West Norfolk Academies Trust

AQA GCSE BIOLOGY

Knowledge Organiser

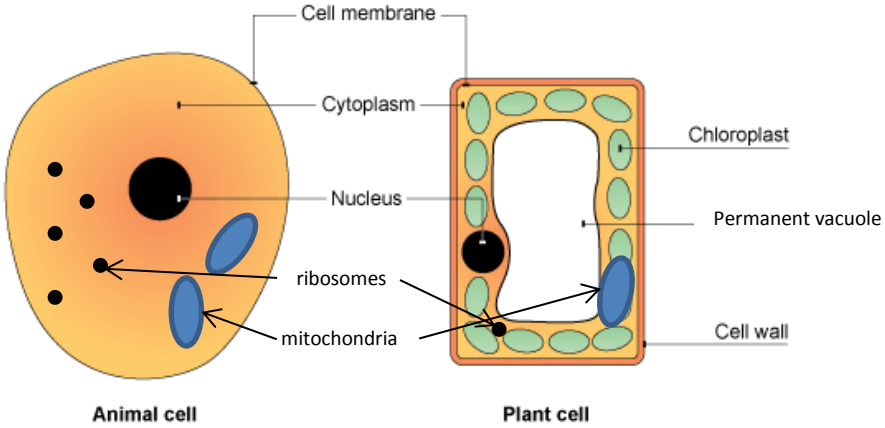
and

Required Practicals

Biology Knowledge Organiser
B1 - Cell structure and transport

Eukaryotic Cells

Eukaryotic cells include all plant and animal cells. Their most important feature is that they have a nucleus, unlike prokaryotic cells.

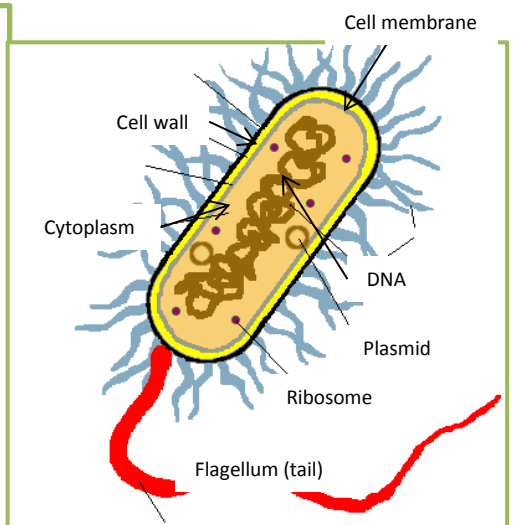


Prokaryotic Cells

Bacteria are prokaryotic cells (all bacteria are single-celled organisms). The most important differences to eukaryotic cells are that they are smaller and their genetic material (DNA) is not enclosed in a nucleus.

Prokaryotic cells have DNA in a loop, and, in addition to the main loop of DNA, they have small loops of DNA called plasmids.

Plasmids allow bacteria to swap genetic information between them.

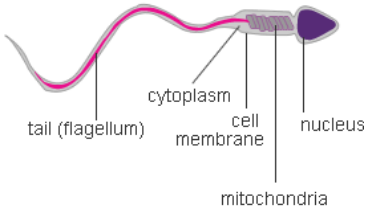


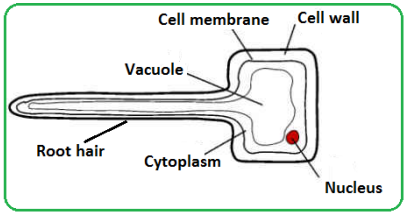
Key Terms	Definitions
Cell	The basic unit of all forms of life.
Eukaryotic Cells	Cells with a nucleus – e.g. plant and animal cells.
Prokaryotic Cells	Bacterial cells; these don't have a nucleus to enclose their genetic material.
Cell Membrane	The border of all types of cell. The cell membrane separates the inside of the cell from the environment. It controls the movement of substances into and out of the cell.
Sub-cellular structure	A part of a cell. (Sub- means less than – so these are the component parts of cells.)
Nucleus	The enclosure for genetic material found in plant and animal cells.
Cytoplasm	The interior of a cell, where most of the chemical reactions needed for life take place.
Mitochondria	The sub-cellular structure where aerobic respiration takes place.
Ribosome	The sub-cellular structure where proteins are made (synthesised)
Chloroplast	A sub-cellular structure responsible for photosynthesis – only found in plant cells and algal cells.
Permanent Vacuole	A sub-cellular structure only found in plant and algal cells – it is filled with cell sap (a store of nutrients for the cell).
Cell Wall	A sub-cellular structure that is never found in animal cells. It is made of cellulose, it is outside the cell membrane and it strengthens the cell.
DNA	The molecule that holds the genetic information in a cell. In eukaryotic cells, it is one linear strand. In prokaryotic cells, the DNA forms a loop.
Plasmid	A small loop of DNA, only found in prokaryotic cells.

Biology Knowledge Organiser
B1 - Cell structure and transport

Multicellular Organisms

You are a multicellular organism, just like all animals, plants and many types of fungus. But, not all your cells are the same. Cells become specialised by **differentiation**, which means they develop new features to help them perform a specific function. E.g. sperm cells and root hair cells.





Tissues are formed when cells with similar structures and functions work together. For example: muscle tissue in animals; phloem tissue in plants.

Organs are formed from multiple tissues working together. For example: the stomach in animals; the leaf in plants.

Organ systems are formed when multiple organs work together. For example: the digestive system in animals; the vascular (transport) system in plants.

Microscopy

Use of a microscope is called microscopy. Microscopes allowed scientists to discover cells and find all the sub-cellular structures.
Because cells and their parts are very small, it is not useful to measure them in metres. Instead, we use small divisions of the metre as follows:

Centimetre = 1/100 metre (10^{-2}). A centimetre is 1 one hundredth of a metre. (cm)
Millimetre = 1/1000 metre (10^{-3}). A millimetre is 1 one thousandth of a metre. (mm)
Micrometre = 1/1 000 000 (10^{-6}). A micrometre is 1 one millionth of a metre. (µm)
Nanometre = 1/1 000 000 000 (10^{-9}) A nanometre is 1 one billionth of a metre. (nm)

Electron microscopes were a vital invention for understanding cells. They have higher magnification and more resolving power than light microscopes, so they let you see smaller structures.

Key Terms	Definitions
Organism	Any living thing: can be made of one cell or be multicellular.
Multicellular	This describes an organism that is made of lots of cells – such as animals or plants.
Specialised Cell	Almost all cells in multicellular organisms have a particular job, or function. While they usually have all the parts labelled on your cell diagrams, they change to suit their functions. This may include developing different sub-cellular structures (e.g. the tail of a sperm cell).
Tissue	A group of cells with similar structures and functions – i.e. a group of specialised cells.
Organ	An organ is a collection (or aggregation) of tissues performing a specific function.
Organ System	Organs don't operate alone: they work together to form organ systems.
Organism (again)	An organism has many organ systems, all contributing to its survival.
Light microscope	A usual school microscope is a light microscope. You can see large sub-cellular structures like a nucleus with it, but not a lot more detail than that.
Magnification	This is the measure of how much a microscope can enlarge the object you are viewing through it.
Resolution	This is the measure of the level of detail you can see with a microscope.
Electron microscope	A type of microscope with much high magnification and resolution than a light microscope. Essential for discovering the smaller sub-cellular structures.

Equation	Meanings of terms in equation
$magnification = \frac{size\ of\ image}{size\ of\ real\ object}$	*The image Is how it looks through the microscope. The real object is what you are looking at. The image and object must be measured with the same unit, e.g. both in nm.*

Biology Knowledge Organiser
B1 - Cell structure and transport

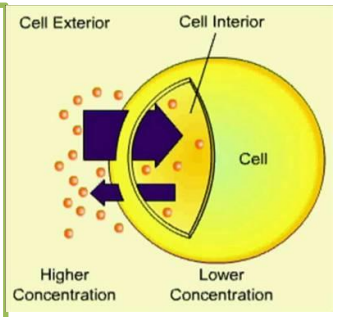
Exchange and Transport

To stay alive, all organisms must exchange substances with their environment. This means they must transport **into** cells the substances they need from the environment and transport **out** waste products to the environment.

Substances can be transported into or out of cells by: **diffusion, osmosis** or **active transport**.

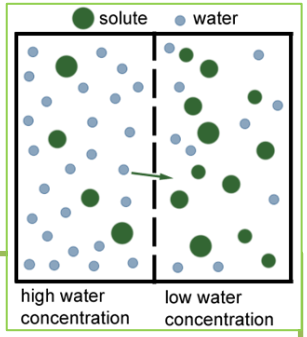
Diffusion

Diffusion allows many substances to move into or out of cells. Thanks to the random motion of particles in liquids and gases, particles will spread out until the concentration is equal throughout. If there is a cell membrane that lets the substance through (is **permeable**) in the way, it doesn't matter. Overall, the **net movement** of the substance will be from higher to lower concentration, as the diagram shows.



Diffusion is the process by which oxygen is transported into the bloodstream, and carbon dioxide is transported out (in the lungs, or gills of fish). It is also how the waste product **urea** moves from cells into the bloodstream, before removal in the urine.

The <u>rate</u> of diffusion is affected by:
1. the steepness of the concentration gradient
2. the temperature (a higher temperature increases the rate of diffusion as particles have more kinetic energy)
3. The surface area of the membrane (a larger surface area of cell membrane increases the rate of diffusion into/out of a cell).



Osmosis

Osmosis is the movement of water from a more dilute solution (more 'watery') to a more concentrated solution (less 'watery') across a <u>partially permeable membrane</u>, such as a cell membrane. Osmosis causes cells to swell up if they are placed in a dilute solution, or shrivel up if they are placed in a concentrated solution (a solution of salt, for instance, or sugar).

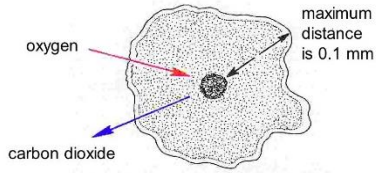
Key Terms	Definitions
Diffusion	The net (overall) movement of particles from a higher concentration to a lower concentration, simply due to the random motion of particles in a liquid or gas. Diffusion happens across cell membranes, from higher to lower concentration. It does not require any energy from the cell.
Concentration gradient	The difference in concentration of a substance between two places. A 'steeper' concentration gradient means there is a bigger difference in concentration.
Surface area to volume ratio	The surface area divided by the volume of an organism, organ or cell. Generally, the smaller something is, the larger the surface area to volume ratio.
Exchange surface	A place, such as the walls of the small intestine, where exchange of substances takes place e.g. by diffusion across it.
Diffusion pathway	The distance over which a substance must diffuse. A thin wall or membrane is a short diffusion pathway.
Osmosis	Osmosis only describes the movement of water. It is the diffusion of water from a dilute solution to a more concentrated solution across a partially permeable membrane.
Partially permeable membrane	A membrane that only allows some substances through – others are prevented from travelling through.
Active transport	The movement of substances **against** the concentration gradient – from lower to higher concentration. This requires energy from respiration.

Active transport

Active transport is so-named because it <u>requires energy</u>. A good example of where it happens is in plant roots. Root hair cells (see specialised cells topic) absorb mineral ions (like magnesium ions and nitrate ions) from the very dilute solution in the soil by active transport. They need ions like these for healthy growth. An example in animals is absorption of sugar from the intestine into the blood – the blood has a higher sugar concentration so active transport is needed. The sugar is needed by all cells in the body for respiration.

Biology Knowledge Organiser
B1 - Cell structure and transport

Adaptations for efficient exchange and transport



Unicellular organisms have a very large surface area to volume ratio compared to multicellular organisms. This means that they simply exchange substances through their cell membrane directly with their environment. They are small enough that diffusion is sufficient to meet their needs (see diagram).

However in multicellular organisms, cells that are not at the surface wouldn't be able to directly exchange substances with the environment. This is why organs with specialised exchange surfaces have evolved. Without lungs, gills, or leaves, for example, multicellular organisms wouldn't be able to obtain all the substances they need to survive, or be able to get rid of waste products efficiently.

Specialised exchange surfaces

To be effective at exchanging substances with the environment, any exchange surface must have a **large surface area**, and a thin wall/membrane for a **short diffusion pathway**. In animals, a constant blood supply also increases effectiveness, and in the lungs, ventilation (breathing in and out) increases effectiveness by refreshing the concentration gradient with each breath.

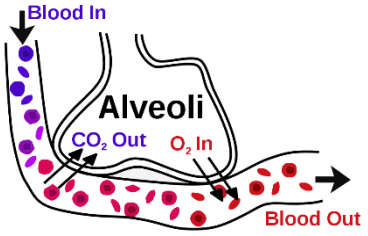
Exchange in animals and plants

Gas exchange in many animals, including us, happens in the lungs. The structures in the lungs where it happens are the **alveoli**. There are millions of these tiny air sacs, so in total their surface area is gigantic. They also have a short diffusion pathway, a good blood supply and air supply due to **ventilation**. (look at the diagram of one alveolus)

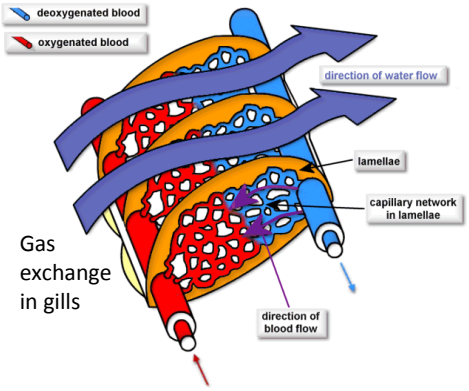
In fish, gills are where gas exchange takes place (see diagram). Again, a huge surface area increases the efficiency of gas exchange, along with a short diffusion pathway and good blood supply. The huge surface area comes from the division of gills into very thin plates of tissue called lamellae. This also creates the short diffusion pathway.

In plants, the roots absorb water and mineral ions. The root hair cells have **long projections** that increase the surface area of this exchange surface, and shorten the diffusion pathway. The leaves are responsible for gas exchange, including oxygen out and water vapour out, and carbon dioxide in. Being flat and broad increases the effectiveness of the leaves as exchange surfaces, by increasing the surface area and shortening the diffusion pathway. In leaves, exchange happens through microscopic holes called **stomata**.

Key Terms	Definitions
Small intestine	The organ in the digestive system where products of digestion are absorbed into the bloodstream.
Lungs	The organs were gas exchange takes place. The air sacs where gases are actually exchanged are called **alveoli**.
Gills	The organs in fish where gas exchange takes place. Oxygen is absorbed from the water into the blood, and carbon dioxide is transferred to the water.
Leaves	The plant organs responsible for gas exchange.
Ventilation	Technical term for breathing in and out. Breathing in brings fresh air, with a relatively high oxygen concentration, into the lungs, and breathing out removes the air with a relatively high concentration of carbon dioxide (and low concentration of oxygen).

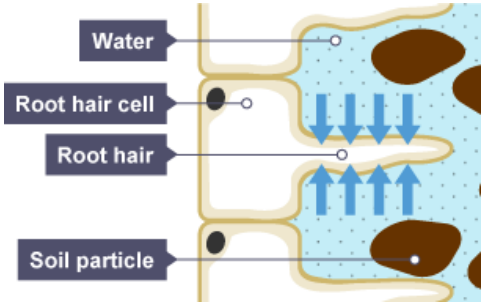


Gas exchange in lungs

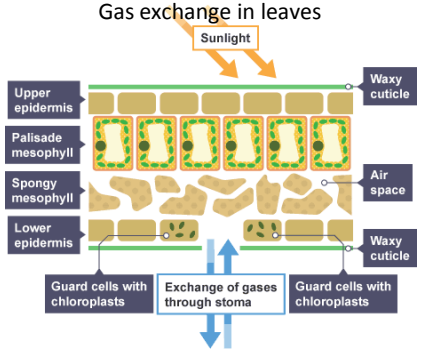


Gas exchange in gills

Substance exchange in roots



Gas exchange in leaves

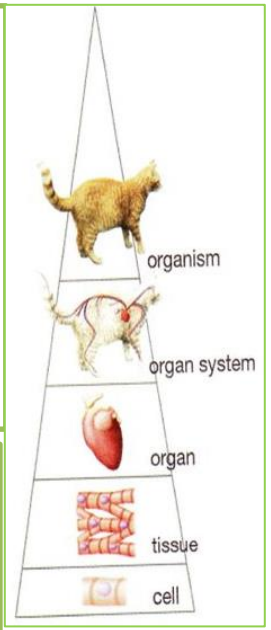


Biology Knowledge Organiser
B2 - Cell division

Unicellular vs. multicellular organisms

Unicellular organisms' bodies are simply one cell. All bacteria and other prokaryotic organisms are unicellular. **Multicellular** organisms are made of many cells and are much more complex. In multicellular organisms, cells **differentiate** to become **specialised cells**, carrying out specific roles in the organism.

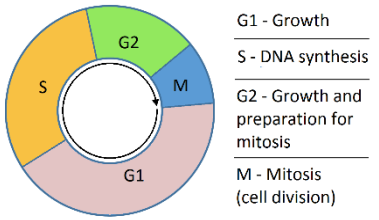
The levels of organisation in multicellular organisms form a **hierarchy**. In biology, hierarchies get simpler as you go down; or more complex as you go up because the upper things are made up of the things below them. The organisational hierarchy in multicellular organisms is shown here.



Stem cells

Once cells are specialised, they can't go back to being an unspecialised cell. This is why we all start life as a mass of unspecialised cells, called **stem cells** – this is what an embryo is. Stem cells can divide to make new cells and can differentiate to become specialised cells.

In an young embryo, all the cells are stem cells, so they can be taken, cloned and used to produce any human cells by differentiation.
In adults, there are not many stem cells left – most have differentiated. But there are some, for repair and replacement of specialised cells. For instance, there are stem cells in the bone marrow. These can be collected, cloned and made to differentiate into any type of blood cell. Using stem cells in this way is an active area of medical research, to treat conditions like diabetes and paralysis.

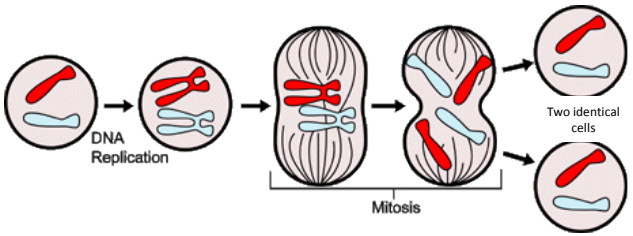


G1 - Growth

S - DNA synthesis

G2 - Growth and preparation for mitosis

M - Mitosis (cell division)



Key Terms	Definitions
Unicellular	Describes organisms formed of only one cell: like all prokaryotic organisms
Multicellular	Describes organisms made of many cells.
Differentiation	The process of becoming a specialised cell. Specialised cells are the result of differentiation of **stem cells**.
Stem cells	Cells that are undifferentiated. Stem cells are capable of forming many more cells of the same type (by cell division), and forming certain types of specialised cell by cell division.
Embryo	A very young multicellular organism, formed by fertilisation. Embryos are made of stem cells.
Cell cycle	The series of stages during which cells divide to make new cells. In the cell cycle, the DNA is replicated (copied exactly) and the cell splits by mitosis into two cells with one set of DNA each.
Mitosis	The specific part of the cell cycle where the cell divides to make two new cells, which are identical.
Chromosome	A structure containing one molecule of DNA. One chromosome contains many genes. In body cells, chromosomes are found in **pairs** (since you inherit one copy of each chromosome from your mother and one copy from your father).

The cell cycle – diagram bottom left

Cells divide to make new cells, for growth and repair, in the **cell cycle**. It isn't as simple as the cell splitting in two: it must prepare before doing that.

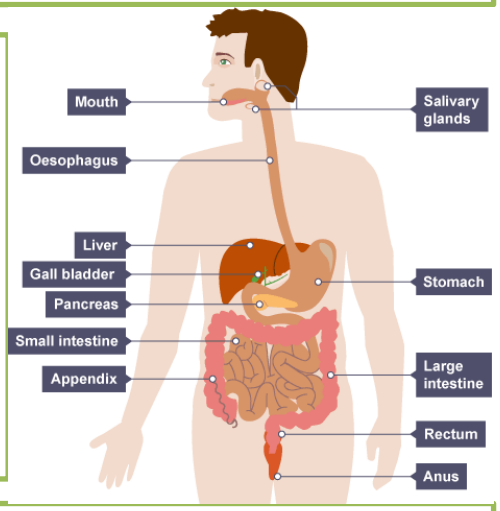
1. The cell grows larger and makes more sub-cellular structures, such as ribosomes and mitochondria. (It makes enough for two cells!)
2. The genetic material (**DNA**) is doubled by making an exact replica of the chromosomes. So, there are two copies of every chromosome at this point (labelled S on the cell cycle diagram).
3. Tiny fibres in the cell pull the copies of each chromosome to opposite ends of the cell, breaking the replica chromosomes apart. This means the nucleus can divide into two, each with the full set of chromosomes.
4. The cytoplasm and cell membranes divide to form two genetically identical cells. This is summarised in the diagram left.

Biology Knowledge Organiser
B3 - Organisation and the digestive system

The human digestive system

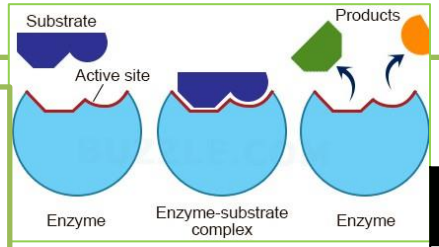
The digestive system breaks down food molecules into molecules our cells can actually use, and absorbs the simpler molecules resulting from digestion. The products of digestion are used to make new molecules we need, and the glucose is used in respiration. It is an **organ system**; the organs of the digestive system are shown on the diagram.

Mechanical digestion occurs in the mouth and stomach especially, where food is physically broken up into smaller pieces. This does not, however, break down the large molecules that our food is made from (carbohydrates, lipids and proteins). That is the role of chemical digestion, which is what enzymes do.



Enzymes and digestion

Enzymes are large proteins; there are many different types. All organisms use enzymes to control chemical reactions (**metabolism**). Enzymes are **catalysts**, so they speed up chemical reactions. They work by having an **active site** with a specific shape. A specific molecule slots into the active site (like a key into a lock) and the reaction takes place. So, the shape of the active site is vitally important, and only one sort of enzyme will work on each substrate. The diagram shows this 'lock and key' model of enzyme action.



Bile

Bile is a vital substance for digestion. It is made in the **liver** and stored in the **gall bladder** before being released into the small intestine just after the stomach. It is **alkaline**, to neutralise the stomach acid and to make the partly digested food pH 8 – the optimum pH for enzymes in the small intestine. It also **emulsifies** fats, meaning it breaks them up into small droplets. This increases the fat droplets' surface area, increasing the rate of digestion by lipase.

Key Terms	Definitions
Enzyme	A biological catalyst that speeds up chemical reactions in living organisms. Enzymes are large proteins.
Digestive enzyme	Enzyme that works in the digestive system, breaking down large food molecules into simpler, smaller molecules for absorption into the blood.
Active site	The part of an enzyme where the reaction takes place. They are very specific in shape, so that a specific substrate fits into the active site.
Denature	To disrupt the shape of the active site of an enzyme. Denaturation happens when the enzyme is at too high a temperature or at the wrong pH for that enzyme.
Substrate	The molecule that fits into an enzyme's active site and reacts to make a product or products.
Carbohydrate	A type of molecule found in all living things. Made of carbon, hydrogen and oxygen. Simple sugars like glucose are carbohydrates, and so are complex sugars like starch – in fact, starch is made of many glucose molecules joined up.
Lipid	Scientific name for fat. Lipids are made up of **glycerol** and **fatty acids**. Made mainly of carbon and hydrogen (+ oxygen).
Protein	Type of molecule made from **amino acids**. Proteins in the body can be **structural** (e.g. muscle is made mainly of proteins) or **metabolic** (control chemical reactions – e.g. enzymes). Made mainly of carbon, hydrogen, oxygen and nitrogen.
Optimum	The ideal temperature or pH for enzymes to work.

Digestive enzyme	Site of production	Site of action	Substrate	Product
Carbohydrase - e.g. amylase	Salivary glands, pancreas and small intestine wall	Mouth, small intestine	Complex carbohydrates - e.g. starch	Simple sugars - e.g. glucose
Protease	Stomach, pancreas, small intestine wall	Stomach, small intestine	Proteins	Amino acids
Lipase	Pancreas, small intestine wall	Small intestine	Lipids	Glycerol and fatty acids

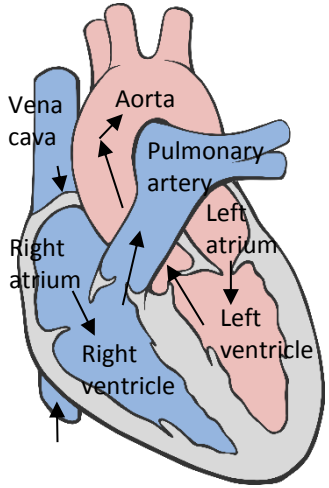
Biology Knowledge Organiser
B4 - Organising animals and plants

The heart

The heart is an organ whose role is to pump blood around the body. In humans and other mammals, the heart is part of a **double circulatory system**. This means the blood goes through the heart twice on its route around the body. It goes: right side of heart → lungs → left side of heart → body (and back to the heart again).

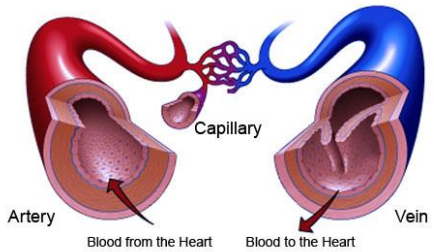
Learn the labelled parts of the heart. The arrows show the direction of blood flow. The heart walls are made mainly of muscle – when the heart 'beats', the muscle contracts to pump the blood.

The natural resting heart rate is controlled by a group of cells in the right atrium that act as a **pacemaker**. These cells set off the impulses that make the heart muscle contract. If there is a fault in the heart and the heart rate is irregular, an **artificial pacemaker** can be fitted to correct these irregularities.



Blood vessels

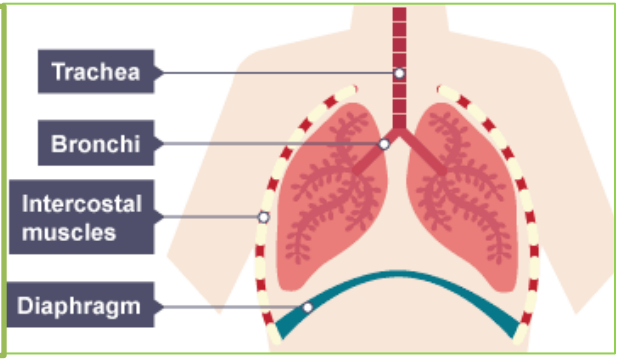
Blood is restricted to blood vessels in the body (unless you cut yourself!). There are three types: **arteries**, **capillaries** and **veins**. Blood being pumped by the heart always travels in the order arteries → capillaries → veins and veins return the blood to the heart. Arteries carry the blood at <u>high pressure</u>, so they have **thick, elastic** walls. Capillaries are where **exchange** takes place, so their walls are **only one cell thick** (for a *short diffusion pathway*). Veins carry the blood back to the heart at <u>low pressure</u>, so their walls are thinner than arteries (much thicker than capillaries though). However, to prevent blood flowing back the wrong way, veins have **valves** in them, which you can see on the diagram.



Key Terms	Definitions
Ventricles	The larger chambers in the heart. The right ventricle pumps blood to the lungs; the left ventricle pumps blood around the whole body.
Atria	Smaller chambers of the heart. These fill with blood from the vena cava and pulmonary vein, then pump the blood into the ventricles.
Aorta	The artery leaving the left ventricle. It branches off to supply, in the end, every cell of the body with blood.
Vena cava	The major vein transporting blood from the whole body back to the heart (to the right atrium)
Pulmonary artery	The blood vessel leaving the right ventricle, carrying blood to the lungs.
Pulmonary vein	Vein leading from the lungs back to the heart (to the left atrium).
Artery	Blood vessel that carries blood away from the heart, at relatively high pressure.
Capillary	Very small, thin-walled blood vessel where exchange of substances between the blood and body cells takes place.
Vein	Blood vessels that return blood to the heart at relatively low pressure. Only these vessels have **valves** in them.
Coronary blood vessel	The heart muscle needs its own blood supply. This comes from branches from the aorta as soon as it leaves the heart called **coronary** arteries.

The lungs

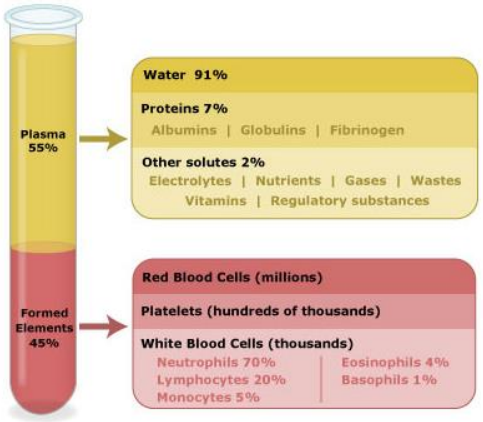
The lungs are the organs responsible for gas exchange in humans and other mammals. Air flows in while breathing in, through the **trachea** (windpipe), through the **bronchi** to each lung, and eventually to the **alveoli**, that you've looked at before. Muscle contraction allows us to breathe in – the **diaphragm** and **intercostal muscles** contract. When they relax, we breathe out.
The lungs are adapted for efficient gas exchange with their short diffusion pathway, huge surface area, and good blood and air supplies.



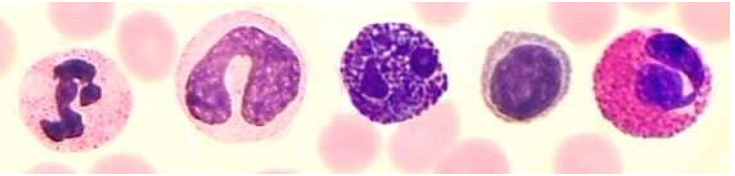
Biology Knowledge Organiser
B4 - Organising animals and plants

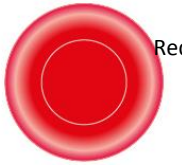
The blood

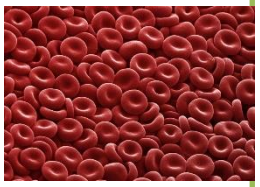
Blood is a tissue. When separated into the component parts as a the diagram shows, we find that just over half of it is made up of plasma. The cells components (mostly red blood cells) are **suspended** in the plasma – meaning they are normally mixed evenly throughout the plasma. The majority of the cell parts is made up of red blood cells, which transport oxygen. The other components are white blood cells and platelets.



Key Terms	Definitions
Plasma	The liquid part of the blood, mostly made of water, but with substances like glucose, proteins, ions and carbon dioxide dissolved in it.
Red blood cells	Disc-shaped cells that contain **haemoglobin**, which can bind to oxygen, so it can be transported from the lungs to tissues.
White blood cells	Cells in the blood that fight infection caused by pathogens.
Platelets	Fragments of cells that cause clotting of blood at a wound, to reduce blood loss.
Clot	A solid clump of blood formed when there is an injury.




Red blood cell




White blood cell

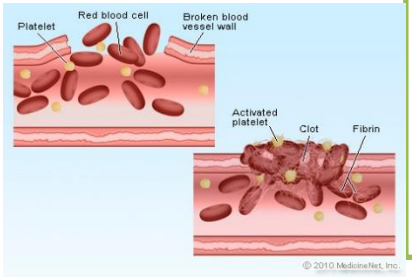
Red blood cells

As you can see in the photograph (taken with a microscope of course!), red blood cells are disc shaped and have a concave surface on each side. This increases their surface area for absorbing and transporting oxygen from the lungs to body tissues. Red blood cells are unusual in that they don't have a nucleus or other organelles. This makes more room for **haemoglobin** – the red-coloured chemical that oxygen actually binds to for transport.

White blood cells

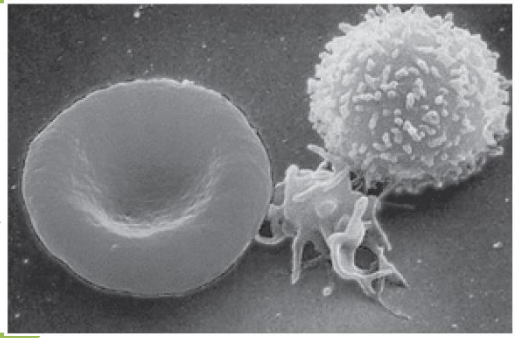
There are actually numerous types of white blood cell, as the photo shows, but they are all part of the immune system and fight communicable disease (disease caused by **pathogens**). They all have large nuclei, because they are very active cells. They can also change shape, which is useful because they can get out of the blood (through tiny gaps in the walls of capillaries) and so they can **engulf** microorganisms – like the photo below of a white blood cell engulfing a yeast cell.

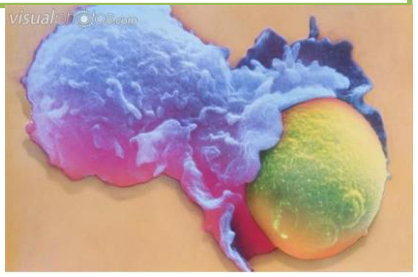

Platelet



Platelets

Platelets are *fragments* of cells – produced deliberately by your body (they aren't simply broken cells!). The photograph here shows a platelet between a red blood cell and a white blood cell. Their role is to initiate (start off) the process of **clotting** at a wound, as shown in the diagram to the left. They create a clot, which blocks the injury in the blood vessel until proper healing can happen, preventing excessive blood loss.





Biology Knowledge Organiser
B4 - Organising animals and plants

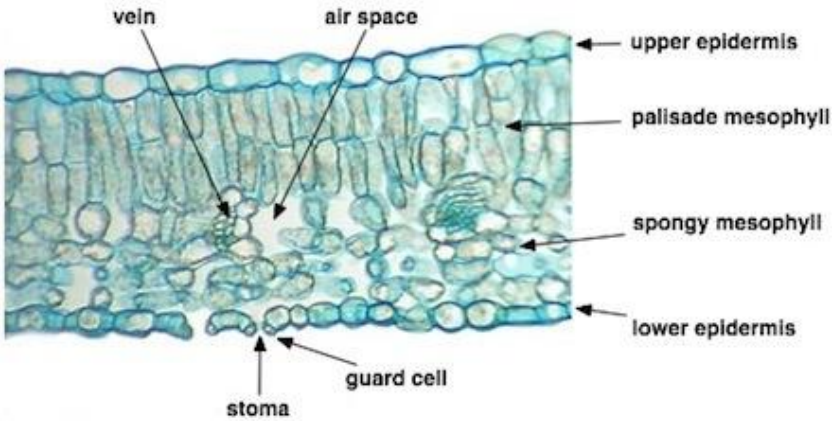
Plant tissues in the leaf and transpiration

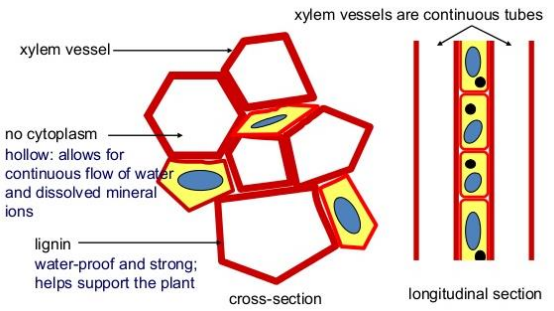
Look at the key terms and definitions for the key types of plant tissue. Leaves are **organs** in plants that contain many of those types of tissue. Together with the stem and roots, they form an **organ system** for transport of substances around the plant. The photograph shows the **transverse section** of a leaf – a thin slice through the leaf, looking edge-on.

The **vein** contains the xylem and phloem vessels. The **stomata** (singular: stoma) are the holes through which gases are exchanged. This includes water vapour. Plants absorb **all** their water in the roots (you've already looked at root hair cells), and keep water moving constantly through by losing water as vapour from the leaves. The constant flow of water up the plant is called the transpiration stream. This loss of water vapour from the leaves is called **transpiration**. Transpiration is sped up by:

- a *higher temperature*, since water molecules have more kinetic energy so diffusion out of stomata is faster
- *Lower humidity* (drier air), since there is a steeper concentration gradient if the air outside the plant is relatively drier than the air in the air spaces
- *Higher air flow* (being windier!), since this refreshes the concentration gradient all the time, as water vapour is blown away from the leaves
- *Higher light intensity*: this increases the rate of photosynthesis, which uses water, so water flows more rapidly up through the plant.

Key Terms	Definitions
Epidermal	Type of plant tissue that covers the surface of a plant
Palisade mesophyll	Tissue in the leaf where photosynthesis takes place
Spongy mesophyll	Tissue in the leaf with air spaces between cells – specialised for gas exchange
Xylem	Narrow tubes in the roots, stem and leaves, which transport water and mineral ions up the plant from the roots
Phloem	Other tubes that run alongside xylem, but transport sugars dissolved in water instead – a process called **translocation**
Meristem	Type of tissue found at growing tips of roots and shoots, containing stem cells so they can differentiate into different sorts of plant cell
Guard cell	In pairs, guard cells form the stomata on leaves – the holes through which gases are exchanged. They can open and close the stomata as required by the plant.
Transpiration	The process by which plants lose water, as vapour, from their leaves through the stomata.





Stomata, guard cells and transpiration

Stomata must be open at least some of the time, to allow carbon dioxide to enter the leaf for photosynthesis. However, guard cells can control how many stomata are open, and how wide open they are. This is useful in dry conditions, because the plant can conserve water instead of losing lots of it through transpiration.

Xylem and Phloem

Xylem tissue is made of hollow tubes, formed from the cell walls of dead cells, and strengthened by a substance called **lignin**. The diagram shows their adaptations to the function of transporting water and minerals.

Phloem, on the other hand, is a tissue made of living cells. They are elongated and stacked to form tubes. Phloem tubes transport food – dissolved sugars – made in the leaves to other parts of the plant, for use in respiration or for storage. The sugary substance they transport is called cell sap, and its transport is called **translocation**. Cell sap flows from one phloem cell to the next through **pores** (holes) in the ends of the cells.

Biology Knowledge Organiser
B5/7 - Diseases

Cancer – a non-communicable disease

Cancer is a non-communicable disease. There are many types of cancer, but they all involve changes in cells (**mutations**) that lead to the cells growing and dividing in an uncontrolled way. Normally, the **cell cycle** (see topic 6) controls cell growth and division, so the body only replaces lost cells. However, in cancer, the control mechanisms are broken and cells divide out of control, producing a mass of cells called a **tumour**.

- **Benign tumours** are growths of abnormal cells, but these do not invade other parts of the body. This is because the tumour is restricted to one area and often surrounded by a membrane. This makes them much less dangerous than **malignant tumours**.
- **Malignant tumours** cause cancer as you'd normally think of it. The cells grow out of control and invade nearby tissues. When mutated cells break off the tumour and get into the bloodstream, the cancer can spread around the body. The mutated cells can then cause more tumours, elsewhere. These are called **secondary tumours**.

In terms of risk factors for cancer, some are very clearly identified (like smoking as a risk factor for lung cancer). There can be **genetic** risk factors for some types of cancer (so the risk factor is inherited from the parents).

Communicable diseases and pathogens

Communicable diseases are sometimes called infectious disease, since they always result from an infection by a **pathogen**. All organisms can be infected by pathogens, so all organisms can suffer from communicable diseases (yes, including plants, and even bacteria can be infected by viruses!). You need to know details of specific diseases (next page), but here is a general description of how each kind of pathogen causes disease:

- **Bacteria** can cause disease if they enter our bodies. They **reproduce** rapidly and can release poisonous chemicals, called **toxins**, that damage our cells. Examples of diseases caused by pathogenic bacteria include cholera, tuberculosis (TB) and food poisoning.
- **Viruses** need a host to survive. They cause disease symptoms by reproducing **inside** cells, and bursting the cell from the inside. This releases them, so they can be passed onto other host cells or other people (e.g. by coughing or sneezing out mucus that contains the viruses).
- **Fungi** can also cause disease, by growing on living tissue (for example, athlete's foot is caused by a fungus).
- **Protists** can cause disease, as they can live in host organisms. A good example is the malarial protist, that causes malaria.

Key Terms	Definitions
Mutation	Change to DNA, altering its function (this is not necessarily dangerous). In cancer, a specific mutation causes cells to divide uncontrollably.
Protist	Whole kingdom of organisms, including some that cause disease.
Transmission	The passing of a pathogen from one organism to another, leading to the spread of communicable (infectious) disease.
Host	The organism that a pathogen lives in or on. When you have a cold, you are the host for the cold virus.

Spread of communicable diseases is caused by the transmission of pathogens

A big problem with pathogens is that they can be passed from one host to another, so the disease they cause can spread. See the table for the methods by which pathogens can be **transmitted**.

We can attempt to reduce the transmission of pathogens by: vaccinating people; destroying vectors (e.g. killing mosquitos with pesticides); being hygienic (i.e. washing our hands!); isolating people who are infected in special hospital wards.

Direct types of transmission	Indirect types of transmission
Direct contact e.g. shaking hands or kissing	A vector (animal) carries the pathogen e.g. mosquitos carry the pathogen that causes malaria
Sexual contact	Droplet infection: droplets of mucus containing a pathogen are sneezed or coughed out by an infected person, and breathed in by someone else. We can also say the pathogen is airborne.
From mother to foetus over the placenta	Waterborne – the pathogen infects water and moves between people when they drink the water

Biology Knowledge Organiser
B5/7 - Diseases

Health and disease

Health is the state of physical and mental wellbeing. So, 'good health' involves good physical and mental wellbeing. 'Poor health' involves problems with one or both aspects. Diseases are major causes of ill-health. Diseases can be classified as **communicable** (can be passed on, as they are caused by **pathogens**) and **non-communicable** (cannot be passed on). Other factors affect health: such as diet, lifestyle, stress, and genetic inheritance, for instance. Often, ill-health is caused or made worse by an interaction of different factors. Some examples:

- If their immune system has a defect, someone is more likely to suffer from communicable diseases, since their body will be worse at fighting pathogens.
- Some viruses, which live inside cells, can trigger cancers. For instance, the HPV virus can trigger cervical cancer (hence the vaccine in year 9 for girls).
- Severe physical health problems can lead to mental health problems, such as depression.
- Immune reactions to infection by a pathogen can trigger allergic reactions, like skin rashes or asthma.

Non-communicable diseases (B7 - Non communicable diseases)

Diseases that are **not** caused by pathogens – non-communicable diseases – are often linked to many different **risk factors**, and these factors may interact to increase the risk. These risk factors may come from someone's lifestyle, or from substances in their body or substances in their environment. In some cases, the link between a risk factor and a particular disease is very clear: we know the risk factor *actually causes* the disease. For other risk factors, we know the linked diseases but not really how the risk factor causes them.

Here are some causal links we do know:

- Poor diet, lack of exercise and smoking have a proven link to **cardiovascular disease**.
- Obesity can cause type 2 diabetes.
- Alcohol causes liver damage and damages brain function.
- Smoking causes lung cancer and other lung diseases (like emphysema).
- Smoking and drinking alcohol during pregnancy causes problems in unborn babies.
- Carcinogens, such as *ionising radiation* (next topic), can cause cancer.

It is important to realise that while these risk factors are real, they don't guarantee the disease. E.g. not ALL obese people will get type 2 diabetes; however, being obese greatly increases the risk of developing the disease.

Key Terms	Definitions
Disease	Any condition that reduces health/causes ill-health.
Communicable	Type of disease that can be passed on. These diseases are caused by **pathogens**, such as viruses. Be clear that the pathogen is the microorganism, and the disease is the collection of symptoms resulting from infection by the pathogen.
Non-communicable	Describes diseases that are not caused by pathogens and cannot be passed on. These are often caused by many factors acting together, known as **risk factors** for the disease.
Pathogen	A microorganism that can infect another organism (a host) and cause disease in that organism. E.g. bacteria and viruses.
Risk factor	Any factor that increases the chance of developing a non-communicable disease, such as smoking or diet.

Using data to discover risk factors

Risk factors aren't always obvious: it requires scientific research to find out what factors are linked to what disease. For many years, people smoked cigarettes thinking it was perfectly healthy (including doctors!). However, research by a scientist called Richard Doll showed that increased use of tobacco in the UK was linked to increased **incidence** of lung cancer (incidence is just how many people get it), as the graph shows (from his 1950 publication). He **sampled** the population and found this **correlation** between the risk factor (smoking) and the disease (lung cancer).

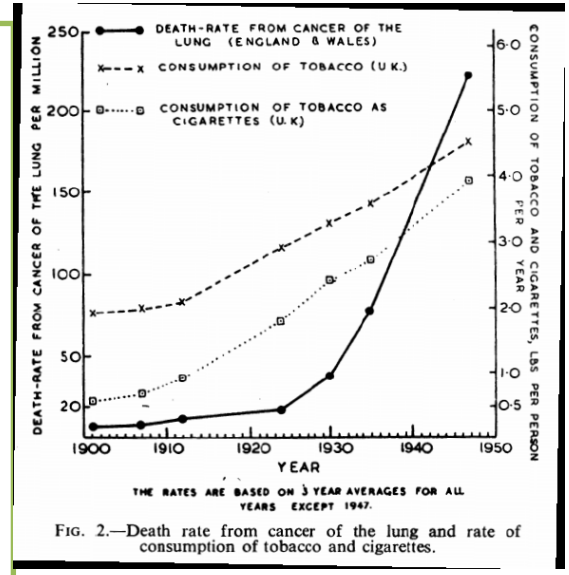


FIG. 2.—Death rate from cancer of the lung and rate of consumption of tobacco and cigarettes.

Biology Knowledge Organiser
B5 - Communicable diseases

Viral diseases

Measles is caused by a virus. It is spread by droplet infection: you'd catch it if you inhaled the droplets containing the virus that someone infected coughed or sneezed out. The symptoms include **fever** and a **red rash on the skin**. Measles is a serious disease – it can even be **fatal** if there are complications. So, most young children are vaccinated against measles.

HIV is a virus that can only be spread by exchange of body fluids: sexual contact or when blood is mixed – which can happen when *intravenous drug users* share needles. HIV cannot be transmitted by kissing or by droplet infection. Infection with HIV causes flu-like symptoms first, but these go away after a couple of weeks. However, the virus has not gone from body – it is living inside immune cells (white blood cells). HIV is NOT the same thing as AIDS, but AIDS can arise from infection by HIV unless treatment takes place. The treatment is **antiretroviral drugs** (so called because HIV is a type of virus called a retrovirus). Without this treatment, AIDS will occur. Here, the body's immune system is so badly damaged it cannot fight off other infections or cancers – so it is very serious.

Tobacco mosaic virus (TMV for short) is a pathogen affecting **plants**. In spite of its name, it affects many species of plant (including tomatoes – see photo). TMV causes discolouration of the leaves, giving a mosaic pattern. This hinders photosynthesis, so plants don't grow very well if they are infected by TMV.

Bacterial diseases

***Salmonella* food poisoning** is caused by a bacteria found in food, or on food where it is prepared in unhygienic conditions. The bacteria can be found in poultry (e.g. chickens), so these animals are **vaccinated** against *Salmonella* to reduce the spread of the pathogen. Inside the body, the bacteria reproduce and produce **toxins** which cause disease. **Symptoms** of *Salmonella* food poisoning include: fever, abdominal cramps, vomiting and diarrhoea.

Gonorrhoea is the name of a **sexually transmitted disease** (STD or STI), rather than the name of the pathogen. The pathogen is a bacterium that is transmitted by sexual contact, so transmission can be prevented with a barrier-type of **contraception**, like a condom. The symptoms include a thick yellow or green discharge from the vagina or penis and pain when urinating (weeing). It used to be that gonorrhoea was easily treated with an **antibiotic** (penicillin, in this case), but there are now many **resistant strains** of bacteria that cause gonorrhoea. (Resistant strains are species of the bacteria on which certain antibiotics do not work.)

Key Terms	Definitions
Fever	Disease symptom linked to raised body temperature, thanks to disruption of the normal homeostasis mechanisms.
HIV	Human Immunodeficiency Virus. A virus that uses immune cells as host cells. HIV infection causes AIDS, but if treated properly, AIDS will never develop in an infected individual.
AIDS	Acquired Immunodeficiency Syndrome. A condition in which the immune system is seriously weakened due to infection by the HIV virus.
Salmonella	A genus of bacteria that can cause food poisoning.
Discharge	A substance being produced by the body that should not be there – a sign of disease.

Fungal diseases

Rose black spot is a fungal disease that affects plants. It causes purple or black spots to develop on leaves (hence the name – see picture). The whole leaf often turns yellow and drops early (i.e. before autumn). Like TMV, the plant's growth is inhibited because the rate of photosynthesis is reduced. The fungus is spread on the wind or in water, transmitting the pathogen to other plants. Treatment options: remove the affected leaves, or use a **fungicide** (a chemical that kills fungi).

Protist diseases

Malaria is a disease caused by a *protist* (see topic 6 for a reminder). The protist has a life cycle that requires it to live inside a **mosquito** for some of the life cycle, and in the body of a mammal – like a human – for other stages of the life cycle. In the mosquito, the protist is found in the salivary glands, which is why the protist can be transmitted to a person when the mosquito sucks their blood. The mosquito acts as a **vector**. In the human, the protist causes malaria. Symptoms include recurrent (repeating) **fever** and malaria can be **fatal**. We can attempt to reduce transmission by targeting the mosquitos: preventing them breeding and avoiding bites using **mosquito nets**.

Biology Knowledge Organiser
B5 - Communicable diseases - Triple science only

Culturing (growing) microorganisms

If conditions are right (correct temperature, plenty of nutrients etc.), bacteria can double their population as often as every 20 minutes. This is because each bacterial cell can make two cells this often, through **binary fission**. It is often useful to deliberately grow microorganisms: for example, to investigate antibiotics or disinfectants. However, you want to only grow the type of microorganism you are trying to study. Without proper care, your **culture** is easily **contaminated**, because there are microorganisms everywhere in the environment. 'Proper care' involves using **aseptic technique**.

Aseptic technique to prepare an uncontaminated culture

Here's how to prepare an uncontaminated culture:

1. Sterilise the Petri dishes and **culture media**. This ensures that there are no microorganisms present at the start.
2. **Inoculating loops** are used to transfer bacteria to the culture medium. These loops are passed through the flame of a Bunsen burner to sterilise them before collecting the bacteria you want to study.
3. After transferring the bacteria under study to the culture medium, the lid of the Petri dish is secured on with tape to prevent other microorganisms from entering. It is stored upside down to prevent condensation flooding the bacteria.
4. The culture is incubated (in schools at 25°C) to allow the microorganisms to grow.

Looking at the results

On the agar plate, bacteria can grow as circular **colonies** or as a **lawn**. The colonies tend to be circles, so you can find their cross-sectional area using $A = \pi r^2$ (area of a circle equation). See first photo for examples of colonies.

On the second photo, a lawn culture has been grown. The small white discs of paper placed on the lawn were soaked in solutions of antibiotic or disinfectant. The antibiotic/disinfectant diffuses into the agar gel and, if it works, it kills the bacteria nearby. This leaves a clear area on the agar plate. Again, the clear area can be calculated since they are circular. The larger the clear area, the more effective the antibiotic/disinfectant on the type of bacteria that's been grown.

Key Terms	Definitions
Culture	A population of microorganisms that has been deliberately grown to study.
Binary fission	How bacteria multiply. One bacterial cell divides into two, forming two identical cells.
Contamination	When unwanted bacteria (or other microorganisms) mix in with the bacteria you are trying to grow.
Aseptic	Without contaminating microorganisms
Culture medium	Substance on which microorganisms are grown, which provides them with nutrients. E.g. agar gel, nutrient broth.
Inoculating loop	Equipment used to transfer microorganisms (e.g. bacteria) to a culture medium for growth and study.
Agar plate	A Petri dish filled with agar gel.
Colony	A population of bacteria. Colonies look like circles of growth in an agar plate.
Lawn culture	An agar plate spread evenly with bacteria. This is useful for testing antiseptics/antibiotics.
Mean division time	The average time it takes for a type of bacteria to divide once, under certain conditions.

The size of bacterial populations

If you know how quickly bacteria divide (mean division time) and how long they've been incubated, you can calculate the population size by working out how many division cycles have occurred.
e.g. the mean division time = 20 min and they've been incubated for two hours. 6 cycles of division have occurred. Say we started with 1 cell. 1 → 2 → 4 → 8 → 16 → 32 → 64, or $2^6 = 64$. When the numbers get very large, standard form is useful.

Biology Knowledge Organiser
B6 - Preventing and treating disease

Monoclonal antibodies

Antibodies are natural tools for recognising specific molecules. This property can be fantastically useful. Monoclonal antibodies are copies of the same antibody, produced in a lab for a specific purpose. Here's how they are made: (also see diagram at bottom of page)

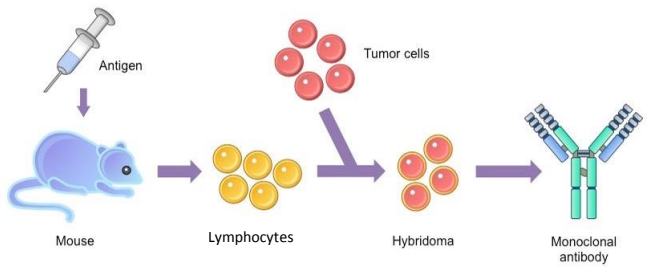
1. Mouse **lymphocytes** are stimulated to make a specific antibody, by giving them a specific antigen
2. These lymphocytes are combined with a type of tumour cell to make a **hybridoma** cell.
3. Like other cancer cells, this hybridoma cell can divide rapidly. It also makes the antibody that is desired.
4. The hybridoma cell is cloned, to there are many identical copies all making the same antibody.
5. After a large amount has been made, the antibody is separated from the cells for use.

Using monoclonal antibodies

There are dozens of uses for monoclonal antibodies: the thing to remember is that they are used when a specific molecule needs to be recognised. Examples to know:

- **Pregnancy tests** use monoclonal antibodies that specifically bind to a hormone made in the placenta – which is only present in pregnant women.
- Lab tests for levels of specific chemicals in blood samples, or to detect specific pathogens.
- To **identify specific molecules** in a cell or tissue. One way to do this is to attach a fluorescent dye to the antibodies, so under a microscope you can see exactly where the specific molecule is located in the cells/tissues.
- **Disease treatment**, although not commonly. Monoclonal antibodies can have drug molecules attached to them, and because they only bind to certain antigens you can get them to stick to cancer cells ONLY – so the chemotherapy hits the tumour, but not the healthy cells of the body. Smart.

Although there's great promise, using monoclonal antibodies in medicine is not so widespread – there are quite a few side effects. They are also expensive to produce.



Key Terms	Definitions
Monoclonal	All the same, due to all coming from cloned cells
Antibody	Protein molecule made by white blood cells to fight pathogens. Each antibody is specific to one antigen.
Antigen	A molecule found on the surface of cells (or viruses), often made of protein. Antibodies, if they are the right sort, bind to antigens.
Bind	Stick to, due to having shapes that fit together.
Lymphocyte	Type of white blood cell that makes antibodies.
Chlorosis	Yellowing of leaves.

Plant diseases

Obviously a plant can't tell you when it is sick. But some easy signs can indicate disease:

- Stunted growth (which may be caused by deficiency in **nitrates**, since nitrates are needed to make protein)
- Spots on leaves
- Areas of decay
- Growths that shouldn't be there (like tumours)
- Malformed stems/leaves
- Discolouration (including **chlorosis**, which is caused by a deficiency in magnesium – since magnesium is used to make chlorophyll)
- Presence of pests

If you see these dreadful signs, you could identify the specific disease by:

- Checking your gardening books/websites
- Taking infected plants to a lab to identify the pathogen
- Using testing kits containing **monoclonal antibodies**!

Plant defences against disease, or against getting eaten

Plants can prevent invasions by microbes with physical defences, such as:

- Cellulose cell walls
- The tough waxy cuticles on their leaves
- Layers of dead cells (e.g. bark) around stems that can be shed (fall off)

Plants also have chemical defences, including:

- Antibacterial chemicals
- Poisons to stop herbivorous animals from eating them

Plants also have mechanical adaptations to defend themselves:

- Thorns and hairs to deter animals from eating them
- Leaves which droop or curl up when they are touched
- **Mimicry** to trick animals into thinking they are poisonous/bad to eat

Biology Knowledge Organiser
B6 - Preventing and treating disease

Human defence systems

Pathogens are all over the place, so humans have evolved defence systems to deal with them. We have **non-specific defences**, which keep pathogens from entering the body (although, of course, they can fail to do this – otherwise you'd never get sick!). If pathogens do get in, we have the **immune system**, which destroys the pathogen inside the body.

Non-specific defences:

- The **skin**! Our main barrier against pathogens getting in. The vast majority of pathogens cannot get through the skin at all – they have to enter somewhere else. Also, the skin scabs over to provide a quick barrier if there is a cut or wound.
- The **nose** has hairs and mucus to trap microorganisms so they don't get any further than the nose. If you don't blow your nose, the mucus ends up in the back of the throat and you swallow it – this is harmless, because the stomach acid kills any microorganisms in there.
- The **trachea** and **bronchi** also contain mucus. This traps microorganisms that are breathed in, and the mucus, again, can be swallowed harmlessly.
- The **stomach** produces hydrochloric acid (at pH 2), which kills most microorganisms that are swallowed.

The immune system responds if pathogens enter the body properly – i.e. if they get into the bloodstream. The most important cells in the immune system are the white blood cells. They help defend against pathogens by:

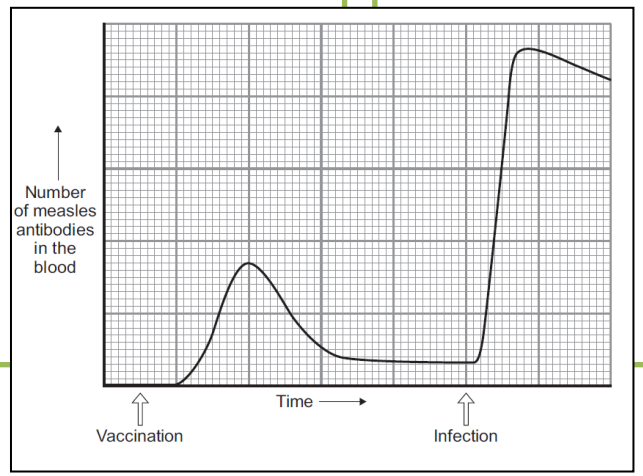
- **Phagocytosis**. This is the *engulfing* and *digesting* of pathogens by white blood cells, destroying the pathogens.
- **Antibody production**. White blood cells produce chemicals called antibodies that bind to pathogens and destroy them. These are *specific*, meaning only one particular antibody type will bind to one particular pathogen.
- **Antitoxin production**. Some pathogens, especially bacteria, produce poisonous toxins. These are neutralised by antitoxins – another sort of chemical produced by white blood cells. Again, antitoxins are specific to specific toxins.

Key Terms	Definitions
Defence systems	Structures and mechanisms we have to prevent pathogens entering the body, and to fight them off if they do enter. Includes non-specific defences (act on any pathogen) and specific defences (target the particular pathogen you've been infected by).
Mucus	A sticky substance produced by many epithelial (surface-covering) tissues in the body, to trap dust particles and microorganisms so they can't enter the body.
Antibody	Chemical produced by white blood cells that destroys specific pathogens.
Antitoxin	Chemical produced by white blood cells that neutralises specific toxins.

Vaccination

Vaccination is great on two fronts: it stops the vaccinated individual from getting ill AND it helps prevent the spread of communicable diseases. If a large proportion of the population is vaccinated, it is very unlikely that an *unvaccinated* person would be exposed to the pathogen, so everyone is protected.

1. A vaccine contains a small quantity of a **dead or inactive** form of a **pathogen** (usually a virus, such as the measles virus – see graph).
2. Delivering a vaccine stimulates a **primary** immune response. White blood cells produce antibodies to destroy the pathogen, but this is slow.
3. Specialised white blood cells (memory cells) remain in the blood afterwards.
4. This means that if an infection by the real pathogen takes place in the future, there is a **secondary** immune response by the white blood cells, which is *quicker* than the primary immune response.
5. The secondary immune response starts faster (see graph), involves the production of far more antibodies (a *stronger* response) and the level of antibodies stays higher for longer.
6. This means the pathogen is destroyed before you even realise you are ill.



Biology Knowledge Organiser
B6 - Preventing and treating disease

Treating disease with drugs

Despite our non-specific defences and our immune systems, we still get sick due to communicable diseases. Fortunately, we've developed a huge range of drugs to treat diseases. (Drugs and medicines are synonymous; we can also say 'medical drugs' to mean those that treat disease rather than drugs taken for recreation.)

Antibiotics

Antibiotics have only been produced since the 1940s, but they have changed the world in that time. The first antibiotic was discovered (not made – it was produced by a fungus!) by Alexander Fleming. He found that a fungus called *Penicillium* worked to kill bacteria he was growing in an agar plate. Named for the fungus that produced the chemical, this was the first antibiotic: penicillin. It is still used today.

Antibiotics treat **bacterial** diseases **only**, because they kill pathogenic bacteria in the body. In this way, they can cure bacterial diseases. Antibiotics are *specific* – so you need to use the right antibiotic to kill the particular bacteria that has infected you. So, antibiotics have saved millions of lives, by successfully treating people with bacterial infections. However, a big issue with the use of antibiotics is that many strains (types) of **resistant bacteria** have emerged (more on this in topic 16).

Antibiotics CANNOT kill viruses, so cannot treat viral diseases. Since viruses live *inside* host cells, it is very difficult to kill viruses without also damaging the body tissues they live in.

Painkillers

Painkillers are examples of medical drugs that treat the **symptoms** of disease, without actually getting to the cause and killing the pathogens. An example is **aspirin**, a painkiller that was first extracted from the bark of willow trees.

Discovering new drugs

There is a constant demand for new drugs – for better treatments, to treat diseases without any current cures, and to deal with antibiotic resistance. Chemicals that *might* work as effective drugs are constantly being discovered or synthesised in labs. Many drugs were discovered in living organisms: e.g. the heart drug **digitalis** originates from **foxgloves**. There are other examples above. However, any of these newly discovered/made chemicals must be thoroughly tested before they can be used in humans.

Key Terms	Definitions
Drug	Any chemical that causes chemical changes in the body. Most drugs are medical – used to treat disease.
Antibiotic	Type of drug that treats bacterial disease by killing pathogenic bacteria.
Antiretroviral	Type of drug that *can* kill viruses: these are used to treat infection by HIV.
Painkiller	Drug that only treats the symptoms of disease, rather than killing pathogens.
Symptoms	Problems with the body arising from disease and indicating that there is a disease. E.g. coughing, headaches, vomiting.
Toxicity	From 'toxic', toxicity means how harmful a drug is to healthy body tissues.
Efficacy	How well a drug actually treats the disease it is designed to treat.
Dose	How much of a drug is given to a patient, and how many times a day and so on.

Development and testing of new drugs

New chemicals, potential medical drugs, are tested to find out if they are **safe** and **effective** (they actually treat the disease they are supposed to!). There are many stages to this testing. We refer to the part before giving the drug to humans as 'preclinical testing' and to the stages where humans received the drugs as ' clinical trials'. Together, these stages tell us about the drug **toxicity, efficacy** and information about the **dose** that should be given. Here's the sequence:

1. **Preclinical testing** is in a lab. The drug is tested on cells and tissues grown for drug testing, and on animals like rats bred for drug testing. This checks that the drug is not toxic, and can give information about efficacy too.
2. **Clinical trials** are tests on humans. First, new drugs are given in very low doses to healthy volunteers, to check that they are not toxic and don't cause major side effects.
3. If the drug is safe, clinical trials using people with the disease take place. These trials test how well the drug works for the disease, and identifies the optimum dose.

In any clinical trial, **double blind** testing is often used. Some patients are given a **placebo** (fake version of the drug), and neither scientist/doctor or patient know who has the placebo and who has the real drug until afterwards. This ensures that effects due to people's expectations can be ruled out.

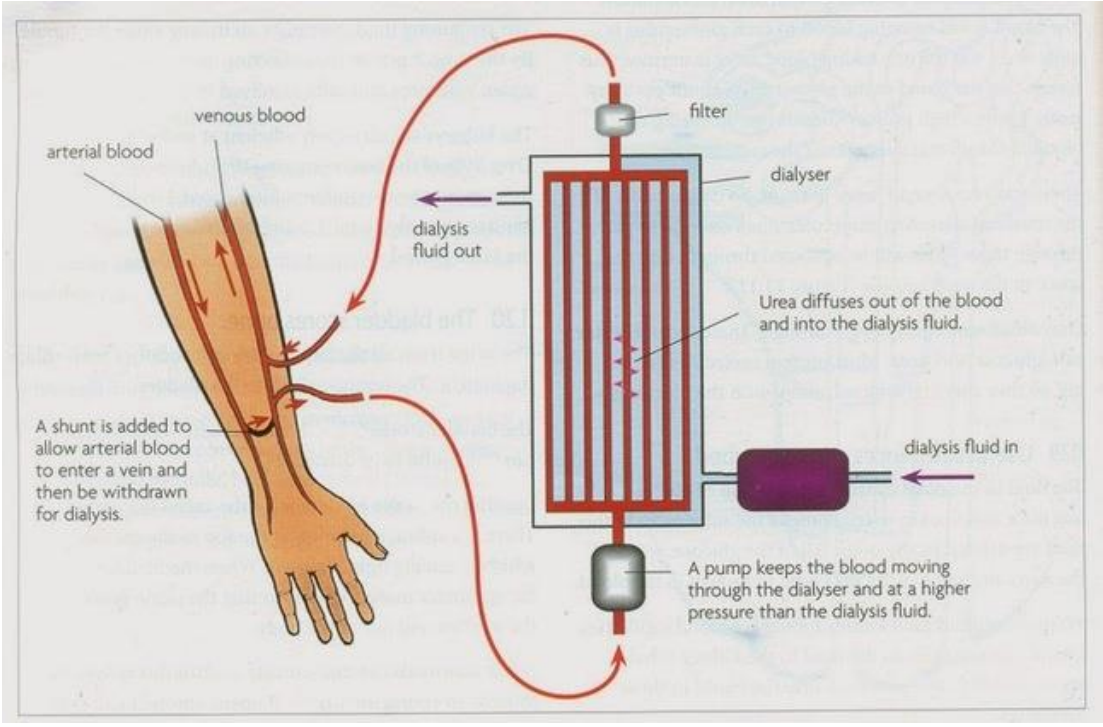
Biology Knowledge Organiser
B7 - Non-communicable diseases

Kidney failure

If they kidneys fail, it is extremely dangerous. Kidney failure can be treated by a kidney **transplant** or using kidney **dialysis.** A transplant has the benefit for the patient of not needing to spend lots of time on a dialysis machine. However, they need to take **immunosuppressant drugs** to prevent rejection of the transplanted kidney. These leave them more susceptible to infections.

Dialysis machines keep people with kidney failure alive because they filter the blood for them. However, the patient would need to spend many hours a week connected to the machine to prevent urea reaching unsafe levels in the bloodstream.

The dialysis machine works as shown in the diagram. Notice that inside the machine, there is a large surface area to increase the rate of diffusion of urea out of the bloodstream.



Key Terms	Definitions
Dialysis	Treatment for kidney failure, in which a machine filters toxic substances from the blood instead of the kidneys.
Diabetes	Condition where blood glucose concentration is not controlled properly by the body.
Insulin	The hormone, produced in the pancreas, that reduces blood glucose concentration by making cells absorb glucose from the blood.
Immunosupp-ressant	Type of drug that reduces the responses of the immune system. This makes sure that 'foreign' organs (like a transplanted kidney) are not fought by the immune system – a situation called rejection.

Diabetes – a non-communicable disease

Diabetes is a group of disorders where blood glucose cannot be properly regulated by the body, which is potentially very dangerous. There are two types, with different causes and treatments.

Type 1 diabetes	Type 2 diabetes
Caused by a defect in the pancreas, where the cells that produce insulin don't work.	There is no problem with the pancreas – it produces insulin as usual. BUT, body cells no longer respond to the insulin.
The effect: Blood glucose concentration cannot be controlled by the body.	The effect: Blood glucose concentration cannot be controlled by the body.
Treatment is injections of insulin. The insulin is produced by genetically engineered bacteria.	Insulin injections will have no effect, so the treatment is a carbohydrate-controlled diet and exercise.
The cause is unknown, but we do know it involves the insulin-producing cells getting destroyed.	Obesity is a major risk factor for type 2 diabetes. There is also a genetic risk factor.

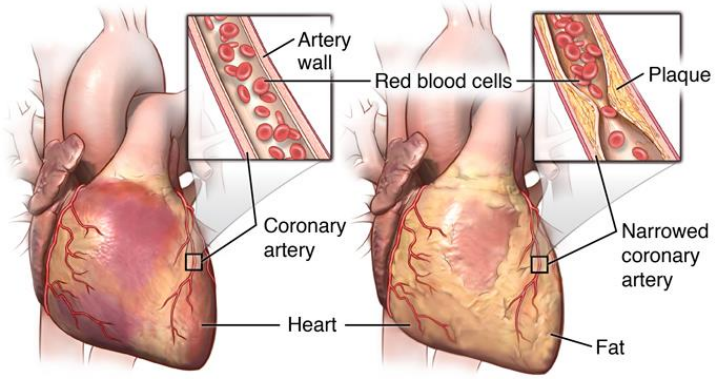
Biology Knowledge Organiser
B7 - Non-communicable diseases

Coronary heart disease: a non-communicable disease

Recall that **coronary** arteries are the arteries that provide the heart muscle with blood, so they get oxygen and glucose (and to take away waste products). Coronary heart disease involves the narrowing of these arteries, due to the build up fatty material (called a **plaque** – see diagram) in there. This reduces the blood flow through the coronary arteries, so the heart muscle receives insufficient oxygen. When serious, this leads to a heart attack (where part of the heart muscle dies due to lack of oxygen).

Treatments for coronary heart disease:

- Insert a **stent** into the narrowed artery to widen it again. This is a kind of wire mesh that pushes the artery walls out and keeps the artery open.
- Take **statins**. These drugs reduce blood **cholesterol** levels, which is linked to the fatty material deposits. Lowering cholesterol reduces the rate of fatty material build up.



Normal heart and artery | Artery with plaque buildup

Heart transplants

If the heart fails (called **heart failure**) and cannot be repaired, the heart can be transplanted. In fact, the heart and lungs can be transplanted together if required. The replacement heart has to come from a **donor** – many people agree to donate their organs after they die to save the lives of others.

However, there is a shortage of donor organs, like hearts. So people with heart failure may have to wait a while. In this case, **artificial hearts** can be used to keep someone alive while they wait. These are pretty amazing – have a look at the photo.

Key Terms	Definitions
Coronary	To do with the heart, especially the blood vessels that supply the heart muscle with blood.
Stent	A mesh or cage-like structure that keeps coronary arteries open so blood can flow through.
Statins	Medicinal drugs used to lower blood cholesterol. High blood cholesterol is a risk factor for coronary heart disease.
Valve	Structures in the heart that prevent blood flowing the wrong way.
Heart failure	Where the heart cannot pump blood around the body properly.

Other heart diseases

The valves in the heart are vital to prevent blood flowing in the wrong direction. In some people there is fault in the heart valves. The valve may get a leak, or might not open fully – see diagram.

- If one or more of the valves **leaks**, blood flows backwards in the heart. This means the blood does not transport oxygen as efficiently and also increases the risk of infection in the heart.
- If a valve **doesn't open fully**, the heart has to work harder to pump the blood as your body requires. This increases strain on the heart, making other heart problems more likely.

Valve doesn't open all the way, not enough blood passes through

Valve doesn't close all the way so blood leaks backwards

These valve problems can be treated by replacing the valves. Replacement valves can be **biological** – from a living organism (including pigs! Their heart is the same size as ours so their valves fit) or **mechanical** – a synthetic version. See the photos – mechanical on the right.

Biology Knowledge Organiser
B8 - Photosynthesis

Photosynthesis.

For us, it is a very good thing that photosynthesis evolved. The process of photosynthesis, carried out by plants and algae, is at the foot of every food chain. It captures light energy from the sun and redistributes it to chemical potential energy – we can make use of chemical potential energy: that's what our food contains! Since photosynthesis involves the transfer of light energy to chemical potential energy in cells, it is an **endothermic** reaction.

The reaction can be shown in these equations:

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

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

The oxygen released by photosynthesis has built up in the atmosphere over millions of years – again, good news for us, since we require oxygen for respiration, just like all living organisms.

Photosynthesis occurs in the **chloroplasts** of plant cells. Simple molecules like carbon dioxide and water can't be used as food. However, glucose and other more complex molecules can – so you can think of photosynthesis as a reaction that produces food.

Using The Glucose From Photosynthesis.

Obviously, plants didn't evolve simply for our benefit. They carry out photosynthesis to meet their own needs. The glucose produced in photosynthesis can be:

- Used in respiration in the cells of the plant/algae
- Converted into **starch** for storage. Starch is good for storage as it is *insoluble*, so it doesn't affect the osmosis occurring in the plant, unlike glucose.
- Used to produce **fats or oils (lipids)** for storage. This is particularly noticeable in seeds and nuts.
- Used to produce **cellulose**, which is a component of the cell wall. Cellulose strengthens the cell wall.
- Used to produce **amino acids**, which in turn are used to synthesise proteins (in the ribosomes). To produce amino acids, plants also require **nitrates** from the soil.

Simple lab tests can be used to identify starch, glucose and protein. Starch turns **iodine** a blue-black colour. Glucose turns **Benedict's solution** orange-red when heated with it. Proteins turn **Biuret's reagent** purple.

Key Terms	Definitions
Photosynthesis	The endothermic reaction that transfers light energy to chemical potential energy. In it, simple molecules (CO_2 and H_2O) are converted into more complex molecules (glucose) that can be used for food.
Nitrates	Ions containing nitrogen and oxygen. These are found in the soil; plants need nitrates to produce amino acids.
Rate	As always, rate means how quickly something happens.
Light intensity	The amount/strength of light. Use this term instead of 'amount of light'.
Chlorophyll	The green pigment in leaves that absorbs light for photosynthesis. Chlorophyll is found in **chloroplasts**.

The Rate Of Photosynthesis.

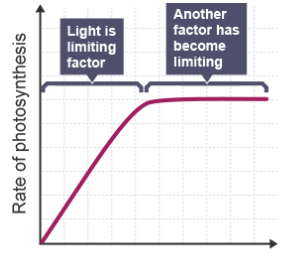
The following factors affect the rate of photosynthesis:

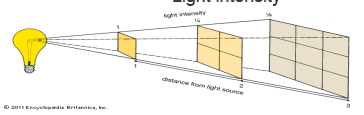
- **Temperature**: because all chemical reactions speed up as the temperature increases. However, as photosynthesis is controlled by enzymes, too high a temperature prevents photosynthesis (more on this in the metabolism section).
- **Carbon dioxide concentration**: the higher the concentration of CO_2 in the air, the more is available for photosynthesis, so the rate of photosynthesis increases as concentration increases.
- **Light intensity**: as the equation shows, photosynthesis requires light energy. So, the higher the light intensity, the higher the rate of photosynthesis.
- **Amount of chlorophyll**: more chlorophyll means more light can be absorbed. Some leaves have pale parts, as you may have seen, due to a lack of chlorophyll. The rate of photosynthesis is obviously much lower in the pale parts compared to the deep green parts.

HT: at any given time, any one of these factors may be **limiting** the rate of photosynthesis. This can be shown on graphs – see example. When it comes to light intensity, it varies with distance according to an *inverse square law*:

$$\text{light intensity} = \frac{1}{distance\ from\ source^2}$$

In commercial growing of plants (e.g. tomatoes in a greenhouse), the conditions are optimised to maximise the rate of photosynthesis and obtain the highest profit.





Biology Knowledge Organiser
B9 - Respiration

Respiration.

Photosynthesis produces chemicals (like glucose) that can be used as food by all living organisms. In **respiration**, the chemical potential energy stored in food molecules is transferred through **oxidation** reactions (where oxygen, originally from the air, reacts with the food molecules). The energy transferred allows living cells to do **work**.

As you know, doing work means transferring energy. The kinds of work done by cells and organisms include:

- Chemical reactions to build larger molecules from smaller ones. E.g. making proteins such as enzymes from amino acids.
- Movement. E.g. movements of our body are possible due to muscle contractions. This requires energy from respiration.
- Keeping warm. This is an example of homeostasis: using energy from respiration to maintain body temperature at a set point (37°C).

There are two types of respiration: **aerobic** and **anaerobic**.

Aerobic vs. Anaerobic Respiration.

Aerobic respiration occurs when oxygen is used in the reaction. It is shown by these equations:

glucose + oxygen → carbon dioxide + water

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

This reaction releases energy that can be used by organisms, as described above. Compared to anaerobic respiration, aerobic respiration releases much more energy.

Anaerobic respiration occurs when there is insufficient oxygen available for complete oxidation of the glucose. The reaction that happens is different in animal cells compared to plant and yeast cells.

In *animals*: glucose → lactic acid

In *plants* and *yeast*: glucose → ethanol and carbon dioxide

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

Anaerobic respiration releases much less energy than aerobic respiration. In yeast, we call the anaerobic respiration **fermentation**. This is a very useful process: for making bread (the CO_2 makes it rise) and making alcoholic drinks (since ethanol is a type of alcohol).

Key Terms	Definitions
Aerobic	Using oxygen
Anaerobic	Not using oxygen
Oxidation	A reaction with oxygen. In this case, food molecules like glucose reacting with oxygen.
Fatigue	Tiredness. Fatigue in muscles is caused by a build-up of lactic acid, which is produced during anaerobic respiration (when there is insufficient oxygen).
Oxygen debt	After exercise, the lactic acid has built up and caused an **extra** need for oxygen – called the oxygen debt.
Lactic acid	Chemical produced by the incomplete oxidation of glucose (anaerobic respiration).

The Response To Exercise.

During exercise, more energy is required by the body that when resting, due to increased muscle contractions. The body reacts to this increased **demand** for energy:

- The heart rate, breathing rate, and volume of each breath all increase. Together, these increase the amount of **oxygenated blood** reaching the muscles. The oxygenated blood provides the extra oxygen and glucose needed for respiration in muscle cells, to transfer more energy to meet demand.

However, if insufficient oxygen reaches muscles but exercise continues, the muscle cells use **anaerobic respiration** to transfer energy. From the equation, you can see that incomplete oxidation of glucose takes place and **lactic acid** is produced. The lactic acid builds up and causes an **oxygen debt**. The lactic acid building up also causes **fatigue**. Removing the lactic acid after exercise is the cause of the oxygen debt – the oxygen debt is why you breathe deeply after exercise for some time. You are 'repaying' the oxygen debt.

HT: oxygen debt, to be precise, is the amount of extra oxygen needed to react with lactic acid in muscles and remove it from cells. The blood flow through muscles removes lactic acid and transports it to the liver. In the liver, the lactic acid is converted back into glucose. This reaction requires energy, hence the extra need for oxygen (for aerobic respiration to provide that energy).

Biology Knowledge Organiser
B9 - Respiration

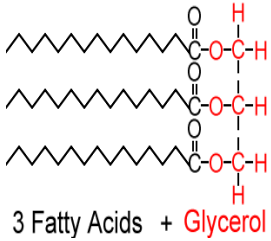
Metabolism.

Metabolism is a very big term in biology. It is the name given to collectively describe ALL the chemical reactions happening in a cell or in the whole body. So, respiration in all cells is an example of metabolism, and so is photosynthesis in plants.

Many reactions that cells perform require **energy**, so metabolism relies on energy transferred by respiration. Furthermore, chemical reactions in cells are controlled by **enzymes**. As we're talking about chemical reactions, *reactants* are used to make *products*: new molecules are synthesised.

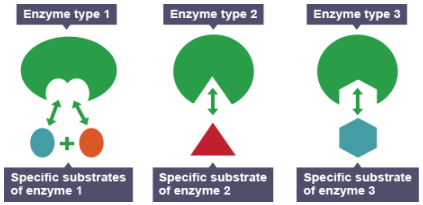
To learn: metabolism includes these reactions:

- Conversion of glucose to glycogen (in animals), or to starch or cellulose (in plants).
- Making lipid (fat) molecules from one molecule of **glycerol** and three molecules of **fatty acids** (see diagram).
- In plants, the use of glucose and nitrate ions to make amino acids. These amino acids are then used to synthesise proteins.
- Respiration, both aerobic and anaerobic.
- Breaking down excess proteins into amino acids, then into **urea** for excretion in the urine.



Factors Affecting Enzymes.

Recap your knowledge of how enzymes work from Topic 7.

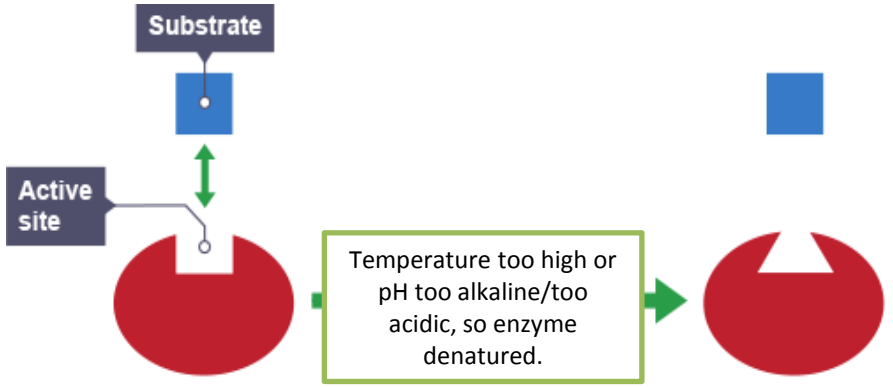


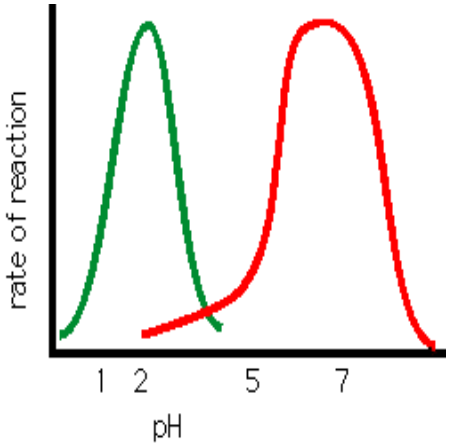
Enzymes are highly **specific**, meaning that each type of enzyme only causes a reaction by one type molecule. This comes about due to the specific shape of the active site: only one molecule (according to its shape) will fit into the active site. See diagram for an illustration.

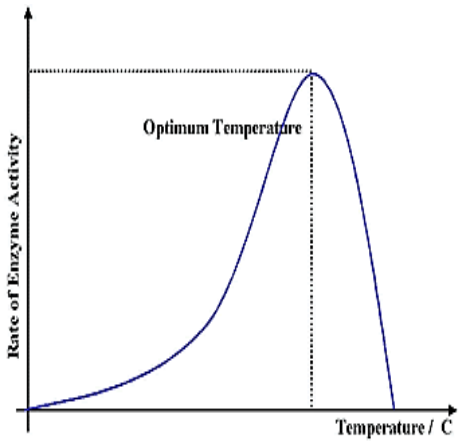
Enzymes have an optimum temperature and pH. If the temperature is **too high** (for most enzymes, above about 45°C), or the pH is **too acidic** OR **too alkaline**, the enzyme **denatures**. This means the active site changes shape. As a result, the substrate no longer fits into the active site, to the enzyme doesn't work any more (see diagram).

This leads to results with enzyme controlled reactions as shown in the graphs. The rate of the reaction catalysed by the enzyme is on the y-axis. The peak represents the optimum temperature/pH. Notice that different enzymes have different optimums – as shown on the pH graph with the two lines.

Key Terms	Definitions
Metabolism	The sum of all the chemical reactions in a cell or in the body of an organism.
Enzyme	Large protein molecule that acts as a biological catalyst, dramatically speeding up chemical reactions in organisms.
Synthesis	Making something new. E.g. new molecules in metabolism.
Active site	The part of an enzyme molecule into which the substrate fits – so the shape of the active site is vital.
Substrate	The molecule an enzyme 'works on' to make a product/products.
Optimum	The ideal or perfect condition . Enzymes have an optimum temperature and an optimum pH.







Biology Knowledge Organiser
B10 - The human nervous system

Homeostasis

Unless chemical and physical conditions in the body are kept within strict limits, cells die. Thus, our bodies constantly and automatically regulate the internal conditions in the body to maintain optimum functions. This regulation is called **homeostasis**. It is vital for proper enzyme functioning, and indeed all cell functions.

Some factors that need controlling by homeostasis in the human body:
- Blood glucose concentration
- Body temperature
- Water levels
- Nitrogen levels.

The regulation that takes place can be carried out by the **nervous system**, the **endocrine system** (which produces hormones), or a combination of the two. These automatic control systems we use for homeostasis all include:
- Receptor cells – these detect changes in the environment. Changes are called **stimuli**.
- Coordination centres – these receive information from receptor cells (electrical or chemical information) and process the information. Examples include the brain, spinal cord and pancreas.
- Effectors – these are muscles or glands, which carry out the responses as directed by the control centre. Muscles **contract** and glands release chemicals, such as hormones.

The human nervous system

The nervous system is a network of neurones (nerve cells), bundled into nerves. It includes the nerves all over the body and the **central nervous system**, which consists of the **brain** and **spinal cord**. The nervous system allows us to react to the surroundings and control our behaviour. It can act involuntarily (in **reflexes**) or voluntarily.

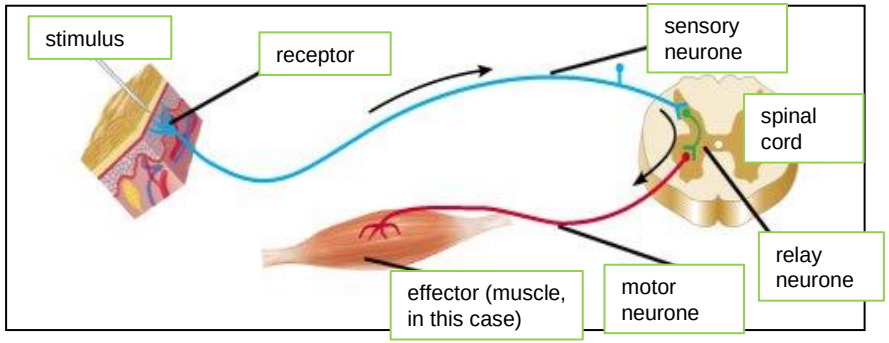
Information from receptors, in the form of electrical impulses, passes along neurones to the central nervous system (CNS for short); the CNS coordinates the response by transmitting electrical impulses to the effectors (see above).

A reflex arc causes reflex actions, which are rapid and automatic (automatic because they don't involve the conscious part of the brain).

Key Terms	Definitions
Homeostasis	Regulating the internal conditions of the body in response to internal or external changes, to maintain optimum conditions for the body's functioning
Endocrine system	The network of hormone-producing glands in the body. Hormones are chemical messengers that travel in the bloodstream to their target tissues.
Blood glucose	Glucose (a simple sugar) is transported in the blood, as all cells require it for respiration. The concentration of blood glucose must be kept within very tight limits at all times.
Stimulus	A change in the environment, detected by a receptor cell. E.g. light, sound, chemicals (smells and tastes), pressure, pain, temperature etc.
Nerve	A nerve is just a collection of many nerve cells; nerve cells are called **neurones**. Neurones transmit (carry) information as **electrical impulses**.

The reflex arc and reflex actions

Reflex actions, for instance pulling your hand away from a pain stimulus, follow a simple pathway.
1. The **receptor** detects the **stimulus** and passes electrical impulses along the **sensory neurone** to the CNS (the spinal cord part, in this case).
2. There is a junction (tiny gap) between the sensory neurone and the **relay neurone** called a **synapse**. Here, a chemical is released that diffuses across the gap and causes an electrical impulse to pass along the relay neurone.
3. There is another synapse between the relay neurone and the **motor neurone**, again a chemical is released that causes the electrical impulse to pass along the motor neurone.
4. The impulse arrives at the **effector** – in this example, a muscle that contracts to pull your hand away from the source of pain.

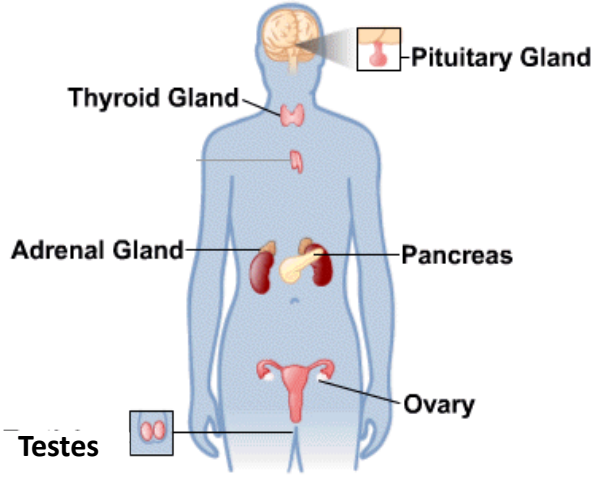


Biology Knowledge Organiser
B11 - Hormonal coordination

The human endocrine system

Hormones are released by endocrine glands directly into the bloodstream so they can be transported to a target organ or tissue and cause an effect. In comparison with the nervous system, the effects caused by the endocrine system are slower but act for longer. The hormones themselves are large chemical molecules.

The most important endocrine gland is the **pituitary gland** – think of it as a master gland that secretes many hormones that act on *other endocrine glands*, which then release hormones of their own. Learn the positions of the endocrine glands indicated on the diagram.



Diabetes

Diabetes is a group of disorders where blood glucose cannot be properly regulated by the body, which is potentially very dangerous. There are two types, with different causes and treatments. More on this in topic 13: how do organisms get sick?

Controlling blood glucose concentration

The monitoring and control of blood glucose concentration are both carried out by the **pancreas**. When blood glucose concentration rises (for instance, soon after eating), the pancreas detects this and releases the hormone **insulin**. Insulin causes glucose to move out of the blood and into cells. In particular, muscle and liver cells take in glucose and convert it to a much bigger molecule called **glycogen** for storage, rather than keeping it as glucose in their cytoplasm. This, obviously, *lowers* the blood glucose concentration back down to what it should be.

HT: when blood glucose concentration drops too low, the pancreas detects this and releases a different hormone: **glucagon**. Glucagon causes muscle and liver cells to convert glycogen back into glucose and release it into the blood. This obviously *raises* the blood glucose concentration back up. Therefore, using insulin and glucagon, the pancreas can keep your blood glucose concentration within very tight limits – an excellent example of homeostasis.

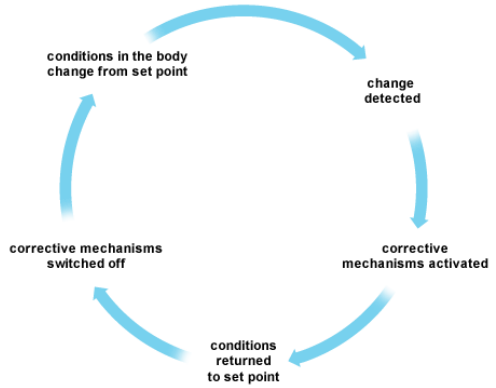
Key Terms	Definitions
Hormone	A large chemical released by an endocrine gland; hormones have target tissues/organs and they produce an effect when they reach them.
Target organ/tissue	The destination of a hormone and the place where the effect caused by the hormone actually happens.
Secrete	The proper term for 'release' of a chemical in the body, such as a hormone from an endocrine gland.
Insulin	The hormone released by the pancreas that lowers blood glucose concentration, by making cells take in glucose from the blood.
Glycogen	Large chemical, made from glucose, that acts as a store of glucose in liver and muscle cells.
Pituitary gland	The 'master gland' of the endocrine system, since, through its hormone release, it can make other endocrine glands release hormones.

HT: negative feedback

Negative feedback is an important concept in homeostasis. Secretion of hormones is stimulated by a change from the normal level of a condition in the body. The hormone brings the condition back under control, so its release is no longer stimulated. In a round about way, hormones end up preventing their own release – this is called negative feedback. The diagram shows this in general. The level of many hormones can be controlled in this way.

Thyroxine, secreted by the thyroid gland, is controlled by negative feedback, for example. Thyroxine stimulates the **basal metabolic rate** – the baseline for the speed of chemical reactions in the body. This is important in growth and development.

Another hormone you need to know about is adrenaline. This is released by the adrenal glands when you are scared or stressed. It increases the heart rate, increasing the delivery of oxygen and glucose to the brain and muscles. This prepares the body for 'fight or flight' – combat or running away.



Biology Knowledge Organiser
B11 - Hormonal coordination

Hormones and Human Reproduction

Hormones, those chemical messengers that travel in the bloodstream, control many aspects of reproduction, including the **menstrual cycle**, which is essential for sexual reproduction in humans (and other animals).

- During **puberty** the reproductive hormones (see key terms) cause the development of **secondary sex characteristics**. These are the distinctive features of men and women that develop during puberty (e.g. beards and breasts).
- **Testosterone** is the main male reproductive hormone. It is produced in the **testes** and it *stimulates sperm production* (sperm cells are also produced in the testes).
- **Oestrogen** is produced in the ovaries (in women), largely responsible for bringing about changes at puberty.

The menstrual cycle is not only the period, although this is where is usually considered to start. The average length of a menstrual cycle is 28 days. The whole purpose of the menstrual cycle is to ready the body for pregnancy, by:

- Shedding (releasing) the uterus lining from the previous cycle – causing the period (aka **menstruation**)
- Allowing an egg to **mature** in the ovary (this is stimulated by the hormone **FSH**).
- Thickening and maintaining the **uterus lining** in preparation for pregnancy (this is controlled by **oestrogen** and **progesterone**).
- Releasing an egg (**ovulation**), about two weeks after the period started (this is stimulated by the hormone **LH**).

Contraception – preventing pregnancy

One class of contraceptive methods is **hormonal contraception**. Oral contraceptives ("the pill") contain hormones to inhibit FSH production so **no eggs mature**. Injections, implants of hormone-releasing devices, or skin patches can be used for slow-release progesterone, which inhibits the maturation and release of eggs for months or even years.

Non-hormonal methods include:

- **Barrier** methods, like condoms or diaphragms. These prevent sperm reaching the egg.
- **Intrauterine devices** (in the uterus) that prevent any embryos produced from implanting in the uterus. They may also release progesterone, like the hormonal methods above.
- **Spermicidal agents** – chemicals that kill or disable sperm. These are not very effective!
- **Abstinence** – obviously, there will be no pregnancy without sex. An ineffective method of contraception is attempting to time abstinence so you don't have sex while an egg is in the oviduct.
- **Sterilisation** with **surgery**: for men, this involves cutting and tying the sperm ducts so no sperm are included in the ejaculate. For women, the procedure is more invasive, involving cutting and tying the oviducts so no eggs reach the uterus, and no sperm can get to them.

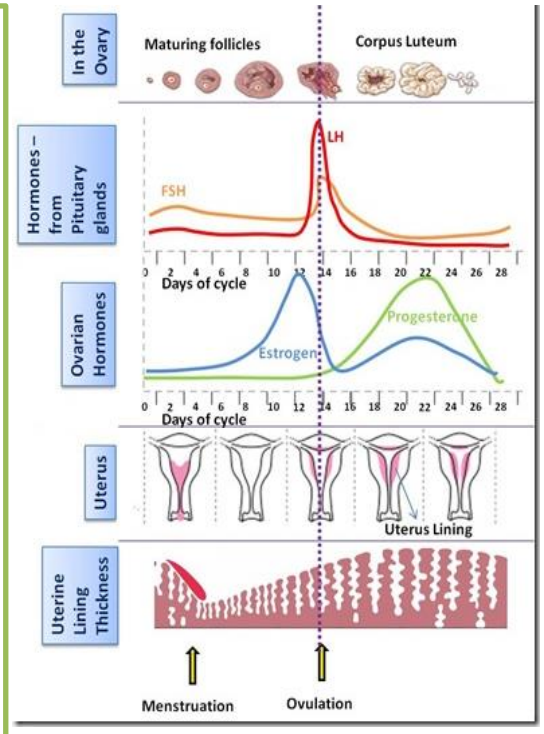
Key Terms	Definitions
Reproductive hormones	Those hormones that control reproduction. Important examples: testosterone (in males); oestrogen and progesterone (in females).
FSH	Follicle Stimulating Hormone. This is released by the pituitary gland and causes maturation of an egg in the ovary.
LH	Luteinising Hormone. This is released by the pituitary gland and it causes release of a mature egg (ovulation).
Uterus lining	The inside of the wall of the uterus. This is where an embryo implants when it is only a few cells in size.
Maturation	Becoming mature. All a woman's eggs are in her ovary when she is born, but they must mature before they are released.

HT: Interactions of hormones in the menstrual cycle

The four hormones involved in the menstrual cycle affect each other. Key points:

- FSH stimulates the released of oestrogen
- High levels of oestrogen stimulate the release of LH
- High levels of oestrogen **inhibit** (reduce) the production of FSH
- Progesterone inhibits the production of both LH and FSH

The changing hormone levels throughout the cycle can be graphed as shown – make sure you are familiar with the sequence and changing hormone levels.



Biology Knowledge Organiser
B11 - Hormonal coordination

HT: Hormones to treat infertility

Hormones can be used not only to prevent pregnancy, but to improve the chances of getting pregnant in cases of infertility. Fertility drugs contain FSH and LH, which may help a woman to get pregnant, as the cause of infertility may be low levels of these hormones. Failing this, **In Vitro Fertilisation (IVF)** can be used. Here's how it works:

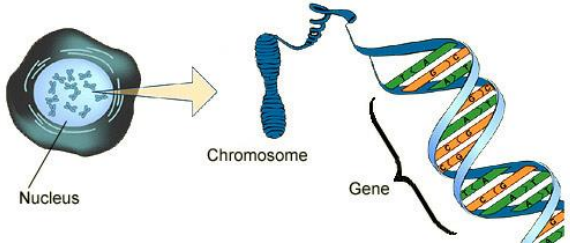
1. The mother is given **FSH** by injection to stimulate eggs to mature – a high dose is given so many eggs mature. **LH** is also given, getting eggs ready for ovulation.
2. Once eggs have had time to mature and are ready for ovulation, but before they actually get released into the oviduct, they are **collected** from the **ovaries**.
3. In a lab ('in glass' – a Petri dish: this is what in vitro means), the eggs are **fertilised** by sperm from the father. The mother can use a sperm donor at this point.
4. Still in the lab, in a Petri dish, these fertilised eggs grow into **embryos** of a few cells.
5. As tiny balls of cells, ready for implantation, one or two embryos are **inserted** into the mother's **uterus**. They used to insert more than this, to increase the chances of pregnancy, but as effectiveness increased the number of *multiple births* (twins, triplets etc.) increased, which are a bit more risky than pregnancies with one baby.

So, IVF has allowed many people to have children who couldn't otherwise. It is stressful though – physically uncomfortable and emotional, because it still only works far less than half of the time. Also, the success rate drops with age. As mentioned, multiple births are more likely in IVF, and these are more risky to mother and baby.

DNA

DNA is a chemical, a compound made of elements you know – carbon, hydrogen, nitrogen, oxygen, phosphorus. It is a polymer – meaning a very long molecule with units that repeat over and over. Each molecule of DNA is in fact made of two strands that run opposite one another and join in the middle (see diagram). These two strands form a spiral we call a **double helix** – double because there are two strands, and helix is just another word for spiral.

DNA is contained in **chromosomes**, where each chromosome contains one molecule of DNA – one long double helix each (there are also protein molecules as part of chromosomes). Short (compared to the whole molecule) sections of DNA called **genes** code for *proteins* (see diagram). This is how DNA gives you characteristics – the genes inherited from the parents, on the chromosomes they pass on to you, code for the *sequence of amino acids to make specific proteins.*



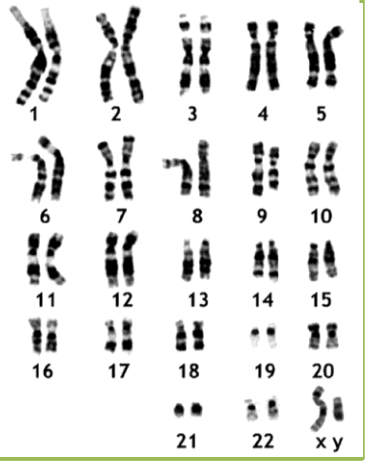
Key Terms	Definitions
Infertility	Problems conceiving (getting pregnant). Treatments for female infertility given left (HT only).
IVF	In Vitro Fertilisation. This means 'in glass' fertilisation – meaning fertilisation happens in a lab.
DNA	The chemical that makes up the genetic material in all cells. DNA is a polymer and arranged as a double helix.
Chromosome	Structure in cells containing one molecule of DNA. Body cells contain two copies of each chromosome – one from each parent.
Genome	The entire genetic material of an organism.
Gene	A section of DNA. Each gene is a code for a sequence of **amino acids**, so each gene codes for a specific protein.

The genome

The genome is the word to describe all the genetic material of an organism. The human genome has been fully sequenced, so we know exactly the order of genes on each chromosome. (Note: in genetic terms, humans are extremely similar so we do have a general human genome. Everyone will vary slightly from it, but by less than 1%.) The micrograph shows the 23 pairs of chromosomes found in human cells, where pair 23 is the sex chromosomes (XY in this person).

Understanding the human genome is very useful for all sorts of reasons, including:

- Helping the search for genes linked to specific diseases
- Understanding inherited disorders (more on these later)
- Using the tiny differences in genetic information between people to track how humans have migrated all over the planet.



Biology Knowledge Organiser
B13 - Reproduction

Genetic inheritance

All the genes you have, you inherited from your parents. They gave you half your genome each. Since they gave you one from each pair of chromosomes you have now, they in fact gave you one copy of each gene each – i.e. genes for the same thing. We call the two different versions of each gene **alleles**. Some characteristics are controlled by one gene – or rather, the two alleles of a single gene. E.g. fur colour in mice, red-green colour blindness in humans. However, most characteristics come about thanks to many genes and their interactions, not just one gene.

The alleles present in an individual organism cause body cells to produce certain proteins, or versions of proteins (as this is what a gene does remember). This is called **expression** of a gene, and leads to physical characteristics we call **phenotypes**.

This is easier with an example. Look at the cats below: the allele for short fur in cats is dominant to the allele for long fur. Let's call the alleles F and f respectively. In the top example, both parents are homozygous dominant (genotype: FF). This means all the gametes they produce will have one F in them, so at fertilisation the only possibility is for the offspring to get FF. So all their offspring have the short fur **phenotype**.

In the second row, both parents have long hair, so they must both have the genotype ff (homozygous recessive). Consequently, all their offspring must have long hair too.

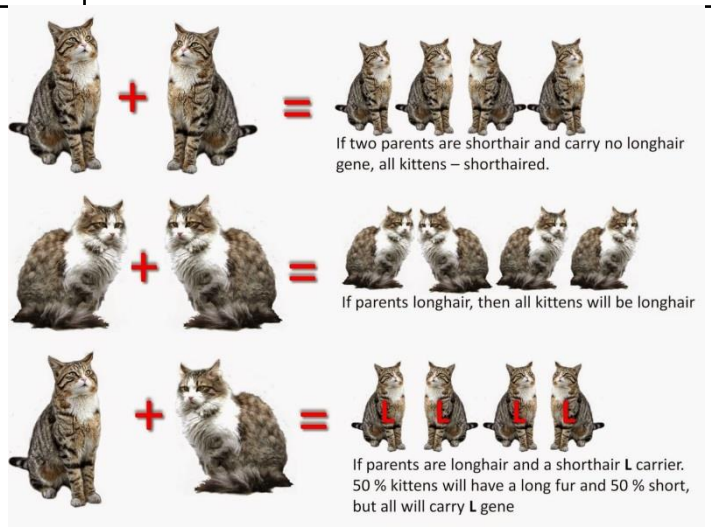
In the third row, the first parent has short hair but is heterozygous (genotype: Ff) – so they still have short hair as the short hair allele is dominant. If they mate with a long hair cat (genotype ff), there are different probabilities for offspring phenotypes, as they will get *either* F or f from the first parent. So, half of them will have short hair (with genotype Ff) and half will have long hair (with genotype ff).

Probability and ratios

Knowing the genotypes of the parents allows you to work out the **probability** of each genotype (and therefore phenotype) in the offspring. It does not guarantee, like in the bottom cat example, that they'll have four kittens, or that half will have long hair. What it tells us is: for each kitten, there is a 50% chance of it having long hair.

The other way of saying this is that the **expected ratio** of offspring genotypes is 1:1 for long:short hair. So if the bottom two cat parents had 50 kittens, we'd expect 25 of each hair length.

Key Terms	Definitions
Allele	A form or version of a gene. Since you inherit a copy of each chromosome from each parent, you have two copies of each gene – we call these two versions alleles.
Express	In genetics, to 'express' a gene means for it to be used by the body to make a protein, causing a characteristic.
Dominant	Describes alleles that are always expressed (so you see the effects in the organism). Indicated with a capital letter to represent the allele e.g. D.
Recessive	Describes alleles that are only expressed if there are two recessive copies (one from each parent). In other words, recessive alleles are only expressed if there is **no** dominant allele present. Indicated with a lower case letter to represent the allele e.g. d.
Genotype	The combination of alleles that an individual has. Often represented with two letters: e.g. DD, Dd or dd.
Phenotype	The physical characteristic that results from a particular genotype.
Homozygous	Describes a genotype where both alleles are the same – e.g. DD is homozygous dominant; dd is homozygous recessive.
Heterozygous	Describes a genotype where the two alleles are different (one dominant, one recessive) – e.g. Dd.



Biology Knowledge Organiser
B12 - Homeostasis in action

Controlling water and nitrogen balance in the body

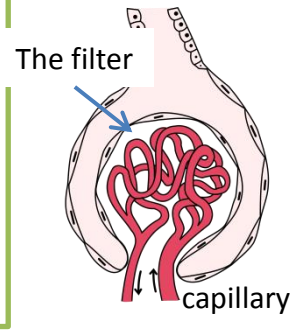
Maintaining water levels in the body is essential for proper functioning of body cells. You must regularly 'top up' your water (by having a drink!), as it is constantly being lost from the body. Water is lost in these ways:

- Water vapour is lost from the **lungs** when we exhale (breathe out)
- Water (along with ions and urea) is lost from the **skin** in sweat
- Water (along with ions and urea) is lost through the **kidneys** in urine.

We can't control the first two methods of water loss – you have to breathe and sweating is unavoidable (and varies according to temperature of the surroundings, of course). However, the amount of water lost in urine can be controlled – by the endocrine system. So, your body can remove excess water in the urine, or keep some water back by not putting so much in the urine.

Kidney function

Kidneys produce urine in two stages: by **filtration** of the blood then **selective reabsorption** of useful substances. Only small molecules can get through the filter (which is why there aren't any red blood cells in your urine). The kidney then **reabsorbs** (takes back in) the substances you need – **all** the glucose, many of the ions and most of the water.



Key Terms	Definitions
Urea	A chemical that must be removed from the body, as it is mildly toxic. It is produced in the liver from excess (too much) amino acids. Urea contains nitrogen.
Urine	Wee! Urine contains water (in variable amounts), ions and, most importantly, urea. Urine is produced in the kidneys.
Excretion	Any process that removes substances from the body.
Filtration	In the kidney, filtration of the blood means large particles/cells/molecules remain in the blood (e.g. red blood cells) and small molecules go through the filter (e.g. water, ions, glucose, urea).
Reabsorption	In the kidney, many substances are taken back into the blood even though they were just filtered out. 100% of glucose is reabsorbed (unless someone has diabetes) and most of the water and ions.

HT: urea formation and hormonal control of water level

Urea is a product made in the liver. The digestion of proteins (from the diet) results in excess amino acids which need to be excreted safely. The liver removes the amino part of the amino acids (NH_3) – a process called **deamination**. The **ammonia** produced is toxic so it is immediately converted to **urea** in the liver cells, which is far less harmful. The urea enters the bloodstream so it can be filtered out in the kidneys.

ADH is the hormone that controls water level in the body. It is released by the pituitary gland when the water level drops (the blood is too concentrated). The target organ for ADH is the kidney – ADH causes the kidneys to reabsorb more water into the blood, so the water level increases again. The release of ADH is controlled by negative feedback.

Biology Knowledge Organiser
B13 - Reproduction

Inherited disorders

Some disorders (or diseases – same thing really) are inherited, so we can also call them **genetic disorders**. If someone inherits a certain allele/combination of alleles, they have the inherited disorder. Two examples to know:

- **Polydactyly**: a condition where people have extra fingers or toes. This is caused by a dominant allele, so only one copy is needed to have the condition.
- **Cystic fibrosis**: a condition where protein pumps in cell membranes don't work properly, leading to thick and sticky mucus being produced in the lungs and intestines. This is caused by a recessive allele, so individuals with cystic fibrosis are all homozygous recessive.

Studying family trees can help genetic scientists decide whether a disorder is caused by a recessive or dominant allele. In the family tree shown, C is the allele for healthy cell membranes, and c is the allele for disordered cell membranes. Both parents must have at least one c to have children with cystic fibrosis, as the family tree shows. (Note: anyone without a genotype shown has the genotype CC).

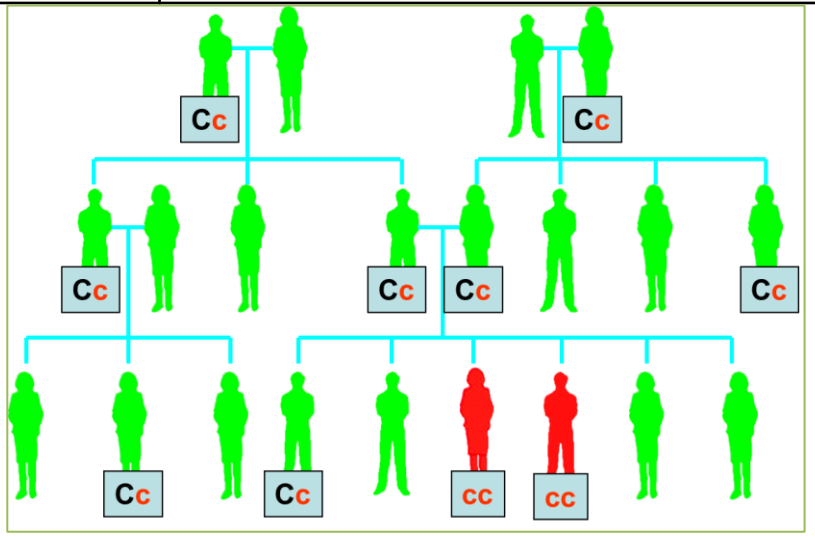
Since we know which alleles cause conditions like these, unborn babies, or embryos produced during IVF, can be checked – or **screened** – to see if they have the inherited disorder. This practice, *embryo screening*, can be used to inform whether an embryo should be implanted in IVF, or, if used during pregnancy, to decide whether an abortion should take place. Obviously, these are huge decisions and the right to life of the embryo must be weighed against the difficulties they'll face with an inherited condition and the personal choice and beliefs of the parents.

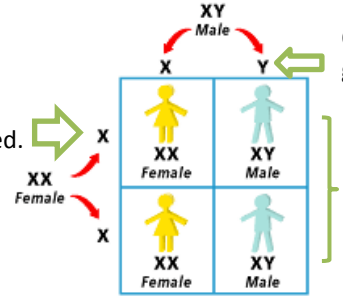
Sex determination

In biology, sex is not short for sexual intercourse. Sex means male or female – so is only relevant to organisms that reproduce sexually. The sex of offspring is determined by the combination of sex chromosomes inherited from the parents. Of the 23 pairs of chromosomes all humans have, 22 control body characteristics and the 23rd pair determines sex. [Note: like all chromosomes, the sex chromosomes carry genes, they just have the extra function of sex determination.] Human females have the combination for pair 23: XX. We say they have two X chromosomes. Human males have the combination XY for pair 23 (they are different).

When having children, then, mothers always pass on one X chromosome to their offspring. Males can pass on an X chromosome OR a Y chromosome – there's a 50:50 chance of each. This is because, when cells divide by meiosis to make gametes, all the female gametes contain an X, but half the sperm cells have an X, half have a Y. How these combine to give a 50% chance of a girl is shown in the **Punnett square** to the right.

Key Terms	Definitions
Screening	The practice of checking for a disease or an inherited disorder.
Carrier	An individual with one copy of the recessive allele that causes an inherited disorder (e.g. Cc for the cystic fibrosis genotype). As a result, they don't have the disorder, but they can pass one allele for it onto their offspring.
Sex chromosomes	Pair 23 in humans. Females have the combination XX, males have the combination XY.
Genetic cross	An unglamorous term given to mating between two individuals, producing offspring.
Punnett square	A tool used to predict the outcome of a genetic cross.





On the side, the possible female gametes are placed.

On the top, the possible male gametes are placed.

The possible combinations are shown. The ratio of female:male is 2:2, simplifying to 1:1.

Biology Knowledge Organiser
B13 - Reproduction

Types of reproduction

Organisms can reproduce sexually or asexually.

- **Sexual reproduction** involves <u>two</u> parents and produces genetically unique offspring. Each parent produces a sex cell (**gamete**), which fuse as part of sexual reproduction. This means that each parent contributes 50% of the genetic information to the offspring, and the offspring is *genetically unique*.
- **Asexual reproduction** involves only one parent and there is **no** fusion of gametes. As a result, there is **no** mixing of genetic information and the offspring are *genetically identical* to the parent (they are **clones** of their parent). No meiosis takes place (since there are no gametes); only mitosis is involved.

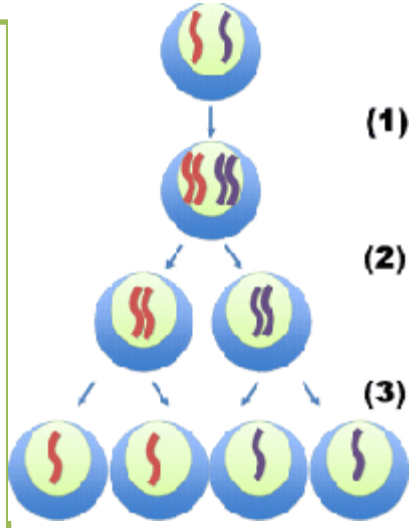
Key Terms	Definitions
Reproduction	Making offspring. All organisms reproduce.
Offspring	Offspring is a generic term for children – it applies to any type of organism.
Gametes	Sex cells, such as pollen, egg cells, sperm cells. Gametes are produced by meiosis.
Meiosis	Type of cell division that produces gametes. Gametes are genetically unique (compare to *mitosis*, where genetically identical daughter cells are produced).
Fusion	The joining/fusing of sex cells in sexual reproduction.
Differentiation	The process of becoming a specialised cell. Specialised cells are the result of differentiation of **stem cells**.

Meiosis

You already know how mitosis is used to replace cells in the body. Meiosis is the other form of cell division, but quite different. Meiosis produces **<u>gametes</u>**, so it happens in **reproductive organs** (e.g. sperm cells are produced by meiosis in the testes; egg cells are produced by meiosis in the ovaries).

DNA in the nucleus of cells is arranged into structures called **chromosomes**. In all body cells, the chromosomes appear in pairs (in humans, there are 23 pairs, so 46 chromosomes altogether). However, in gametes, there are **half** the number of chromosomes of body cells, since they contain one from each chromosome pair (in humans, this means that gametes contain 23 chromosomes).

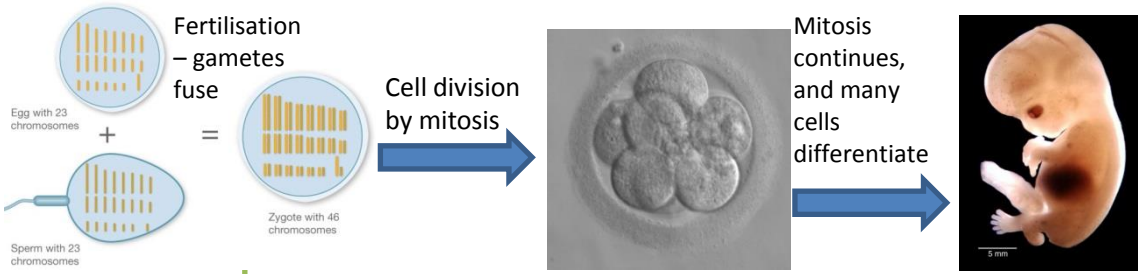
In meiosis, the DNA is replicated to start with (just like mitosis – step 1 in diagram). But then the cell divides **twice** – i.e. divides into *four* cells – so each cell ends up with **half** the genetic information: a <u>single set</u> of chromosomes. At stage 2 – the pairs are split up, then at stage 3 the copies of chromosomes are separated. The four cells produced are **gametes**, and all of them are **different** to each other – they are <u>genetically unique</u>.



Fertilisation

Obviously, fertilisation only happens in sexual reproduction. The male and female gametes **fuse**. Their nuclei join together into one and the genetic information is combined. Consequently, you have 50% of your genetic information from your mother and 50% from your father. The cell that is produced has the full set of chromosomes (in pairs again) – the normal number is restored. Again, this is 46 chromosomes (23 pairs) in humans. The diagram shows this.

The new cell is ready to grow into an embryo. It does this through mitosis, increasing the number of cells. To be precise, each cell divides to make two cells. This means that a young embryo doubles the number of cells each 'round' of mitosis. After a ball of cells is produced, the cells start to **differentiate** – become specialised. So you are no longer just a blob.



Biology Knowledge Organiser
B14 - Variation and evolution

Variation

Organisms vary, both organisms of different species (obviously) and organisms of the same species (also obviously!). Variation (differences) are caused by both genetic causes and environmental causes.

- Some differences are only due to **inherited** genes – they are entirely **genetic**;
- Some differences are only due to the conditions in which an organism developed and lives – they are entirely **environmental**;
- Some differences are due to a **combination** of genetic and environmental influences. In this case, we say the genome of an organism and its environment **interact** to affect the phenotype of the organism.

In most populations of most species of organism, there is a lot of genetic variation. The general term for versions of the same organism (i.e. different individuals of a species) is with different genetic information is **variants**. All variants arise from **mutations**. Mutations can be dangerous (remember your work on cancer, for instance), but usually have no effect. Sometimes, they have a beneficial effect. Overall:

- Mutations happen continuously;
- most mutations will not affect the phenotype at all;
- some will influence the phenotype (maybe change it a bit);
- very few mutations cause a total change in phenotype.

The last case is rare, but very important. If a mutation occurs that leads to a new phenotype, and the new phenotype makes the organism better suited to the environment, it will lead to a rather rapid change in the species, by **natural selection**.

Evolution

Evolution is the change in inherited (genetic) characteristics of organisms over time. Many theories of evolution have been suggested, but Darwin's theory of natural selection is the one with by far the most evidence. Darwin noticed that all organisms produce more offspring than they need to replace themselves, and yet population sizes stay pretty steady from generation to generation. He also observed that all species show variation, and that life is tough for organisms – only the best adapted survive. So, based on these observations, we can explain evolution by natural selection like this:

1. A population of organisms shows variation – there are **variants** in the population
2. The organisms are in **competition** to survive
3. **Survival of the fittest** – only the variants with the phenotypes best suited to the environment get to survive
4. **Reproduction** – those who survive get to reproduce
5. **Genetic inheritance** – their offspring inherit the genes from their parents, so the successful phenotype becomes more common in the next generation. This continues from generation to generation.

Key Terms	Definitions
Variation	Differences in the characteristics of individuals in a population.
Genetic variation	Differences in the genome between individuals. This often causes differences in physical characteristics.
Variants	Different versions of the same thing. Often this term is used to describe individuals who are different from others in a specific genetic way – for instance the 'long haired cat variant' from earlier.
Mutation	A change to DNA. Mutations can cause a change in the sequence of amino acids being produced, affecting the protein being produced from the DNA code.
Evolution	Change in the inherited characteristics of organisms over time. Evolution happens through **natural selection**.
Natural selection	The process that changes the inherited characteristics of organisms over time. This explains the adaptations of organisms to their environment AND the formation of new species of organism.
Common ancestor	An ancestor in common. For instance, if you have a sister, your granddad is a common ancestor to you both.

New species

The theory of evolution by natural selection tells us that all species of living things have evolved from a single, simple type of life form. We know this **common ancestor** was alive on Earth over three billion years ago. How we ended up with millions of different species from this single species is also explained by evolution by natural selection.

Essentially, two populations of one species (e.g. a population of fish is divided into two populations by geographical changes such as the joining of North and South America) can become two different species. This happens when the two populations become so different in their phenotypes that they can no longer **interbreed** to produce **fertile offspring**. This is the point when we define them as different species. For example, tigers and lions are different species (the population of their common ancestor has been separated for a long time) – they can interbreed (producing a liger), but ligers are infertile. So their parents are different species.

Biology Knowledge Organiser
B14 - Variation and evolution

Selective breeding

In selective breeding, domesticated animals or plants are bred for particular **genetic** characteristics. This is not a new thing: humans have been choosing which animals/plants to breed together ever since agriculture was invented many thousands of years ago. The organisms with desired characteristics are chosen and deliberately bred together – if all goes well, the offspring have inherited the desired characteristics. The offspring with those characteristics are then bred together, and so on for many generations until all the offspring have the desired characteristic. Some examples of characteristics that selective breeding is used to obtain:

- Disease resistance in food crops
- Animals which produce more e.g. milk or meat
- Domestic (pet) dogs with gentle natures, high intelligence and so on
- Large or unusual flowers.

So, selective breeding is very useful. However, because of the deliberate selection of organisms with certain genetic characteristics for breeding, **inbreeding** can result from its use.

Genetic engineering

Genetic engineering is common and extremely useful. Recall that one gene codes for one protein, which in turn leads to specific characteristic. If an organism has the gene for a characteristic you want, you can transfer that gene into the genome of a different organism altogether. This has allowed, for example, the genetic engineering of plant crops to make them resistant to disease or to produce bigger, better fruit. Another key example is the genetic engineering of bacteria so they produce human insulin for treatment of type 1 diabetes.

How genetic engineering works:
Genes from an organism with a desired characteristic are 'cut out' of their genome and transferred to the cells of other organisms, in such as way that the second organism uses the gene from the first one. The resulting organism is called a **genetically modified** organism.

Good examples of GM crops include those that are now resistant to attack by insects, or are not affected by the herbicides that farmers use to kill weeds (obviously, it would be bad news to use a herbicide that kills your weeds but also your crops). GM crops are also often produced to have higher **yields**.

Key Terms	Definitions
Selective breeding	Also known as **artificial selection**. A technique of improving domesticated animals and plants for humans benefit, by breeding for particular genetic characteristics.
Domesticated	Animals/plants used in agriculture (or for pets!) are called domesticated species.
Inbreeding	The result of selective breeding can be inbreeding, where limited genetic variation can make organisms more prone to disease or inherited defects.
Genetic engineering	Modifying the genome of an organism by introducing a gene from another organism, giving a desired characteristic.
Genetically modified	GM for short. Describes organisms (especially crops) that have had their genome modified by genetic engineering.
Yield	The amount of useful product you get from a plant or animal used in agriculture (e.g. mass of fruit).
Vector (HT)	In the context of genetic engineering, a vector is a piece of genetic material used to transfer a gene. It is usually a bacterial plasmid or virus.

Genetic engineering – the controversy

There are some concerns about GM crops. The most important include concerns about how the GM crops may effect wild flowers and insects. There is not thought to be any risk to human health eating them, but some people call for more research on this.
Research is going on into how genetic modification might be used to overcome inherited disorders in humans.

HT: Genetic engineering – the steps

The summary is given left. The steps in more detail:

1. **Enzymes** are used to cut out, or *isolate*, the required gene.
2. This gene is placed in a **vector**, so it can be *transferred* to the organism you intend to genetically modify.
3. The vector is used to insert the gene into cells of the second organism (e.g. the food crop). This has to be done at an early stage of development (i.e. as a tiny *embryo*) so the organism develops with the desired characteristic.

[It wouldn't be much help to add the gene to an adult, since you'd have to add it to every cell to give them the desired characteristic.]

Biology Knowledge Organiser
B15 - Genetics and evolution

Classification the traditional way

People have always given living organisms names and attempted to group them together based on their similarities. The first system that has stuck around is the classification system described by Carl Linnaeus, in which he sorted organisms according to their **structure** (anatomy) and **characteristics**. He came up with a **hierarchical** system, where the larger groups contain all the smaller groups below them. It is called the Linnaean system, after him.

These groups, in order of size (based on how many organisms fit in each one) are called: **kingdom, phylum, class, order, family, genus** and **species**. Species are what you think of as individual types of organism – like tigers, oak trees or great white sharks. It is worth remembering that some organisms that are given one name in everyday language actually represent many species. For instance, there are many species of eagle and many species of shark.

When giving the scientific name of an organism, you give the genus and species. E.g. great white sharks are *Carcharodon carcharias*, humans are *Homo sapiens*. This is called the **binomial system** for naming species.

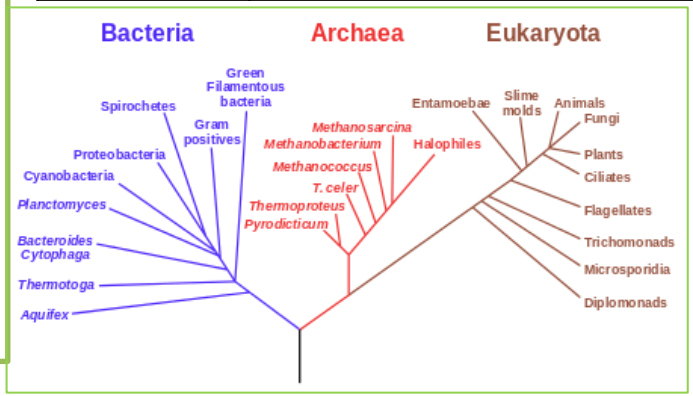
Classification the modern way

The Linnaean system dates back to the 18th century. Since then, knowledge and understanding of the internal structure of cells and biochemistry has developed significantly. Analysis of genetic material in cells has shown that the five kingdoms suggested by Linnaeus are not the best way to divide up life. A **three-domain system** is now used (although the Linnaean system is still very useful, and commonly used). The three-domain system was suggested by Carl Woese.

Woese's chemical analysis showed that there are three distinct groups of life, into which all organisms can fit without overlapping. These are called domains: the Archaea, Bacteria, and Eukaryota. One of the key things about this system is that is recognised that two huge groups of organisms (archaea and bacteria) are actually different. In the Linnaean system, they were bunched together in the 'bacteria' kingdom.

Since it is based on genetic analysis, the three-domain system links to the closeness of the relationship between organisms. We know all life on Earth is related (since we all use the same genetic code). That's why, when you draw an evolutionary tree (right), it starts with one 'trunk' – the first life on Earth (the **common ancestor** for us all). But, clearly, life has split into many different groups, as shown with the examples on the tree here.

Key Terms	Definitions
Classification	Sorting into groups. Traditional classification of organisms depends on their structure, but more modern methods involve analysing the biochemical similarities between organisms to classify them.
Kingdom	The largest group in the Linnaean system. In this model, there are five kingdoms (animals, plants, fungi, bacteria and protists).
Biochemistry	The study of chemicals in living organisms, such as DNA, proteins, carbohydrates and lipids.
Three-domain system	A modern model of classification, based on the genetic differences between organisms.
Archaea	Unicellular, like bacteria, but biochemically very different. These organisms often live in extreme environments, like very hot water around geysers. No-one realised that they were fundamentally different to bacteria before the chemical analysis was performed.
Bacteria	Also called 'true bacteria' – the prokaryotic organisms you think of as bacteria. (Check your knowledge on prokaryotic cells)
Eukaryota	All organisms with a nucleus, like us, plants, fungi and protists. All multicellular organisms fit into this domain (but it does include many unicellular organisms!).
Evolutionary tree	A method used to show how closely related organisms are. For living organisms, we can use genetic analysis; for extinct organisms, the fossil record suggest the relationships.



Biology Knowledge Organiser
B15 - Genetics and evolution

Evidence for evolution

There is a vast haul of evidence to support Darwin's theory of evolution by natural selection. This evidence has built up over time: for example, Darwin didn't know about genes so found it hard to explain inheritance from parents in full. Obviously, we've got this knowledge now.

Thanks to all this evidence, Darwin's theory for evolution is now very widely accepted. Two key bodies of evidence for you to know are: the fossil record, and the evolution of resistant bacteria.

Fossils

Fossils are the remains of organisms. They are always old, typically millions of years old, and are found in rocks. They can form by:

1. The organism or parts of the organism don't **decay** because the conditions are not right for decay by microorganisms. For example, mammoths have been preserved in frozen mud.
2. Parts of the organism are replaced by **minerals** from the surrounding rocks as they decay. Most often, this results in soft tissues (e.g. muscle, skin) *decaying* normally, but the form of bones is preserved by the minerals in bones being swapped for minerals from the *rocks/sediments* that the dead organisms were buried under.
3. Preserved **traces** of organisms – so not their actual bodies, but traces like footprints, droppings, burrows and the traces of roots.

As most fossils are formed from bones, and many early forms of life had **soft bodies** (no bones), there are few traces of early forms of life. Any traces there were tend to have been destroyed by geological activity (movements of tectonic plates, volcanic activity and so on). This means the fossil record is **incomplete** and scientists cannot be totally sure about the origin of life on Earth.

The fossil record helps scientists fill in timelines and **evolutionary trees** to show how life has changed over time on Earth. Using evolutionary trees shows the closeness of relationships between different species.

Extinction

Extinctions of a species can happen for many reasons, and often extinction is due to more than one factor working together. Some key factors that may contribute to extinction of a species:

- Development of <u>new</u> species, so the old species doesn't exist any more
- <u>New</u> diseases affecting a species, which they aren't adapted to and can't survive
- <u>New</u> predators, to which a species cannot adapt fast enough to survive
- <u>Changes</u> to the environment, to which the species cannot adapt by natural selection, including <u>catastrophic</u> events (like the meteor strike that caused extinction of loads of species, e.g. dinosaurs)
- <u>New</u> competitors that are better adapted to the environment than the species.

Key Terms	Definitions
Fossil	The remains of organisms from millions of years ago, found in rocks. They are formed in different ways – see main text.
Strain	A variant of microorganism within a species – so they are not a different species to other variants, but have a key difference in their phenotype (e.g. being resistant to an antibiotic). New strains are produced by **mutations**.
Resistant strain	Describes a variant form of bacteria with resistance (NOT immunity) to a specific antibiotic.
MRSA	An example of a resistant strain of bacteria. It stands for methicillin resistant *Staphylococcus aureus*.
Extinction	When NO individuals of a species remain alive.
Evolutionary tree	A timeline that shows how closely related different species are to each other.

Resistant bacteria

The key factor that affects the **rate** of evolution is how fast an organism reproduces. Bacteria can reproduce as fast as doubling every 20 minutes, so they can evolve rapidly.

Thanks to a **mutation**, strains of bacteria that are **resistant** to an antibiotic can emerge. These are NOT killed by antibiotics used to try to kill them when the bacteria has infected someone. Consequently, they <u>survive</u> and <u>reproduce</u>, so the size of the resistant strain population increases generation to generation, while the non-resistant strain is wiped out. Furthermore, the resistant strain is likely to spread because if it infects other people and:

- They are not immune to it
- And there is no effective treatment.

Society benefits if we <u>reduce</u> the rate of development of antibiotic resistant strains of bacteria. Some methods to help save the day:

- Antibiotics should not be **prescribed** by doctors where they are not needed (especially for viral infections, since antibiotics don't work on viruses).
- Patients need to **finish the full course** of antibiotics they get prescribed, reducing the chance of any surviving and mutating to form resistant strains.
- **Restrict** the use of antibiotics in **agriculture**, as at present many animals receive antibiotics all the time to prevent infections and encourage growth.

We also badly need new antibiotics. However, it is slow and expensive to develop new antibiotic drugs, and at the moment we are not keeping up with the emergence of resistant strains of bacteria.

Biology Knowledge Organiser
B16 - Adaptation, interdependence and competition

Ecology and Interdependence

Ecology is the study of everything from individual organisms to the whole biosphere (everywhere that life is found on Earth). An ecosystem is an interconnecting network of living organisms and their environment.

The feeding relationships are one way in which organisms depend on each other. To begin with, almost all organisms rely on the Sun as the original source of energy for their ecosystem. **Plants** and **algae** can make use of the Sun's energy to produce food molecules, in the process of photosynthesis. This is why they are called **producers**. Other types of organism can't do this, so they rely on the plants and algae. **Consumers** eat the producers, so the energy from the sun flows through the ecosystem. Molecules (which are stores of energy) also flow through, and get recycled when organisms produce waste (poo and wee!) and after they die and decay. The diagram helps to show this.

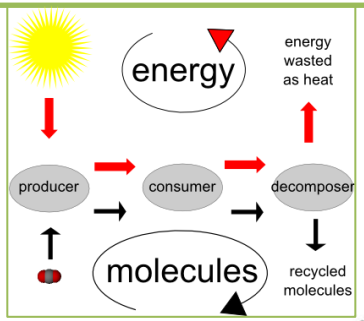
You can see that all the organisms in the ecosystem depend on each other. This is called **interdependence**. The consumers wouldn't survive without the producers capturing energy from the sun, the producers wouldn't survive without the decomposers recycling molecules for them to use (e.g. nutrients from the soil), and the decomposers need the waste from other organisms, and their bodies once they die. A stable community is one where all the species' populations and the abiotic factors are in balance; as a result, population sizes don't change much in stable communities.

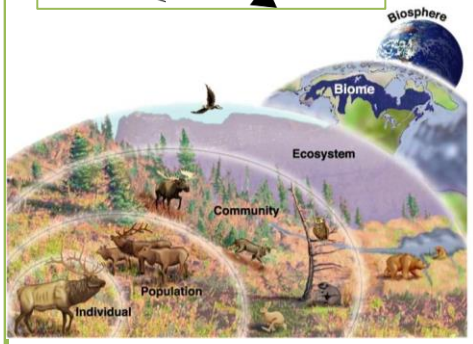
Biotic and abiotic factors affecting organisms

Communities of organisms are obviously affected by the environmental factors of their habitat. Factors that are non-living are called **abiotic** factors; those that are living are called **biotic** factors. These may affect the distribution of organisms (i.e. how they are spread out in the environment), their population size, their growth, behaviour or anything else really.

Examples of abiotic factors: light intensity; temperature; moisture levels; soil pH and mineral content; wind intensity and direction; carbon dioxide level for plants; oxygen levels dissolved in water for **aquatic** animals.

Examples of biotic factors: food availability; new predators arriving; new pathogens; competition between species. Competition can actually lead to extinction of a species – if another species outcompetes it, the first one may end up without sufficient numbers to breed.





Key Terms	Definitions
Biosphere	Wherever life is found on Earth (and in the atmosphere).
Biome	A large zone of life with particular characteristics – e.g. tropical rainforest, arctic tundra.
Ecosystem	A complex network of **communities** of organisms, which all depend on each other and which are adapted to the biotic and abiotic conditions they live in.
Community	A group of **interdependent** organisms. Communities interact with each other and with the physical environment – **ecosystem** refers to the interaction of living communities with the non-living environment.
Habitat	A specific set of conditions, usually a specific location, where an organism (or organisms) is adapted to live.
Population	A whole group of organisms – for instance, all the buffalo on the savannah, or all the greenfly on one rose bush.
Interdependence	All organisms in a community rely on one another – for food, shelter, pollination, seed dispersal, nutrient recycling and so on.
Biotic	Living factors affecting a community.
Abiotic	Non-living factors affecting a community (e.g. light intensity, temperature, soil pH).

Adaptations

ALL organisms, now matter how simple they might seem, are adapted to their natural environment. Their features, or adaptations, enable survival in the particular conditions where they live. Adaptations can be:

- **Structural**: adaptations in terms of body form and shape. This would include examples like: streamlined shape for speed; long stem to maximise light exposure
- **Behavioural**: adaptations of behaviour – for instance, hunting behaviours, using tools, plants growing in the direction of a source of light.
- **Functional**: adaptations in terms of how the body works. For instance: being able to digest a certain food, maintaining a constant body temperature and so on.

Some organisms are adapted to live in what we would consider to be extreme environments – for instance, very high temperatures, high pressures, high salt concentration. The organisms that can survive in these kinds of conditions are called **extremophiles**. A great place to find extreme conditions and extremophiles is around and inside deep sea hydrothermal vents.

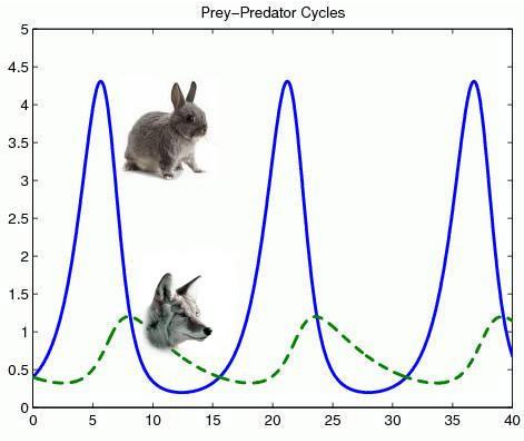
Biology Knowledge Organiser
B17 - Organising an ecosystem

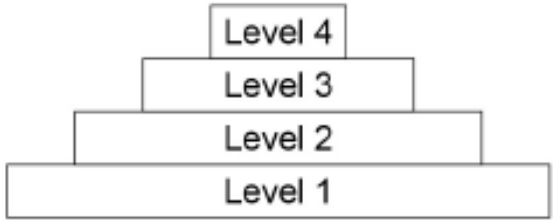
Organisation of ecosystems and trophic levels

Apart from some ecosystems in deep sea vents, ALL biomass on Earth is produced by **photosynthetic** organisms. So, these organisms are called **producers (trophic level 1)**. This is vital for other organisms, since these producers start off food chains. **Food chains** represent the feeding relationships in a community. The producer is usually a green plant or algae, and they make **glucose** by photosynthesis.

The producers are eaten by **primary consumers (trophic level 2)**, which might be eaten by the next trophic level – **secondary consumers (trophic level 3)**. The secondary consumers may be eaten by **tertiary consumers (trophic level 4)**. Of the consumers, if they kill and eat other animals, they are called **predators**. The animals eaten by predators are their **prey**. Carnivores that don't get eaten by anything else are called **apex predators**.

In a *stable* community (one that stays pretty steady in terms of population sizes), the population size of predators and their prey rise and fall in cycles, as the graph shows. When there aren't many predators, the prey population grows rapidly. When it rises, there is more food for predators so their population increases. This puts pressure on the prey so their population drops – cycles, see graph.





Key Terms	Definitions
Photosynthetic	Describes any organism that can carry out photosynthesis, producing biomass from simple chemicals (CO_2 and H_2O)
Biomass	The materials that living things are made from: proteins, carbohydrates and lipids.
Food chain	Used to represent the feeding relationships in a community. Starts with a producer and shows what organism eats what, as well as how energy and biomass are transferred in the community.
Trophic level	Position in a food chain. Producers = level 1.
Ingest	Eat/consume
Egest	Excrete as faeces

Pyramids of biomass

Biomass is simply living mass/material. Biomass is made by producers, but bear in mind they only transfer about 1% of the energy from light that hits them. A pyramid of biomass has trophic level 1 at its base, and each block of the pyramid has a width to represent the amount of mass at each trophic level. See diagram.

The blocks HAVE TO get smaller, because not all biomass is transferred from one trophic level to the next (only about 10% in fact). This is because:

- Not all of the organisms in each trophic level actually get eaten by the trophic level above
- Not all the material that is eaten (**ingested**) is actually absorbed into the body – some is **egested** as faeces
- Large amounts of the biomass absorbed at each trophic level is used in **respiration** (especially glucose, of course) – meaning that the biomass is converted to carbon dioxide and water. These products are released in urine and breathing out. (furthermore, urea is lost in urine, so it isn't available for the next trophic level).

As a result of all this, usually the number of organisms decreases as you go up the trophic levels (although it also depends on the size of the organisms!).

Biology Knowledge Organiser
B17 - Organising an ecosystem

Decomposition

Decomposition is the breaking down, or decay, of biological material. Microorganisms digest dead organic material to simpler molecules, so the complex molecules bodies are made from (like proteins, lipids and carbohydrates) are recycled in the environment. They do this be secreting enzymes into their immediate environment and absorbing the soluble products of digestion by diffusion.

The **rate** of decay is affected by:

- **Temperature** – the activity of decomposers increases as it gets warmer (although decomposers are killed by very high temperatures)
- **Water** – moist conditions speed up decay because molecules to be digested may be dissolved
- Availability of **oxygen** – decay is fastest if there is a good supply of oxygen, simply because the decomposers can then respire more efficiently. This is why compost bins should have hole sin the side!

Compost is just the material left after decay of waste organic material has happened. Compost is very useful to farmers and gardeners as a natural fertilisers for crops.

Where decay happens without oxygen, **anaerobic** decay takes place. This produces **methane** gas. This can be very helpful – methane is a good fuel, so it is deliberately produced like this in many places, especially warm countries. The decay happens in a **biogas generator** – biogas just refers to the methane.

The water cycle and the carbon cycle

Like carbon, water is constantly cycled in ecosystems between abiotic and biotic components of the ecosystem. Water is released in aerobic respiration by all organisms. In terms of the abiotic components, water is constantly evaporated and precipitated (so, goes from land/waterways to the atmosphere and back again). The water precipitated provides fresh water for organisms on land before draining into the sea.

In all ecosystems, many materials have to be cycled through the biotic and abiotic components of the ecosystem – e.g. water, carbon, minerals, nitrogen. Microorganisms play a key role in cycling such materials. Carbon can appear in abiotic locations (the air as CO_2, in soil minerals) and biotic locations (in the carbohydrates, lipids and proteins that living organisms are built from). When we say it is cycled through these components, we mean that carbon atoms don't stay in any material for ever. They are cycled by various processes:

- **Photosynthesis** – takes carbon from the atmosphere (in the form of CO_2) and converts it to biomass
- **Respiration** – all living organisms, including plants and microorganisms, respire, which converts biomass into CO_2, which enters the atmosphere. While decay is taking place, carried out by microorganisms, they respire, which releases CO_2.
- **Feeding** – when consumers eat other organisms, the carbon in the other organism's biomass is transferred to the consumer.

Key Terms	Definitions
Decomposer	An organism that digests dead organic material.
Distribution	Describes how organisms are spread in an ecosystem.
Abundance	How many individuals of a particular species there are.
Quadrat	A square frame used for sampling plants in an ecosystem. Can be used for counting plants for measuring the coverage of the ground by a particular species.
Transect	Sampling method where a quadrat is laid down at regular intervals along a line. This is used to measure the change in distribution of organisms when a particular factor changes, such as light intensity.
Interval	The spaces between measurements – e.g. on a transect, the interval might be 1 m.

Measurements of ecosystems

Biologists measure both the **distribution** and **abundance** of organisms in ecosystems to help us understand them (see definitions). It would be impractical to attempt to count e.g. all the seaweed on a beach, so biologists use **sampling** techniques. If you just want to measure the abundance in an area, or to compare two locations for abundance of e.g. seaweed, ***random sampling*** would probably be used of the area. To count plants, quadrats are used. If, however, you are interested in how the distribution (spread) of organisms changes as a factor changes, you measure along a **transect**. For instance, with the seaweed example, you could set up your transect line down the beach towards the water (just using a long tape measure) and measure the coverage by seaweed at 2 metre **intervals**, or some other suitable interval. Data may be summarised using means, modes or medians, and graphs can be produced to represent differences between locations, or the change in distribution along a transect.

Biology Knowledge Organiser
B18 - Biodiversity and ecosystems

Biodiversity

Biodiversity, the variety of all the species of organisms, can be measured at the level of a community, ecosystem or the whole earth (biosphere). A large biodiversity increases the stability of ecosystems, because it reduces the dependence of one species on another, for instance for food. So, for example, if a species has only one food source (think: pandas and bamboo shoots), it may be easily threatened by environmental changes.

In spite of our future as a species on Earth depends totally on maintenance of biodiversity, many human activities threaten biodiversity. Indeed, in many ecosystems, we have already significantly reduced biodiversity. For instance, deforestation had damaged biodiversity in all kinds of forest. Our waste, polluting land, air and sea, has negatively affected biodiversity in many areas. And the big one: global warming is already having measurable effects on global biodiversity. It is only recently that humans have taken any measures to try to prevent our damage to biodiversity going too much further – obviously, we don't yet know if these measures will be enough.

Land use

Humans reduce the amount of land available for other organisms by: building, quarrying, farming and dumping waste (landfill). This in turn can reduce biodiversity.

Peat bogs are made of peat, a type of fossil fuel formed from dead plants. Peat bogs are destroyed as peat can be used as a fuel and is a very good fertiliser if you're growing plants. This has seriously reduced the area of this habitat and reduced biodiversity as a result. Furthermore, using peat as a fuel produces CO_2 (contributing to global warming) and using it as a fertiliser (in compost) allows it to decay, which also produces CO_2.

Key Terms	Definitions
Evaporated	Water changing state from liquid to vapour.
Precipitated	Water changing from vapour to liquid/solid form – i.e. rain, hail, snow.
Biodiversity	The variety of all the different species of organisms.

Waste management

Since the human population is growing at an incredible rate, and in general people's living standard is going up globally, we (the human population) is using more and more resources and producing more and more waste. Our waste causes pollution, which can occur:

- In water, thanks to sewage, fertilisers running off farmland, or toxic chemicals used in industry;
- In the air, from smoke, waste gases and acidic gases (e.g. sulphur dioxide)
- On land, from landfill (rubbish dumps) and from toxic chemicals.

Pollution kills organisms; therefore it can reduce biodiversity.

Deforestation

Deforestation on a large scale happens to provide land, with the largest areas cleared for raising cattle, to plant rice fields and to grow crops that can be made into biofuels. Our food and fuel needs conflict with the need to preserve forests and rainforests so biodiversity is maintained.

Global warming

As you'll know, since the industrial revolution, human activities have dramatically increased the levels of greenhouse gases in the atmosphere. The main gases involved are carbon dioxide and methane. The molecules of these gases absorb infrared (heat) radiation and re-radiate it, causing gradual but measurable increases the atmosphere's, and therefore Earth's, temperature. Global warming as caused by humans used to be controversial; now, thousands of peer-reviewed publications later, the global scientific consensus is that humans are definitely causing climate change through global warming.

Biology Knowledge Organiser
B18 - Biodiversity and ecosystems

The impact of environmental change

Environmental changes affect the **distribution** of species in an ecosystem. Environmental changes can be seasonal (summer vs. winter), geographic (e.g. flooding, volcanic activity and so on) or caused by human interaction with the environment (e.g. anthropogenic climate change). Changes that affect organisms include temperature, availability of water and the composition of gases in the atmosphere. Be ready to evaluate the impact of examples of environmental changes on distribution of species.

Maintaining biodiversity

As you've seen, many human activities have negative effects on biodiversity. However, as the scale of our negative influence has become more and more apparent, scientists and concerned citizens have brought in programmes to try to reduce our negative influences. Here are the key examples you should know:

- **Breeding programmes** for endangered species. For instance, tigers and pandas are bred in captivity to ensure they do not become extinct.
- **Protection** and **regeneration** of rare habitats. This includes passing laws to ensure people leave certain areas alone (e.g. parts of the Great Barrier Reef). Regeneration means activity trying to bring a habitat back to its former glory.
- Reintroduction of **field margins** and **hedgerows** in agricultural areas where farmers only grow one kind of crop. Growing one sort of crop (called monoculture) is bad for biodiversity because it only provides a habitat for a few species. So, farmers are encouraged to used hedges (not fences) and leave a margin around the edge of their crop fields, so wild plants can grow there, which in turn allows other organisms (e.g. insects) to survive there too. This improves biodiversity on agricultural land.
- Reduction of **deforestation** and carbon dioxide by some governments. There have been numerous attempts, not always totally successful, to get governments of countries around the world to agree to specific targets for how much carbon dioxide they emit, since global warming is, of course, a worldwide problem. As with many things in politics, agreement is very difficult to obtain… but progress has been made in these international agreements.
- **Recycling** resources rather than dumping in landfill. You are used to recycling as much of your household waste as you can. Work continues to increase the range of materials that can be recycled so we can continue to reduce the amount of waste dumped in landfill.

Key Terms	Definitions
Breeding programme	Producing offspring, especially of endangered species to protect their population.
Field margin	The area around the edge of a field between the crop and the fence/hedge/wall.
Hedgerow	The barrier at an edge of a field made of growing plants, as opposed to a fence or wall.

A lovely big field margin, and hedgerow on the left

Biology Knowledge Organiser
B18 - Biodiversity and ecosystems

Food security

Food security is having enough food to feed a population. Unfortunately, many populations around the world suffer from a lack of food security. Numerous biological factors threaten food security, including:

- Increasing **birth rate** raising the population
- Changing **diets**, which often results in scarce foods being imported to countries where they can't grow them, or results in people eating more meat
- New **pests** (insects that eat plants) or pathogens that affect crops
- **Environmental changes** (including effects of climate change) that affects food production
- The **cost** of doing agriculture – e.g. price of seeds for crops, or farming equipment
- **War** can affect the availability of water for crops/animals, or directly affect the availability of food.

So, a major global challenge is finding sustainable methods to feed everyone on Earth. Whoa.

Farming techniques

Food production efficiency links to the flow of biomass in food chains and pyramids of biomass, so check you know that. The basic idea is that if you reduce energy transfers from food animals (like chickens, pigs and cows) to the environment. This means they don't have to respire so much, meaning that more of the biomass the animal **consumes** is converted to biomass in their bodies.

- Keeping the animals **warm** (indoors) reduces the use of respiration to maintain their body temperature. Therefore more of the biomass they eat is used to build their bodies, rather than being used up in respiration.
- **Limiting** their **movement** – which yes, does sound rather cruel. Again, this reduces the need for energy from respiration; therefore less of the biomass eaten is used in respiration and more is converted to biomass in the animals' bodies.
- Feeding animals a **high protein** diet to speed up growth.

Key Terms	Definitions
Sustainable	Able to continue/maintain something. For instance, sustainable food production won't use up all of food resource.
Fishery	A farm where fish are bred for food OR a part of the sea/lake where fish are caught for food.
Biotechnology	Technology that involves manipulating living things.

Sustainable fisheries

The amount of fish in the ocean that people eat (**fish stocks**) is dropping. The solution is to restrict fishing so there are enough left to breed and replace those caught. There are two main ways to keep people from catching too many, so **fisheries** stay sustainable:

1. Control **net sizes** so not too many fish are caught
2. **Fishing quotas** – this is a legal limit on how many fish a company can catch. They get fined if they catch more than their quota.

Without methods like this, certain species may die out altogether.

Role of biotechnology

Modern biotechnology can help with food security.

- Genetic modification (genetic engineering) can produce crops with higher **yields** (more food per plant) or better nutritional value. An example is Golden Rice, which provides vitamin A.
- **Mycoprotein** (e.g. Quorn) is grown in tanks. The fungus *Fusarium* grows on glucose syrup in aerobic conditions, then the biomass is harvested. Huge quantities can be cultured at a time, so it's a pretty efficient way of making food.

Required Practical
Biology - Microscopy

Objective: Use a light microscope to observe, draw and label biological specimens.

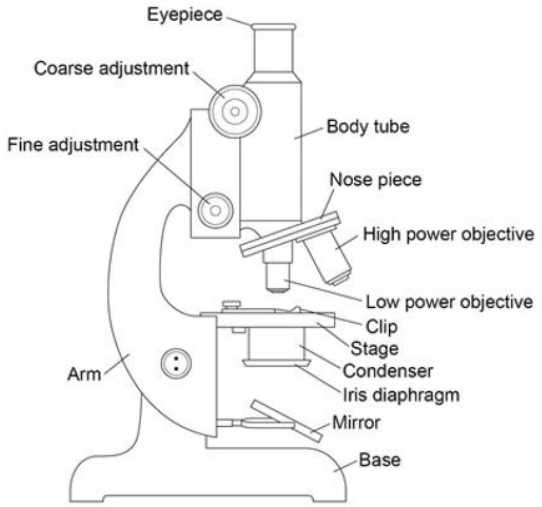
In this practical you will:

- use an optical microscope to look at and draw the cells on your microscope slide.
- identify structures within the cells.
- make a note of the magnification used.

Total magnification = Eyepiece lens magnification × Objective lens magnification

Instructions for using a microscope:

1. Put the slide on the microscope stage.
2. Turn the nose piece to select the lowest power objective lens (this is usually ×4 objective lens). The end of the objective lens needs to almost touch the slide.
3. Turn the coarse adjustment knob to move the lens towards the slide. Look from the side (not through the eyepiece) when you are adjusting the lens.
4. Now look through the eyepiece. Slowly turn the coarse adjustment knob in the direction to increase the distance between the objective lens and the slide. Do this until the cells come into focus.
5. Slightly turn the fine adjustment knob to bring the cells into a clear focus. Use the low power objective lens (totalling x40 magnification) to look at the cells.
6. When you have found some cells, turn the nose piece to switch to a higher power lens (×100 or ×400 magnification).
7. You will have to use the fine adjustment knob again to bring the cells back into focus.
8. Make a clear, labelled drawing of some of the cells. Make sure that you draw and label any component parts of the cell. Use a pencil to draw the cells.
9. Write the magnification underneath your drawing. Remember to multiply the objective magnification by the eyepiece magnification.



Apparatus

- a microscope
- prepared slides of plant and animal cell

Required Practical
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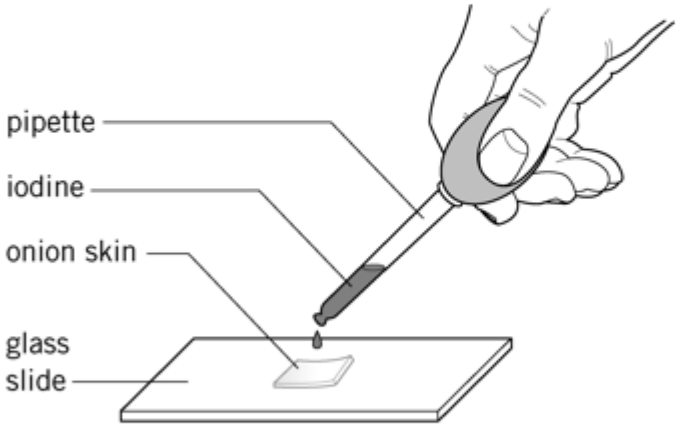
- identify structures within the cells.
- make a note of the magnification used.

Preparing your slide

1. Collect a sample of the cell you want to observe.
2. Remove the inner skin of a layer of onion using forceps, or a thin layer or *Elodea* or filamentous algae using the scalpel.
3. Place the thin slice onto a clean glass slide. Use your forceps to keep the onion skin flat on the glass slide.
4. Using a pipette, add one or two drops of dilute iodine solution on top of the onion skin or slice of algae or plant.



5. Hold the coverslip by its side and lay one edge of the cover slip onto the microscope slide near the specimen.
6. Lower the cover slip slowly so that the liquid spreads out.

Safety

- Take care when handling glass slides as they are very fragile.
- Avoid getting iodine solution on your skin.
- Wear eye protection.
- Take care not to break the slide by moving the objective lens too far downwards.

Required Practical
Biology - Osmosis

Objective: Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

In this practical you will:

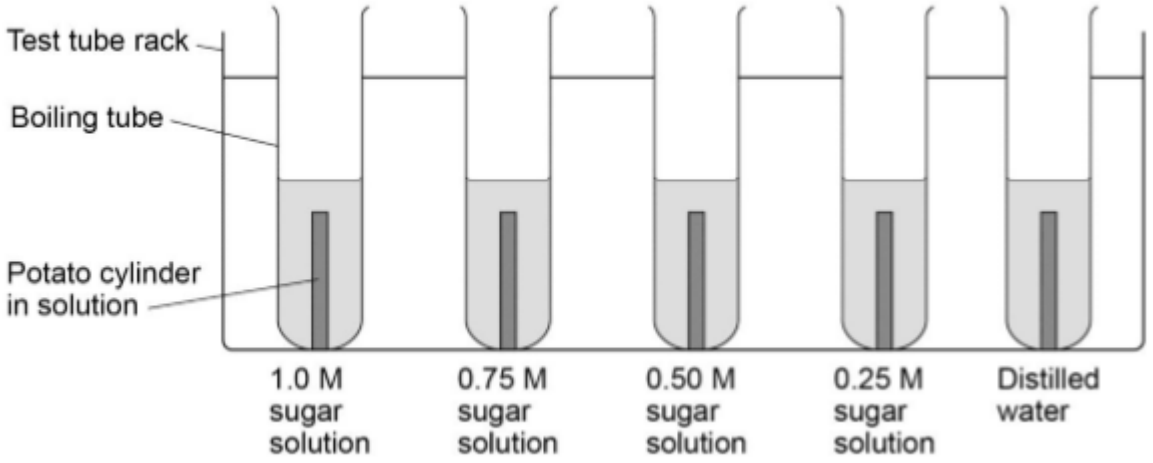
- prepare samples of potato and place them in different concentrations of sugar or sodium chloride (salt) solution.
- make measurements of mass and length of your samples before and after soaking them in the solutions.

Method

1. Use a cork borer to cut five potato cylinders of the same diameter.
2. Use the knife to trim off any potato skin on each potato cylinder. Then trim each potato cylinder so that they are all the same length.
3. Accurately measure the mass of each potato cylinder.
4. Accurately measure the length of each cylinder.
5. Record your measurements in a table like the one shown over the page.
6. Measure 10 cm^3 of each concentration of sugar or salt solution and put into boiling tubes. Label each boiling tube clearly.
7. Measure 10 cm^3 of the distilled water and put into the fifth boiling tube. Label the boiling tube clearly.
8. Add one potato cylinder to each boiling tube.
9. Leave the potato cylinders in the boiling tubes for a chosen amount of time.
10. Remove the potato cylinders from the boiling tubes and carefully blot them dry with the paper towels.
11. Measure the new mass and length of each potato cylinder again. Record your measurements for each concentration in your table.

Analysis of your results

- Calculate the change in mass and length of each potato cylinder. Record your results in your table.
- Calculate the percentage change in mass and length of each potato cylinder and record your results in your table.
- Write a paragraph to state what has happened and how this relates to the theory of osmosis in cells.



Required Practical
Biology - Osmosis

Objective: Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.

Apparatus

- a potato
- a cork borer
- a ruler
- A 10cm^3 measuring cylinder
- labels
- five boiling tubes
- a test tube rack
- paper towels
- a sharp knife or scalpel
- a white tile
- a range of sugar or salt solutions
- distilled water
- a top-pan balance accurate to at least 0.01 g

Health and safety

Take care with sharp knives.

	1.0 M sugar solution	0.75 M sugar solution	0.5 M sugar solution	0.25 M sugar solution	Distilled water
Initial mass in g	6.08	5.97	6.10	5.92	5.98
Final mass in g	4.05	3.82	4.00	4.45	6.48
Change in mass in g	–2.03	–2.15	–2.10	–1.47	+0.05
Percentage change in mass	-33.4	-36.0	-34.4	-24.8	+8.3
Initial length in cm	3.2	3.3	3.3	3.1	3.2
Final length in cm	2.5	2.7	2.8	3.2	3.7
Change in length in cm	–0.7	–0.6	–0.5	+0.1	+0.5
Percentage change in length	–22.0	–17.0	–1.4	+2.0	+16.0

Required Practical
Biology - Enzymes

Objective: Investigate the effect of pH on the rate of reaction of amylase enzyme.

In this practical you will:

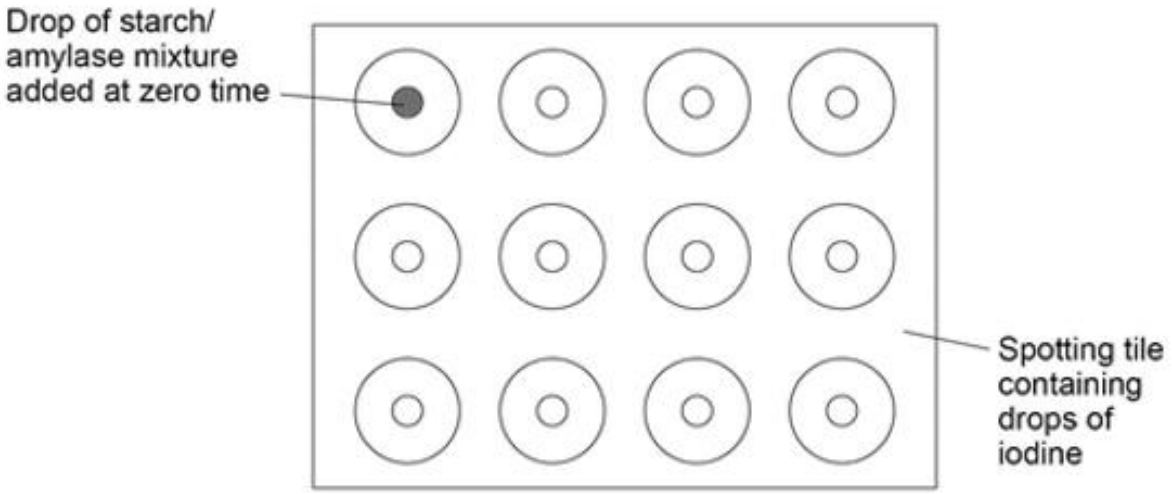
- use the enzyme amylase to break down starch at different pH values.
- measure the pH of different solutions.
- use a water bath to keep reacting solutions at a constant temperature.
- use a continuous sampling technique.
- use iodine solution as an indicator of the breakdown of starch into sugars.

Method

1. Heat your water bath to 35^{O}C.
2. Put 2 cm^3 of each buffered solution into individual, separate test tubes. Label each tube with the pH of the solution.
3. Label 5 test tubes 'Starch' and add 4 cm^3 of starch solution into each tube.
4. Put a thermometer in one of the starch test tubes to monitor the temperature. Leave the thermometer in this tube throughout the experiment.
5. Add 10 cm^3 of Amylase solution into another test tube. Label the tube 'amylase'.
6. Put all the test tubes into the water bath.
7. Allow the solutions to reach 35 °C.
8. While the solutions are reaching the required temperature, put one drop of Iodine solution into each depression on your spotting tile. Put a drop of starch solution in the first depression of the tile. This is your 'zero time' mixture. You will use this as a comparison of colour for your test buffers. Starch gives a blue-black colour with iodine, and the iodine stays brown if all the starch has broken down to glucose.
9. When all the tubes have reached 35 °C take one of the tubes of starch from the water bath and add the 2cm^3 of your first pH buffered solution. Stir the mixture with a glass rod.
10. Use the pipette to add 2 cm^3 of amylase solution to the mixture. Start the stop clock as soon as you add the amylase. Keep stirring the mixture with the glass rod.
11. After 10 seconds, remove one drop of the mixture with a glass rod.
12. Put this drop on the second depression of your spotting tile. Refer to diagram over the page.
13. Rinse the glass rod with water.
14. Every 10 seconds, use the glass rod to remove one drop of the mixture. Put each drop onto the iodine solution in the next depression on the spotting tile. Remember to rinse the glass rod with water after putting each drop on the spotting tile.
15. Keep sampling every 10 seconds until the iodine does not change colour.
16. Record your results in a table like the one over the page.
17. Repeat steps 10 to17 with both of your other pH buffered solutions.

Required Practical
Biology - Enzymes

Objective: Investigate the effect of pH on the rate of reaction of amylase enzyme.



Apparatus
- 10 test tubes
- a test tube rack
- a water bath
- a thermometer
- a spotting tile
- a $5cm^3$ measuring cylinder
- Pasteur pipettes
- a glass rod
- a stop clock
- starch solution
- amylase solution
- iodine solution
- labelled buffered solutions at a range of pH values
- labels

pH of solution	Time for amylase to completely break down the starch in seconds

Task Enzymes are biological catalysts. Explain what happens to the starch when the amylase is added.

Health and safety
Use eye protection.
Iodine is harmful, avoid contact with skin.

pH of solution	Time for amylase to completely break down the starch in seconds (at 35°C)
5	29
6	46
7	160
8	>300

Required Practical
Biology – Food tests

Objective: Use qualitative reagents to test for a range of carbohydrates, lipids and proteins. To include: Benedict's test for sugars, Iodine test for starch and Biuret reagent for protein.

In this practical you will use qualitative reagents to test for the presence of carbohydrates, lipids and proteins in a range of foods.

Test for carbohydrates.

The Benedict's test for sugars.

Apparatus
- food sample
- a test tube
- Benedict's solution
- traditional water bath to include Bunsen burner use
- thermometer
- pipettes

Method

1. Set up your traditional water bath set up using a Bunsen burner.
2. Put some of the food sample into a test tube.
3. Add a few drops of Benedict's solution to the sample in the test tube.
4. Put the test tube in the water bath at a minimum of 80°C for about 5 minutes.
5. Note down any colour change in your table of results.

Positive test: Benedict's solution will turn brick red / orange in the presence of sugar.

Name of food tested	Colour produced with Benedict's solution	Colour produced with iodine solution	Cloudy layer produced with ethanol	Colour produced with Biuret solution

Write a conclusion to state which food groups are present one of the food samples you tested and an explanation of how you know this.

Required Practical
Biology – Food tests

Objective: Use qualitative reagents to test for a range of carbohydrates, lipids and proteins. To include: Benedict's test for sugars, Iodine test for starch and Biuret reagent for protein.

Test for carbohydrates.

The Iodine test for starch.

Apparatus

- food sample
- a test tube
- iodine solution
- pipettes

Method

1. Put some of the food sample into a test tube.
2. Add a few drops of Iodine solution.
3. Note down any colour change in your table of results.

Positive test: Iodine solution will turn dark blue / black in the presence of starch.

Test for lipids

Apparatus

- food sample
- a test tube
- ethanol
- distilled water.

Method

1. Put some of the food sample into a test tube.
2. Add a few drops of distilled water.
3. Add a few drops of ethanol. Care: Ethanol is highly flammable. Keep the solution away from any flames.
4. Shake the solution gently.
5. Note what you see in your table of results.

Positive test: The solution will turn cloudy if lipids are present.

Test for protein

Apparatus

- a test tube
- a 10cm^3 measuring cylinder
- Biuret solution A and Biuret solution B

Method

1. Put some of the food sample into a test tube.
2. Add 1cm^3 of Biuret solution A and 1 cm^3 of Biuret solution B to the test tube. Care: Biuret solution contains copper sulphate, which is poisonous, and sodium hydroxide, which is corrosive. Handle the solution with care. Wash immediately if you spill it on your skin, and wipe up any spills.
3. Shake the tube gently to mix.
4. Note any colour change in your table of results.

Positive test: Biuret solution will turn purple in the presence of proteins.

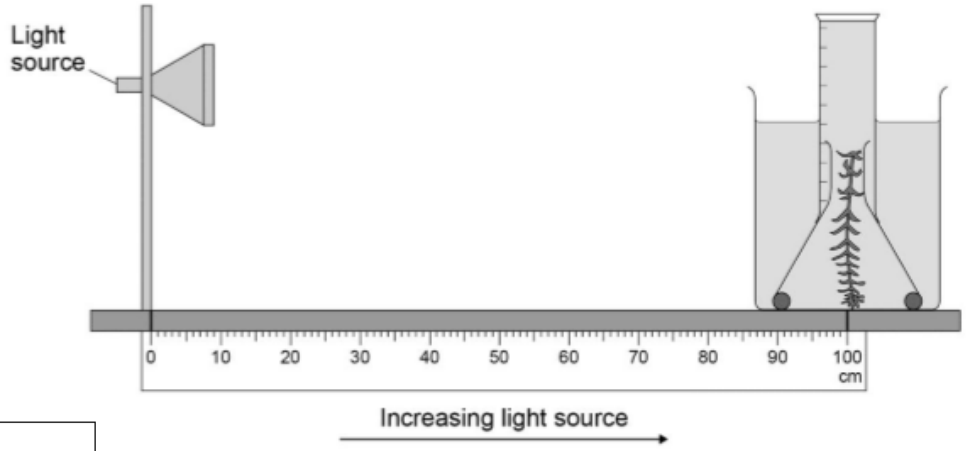
Required Practical
Biology - Photosynthesis

Objective: Investigate the effect of light intensity on the rate of photosynthesis using an aquatic organism such as pondweed.

In this practical you will measure the volume of oxygen produced by the pondweed as the light intensity changes as the light source is moved.

Method

1. Put your 10cm piece of pond weed (cut edge at top) into a beaker of water.
2. Cover the pondweed with an inverted filter funnel – raised off the bottom of the beaker with plasticine.
3. Fill the measuring cylinder with water and gently position as in the diagram.
4. Use the ruler to position the beaker of pondweed 1 metre away from the light source. Your experiment should look like this:



5. Start the stop watch and:
   a. count and record the number of bubbles released in three minutes.
   b. record the volume of gas produced and collected in the measuring cylinder in the same three minutes.
6. Record your results in a table like this one:

	Increasing light intensity				
	100cm	80cm	60cm	40cm	20cm
Number of gas bubbles					
Volume of gas cm^3					

Evaluation

Which method of recording gas collection was most accurate and why?

7. Move the light source so that the pondweed beaker is 80cm away.
8. Refill the measuring cylinder with water and gently position as in the diagram. Then repeat steps 5 and 6.
9. Repeat for distances of 60, 40 and 20cm.

Required Practical
Biology – Reaction time

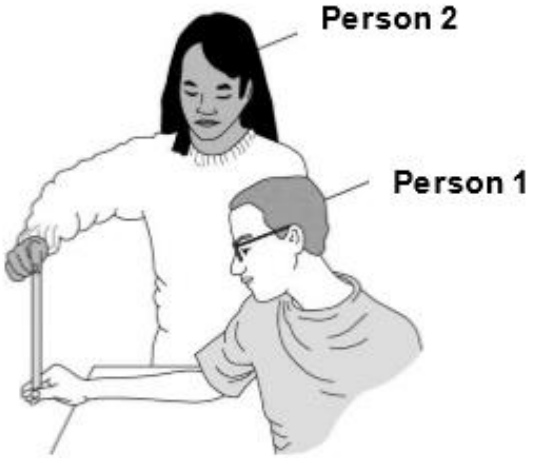
Objective: Plan and carry out an investigation into the effect of a factor on human reaction time.

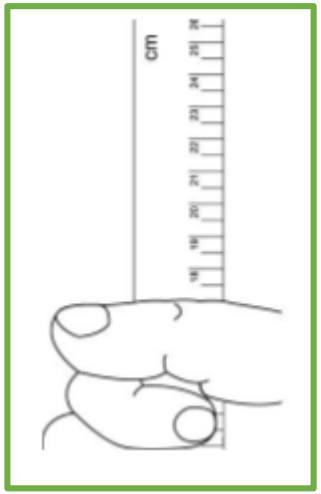
In this practical you will:

- decide which factor you want to investigate that will have an effect on human reaction time.
- work with a partner to use the ruler drop test.
- use your results to calculate your reaction time before and after you made the change.

Method for standard human reaction time test

1. Work with a partner to do this test. Choose who will be person 1 and who will be person 2.
2. Each of you should use your dominant hand to do this experiment. If you are right handed then your dominant hand is your right hand.
3. Person 1 sits down on the chair, with good upright posture and eyes looking across the room.
4. Person 1 puts the forearm of their dominant arm across the table with their hand overhanging the edge.
5. Person 2 holds a ruler vertically with the bottom end (the end with the 0cm mark) in between person 1's thumb and first finger. They will tell person 1 to prepare to catch the ruler.
6. Person 1 catches the ruler with their thumb and first finger as quickly as possible when it drops.
7. Record the number on the ruler that is level with the top of person 1's thumb.
8. Have a short rest, then repeat the test several times.
9. Record your results on a table.
10. Repeat the test with person 2 catching the ruler and person 1 dropping it.
11. Record person 2's results on the table.
12. Use a conversion table to convert your ruler measurements into reaction times.
13. Make the change that you are investigating to change human reaction time.
14. Repeat steps 1-9 for each person and record the results in your data table.





Required Practical
Biology – Reaction time

Objective: Plan and carry out an investigation into the effect of a factor on human reaction time.

Apparatus

- a metre ruler
- a chair
- a table
- any further equipment needed depending on the factor you are changing

Analysing the data

Do your results reflect your hypothesis? Did the factor you changed have any effect on your reaction time?
Consider your own and your partner's results. Are your reaction times similar? If not, can you explain why?
What type of errors might have happened to affect your results?

Investigation

What factor have I decided to change?
How will I change it?
What affect do I think it will have on human reaction time?

Drop test attempt	Ruler measurements in cm		Reaction times in seconds	
	Person 1	Person 2	Person 1	Person 2
1	48	32	0.31	0.26
2	44	30	0.30	0.25
3	37	27	0.28	0.23
2	29	28	0.24	0.24
5	26	25	0.23	0.23
6	34	21	0.26	0.21
7	34	26	0.26	0.23
8	20	25	0.21	0.23
9	32	29	0.26	0.24
10	19	27	0.20	0.23

Required Practical
Biology – Reaction time

Objective: Plan and carry out an investigation into the effect of a factor on human reaction time.

Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)	Reading from ruler (cm)	Reaction time (s)
1	0.05	21	0.21	41	0.29	61	0.35	81	0.41
2	0.06	22	0.22	42	0.29	62	0.36	82	0.41
3	0.08	23	0.22	43	0.30	63	0.36	83	0.41
4	0.09	24	0.22	44	0.30	64	0.36	84	0.41
5	0.10	25	0.23	45	0.30	65	0.36	85	0.42
6	0.11	26	0.23	46	0.31	66	0.37	86	0.42
7	0.12	27	0.23	47	0.31	67	0.37	87	0.42
8	0.13	28	0.24	48	0.31	68	0.37	88	0.42
9	0.14	29	0.24	49	0.32	69	0.38	89	0.43
10	0.14	30	0.25	50	0.32	70	0.38	90	0.43
11	0.15	31	0.25	51	0.32	71	0.38	91	0.43
12	0.16	32	0.26	52	0.33	72	0.38	92	0.43
13	0.16	33	0.26	53	0.33	73	0.39	93	0.44
14	0.17	34	0.26	54	0.33	74	0.39	94	0.44
15	0.18	35	0.27	55	0.34	75	0.39	95	0.44
16	0.18	36	0.27	56	0.34	76	0.39	96	0.44
17	0.19	37	0.28	57	0.34	77	0.40	97	0.45
18	0.19	38	0.28	58	0.34	78	0.40	98	0.45
19	0.20	39	0.28	59	0.35	79	0.40	99	0.45
20	0.21	40	0.29	60	0.35	80	0.40	100	0.45

Required Practical
Biology – Field investigations

Objective: Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.

In this practical you will:

- work in a group to use a quadrat to estimate the population size of a plant species in a survey area.
- use a transect line and a quadrat to investigate the effect of light intensity on the number of plants in a survey area.

Method - Investigating the population size of a plant species using random sampling

Your teacher will have prepared a survey area for you and will show you how to identify the plants (eg plantain) you are surveying. You will need to work in groups of three.

1. Collect two numbers, one from each bag or use a random number generator.
2. Use the numbers and the tape measures to locate the first position for your quadrat.
3. Lay the quadrat on the ground.
4. Replace the numbers in the bags.
5. Count and record the number of the chosen plant species inside the quadrat.
6. Repeat steps 1–5 until you have recorded the numbers of chosen plant species in ten quadrats.
7. Your teacher will show you how to estimate the population of plantain using the equation

$$\text{estimated population size} = \frac{\text{total area}}{\text{area sampled}} \times \text{number of plantain counted}$$

Task
Design a results table and record the number of each type of chosen species you could see in each of your ten quadrats.

Apparatus

- a quadrat
- bags of numbers

Required Practical
Biology – Field investigations

Objective: Measure the population size of a common species in a habitat. Use sampling techniques to investigate the effect of a factor on the distribution of this species.

In this practical you will:

- work in a group to use a quadrat to estimate the population size of a plant species in a survey area.
- use a transect line and a quadrat to investigate the effect of light intensity on the number of plants in a survey area.

Method - Investigating the effect of light intensity on plant distribution using a transect line

Your teacher will help you choose a species of plant to identify.

1. Put the 30m tape measure in a line from the base of a tree to an open area of ground.
2. Put the quadrat against the transect line. One corner of the quadrat should touch the 0m mark on the tape measure.
3. Count the number of plants inside the quadrat.
4. Use the light meter to measure the light intensity at this position.
5. Record your results in a table like the one on the right.
6. Move the quadrat 5m up the transect line and count the number of plants again. Measure the light intensity at this position. Record your results in your table.
7. Continue to place the quadrat at 5m intervals up the transect line. Count the number of plants and measure the light intensity in each quadrat.

Distance along the transect line in m	Number of plants in quadrat	Light intensity
0		
5		
10		
15		
20		
25		
30		

Apparatus

- a quadrat
- a 30m tape measure
- a light meter

Task

Plot and draw appropriate graphs, selecting appropriate scales for the axes. Write a sentence to describe the relationship you see in your graphs.