIAL – NERVE
NERVOUS SYSTEM	BRAIN, SPINAL CORD	– NERVE
REPRODUCTIVE SYSTEM	OVARY, CERVIX, UTERUS, VAGINA, TESTES, PENIS	– MUSCLE – CONNECTIVE – NERVOUS – ERECTILE

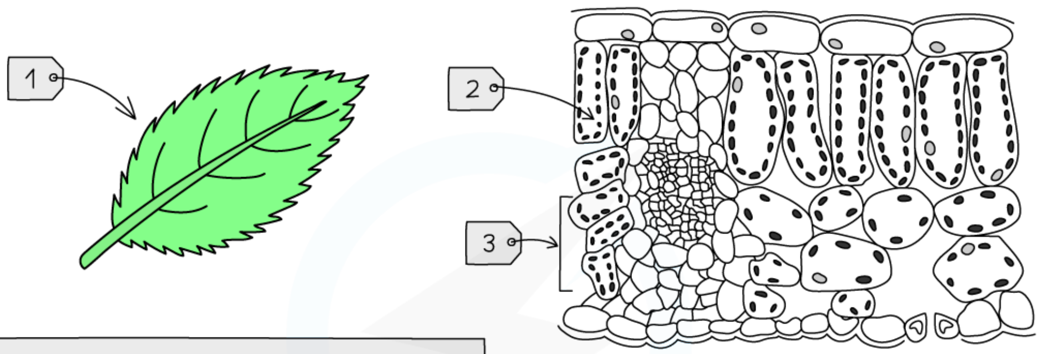
2 ORGANISATION OF THE ORGANISM

2.3 LEVELS OF ORGANISATION cont...

YOUR NOTES

- Your syllabus states that you should be able to identify the different levels of organisation in drawings, diagrams and images of familiar material
- An example of this is shown in the exam question below

THE DIAGRAMS SHOW A LEAF AND ITS INTERNAL STRUCTURE



WHAT ARE THE LEVELS OF ORGANISATION OF THE LABELLED STRUCTURES?

	1	2	3
A	CELL	TISSUE	ORGAN SYSTEM
B	ORGAN	CELL	TISSUE
C	ORGAN SYSTEM	TISSUE	CELL
D	TISSUE	CELL	ORGAN

Typical levels of organisation question

EXTENDED EXAM TIP

Your syllabus requires you to identify the different levels of organisation in drawings, diagrams and images of **unfamiliar material**, ie structures you may not have seen before. In order to ensure the best chance of success, make sure you are very clear on the difference between a cell, a tissue and an organ and practise identifying these in past paper questions (they come up most frequently in the **multiple choice paper**).

2 ORGANISATION OF THE ORGANISM

2.4 SIZE OF SPECIMENS

YOUR NOTES

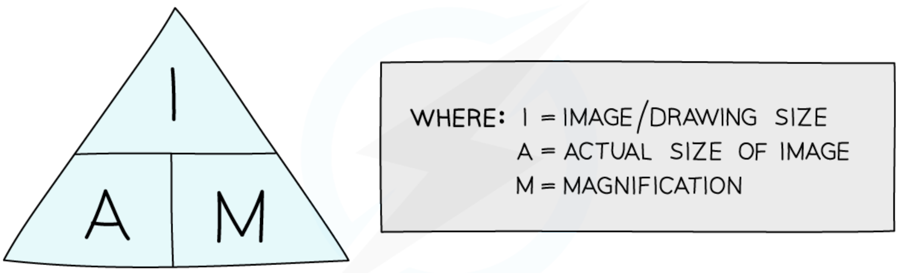
Calculating Magnification & Specimen Size: Basics

Calculating magnification and specimen size using millimetres as units

- Magnification is calculated using the following equation:

$$\text{MAGNIFICATION} = \frac{\text{IMAGE (DRAWING) SIZE}}{\text{ACTUAL SIZE}}$$

- A better way to remember the equation is using an **equation triangle**:



Magnification equation

- Rearranging the equation to find things other than the magnification becomes easy when you remember the triangle - **whatever you are trying to find, place your finger over it and whatever is left is what you do**, so:
    - Magnification = image size / actual size
    - Actual size = image size / magnification
    - Image size = magnification x actual size
- Remember magnification **does not have any units** and is just written as 'x 10' or 'x 5000'

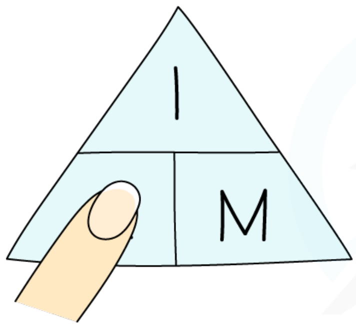
2 ORGANISATION OF THE ORGANISM

YOUR NOTES

- Let's look at an example:

  An **image** of an animal cell is 30 mm in size and it has been **magnified** by a factor of x 3000.
  What is the **actual** size of the cell?

  To find the **actual** size of the cell:



$$A = \frac{I}{M} = \frac{30\,\text{mm}}{3000} = 0.01\,\text{mm}$$

$$0.01\,\text{mm} = 10\,\mu\text{m}$$

Worked example using the magnification equation

EXAM TIP

This skill most frequently comes up in paper 5 and 6 (although it also comes up in the multiple choice and occasionally the theory paper) and you will **definitely** have to calculate either magnification, drawing size or actual size in a least one paper. To ensure you do not lose marks:

1. **Always look at the units** that have been given in the question - if you are asked to measure something, most often you will be expected to measure it in millimetres NOT in centimetres - double check the question to see!
2. **Learn the equation triangle** for magnification and write it on the page straight away
3. Don't forget that **magnification has NO UNITS** - students often lose a mark because they put one in

2 ORGANISATION OF THE ORGANISM

2.4 SIZE OF SPECIMENS cont...

YOUR NOTES

EXTENDED ONLY

Calculating Magnification & Size of Specimens

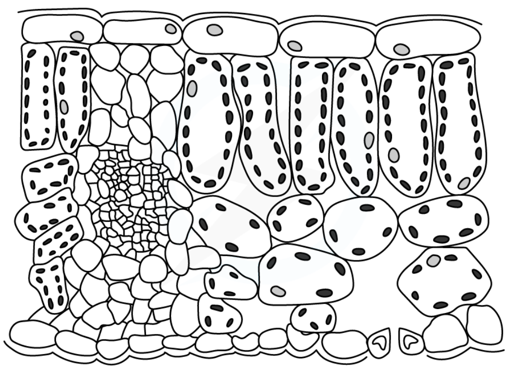
Using millimetres and micrometres as units

- The table below shows how millimetres are related to two other measures of length

UNIT	LENGTH IN mm
1 CENTIMETRE (cm)	10 mm
1 MILLIMETRE (mm)	1 mm
1 MICROMETRE (m)	0.001 mm

- What this basically means is that **1mm = 1000μm** and **1cm = 10,000μm**
- This usually comes up in questions where you have **two different units** and you need to ensure that you **convert them both into the same unit** before proceeding with the calculation
- For example:

THE ACTUAL THICKNESS OF THE LEAF BELOW IS 2000μm, BUT THE IMAGE SIZE OF THE LEAF IN THE DIAGRAM IS 50mm



WHAT IS THE MAGNIFICATION OF THE DIAGRAM?

A x0.025 B x25 C x100 D x100 000

Example extended magnification question

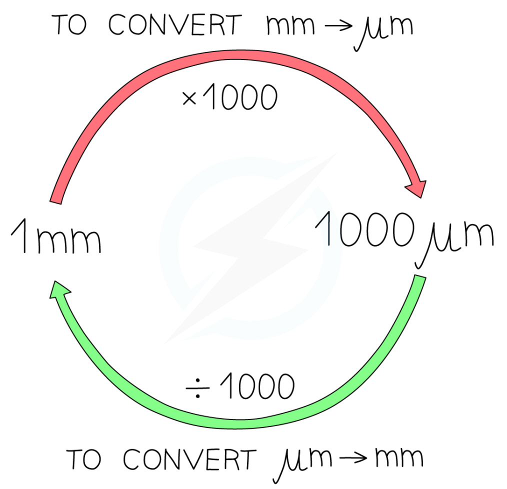
2 ORGANISATION OF THE ORGANISM

YOUR NOTES

EXTENDED ONLY cont...

- Remember 1mm = 1000μm
- 2000 / 1000 = 2 so the actual thickness of the leaf is 2mm and the drawing thickness is 50mm
- Magnification = image size / actual size = 50 / 2 = 25
- So the magnification is x 25 (NO UNITS)

The following diagram may help with unit conversion between mm and μm:



Converting units

EXAM TIP

If you are given a question with **two different units** in it, make sure you **convert them to the same unit** before doing your calculation.
If you don't, there is a good chance that your answer will be the same as one of the incorrect options in a multiple choice question so you may think you got it right when, in fact, you haven't!

> NOW TRY SOME EXAM QUESTIONS

2 ORGANISATION OF THE ORGANISM

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which row of the table below correctly matches functions to some of the components in a root hair cell?

	cell wall	cell membrane	mitochondria
A	support	active transport	energy release
B	energy release	active transport	nutrition
C	support	active transport	nutrition
D	active transport	support	energy release

QUESTION 2

Which of the following orders would be correct showing the size of structures from biggest to smallest?

A chromosome → red blood cell → stomach → gene → nucleus

B stomach → red blood cell → gene → chromosome

C stomach → red blood cell → nucleus → chromosome → gene

D gene → chromosome → red blood cell → stomach

QUESTION 3

A list of subcellular structures is given below.

1 Nucleus

2 Ribosomes

3 Vacuole

4 Chloroplast

A plant cell and an animal cell are observed under a light microscope.

Which of the above structures would always be visible in a plant cell?

A 1, 2 & 4 **B** 1, 3 & 4 **C** 1 & 3 only **D** 1 & 4 only

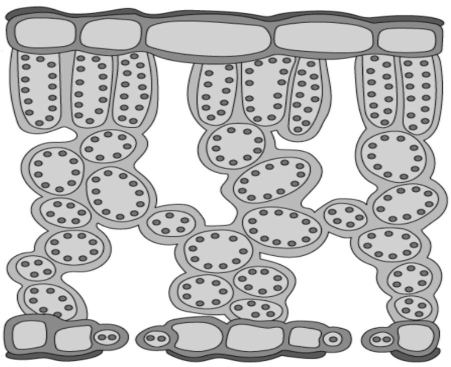
2 ORGANISATION OF THE ORGANISM

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 4

Some of the processes carried out by living organisms are illustrated in the diagram below.



What would be the correct magnification of the image?

A x 5

B x 184

C x 0.184

D x 500

QUESTION 5

Which of the following terms would be correct to describe a leaf, a root and stem?

A Cell

B Tissue

C Organ

D Organ system

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

Head to savemyexams.co.uk
for more questions and revision notes

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

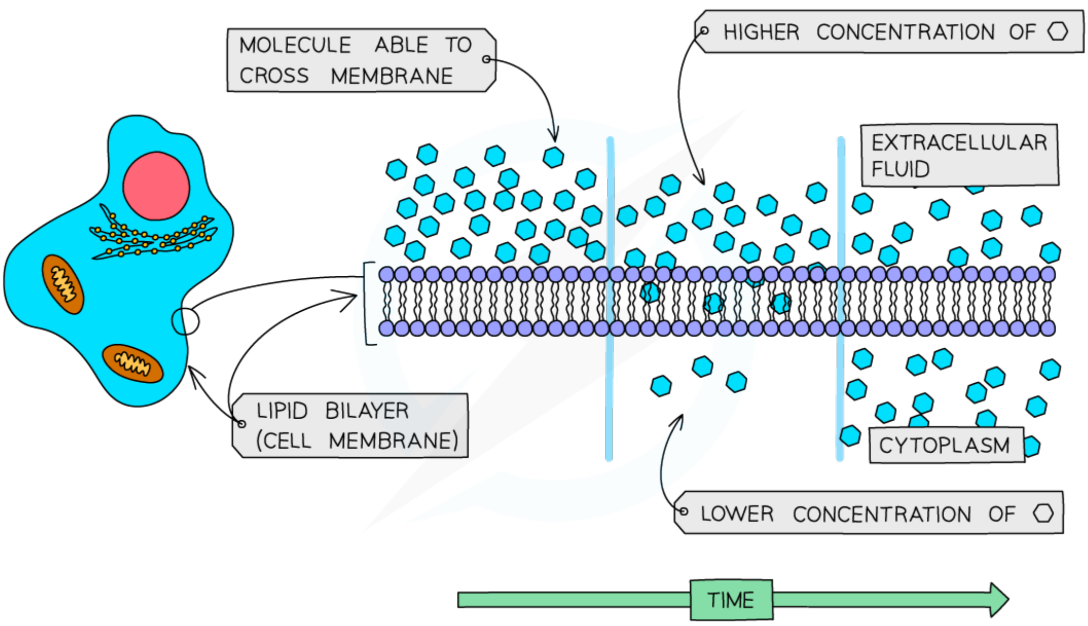
CONTENTS:

VIEW EXAM QUESTIONS

3.1 DIFFUSION

Diffusion in Living Organisms

- **Diffusion** is the movement of molecules from a region of its **higher** concentration to a region of its **lower** concentration
- Molecules move **down** a **concentration gradient**, as a result of their **random movement**



Diffusion across the cell membrane

3 MOVEMENT IN & OUT OF CELLS

3.1 DIFFUSION cont...

YOUR NOTES

- For **living cells**, the principle of the movement down a concentration gradient is the same, but the cell is surrounded by a **cell membrane** which can restrict the free movement of the molecules
- The cell membrane is a **partially permeable membrane** – this means it allows some molecules to cross easily, but others with difficulty or not at all
- The simplest sort of selection is based on the **size** of the molecules
- Diffusion helps living organisms to:
  - obtain many of their **requirements**
  - get rid of many of their **waste products**
  - carry out **gas exchange** for **respiration**

Examples of diffusion in living organisms

You will need to learn examples of substances that organisms obtain by diffusion. Don't forget that plants require oxygen for respiration at all times, as well as carbon dioxide for photosynthesis when conditions for photosynthesis are right (e.g. enough light and a suitable temperature).

SITE	MOLECULES MOVING	FROM	TO
SMALL INTESTINE	DIGESTED FOOD PRODUCTS – GLUCOSE, AMINO ACIDS, FATTY ACIDS AND GLYCEROL ETC.	LUMEN OF SMALL INTESTINE	BLOOD / LYMPH IN VILLI FOUND COVERING SMALL INTESTINE WALLS
LEAF	OXYGEN	AIR SPACES BETWEEN MESOPHYLL CELLS	MITOCHONDRIA IN ALL CELLS
LEAF	CARBON DIOXIDE	AIR SPACES BETWEEN MESOPHYLL CELLS	CHLOROPLASTS IN MESOPHYLL CELLS
LEAF	WATER VAPOUR	STOMATAL PORES	AIR OUTSIDE STOMATA
LUNGS	OXYGEN	ALVEOLAR AIR SPACE	BLOOD IN CAPILLARIES AROUND ALVEOLI
LUNGS	CARBON DIOXIDE	BLOOD IN CAPILLARIES AROUND ALVEOLI	ALVEOLAR AIR SPACE

Examples of diffusion in living organisms

3 MOVEMENT IN & OUT OF CELLS

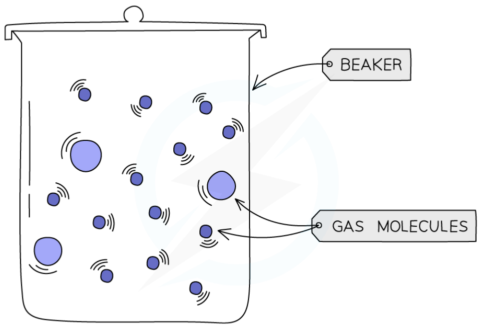
3.1 DIFFUSION cont...

YOUR NOTES

EXTENDED ONLY

Brownian Motion

- All particles move randomly at all times
- This is known as Brownian motion
- The energy for diffusion comes from the kinetic energy of this random movement of molecules and ions

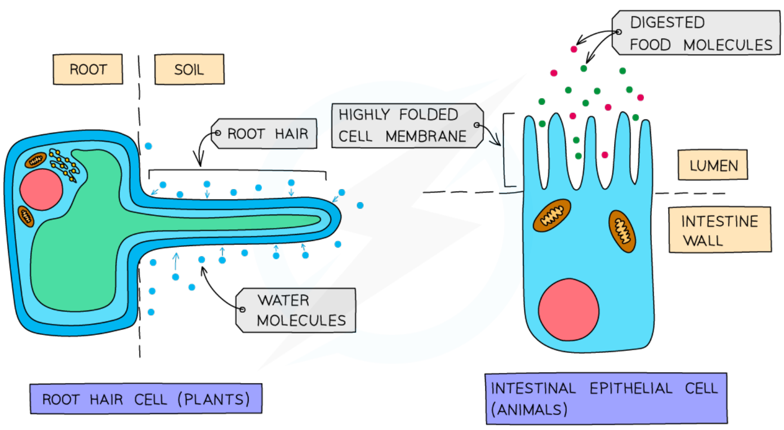


Brownian motion

Factors that Influence Diffusion

Surface area to volume ratio

- The **bigger** a cell or structure is, the **smaller its surface area to volume ratio** is, slowing down the rate at which substances can move across its surface
- Many cells which are adapted for diffusion have **increased surface area** in some way – eg root hair cells in plants (which absorb water and mineral ions) and cells lining the ileum in animals (which absorb the products of digestion)



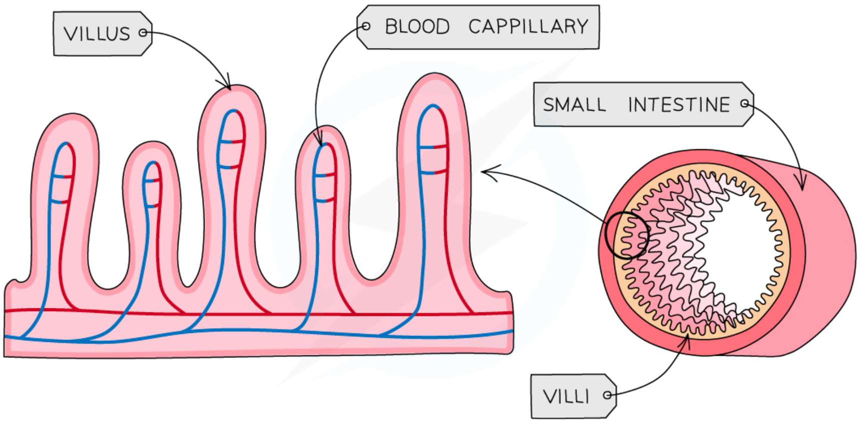
Cell adaptations for diffusion

3 MOVEMENT IN & OUT OF CELLS

3.1 DIFFUSION cont...

YOUR NOTES

EXTENDED ONLY cont...



The highly folded surface of the small intestine increases its surface area

Three factors that affect the rate of diffusion and therefore the movement of molecules through membranes:

Distance

- The **smaller the distance** molecules have to travel the **faster** transport will occur
- This is why blood capillaries and alveoli have walls which are only **one cell thick**, ensure the rate of diffusion across them is as fast as possible

Temperature

- The **higher the temperature**, the **faster** molecules move as they have more energy
- This results in **more collisions against the cell membrane** and therefore a faster rate of movement across them

Concentration Gradient

- The **greater the difference in concentration** either side of the membrane, the faster movement across it will occur
- This is because on the side with the higher concentration, **more random collisions against the membrane** will occur

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

3.1 DIFFUSION cont...

EXAM TIP

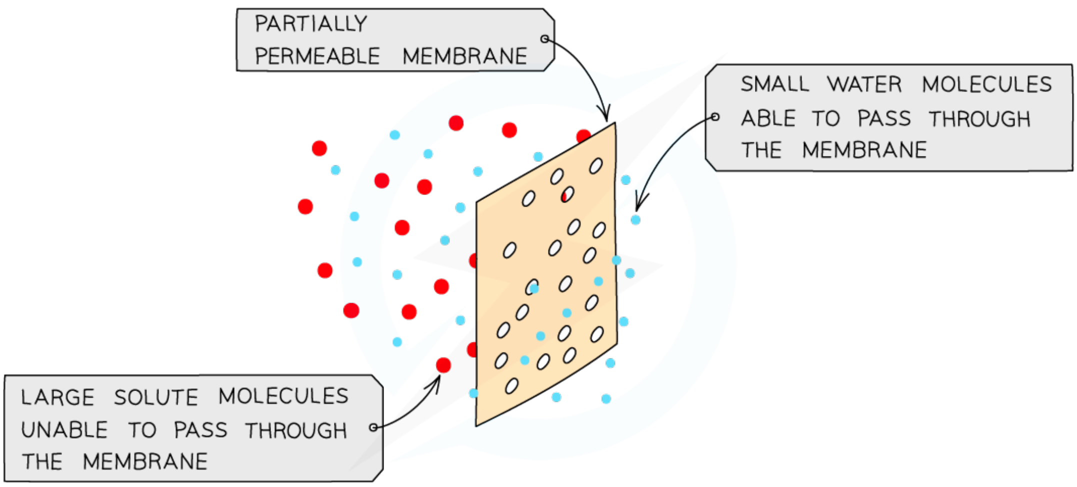
You should have carried out investigations into the factors that influence the rate of diffusion and so should:

- be able to use the information above to explain experimental results in an exam
- and plan and carry out an experiment which can investigate the effect of one of these factors.

3.2 OSMOSIS

Osmosis Theory: Basics

- All cells are surrounded by a cell membrane which is **partially permeable**
- **Water** can move in and out of cells by osmosis
- Osmosis is the diffusion of water molecules from a **dilute solution** (high concentration of water) to a **more concentrated** solution (low concentration of water) across a **partially permeable membrane**
- In doing this, water is moving down its **concentration gradient**
- The cell membrane is partially permeable which means it allows **small molecules** (like water) through but not larger molecules (like solute molecules)



Osmosis and the partially permeable membrane

3 MOVEMENT IN & OUT OF CELLS

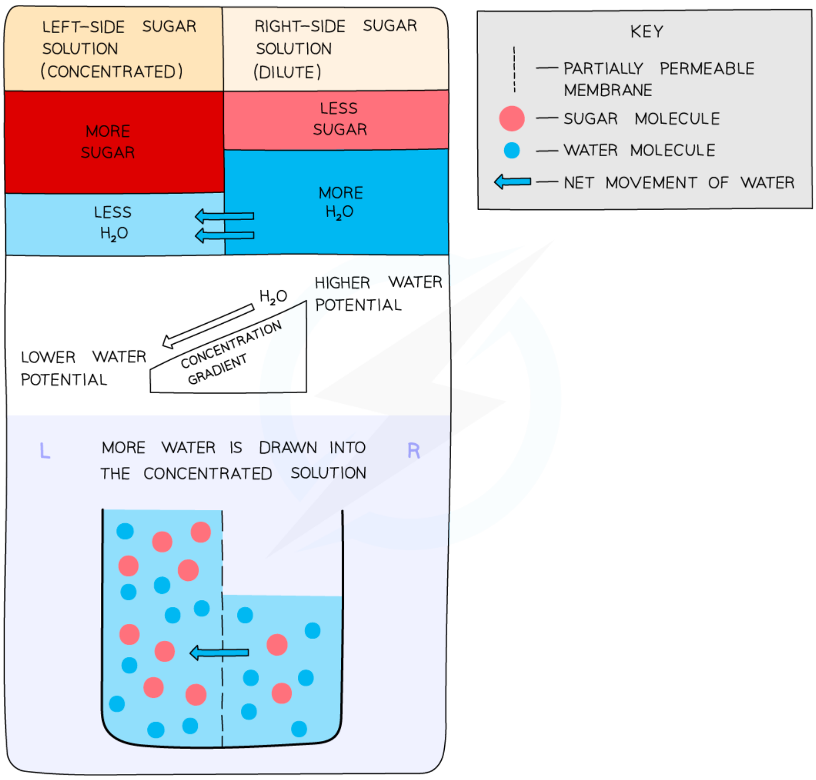
3.2 OSMOSIS cont...

YOUR NOTES

EXTENDED ONLY

Osmosis Theory

- Osmosis is the net movement of water molecules from a region of **higher water potential** (dilute solution) to a region of **lower water potential** (concentrated solution), through a **partially permeable membrane**.
- It can get a little confusing to talk about the 'concentration of water' when we also talk about solutions being 'concentrated' (having a lot of solute in them), so instead we can say that a **dilute solution** has a **high water potential** (the right hand side of the diagram below) and a **concentrated solution** has a **low water potential** (the left-hand side of the diagram below)



How osmosis works

EXAM TIP

The best explanations to do with osmosis will refer to water potential, so if you are aiming for a 7, 8 or 9 you will need to understand the concept and use it in your explanations.

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

3.2 OSMOSIS cont...

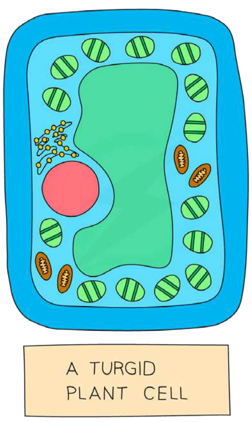
Osmosis Experiments: Basics

- The most common osmosis practical involves cutting **cylinders of potato** and placing them into **distilled water** and **sucrose solutions** of increasing concentration
- The potato cylinders are weighed before placing into the solutions
- They are left in the solutions for 20 – 30 minutes and then removed, dried to remove excess liquid and reweighed
- The potato cylinder in the distilled water will have **increased its mass the most**
- The potato cylinder in the strongest sucrose concentration will have **decreased its mass the most**
- If there is a potato cylinder that has not increased or decreased in mass, it means there was **no overall movement of water** into or out of the potato cells

EXTENDED ONLY

Osmosis Experiments

- The most common osmosis practical involves cutting **cylinders of potato** and placing them into **distilled water** and **sucrose solutions** of increasing concentration
- The potato cylinders are weighed before placing into the solutions
- They are left in the solutions for 20 – 30 minutes and then removed, dried to remove excess liquid and reweighed
- The potato cylinder in the distilled water will have **increased its mass the most** as there is a greater concentration gradient in this tube between the distilled water (high water potential) and the potato cells (lower water potential)
- This means more water molecules will move **into** the potato cells by **osmosis**, pushing the cell membrane against the cell wall and so increasing the **turgor pressure** in the cells which makes them **turgid** – the potato cylinders will feel hard



A turgid plant cell

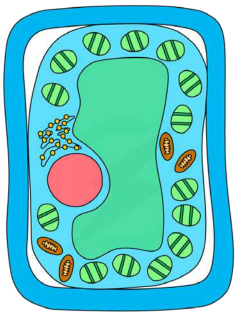
3 MOVEMENT IN & OUT OF CELLS

3.2 OSMOSIS cont...

YOUR NOTES

EXTENDED ONLY cont...

- The potato cylinder in the strongest sucrose concentration will have **decreased its mass** the most as there is a greater concentration gradient in this tube between the potato cells (higher water potential) and the sucrose solution (lower water potential)
- This means more water molecules will move **out of** the potato cells by **osmosis**, making them **flaccid** and decreasing the mass of the cylinder – the potato cylinders will feel floppy
- If looked at underneath the microscope, cells from this potato cylinder might be **plasmolysed**, meaning the cell membrane has pulled away from the cell wall



A PLASMOLYSED PLANT CELL

A plasmolysed plant cell

- If there is a potato cylinder that has not increased or decreased in mass, it means there was **no overall net movement of water** into or out of the potato cells
- This is because the solution that cylinder was in was the same concentration as the solution found in the cytoplasm of the potato cells, so there was **no concentration gradient**

EXAM TIP

Questions involving osmosis experiments are common and you should be able to use your knowledge of these processes to explain the results.

Don't worry if it is an experiment you haven't done – simply figure out where the higher concentration of water molecules is – this is the solution with the higher water potential – and explain which way the molecules move due to the differences in water potential.

3 MOVEMENT IN & OUT OF CELLS

3.2 OSMOSIS cont...

YOUR NOTES

Importance of Osmosis in Tissues

- When water moves into a plant cell, the vacuole gets bigger, **pushing the cell membrane against the cell wall**
- Water entering the cell by osmosis makes the cell **rigid and firm**
- This is important for plants as the effect of all the cells in a plant being firm is to **provide support and strength for the plant** – making the plant stand upright with its leaves held out to catch sunlight
- The pressure created by the **cell wall** stops too much water entering and **prevents the cell from bursting**
- If plants do not receive enough water the cells cannot remain rigid and firm (turgid) and the plant **wilts**

EXTENDED ONLY

Osmosis in Tissues

In plant tissues

- Plant cells that are **turgid** are full of water and contain a **high turgor pressure** (the pressure of the cytoplasm pushing against the cell wall)
- This pressure **prevents any more water entering** the cell by osmosis, even if it is in a solution that has a higher water potential than inside the cytoplasm of the cells
- This **prevents** the plant cells from taking in too much water and **bursting**
- Plant roots are surrounded by soil water and the cytoplasm of root cells has a **lower water potential** than the soil water
- This means water will move across the cell membrane of root hair cells **into the root** by **osmosis**
- The water moves across the root from cell to cell by osmosis until it reaches the xylem
- Once they enter the xylem they are transported away from the root by the transpiration stream, helping to maintain a concentration gradient between the root cells and the xylem vessels

3 MOVEMENT IN & OUT OF CELLS

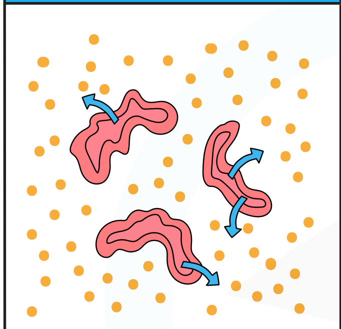
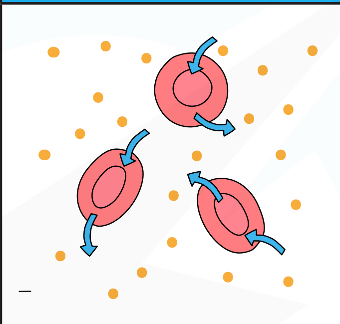
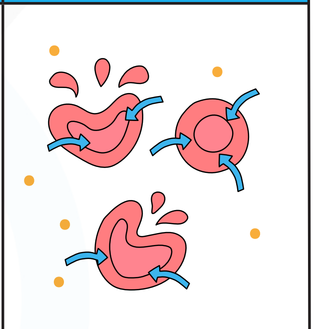
3.2 OSMOSIS cont...

YOUR NOTES

EXTENDED ONLY cont...

In animal tissues

- **Animal cells** also lose and gain water as a result of osmosis
- As animal cells **do not have a supporting cell wall**, the results on the cell are more severe
- If an animal cell is placed into a **strong sugar solution** (with a lower water potential than the cell), it will lose water by osmosis and become **crenated** (shrivelled up)
- If an animal cell is placed into **distilled water** (with a higher water potential than the cell), it will gain water by osmosis and, as it **has no cell wall to create turgor pressure**, will continue to do so until the cell membrane is stretched too far and it **bursts**

HYPERTRONIC SOLUTION	IOSOTONIC SOLUTION	HYPOTONIC SOLUTION
		
– RED BLOOD CELLS HAVE HIGHER WATER POTENTIAL THAN SOLUTION – NET MOVEMENT OF WATER OUT – SHRIVELLED CELLS	– WATER POTENTIAL EQUAL BETWEEN RED BLOOD CELL AND SOLUTION – NO NET MOVEMENT OF WATER – NORMAL CELLS	– RED BLOOD CELLS HAVE LOWER WATER POTENTIAL THAN SOLUTION – NET MOVEMENT OF WATER IN – CELLS SWELL. MAY LYSE (BURST)

KEY
= MOVEMENT OF WATER BY OSMOSIS
= SOLUTE

Effect of osmosis on animal cells

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

3.3 ACTIVE TRANSPORT

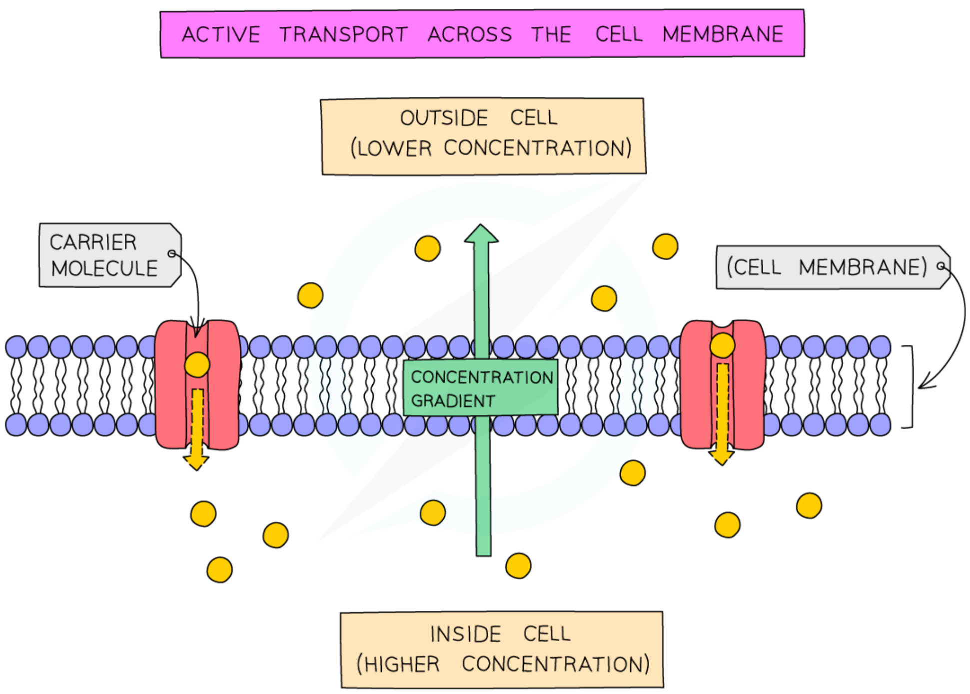
What is Active Transport?

- Active transport is the movement of particles through a cell membrane from a region of **lower concentration** to a region of **higher concentration** using **energy** from **respiration**

EXTENDED ONLY

Examples of Active Transport

- Energy is needed because particles are being moved **against a concentration gradient**, in the opposite direction from which they would naturally move (by diffusion)
- Examples of active transport include:
    - **uptake of glucose** by epithelial cells in the villi of the small intestine and by kidney tubules in the nephron
    - **uptake of ions** from soil water by root hair cells in plants



Active transport across the cell membrane

3 MOVEMENT IN & OUT OF CELLS

3.3 ACTIVE TRANSPORT cont...

YOUR NOTES

EXTENDED ONLY cont...

How Protein Molecules Move Particles

- Active transport works by using **carrier proteins embedded in the cell membrane** to pick up specific molecules and take them through the cell membrane **against their concentration gradient**:

1. Substance combines with **carrier protein molecule** in the cell membrane
2. Carrier transports substances across membrane using **energy from respiration** to give them the kinetic energy needed to change shape and move the substance through the cell membrane
3. Substance released into cell

> NOW TRY SOME EXAM QUESTIONS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Osmosis is:

A The active movement of molecules from a region of their lower concentration to a region of their higher concentration.

B The movement of water through a partially permeable membrane from a more concentrated to a more dilute solution

C Particles from a region of lower concentration to a region of higher concentration using energy from respiration.

D The movement of water through a partially permeable membrane from a more dilute to a more concentrated solution.

QUESTION 2

A group of students carried out an investigation into osmosis using cylinders of potato. The results from their experiment are shown below.

concentration of salt solution / mol dm^3	mass of potato cylinder at start / g	mass of potato cylinder after 24 hours / g
0.2	2.5	2.7

Which statement below correctly explains this change in length?

	movement of water	cause of this movement
A	out of the potato cells	The salt solution has a lower water potential than the potato cells.
B	out of the potato cells	The salt solution has a higher water potential than the potato cells.
C	into the potato cells	The salt solution has a lower water potential than the potato cells.
D	into the potato cells	The salt solution has a higher water potential than the potato cells.

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

How does a water vapour molecule move out of the air space of a leaf into the atmosphere on a dry day?

A Active transport

B Diffusion

C Evaporation

D Transpiration

QUESTION 4

Which of the following statements would be correct for both diffusion and osmosis?

	does not require energy from the cell	molecules must be separated by a partially permeable membrane	molecules more from a dilute to a more concentrated solution
A	✔	✔	✘
B	✘	✘	✔
C	✔	✘	✔
D	✔	✘	✔

3 MOVEMENT IN & OUT OF CELLS

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 5

A number of red blood cells were immersed in a pure solution of water before being observed under a microscope. There was a dramatic change in their appearance.

Which row of the table below correctly describes and explains what happened to the red blood cells?

	direction of water movement	from higher to lower concentration	from higher to lower water potential	effect
A	✔	✔	✘	cells burst
B	✘	✘	✔	cells burst
C	✔	✘	✔	cells shrink
D	✔	✘	✔	cells shrink

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4 BIOLOGICAL MOLECULES

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

4.1 CARBOHYDRATES, FATS & PROTEINS

Chemical Elements

- Most of the molecules in living organisms fall into three categories: **carbohydrates**, **proteins** and **lipids**
- These **all contain carbon** and so are described as **organic** molecules

MOLECULE	CHEMICAL ELEMENTS
CARBOHYDRATE	CARBON, OXYGEN AND HYDROGEN
PROTEIN	ALL CONTAIN CARBON, OXYGEN, HYDROGEN AND NITROGEN AND SOME CONTAIN SMALL AMOUNTS OF OTHER ELEMENTS SUCH AS SULPHUR
LIPID	CARBON, OXYGEN AND HYDROGEN

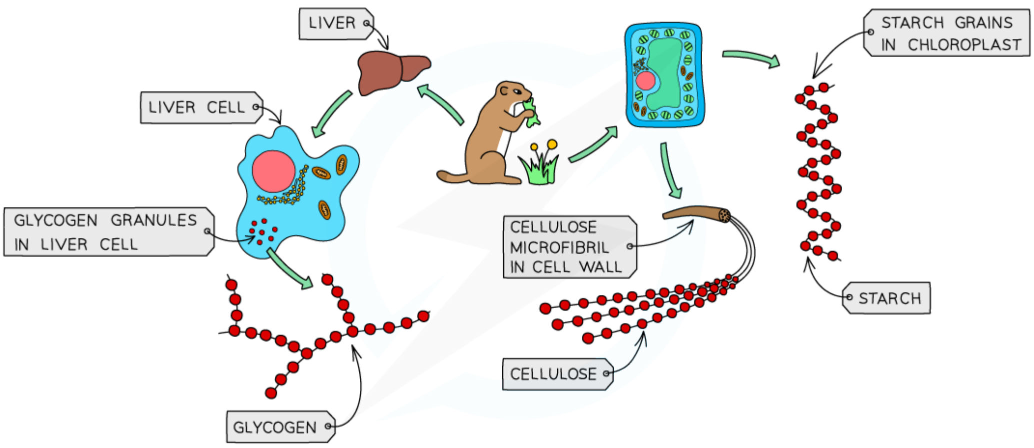
Carbohydrates

- Long chains of **simple sugars**
- **Glucose** is a simple sugar (a monosaccharide)
- When **2** glucose molecules join together **maltose** is formed (a disaccharide)
- When lots of glucose molecules join together **starch, glycogen or cellulose** can form (a polysaccharide)

4 BIOLOGICAL MOLECULES

4.1 CARBOHYDRATES, FATS & PROTEINS cont...

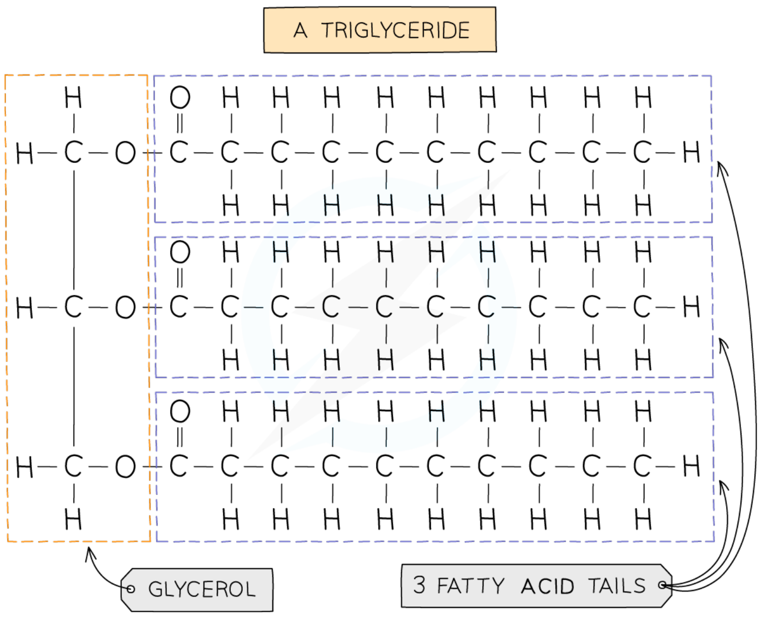
YOUR NOTES



Glycogen, cellulose and starch are all made from glucose molecules

Fats

- Most fats (lipids) in the body are made up of **triglycerides**
- Their basic unit is **one glycerol and three fatty acids**
- The fatty acids vary in size and structure
- Lipids are divided into **fats** (solids at room temperature) and **oils** (liquids at room temperature)



Structure of a triglyceride

4 BIOLOGICAL MOLECULES

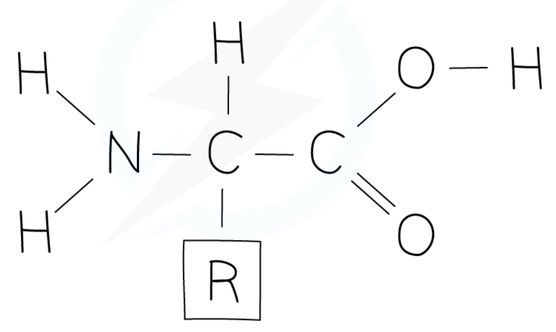
YOUR NOTES

4.1 CARBOHYDRATES, FATS & PROTEINS cont...

Proteins

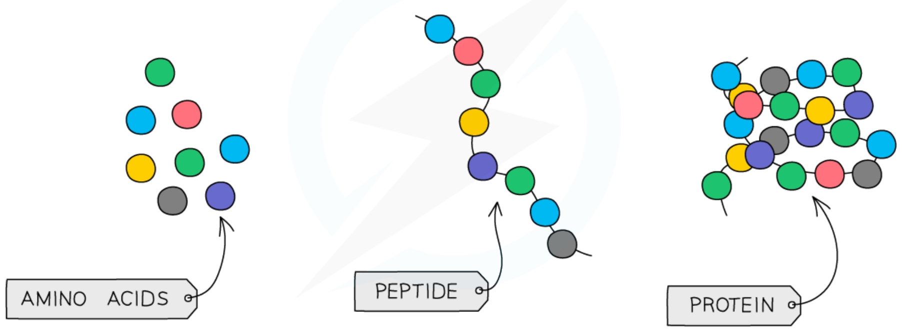
- Long chains of **amino acids**
- There are about 20 different amino acids
- They all contain the **same basic structure** but the **'R' group is different for each one**
- When amino acids are joined together a protein is formed
- The amino acids can be arranged in any order, resulting in hundreds of thousands of different proteins
- Even a small difference in the order of the amino acids results in a different protein being formed

GENERAL STRUCTURE OF AMINO ACIDS



General amino acid structure

HOW YOUR BODY USES AMINO ACIDS AS BUILDING BLOCKS



Amino acids join together to form proteins

4 BIOLOGICAL MOLECULES

4.1 CARBOHYDRATES, FATS & PROTEINS cont...

YOUR NOTES

EXTENDED ONLY

Protein Shape

- There are thousands of different proteins in the human body and other organisms
- Many of these proteins are **different shapes** and the shape often has an important effect on the function of the protein
- For example:
  - Enzymes have an area in them known as the **active site** – this is important as this is the place where another molecule fits into the enzyme in order for a reaction to take place
  - If the **shape of the active site does not match the shape of the molecule** that fits into it, the **reaction will not take place**
  - Every enzyme has a different shaped active site
  - **Antibodies** are proteins produced by certain types of **white blood cell** to attach to antigens on the surface of **pathogens**
  - The **shape of the antibody must match the shape of the antigen** so that it can attach to it and signal it for destruction
- The **different sequences of amino acids** cause the polypeptide chains to **fold in different ways** and this gives rise to the different shapes of proteins
- In this way every protein has a **unique 3-D shape** that enables it to carry out its function

4 BIOLOGICAL MOLECULES

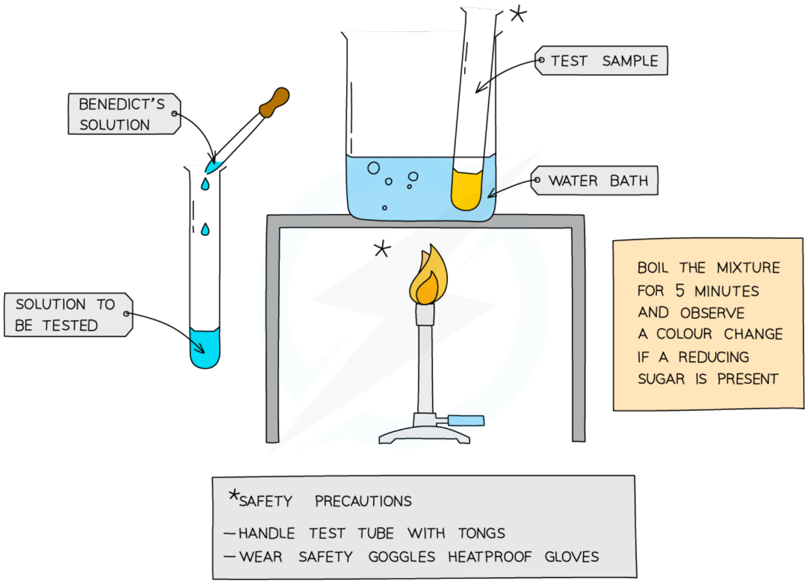
4.2 FOOD TESTS

YOUR NOTES

Describing Food Tests

Test for glucose (a reducing sugar)

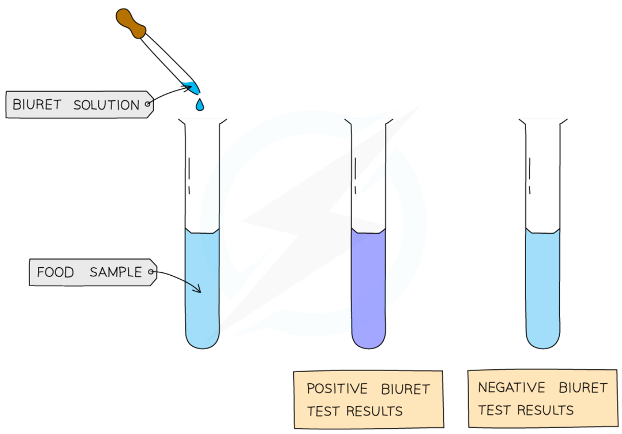
- Add **Benedict's solution** into sample solution in test tube
- **Heat** at 60 – 70 °c in water bath for **5 minutes**
- Take test tube out of water bath and observe the colour
- A positive test will show a colour change from **blue to orange or brick red**



The Benedict's test for glucose

Test for protein

- Add drops of biuret solution to the food sample
- A positive test will show a colour change from blue to violet / purple



The biuret test for protein

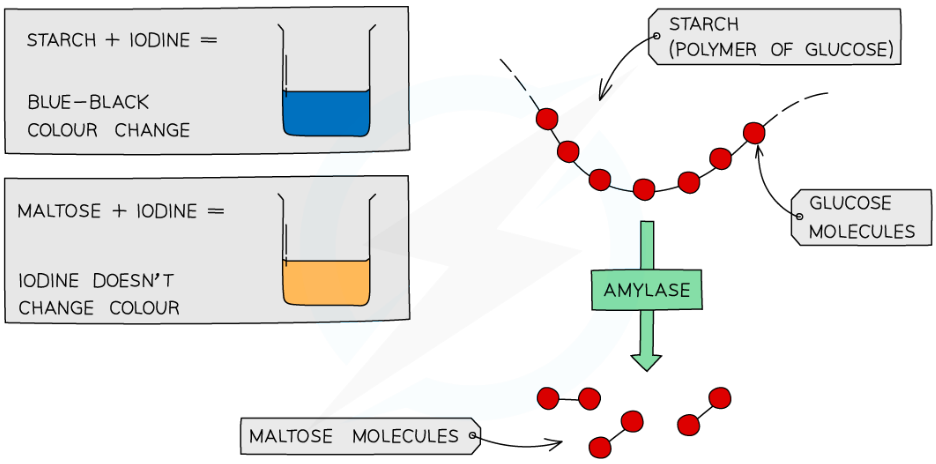
4 BIOLOGICAL MOLECULES

4.2 FOOD TESTS cont...

YOUR NOTES

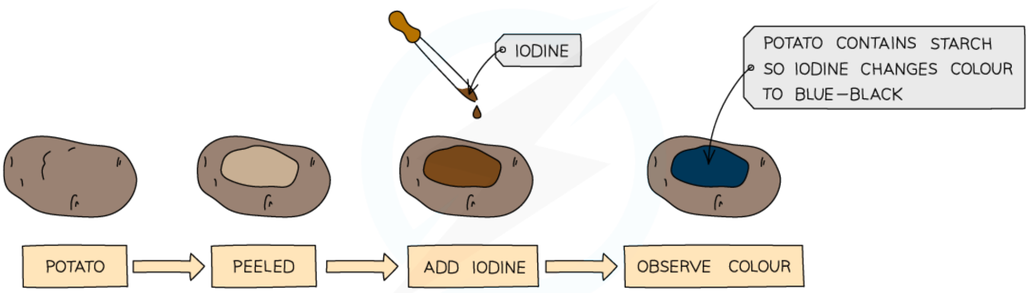
Test for starch using iodine

We can use iodine to test for the presence or absence of starch in a food sample.



The iodine test for starch

- Add drops of iodine solution to the food sample
- A positive test will show a colour change from orange–brown to blue-black



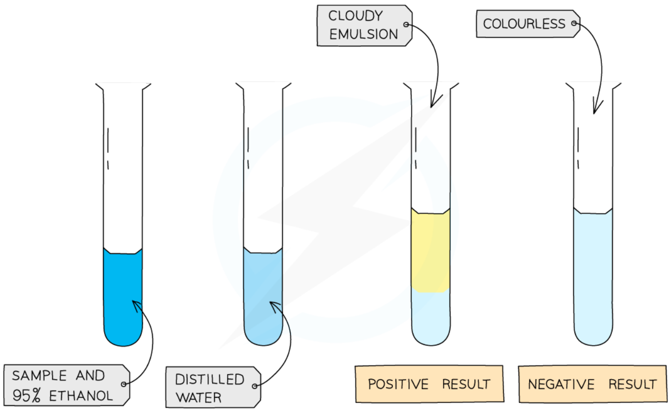
Testing a potato to prove the presence of starch

4 BIOLOGICAL MOLECULES

4.2 FOOD TESTS cont...

Test for lipids

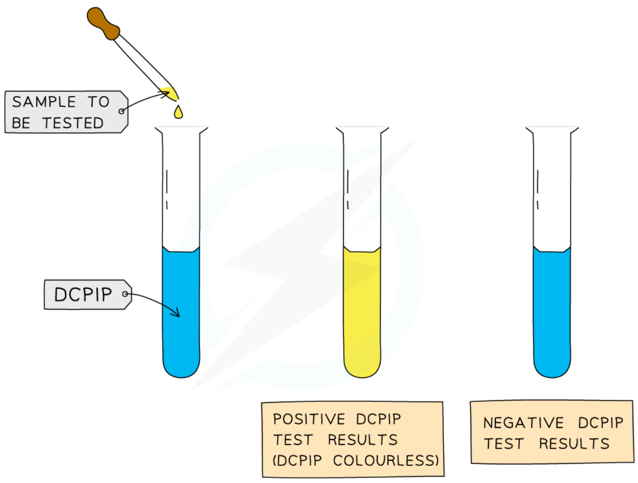
- Food sample is mixed with **2cm3** of ethanol and shaken
- The ethanol is added to an equal volume of **cold water**
- A positive test will show a **cloudy emulsion** forming



The ethanol test for lipids

Test for vitamin C

- Add 1cm3 of **DCPIP** solution to a test tube
- Add a small amount of food sample (as a solution)
- A positive test will show the **blue colour of the dye disappearing**



The DCPIP test for vitamin C

EXAM TIP

When describing food tests in exam answers, make sure you give the starting colour of the solution and the colour it changes to for a positive result.

YOUR NOTES

4 BIOLOGICAL MOLECULES

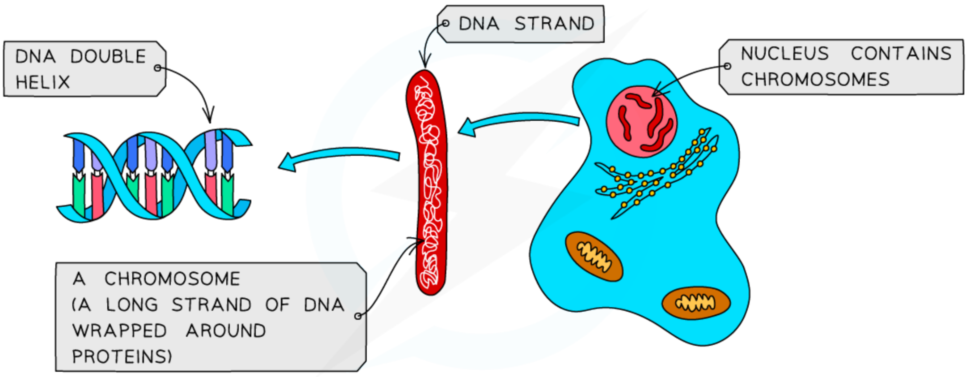
4.3 DNA STRUCTURE

YOUR NOTES

EXTENDED ONLY

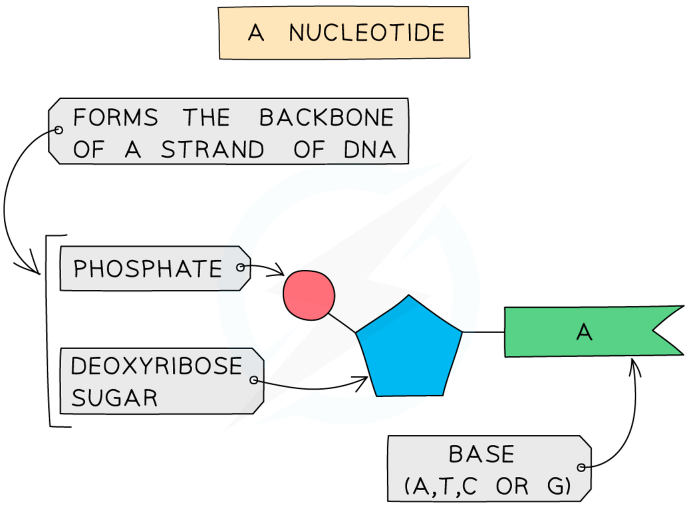
Describing DNA Structure

- DNA, or deoxyribonucleic acid, is the molecule that contains the instructions for growth and development of all organisms
- It consists of two strands of DNA wound around each other in what is called a **double helix**



DNA, chromosomes and the nucleus

- The individual units of DNA are called **nucleotides**



A nucleotide

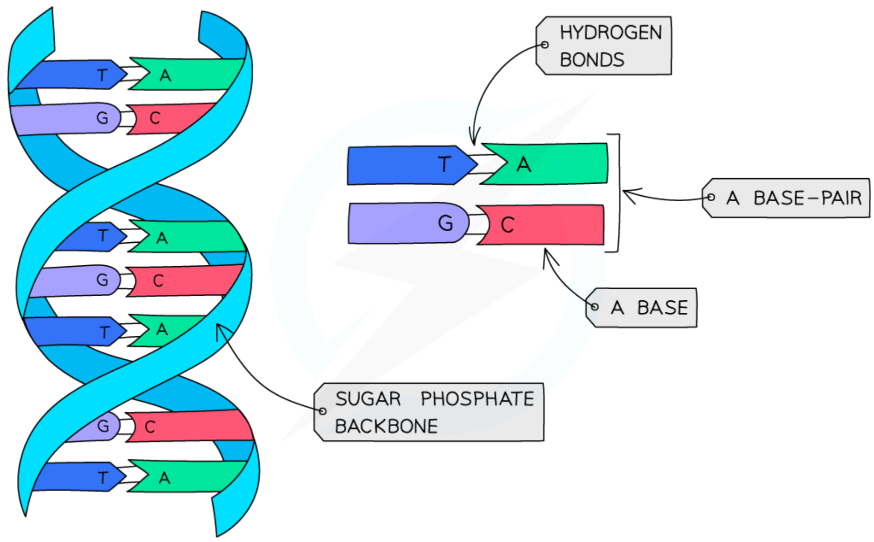
4 BIOLOGICAL MOLECULES

4.3 DNA STRUCTURE cont...

YOUR NOTES

EXTENDED ONLY cont...

- All nucleotides contain the same phosphate and deoxyribose sugar, but differ from each other in the **base** attached
- There are four different bases, **Adenine (A)**, **Cytosine (C)**, **Thymine (T) and Guanine (G)**
- The bases on each strand pair up with each other, holding the two strands of DNA in the double helix
- The bases always pair up in the same way:
- Adenine always pairs with Thymine **(A-T)**
- Cytosine always pairs with Guanine **(C-G)**



DNA Base Pairs

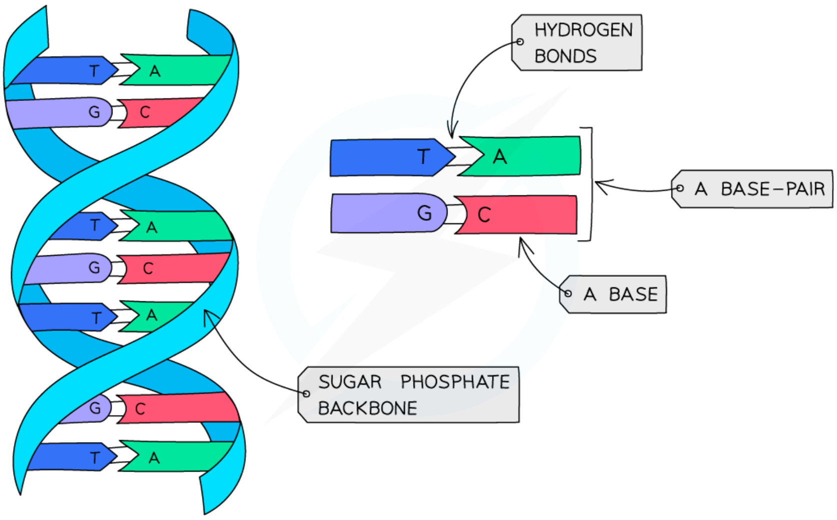
- The phosphate and sugar section of the nucleotides form the 'backbone' of the DNA strand (like the sides of a ladder) and the base pairs of each strand connect to form the rungs of the ladder

4 BIOLOGICAL MOLECULES

4.3 DNA STRUCTURE

YOUR NOTES

EXTENDED ONLY cont...



The DNA helix is made from two strands of DNA held together by hydrogen bonds

- It is this sequence of bases that holds the code for the formation of proteins

EXAM TIP

You do not need to learn the names of the bases, just their letter.

Know which bonds with which as this is the most commonly asked question about this topic.

4 BIOLOGICAL MOLECULES

4.4 WATER

YOUR NOTES

Importance as a Solvent

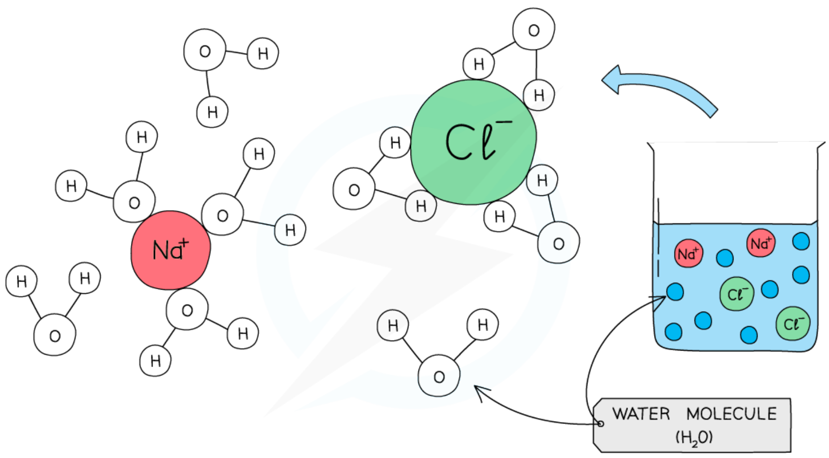
- Water is important for all living organisms as **many substances are able to dissolve in it** (it is a **solvent**)
- This makes it incredibly useful and essential for all life on Earth

EXTENDED ONLY

Role within Organisms

Water is important as a solvent in the following situations within organisms:

- Dissolved substances can be **easily transported** around organisms – eg xylem and phloem of plants and dissolved food molecules in the blood
- **Digested food molecules** are in the alimentary canal but need to be moved to cells all over the body – without water as a solvent this would not be able to happen
- Toxic substances such as **urea** and substances in excess of requirements such as salts can dissolve in water which makes them easy to **remove from the body in urine**
- Water is also an important part of the **cytoplasm** and plays a role in ensuring **metabolic reactions can happen** as necessary in cells



Water as a solvent

> NOW TRY SOME EXAM QUESTIONS

4 BIOLOGICAL MOLECULES

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Large food molecules are composed from smaller molecules chemically bonded together.

Which of the following statements is false?

A Glucose molecules are the basic units of cellulose

B Glycerol is a basic unit of oils.

C Simple sugars like glucose are the basic unit of fats.

D Amino acids are basic units of proteins.

QUESTION 2

DNA is a large molecule made from two chains of nucleotides held together by cross-links between pairs of bases.

Which of the following is a correct base pair?

A T with C

B G with A

C C with G

D C with A

QUESTION 3

A group of students tested four different foods using some common food tests. Their results are shown in the table below.

Which food contains reducing sugar and Vitamin C but not protein or starch?

	Benedict's test	Biuret test	Iodine test	DCPIP test
A	brick-red	purple	brown	colourless
B	brick-red	blue	brown	colourless
C	blue	blue	black	blue
D	brick-red	blue	black	colourless

4 BIOLOGICAL MOLECULES

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

A strand of DNA is shown below:

T — G — A — A — C — T — A — G — C — C

What would the correct order of bases be on the complementary strand of DNA?

A A — C — T — T — A — A — T — C — G — G

B C — A — G — G — T — C — G — A — T — T

C T — G — A — A — C — T — A — G — C — C

D A — C — T — T — G — A — T — C — G — G

QUESTION 5

Three statements about proteins are given below.

1. Different sequences of amino acids give different shapes to protein molecules
2. Amylase is made from a sequence of amino acids joined together forming a non-specific 3D shape.
3. When mixed with Biuret solution, there is a colour change from blue to purple.

Which of the statements above are true?

A 1 & 2 only **B** 1, 2 & 3 **C** 1 & 3 only **D** 3 only

5 ENZYMES

YOUR NOTES

CONTENTS:

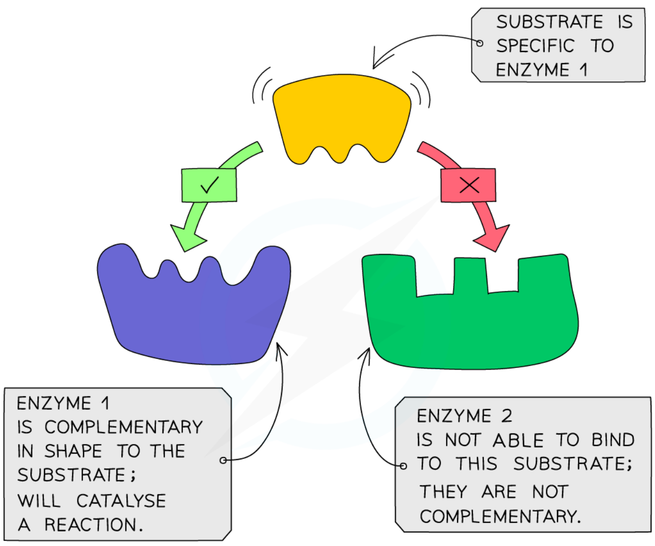
5.1 HOW ENZYMES WORK

What are Enzymes?

Enzymes:

- Are **catalysts** that **speed up** the rate of a chemical reaction **without being changed** or used up in the reaction
- Are **proteins**
- Are **biological catalysts** (biological because they are **made in living cells**, catalysts because they speed up the rate of chemical reactions without being changed)
- Enzymes are necessary to all living organisms as they **maintain reaction speeds** of all metabolic reactions (all the reactions that keep an organism alive) at a rate that can **sustain life**
- For example, if we did not produce digestive enzymes, it would take around 2 – 3 weeks to digest one meal; with enzymes, it takes around 4 hours

How do Enzymes Work?



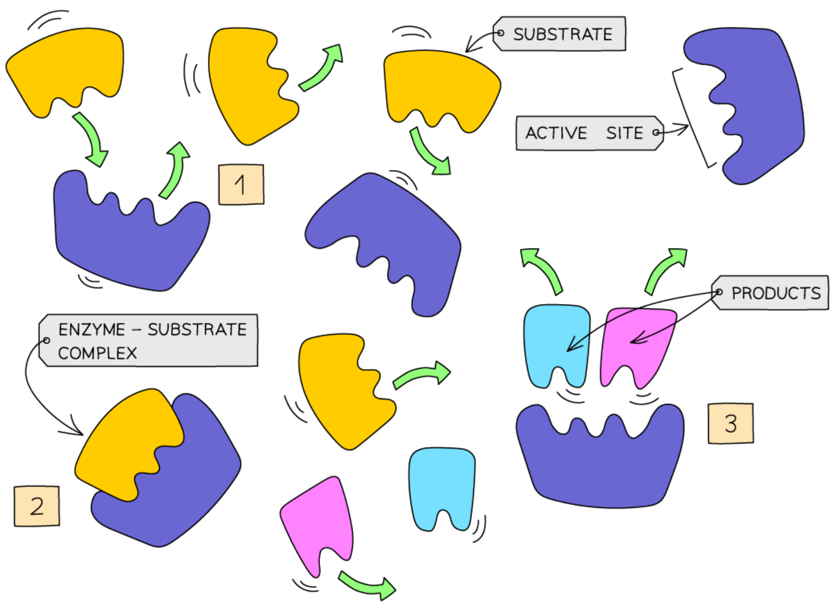
Enzyme substrate specificity

5 ENZYMES

5.1 HOW ENZYMES WORK cont...

YOUR NOTES

- Enzymes are **specific** to one particular substrate (molecule(s) that get broken down or joined together in the reaction) as the enzyme is a complementary shape to the substrate
- The product is made from the substrate(s) and is released



Enzyme specificity: lock and key model of enzyme activity

EXTENDED ONLY

Enzyme Specificity

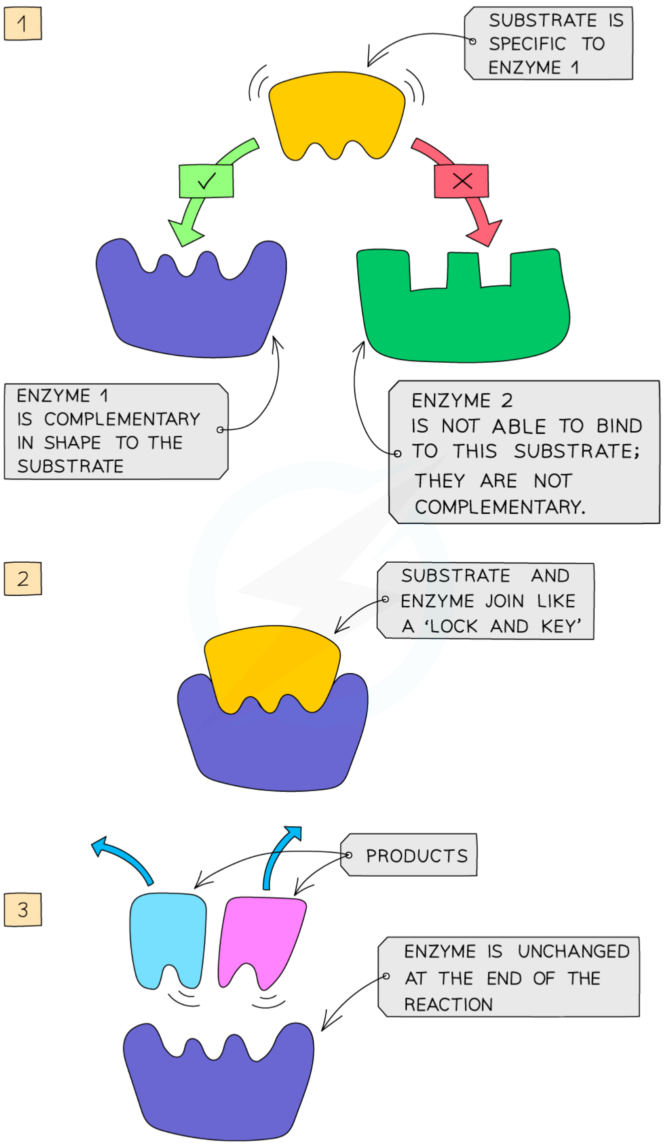
- Enzymes are **specific** to one particular substrate(s) as the **active site** of the enzyme, where the substrate attaches, is a complementary shape to the substrate
- This is because the enzyme is a protein and has a **specific 3-D shape**
- This is known as the **lock and key hypothesis**
- When the substrate moves into the enzyme's active site they become known as the **enzyme-substrate complex**
- After the reaction has occurred, the **products** leave the enzyme's active site as they no longer fit it and it is free to take up another substrate

5 ENZYMES

5.1 HOW ENZYMES WORK cont...

YOUR NOTES

EXTENDED ONLY cont...



How enzymes work

1. Enzymes and substates randomly move about in solution
2. When an enzyme and its complementary substrate randomly collide – with the substrate fitting into the active site of the enzyme – an enzyme-substrate complex forms, and the reaction occurs.
3. A product (or products) forms from the substrate(s) which are then released from the active site. The enzyme is unchanged and will go on to catalyse further reactions.

5 ENZYMES

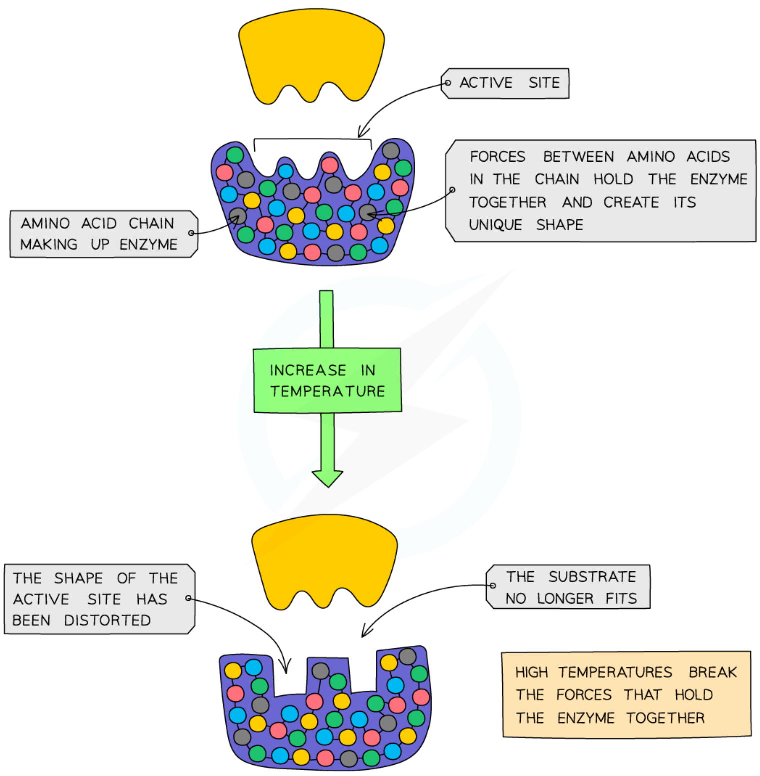
5.1 HOW ENZYMES WORK cont...

YOUR NOTES

EXTENDED ONLY cont...

Effect of Temperature on Enzyme Function

- Enzymes are **proteins** and have a **specific shape**, held in place by **bonds**
- This is extremely important around the **active site** area as the specific shape is what ensures the **substrate will fit into the active site** and enable the reaction to proceed
- Enzymes work fastest at their '**optimum temperature**' – in the human body, the optimum temperature is 37ºC
- Heating to high temperatures (beyond the optimum) will **break the bonds** that hold the enzyme together and it will lose its shape -this is known as **denaturation**
- Substrates cannot fit into denatured enzymes as the shape of their active site has been lost
- Denaturation is **irreversible** – once enzymes are denatured they cannot regain their proper shape and activity will stop



Effect of temperature on enzyme activity

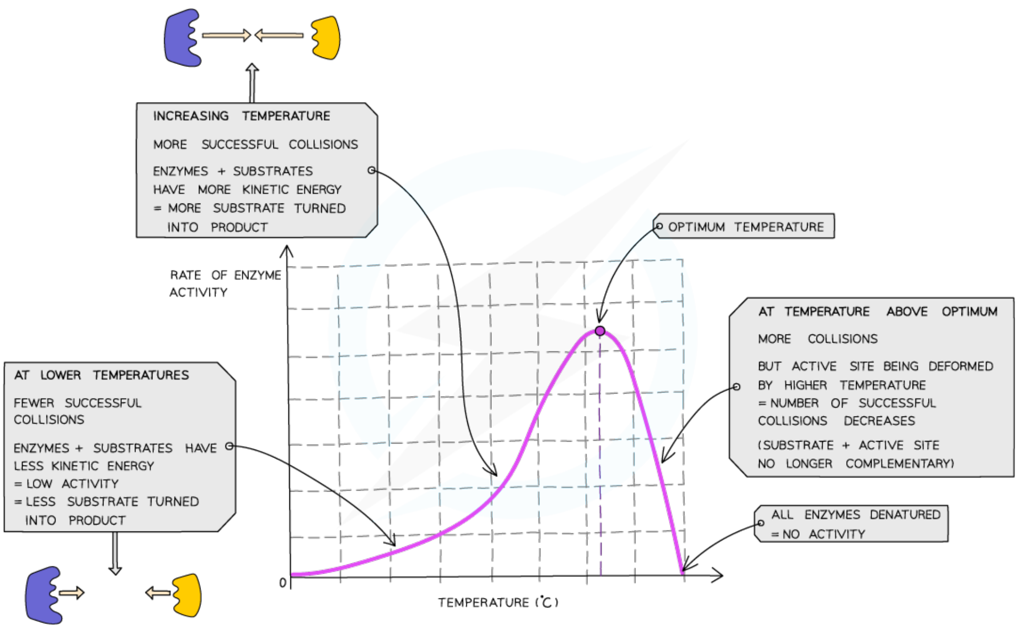
5 ENZYMES

5.1 HOW ENZYMES WORK cont...

YOUR NOTES

EXTENDED ONLY cont...

- Increasing the temperature from 0ºC to the optimum increases the activity of enzymes as the **more energy the molecules have the faster they move and the number of collisions with the substrate molecules increases**, leading to a faster rate of reaction
- This means that **low temperatures do not denature enzymes**, they just make them work more slowly



Graph showing the effect of temperature on the rate of enzyme activity

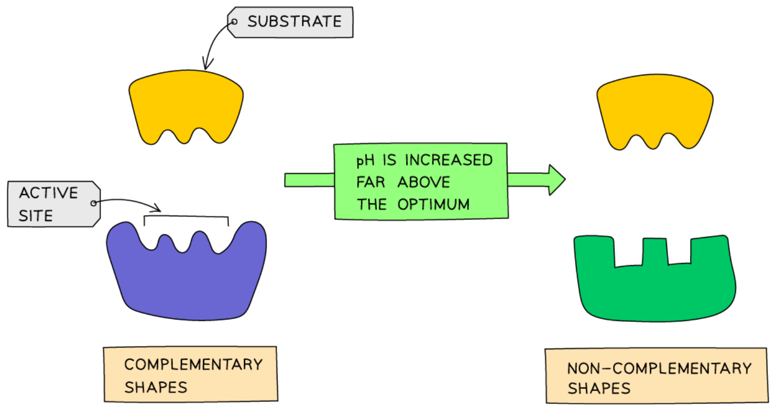
5 ENZYMES

5.1 HOW ENZYMES WORK cont...

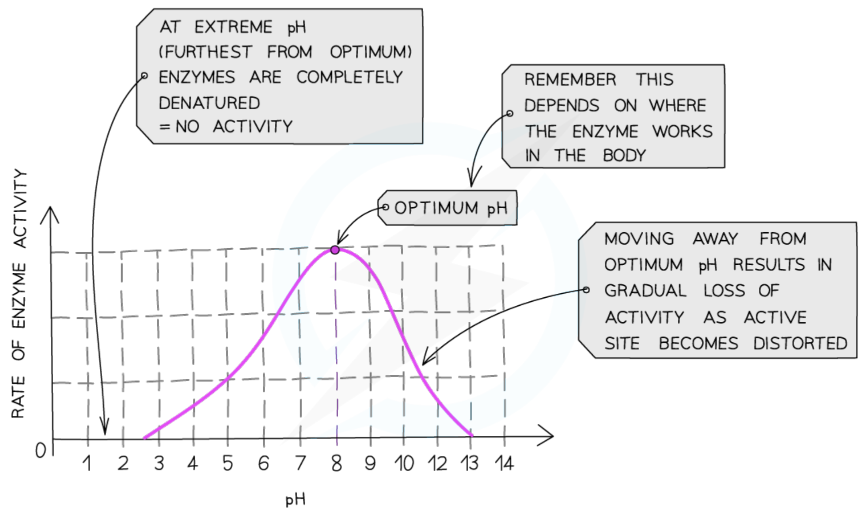
EXTENDED ONLY cont...

Effect of pH on Enzyme Activity

- The optimum pH for most enzymes is 7 but some that are produced in acidic conditions, such as the stomach, have a lower optimum pH (pH 2) and some that are produced in alkaline conditions, such as the duodenum, have a higher optimum pH (pH 8 or 9)
- If the **pH is too high or too low**, the **bonds** that hold the amino acid chain together to make up the protein can be **destroyed**
- This will **change the shape of the active site**, so the substrate can no longer fit into it, reducing the rate of activity
- Moving too far away from the optimum pH will cause the enzyme to **denature** and activity will stop



Effect of pH on enzyme activity



Graph showing the effect of pH on rate of activity for an enzyme from the duodenum

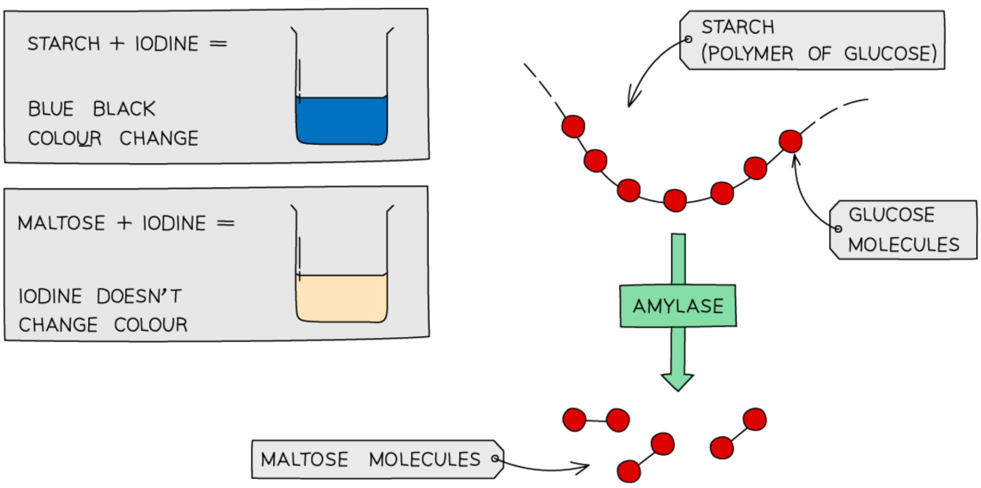
5 ENZYMES

YOUR NOTES

5.2 ENZYME INVESTIGATIONS

Enzyme Investigations

- Amylase is an enzyme that digests **starch** (a polysaccharide of glucose) **into maltose** (a disaccharide of glucose)
- Starch can be tested for easily using **iodine solution**



Using iodine to test for starch

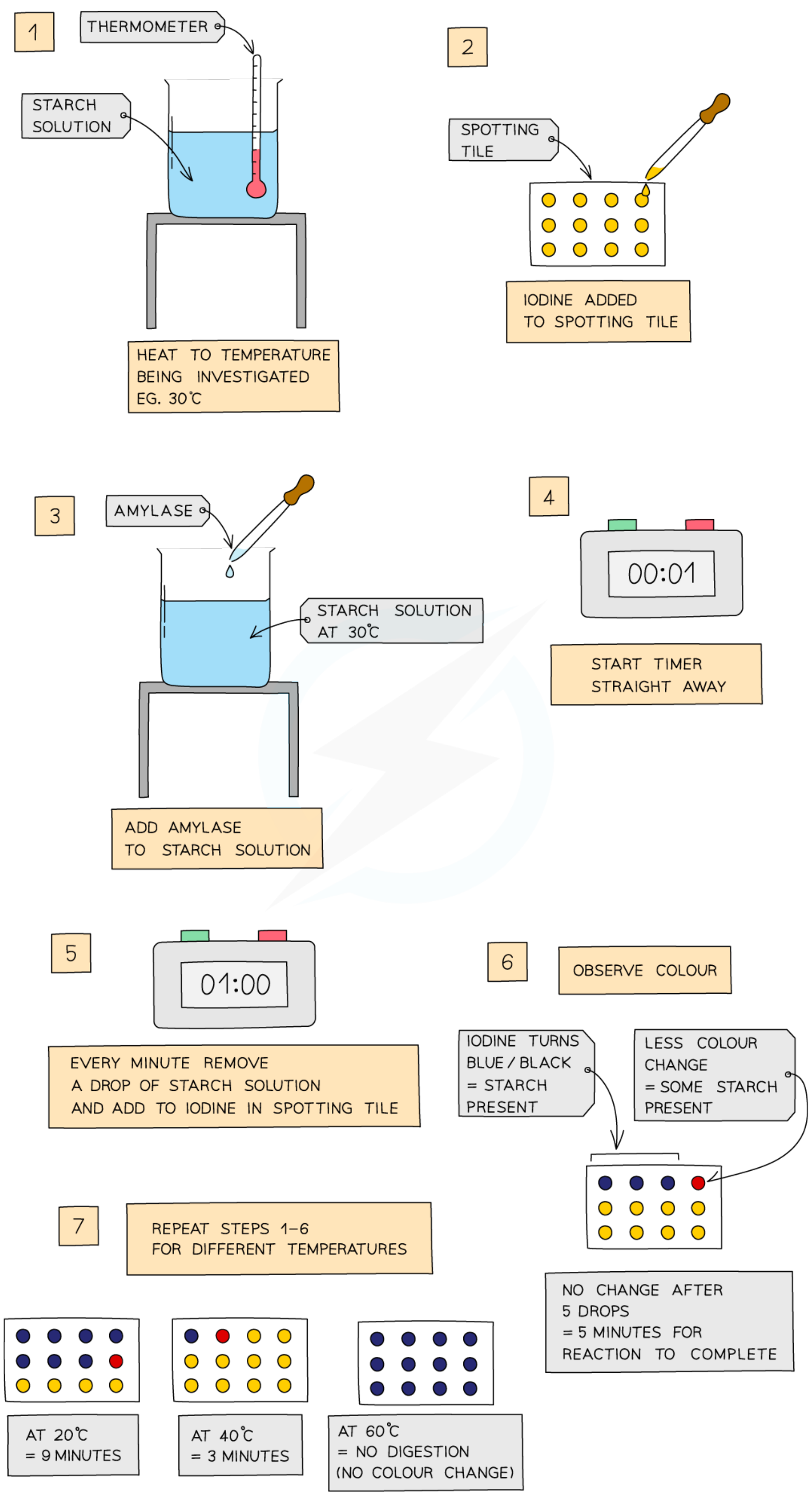
Investigating the Effect of Temperature on Amylase

- **Starch solution** is heated to a set temperature
- **Iodine** is added to wells of a spotting tile
- **Amylase** is added to the starch solution and mixed well
- Every minute, droplets of solution are added to a new well of iodine solution
- This is continued until the iodine **stops turning blue-black** (this means there is **no more starch** left in the solution as the amylase has broken it all down)
- Time taken for the reaction to be completed is recorded
- Experiment is repeated at different temperatures
- The quicker the reaction is completed, the faster the enzyme is working

5 ENZYMES

YOUR NOTES

5.2 ENZYME INVESTIGATIONS cont...



Investigating the effect of temperature on enzyme activity

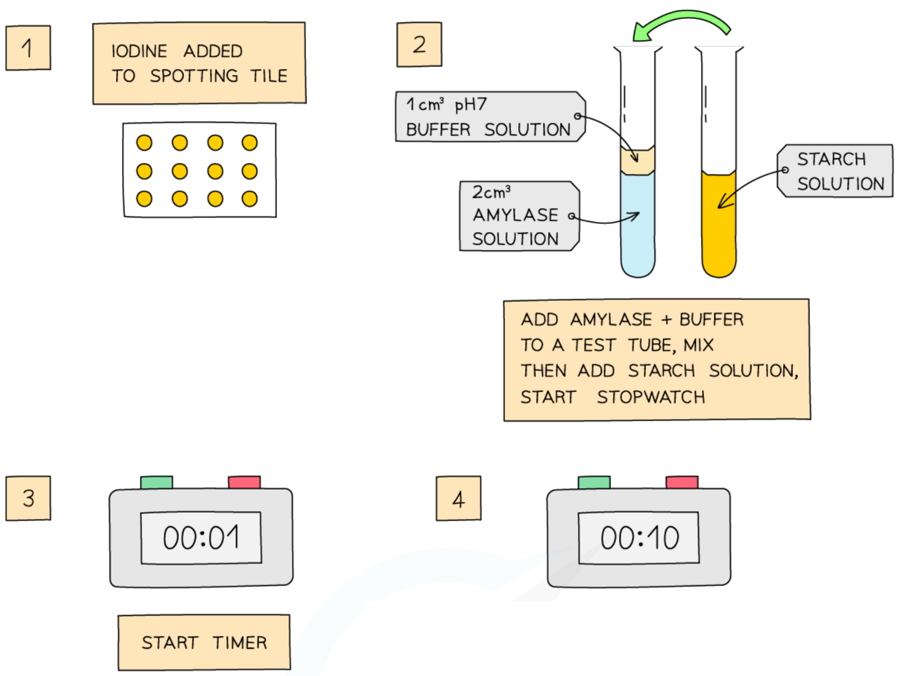
5 ENZYMES

5.2 ENZYME INVESTIGATIONS cont...

Investigating the Effect of pH on the Working of the Enzyme Amylase

YOUR NOTES

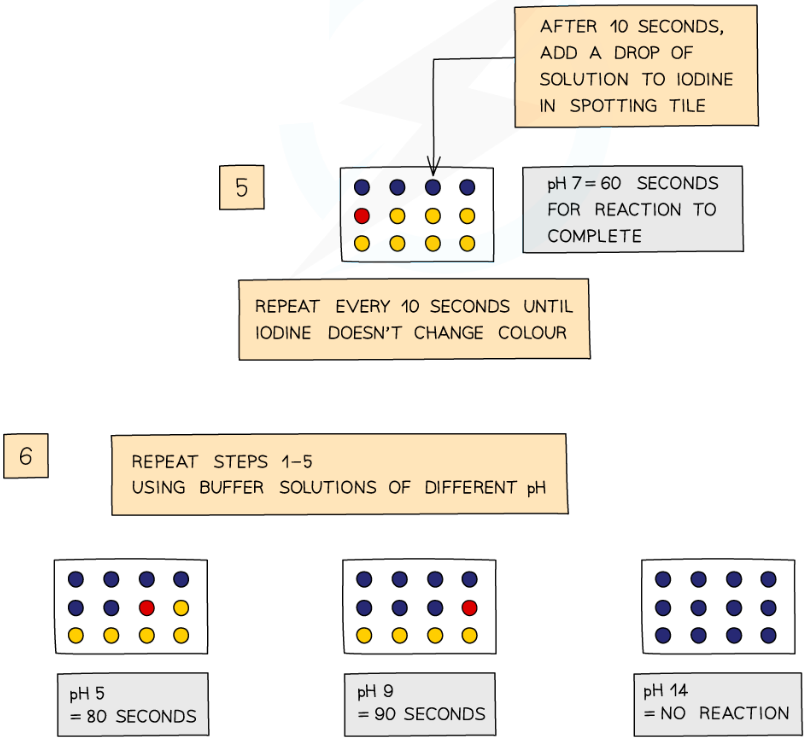
- Place single drops of **iodine** solution in rows on the tile
- Label a test tube with the pH to be tested
- Use the syringe to place 2cm^3 of **amylase** in the test tube
- Add 1cm^3 of **buffer solution** to the test tube using a syringe
- Use another test tube to add 2cm^3 of **starch solution** to the amylase and buffer solution, start the stopwatch whilst mixing using a pipette
- After 10 seconds, use a pipette to place one drop of mixture on the first drop of iodine, which should turn blue black
- Wait another 10 seconds and place another drop of mixture on the second drop of iodine
- Repeat every 10 seconds **until iodine solution remains orange brown**
- Repeat experiment at different pH values – the less time the iodine solution takes to remain orange brown, the quicker all the starch has been digested and so the better the enzyme works at that pH



5 ENZYMES

5.2 ENZYME INVESTIGATIONS cont...

YOUR NOTES



Investigating the effect of pH on enzyme activity

EXAM TIP

Describing and explaining experimental results for enzyme experiments is a common type of exam question.
So understand what is happening and, for a 7, 8 or 9, be able to:

- relate this to changes in the active site of the enzyme when it has denatured
- or, if it is a low temperature, relate it to the amount of kinetic energy the molecules have.

> NOW TRY SOME EXAM QUESTIONS

5 ENZYMES

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which of the following best describes what an enzyme is?

A A catalyst that speeds up reactions in cells, being used up in the process

B A protein that speeds up reactions in cells, being used up in the process

C A carbohydrate that functions as a biological catalyst

D A protein that functions as a biological catalyst

QUESTION 2

What is a feature of all catalysts?

A They are made from protein

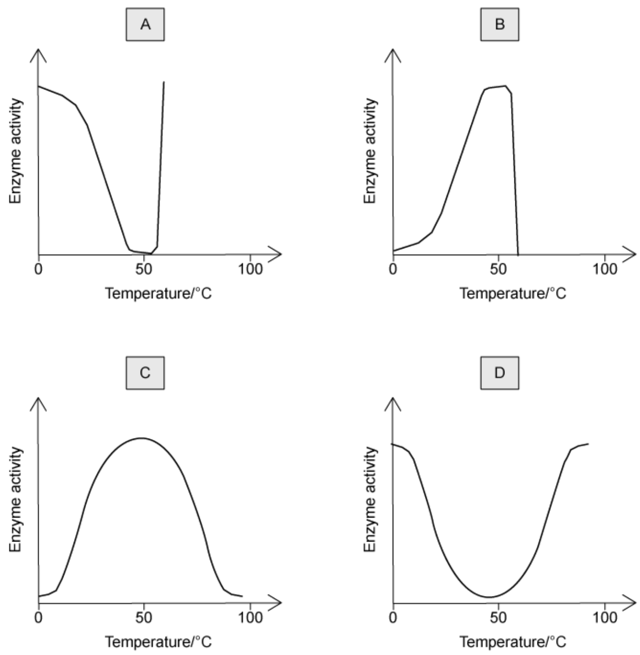
B They are not changed by the reaction

C They are broken down in the reaction

D They are altered by the rate of the reaction

QUESTION 3

Which graph in the image below shows the correct effect of temperature on the activity of an enzyme?



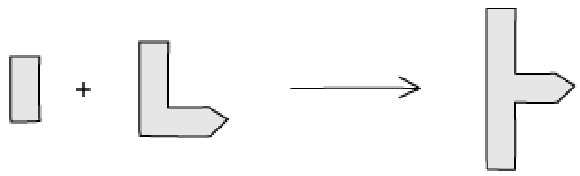
5 ENZYMES

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 4

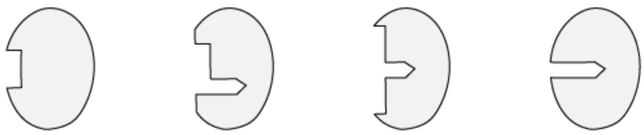
The image below represents a chemical reaction.



Reactants   Product

Which of the following best represents the enzyme responsible for catalysing this reaction?

A B C D



QUESTION 5

What can be said to be true of all enzymes?

	Their optimum ph is 7	They are made from amino acids	They move about randomly in a fluid
A	✗	✗	✗
B	✗	✓	✓
C	✓	✗	✓
D	✓	✓	✗

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

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for more questions and revision notes

6 PLANT NUTRITION

YOUR NOTES

CONTENTS:

6.1 PHOTOSYNTHESIS

Photosynthesis Theory: Basics

- Green plants make the carbohydrate **glucose** from the raw materials **carbon dioxide** and **water**
- At the same time **oxygen** is made and released as a waste product
- The reaction requires **energy** which is obtained by the pigment **chlorophyll** trapping light from the Sun
- So photosynthesis can be defined as **the process by which plants manufacture carbohydrates from raw materials using energy from light**
- It can be summed up in the following equation:

$$\text{CARBON DIOXIDE} + \text{WATER} \xrightarrow[\text{CHLOROPHYLL}]{\text{LIGHT}} \text{GLUCOSE} + \text{OXYGEN}$$

Photosynthesis word equation

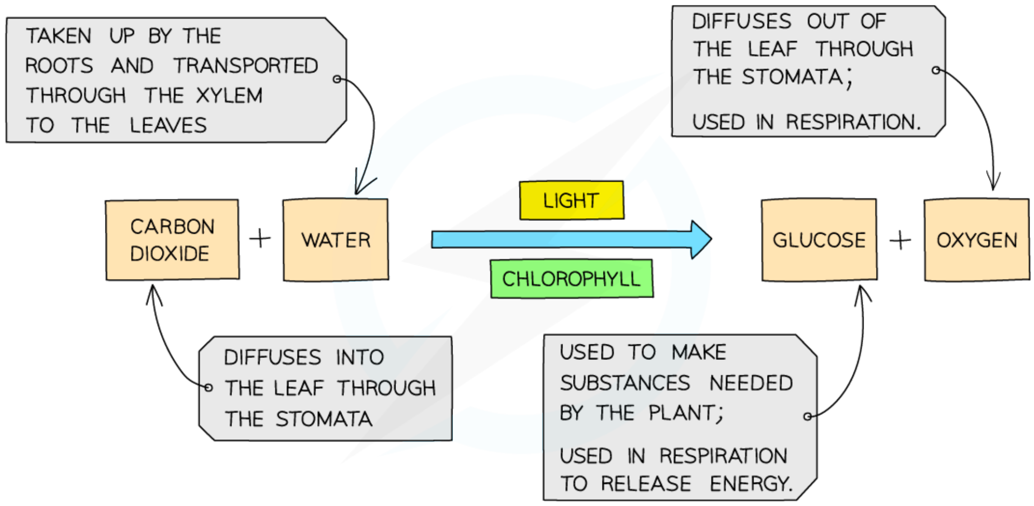
EXAM TIP

If asked for the raw materials required for photosynthesis, the answer is carbon dioxide and water. Although required for the reaction to take place, light energy is not a substance and therefore cannot be a raw material.

6 PLANT NUTRITION

YOUR NOTES

6.1 PHOTOSYNTHESIS cont...



How plants get the materials they need

EXTENDED ONLY

Photosynthesis Theory

- The **balanced chemical equation** for photosynthesis is:

$$6\,CO_2 + 6H_2O \xrightarrow[\text{CHLOROPHYLL}]{\text{LIGHT}} C_6H_{12}O_6 + 6\,O_2$$

Balanced chemical equation for photosynthesis

- The **light energy** is converted into **chemical energy** in the **bonds** that are holding the atoms in the glucose molecules together

6 PLANT NUTRITION

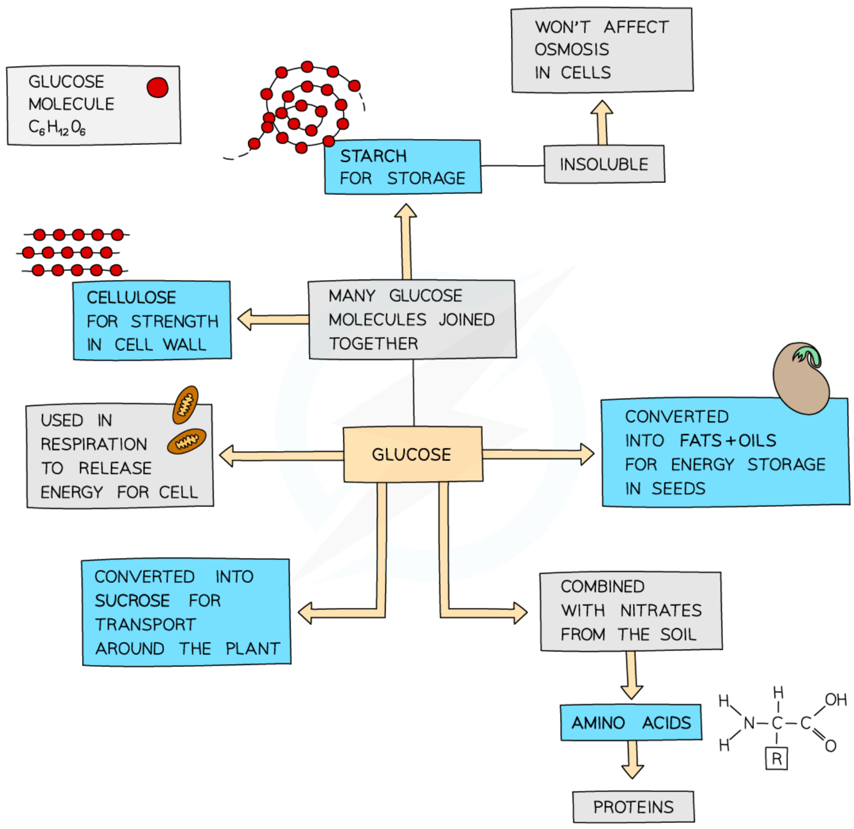
6.1 PHOTOSYNTHESIS cont...

YOUR NOTES

EXTENDED ONLY

The Products of Photosynthesis

- Plants use the glucose they make as a **source of energy** in **respiration**
- They can also convert it into **starch** for storage, into **lipids** for an energy source in seeds, into **cellulose** to make cell walls or into **amino acids** (used to make proteins) when combined with nitrogen and other mineral ions absorbed by roots



The fate of glucose

EXAM TIP

The photosynthesis equation is the exact reverse of the aerobic respiration equation – so if you have learned one you also know the other one!

You will usually get more marks for providing the balanced chemical equation than the word equation.

6 PLANT NUTRITION

6.2 INVESTIGATING PHOTOSYNTHESIS

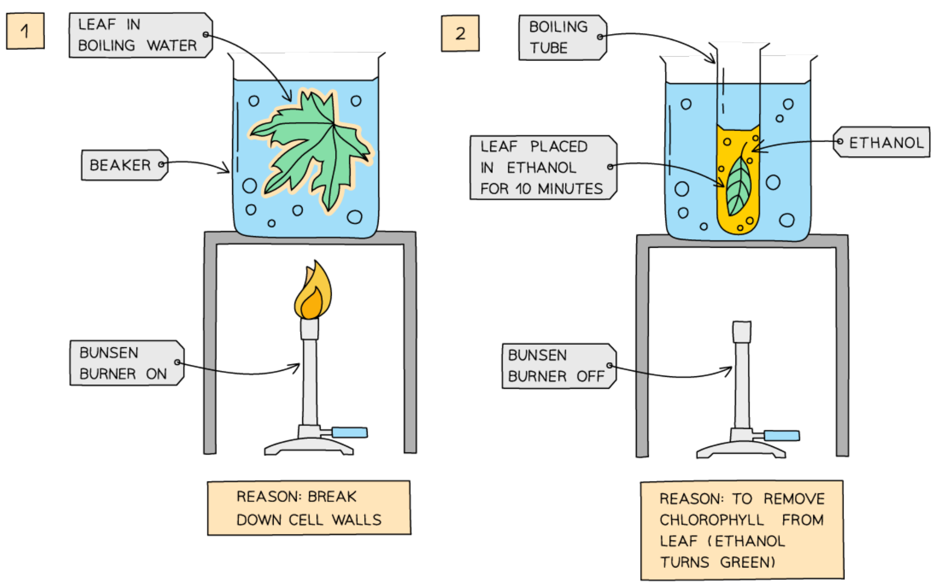
YOUR NOTES

Starch Production & Need for Chlorophyll

- Although plants make glucose in photosynthesis, **leaves cannot be tested for its presence** as the glucose is quickly used, converted into other substances and transported or stored as starch
- Starch is stored in chloroplasts where photosynthesis occurs so **testing a leaf for starch** is a reliable indicator of which parts of the leaf are photosynthesising

Leaves can be tested for starch using the following procedure:

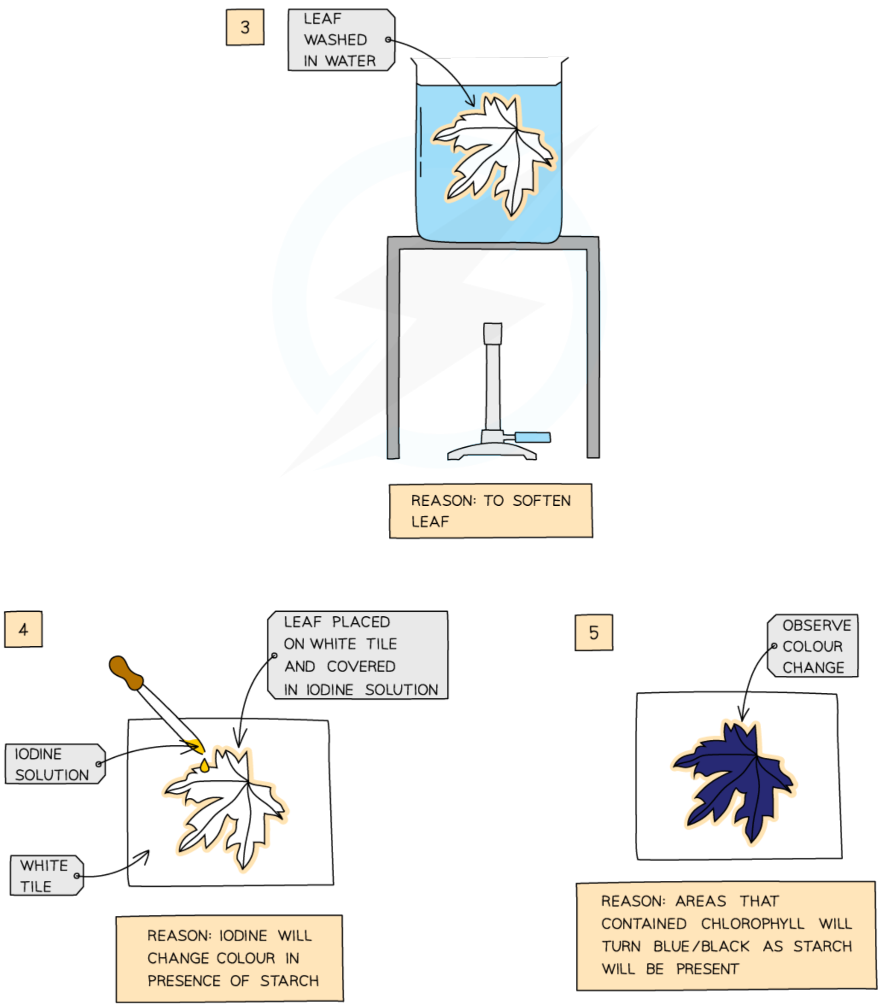
- A leaf is dropped in **boiling water** to **kill and break down the cell walls**
- The leaf is left for 5-10 minutes in hot **ethanol** in a boiling tube. This **removes the chlorophyll** so colour changes from iodine can be seen more clearly
- The leaf is dipped in boiling water to soften it
- The leaf is spread out on a white tile and covered with **iodine solution**
- In a green leaf, the entire leaf will turn **blue-black** as photosynthesis is occuring in all areas of the leaf
- This method can also be used to test whether chlorophyll is needed for photosynthesis by using a **variegated** leaf (one that is partially green and partially white)
- The white areas of the leaf contain no chlorophyll and when the leaf is tested **only the areas that contain chlorophyll stain blue-black**
- The areas that had no chlorophyll remain orange-brown as **no photosynthesis is occurring here and so no starch is stored**



6 PLANT NUTRITION

6.2 INVESTIGATING PHOTOSYNTHESIS cont...

YOUR NOTES



Testing a variegated leaf for starch

- Care must be taken when carrying out this practical as **ethanol is extremely flammable**, so at that stage of the experiment the Bunsen burner should be turned off. The safest way to heat the ethanol is in an electric water bath rather than using a beaker over a Bunsen burner with an open flame

6 PLANT NUTRITION

6.2 INVESTIGATING PHOTOSYNTHESIS cont...

YOUR NOTES

The Need for Light in Photosynthesis

- The same procedure as in the investigation above can be used to investigate if light is needed for photosynthesis
- Before starting the experiment the plant needs to be **destarched** by placing in a dark cupboard for 24 hours
- This ensures that **any starch already present in the leaves will be used up** and will not affect the results of the experiment
- Following destarching, a leaf of the plant can be **partially covered with aluminium foil** and the plant placed in sunlight for a day
- The leaf can then be removed and tested for starch using iodine
- The area of the leaf that was covered with aluminium foil will remain **orange-brown** as it did not receive any sunlight and could not photosynthesise, while the area exposed to sunlight will turn **blue black**
- This proves that light is necessary for photosynthesis and the production of starch

The Need for Carbon Dioxide in Photosynthesis

- Destarch a plant
- Tie a clear bag containing **sodium hydroxide**, which will **absorb carbon dioxide** from the surrounding air, around one leaf
- Tie a clear bag containing **water** (control experiment), which will **not absorb carbon dioxide** from the surrounding air, around another leaf
- Place the plant in bright light for several hours.
- Test both leaves for starch using iodine
- The leaf from the bag containing sodium hydroxide will r**emain orange brown** as it could not photosynthesise due to lack of carbon dioxide
- The leaf from the control bag containing water should turn blue black as it had all necessary requirements for photosynthesis

6 PLANT NUTRITION

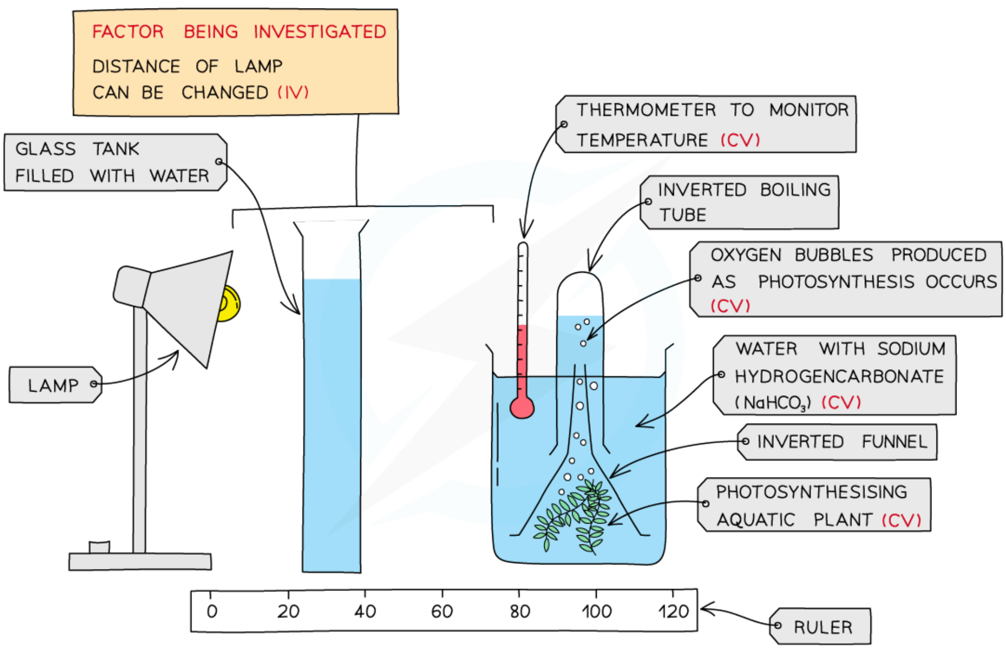
6.2 INVESTIGATING PHOTOSYNTHESIS cont...

YOUR NOTES

The Rate of Photosynthesis Using a Water Plant

- The plants usually used are **Elodea** or **Camboba** – types of pondweed
- As photosynthesis occurs, oxygen gas produced is released
- As the plant is in water, the oxygen released can be seen as **bubbles** leaving the cut end of the pond weed
- The number of **bubbles produced over a minute** can be counted to record the rate
- The more bubbles produced per minute, the faster the rate of photosynthesis
- A more accurate version of this experiment is to collect the oxygen released in a test tube inverted over the top of the pondweed over a longer period of time and then measure the **volume of oxygen** collected
- This practical can be used in the following ways:

Investigating the effect of changing light intensity by moving a lamp different distances away from the beaker containing the pondweed



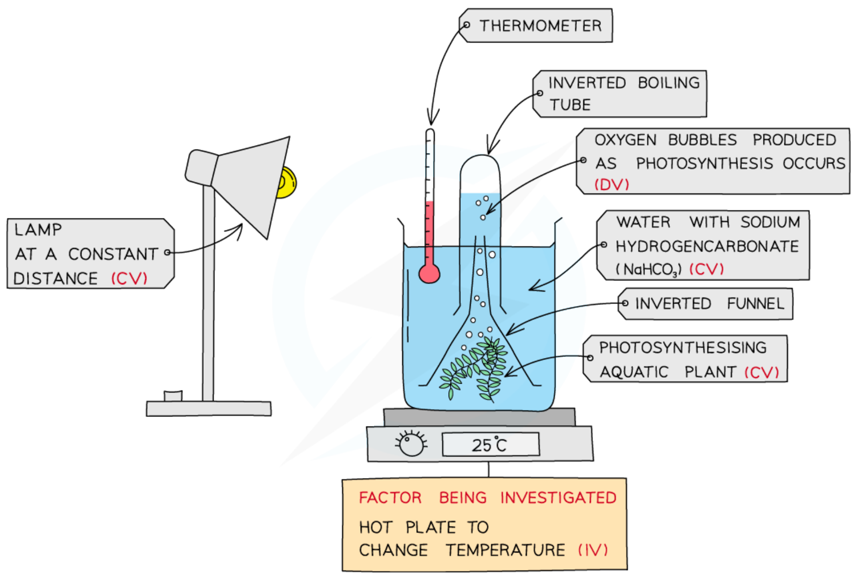
Investigating the effect of changing light intensity on the rate of photosynthesis

6 PLANT NUTRITION

YOUR NOTES

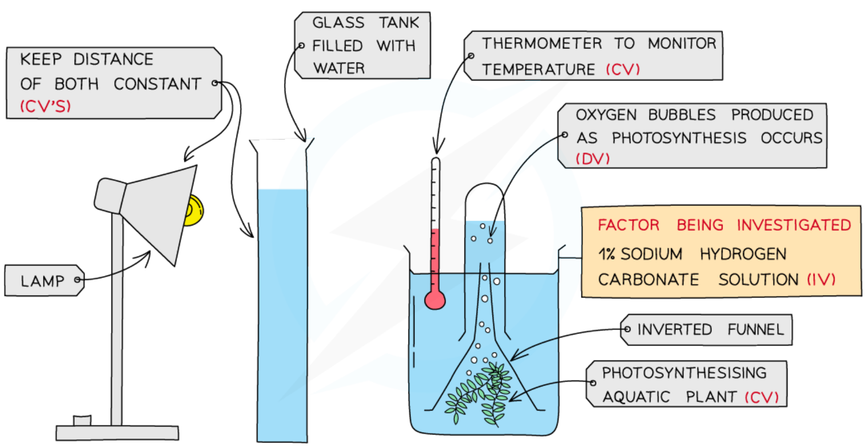
6.2 INVESTIGATING PHOTOSYNTHESIS cont...

Investigating the effect of changing temperature by changing the temperature of the water in the beaker



Investigating the effect of changing temperature on the rate of photosynthesis

Investigating the effect of changing carbon dioxide concentration by dissolving different amounts of sodium hydrogen carbonate in the water in the beaker



Investigating the effect of changing carbon dioxide concentration on the rate of photosynthesis

- Care must be taken when investigating a condition to **keep all other variables constant** in order to ensure a **fair test** – for example, when investigating changing light intensity, a **glass tank** should be placed in between the lamp and the beaker to **absorb heat** from the lamp and so avoid changing the temperature of the water as well as the light intensity

6 PLANT NUTRITION

YOUR NOTES

6.2 INVESTIGATING PHOTOSYNTHESIS cont...

EXAM TIP

Alternative ways of measuring the gas (oxygen) given off in these experiments would be to measure the volume of gas produced using an inverted measuring cylinder with graduations filled with water that readings can be taken from as the water is displaced by the gas, or by using a syringe attached by a delivery tube to the funnel.

6.3 LIMITING FACTORS

EXTENDED ONLY

What is a Limiting Factor?

- If a plant is given unlimited sunlight, carbon dioxide and water and is at a warm temperature, the limit on the rate (speed) at which it can photosynthesise is its own ability to absorb these materials and make them react
- However, most often plants do not have unlimited supplies of their raw materials so their rate of photosynthesis is **limited** by **whatever factor is the lowest at that time**
- So a **limiting factor** can be defined as **something present in the environment in such short supply that it restricts life processes**
- There are **three** main factors which limit the rate of photosynthesis:
    - **Temperature**
    - **Light intensity**
    - **Carbon dioxide concentration**
- Although water is necessary for photosynthesis, it is **not considered a limiting factor** as the amount needed is relatively small compared to the amount of water transpired from a plant so there is hardly ever a situation where there is not enough water for photosynthesis

6 PLANT NUTRITION

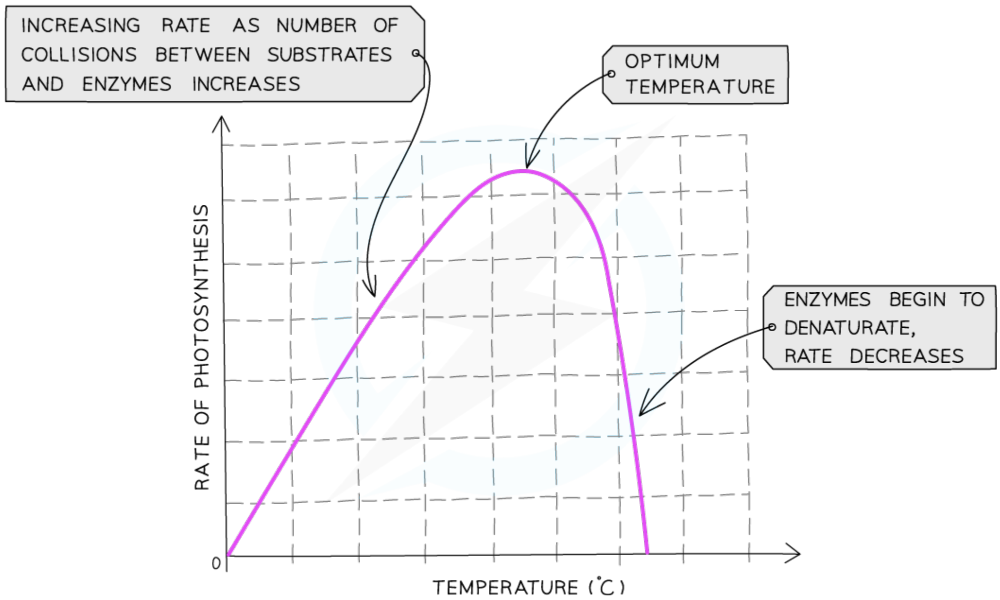
6.3 LIMITING FACTORS cont...

YOUR NOTES

EXTENDED ONLY cont...

Temperature

- As temperature increases the rate of photosynthesis increases as the reaction is **controlled by enzymes**
- However, as the reaction is controlled by enzymes, this trend only continues up to a certain temperature beyond which the enzymes begin to **denature** and the rate of reaction **decreases**



The effect of temperature on the rate of photosynthesis

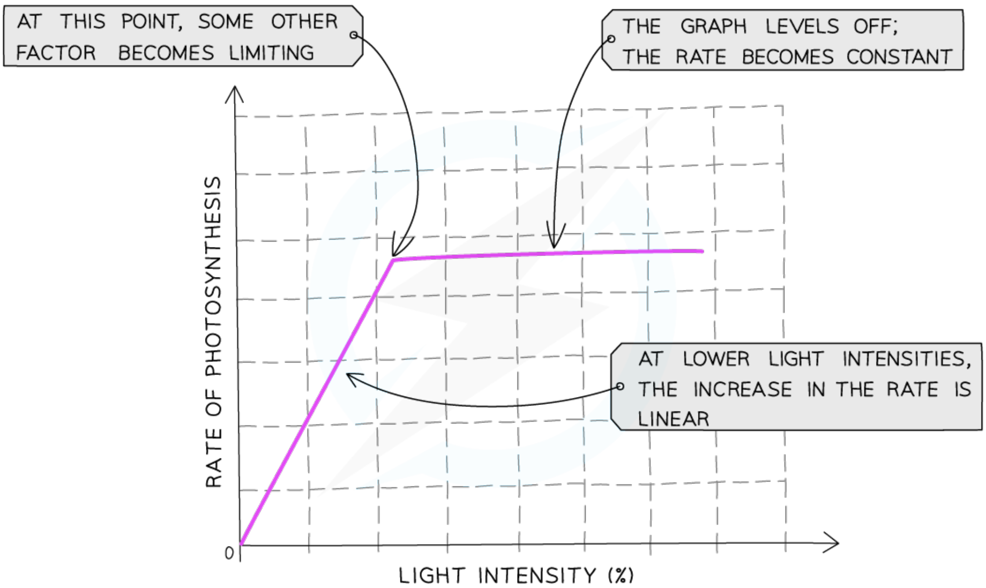
6.3 LIMITING FACTORS cont...

YOUR NOTES

EXTENDED ONLY cont...

Light Intensity

- The **more light** a plant receives, the **faster the rate** of photosynthesis
- This trend will continue until some other factor required for photosynthesis prevents the rate from increasing further because it is now in short supply



The effect of light intensity on the rate of photosynthesis

At low light intensities, increasing the intensity will initially increase the rate of photosynthesis. At a certain point, increasing the light intensity stops increasing the rate.The rate becomes constant regardless of how much light intensity increases as something else is limiting the rate.

- The factors which could be limiting the rate when the line on the graph is horizontal include **temperature not being high enough** or **not enough carbon dioxide**

6 PLANT NUTRITION

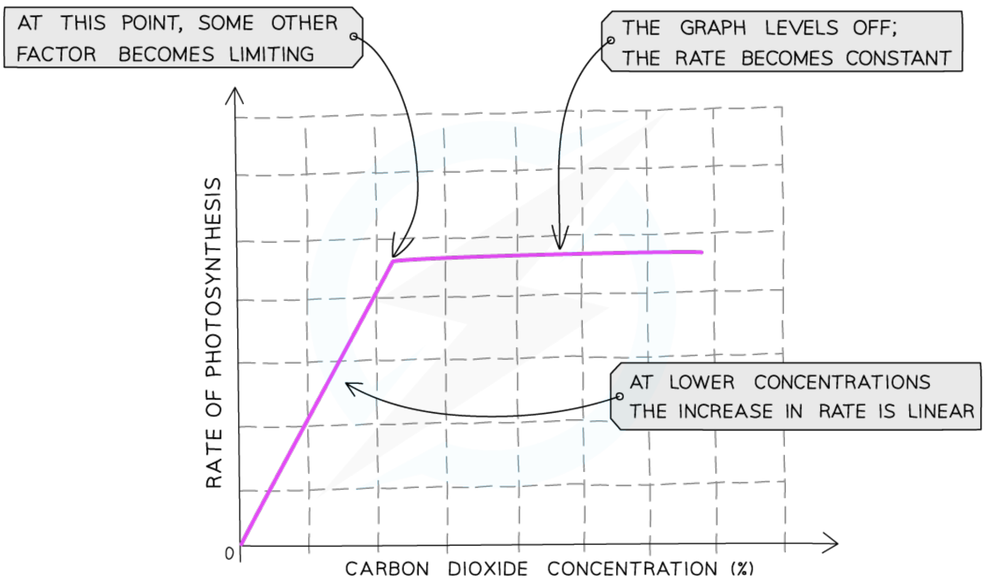
6.3 LIMITING FACTORS cont...

YOUR NOTES

EXTENDED ONLY cont...

Carbon Dioxide Concentration

- Carbon dioxide is one of the raw materials required for photosynthesis
- This means the **more carbon dioxide** that is present, **the faster the reaction** can occur
- This trend will continue until some other factor required for photosynthesis prevents the rate from increasing further because it is now in short supply



The effect of carbon dioxide concentration on the rate of photosynthesis

- The factors which could be limiting the rate when the line on the graph is horizontal include **temperature not being high enough** or **not enough light**

6 PLANT NUTRITION

6.3 LIMITING FACTORS cont...

YOUR NOTES

EXTENDED ONLY

Changing Glasshouse Conditions

- The knowledge about limiting factors and how they affect the rate of photosynthesis can be used to help **control factors in glass houses** to ensure **maximum crop yields** for farmers
- Growing crops outside does not allow farmers to control any of these factors to increase growth of plants
- In a glass house, several conditions can be manipulated to increase the rate of photosynthesis, including:
  - **artificial heating** (enzymes controlling photosynthesis can work faster at slightly higher temperatures – only used in temperate countries such as the UK)
  - **artificial lighting** (plants can photosynthesise for longer)
  - **increasing carbon dioxide content** of the air inside (plants can photosynthesise quicker)
  - **regular watering**
- When considering the use of glasshouses and manipulating conditions like this, farmers need to balance the **extra cost** of providing heating, lighting and carbon dioxide against the **increased income**
- In **tropical countries** where temperatures are much hotter, glasshouses may still be used to control other conditions however they may need to be **ventilated** to release hot air and **avoid temperatures rising too high**, which could cause the denaturation of the enzymes controlling the photosynthesis reaction

EXAM TIP

Interpreting graphs of limiting factors can be confusing for many students, but it's quite simple.

In the section of the graph where the rate is increasing (the line is going up), the limiting factor is **whatever the label on the x axis (the bottom axis) of the graph is**.

In the section of the graph where the rate is not increasing (the line is horizontal), the limiting factor will be **something other than what is on the x axis** – choose from **temperature**, **light intensity** or **carbon dioxide concentration**.

6 PLANT NUTRITION

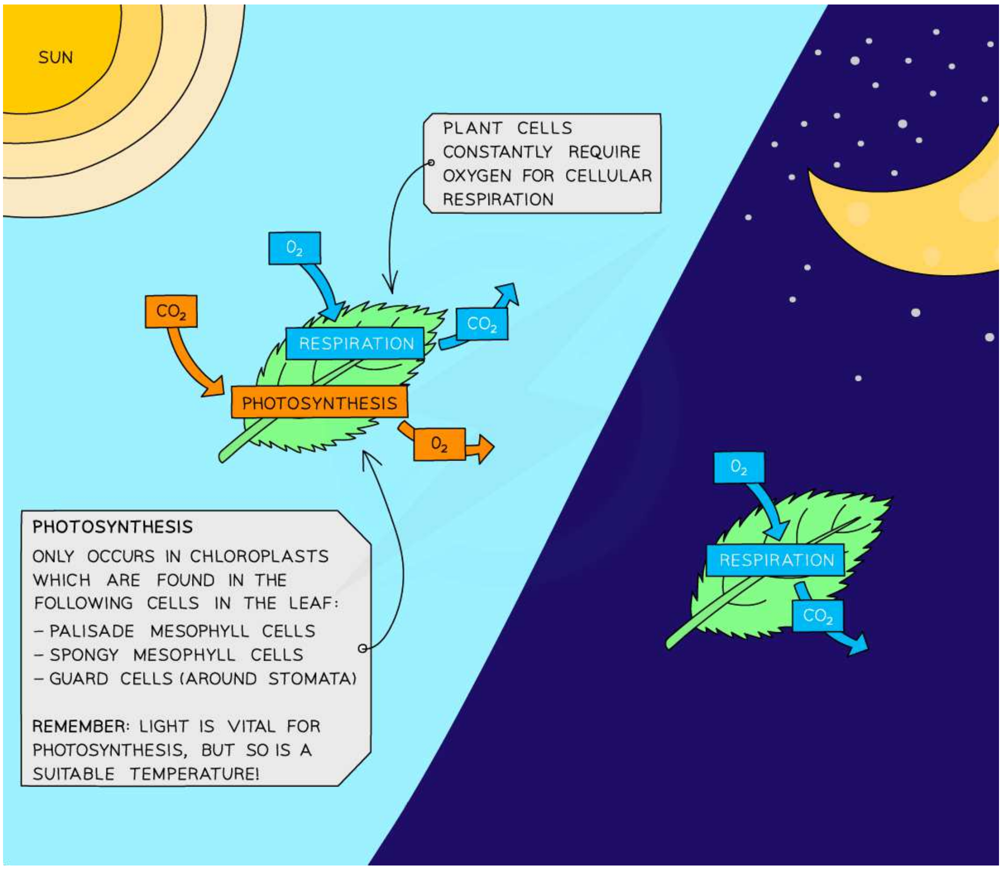
6.4 INVESTIGATING GAS EXCHANGE

YOUR NOTES

EXTENDED ONLY

Effect of Light on Net Gas Exchange

- Plants are **respiring all the time** and so plant cells are **taking in oxygen and releasing carbon dioxide** as a result of aerobic respiration
- Plants also **photosynthesise during daylight** hours, for which they need to **take in carbon dioxide and release the oxygen** made in photosynthesis
- At night, plants do not photosynthesise but they continue to respire, meaning **they take in oxygen and give out carbon dioxide**



Photosynthesis and respiration in plants

6 PLANT NUTRITION

6.4 INVESTIGATING GAS EXCHANGE cont...

YOUR NOTES

EXTENDED ONLY cont...

- During the day, especially when the sun is bright, **plants are photosynthesising at a faster rate than they are respiring**, so there is a **net intake of carbon dioxide and a net output of oxygen**
- We can investigate the effect of light on the **net gas exchange** in an aquatic plant using a **pH indicator** such as **hydrogencarbonate indicator**
- This is possible because carbon dioxide is an **acidic gas** when dissolved in water
- Hydrogencarbonate indicator shows the **carbon dioxide concentration in solution**

The table shows the colour that the hydrogencarbonate indicator turns at different levels of carbon dioxide concentration:

CONCENTRATION OF CARABON DIOXIDE	COLOUR OF HYDROGEN CARBON INDICATOR	CONDITIONS IN PLANT
HIGHEST	YELLOW	MORE RESPIRATION > PHOTOSYNTHESIS – LOWER pH (MORE ACID)
HIGHER	ORANGE	
ATMOSPHERIC LEVEL	RED	PHOTOSYNTHESIS = RESPIRATION
LOWER	MAGENTA	MORE PHOTOSYNTHESIS > RESPIRATION – HIGHER pH (MORE ALKALINE)
LOWEST	PURPLE	

6 PLANT NUTRITION

6.4 INVESTIGATING GAS EXCHANGE cont...

YOUR NOTES

EXTENDED ONLY cont...

- Several leaves from the same plant are placed in stoppered boiling tubes containing some **hydrogen carbonate indicator**
- The effect of light can then be investigated over a period of a few hours

Results from a typical gas exchange experiment are shown in the table below:

TUBE	CONTENTS	CONDITIONS	INDICATOR TURNS	CONCLUSION
A	LEAF	LIGHT	PURPLE	THERE IS A NET INTAKE OF OXYGEN BY A LEAF IN LIGHT
B	LEAF	DARK	YELLOW	THERE IS A NET INTAKE OF CARBON DIOXIDE BY A LEAF IN THE DARK
C	NO LEAF	LIGHT	RED	THIS IS THE CONTROL – THE TWO OTHER TUBES CAN BE COMPARED WITH IT

6 PLANT NUTRITION

6.5 LEAF STRUCTURE

YOUR NOTES

Structure of the Leaf

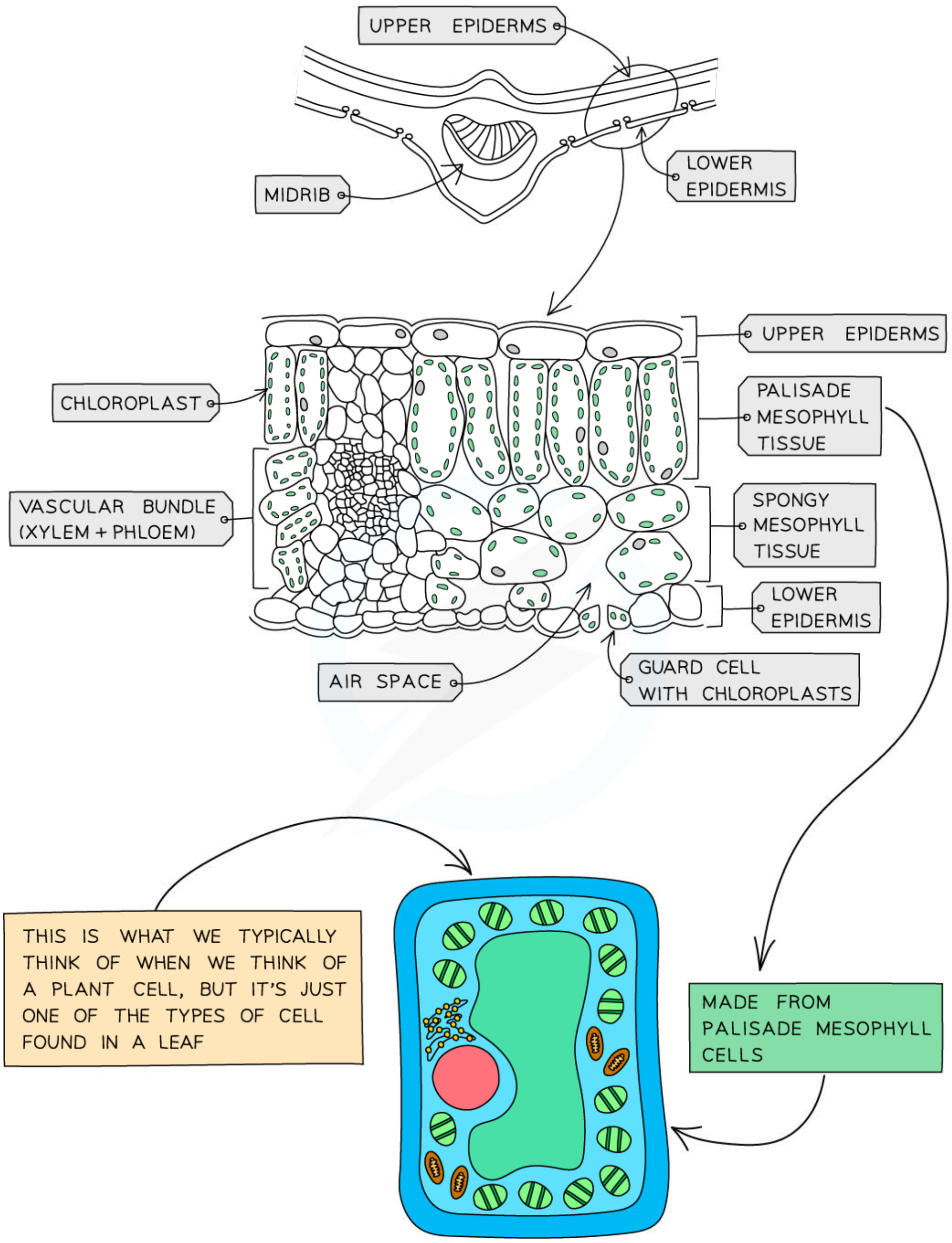


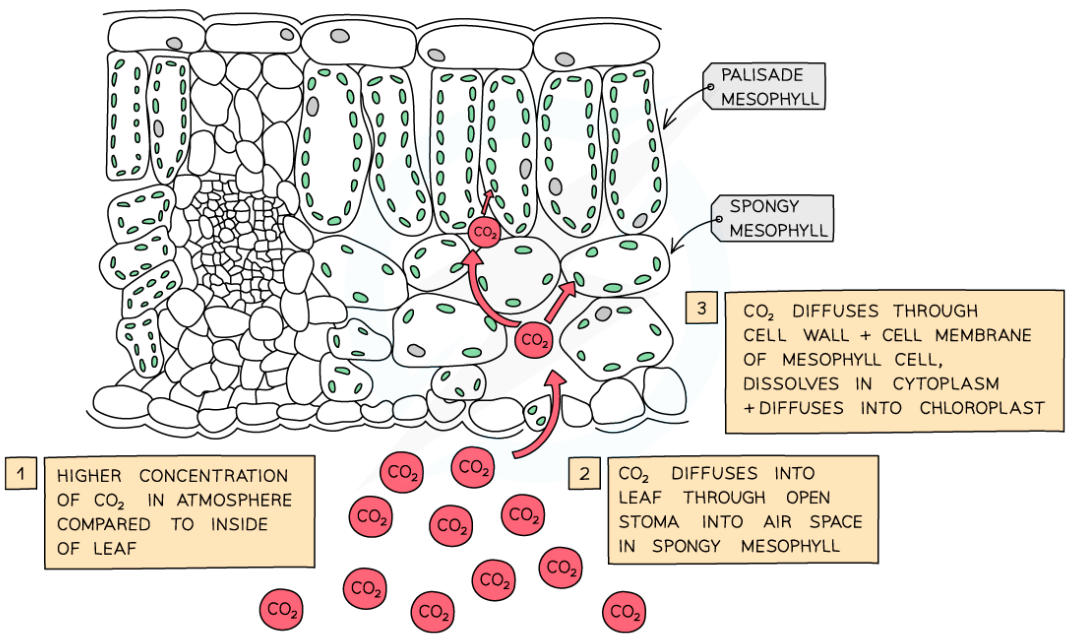
Diagram showing the cross section of a leaf

6 PLANT NUTRITION

6.5 LEAF STRUCTURE cont...

YOUR NOTES

PATHWAY OF CO_2 MOLECULE WHEN LEAF IS PHOTOSYNTHESISING



How photosynthesising cells obtain carbon dioxide

Pathway of carbon dioxide from atmosphere to chloroplasts by diffusion:

ATMOSPHERE
↓
AIR SPACES AROUND SPONGY MESOPHYLL TISSUE
↓
LEAF MESOPHYLL CELLS
↓
CHLOROPLAST

6 PLANT NUTRITION

YOUR NOTES

6.5 LEAF STRUCTURE cont...

STRUCTURE	DESCRIPTION
WAX CUTICLE	PROTECTIVE LAYER ON TOP OF THE LEAF, PREVENTS WATER FROM EVAPORATING
UPPER EPIDERMIS	THIN AND TRANSPARENT TO ALLOW LIGHT TO ENTER PALISADE MESOPHYLL LAYER UNDERNEATH IT
PALISADE MESOPHYLL	COLUMN SHAPED CELLS TIGHTLY PACKED WITH CHLOROPLASTS TO ABSORB MORE LIGHT, MAXIMISING PHOTOSYNTHESIS
SPONGY MESOPHYLL	CONTAINS INTERNAL AIR SPACES THAT INCREASES THE SURFACE AREA TO VOLUME RATIO FOR THE DIFFUSION OF GASES (MAINLY CARBON DIOXIDE)
LOWER EPIDERMIS	CONTAINS GUARD CELLS AND STOMATA
GUARD CELL	ABSORBS AND LOSES WATER TO OPEN AND CLOSE THE STOMATA TO ALLOW CARBON DIOXIDE TO DIFFUSE IN, OXYGEN TO DIFFUSE OUT
STOMATA	WHERE GAS EXCHANGE TAKES PLACE; OPENS DURING THE DAY, CLOSES DURING THE NIGHT. EVAPORATION OF WATER ALSO TAKES PLACE FROM HERE. IN MOST PLANTS, FOUND IN MUCH GREATER CONCENTRATION ON THE UNDERSIDE OF THE LEAF TO REDUCE WATER LOSS
VASCULAR BUNDLE	CONTAINS XYLEM AND PHLOEM TO TRANSPORT SUBSTANCES TO AND FROM THE LEAF
XYLEM	TRANSPORTS WATER INTO THE LEAF FOR MESOPHYLL CELLS TO USE IN PHOTOSYNTHESIS AND FOR TRANSPIRATION FROM STOMATA
PHLOEM	TRANSPORTS SUCROSE AND AMINO ACIDS AROUND THE PLANT

6 PLANT NUTRITION

6.5 LEAF STRUCTURE cont...

YOUR NOTES

EXTENDED ONLY

Adaptations of Leaf for Photosynthesis

FEATURE	ADAPTATION
LARGE SURFACE AREA (LEAF)	INCREASES SURFACE AREA FOR THE DIFFUSION OF CARBON DIOXIDE AND ABSORPTION OF LIGHT FOR PHOTOSYNTHESIS
THIN	ALLOWS CARBON DIOXIDE TO DIFFUSE TO PALISADE MESOPHYLL CELLS QUICKLY
CHLOROPHYLL	ABSORBS LIGHT ENERGY SO THAT PHOTOSYNTHESIS CAN TAKE PLACE
NETWORK OF VEINS	ALLOWS THE TRANSPORT OF WATER TO THE CELLS OF THE LEAF AND CARBOHYDRATES FROM THE LEAF FOR PHOTOSYNTHESIS (WATER FOR PHOTOSYNTHESIS, CARBOHYDRATES AS A PRODUCT OF PHOTOSYNTHESIS)
STOMATA	ALLOWS CARBON DIOXIDE TO DIFFUSE INTO THE LEAF AND OXYGEN TO DIFFUSE OUT
EPIDERMIS IS THIN AND TRANSPARENT	ALLOWS MORE LIGHT TO REACH THE PALISADE CELLS
THIN CUTICLE MADE OF WAX	TO PROTECT THE LEAF WITHOUT BLOCKING SUNLIGHT
PALISADE CELL LAYER AT TOP OF LEAF	MAXIMISES THE ABSORPTION OF LIGHT AS IT WILL HIT CHLOROPLASTS IN THE CELLS DIRECTLY
SPONGY LAYER	AIR SPACES ALLOW CARBON DIOXIDE TO DIFFUSE THROUGH THE LEAF, INCREASING THE SURFACE AREA
VASCULAR BUNDLES	THICK CELL WALLS OF THE TISSUE IN THE BUNDLES HELP TO SUPPORT THE STEM AND LEAF

6 PLANT NUTRITION

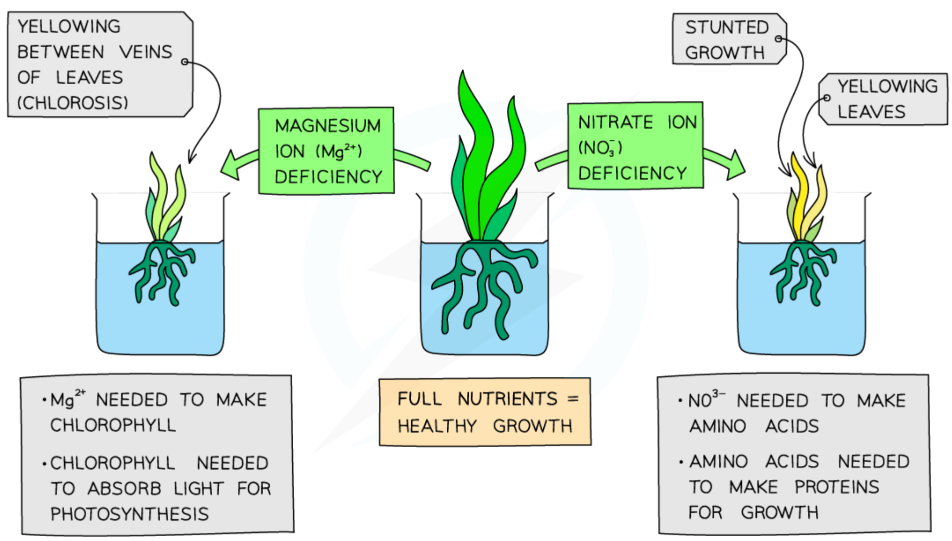
6.6 MINERAL REQUIREMENTS

The Need for Mineral Ions

- Photosynthesis produces carbohydrates, but plants contain many other types of biological molecule; such as proteins, lipids and nucleic acid (DNA).
- As plants do not eat, they need to **make these substances themselves**
- Carbohydrates contain the elements carbon, hydrogen and oxygen but proteins, for example, contain **nitrogen** as well (and certain amino acids contain other elements too)
- Other chemicals in plants contain different elements as well, for example chlorophyll contains **magnesium** and **nitrogen**
- This means that without a source of these elements, plants cannot photosynthesise or grow properly
- Plants obtain these elements in the form of **mineral ions actively absorbed from the soil by root hair cells**
- 'Mineral' is a term used to describe any naturally occurring inorganic substance.

EXTENDED ONLY

Effects of Mineral Ion Deficiencies



Mineral deficiencies in plants

YOUR NOTES

6 PLANT NUTRITION

6.6 MINERAL REQUIREMENTS cont...

YOUR NOTES

EXTENDED ONLY cont...

MINERAL ION	FUNCTION	DEFICIENCY
MAGNESIUM	MAGNESIUM IS NEEDED TO MAKE **CHLOROPHYLL**	CAUSES YELLOWING BETWEEN THE VEINS OF LEAVES (**CHLOROSIS**)
NITRATE	NITRATES ARE A SOURCE OF NITROGEN NEEDED TO MAKE **AMINO ACIDS** (TO BUILD PROTEINS)	CAUSES **STUNTED GROWTH** AND **YELLOWING OF LEAVES**

> NOW TRY SOME EXAM QUESTIONS

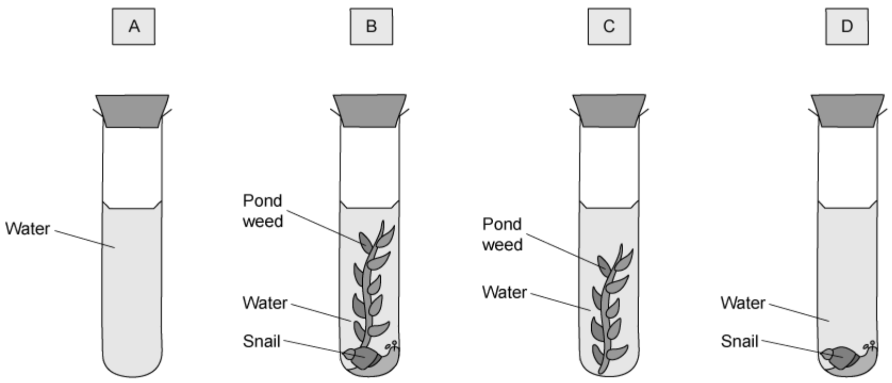
6 PLANT NUTRITION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

An experiment is set up with four test tubes as shown in the diagram below.



All four test tubes are left in sunlight for 6 hours.

Which test tube would contain the least amount of dissolved carbon dioxide after 6 hours?

QUESTION 2

Which row of the table below shows the correct effects of deficiencies of essential minerals for plant growth?

	effect of magnesium ion deficiency	effect of nitrate ion deficiency
A	yellow leaves	stunted growth
B	stunted growth	long roots
C	small leaves	yellow leaves
D	stunted growth	yellow leaves

6 PLANT NUTRITION

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

Which of the following options is the best explanation for the role of chlorophyll in photosynthesis:

Chlorophyll…

A transfers light energy from the sun because it has magnesium ions.

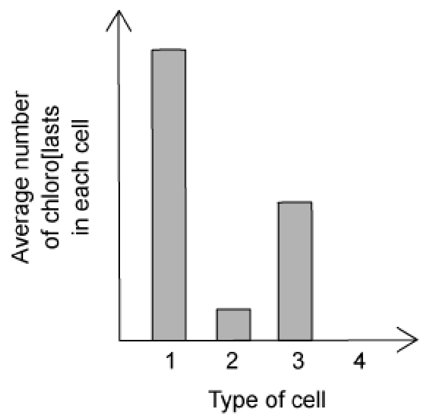
B transfers chemical potential energy from sunlight into organic molecules which can be used to synthesise carbohydrates such as glucose.

C transfers light energy from the sun into chemical energy in inorganic molecules which can be used for growth.

D transfers light energy into chemical potential energy into glucose molecules which are used in the synthesis of other carbohydrates.

QUESTION 4

The average number of chloroplasts found in four different types of cell from the leaf of a plant are shown in the bar chart below.



What are the names of the four types of cell?

	1	2	3	4
A	spongy mesophyll cell	epidermal cell	palisade mesophyll cell	guard cell
B	palisade mesophyll cell	guard cell	spongy mesophyll cell	epidermal cell
C	epidermal cell	spongy mesophyll cell	palisade mesophyll cell	guard cell
D	palisade mesophyll cell	spongy mesophyll cell	guard cell	epidermal cell

6 PLANT NUTRITION

EXAM QUESTIONS cont...

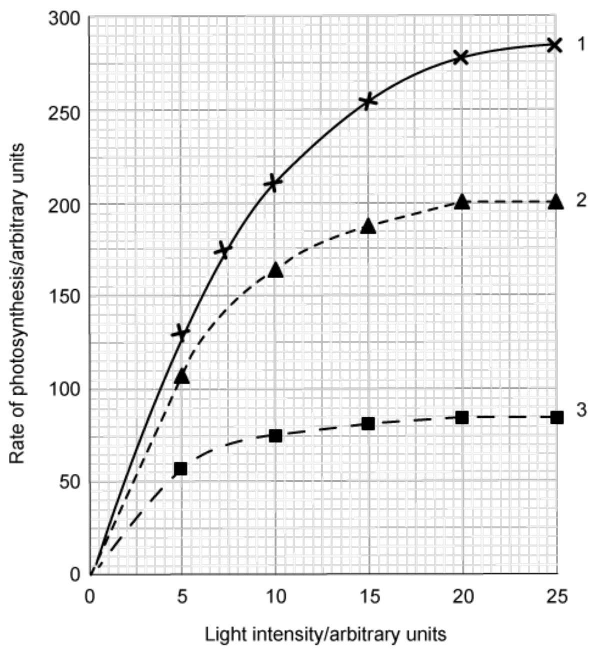
YOUR NOTES

QUESTION 5

The diagram below shows how the rate of photosynthesis is affected by different conditions.

Key

	Temp /°C	CO_2 /%
1	30	0.13
2	20	0.13
3	30	0.03



What of the following correctly identifies the limiting factor for photosynthesis at the three points on the graph?

	1	2	3
A	light intensity	light intensity	carbon dioxide concentration
B	temperature	temperature	light intensity
C	light intensity	temperature	carbon dioxide concentration
D	light intensity	carbon dioxide concentration	temperature

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

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for more questions and revision notes

7 HUMAN NUTRITION

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

7.1 DIET

Balanced Diet

- A balanced diet consists of all of the food groups in the correct proportions
- The necessary food groups are:
  - **Carbohydrates**
  - **Proteins**
  - **Lipids**
  - **Vitamins**
  - **Minerals**
  - **Dietary Fibre**
  - **Water**

FOOD TYPE	FUNCTION	SOURCES
CARBOHYDRATE	SOURCE OF ENERGY	BREAD, CEREALS, PASTA, RICE, POTATOES
PROTEIN	GROWTH AND REPAIR	MEAT, FISH, EGGS, PULSES, NUTS
LIPID	INSULATION AND ENERGY STORAGE	BUTTER, OIL, NUTS
DIETARY FIBRE	PROVIDES BULK (ROUGHAGE) FOR THE INTESTINE TO PUSH FOOD THROUGH IT	VEGETABLES, WHOLE GRAINS
VITAMINS	NEEDED IN SMALL QUANTITIES TO MAINTAIN HEALTH	FRUITS AND VEGETABLES
MINERALS	NEEDED IN SMALL QUANTITIES TO MAINTAIN HEALTH	FRUITS AND VEGETABLES, MEATS, DAIRY PRODUCTS
WATER	NEEDED FOR CHEMICAL REACTIONS TO TAKE PLACE IN CELLS	WATER, JUICE, MILK, FRUITS AND VEGETABLES

7 HUMAN NUTRITION

YOUR NOTES

7.1 DIET cont...

Specific vitamin & mineral requirements:

VITAMIN / MINERAL	FUNCTION	SOURCES
VITAMIN C	FORMS AN ESSENTIAL PART OF **COLLAGEN** PROTEIN, WHICH **MAKES UP SKIN, HAIR, GUMS AND BONES** DEFICIENCY CAUSES **SCURVY**	CITRUS FRUIT, STRAWBERRIES, GREEN VEGETABLES
VITAMIN D	HELPS THE BODY TO ABSORB CALCIUM AND SO REQUIRED FOR **STRONG BONES AND TEETH**	OILY FISH, EGGS, LIVER, DAIRY PRODUCTS, ALSO MADE NATURALLY BY THE BODY IN SUNLIGHT
CALCIUM	NEEDED FOR **STRONG TEETH AND BONES** AND INVOLVED IN THE CLOTTING OF BLOOD DEFICIENCY CAN LEAD TO OSTEOPOROSIS LATER IN LIFE	MILK, CHEESE, EGGS
IRON	NEEDED TO MAKE **HAEMOGLOBIN**, THE PIGMENT IN RED BLOOD CELLS THAT TRANSPORTS OXYGEN	RED MEAT, LIVER, LEAFY GREEN VEGETABLES LIKE SPINACH

EXTENDED ONLY

Causes & Effects of Vitamin & Mineral Deficiencies

SUBSTANCE DEFICIENT	CAUSE	EFFECT
VITAMIN D	LACK OF SUNLIGHT, FISH, EGGS, BUTTER IN DIET	CAUSES **RICKETS** – WHERE BONES BECOME SOFT AND DEFORMED (THIS IS BECAUSE VITAMIN D IS NEEDED FOR ABSORPTION OF CALCIUM INTO THE BODY WHICH IS A KEY COMPONENT OF BONES AND TEETH)
IRON	LACK OF LEAFY GREEN VEGETABLES, RED MEAT, LIVER	CAUSES **ANAEMIA** – WHERE THERE ARE NOT ENOUGH RED BLOOD CELLS SO TISSUES DO NOT GET ENOUGH OXYGEN DELIVERED TO THEM (THIS IS BECAUSE IRON IS A KEY COMPONENT OF HAEMOGLOBIN)

7 HUMAN NUTRITION

7.1 DIET cont...

YOUR NOTES

Effects of Malnutrition

- **Malnutrition** is caused by **not eating a balanced diet**
- There are different types of malnutrition depending on the cause of the imbalance
- They include:
  - **Starvation**
  - **Coronary heart disease**
  - **Constipation**
  - **Obesity**

TYPE	CAUSE	EFFECT
STARVATION	TAKING IN LESS ENERGY THAN IS USED (OVER A LONG PERIOD)	BODY STARTS TO BREAK DOWN ENERGY STORES – FIRST FAT AND THEN MUSCLE TISSUE, LEADING TO SEVERE WEIGHT LOSS AND EVENTUALLY DAMAGE TO HEART AND IMMUNE SYSTEM, INCREASING THE RISK OF MANY DISEASES
CORONARY HEART DISEASE	DIET TOO HIGH IN SATURATED FAT AND CHOLESTEROL	FAT DEPOSITS BUILD UP IN ARTERIES SUPPLYING THE HEART, REDUCING FLOW OF BLOOD TO THE HEART MUSCLE CELLS WHICH DO NOT WORK PROPERLY DUE TO LACK OF OXYGEN. CAN LEAD TO HEART ATTACKS AND DEATH
CONSTIPATION	LACK OF FIBRE IN THE DIET	FOOD LACKS BULK FOR MUSCLES TO PUSH IT THROUGH THE ALIMENTARY CANAL AND SO RISK OF DISEASES SUCH AS BOWEL CANCER ARE INCREASED
OBESITY	TAKING IN MORE ENERGY THAN IS USED	EXTRA ENERGY STORED AS FAT, WEIGHT INCREASES AND CONTRIBUTES TO DEVELOPMENT OF MANY DISEASES SUCH AS HEART DISEASE AND DIABETES

7 HUMAN NUTRITION

7.1 DIET cont...

YOUR NOTES

EXTENDED ONLY

Protein Energy Malnutrition

- In many countries in the world, droughts, natural disasters, wars and a poor economy can lead to mass malnutrition in large areas of the country
- The two types of malnutrition most common in these situations are termed '**protein energy malnutrition**' (PEM)and they are:
- **Kwashiorkor** – caused by a **lack of protein** in the diet, most common in children under 2.
  - Often caused by poverty as high protein foods tend to be more expensive and scarcer.
  - Children suffering from kwashiorkor are always underweight for their age but they often have a swollen abdomen as their diet may contain a lot of carbohydrate
- **Marasmus** – the most severe form of PEM, where there is a **lack of both protein and energy** in the diet.
  - People suffering from this have a much lower body weight than normal and look emaciated

Dietary Needs of Different Individuals

FACTOR	DIETARY NEEDS
AGE	THE AMOUNT OF ENERGY THAT YOUNG PEOPLE NEED **INCREASES TOWARDS ADULTHOOD AS THIS ENERGY IS NEEDED FOR GROWTH** CHILDREN NEED A HIGHER PROPORTION OF PROTEIN IN THEIR DIET THAN ADULTS AS THIS IS REQUIRED FOR **GROWTH** ENERGY NEEDS OF ADULTS **DECREASE** AS THEY AGE
ACTIVITY LEVELS	THE MORE ACTIVE, THE MORE ENERGY REQUIRED FOR MOVEMENT AS **MUSCLES ARE CONTRACTING MORE AND RESPIRING FASTER**
PREGNANCY	DURING PREGNANCY, ENERGY REQUIREMENTS INCREASE AS **ENERGY IS NEEDED TO SUPPORT THE GROWTH OF THE DEVELOPING FOETUS**, AS WELL AS THE LARGER MASS THAT THE MOTHER NEEDS TO CARRY AROUND EXTRA **CALCIUM** AND **IRON** ARE ALSO NEEDED IN THE DIET TO HELP BUILD THE BONES, TEETH AND BLOOD OF THE FETUS
BREASTFEEDING	**ENERGY** REQUIREMENTS **INCREASE** AND EXTRA **CALCIUM** STILL NEEDED TO MAKE HIGH QUALITY BREAST MILK

7 HUMAN NUTRITION

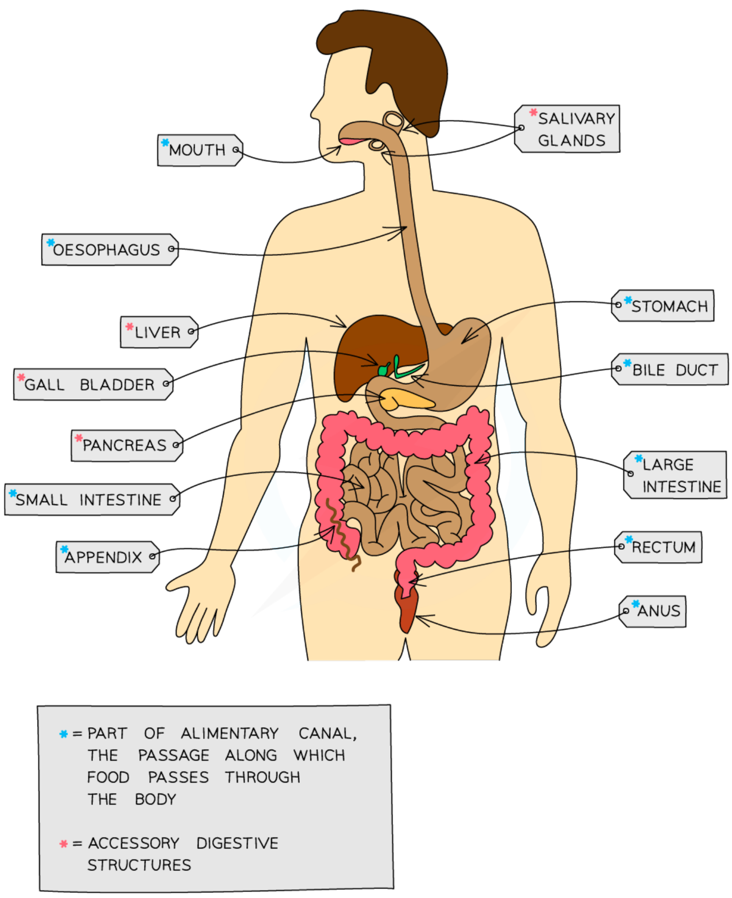
7.2 THE ALIMENTARY CANAL

YOUR NOTES

The Stages of Food Breakdown

- Food taken into the body goes through 5 different stages during its passage through the **alimentary canal** (the gut)
- **Ingestion – the taking of substances**, e.g. food and drink, **into the body through the mouth**
- **Mechanical digestion – the breakdown of food** into smaller pieces **without chemical change** to the food molecules
- **Chemical digestion** – the breakdown of **large, insoluble molecules** into small, **soluble molecules**
- **Absorption** – the movement of **small food molecules and ions** through the wall of the intestine **into the blood**
- **Assimilation** – the movement of digested food molecules **into the cells of the body where they are used**, becoming part of the cells
- **Egestion** – the passing out of food that has **not been digested or absorbed, as faeces**, through the anus

Structure & Function of the Alimentary Canal



The human digestive system

7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL cont...

YOUR NOTES

STRUCTURE	FUNCTION
MOUTH / SALIVARY GLANDS	THE MOUTH IS WHERE **MECHANICAL DIGESTION** TAKES PLACE – **TEETH CHEW FOOD** TO BREAK IT INTO SMALLER PIECES AND INCREASE IT'S SURFACE AREA TO VOLUME RATIO **AMYLASE ENZYMES** IN SALIVA START DIGESTING STARCH INTO MALTOSE THE FOOD IS SHAPED INTO A BOLUS (BALL) BY THE TONGUE AND LUBRICATED IN SALIVA SO IT CAN BE SWALLOWED EASILY
OESOPHAGUS	TUBE THAT **CONNECTS THE MOUTH TO THE STOMACH** WHERE THE FOOD BOLUS GOES AFTER BEING SWALLOWED WAVE – LIKE CONTRACTIONS WILL TAKE PLACE TO PUSH THE FOOD BOLUS DOWN WITHOUT RELYING ON GRAVITY
STOMACH	FOOD IS **MECHANICALLY DIGESTED BY CHURNING** ACTIONS WHILE **PROTEASE ENZYMES** START TO CHEMICALLY DIGEST PROTEINS **HYDROCHLORIC ACID** IS PRESENT TO KILL BACTERIA IN FOOD AND PROVIDE THE OPTIMUM PH FOR PROTEASE ENZYMES TO WORK
SMALL INTESTINE	FIRST SECTION IS CALLED THE **DUODENUM** AND IS WHERE THE FOOD COMING OUT OF THE STOMACH FINISHES BEING DIGESTED BY ENZYMES PRODUCED HERE AND ALSO SECRETED FROM THE PANCREAS PH OF THE SMALL INTESTINE IS **SLIGHTLY ALKALINE** – AROUND PH 8 – 9 SECOND SECTION IS CALLED THE **ILEUM** AND IS WHERE ABSORPTION OF DIGESTED FOOD MOLECULES TAKES PLACE THE ILEUM IS LONG AND LINED WITH VILLI TO INCREASE THE SURFACE AREA OVER WHICH ABSORPTION CAN TAKE PLACE
LARGE INTESTINE	**WATER IS ABSORBED** FROM REMAINING MATERIAL IN THE COLON TO PRODUCE FAECES FAECES IS STORED IN THE **RECTUM** AND REMOVED THROUGH THE **ANUS**
PANCREAS	PRODUCES **ALL THREE TYPES OF DIGESTIVE ENZYME**; AMYLASE, PROTEASE AND LIPASE SECRETES ENZYMES IN AN **ALKALINE FLUID** INTO THE DUODENUM FOR DIGESTION TO RAISE PH OF FLUID COMING OUT OF THE STOMACH
LIVER	PRODUCES **BILE** TO EMULSIFY FATS (BREAK LARGE DROPLETS INTO SMALLER DROPLETS) – AN EXAMPLE OF **MECHANICAL DIGESTION** AMINO ACIDS NOT USED TO MAKE PROTEINS BROKEN DOWN HERE (DEAMINATION) WHICH **PRODUCES UREA**
GALL BLADDER	**STORES BILE** TO RELEASE INTO DUODENUM AS REQUIRED

7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL cont...

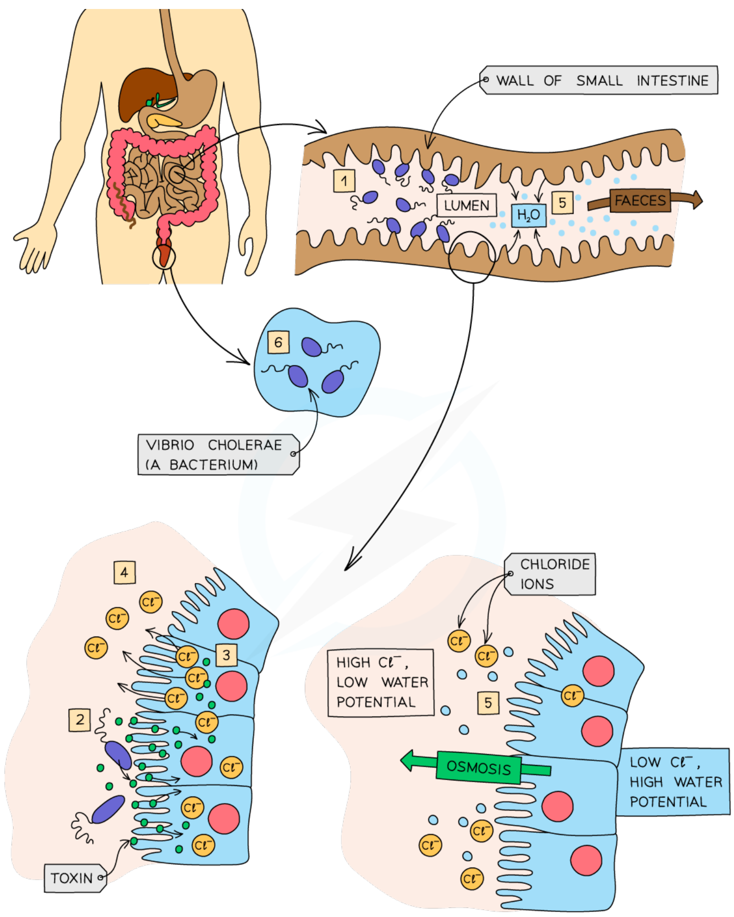
YOUR NOTES

Diarrhoea Causes & Treatment

- Diarrhoea is **the loss of watery faeces from the anus**
- If it is severe and continues for a long time, it can **lead to death**
- Severe diarrhoea can cause the **loss of significant amounts of water and ions** from the body, causing the tissues and organs to stop working properly
- It can be effectively treated by **oral rehydration therapy**
- This is a **drink with a small amount of salt and sugar** dissolved in it
- There are many causes of diarrhoea, one of which is infection with **Vibrio cholerae bacteria**, which causes the disease **cholera**

EXTENDED ONLY

How Does Vibrio Cholerae Cause Diarrhoea?



How cholera leads to diarrhoea

7 HUMAN NUTRITION

7.2 THE ALIMENTARY CANAL cont...

YOUR NOTES

EXTENDED ONLY cont...

- Ingested via **infected water or food**, if it enters the small intestine it can cause illness in the following way:

    1. Bacteria attach to the wall of the **small intestine**
    2. They produce a **toxin**
    3. The toxin stimulates the cells lining the intestine to **release chloride ions** from inside the cells into the lumen of the intestine
    4. The chloride ions accumulate in the lumen of the small intestine and **lower the water potential** there
    5. Once the water potential is lower than that of the cells lining the intestine, **water starts to move out of the cells** into the intestine (by osmosis)
    6. Large quantities of water are lost from the body in **watery faeces**
    7. The blood contains **too little chloride ions and water**

7.3 MECHANICAL DIGESTION

Mechanical Digestion: Basics

- Mechanical digestion is the **breakdown of food into smaller pieces** without chemical change to the food molecules
- It is mainly carried out by the **chewing** action of the **teeth**, the **churning** action of the **stomach** and the **emulsification of fats** by **bile** in the duodenum

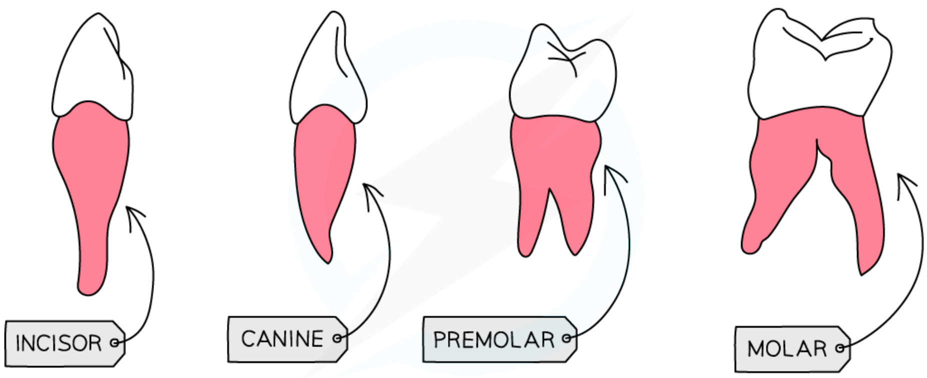
7 HUMAN NUTRITION

7.3 MECHANICAL DIGESTION cont...

YOUR NOTES

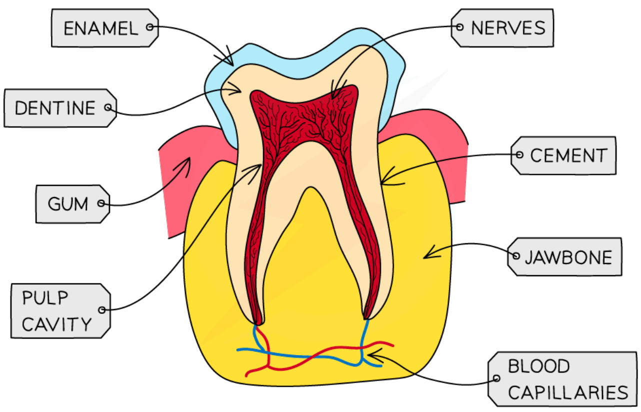
Types of Teeth

- Teeth are held firmly in the bone of the jaw
- They are used for chewing to increase the surface area of the food so that it can be exposed to saliva and other digestive juices and broken down more quickly
- The differing shapes and sizes of teeth enable them to perform slightly different functions:
- Incisors – chisel shaped for biting and cutting
- Canines – pointed for tearing, holding and biting
- Premolars and molars – larger, flat surfaces with ridges at the edges for chewing and grinding up food



Types of teeth

Structure of a Typical Tooth



Structure of a typical tooth

7 HUMAN NUTRITION

7.3 MECHANICAL DIGESTION cont...

YOUR NOTES

Dental Decay

- Tooth decay and gum disease are both caused by **bacteria**
- Many bacteria live in the mouth and most are harmless, however some form a **sticky film** with saliva, called **plaque**, which coats teeth and the areas where they attach to gums
- To begin with, plaque is soft and easy to remove, however if it hardens and forms **tartar**, it cannot be removed by brushing
- Tartar around the edges of teeth and gums can allow bacteria to work their way into roots, causing **gum disease** and loss of teeth
- If **sugar** is left in the mouth after eating, bacteria in plaque will feed on it
- They use it in **respiration** and turn it into **acids**
- The acids gradually **dissolve the enamel coating** of the teeth, working its way into the **dentine**
- Dentine is softer than enamel and so **dissolves more easily** and quickly
- This is **tooth decay** and if not dealt with, can cause painful infections and loss of teeth

Dental Health

- **Reducing the amount** of sugar eaten can prevent tooth decay
- **Brushing teeth regularly** removes the buildup of plaque that can cause gum disease and removes the sugars in the mouth so bacteria cannot turn them into acids and cause tooth decay
- Teeth should be brushed with a **fluoride toothpaste** as this helps to strengthen enamel and reduce damage from acids
- **Regular visits to a dentist** ensures that any signs of gum disease or tooth decay can be dealt with promptly

7 HUMAN NUTRITION

7.4 CHEMICAL DIGESTION

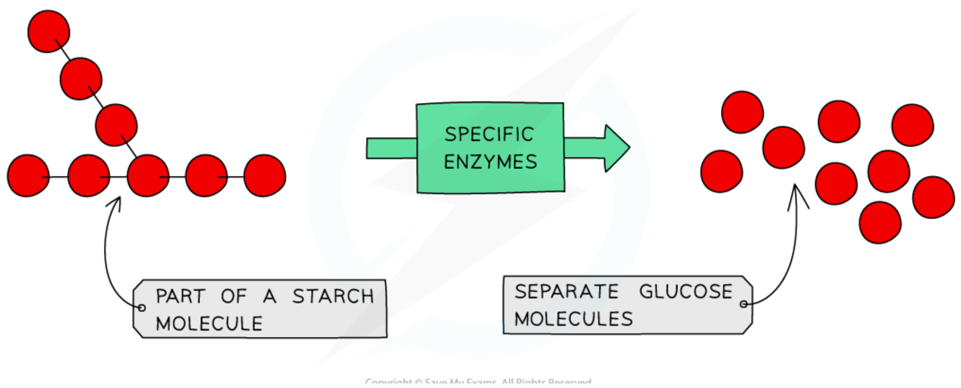
YOUR NOTES

Enzyme Action in the Alimentary Canal

- The purpose of digestion is to **break down large, insoluble molecules (carbohydrates, proteins and lipids) into small, soluble molecules that can be absorbed into the bloodstream**
- Food is partially digested **mechanically** (by chewing, churning and emulsification) in order to break large pieces of food into smaller pieces of food which **increases the surface area for enzymes** to work on
- Digestion mainly takes place **chemically**, where bonds holding the large molecules together are broken to make smaller and smaller molecules
- Chemical digestion is controlled by **enzymes** which are produced in different areas of the digestive system
- There are three main types of digestive enzymes – **carbohydrases, proteases and lipases**

Carbohydrases: Basics

- **Amylases** are produced in the **mouth** and the **pancreas** (secreted into the **duodenum**)
- Amylases digest **starch into smaller sugars**



The digestion of starch

EXTENDED ONLY

Carbohydrases

- **Amylase** is secreted into the alimentary canal in the **mouth** and the **duodenum** (from the pancreas) and digests **starch to maltose** (a disaccharide)
- **Maltose** is digested by the enzyme **maltase** into **glucose** on the membranes of the epithelium lining the small intestine

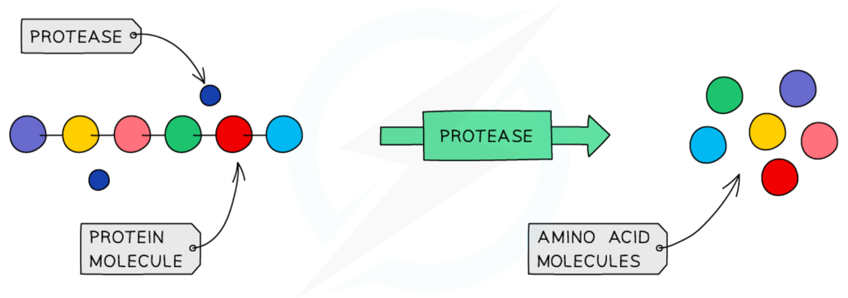
7 HUMAN NUTRITION

YOUR NOTES

7.4 CHEMICAL DIGESTION cont...

Proteases: Basics

- Proteases break down **proteins into amino acids** in the **stomach and small intestine** (using an enzyme produced in the pancreas)



The digestion of proteins

EXTENDED ONLY

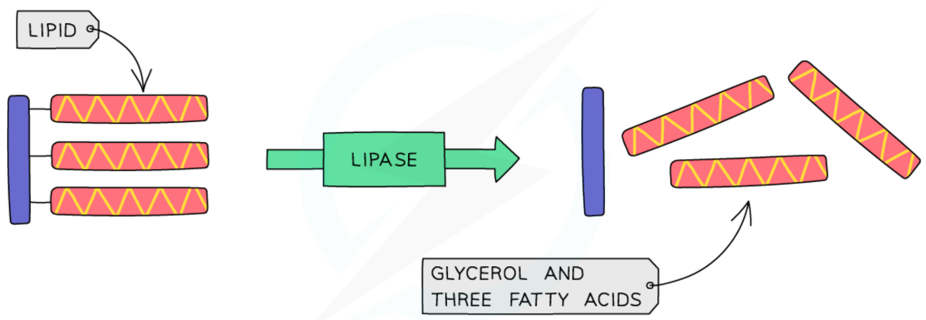
Proteases

Protein digestion takes place in the stomach and duodenum with two main enzymes produced:

- **Pepsin** is produced in the **stomach**
- **Trypsin** is produced in the **pancreas** and secreted into the **duodenum**

Lipases

- **Lipase** enzymes are produced in the **pancreas** and secreted into the **duodenum**
- They digest lipids **into fatty acids and glycerol**



The digestion of lipids

7 HUMAN NUTRITION

YOUR NOTES

7.4 CHEMICAL DIGESTION cont...

The Role of Hydrochloric Acid

- The Role of Hydrochloric Acid
- The stomach produces several fluids which together are known as **gastric juice**
- One of the fluids produced is **hydrochloric acid**
- This **kills bacteria** in food and gives **an acid pH for enzymes** to work in the stomach

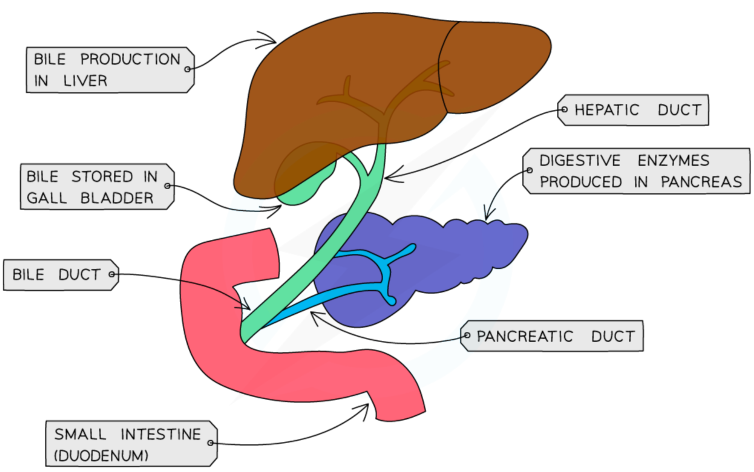
EXTENDED ONLY

How is a Low pH Helpful in the Stomach?

- The low pH kills bacteria in food that we have ingested as it **denatures the enzymes in their cells**, meaning they cannot carry out any cell reactions to maintain life
- **Pepsin**, produced in the stomach, is an example of an enzyme which has a very low optimum pH – around **pH 2**
- The hydrochloric acid produced in the stomach ensures that conditions in the stomach **remain within the optimum range** for pepsin to work at its fastest rate

The Role of Bile

- Cells in the **liver** produce bile which is then stored in the **gallbladder**



Bile production and secretion

7 HUMAN NUTRITION

7.4 CHEMICAL DIGESTION cont...

Bile has two main roles:

- It is **alkaline** to **neutralise the hydrochloric acid** which comes from the stomach. The enzymes in the small intestine have a higher (more alkaline) optimum pH than those in the stomach
- It **breaks down large drops of fat into smaller ones**. This is known as **emulsification**. The larger surface area allows lipase to chemically break down the lipid into glycerol and fatty acids faster

EXAM TIP

Emulsification is the equivalent of tearing a large piece of paper into smaller pieces of paper.

This is an example of mechanical digestion, not chemical digestion – breaking something into smaller pieces **does not break bonds or change the chemical structure of the molecules** which make it up, which is the definition of chemical digestion.

7.5 ABSORPTION

Absorption of Food & Water

- Absorption is the **movement of digested food molecules from the digestive system into the blood (glucose and amino acids) and lymph (fatty acids and glycerol)**
- **Water** is absorbed in both the **small intestine** and the **colon**, but most **absorption of water** also happens in the **small intestine**
- Absorption takes place in the second section of the small intestine, the **ileum**

EXTENDED ONLY

How is the Ileum Adapted for Absorption?

- The ileum is adapted for absorption as it is **very long** and has a **highly folded surface with millions of villi** (tiny, finger like projections)
- These adaptations massively **increase the surface area** of the ileum, allowing absorption to take place faster and more efficiently

YOUR NOTES

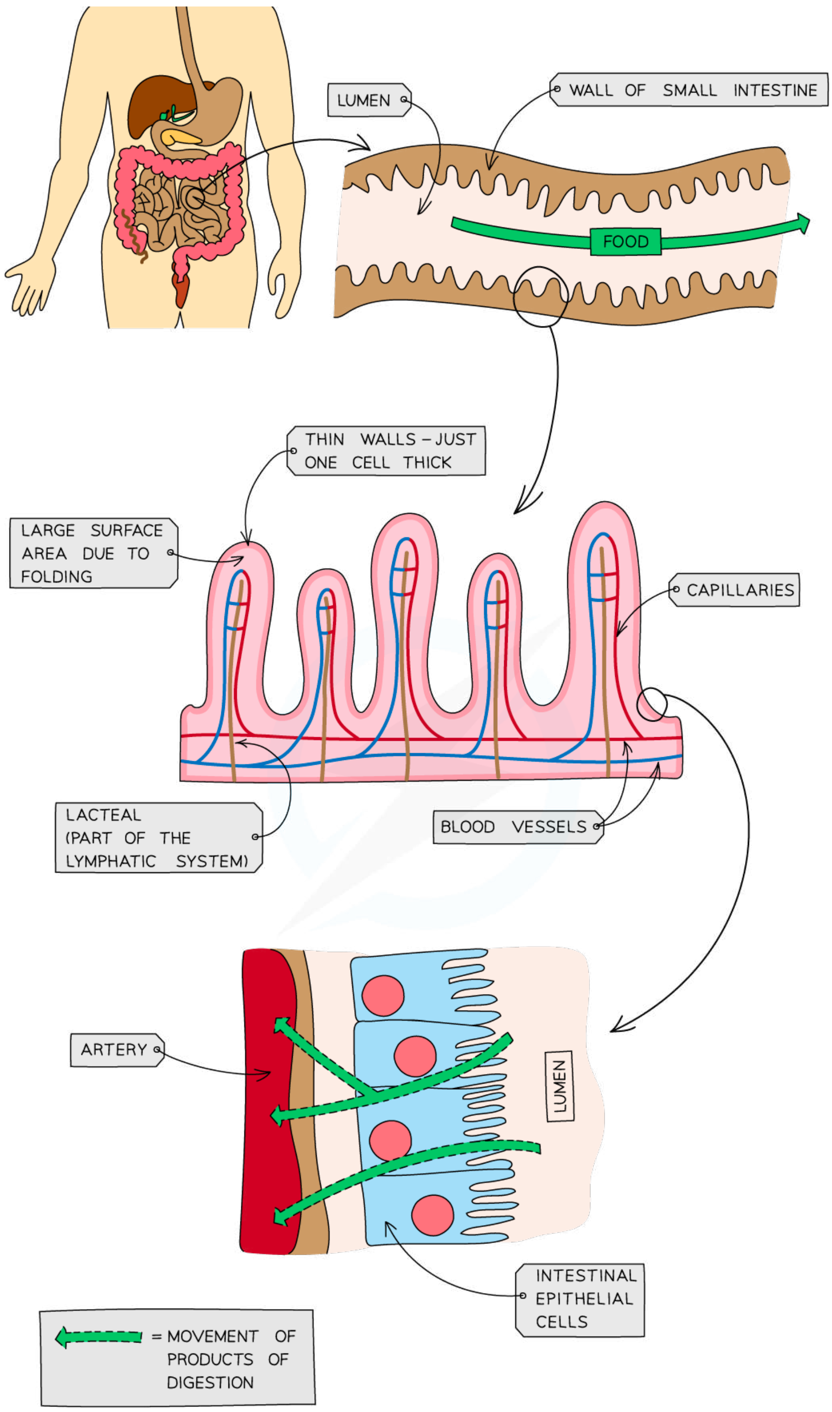
7 HUMAN NUTRITION

7.5 ABSORPTION cont...

YOUR NOTES

EXTENDED ONLY cont...

Structure & Adaptations of a Villus



Adaptations of the small intestine

7 HUMAN NUTRITION

7.5 ABSORPTION cont...

YOUR NOTES

EXTENDED ONLY cont...

- **Microvilli** on the surface of the villus further increase surface area for faster absorption of nutrients
- Wall of villus is **one cell thick** meaning that there is only a short distance for absorption to happen by diffusion and active transport
- Well supplied with a **network of blood capillaries** that transport glucose and amino acids away from the small intestine in the blood
- **Lacteal** runs through the centre of the villus to transport fatty acids and glycerol away from the small intestine in the lymph

EXAM TIP

The way in which the structure of a villus is related to its function comes up frequently in exam questions.

So ensure you have learned these adaptations.

> NOW TRY SOME EXAM QUESTIONS

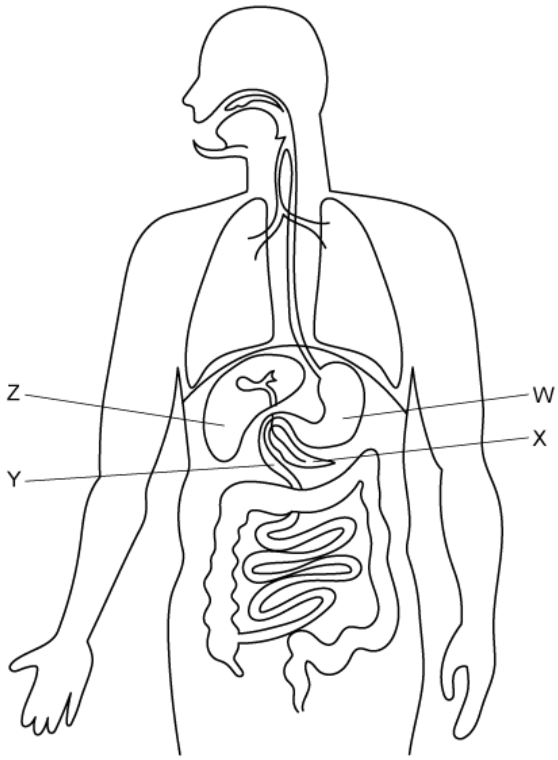
7 HUMAN NUTRITION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The diagram below shows the organs of the digestive system.



In which organs does the digestion of proteins take place?

A W & Y

B W & Z

C Z only

D W & X

QUESTION 2

A patient suffering with persistent diarrhoea calls a doctor.

What treatment should the doctor advise the patient to take?

A Drinking pure water

B Drinking a solution of sugar and salt

C Taking antibiotics

D Eating more protein

7 HUMAN NUTRITION

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

Which of the following is a correct function of bile?

A To emulsify proteins

B To provide enzymes for the digestion of lipids

C To neutralise the alkaline conditions of food entering the duodenum

D To increase the surface area of lipids for digestion

QUESTION 4

A student ate a meal which contained a type of biomolecule, X.
The digestion of biomolecule X started in the mouth, and finished in the duodenum.

What is the product of the digestion of biomolecule X?

A Amino acids

B Protein

C Glucose

D Starch

QUESTION 5

Dietary fibre contains complex carbohydrates which cannot be broken down by enzymes produced in the human digestive system. Fibre passes through several structures after leaving the stomach.

In which order does dietary fibre pass through these structures?

A Pancreas → duodenum → ileum → rectum

B Duodenum → ileum → colon → rectum

C Duodenum → pancreas → ileum → rectum

D Ileum → duodenum → colon → rectum

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

8 TRANSPORT IN PLANTS

YOUR NOTES

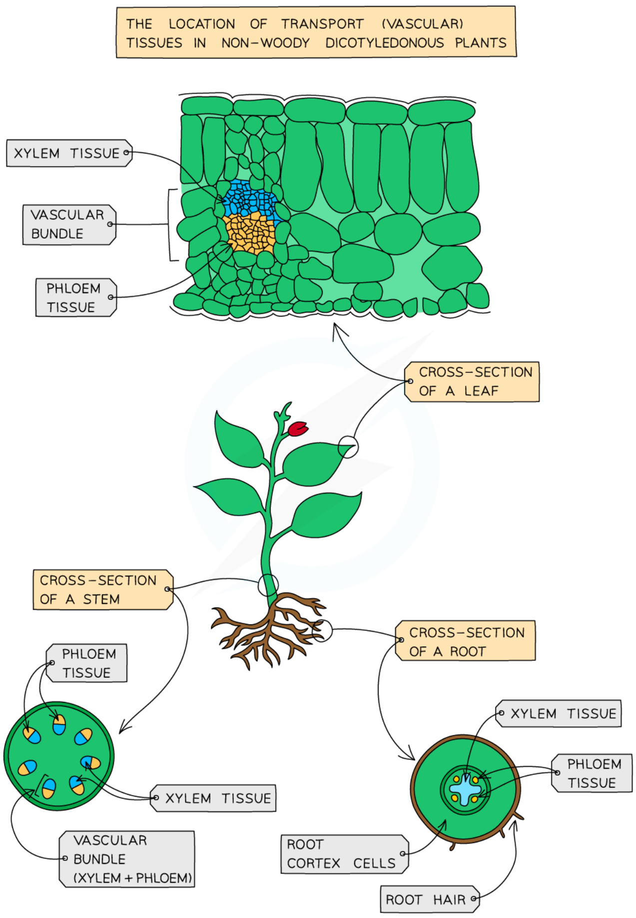
CONTENTS:

VIEW EXAM QUESTIONS

8.1 VASCULAR TISSUE

Functions

- Plants contain two types of transport vessel:
    - **Xylem vessels** – transport water and minerals (pronounced: zi-lem) from the roots to the stem and leaves
    - **Phloem vessels** – transport food materials (mainly sucrose and amino acids) made by the plant from photosynthesising leaves to non-photosynthesising regions in the roots and stem (pronounced: flow-em)
- These vessels are arranged throughout the root, stem and leaves in groups called **vascular bundles**.



Vascular tissue in a dicotyledonous plant

8 TRANSPORT IN PLANTS

YOUR NOTES

8.1 VASCULAR TISSUE cont...

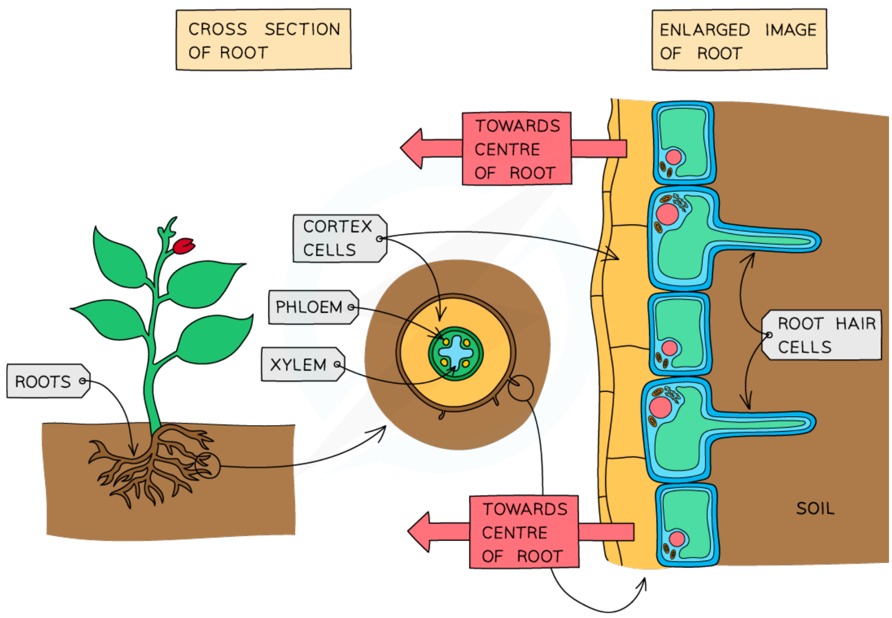
EXAM TIP

If you are asked to identify the xylem or phloem in a diagram showing a cross section of a root, stem or leaf just remember that xylem is always on the inside and phloem is always on the outside.

8.2 WATER UPTAKE

Root Hair Cells

- Root hairs are single-celled extensions of epidermis cells in the root
- They grow between soil particles and absorb water and minerals from the soil
- Water enters the root hair cells by osmosis
- This happens because soil water has a higher water potential than the cytoplasm of the root hair cell



Structure of the root

8 TRANSPORT IN PLANTS

8.2 WATER UPTAKE cont...

YOUR NOTES

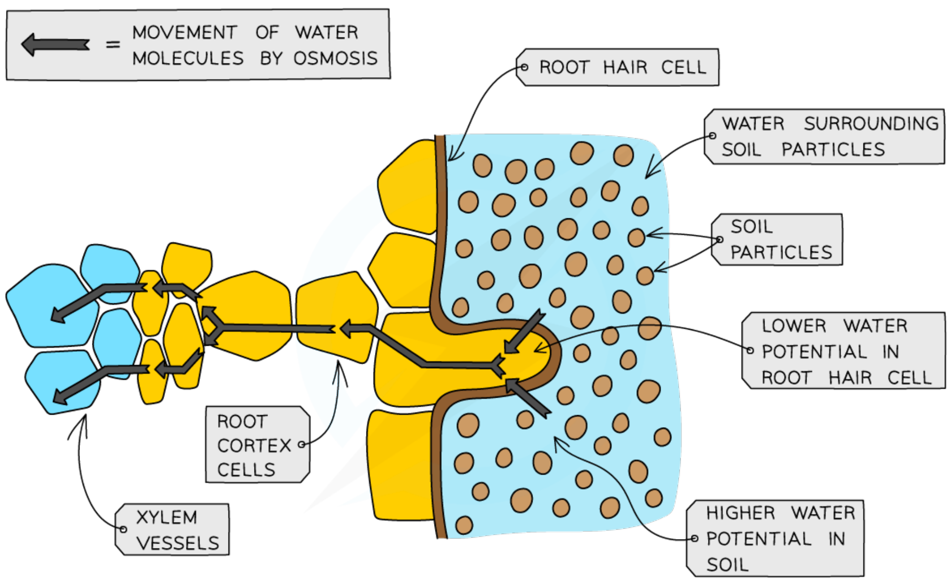
EXTENDED ONLY

How the Large Surface Area of Root Hair Cells is Useful

- The root hair increases the surface area of the cells significantly
- This large surface area is important as it **increases the rate of the absorption of water by osmosis and mineral ions by active transport**

Pathway of Water through Root to Leaf

- Osmosis causes water to pass into the root hair cells, through the root cortex and into the xylem vessels:



Pathway of water into and across a root

- Once the water gets into the xylem, it is carried up to the leaves where it enters mesophyll cells
- So the pathway is:

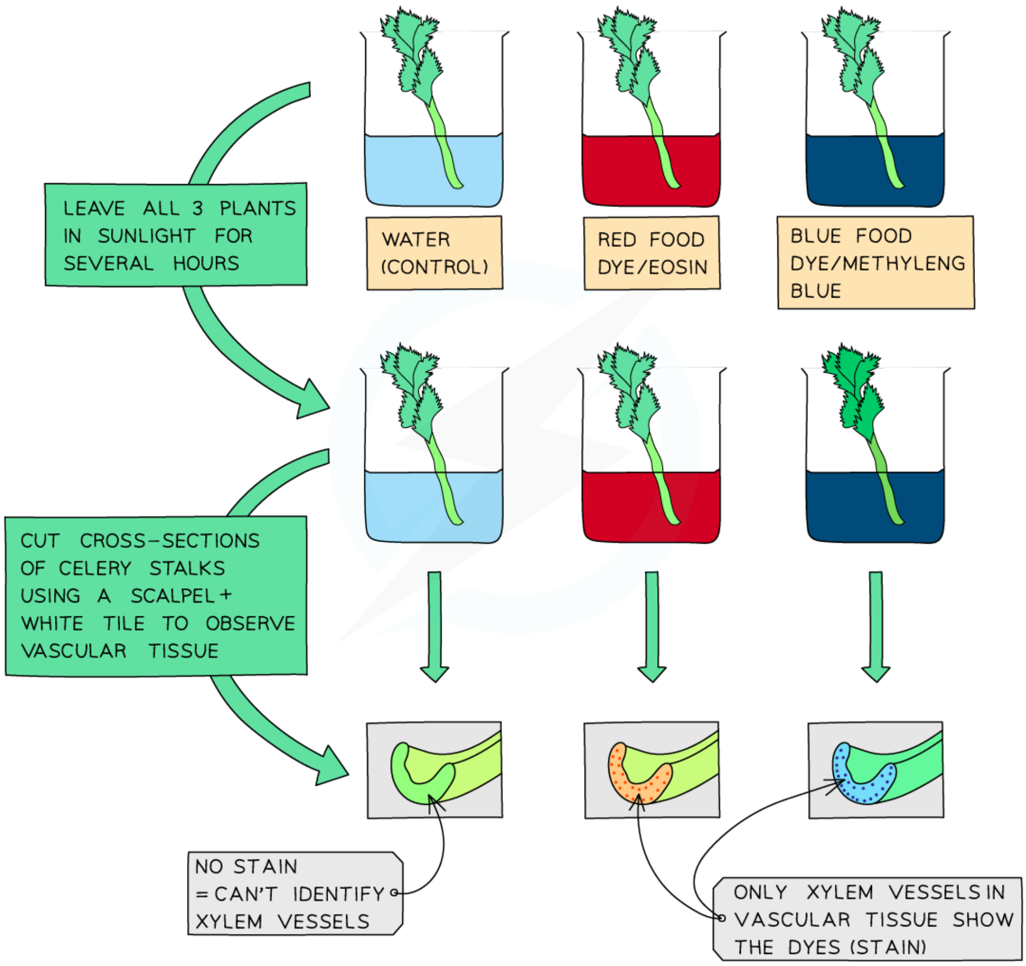
ROOT HAIR CELL ⟶ ROOT CORTEX CELLS ⟶ XYLEM ⟶ LEAF MESOPHYLL CELLS

8 TRANSPORT IN PLANTS

YOUR NOTES

8.2 WATER UPTAKE cont...

- The pathway can be investigated by placing a plant (like celery) into a beaker of water that has had a stain added to it (food colouring will work well)
- After a few hours, you can see the leaves of the celery turning the same colour as the dyed water, proving that water is being taken up by the celery
- If a cross section of the celery is cut, only certain areas of the stalk is stained with the dye, showing that the water is being carried in specific vessels through the stem – these are the xylem vessels



Investigating water movement in plants using a stain

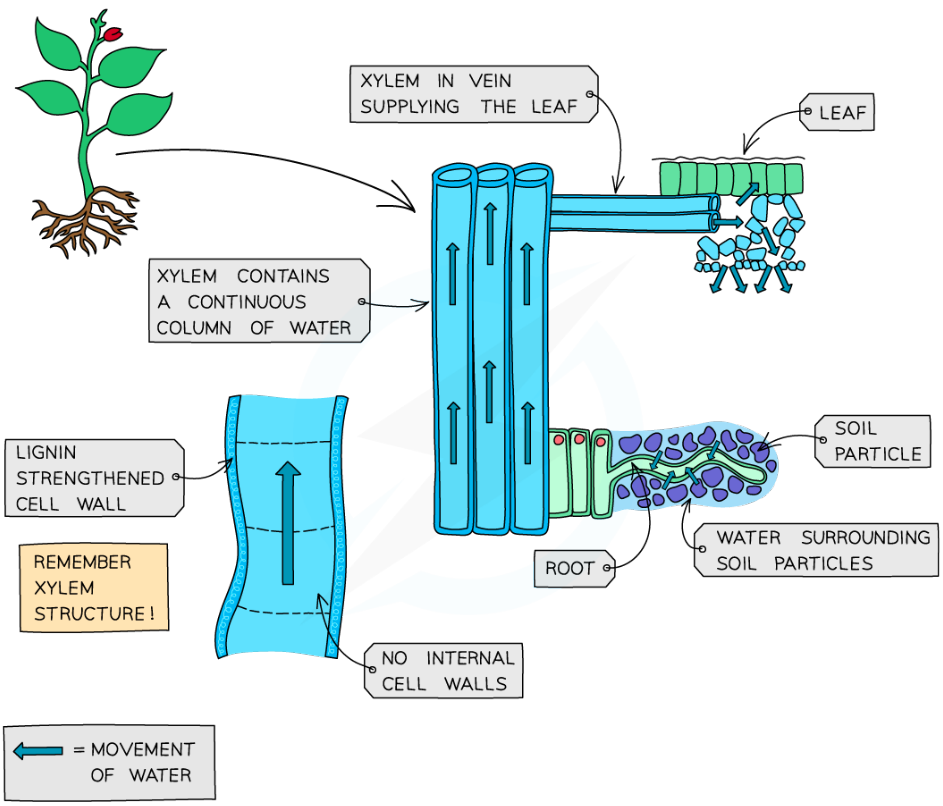
8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION

YOUR NOTES

What is Transpiration?

- **Water** travels up **xylem** from the roots into the leaves of the plant to replace the water that has been lost due to **transpiration**
- Transpiration is defined as the **loss of water vapour from plant leaves by evaporation of water at the surfaces of the mesophyll cells followed by diffusion of water vapour through the stomata**
- Xylem is adapted in many ways:
    - A substance called **lignin** is deposited in the cell walls which causes the xylem cells to die
    - These cells then become **hollow** (as they lose all their organelles and cytoplasm) and join end-to-end to form a **continuous tube** for water and mineral ions to travel through from the roots
    - Lignin strengthens the plant to help it withstand the pressure of the water movement
- Movement in xylem **only takes place in one direction** – from **roots to leaves** (unlike phloem where movement takes place in different directions)

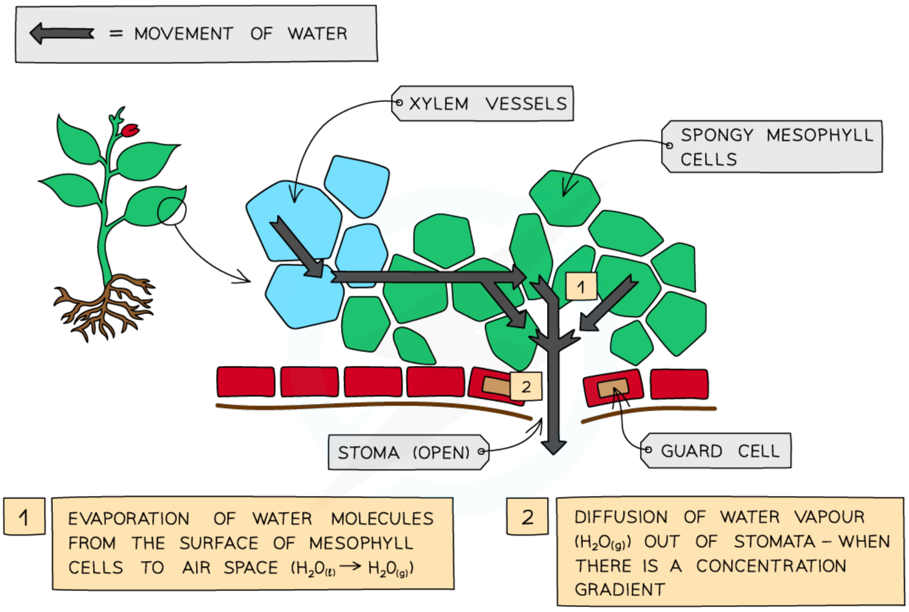


Water uptake, transport and transpiration

8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION cont...

YOUR NOTES



Transpiration in plants

- **Transpiration has several functions in plants:**
    - transporting **mineral ions**
    - providing **water to keep cells turgid** in order to support the structure of the plant
    - providing **water** to leaf cells for **photosynthesis**
    - keeping the **leaves cool** – the conversion of water (liquid) into water vapour (gas), as it leaves the cells and enters the airspace, requires heat energy. The using up of heat to convert water into water vapour helps to cool the plant down

EXTENDED ONLY

How does Transpiration Occur?

- **Evaporation** takes place from the surfaces of spongy mesophyll cells
- The **many interconnecting air spaces** between these cells and the stomata creates a **large surface area**
- This means evaporation can happen rapidly **when stomata are open**

8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION cont...

YOUR NOTES

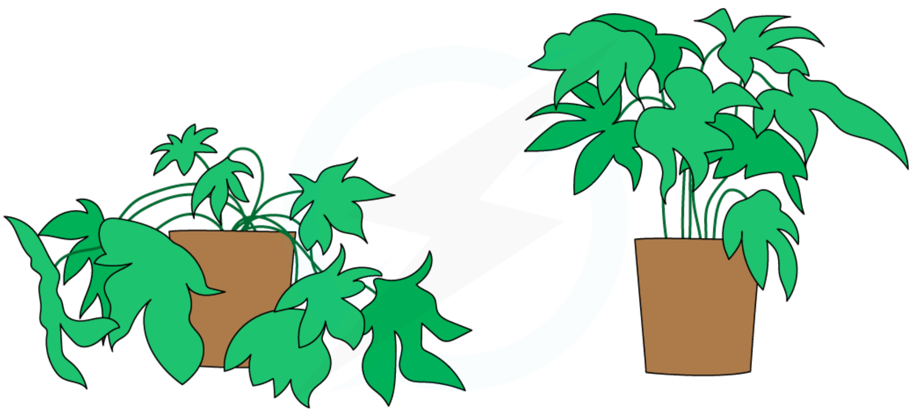
EXTENDED ONLY cont...

How is the Transpiration Stream Created?

- Water molecules are attracted to each other by **cohesion** – creating a continuous column of water up the plant
- Water moves through the xylem vessels in a continuous **transpiration stream** from roots to leaves via the stem
- Transpiration produces a **tension** or 'pull' on the water in the xylem vessels by the leaves
- As water molecules are held together by **cohesive forces** (each individual molecule 'pulls' on the one below it), so water is pulled up through the plant
- If the rate of transpiration from the leaves **increases**, water molecules are pulled up the xylem vessels **quicker**

Wilting

- If more water evaporates from the leaves of a plant than is available in the soil to move into the root by osmosis, then **wilting** will occur
- This is when all the cells of the plant are not full of water, so the strength of the cell walls cannot support the plant and it starts to collapse



A wilted plant cannot support itself and starts to collapse

8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION cont...

YOUR NOTES

Investigating Factors Affecting Transpiration

FACTOR	EFFECT ON RATE OF TRANSPIRATION
TEMPERATURE	INCREASES WITH INCREASING TEMPERATURE
HUMIDITY	DECREASES WITH INCREASING HUMIDITY

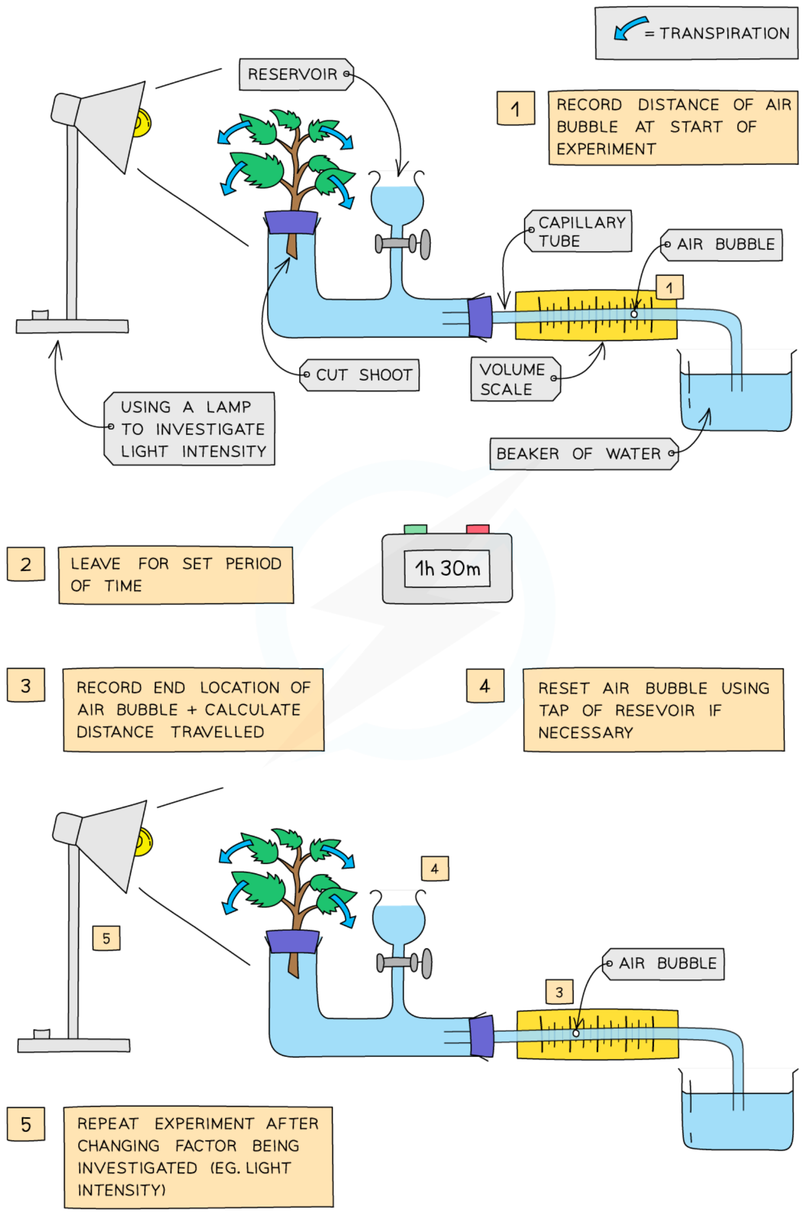
Investigating the role of environmental factors in determining the rate of transpiration from a leafy shoot

- Cut a shoot underwater to **prevent air entering the xylem** and place in tube
- Set up the apparatus as shown in the diagram below and make sure it is airtight, using vaseline to seal any gaps
- Dry the leaves of the shoot (wet leaves will affect the results)
- Remove the capillary tube from the beaker of water to allow a single **air bubble** to form and place the tube back into the water
- Set up the environmental factor you are investigating
- Allow the plant to adapt to the new environment for 5 minutes
- Record the **starting location** of the air bubble
- Leave for a set period of time
- Record the **end location** of air bubble
- Change the light intensity or wind speed or level of humidity or temperature (only one – whichever factor is being investigated)
- Reset the bubble by opening the tap below the reservoir
- Repeat the experiment
- The **further the bubble travels in the same time period, the faster transpiration is occurring** and vice versa

8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION cont...

YOUR NOTES



Investigating transpiration rates using a potometer

Environmental factors can be investigated in the following ways:

- **Temperature** : Temperature of room (cold room and warm room)
- **Humidity** : Spray water in plastic bag and wrap around plant

EXAM TIP

Remember when designing an investigation to ensure a fair test:
You must keep all factors the same other than the one you are investigating.

8 TRANSPORT IN PLANTS

YOUR NOTES

8.3 TRANSPIRATION cont...

EXTENDED ONLY

Temperature & Humidity on Transpiration Rate

FACTOR	EFFECT	EXPLANATION
TEMPERATURE	INCREASED	– IF TEMPERATURE INCREASES THE WATER MOLECULES WILL HAVE MORE KINETIC ENERGY, CAUSING THEM TO MOVE FASTER WHICH MEANS THEY WILL EVAPORATE MORE EASILY
HUMIDITY	DECREASED	– IN A HUMID ENVIRONMENT, AIR IS ALMOST SATURATED WITH WATER VAPOUR – THIS MEANS THERE IS HARDLY ANY CONCENTRATION GRADIENT BETWEEN THE AIRSPACES INSIDE THE LEAF AND THE AIR OUTSIDE THE LEAF, THEREFORE THE RATE OF EVAPORATION IS SLOW

8.4 TRANSLOCATION

EXTENDED ONLY

Transport of Food

- The soluble products of photosynthesis are **sugars (mainly sucrose) and amino acids**
- These are transported around the plant in the **phloem tubes** which are made of living cells (as opposed to xylem vessels which are made of dead cells)
- The cells are joined end to end and contain holes in the end cell walls (called **sieve plates**) which allow **easy flow of substances** from one cell to the next
- The transport of sucrose and amino acids in phloem, from regions of production to regions of storage or use, is called **translocation**

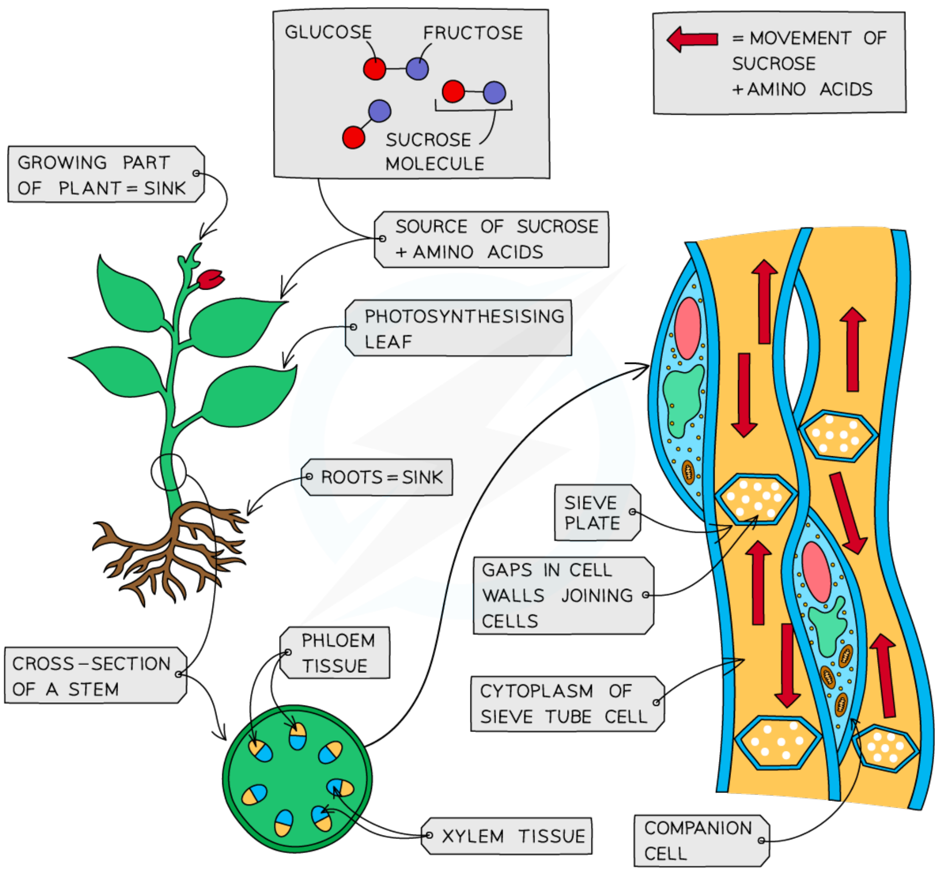
8 TRANSPORT IN PLANTS

8.4 TRANSLOCATION cont...

YOUR NOTES

EXTENDED ONLY cont...

- Transport in the phloem **goes in many different directions** depending on the stage of development of the plant or the time of year; however dissolved food is always transported from **source** (where it's made) to **sink** (where it's stored or used):
  - During **winter**, when many plants have no leaves, the phloem tubes may transport dissolved sucrose and amino acids from the storage organs to other parts of the plant so that respiration can continue
  - During a **growth period** (eg during the spring), the storage organs (eg roots) would be the source and the many growing areas of the plant would be the sinks
  - **After the plant has grown** (usually during the summer), the leaves are photosynthesizing and producing large quantities of sugars; so they become the source and the roots become the sinks – storing sucrose as starch until it is needed again



Translocation through the phloem

8 TRANSPORT IN PLANTS

8.3 TRANSPIRATION cont...

YOUR NOTES

EXTENDED ONLY cont...

Comparision between xylem and phloem tissue

TISSUE	WHAT IS MOVED	PROCESS	DIRECTION OF FLOW	CELLS
XYLEM	WATER AND MINERAL IONS	TRANSPIRATION STREAM	ONE WAY FROM ROOTS TO LEAVES	DEAD
PHLOEM	SUCROSE AND AMINO ACIDS	TRANSLOCATION	IN ALL DIRECTIONS	LIVING

> NOW TRY SOME EXAM QUESTIONS

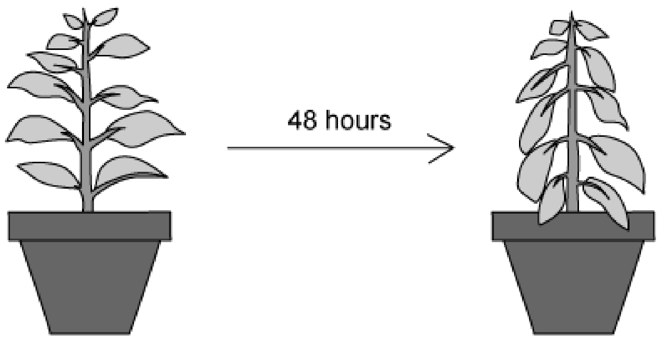
8 TRANSPORT IN PLANTS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The diagram below shows a potted plant and the same plant 48 hours later.



What has caused the plant's appearance to change?

Which process causes this change?

A Water loss by translocation is greater than water uptake

B Water evaporating from the leaves by translocation

C Water loss by transpiration is greater than water uptake

D Water loss from the leaves by osmosis

QUESTION 2

Which order below is correct in describing the pathway of water as it travels from the roots through a plant?

A Root hair cell → xylem → mesophyll cells → air space → stomata

B Root hair cell → xylem → air spaces → mesophyll cells → stomata

C Root hair cell → mesophyll cells → phloem → stomata

D Root hair cell → cortex cells → mesophyll cells → xylem → stomata

8 TRANSPORT IN PLANTS

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

Which of the following is a correct explanation of the process of translocation?

A The movement of mineral ions through the xylem of a plant

B The movement of sucrose and amino acids through the phloem from a source to a sink

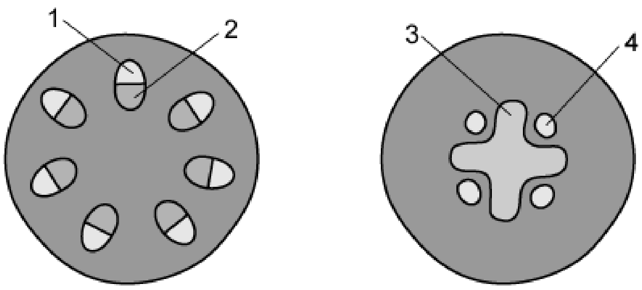
C The unidirectional movement of sucrose and amino acids through the phloem.

D The movement of sucrose and amino acids through the phloem from a sink to a source

QUESTION 4

A dicot plant is placed into a bowl of water coloured with red dye.
After 1 hour, a cross section of one of the roots is cut.
After 4 hours, a cross section is cut from the stem.

Which labelled regions would be stained red in each case?



A 1 and 3 **B** 1 and 4 **C** 2 and 4 **D** 2 and 3

8 TRANSPORT IN PLANTS

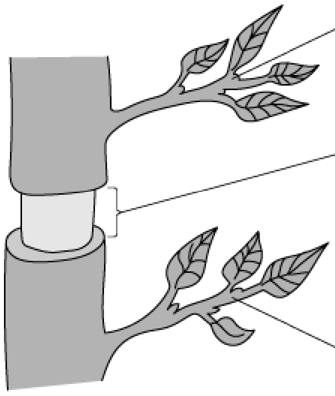
YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5

The diagram below shows part of the trunk of a small dicotyledonous tree with a ring of bark removed.

Removing the ring of bark removes one type of transport tissue but leaves the other type intact.



What effect does removing the bark have on the two branches?

	Upper branch		Lower branch	
	Leaves	Growth	Leaves	Growth
A	normal	normal	normal	reduced
B	wilted	normal	wilted	normal
C	wilted	reduced	normal	normal
D	normal	reduced	wilted	reduced

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for more questions and revision notes

9 TRANSPORT IN ANIMALS

YOUR NOTES

CONTENTS:

9.1 CIRCULATION IN ANIMALS

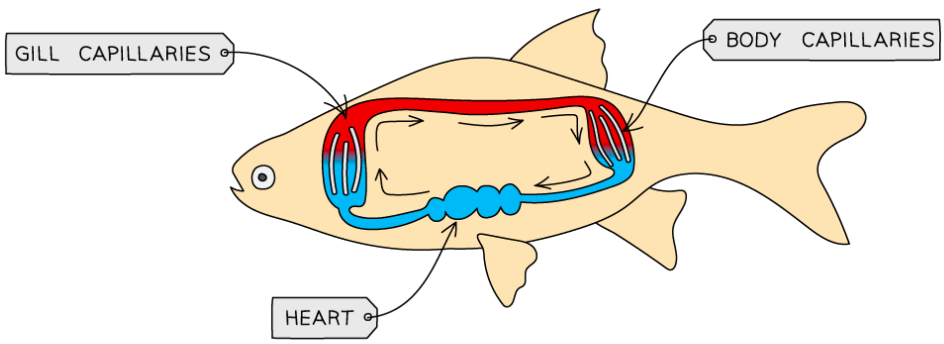
The Circulatory System

- The circulatory system is a system of blood vessels with a pump and valves to ensure one-way flow of blood

EXTENDED ONLY

Circulation in Different Animals

- Fish have a **two chambered heart** and a **single circulation**
- This means that **for every one circuit of the body, the blood passes through the heart once**

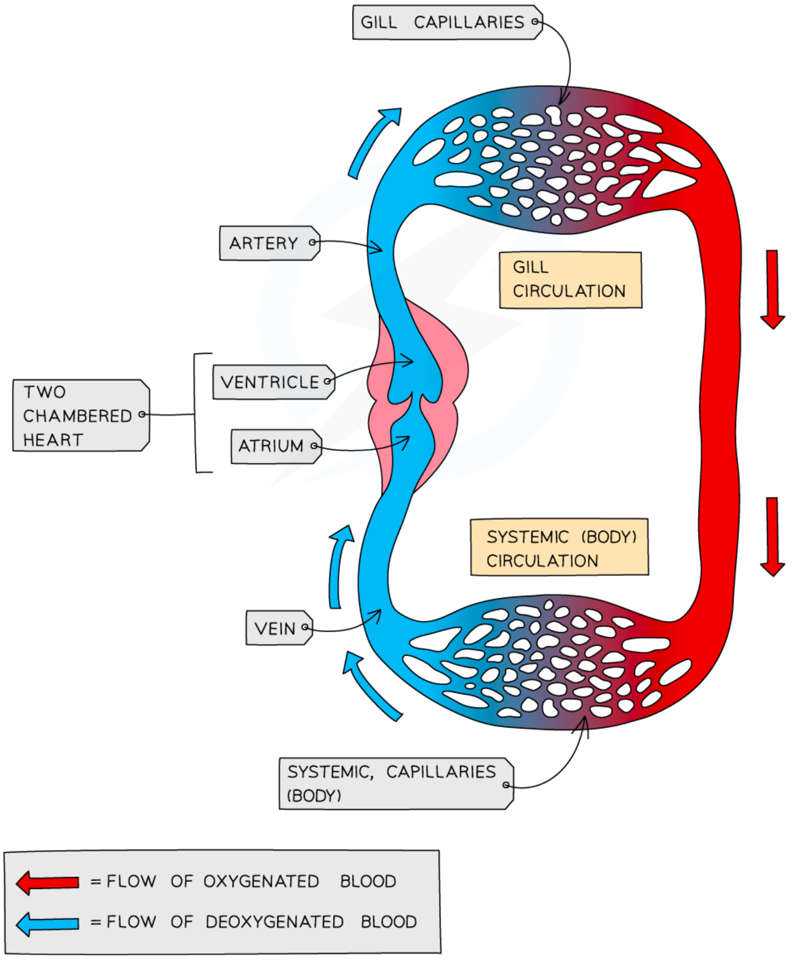


9 TRANSPORT IN ANIMALS

9.1 CIRCULATION IN ANIMALS cont...

YOUR NOTES

EXTENDED ONLY cont...



The single circulatory system in fish

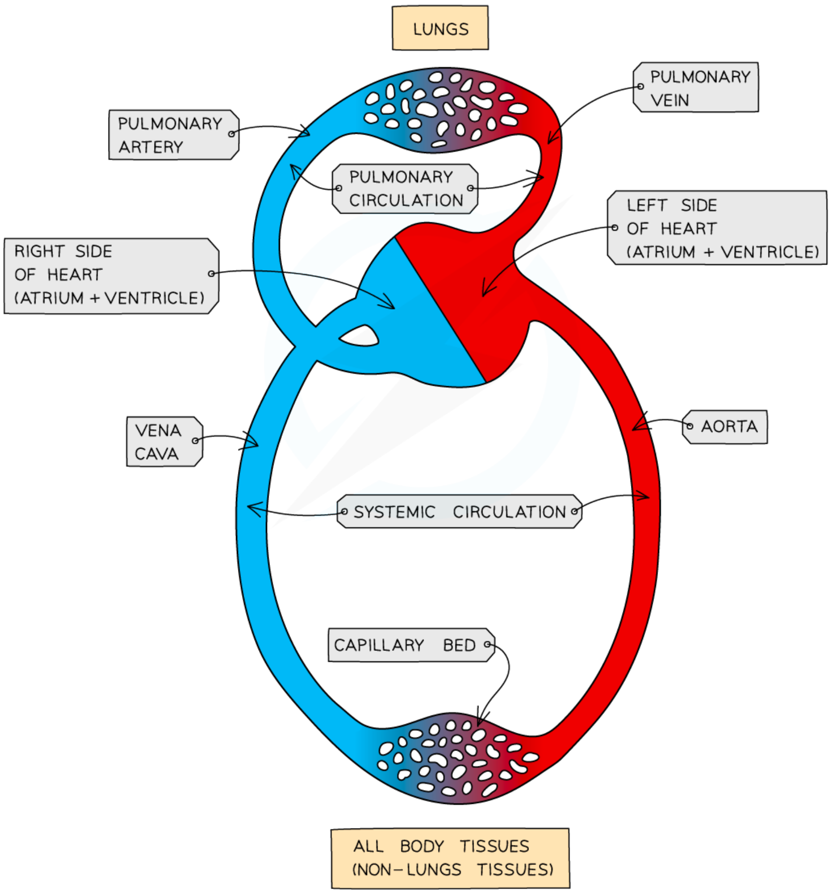
- Mammals have a **four chambered heart** and a **double circulation**
- This means that for **every one circuit of the body, the blood passes through the heart twice**
- The right side of the heart receives **deoxygenated blood** from the body and pumps it **to the lungs** (the **pulmonary circulation**)
- The left side of the heart receives **oxygenated blood** from the lungs and pumps it **to the body** (the **systemic circulation**)

9 TRANSPORT IN ANIMALS

9.1 CIRCULATION IN ANIMALS cont...

YOUR NOTES

EXTENDED ONLY cont...



The double circulatory system in mammals

Advantages of a Double Circulation

- Blood travelling through the small capillaries in the lungs **loses a lot of pressure** that was given to it by the pumping of the heart, meaning it **cannot travel as fast**
- By returning the blood to the heart after going through the lungs its **pressure can be raised** again before sending it to the body, meaning **cells** can be supplied with the **oxygen and glucose** they need for respiration **faster and more frequently**

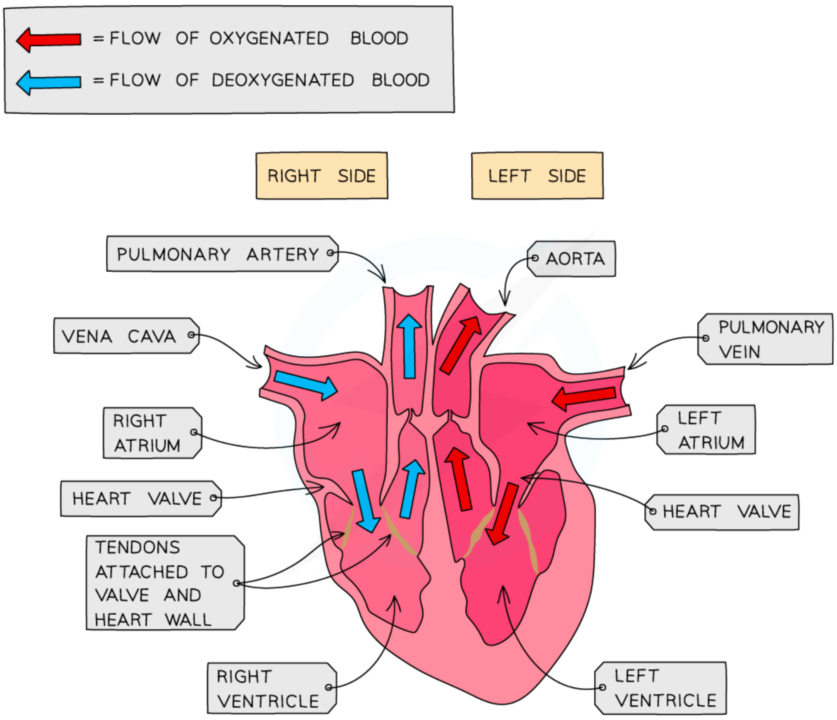
9 TRANSPORT IN ANIMALS

9.2 THE HEART

YOUR NOTES

Structure: Basics

- The heart is **labelled as if it was in the chest** so what is your left on a diagram is actually the right hand side and vice versa
- The right side of the heart receives **deoxygenated blood** from the body and pumps it **to the lungs**
- The left side of the heart receives **oxygenated blood** from the lungs and pumps it **to the body**
- Blood is pumped **towards** the heart in veins and **away** from the heart in **arteries**
- The two sides of the heart are separated by a muscle wall called the **septum**
- The heart is made of **muscle tissue** which is supplied with blood by the **coronary arteries**



Structure of the heart

EXAM TIP

Remember: Arteries carry blood Away from the heart

9 TRANSPORT IN ANIMALS

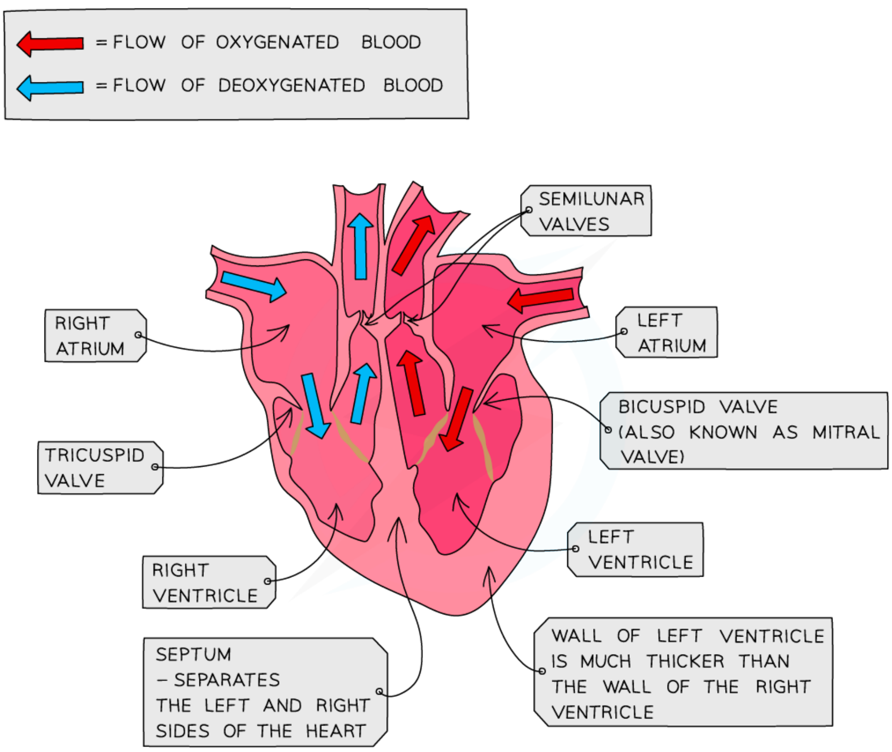
9.2 THE HEART cont...

YOUR NOTES

EXTENDED ONLY

Structure

- The **ventricles** have thicker muscle walls than the **atria** as they are pumping blood out of the heart and so need to **generate a higher pressure**
- **The left ventricle has a thicker muscle wall than the right ventricle** as it has to pump blood at high pressure around the **entire body**, whereas the right ventricle is pumping blood at lower pressure to the **lungs**
- The **septum** separates the two sides of the heart and so **prevents mixing of oxygenated and deoxygenated blood**



Structure of the heart showing the different valves

9 TRANSPORT IN ANIMALS

9.2 THE HEART cont...

YOUR NOTES

EXTENDED ONLY cont...

The Function of the Valves

- The basic function of all valves is to **prevent blood flowing backwards**
- There are two sets of valves in the heart:
  - The **atrioventricular valves** separate the atria from the ventricles
  - The valve in the right side of the heart is called the **TRICUSPID** and the valve in the left side is called the **BICUSPID**
  - These valves are pushed **open when the atria contract** but when the **ventricles contract they are pushed shut** to prevent blood flowing back into the atria
  - The **semilunar valves** are found in the two blood arteries that come out of the top of the heart
  - They are unusual in that they are the **only two arteries in the body that contain valves**
  - These valves **open when the ventricles contract** so blood squeezes past them out of the heart, but then shut to avoid blood flowing back into the heart

Pathway of Blood through the Heart

- **Deoxygenated blood** coming from the body flows into the **right atrium** via the vena cava
- Once the right atrium has filled with blood the heart gives a little beat and the blood is pushed through the **tricuspid (atrioventricular) valve** into the **right ventricle**
- The walls of the ventricle **contract** and the blood is pushed into the **pulmonary artery** through the **semi lunar valve** which prevents blood flowing backwards into the heart
- The blood travels to the lungs and moves through the capillaries past the alveoli where gas exchange takes place (this is why there has to be low pressure on this side of the heart – blood is going directly to capillaries which would burst under higher pressure)
- **Oxygen rich blood** returns to the **left atrium** via the **pulmonary vein**
- It passes through the **bicuspid (atrioventricular) valve** into the **left ventricle**
- The thicker muscle walls of the ventricle contract strongly to push the blood forcefully into the **aorta** and all the way around the body
- The **semi lunar valve** in the aorta prevents the blood flowing back down into the heart

9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE

YOUR NOTES

Exercise & Heart Rate

- Heart activity can be monitored by using an **ECG**, measuring **pulse rate** or **listening to the sounds of valves closing** using a stethoscope
- Heart rate (and pulse rate) is measured in beats per minute (bpm)
- To investigate the effects of exercise on heart rate, record the pulse rate at rest for a minute
- Immediately after they do some exercise, record the pulse rate every minute until it returns to the resting rate
- This experiment will show that during exercise the heart rate increases and may take several minutes to return to normal

EXTENDED ONLY

Why does Heart Rate Increase during Exercise?

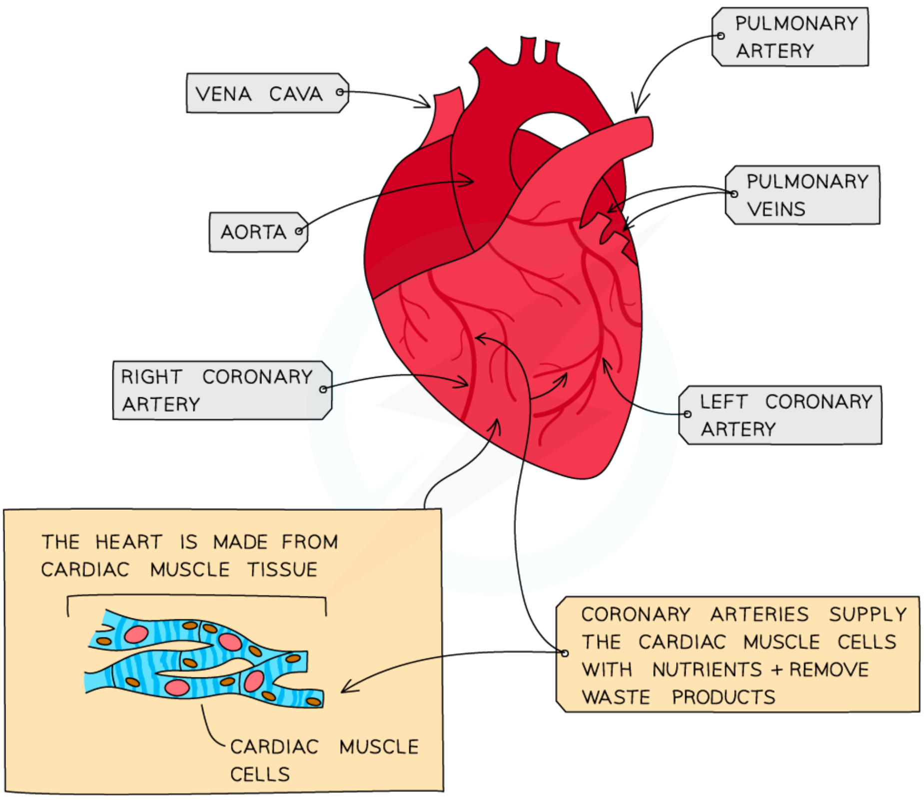
- So that **sufficient blood** is taken to the working muscles to provide them with enough **nutrients and oxygen** for **increased respiration**
- An increase in heart rate also allows for **waste products to be removed at a faster rate**
- Following exercise, the heart continues to beat faster for a while to ensure that **all excess waste products are removed** from muscle cells
- It is also likely that muscle cells have been respiring **anaerobically** during exercise and so have built up an **oxygen debt**
- This needs to be 'repaid' following exercise and so the heart continues to beat faster to ensure that **extra oxygen is still being delivered to muscle cells**

9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES

Coronary Heart Disease



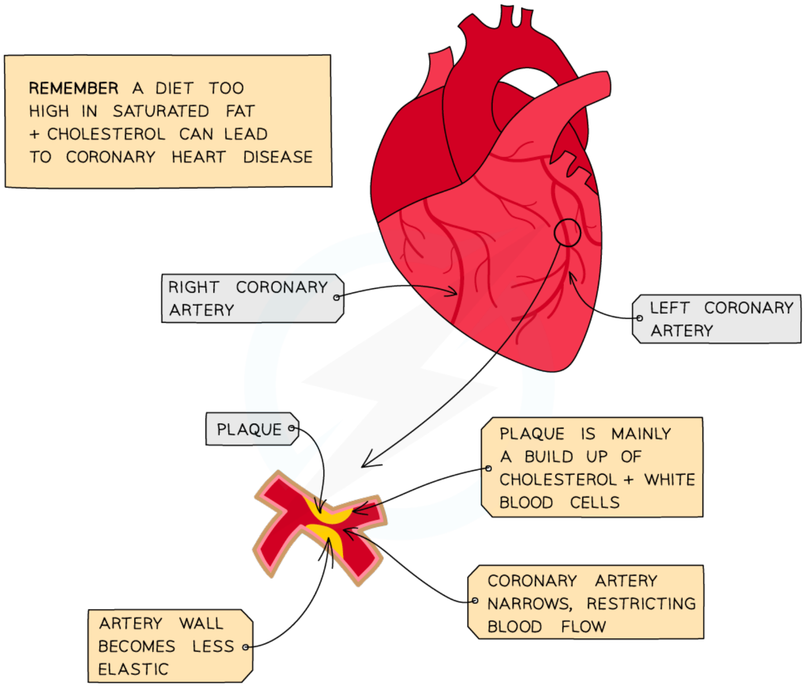
The coronary arteries

- The heart is made of **muscle cells** that need their own supply of blood to deliver oxygen, glucose and other nutrients and remove carbon dioxide and other waste products
- The blood is supplied by the **coronary arteries**
- If a coronary artery becomes partially or completely **blocked by fatty deposits called 'plaques'** (mainly formed from **cholesterol**), the arteries are not as elastic as they should be and therefore cannot stretch to accommodate the blood which is being forced through them – leading to **coronary heart disease**
- **Partial blockage** of the coronary arteries creates a restricted blood flow to the cardiac muscle cells and results in severe chest pains called **angina**
- **Complete blockage** means cells in that area of the heart will not be able to respire and can no longer contract, leading to a **heart attack**

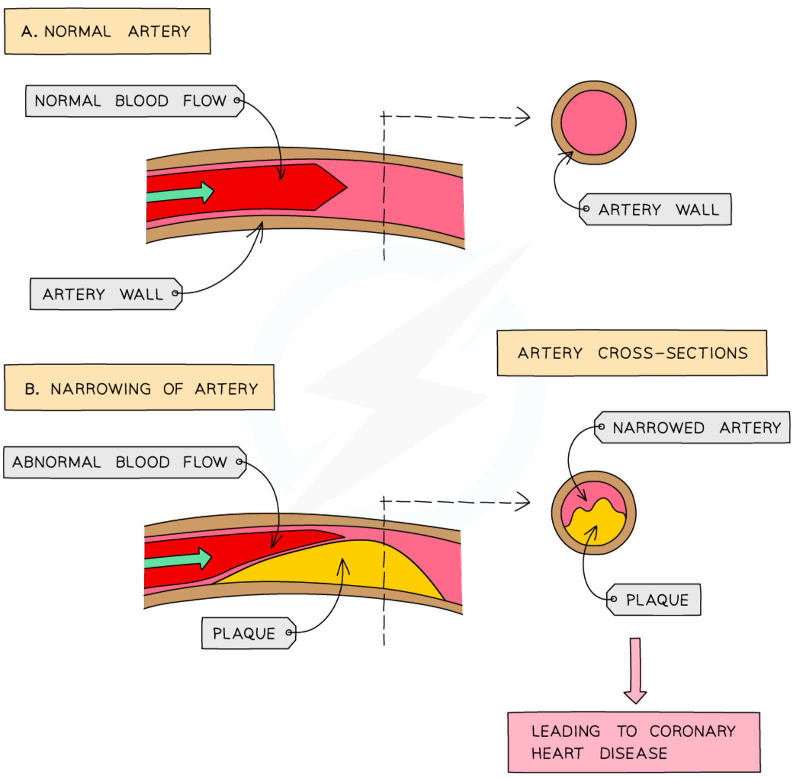
9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES



Buildup of plaque in the coronary arteries



Effect of narrowing of arteries

9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES

Risk Factors for Coronary Heart Disease

FACTOR	EXPLANATION
POOR DIET	EATING MORE **SATURATED FAT INCREASES CHOLESTEROL LEVELS**, INCREASING THE CHANCE OF THE BUILDUP OF FATTY PLAQUES
STRESS	WHEN UNDER STRESS, HORMONES PRODUCED CAN **INCREASE BLOOD PRESSURE**, INCREASING THE CHANCE OF A BLOCKAGE IN THE CORONARY ARTERIES
SMOKING	NICOTINE IN CIGARETTES WILL CAUSE BLOOD VESSELS TO BECOME NARROWER, **INCREASING BLOOD PRESSURE** WHICH WILL CAUSE THE BUILDUP OF FAT GLOBULES. IF THIS OCCURS IN THE CORONARY ARTERY, THIS WILL CAUSE CORONARY HEART DISEASE
GENETIC PREDISPOSITION	STUDIES SHOW THAT PEOPLE WITH A **HISTORY OF CORONARY HEART DISEASE IN THEIR FAMILY ARE MORE LIKELY TO DEVELOP IT THEMSELVES**, SUGGESTING IT PARTLY HAS A GENETIC BASIS
AGE	THE RISK OF DEVELOPING CORONARY HEART DISEASE **INCREASES** AS YOU GET OLDER
GENDER	**MALES** ARE **MORE LIKELY** TO DEVELOP CORONARY HEART DISEASE THAN FEMALES

EXTENDED ONLY

Prevention & Treatment

Reducing the risks of developing coronary heart disease:

- **Quit smoking**
- **Reduce animal fats** in diet and eat more fruits and vegetables – this will reduce cholesterol levels in the blood and help with weight loss if overweight
- **Exercise regularly** – again, this will help with weight loss, decrease blood pressure and cholesterol levels and help reduce stress

9 TRANSPORT IN ANIMALS

9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES

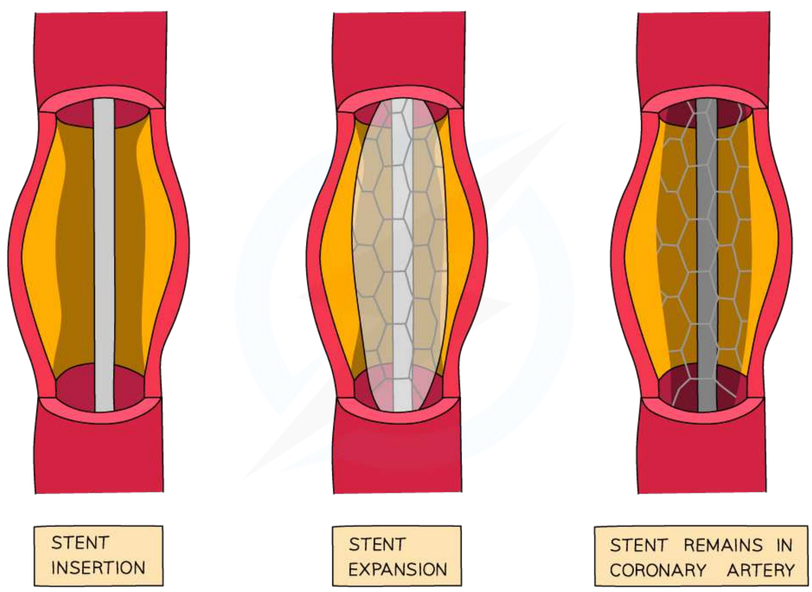
EXTENDED ONLY cont...

Treatment of coronary heart disease:

- **Aspirin** can be taken daily to **reduce the risk of blood clots** forming in arteries
- Surgical treatments include:

1. Angioplasty

- A narrow catheter (tube) is threaded through the groin up to the blocked vessel
- A tiny balloon inserted into the catheter is pushed up to the blocked vessel and then inflated
- This flattens the plaque against the wall of the artery, clearing the blockage
- To keep the artery clear, a **stent** (piece of metal / plastic mesh) is also inserted which pushes against the wall of the artery
- Sometimes the stent is coated with a drug that slowly releases medication to prevent further build up of plaque



Inserting a stent into a blocked artery

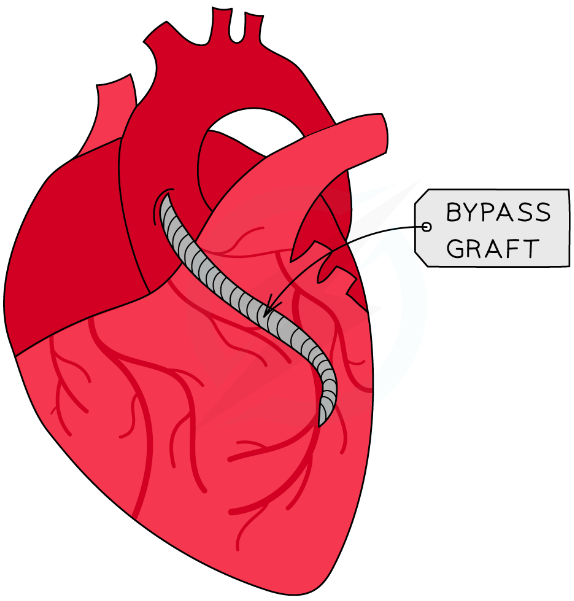
9.3 HEART DISEASE & EXERCISE cont...

YOUR NOTES

EXTENDED ONLY cont...

2. Coronary bypass surgery

- A piece of blood vessel is taken from the patient's leg, arm, or chest and used to **create a new passage for the flow of blood** to the cardiac muscle, bypassing the blocked area
- The number of bypass grafts gives rise to the name of the surgery, so a 'triple heart bypass' would mean three new bypass grafts being attached



Coronary bypass graft

9 TRANSPORT IN ANIMALS

9.4 BLOOD VESSELS

YOUR NOTES

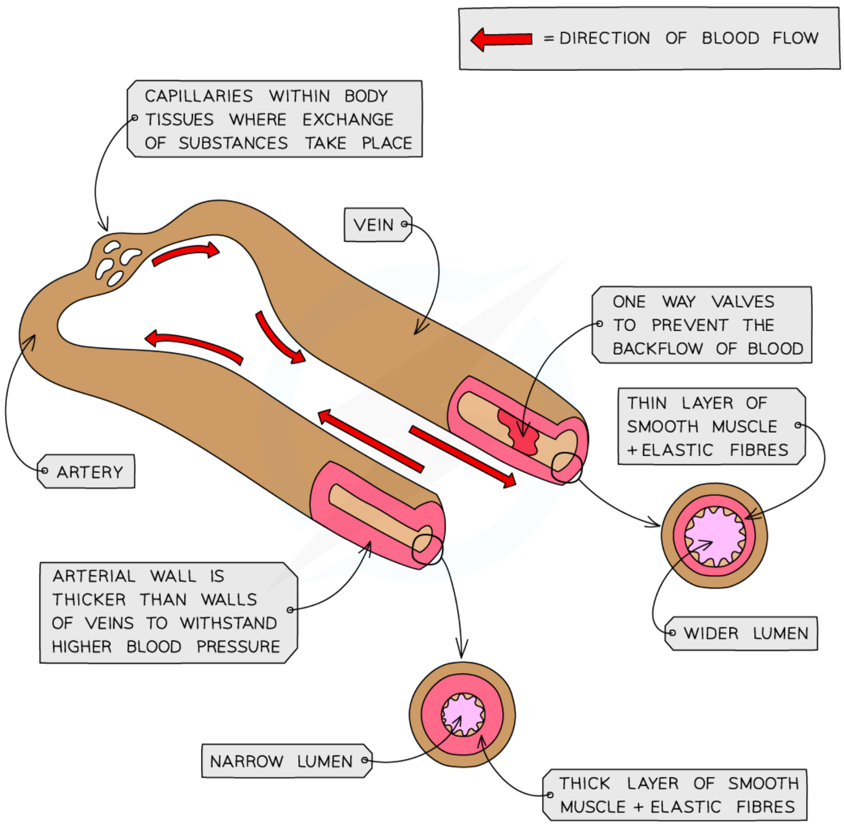
Arteries, Veins & Capillaries

Arteries

- Carry blood at **high pressure away from the heart**
- Carry **oxygenated** blood (other than the pulmonary artery)
- Have **thick muscular walls** containing elastic fibres
- Have a **narrow lumen**
- Speed of flow is **fast**

Veins

- Carry blood at **low pressure towards the heart**
- Carry **deoxygenated** blood (other than the pulmonary vein)
- Have **thin** walls
- Have a **large lumen**
- Contain **valves**
- Speed of flow is **slow**



Comparing arteries and veins

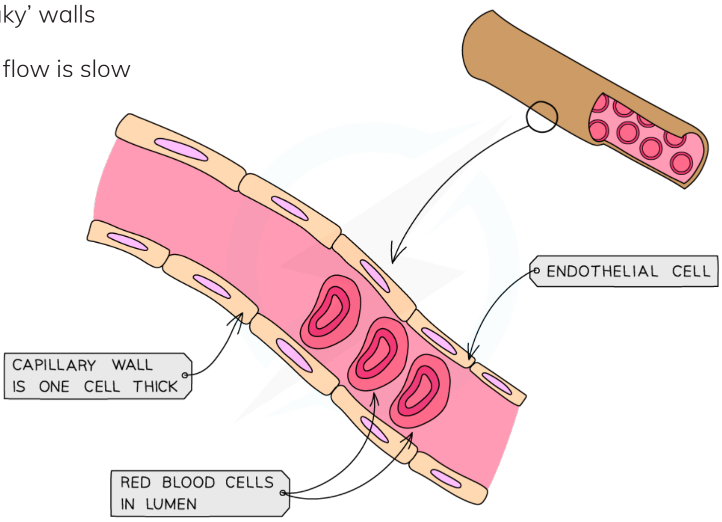
9 TRANSPORT IN ANIMALS

9.4 BLOOD VESSELS cont...

YOUR NOTES

Capillaries

- Carry blood at low pressure within tissues
- Carry both oxygenated and deoxygenated blood
- Have walls that are one cell thick
- Have 'leaky' walls
- Speed of flow is slow



Structure of a capillary

EXTENDED ONLY

How Structure of Blood Vessels is Adapted to their Function

Arteries

- Have thick muscular walls containing elastic fibres **to withstand high pressure of blood and maintain the blood pressure as it recoils after the blood has passed through**
- Have a narrow lumen **to maintain high pressure**

Veins

- Have a large lumen **as blood pressure is low**
- Contain valves **to prevent the backflow of blood as it is under low pressure**

Capillaries

- Have walls that are one cell thick **so that substances can easily diffuse in and out of them**
- Have 'leaky' walls **so that blood plasma can leak out and form tissue fluid surrounding cells**

9 TRANSPORT IN ANIMALS

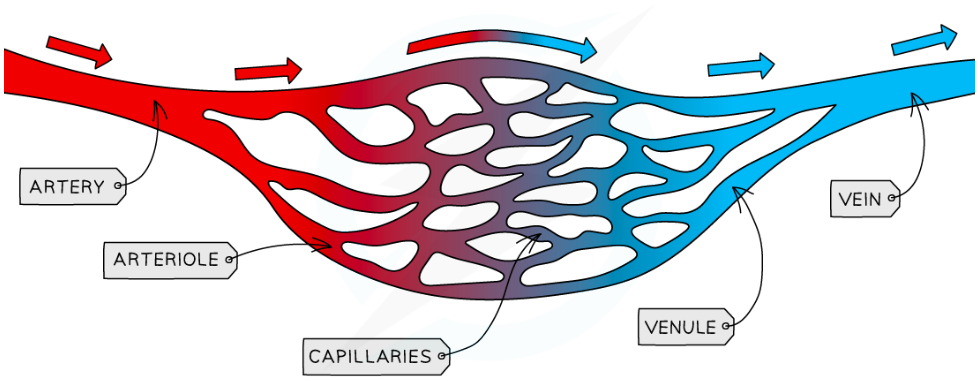
9.4 BLOOD VESSELS cont...

YOUR NOTES

EXTENDED ONLY

Arterioles & Venules

- As arteries **divide more** as they get further away from the heart, they get **narrower**
- The narrow vessels that connect arteries to capillaries are called **arterioles**
- Veins also get narrower the further away they are from the heart
- The narrow vessels that connect capillaries to veins are called **venules**



The blood vessel network

Shunt Vessels

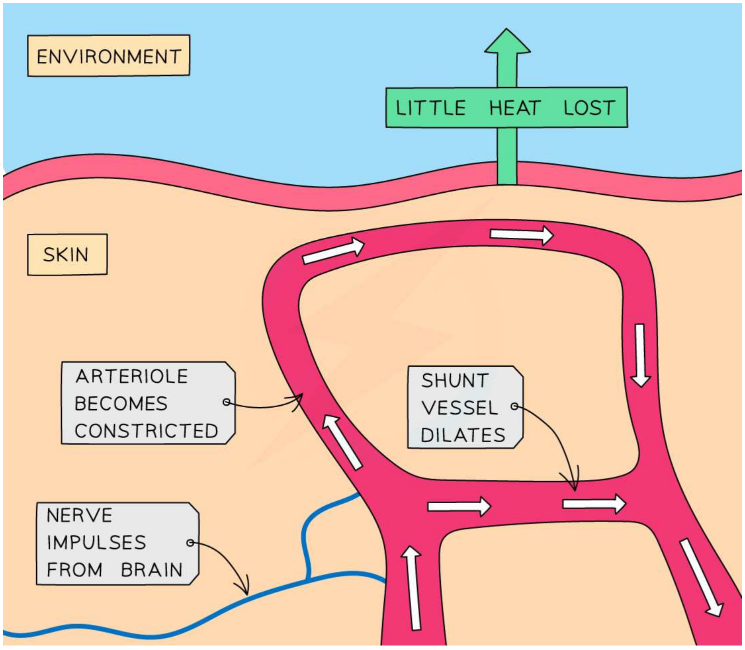
- Sometimes the cardiovascular system need to redistribute the blood to specific areas of the body
- For example:
    - During exercise, more of it goes to the working muscles and less of it goes to other body organs such as the digestive system
    - When we are hot, more blood flows through the surface of the skin and when we are cold less blood flows through the surface of the skin
- This redirection of blood flow is caused by the use of a vascular shunt vessel
- The shunt vessels can open or close to control the amount of blood flowing to a specific area

9 TRANSPORT IN ANIMALS

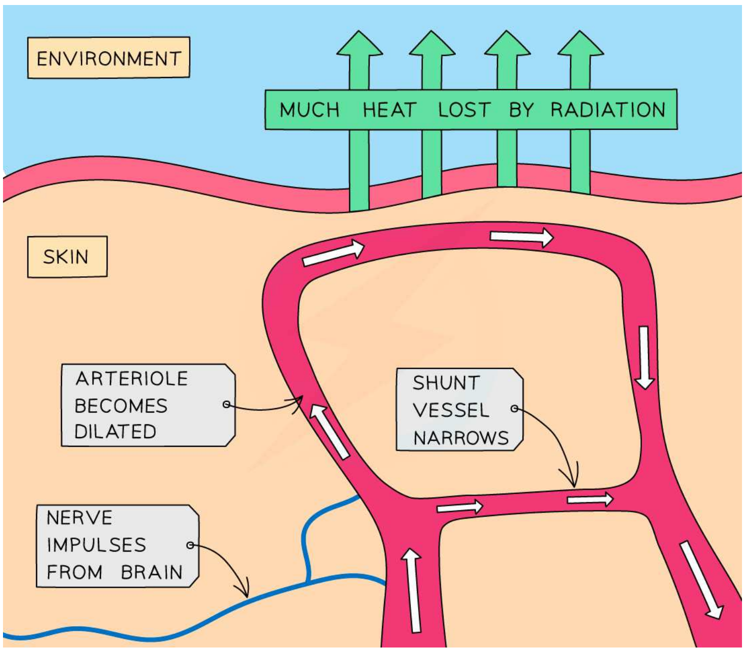
9.4 BLOOD VESSELS cont...

YOUR NOTES

EXTENDED ONLY cont...



A shunt vessel in the skin when we are cold



A shunt vessel in the skin when we are hot

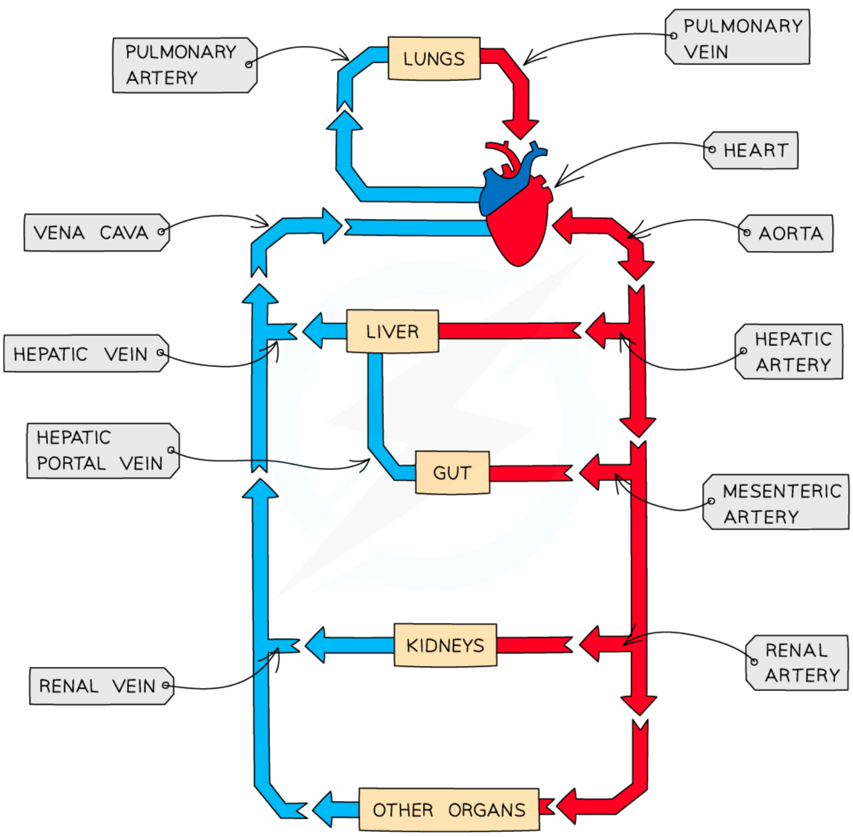
9 TRANSPORT IN ANIMALS

9.4 BLOOD VESSELS cont...

YOUR NOTES

Circulation around the Body

- Blood is carried **away from the heart** and towards organs in **arteries**
- These narrow to arterioles and then capillaries as they pass through the organ
- The capillaries widen to venules and finally veins as they move away from the organs
- Veins carry blood back **towards the heart**



The circulatory system

Important Blood Vessels

ORGAN	TOWARDS ORGAN	AWAY FROM ORGAN
HEART	VENA CAVA, PULMONARY VEIN	AORTA, PULMONARY ARTERY
LUNG	PULMONARY ARTERY	PULMONARY VEIN
KIDNEY	RENAL ARTERY	RENAL VEIN

9 TRANSPORT IN ANIMALS

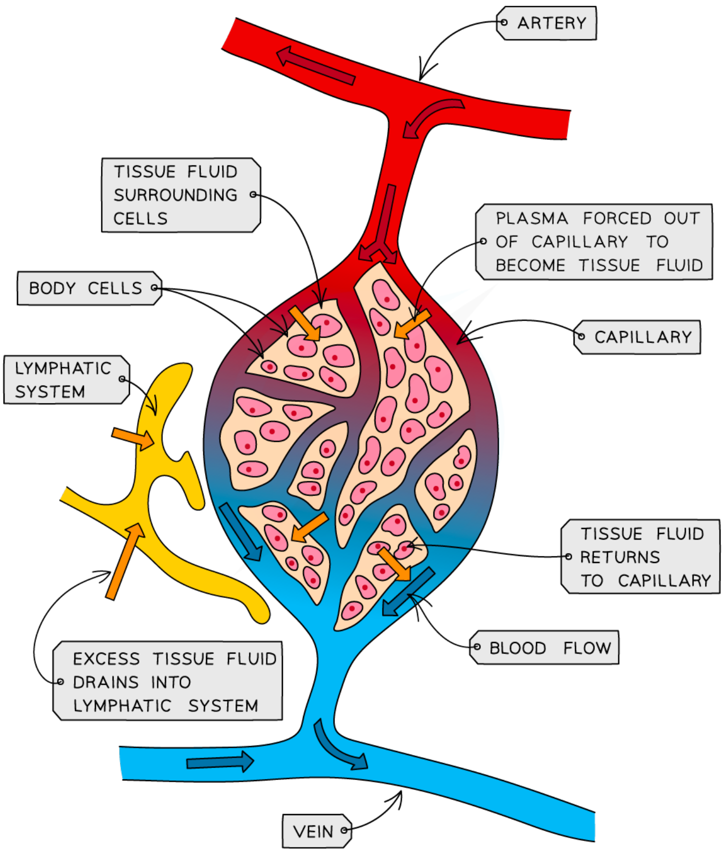
9.5 THE LYMPHATIC SYSTEM

YOUR NOTES

EXTENDED ONLY

Lymph Fluid

- The walls of the capillaries are so thin that water, dissolved solutes and dissolved gases easily leak out of them / pass through the walls from the plasma into the **tissue fluid** surrounding the cells
- Cells **exchange materials** (such as water, oxygen, glucose, carbon dioxide, mineral ions) **across their cell membranes** with the tissue fluid surrounding them by diffusion, osmosis or active transport
- More fluid leaks out of the capillaries than is returned to them and this excess fluid passes into the lymphatic system and becomes **lymph fluid**



How lymph forms

9 TRANSPORT IN ANIMALS

YOUR NOTES

9.5 THE LYMPHATIC SYSTEM cont...

EXTENDED ONLY cont...

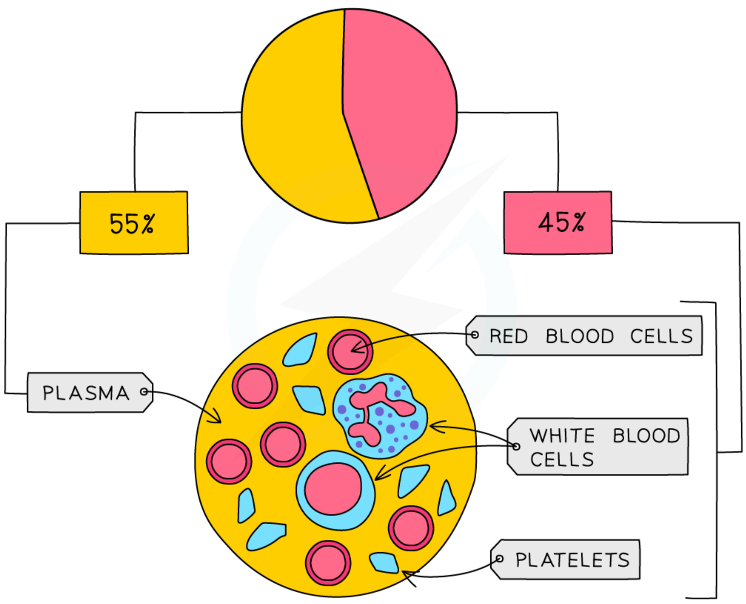
Lymph Vessels & Nodes

- The lymphatic system is formed from a **series of tubes which flow from tissues back to the heart**
- It connects with the blood system near to the heart, where lymph fluid is **returned** to the blood plasma
- **Lymph nodes** are small clusters of lymphatic tissue found throughout the lymphatic system, especially in the neck and armpits
- Large numbers of **lymphocytes** are found in lymph nodes
- Tissues associated with the lymphatic system, such as **bone marrow**, produce these lymphocytes
- Lymphocytes play an important role in **defending the body against infection**

9.6 BLOOD

Components of Blood

- Blood consists of **red blood cells, white blood cells, platelets and plasma**



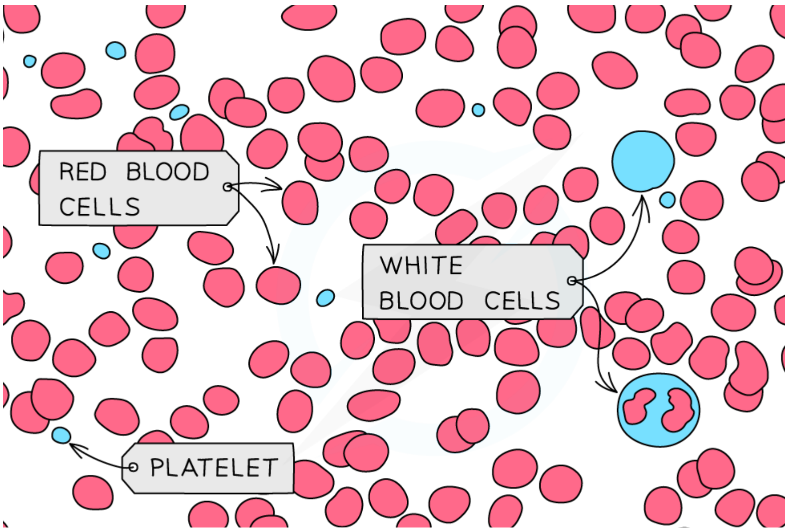
Composition of human blood

9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

YOUR NOTES

COMPONENT	STRUCTURE
RED BLOOD CELLS	BICONCAVE DISCS CONTAINING NO NUCLEUS BUT PLENTY OF THE PROTEIN HAEMOGLOBIN
WHITE BLOOD CELLS	LARGE CELLS CONTAINING A BIG NUCLEUS, DIFFERENT TYPES HAVE SLIGHTLY DIFFERENT STRUCTURES AND FUNCTIONS
PLATELETS	FRAGMENTS OF CELLS
PLASMA	STRAW COLOURED LIQUID



Blood micrograph

9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

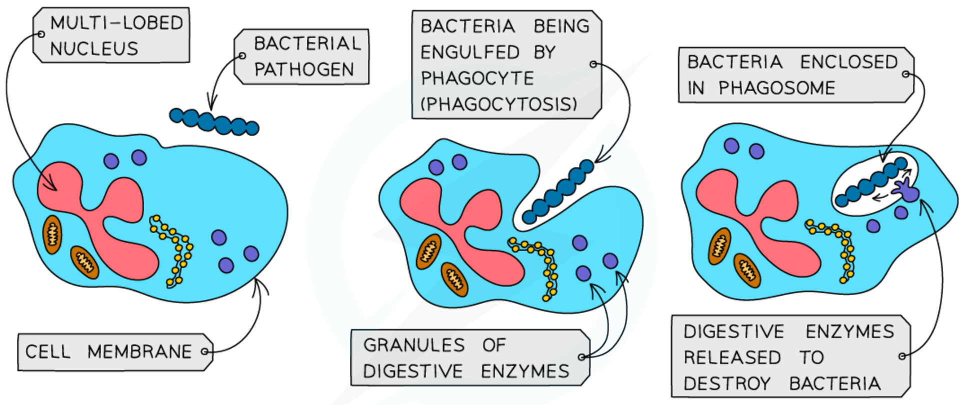
EXTENDED ONLY

Types of White Blood Cell

- White blood cells are part of the body's **immune system**, defending against infection by pathogenic microorganisms
- There are two main types, **phagocytes and lymphocytes**

Phagocytes

- Carry out **phagocytosis** by **engulfing and digesting pathogens**



Phagocytosis

- Phagocytes have a sensitive cell surface membrane that can detect chemicals produced by pathogenic cells
- Once they encounter the pathogenic cell, they will engulf it and **release digestive enzymes** to digest it
- They can be easily recognised under the microscope by their **multi-lobed nucleus** and their **granular cytoplasm**

Lymphocytes

- Produce **antibodies** to destroy pathogenic cells and **antitoxins** to neutralise toxins released by pathogens
- They can easily be recognised under the microscope by their **large round nucleus** which takes up nearly the whole cell and their **clear, non granular cytoplasm**

YOUR NOTES

9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

YOUR NOTES

Functions of the Parts of Blood

- **Plasma** is important for the transport of **carbon dioxide, digested food (nutrients), urea, mineral ions, hormones and heat energy**
- **Red blood cells transport oxygen around the body** from the lungs to cells which require it for aerobic respiration
- They carry the oxygen in the form of **oxyhaemoglobin**
- **White blood cells** defend the body against infection by pathogens by carrying out **phagocytosis and antibody production**
- **Platelets** are involved in **helping the blood to clot**

EXTENDED ONLY

Blood Clotting

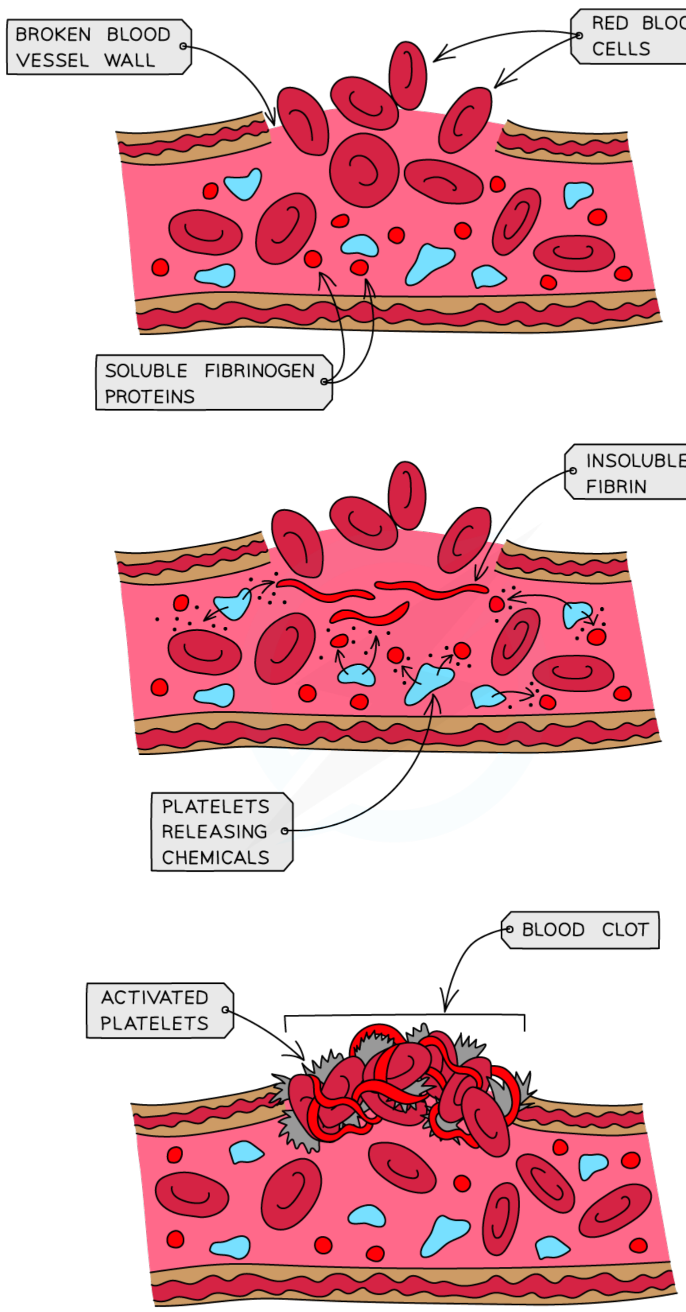
- Platelets are **fragments of cells which are involved in blood clotting** and forming scabs where skin has been cut or punctured
- Blood clotting **prevents continued / significant blood loss** from wounds
- Scab formation seals the wound with an insoluble patch that **prevents entry of microorganisms** that could cause infection
- It remains in place until new skin has grown underneath it, sealing the skin again
- When the skin is broken (i.e. there is a wound) platelets arrive to stop the bleeding
- A series of reactions occur within the blood plasma
- Platelets release chemicals that cause **soluble fibrinogen proteins** to convert into **insoluble fibrin** and form an **insoluble mesh** across the wound, trapping red blood cells and therefore **forming a clot**.
- The clot eventually dries and develops into a **scab** to protect the wound from bacteria entering

9 TRANSPORT IN ANIMALS

9.6 BLOOD cont...

YOUR NOTES

EXTENDED ONLY cont...



How the blood clots

> NOW TRY SOME EXAM QUESTIONS

9 TRANSPORT IN ANIMALS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which of the following would be found dissolved in the blood plasma of a human?

A Glucose, urea and hormones

B Oxygen, urea and starch

C Carbon dioxide, hormones and haemoglobin

D Carbon dioxide, oxygen and urea

QUESTION 2

Which blood vessel has a relatively low carbon dioxide concentration, a high oxygen concentration and a low blood pressure?

A Pulmonary artery

B Pulmonary vein

C Aorta

D Vena cava

QUESTION 3

Which of the following is a method that a doctor would suggest to a patient to reduce their risk of developing coronary heart disease?

A Inserting a stent into a coronary artery

B Coronary heart bypass surgery

C Angioplasty

D Controlled exercise

9 TRANSPORT IN ANIMALS

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

Which row of the table below shows the correct chambers of the heart, from those with the thinnest walls to those with the thickest?

	thinnest	→	thickest
A	left ventricle	right ventricle	left atrium
B	left atrium	left ventricle	right ventricle
C	right ventricle	left atrium	left ventricle
D	left atrium	right ventricle	left ventricle

QUESTION 5

Which of the following is a correct explanation as to why mammals have a double circulatory system?

A To reduce pressure of blood returning from the lungs to supply cells of the body most efficiently with the reactants for respiration

B To increase the pressure of blood sent to the lungs to supply cells of the body most efficiently with the reactants for respiration

C To increase the pressure of blood returning from the lungs to supply cells of the body most efficiently with the reactants for respiration

D To reduce pressure of blood sent to the lungs to supply the cells most efficiently with the products for respiration

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

10 DISEASEES & IMMUNITY

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

10.1 SPREAD OF DISEASE

Pathogens

- A pathogen is a **disease-causing organism**
- Pathogens are passed on from one host to another and therefore the diseases they cause are known as **transmissible diseases**
- Pathogens can be passed on from host to host in different ways, including:
- **Direct contact** – the pathogen is passed directly from one host to another by transfer of body fluids such as blood or semen (eg HIV, gonorrhoea, hepatitis B & C)
- **Indirect contact** – the pathogen leaves the host and is carried in some way to another, uninfected individual

METHOD OF TRANSMISSION	EXAMPLES OF DISEASES SPREAD IN THIS WAY
DROPLETS IN AIR	COMMON COLD, INFLUENZA
FOOD OR WATER	CHOLERA, TYPHOID, DYSENTERY
TOUCHING CONTAMINATED SURFACES	ATHLETES FOOT, SALMONELLA (CAN BE TRANSMITTED ON THE FEET OF FLIES WHO LAND ON FOOD THAT IS THEN EATEN)
INSECT BITES	MALARIA, DENGUE FEVER

10 DISEASEES & IMMUNITY

10.1 SPREAD OF DISEASE cont...

YOUR NOTES

Defences Against Pathogens

There are **three** main ways in which the body defends itself against disease:

1. **Mechanical barriers** – structures that make it difficult for pathogens to get past them and into the body

   a) **Skin** – covers almost all parts of your body to prevent infection from pathogens. If it is cut or grazed, it immediately begins to heal itself, often by forming a scab.

   b) **Hairs in the nose** – these make it difficult for pathogens to get past them further up the nose so they are not inhaled into the lungs

2. **Chemical barriers** – substances produced by the body cells that trap / kill pathogens before they can get further into the body and cause disease

   a) **Mucus** – made in various places in the body, pathogens get trapped in the mucus and can then be removed from the body (by coughing, blowing the nose, swallowing etc)

   b) **Stomach acid** – contains hydrochloric acid which is strong enough to kill any pathogens that have been caught in mucus in the airways and then swallowed or have been consumed in food or water

3. **Cells** – different types of **white blood cell** work to prevent pathogens reaching areas of the body they can replicate in

   a) By **phagocytosis** – engulfing and digesting pathogenic cells

   b) By producing **antibodies** – which clump pathogenic cells together so they can't move as easily (known as **agglutination**) and releasing chemicals that signal to other cells that they must be destroyed

10.2 IMMUNITY

EXTENDED ONLY

Antigens & Antibodies

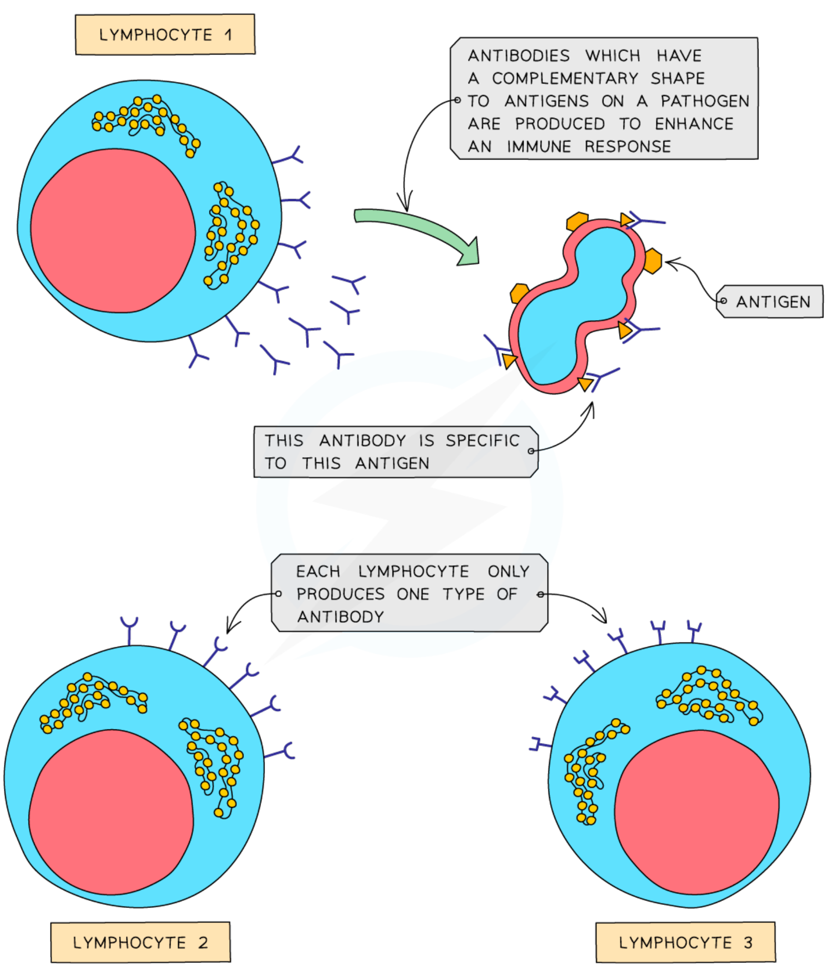
- All cells have proteins and other substances projecting from their cell membrane
- These are known as **antigens** and are **specific** to that type of cell
- Lymphocytes have the ability to 'read' the antigens on the surfaces of cells and recognise any that are foreign
- They then make **antibodies** which are a **complementary shape to the antigens** on the surface of the pathogenic cell

10 DISEASEES & IMMUNITY

YOUR NOTES

10.2 IMMUNITY cont...

EXTENDED ONLY cont...



Antigens and antibodies

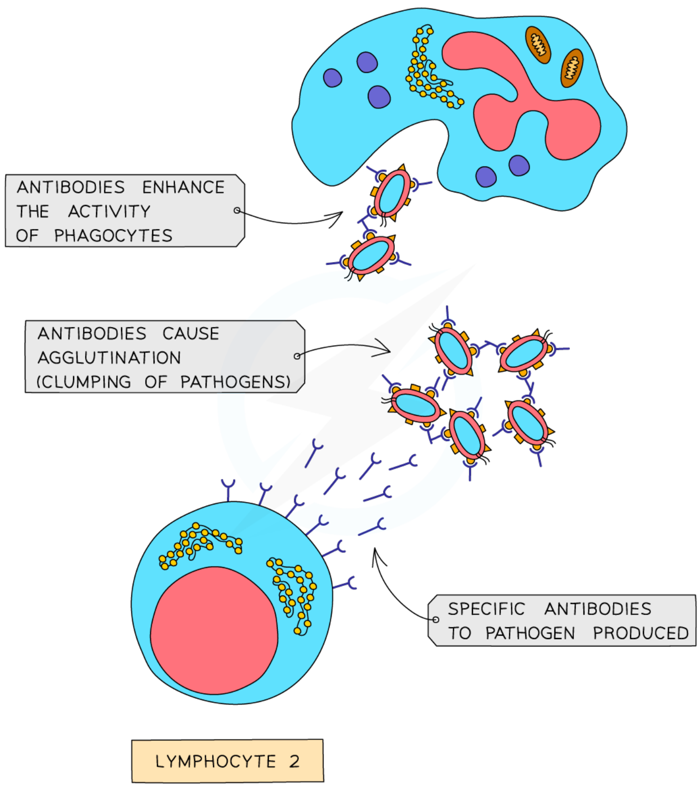
- The antibodies attach to the antigens and cause **agglutination** (clumping together)
- This means the pathogenic cells cannot move very easily
- At the same time, **chemicals** are released that signal to **phagocytes** that there are cells present that need to be destroyed

10 DISEASEES & IMMUNITY

10.2 IMMUNITY cont...

YOUR NOTES

EXTENDED ONLY cont...



Agglutinated pathogens cannot move easily

- The **initial response** of a lymphocyte encountering a pathogen for the first time and making specific antibodies for its antigens can take **a few days**, during which time an individual may get sick
- Lymphocytes that have made antibodies for a specific pathogen for the first time will then make **'memory cells'** that retain the instructions for making those specific antibodies for that type of pathogen
- This means that, in the case of reinfection by the same type of pathogen, **antibodies can very quickly be made** in greater quantities and the pathogens destroyed before they are able to multiply and cause illness
- This is how people can become **immune** to certain diseases after only having them once
- It does not work with all disease-causing microorganisms as some of them **mutate** fairly quickly and change the antigens on their cell surfaces
- Therefore, if they invade the body for a second time, the memory cells made in the first infection will not recall them as they now have slightly different antigens on their surfaces (e.g. the cold virus)

10 DISEASEES & IMMUNITY

10.2 IMMUNITY cont...

EXTENDED ONLY cont...

Active & Passive Immunity

Active Immunity

- Making antibodies and developing memory cells for future response to infection is known as **active immunity**
- There are **two ways** in which this active immune response happens:
  - The body has become **infected with a pathogen** and so the lymphocytes go through the process of making antibodies specific to that pathogen
  - **Vaccination**
- Active immunity is **slow-acting** and **provides long-lasting immunity**

Passive Immunity

- This is when **ready-made antibodies**, from another source, are introduced to the body
- Passive immunity is a **fast-acting**, **short-term defence** against a pathogen by antibodies acquired from another individual, eg:
  - From **mother to infant** via **breast milk** – this is important as it helps the very young to fight off infections until they are **older and stronger** and their immune system is more responsive
  - **Injected antibodies** for certain diseases where the individual is already infected and a fast response is required, like **rabies** or **tetanus**
- The body **does not make its own antibodies or memory cells** in passive immunity, hence the nam

Diseases Caused by the Immune System

- Occasionally, the cells of the immune system start to **attack the body's own cells**
- This is rare as lymphocytes usually **recognise** their own body cells by the **antigens** on the cell surfaces and do not respond to them
- In this situation, **specific body cells are targeted by lymphocytes** and antibodies are made against them, destroying them
- One example of this type of disease is **Type 1 diabetes**
- People who suffer from this disease no longer make their own insulin and so are unable to regulate their blood glucose levels
- This is because their immune system is **targeting and destroying the pancreatic cells which are responsible for making the insulin**, eventually leading to dangerously high glucose levels in the blood

10 DISEASEES & IMMUNITY

10.2 IMMUNITY cont...

YOUR NOTES

EXAM TIP

There is often a lot of confusion amongst students regarding the terms antigen, antibody and antibiotic:

- An **antigen** is a chemical found on the surface of a cell
- An **antibody** is a chemical made by lymphocytes that is complementary to an antigen and, when attached, clumps them together and signals the cells they are on for destruction
- An **antibiotic** is a drug that slows down or stops the growth of bacteria

10.3 VACCINATION

What is Vaccination?

- Vaccinations give **protection against specific diseases** and **boost the body's defence against infection** from pathogens without the need to be exposed to dangerous diseases that can lead to death
- The level of protection in a population depends on the **proportion of people vaccinated**

EXTENDED ONLY

How does Vaccination Work?

- Vaccines allow a **dead or altered form** of the disease-causing pathogen, which contains specific antigens, to be introduced into the body
- In this weakened state, the pathogen **cannot cause illness** but can **provoke an immune response**
- Lymphocytes produce **complementary antibodies** for the antigens
- The antibodies target the antigen and attach themselves to it in order to create **memory cells**
- The memory cells remain in the blood and will **quickly respond** to the antigen if it is encountered again in an infection by a 'live' pathogen
- As memory cells have been produced, this immunity is **long-lasting**

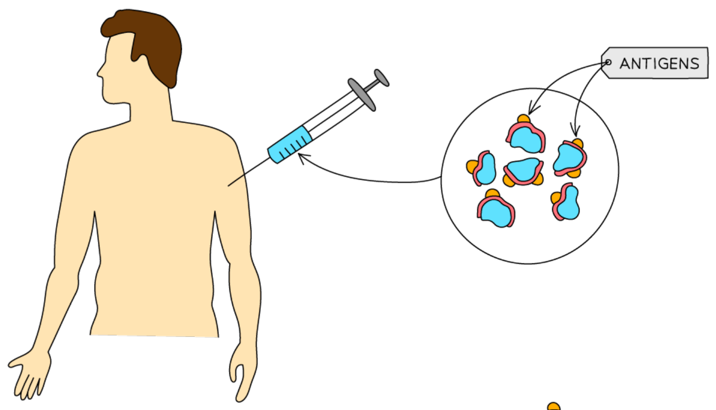
10 DISEASEES & IMMUNITY

10.3 VACCINATION cont...

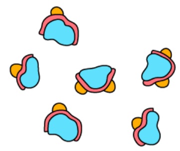
YOUR NOTES

EXTENDED ONLY cont...

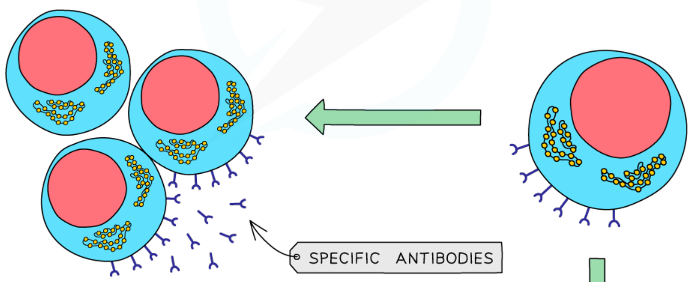
1 HARMLESS PATHOGEN INJECTED



2 ANTIGENS TRIGGER AN IMMUNE RESPONSE. IT CAN TAKE DAYS FOR A LYMPHOCYTE MAKING COMPLEMENTARY ANTIBODIES TO BE ACTIVATED.

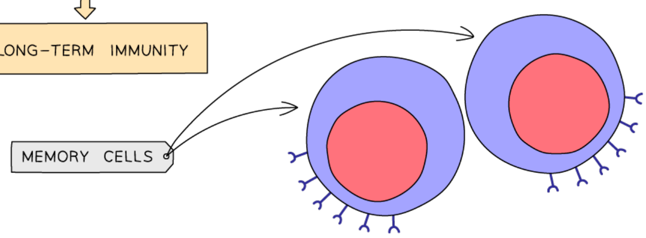


3 LYMPHOCYTE ABLE TO PRODUCE COMPLEMENTARY ANTIBODIES MULTIPLIES, ANTIBODIES RELEASED.



4 MEMORY CELLS (LASTING YEARS) ARE PRODUCED. IF ANTIGEN IS ENCOUNTERED AGAIN, ANTIBODIES ARE PRODUCED MUCH FASTER.

= LONG-TERM IMMUNITY



Vaccination

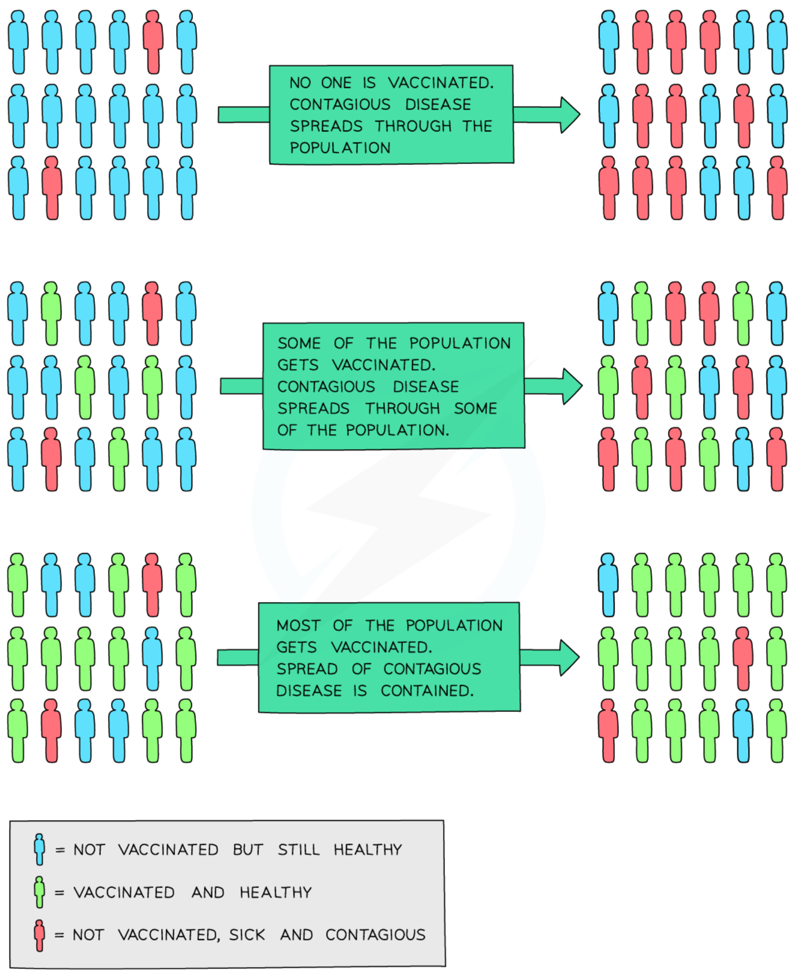
10 DISEASEES & IMMUNITY

10.3 VACCINATION cont...

EXTENDED ONLY cont...

How Does Vaccination Control the Spread of Disease?

- If a **large enough percentage** of the population is vaccinated, it **provides protection for the entire population** because there are **very few places for the pathogen to breed** – it can only do so if it enters the body of an unvaccinated person
- This is known as **herd immunity**
- If the number of people vaccinated against a specific disease **drops** in a population, it leaves the rest of the population at risk of **mass infection**, as they are more likely to come across people who are infected and contagious
- This **increases the number of infections**, as well as the number of people who could die from a specific infectious disease



Herd immunity

YOUR NOTES

10 DISEASEES & IMMUNITY

YOUR NOTES

10.3 VACCINATION cont...

EXTENDED ONLY cont...

Herd immunity prevents epidemics and pandemics from occurring in populations

- This is the reason that many vaccinations are given to **children**, as they are regularly seen by medical practitioners and can be vaccinated early to ensure the entire vaccinated population remains at a high level
- In certain instances, vaccination programmes are run with the aim of **eradicating** certain dangerous diseases, as opposed to controlling them at low levels
- An example of a disease which has been eradicated as a result of a successful vaccination programme is **smallpox**, which was officially eradicated in 1980 after a vaccination programme run by the World Health Organisation since the mid-1950s

10.4 CONTROLLING SPREAD OF DISEASE

Ways to Prevent Transfer of Pathogens

- The simplest way to prevent disease is to **stop pathogens from spreading**
- This means using simple measures such as **good hygiene and effective sanitation and waste disposal** to contain pathogens and dispose of them safely

10 DISEASEES & IMMUNITY

10.4 CONTROLLING SPREAD OF DISEASE cont...

YOUR NOTES

MEASURE TO PREVENT SPREAD	HOW IT WORKS
HYGIENIC FOOD PREPARATION	– KEEP FOOD COLD SO BACTERIA AND FUNGI REPRODUCE MORE SLOWLY – PREPARE FOOD HYGIENICALLY TO AVOID CONTAMINATION FROM PATHOGENS BY WASHING HANDS WELL WITH SOAP AND CLEANING WORK SURFACES WITH PRODUCTS SUCH AS BLEACH TO KILL PATHOGENS – COOK FOOD WELL (LONG ENOUGH AT HIGH TEMPERATURE) TO KILL BACTERIA AND FUNGI – COVER FOOD TO PREVENT FLIES LANDING ON IT BEFORE EATING – USE SEPARATE CHOPPING BOARDS/UTENSILS FOR CUTTING UNCOOKED MEAT – WASH HANDS AFTER USING THE BATHROOM BEFORE HANDLING FOOD
PERSONAL HYGIENE	– WASHING WITH SOAP REMOVES SUBSTANCES WHICH TRAP PATHOGENS AS WELL AS PATHOGENS THEMSELVES FROM THE SKIN – USE TISSUES TO CATCH SNEEZES AND COUGHS – DISPOSE OF USED TISSUES AS SOON AS POSSIBLE AS PATHOGENS CAN STILL BE ALIVE – WASH HANDS AFTER USING THE BATHROOM
WASTE DISPOSAL	– WASTE FOOD IS A FOOD SOURCE FOR FLIES THAT CAN ACT AS VECTORS FOR TRANSMISSIBLE DISEASES AND SO SHOULD BE DISPOSED OF IN A SEALED CONTAINER – RUBBISH BINS SHOULD BE COVERED AND REMOVED TO THE LANDFILL FOR DISPOSAL OR BURNING REGULARLY – ALL RUBBISH SHOULD BE STORED BEFORE COLLECTION AWAY FROM HUMAN HABITATION
SANITATION	– HOMES AND PUBLIC PLACES SHOULD HAVE PLUMBING AND DRAINS TO SAFELY REMOVE FAECES AND WASTE WHICH CAN CARRY PATHOGENS – RAW SEWAGE SHOULD BE TREATED TO REMOVE SOLID WASTE AND KILL PATHOGENS BEFORE BEING RELEASED INTO THE ENVIRONMENT

> NOW TRY SOME EXAM QUESTIONS

10 DISEASEES & IMMUNITY

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The blood contains lymphocytes. What is their purpose?

A Transport of hormones

B Phagocytosis

C Antibody production

D Sensitivity

QUESTION 2

The immune system recognises which part of a pathogen?

A Antibiotic

B Antigen

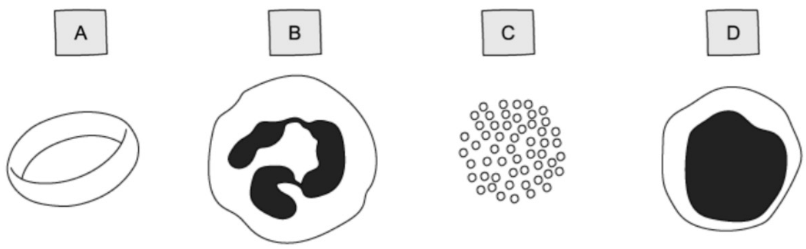
C Active site

D Antibody

QUESTION 3

Components of the blood from a mammal are shown in the diagram below.

In which component would you expect to find the remains of the breakdown of bacterial cells.



YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

The body has a number of barriers to prevent infection by pathogens.

Which of the options below are both chemical barriers?

A Skin and hairs in the nose

B Mucus and antibodies

C Skin and stomach acid

D Mucus and stomach acid

QUESTION 5

Which of the following diseases listed below are not caused by infectious pathogens?

1 Coronary Heart Disease

2 Cholera

3 AIDs

4 Scurvy

A 2 only **B** 1 and 4 **C** 2 and 3 **D** 2, 3 and 4

11 GAS EXCHANGE IN HUMANS

CONTENTS:

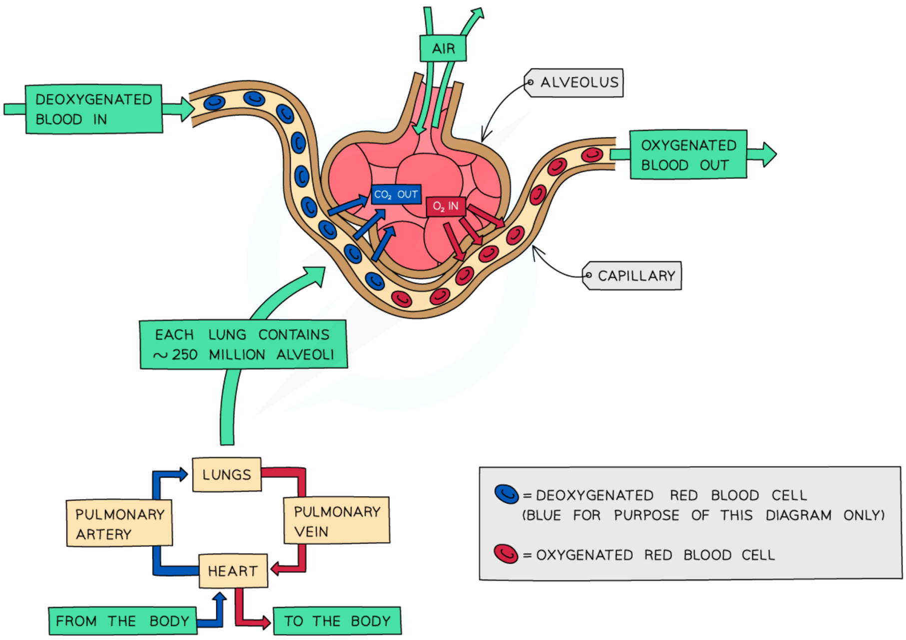
VIEW EXAM QUESTIONS

YOUR NOTES

11.1 THE BREATHING SYSTEM

Features of Gas Exchange Surfaces

- The surfaces where gas exchange occurs in an organism are very different and different organisms have evolved different mechanisms for getting the gases to the gas exchange surface depending on size, where they live etc.
- All gas exchange surfaces have features in common
- These features allow the maximum amount of gases to be exchanged across the surface in the smallest amount of time
- They include:
    - **Large surface area** to allow faster diffusion of gases across the surface
    - **Thin walls** to ensure diffusion distances remain short
    - **Good ventilation with air** so that diffusion gradients can be maintained
    - **Good blood supply** to maintain a high concentration gradient so diffusion occurs faster



The alveolus is the gas exchange surface in humans

11 GAS EXCHANGE IN HUMANS

11.1 THE BREATHING SYSTEM cont...

YOUR NOTES

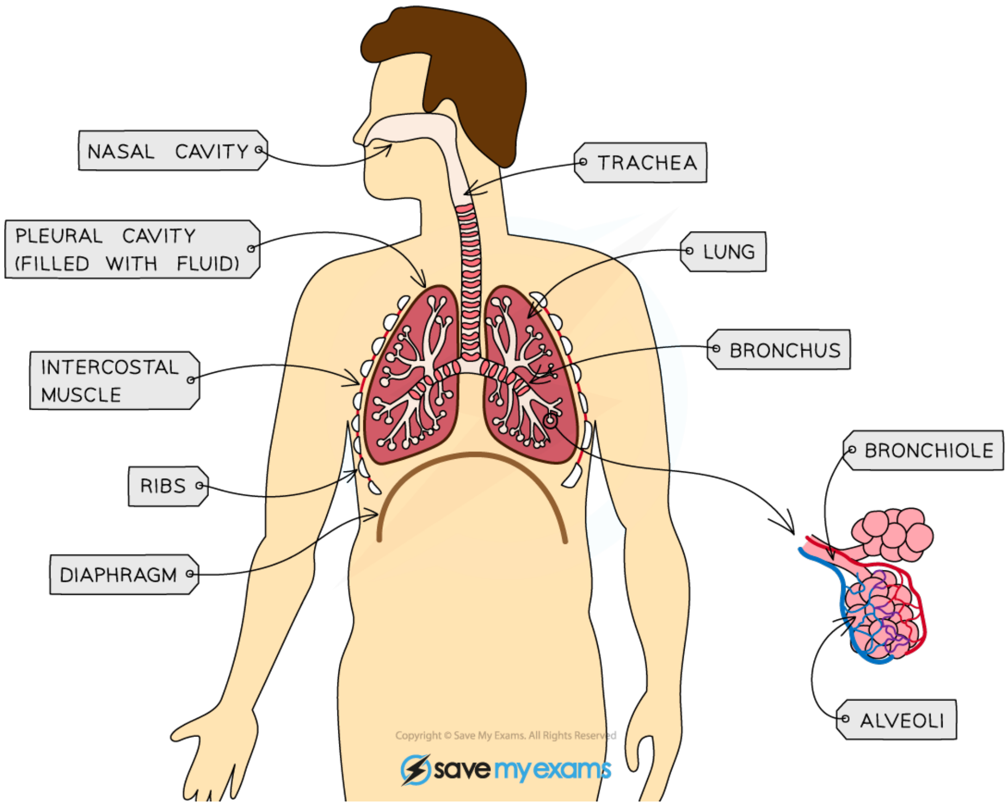
EXAM TIP

Several of the features of alveoli that make them suited to their function are the same as those that make villi suited to their function; or root hair cells suited to their function.

This is because all of these structures are involved in transporting substances across their surfaces – by diffusion, active transport, osmosis or a combination.

So if you learn the features for one, you also know many of the features of the others!

Structure of the Breathing System



Structures in the human breathing system

11 GAS EXCHANGE IN HUMANS

11.1 THE BREATHING SYSTEM cont...

YOUR NOTES

STRUCTURE	DESCRIPTION
RIBS	BONE STRUCTURE THAT PROTECTS INTERNAL ORGANS SUCH AS THE LUNGS
INTERCOSTAL MUSCLE	MUSCLES BETWEEN THE RIBS WHICH CONTROL THEIR MOVEMENT CAUSING INHALATION AND EXHALATION
DIAPHRAGM	SHEET OF CONNECTIVE TISSUE AND MUSCLE AT THE BOTTOM OF THE THORAX THAT HELPS CHANGE THE VOLUME OF THE THORAX TO ALLOW INHALATION AND EXHALATION
TRACHEA	WINDPIPE THAT CONNECTS THE MOUTH AND NOSE TO THE LUNGS
LARYNX	ALSO KNOWN AS THE VOICE BOX, WHEN AIR PASSES ACROSS HERE WE ARE ABLE TO MAKE SOUNDS
BRONCHI (PL)	LARGE TUBES BRANCHING OFF THE TRACHEA WITH ONE BRONCHUS (SIN) FOR EACH LUNG
BRONCHIOLES	BRONCHI SPLIT TO FORM SMALLER TUBES CALLED BRONCHIOLES IN THE LUNGS CONNECTED TO ALVEOLI
ALVEOLI	TINY AIR SACS WHERE GAS EXCHANGE TAKES PLACE

11 GAS EXCHANGE IN HUMANS

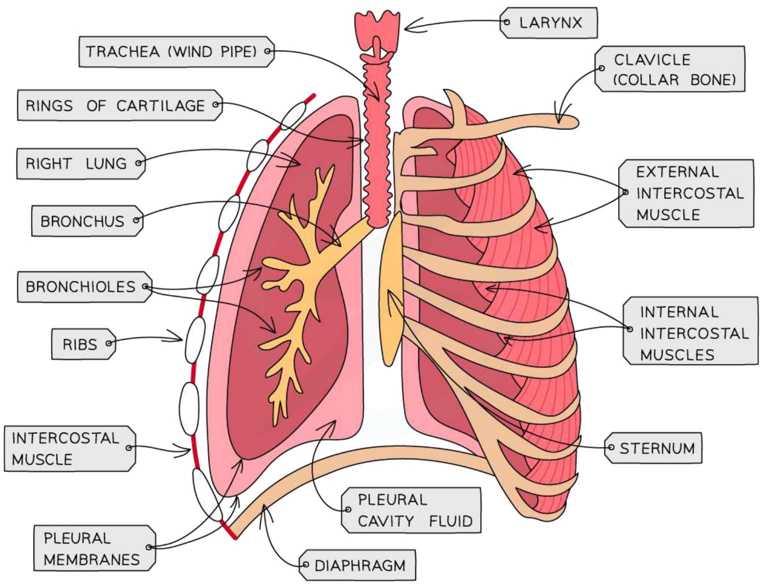
11.1 THE BREATHING SYSTEM cont...

YOUR NOTES

EXTENDED ONLY

The Intercostal Muscles

- Muscles are only able to pull on bones, not push on them
- This means that there must be two sets of intercostal muscles; one to pull the rib cage up and another set to pull it down
- One set of intercostal muscles is found on the outside of the ribcage (the **external** intercostal muscles)
- The other set is found on the inside of the rib cage (the **internal** intercostal muscles)



The lungs

There are two sets of intercostal muscles: the external, on the outside of the rib cage, and the internal, on the inside of the rib cage

The Trachea

- Rings of cartilage surround the trachea (and bronchi)
- The function of the cartilage is to support the airways and keep them open during breathing
- If they were not present then the sides may collapse inwards when the air pressure inside the tubes drops

11 GAS EXCHANGE IN HUMANS

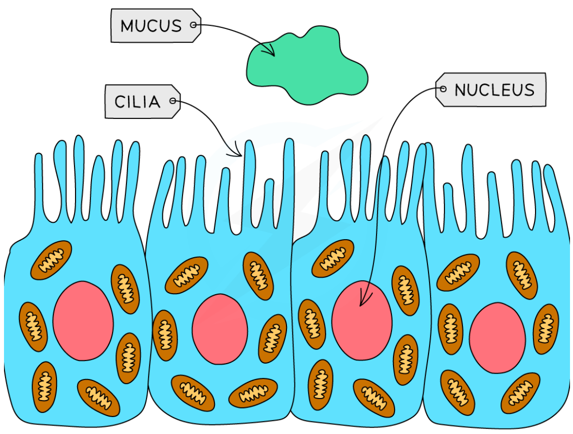
11.1 THE BREATHING SYSTEM cont...

YOUR NOTES

EXTENDED ONLY cont...

The Function of Cilia & Mucus

- The passages down to the lungs are lined with **ciliated epithelial cells**
- Cilia comes from the Latin for eyelash, so unsurprisingly these cells have tiny hairs on the end of them that **beat** and **push mucus up the passages towards the nose and throat** where it can be removed
- The **mucus** is made by special mucus-producing cells called goblet cells because they are shaped like a goblet, or cup
- The mucus traps **particles, pathogens like bacteria or viruses, and dust and prevents them getting into the lungs** and damaging the cells there



Ciliated cells

Mucus traps particles, dust and pathogens and cilia beat and push it up and away from the lungs

EXAM TIP

The function of cilia and mucus is often a three mark question on the extended paper. The examiners are looking for you to state the following:

- The mucus is produced by goblet cells and traps bacteria, dust, particles
- The cilia beat
- and push the mucus away from the lungs towards the throat

This is quite simple, but often marks are lost as students haven't been precise enough with their explanations!

11 GAS EXCHANGE IN HUMANS

11.2 VENTILATION OF THE LUNGS

YOUR NOTES

EXTENDED ONLY

Inhalation & Exhalation

- The external and internal intercostal muscles work as **antagonistic** pairs (meaning they work in different directions to each other)
- During **inhalation** the **external set of intercostal muscles contract** to pull the ribs **up and out**
- During **exhalation** the **internal set of intercostal muscles contract** to pull the ribs **down and in**
- The point of this is to increase or decrease the **volume** of the chest cavity (**thorax**) so that the lungs can follow and increase or decrease in size
- The **muscle surrounding the diaphragm** also helps to increase and decrease the volume of the thorax
- This means that when we are doing 'quiet breathing' there may be no noticeable chest movement as the lungs are ventilated mainly by changes in the **shape of the diaphragm**
- When we need to increase the rate of gas exchange (for example during strenuous activity) the intercostal muscles will also work to **pull the ribs up and out** and increase the volume of the thorax more
- This is because we now require a **greater volume of gases to be exchanged**, so we need to inflate the lungs quicker and almost to their maximum
- As the **volume of the thorax increases, the pressure inside the lungs decreases**
- Once it drops **below** the air pressure **outside** the lungs, air will be forced in
- During **exhalation**, the reverse occurs; volume **decreases**, pressure in the thorax **increases** and air is forced out

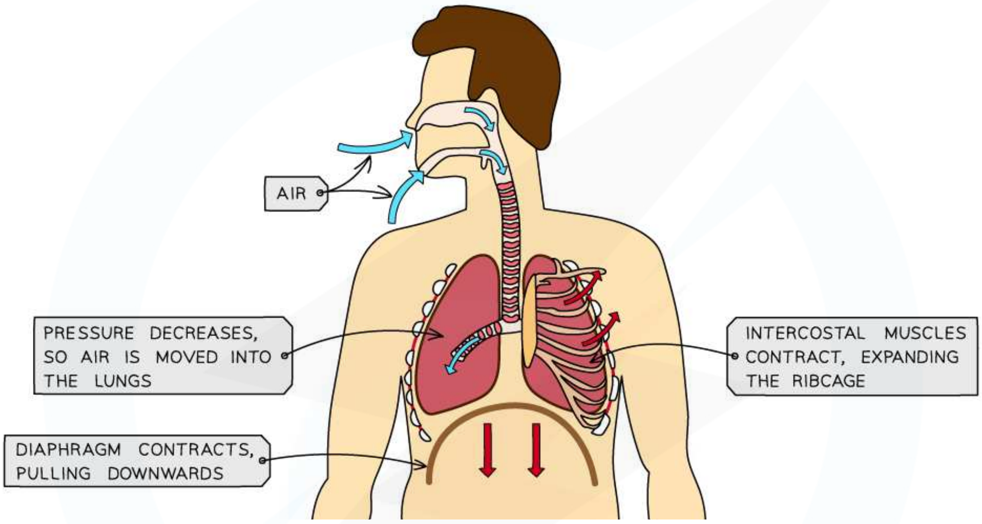
11 GAS EXCHANGE IN HUMANS

11.2 VENTILATION OF THE LUNGS cont...

YOUR NOTES

EXTENDED ONLY cont...

INHALATION



BREATHING IN

- EXTERNAL INTERCOSTAL MUSCLES CONTRACT
- INTERNAL INTERCOSTAL MUSCLES RELAX
- RIBCAGE MOVES UP AND OUT
- DIAPHRAGM CONTRACTS AND FLATTENS
- PRESSURE INSIDE THORAX DICREASES
- AIR IS DRAWN IN

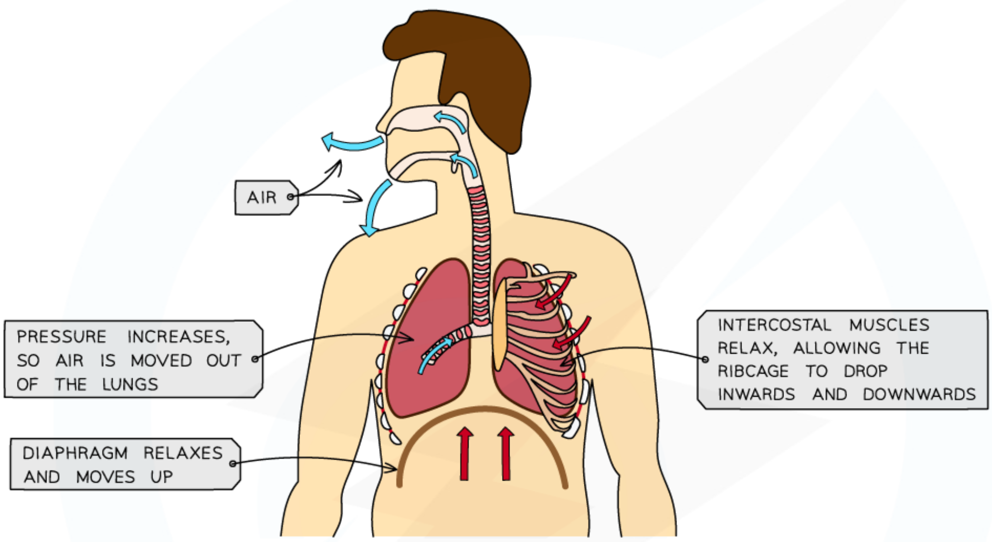
11 GAS EXCHANGE IN HUMANS

11.2 VENTILATION OF THE LUNGS cont...

YOUR NOTES

EXTENDED ONLY cont...

EXHALATION



BREATHING OUT

- INTERNAL INTERCOSTAL MUSCLES CONTRACT
- EXTERNAL INTERCOSTAL MUSCLES RELAX
- RIBCAGE MOVES DOWN AND IN
- DIAPHRAGM RELAXES AND BECOMES DOME–SHAPED
- PRESSURE INSIDE THORAX INCREASES
- AIR IS FORCED OUT

11 GAS EXCHANGE IN HUMANS

YOUR NOTES

11.2 VENTILATION OF THE LUNGS cont...

EXAM TIP

- This sequence of events is a common exam question
- So be able to explain in detail what is happening when breathing in and out to:
  - **the external and internal intercostal muscles**
  - **the rib cage**
  - **the diaphragm**
  - **the volume and the pressure of the lungs**
- Remember, if you learn one, the other is almost exactly the opposite.
- You may see the terms **inhalation** OR **inspiration** (breathing in), and **exhalation OR expiration** (breathing out). Both sets of terms mean exactly the same thing, so don't let them confuse you!

11.3 COMPOSITION OF AIR

Differences between Inhaled & Exhaled Air

- Air that is breathed in and air that is breathed out has **different amounts of gases** in it due to exchanges that take place in the **alveoli**
- Atmospheric air contains around **20 – 21% oxygen**, of which we only absorb around 4 – 5%, breathing out air containing around **16% oxygen**
- Normal **carbon dioxide content of air is around 0.04%** and, as carbon dioxide diffuses into the alveoli from the blood, we breathe out air containing around **4% carbon dioxide**
- We also breathe out air containing **more water vapour** than the air we breathe in, and the temperature of exhaled air is **higher** than inhaled air

GAS	INSPIRED AIR	EXPIRED AIR
OXYGEN	21%	16%
CARBON DIOXIDE	0.04%	4%
NITROGEN	78%	78%

11.3 COMPOSITION OF AIR

YOUR NOTES

EXTENDED ONLY

Reasons for Differences in Inhaled & Exhaled Air

GAS	INSPIRED AIR	EXPIRED AIR	REASON FOR DIFFERENCE
OXYGEN	21%	16%	OXYGEN IS REMOVED FROM BLOOD BY RESPIRING CELLS SO BLOOD RETURNING TO LUNGS HAS A LOWER OXYGEN CONCENTRATION THAN THE AIR IN THE ALVEOLI WHICH MEANS OXYGEN DIFFUSES INTO THE BLOOD IN THE LUNGS
CARBON DIOXIDE	0.04%	4%	CARBON DIOXIDE IS PRODUCED BY RESPIRATION AND DIFFUSES INTO BLOOD FROM RESPIRING CELLS; THE BLOOD TRANSPORTS THE CARBON DIOXIDE TO THE LUNGS WHERE IT DIFFUSES INTO THE ALVEOLI AS IT IN A HIGHER CONCENTRATION IN THE BLOOD THAN IN THE AIR IN THE ALVEOLI
WATER VAPOUR	LOWER	HIGHER	WATER EVAPORATES FROM THE MOIST LINING OF THE ALVEOLI INTO THE EXPIRED AIR AS A RESULT OF THE WARMTH OF THE BODY
NITROGEN	78%	78%	NITROGEN GAS IS VERY STABLE AND SO CANNOT BE USED BY THE BODY, FOR THIS REASON ITS CONCENTRATION DOES NOT CHANGE IN INSPIRED OR EXPIRED AIR

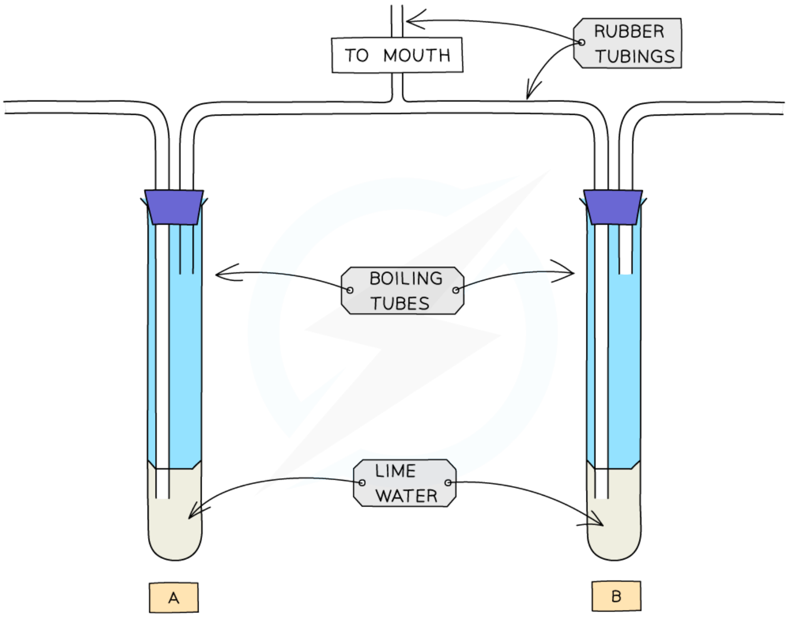
Using Limewater to Test for CO_2 in Exhaled Air

- We can use the apparatus below to investigate the difference between the amount of carbon dioxide in inhaled air and exhaled air

11 GAS EXCHANGE IN HUMANS

YOUR NOTES

11.3 COMPOSITION OF AIR cont...



The limewater test

- When we breathe in, the air is drawn through boiling tube A
- When we breathe out, the air is blown into boiling tube B
- **Lime water** is **clear** but becomes **cloudy** (or milky) when carbon dioxide is bubbled through it
- The lime water in **boiling tube A will remain clear**, but the limewater in **boiling tube B will become cloudy**
- This shows us that the **percentage of carbon dioxide in exhaled air is higher than in inhaled air**

11.4 EXERCISE & BREATHING

Investigating the Effect of Exercise on Breathing

- Exercise increases the **frequency and depth of breathing**
- This can be investigated by **counting the breaths taken during one minute at rest** and **measuring average chest expansion over 5 breaths** using a tape measure held around the chest
- Exercise for a set time (at least 3 minutes)
- Immediately after exercising, **count the breaths taken in one minute** and measure the **average chest expansion over 5 breaths**
- Following exercise, the **number of breaths per minute will have increased** and the **chest expansion will also have increased**

11 GAS EXCHANGE IN HUMANS

11.4 EXERCISE & BREATHING

YOUR NOTES

EXTENDED ONLY

Explaining the Effect of Exercise on Breathing

- Frequency and depth of breathing **increase when exercising**
- This is because muscles are working harder and aerobically respiring more and they **need more oxygen to be delivered to them** (and carbon dioxide removed) to keep up with the energy demand
- If they cannot meet the energy demand they will also **respire anaerobically**, producing **lactic acid**
- After exercise has finished, the lactic acid that has built up in muscles needs to be **removed** as it **lowers the pH of cells** and can **denature enzymes** catalysing cell reactions
- It can only be removed by combining it with oxygen – this is known as '**repaying the oxygen debt'**
- This can be tested by seeing how long it takes after exercise for the breathing rate and depth to return to normal – **the longer it takes, the more lactic acid produced during exercise and the greater the oxygen debt that needs to be repaid**

Carbon Dioxide Concentration & The Brain

- As respiration rates increase, **more carbon dioxide is produced** and enters the blood
- Carbon dioxide is an **acidic gas** in solution and so it can affect the working of enzymes in the cells and needs to be removed as quickly as possible
- As blood flows through the **brain**, the increase in carbon dioxide concentration stimulates **receptor cells**
- These send impulses to the muscles of the lungs, causing them to contract **faster and more strongly**
- This causes the **frequency and depth of breathing to increase** until the carbon dioxide concentration of the blood has lowered sufficiently

> NOW TRY SOME EXAM QUESTIONS

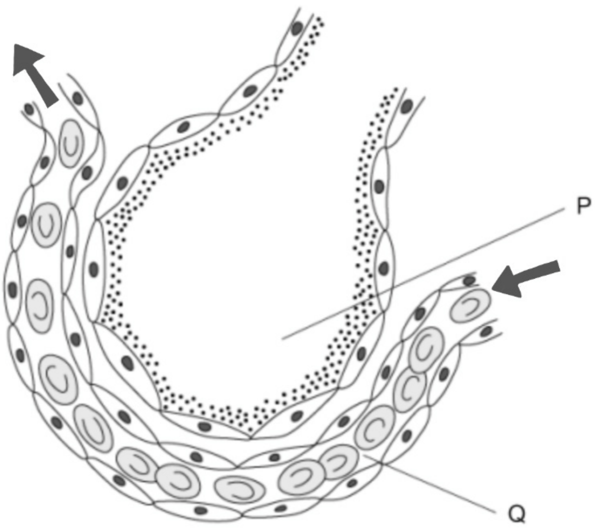
11 GAS EXCHANGE IN HUMANS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The diagram below shows a cross-section through an alveolus and a capillary.



Why does oxygen move from P to Q?

A The concentration of carbon dioxide is lower in the alveolus than in the blood.

B The concentration of oxygen in the blood is lower than in the air in the capillary

C Oxygen must replace carbon dioxide.

D The concentration of oxygen in the blood is lower than the air in the alveolus.

QUESTION 2

What makes the alveoli suitable as a gas exchange surface in mammals?

	a dense capillary network	large total surface area
A	✘	✘
B	✔	✘
C	✘	✔
D	✔	✔

11 GAS EXCHANGE IN HUMANS

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

What of the following shows the correct path of oxygen as it enters the lungs?

A trachea → bronchiole → bronchus → alveolus

B trachea → bronchus → bronchiole → alveolus

C alveolus → bronchus → bronchiole → trachea

D alveolus → bronchiole → bronchus → trachea

QUESTION 4

Some amphibians, such as frogs, can use their skin as a gas exchange surface.

What are the most likely characteristics of the surface of the skin in these amphibians?

	surface area	type of skin
A	small	thick
B	large	thick
C	small	thin
D	large	thin

QUESTION 5

What of the following correctly describes the actions of the intercostal muscles and the diaphragm when we breathe in?

	external intercostal muscles	internal intercostal muscles	diaphragm
A	contract	relax	domed
B	contract	relax	flat
C	relax	contract	domed
D	relax	contract	flat

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

12 RESPIRATION

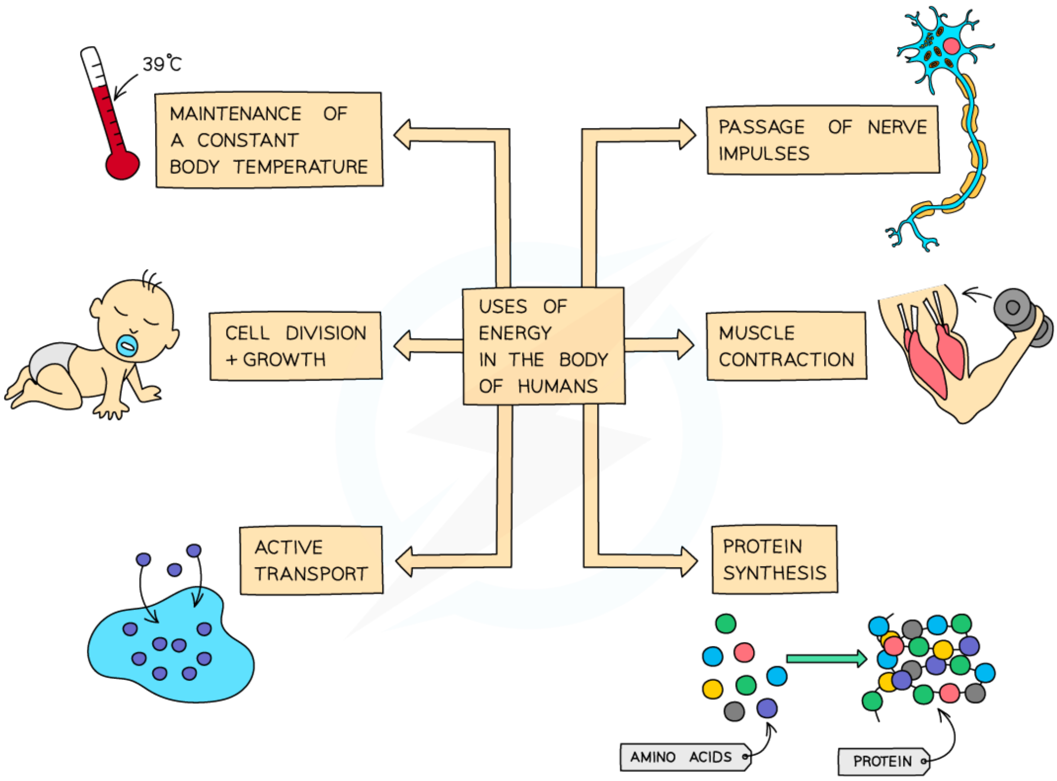
YOUR NOTES

CONTENTS:

12.1 RESPIRATION BASICS

Uses of Energy in the Body

- Respiration is a chemical process that involves the breakdown of nutrient molecules (specifically glucose) in order to release the energy stored within the bonds of these molecules
- Respiration can take place with oxygen (**aerobically**) or without oxygen (**anaerobically**). Much less energy is released for each glucose molecule broken down anaerobically compared to the energy released when it is broken down aerobically
- Respiration occurs in all living cells. Most of the chemical reactions in aerobic respiration take place in the mitochondria



Uses of energy in the human body

12 RESPIRATION

YOUR NOTES

12.1 RESPIRATION BASICS cont...

- Humans need this energy to do the following things:
  - Contract muscle
  - Synthesise proteins
  - Cell division (to make new cells)
  - Grow
  - Enable active transport to take place
  - Allow nerve impulses to be generated
  - Maintain a constant internal body temperature

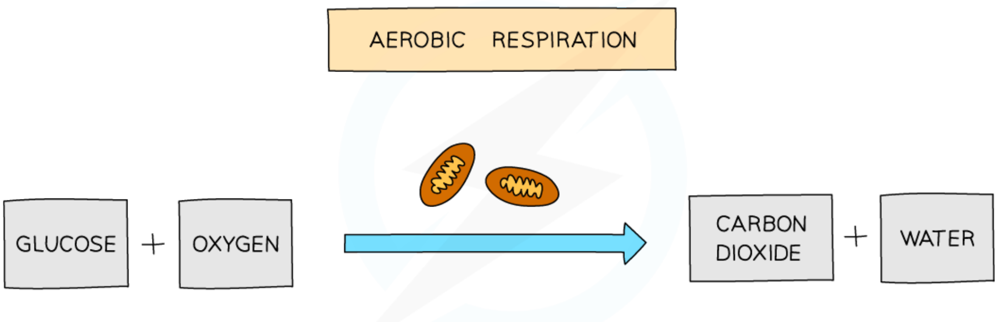
How is Respiration Controlled?

Respiration is a series of reactions which are controlled by enzymes. You need to be able to state this in an exam!

12.2 AEROBIC RESPIRATION

Aerobic Respiration: Basics

- **Aerobic** respiration requires **oxygen** and is defined as **the chemical reactions in cells that use oxygen to break down nutrient molecules to release energy**
- It is the **complete breakdown of glucose** to release a **relatively large amount of energy** for use in cell processes
- It **produces carbon dioxide and water** as well as releasing useful cellular energy



Word equation for aerobic respiration

12 RESPIRATION

YOUR NOTES

12.2 AEROBIC RESPIRATION cont...

EXAM TIP

Remember, this equation is **the same as the photosynthesis equation**, only the other way around – so if you know one, you know the other one too!

EXTENDED ONLY

Chemical Equation

AEROBIC RESPIRATION

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

Balanced equation for aerobic respiration

EXAM TIP

There are usually 3 marks given for the aerobic respiration chemical equation in an exam:

- one for getting the correct formula for glucose and oxygen
- one for getting the correct formula for carbon dioxide and water
- one for balancing the equation correctly

So make sure you can do all three to gain maximum marks!

12 RESPIRATION

12.2 AEROBIC RESPIRATION cont...

YOUR NOTES

Investigating Uptake of Oxygen by Respiring Organisms

- We can investigate aerobic respiration in living organisms by **measuring the amount of oxygen that they take from the air**
- This is done by measuring the **change in volume** in an enclosed tube containing the organisms
- However, as they respire the organisms release **carbon dioxide**, which increases the gas volume
- The carbon dioxide must therefore be removed from the tube using a chemical like **soda lime or sodium hydroxide**, otherwise it will make the experiment results inaccurate
- Any small organisms can be used in the apparatus, including **seeds** or **arthropods**
- The apparatus (shown below) is known as a **respirometer**

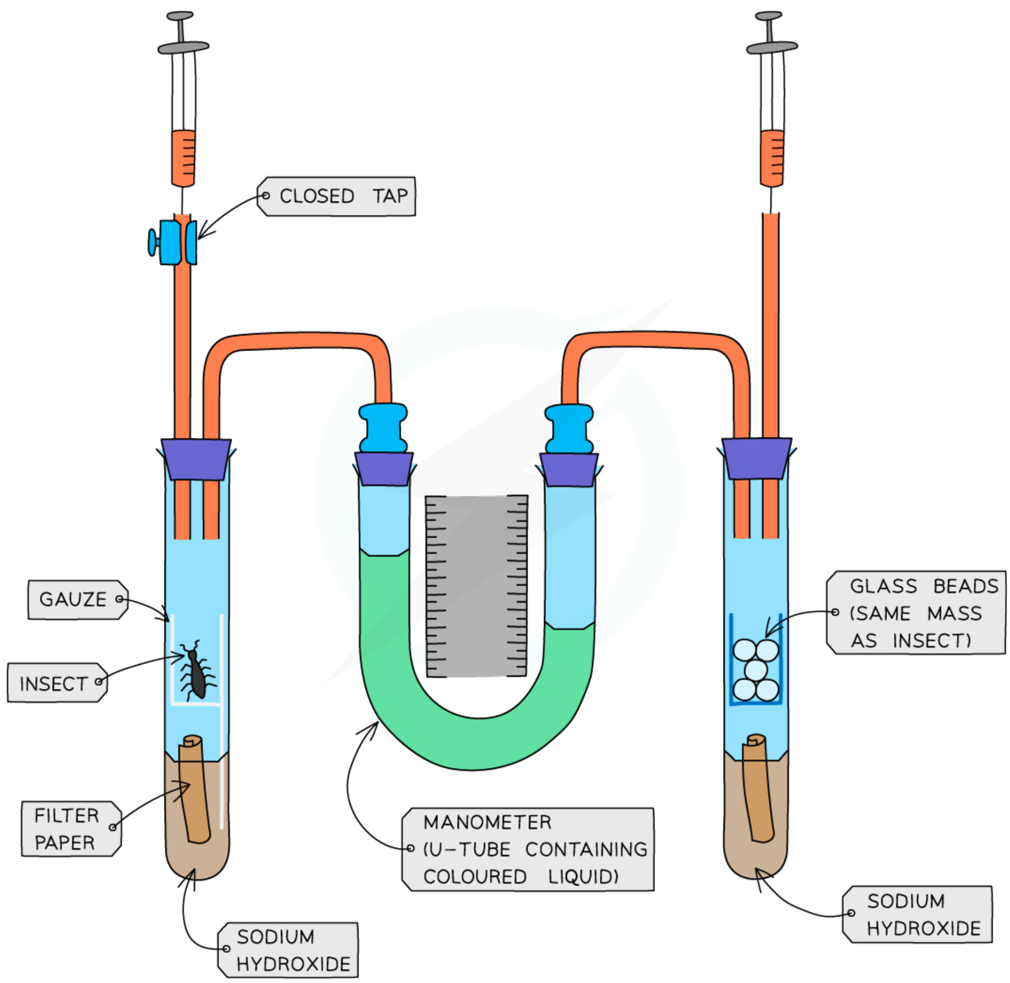


Diagram showing the setup of a respirometer

12 RESPIRATION

YOUR NOTES

12.2 AEROBIC RESPIRATION cont...

- The apparatus consists of two tubes, one containing the living organisms, and the other containing glass beads to act as a **control**
- Once the apparatus has been set up, the **movement of the coloured liquid towards the insect** will give a measure of the volume of oxygen taken up by the insect for respiration
- The reduction of volume in the tube increases pressure, causing the coloured liquid to move
- The distance moved by the liquid in a given time is measured, which will provide the **volume of oxygen taken in by the insect per minute**

EXAM TIP

What is a control?

- A control is a **duplicate experiment set up** with the condition being investigated having been removed or neutralised in some way.
- In the experiment above, the control is the glass beads. As they are not alive, they will definitely not be respiring.
- Therefore, if the volume of oxygen in the tube with the glass beads decreases during the course of the experiment, we know that the condition being investigated (respiration in living organisms) is not the cause of it.
- So, a control helps to make your experiment **valid**.

EXTENDED ONLY

Investigating the Effect of Temperature on the Rate of Respiration

- To investigate the effect of temperature on the rate of respiration of germinating seeds, the respirometer can be set up and the tubes submerged in a series of **water baths** set at different temperatures, eg 10°C, 15°C, 20°C, 25°C, 30°C
- The seeds should be kept in the water bath for 15 minutes before the start of the experiment to ensure they have **acclimated to the temperature**
- As respiration is an enzyme-controlled reaction, it is unlikely to work faster beyond around 40°C as the enzymes will denature

12 RESPIRATION

YOUR NOTES

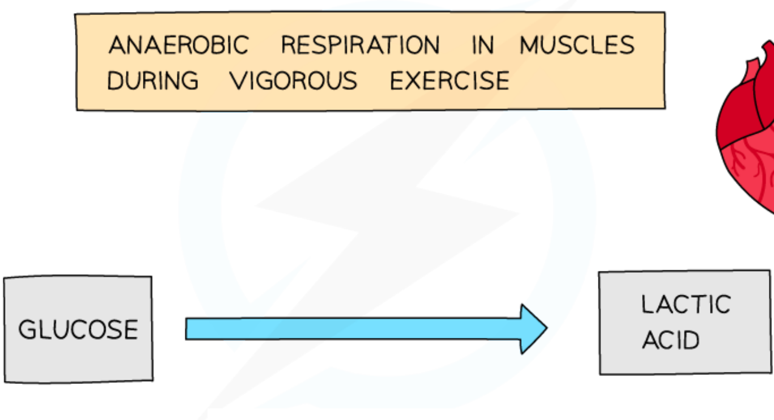
12.3 ANAEROBIC RESPIRATION

Anaerobic Respiration: Basics

- **Anaerobic** respiration does **not require oxygen** and is defined as the **chemical reactions in cells that break down nutrient molecules to release energy without using oxygen**
- It is the **incomplete breakdown of glucose** and releases a **relatively small amount** of energy for use in cell processes
- It produces different breakdown products depending on the type of organism it is taking place in.
- You need to know the equations for anaerobic respiration in **humans** (animals) and the microorganism **yeast**.

Anaerobic Respiration in Animals

- Anaerobic respiration mainly takes place in muscle cells during vigorous exercise.
- When we exercise vigorously, our muscles have a higher demand for energy than when we are resting or exercising normally. Our bodies can only deliver so much oxygen to our muscle cells for aerobic respiration.
- In this instance, as much glucose as possible is broken down with oxygen, and some glucose is broken down without it, producing lactic acid instead.
- There is still energy stored within the bonds of lactic acid molecules that the cell could use; for this reason, less energy is released when glucose is broken down anaerobically.



Word equation for anaerobic respiration in animals

12.3 ANAEROBIC RESPIRATION cont...

YOUR NOTES

EXTENDED ONLY

Lactic Acid & The Oxygen Debt

- **Lactic acid** builds up in muscle cells and **lowers the pH** of the cells (making them more acidic)
- This could **denature the enzymes in cells** so it needs to be removed
- Cells excrete lactic acid into the blood. When blood passes through the liver, lactic acid is taken up into **liver** cells where it is **oxidised**, producing carbon dioxide and water (Lactic acid reacts with oxygen – this is actually **aerobic respiration** with lactic acid as the nutrient molecule instead of glucose)
- So the waste products of lactic acid oxidation are carbon dioxide and water
- This is the reason we **continue to breath heavily** and our **heart rate remains high** even after finishing exercise – we need to transport the lactic acid from our muscles to the liver, and continue getting larger amounts of oxygen into the blood to oxidise the lactic acid
- This is known as '**repaying the oxygen debt**'

EXAM TIP

Many students get confused about the products of anaerobic respiration in animals

The ONLY product made is **lactic acid**

Carbon dioxide is NOT one of the products made in anaerobic respiration in animals – it is made in aerobic respiration!

Anaerobic Respiration in Yeast

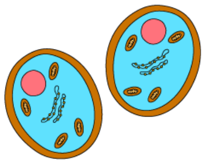
- We take advantage of the products of anaerobic respiration in **yeast** by using it in **bread making** (where the carbon dioxide produced helps dough to rise) and in **brewing** (where the ethanol produced makes beer)

12 RESPIRATION

12.3 ANAEROBIC RESPIRATION cont...

YOUR NOTES

ANAEROBIC RESPIRATION IN YEAST



GLUCOSE → ALCOHOL + CARBON DIOXIDE

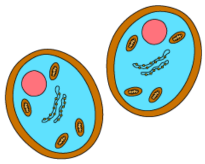
Word equation for anaerobic respiration in yeast

EXTENDED ONLY

Chemical Equation

The balanced chemical equation for anaerobic respiration in yeast is:

ANAEROBIC RESPIRATION IN YEAST



$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Balanced equation for anaerobic respiration in yeast

Comparison of Aerobic & Anaerobic Respiration

	AEROBIC	ANAEROBIC
OXYGEN	NEEDED	NOT NEEDED
GLUCOSE BREAKDOWN	COMPLETE	INCOMPLETE
PRODUCTS	CARBON DIOXIDE AND WATER	ANIMAL CELLS: LACTIC ACID YEAST: CARBON DIOXIDE AND ETHANOL
ENERGY RELEASED	A LOT	A LITTLE

> NOW TRY SOME EXAM QUESTIONS

12 RESPIRATION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which row in the table below shows the correct products produced by anaerobic respiration in yeast and in animals?

	animals		yeast	
	lactic acid	carbon dioxide	lactic acid	carbon dioxide
A	✘	✔	✘	✘
B	✔	✘	✘	✔
C	✘	✔	✔	✘
D	✔	✔	✔	✘

QUESTION 2

Glucose is broken down in the chemical processes of aerobic respiration.

Which row of the table below shows the correct products of this breakdown?

	animals		yeast	
	energy	water	lactic acid	carbon dioxide
A	✘	✘	✔	✘
B	✔	✘	✘	✔
C	✘	✔	✘	✔
D	✔	✔	✘	✔

QUESTION 3

Which of the following is the correct word equation for aerobic respiration in plants?

A glucose + oxygen → carbon dioxide + water

B carbon dioxide + water → glucose + oxygen

C glucose + water → carbon dioxide + oxygen

D glucose + carbon dioxide → water + oxygen

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 4

During vigorous exercise, such as cycling uphill, lactic acid builds up in the muscles.

How is this lactic acid removed during recovery?

A excretion of lactic acid by the kidneys

B anaerobic respiration of lactic acid in the muscles

C aerobic respiration of lactic acid in the liver

D excretion of lactic acid by the lungs

QUESTION 5

Four metabolic reactions that can occur in living organisms are shown below:

1 $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

2 glucose → lactic acid

3 $6CO_2 + 6H_2O \rightarrow C6H_{12}O_6 + 6O_2$

4 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

Which of the above reactions take place in yeast cells to release energy?

A 1 and 2 **B** 1 and 3 **C** 3 and 4 **D** 1 and 4

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

Head to savemyexams.co.uk
for more questions and revision notes

13 EXCRETION IN HUMANS

YOUR NOTES

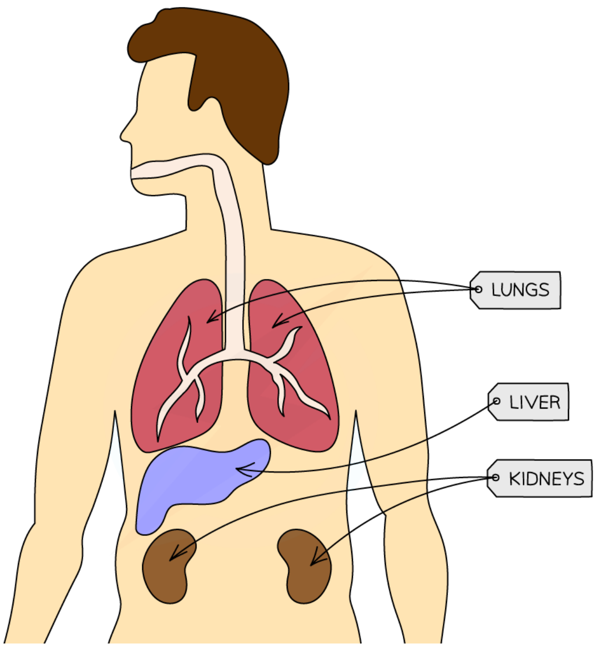
CONTENTS:

VIEW EXAM QUESTIONS

13.1 THE EXCRETORY SYSTEM

Excretory Products

- Unlike plants, humans have organs which are specialised for the removal of certain excretory products
- They include the **lungs and kidneys**
- The **liver** also has a vital role in excretion



Organs involved in excretion

ORGAN	MAINLY EXCRETES	EXPLANATION
LUNGS	CARBON DIOXIDE	THE LUNGS EXCRETE CARBON DIOXIDE (A WASTE PRODUCT OF AEROBIC RESPIRATION) DURING EXHALATION
KIDNEYS	EXCESS WATER, SALTS AND UREA	THE KIDNEYS EXCRETE EXCESS WATER, EXCESS SALTS AND UREA (FORMED IN THE LIVER FROM EXCESS AMINO ACIDS) BY PRODUCING URINE

13 EXCRETION IN HUMANS

13.1 THE EXCRETORY SYSTEM cont...

YOUR NOTES

EXTENDED ONLY

The Need for Excretion

- Excretion is the **removal of the waste substances of metabolic reactions** (the chemical reactions that take place inside cells), toxic materials and **substances in excess of requirements**
- **Carbon dioxide** must be excreted as it dissolves in water easily to form an acidic solution which can **lower the pH of cells**
- This can **reduce the activity of enzymes** in the body which are essential for controlling the rate of metabolic reactions
- For this reason, too much carbon dioxide in the body is **toxic**
- **Urea** is also toxic to the body in higher concentrations and so must be excreted

The Role of the Liver

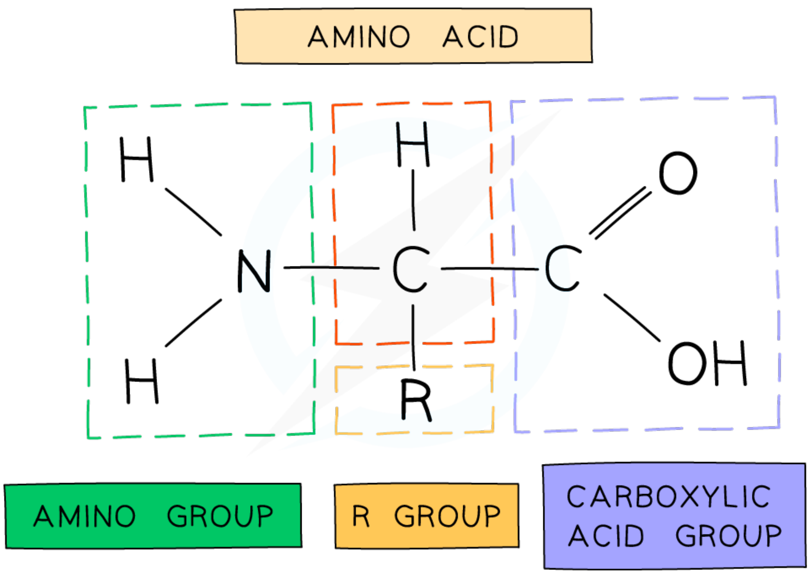
- Many digested food molecules absorbed into the blood in the small intestine are carried to the liver for **assimilation** (when food molecules are converted to other molecules that the body needs)
- These include amino acids, which are used to build proteins such as **fibrinogen**, a protein found in blood plasma that is important in blood clotting
- **Excess amino acids** absorbed in the blood that are not needed to make proteins **cannot be stored**, so they are broken down in a process called **deamination**
- Enzymes in the liver split up the amino acid molecules
- The part of the molecule which contains **carbon** is turned into **glycogen** and stored
- The other part, which contains **nitrogen**, is turned into **ammonia**, which is highly toxic, and so is immediately converted into urea, which is less toxic
- The urea dissolves in the blood and is taken to the kidney to be excreted
- A small amount is also excreted in **sweat**

13 EXCRETION IN HUMANS

13.1 THE EXCRETORY SYSTEM cont...

YOUR NOTES

EXTENDED ONLY cont...



Amino acid groups

- In deamination, the nitrogen-containing amino group is removed and converted into ammonia and then urea to be excreted

EXAM TIP

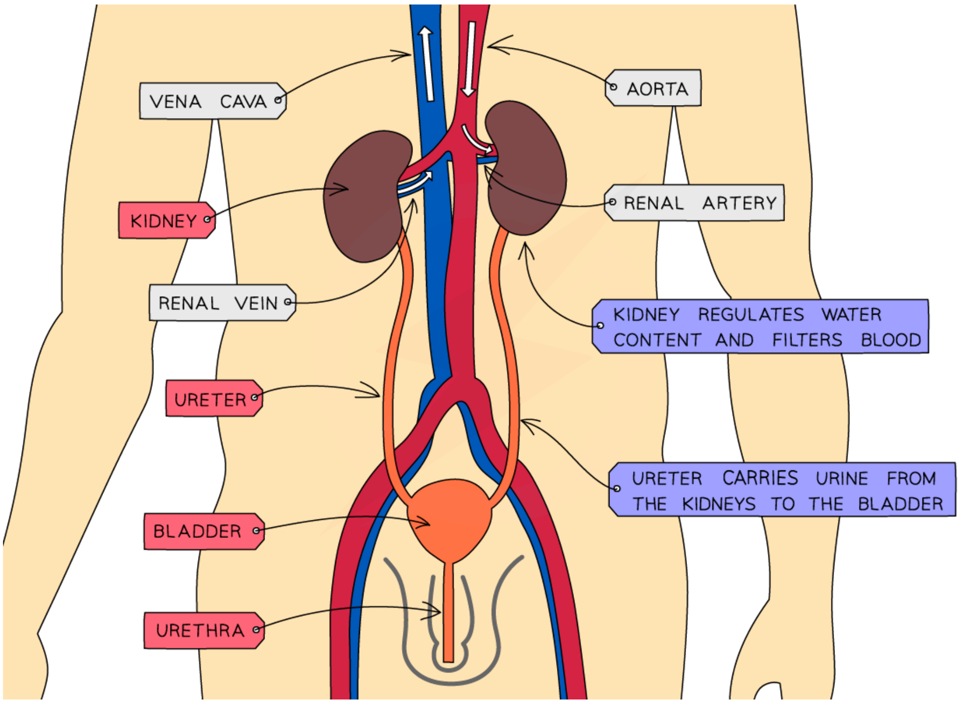
Excretion and **egestion** are two terms that often get confused:

- **Excretion** is the removal from the body of waste products of metabolic reactions, toxic substances and substances in excess of requirements
- **Egestion** is the expulsion of undigested food waste from the anus

13 EXCRETION IN HUMANS

13.2 THE URINARY SYSTEM

Structure



The urinary system in humans

Main structures involved:

STRUCTURE	EXPLANATION
KIDNEY	TWO BEAN–SHAPED ORGANS THAT FILTER THE BLOOD
URETER	TUBE CONNECTING THE KIDNEY TO THE BLADDER
BLADDER	ORGAN THAT STORES URINE (EXCESS WATER, SALTS AND UREA) AS IT IS PRODUCED BY THE KIDNEY
URETHRA	TUBE THAT CONNECTS THE BLADDER TO THE EXTERIOR; WHERE URINE IS RELEASED

YOUR NOTES

13 EXCRETION IN HUMANS

YOUR NOTES

13.2 THE URINARY SYSTEM cont...

EXAM TIP

Note the difference between the '**ureter**' and the '**urethra**'.

These two names are commonly confused by students so take care to learn them and know which tube is which – they are NOT interchangeable!

Changes in Urine

- The **colour** and **quantity** of urine produced in the body can change quickly
- **Large quantities** of urine are usually **pale yellow** in colour because it contains a lot of water and so the urea is **less concentrated**
- **Small quantities** of urine are usually **darker yellow / orange** in colour because it contains little water and so the urea is **more concentrated**
- There are various reasons why the concentration of urine will change, including:
    - **Water intake** – the more fluids drunk, the more water will be removed from the body and so a **large quantity of pale yellow, dilute urine** will be produced
    - **Temperature** – the higher the temperature the more water is lost in sweat and so less will appear in urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced
    - **Exercise** – the more exercise done, the more water is lost in sweat and so less will appear in urine, meaning a **smaller quantity of dark yellow, concentrated urine** will be produced

13.3 THE KIDNEY

EXTENDED ONLY

The Kidney

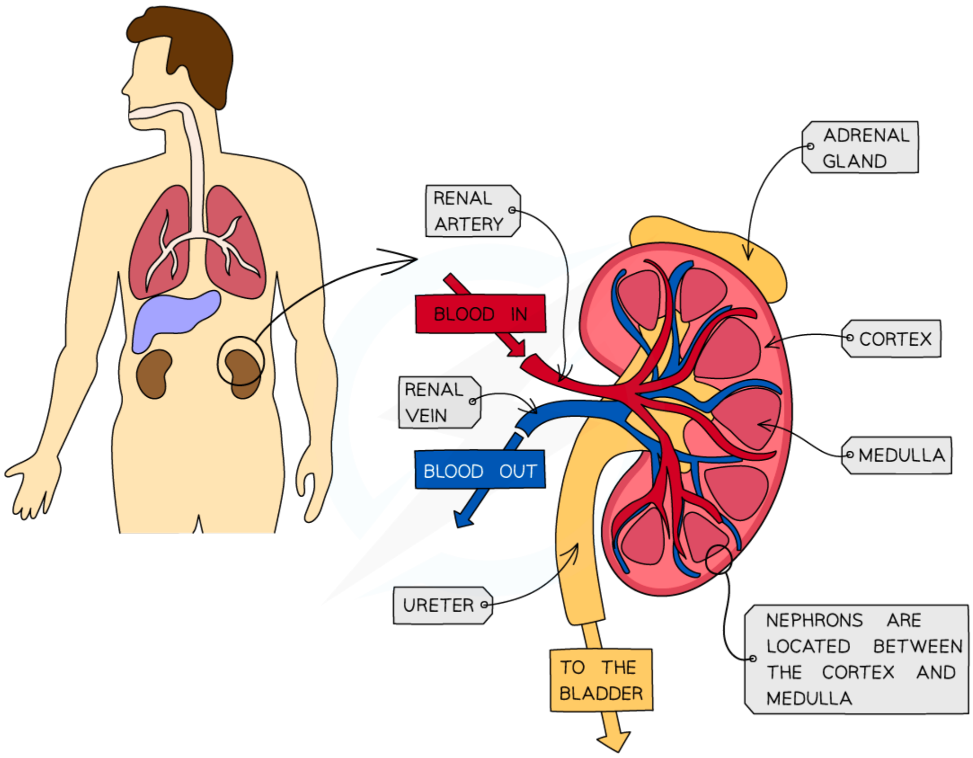
- The kidneys are located in the back of the abdomen and have two important functions in the body:
    - they regulate the water content in the blood
    - they excrete the toxic waste products of metabolism (such as urea) and substances in excess of requirements (such as salts)

13 EXCRETION IN HUMANS

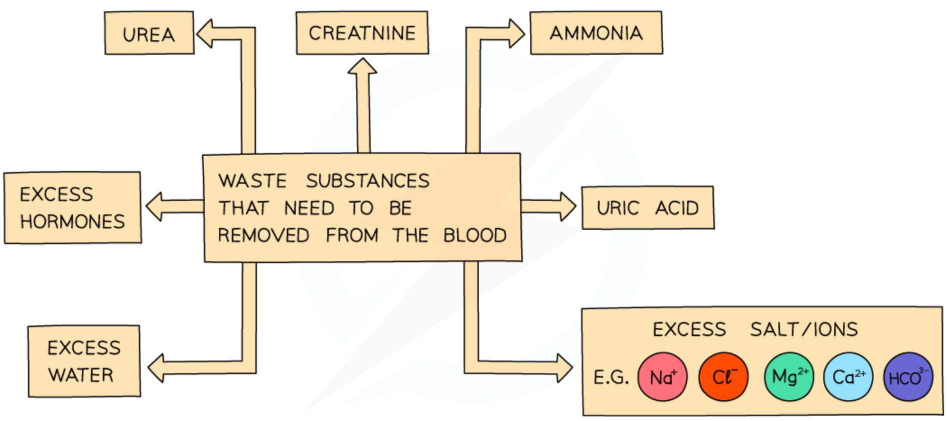
13.3 THE KIDNEY

YOUR NOTES

EXTENDED ONLY cont...



The structure of a human kidney



Waste substances

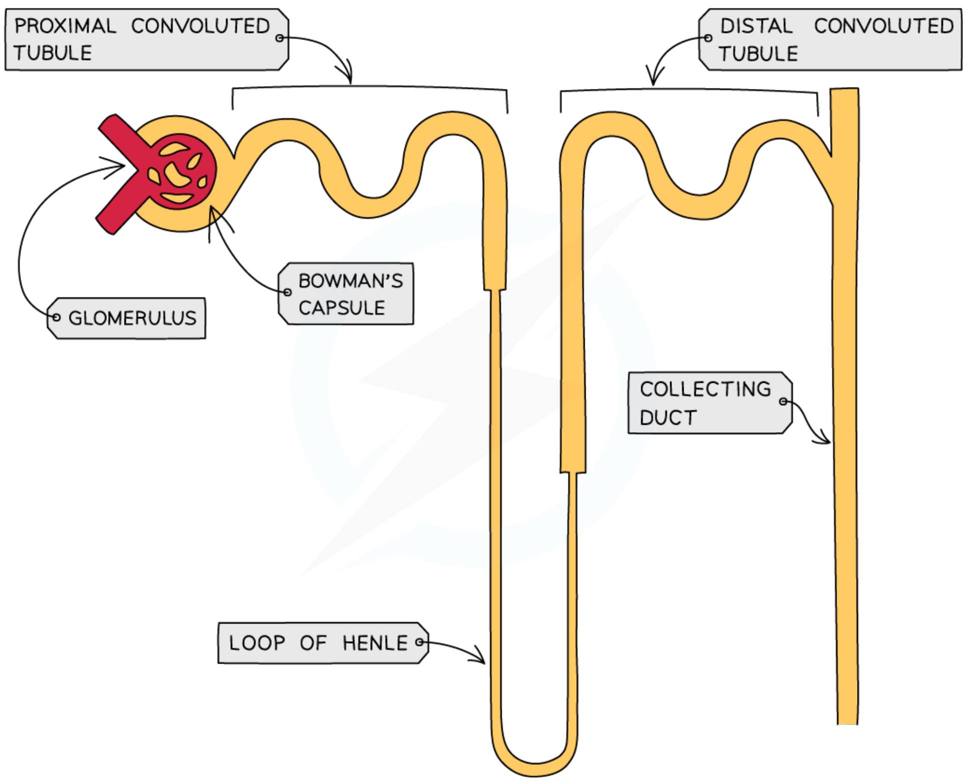
13 EXCRETION IN HUMANS

13.3 THE KIDNEY cont...

YOUR NOTES

EXTENDED ONLY cont...

- Each kidney contains around a million tiny structures called **nephrons**, also known as **kidney tubules** or **renal tubules**
- The nephrons start in the **cortex** of the kidney, loop down into the **medulla** and back up to the cortex
- The contents of the nephrons drain into the innermost part of the kidney and the **urine collects** there before it flows into the **ureter** to be carried to the **bladder** for storage



Structure of a nephron

13 EXCRETION IN HUMANS

13.3 THE KIDNEY

YOUR NOTES

EXTENDED ONLY cont...

The Nephron

1. Ultrafiltration

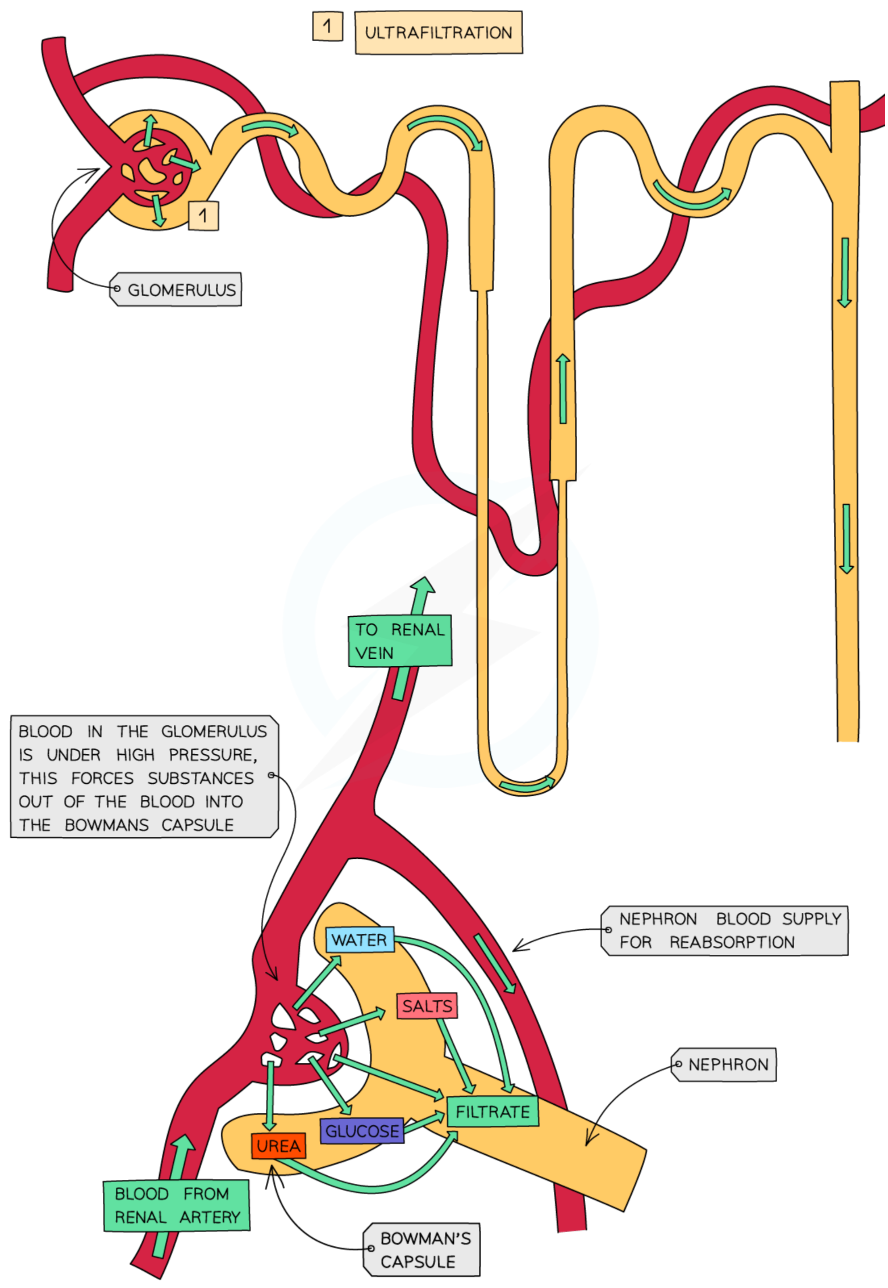


Diagram showing the process of ultrafiltration

13 EXCRETION IN HUMANS

13.3 THE KIDNEY cont...

YOUR NOTES

EXTENDED ONLY cont...

- Arterioles branch off the **renal artery** and lead to each nephron, where they form a knot of capillaries (the **glomerulus**) sitting inside the cup-shaped **Bowman's capsule**
- The capillaries get **narrower** as they get further into the glomerulus which **increases the pressure** on the blood moving through them (which is already at high pressure because it is coming directly from the renal artery which is connected to the **aorta**)
- This eventually causes the smaller molecules being carried in the blood to be **forced out of the capillaries and into the Bowman's capsule**, where they form what is known as the filtrate
- This process is known as **ultrafiltration**
- The substances forced out of the capillaries are: **glucose, water, urea, salts**
- Some of these are useful and will be **reabsorbed back into the blood** further down the nephron

COMPONENT	REABSORBED AT
WATER	LOOP OF HENLE AND COLLECTING DUCT
SALTS	LOOP OF HENLE
GLUCOSE	PROXIMAL (FIRST) CONVOLUTED
UREA	NOT REABSORBED

Components of filtrate

13 EXCRETION IN HUMANS

13.3 THE KIDNEY

YOUR NOTES

EXTENDED ONLY cont...

2. Selective Reabsorption

Reabsorption of Glucose

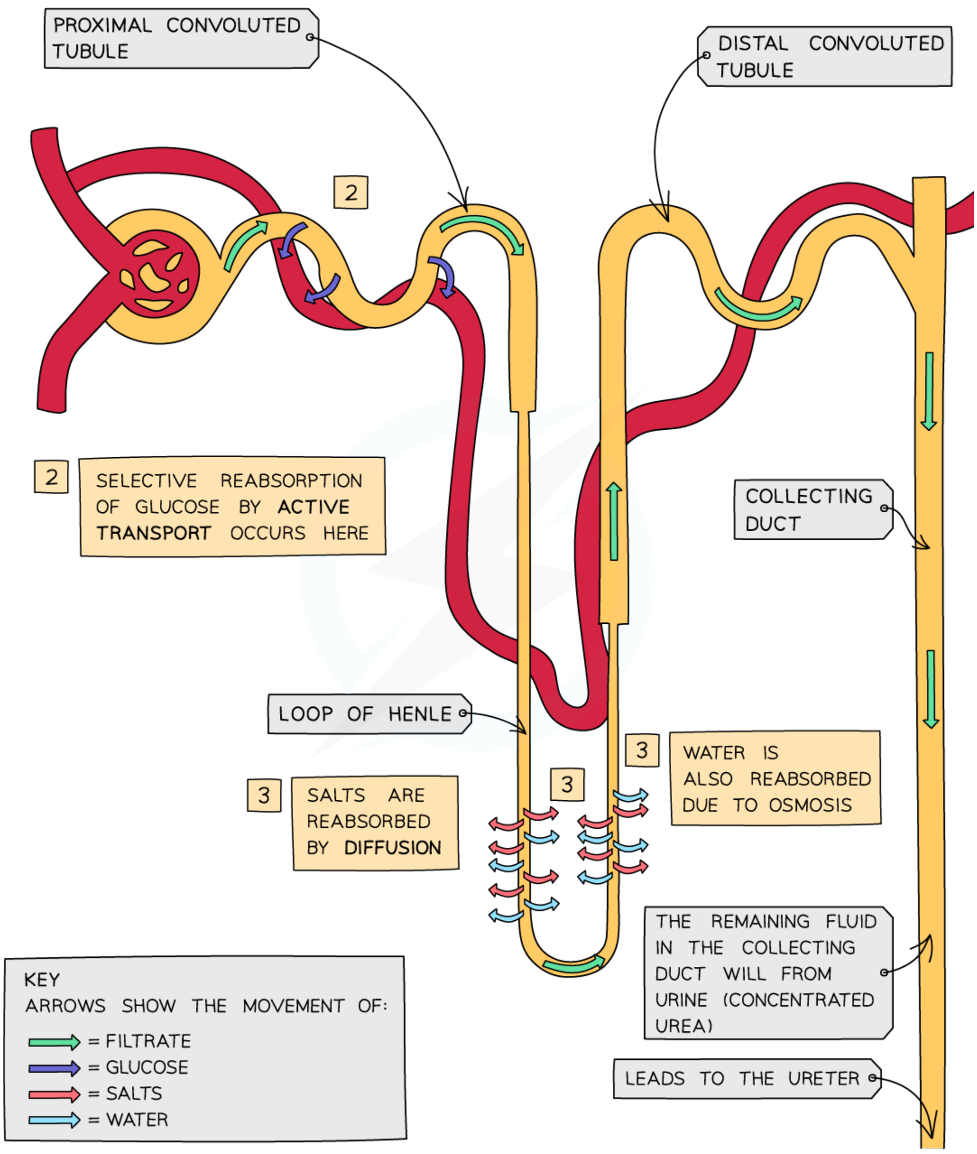


Diagram showing the reabsorption of glucose

13 EXCRETION IN HUMANS

13.3 THE KIDNEY cont...

YOUR NOTES

EXTENDED ONLY cont...

- After the glomerular filtrate enters the Bowman's Capsule, **glucose** is the first substance to be reabsorbed at the **proximal (first) convoluted tubule**
- This takes place by **active transport**
- The nephron is adapted for this by having **many mitochondria** to provide energy for the active transport of glucose molecules
- Reabsorption of glucose **cannot take place anywhere else in the nephron** as the gates that facilitate the active transport of glucose are only found in the proximal convoluted tubule
- In a person with a normal blood glucose level, there are enough gates present to remove all of the glucose from the filtrate back into the blood
- People with **diabetes** cannot control their blood glucose levels and they are often very high, meaning that not all of the glucose filtered out can be reabsorbed into the blood in the proximal convoluted tubule
- As there is nowhere else for the glucose to be reabsorbed, it continues in the filtrate and **ends up in urine**
- This is why one of the first tests a doctor may do to check if someone is diabetic is to test their urine for the presence of glucose

Reabsorption of Water & Salts

- As the filtrate drips through the **Loop of Henle** necessary salts are reabsorbed back into the blood by **diffusion**
- As salts are reabsorbed back into the blood, **water** follows by **osmosis**
- Water is also reabsorbed from the collecting duct in different amounts depending on how much water the body needs at that time

13 EXCRETION IN HUMANS

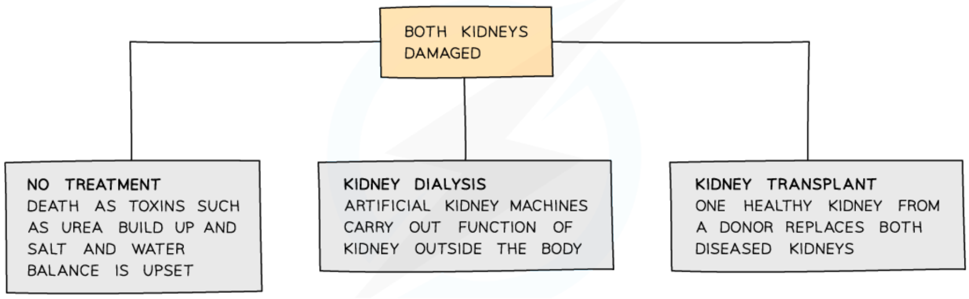
13.4 KIDNEY FAILURE

YOUR NOTES

EXTENDED ONLY cont...

Causes, Consequences, Treatments

- The kidneys might not work properly for several reasons, including **accidents or disease**
- Humans can survive with one functioning kidney, but if both are damaged then there will quickly be a **build-up of toxic wastes** in the body which will be **fatal** if not removed



Treatment options for total kidney failure

Kidney Dialysis

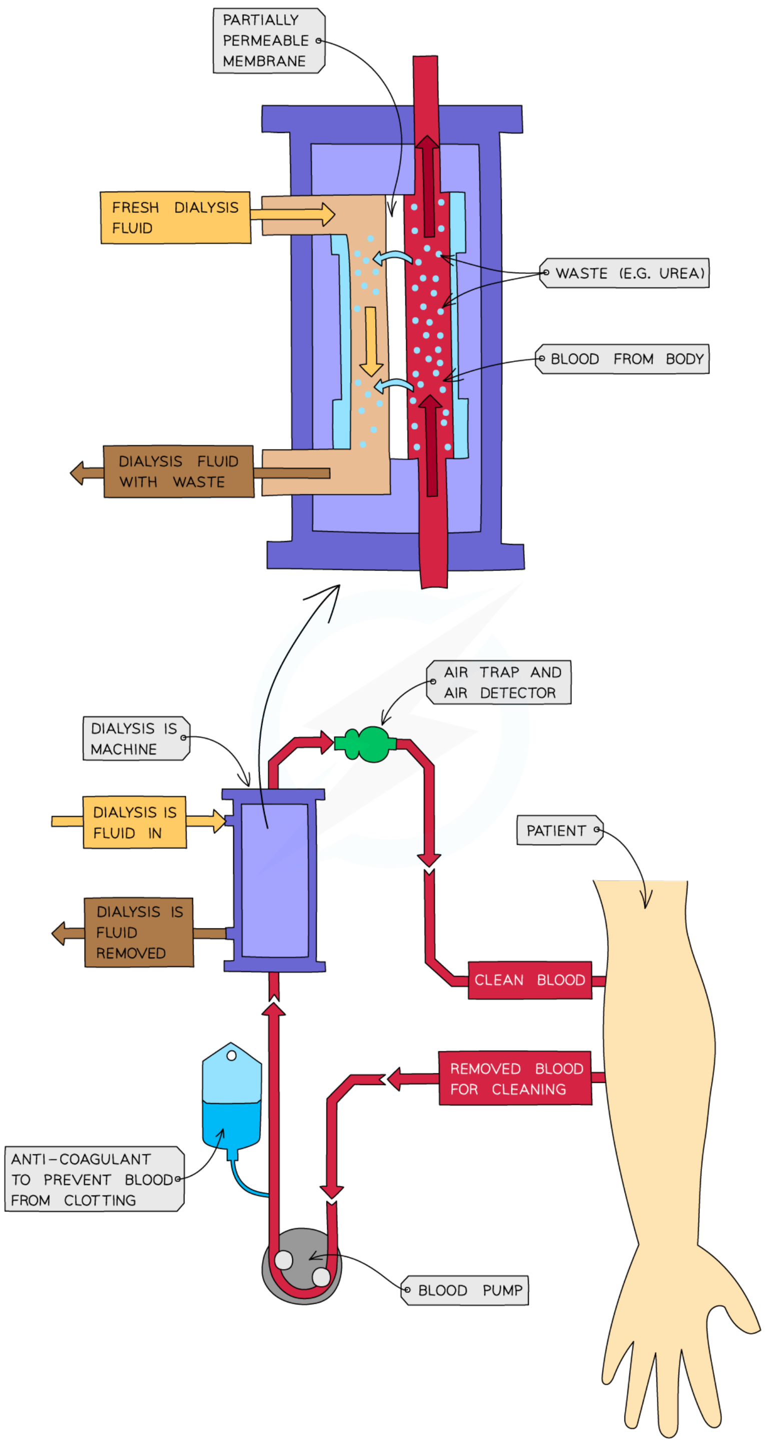
- The usual treatment for someone with kidney failure is **dialysis**
- This is an artificial method of filtering the blood to **remove toxins and excess substances**
- Patients are connected to a dialysis machine which acts as an **artificial kidney** to remove most of the urea and restore/maintain the water and salt balance of the blood
- **Unfiltered blood** is taken from an artery in the arm, pumped into the dialysis machine and then returned to a vein in the arm
- Inside the machine the blood and dialysis fluid are separated by a **partially permeable membrane** – the blood flows in the **opposite direction** to dialysis fluid, allowing **exchange** to occur between the two where a **concentration gradient** exists
- Dialysis fluid contains:
  - a **glucose** concentration similar to a normal level in blood
  - a concentration of **salts** similar to a normal level in blood
  - no **urea**

13 EXCRETION IN HUMANS

13.4 KIDNEY FAILURE cont...

YOUR NOTES

EXTENDED ONLY cont...



How a dialysis machine works to filter the blood

13 EXCRETION IN HUMANS

13.4 KIDNEY FAILURE cont...

YOUR NOTES

EXTENDED ONLY cont...

- As the dialysis fluid has **no urea** in it, there is a **large concentration gradient** – meaning that urea **diffuses** across the partially permeable membrane, **from the blood to the dialysis fluid**
- As the dialysis fluid contains a **glucose** concentration **equal** to a normal blood sugar level, this prevents the net movement of glucose across the membrane as **no concentration gradient** exists
- As the dialysis fluid contains a **salt** concentration **similar to the ideal blood concentration**, movement of salts across the membrane only occurs where there is an **imbalance** (if the blood is too low in salts, they will diffuse into the blood; if the blood is too high in salts, they will diffuse out of the blood)
- The fluid in the machine is **continually refreshed** so that **concentration gradients are maintained** between the dialysis fluids and the blood
- Dialysis may take **3-4 hours to complete** and needs to be done **several times a week** to prevent damage to the body from the buildup of toxic substances in the blood
- An anticoagulant is added to blood before it runs through the machine to **prevent the blood from clotting** and slowing the flow

Kidney Transplants vs Dialysis

- **Kidney transplants** are a better long term solution to kidney failure than dialysis; however, there are several disadvantages to kidney transplants, including:
    - Donors won't have the same antigens on cell surfaces so there will be some **immune response** to the new kidney (risk of rejection is reduced – but not removed – by 'tissue typing' the donor and the recipient first)
    - This has to be suppressed by taking **immunosupressant drugs** for the rest of their lives – these can have long term side effects and leave the patient vulnerable to infections
    - There are **not enough donors** to cope with demand

13 EXCRETION IN HUMANS

13.4 KIDNEY FAILURE cont...

YOUR NOTES

EXTENDED ONLY cont...

- However, if a healthy, close matched kidney is available, then the **benefits** of a transplant over dialysis include:
    - the patient has **much more freedom** as they are not tied to having dialysis several times a week in one place
    - their **diets** can be **much less restrictive** than they are when on dialysis
    - use of dialysis machines is **very expensive** and so this cost is removed
    - a kidney transplant is a long term solution whereas **dialysis will only work for a limited time**

EXAM TIP

When answering questions about dialysis, the best answers will:

- refer to differences in concentration gradients between the dialysis fluid and the blood and
- use this to explain why substances move in certain directions

> NOW TRY SOME EXAM QUESTIONS

13 EXCRETION IN HUMANS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

What is urea produced from?

A Fatty acids

B Glucose

C Amino acids

D Glycerol

QUESTION 2

Which row of the table below correctly displays the correct roles of the following organs in processing waste in the human body?

	kidneys	liver	lungs
A	excretes urea	excretes amino acids	removes carbon dioxide
B	removes carbon dioxide	deamination of amino acids	excretes urea
C	removes urea from blood	deamination of amino acids	removes carbon dioxide
D	excretes urine	deamination of urea	removes carbon dioxide

QUESTION 3

To remain healthy, a person must be able to excrete a number of waste products produced as a result of metabolism. A list of excretory products is given below.

Which of the following would be lost from both the kidneys and lungs?

A Water

B Carbon dioxide

C Glucose

D Urea

13 EXCRETION IN HUMANS

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

Which of the following is a correct example of excretion in mammals?

A The production of carbon dioxide from aerobic respiration.

B The removal of excess salts from the blood.

C The removal of undigested food from the anus.

D The release of hormones from glands.

QUESTION 5

Which of the following is not a main function of the kidneys in a healthy person?

A To reabsorb all glucose

B To regulate blood pressure

C To breakdown toxins

D To eliminate excess sodium and potassium ions

14 COORDINATION & RESPONSE

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

14.1 NERVOUS CONTROL IN HUMANS

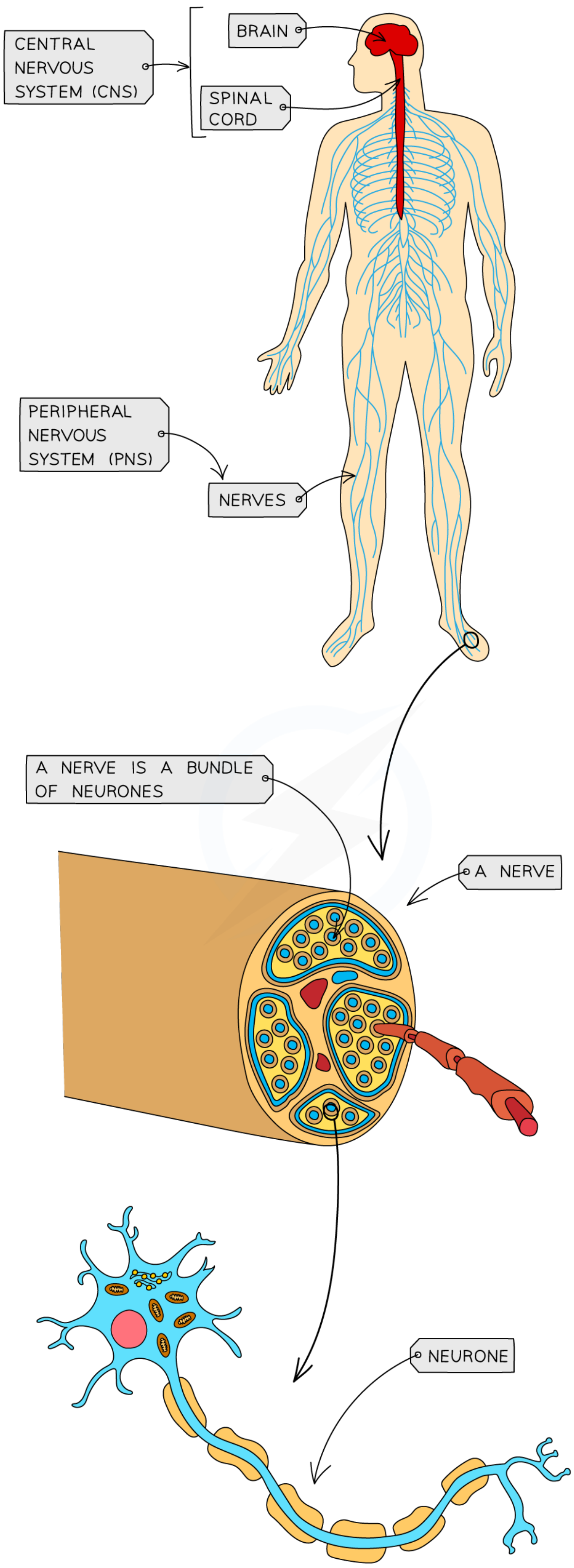
The Nervous System

- The **human nervous system** consists of the:
  - **central nervous system** (CNS) – the brain and the spinal cord
  - **peripheral nervous system** (PNS) – all of the nerves in the body
- It allows us to make sense of our surroundings and respond to them and to **coordinate and regulate body functions**
- Information is sent through the nervous system as **nerve impulses** – electrical signals that pass along nerve cells known as **neurones**
- A bundle of neurones is known as a **nerve**

14 COORDINATION & RESPONSE

14.1 NERVOUS CONTROL IN HUMANS cont...

YOUR NOTES



The human nervous system

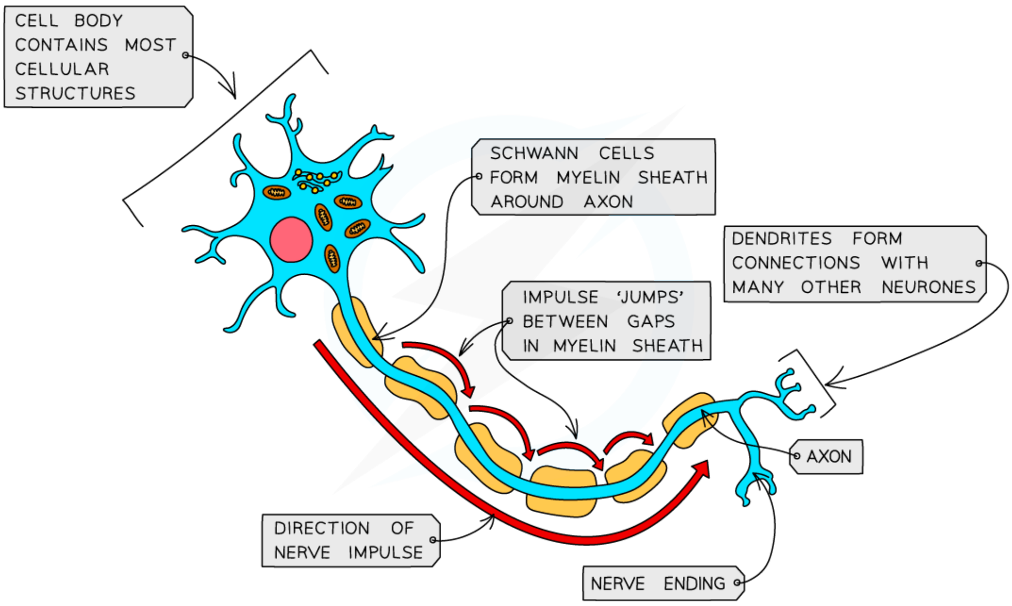
14 COORDINATION & RESPONSE

14.1 NERVOUS CONTROL IN HUMANS cont...

YOUR NOTES

Types of Neurone

- There are three main types of neurone: **sensory, relay and motor**
- Sensory neurones carry impulses **from sense organs to the CNS** (brain or spinal cord)
- **Relay** neurones are found inside the CNS and **connect sensory and motor neurones**
- **Motor** neurones carry impulses **from the CNS to effectors** (muscles or glands)
- Neurones have a long fibre (**axon**)
- This means that less time is wasted transferring the impulse from one cell to another
- The axon is insulated by a fatty sheath with small uninsulated sections along it (called nodes)
- This means that the electrical impulse does not travel down the whole axon, but **jumps from one node to the next**
- Their cell body contains many extensions called **dendrites**
- This means they can **connect to many other neurones** and receive impulses from them, forming a network for easy communication



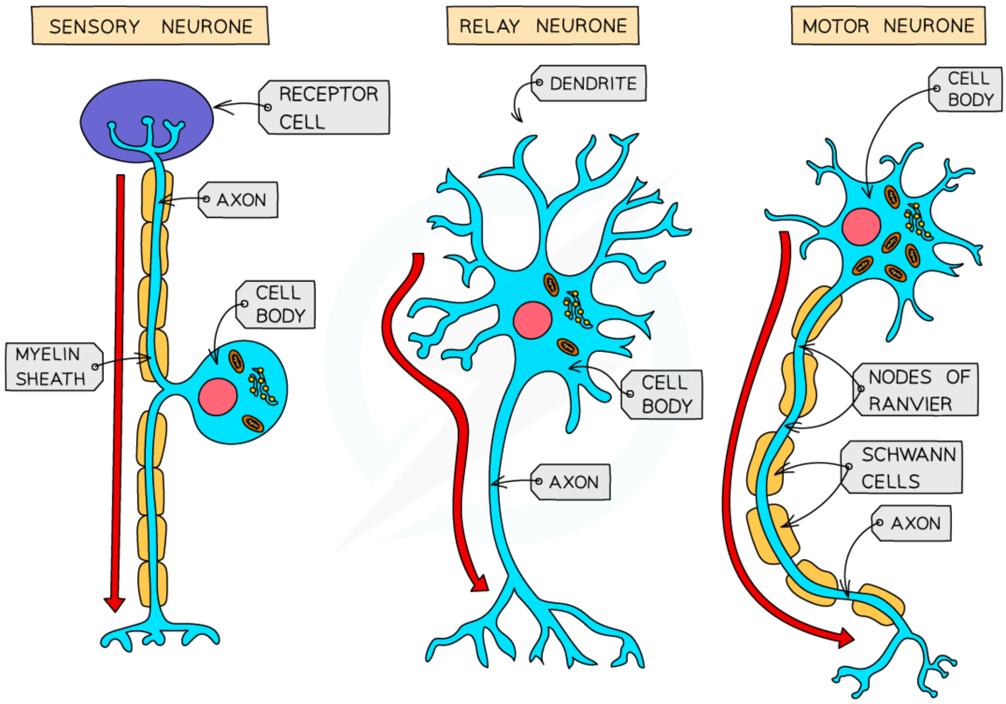
A neurone

14 COORDINATION & RESPONSE

14.1 NERVOUS CONTROL IN HUMANS cont...

YOUR NOTES

Identifying the types of neurone:



The three types of neurone

- **Sensory neurones** are **long** and have a **cell body branching off the middle of the axon**
- **Relay neurones** are **short** and have a **small cell body at one end** with many dendrites branching off it
- **Motor neurones** are **long** and have a **large cell body at one end with long dendrites branching off it**

EXTENDED ONLY

Voluntary & Involuntary Responses

- A voluntary response is one where you make a **conscious decision** to carry out a particular action therefore it **starts with your brain**
- An involuntary (or reflex) response does **not involve the brain as the coordinator** of the reaction and you are **not aware** you have completed it until **after** you have carried it out
- Involuntary actions are usually ones which are **essential to basic survival** and are **rapid**, whereas voluntary responses often **take longer** as we consider what the response might be before doing it

14 COORDINATION & RESPONSE

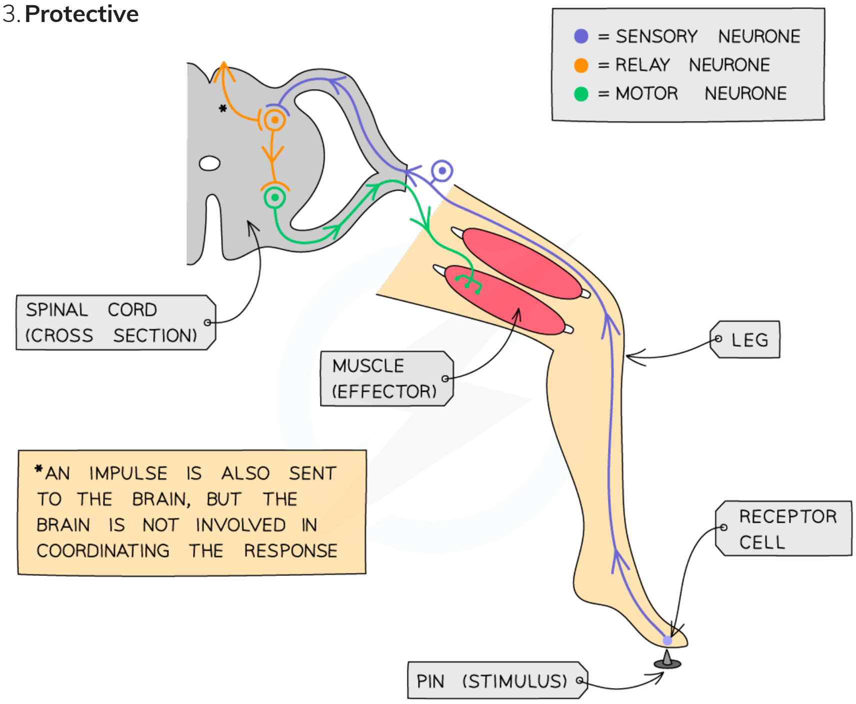
YOUR NOTES

14.2 REFLEXES

The Reflex Arc

- An **involuntary** (or **reflex**) response **does not involve the brain** as the coordinator of the reaction and you are not aware you have completed it until after you have carried it out
- This is an **automatic and rapid response** to a stimulus such as touching something sharp or hot
- As it does not involve the brain, a reflex response is **quicker** than any other type of nervous response
- This helps to **minimise the damage to the body**
- **Reflex actions are:**

1. **Automatic**
2. **Fast**
3. **Protective**

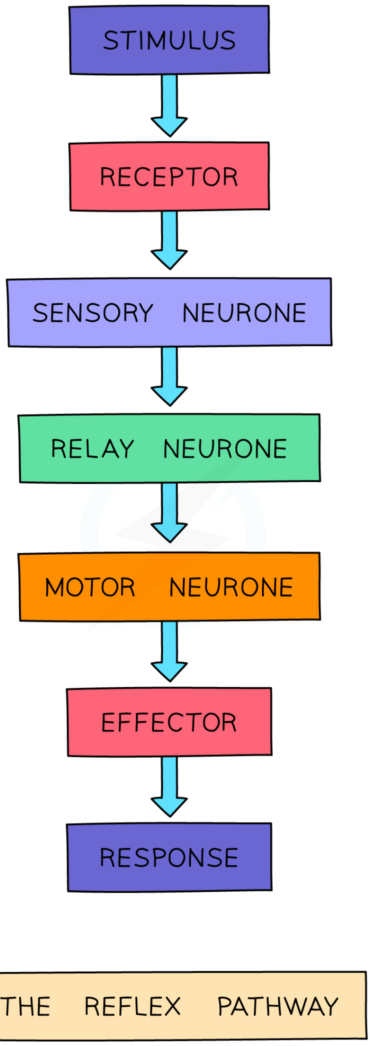


A reflex

4. The pin (the stimulus) is detected by a pain/pressure/touch receptor in the skin
5. Sensory neurone sends electrical impulses to the spinal cord (the coordinator)
6. Electrical impulse is passed on to relay neurone in the spinal cord
7. Relay neurone connects to motor neurone and passes the impulse on
8. Motor neurone carries impulse to a muscle in the leg (the effector)
9. The muscle will contract and pull the foot up and away from the sharp object (the response)

14 COORDINATION & RESPONSE

14.2 REFLEXES cont...



The reflex pathway

YOUR NOTES

EXAM TIP

A common exam question is to be asked to draw arrows on the neurones in the reflex arc diagram to show the direction of movement of the impulse.

Make sure you read questions carefully – not all questions have a line underneath them to write an answer!

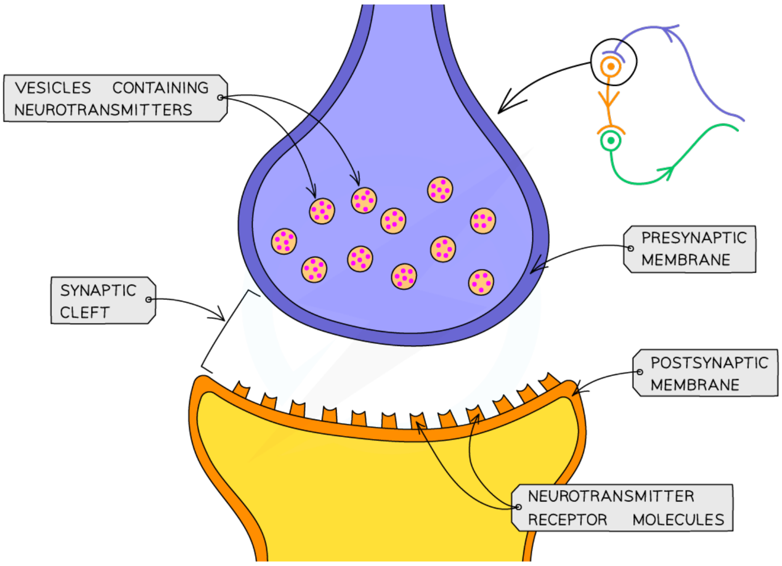
14 COORDINATION & RESPONSE

14.2 REFLEXES cont...

YOUR NOTES

The Synapse: Definition

The junction between two neurones is known as a **synapse**



A synapse

EXTENDED ONLY

How an Impulse is Passed Across a Synapse

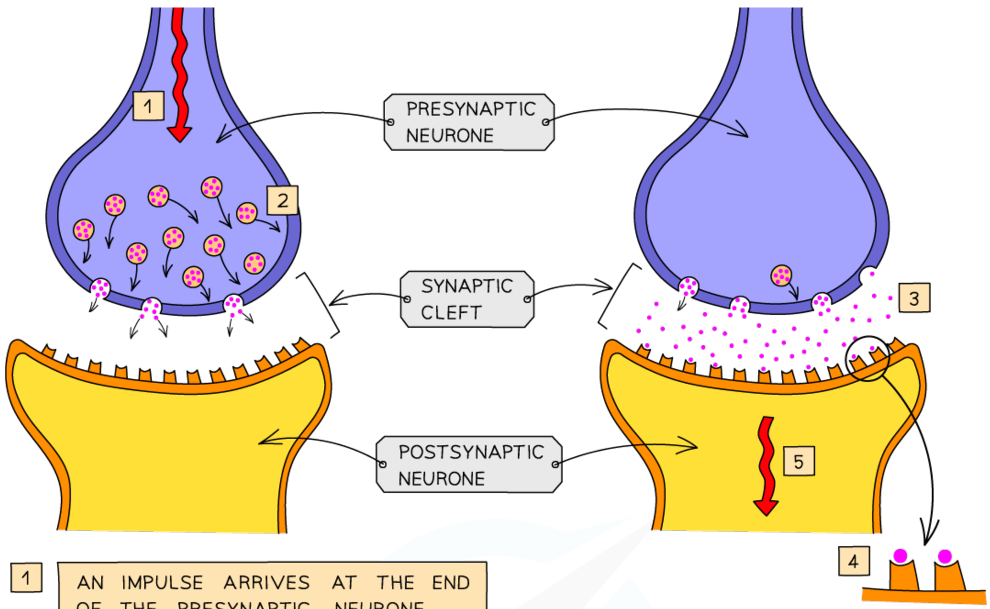
- Neurones never touch each other
- The junctions (gaps) in between them are called **synapses**
- The electrical impulse travels along the first axon
- This triggers the nerve-ending of the presynaptic neurone to release **chemical** messengers called **neurotransmitters** from vesicles which fuse with the presynaptic membrane
- The neurotransmitters **diffuse** across the synaptic gap and **bind with receptor molecules** on the membrane of the second neurone (known as the **post synaptic membrane**)
- This **stimulates** the second neurone to generate an electrical impulse that travels down the second axon
- The neurotransmitters are then **destroyed to prevent continued stimulation** of the second neurone which would cause repeated impulses to be sent
- Synapses ensure that impulses **only travel in one direction**, avoiding confusion within the nervous system if impulses were travelling in both directions
- As this is the only part of the nervous system where messages are **chemical** as opposed to electrical, it is the **only place where drugs can act to affect the nervous system** – eg this is where heroin works

14 COORDINATION & RESPONSE

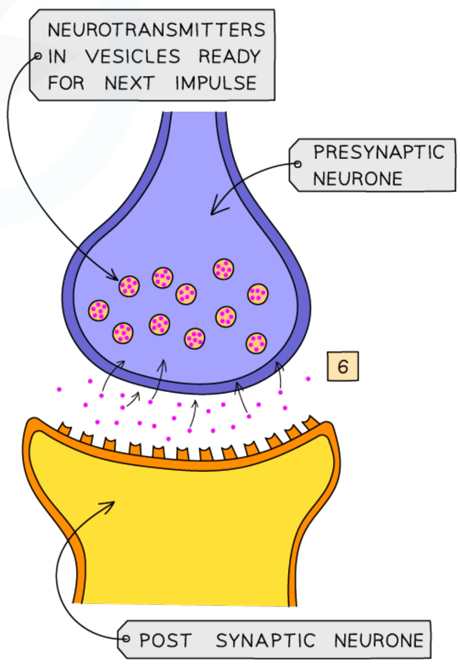
14.2 REFLEXES cont...

YOUR NOTES

EXTENDED ONLY cont...



1. AN IMPULSE ARRIVES AT THE END OF THE PRESYNAPTIC NEURONE
2. VESICLES MOVE TOWARDS, AND FUSE WITH, THE PRESYNAPTIC MEMBRANE. THIS RELEASES NEUROTRANSMITTERS INTO THE SYNAPTIC CLEFT
3. THE NEUROTRANSMITTERS DIFFUSE ACROSS THE SYNAPTIC CLEFT (DOWN A CONCENTRATION GRADIENT)
4. NEUROTRANSMITTERS ATTACH TO RECEPTORS ON THE POSTSYNAPTIC MEMBRANE
5. THIS TRIGGERS AN IMPULSE WHICH TRAVELS ALONG THE POSTSYNAPTIC NEURONE
6. THE NEUROTRANSMITTERS ARE RECYCLED OR DESTROYED ONCE AN IMPULSE IS SENT



How an impulse is passed on at a synapse

14 COORDINATION & RESPONSE

YOUR NOTES

14.2 REFLEXES cont...

EXAM TIP

For maximum marks you will need to be able to understand the **structure** and **functioning** of a synapse and explain **what happens at each step.**

14.3 SENSE ORGANS: THE EYE

Sense Organs

- Receptors are groups of specialised cells
- They **detect a change in the environment and stimulate electrical impulses in response**
- Sense organs contain **groups of receptors** that respond to specific stimuli

SENSE ORGAN	WHAT IT IS SENSITIVE TO	SENSE
SKIN	SENSITIVE TO PRESSURE, HEAT AND COLD (TEMPERATURE) AND PAIN.	TOUCH AND TEMPERATURE
TONGUE	SENSITIVE TO CHEMICALS IN FOOD AND DRINK	TASTE
NOSE	SENSITIVE TO CHEMICALS IN THE AIR	SMELL
EAR	SENSITIVE TO SOUND AND MOVEMENT	a) HEARING b) BALANCE
EYE	SENSITIVE TO LIGHT	SIGHT

- Once the receptor cell in the sense organ has been stimulated, it generates an electrical impulse
- This is passed on to a sensory neurone which carries the impulse to the central nervous system
- Here a response will be decided on and the impulse will be passed to a motor neurone (via a relay neurone)
- The motor neurone carries the impulse to the effector (muscle or gland)
- The effector carries out the response

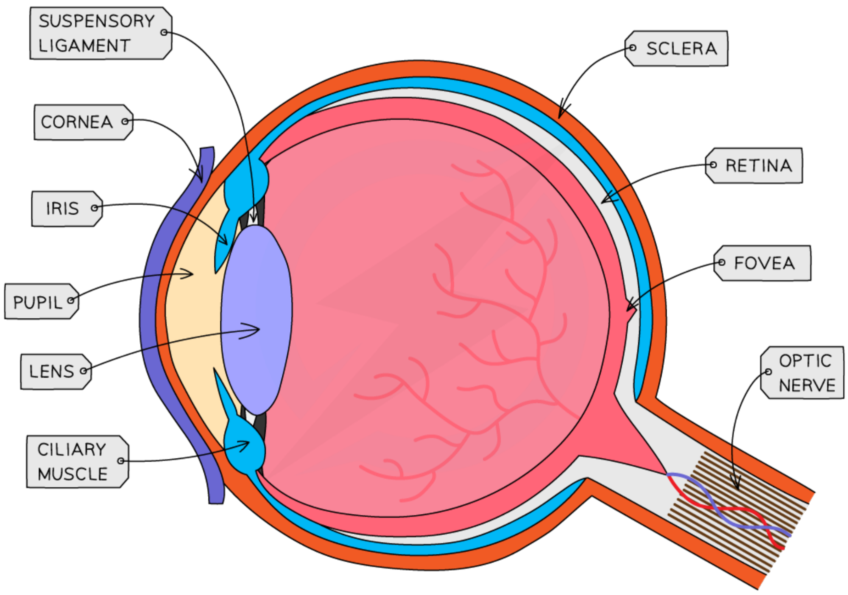
14 COORDINATION & RESPONSE

14.3 SENSE ORGANS: THE EYE cont...

YOUR NOTES

Structure of the Eye & Functions

- The eye is a **sense organ** containing receptor cells that are sensitive to **light** (rod cells) and **colour** (cone cells)



The eye

Function of the parts of the eye

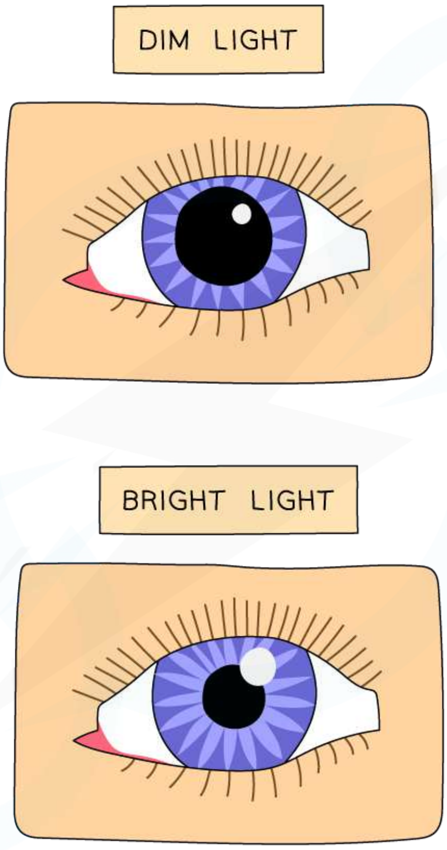
STRUCTURE	FUNCTION
CORNEA	TRANSPARENT LENS THAT REFRACTS (BENDS) LIGHT AS IT ENTERS THE EYE
IRIS	CONTROLS HOW MUCH LIGHT ENTERS THE PUPIL
LENS	TRANSPARENT DISC THAT CAN CHANGE SHAPE TO FOCUS LIGHT ONTO THE RETINA
RETINA	CONTAINS LIGHT RECEPTOR CELLS – RODS (DETECT LIGHT INTENSITY) AND CONES (DETECT COLOUR)
OPTIC NERVE	SENSORY NEURONE THAT CARRIES IMPULSES BETWEEN THE EYE AND THE BRAIN
PUPIL	HOLE THAT ALLOWS LIGHT TO ENTER THE EYE

14.3 SENSE ORGANS: THE EYE

YOUR NOTES

The Pupil Reflex

- This is a **reflex action** carried out to **protect the retina from damage** in bright light and protect us from not seeing objects in dim light
- In **dim light** the pupil **dilates** (widens) in order to allow as much light into the eye as possible
- In **bright light** the pupil **constricts** (narrows) in order to prevent too much light entering the eye and damaging the retina



The pupil reflex

- In dim light, the pupil dilates (becomes larger) to allow more light to enter the eye to improve vision
- In bright light, the pupil constricts (gets smaller) to allow less light to enter the eye to protect the retina from damage

14 COORDINATION & RESPONSE

14.3 SENSE ORGANS: THE EYE cont...

YOUR NOTES

EXTENDED ONLY

How Does the Pupil Reflex Work?

DIM LIGHT

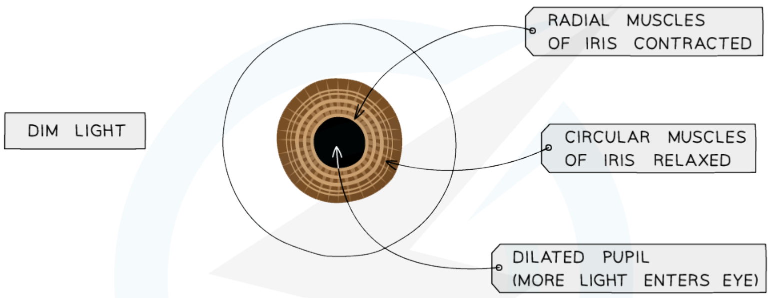


DIAGRAM SHOWING THE EYE IN A DARK ENVIRONMENT

- PHOTORECEPTORS DETECT CHANGE IN ENVIRONMENT (DARK)
- RADIAL MUSCLES CONTRACT
- CIRCULAR MUSCLES RELAX
- PUPIL DILATES (DIAMETER OF PUPIL WIDENS)
- MORE LIGHT ENTERS THE EYE

BRIGHT LIGHT

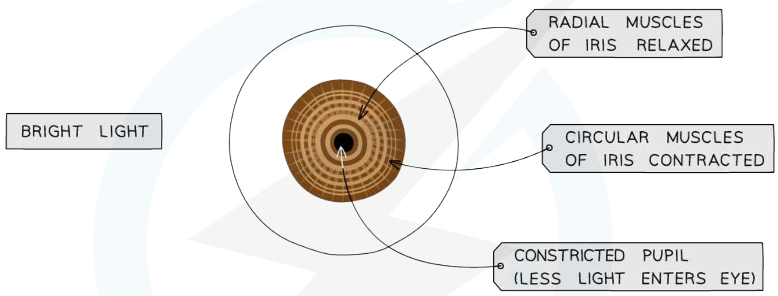


DIAGRAM SHOWING THE EYE IN A BRIGHT ENVIRONMENT

- PHOTORECEPTORS DETECT CHANGE IN ENVIRONMENT (BRIGHT)
- RADIAL MUSCLES RELAX
- CIRCULAR MUSCLES CONTRACT
- PUPIL CONSTRICTS (DIAMETER OF PUPIL NARROWS)
- LESS LIGHT ENTERS THE EYE

14 COORDINATION & RESPONSE

14.3 SENSE ORGANS: THE EYE cont...

YOUR NOTES

EXTENDED ONLY cont...

STIMULUS	RADIAL MUSCLES	CIRCULAR MUSCLES	PUPIL SIZE	AMOUNT OF LIGHT ENTERS
DARK LIGHT	CONTRACTED	RELAXED	WIDE	MORE
BRIGHT LIGHT	RELAXED	CONTRACTED	NARROW	LESS

Accommodation: Viewing Near & Distant Objects

- The way the lens brings about fine focusing is called **accommodation**
- The lens is elastic and its shape can be changed when the **suspensory ligaments** attached to it become tight or loose
- The changes are brought about by the contraction or relaxation of the **ciliary muscles**

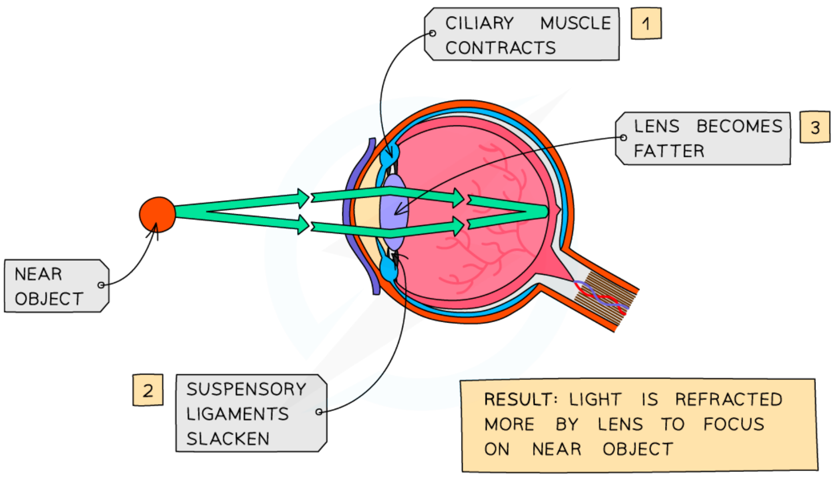


Diagram showing the eye when an object is close up

- Ciliary muscles contract
- Suspensory ligaments slacken
- This allows lens to become fatter
- Light is refracted more

14 COORDINATION & RESPONSE

14.3 SENSE ORGANS: THE EYE cont...

YOUR NOTES

EXTENDED ONLY cont...

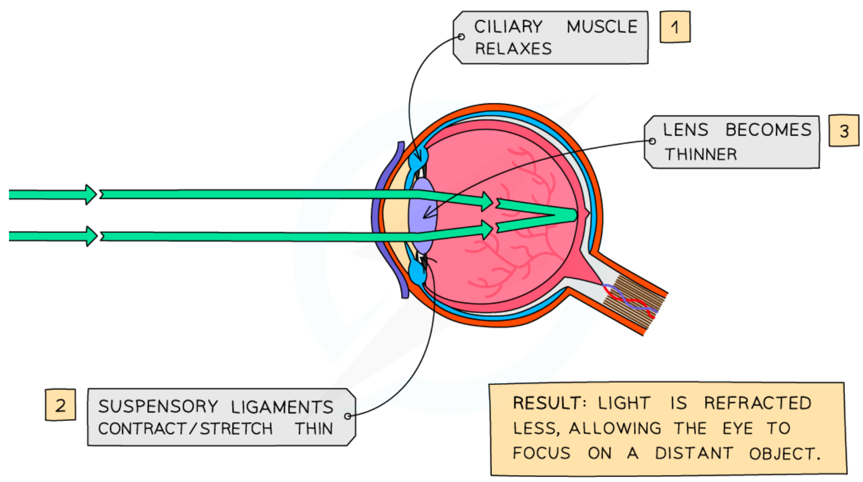


Diagram showing the eye when an object is far away

- Ciliary muscles relax
- Suspensory ligaments stretch thin
- This allows lens to become thinner
- Light is refracted less

	OBJECT FAR AWAY – THE LIGHT IS REFRACTED LESS	OBJECT CLOSE BY – THE LIGHT IS REFRACTED MORE
CILIARY MUSCLES	RELAXED	CONTRACTED
SUSPENSORY LIGAMENTS	PULLED TIGHT	SLACK
LENS	THINNER	FATTER

14 COORDINATION & RESPONSE

14.3 SENSE ORGANS: THE EYE cont...

YOUR NOTES

EXTENDED ONLY cont...

Rods & Cones

- There are two types of receptor cells in the retina:
- **Rods** which are sensitive to **dim light**
- **Cones** which distinguish between **different colours** in bright light
- There are **3 types of cone cells** which are sensitive to **different colours of light** (red, blue and green)
- The **fovea** is an area on the retina where **almost all of the cone cells are found**
- **Rod cells** are found **all over the retina**, other than the area where the **optic nerve attaches to the retina** – there are no light-sensitive cells at all in this area, and so it is known as the **blind spot**

14.4 HORMONES IN HUMANS

What is a Hormone?

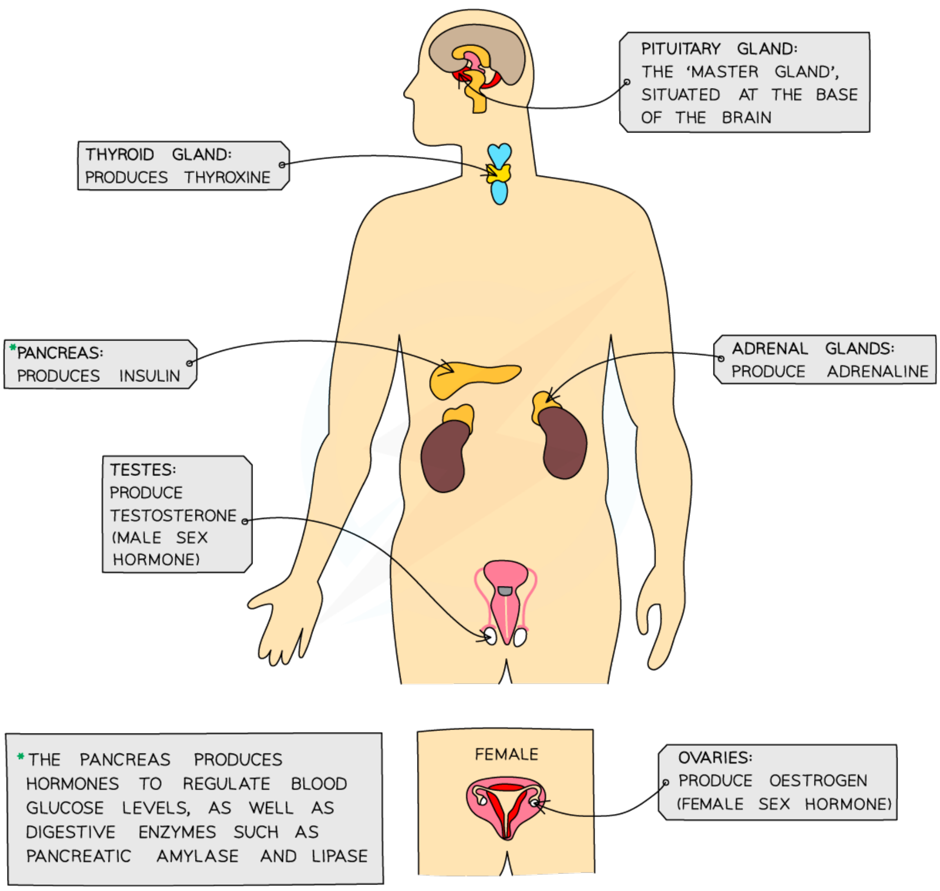
- A **hormone** is a chemical substance produced by a gland and carried by the blood, which alters the activity of one or more specific target organs i.e. they are chemicals which transmit information from one part of the organism to another and bring about a change
- The glands that produce hormones in animals are known collectively as the **endocrine system**
- Endocrine glands have a **good blood supply** as when they make hormones they need to get them into the bloodstream (specifically the blood plasma) as soon as possible so they can travel around the body to the target organs to bring about the response
- Once a hormone has been used, it is destroyed by the **liver**

14 COORDINATION & RESPONSE

14.4 HORMONES IN HUMANS cont...

YOUR NOTES

The Endocrine System



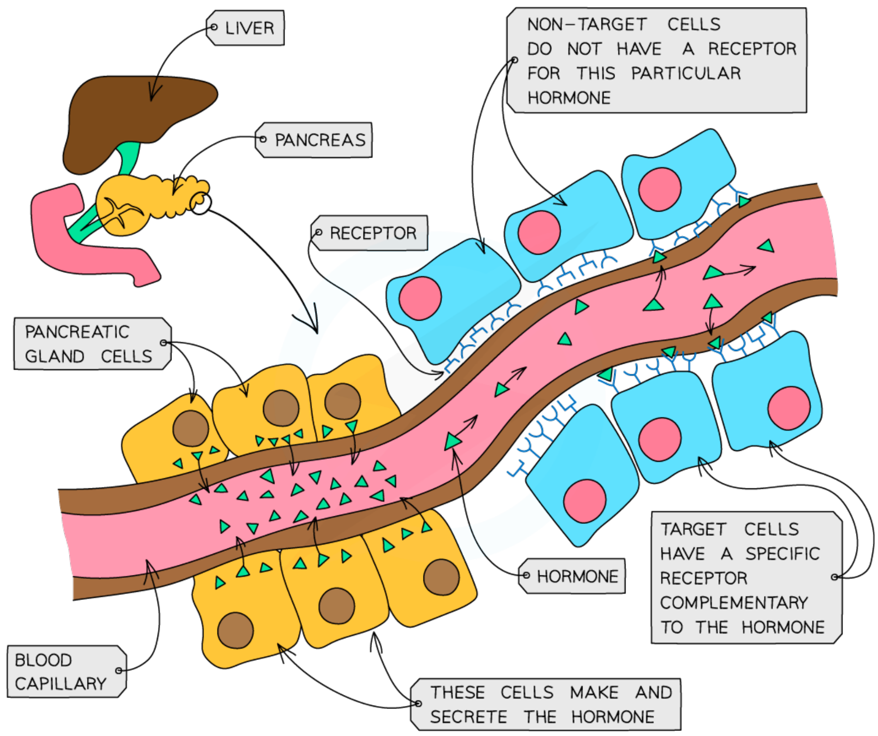
The major endocrine glands in the body

- Endocrine glands have a **good blood supply** as when they make hormones they need to get them into the bloodstream (specifically the blood plasma) as soon as possible so they can travel around the body to the target organs to bring about the response
- Hormones only affect cells with target receptors that the hormone can bind to. These are either found on the cell membrane, or inside cells. Receptors have to be complementary to hormones for their to be an effect
- The liver regulates levels of hormones in the blood; transforming or breaking down any that are in excess

14 COORDINATION & RESPONSE

YOUR NOTES

14.4 HORMONES IN HUMANS cont...



How hormones work

Important hormones in the human body

HORMONE	SOURCE	ROLE	EFFECT
ADRENALINE	ADRENAL GLAND	READIES THE BODY FOR A 'FIGHT OR FLIGHT' RESPONSE	INCREASES HEART AND BREATHING RATE, DILATES PUPILS
INSULIN	PANCREAS	LOWERS BLOOD GLUCOSE LEVELS	CAUSES EXCESS GLUCOSE IN THE BLOOD TO BE TAKEN UP BY THE MUSCLES AND LIVER AND CONVERTED INTO GLYCOGEN FOR STORAGE
TESTOSTERONE	TESTES	MAIN SEX HORMONE IN MALES	DEVELOPMENT OF SECONDARY SEXUAL CHARACTERISTICS IN MALES
OESTROGEN	OVARIES	MAIN SEX HORMONE IN FEMALES	DEVELOPMENT OF SECONDARY SEXUAL CHARACTERISTICS IN FEMALES AND CONTROLS MENSTRUAL CYCLE

14 COORDINATION & RESPONSE

14.4 HORMONES IN HUMANS cont...

YOUR NOTES

EXTENDED ONLY

More about Adrenaline

- Adrenaline is known as the fight or flight hormone as it is **produced in situations where the body may be in danger**
- It causes a range of different things to happen in the body, all designed to prepare it for movement (ie fight or flight).
- These include:
- **Increasing blood glucose concentration for increased respiration in muscle cells**
- **Increasing pulse rate** and **breathing rate** so glucose and oxygen can be **delivered to muscle cells**, and carbon dioxide taken away, from muscles cells **more quickly**
- **Diverting blood flow towards muscles** and away from non-essential parts of the body such as the alimentary canal; again to ensure the reactants of respiration are as available as possible
- **Dilating pupils** to allow as much light as possible to reach the retina so **more information can be sent to the brain**

Comparison of Nervous & Hormonal Control

	NERVOUS SYSTEM	ENDOCRINE SYSTEM
MADE UP OF:	NERVES (NEURONES), BRAIN, SPINAL CORD	GLANDS
TYPE OF MESSAGE:	ELECTRICAL IMPULSE	CHEMICAL HORMONE
SPEED OF TRANSMISSION:	VERY FAST	SLOWER
LENGTH OF EFFECT:	SHORT – UNTIL NERVE IMPULSES STOP	LONGER – UNTIL HORMONE IS BROKEN DOWN

14 COORDINATION & RESPONSE

YOUR NOTES

14.4 HORMONES IN HUMANS cont...

EXAM TIP

Learning the list of effects of adrenaline on the body as it is a fairly common exam question and can be worth several easy marks.

14.5 HOMEOSTASIS: BLOOD GLUCOSE

Homeostasis: Basics

- Homeostasis is defined as **the maintenance of a constant internal environment**

EXTENDED ONLY

Homeostasis

- "The maintenance of a constant internal environment" means that **internal conditions** within your body (such as temperature, blood pressure, water concentration, glucose concentration etc) **need to be kept within set limits** to ensure that reactions in body cells can function, and therefore the organism as a whole, can live
- When one of these conditions deviates far away from the normal if not brought back within set limits the **body will not function properly** and the eventual consequence without medical intervention will be death
- This is why diabetics need to control glucose intake (as their body cannot regulate it for them); why an extremely high and prolonged fever will kill you; or why drinking too little or too much water can damage cells throughout the body – especially the kidneys and brain – and lead to death within days
- Most homeostatic mechanisms in the body are controlled by a process known as **negative feedback**

14 COORDINATION & RESPONSE

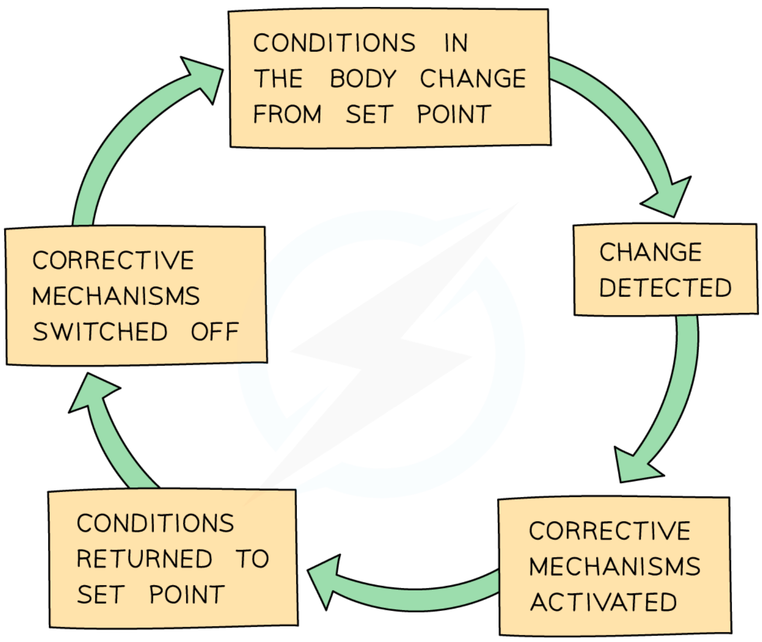
14.5 HOMEOSTASIS: BLOOD GLUCOSE cont...

YOUR NOTES

EXTENDED ONLY cont...

Negative Feedback

- Negative feedback occurs when conditions change from the ideal or **set point**, and returns conditions to this set point
- It works in the following way:
- if the level of something **rises**, control systems are switched on to **reduce it** again
- if the level of something **falls**, control systems are switched on to **raise it** again
- Negative feedback mechanisms are usually a continuous cycle of bringing levels down and then bringing them back up so that overall, they stay within a **narrow range** of what is considered '**normal**'



The negative feedback cycle

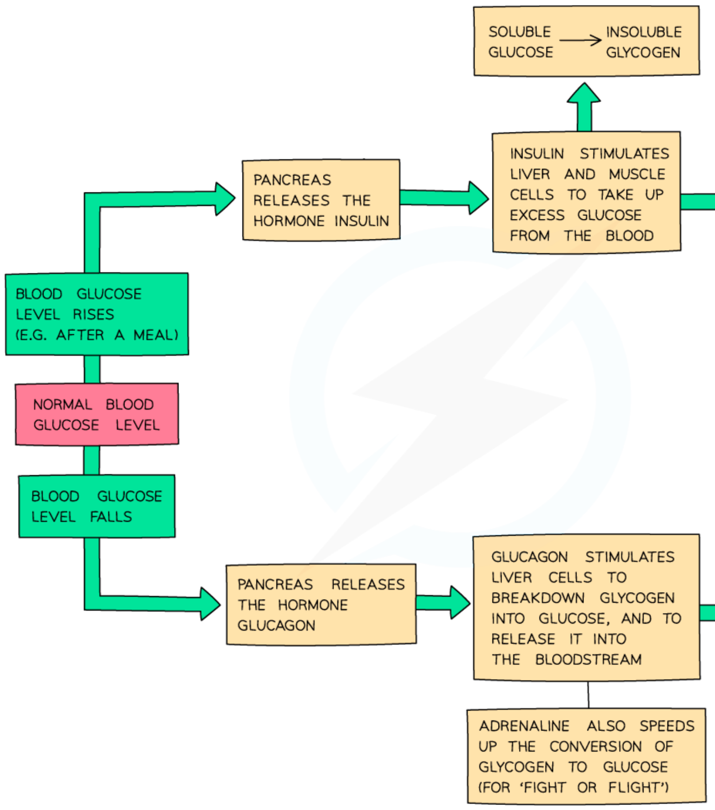
14.5 HOMEOSTASIS: BLOOD GLUCOSE cont...

YOUR NOTES

EXTENDED ONLY cont...

Control of Blood Glucose Levels

- Blood glucose levels are controlled by a negative feedback mechanism involving the production of two **hormones** – **insulin** and **glucagon**
- Both hormones which control blood glucose concentration are made in the **pancreas**
- **Insulin** is produced when **blood glucose rises** and **stimulates liver and muscle cells to convert excess glucose into glycogen to be stored**
- **Glucagon** is produced when **blood glucose falls** and **stimulates liver and muscle cells to convert stored glycogen into glucose to be released into the blood**



Negative feedback regulation of blood glucose levels

14 COORDINATION & RESPONSE

14.5 HOMEOSTASIS: BLOOD GLUCOSE cont...

YOUR NOTES

EXTENDED ONLY cont...

Diabetes

- **Type 1 diabetes** is a condition where the blood glucose levels are not able to be regulated as the **insulin-secreting cells in the pancreas are not able to produce insulin**
- This means that blood glucose levels are often **far too high**
- It can be treated by **injecting insulin**
- The extra insulin causes the liver to convert **glucose into glycogen**, which **reduces** the blood glucose level
- **Symptoms** of diabetes include extreme thirst, weakness or tiredness, blurred vision, weight loss and loss of consciousness in extreme cases
- People with Type 1 diabetes have to **monitor** their blood glucose levels throughout the day as their levels of **physical activity** and their **diet** affect the amount of insulin needed
- They can help to **control** their blood glucose level by being careful with their **diet** – eating foods that will not cause large increases in blood glucose level, and by **exercising**, which can lower blood glucose levels due to increased respiration in the muscles

EXAM TIP

The terms glucagon and glycogen are very often mixed up by students as they sound similar. Remember:

- Glucagon is the **hormone**
- Glycogen is the polysaccharide that **glucose is stored as**

Learn the differences between the spellings and what each one does so you do not get confused in the exam!

14 COORDINATION & RESPONSE

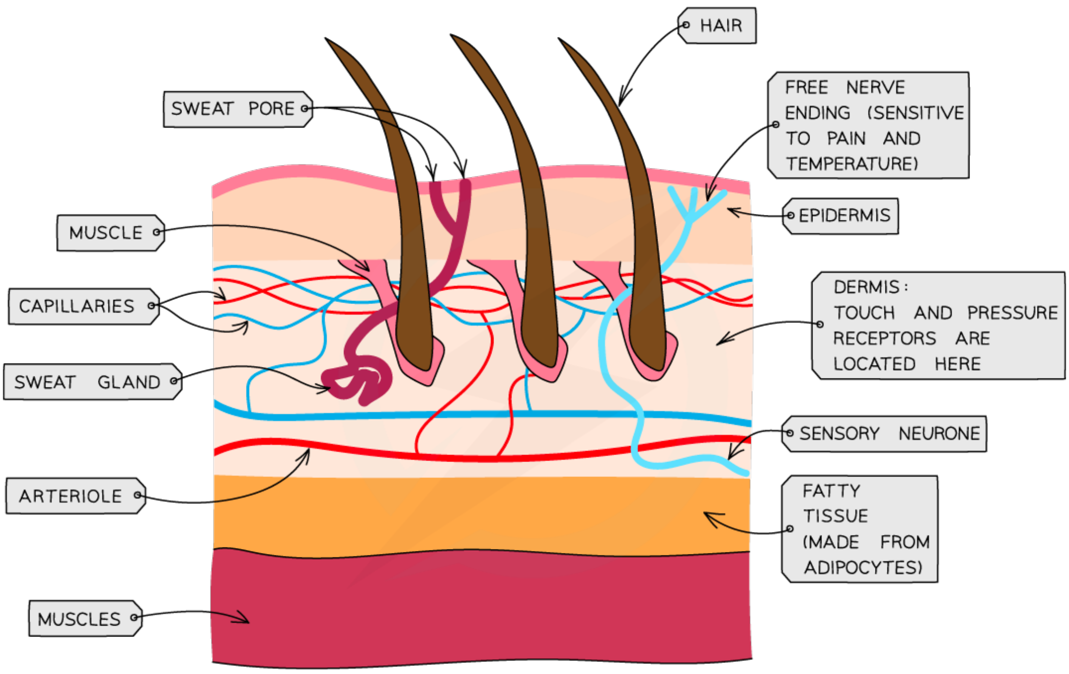
14.6 HOMEOSTASIS: TEMPERATURE CONTROL

YOUR NOTES

The Skin & Homeostasis

- Control of body temperature is a **homeostatic** mechanism
- Homeostasis is **the maintenance of a constant internal environment**
- This means that **internal conditions within your body** (such as temperature, blood pressure, water concentration, glucose concentration etc) need to be **kept within set limits** in order to ensure that reactions in body cells can function and therefore the organism as a whole can live
- The human body maintains the temperature at which enzymes work best, around **37°C**
- If body temperature increases over this temperature, **enzymes will denature** and become less effective at catalysing reactions such a respiration

Structure of the Skin



A cross-section of human skin

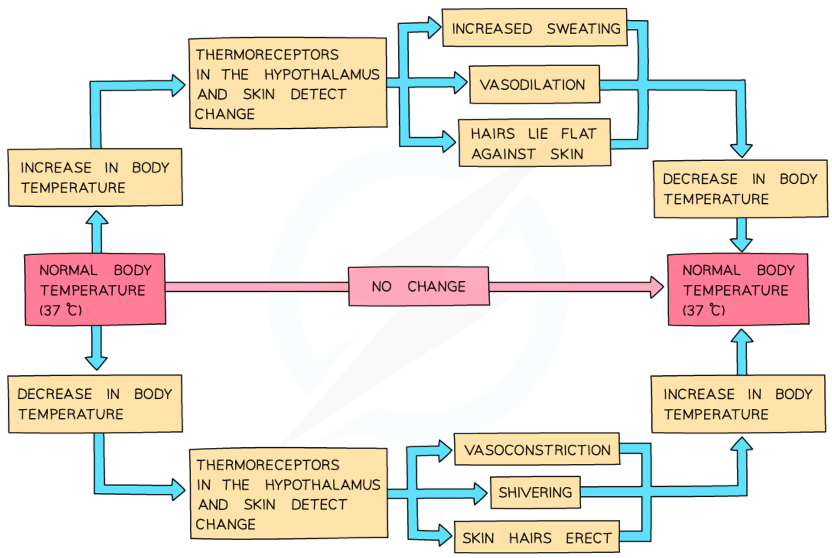
14 COORDINATION & RESPONSE

14.6 HOMEOSTASIS: TEMPERATURE CONTROL cont...

YOUR NOTES

Regulating Temperature: Basics

- Regulation is controlled by the **brain** which contains **receptors** sensitive to the temperature of the blood
- The **skin** also has **temperature receptors** and sends nervous impulses to the brain via **sensory neurones**
- The brain responds to this information by sending nerve impulses to **effectors** in the skin to **maintain the temperature within a narrow range of the optimum, 37°C**
- **Fatty tissue** under the dermis acts as a layer of **insulation** to prevent too much body heat being lost through the skin



Homeostatic responses to changes in body temperature

WHEN WE ARE HOT	WHEN WE ARE COLD
SWEAT IS SECRETED BY SWEAT GLANDS THIS COOLS SKIN BY **EVAPORATION.** HEAT ENERGY FROM THE BODY IS LOST AS LIQUID WATER IN SWEAT BECOMES WATER VAPOUR (A STATE CHANGE).	SKELETAL MUSCLES CONTRACT RAPIDLY AND WE **SHIVER.** THESE INVOLUTARY MUSCLE CONTRACTIONS NEED **ENERGY FROM RESPIRATION** AND SOME OF THIS IS **RELEASED AS HEAT.**
HAIRS **LIE FLAT** AGAINST THE SKIN, ALLOWING AIR TO FREELY CIRCULATE. THIS INCREASES HEAT TRANSFER TO ENVIRONMENT BY **RADIATION.**	ERECT HAIRS **TRAP A LAYER OF AIR AROUND THE SKIN** WHICH ACTS AS AN **INSULATOR**, PREVENTING HEAT LOSS BY RADIATION.

14 COORDINATION & RESPONSE

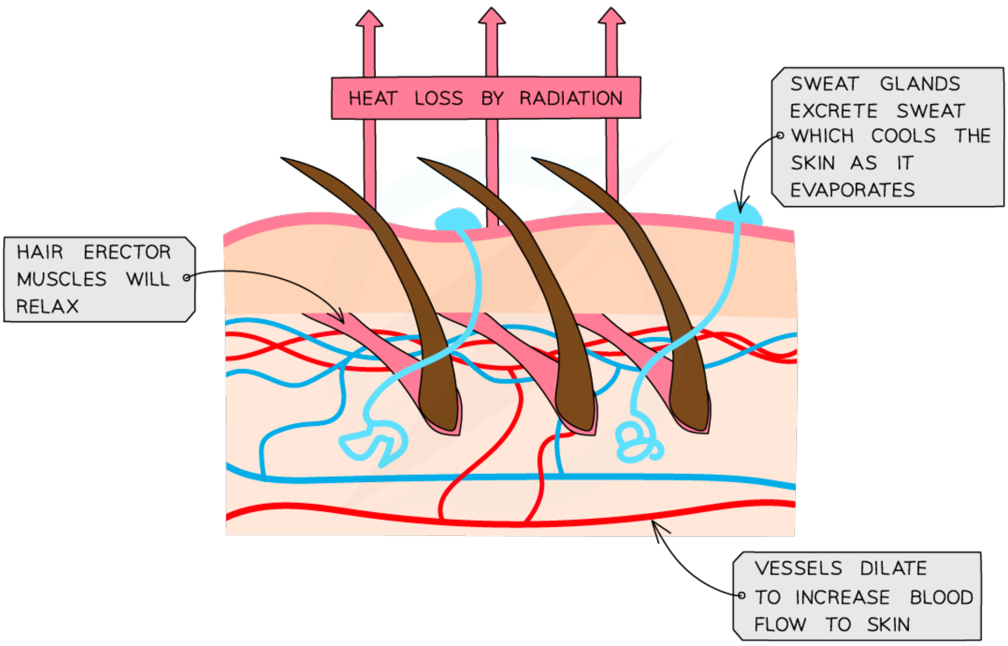
14.6 HOMEOSTASIS: TEMPERATURE CONTROL cont...

YOUR NOTES

EXTENDED ONLY

Vasodilation & Vasoconstriction

- When we are **cold** blood flow in capillaries slows down because arterioles leading to the skin capillaries get narrower – this is known as **vasoconstriction**
- This **reduces the amount of heat lost from blood by radiation** as less blood flows through the surface of the skin
- When we are **hot** blood flow in capillaries increases because blood vessels to the skin capillaries get wider – this is known as **vasodilation**
- This cools the body as blood (which carries heat around the body) is flowing at a faster rate through the skin's surface and so **more heat is lost by radiation**



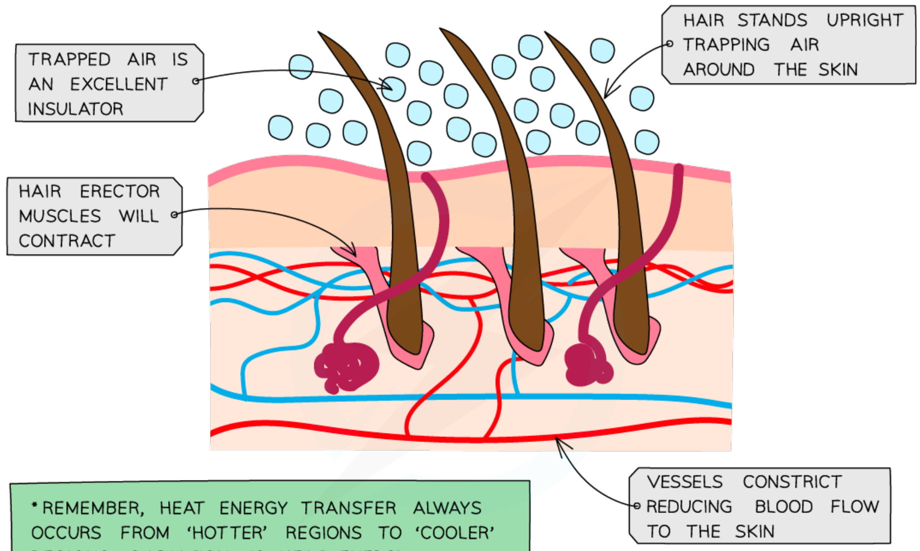
Responses in the skin when hot

14 COORDINATION & RESPONSE

14.6 HOMEOSTASIS: TEMPERATURE CONTROL cont...

YOUR NOTES

EXTENDED ONLY cont...



• REMEMBER, HEAT ENERGY TRANSFER ALWAYS OCCURS FROM 'HOTTER' REGIONS TO 'COOLER' REGIONS. RADIATION IS HEAT ENERGY TRANSFER BY ELECTROMAGNETIC RADIATION. CONDUCTION AND CONVECTION ARE THE OTHER TWO TYPES.

Responses in the skin when cold

14.7 TROPIC RESPONSES

Plant Tropisms

- Plants can respond to changes in environment (stimuli) for survival, e.g. **light, water, gravity**
- Their responses are usually **much slower** than animals
- They grow either **towards a stimulus** (known as a positive response) or **away from a stimulus** (known as a negative response)
- The responses are known as **tropisms**

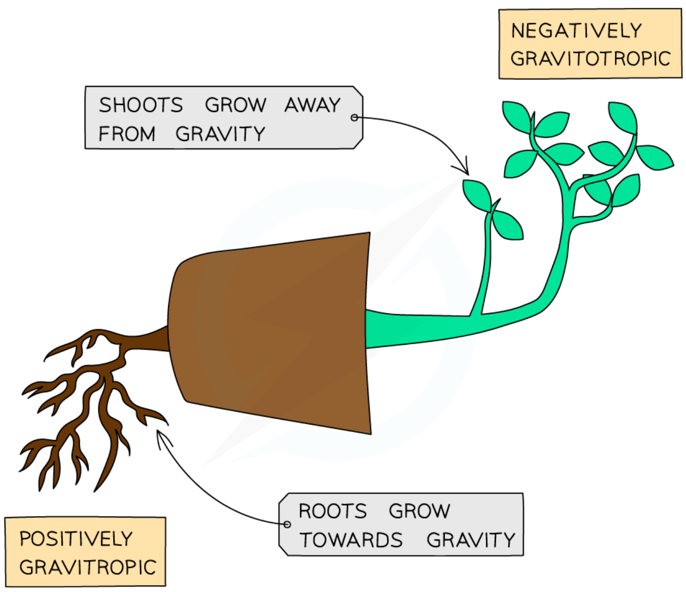
14 COORDINATION & RESPONSE

14.7 TROPIC RESPONSES cont...

YOUR NOTES

STIMULUS	NAME OF RESPONSE	DEFINITION	POSITIVE RESPONSE	NEGATIVE RESPONSE
GRAVITY	GRAVITROPISM (SOMETIMES CALLED GEOTROPISM)	GROWTH TOWARDS OR AWAY FROM GRAVITY	GROWTH TOWARDS GRAVITY (EG ROOTS)	GROWTH AWAY FROM GRAVITY (EG SHOOTS)
LIGHT	PHOTOTROPISM	GROWTH TOWARDS OR AWAY FROM THE DIRECTION OF LIGHT	GROWTH TOWARDS LIGHT (EG SHOOTS)	GROWTH AWAY FROM LIGHT (EG ROOTS)

- It is very important to a plant that its roots and shoots grow in the right directions
- Shoots must grow **upwards**, away from gravity and towards light, so that leaves are able to absorb sunlight
- This means that shoots have a **positive phototropic response** and a **negative gravitropic response**
- Roots need to grow **downwards** into the soil, away from light and towards gravity, in order to anchor the plant and absorb water and minerals from the soil particles.
- This means that roots have a **negative phototropic response** and a **positive gravitropic response**



Placing a plant on its side shows the gravitropic responses (also known as geotropic responses)

14 COORDINATION & RESPONSE

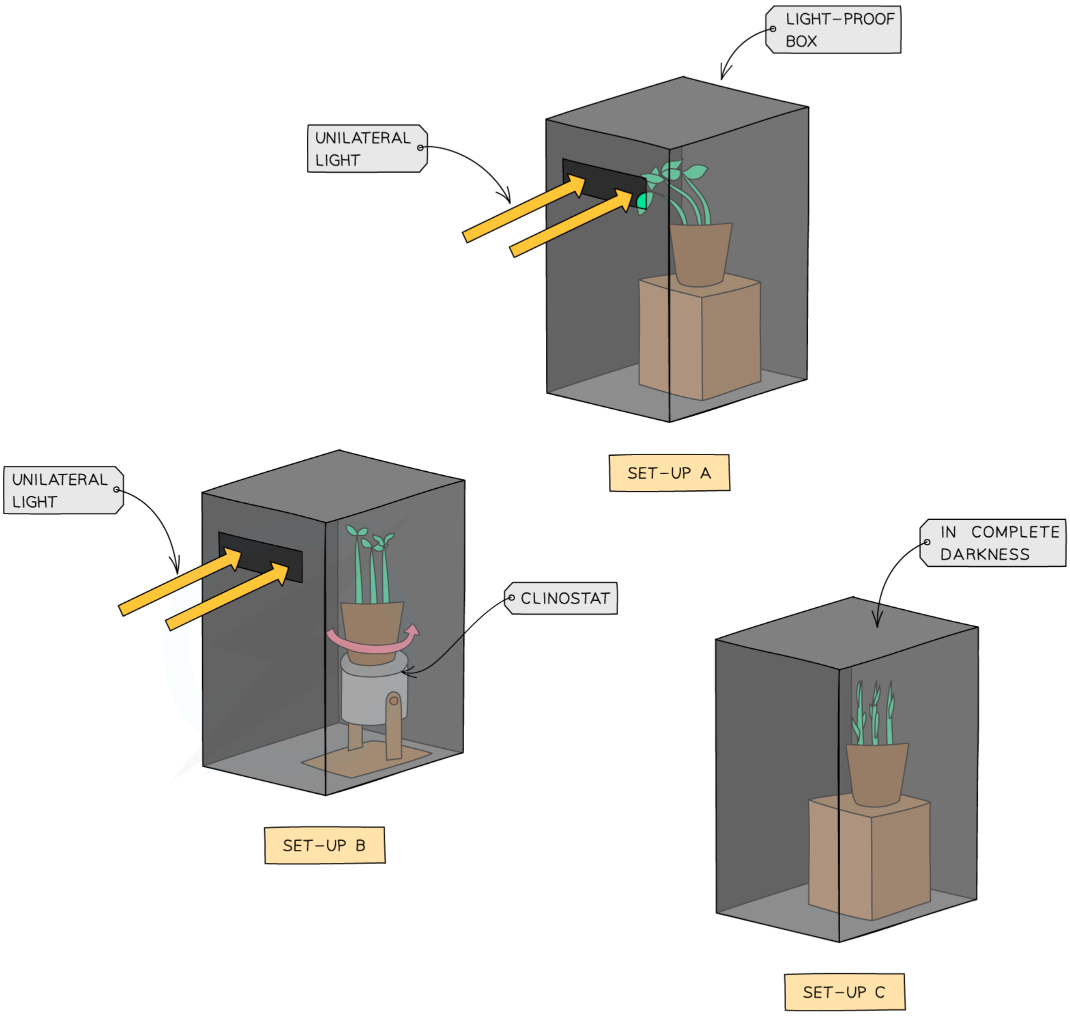
14.7 TROPIC RESPONSES cont...

YOUR NOTES

Investigating Tropisms

Phototropisms

- Three identical plants are set up as shown below (A, B and C)



Investigating the phototropic response

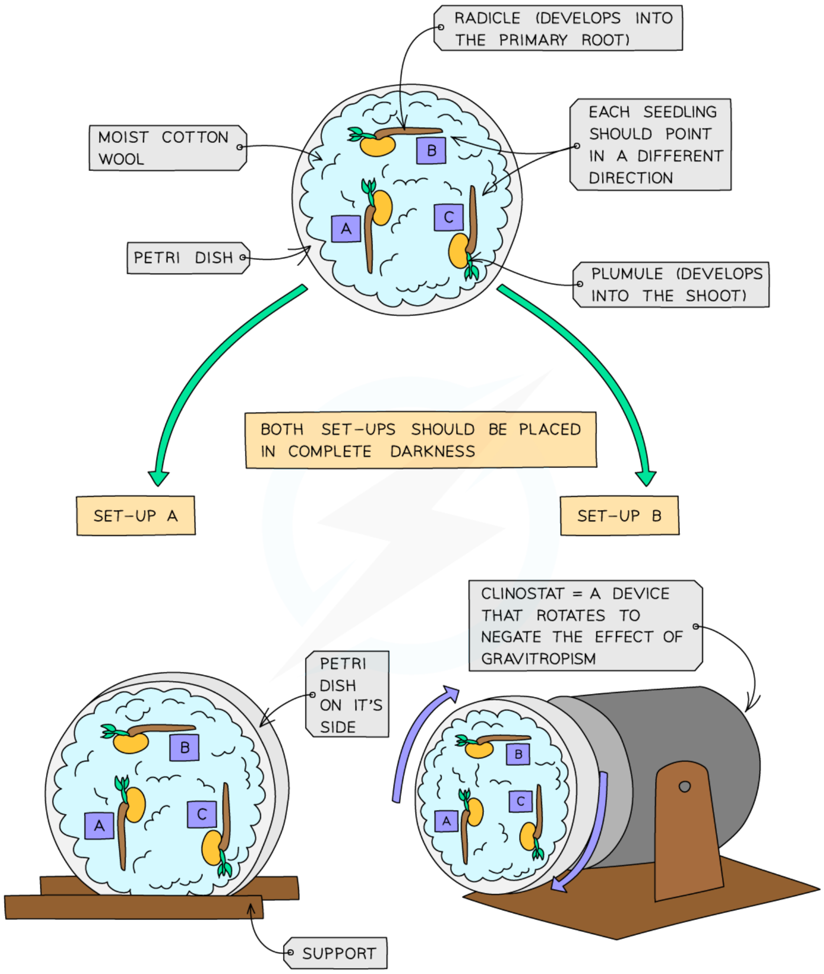
- The seedlings in A grow **towards** the light source
- In B the effect of the light only coming from one direction has been **cancelled out** by using a **clinostat** (it revolves slowly and repeatedly so the shoots are evenly exposed to light)
- This means all sides of the seedlings get an **equal amount of light** so they do not curve towards the light source but grow straight up
- In C the seedlings grow straight up **looking for light** and the plant becomes tall and slender with yellowing leaves due to the lack of light

14 COORDINATION & RESPONSE

YOUR NOTES

14.7 TROPIC RESPONSES cont...

Gravitropism



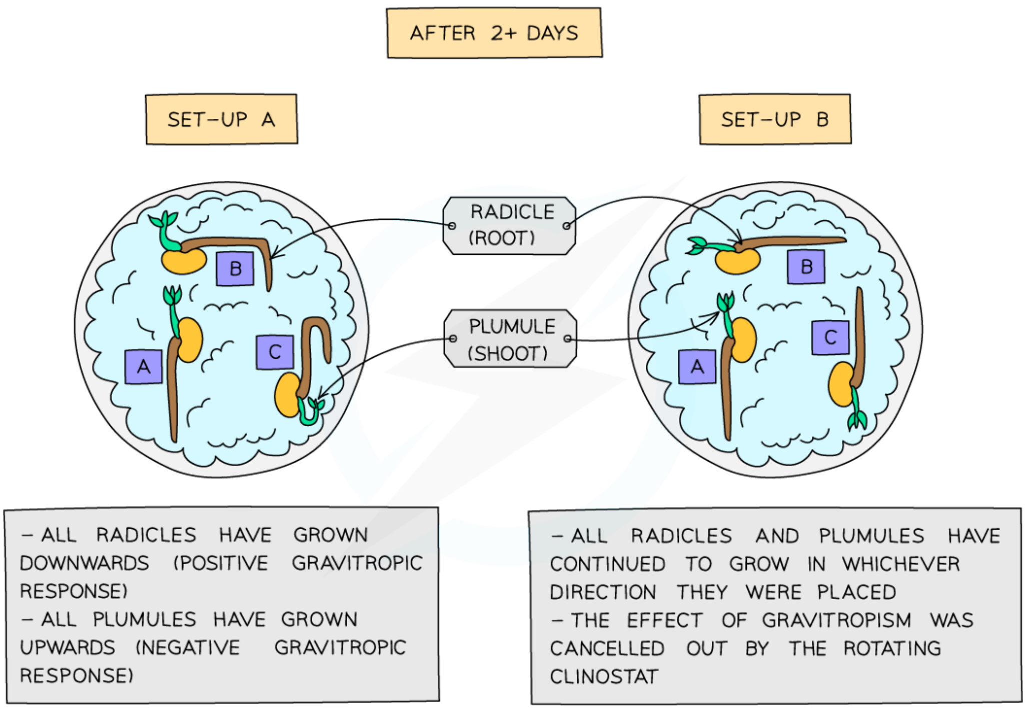
Investigating the gravitropic response (set-up)

- Add some damp cotton wool to two petri dishes
- Place 3 bean seedlings in the cotton wool in each petri dish
  - A – radicle facing **downwards**
  - B – horizontally
  - C – radicle (root grows from here) facing **upwards**
- Cover each dish with a lid
- Attach one petri dish to a support so that it's on its side
- Attach the second petri dish to a clinostat (as shown in the diagrams above).
- Place both in a **light-proof box** (so that the seedlings are in complete darkness), leave for two days and then observe growth of the seedlings

14 COORDINATION & RESPONSE

YOUR NOTES

14.7 TROPIC RESPONSES cont...



Investigating the gravitropic response (results)

- In the first petri dish **all radicles (roots) have grown downwards** (positive gravitropic response) regardless of which way they were initially facing (horizontal, up or down) and **all plumules (shoots) have grown upwards** (negative gravitropic response)
- In the second petri dish, all radicles and all plumules have all grown **neither up nor down** but straight outwards **in whichever direction they were placed** as the **effect of gravity** has been **cancelled out by the revolving of the clinostat** – they have shown no gravitropic response at all
- The experiment needs to be done in a lightproof box in order to **cancel out the effect of light on the growth of the seedlings**

EXAM TIP

Know what a clinostat is and what it does (cancel out the effect of light or gravity).

14 COORDINATION & RESPONSE

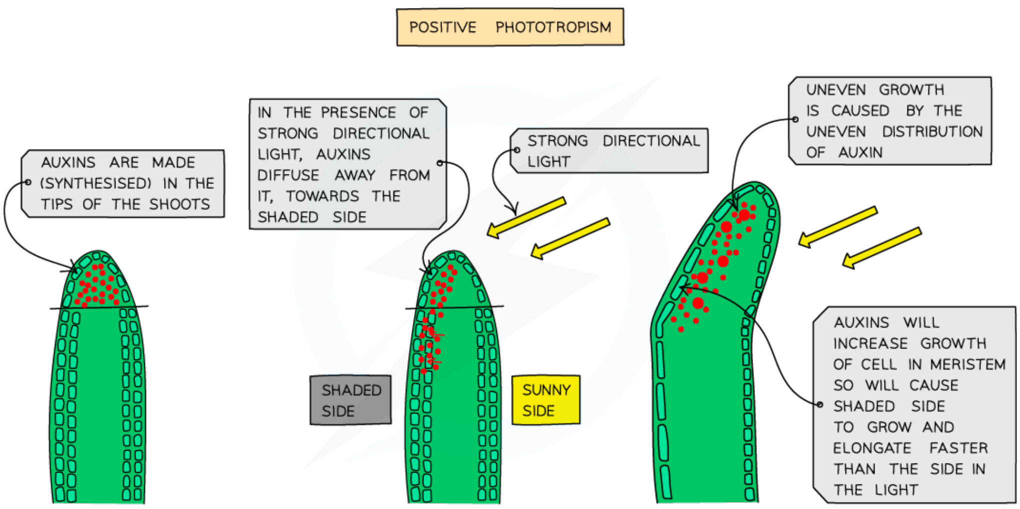
14.7 TROPIC RESPONSES cont...

YOUR NOTES

EXTENDED ONLY

The Role of Auxin

- Plants respond to stimuli by producing a **growth hormone called auxin** which controls the direction of growth of roots or stems
- Therefore we say plants control their growth chemically
- Auxin is mostly made in the **tips** of the growing stems and roots and can diffuse to other parts of the stems or roots; spreading from a high concentration in the shoot tips down the shoot to an area of lower concentration
- Auxin stimulates the cells behind the tip **to elongate** (get larger); the more auxin there is, the faster they will elongate and grow
    - This is an important point. Only the region behind the tip of a shoot is able to contribute to growth by cell division and cell elongation. This part of a shoot is called the meristem
- If light shines all around the tip, auxin is distributed evenly throughout and the cells in the meristem grow at the same rate – this is what normally happens with plants growing outside
- When light shines on the shoot predominantly from one side though, the auxin produced in the tip **concentrates on the shaded side**, making the cells on that side elongate and grow faster than the cells on the sunny side
- This unequal growth on either side of the shoot **causes the shoot to bend** and grow in the direction of the light



Positive phototropism in plant shoots

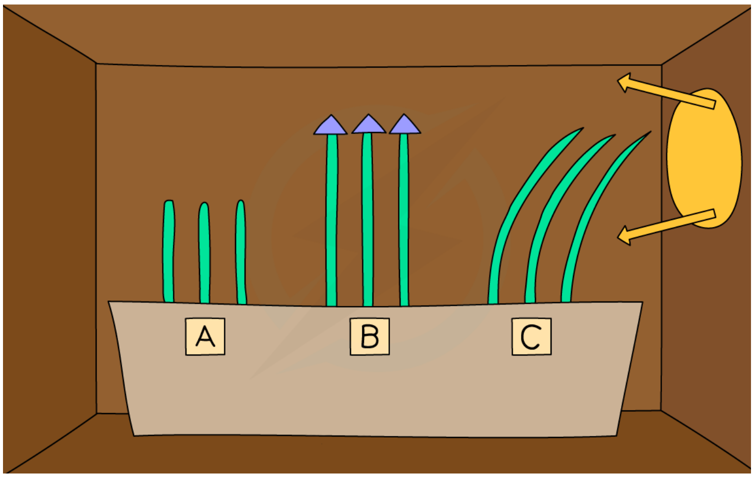
14 COORDINATION & RESPONSE

14.7 TROPIC RESPONSES cont...

YOUR NOTES

EXTENDED ONLY cont...

The role of auxin can be tested using seedlings placed in a box that has a slit on one side, only allowing light in from one direction:



Investigating the phototropic response set-up

	SEEDLING A	SEEDLING B	SEEDLING C
TREATMENT	THE TIPS OF THE STEMS HAVE BEEN REMOVED	NO LIGHT REACHES THE TIPS	MORE LIGHT REACHES ONE SIDE OF THE TIPS
EFFECT ON AUXIN CONCENTRATION	NO AUXIN IS PRODUCED	EQUAL CONCENTRATION OF AUXIN ON BOTH SIDES OF THE TIP	GREATER CONCENTRATION OF AUXIN ON SHADED SIDE
RESULT	THE STEMS DO NOT GROW LONGER	THE STEMS GROW EVENLY AND LONGER ON BOTH SIDES	THE CELLS ON THE DARKER SIDE OF THE STEMS GROW LONGER AND FASTER THAN CELLS IN THE LIGHT
REASON	THIS PROVES THAT AUXIN IS MADE IN THE TIP AND IS NEEDED TO STIMULATE CELL ELONGATION AND THEREFORE GROWTH. WITHOUT THE TIP, AND THEREFORE WITHOUT AUXIN, THERE IS NO FURTHER GROWTH IN THE STEM	THIS PROVES THAT IT IS THE EFFECT OF LIGHT ON AUXIN THAT CAUSES PHOTOTROPISM. THERE IS NO UNEVEN DISTRIBUTION OF AUXIN THROUGHOUT THE SHOOT TIP, SO GROWTH IS EVEN	THIS PROVES THAT SHOOTS GROW TOWARDS THE LIGHT BECAUSE THERE IS AN UNEVEN DISTRIBUTION OF AUXIN IN THE SHOOT TIP, CAUSED BY AUXIN'S RESPONSE TO LIGHT

14 COORDINATION & RESPONSE

14.7 TROPIC RESPONSES cont...

YOUR NOTES

EXTENDED ONLY cont...

Plant Hormones & Weedkillers

- Most **weedkillers** contain **synthetic hormones** like auxin – known as **2,4D**
- They are **selective** so they are sprayed onto an area such as a lawn or farm crops and the synthetic auxin **affects the weeds but not the grass / crop plants**
- The weeds respond by **growing very fast** and then **dying**, leaving more **space, nutrients and water** for the grass or crop plants to grow

EXAM TIP

You should be able to explain the results of an **experiment** into the effect of light on the growth of shoots.

Your syllabus does NOT require you to know anything about the effect of light (or gravity) on the growth of roots so don't spend time learning anything about it!

> NOW TRY SOME EXAM QUESTIONS

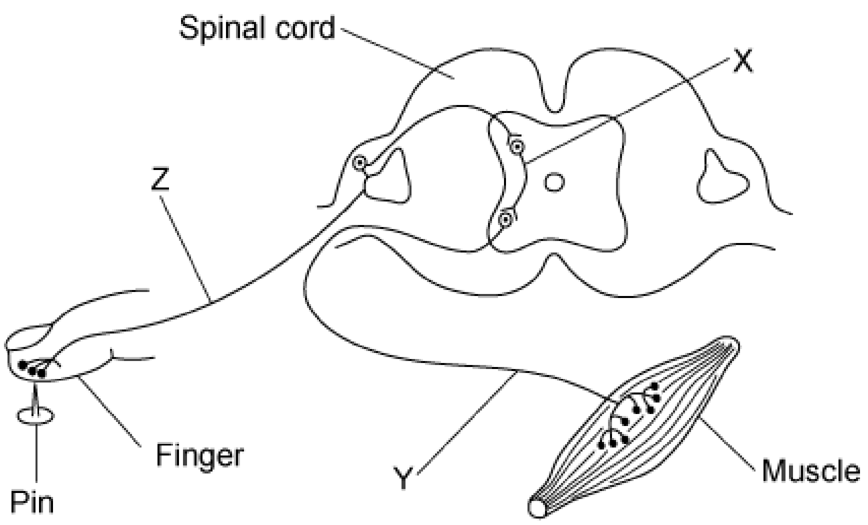
14 COORDINATION & RESPONSE

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The image below shows a simple reflex arc.



Which of the following sequences correctly shows the order of cells that an impulse passes through during a reflex action?

	first	→	last
A	Z	X	Y
B	X	Y	Z
C	Y	X	Z
D	Z	Y	X

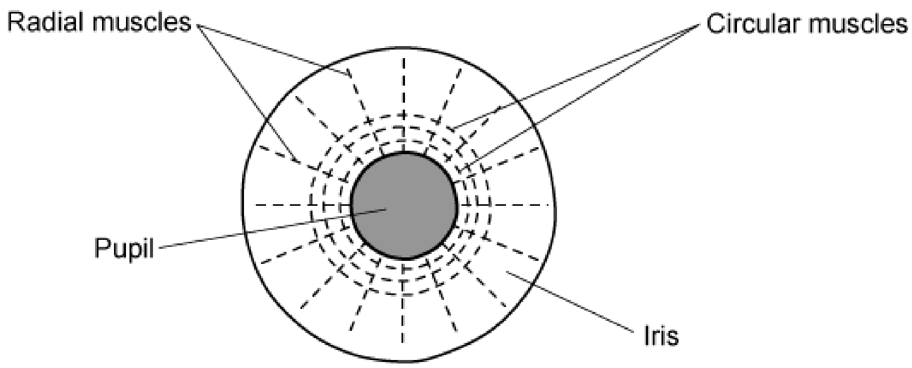
14 COORDINATION & RESPONSE

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 2

The image below shows some of the structures in the eye.



The circular and radial muscles can control the size of the pupil in the eye.

How would they respond in the eye of a person walking from a brightly lit room into a dark one?

	radial muscles	circular muscles	pupil
A	relaxes	contracts	constricts
B	relaxes	contracts	dilated
C	contracts	relaxes	dilated
D	contracts	relaxes	constricts

EXAM QUESTIONS cont...

YOUR NOTES

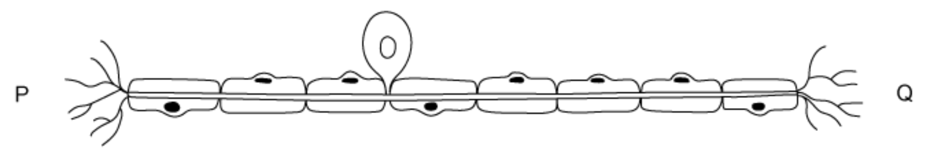
QUESTION 3

Which row of the following table correctly describes what happens in the body after a person consumes a can of sugary drink?

	role of the pancreas	role of the liver	effect
A	releases glucagon	converts glycogen into glucose	blood sugar levels rise
B	releases insulin	converts excess glucose into glycogen	blood sugar level falls
C	releases glucagon	converts excess glucose into glycogen	blood sugar level falls
D	releases insulin	converts glycogen into glucose	blood sugar levels rise

QUESTION 4

The image below shows a cell from the nervous system. The cell forms part of a reflex arc.



An impulse moves along the neurone from Q to P.

What structures would be found at P and Q?

	P	Q
A	receptor	relay neurone
B	relay neurone	receptor
C	motor neurone	relay neurone
D	gland	relay neurone

14 COORDINATION & RESPONSE

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5

An athlete takes part in a marathon.

What would the effect of an athlete taking part in a marathon race on a hot, sunny day?

	volume of water reabsorbed in the kidneys	volume of water lost from the skin	effect on hairs on the skin
A	less	decreases	lie flat
B	more	decreases	erect
C	less	increases	lie flat
D	more	increases	lie flat

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

Head to savemyexams.co.uk
for more questions and revision notes

15 DRUGS

YOUR NOTES

CONTENTS:

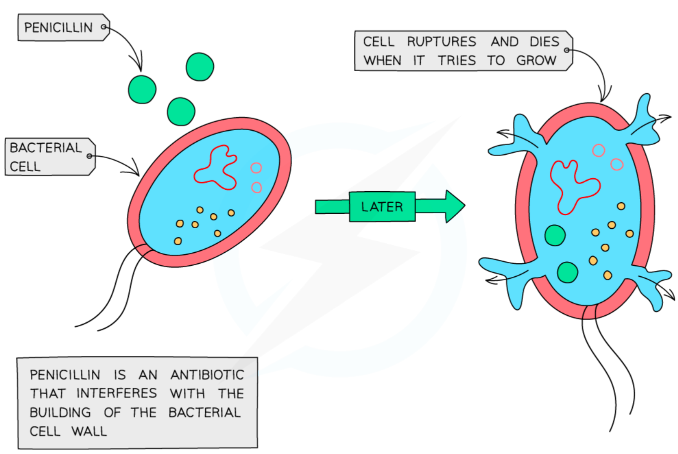
15.1 MEDICINAL DRUGS

What is a Drug?

- A drug is **any substance taken into the body that modifies or affects chemical reactions in the body**
- Some drugs are medicinal drugs that are used to treat the symptoms or causes of a disease – for example, **antibiotics**

Antibiotics

- Antibiotics are **chemical substances** made by certain **fungi or bacteria** that affect the working of bacterial cells, either by **disrupting their structure or function** or by **preventing them from reproducing**
- Antibiotics are **effective against bacteria but not against viruses**
- Antibiotics target processes and structures that are specific to bacterial (prokaryotic) cells; as such they do not generally harm animal cells



How antibiotics work

Why Don't Antibiotics Affect Viruses? The Basics

- Some bacteria that cause disease have **become** resistant to antibiotics and this **reduces the effectiveness of prescribed antibiotics** when someone has a bacterial infection, as it might be caused by a type of bacteria that is resistant to that particular antibiotic

15 DRUGS

15.1 MEDICINAL DRUGS cont...

EXTENDED ONLY

Why Don't Antibiotics Affect Viruses?

- Viruses cannot be treated with antibiotics
- This is because antibiotics work by **disrupting cell functions such as respiration, or breaking down the structure of the cell in some way**
- However, viruses **do not carry out any cell functions** and **do not have cell walls, cell membranes or any cell organelles** as viruses infect and utilise the machinery of animal cells to reproduce, which are not affected by antibiotics
- Therefore the action of antibiotics **do not affect them**

Antibiotic Resistance

- Since the first antibiotic was discovered in 1928, many more have been discovered and developed
- Antibiotics were and are **widely overused**
- Commonly prescribed antibiotics are becoming **less effective** due to a number of reasons:
  - **overuse** and being prescribed when not really necessary
  - patients **failing to complete the fully prescribed cours**e by a doctor
  - large scale **use of antibiotics in farming** to prevent disease when livestock are kept in close quarters, even when animals are not actually sick
- This has lead to the effectiveness of antibiotics being reduced, and the incidence of antibiotic resistance increasing
- These bacteria are commonly known as superbugs and the most common is **MRSA**
- Ways individuals can help **prevent** the incidence of antibiotic resistance increasing include:
  - only taking antibiotics when **absolutely essential**
  - when prescribed a course of antibiotics, **ensure that the entire course is completed** even if you feel better after a few days

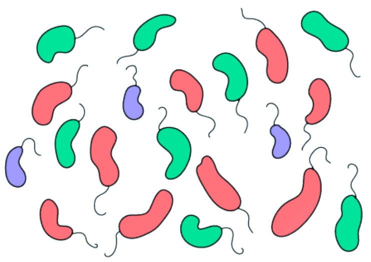
YOUR NOTES

15 DRUGS

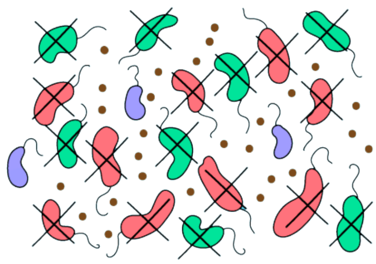
15.1 MEDICINAL DRUGS cont...

EXTENDED ONLY cont...

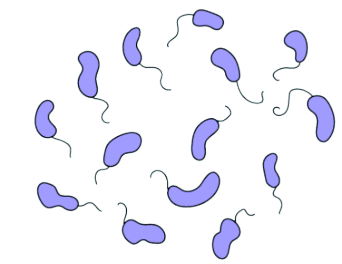
1 A POPULATION OF BACTERIA IN THE GUT. SOME HAVE ANTIBIOTIC RESISTANCE



2 WHEN EXPOSED TO AN ANTIBIOTIC, BACTERIA CAUSING ILLNESS, AS WELL AS HEALTHY GUT BACTERIA, ARE KILLED

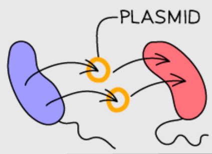


3 WITH REDUCED COMPETITION FOR NUTRIENTS, ANTIBIOTIC–RESISTANT BACTERIA MULTIPLY, FORMING A LARGER POPULATION THAT IS DIFFICULT TO CONTROL



KEY:
= PATHOGENIC, ANTIBIOTIC RESISTANT, BACTERIUM
= HEALTHY GUT BACTERIUM
= PATHOGENIC BACTERIUM

PLASMIDS WITH ANTIBIOTIC–RESISTANT GENES CAN BE SHARED BETWEEN BACTERIA OF BOTH THE SAME AND DIFFERENT SPECIES.



Antibiotic resistance

YOUR NOTES

15 DRUGS

15.2 MISUSED DRUGS

YOUR NOTES

Alcohol

- Wines, beers and spirits contain an alcohol called **ethanol**
- It is a **depressant drug** – it slows down signals in the nerves and brain
- Because alcohol **increases reaction times** (meaning it increases the time taken to react to situations because it slows down signalling in the brain), there are **legal limits for drinking and driving** in many countries

SHORT–TERM EFFECTS	LONG–TERM EFFECTS
VOMITING – ALCOHOL IS TOXIC TO THE BODY AND THIS IS THE QUICKEST WAY TO GET RID OF IT	DAMAGES THE BRAIN CAUSING MEMORY LOSS AND CONFUSION
IMPAIRED JUDGEMENT AND POTENTIALLY VIOLENT BEHAVIOUR – THE USER HAS REDUCED SELF–CONTROL	HEAVY ALCOHOL ABUSE OVER A LONG PERIOD OF TIME DAMAGES THE LIVER, CAUSING CIRRHOSIS
IMPAIRED BALANCE AND MUSCLE CONTROL	
SLEEPINESS AND, WHEN CONSUMED IN LARGE ENOUGH QUANTITIES, UNCONSCIOUSNESS	

- The **liver** removes alcohol from the bloodstream
- It has enzymes that break down alcohol but the products of the reactions involved are toxic and, over time, the liver can be **irreparably damaged**
- In many people, alcohol can be a very **addictive** drug

15 DRUGS

15.2 MISUSED DRUGS cont...

YOUR NOTES

Heroin

- Heroin is a powerful **depressant** drug
- It **reduces pain** and **slows down breathing**
- It is **highly addictive** and users quickly develop a **tolerance** for it, meaning they need larger and larger amounts in order to feel the same effects – this increases the risk of accidentally **overdosing**, which can cause **death**
- This means they need **more money** to pay for the **increased amounts of the drug** they are taking; as the drug makes them **less able to cope with everyday life and maintain a job**, they may **turn to crime** in order to get the money they need
- As it is so addictive, if a user stops taking heroin they suffer from significant **withdrawal symptoms**, such as **nausea, muscle cramps, sweating, anxiety** and **difficulty sleeping**
- Heroin can be taken into the body in different ways; one of the most common is **injecting with a syringe**
- As syringe needles cost money, heroin addicts may share needles which increases the risk of **transmission of blood-borne infections such as HIV**

EXTENDED ONLY

How does Heroin Affect the Nervous System?

- In the brain there are many different **chemical neurotransmitters** that transfer nerve impulses across synapses
- The neurotransmitters diffuse across the synapse and fit into **receptor molecules** on the postsynaptic membrane
- One group of neurotransmitters is called **endorphins** which help to **reduce sensations of pain, affect mood and reduce sensations of hunger and thirst**
- When it enters the brain, heroin is metabolised to **morphine**
- Morphine molecules **fit into some of the endorphin receptors** and this is why taking heroin makes users feel so good
- Taking heroin can **reduce the production of natural endorphins** and other neurotransmitters, which is why repeated use **leads to the need for greater and greater amounts** in order to get the same feelings

15 DRUGS

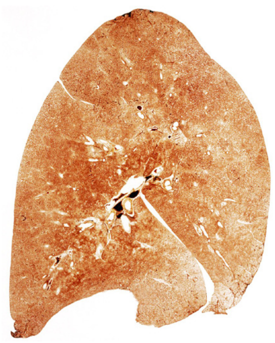
15.2 MISUSED DRUGS cont...

YOUR NOTES

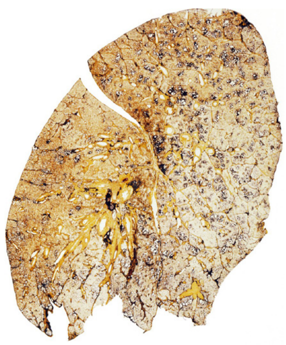
Tobacco & The Gas Exchange System

Tobacco & Disease

- Smoking causes **chronic obstructive lung disease, coronary heart disease** and increased risks of several different types of cancer, including **lung cancer**
- Chemicals in cigarettes include:
  - **Tar** – a carcinogen (a substance that causes cancer))
  - **Nicotine** – an addictive substance which also narrows blood vessels
  - **Carbon monoxide** – reduces the oxygen-carrying capacity of the blood



Section through a normal lung



Section through a smoker's lung

Effects on the Gas Exchange System

Tar

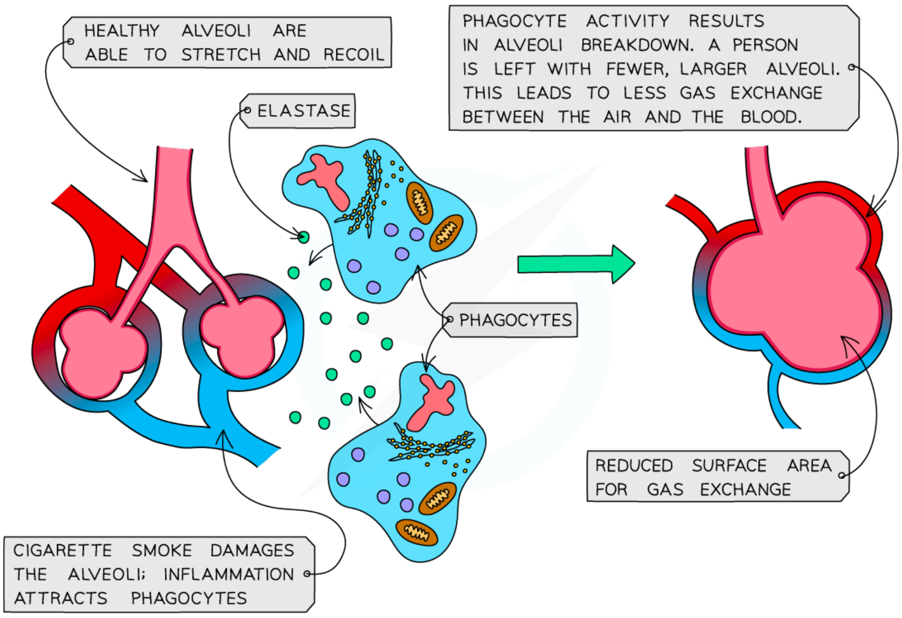
- Tar is a **carcinogen** and is linked to increased chances of cancerous cells developing in the lungs
- It also contributes to **COPD**, which occurs when **chronic bronchitis** and **emphysema**, two different diseases which are frequently linked to smoking, occur together
- Chronic bronchitis is caused by **tar** which stimulates goblet cells and mucus glands to enlarge, **producing more mucus**
- It destroys **cilia**, inhibiting the cleaning of the airways, and **mucus** (containing dirt, bacteria and viruses) **builds up**, blocking the smallest bronchioles
- A **smoker's cough** is the attempt to move the mucus but it **damages the epithelia** resulting in scar tissue, which **narrows the airways** and makes **breathing difficult**
- **Emphysema** develops as a result of **frequent infection**, meaning **phagocytes** are attracted to the lungs where they release **elastase** – an enzyme that **breaks down the elastin in the alveoli walls**, to enable them to reach the surface where the bacteria are
- Without adequate elastin, the **alveoli cannot stretch**, so they recoil and many burst
- The breakdown of alveoli results in the appearance of large air spaces, **reducing the surface area for gas exchange** and making sufferers breathe more rapidly

15 DRUGS

YOUR NOTES

15.2 MISUSED DRUGS cont...

- As it progresses, patients become **breathless and wheezy** – they may need a constant supply of oxygen to stay alive



The breakdown of alveoli in emphysema reduces the surface area for gas exchange

Carbon monoxide

- **Carbon monoxide binds irreversibly to haemoglobin**, reducing the capacity of blood to carry oxygen
- This puts more strain on the breathing system as **breathing frequency and depth need to increase** in order to get the same amount of oxygen into the blood
- It also puts more strain on the circulatory system to pump the blood faster around the body and **increases the risk of coronary heart disease and strokes**

Nicotine

- **Nicotine narrows blood vessels** so will put more strain on the circulatory system and **increase blood pressure**
- Narrow blood vessels are more likely to become clogged with fat, including cholesterol – if this happens in the coronary artery, this causes **coronary heart disease**
- This means the heart muscle cells do not get sufficient oxygen and so less aerobic respiration takes place
- To compensate the cells respire **anaerobically**, producing **lactic acid** which cannot be removed (due to lack of blood supply)
- This creates a **low pH** environment in the cells causing **enzymes to denature** and eventually **heart muscle cells will die**
- If enough die this can cause a **heart attack**

15 DRUGS

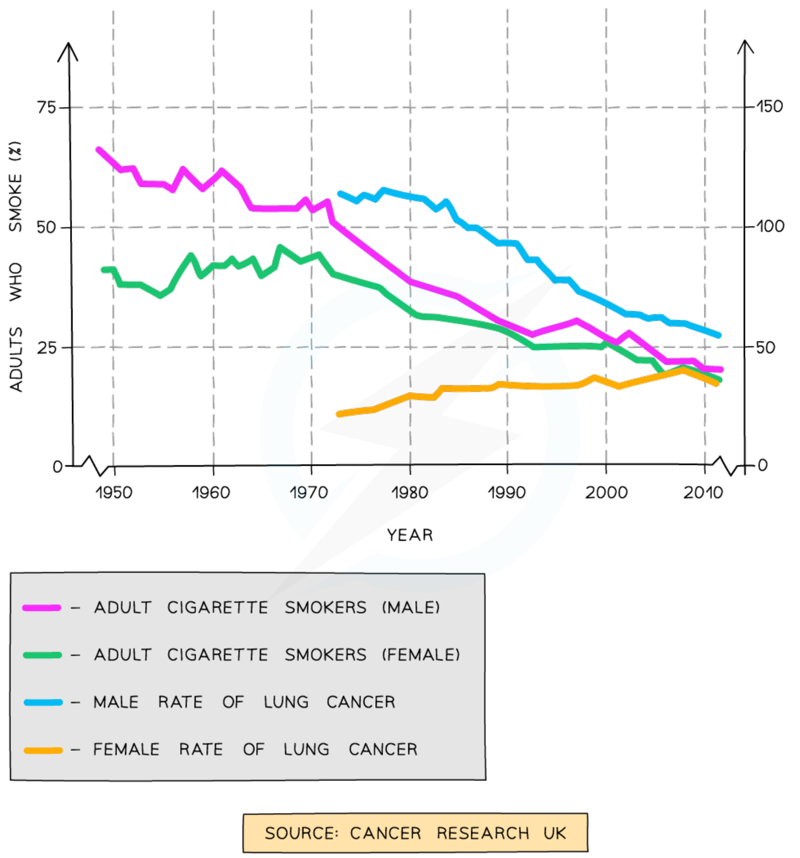
15.2 MISUSED DRUGS cont...

YOUR NOTES

EXTENDED ONLY

Smoking & Lung Cancer: Is There a Link?

- The majority of cases of lung cancer are caused by smoking



Graph showing correlation between numbers of adults who smoke and lung cancer rates over time

- Note that, as the general trend for the number of adult smokers decreases, so does the trend for lung cancer rates a few years later (as cancer takes some time to develop)
- The trend in the rate of developing lung cancer for women has been increasing, while in men it is decreasing
- This is because the numbers of female smokers – unlike men – continued to increase in the 1950s and 1960s before starting to fall
- As cancer takes some years to develop, a fall in female rates of lung cancer is likely to occur later

15 DRUGS

15.2 MISUSED DRUGS cont...

EXTENDED ONLY cont...

Performance-Enhancing Drugs in Sport

- Hormones produced in the body help to control the way it develops and responds to changes
- Some people take additional hormones to **increase these effects**
- This is most commonly done to **improve sporting performance**
- **Testosterone** is the hormone produced in the testes that affects the development of male secondary sexual characteristics
- It is one of a group of hormones known as **steroids** which stimulate **anabolic reactions** to occur in the body (meaning the synthesis of large molecules from smaller ones), so it is known as an **anabolic steroid**
- One of the effects of testosterone is to cause **more proteins to be made in muscles** so that muscles become larger and stronger
- Taking anabolic steroids therefore **increases muscle mass, helps athletes train harder and for longer periods of time**, and can **increase aggression** which can give an edge when competing
- The use of anabolic steroids in sports is banned as it gives an **unfair advantage** and also has **serious side effects**, including:
    - increases risk of heart disease
    - increases risk of liver damage
    - increases risk of kidney damage
    - affect the menstrual cycle in women
    - decreases the ability of the immune system to destroy pathogens

EXAM TIP

Most questions about smoking and lung cancer expect you to analyse data in a table or graph and discuss it to show the evidence for a link, as shown in the notes above.

Keep your points concise and refer to the data as much as possible.

> NOW TRY SOME EXAM QUESTIONS

YOUR NOTES

15 DRUGS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which organ is the most damaged by excessive alcohol drinking?

A liver

B heart

C pancreas

D stomach

QUESTION 2

Which of the following statements about antibiotics is not correct?

A some antibiotics are produced by fungi

B some bacteria are resistant to antibiotics

C antibiotics are used to treat diseases caused by viruses

D when taking antibiotics for an infection, the treatment should be completed.

QUESTION 3

A man has been smoking for many years.

Which of the following statements could not be correct?

A the cilia in the trachea have been destroyed

B he is addicted to nicotine

C his arteries are blocked with tar

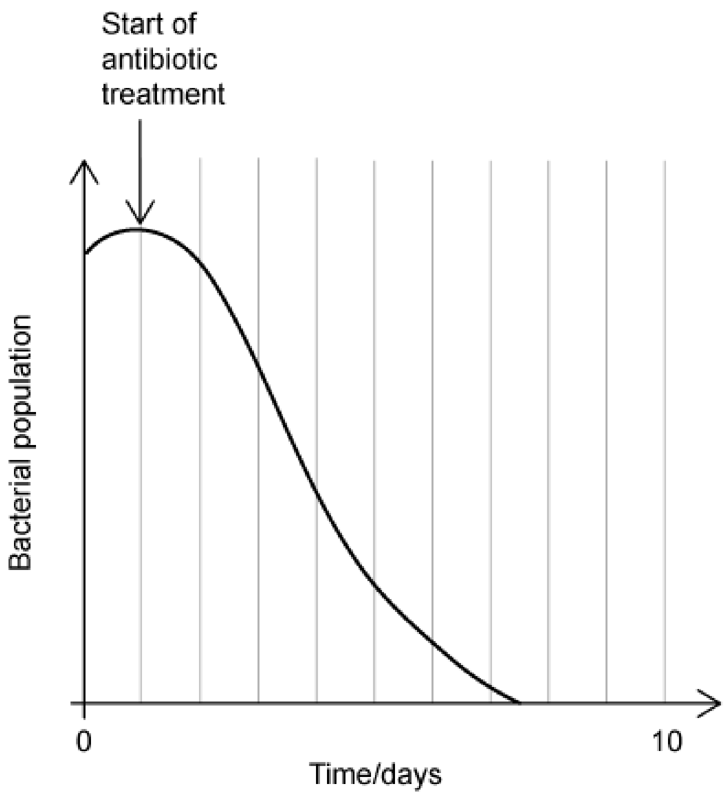
D the surface area of the lungs is reduced

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

The data in the graph shows the effect of an antibiotic on the population of bacteria in the blood.



What can be concluded from the data?

A antibiotics take 10 days to kill all bacteria

B antibiotics cause reduction of division in bacteria

C antibiotics are effective against viral and bacterial infections

D before the start of the antibiotic treatment the bacterial population was increasing

15 DRUGS

EXAM QUESTIONS cont...

QUESTION 5

Which two of the following statements correctly describe the effect of smoking cigarettes?

1 Goblet cells produce more mucus

2 Goblet cells stop producing mucus

3 Cilia beat more slowly

4 Cilia beat more quickly

A 1 and 3 **B** 2 and 3 **C** 1 and 4 **D** 2 and 4

YOUR NOTES

16 REPRODUCTION

YOUR NOTES

CONTENTS:

16.1 TYPES OF REPRODUCTION

Asexual Reproduction

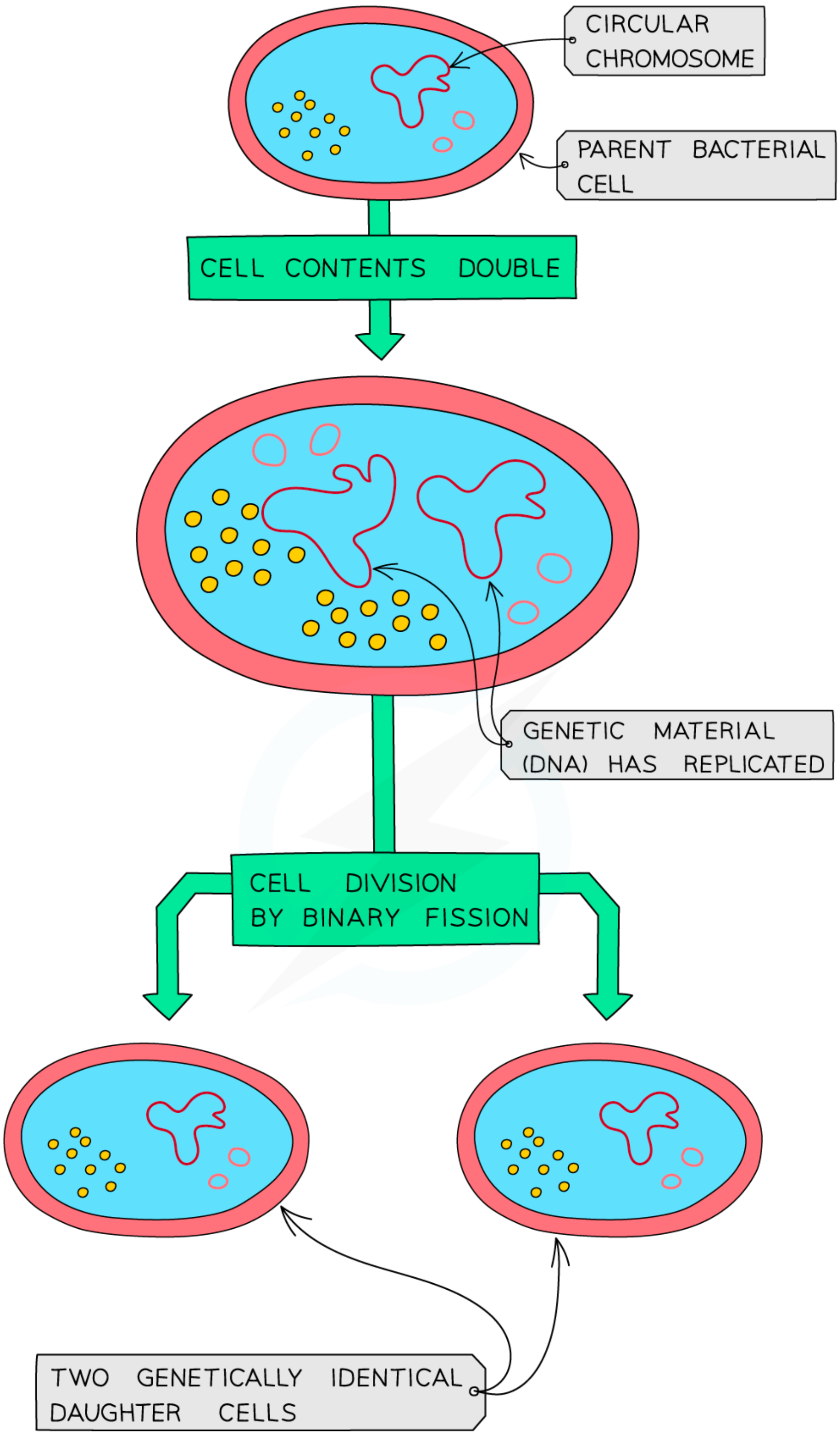
- Asexual reproduction does not involve sex cells or fertilisation
- Only one parent is required so there is no fusion of gametes and no mixing of genetic information
- As a result, the offspring are genetically identical to the parent and to each other (clones)
- Asexual reproduction is defined as a process resulting in genetically identical offspring from one parent

Bacteria produce exact genetic copies of themselves in a type of asexual reproduction called binary fission:

16 REPRODUCTION

16.1 TYPES OF REPRODUCTION cont...

YOUR NOTES



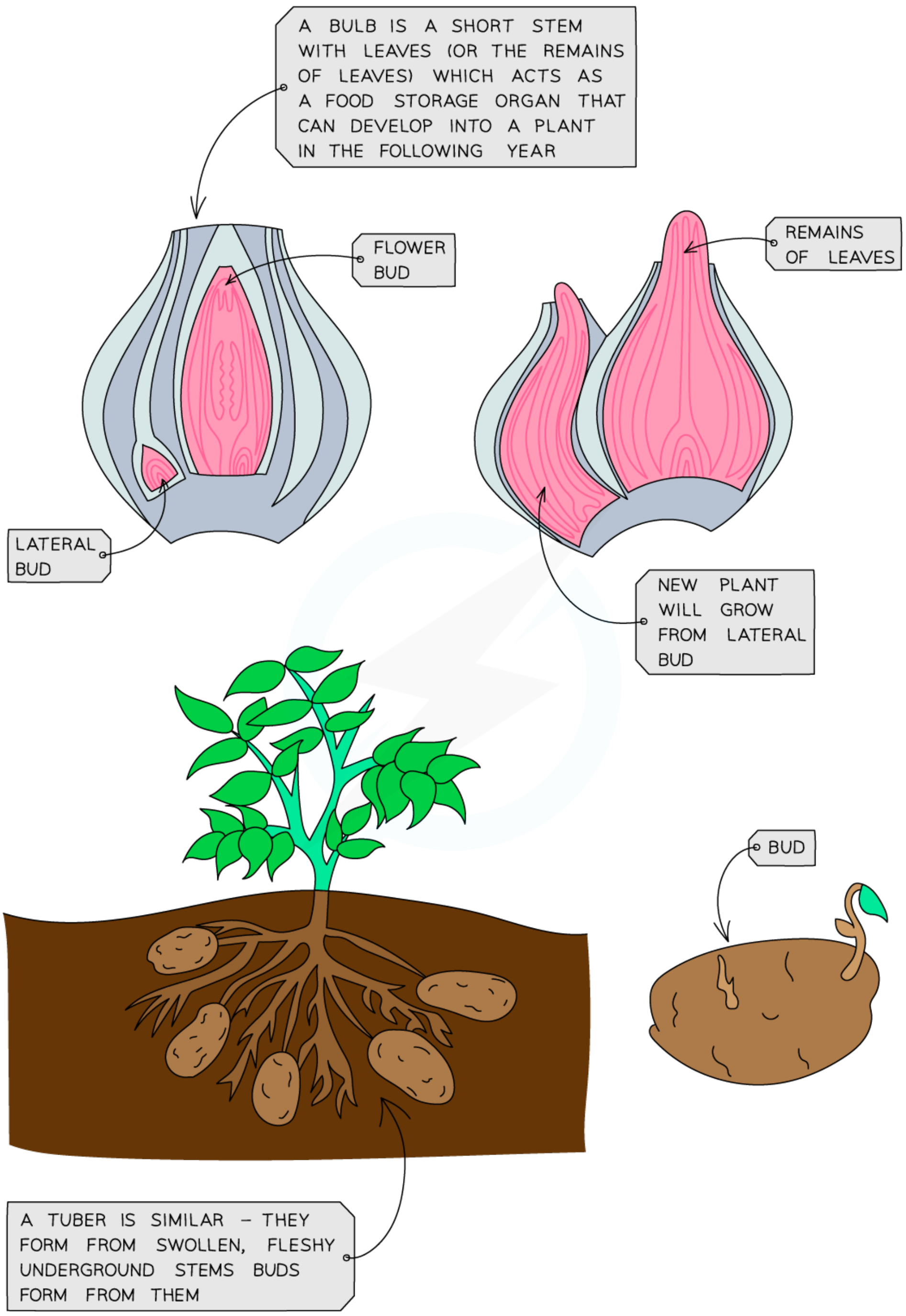
Bacterial binary fission

16 REPRODUCTION

16.1 TYPES OF REPRODUCTION cont...

YOUR NOTES

Plants can reproduce asexually using bulbs and tubers; these are food storage organs from which budding can occur, producing new plants which are genetically identical to the parent plant:

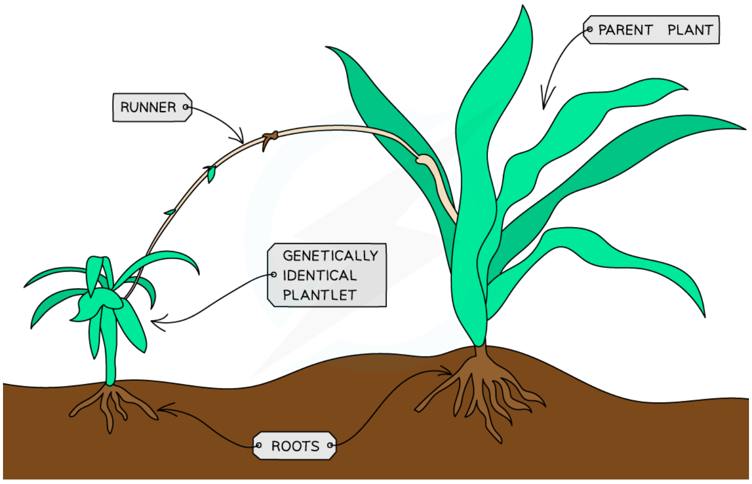


Asexual reproduction in plants using bulbs or tubers

16 REPRODUCTION

16.1 TYPES OF REPRODUCTION cont...

Some plants grow side shoots called runners that contain tiny plantlets on them (a good example of this are strawberry plants. These will grow roots and develop into separate plants, again being genetically identical to the parent plant:



A runner and plantlet

EXTENDED ONLY

Advantages & Disadvantages of Asexual Reproduction

ADVANTAGES	DISADVANTAGES
POPULATION CAN BE INCREASED RAPIDLY WHEN CONDITIONS ARE RIGHT	LIMITED GENETIC VARIATION IN POPULATION – OFFSPRING ARE GENETICALLY IDENTICAL TO THEIR PARENTS
CAN EXPLOIT SUITABLE ENVIRONMENTS QUICKLY	POPULATION IS VULNERABLE TO CHANGES IN CONDITIONS AND MAY ONLY BE SUITED FOR ONE HABITAT
MORE TIME AND ENERGY EFFICIENT	DISEASE IS LIKELY TO AFFECT THE WHOLE POPULATION AS THERE IS NO GENETIC VARIATION
REPRODUCTION IS COMPLETED MUCH FASTER THAN SEXUAL REPRODUCTION	

- Specifically in **crop plants**, asexual reproduction can be advantageous as it means that a plant that has good characteristics (high yield, disease-resistant, hardy) can be made to reproduce asexually and the **entire crop will show the same characteristics**

YOUR NOTES

16 REPRODUCTION

16.1 TYPES OF REPRODUCTION cont...

YOUR NOTES

Sexual Reproduction

- Sexual reproduction is a **process involving the fusion of the nuclei of two gametes (sex cells) to form a zygote (fertilised egg cell) and the production of offspring that are genetically different from each other**
- Fertilisation is defined as the **fusion of gamete nuclei**, and as each gamete comes from a different parent, there is variation in the offspring

EXTENDED ONLY

Gametes & Zygotes

- A **gamete** is a sex cell (in animals: sperm and ovum; in plants pollen nucleus and ovum)
- Gametes differ from normal cells as they contain **half the number of chromosomes** found in other body cells – we say they have a **haploid nucleus**
- This is because they only contain **one copy of each chromosome**, rather than the two copies found in other body cells
- In human beings, a normal body cell contains **46 chromosomes** but each gamete contains **23 chromosomes**
- When the male and female gametes fuse, they become a zygote (fertilised egg cell)
- This contains the full **46 chromosomes**, half of which came from the father and half from the mother – we say the zygote has a **diploid nucleus**

Advantages & Disadvantages of Sexual Reproduction

ADVANTAGES	DISADVANTAGES
INCREASES GENETIC VARIATION	TAKES TIME AND ENERGY TO FIND MATES
THE SPECIES CAN ADAPT TO NEW ENVIRONMENTS DUE TO VARIATION, GIVING THEM A SURVIVAL ADVANTAGE	DIFFICULT FOR ISOLATED MEMBERS OF THE SPECIES TO REPRODUCE
DISEASE IS LESS LIKELY TO AFFECT POPULATION (DUE TO VARIATION)	

- Most crop plants reproduce sexually and this is an advantage as it means **variation is increased** and a genetic variant may be produced which is better able to cope with weather changes, or produces significantly higher yield
- The disadvantage is that the variation may lead to offspring that are **less successful** than the parent plant at growing well or producing a good harvest

16 REPRODUCTION

16.2 SEXUAL REPRODUCTION IN PLANTS

YOUR NOTES

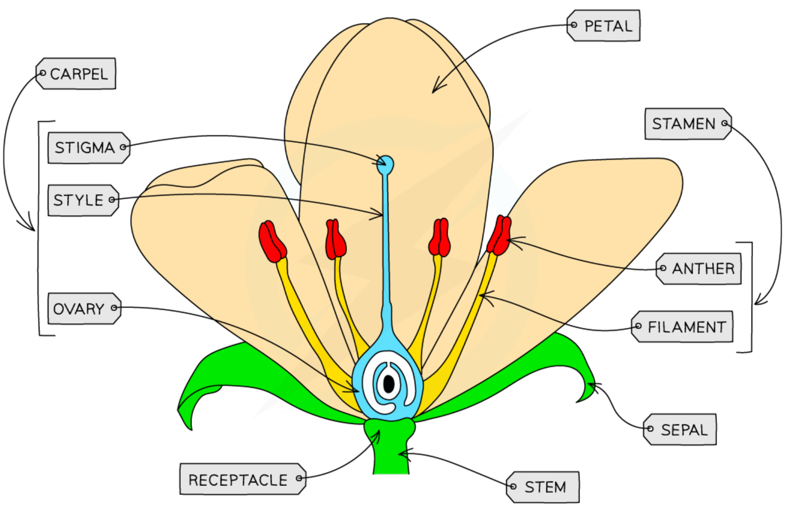
Flowers & Pollination

- Flowers are the **reproductive organ** of the plant
- They usually contain both male and female reproductive parts
- Plants produce **pollen** which contains a nucleus inside that is the **male gamete**
- Unlike the male gamete in humans (sperm), pollen is not capable of locomotion (moving from one place to another)
- This means plants have to have mechanisms in place to **transfer pollen from the anther to the stigma**
- This process is known as **pollination** and there are two main mechanisms by which it occurs: transferred by **insects** (or other animals like birds) or transferred by **wind**
- The structure of insect and wind-pollinated flowers are slightly different as each is adapted for their specific function

Parts of a Flower

STRUCTURE	DESCRIPTION
SEPAL	PROTECTS UNOPENED FLOWER
PETALS	BRIGHTLY COLOURED IN INSECT – POLLINATED FLOWERS TO ATTRACT INSECTS
ANTHER	PRODUCES AND RELEASES THE MALE SEX CELL (POLLEN GRAIN)
STIGMA	TOP OF THE FEMALE PART OF THE FLOWER WHICH COLLECTS POLLEN GRAINS
OVARY	PRODUCES THE FEMALE SEX CELL (OVUM)
OVULE	CONTAINS THE FEMALE SEX CELLS (FOUND INSIDE THE OVARY)

General flower structure

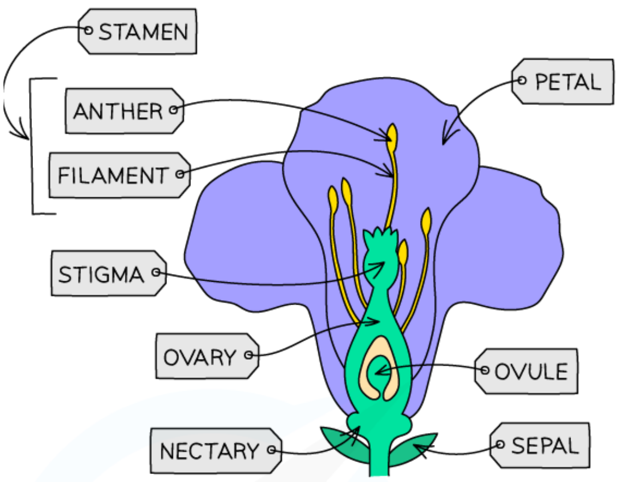


16 REPRODUCTION

YOUR NOTES

16.2 SEXUAL REPRODUCTION IN PLANTS cont...

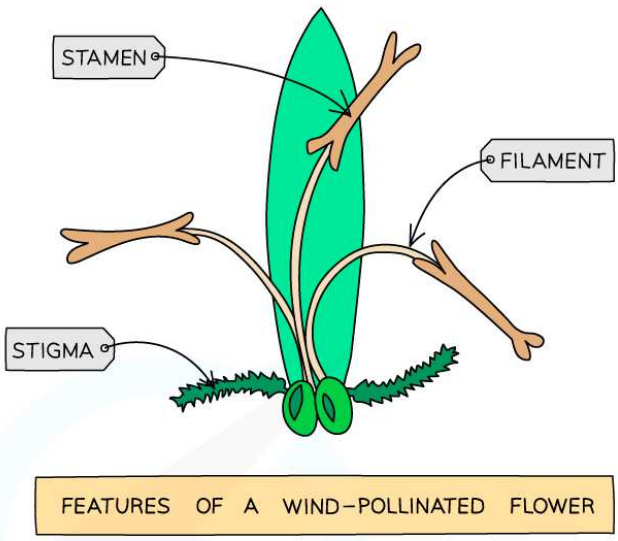
Adaptations for pollination

FEATURE	INSECT–POLLINATED
	 FEATURES OF AN INSECT–POLLINATED FLOWER
PETALS	LARGE AND BRIGHTLY COLOURED TO ATTRACT INSECTS
SCENT AND NECTAR	PRESENT – ENTICES INSECTS TO VISIT THE FLOWER AND PUSH PAST STAMEN TO GET TO NECTAR
NUMBER OF POLLEN GRAINS	MODERATE – INSECTS TRANSFER POLLEN GRAINS EFFICIENTLY WITH A HIGH CHANCE OF SUCCESSFUL POLLINATION
POLLEN GRAINS	LARGER, STICKY AND / OR SPIKY TO ATTACH TO INSECTS AND BE CARRIED AWAY
ANTHERS	INSIDE FLOWER, STIFF AND FIRMLY ATTACHED TO BRUSH AGAINST INSECTS
STIGMA	INSIDE FLOWER, STICKY SO POLLEN GRAINS STICK TO IT WHEN AN INSECT BRUSHES PAST

16 REPRODUCTION

16.2 SEXUAL REPRODUCTION IN PLANTS cont...

YOUR NOTES

FEATURE	WIND–POLLINATED
	
PETALS	SMALL AND DULL, OFTEN GREEN OR BROWN IN COLOUR
SCENT AND NECTAR	ABSENT – NO NEED TO WASTE ENERGY PRODUCING THESE AS NO NEED TO ATTRACT INSECTS
NUMBER OF POLLEN GRAINS	LARGE AMOUNTS – MOST POLLEN GRAINS ARE NOT TRANSFERRED TO ANOTHER FLOWER SO THE MORE PRODUCED, THE BETTER THE CHANCE OF SOME SUCCESSFUL POLLINATION OCCURRING
POLLEN GRAINS	SMOOTH, SMALL AND LIGHT SO THEY ARE EASILY BLOWN BY THE WIND
ANTHERS	OUTSIDE FLOWER, SWINGING LOOSE ON LONG FILAMENTS TO RELEASE POLLEN GRAINS EASILY
STIGMA	OUTSIDE FLOWER, FEATHERY TO CATCH DRIFTING POLLEN GRAINS

- The pollen produced by insect and wind-pollinated flowers is also different:
  - Insect-pollinated flowers produce **smaller amounts** of **larger, heavier** pollen grains that often contain **spikes or hooks** on the outside so they are better able to stick to insects
  - Wind-pollinated flowers produce **large amounts** of **small, lightweight** pollen grains that are usually **smooth**

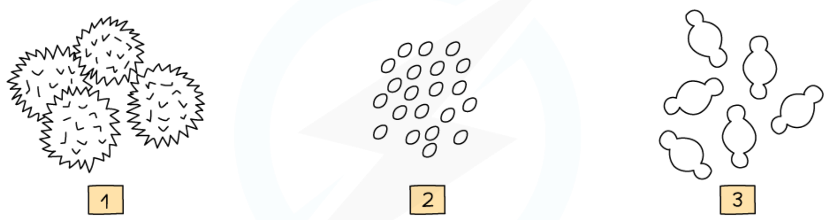
16 REPRODUCTION

YOUR NOTES

16.2 SEXUAL REPRODUCTION IN PLANTS cont...

Here is an example of a multiple-choice question asking students to use their knowledge to identify types of pollen grain:

THE DIAGRAMS SHOW POLLEN GRAINS FROM THREE DIFFERENT SPECIES OF PLANT AS THEY APPEAR UNDER THE MICROSCOPE.
THE DIAGRAMS ARE ALL TO THE SAME SCALE.



WHICH POLLEN GRAINS ARE INVOLVED IN INSECT-POLLINATION?

A. 1 AND 2 B. 1 ONLY C. 2 AND 3 D. 3 ONLY

A multiple-choice question asking students to use their knowledge to identify types of pollen grain

EXTENDED ONLY

Self & Cross-Pollination

- Cross-pollination occurs when the **pollen from one plan**t is transferred to the stigma of **another plant of the same species**
- This is the way most plants carry out pollination as it **improves genetic variation**
- Occasionally, the pollen from a flower can **land on its own stigma** or on the **stigma of another flower on the same plant** – this is known as self-pollination
- Self-pollination **reduces genetic variety of the offspring** as all the gametes come from the same parent (and are therefore genetically identical)
- Lack of variation in the offspring is a disadvantage if environmental conditions change, as it is **less likely that any offspring will have adaptations that suit the new conditions** well
- On the other hand, cross-pollination relies completely on the presence of pollinators and this can be a problem if those **pollinators** are **missing** (eg the reduction in **bee** numbers is of great importance to humans as bees pollinate a large number of food crops) – this doesn't apply to wind-pollinated plants

16 REPRODUCTION

16.2 SEXUAL REPRODUCTION IN PLANTS cont...

YOUR NOTES

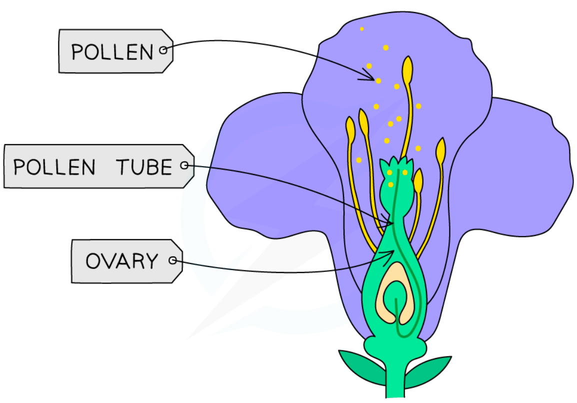
Fertilisation: Basics

- Fertilisation occurs when a **pollen nucleus fuses with an ovum nucleus** in the ovule

EXTENDED ONLY

Fertilisation

- As the pollen has no 'tail' to swim to the ovary of a plant, in order to reach the 'female' nucleus in the ovary it has to grow a **pollen tube**
- This only happens if the pollen grain has landed on the right kind of stigma (i.e. of the same species as the flower the pollen came from)
- The nucleus inside the pollen grain **slips down the tube** as it grows down the style towards the ovary
- The ovary contains one or more **ovules** which each contain an ovum with a female nucleus that a male pollen nucleus can fuse with
- Once the nuclei (pl) have joined together, that ovule has been fertilised and a **zygote** has been formed
- The zygote will start to divide and eventually form a **seed** within the ovule
- As different plants have different numbers of ovules, this explains why different fruits (which develop from the ovary) have different numbers of seeds (which develop from the ovules)

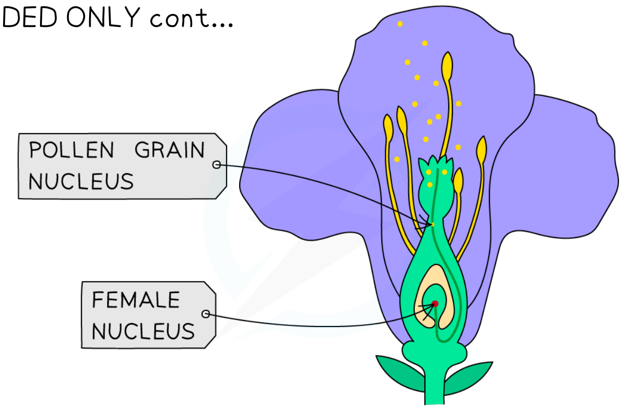


Growth of a pollen tube

16 REPRODUCTION

16.2 SEXUAL REPRODUCTION IN PLANTS cont...

EXTENDED ONLY cont...



Fertilisation in a flowering plant

EXAM TIP

Students often get confused between pollination and fertilisation in plants, but they are not the same thing.

Think of pollination as the plant's equivalent to human sexual intercourse – after sex, the male sex cells (sperm) have been deposited into the female.

But, for fertilisation to occur, the **nucleus from a male sperm cell has to fuse with the nucleus of a female sex cell** (egg) and the sperm has to travel to find the egg before this happens. It's exactly the same in plants!

16.3 GERMINATION

Factors Affecting Germination

- **Germination** is the **start of growth in the seed**
- Three factors are required for successful germination:
  - **Water** – allows the seed to swell up and the enzymes in the embryo to start working so that growth can occur
  - **Oxygen** – so that energy can be released for germination
  - **Warmth** – germination improves as temperature rises (up to a maximum) as the reactions which take place are controlled by enzymes
- As carbon dioxide is not necessary for germination but also does not inhibit it, it makes no difference whether it is present or not

YOUR NOTES

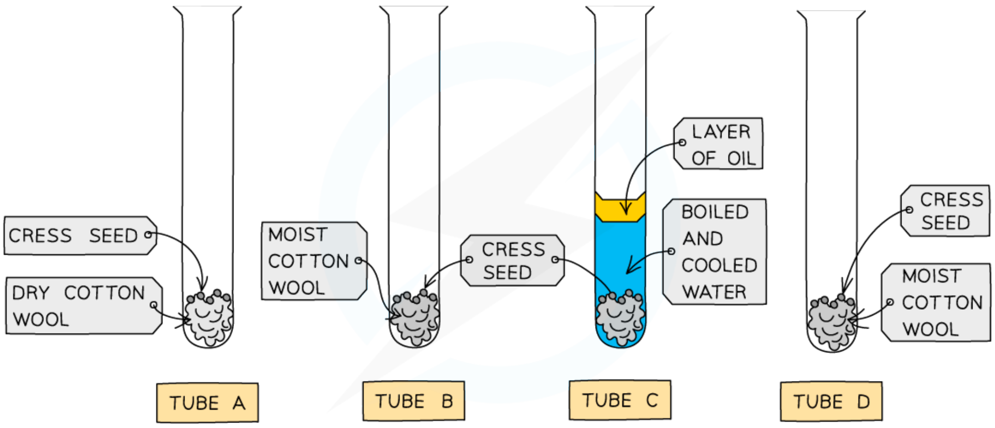
16 REPRODUCTION

16.3 GERMINATION cont...

YOUR NOTES

Investigating Germination

- Set up 4 boiling tubes each containing 10 cress seeds on cotton wool
- Set each test tube as shown in diagram below
- Leave tubes in set environment for a period of time: A, B and C incubated at 20°C; D placed in a fridge at 4°C
- Compare results and see which tube has the greatest number of germinated seeds



Conditions required for germination

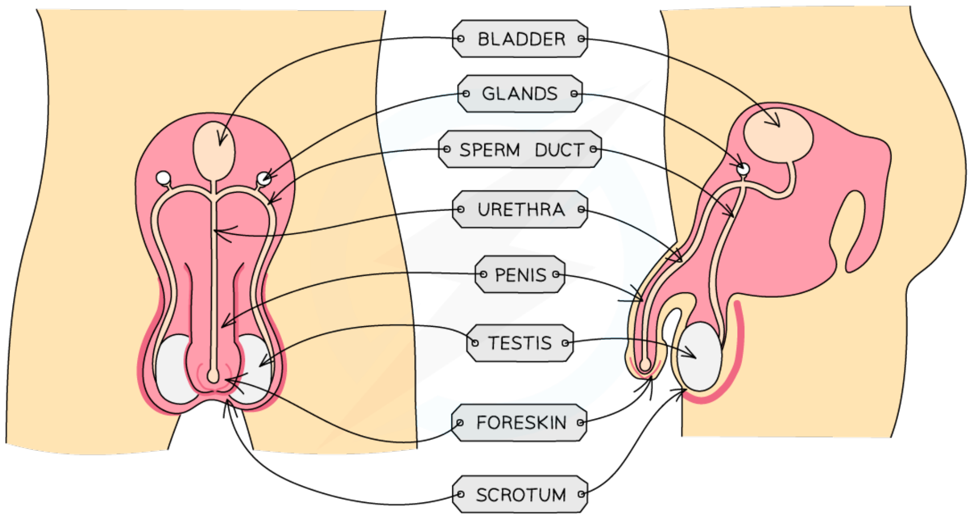
TEST TUBE	FACTOR BEING TESTED	SEEDS GERMINATED
A	WATER / MOISTURE	NO
B	CONTROL (ALL FACTORS PRESENT)	YES
C	OXYGEN	NO
D	WARM TEMPERATURE	NO

16 REPRODUCTION

16.4 SEXUAL REPRODUCTION IN HUMANS

YOUR NOTES

The Male Reproductive System



Male reproductive structures

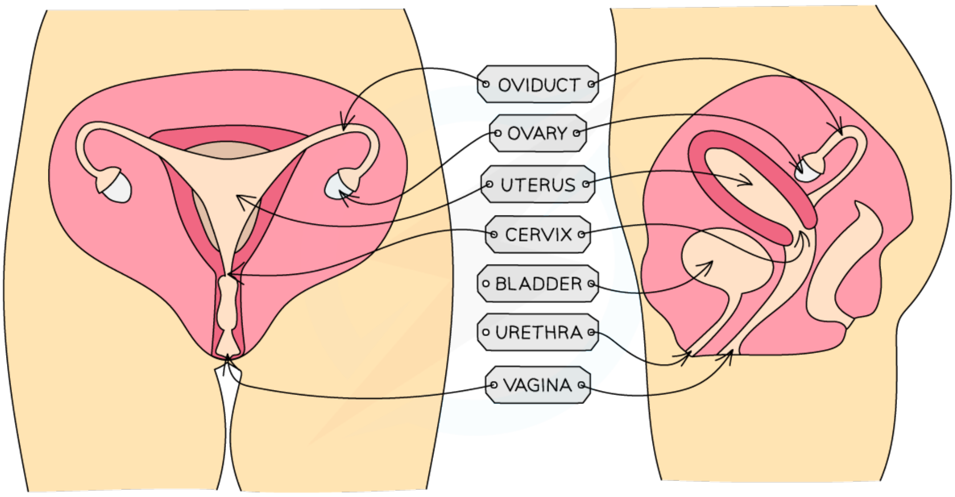
STRUCTURE	FUNCTION
PROSTATE GLAND	PRODUCES FLUID CALLED SEMEN THAT PROVIDE SPERM CELLS WITH NUTRIENTS
SPERM DUCT	SPERM PASSES THROUGH THE SPERM DUCT TO BE MIXED WITH FLUIDS PRODUCED BY THE GLANDS BEFORE BEING PASSED INTO THE URETHRA FOR EJACULATION
URETHRA	TUBE RUNNING DOWN THE CENTRE OF THE PENIS THAT CAN CARRY OUT URINE OR SEMEN, A RING OF MUSCLE IN THE URETHRA PREVENTS THE URINE AND SEMEN FROM MIXING
TESTIS	CONTAINED IN A BAG OF SKIN (SCROTUM) AND PRODUCES SPERM (MALE GAMETE) AND TESTOSTERONE (HORMONE)
SCROTUM	SAC SUPPORTING THE TESTES OUTSIDE THE BODY TO ENSURE SPERM ARE KEPT AT TEMPERATURE SLIGHTLY LOWER THAN BODY TEMPERATURE
PENIS	PASSES URINE OUT OF THE BODY FROM THE BLADDER AND ALLOWS SEMEN TO PASS INTO THE VAGINA OF A WOMAN DURING SEXUAL INTERCOURSE

16 REPRODUCTION

16.4 SEXUAL REPRODUCTION IN HUMANS cont...

YOUR NOTES

The Female Reproductive System



Female reproductive structures

STRUCTURE	FUNCTION
OVIDUCT	CONNECTS THE OVARY TO THE UTERUS AND IS LINED WITH CILIATED CELLS TO PUSH THE RELEASED OVUM DOWN IT. FERTILISATION OCCURS HERE
OVARY	CONTAINS OVA (FEMALE GAMETES) WHICH WILL MATURE AND DEVELOP WHEN HORMONES ARE RELEASED
UTERUS	MUSCULAR BAG WITH A SOFT LINING WHERE THE FERTILISED EGG (ZYGOTE) WILL BE IMPLANTED TO DEVELOP INTO A FOETUS
CERVIX	RING OF MUSCLE AT THE LOWER END OF THE UTERUS TO KEEP THE DEVELOPING FOETUS IN PLACE DURING PREGNANCY
VAGINA	MUSCULAR TUBE THAT LEADS TO THE INSIDE OF THE WOMAN'S BODY, WHERE THE MALE'S PENIS WILL ENTER DURING SEXUAL INTERCOURSE AND SPERM ARE DEPOSITED

16 REPRODUCTION

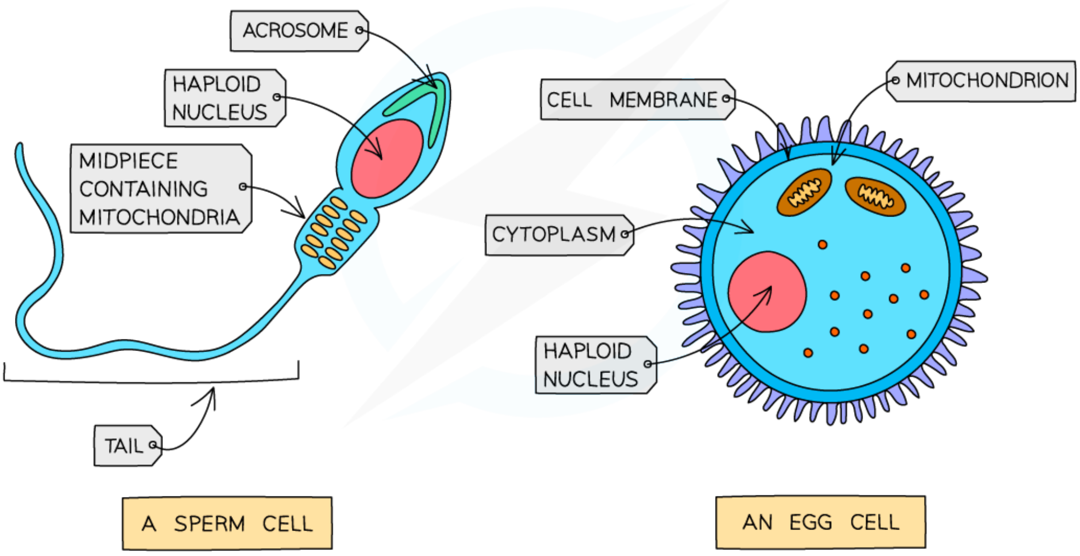
YOUR NOTES

16.4 SEXUAL REPRODUCTION IN HUMANS cont...

Gametes & Fertilisation

- Fertilisation is the **fusion of the nuclei from a male gamete (sperm cell) and a female gamete (egg cell)**
- It occurs in the **oviducts**
- Gametes have **adaptations** to increase the chances of fertilisation and successful development of an embryo

SPERM CELL	EGG CELL
HAS A FLAGELLUM (TAIL)	CYTOPLASM CONTAINING A STORE OF ENERGY
CONTAINS ENZYMES IN THE HEAD REGION (ACROSOME)	JELLY–LIKE COATING THAT CHANGES AFTER FERTILISATION



Comparing sperm and egg cells

16 REPRODUCTION

16.4 SEXUAL REPRODUCTION IN HUMANS cont...

YOUR NOTES

EXTENDED ONLY

Adaptations of Gametes Explained

GAMETE	ADAPTIVE FEATURE	REASON
SPERM	HAS A FLAGELLUM (TAIL)	ENABLES IT TO SWIM TO THE EGG
	CONTAINS ENZYMES IN THE HEAD REGION (ACROSOME)	TO DIGEST THROUGH THE JELLY COAT AND CELL MEMBRANE OF AN EGG CELL WHEN IT MEETS ONE
	CONTAINS MANY MITOCHONDRIA	PROVIDE ENERGY FROM RESPIRATION SO THAT THE FLAGELLUM CAN MOVE BACK AND FORTH FOR LOCOMOTION
EGG	CYTOPLASM CONTAINING A STORE OF ENERGY	PROVIDES ENERGY FOR THE DIVIDING ZYGOTE AFTER FERTILISATION
	JELLY LIKE COATING THAT CHANGES AFTER FERTILISATION	FORMS AN IMPENETRABLE BARRIER AFTER FERTILISATION TO PREVENT OTHER SPERM NUCLEI ENTERING THE EGG CELL

Comparison of Male & Female Gametes

	SPERM	EGG
SIZE	VERY SMALL (45 μm)	LARGE (0.2mm)
STRUCTURE	HEAD REGION AND FLAGELLUM, MANY STRUCTURAL ADAPTATIONS	ROUND CELL WITH FEW STRUCTURAL ADAPTATIONS, COVERED IN A JELLY COATING
MOTILITY	CAPABLE OF LOCOMOTION	NOT CAPABLE OF LOCOMOTION
NUMBERS	PRODUCED EVERY DAY IN HUGE NUMBERS (AROUND 100 MILLION PER DAY)	THOUSANDS OF IMMATURE EGGS IN EACH OVARY, BUT ONLY ONE RELEASED EACH MONTH

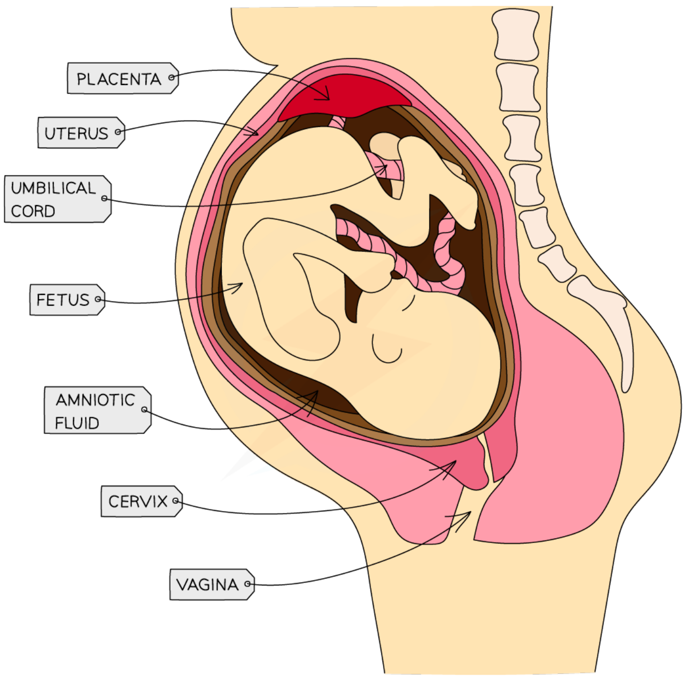
16 REPRODUCTION

16.5 PREGNANCY & BIRTH

YOUR NOTES

Growth & Development of the Fetus

- After fertilisation in the **oviduct**, the zygote travels towards the **uterus**
- This takes about 3 days, during which time the zygote will divide several times to form a ball of cells known as an **embryo**
- In the uterus, the embryo embeds itself in the thick lining (**implantation**) and continues to grow and develop
- The gestation period for humans is **9 months**
- Major **development of organs** takes place within the **first 12 weeks**, during which time the embryo gets nutrients from the mother by **diffusion through the uterus lining**
- After this point the organs are all in place, the **placenta** has formed and the embryo is now called a **fetus**
- The remaining gestation time is used by the fetus to **grow bigger in size**



The fetus in the uterus

- The fetus is surrounded by an **amniotic sac** which contains **amniotic fluid** (made from the mother's blood plasma)
- This protects the fetus during development by **cushioning it from bumps** to the mother's abdomen
- The **umbilical cord** joins the fetus's blood supply to the **placenta** for exchange of nutrients and removal of waste products

16 REPRODUCTION

16.5 PREGNANCY & BIRTH cont...

YOUR NOTES

EXTENDED ONLY

The Placenta

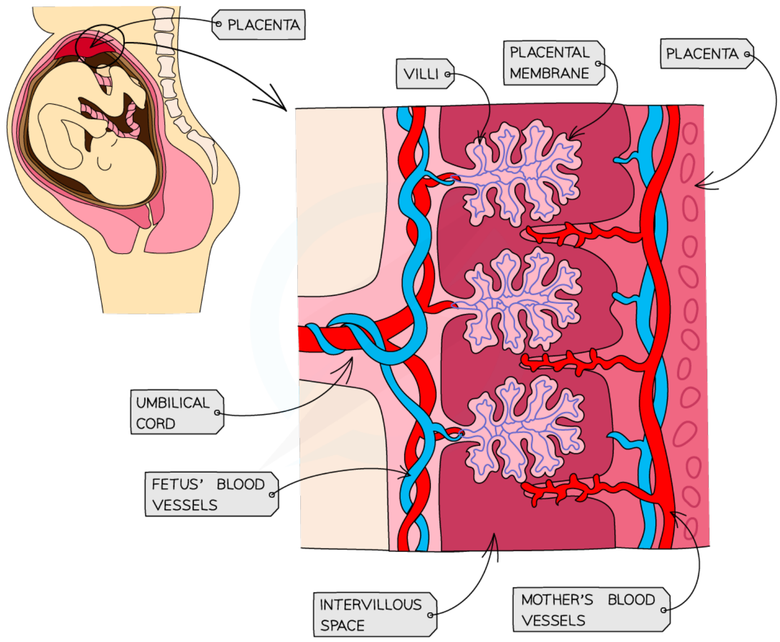
- During the gestation period the fetus develops and grows by gaining the **glucose, amino acids, fats, water** and **oxygen** it needs from the mother's blood
- The bloods run opposite each other, never mixing, in the **placenta**
- The fetus's blood connects to and from the placenta by the **umbilical cord**
- The mother's blood also absorbs the **waste** from the fetus's blood in the placenta; substances like **carbon dioxide** and **urea** are removed from the fetus's blood so that they do not build up to dangerous levels
- Movement of all molecules across the placenta occurs by **diffusion** due to **difference in concentration gradients**
- The placenta is adapted for this diffusion by having a **large surface area** and a **thin wall** for efficient diffusion
- The placenta acts as a **barrier** to prevent toxins and pathogens getting into the fetus's blood
- Not all **toxin molecules** or **pathogenic organisms** (such as **viruses**, eg **rubella**) are stopped from passing through the placenta (this usually depends on the size of the molecule)
- This is why pregnant women are advised **not to smoke during pregnancy** as molecules like **nicotine** can pass across the placenta
- After the baby has been born, the **umbilical cord is cut** – this does not hurt as there are no nerves in it, just two blood vessels
- It is tied off to prevent bleeding and shrivels up and falls off after a few days leaving the belly button behind
- The placenta detaches from the uterus wall shortly after birth and is pushed out due to contractions in the muscular wall of the uterus – known as the **afterbirth**

16 REPRODUCTION

16.5 PREGNANCY & BIRTH cont...

YOUR NOTES

EXTENDED ONLY cont...



The placenta

EXAM TIP

It is worth learning at least **two specific substances** that move in either direction across the placenta

This is a common exam question and non-specific answers such as 'waste products' and 'nutrients' will not get any marks!

Stages of Birth

- Amniotic sac breaks
- Muscles in the uterus wall contract
- Cervix dilates (gets wider)
- Baby passes out through the vagina
- Umbilical cord is tied and cut
- Afterbirth is delivered

YOUR NOTES

16.5 PREGNANCY & BIRTH cont...

Antenatal Care

- Antenatal (**before birth**), care is the name given to the care and advice given to expectant mothers along with checks on fetal growth and development
- Whilst pregnant, expectant mothers are given advice on:
  - **diet** including the need to take **folic acid** to prevent developmental issues with the fetus and the importance of a **balanced diet**
  - **exercise** to stay fit
  - health precautions such as avoiding infections, **tobacco**, **alcohol** and other **drugs**

EXTENDED ONLY

Breastfeeding

- During pregnancy the mammary glands enlarge and become prepared to secrete milk
- Shortly after birth, the mother will be stimulated to release milk due to the sucking action of the baby at the breast
- Some mothers struggle to breastfeed successfully and so may feed the baby using formula milk in a bottle

TYPE OF FEEDING	ADVANTAGES	DISADVANTAGES
BREASTFEEDING	CONTAINS EXACTLY THE RIGHT NUTRIENTS IN THE RIGHT AMOUNTS THE BABY NEEDS AT DIFFERENT STAGES	IF IT DOES NOT COME EASILY TO THE MOTHER IT CAN CONTRIBUTE TO POSTNATAL DEPRESSION
	CONTAINS ANTIBODIES WHICH HELP THE BABY PREVENT INFECTION	RESPONSIBILITY FOR FEEDING THE BABY IS SOLELY WITH THE MOTHER
	HELPS DEVELOP A BOND BETWEEN MOTHER AND BABY	
	IS FREE	
BOTTLE FEEDING	ALLOWS THE FATHER TO BOND WITH THE BABY	RISK OF INFECTION IS INCREASED IF BOTTLES AND EQUIPMENT ARE NOT PROPERLY STERILISED
	ALLOWS THE MOTHER MORE FREEDOM AS SHE IS NOT SOLELY RESPONSIBLE FOR FEEDING THE BABY	IS EXPENSIVE

16 REPRODUCTION

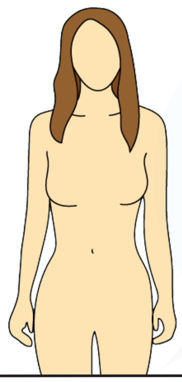
16.6 HUMAN SEX HORMONES

Secondary Sexual Characteristics

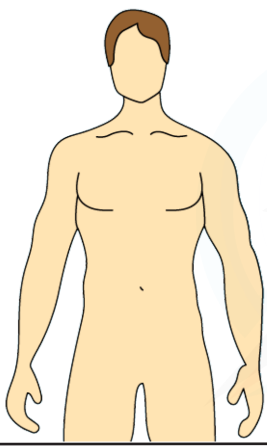
YOUR NOTES

- Primary sexual characteristics are present during development in the uterus and are the differences in reproductive organs etc between males and females
- Secondary sexual characteristics are the **changes that occur during puberty** as children become adolescents
- They are controlled by the release of **hormones – oestrogen** in girls and **testosterone** in boys

Female secondary sexual characteristics

FEMALE	EFFECTS OF OESTROGEN
	BREASTS DEVELOP
	BODY HAIR GROWS
	MENSTRUAL CYCLE BEGINS
	HIPS GET WIDER

Male secondary sexual characteristics

MALE	EFFECTS OF TESTOSTERONE
	GROWTH OF PENIS & TESTES
	GROWTH OF FAACIAL & BODY HAIR
	MUSCLES DEVELOP
	VOICE BREAKS
	TESTES START TO PRODUCE SPERM

- Some changes occur to both boys and girls, including **growth of sexual organs** and **growth of body hair**
- **Emotional changes** also occur due to the increased levels of hormones in the body
- These include more interest in sex and increased mood swings

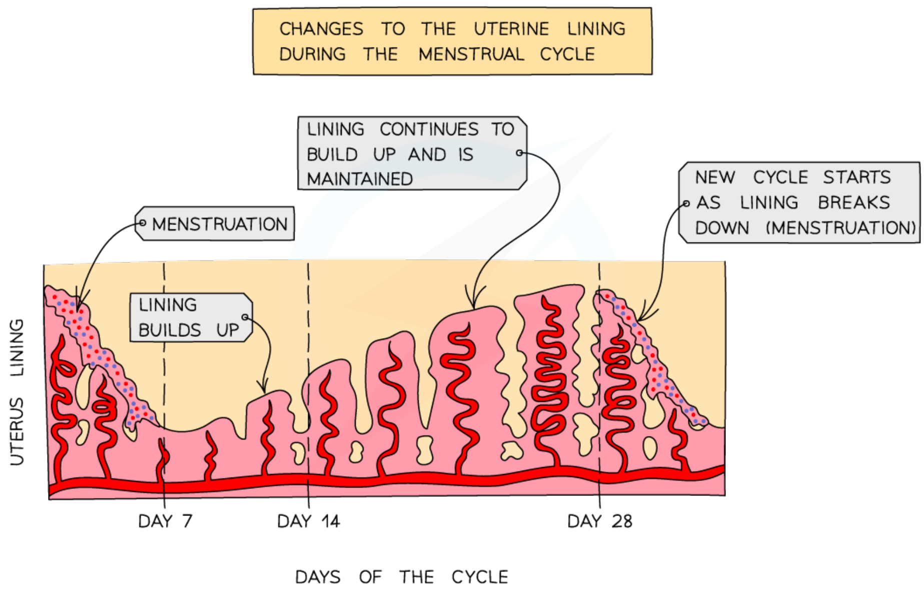
16 REPRODUCTION

YOUR NOTES

16.6 HUMAN SEX HORMONES cont...

The Menstrual Cycle

- Starts in early adolescence in girls (around age 12) and is controlled by **hormones**
- The average menstrual cycle is **28 days** long
- **Ovulation** (the release of an egg) occurs about **halfway** through the cycle (day **14**) and the egg then travels down the oviduct to the uterus
- Failure to fertilise the egg causes **menstruation** (commonly called a period) to occur – this is caused by the **breakdown of the thickened lining of the uterus**
- Menstruation lasts around **5 – 7 days** and signals the beginning of the next cycle
- After menstruation finishes, the lining of the uterus starts to thicken again in preparation for possible implantation in the next cycle



Changes in the lining of the uterus during the menstrual cycle

EXTENDED ONLY

Hormonal Control of the Menstrual Cycle

- The menstrual cycle is controlled by hormones released from the **ovary** and the **pituitary gland** in the brain

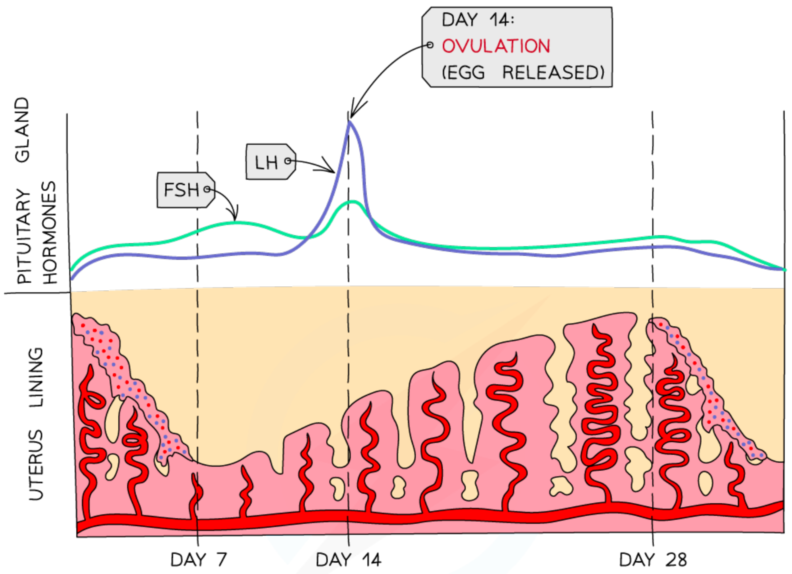
16 REPRODUCTION

16.6 HUMAN SEX HORMONES cont...

YOUR NOTES

EXTENDED ONLY cont...

FSH and LH



FSH	– STIMULATES EGG MATURATION IN THE FOLLICLES OF THE OVARY – STIMULATES FOLLICLES IN THE OVARIES TO SECRETE OESTROGEN

LH	– AT ITS PEAK STIMULATES OVULATION (RELEASE OF EGG INTO OVIDUCT) – RESULTS IN THE FORMATION OF A CORPEUS LUTEUM

Changes in the levels of the pituitary hormones FSH and LH in the blood during the menstrual cycle

- **FSH** (**f**ollicle **s**timulating **h**ormone) is released by the **pituitary gland** and causes an **egg to start maturing** in the ovary
- It also **stimulates the ovaries** to start releasing **oestrogen**
- The **pituitary gland** is stimulated to release **l**uteinising **h**ormone (**LH**) when **oestrogen** levels have reached their peak
- **LH** causes **ovulation to occur** and also **stimulates the ovary** to produce **progesterone**

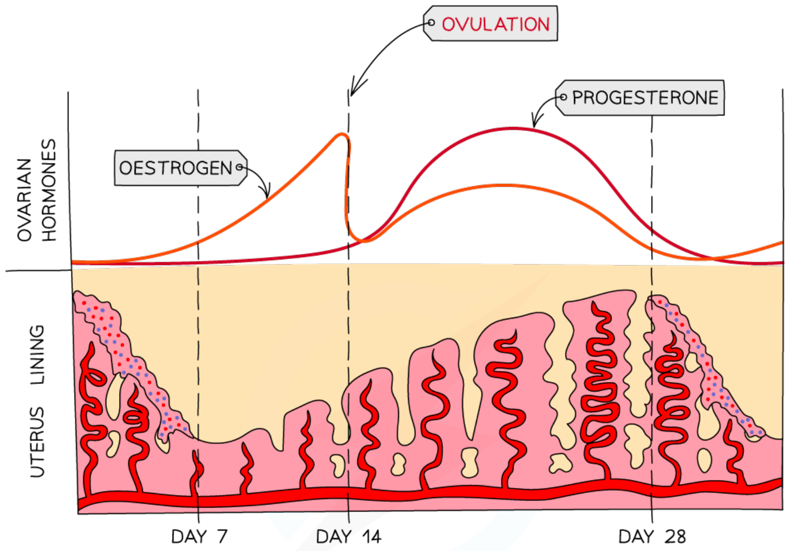
16 REPRODUCTION

16.6 HUMAN SEX HORMONES cont...

YOUR NOTES

EXTENDED ONLY cont...

The roles of oestrogen and progesterone



OESTROGEN	– STIMULATES THE UTERUS TO DEVELOP A LINING (TO REPLACE THE LINING LOST DURING MENSTRUATION) – POST–OVULATION, INHIBITS FSH AND LH PRODUCTION IN THE PITUITARY GLAND

PROGESTERONE	– MAINTAINS AND THICKENS LINING OF THE UTERUS – INHIBITS FSH AND LH PRODUCTION – IF FERTILISATION DOESN'T OCCUR, LEVELS DROP AND MENSTRUATION OCCURS.

Changes in the levels of oestrogen and progesterone in the blood during the menstrual cycle

- **Oestrogen** levels rise from day 1 to peak just before **day 14**
- This causes the **uterine wall to start thickening** and the **egg to mature**
- The peak in oestrogen occurs just before the egg is released
- **Progesterone** stays low from day 1 – 14 and starts to rise once ovulation has occurred
- The increasing levels **cause the uterine lining to thicken further**; a fall in progesterone levels causes the uterine lining to break down (**menstruation** / '**period**')

16 REPRODUCTION

16.6 HUMAN SEX HORMONES cont...

YOUR NOTES

EXTENDED ONLY cont...

Interaction between all four of the menstrual cycle hormones

- The pituitary gland produces **FSH** which stimulates the development of a **follicle** in the ovary
- An egg develops inside the follicle and the follicle produces the hormone **oestrogen**
- Oestrogen causes **growth and repair of the lining of the uterus wall** and inhibits production of **FSH**
- When oestrogen rises to a high enough level it stimulates the release of LH from the pituitary gland which causes **ovulation** (usually around day 14 of the cycle)
- The follicle becomes the **corpus luteum** and starts producing **progesterone**
- Progesterone **maintains the uterus lining** (the thickness of the uterus wall)
- If the ovum is not fertilised, the corpus luteum breaks down and progesterone levels drop
- This causes **menstruation**, where the uterus lining breaks down and is removed through the vagina – commonly known as having a period
- If pregnancy does occur the corpus luteum **continues to produce progesterone**, preventing the uterus lining from breaking down and **aborting** the pregnancy
- It does this until the **placenta** has developed, at which point it starts secreting progesterone and **continues to do so throughout the pregnancy**

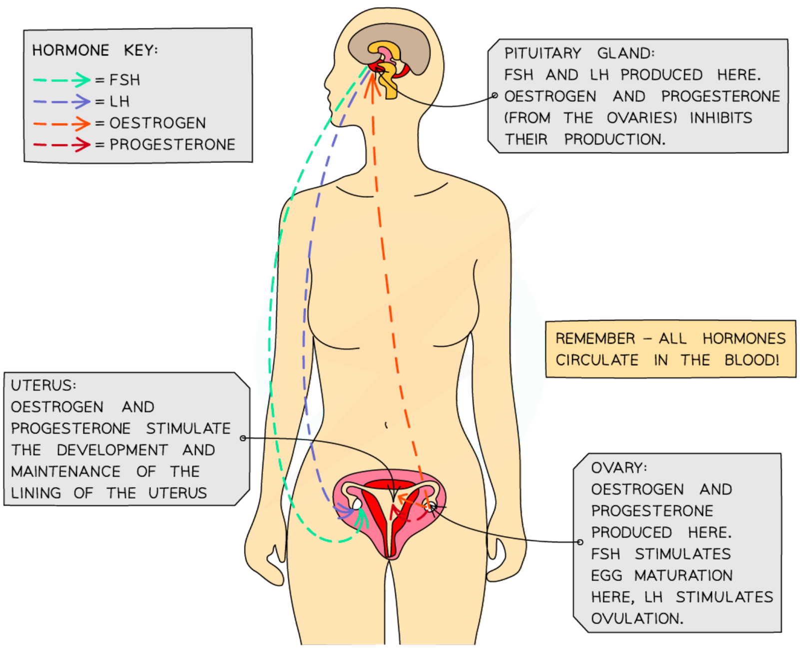


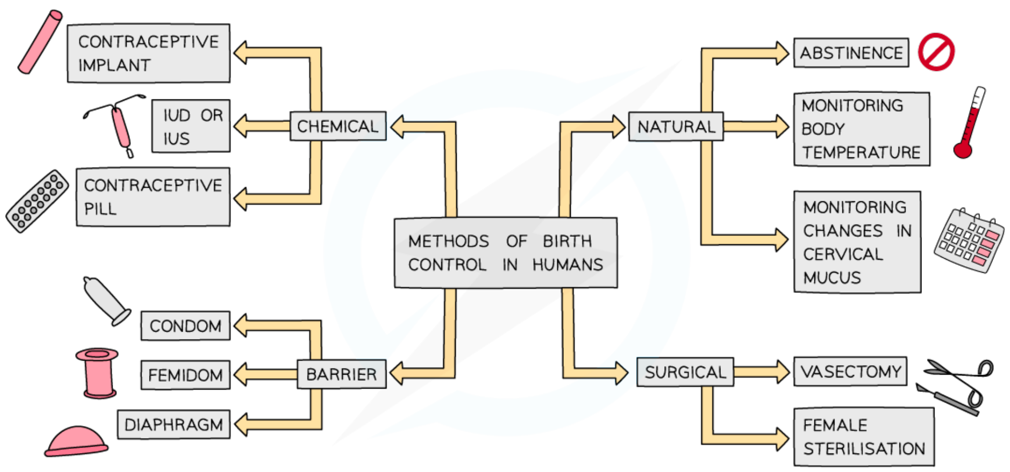
Diagram showing where hormones involved in the menstrual cycle are made and act

16 REPRODUCTION

16.7 CONTRACEPTION & FERTILITY

YOUR NOTES

Types of Birth Control



- Birth control methods are important in **keeping family sizes small** and in **limiting the increase in human population**
- Humans can use mechanical, chemical, surgical and natural contraceptive methods to prevent a pregnancy
- Some birth control methods also give protection from **sexually transmitted infections**

Natural

- **Abstinence**
  - avoiding sexual intercourse completely
- **Rhythm method**
  - avoiding sexual intercourse during the fertile period of the menstrual cycle when ovulation occurs
  - the exact time ovulation happens can be worked out by monitoring body temperature and quality of cervical mucus
  - this is the least reliable method of birth control

Chemical

- **IUD / IUS**
  - an intrauterine device or intrauterine system is a small device fitted inside the uterus by a doctor or nurse
  - it releases sex hormones which thicken the mucus produced in the cervix, making it difficult for sperm to swim into the uterus

16 REPRODUCTION

YOUR NOTES

16.7 CONTRACEPTION & FERTILITY cont...

- it also thins the lining of the uterus, making it more difficult for a fertilised egg to implant
- an IUD also interferes with passage of sperm through the uterus, in which way it is acting as a barrier method of birth control

- **Contraceptive pill, implant, injection**
  - may contain just progesterone or a mixture of progesterone and oestrogen
  - very effective when taken regularly
  - the hormones can also be delivered from a small skin implant or an injection, both of which last several months and increase the effectiveness as they remove the risk of forgetting to take a pill regularly

Barrier

- These all work by preventing sperm from reaching the egg
- **Condom**
  - latex sheath worn over the penis
  - prevents sperm entering the vagina as ejaculate remains in condom
  - also protects against STIs
- **Femidom**
  - latex sheath inserted into the vagina
  - prevents entry of sperm into the vagina
- **Diaphragm**
  - a rubber cap that fits over the entrance to the cervix
  - prevents entry of sperm into uterus
  - often used with a spermicide (cream which kills sperm)

Surgical

- **Vasectomy**
  - the sperm ducts are cut, meaning that no sperm is present in the semen when ejaculation occurs
  - very effective but difficult to reverse
- **Female sterilisation (tubal ligation)**
  - the oviducts are cut or tied off, preventing eggs from reaching the uterus or sperm from reaching the eggs
  - very effective but difficult to reverse

16 REPRODUCTION

16.7 CONTRACEPTION & FERTILITY

YOUR NOTES

EXTENDED ONLY

How Do Contraceptive Hormones in The Pill Work?

- They work by mimicking some of the hormone levels during pregnancy
- By raising the levels of progesterone and oestrogen, the uterus lining is maintained and development of another egg cell is prevented
- This means that sex at any time of the month cannot cause pregnancy as no egg is released to be fertilised

Fertility Treatments

- In situations where couples find it difficult to conceive, fertility treatments can improve their chances
- There are several different options, depending on what the fertility issue is

Artificial Insemination (AI)

- If the male is **not producing healthy sperm**, donor sperm can be used
- The sperm are placed into the female's vagina at the fertile point in her menstrual cycle
- **Social issues to consider include:**
    - The male must be able to cope with the fact that the child is not biologically his
    - Sperm donors may father multiple children who are not able to know their parentage

Fertility Drugs

- This method is used when the **female is not producing enough eggs**
- Hormones, including FSH, are given to her to **stimulate egg production**
- **Social issues to consider include:**
    - Several eggs can be released at once so this increases the chance of multiple births (twins or triplets etc)

16 REPRODUCTION

16.7 CONTRACEPTION & FERTILITY cont...

YOUR NOTES

EXTENDED ONLY

In Vitro Fertilisation (IVF)

- If the female cannot conceive naturally even after taking fertility drugs, or if there are issues with both male and female fertility in a couple, **IVF** can be used
- This involves fertility drugs being given to the female to stimulate egg production before they are **harvested from the ovary**
- The eggs are then **inseminated in a petri dish** using sperm from the male ('in vitro' means 'in glass') and, **once embryos have formed**, they are **placed back into the uterus** of the female
- **Several embryos are implanted** to increase the chance of one developing further
- **Social issues to consider include:**
    - IVF is relatively expensive and not all couples can afford it
    - As several embryos are implanted, the risk of multiple births is quite high
    - Some women use IVF to get pregnant at a later age than they would be able to conceive naturally

16.8 SEXUALLY TRANSMITTED INFECTIONS

STIs & HIV / AIDS

- Unprotected sexual intercourse can lead to the transfer of pathogens via exchange of body fluids
- Infections passed on in this way are known as sexually transmitted infections (STIs)
- An example of an STI is HIV, the virus that usually leads to the development of acquired immunodeficiency disease (AIDS)
- HIV can also be spread via sharing needles with an infected person, blood transfusions with infected blood and from mother to fetus through the placenta and mother to baby via breastfeeding

16 REPRODUCTION

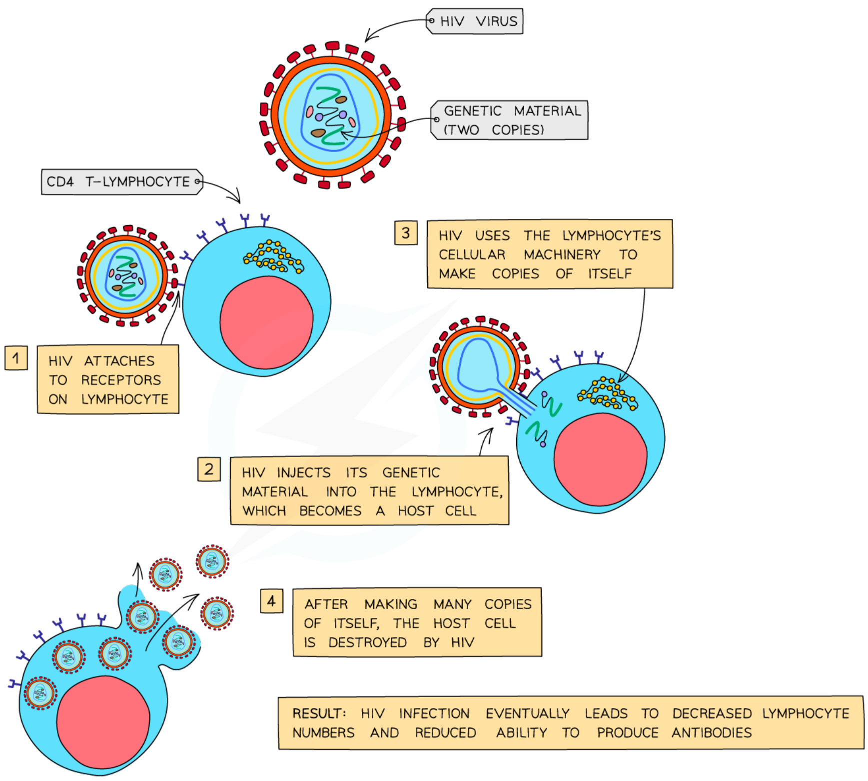
16.8 SEXUALLY TRANSMITTED INFECTIONS cont...

YOUR NOTES

EXTENDED ONLY

How HIV Affects the Immune System

- Immediately after infection, people often suffer **mild flu-like symptoms**
- These symptoms pass and for a period of time **infected people might not know they are infected**
- The virus infects a certain type of **lymphocyte** of the body's immune system
- Normally lymphocytes **seek out and destroy pathogens** that enter the body, producing antibodies that attach to pathogens, enhancing phagocytic activity
- However HIV avoids being recognised and destroyed by lymphocytes by repeatedly **changing its protein coat**
- It then infects a certain type of lymphocyte and **uses the cells' machinery to multiply**
- This **reduces the number of lymphocytes** of the immune system, and also **the number of antibodies** that can be made
- This decreases the body's ability to fight off infections, eventually leading to **AIDS (Acquired immunodeficiency)**



How HIV affects lymphocytes

16 REPRODUCTION

16.8 SEXUALLY TRANSMITTED INFECTIONS cont...

YOUR NOTES

Controlling the Spread of STIs

- The spread of STIs such as HIV are best controlled by:
  - **Limiting the number of sexual partners** an individual has
  - **Not having unprotected sex**, but making sure to always use a **condom**
  - **Getting tested** if unprotected sex or sex with multiple partners has occurred
  - Raising awareness by **education programmes**

> NOW TRY SOME EXAM QUESTIONS

16 REPRODUCTION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

During birth the following processes happen

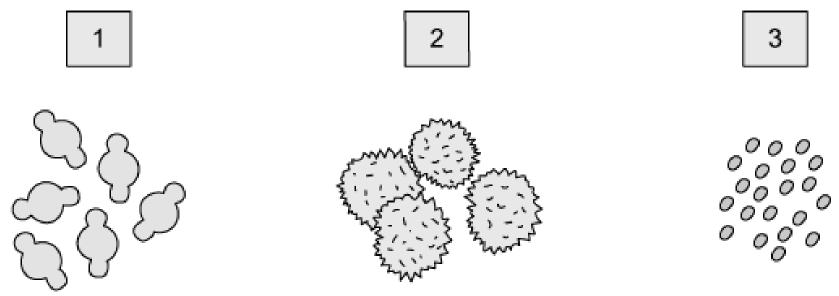
1. Breaking of the amniotic sac
2. Contraction of the muscles in the uterine wall
3. Cutting of the umbilical cord

In which order do these processes usually occur?

A 2 → 3 → 1 **B** 2 → 1 → 3 **C** 3 → 1 → 2 **D** 3 → 2 → 1

QUESTION 2

The diagrams show 3 different species of pollen grains as they appear under a microscope. The diagrams are all to the same scale.



Which pollen grains are involved in insect pollination?

A 1 and 2

B 2 and 3

C 2 only

D all of them

16 REPRODUCTION

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 3

The table below shows some advantaged and disadvantages of sexual and asexual reproduction.

Which row is correct?

	advantage of sexual reproduction	advantage of asexual reproduction
A	less population growth	only one parent needed
B	more energy efficient	gametes can be transferred by the environment
C	no transfer of gametes	does not compete with parent for nutrients
D	more genetic variation	faster

QUESTION 4

Students were discussing how to remember the difference between two groups of cells, 'many, minute and motile' or 'few, fat and fixed'

What group of cells were they referring to?

A male and female gametes

B animal and plant cells

C red and white blood cells

D xylem and phloem cells

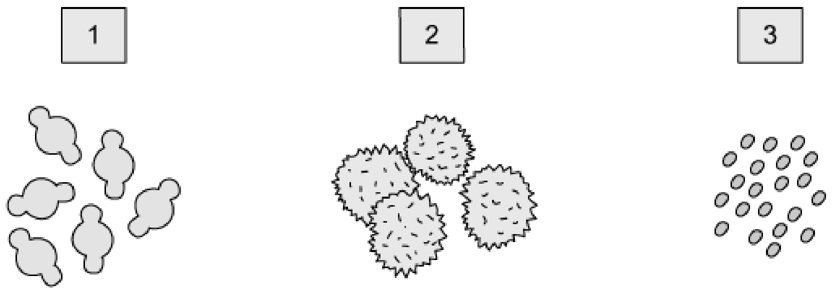
16 REPRODUCTION

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5

The diagram below shows a flower.



Which of these processes have taken place?

	pollination	fertilisation
A	no	no
B	no	yes
C	yes	yes
D	yes	no

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK

Head to savemyexams.co.uk
for more questions and revision notes

17 INHERITANCE

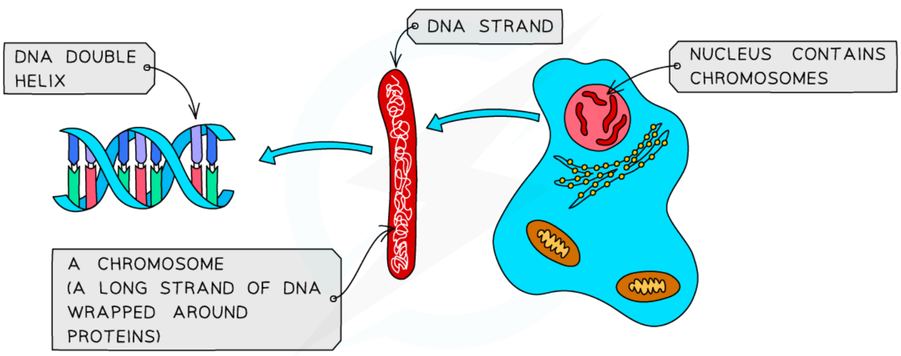
YOUR NOTES

CONTENTS:

17.1 DEFINITIONS

Defining Inheritance & Related Terms

- **Inheritance** is the **transmission of genetic information from generation to generation**
- **Chromosomes** are located in the **nucleus** of cells
- They are **thread-like structures of DNA, carrying genetic information in the form of genes**
- A **gene** is a short length of **DNA** found on a chromosome that **codes for a specific protein**
- This could be a structural protein such as collagen found in skin cells, an enzyme or a hormone
- Genes control our characteristics as they code for proteins that play important roles in what our cells do



Genes are short lengths of DNA that code for a protein.
They are found on chromosomes

- Alleles are **different versions of a particular gene**. The ABO gene for blood group type has three alleles, IA, IB and IO

17 INHERITANCE

17.1 DEFINITIONS cont...

EXTENDED ONLY

Diploid & Haploid Nuclei

- All humans have **23 different chromosomes** in each cell
- In most body cells, not including the gametes (sex cells), we have 2 copies of each chromosome, leading to a total of **46 chromosomes**
- Nuclei with two sets of chromosomes are known as **diploid nuclei**
- The **gametes** (egg and sperm cells) only have one copy of each chromosome, meaning they have a **total of 23 chromosomes** in each cell
- Nuclei with one set of unpaired chromosomes are known as **haploid nuclei**

EXAM TIP

An easy way to remember the difference between haploid and diploid is to remember:

Haploid = Half the normal number of chromosomes.

It's worth noting that the human diploid chromosome number is 46. In an exam, you may be given information about a different species, with a different number of chromosomes. Make sure you read exam questions carefully.

17.2 INHERITANCE OF SEX

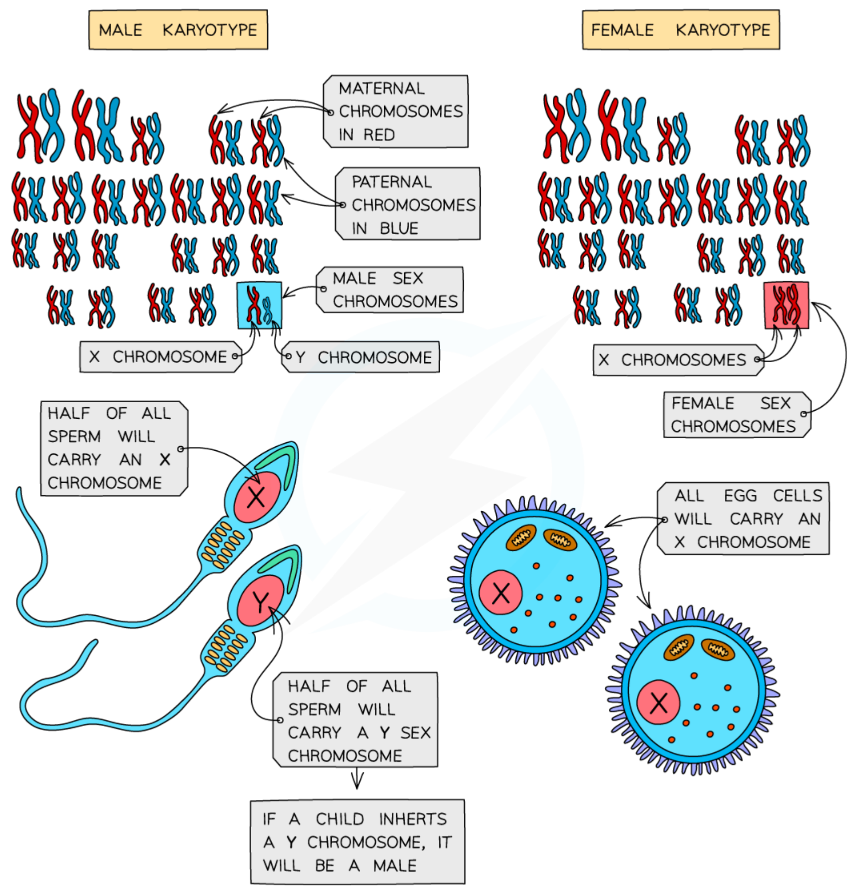
- Sex, or gender, is determined by an **entire chromosome pair** (as opposed to most other characteristics that are just determined by one or a number of genes)
- **Females** have the sex chromosomes **XX**
- **Males** have the sex chromosomes **XY**
- As only a father can pass on a Y chromosome, he is **responsible for determining the gender of the child**

YOUR NOTES

17 INHERITANCE

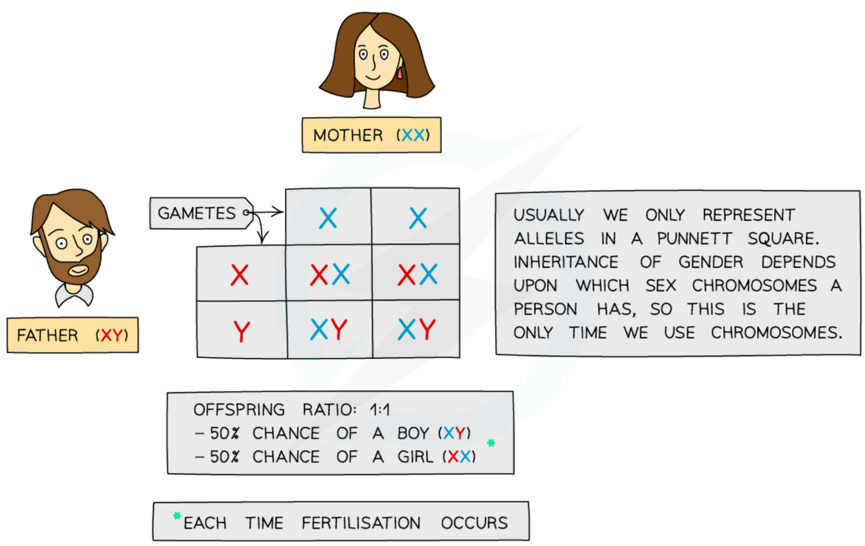
YOUR NOTES

17.2 INHERITANCE OF SEX cont...



Sperm cells determine the sex of offspring

- The inheritance of gender can be shown using a **genetic diagram** (known as a **Punnett square**), with the X and Y chromosomes taking the place of the alleles usually written in the boxes



Punnett square showing the inheritance of gender

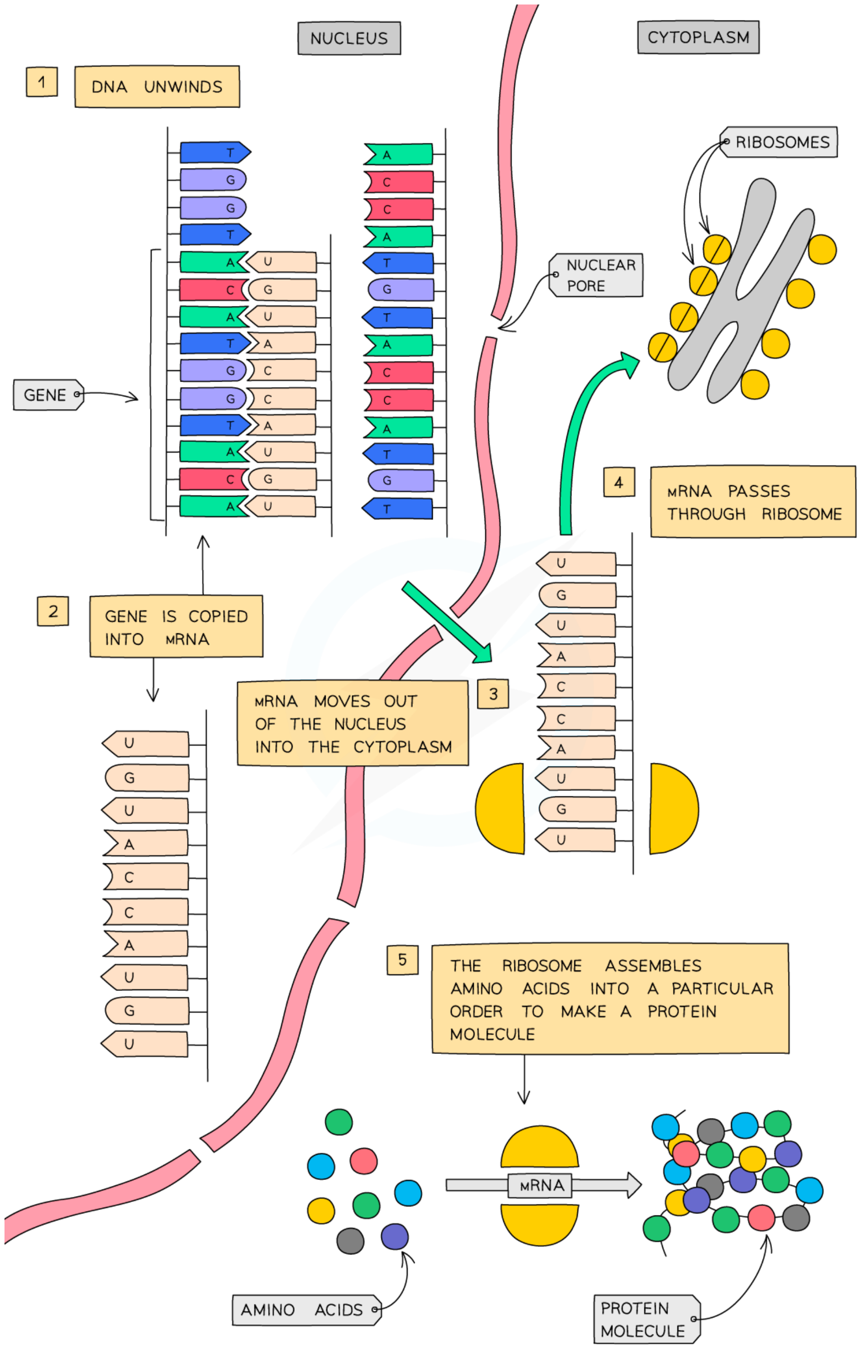
17 INHERITANCE

17.3 PROTEIN SYNTHESIS

YOUR NOTES

EXTENDED ONLY

Transcription & Translation



Protein synthesis

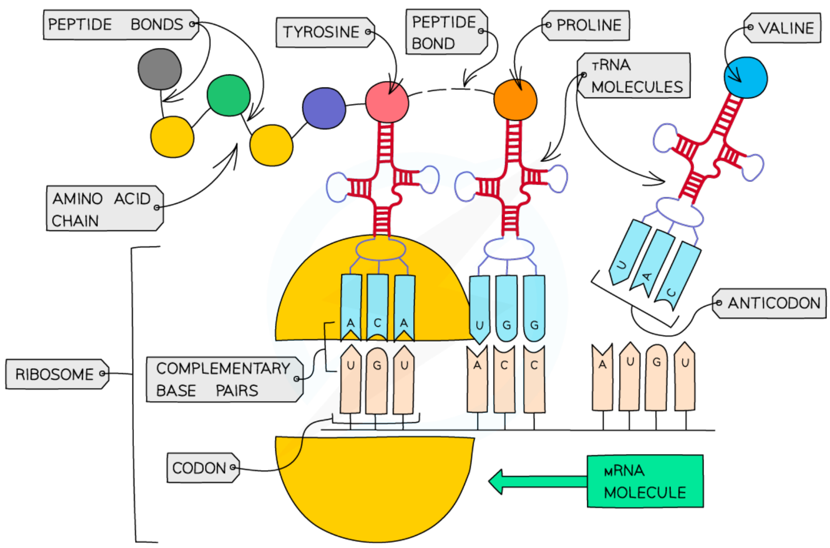
17 INHERITANCE

YOUR NOTES

17.3 PROTEIN SYNTHESIS cont...

EXTENDED ONLY cont...

- Proteins are made by **ribosomes** with the sequence of amino acids controlled by the **sequence of bases** contained within DNA
- DNA **cannot travel out of the nucleus** to the ribosomes (it is far too big to pass through a nuclear pore) so the base code of each gene is transcribed onto an RNA molecule called **messenger RNA** (mRNA).
- mRNA then **moves out of the nucleus** and attaches to a ribosome
- The ribosome 'reads' the code on the mRNA in groups of three
- Each triplet of bases **codes for a specific amino acid**
- In this way the ribosome **translates** the sequence of bases into a **sequence of amino acids** that make up a protein
- Once the amino acid chain has been assembled, it is released from the ribosome so it can fold and form the final structure of the protein



The triplet code of DNA (carried by mRNA) is read by the ribosome and amino acids are attached together in a specific sequence to form the protein

- In this way, DNA **controls cell function** by **controlling the production of proteins**
- The proteins may be **enzymes, antibodies,** or **receptors** for **neurotransmitters**
- Although all body cells in an organism contain the same genes, **many genes in a particular cell are not expressed** because **the cell only makes the specific proteins it needs**

17 INHERITANCE

17.4 CELL DIVISION

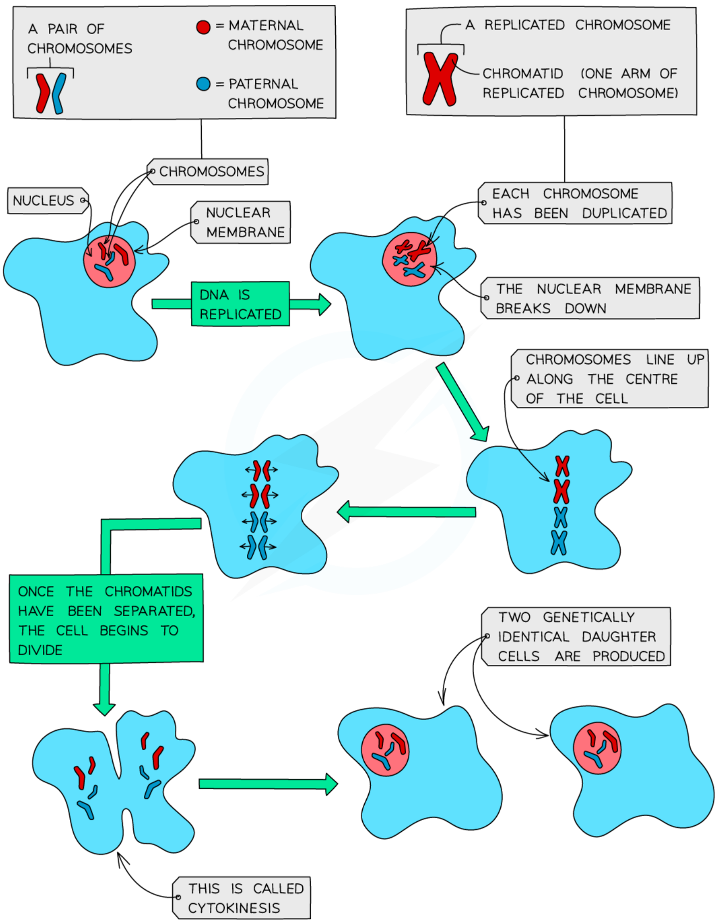
YOUR NOTES

Mitosis: Basics

- Most body cells have two copies of each chromosome
- We describe these cells as **diploid**
- When cells divide their chromosomes double beforehand
- This ensures that when the cell splits in two, each new cell still has two copies of each chromosome (is still diploid)
- This type of cell division is used for **growth, repair of damaged tissues, replacement of cells** and **asexual reproduction** and is known as **mitosis**
- Mitosis is defined as **nuclear division giving rise to genetically identical cells**

EXTENDED ONLY

Mitosis



The process of cell division by mitosis

17 INHERITANCE

YOUR NOTES

17.4 CELL DIVISION cont...

EXTENDED ONLY cont...

Process:

- Just before mitosis, each chromosome in the nucleus copies itself exactly (forms x – shaped chromosomes)
- Chromosomes line up along the centre of the cell where cell fibers pull them apart
- The cell divides into two; each new cell has a copy of each of the chromosomes

Importance:

- All cells in the body (excluding gametes) are produced by mitosis of the zygote
- Mitosis is important for replacing cells e.g, skin cells, red blood cells and for allowing growth (production of new cells e.g. when a zygote divides to form an embryo)

Occurs in:

- Growth: mitosis produces new cells
- Repair: to replace damaged or dead cells
- Asexual reproduction: mitosis produces offspring that are genetically identical to the parent

Stem Cells

- Many tissues in the human body contain a small number of **unspecialised cells**
- These are called **stem cells** and their function is to divide by mitosis and **produce new daughter cells that can become specialised** within the tissue and be used for different functions

Meiosis: Basics

- **Meiosis** is a type of nuclear division that **gives rise to cells that are genetically different**
- It is used to produce the **gametes** (sex cells)

17 INHERITANCE

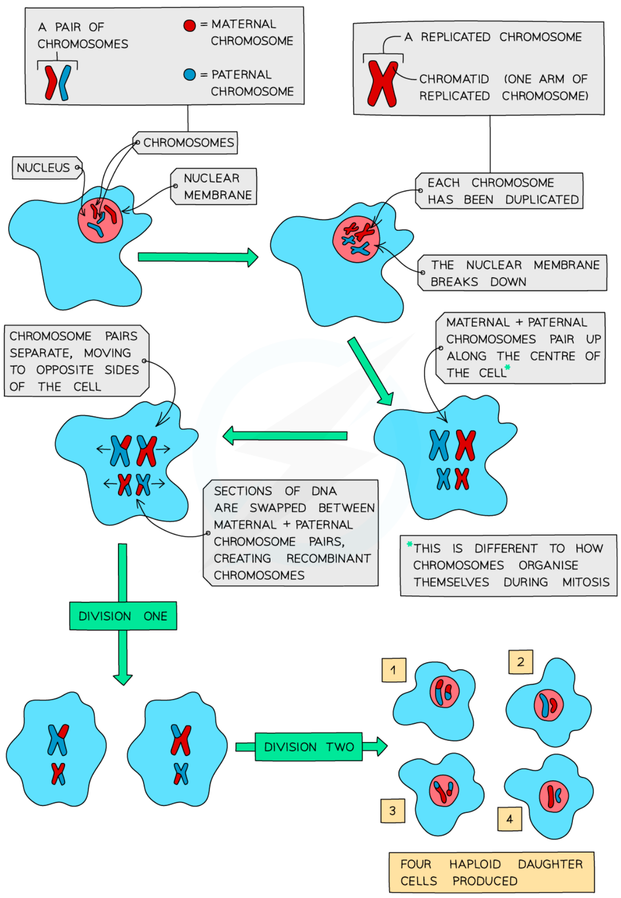
17.4 CELL DIVISION cont...

YOUR NOTES

EXTENDED ONLY

Meiosis

- The number of chromosomes must be **halved** when the **gametes** (sex cells) are formed
- Otherwise there would be double the number of chromosomes after they join at fertilisation in the zygote (fertilized egg)
- This halving occurs during **meiosis**, and so it is described as a **reduction division** in which the **chromosome number is halved from diploid to haploid**, resulting in **genetically different cells**
- It starts with chromosomes doubling themselves as in mitosis and lining up in the centre of the cell
- After this has happened the cells divide twice so that only one copy of each chromosome passes to each gamete
- We describe gametes as being **haploid** – having half the normal number of chromosomes
- Because of this double division, meiosis produces **four** haploid cells



The process of cell division by meiosis to produce haploid gamete cells

17 INHERITANCE

17.4 CELL DIVISION cont...

YOUR NOTES

EXTENDED ONLY cont...

Process:

- Each chromosome makes identical copies of itself (forming X-shaped chromosomes)
- First division: chromosomes pair up along the centre of the cell, recombination occurs and then cell fibres will pull the pairs apart, each new cell will have one of each recombinant chromosome pair
- Second division: chromosomes will line up along the centre of the cell, cell fibres will pull them apart (as with mitosis)
- A total of four haploid daughter cells will be produced

Importance:

- Production of gametes e.g. sperm cells and egg cells, pollen grains and ovum
- Increases genetic variation of offspring
- Meiosis produces variation by forming new combinations of maternal and paternal chromosomes every time a gamete is made, meaning that when gametes fuse randomly at fertilisation, each offspring will be different from any others

Differences between Mitosis & Meiosis

MITOSIS	MEIOSIS
TWO CELLS PRODUCED (KNOWN AS DAUGHTER CELLS)	FOUR CELLS PRODUCED (KNOWN AS DAUGHTER CELLS)
DAUGHTER CELLS ARE DIPLOID	DAUGHTER CELLS ARE HAPLOID
DAUGHTER CELLS ARE GENETICALLY IDENTICAL TO EACH OTHER AND TO THE PARENT CELL	DAUGHTER CELLS ARE GENETICALLY DIFFERENT FROM EACH OTHER AND THE PARENT CELL
ONE CELL DIVISION OCCURS	TWO CELL DIVISIONS OCCUR

EXAM TIP

Questions on cell division often ask for **differences between mitosis and meiosis.**
Learn 2 or 3 and remember to **BE SPECIFIC** when giving your answer.
You should also know the reasons for:

- a specific type of cell division taking place
- and the types of cells where each happen.

17 INHERITANCE

17.5 MONOHYBRID INHERITANCE

YOUR NOTES

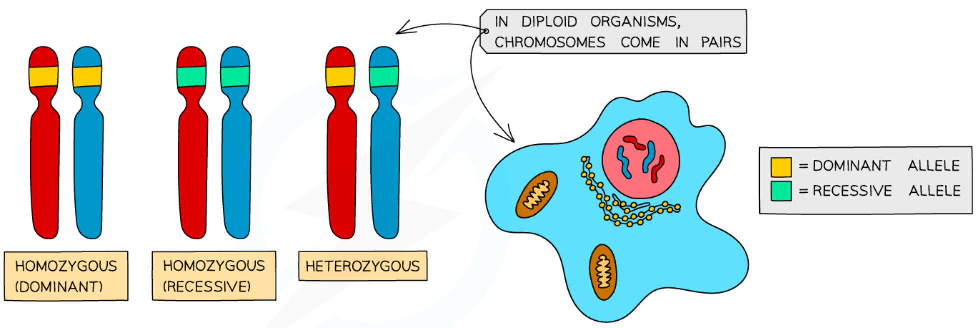
Definitions

- A **gene** is a short length of DNA found on a chromosome that codes for a particular **characteristic** (expressed by the formation of different proteins)
- **Alleles** are variations of the same gene
- For example, the gene for eye colour can have the alleles blue or brown
- As we have two copies of each chromosome, we have two copies of each gene and therefore two alleles for each gene
- One of the alleles is inherited from the mother and the other from the father
- This means that the alleles do not have to 'say' the same thing
- For example, an individual has two copies of the gene for eye colour but **one allele could code for brown eyes and one allele could code for blue eyes**
- The observable characteristics of an organism (seen just by looking – like eye colour, or found – like blood type) is called the **phenotype**
- The **combination of alleles that control each characteristic** is called the **genotype**
- Alleles can be **dominant** or **recessive**
- A dominant allele **only needs to be inherited from one parent** in order for the characteristic to show up in the phenotype
- A recessive allele needs to be **inherited from both parents in order** for the characteristic to show up in the phenotype
- If there is only one recessive allele, it will remain hidden and the dominant characteristic will show
- If the two alleles of a gene are the same, we describe the individual as being **homozygous** (homo = same)
- An individual could be **homozygous dominant** (having two copies of the dominant allele), or **homozygous recessive** (having two copies of the recessive allele)
- If the two alleles of a gene are different, we describe the individual as being **heterozygous** (hetero = different)
- When completing genetic diagrams, alleles are abbreviated to single letters
- The dominant allele is given a **capital letter** and the recessive allele is given the same letter, but **lower case**

17 INHERITANCE

YOUR NOTES

17.5 MONOHYBRID INHERITANCE cont...



Alleles of a gene can carry the same instructions or different instructions. You can only inherit two alleles for each gene, and they can be the same or different

- We **cannot always tell the genotype** of an individual for a particular characteristic just by looking at the phenotype – a phenotype associated with a dominant allele will be seen in both a dominant homozygous and a dominant heterozygous genotype
- If two individuals who are both **identically homozygous** for a particular characteristic are bred together, they will **produce offspring with exactly the same genotype and phenotype as the parents** – we describe them as being 'pure breeding' as they will always produce offspring with the same characteristics
- A **heterozygous** individual can pass on **different alleles** for the same characteristic each time it is bred with any other individual and can therefore **produce offspring with a different genotype and phenotype than the parents** – as such, **heterozygous individuals are not pure breeding**

Genetic Diagrams

- **Monohybrid inheritance** is the inheritance of characteristics controlled by a single gene (mono = one)
- This can be determined using a genetic diagram known as a **Punnett square**
- A Punnett square diagram shows the **possible combinations of alleles** that could be produced in the offspring
- From this the **ratio** of these combinations can be worked out
- Remember the **dominant allele** is shown using a capital letter and the **recessive allele** is shown using the same letter but lower case
- You should always write the **dominant allele first, followed by the recessive allele**
- **Example:**
- The height of pea plants is controlled by a single gene that has two alleles: tall and short
- The tall allele is dominant and is shown as **T**
- The small allele is recessive and is shown as **t**

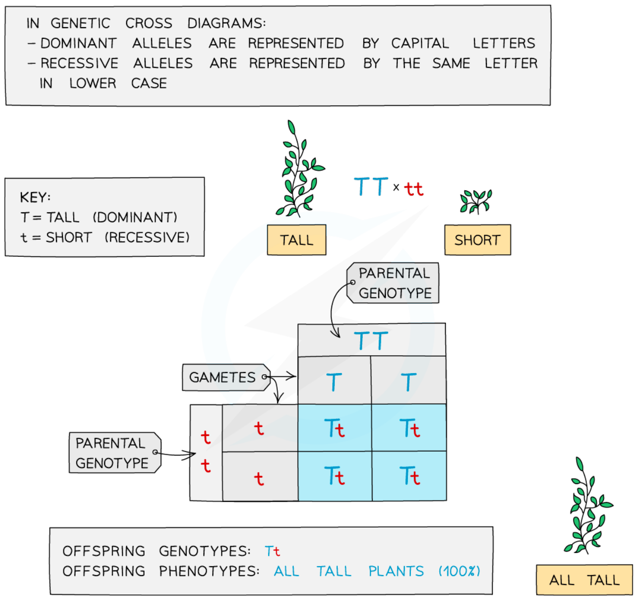
17 INHERITANCE

YOUR NOTES

17.5 MONOHYBRID INHERITANCE cont...

'Show the possible allele combinations of the offspring produced when a pure breeding short plant is bred with a pure breeding tall plant'

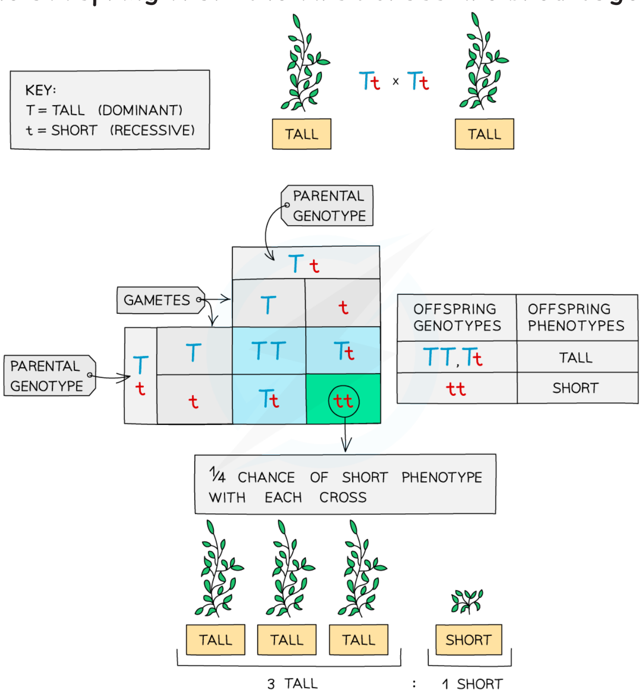
- The term '**pure breeding**' indicates that the individual is homozygous for that characteristic



A pure–breeding genetic cross in pea plants

- This shows that there is a 100% chance that all the offspring will be tall

'Show the possible allele combinations of the offspring produced when two of the offspring from the first cross are bred together'



A genetic cross diagram (F2 Generation)

17 INHERITANCE

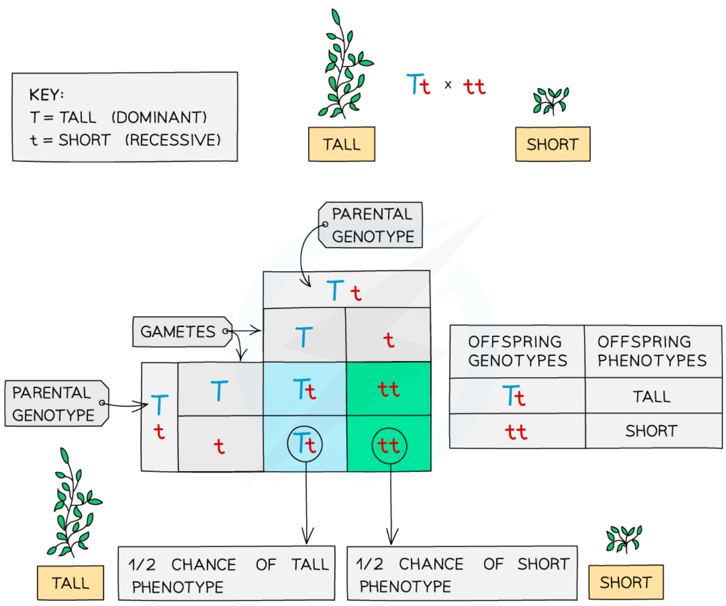
YOUR NOTES

17.5 MONOHYBRID INHERITANCE cont...

- All of the offspring of the first cross have the same genotype, **Tt** (heterozygous), so the possible combinations of offspring bred from these are:
    - There is more variation in this cross, with a **3:1** ratio of tall : short, meaning each offspring has a 75% chance of being tall and a 25% chance of being short
    - The F2 generation is produced when the offspring of the F1 generation (pure-breeding parents) are allowed to interbreed

'Show the results of crossing a heterozygous plant with a short plant'

- The heterozygous plant will be tall with the genotype **Tt**
- The short plant is showing the recessive phenotype and so must be homozygous recessive – **tt**
- The results of this cross are as follows:



A cross between a heterozygous plant with a short plant

- In this cross, there is a **1:1 ratio of tall to short**, meaning a **50%** chance of the offspring being tall and a **50%** chance of the offspring being short

17 INHERITANCE

17.5 MONOHYBRID INHERITANCE cont...

YOUR NOTES

How to construct Punnett squares

- Determine the parental genotypes
- Select a letter that has a clearly different lower case, for example: Aa, Bb, Dd
- Split the alleles for each parent and add them to the Punnett square around the outside
- Fill in the middle four squares of the Punnett square to work out the possible genetic combinations in the offspring
- You may be asked to comment on the ratio of different allele combinations in the offspring, calculate a percentage chances of offspring showing a specific characteristic or just determine the phenotypes of the offspring
- Completing a Punnett square allows you to predict the probability of different outcomes from monohybrid crosses

EXAM TIP

You should always write the dominant allele first, followed by the recessive allele.

If you are asked to use your own letters to represent the alleles in a Punnett square, try to **choose a letter that is obviously different** as a capital than the lower case so the examiner is not left in any doubt as to which is dominant and which is recessive. For example, C and c are not very different from each other, whereas A and a are!

EXTENDED ONLY

Identifying an Unknown Genotype

- Breeders can use a **test cross** to find out the genotype of an organism showing the dominant phenotype
- This involves crossing the unknown individual with an individual showing the recessive phenotype – if the individual is showing the recessive phenotype, then its genotype must be homozygous recessive
- By looking at the **ratio of phenotypes in the offspring**, we can tell whether the unknown individual is homozygous dominant or heterozygous

17 INHERITANCE

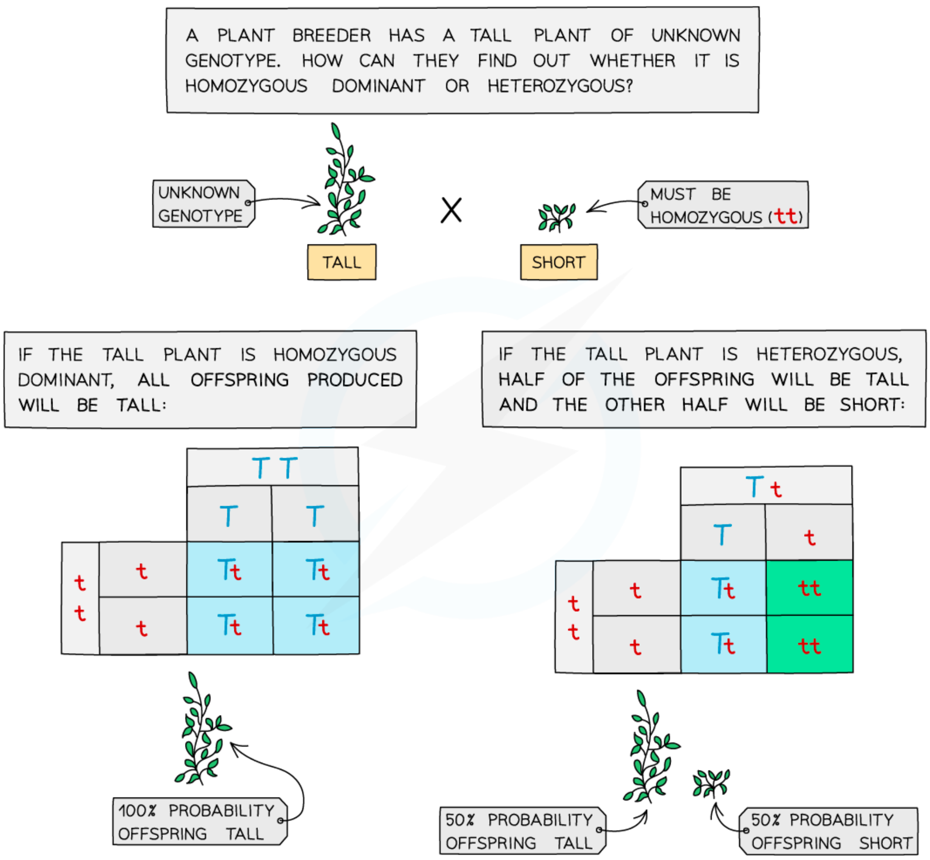
YOUR NOTES

17.5 MONOHYBRID INHERITANCE cont...

EXTENDED ONLY cont...

A plant breeder has a tall plant of unknown genotype. How can they find out whether it is homozygous dominant or heterozygous?'

- The short plant is showing the recessive phenotype and so must be homozygous recessive – **tt**



Determining genotypes from offspring

- If the tall plant is homozygous dominant, all offspring produced will be tall
- If the tall plant is heterozygous, half the offspring will be tall and the other half will be short

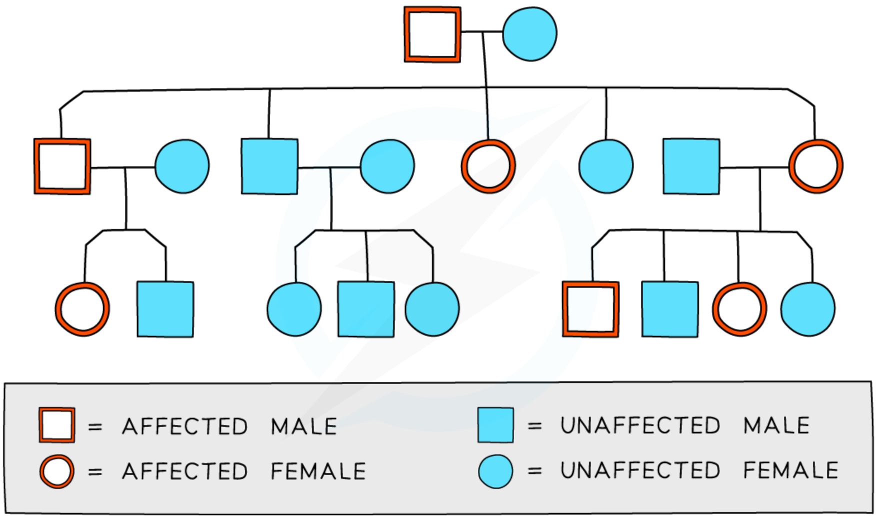
17 INHERITANCE

17.5 MONOHYBRID INHERITANCE cont...

YOUR NOTES

Family Pedigrees

- Family pedigree diagrams are usually used to trace the **pattern of inheritance** of a specific characteristic (usually a disease) **through generations of a family**
- This can be used to work out the probability that someone in the family will inherit the genetic disorder



A family pedigree chart

- Males are indicated by the **square shape** and females are represented by circles
- Affected individuals are **red** and unaffected are **blue**
- Horizontal lines between males and females show that they have produced children (which are shown underneath each couple)
- The family pedigree above shows:
  - both males and females are affected
  - every generation has affected individuals
  - that there is one family group that has no affected parents or children
  - the other two families have one affected parent and affected children as well

17 INHERITANCE

YOUR NOTES

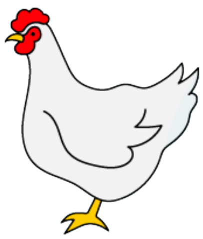
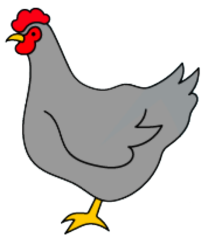
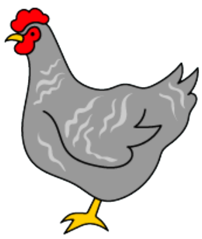
17.6 CODOMINANCE & SEX–LINKED CHARACTERISTICS

EXTENDED ONLY

Codominance

- Some genes have alleles that are **equally dominant** and so are both expressed equally in the phenotype
- This is known as **codominance**
- Both codominant alleles are shown with upper case letters in genetic diagrams, but the **letters used are different**
- For example, feather colour in hens may be white, black or speckled (it has both white feathers and black feathers)
- The alleles can be shown as **W** for white and **B** for black
- There are three possible genotypes: **WW, BB and BW**
- There are also three possible phenotypes: WW = white, BB = black, and BW = speckled

Inheritance of a characteristic with codominant alleles

			
PHENOTYPE	WHITE	BLACK	SPECKLES
GENOTYPE	WW	BB	BW

Inheritance of Blood Group

- Inheritance of blood group is an example of codominance
- There are three alleles of the gene governing this instead of the usual two
- Alleles I^A and I^B are codominant, but both are dominant to I^O
- I represents the gene and the superscript A, B and O represent the alleles
- I^A results in the production of antigen A in the blood
- I^B results in the production of antigen B in the blood
- I^O results in no antigens being produced in the blood
- These three possible alleles can give us the following genotypes and phenotypes:

17 INHERITANCE

17.6 CODOMINANCE & SEX-LINKED CHARACTERISTICS cont...

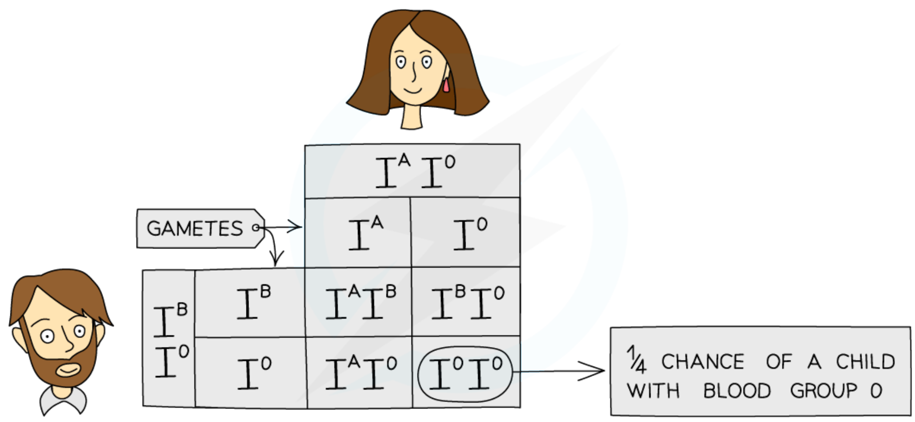
YOUR NOTES

EXTENDED ONLY cont...

GENOTYPE	PHENOTYPE
$I^A I^A$ OR $I^A I^O$	A
$I^B I^B$ OR $I^B I^O$	B
$I^A I^B$	AB
$I^O I^O$	O

- We can use genetic diagrams to predict the outcome of crosses that involve codominant alleles:

'Show how a parent with blood group A and a parent with blood group B can produce offspring with blood group O'



Punnett square showing the inheritance of Blood Group

- The parent with blood group A has the genotype $I^A I^O$
- The parent with the blood group B has the genotype $I^B I^O$
- We know these are their genotypes (as opposed to both being homozygous) as they are able to produce a child with blood group O and so the child must have inherited an allele for group O from each parent
- Parents with these blood types have a 25% chance of producing a child with blood type O

17 INHERITANCE

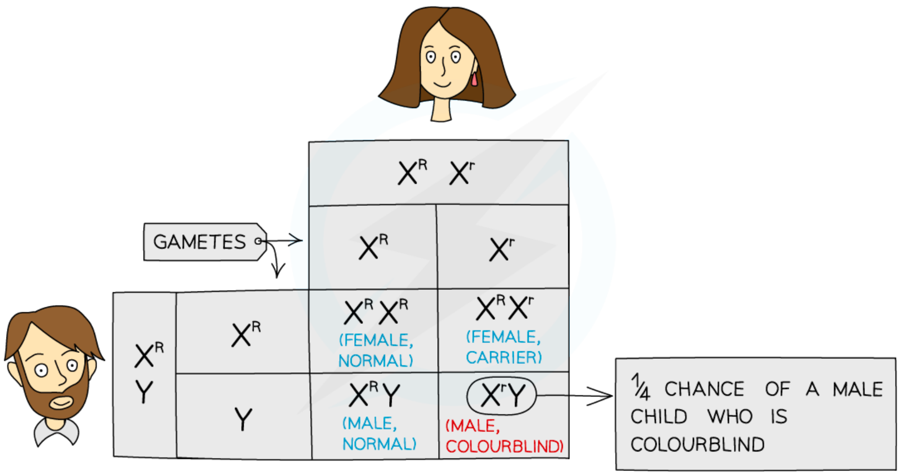
17.6 CODOMINANCE & SEX–LINKED CHARACTERISTICS cont...

YOUR NOTES

EXTENDED ONLY cont...

Sex–Linked Characteristics

- When alleles that control a particular characteristic are found on the **sex chromosomes**, we describe the inheritance that results as '**sex linked**'
- In almost all cases, there are **only alleles on the X chromosome** as the **Y chromosome is much smaller**
- Because males **only have one X chromosome**, they are **much more likely to show sex-linked recessive conditions** (such as red-green colour blindness and haemophilia)
- Females, having two copies of the X chromosome, are likely to inherit one dominant allele that masks the effect of the recessive allele
- A female with one recessive allele masked in this way is known as a **carrier**; she doesn't have the disease, but she has a 50% chance of passing it on to her offspring
- If that offspring is a male, he will have the disease
- The results of a cross between a normal male and a female who is a carrier for colourblindness is as follows:



Punnett square showing the inheritance of colourblindness, an X–linked condition

- In the cross above, there is a 25% chance of producing a male who is colourblind, a 25% chance of producing a female carrier, a 25% chance of producing a normal female and a 25% chance of producing a normal male

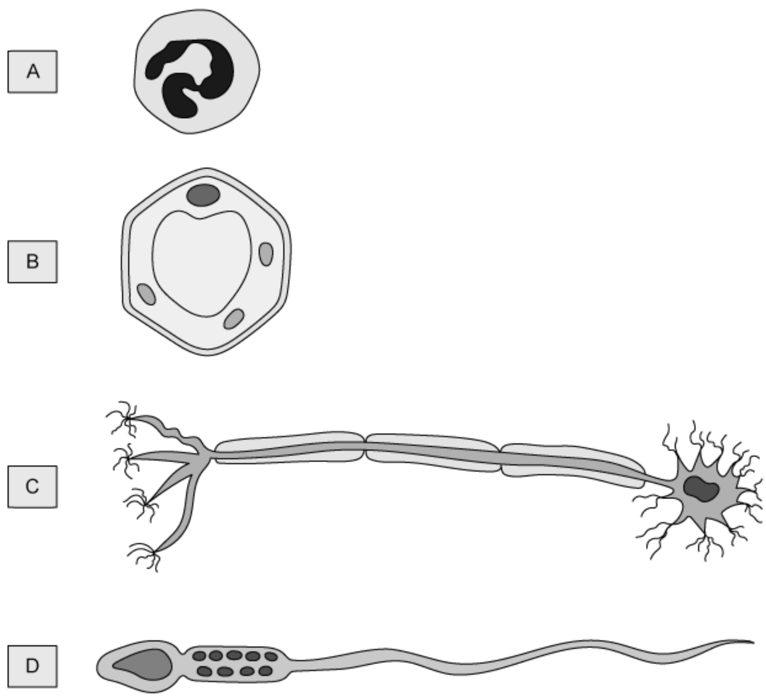
> NOW TRY SOME EXAM QUESTIONS

17 INHERITANCE

EXAM QUESTIONS

QUESTION 1

New cells are formed by cell division of existing cells. The diagram below shows four different cells. Which one is formed by meiosis?



QUESTION 2

Albinism is a condition where pigment does not get produced in the skin, hair and eyes. This is an inherited condition that is caused by a recessive allele.

If both parents have albinism what are the chances of the offspring being an albino child?

A 0%

B 25%

C 75%

D 100%

YOUR NOTES

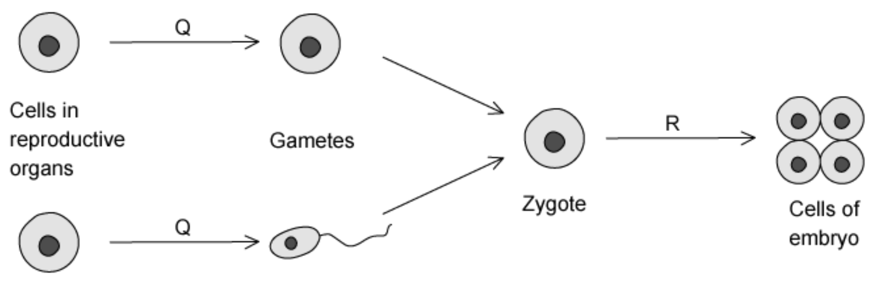
17 INHERITANCE

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 3

The diagram below shows the process in sexual reproduction.



Which of the processes are shown by stages Q and R?

	Q	R
A	meiosis	mitosis
B	mitosis	mitosis
C	meiosis	meiosis
D	mitosis	meiosis

QUESTION 4

What does the term haploid mean?

A A nucleus containing two sets of chromosomes

B A nucleus containing a single set of chromosomes

C A person with only one X chromosome

D A person with XXY chromosomes

17 INHERITANCE

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5

A farmer is growing pea plants; the allele for tall is T and is dominant to the allele for dwarf, t. She wants to know what cross she would need to do to produce a ratio of 1 tall: 1 dwarf plants?

A tt x tt

B Tt x Tt

C TT x Tt

D Tt x tt

18 VARIATION & SELECTION

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

18.1 VARIATION

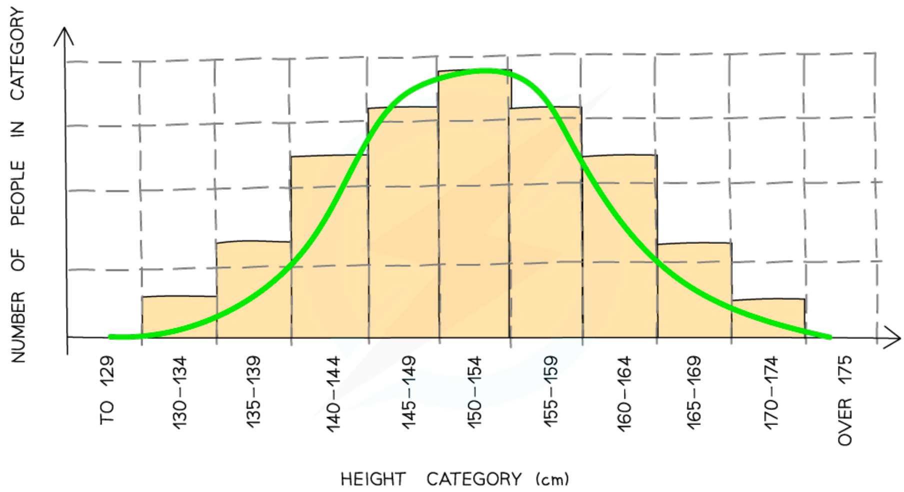
Types of Variation

- Variation is defined as **differences between individuals of the same species**
- **Phenotypic variation** is the difference in features between individuals of the same species
- Some of these differences are caused by differences in genes, which is **genetic variation**
- Phenotypic variation can be divided into two types depending on **how you are able to group the measurements:**
    - **Continuous Variation** is when there are very many small degrees of difference for a particular characteristic between individuals and they are arranged in order and can usually be measured on a scale
    - Examples include height, mass, finger length etc. where there can be many 'inbetween' groups
    - **Discontinuous Variation** is when there are distinct differences for a characteristic
    - For example, people are either blood group A, B, AB or O; are either male or female; can either roll their tongue or not – there are no 'inbetweens'
- When graphs of these data are plotted, continuous variation gives smooth bell curves (a result of all the small degrees of difference), whereas discontinuous variation gives a step-like shape

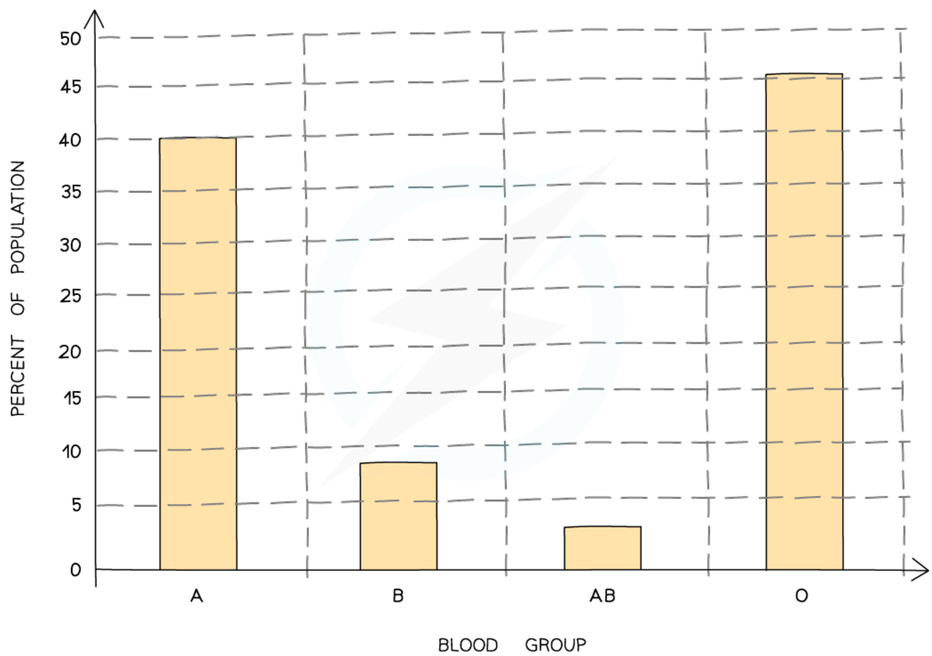
18 VARIATION & SELECTION

18.1 VARIATION cont...

YOUR NOTES



Height is an example of continuous variation which gives rise to a smooth bell–shaped curve when plotted as a graph



Blood group is an example of discontinuous variation which gives rise to a step–shaped graph

18 VARIATION & SELECTION

18.1 VARIATION cont...

YOUR NOTES

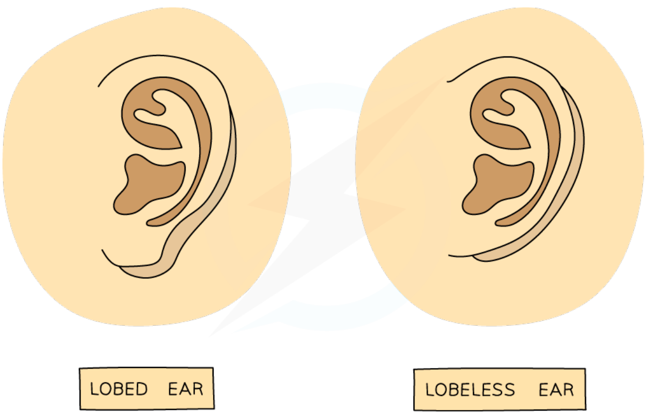
EXTENDED ONLY

Phenotypic Variation

- Phenotypic variation can be caused in two main ways:
  - It can be **genetic** – controlled entirely by genes
  - Or it can be **environmental** – caused entirely by the environment in which the organism lives

Genetic Variation

- Examples of genetic variation in humans include:
  - **blood group**
  - **eye colour**
  - **gender**
  - **ability to roll tongue**
  - **whether ear lobes are free or fixed:**



Whether earlobes are attached (lobeless) or free (lobed) is an example of genetic variation

18 VARIATION & SELECTION

18.1 VARIATION cont...

YOUR NOTES

EXTENDED ONLY cont...

Environmental Variation

- Characteristics of all species can be affected by environmental factors such as climate, diet, accidents, culture, lifestyle and accidents during lifetime
- In this instance 'environmental' simply means 'outside of the organism'
- Examples include:
  - An accident may lead to **scarring** on the body
  - Eating too much and not leading an active lifestyle will cause **weight gain**
  - Being raised in a certain country will cause you to speak a certain **language** with a certain **accent**
  - A plant in the shade of a big tree will grow **taller** to reach more light

Genetic and Environmental Causes

- Discontinuous variation is usually caused by **genetic variation alone**
- Continuous features often vary because of a combination of genetic and environmental causes, for example:
  - tall parents will **pass genes** to their children for height
  - their children have the **genetic potential** to also be tall
  - however if their **diet is poor** then they will not grow very well
  - therefore their **environment** also has an impact on their height
- Another way of looking at this is that although genes decide what characteristics we inherit, the surrounding environment will affect how these inherited characteristics develop

18 VARIATION & SELECTION

18.2 MUTATIONS

YOUR NOTES

Causes & Effects of Mutations

- Mutations are **random genetic changes**
- Most mutations have **no effect** on the phenotype as the protein that a mutated gene produces may work just as well as the protein from the non-mutated gene
- Rarely, mutations lead to the development of new alleles and so new phenotypes and if they do, most have a **small effect** on the organism
- Occasionally, the new allele gives the individual a **survival advantage** over other members of the species
- For example:
  - A bird develops a mutation leading to a change in feather colours
  - This makes it more attractive to birds of the opposite sex
  - Which causes the bird to breed more frequently and have more chances of passing on the mutated phenotype to the next generation
- Mutations can also lead to **harmful changes** that can have dramatic effects on the body – for example, **sickle cell anaemia** in humans
- Mutations happen **spontaneously and continuously** but their frequency can be increased by exposure to the following:
  - **Gamma rays, x – rays and ultraviolet rays** – all types of ionising radiation which can damage bonds and cause changes in base sequences
  - **Certain types of chemicals** – for example chemicals such as tar in tobacco
- Increased rates of mutation can cause cells to become **cancerous**, which is why the above are linked to increased incidence of different types of cancer

EXTENDED ONLY

Sickle Cell Anaemia

Symptoms

- Sickle cell anaemia was the first genetic disease to be described in terms of a **gene mutation**
- A gene mutation is a **change in the base sequence of DNA**
- The mutation **changes the molecule haemoglobin**, causing the red blood cells (RBC's) to become stiff and sometimes **sickle-shaped** when they release oxygen to the body tissues
- The sickled cells tend to get **stuck** in narrow blood vessels, **blocking the flow of blood**

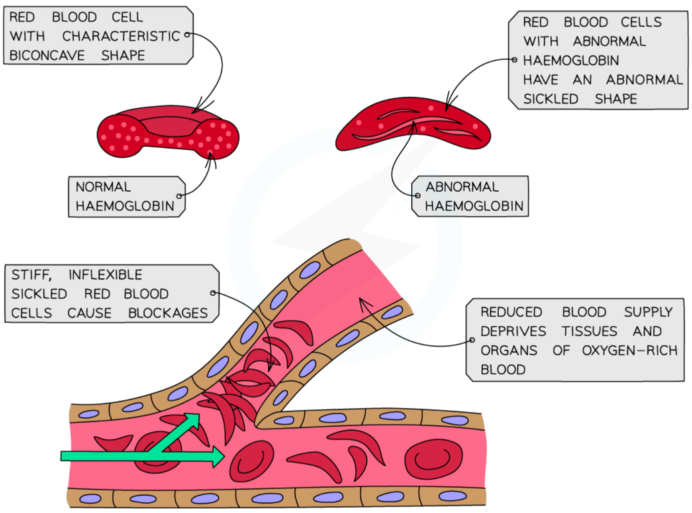
18 VARIATION & SELECTION

18.2 MUTATIONS cont...

YOUR NOTES

EXTENDED ONLY cont...

- As a result, those with sickle cell disease suffer painful "crises" in their joints and bones
- They may suffer **strokes, blindness, or damage to the lungs, kidneys, or heart**. They must often be hospitalized for blood transfusions and are at risk for a life-threatening complication called **acute chest syndrome**
- Although many sufferers of sickle cell disease die before the age of 20, modern medical treatments can sometimes prolong these individuals' lives into their 40s and 50s



Sickle cell anaemia is caused by abnormal haemoglobin which changes the shape of red blood cells

Inheritance

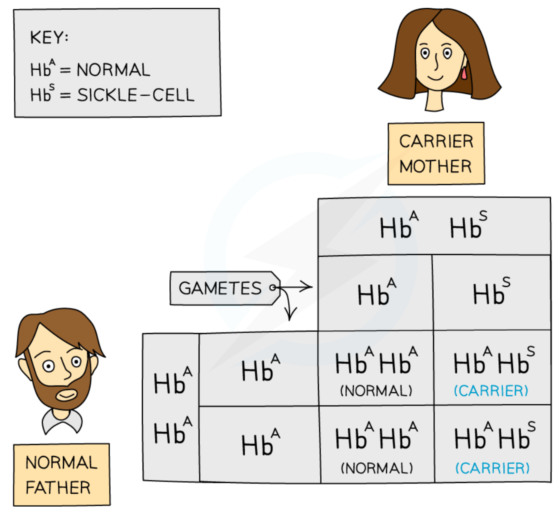
- There are two versions or alleles of the gene important for the inheritance of sickle cell anaemia : **A and S**
- The two alleles are **codominant**, meaning there is no 'dominant' or 'recessive' version of the gene
- Individuals with two A alleles **(Hb^AHb^A)** have **normal haemoglobin**, and therefore normal RBCs
- Those with two S alleles **(Hb^SHb^S)** develop **sickle cell anaemia**
- Those who are **heterozygous** for sickle cell **(Hb^AHb^S) produce both normal and abnormal haemoglobin** (as the alleles are codominant)
- Heterozygous individuals are usually healthy, but they **may suffer some symptoms of sickle cell anaemia under conditions of low blood oxygen**, such as high altitudes or during exercise
- Heterozygous individuals are said to be '**carriers**' of the sickle cell gene and are said to have **'sickle cell trait'**

18 VARIATION & SELECTION

18.2 MUTATIONS cont...

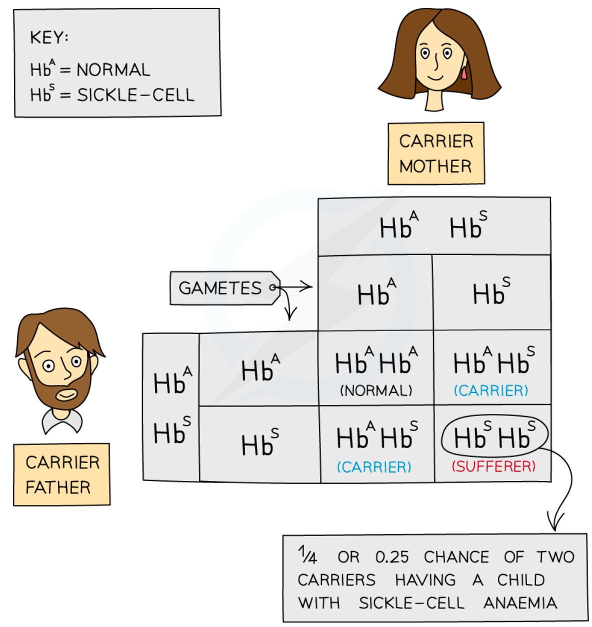
EXTENDED ONLY cont...

- Inheritance of sickle cell trait:



If one parent is a carrier of the sickle cell trait, there is a 1/2 chance their offspring will inherit the trait

- Inheritance of sickle cell disease:



If both parents are carriers of the sickle cell trait, there is a 1/4 chance they will have a child that suffers from sickle cell disease

YOUR NOTES

18 VARIATION & SELECTION

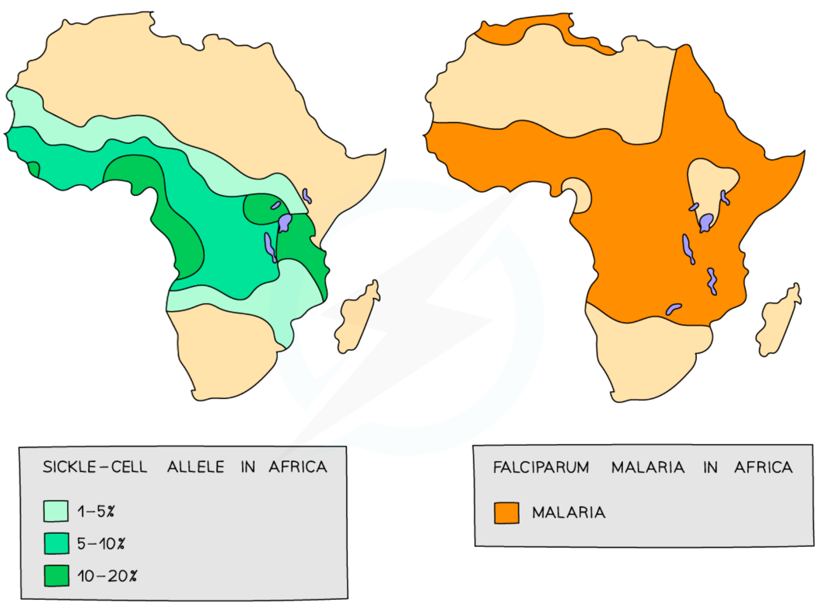
18.2 MUTATIONS cont...

YOUR NOTES

EXTENDED ONLY cont...

Sickle cell anaemia & natural selection

- In the United States, about **1 in 500** African-Americans develops sickle cell anaemia
- In Africa, about **1 in 100** individuals develops the disease
- Why is the frequency of such a serious disease so much higher in Africa? The answer is to do with **malaria**
- Malaria is a disease spread by **mosquitoes that are endemic in many areas of Africa** and causes over 1 million deaths per year
- In the late 1940s, studies of diseases in populations suggested a connection between African populations, malaria and sickle cell disease
- A theory was suggested; if the heterozygous individuals (Hb^AHb^S) are protected from malaria, and the negative effects (of sickle cell) are only present in the small proportion of people who are homozygous for the affected allele (Hb^SHb^S), then the affected allele could become more common
- Later studies supported this theory, showing that **African children who are heterozygous for the sickle cell allele have a ten-fold reduction in their risk of getting malaria**
- This means that there is a strong correlation between the prevalence of sickle cell anaemia in areas of the world where malaria is common



In areas of Africa where malaria is common, there is a corresponding higher rate of sickle cell disease

18 VARIATION & SELECTION

YOUR NOTES

18.2 MUTATIONS cont...

EXAM TIP

You should be able to explain **how these maps support the idea** that having a sickle cell allele gives resistance to malaria.

You should also be able to use **numerical data and graphs** given in exam questions to explain this.

18.3 ADAPTIVE FEATURES

Adaptations

- An adaptive feature is an **inherited feature that helps an organism to survive and reproduce in its environment**
- You should be able to interpret images or other information about a species in order to describe its adaptive features, for example:
  - Plants that live in different types of habitat have leaves that show adaptations for survival. The table shows some features of the leaves of three species of plant from different types of habitat.

SPECIES	HABITAT	ORIENTATION OF THE LEAVES	INDIVIDUAL LEAF AREA / cm^2	MEAN STOMATAL DENSITY / NUMBER OF STOMATA PER mm^2	
				UPPER EPIDERMIS	LOWER EPIDERMIS
ANNUAL MEADOW GRASS, POA ANNUA	GRASSLAND	VERTICAL	1 – 10	125	135
WHITE WATER LILY, NYMPAEA ALBA	THE SURFACE OF PONDS AND LAKES	HORIZONTAL	MORE THAN 1000	460	NONE
COMMON MYRTLE, MYRTUS COMMUNIS	DRY SCRUBLAND	HORIZONTAL	2 – 4	NONE	508

A typical question might be to explain how the leaf area and distribution and density of stomata help different species of plant survive in their different habitats

18 VARIATION & SELECTION

18.3 ADAPTIVE FEATURES cont...

YOUR NOTES

EXTENDED ONLY

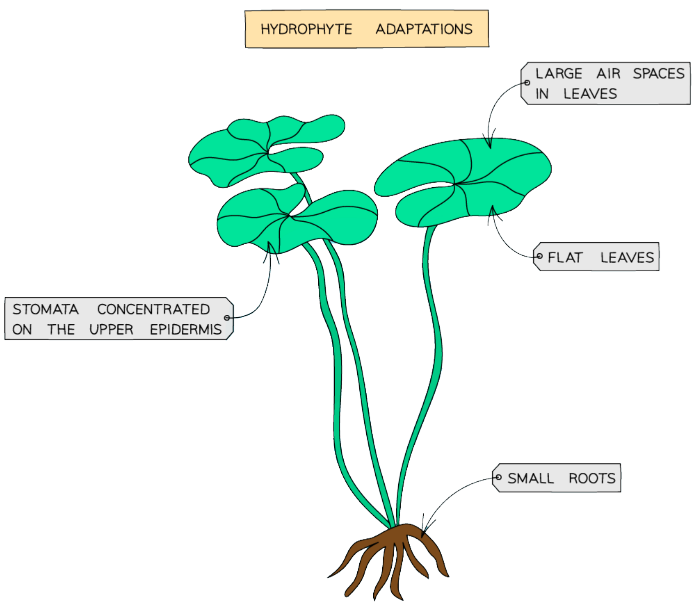
Adaptations & Fitness

- Adaptive features are the **inherited functional features of an organism that increase its fitness**
- Fitness is the **probability of an organism surviving and reproducing in the environment in which it is found**

Hydrophytes & Xerophytes

Hydrophytes

- Plants adapted to live in extremely wet conditions
- Common adaptations include:
  - Large air spaces in their leaves to keep them close to the surface of the water where there is more light for photosynthesis
  - Small roots as they can also extract nutrients from the surrounding water through their tissues
  - Stomata usually open all the time and mainly found on the upper epidermis of the leaf where they can exchange gases much more easily with the air



Hydrophytes are adapted to live in wet conditions such as ponds

18 VARIATION & SELECTION

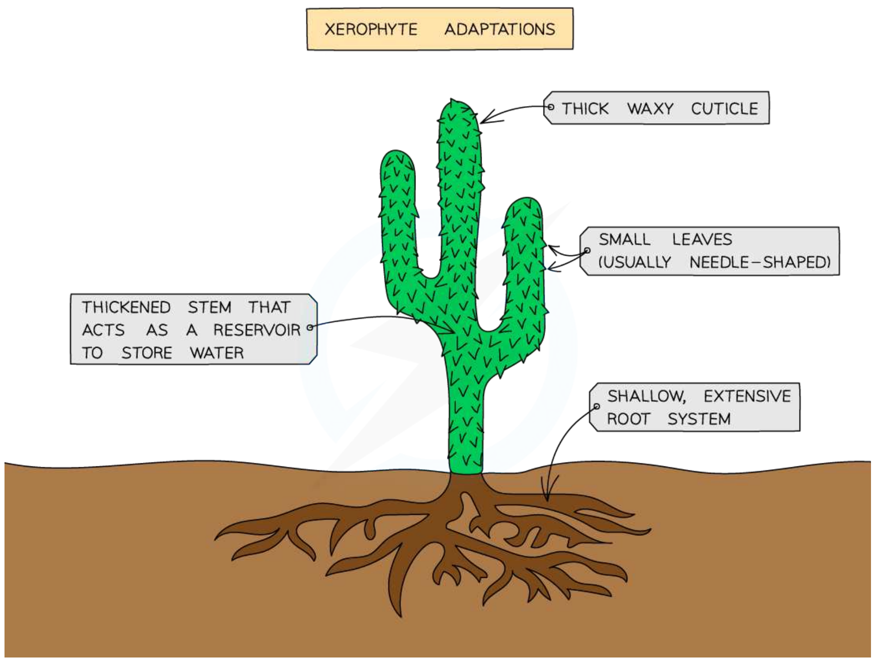
18.3 ADAPTIVE FEATURES cont...

YOUR NOTES

EXTENDED ONLY cont...

Xerophytes

- Plant adapted to live in **extremely dry conditions**
- Common adaptations include:
  - **Thick waxy cuticle** – the cuticle cuts down water loss in two ways: it acts as a barrier to evaporation and also the shiny surface reflects heat and so lowers temperature
  - **Sunken stomata**: stomata may be sunk in pits in the epidermis; moist air trapped here lengthens the diffusion pathway and reduces evaporation rate
  - **Leaf rolled** with stomata inside and an inner surface **covered in hairs** – traps moist air and prevents air movement across stomata which reduces transpiration
  - **Small leaves**: many xerophytic plants have small, needle-shaped leaves which reduce the surface area and therefore the evaporating surface
  - **Extensive shallow roots** allowing for the quick absorption of large quantities of water when it rains
  - **Thickened leaves or stems** which contain cells that store water



Xerophytes are adapted to live in extremely dry conditions such as deserts

18 VARIATION & SELECTION

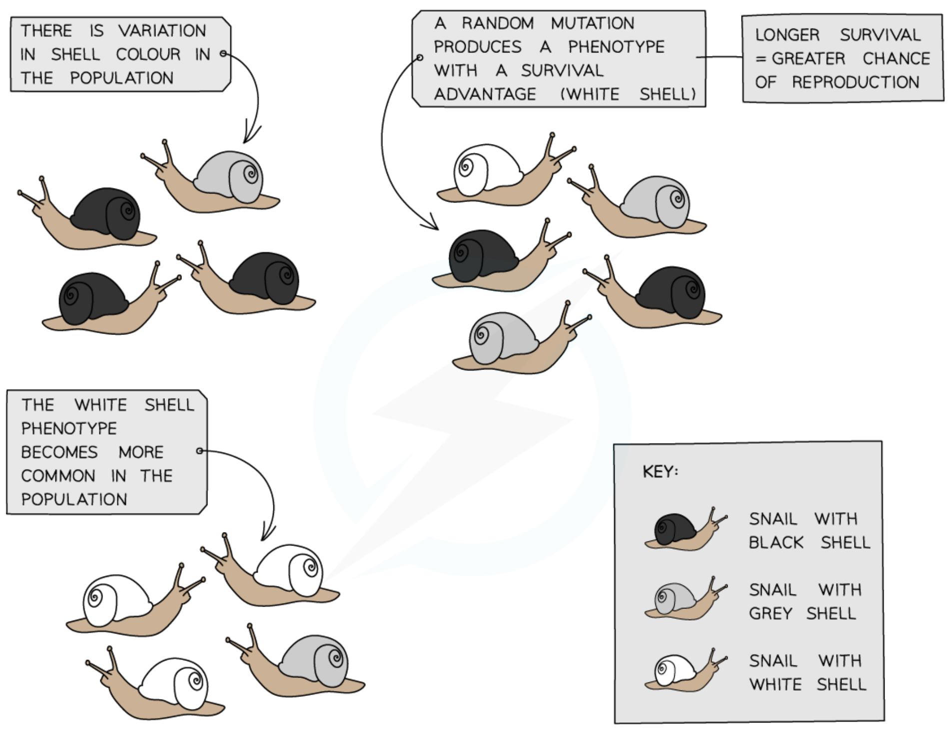
18.4 NATURAL SELECTION & EVOLUTION

YOUR NOTES

Natural Selection

- In any environment, the individuals that have the best adaptive features are the ones most likely to survive and reproduce
- This results in **natural selection**:
    - Individuals in a species show a **range of variation** caused by differences in genes
    - When organisms reproduce, they **produce more offspring** than the environment is able to support
    - This leads to **competition** for food and other resources which results in a **'struggle for survival'**
    - Individuals with characteristics **most suited to the environment** have a higher chance of survival and **more chances to reproduce**
    - Therefore the alleles resulting in these characteristics are **passed to their offspring at a higher rate** than those with characteristics less suited to survival
    - This means that in the next generation, there will be a **greater number of individuals** with the **better-adapted variations** in characteristics
- This theory of natural selection was put forward by **Charles Darwin** and became known as **'survival of the fittest'**

An example of natural selection



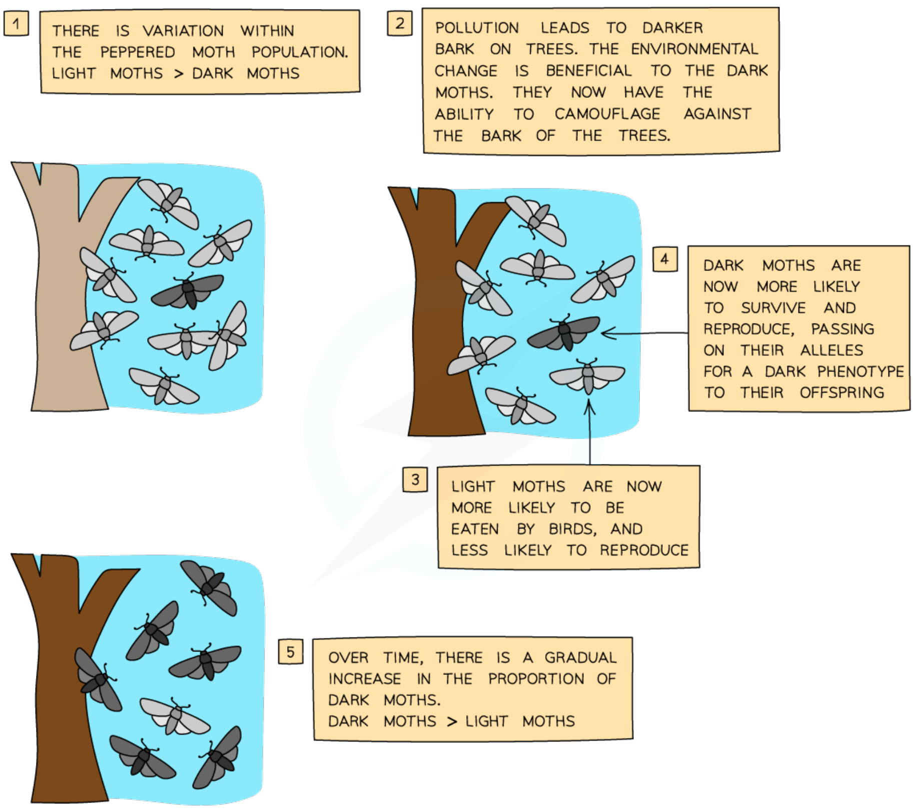
Natural selection illustrated by snail shell colour

18 VARIATION & SELECTION

18.4 NATURAL SELECTION & EVOLUTION cont...

YOUR NOTES

- Within the population of snails there is variation in shell colour
- Normal varieties of shell colours in this snail species is black or grey (as evidenced by the first picture)
- **Chance mutations** lead to a small number of snails / one snail having a white shell
- This 'small number' is shown in the second diagram where there are less white shelled snails than black or grey shelled snails
- The white shelled snail(s) **survive longer**
- This is the 'survival of the fittest', a term used to explain why some organisms succeed in the competitive struggle for survival against other members of their population
- The reason the white shelled snail(s) survive longer is **because they are better camouflaged**
- This means that they are **less likely to be seen by predators** and eaten
- As they survive longer they get **more opportunities to reproduce**
- And so the allele for white shells is passed onto offspring more frequently than the alleles for black or grey shells
- **Over generations, this is repeated** until the majority of snails in the population have white shells



Another good example of natural selection is the evolution of the peppered moths

18 VARIATION & SELECTION

18.4 NATURAL SELECTION & EVOLUTION cont...

YOUR NOTES

EXAM TIP

There are hundreds of thousands of examples of natural selection and you cannot possibly be familiar with all of them, however, they ALL follow the same sequence described above:

Based on the idea that within a species there is always variation and chance mutations, some individuals will develop a phenotype (characteristic) that gives them a survival advantage and therefore will:

- live longer,
- breed more
- and be more likely to pass their genes on.

Repeated over generations, the 'mutated' phenotype will become the norm. Remember, it is the concept you have to understand, not the specific example.

EXTENDED ONLY

Evolution

- If the environment **does not change**, selection does not change
- This will favour individuals with the **same characteristics** as their parents
- If the environment **changes**, or a chance mutation produces a **new allele**, selection might now **favour individuals with different characteristics** or with the new allele
- So the individuals that survive and reproduce will have a **different set of alleles** that they pass on to their offspring
- Over time, this will bring about a **change in the characteristics of the species** – it will produce **evolution**
- Evolution is defined as the **change in adaptive features of a population over time as a result of natural selection**
- Natural selection results in a **process of adaptation**, which means that, over generations, those features that are better adapted to the environment become more common
- This means populations of organisms become **better suited to their environment**
- A good example of this is the **development of antibiotic** resistance by bacteria

18 VARIATION & SELECTION

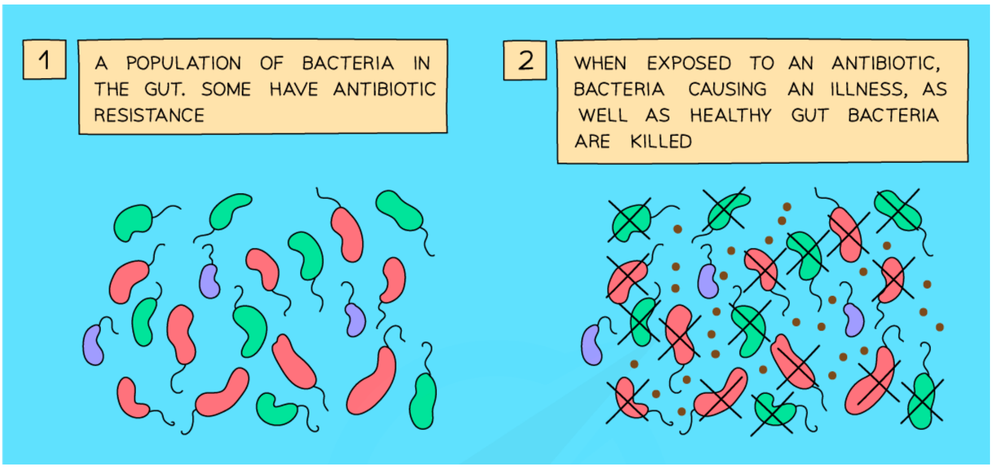
18.4 NATURAL SELECTION & EVOLUTION cont...

YOUR NOTES

EXTENDED ONLY cont...

Antibiotic Resistance in Bacteria

- An **antibiotic** is a chemical that can kill or inhibit the growth and reproduction of bacteria
- They are extremely useful to humans as some bacteria are **pathogenic** and can cause life-threatening disease
- Bacteria reproduce, on average, every 20 minutes and therefore **evolution occurs in a much shorter time span**
- Like all other organisms, **within a population there will be variation** caused by mutation
- A chance mutation might cause **some bacteria to become resistant** to an antibiotic (eg penicillin)
- When the population is treated with this antibiotic, the **resistant bacteria do not die**
- This means they can **continue to reproduce with less competition** from non-resistant bacteria, which are now dead
- Therefore the **genes for antibiotic resistance are passed on** with a much greater frequency to the next generation
- Over time the **whole population of bacteria becomes antibiotic-resistant** because the bacteria are best suited to their environment
- This is an example of natural selection that humans have helped to develop due to **overuse of antibiotics** in situations where they were not really necessary, for example:
  - for treatment of non-serious infections
  - routine treatment to animals in agriculture
  - failure to finish prescribed course of antibiotics

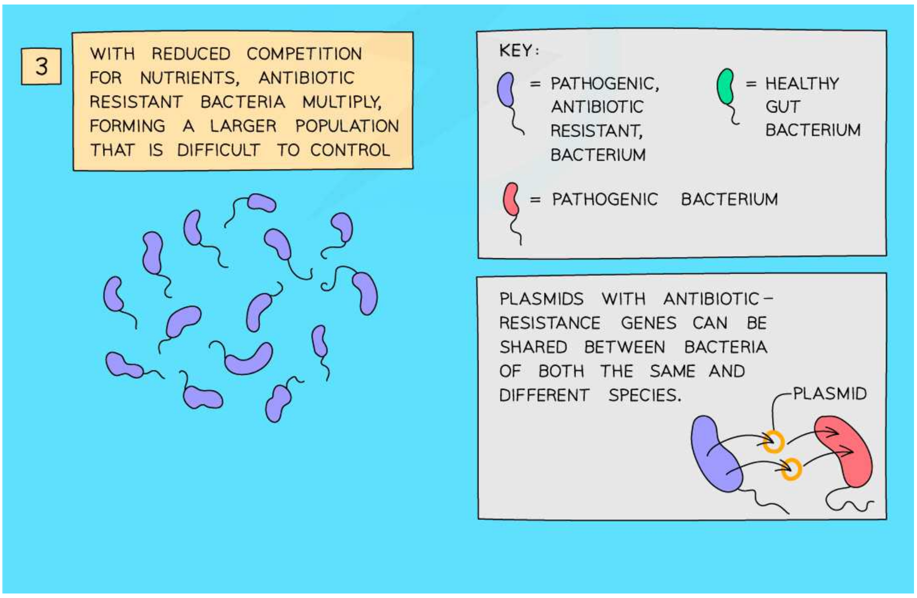


18 VARIATION & SELECTION

18.4 NATURAL SELECTION & EVOLUTION cont...

YOUR NOTES

EXTENDED ONLY cont...



Development of antibiotic resistance in bacteria

- Increases in the population of antibiotic-resistant bacteria cause infections and diseases which are harder to control as it is **difficult to find antibiotics that certain strains of bacteria are not resistant to**
- An example of this is **MRSA**, a very dangerous bacterial strain that is resistant to most antibiotics
- If someone gets infected with MRSA they cannot be treated easily
- Adding to these difficulties, the number of new antibiotics discovered has slowed significantly

18 VARIATION & SELECTION

18.5 SELECTIVE BREEDING

YOUR NOTES

Artificial Selection

- Selective breeding means to **select individuals with desirable characteristics and breed them together**
- The process doesn't stop there though because it's likely that not all of the offspring will show the characteristics you want so **offspring that do show the desired characteristics are selected and bred together**
- This process has to be **repeated for many successive generations** before you can definitely say you have a **'new breed'** which will **reliably** show those selected characteristics in all offspring

EXTENDED ONLY

Natural vs Artificial Selection

NATURAL SELECTION	ARTIFICIAL SELECTION
OCCURS NATURALLY	ONLY OCCURS WHEN HUMANS INTERVENE
RESULTS IN DEVELOPMENT OF POPULATIONS WITH FEATURES THAT ARE BETTER ADAPTED TO THEIR ENVIRONMENT AND SURVIVAL	RESULTS IN DEVELOPMENT OF POPULATIONS WITH FEATURES THAT ARE USEFUL TO HUMANS AND NOT NECESSARILY TO SURVIVAL OF THE INDIVIDUAL
USUALLY TAKES A LONG TIME TO OCCUR	TAKES LESS TIME AS ONLY INDIVIDUALS WITH THE DESIRED FEATURES ARE ALLOWED TO REPRODUCE

Selectively Breeding Plants

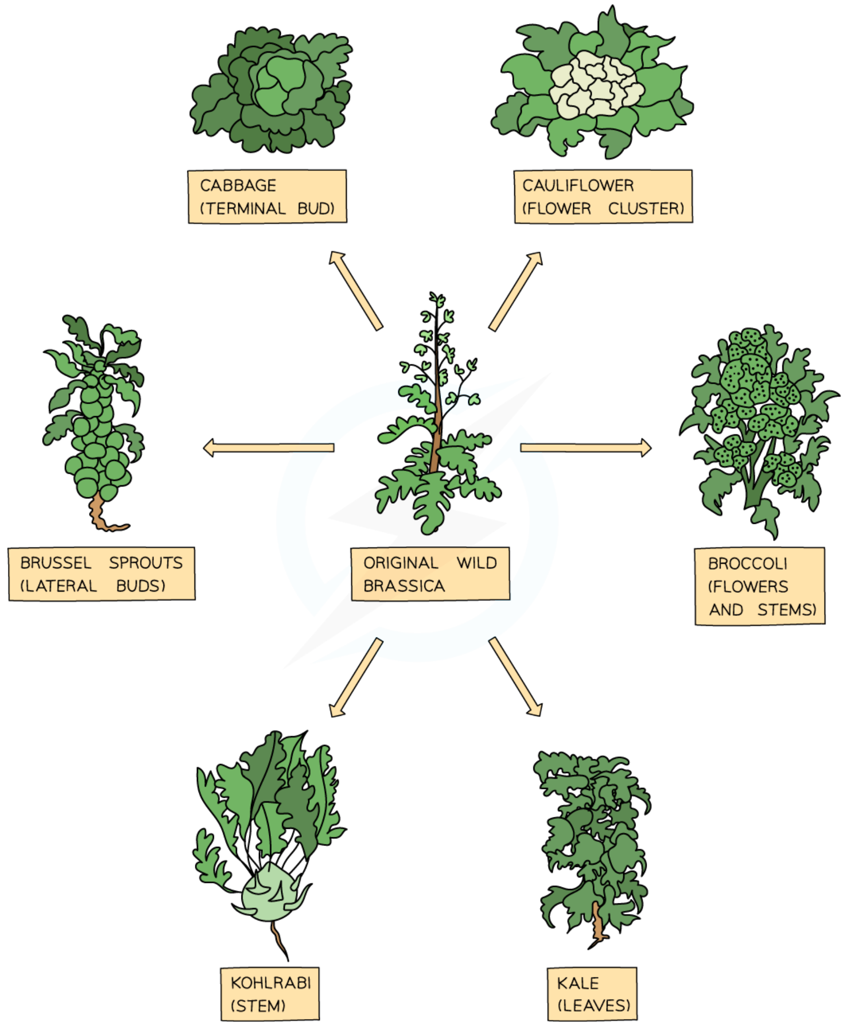
- Plants are selectively bred by humans for development of many characteristics, including:
  - disease resistance in food crops
  - increased crop yield
  - hardiness to weather conditions (e.g. drought tolerance)
  - better tasting fruits
  - large or unusual flowers
- An example of a plant that has been selectively bred in multiple ways is wild brassica, which has given rise to cauliflower, cabbage, broccoli, brussel sprouts, kale and kohlrabi:

18 VARIATION & SELECTION

18.5 SELECTIVE BREEDING cont...

YOUR NOTES

EXTENDED ONLY cont...



An example of selective breeding in plants

Selectively Breeding Animals

- Selective breeding of animals has been carried out by humans for thousands of years
- It takes place in the same way as selective breeding of plants
- Individuals with the **characteristics you want are bred together** (often several different parents all with the desired characteristics are chosen so siblings do not have to be bred together in the next generation)
- Offspring that show the desired characteristics are **selected and bred together**

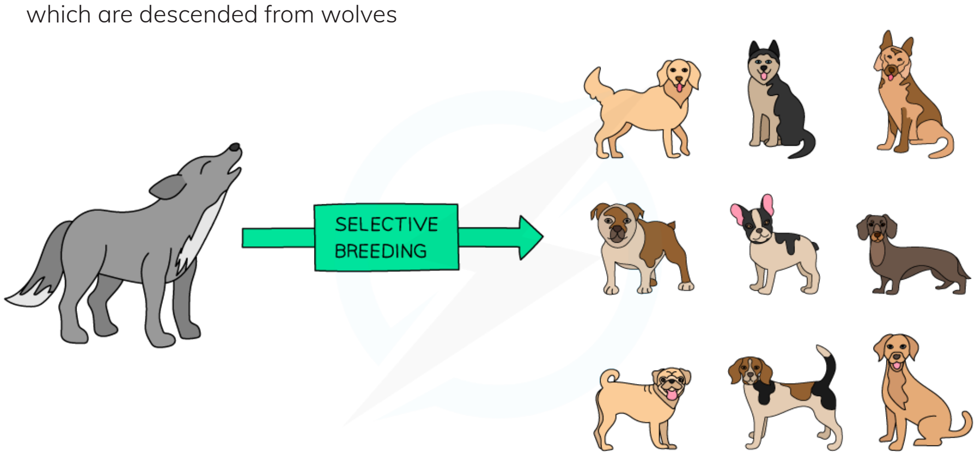
18 VARIATION & SELECTION

18.5 SELECTIVE BREEDING cont...

YOUR NOTES

EXTENDED ONLY cont...

- This process is **repeated for many successive generations** before you can definitely say you have a 'new breed' which will reliably show those selected characteristics in all offspring
- Animals are commonly selectively bred for various characteristics, including:
    - **cows, goats and sheep that produce lots of milk or meat**
    - **chickens that lay large eggs**
    - **domestic dogs that have a gentle nature**
    - **sheep with good quality wool**
    - **horses with fine features and a very fast pace**
- An example of an animal that has been selectively bred by humans in many ways to produce breeds with many different characteristics is the **domestic dog**, all breeds of which are descended from wolves



Selective breeding has produced many different breeds of domestic dog

EXAM TIP

Make sure that you include the need to **repeat the selective breeding for many generations** in any exam answer you give

Selecting two parents with desired characteristics, breeding them and stopping there is not selective breeding and will not give rise to a new breed.

> NOW TRY SOME EXAM QUESTIONS

18 VARIATION & SELECTION

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

An island's entire population of a species of butterfly are descended from just two parents. These were introduced from the mainland.

Which of the following statements about this species of butterfly, compared with that of the mainland, is correct?

A The population shows more genetic variety.

B The population will adapt more slowly to environmental changes.

C The population shows more genetic variety.

D The population is less in danger of collapsing from disease.

QUESTION 2

What is a mutation?

A A process used in genetic engineering.

B A type of continuous variation.

C A condition caused by a dominant allele.

D A change in a gene.

QUESTION 3

Which of the following characteristics show discontinuous variation?

A Length of foot

B Weight

C Tongue rolling

D Height

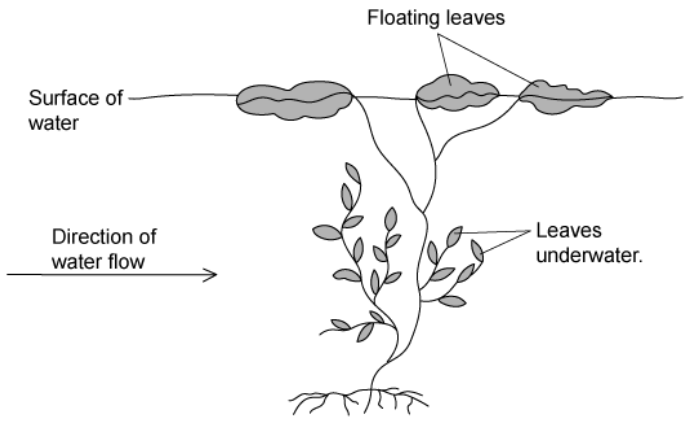
18 VARIATION & SELECTION

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

The diagram shows a hydrophyte in a stream.



What statement is true about the leaves underwater?

A They offer little resistance to water flow.

B They have a thick cuticle.

C They require many xylem vessels for support.

D They cannot photosynthesise.

QUESTION 5

A patient with a bacterial infection is treated with antibiotics, but some of the bacteria survive.

Which statement is correct about the bacteria that have survived?

A The bacteria will now be resistant to all antibiotics.

B The resistant bacteria is a result of selective breeding.

C The bacteria will have undergone a process of natural selection.

D The antibiotic will now work better on the next generation of bacteria.

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19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

19.1 FOOD CHAINS & WEBS

Types of Variation

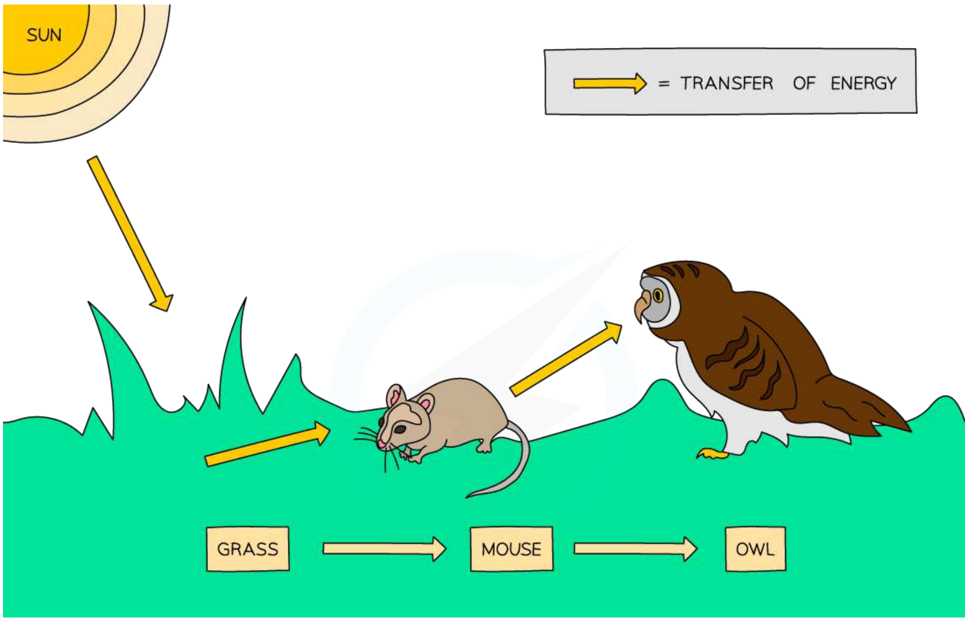
TERM	DEFINITION
PRODUCERS	ORGANISMS THAT PRODUCE **THEIR OWN ORGANIC NUTRIENTS USUALLY USING ENERGY FROM SUNLIGHT.** PLANTS ARE PRODUCERS AS THEY CARRY OUT PHOTOSYNTHESIS TO MAKE GLUCOSE
HERBIVORE	AN ANIMAL THAT GETS ITS ENERGY BY **EATING PLANTS**
CARNIVORE	AN ANIMAL THAT GETS ITS ENERGY BY **EATING OTHER ANIMALS**
PRIMARY CONSUMERS	HERBIVORES – THEY **FEED ON PRODUCERS** (PLANTS)
SECONDARY CONSUMERS	PREDATORS THAT **FEED ON PRIMARY CONSUMERS**
TERTIARY CONSUMERS	PREDATORS THAT **FEED ON SECONDARY CONSUMERS**
DECOMPOSERS	BACTERIA AND FUNGI THAT GET THEIR ENERGY FROM **FEEDING OFF DEAD AND DECAYING ORGANISMS AND UNDIGESTED WASTE** (SUCH AS FAECES) BY SECRETING ENZYMES TO BREAK THEM DOWN

19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

Food Chains



A food chain with three trophic levels

- A food chain shows the transfer of energy from one organism to the next, starting with a producer
- The source of all energy in a food chain is **light energy from the Sun**
- The arrows in a food chain show the **transfer of energy** from one trophic level to the next
- Energy is transferred from one organism to another by ingestion (eating)
- In the food chain above:

POSITION IN FOOD CHAIN	ORGANISM	EXPLANATION
PRODUCER	GRASS SEED	MAKES ITS OWN FOOD USING ENERGY FROM SUNLIGHT IN PHOTOSYNTHESIS
PRIMARY CONSUMER	VOLE	EATS THE PRODUCER
SECONDARY CONSUMER	BARN OWL	EATS THE PRIMARY CONSUMER

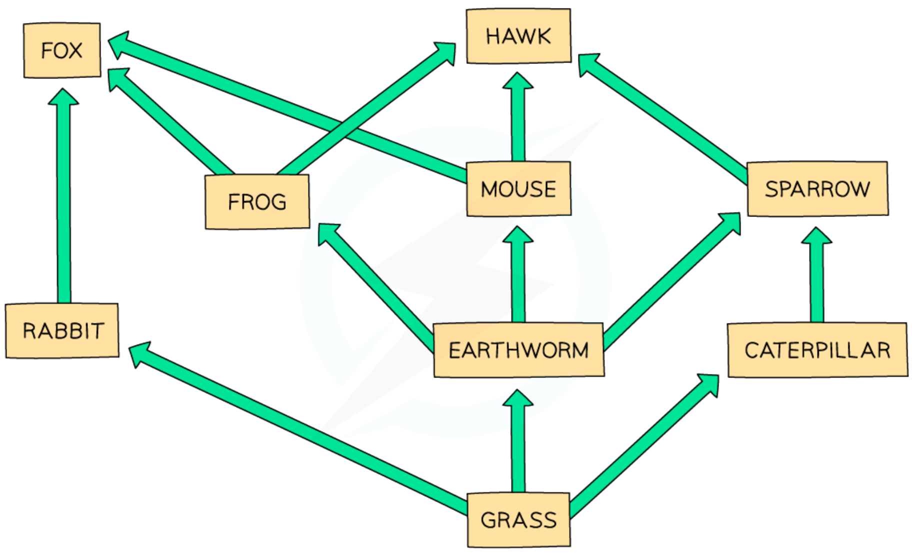
19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

Food Webs

- A **food web** is a network of interconnected food chains
- Food webs are more realistic ways of showing connections between organisms within an ecosystem as **animals rarely exist on just one type of food source**



A food web shows the interdependence of organisms

- Food webs give us a lot more information about the transfer of energy in an ecosystem
- They also show **interdependence** – how the change in one population can affect others within the food web
- For example, in the food web above, **if the population of insects decreased**:
  - The population of **grass plants would increase** as there are now less species feeding off them
  - The populations of **frogs and voles would decrease significantly** as insects are their only food source
  - The population of **thrushes would decrease slightly** as they eat insects but also have another food source to rely on (slugs)
- Most of the changes in populations of animals and plants happen as a result of **human impact** – either by **overharvesting of food species** or by **introduction of foreign species to a habitat**
- Due to interdependence, these can have **long-lasting knock-on effects** to organisms throughout a food chain or web

19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

EXAM TIP

Questions about interdependence in food webs are common and easy to gain marks on if you answer them fully and correctly.

Do not say an animal or plant would 'die out' as this is unlikely to happen – stick to using the words decrease or increase.

If in doubt, always **give your reason for the increase or decrease** in population.

19.2 ENERGY

Trophic Levels

- Trophic levels describe the **position of an organism in a food chain, web or pyramid**
- Animals (known as consumers) can be at **different trophic levels within the same food web** as they may eat both primary, secondary and / or tertiary consumers
- Energy flows from the sun to the first trophic level (producers) in the form of **light**
- **Producers** convert **light energy into chemical energy** and it flows in this form from one consumer to the next
- Eventually **all energy is transferred to the environment** – energy is passed on from one level to the next with some being used and lost at each stage
- Energy flow is a **non-cyclical process** – once the energy gets to the top of the food chain or web, **it is not recycled but 'lost' to the environment**
- This is in **direct contrast** to the chemical elements that organisms are made out of, which are repeatedly recycled

TROPHIC LEVEL	REASON
PRODUCERS	THEY **PRODUCE THEIR OWN ORGANIC NUTRIENTS USUALLY USING ENERGY FROM SUNLIGHT**
PRIMARY CONSUMERS	HERBIVORES – THEY **FEED ON PRODUCERS** (PLANTS)
SECONDARY CONSUMERS	PREDATORS THAT **FEED ON PRIMARY CONSUMERS**
TERTIARY CONSUMERS	PREDATORS THAT **FEED ON SECONDARY CONSUMERS**
QUATERNARY CONSUMERS	PREDATORS THAT **FEED ON TERTIARY CONSUMERS**

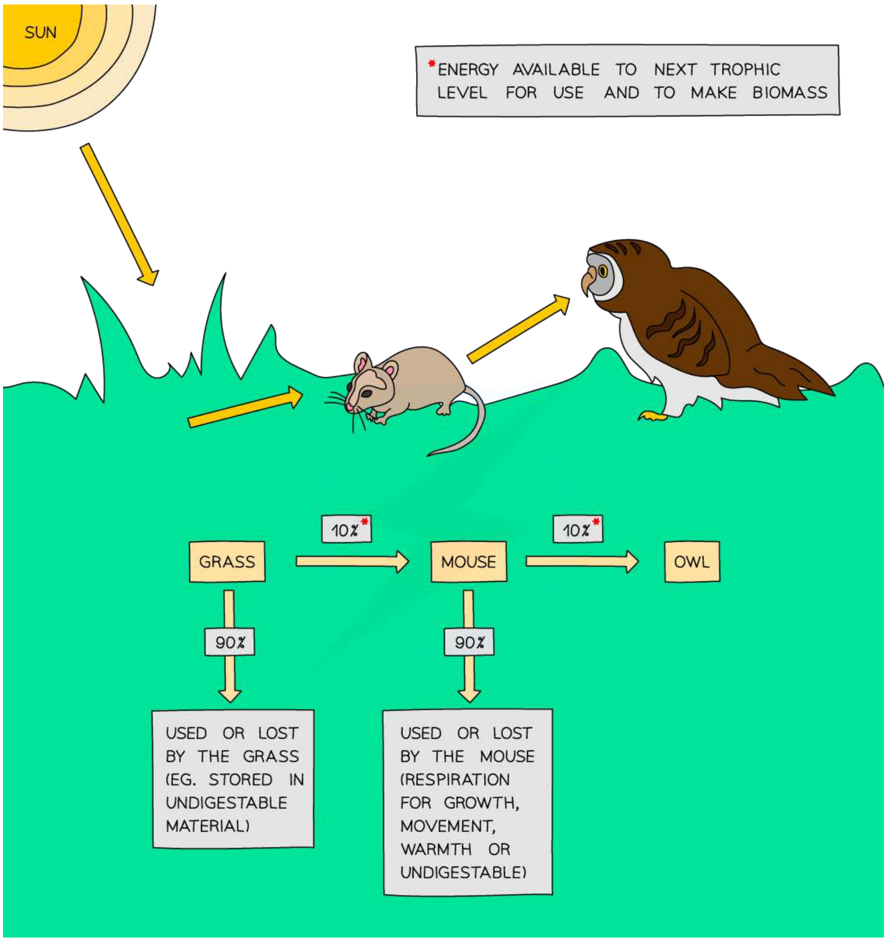
19 ORGANISMS & THEIR ENVIRONMENT

19.2 ENERGY cont...

YOUR NOTES

Transfer of Energy

- At each stage in a food chain only about **10% of the energy received by an organism gets passed on** to the next trophic level:



Energy transfer through a food chain

Why is this?

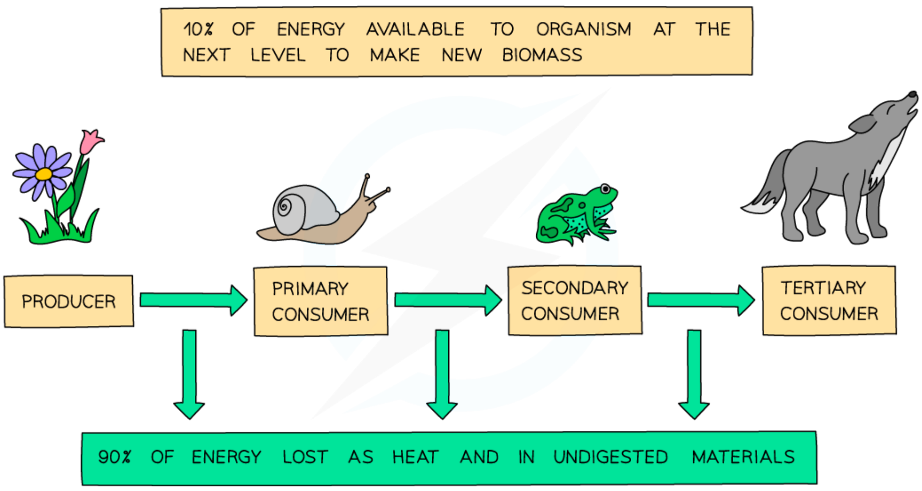
- In order for the energy to be passed on, **it has to be consumed (eaten)**
- However **not all of the energy grass plants receive goes into making new cells** that can be eaten
- The same goes for the energy the vole gets from the grass, and the energy the barn owl gets from the vole
- **Only the energy that is made into new cells remains with the organism to be passed on**
- Even then, some of this energy **does not get consumed** – for example few organisms eat an entire organism, including roots of plants or bones of animals – but **energy is still stored in these parts and so it does not get passed on**

19 ORGANISMS & THEIR ENVIRONMENT

19.2 ENERGY cont...

YOUR NOTES

- The majority of the energy an organism receives gets 'lost' (or 'used') through:
  - **making waste products** eg (urine) that get removed from the organism
  - **as movement**
  - **as heat** (in mammals and birds that maintain a constant body temperature)
  - **as undigested waste** (faeces) that is removed from the body and provides food for decomposers
- This inefficient loss of energy at each trophic level explains why **food chains are rarely more than 5 organisms long**
- In the example above, something that preyed regularly on the barn owl would only get 0.1J of energy from each barn owl it ate
- In order to survive, it would have to:
- eat a huge number of them every day to get the amount of energy it needed to survive (are there that many barn owls close together?)
- not expend much energy itself hunting them (is this likely?)



Energy is lost at each trophic level for several reasons

EXAM TIP

This is a complicated concept but by learning the main ways in which energy is lost between trophic levels, you will be able to answer most questions on this topic.

Read the question carefully and tailor your answer to the specific organism you are being asked about – eg plants do not produce urine or faeces so you could not give this as one of the ways in which they use energy that cannot be passed on!

19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

19.2 ENERGY cont...

Energy Transfer in Human Food Chains

- Humans are **omnivores**, obtaining energy from both plants and animals, and this gives us a **choice of what we eat**
- These choices, however, have an **impact on what we grow** and how we use ecosystems
- Think of the following food chains, both involving humans

wheat ⟶ cow ⟶ human

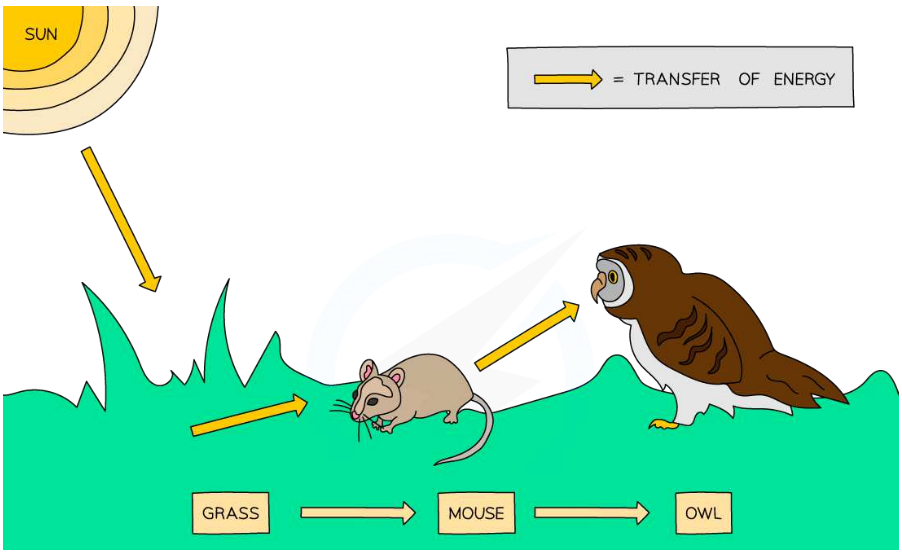
wheat ⟶ human

- Given what we know about **energy** transfer in food **chains**, it is clear that if humans eat the wheat there is **much more energy available** to them than if they eat the cows that eat the wheat
- This is because **energy is lost from the cows**, so there is less available to pass on to humans
- Therefore, it is **more energy efficient within a crop food chain for humans to be the herbivores rather than the carnivores**
- In reality, we often feed animals on plants that we cannot eat (eg grass) or that are too widely distributed for us to collect (eg algae in the ocean which form the food of the fish we eat)

19.3 PYRAMIDS

Pyramids of Number

- A pyramid of numbers shows **how many organisms** we are talking about at each level of a food chain.
- The **width of the box** indicates the **number of organisms** at that trophic level
- For example, consider the following food chain:



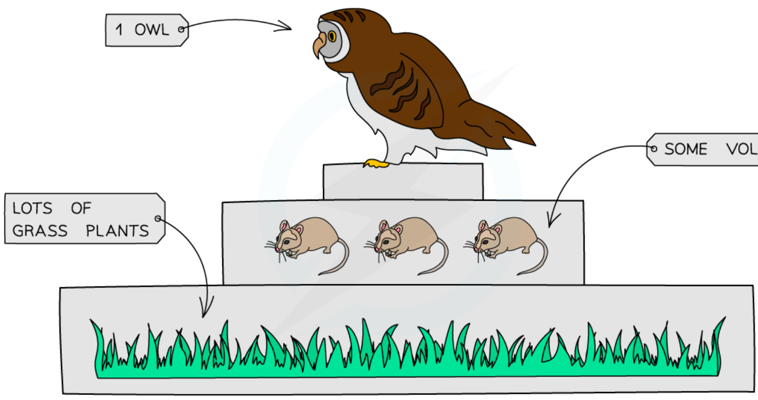
A food chain shows the transfer of energy

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

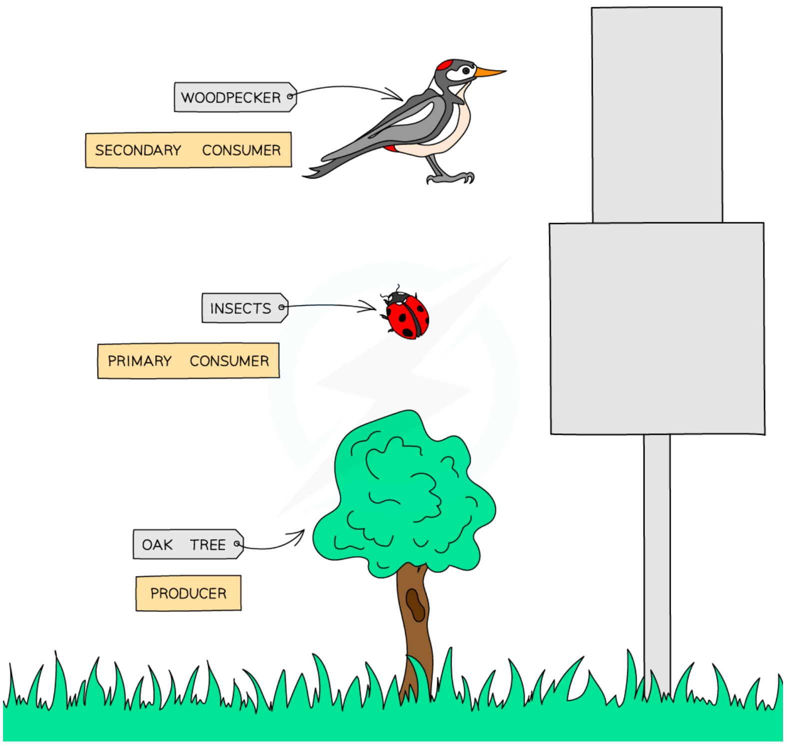
YOUR NOTES

- Ask yourself the following questions:
  - Is it likely that there would be more voles in an area than grass plants?
  - How many voles might one barn owl need to eat per day? If it's more than one, is it likely that there are more barn owls in an area than voles?
- So, a pyramid of numbers for this food chain would look like this:



A pyramid of numbers

- Despite the name (and the example above), a **pyramid of numbers doesn't always have to be pyramid-shaped**, for example:



Pyramids of numbers are not always pyramid–shaped

- This is because the **size of the organism is also important** – one large organism, like the oak tree in the pyramid above, contains enough energy to support many smaller organisms (the insects)

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

YOUR NOTES

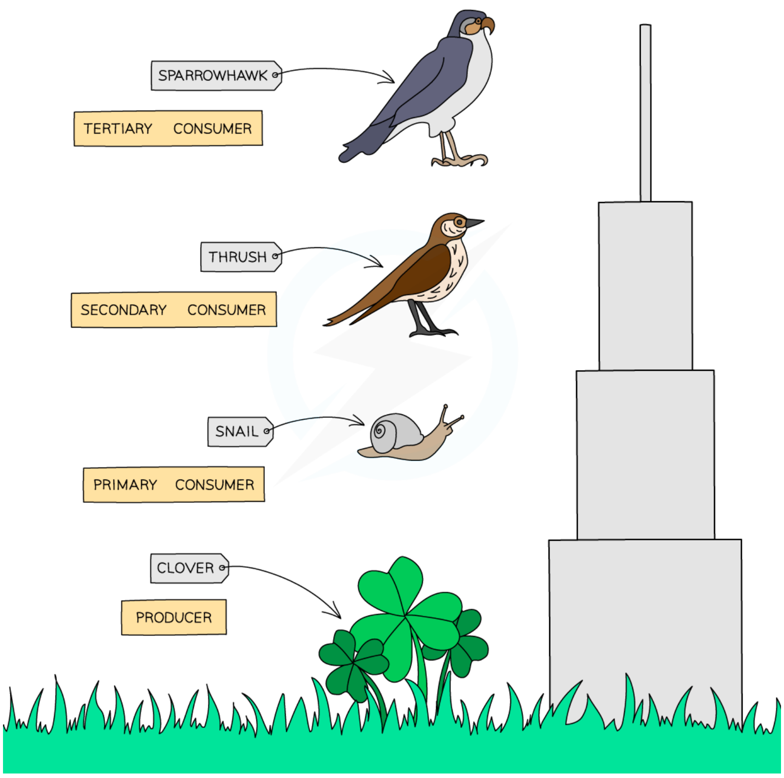
Rules to remember when drawing a pyramid of numbers:

- You **cannot change the trophic level of the organisms** – they must stay in the same order as in the food chain with producers on the bottom, followed by primary consumers, then secondary consumers, then tertiary consumers
- Generally, the **larger an individual organism is, the less of them there are**

EXTENDED ONLY

Pyramids of Biomass

- A pyramid of biomass shows **how much mass the creatures at each level would have without including all the water that is in the organisms** (their 'dry mass')
- Pyramids of biomass are **ALWAYS pyramid-shaped**, regardless of what the pyramid of numbers for that food chain looks like
- This is because the **mass of organisms has to decrease as you go up a food chain** – if we take our first food chain as an example, it's impossible to have 10kg of grass feeding 50kg of voles feeding 100kg of barn owls



A pyramid of biomass

- Pyramids of biomass provide a much better idea of the **quantity** of the plant or animal material at each level of a food chain and therefore are a better way of representing interdependence within the food chain

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

YOUR NOTES

EXAM TIP

Remember that pyramids of biomass are ALWAYS pyramid-shaped, so they are easy to draw, but pyramids of number can be any shape.

Make sure you learn the rules for drawing a pyramid of numbers to get it correct.

19.4 NUTRIENT CYCLES

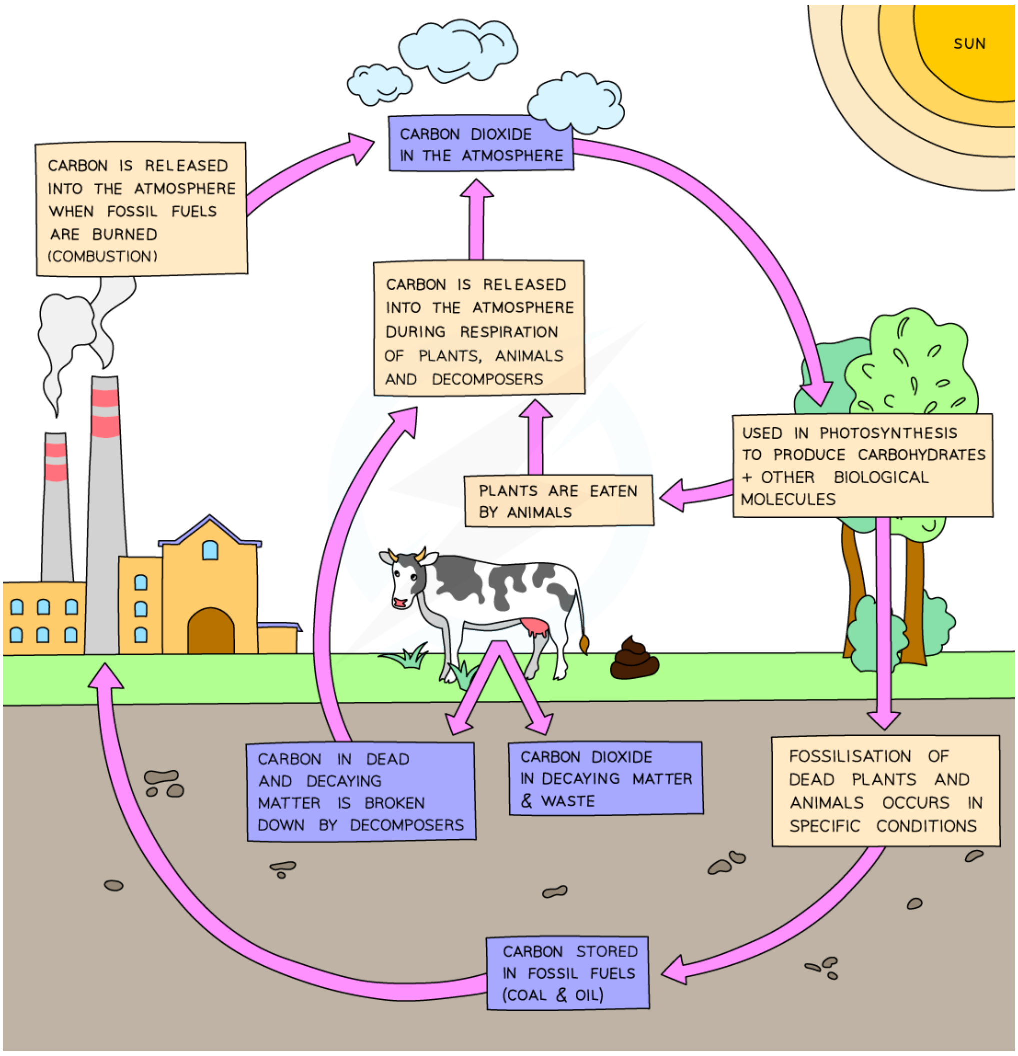
The Carbon Cycle

- Nutrients such as carbon and nitrogen are not endless resources
- There is a finite amount of each element on the planet and as such, they need to be **recycled** in order to allow new organisms to be made and grow
- **Carbon** is taken out of the atmosphere in the form of **carbon dioxide** by plants to be used for photosynthesis
- It is passed on to animals (and microorganisms) by **feeding**
- It is returned to the atmosphere in the form of **carbon dioxide** by plants, animals and microorganisms as a result of **respiration**
- If animals and plants die in conditions where decomposing microorganisms are not present, the carbon in their bodies can be converted, over millions of years and significant pressure, into **fossil fuels**
- When fossil fuels are burned (the process is known as **combustion**), the carbon combines with oxygen and **carbon dioxide is released** into the atmosphere
- **Increased use of fossil fuels** is contributing to an increase in the carbon dioxide content of the atmosphere
- In addition, **mass deforestation** is **reducing the amount of producers** available to take carbon dioxide out of the atmosphere by photosynthesis
- This problem is exacerbated by the fact that in many areas of the world, deforestation is taking place for land rather than for the trees themselves, and as such they are **burnt down, releasing yet more carbon dioxide into the atmosphere**

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES



The carbon cycle

EXAM TIP

The carbon cycle is simple:

- Carbon is taken out of the atmosphere by photosynthesis
- It is passed on to animals and decomposers by **feeding**
- It is returned by **respiration**; in plants, in animals and in decomposing microorganisms
- In addition, it is returned (in increasing amounts) by combustion of fossil fuels
- You should be able to identify what each arrow represents in any diagram of the carbon cycle

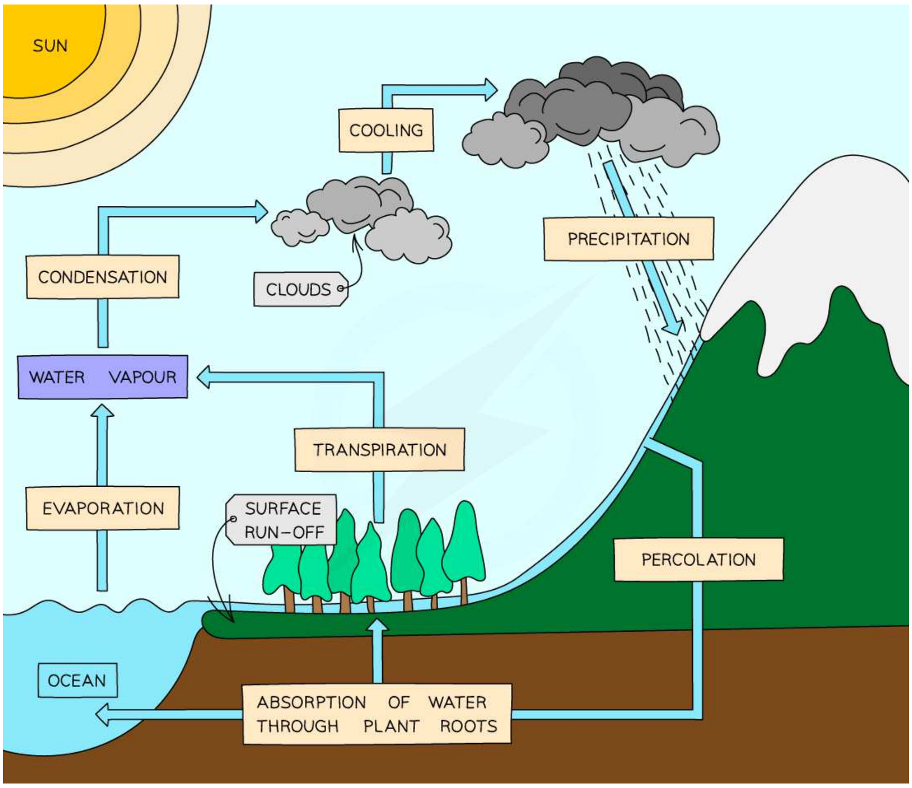
19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

19.4 NUTRIENT CYCLES cont...

The Water Cycle

- Water molecules move between various locations – such as rivers, oceans and the atmosphere – by specific processes
- This is possible because water changes state at a relatively low temperature



The water cycle

- **Water enters the atmosphere as water vapour in one of two processes:**
  - Energy from the Sun heats the Earth's surface and water **evaporates** from oceans, rivers and lakes
  - **Transpiration** from plants releases water vapour into the air
- **The warmer air of the lower atmosphere rises, taking the water vapour with it**
  - The moist air cools down as it rises
  - Water vapour **condenses** back into liquid water, forming **clouds**
- **Water returns to Earth in the form of precipitation**
  - As the water droplets in the cloud get **bigger and heavier**, they begin to fall as **rain, snow and sleet**
  - This is called precipitation

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES

EXAM TIP

Make sure you can **identify each of these processes on a diagram** as this is a common multiple choice question.

EXTENDED ONLY

The Nitrogen Cycle

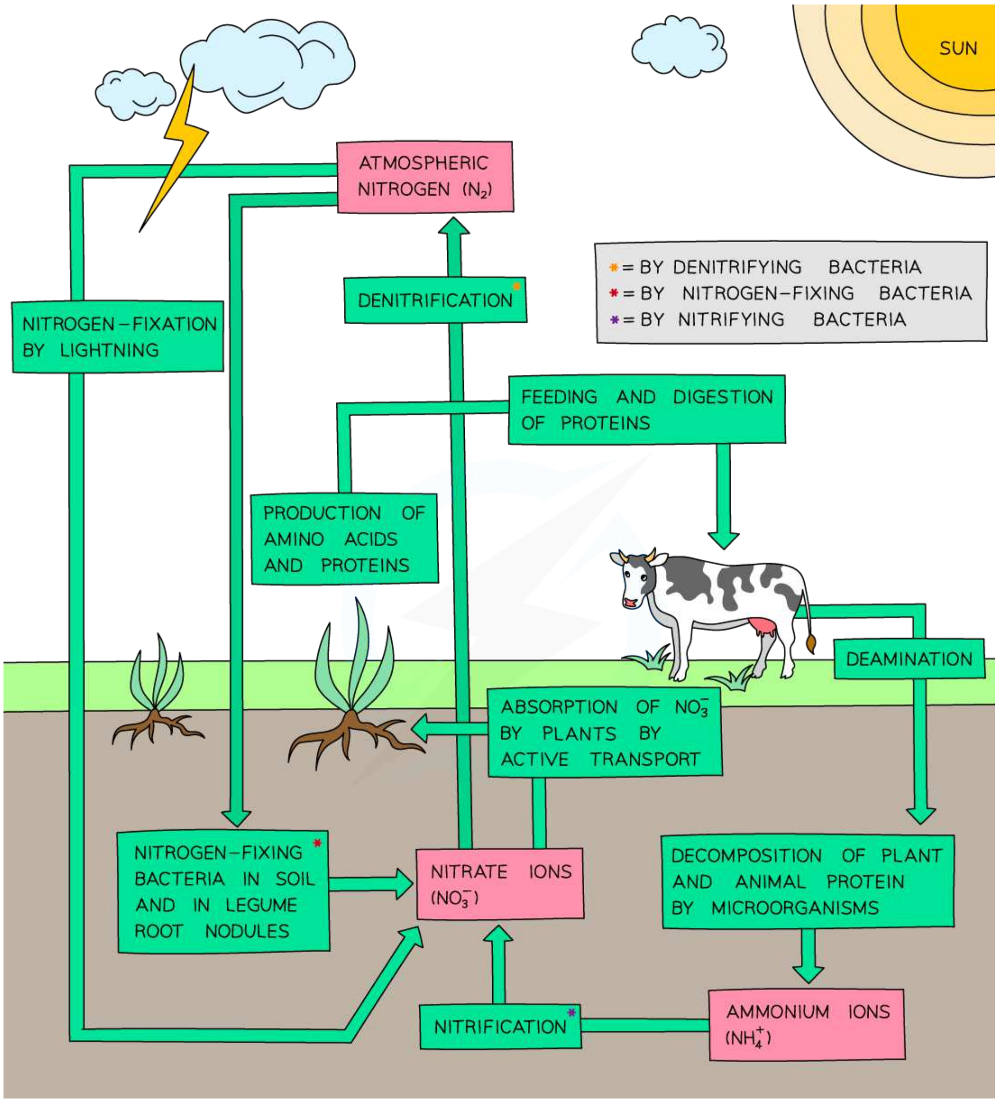
- **Nitrogen** as an element is required to make proteins
- **Neither plants nor animals can absorb it from the air** as N2 gas is very stable and the bonds holding the nitrogen atoms together would need massive amounts of energy to break (the two nitrogen atoms in a nitrogen molecule are held together by a triple covalent bond)
- However, there are two ways it can be taken out of the air and converted into something easier to absorb:
    - **Nitrogen fixing bacteria** found 'free living' in soil and also in the root nodules of certain plants (peas, beans, clover – we call them leguminous plants) take N2 gas and change it into nitrates in the soil
    - **Lightning can 'fix' N_2 gas**, splitting the bond between the two atoms and turning them into nitrous oxides like N_2O and NO_2 that dissolve in rainwater and 'leach' into the soil
- Plants absorb the **nitrates** they find in the soil and use the nitrogen in them to make proteins
- Animals **eat** the plants (or other animals) and get the nitrogen they need from the proteins in the plant or animal
- **Waste** (urine and faeces) from animals sends nitrogen back into the soil as ammonium compounds (the urea in urine contains nitrogen)
- When the animals and plants die, they **decay** and all the proteins inside them are broken down into ammonium compounds and put back into the soil by decomposers
- The plants can't absorb ammonium compounds though, so a second type of soil bacteria, **nitrifying bacteria**, convert the ammonium compounds to nitrites and then to nitrates, which can then be absorbed by plants – and so the cycle goes on
- Finally, there is a third, unhelpful type of (anaerobic) bacteria called **denitrifying bacteria** found in poorly aerated soil (ie not much oxygen)
- These bacteria take the nitrates **out of the soil** and convert them back into N_2 gas
- Farmers can help reduce the amount of these unhelpful bacteria by ploughing and turning over soil

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES

EXTENDED ONLY cont...



The nitrogen cycle

EXAM TIP

Students often find the nitrogen cycle quite difficult, but if you make an effort to **learn the three types of bacteria and what they do** it becomes much simpler.

19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

19.5 POPULATIONS

Definition of Population

- A population is defined as:
  - **a group of organisms of one species, living in the same area at the same time**

EXTENDED ONLY

Definitions

- A community is defined as:
  - **all of the populations of different species in an ecosystem**
- An ecosystem is defined as:
  - **a unit containing the community of organisms and their environment, interacting together** (eg a decomposing log, a lake)

Factors Affecting Population Growth

- All living organisms compete with each other for **food, water and living space**
- Those which are the best adapted to their environments generally increase their populations at the expense of those less well adapted
- Population growth in most organisms is controlled by the following three factors:
  - **Food supply**
  - **Predation**
  - **Disease**

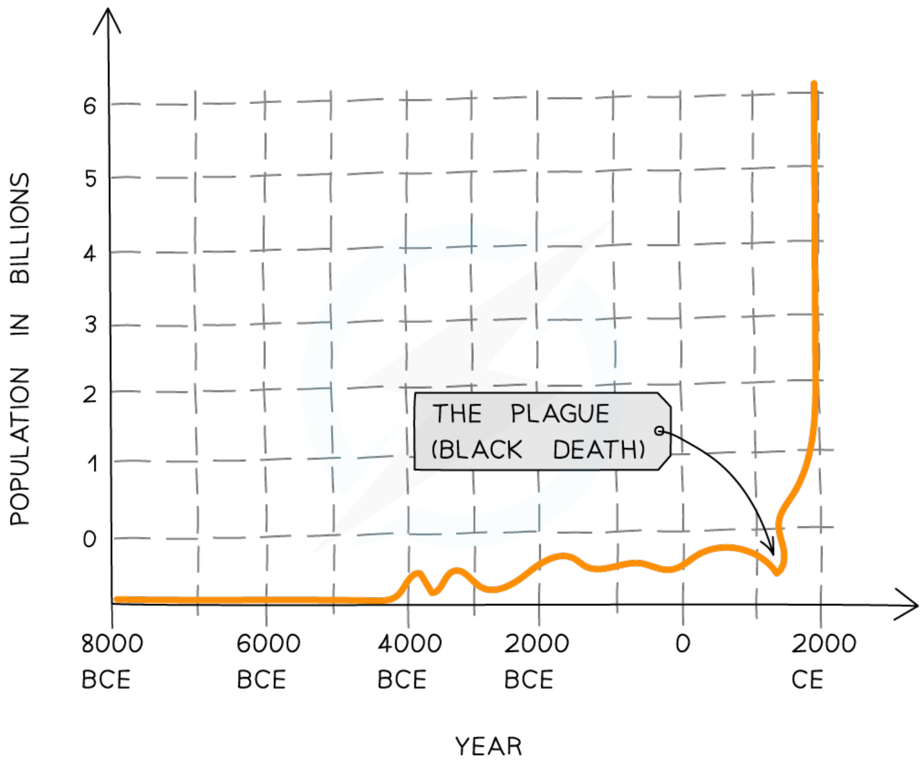
19 ORGANISMS & THEIR ENVIRONMENT

19.5 POPULATIONS cont...

YOUR NOTES

Human Population Growth

- Human population growth globally has been increasing **exponentially** for the last 150 years



Human population growth is growing exponentially

- There are many reasons for this exponential growth, including:
- **Improved technology** leading to an **abundance of food** = rapid increase in birth rate
- **Improved medicine, hygiene and health care** = decrease in death rate

EXAM TIP

There are many different ways of showing human population growth.

In an exam, **look carefully at the data to figure out the trend** it is showing and think about **how that links to social implications**, locally and globally, of the growth of the human population.

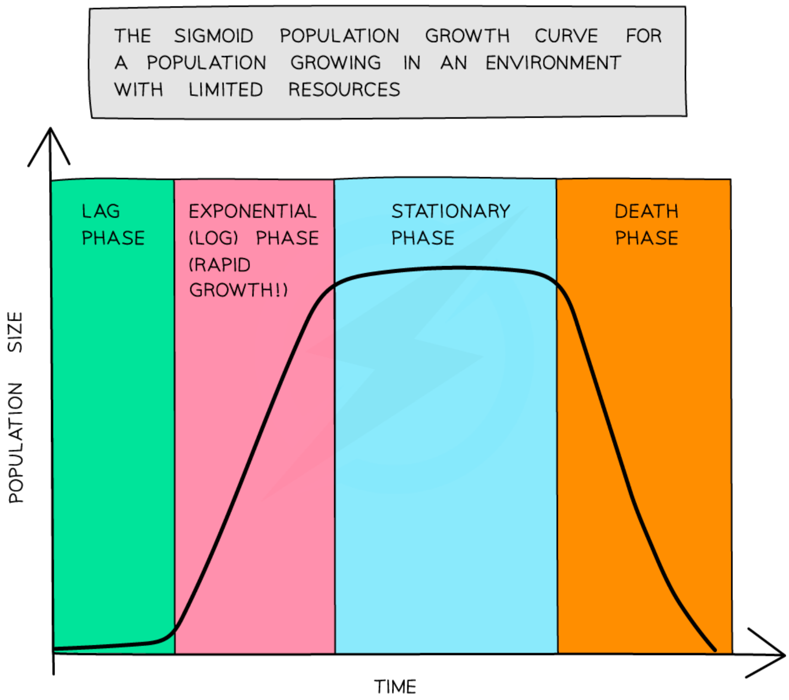
19.5 POPULATIONS cont...

YOUR NOTES

EXTENDED ONLY

Growth Curves

- If the growth of microorganisms in a fermenter is measured over time, the population growth looks like the graph below



A typical growth curve for a population in an enclosed environment

- The shape of this curve (a little like an 'S'), gives it its name – a **sigmoid growth curve**
- The curve has four distinct phases:
    - **Lag phase**: organisms are **adapting to the environment** before they are able to reproduce; in addition, at this stage there are very few organisms and so reproduction is not producing larger numbers of offspring
    - **Log phase** (aka **exponential** phase): **food supply is abundant, birth rate is rapid** and **death rate is low; growth is exponential** and only limited by the number of new individuals that can be produced

19 ORGANISMS & THEIR ENVIRONMENT

19.5 POPULATIONS cont...

YOUR NOTES

EXTENDED ONLY cont...

- **Stationary phase**: population **levels out** due to a **factor in the environment**, such as a nutrient, **becoming limited** as it is not being replenished; birth rate and death rate are equal and will remain so until either the nutrient is replenished or becomes severely limited
- **Death phase**: population **decreases** as death rate is now greater than birth rate; this is usually because **food supply is short** or **metabolic wastes produced by the population have built up to toxic levels**

- Organisms in a natural environment are **unlikely to show population growth like a sigmoid growth curve** because they are affected by many other factors, including:
  - **changing temperature or light**
  - **predators**
  - **disease**
  - **immigration** (individuals moving into the area)
  - **emigration** (individuals moving out of the area)

> NOW TRY SOME EXAM QUESTIONS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The diagram below shows a food chain

grass → locusts → snakeseagles

If the number of snakes decrease due to disease, what will happen to the number of other organisms in the food chain?

	grass	locusts	eagles
A	increase	increase	increase
B	increase	decrease	increase
C	decrease	decrease	decrease
D	decrease	increase	decrease

QUESTION 2

Which of the following is a correct example of a population?

A All the animals in a forest.

B All the goldfish in a pond.

C All the species of animals in Europe.

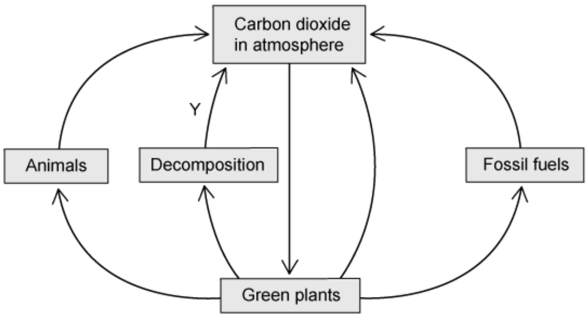
D All the people born in Scotland over 150 years.

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

The diagram below illustrates part of the carbon cycle.



Which process is shown by the arrow labelled Y?

A Photosynthesis

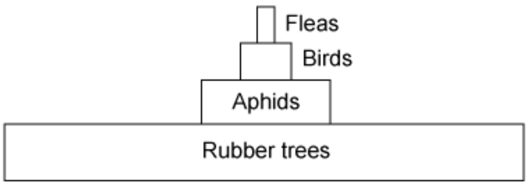
B Feeding

C Respiration

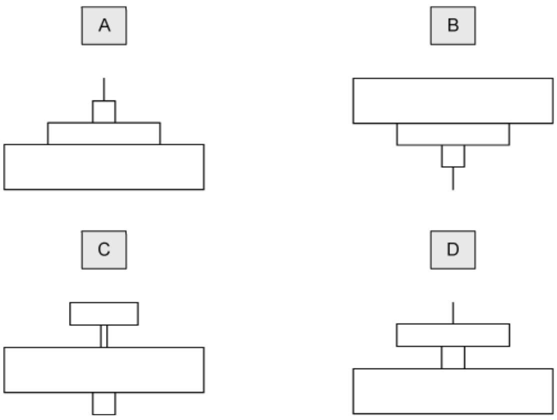
D Combustion

QUESTION 4

The image below shows a pyramid of biomass for a food chain in a rainforest ecosystem.



What would be an appropriate pyramid of numbers for this food chain?



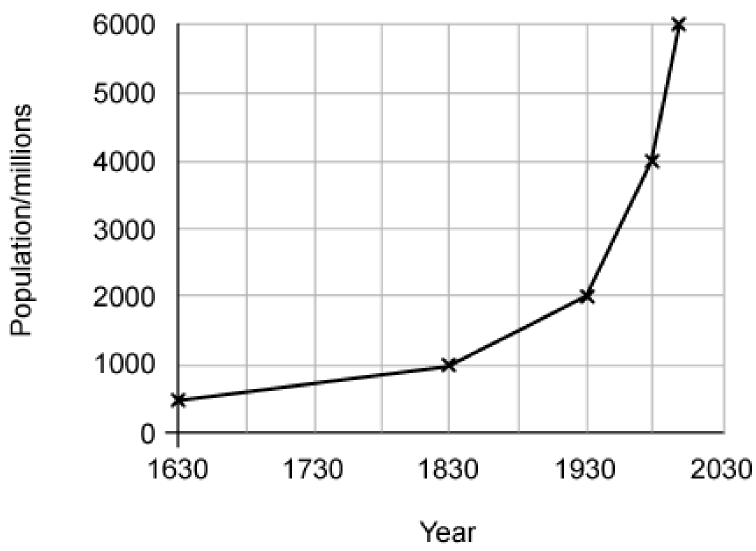
19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 5

The graph below shows the growth of the human population globally since 1630.



Which of the following options represents the longest time period taken for the population of humans to double?

A 100 years

B 200 years

C 300 years

D 400 years

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20 BIOTECHNOLOGY & GENETIC ENGINEERING

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

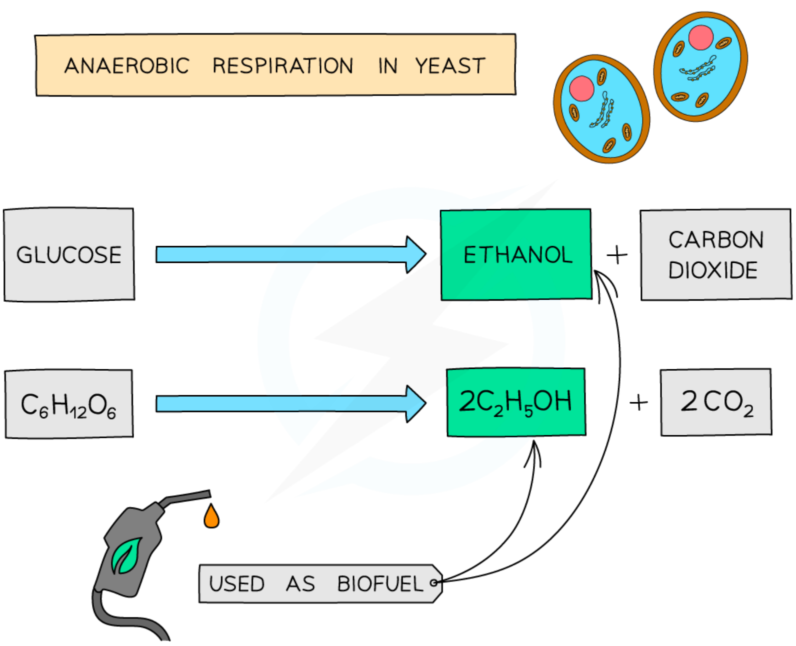
20.1 BIOTECHNOLOGY

Use of Bacteria

- Microorganisms can be used by humans to produce foods and other useful substances
- The most common type of microorganisms used in biotechnology are **bacteria**
- They are useful because they are **capable of producing complex molecules** (eg certain bacteria added to milk produce enzymes that turn the milk into yoghurt)
- They are also useful because they **reproduce rapidly**, meaning the amount of chemicals they can produce can also rapidly increase

Biofuels

- **Yeast** is a single-celled fungus that uses sugar as its food source
- When it respires, ethanol and carbon dioxide are produced (and energy is released)



The alcohol produced by fermentation of glucose can be used as biofuel

20 BIOTECHNOLOGY & GENETIC ENGINEERING

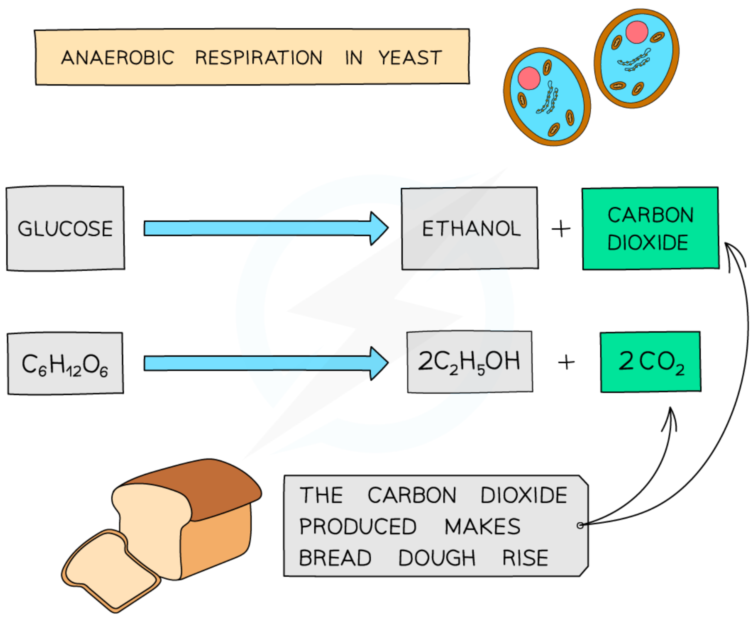
YOUR NOTES

20.1 BIOTECHNOLOGY cont...

- The **ethanol** produced in this reaction is increasingly being used as a **biofuel** (a fuel made from living organisms rather than a fossil fuel like oil, coal or gas)
- In countries such as Brazil, biofuel is partly replacing petrol as the fuel for cars and other vehicles
- **Plant material** is used as the **substrate** for producing ethanol (as a source of glucose) – it is chopped up into small pieces and mixed with **yeast** which respires anaerobically and produces ethanol
- The liquid is separated from the remaining solids and any water is removed, leaving a **concentrated solution of ethanol**
- Sometimes the **waste parts** of crop plants, such as the stalks or outer leaves, are used, but in other places, **crops are grown specifically** to be harvested for making ethanol
- In some places, this is causing concern that there is **less land available** for local people to grow food crops needed for survival

Bread Making

- Yeast will **respire anaerobically** if it has access to plenty of **sugar**, even if oxygen is available
- This is taken advantage of in **bread making**, where the yeast is mixed with flour and water and respires anaerobically, producing **carbon dioxide**:



The carbon dioxide produced by fermentation (anaerobic respiration) of glucose is what makes bread dough rise

- The **carbon dioxide** produced by the yeast during respiration is caught in the dough, causing the bread to **rise**

20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.1 BIOTECHNOLOGY cont...

YOUR NOTES

Fruit Juice Production

- Fruit juice is produced by squeezing the fruits to remove the juice
- Chopping the fruit up before squeezing helps to release a lot more juice, but this does not break open all the cells so **a lot of juice is lost**
- By adding an enzyme called **pectinase** to the chopped up fruit, more juice is released
- Pectinase works by breaking down a chemical called **pectin** that is found inside plant cell walls
- Once pectin is broken down, the **cell walls break more easily** and more juice can be squeezed out of the fruit
- Adding pectinase to fruits also helps to **produce a clearer juice** as larger polysaccharides like pectin can make the juice seem cloudy – once they are broken down into smaller molecules, the juice becomes clearer

Biological Washing Powders

- Many stains on clothes are **organic molecules** – oil from skin, protein from blood, fat and protein from food
- Detergents that only contain soap can remove some of these stains when mixed with hot water, but it can take **a lot of time and effort and very high temperatures** to remove the stains entirely
- Biological washing powders contain **enzymes** similar to the digestive enzymes produced in the alimentary canal that help to break down large food molecules
- Using biological washing powders has several advantages, including:
    - **Quickly** breaking down **large, insoluble molecules** such as fats and proteins into **smaller**, **soluble ones** that **will dissolve** in washing water
    - They are **effective at lower temperatures**, meaning **less energy (and money)** has to be used in order to wash clothes to get them clean as washing water does not need to be heated to higher temperatures
    - They can be used to clean **delicate fabrics** that would not be suitable for washing at high temperatures

20 BIOTECHNOLOGY & GENETIC ENGINEERING

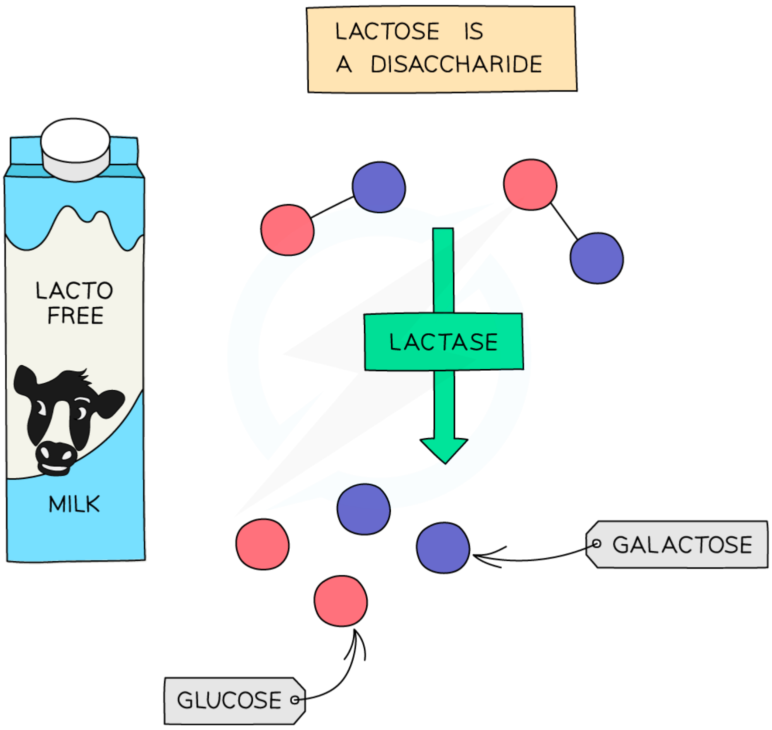
20.1 BIOTECHNOLOGY cont...

YOUR NOTES

EXTENDED ONLY

Lactose-Free Milk

- Lactose is the **sugar found in milk**
- Human babies are born with the ability to produce **lactase**, the **enzyme** that breaks down lactose
- In certain areas of the world, many people **lose the ability to produce lactase as they get older**
- This means that they can become **lactose intolerant** and react badly to the lactose in milk and products made from milk (cheese, yoghurt etc)
- Symptoms of lactose intolerance include **nausea, flatulence and diarrhoea** as their digestive system is upset by the lactose
- Milk can be made **lactose free** by **adding the enzyme lactase to it** and leaving it to stand for a while to allow the enzyme to break down the lactose



Lactose-free milk is a product made from adding the enzyme lactase to dairy milk to break down the sugars in it

20 BIOTECHNOLOGY & GENETIC ENGINEERING

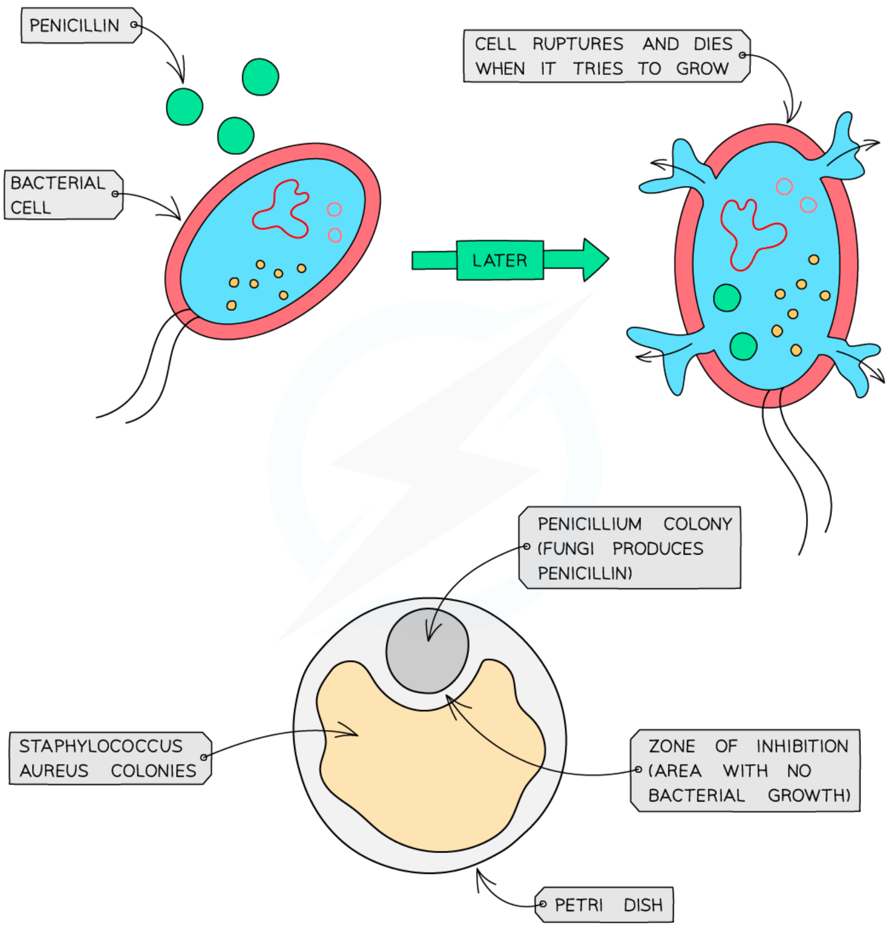
YOUR NOTES

20.1 BIOTECHNOLOGY cont...

EXTENDED ONLY cont...

Penicillin Production

- Penicillin was the **first antibiotic** discovered in 1928 by **Alexander Fleming**
- He noticed that some bacteria he had left in a Petri dish had been killed by the naturally occurring **Penicillium mould**
- The penicillium mould produces a **chemical** to prevent it being infected by certain types of bacteria



Penicillin produced by the fungus Penicillium inhibits bacterial growth

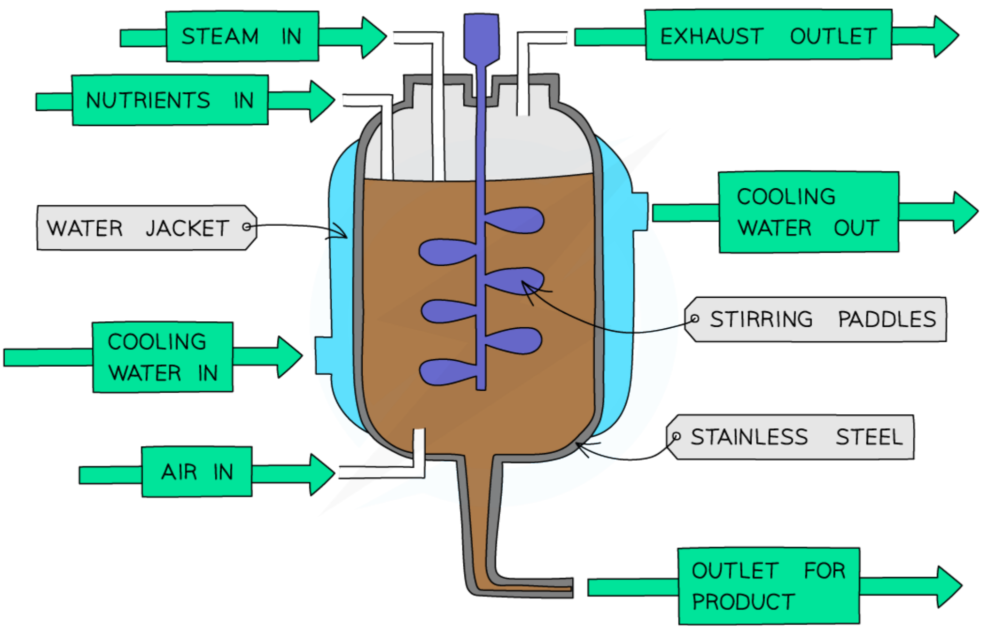
20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.1 BIOTECHNOLOGY cont...

YOUR NOTES

EXTENDED ONLY cont...

- The chemical was isolated and named **penicillin**
- Since the discovery of penicillin, methods have been developed to **produce it on a large scale**, using an **industrial fermenter**



A diagram of an industrial fermenter used to produce large quantities of microorganisms

- **Fermenters** are containers used to grow ('**culture**') microorganisms like bacteria and fungi in **large amounts**
- These can then be used for many biotechnological processes like producing **genetically modified bacteria** and the **penicillium mould that produces penicillin**
- The advantage of using a fermenter is that **conditions can be carefully controlled** to produce large quantities of exactly the right type of microorganism

20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.1 BIOTECHNOLOGY cont...

YOUR NOTES

EXTENDED ONLY cont...

CONDITION	WHY AND HOW IT IS CONTROLLED
ASEPTIC PRECAUTIONS	FERMENTER IS CLEANED BY STEAM TO KILL MICROORGANISMS AND PREVENT CHEMICAL CONTAMINATION, WHICH ENSURES ONLY THE DESIRED MICROORGANISMS WILL GROW
NUTRIENTS	NUTRIENTS ARE NEEDED FOR USE IN RESPIRATION TO RELEASE ENERGY FOR GROWTH AND TO ENSURE THE MICROORGANISMS ARE ABLE TO REPRODUCE
OPTIMUM TEMPERATURE	TEMPERATURE IS MONITORED USING PROBES AND MAINTAINED USING THE WATER JACKET TO ENSURE AN OPTIMUM ENVIRONMENT FOR ENZYMES TO INCREASE ENZYME ACTIVITY (ENZYMES WILL DENATURE IF THE TEMPERATURE IS TOO HIGH OR WORK TOO SLOWLY IF IT IS TOO LOW)
OPTIMUM PH	PH INSIDE THE FERMENTER IS MONITORED USING A PROBE TO CHECK IT IS AT THE OPTIMUM VALUE FOR THE PARTICULAR MICROORGANISM BEING GROWN. THE PH CAN BE ADJUSTED, IF NECESSARY, USING ACIDS OR ALKALIS.
OXYGENATION	OXYGEN IS NEEDED FOR AEROBIC RESPIRATION TO TAKE PLACE
AGITATION	STIRRING PADDLES ENSURE THAT MICROORGANISMS, NUTRIENTS, OXYGEN, TEMPERATURE AND PH ARE EVENLY DISTRIBUTED THROUGHOUT THE FERMENTER

20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.2 GENETIC ENGINEERING

YOUR NOTES

Genetic Engineering Examples

- Genetic engineering is **changing the genetic material of an organism by removing, changing or inserting individual genes from another organism**
- The organism receiving the genetic material is said to be **'genetically modified'**, or is described as a **'transgenic organism'**
- The DNA of the organism that now contains DNA from another organism as well is known as **'recombinant DNA'**
- There are many examples of genetically modified organisms, including:
    - The gene for **human insulin** has been inserted into **bacteria** which then produce human insulin which can be collected and purified for medical use for diabetics
    - **Crop plants**, such as wheat and maize, have been genetically modified to contain a gene from a bacterium that **produces a poison that kills insects**, making them **resistant to insect pests** such as caterpillars
    - **Crop plants** have also been genetically modified to make them **resistant to certain herbicides** (chemicals that kill plants), meaning that when the herbicide is sprayed on the crop it only kills weeds and does not affect the crop plant
    - Some crops have been genetically modified to **produce additional vitamins**, eg **'golden rice'** contains genes from another plant and a bacterium which make the rice grains produce a chemical that is turned into **vitamin A** in the human body, which could help prevent deficiency diseases in certain areas of the world

20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.2 GENETIC ENGINEERING cont...

YOUR NOTES

EXTENDED ONLY

Advantages & Disadvantages of GM Crops

ADVANTAGES	DISADVANTAGES
REDUCED USE OF CHEMICALS SUCH AS HERBICIDES AND PESTICIDES – BETTER FOR THE ENVIRONMENT CHEAPER / LESS TIME–CONSUMING FOR FARMERS	INCREASED COSTS OF SEEDS – COMPANIES THAT MAKE GM SEEDS CHARGE MORE FOR THEM TO COVER THE COST OF DEVELOPING THEM THIS CAN MEAN SMALLER, POORER FARMERS CANNOT COMPETE WITH LARGER FARMS
INCREASED YIELDS FROM THE CROPS AS THEY ARE NOT COMPETING WITH WEEDS FOR RESOURCES OR SUFFERING FROM PEST DAMAGE	INCREASED DEPENDENCY ON CERTAIN CHEMICALS, SUCH AS THE HERBICIDES THAT CROPS ARE RESISTANT TO – OFTEN MADE BY THE SAME COMPANIES THAT PRODUCE THE SEED AND MORE EXPENSIVE TO BUY
	RISK OF INSERTED GENES BEING TRANSFERRED TO WILD PLANTS BY POLLINATION WHICH COULD REDUCE THE USEFULNESS OF THE GM CROP (EG IF WEEDS ALSO GAIN THE GENE THAT MAKES THEM RESISTANT TO HERBICIDE)
	REDUCED BIODIVERSITY AS THERE ARE FEWER PLANT SPECIES WHEN HERBICIDES HAVE BEEN USED – THIS CAN IMPACT INSECTS AND INSECT–EATING BIRDS
	SOME RESEARCH HAS SHOWN THAT PLANTS THAT HAVE HAD GENES INSERTED INTO THEM DO NOT GROW AS WELL AS NON–GM PLANTS

20 BIOTECHNOLOGY & GENETIC ENGINEERING

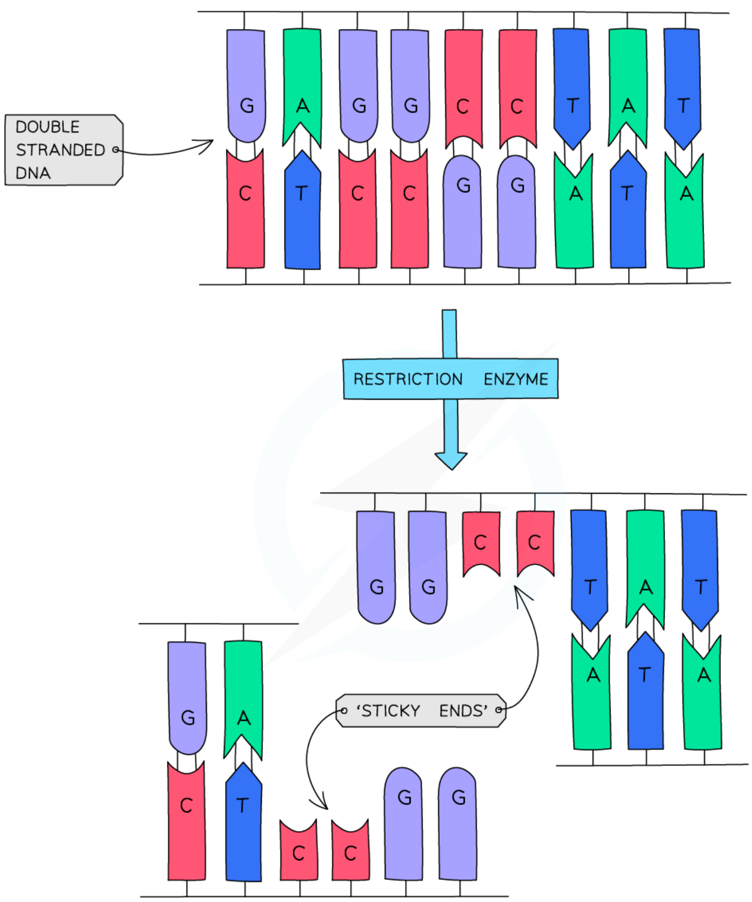
20.2 GENETIC ENGINEERING cont...

YOUR NOTES

EXTENDED ONLY cont...

Process of Genetic Engineering

- The gene that is to be inserted is located in the original organism (for example, this could be the gene for human insulin)
- **Restriction enzymes** are used to isolate the required gene, leaving it with '**sticky ends**' (a short section of unpaired bases)
- A bacterial plasmid is **cut by the same restriction enzyme leaving it with corresponding sticky ends** (plasmids are **circles of DNA** found inside bacterial cells)



Restriction enzymes cut DNA strands at specific sequences to form 'sticky ends'

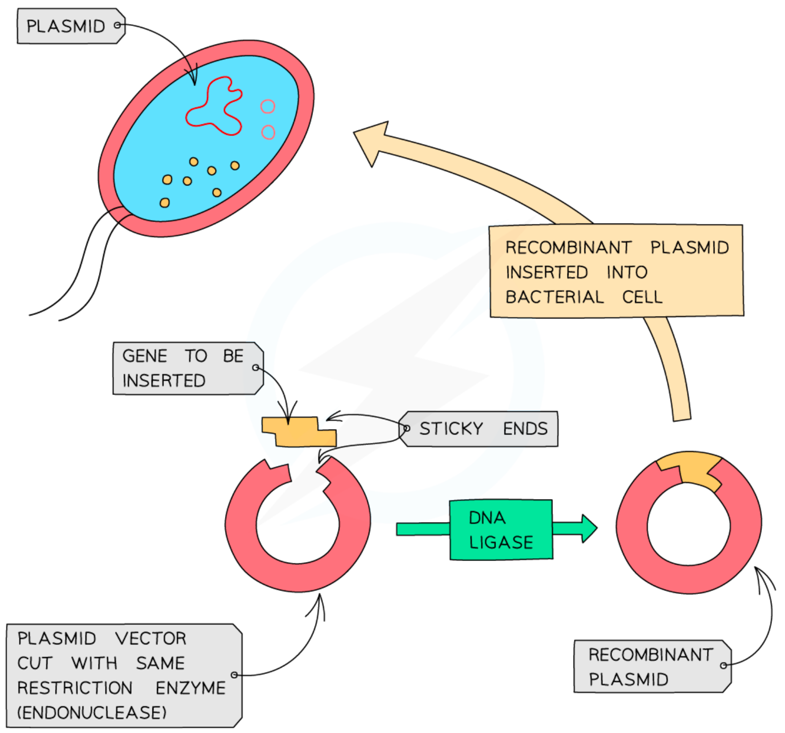
- The plasmid and the isolated gene are joined together by **DNA ligase enzyme**
- If two pieces of DNA have **matching sticky ends** (because they have been **cut by the same restriction enzyme**), DNA ligase will link them to form a single, unbroken molecule of DNA

20 BIOTECHNOLOGY & GENETIC ENGINEERING

20.2 GENETIC ENGINEERING cont...

YOUR NOTES

EXTENDED ONLY cont...



DNA ligase is used to join two separate pieces of DNA together

- The genetically engineered plasmid is **inserted into a bacterial cell**
- When the bacteria reproduce, the **plasmids are copied as well** and so a recombinant plasmid can **quickly be spread** as the bacteria multiply, and they will then all **express the gene** and make the human protein
- The genetically engineered bacteria can be placed in a **fermenter** to reproduce quickly in controlled conditions and make **large quantities** of the human protein
- Bacteria are extremely useful for genetic engineering purposes because:
  - They contain the **same genetic code** as the organisms we are taking the genes from, meaning they can easily 'read' it and **produce the same proteins**
  - There are **no ethical concerns over their manipulation and growth** (unlike if animals were used, as they can feel pain and distress)
  - The **presence of plasmids** in bacteria, separate from the main bacterial chromosome, makes them **easy to remove and manipulate** to insert genes into them and then place back inside the bacterial cells

> NOW TRY SOME EXAM QUESTIONS

20 BIOTECHNOLOGY & GENETIC ENGINEERING

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which of these statements correctly describes genetic engineering?

A Only breeding from crop plants that are resistant to pests.

B Altering the DNA in crop plants so that they are resistant to herbicides.

C Using yeast to produce ethanol.

D Production of insulin in the pancreas.

QUESTION 2

Genes are isolated from human DNA using ……1…… enzymes.

A bacterial plasmid is cut with the same enzyme creating ……2…… .

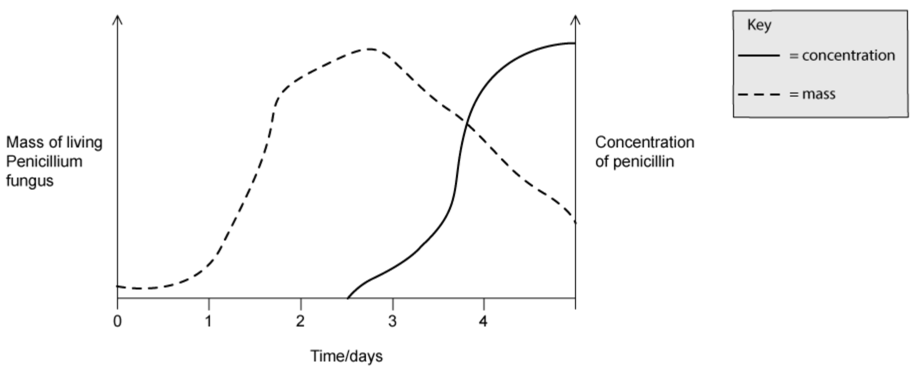
The human DNA is inserted into the bacterial plasmid using the enzyme ……3…… creating a ……4…… plasmid.

Which row correctly completes gaps 1, 2, 3 and 4?

	1	2	3	4
A	restriction	sticky ends	ligase	recombinant
B	ligase	daughter plasmids	ligase	restriction
C	recombinant	new DNA	lipase	daughter
D	ligase	sticky ends	protease	diploid

QUESTION 3

Penicillin is produced in a fermenter by growing the fungus Penicillium.
The graph below shows how the mass of living Penicillium fungus, and the concentration of penicillin, changed over time.



20 BIOTECHNOLOGY & GENETIC ENGINEERING

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 3 cont...

Which day would be the best to harvest the penicillin at?

A 3 days

B 1.5 days

C 5 days

D 3.5 days

QUESTION 4

Which of the following is a reason yeast is used to make bread?

Yeast is used to make bread because...

A it produces ethanol.

B it produces lactic acid.

C it produces carbon dioxide.

D it products oxygen.

QUESTION 5

What is the name of the enzyme used to produce clear apple juice?

A Lipase

B Amylase

C Protease

D Pectinase

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21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

CONTENTS:

VIEW EXAM QUESTIONS

21.1 FOOD SUPPLY

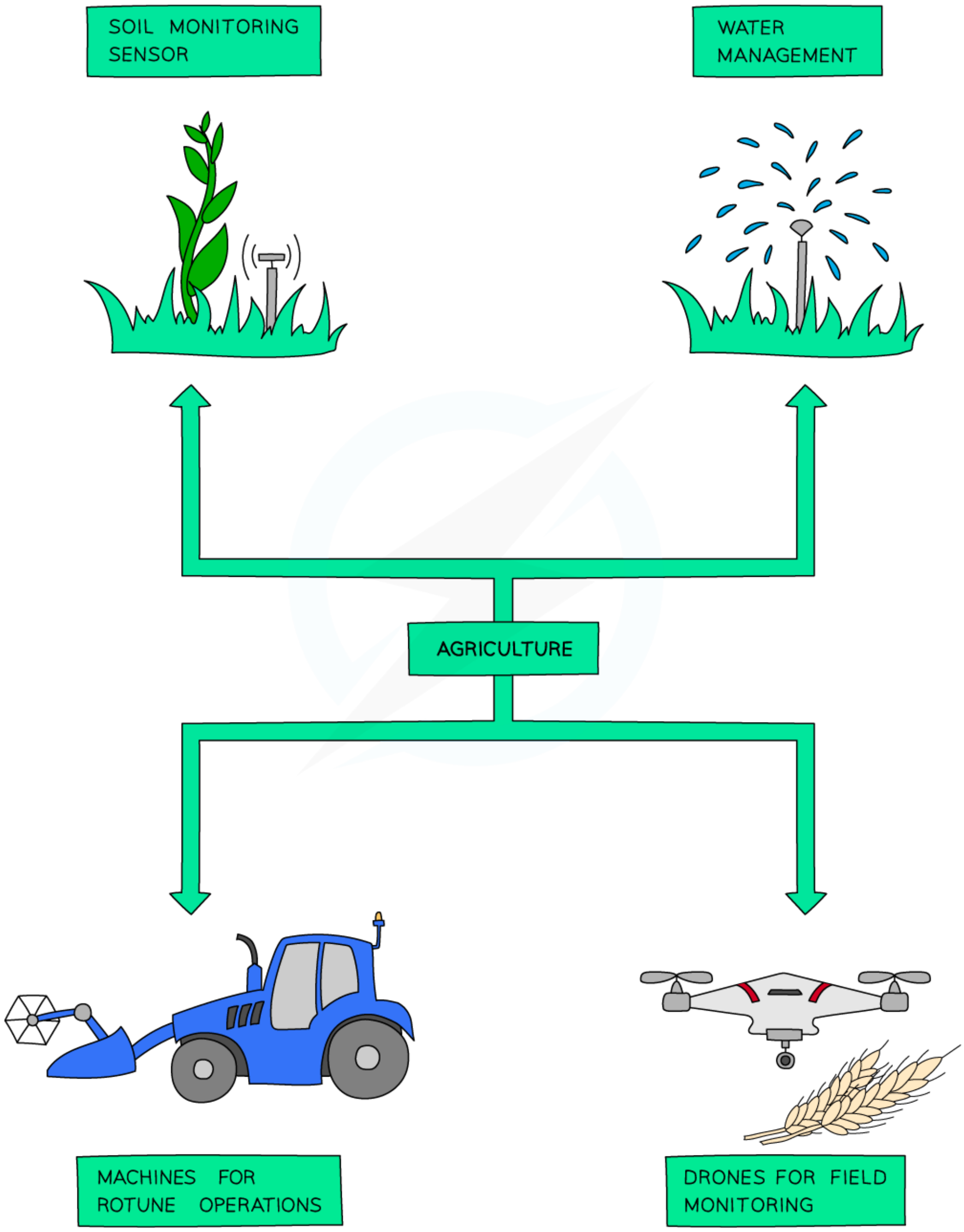
Improving Food Production

- Modern technology has increased food supply substantially in the following ways:
  - **Agricultural machinery** has replaced humans and **improved efficiency** due to the ability to farm **much larger areas** of land
  - **Chemical fertilisers improve yields** – fertilisers increase the amount of nutrients in the soil for plants, meaning that they can grow larger and produce more fruit
  - **Insecticides and herbicides** – these chemicals kill off unwanted insects and weed species, meaning that there is **less damage done** to plants and fruit lost to insects (insecticides), as well as **reducing competition** from other plant species (herbicides)
  - **Selective breeding** – animals and crop plants which produce a large yield are selectively bred to produce breeds that **reliably produce high yields**

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.1 FOOD SUPPLY cont...

YOUR NOTES



Modern agricultural processes allows for cultivation of much larger areas of land for crop plants

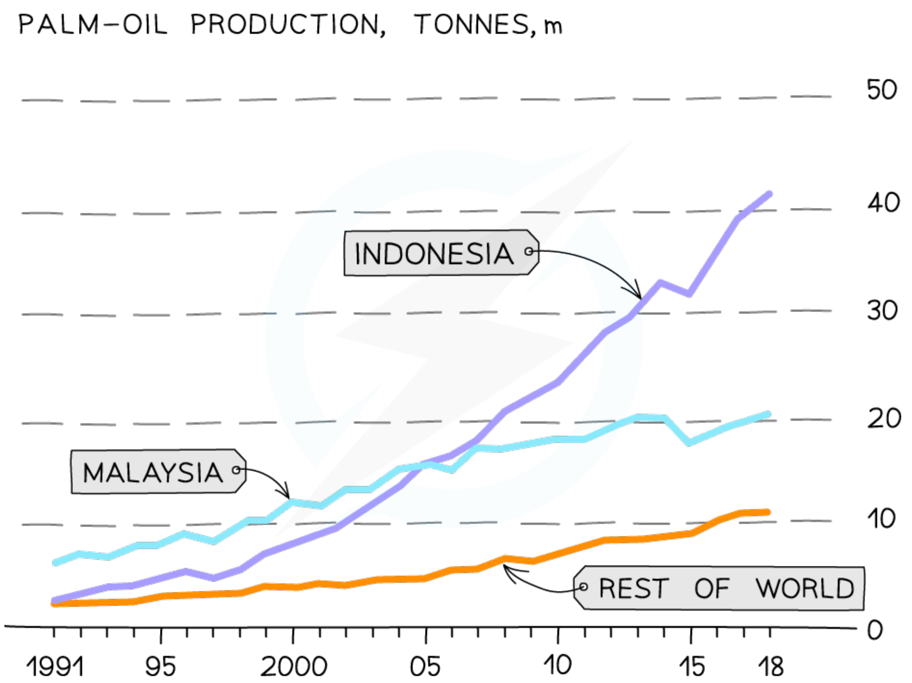
21 HUMAN INGLUENCES ON ECOSYSTEMS

21.1 FOOD SUPPLY cont...

YOUR NOTES

Monocultures

- Monoculture farming means that on a given area of agricultural land only **one type of crop is grown** (eg trees for palm oil grown in Indonesian rainforest)
- This large scale growth of a single variety of plant **does not happen naturally** in ecosystems, where there are **usually many different species of plants** growing which, in turn, **support many species of animals** (high biodiversity)
- In monocultures, **biodiversity is much lower**
- Another issue with monocultures is the **increase in pest populations** – if a particular pest feeds on a crop, farming it in large areas repeatedly means there is an ample supply of food for the pest, causing the population to increase
- Often farmers will spray **insecticides** onto crops in order to control the pests. This leads to:
    - harmless insects being killed as well
    - pollution by pesticides (which are often **persistent chemicals** which accumulate in food chains)
    - pests potentially becoming **resistant** to them, reducing their effectiveness



Palm oil production has increased rapidly over the last 30 years

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

21.1 FOOD SUPPLY cont...

Intensive Livestock Farming

- In developed countries, **large numbers of livestock** are often kept in an area that would **not normally be able to support more than a very small number**
- They are often fed **high energy foods**, regularly given medication such as **antibiotics** as a preventative measure against disease and kept in **artificially warm temperatures** and small spaces that **do not allow for much movement**
- Ecological issues with intensive farming include:
- **reduction in biodiversity** in areas where large amounts of land are used to graze cattle (as only grass is grown so in effect it becomes a monoculture)
- overgrazing can lead to **soil erosion**
- large numbers of cattle produce large amounts of **methane**, a greenhouse gas

Global Food Supply

- When people do not receive enough food, **famine** occurs
- This can be caused by a variety of factors, including **natural disasters, such as drought and flooding, increasing population, poverty**, and **unequal food distribution**
- As the global human population increases, food production must also be increased to support the increasing population
- This is a problem as **more land is required to grow crops and animals**, meaning that **deforestation** is happening at an increasing rate, and there is also an increasing amount of **greenhouse gases** emitted from animal production
- Greenhouse gases cause **global warming**, which is a worldwide issue that leads to increased natural disasters, such as **tropical storms and drought**, as well as **rising sea levels**, which floods homes and reduces the amount of habitable land

21.2 HABITAT DESTRUCTION

Reasons for Habitat Destruction

- The increasing human population of the planet is causing destruction of many habitats from rainforest to woodland to marine
- Many habitats are destroyed by humans **to make space for other economic activities**, or by **pollution** from these activities, and this **reduces the biodiversity** of these areas
- This **interrupts food chains and webs**, meaning that more species may die because their prey is gone
- The main reasons for habitat destruction include:

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.2 HABITAT DESTRUCTION cont...

YOUR NOTES

REASON	EXPLANATION
CLEARING LAND FOR FARMING AND HOUSING	– CROPS, LIVESTOCK AND HOMES ALL TAKE UP A LARGE AMOUNT OF SPACE – AS THERE IS AN INCREASING POPULATION AND DEMAND FOR FOOD, THE AMOUNT OF LAND AVAILABLE FOR THESE THINGS MUST BE INCREASED BY CLEARING HABITATS SUCH AS FORESTS (DEFORESTATION)
EXTRACTION OF NATURAL RESOURCES	– NATURAL RESOURCES SUCH AS WOOD, STONE AND METALS MUST BE GATHERED TO MAKE DIFFERENT PRODUCTS. – THEREFORE MANY TREES ARE CUT DOWN, DESTROYING FOREST HABITATS. IN ADDITION, SOME RESOURCE EXTRACTION TAKES UP A LARGE AMOUNT OF SPACE – FOR EXAMPLE: MINING, WHICH MEANS THAT THE LAND MUST BE CLEARED FIRST
MARINE POLLUTION	– HUMAN ACTIVITIES LEAD TO THE POLLUTION OF MARINE HABITATS – IN MANY PLACES, OIL SPILLS AND OTHER WASTE POLLUTES THE OCEANS, KILLING SEA LIFE – IN ADDITION, EUTROPHICATION CAN OCCUR WHEN FERTILISERS FROM INTENSIVELY FARMED FIELDS ENTERS WATERWAYS – THIS CAUSES A HUGE DECREASE IN BIODIVERSITY IN THESE AREAS AS MOST AQUATIC SPECIES LIVING IN THESE WATERWAYS DIE FROM LACK OF OXYGEN

Deforestation

- Deforestation is the **clearing of trees** (usually on a large scale)
- If trees are replaced by replanting it can be a **sustainable** practice
- Generally the trees are being cleared for the **land to be used in a different way** (for building, grazing for cattle, planting of monocultures such as palm oil plantations etc) and therefore it is not sustainable
- As the amount of the Earth's surface covered by trees decreases, it causes increasingly negative effects on the environment and is a **particularly severe example of habitat destruction**
- Undesirable effects of deforestation include:
    - **Extinction** of species
    - Loss of **soil**
    - **Flooding**
    - Increase of **carbon dioxide** in the atmosphere

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

21.2 HABITAT DESTRUCTION cont...

EXTENDED ONLY

Consequences of Deforestation

EFFECT	CONSEQUENCE
EXTINCTION / LOSS OF BIODIVERSITY	– FOREST HABITATS, ESPECIALLY TROPICAL RAINFORESTS, HAVE A HUGE RANGE OF BIODIVERSITY AND AS HABITAT IS DESTROYED IT CAUSES THE LOSS OF LARGE NUMBERS OF PLANT AND ANIMAL SPECIES – MANY OF THESE SPECIES ARE ONLY FOUND IN THESE AREAS AND THEREFORE WILL BECOME EXTINCT
SOIL EROSION	– TREE ROOTS HELP TO STABILISE THE SOIL, PREVENTING IT FROM BEING ERODED BY RAIN – TREES WILL USUALLY TAKE UP NUTRIENTS AND MINERALS FROM THE SOIL THROUGH THEIR ROOTS – WITHOUT TREES, NUTRIENTS AND MINERALS WILL REMAIN UNUSED IN THE SOIL SO WILL BE WASHED AWAY INTO RIVERS AND LAKES BY RAIN (LEACHING) – THIS LOSS OF SOIL NUTRIENTS IS PERMANENT AND MAKES IT VERY DIFFICULT FOR FOREST TREES TO REGROW, EVEN IF THE LAND IS NOT CULTIVATED WITH CROP PLANTS OR GRASS FOR CATTLE
FLOODING	– WITHOUT TREES THE TOPSOIL WILL BE LOOSE AND UNSTABLE SO WILL BE EASILY WASHED AWAY BY RAIN, INCREASING THE RISK OF FLASH FLOODING AND LANDSLIDES
INCREASED CARBON DIOXIDE IN ATMOSPHERE	– TREES CARRY OUT PHOTOSYNTHESIS DURING WHICH THEY TAKE IN CARBON DIOXIDE AND RELEASE OXYGEN – THE REMOVAL OF SIGNIFICANT NUMBERS OF TREES MEANS LESS CARBON DIOXIDE IS BEING REMOVED FROM THE ATMOSPHERE (AND LESS OXYGEN RELEASED) – WHEN AREAS OF LAND IN FORESTS ARE CLEARED FOR LAND USE, THE TREES ARE OFTEN BURNED AS OPPOSED TO BEING CUT DOWN. THIS RELEASES CARBON DIOXIDE (IT IS AN EXAMPLE OF COMBUSTION), FURTHER INCREASING CARBON DIOXIDE LEVELS IN THE ATMOSPHERE AND CONTRIBUTING TO GLOBAL WARMING

21.3 LAND, WATER & AIR POLLUTION

Causes & Effects of Pollution

- Human activities have led to the pollution of land, water and air
- Pollution comes from a variety of sources, including **industry and manufacturing processes, waste and discarded rubbish, chemicals** from farming practices, **nuclear fall-out**, and **untreated sewage**

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

21.3 LAND, WATER & AIR POLLUTION cont...

POLLUTANT	SOURCE / CAUSE	EFFECT
UNTREATED SEWAGE	LACK OF SEWAGE TREATMENT PLANTS IN INHABITED AREAS (DUE TO POOR INFRASTRUCTURE / LACK OF MONEY) MEANING SEWAGE RUNS / IS PUMPED INTO STREAMS OR RIVERS.	PROVIDES A GOOD SOURCE OF FOOD FOR BACTERIA WHICH INCREASE RAPIDLY, DEPLETING THE OXYGEN DISSOLVED IN THE WATER (AS THEY RESPIRE AEROBICALLY) AND CAUSING DEATH OF AQUATIC ORGANISMS SUCH AS FISH – KNOWN AS **EUTROPHICATION**
CHEMICAL WASTE	CHEMICALS SUCH AS HEAVY METALS LIKE MERCURY CAN BE RELEASED FROM FACTORIES INTO RIVERS AND OCEANS OR LEACH INTO LAND SURROUNDING THE FACTORIES	MANY HEAVY METALS AND OTHER CHEMICALS ARE PERSISTENT – THEY DO NOT BREAK DOWN AND SO CAN BUILD UP IN FOOD CHAINS (KNOWN AS BIOACCUMULATION), POISONING THE TOP CARNIVORES
DISCARDED RUBBISH	MUCH RUBBISH CONSISTS OF PLASTIC THAT IS EITHER DISCARDED OR BURIED IN LANDFILLS.	MUCH RUBBISH, SUCH AS THAT MADE FROM PLASTIC, IS NON-BIODEGRADABLE AND REMAINS IN THE ENVIRONMENT FOR HUNDREDS OF YEARS. ANIMALS ALSO EAT THE PLASTIC AS IT BREAKS INTO SMALLER PIECES (ESPECIALLY IN THE OCEAN) AND IT CAN GET INTO FOOD CHAINS THIS WAY
FERTILISERS	RUNOFF FROM AGRICULTURAL LAND IF APPLIED IN TOO HIGH A CONCENTRATION	CAUSES ALGAL BLOOMS WHICH THEN DIE AND PROVIDE A GOOD SOURCE OF FOOD FOR DECOMPOSING BACTERIA WHICH INCREASE RAPIDLY, DEPLETING THE OXYGEN DISSOLVED IN THE WATER (AS THEY RESPIRE AEROBICALLY) AND CAUSING DEATH OF AQUATIC ORGANISMS SUCH AS FISH KNOWN AS EUTROPHICATION
INSECTICIDES & HERBICIDES	SPRAYED ON CROPS TO PREVENT DAMAGE BY INSECTS AND GROWTH OF WEEDS	BIOACCUMULATION, LOSS OF BIODIVERSITY, DAMAGE TO BENEFICIAL INSECTS, CAN BUILD UP IN SOIL TO TOXIC CONCENTRATIONS AND HARM OTHER ORGANISMS
NUCLEAR FALLOUT	RADIOACTIVE PARTICLES THAT GET INTO THE ENVIRONMENT FROM ACCIDENTAL LEAKAGE FROM NUCLEAR POWER PLANTS OR EXPLOSION OF A NUCLEAR BOMB	SOME RADIOACTIVE PARTICLES HAVE LONG HALF-LIVES AND CAN REMAIN IN THE ENVIRONMENT FOR MANY YEARS. THEY CAN CAUSE INCREASED RISKS OF CANCER AND SMALLER PARTICLES CAN BE CARRIED BY WINDS HUNDREDS OF MILES FROM THE ORIGINAL SITE OF EXPOSURE
METHANE	CATTLE FARMING, RICE FIELDS, LANDFILLS	METHANE IS A GREENHOUSE GAS WHICH CONTRIBUTES TO THE ENHANCED GREENHOUSE EFFECT THAT IS CAUSING CLIMATE CHANGE
CARBON DIOXIDE	PRODUCED WHEN FOSSIL FUELS ARE BURNT, ALSO RELEASED WHEN TREES ARE BURNT TO CLEAR LAND FOR HUMAN USE	CARBON DIOXIDE IS A GREENHOUSE GAS WHICH CONTRIBUTES TO THE ENHANCED GREENHOUSE EFFECT THAT IS CAUSING CLIMATE CHANGE

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.4 MORE SOURCES & EFFECTS OF POLLUTION

YOUR NOTES

EXTENDED ONLY

Plastic Pollution

- Plastics have a large negative impact on both land and water habitats due to their non-biodegradability
- In marine habitats:
- Animals often try to **eat plastic** or **become caught in it**, leading to injuries and death
- As the plastic breaks down it can **release toxins** that affect marine organisms
- Once it has broken down into **very small particles**, it is commonly ingested by animals and **enters the food chain**
- On land:
- Plastic is generally disposed of by **burying in landfills**
- As it breaks down, it releases **toxins** into the surrounding soil and as such the **land is no good for growing crops or grazing animals** and can only be used for building on several decades after burial

Female Hormones

- Female **contraceptive hormones** are excreted from the body in urine and then **make their way into the water supply**, as they are not filtered out by sewage treatment plants
- If they reach male aquatic organisms, such as fish and frogs, which are very sensitive to the hormones, it causes **feminisation**
- This is where male organisms begin to **produce eggs** and **lose the ability to reproduce**
- Consequently, a **smaller amount of offspring is produced** which can harm the species survival and also **disrupts food chains** for animals that usually feed off these organisms
- In addition, these hormones can **reduce the sperm count in human males**, which causes **fertility problems**

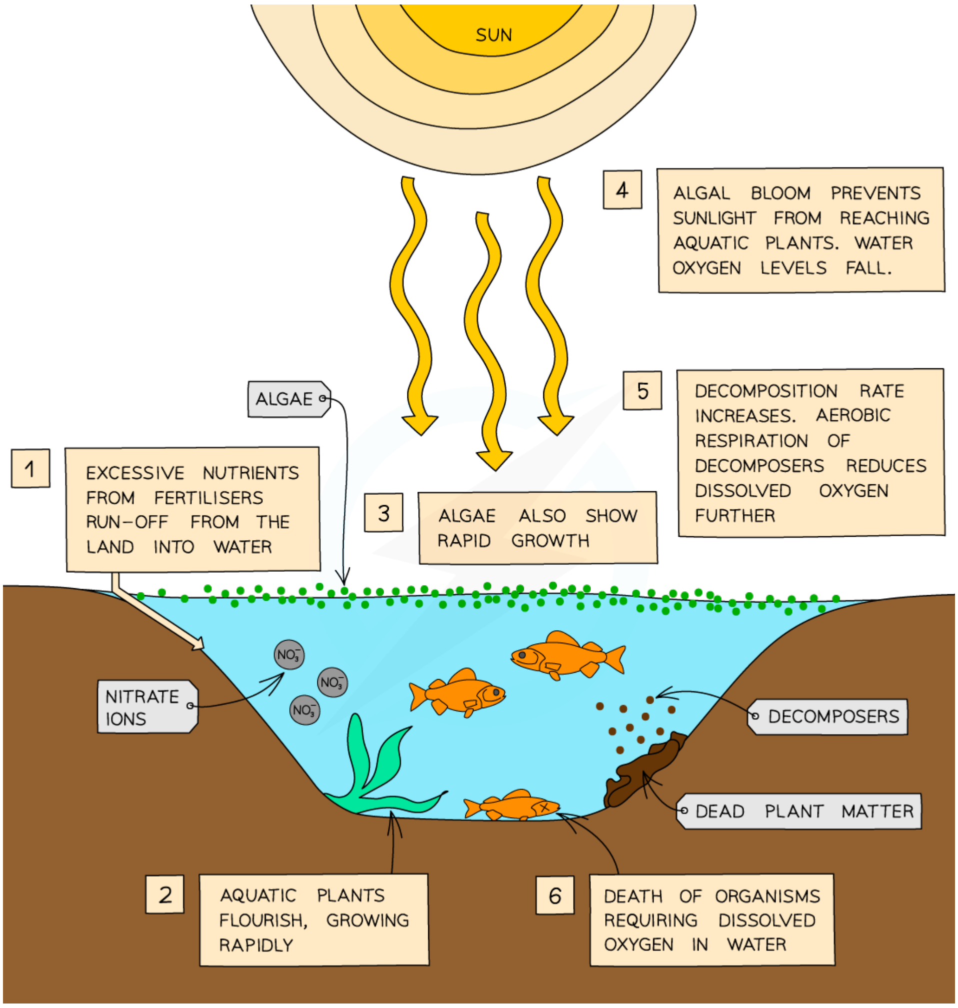
21 HUMAN INGLUENCES ON ECOSYSTEMS

21.4 MORE SOURCES & EFFECTS OF POLLUTION cont...

EXTENDED ONLY cont...

Eutrophication

- Runoff of fertiliser from farmland enters the water and causes **increased growth of algae** and water plants
- The resulting 'algal bloom' **blocks sunlight** so water plants on the bottom start to die, as does the algae when competition for nutrients becomes too intense
- As water plants and algae die in greater numbers, **decomposing bacteria increase in number** and **use up the dissolved oxygen** whilst respiring aerobically
- As a result there is less oxygen dissolved in water, so **aquatic organisms such as fish and insects may be unable to survive**



Sequence of events causing eutrophication in lakes and rivers

YOUR NOTES

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.4 MORE SOURCES & EFFECTS OF POLLUTION

YOUR NOTES

EXTENDED ONLY cont...

Acid Rain

- **Combustion of fossil fuels** that contain sulfur impurities creates sulfur dioxide
- This is released into the atmosphere where it combines with oxygen to form sulfur trioxide
- Sulfur trioxide dissolves in water droplets in clouds and forms **acid rain**

CAUSES	SOURCES	EFFECTS	POSSIBLE SOLUTIONS
SULPHUR DIOXIDE, OXIDES OF NITROGEN	BURNING OF FOSSIL FUELS COMBUSTION OF PETROL IN CAR ENGINES	1. DAMAGE TO LEAVES, KILLING PLANTS; 2. ACIDIFICATION OF LAKES, KILLING ANIMALS; 3. INCREASED RISK OF ASTHMA ATTACKS AND BRONCHITIS IN HUMANS; 4. CORROSION OF STONEWORK ON BUILDINGS; 5. RELEASE OF ALUMINIUM FROM THE SOIL INTO LAKES THAT ARE TOXIC TO FISH.	1. CHANGING THE POWER STATIONS FROM COAL AND OIL TO RENEWABLE ENERGY SOURCES 2. USING 'SCRUBBERS' IN POWER STATION CHIMNEYS SULPHUR DIOXIDE 3. USING CATALYTIC CONVERTERS IN CAR EXHAUSTS TO CONVERT OXIDES OF NITROGEN TO HARMLESS NITROGEN

Climate Change

- A greenhouse gas is a gas that **absorbs infrared radiation from the Sun** so it remains trapped in the Earth's atmosphere
- This is important to ensure Earth is warm enough for life, however if levels of these gases in the atmosphere increase it leads to an increase in the greenhouse effect which causes the **Earth's average temperature to rise**
- There are many greenhouse gases, the most important are:
    - **Water vapour**
    - **Carbon dioxide**
    - **Methane**
    - **Nitrous oxides**
    - **CFCs**

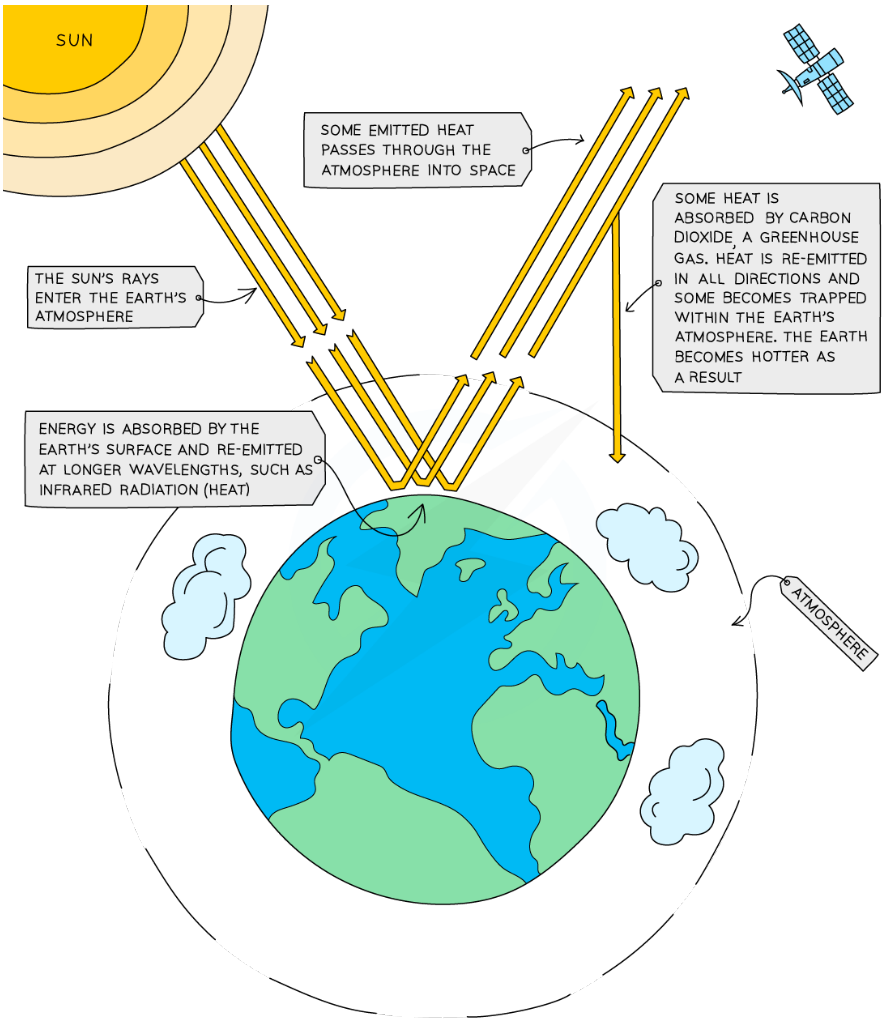
21 HUMAN INGLUENCES ON ECOSYSTEMS

21.4 MORE SOURCES & EFFECTS OF POLLUTION cont...

YOUR NOTES

EXTENDED ONLY cont...

- The greenhouse effect works in the following way:
  - The Sun emits rays that enter the Earth's atmosphere
  - The heat **bounces back** from the Earth's surface
  - Some heat is reflected back out into space
  - Some heat is **absorbed by greenhouse gases** and is trapped within the Earth's atmosphere – this is normal
  - However, as the levels of greenhouse gases in the atmosphere rise due to human activities the Earth's **average temperature rises beyond normal** (an **enhanced greenhouse effect**), causing **global warming** or **climate change**



How the greenhouse effect works

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.4 MORE SOURCES & EFFECTS OF POLLUTION

YOUR NOTES

EXTENDED ONLY cont...

Consequences of global warming due to an enhanced greenhouse effect:

- **Ocean temperatures increase** which causes melting of polar ice caps / rising sea levels / flooding / coral bleaching
- Increasing temperatures can cause **extreme weather** like super storms, flooding, droughts
- These extreme weather events can lead to **changes in or loss of habitats**
- This means that there will be a **decrease in biodiversity** as food chains are disrupted and extinction rates increase
- There could also be **increases in migration** of species to new places, increased **spread of pests and disease**

EXAM TIP

Water pollution from sewage and water pollution from fertiliser runoff have the same end result (increase in decomposing bacteria leading to a decrease in dissolved oxygen and death of aquatic organisms)

But they **do not arrive at this point in the same way** and you need to **learn both and be aware of the differences between them**

A common misconception is that sewage pollution also causes growth of water plants and algal blooms – this is very rarely the case, only runoff of fertiliser does this

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

21.5 CONSERVATION

Sustainable Resources

- We use many resources from the Earth; some, such as food, water and wood, are **sustainable resources**
- A sustainable resource is one which is **produced as rapidly as it is removed from the environment so that it does not run out**
- Some resources, such as **fossil fuels** (coal, oil and natural gas), are non renewable because what we use cannot be replaced
- These resources, once used, cannot be produced any more and so they need to be **conserved** by **reducing the amount we use** and finding other, **sustainable resources to replace them**
- Fossil fuels are being used as an **energy source** in increasing amounts
- In addition, they are the **raw materials** for many other products we make – eg almost all **plastics** that are made start with oil as a raw material
- Some products, especially those made from **paper, plastic, glass or metal**, can be **reused and recycled** – this reduces waste in the environment and reduces the amounts of raw materials and energy needed to make new products
- Some resources, such as **forests and fish stocks**, can be maintained – enabling us to **harvest them sustainably** so that they will **not run out in the future**

EXTENDED ONLY

Sustainable Development

- Sustainable development is defined as **development providing for the needs of an increasing human population without harming the environment**
- When developing the way in which we use resources to manage them sustainably, we have to **balance conflicting demands** – eg:
    - the need for **local people** to be able to utilise the resources they have in their immediate environment with the needs of **large companies** to make money from resources such as forests and fish
    - the need for balancing the **needs of humans for resources** with the **needs of the animals and plants** that live in the areas the resources are taken from (preventing loss of habitat and extinction)
    - the need to balance what **current populations need** with what **future populations might need** – for example if we harvest all the fish we need to feed people now, this might lead to overfishing which would deplete stocks for future generations
- For development to occur sustainably, **people need to cooperate at local, national and international levels** in the planning and management of resources

21 HUMAN INGLUENCES ON ECOSYSTEMS

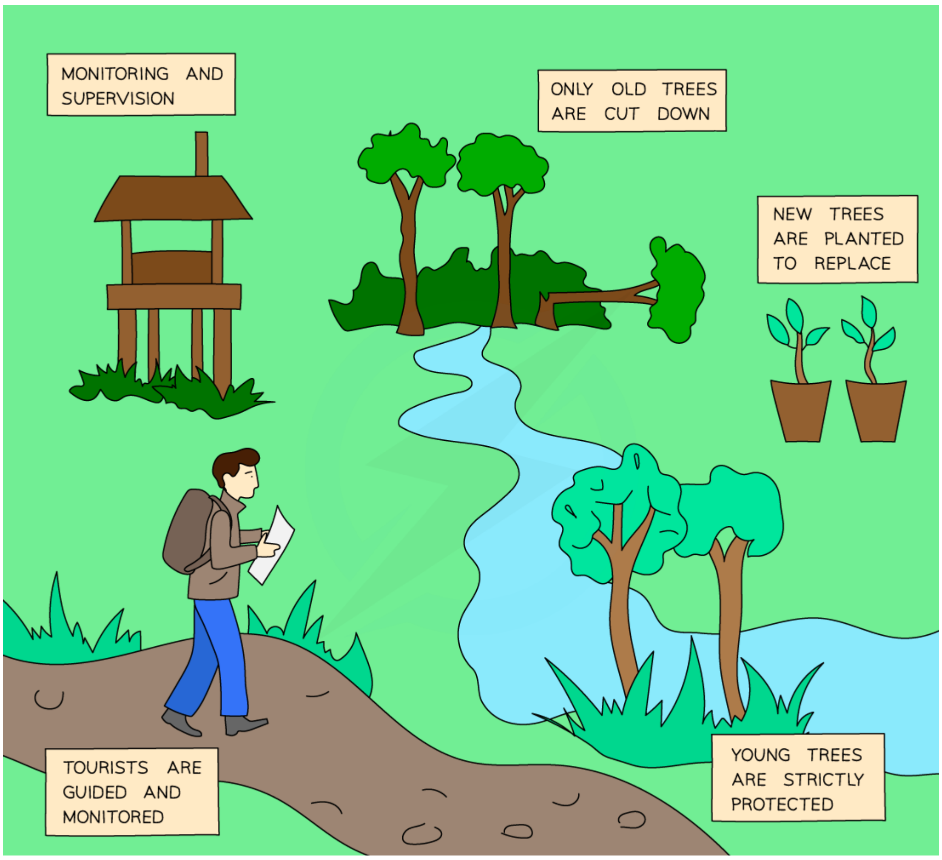
21.5 CONSERVATION cont...

YOUR NOTES

EXTENDED ONLY

Sustaining Forests

- Forests are needed to produce **paper products** and **provide wood for timber**
- Much of the world's paper is now produced from forests which **replant similar trees when mature trees are cut**, ensuring that there will be adequate supply in the future
- Tropical hardwoods such as teak and mahogany take many years to regrow but are highly desirable for furniture
- Using these types of wood has now been made more sustainable due to the **introduction of several schemes** designed to **monitor logging** companies and track the wood produced (eg the Forestry Stewardship Council)
- **Education** helps to ensure logging companies are aware of sustainable practices and consumers are aware of the importance of buying products made from sustainable sources



More efforts are being made to manage forests sustainably so consumers know they are not causing damage to forests

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.5 CONSERVATION cont...

YOUR NOTES

EXTENDED ONLY

Sustaining Fish Stocks

- Managing fish stocks sustainably includes:
- Controlling the **number of fish** caught each year (quotas)
- Controlling the **size of fish** caught (to ensure there are enough fish of a suitable age for breeding remaining)
- Controlling the **time of year** that certain fish can be caught (to prevent large scale depletion of stocks when fish come together in large numbers in certain areas to breed)
- **Restocking** (breeding and keeping offspring until they are large enough to survive in their natural habitat then releasing)
- **Educating fishermen** as to local and international laws and **consumers** so they are aware of types of fish which are not produced sustainably and can avoid them when buying fish

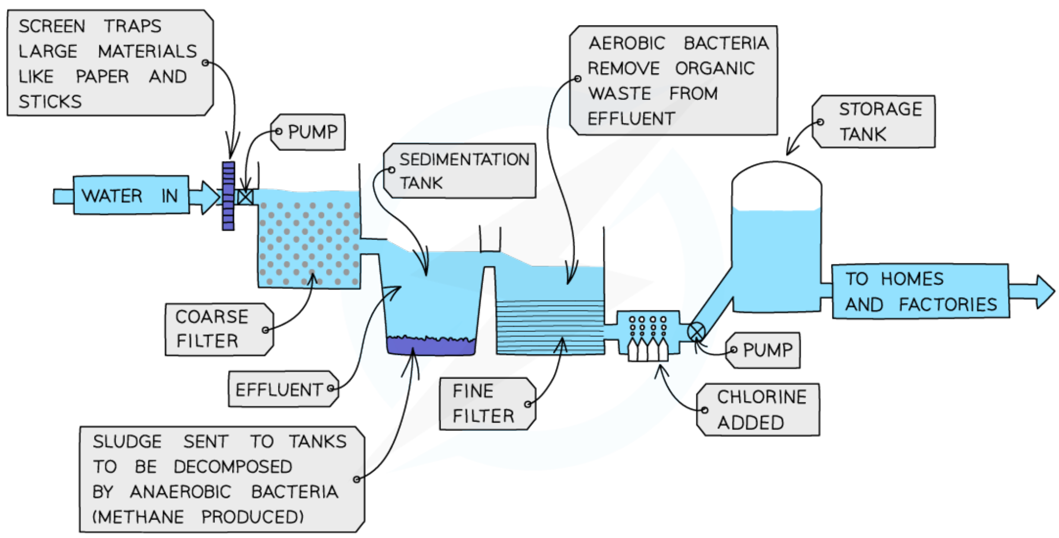
Sewage Treatment

- As human population grows, the need for fresh water increases
- A significant amount of water we consume is used to **flush away human waste** (sewage) into pipes
- The pipes carry the sewage and water to **treatment plants** where the **organic waste is removed and the water cleaned** so it can be returned to natural water sources without causing eutrophication
- Crude sewage flows through a **screen** in which **large materials like paper and sticks are trapped** so they can be removed and burned
- The sewage is passed slowly through channels where **grit and other heavy particles picked up along the way settle to the bottom** – the grit is later washed and returned to the land
- The channels lead into **sedimentation tanks** where the **solid material settles on the bottom as sludge** and the liquid part, called **effluent**, remains on top
- The **sludge** is removed by pumping it into tanks where **anaerobic bacteria** decompose it – often the bacteria produce **methane** which can be collected and used as an energy source for the plant
- The **effluent (liquid)** is treated with **aerobic bacteria** to remove any organic waste in it, before being treated with **chlorine** to kill the bacteria
- At this point it is clean enough to **return to natural water systems** or be passed on to a second treatment plant where it is **processed further** to make it pure enough to reuse as **drinking water**

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

21.5 CONSERVATION cont...



Water containing sewage goes through several stages of treatment before being returned to natural water systems

Endangered Species

- An endangered species is at risk of becoming **extinct**
- There are several reasons why a species can become endangered – the **population of the species may fall below a critical level** due to
  - **hunting**
  - **climate change**
  - **pollution**
  - **loss of habitat**
  - **introduction of non-native species** that outcompete native species
- Endangered species can be helped by conservation measures such as:
  - **education** programmes
  - **captive breeding** programmes
  - **monitoring and legal protection** of the species and of their habitats
  - **seed banks** as a conservation measure for plants – seeds of endangered plant species are carefully stored so that new plants may be grown in the future

21 HUMAN INGLUENCES ON ECOSYSTEMS

21.5 CONSERVATION cont...

YOUR NOTES

EXTENDED ONLY

Endangered Species

- A species may be at risk of becoming extinct **if there is not enough genetic variation in the population** as random changes in the environment may quickly cause extinction because the **remaining organisms are all very similar and may not have the adaptations to survive such changes**
- There are moral, cultural and scientific reasons for conservation programmes, including:
  - **reducing extinction rates** of both plant and animal species
  - keeping damage to food chains and food webs to a minimum and **protecting vulnerable ecosystems** (eg the rainforests)
  - **protecting our future food supply** and **maintaining nutrient cycles and possible sources of future medical drugs and fuels**

> NOW TRY SOME EXAM QUESTIONS

21 HUMAN INGLUENCES ON ECOSYSTEMS

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

Which of the following would be a negative feature of monoculture crops on an ecosystem?

A Monoculture crops produce more food.

B Monoculture crops produce less food.

C The genetic variation of organisms is reduced.

D Crops need harvesting at the same time.

QUESTION 2

Which of the following effects is least likely to be as a result of deforestation?

A A greater risk of flooding.

B An increase in biodiversity.

C An increase in soil erosion.

D An increase in the level of carbon dioxide in the atmosphere.

QUESTION 3

A large quantity of non-selective herbicide is spread over a field. However, some of the herbicide washes into a nearby stream.

What is the effect of the herbicide on the weeds in the field and on the plants in the stream?

	weeds in field	plants in stream
A	more growth	less growth
B	less growth	more growth
C	less growth	less growth
D	more growth	more growth

21 HUMAN INGLUENCES ON ECOSYSTEMS

YOUR NOTES

EXAM QUESTIONS cont...

QUESTION 4

Rapid growth of algae on the surface of the water can occur as a result of nitrates entering a reservoir of water. This causes the following changes in the reservoir:

1 An increase in aerobic respiration by decomposers.

2 A decrease in the concentration of dissolved oxygen in the water.

3 Fish and other aquatic animals die.

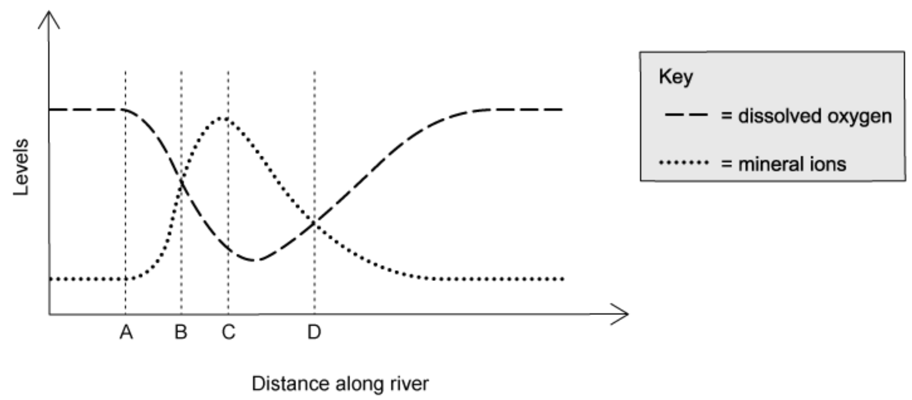
4 Producers die and decomposition increases.

In which order do these changes occur?

A 1 → 2 → 4 → 3 **B** 3 → 1 → 2 → 4 **C** 4 → 1 → 2 → 3 **D** 4 → 3 → 1 → 2

QUESTION 5

The levels of dissolved oxygen were measured in a river, the results were plotted on a graph, this is shown below.
At which point does raw sewage enter the river?



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