# 2.1/4.1 Classification & Biodiversity

Classification is the organisation of organisms into groups. Living organisms can be broadly classified into five groups:

- Plants - flowering and non-flowering
- Animals - vertebrate (backbone) and invertebrate (no backbone)
- Fungi
- Protoctists (single celled organisms)
- Bacteria

Organisms are often classified based on similar physical features. The classification of organisms is important because:

- It makes it easier to identify organisms.
- It aids communication between scientists.

| | |
|---|---|
| KINGDOM | There are 5 kingdoms: animals, plants, fungi, single celled organisms, and bacteria. |
| PHYLUM | Groups get smaller and organisms become more similar as they have more **morphological features** (body structures) in common. |
| CLASS | |
| FAMILY | |
| GENUS | The first part of an organism's scientific name. Starts with a capital letter e.g. Panthera. |
| SPECIES | The second part of an organism's scientific name e.g. tigris. |

Organisms are given scientific names to facilitate universal communication:

- Scientific name given in two words.
- First name (genus) begins with a capital letter.
- Second name (species) begins with a lowercase letter.
- Words written in *italics*, or if handwritten underlined. e.g. *Panthera tigris* or Panthera tigris.

## Adaptations

Adaptations are characteristics of an organism that increase its chance of survival. They are **changes in the organisms to suite its location.** They are maintained by natural selection. There are two types of adaptation:

- Morphological - structural adaptation e.g. camouflage.
- Behavioural - aspect of behaviour that aids survival e.g. bird calls.

## Competition

Organisms require different resources from the environment:

- Light
- Food
- Oxygen
- Water
- Minerals

These resources are limited, creating competition between organisms.

Competition occurs between members of the same species (Intraspecific competition) e.g. for the same food and between members of different species (Interspecific competition) e.g. for space.

# Biodiversity

Biodiversity is a combination of:

- Species diversity (variety of living organisms)
- Total number of each species

## What is its importance?

It is important for:

- Food
- Potential foods
- Future medicines.
- Industrial materials
- Human well-being
- Ecotourism benefits communities.


## Biodiversity can be protected by...

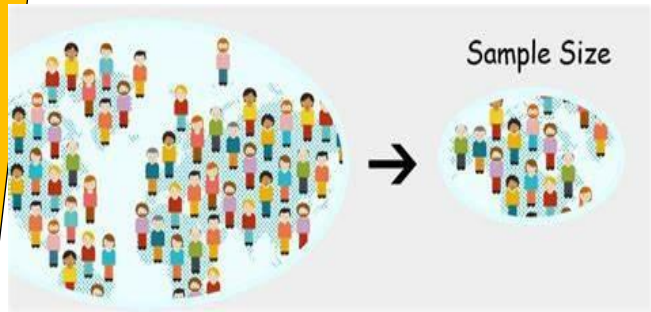
- Captive breeding programmes to increase the number within endangered species
- Conservation schemes to protect entire ecosystems e.g. National parks.
- Sustainable farming e.g. fishing quotas, fewer pesticides.
- SSSI – Site of Special Scientific Interest
- CITES - Convention on International Trade of Endangered Species
- Seed banks

Passing legislation to protect habitats can be difficult because the needs of the human population sometimes conflict with the conservation of the environment e.g. a rising human population means we need more food, however, farmland disrupts natural habitats and reduces biodiversity.

# Sampling

Biodiversity can be estimated by sampling areas of an ecosystem. When choosing a sample area, ensure:

- Sample is of a sufficient size - the larger the sample size, the more representative of the area and the greater its validity
- Avoid bias when choosing sample areas
- Sampling method has no effect on the results



# Quadrats

A quadrat is a square frame divided into smaller square sections. It can be used to investigate the biodiversity of an area by:

- Counting members of each species present in the quadrat.
- Estimating the % coverage of each species

A quadrat can be used as follows:

1. Position two 20 m tape measures at right angles along the border of the sample area.
2. Use a random number generator to randomly select two numbers which serve as the x-coordinate and y-coordinate with the tape measures as the axis.
3. At each location, place the lower left-hand corner of the quadrat at the coordinate point.
4. Identify and record the numbers of each species present or the % coverage of each species.

## Example calculation

The number of daisies in an area of 1000 m2 is to be estimated. The sample is 100 quadrats of with sides that measure 0.5 m. 220 daisies are counted. Calculate the number of daisies in the area.

Area of each quadrat = 0.5m × 0.5m = 0.25 m2 with 100 quadrats
Total area = 100 × 0.25m2 = 25 m2
220 daisies in 25m2
Total number of daisies = (1000/25) x220 = 8800 daisies.

# Transects

Sometimes investigators want to know:

- **How many animals and plants are found in an environment,**

**AND**

- **How the animals and plants are distributed (to investigate different environmental factors).**

These questions can be answered by using a transect. A transect is a series of quadrat samples taken in a line.

- A tape measure or rope is laid out across the are to be sampled; this is the transect line,
- Quadrats are laid down at regular intervals along the transect line,
- The animals and plants in the quadrats are recorded.

# Capture, Mark, Recapture – Higher Tier Only

The capture-recapture method is used to sample animal populations:

1. **Capture** a number of individuals of one species.
2. **Mark** the captured individuals.
3. **Release** back into the sample area.
4. After a suitable period of time, **recapture** more individuals of the same species.
5. Count the number of marked individuals.
6. Estimate the total population using the equation.

## Equation for capture, mark, recapture

$$N = \frac{M \times C}{R}$$

N = total population size estimate
M = total number of animals initially captured and marked
C = total number of animals captured the second time
R = total number of marked animals recaptured the second time

## Accurate results are obtained only when:

- Adequate time between first and second samplings.
- No significant movement of the population into or out of the area during the time between samples.
- Marking method does not adversely affect animal survival e.g. disrupting camouflage.
- Marking method does not affect the probability of recapture.
- Marks do not rub off.
- Few births or deaths in the population.


# Biological control (Biocontrol)

**Biological control** is when a new organism (often described as an '**alien species**') is **deliberately** introduced into an ecosystem to control a pest or pathogen.

An **alien species** is a new species that is introduced into an area (where it is not naturally found). There are many problems associated with the introduction of alien species:

Alien species population may **grow out of control** if they do not have a natural predator
They may **outcompete** or **prey on** existing species
They may carry **new diseases** that could infect existing species

Detailed **research** and **trials** must be carried out before the introduction of alien species into an area.

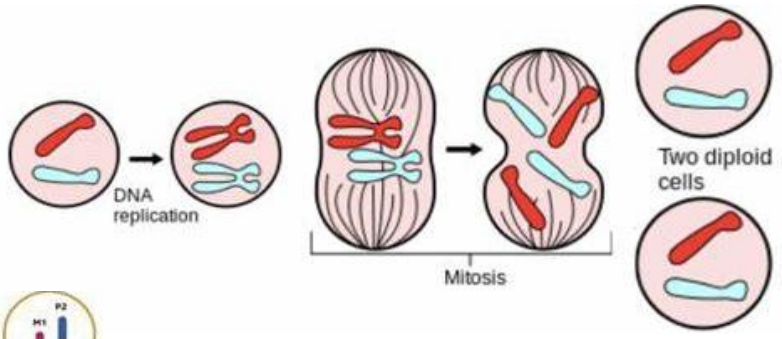
# 2.2/4.2 Cell Division & Stem Cells

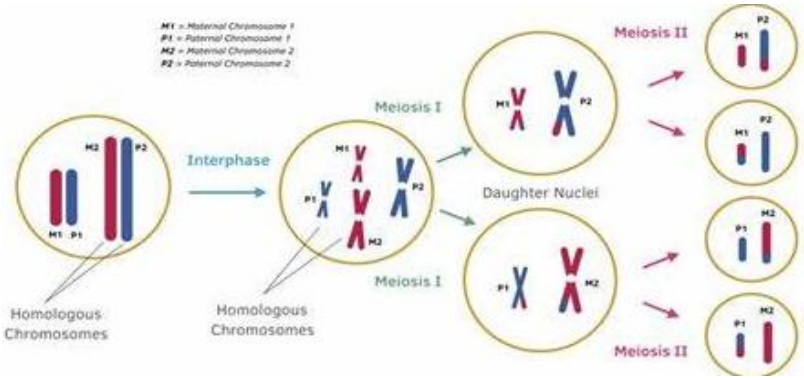
## Cell Division

Chromosomes

A **chromosome** is a **linear DNA molecule** tightly coiled around **proteins**. It carries genetic information in the form of **genes**. Chromosomes are found in **pairs** (one from each parent) in all body cells.
Human body cells contain **23 pairs** of chromosomes (46 chromosomes in total).
Chromosome pairs are not identical as they may contain different alleles (versions of a gene).

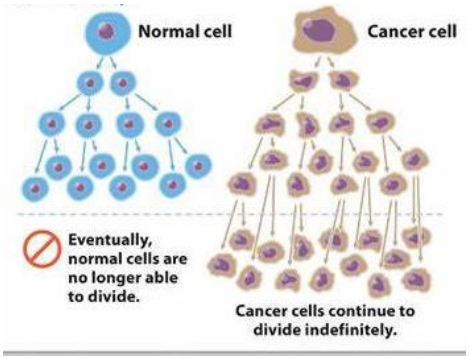
**Sex chromosomes** are a pair of chromosomes that determine sex. Males have an X and a Y chromosome. Females have two X chromosomes.




## Mitosis and Meiosis

| Mitosis | Meiosis |
|---|---|
| Occurs in non-reproductive cells | Occurs only in reproductive cells |
| Produces two daughter cells | Produces four daughter cells |
| Daughter cells genetically identical | Daughter cells genetically different |
| Daughter cells have 46 chromosomes (Diploid) | Daughter cells have 23 chromosomes (Haploid) |
| Important for the growth, repair and replacement of damaged cells | Important for the formation of gametes during sexual reproduction |




## Uncontrolled Cell Division

Cancer is **a non-communicable** disease in which uncontrolled **mitosis** (due to damaged DNA) leads to the formation of a primary tumour. Tumour cells break off and spread to other tissues forming secondary tumours.

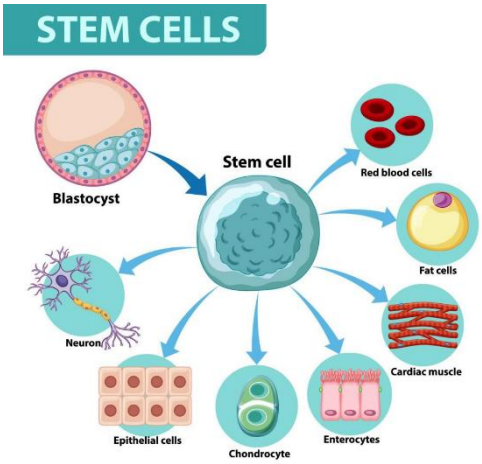
## Stem Cells

Stem cells are **unspecialised** cells capable of **differentiating** into a range of different cell types. In humans, stem cells can be found in early **embryos** or in **adult** tissues such as the bone marrow.

- **Embryonic stem cells** - unspecialised and capable of differentiating into any cell type, enable the growth and development of tissues in embryos.

- **Adult stem cells** - can differentiate into a limited range of cell types, enable the replacement of dead or damaged cells.

There are also ethical issues surrounding the use of stem cells, In particular, embryonic stem cells. Embryos used to provide these stem cells are usually destroyed which is controversial on ethical grounds.




| Advantages | Disadvantages |
|---|---|
| • Used to **treat damage** or **disease** e.g. type 1 diabetes, heart disease<br>• Used to treat diseases that would otherwise be untreatable<br>• **Not rejected** by the body<br>• Do not have to be matched to the patient's tissue type<br>• Can be used to **grow organs** for transplants | • May become **contaminated** during preparation and when transplanted transmit infections to the patient<br>• Difficult to find suitable stem cell donors<br>• No guarantee that treatment will work<br>• Transplanted stem cells could cause **tumours**<br>• **Long term risks** are unknown<br>• Potential **side effects** |

# 2.3/4.3 DNA & Inheritance

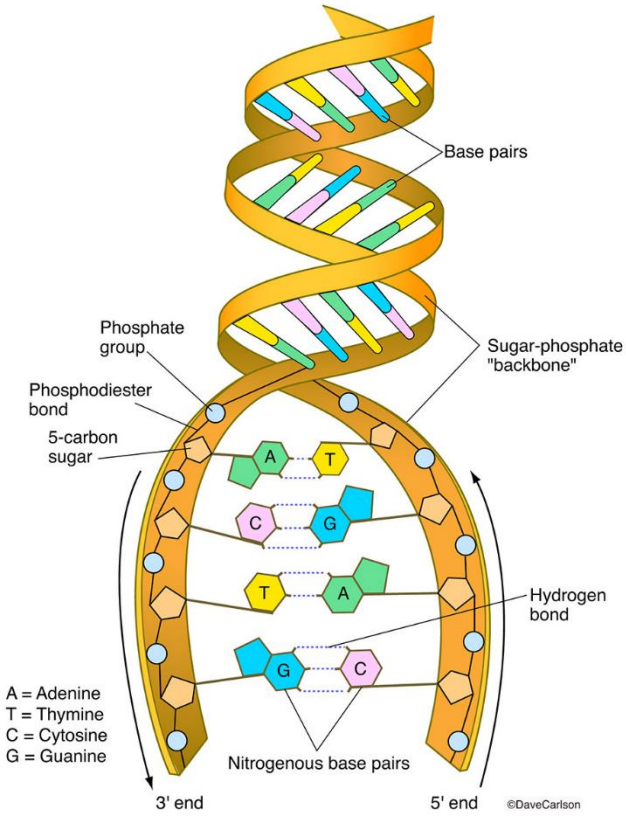
## DNA

DNA is a double-stranded polymer of nucleotides, wound to form a **double helix**.
Each strand consists of **alternating sugar** and **phosphate** molecules. The **two strands** are **joined** by a pair of **bases**.

There are four bases: **A (adenine), T (thymine), C (cytosine) and G (guanine).** A pairs with T and C pairs with G.

**A gene is a section of DNA**. It codes for a protein.
**Higher Tier Only**

- A sequence of three bases in a gene forms a triplet.
- Each triplet codes for an amino acid.
- Order of amino acids determines the structure and function of the protein formed.




## Sex determination in humans

Sex chromosomes are one of the 23 pairs of chromosomes that determines sex:

- Males have an X and a Y chromosome (genotype XY)
- Females have two X chromosomes (genotype XX)

Meiosis produces gametes with half the number of chromosomes and thus a single sex chromosome. All egg cells contain an X chromosome only, whilst male sperm cells may contain an X or a Y chromosome.
The baby's sex therefore depends on which sperm cell fertilises the egg.
**A Punnett square can be used to illustrate sex determination:**

| | | Female genotype | |
|---|---|---|---|
| | | **X** | **X** |
| Male genotype | **X** | XX | XX |
| | **Y** | XY | XY |

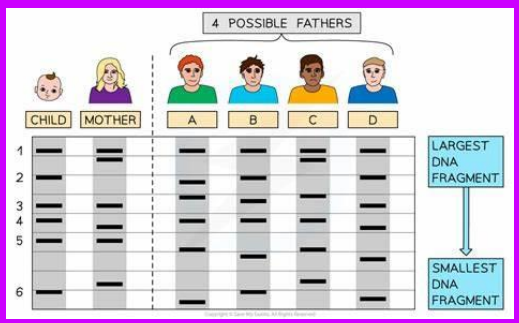
There is a 50% chance of the offspring being a female (XX) or a male (XY)

| Term | Definition |
|---|---|
| **Gene** | A length of DNA that codes for the production of a particular protein |
| **Allele** | A version of a gene |
| **Gamete** | Reproductive cells (e.g. egg and sperm cells) that contain a single copy of each chromosome |
| **Dominant** | Describes an allele that is always expressed<br>Represented with a capital letter e.g. F |
| **Recessive** | An allele that is only expressed in the absence of a dominant allele<br>Represented with a small letter e.g. f |
| **Homozygous** | Having two identical alleles of a gene e.g. FF or ff |
| **Heterozygous** | Having two different alleles of a gene e.g. Ff |
| **Genotype** | An organism's genetic composition, describes all alleles |
| **Phenotype** | An organism's observable characteristics |
| **F1 generation** | First generation in a genetic cross - the offspring produced when two organisms interbreed |
| **F2 generation** | Second generation in a genetic cross - the offspring produced when two organisms from the F1 generation are bred together |
| **Selfing** | An artificial method of self-pollinating plants |

# Genetic Profiling

Genetic profiling is a method of comparing DNA:

1. Sample of cells collected
2. DNA extracted from cells
3. DNA sample cut into fragments using enzymes
4. Fragments separated into bands, creating a genetic profile




The patterns of the bands can be compared to view similarities in the DNA sequences.

Genetic profiling can be used for:

- **Paternity testing**
- **Forensics**
- **Classification**

# Inheritance

Single gene inheritance
Most characteristics of an organism are determined by multiple genes interacting, however some are determined by a single gene. **Monohybrid inheritance** is the inheritance of a single gene. A **Punnett square** can be used to illustrate this single gene inheritance.

E.g. PKU is a recessive condition. **Two heterozygous** parents (Pp) have offspring. Predict the **proportion** of offspring that will have PKU.

| | | Female genotype | |
|---|---|---|---|
| | | **P** | **p** |
| Male genotype | **P** | PP | Pp |
| | **p** | Pp | pp |

The outcomes are PP, Pp and pp.
As P is dominant, there is a 75% chance that the offspring will not have the PKU phenotype (PP and Pp). However, those offspring that have the 'Pp' genotype are carriers. There is a 25% chance that the offspring will have PKU (pp).

## Genetic Engineering

Genetic engineering is the modification of the genome of an organism by the insertion of a desired
gene from another organism. It enables the formation of an organism with beneficial characteristics. Genetically engineered organisms are known as GM organisms.

| Benefits | Risks |
|---|---|
| • Increased crop yields for growing population e.g. herbicide-resistance, disease-resistance.<br>• Useful in medicine e.g. insulin-producing bacteria, anti-thrombin in goat milk.<br>• GM crops produce scarce resources e.g. GM golden rice produces a source of Vitamin A.<br>• GM crops can produce oils which can be used as biofuels, an alternative to fossil fuels. | • Long-term effects of consumption of GM crops are unknown.<br>• Negative environmental impacts e.g. reduction in biodiversity, impact on food chain, contamination of non-GM crops forming 'superweeds'.<br>• GM seeds are expensive.<br>• GM plants could become a pest themselves e.g. due to herbicide-resistance. |

# 2.4/4.4 Variation and Evolution

## Variation

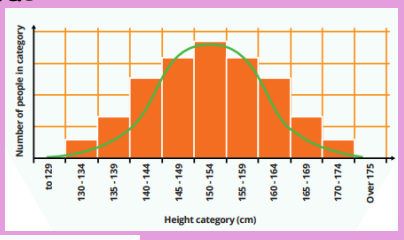
**There are two causes of variation. These can be either:**

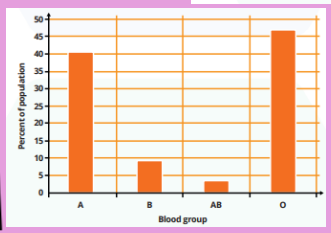
| Variation | Description |
|---|---|
| **Genetic** | Differences in the **genotypes** of organisms of the same species due to the presence of different **alleles**. It creates differences in **phenotypes**. |
| **Environmental** | Differences in **phenotype** that are acquired during the lifespan of an organism due to **environmental factors** e.g. diet, lifestyle, climate, exposure to light etc. |

Some variation may be due to a **combination** of both genetics and the environment e.g. an individual's genes may make them predisposed to being tall, however, lack of nourishment during childhood may stunt growth.

**There are two types of variation: continuous and discontinuous**

| Variation | Description |
|---|---|
| Continuous | Produces characteristics which **do not fall** into distinct categories, instead showing a **continuous** range e.g. height, weight. |
| Discontinuous | Produces characteristics that fall into **distinct categories** e.g. gender, eye colour, blood group. |




## Reproduction – Two Types

### Sexual reproduction

- 2 Parents
- Gametes are made
- Genetic variation in offspring
- Common in animals and plants

### Asexual reproduction

- 1 Parent
- No gametes or mate, meaning **a lot** of offspring made quickly
- No genetic variation in offspring – **Clones (genetically identical)**

# Mutations

A mutation is a **change in a gene**.
They occur randomly but the rate of mutation can be **increased** by **ionising radiation**.
Some mutations can be inherited and cause disease.

Mutations may result in the formation of harmful alleles. If these alleles are present in an organism's sex cells (gametes) they may be inherited by offspring. An example of this:

# Cystic Fibrosis

Cystic fibrosis is a recessive condition resulting in the production of sticky mucus that affects the lungs and digestive system.

If both parents carry the recessive Cystic fibrosis gene there is a $\frac{1}{4}$ chance that a child will have the disease.

| | N | n |
|---|---|---|
| N | NN | Nn |
| n | Nn | nn |

Gene therapy can be used to treat the disease. An inhaler can be used to get the gene into lung cells but as cells renew the gene is not copied and so new cells do not contain the normal gene. Gene therapy is a treatment not a cure.

# Evolution

Variation in species that can be **inherited** are the basis of **evolution**.
**Charles Darwin** and **Alred Russel Wallace** worked on the theory of evolution by natural selection.

1. **Mutation** – Random changes in genes cause variations in a species.
2. **Variation** – This causes differences between organisms of the same species.
3. **Advantage** – The variation gives this organism an advantage over others.
4. **Survival** – This organism is now more likely to survive (Survival of the fittest).
5. **Breeding** – This organism reproduces, passing their gene onto the next generation.

If environmental change is too quick for species to adapt by natural selection **extinction** may occur.

# Modelling Natural Selection

We can use a model to demonstrate how camouflaged organisms have an advantage against predation.
1. Arrange small pieces of plain and patterned card on a plain background.
2. Use forceps to model a predator beak/jaw and record how many of each type of card you pick up in 15 seconds with the forceps.

This model shows that you are more likely to select prey that is more easily seen (less camouflaged). This leaves the camouflaged organisms to breed and pass on their genes.

# Human genome project

Studying human DNA gives us more information to develop new ways to treat, cure, or even prevent disease.

- Disease-causing alleles identified more rapidly
- Predict an individual's response to certain drugs

# 2.5/4.5 Response and Regulation

The nervous system is made up of the brain and spinal cord (central nervous system, CNS) along with specialised nerves that carry information as impulses into and out of the CNS.

The nervous system controls movement by sending electrical signals (**impulses**) along a network of specialised nerve cells known as neurones. This allows an organism to rapidly react to environmental and internal changes.

Sense organs are a group of receptor cells that detect specific stimuli (environmental and internal changes e.g. temperature, sound) and send information to the CNS along neurones.

| Sense organ | Stimulus |
|---|---|
| Eye | Light |
| Ear | Sound |
| Nose | Chemical smells |
| Tongue | Chemical tastes |
| Skin | Pain, pressure, temperature |

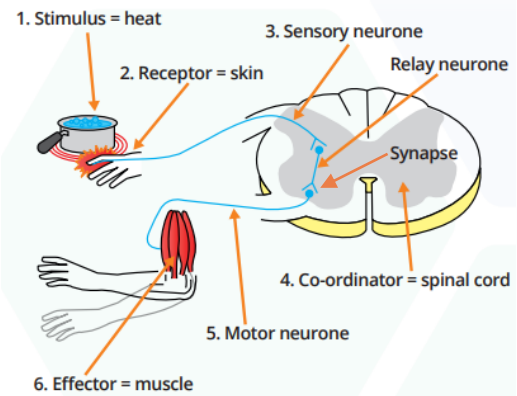
There are three types of neurones:

- Sensory neurone - carries impulses from receptors (sense organs) to the CNS.
- Relay neurone - carries impulses from sensory neurones to motor neurones in the CNS.
- Motor neurone - carries impulses from the CNS to effectors (muscles and glands).

A synapse is a small gap between neurones across which a nerve impulse is transmitted via neurotransmitters. – **Higher Tier**

## The reflex arc - Higher tier

This is the path taken by an electrical impulse from stimulus to response by an effector (muscle or gland). Withdrawal action reflex is shown here where an automatic reaction to the hot pan causes a quick withdrawal from the area.

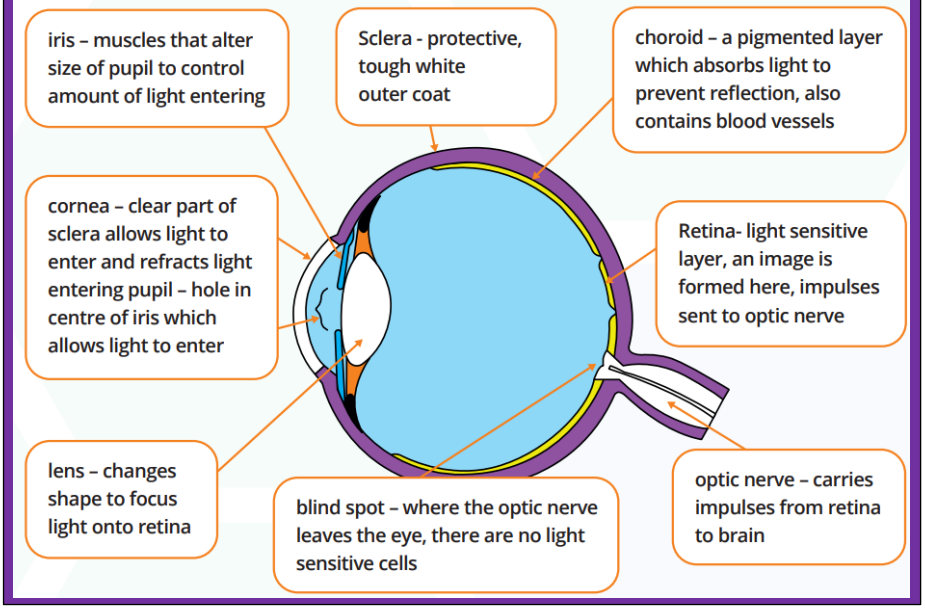



A reflex response is always FAP:

- Fast
- Automatic
- Protective (Protection)

## The eye – Triple Only

Two reflex actions studied occur in the eye. Blinking and the pupil reflex.



## Homeostasis

**Homeostasis** is the maintenance of a **stable internal environment** in the body despite fluctuations in internal and external conditions. It is important to ensure **optimum conditions** for **enzymes** and **cellular processes** in the body.

**Temperature**, **blood glucose concentration** and **water levels** must be maintained. Hormones are chemical messengers carried by the blood which control many of the body's functions such as homeostasis.

## Glucose Regulation

The amount of glucose in your blood is controlled by hormones (chemical messengers) that travel in blood from the gland where they are produced, in this case the pancreas to the target organ, in this case the liver.

When glucose (sugar) levels are **too high**:

1. The brain detects **high glucose** levels in blood
2. **Insulin** is released from the **pancreas** into the **blood**
3. The **insulin travels** to the **liver**
4. The liver turns **glucose** into **glycogen** for storage
5. **Glucose** level **decreases** in the blood to a normal level

When glucose levels are **too low**: (**Higher Tier Only**)

1. The brain detects **low glucose** levels in the blood
2. **Glucagon** is released from the **pancreas** into the **blood**
3. The **glucagon travels** to the **liver**
4. The liver turns **glycogen** into **glucose**
5. **Glucose** level **increases** in the blood to a normal level

**Negative feedback is** a corrective mechanism that allows only small fluctuations around a set point. An example of this is the control of blood glucose concentration.

# Diabetes

Diabetes is a condition where you are unable to control your own blood glucose levels. **In Type I diabetes** the body does not release insulin. **In type II** diabetes the body cells do not respond to the chemical signal from insulin.

| Type of diabetes | Cause | Treatment |
|---|---|---|
| Type 1 | Immune system attacks and destroys insulin-producing cells ∴ pancreas does not produce enough insulin. | • Daily insulin injections at meal times.<br>• Managing diet (limiting intake of refined sugars).<br>• Regularly testing blood glucose levels. |
| Type 2 | Person develops insulin resistance (links to obesity). | • Managing diet.<br>• Regular exercise.<br>• Drugs e.g. metformin. |

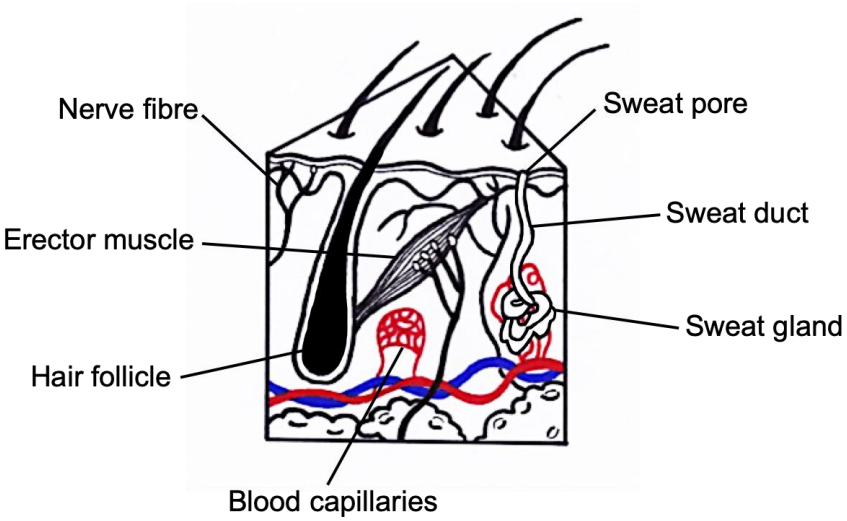
# Control of body temperature

Body temperature must be controlled because...

- Enzymes work best at their optimum temperature (37°C).
- Deviations from the optimum decrease the rate of enzyme-controlled reactions.

The skin is the main organ responsible for the control of body temperature. The structure of a section of skin is shown below.

The control of body temperature is an example of negative feedback.




| Temperature increases above 37°C (Too High) | Temperature decreases below 37°C (Too Low) |
|---|---|
| **Vasodilation**: Dilation of blood vessels near skin surface. Blood flows closer to the skin surface ∴greater heat loss to surroundings. | **Vasoconstriction**: Constriction of blood vessels near skin surface. Less blood flows close to skin surface ∴ reduced heat loss to surroundings. |
| **Sweating**: More sweat is produced the sweat moves onto the surface of the skin, evaporating and removing heat. | **Little sweat** is produced. |
| **Erector muscles relax**: Hairs lie flat. Reduced insulation. | **Erector muscles contract**: Hairs stand on end creating pockets of air between hairs and a layer of insulation. |
| **No shivering**. | **Shivering**: Involuntary contraction of muscles generates heat energy from respiration. |

# Lifestyle choices

Some conditions are affected by lifestyle choices:

- **Obesity** increases the risk of **type 2 diabetes**.
- **Drugs** affect chemical processes within the body and can produce **damaging** side effects.
- **Alcohol decreases reaction times** and causes liver damage, cardiovascular disease etc.

# Plant responses

Plant **tropisms** are the **growth responses** of a plant to stimuli. A **positive** tropism is the growth of a plant **towards** a stimulus whereas a **negative** tropism is the growth of a plant **away** from a stimulus.

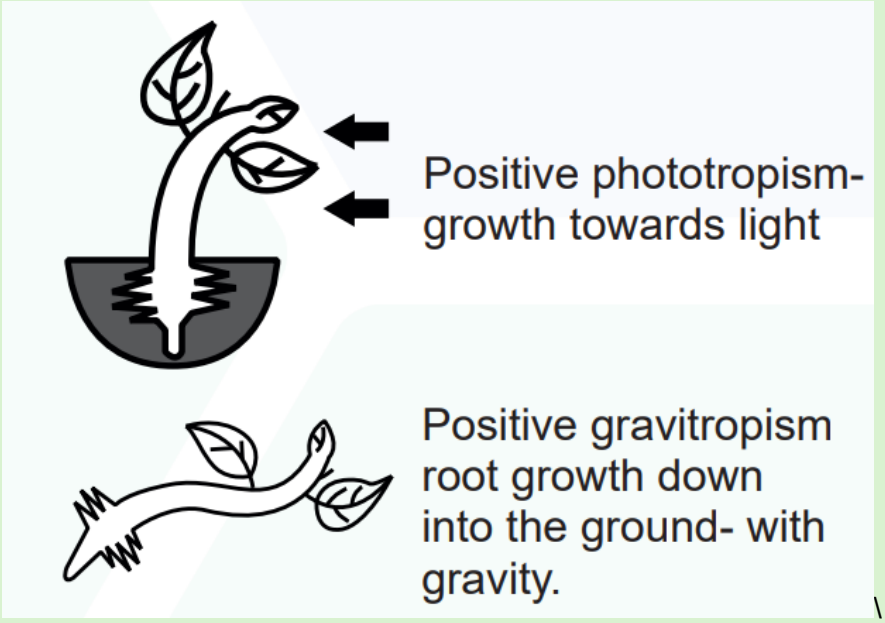
Plant tropisms are controlled by the hormone **auxin**, which **stimulates** growth in plant shoots and inhibits growth in plant roots. Two types of plant tropisms are **phototropism** and **gravitropism**.

**Phototropism** is a plant's growth response towards light.

- Plant shoots are positively phototropic as they grow towards the light.

**Gravitropism** is a plant's growth response to gravity.

- Plant roots are positively gravitropic as they grow towards gravity.



# 2.6 Role of Kidney in Homeostasis – Triple

**The Excretory System - Removes urea a waste product of metabolism and regulates the water content of the blood.**

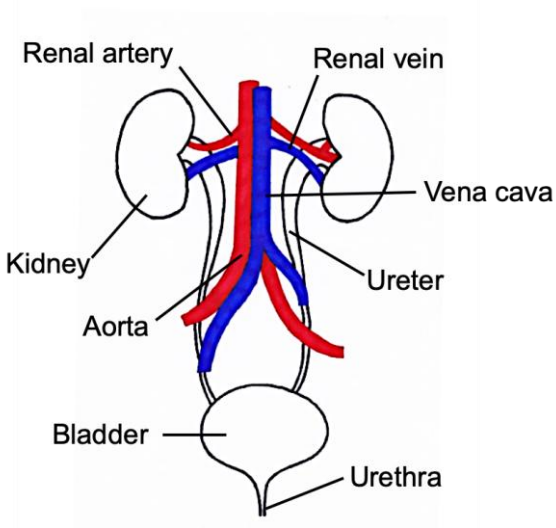
**The kidney has a range of functions:**

- **Removes toxic waste substances from the body.**
- **Osmoregulation.**
- **Controls the volume and concentration of urine.**

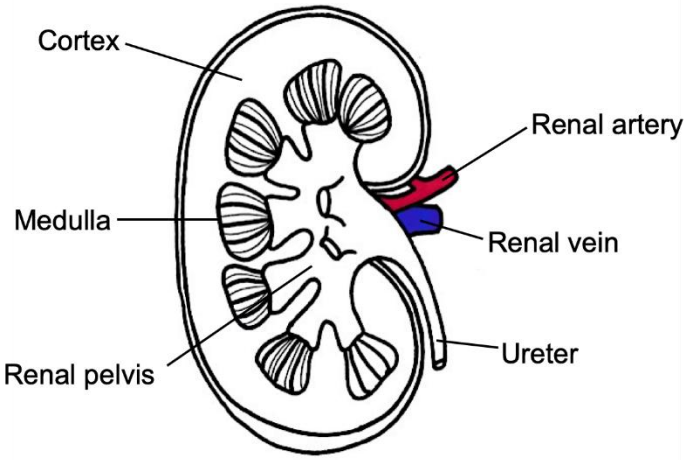
## Detecting disease

**Red blood cells** in urine indicates **kidney damage or disease**. We can test for this using **Biurets solution**.

**Glucose** in the urine can indicate **diabetes**. We can check for this using **Benedicts Reagent**.



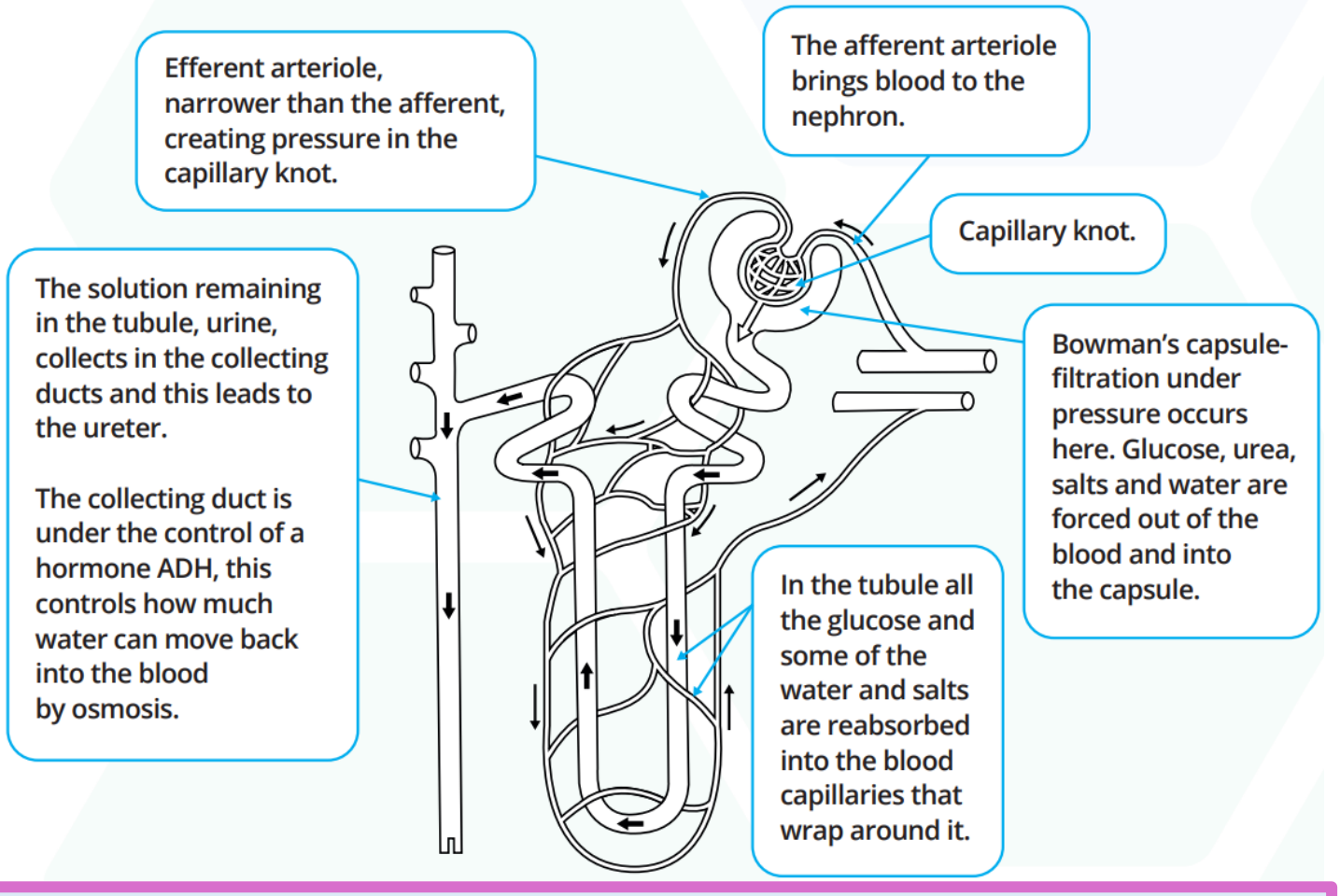

(a) structure of the human excretory system




(b) structure of a section through the kidney

| Structure | Function |
|---|---|
| **Renal artery** | Supplies blood to the kidneys |
| **Renal vein** | Drains blood from the kidneys |
| **Ureter** | Takes urine to the bladder from the kidneys |
| **Urethra** | Releases urine from the bladder, out of the body |

# The Nephron – Higher Tier Only (Triple)




## The process of excretion

There are three stages involved in the formation of urine:

- Filtration
- Selective reabsorption
- Osmoregulation Filtration

**Filtration**

- Blood flows through the capillary knot under high pressure.
- The arteriole leading into the capillary knot is wider than the arteriole taking blood from the capillary knot. This creates a build-up of pressure.
- Small molecules (e.g. urea, glucose), water and salts are filtered out of the blood and into the Bowman's capsule. This is called ULTRAFILTRATION (Filtration under pressure).
- Large molecules (e.g. RBCs, proteins) remain in the blood as they are too large to fit through the pores in the capillary walls.

**Selective reabsorption**

- Glucose, some water and some salts are reabsorbed into the bloodstream.
- The molecules not selectively reabsorbed travel down the kidney tubule as urine and are transported to the bladder via the ureter. Here they are stored and eventually excreted.

**Osmoregulation**

The water content of the blood is adjusted:

- If blood water levels are high, more dilute urine is produced.
- If blood water levels are low, more concentrated urine is produced.

# Osmoregulation by Antidiuretic hormone (ADH)

| Low Water Levels |
|---|
| The brain detects the water content of the blood is too low. |
| More ADH is released into the blood from the pituitary gland. |
| Blood takes more ADH to the collecting duct of the kidney. |
| The collecting duct becomes more permeable to water. |
| Water in the collecting duct is reabsorbed into the blood by osmosis. |
| A small volume of concentrated urine is released. |

| High Water Levels |
|---|
| The brain detects the water content of the blood is too high. |
| Less ADH is released into the blood from the pituitary gland. |
| Blood takes less ADH to the collecting duct of the kidney. |
| The collecting duct becomes less permeable to water. |
| Water is retained in the collecting duct. |
| A large volume of dilute urine is released. |

# Kidney Disease & Treatments

There are two methods of treating kidney disease:

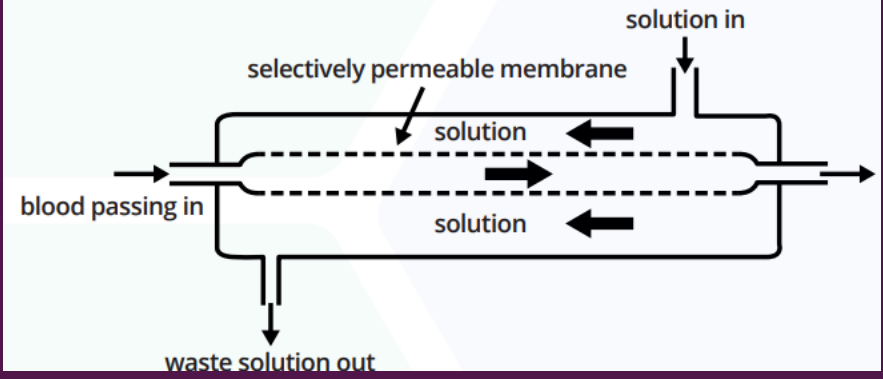
- Kidney dialysis
- Kidney transplant

| Treatments | Advantages | Disadvantages |
|---|---|---|
| **Dialysis** | Immediately available. | A long time spent in hospital attached to a dialysis machine every week and diet is restricted. |
| **Transplant** | Can last 12-15 years with minimal medical intervention. | **Immunosuppressant** drugs must be taken to **avoid rejection.**<br>**A donor must be found** and must have a **similar tissue type** to the recipient, so a close family living donor is preferable. |

## How dialysis works- Higher tier only

Blood is removed from the body and flows through tubing made from a selectively permeable membrane.

Dialysis fluid contains **equal** concentration of **glucose** as the blood. It contains **no urea,** and so urea will diffuse from a high concentration in the blood out into the dialysis fluid which is then disposed of.




Dialysis fluid and blood will flow counter current to each other to maintain a concentration gradient for diffusion of urea across the whole membrane.

# 2.7 Micro-organisms and their applications (Triple)

Micro-organisms can be cultured to **increase** their **population numbers**, enabling scientists to study them more easily e.g. bacteria are too small to be seen individually but once cultured, form **colonies** which can be seen with the naked eye.

Each bacterial **colony** arises from a **single cell**, enabling the **estimation** of the **number of cells** in the **initial culture** e.g. if 5 bacterial colonies are present, it is likely that these have arisen from 5 individual cells. However, **clumping** of cells can lead to misleading estimates.

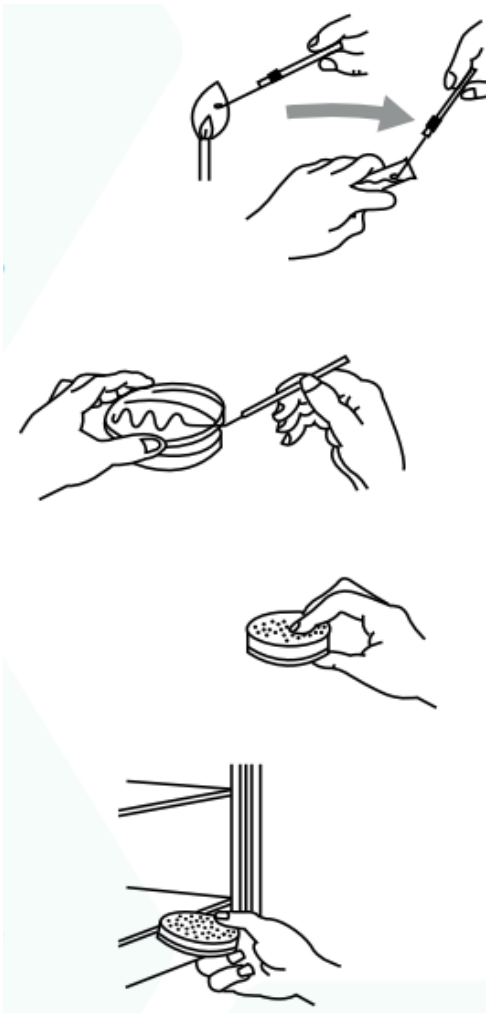
Culturing may be done using **solid agar** or a **nutrient broth**. The culture medium contains the essential **nutrients** required by the micro-organisms.

## Aseptic Technique

When working with micro-organisms it is important that you do not contaminate your work, and your work does not contaminate the environment.
To do this, scientists use aseptic technique.

Bacteria and fungi can be grown on nutrient agar in a Petri dish, to produce an agar plate.

**1. Petri dishes and nutrient agar should be sterilised before the agar is poured.**
2. An inoculating loop is used to transfer bacteria and is sterilised before and after use by heating it to red heat in a Bunsen flame.
**3. Only lift the Petri dish lid slightly as this prevents microorganisms from the air contaminating the culture and vice versa.**
4. After inoculation the lid of the Petri dish should be secured in place by strips of adhesive tape labelled and dated.
**5. Inoculated agar plates are incubated at 25o C in school laboratories for 24-48 hrs, which encourages growth of the culture without growing pathogens.**
6. Sterilise plates and equipment after use.



# Counting Micro-organisms

More than 200 colonies, likely to be clumping together, difficult to identify individual colonies.

20-200 colonies on each plate is a reliable number of colonies to count. Each colony grew from a single bacterium giving an indication of how many were in the original sample.

Fewer than 20 colonies is not a reliable number of colonies to count.

# Controlling Mico-organisms

The growth of micro-organisms can be controlled by temperature. This information is used for food storage.

| Food storage | Effect on bacterial growth |
|---|---|
| Room temperature | Bacterial growth is uncontrolled and rapid |
| Refrigerator | Slows bacterial growth |
| Freezer | Stops bacterial growth |

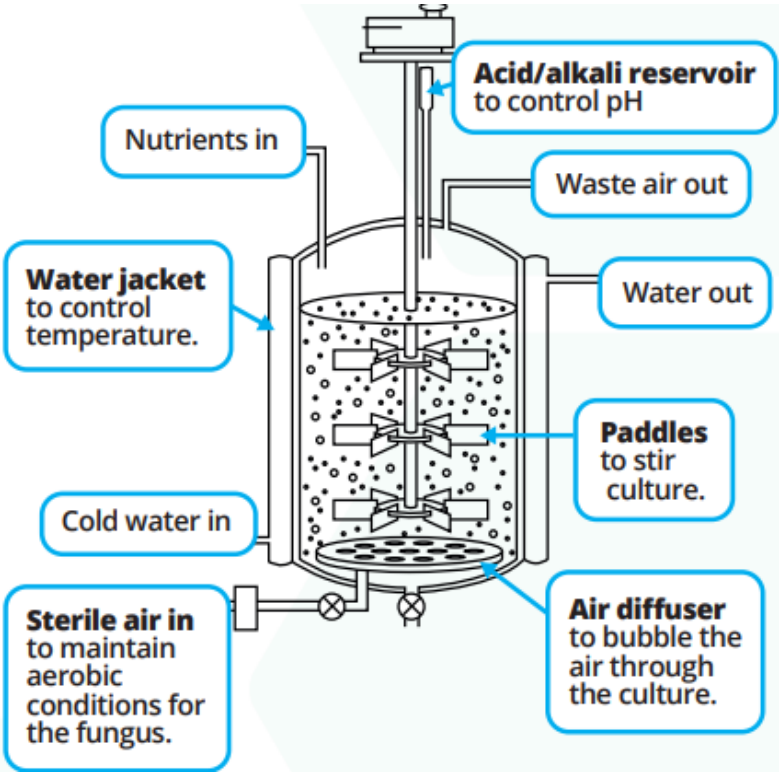
# Growing Micro-organisms

A fungus called *Penicillium* that makes Penicillin can be grown in a fermenter as shown below:

This apparatus provides the microbes with the best conditions for growth.

- Optimum pH
- Optimum temperature
- Oxygen
- Nutrients

The organism grows in the fermenter and secretes the antibiotic into the surrounding medium. After incubation, the culture medium is removed filtered and the penicillin extracted.



# 2.8/4.6 Disease, Defence & Treatment

## Micro-organisms

Micro-organisms are microscopic organisms - they can only be seen under a microscope. There are four types of micro-organism:

- Bacteria
- Fungi (not all fungi are micro-organisms)
- Viruses
- Protists

Micro-organisms can be beneficial to humans, e.g. gut bacteria aid in the digestion of food, skin flora compete with pathogens for resources, reducing infection.


## Communicable disease

A **pathogen** is a disease-causing organism. Pathogens are often micro-organisms such as bacteria, viruses and fungi.

Communicable diseases are caused by pathogens and can be passed directly between individuals in a variety of ways:

- **Contact**
- **Aerosol**
- **Body Fluids**
- **Water**
- **Food**
- **Animals**

## Body defences

Our bodies are adapted to resist infection by microorganisms:

- Skin flora- **bacteria** that make it **difficult** for pathogens to become **established**.
- Intact **skin** is a **barrier** and **blood clots** immediately around wounds.
- **Stomach acid and lysozyme** in tears protect where skin is not present.

# Examples of Communicable diseases – Triple Only

| Disease | Pathogen | Transmission | Effects | Treatment | Prevention |
|---|---|---|---|---|---|
| AIDS | HIV (Human Immunodeficiency Virus) | The virus is spread by blood-to-blood contact, especially during sexual intercourse. | Infects lymphocytes leading to lack of immunity to other infections. | Antiviral drugs taken for life. | Spread by blood-to-blood contact - Use disposable gloves. Sexually transmitted - Use condoms to prevent spread. |
| Chlamydia | Chlamydia trachmatis (bacteria) | Spread during sexual intercourse via the vagina and urethra. | Causes infertility in adults, conjunctivitis and lung problems in babies. | Antibiotics like tetracycline | Sexually transmitted, use condoms to prevent spread. |
| Malaria | Plasmodium (Protist) | Plasmodium is spread via female mosquitoes of the genus Anopheles. Anopheles mosquitoes bite humans and inject Plasmodium into the blood stream. | Destroys red blood cells causing fever | Antimalarial drugs to kill the plasmodium. | Spread by female Anopheles mosquitos. Prevent the mosquitos biting and infecting people by:<br>• killing mosquitoes with insecticide<br>• releasing large numbers of infertile male mosquitoes<br>• biological control of mosquitoes<br>• use of mosquito nets and repellents |

## Keywords

**Antigens**

Antigens are molecules on the surface of all cells that are recognised by the immune system. Pathogens have unique antigens on their surface.

**Antibodies**

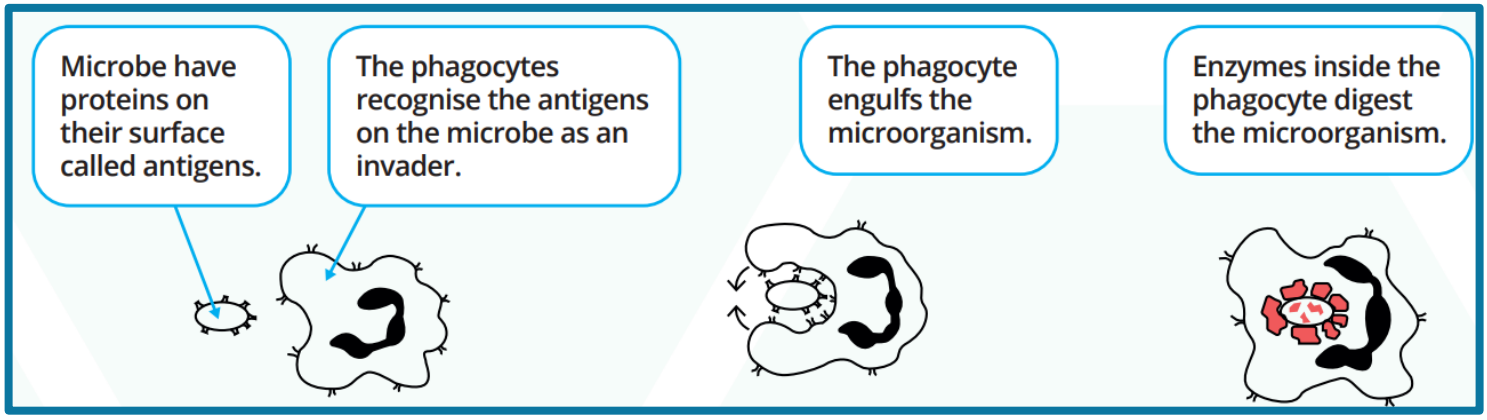
Antibodies are proteins produced by lymphocytes in response to a foreign antigen. Each antibody is specific to an antigen and binds to it.

# The Immune System

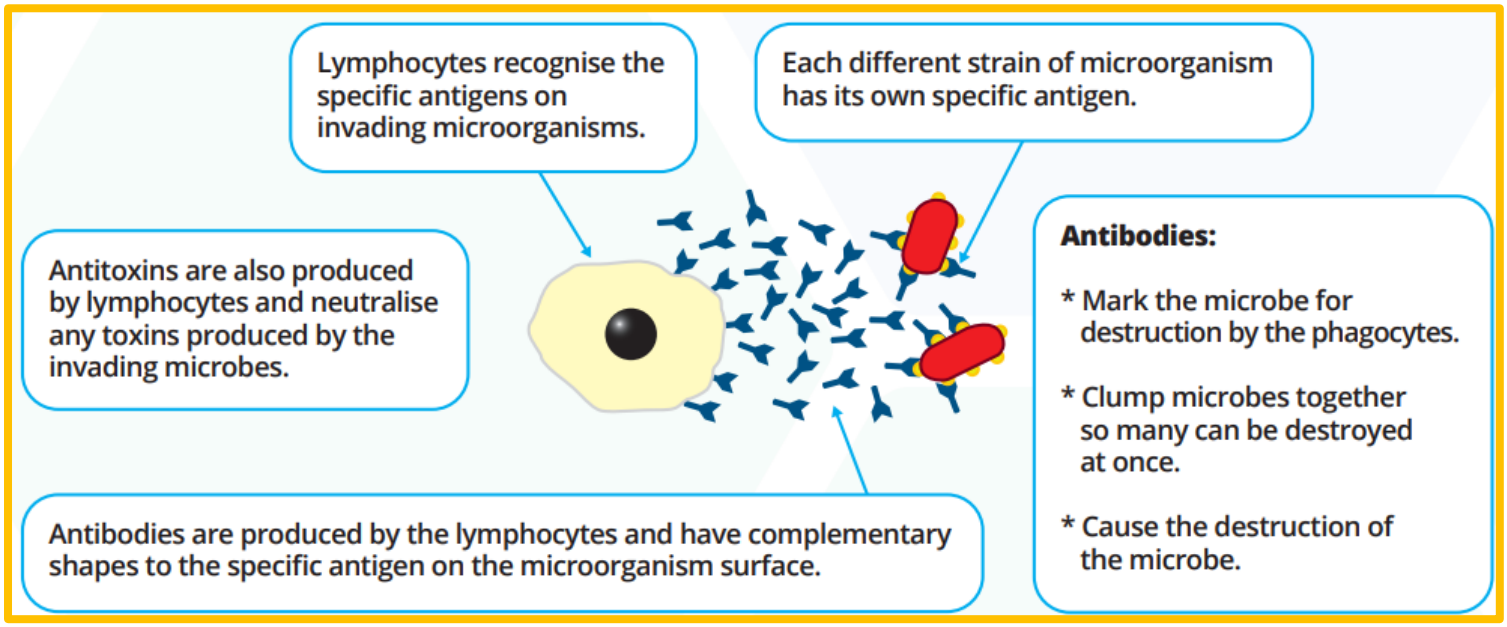
**White blood cells** - If microbes manage to enter the body, then white blood cells in the body will respond. These have **specialised receptors** that can detect foreign **pathogens**.
There are 2 types of WBC. These are **Phagocytes** & **Lymphocytes**.

- **Phagocytes which engulf and digest pathogens.**
- **Lymphocytes which secrete antibodies (see below) and antitoxins (neutralise toxins produced by the pathogen).**

## Phagocytes




## Lymphocytes



**Drug Testing – Testing New Treatments**

**1.Preclinical drug trials**

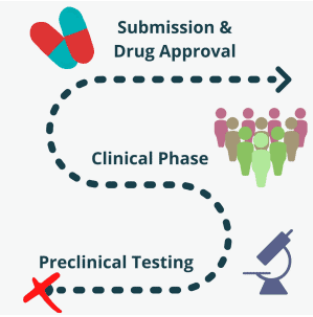
- Testing on human cells grown in the laboratory.
- Testing on animals.
- Testing on healthy human volunteers.

**2. Clinical trials**

- Testing on small groups of patients.

**Clinical trials**

Placebo - Used instead of a drug in a drug trial.
Blind trial - Patients do not know if they have been given the drug or placebo but the doctors know.
Double blind trial - Neither patients nor doctors know if the patient has been given the drug or the placebo, only the researchers know.




**Antibiotics – Disease Treatment**

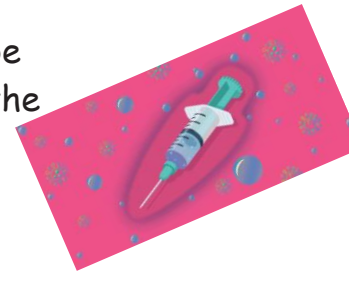
Penicillin, an antibiotic, was discovered by Alexander Fleming in 1928. It was made by a fungus called *Penicillium notatum.*
Now antibiotics are chemically modified and synthetic.
Antibiotics like Penicillin destroy bacteria or stop their growth.
Antibiotics work only on bacteria and fungi. They do not kill viruses.

Some antibiotic-resistant bacteria such as MRSA are causing problems in hospitals. This may have developed from over-use of antibiotics.

Good hygiene like hand washing, alcohol gels, effective cleaning of hospital wards etc. need to be used to prevent the spread.

# Vaccinations

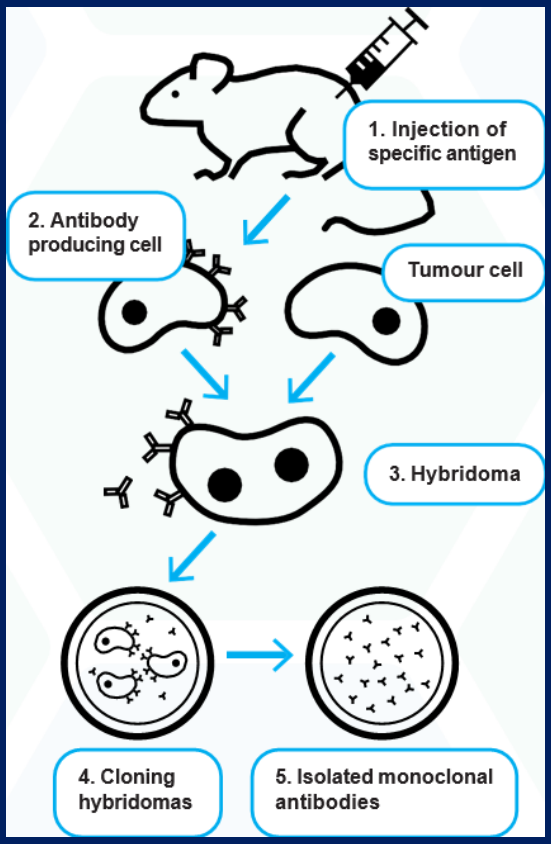
1. A **dead attenuated or part** of the microbe with the **antigen** on is inserted into the body typically by injection.
2. A **lymphocyte** recognises the **antigen** of an "invading microorganism".
3. Lymphocyte produces the specific antibody to kill the microorganism.
4. The **lymphocyte** cell divides repeatedly producing many clones of the cell all producing the same **specific antibody**.
5. Once the microorganisms have been destroyed all the clone cells die off except a few. These cells are **memory cells (Special white blood cells)**.
6. If the same microbe is encountered again the antibodies will be produced **faster** and in **larger numbers**, hopefully destroying the microbes before symptoms are felt. This is immunity!



Some parents may choose **not to** vaccinate their children because...

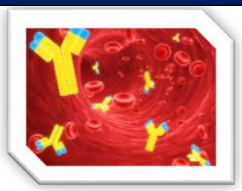
- Concerns about potential side effects/adverse reactions.
- Not guaranteed to work.
- May believe that vaccines are linked to other diseases such as autism, asthma etc.

# Monoclonal Antibodies




1. The antigen that will stimulate the specific antibody production is injected into a mouse.
2. The mouse's immune system (B-lymphocytes) begins to produce antibodies specific to the antigen.
3. One of these antibody producing B-lymphocytes is fused with a tumour cell forming a hybridoma.
4. The hybridoma divides repeatedly producing many clones which all produce the same antibodies (monoclonal antibodies).
5. These Monoclonal antibodies can then be isolated and used for many things.

# Medical uses of monoclonal antibodies



- **Diagnostic tests e.g. for HIV and Chlamydia**
  Monoclonal antibody used to detect the presence of antigens specific to a certain pathogen. Attached to a fluorescent dye, radioactive isotope or enzyme. If the antigen is present a change (e.g. fluorescence) can be observed.
- **Tissue typing for transplants**
  Monoclonal antibodies can match donor organs to patients. This reduces the chance of a transplanted organ being rejected.
- **Monitoring malaria**
  Monoclonal antibody used to detect the presence of antigens specific to the malarial parasite. This can help to track the spread of malaria and can also be used to test the effectiveness of treatments.
- **Cancer treatments**
  Monoclonal antibodies specific to cancer cells are attached to an anti-cancer drug. This allows chemotherapy drugs to target cancerous cells only.