GCSE Biology
Revision notes 2015

Contents

Enzymes

What are enzymes?

Enzymes are **biological catalysts.** They speed up chemical reactions in all living things, and allow them to occur more easily. They occur in plant cells and animal cells. Without them we would not be alive.

Enzymes are just chemical molecules, made up of **proteins.**

Each particular enzyme has a unique, 3-dimensional shape shared by all its molecules. Within this shape there is an area called the **active site** where the chemical reactions occur.

What do enzymes do?

Some enzymes help to break down large molecules.

Others build up large molecules from small ones.

While many others help turn one molecule into another.

Probably the fastest enzyme known is called **catalase.** It breaks the chemical hydrogen peroxide down to water and oxygen. Catalase is found in all cells and protects them from this dangerous waste chemical.

Optimum conditions

Each type of enzyme has its own specific optimum condition under which it works best.

Enzymes work best when they have a high enough substrate concentration for the reaction they catalyse. If too little substrate is available the rate of the reaction is slowed and cannot increase any further.

The **pH** must be correct for each enzyme. If the conditions are too alkaline or acidic then the activity of the enzyme is affected. This happens because the enzyme's shape, especially the active site, is changed. It is **denatured,** and cannot hold the substrate molecule.

Temperature is a key factor too. If it is too cold the enzymes will move around too slowly to meet the substrate molecules, so the reaction rate is slowed. Likewise, if it is too warm they do not work properly either. This is because the extra heat energy shakes them around so much that the active sites change shape so, just like with pH, the enzyme molecules are denatured, and can't hold the substrate.

Enzymes everywhere!

Enzymes control all kinds of reactions in all cells. For example, they help control; **respiration, photosynthesis**, and our digestion, amongst many others.

Protease and **lipase** enzymes are used in biological washing powders to remove those stubborn stains.

Enzymes are also used in making foods and drinks. The enzyme **pectinase** helps to break down the cells in fruit to release more of their juice.

Cells

Cell structure

Plants and **animal cells** share the same basic structural features, although plant cells have a few extra bits.

Animal Cells

Animal cells come in all kinds of shapes and sizes but have the same basic features.

The control centre is the **nucleus;** this contains all the genetic information for the cell and controls all its activities.

The **cytoplasm** is like a big soup of chemicals in which the reactions occur.

Then forming the outside of the cell is the **cell membrane**, which acts as a barrier and controls the transfer of materials into and out of the cell.

Plant Cells

Plant cells also come in a variety of forms but share similar features. In addition to the three basic features found in animal cells, plant cells have some useful extra ones.

Firstly they have a rigid **cell wall** made of fibres of cellulose (which we use to make paper!) that gives them shape and strength. The cell wall fits closely just outside the cell membrane like a plastic box with an inflated balloon stuffed inside.

Secondly they have a **vacuole,** which stores extra water and gives extra support to the cell by pressing hard against the cell wall.

Thirdly, most plant cells also contain small round structures called **chloroplasts,** which contain the green pigment **chlorophyll,** which is needed for photosynthesis.

Tissues, organs and organisms

A living plant or animal is called an **organism** and is made up of lots of cells all working together.

Some of these cells are all of the same type; collectively they are called a **tissue**. They all do the same job, for example connective tissue, which is used in animals to connect other tissues together - and stop us falling apart!

Next, some different tissues are grouped together to make up an **organ** such as the stomach or a leaf.

Finally, some organs work together to form an **organ system** such as the **digestive system.**

Characteristics of Life

All living things show 7 characteristics of life. All plants and animals are alive.

The 7 characteristics are:

- Movement
- Respiration
- Sensitivity
- Growth
- Reproduction
- Excretion
- Nutrition

Moving Molecules

Diffusion: Molecules move from a place of high concentration into a place of low concentration.

Osmosis: a special kind of diffusion, which is very important in Biology; it keeps us alive!!

Key Facts

1. Osmosis **only** involves water molecules- nothing else. Osmosis is water diffusion.
2. Osmosis occurs across a barrier such as a cell membrane which is **'selectively permeable'**, which means it only lets through small molecules like water.

Respiration

What is Respiration?

Respiration is the reason that we need oxygen.

Respiration is the **process of releasing energy from food.** You could think of it as burning the fuel, glucose.

Glucose is the key molecule. It is made by plants in photosynthesis. In animals, although lots of different molecules are absorbed after digestion they are usually turned into glucose. In animals glucose is especially important as two organs can **only** use glucose as a fuel.

The two organs which use glucose as fuel are; the **brain** and the **heart**.

Respiration summarised in this equation:

glucose + oxygen > carbon dioxide + water + energy

Aerobic Respiration: involving oxygen

Anaerobic Respiration: without oxygen

Aerobic Respiration in Plants

Plants make their own food by **photosynthesis.** But they also use aerobic respiration to release energy from it.

So how can the plant get oxygen?

Oxygen from the air is able to diffuse into the leaves of plants through tiny air-holes called **stomata.** This is obvious in plants as they take in oxygen at night-time and give out the carbon dioxide produced by respiration.

Respiration and Photosynthesis

Photosynthesis formula:

Carbon Dioxide + Water + Energy > Glucose + Oxygen

Aerobic respiration occurs in the opposite direction as photosynthesis. So in plants, photosynthesis is building up sugars at the same time as respiration is using them up.

Aerobic Respiration in Animals

We make two sets of breathing movements:

In called **inspiration** also called **inhalation**

Out called **expiration** or **exhalation**

The Human Breathing System

We breathe in by using 2 lots of muscles. The **diaphragm** is a muscle sheet below the lungs, which flattens and pulls down as it contracts. Then between the ribs are **intercostal muscles** which act to pull the ribcage up and outwards.

Expiration, breathing out, is a bit simpler. Usually all we have to do is to let the two sets of muscles relax, so that the diaphragm is moved back up to its original position, and our ribcage falls back into its normal place. This pushes the air out of the lungs.

Air Sacs

Breathing isn't just about making movements. It is about moving gas molecules.

The air that we breathe out has more carbon dioxide in it (4%) than we breathe in (0.04%). It has less oxygen too; the air we breathe in has about 21% oxygen whereas that which we breathe out has 16%.

The lungs

The air enters the lungs down the **trachea** which branches into the right and left **bronchi**. Each bronchus then divides further into bronchioles. After about 20 branchings you reach the air sacs, the alveoli.

Each **alveolus** has a thin layer of epithelial cells separating the air from blood capillaries - a bit like the **villi** in the digestive system.

The **alveoli** have a similar job too; they are involved in moving molecules about.

Oxygen molecules diffuse from the alveoli into the blood stream, where there is a lower concentration of oxygen. The carbon dioxide diffuses the other way, from the high concentration in the blood to the alveoli.

Anaerobic Respiration

Anaerobic respiration is an emergency system of reactions used by animal and plant cells when they cannot get enough oxygen to carry out aerobic respiration but still need to obtain energy to stay alive.

In Animals

When you sprint for a bus, your muscles use so much oxygen that you cannot supply it in time. So they cannot use aerobic respiration. Instead they use anaerobic respiration in the following way:

Glucose > Lactic Acid + Energy

This way of getting energy is not as efficient as aerobic respiration and it also leaves a poisonous chemical, **lactic acid.** This stops your muscles working and they get sore.

When you stop the lactic acid is slowly destroyed but that needs oxygen. The amount of oxygen you need for this is called the **'oxygen debt'.**

In Plants

If the roots of a plant get waterlogged they start to run out of oxygen too. So they need to use a different form of anaerobic respiration. The one they use is this:

Glucose > Ethanol + Energy

It is also the reaction used by yeast cells when they make bread or alcoholic drinks.

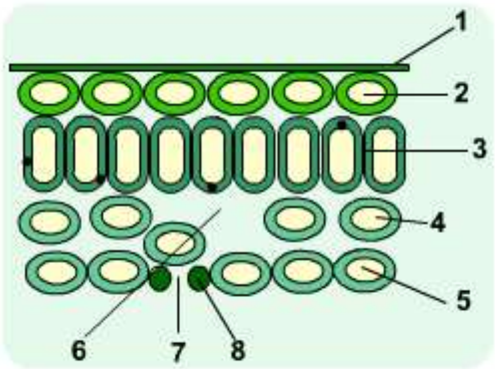
Again, like lactic acid, ethanol is poisonous - that's why it affects brain cells! If there is too much ethanol produced it will kill the cells. So it must be got rid of by using oxygen in aerobic reactions.

Otherwise the plant cells get 'pickled'- permanently!

Photosynthesis

Structure of Leaves

The **leaves** are the part of a plant where most photosynthesis takes place.



Key:

1. Waxy cuticle, this gives the leaf a waterproof layer, which lets in light.
2. Upper epidermis - provides an upper surface.
3. Palisade cells, which are packed full of chloroplasts.
4. Spongy mesophyll. Collection of damp, loosely packed cells.
5. Lower epidermis is the layer of cells on the lower surface.
6. Air space inside the leaf, allows contact between air and moist cell surfaces.
7. Stoma, a hole in the leaf which gases diffuse through.
8. Guard cells, which change shape to close the stoma.

One amazing feature of leaves is that they have tiny holes in them to let the gases carbon dioxide and oxygen enter and exit. One of the holes is called a **'stoma'**, although just to be confusing, when there are more than one they are called **'stomata'**.

A stoma is just a hole. It is controlled by two **guard cells** which change shape to either open or close the hole. Something makes water enter the cells by osmosis and so they swell up and change shape, but no-one is quite sure of the trigger.

Photosynthesis

Photosynthesis is the way that plants make their food using energy from sunlight.

What is the word equation for photosynthesis?

Carbon Dioxide + Water >>sunlight>> Sugar + Oxygen

Chlorophyll: green dye (or pigment) plants use to pick up the energy from the sunlight.

Plants make sugar and use some of it for energy to keep them alive (**respiration**) but they also use some for growth and repair by making fats and proteins.

Plants can use starch or glucose. **Starch** is insoluble (it does not dissolve in water) while glucose is soluble. This means that if starch is used, less water is required to keep its food stored.

Influencing Factors

Things which might affect how well plants can carry out photosynthesis. The amounts of **water, carbon dioxide, sunlight and temperature.**

Amount of water: effected by how much is taken up through the roots and how much is lost from the leaves. If less water is available in the leaf then photosynthesis will occur more slowly.

Carbon Dioxide: if there is less carbon dioxide around then photosynthesis will occur more slowly. There won't be enough of the fuel (substrate) to get the reaction to work

Sun: If there is less sun, which usually means it is cooler too, then there is less energy for photosynthesis and it occurs more slowly. So photosynthesis works best when it is warm and sunny - don't we all!

Photosynthesis and Transpiration

When plants have their stoma open during the day, they can let carbon dioxide and oxygen diffuse through them. However, water can also diffuse out from the moist inside of the leaf to the drier air outside. This movement of water is called **'transpiration'.**

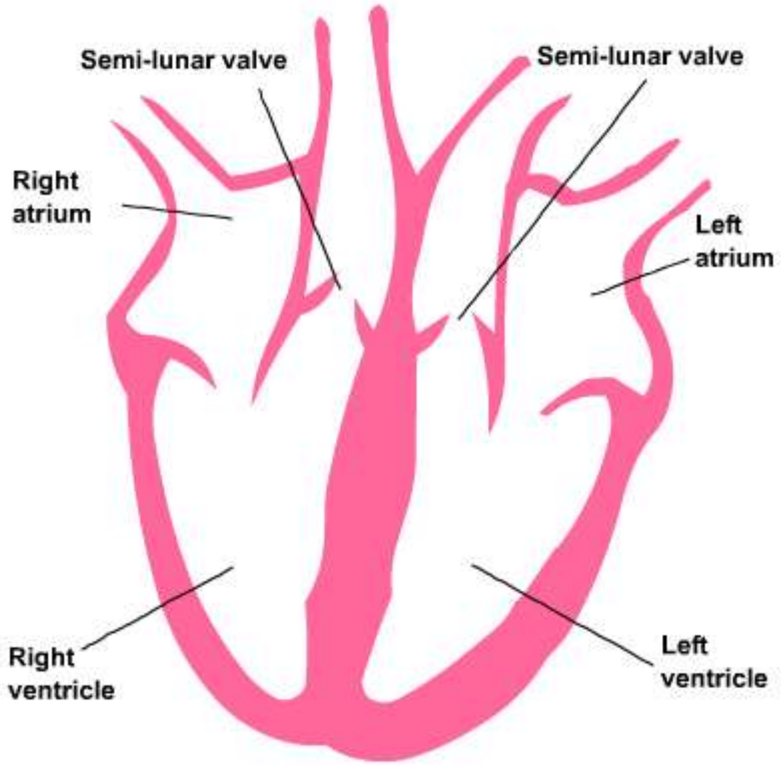
How do plants stop themselves drying out?

They close their stomata. This happens because the guard cells lose water too and go floppy. A very neat trick!

Heart and Circulation

Structure of the Heart

The adult human heart weighs about a kilogram and has four cavities inside it. These **'chambers'** are divided into two at the top called the **atria** (each is called an **atrium**) and two at the bottom, called the **ventricles.**



The diagram shows that the heart is in fact divided neatly in two down its middle so that each side has one atrium and one ventricle. Both the left and right sides of the heart pump blood. The only difference between them is where the blood arrives from and to where it is pumped.

The muscle that makes up the heart is unusual as it doesn't get tired while it pumps. But it can be damaged by drugs and poor diet leading to heart disease.

Blood Vessels

The heart pumps the blood along a series of tubes that are collectively called **blood vessels**. But they are more than just simple pipes.

Arteries

Arteries carry blood away from the heart.

Each time the heart beats it fires blood into the arteries at a high pressure, so they need to be tough so that they don't burst. They are also quite thick with only a small space, known as the **lumen**, down the centre.

Fortunately arteries are provided with a tough outer layer and another layer inside this that can cope with the stretching the pulses of blood. This elastic layer is made up of elastic fibres and smooth muscle which contracts and helps to keep the blood moving along.

The third layer that lines the lumen of the artery is called the **endothelium.** This is made up of special endothelial lining cells which give a smooth surface to the lumen.

Veins

Veins carry blood back to the heart.

The blood returning from the body is at a much lower pressure than that fired out by the beating heart. So veins do not need to be as strong as arteries. Veins have a cross-sectional structure that is very similar to arteries.

One of the obvious differences is that they have a much wider lumen and thinner walls. The other main difference is that veins have valves inside them, while arteries do not.

The valves occur occasionally along their length and ensure that blood can only travel in one direction.

Having valves in arteries would not be much use as it would slow the blood down and stop it reaching those important bits of you, like your head.

Capillaries

Capillaries are tiny, thin-walled vessels. They carry blood close to all the body's cells in its tissues and organs. They may not be the most glamorous of the vessels but they are perhaps the most important.

Capillaries are made up of a single layer of endothelial cells around a very small lumen.

Molecules can easily move into and out of the capillaries by diffusion. This allows food, gas and waste molecules to be taken to and from every cell in the body.

The Circulatory System

The heart and blood vessels carry out a transport function. They carry food molecules, water and oxygen to cells and remove waste products such as carbon dioxide. They form the **circulatory system.**

A double circulation

Instead of just being a single loop the circulation has two interconnected loops, in a sort of figure of eight.

Blood returns from the body to the **right atrium.** The blood has lost most of the oxygen it carries and is now **deoxygenated.**

The **right ventricle** pumps the blood along the **pulmonary artery** to the lungs where it picks up fresh oxygen. It is now **oxygenated.**

The **oxygenated** blood enters the left side of the heart and is pumped out through the **aorta** to the body.

Once it reaches the capillaries around the body, oxygen diffuses out to the surrounding cells.

The deoxygenated blood is carried back towards the heart in the veins. These join up to form the **vena cava** which is the largest vein.

Useful tip: One sneaky exam fact is that veins only carry deoxygenated blood except for the pulmonary vein. This is the only one that carries oxygenated blood because it takes blood from the lungs to the left heart ready to get pumped round the body.

The hepatic circulation

This is a special part of the circulation system.

Normally the circulation system takes blood straight back from the capillaries in each organ or tissue.

But the blood from the digestive system carries all sorts of molecules that have been absorbed there. In order to stop the rest of the blood system getting clogged up there is a special detour. It is called the **hepatic portal system.**

Hepatic means to do with the liver. The liver is the factory organ of the body. It deals with all sorts of chemicals, breaking them down and rearranging them.

The **hepatic portal vein** carries blood to the liver. Then the blood can leave the liver for the heart.

The Blood

Blood isn't just a red liquid. It is five litres of a careful mixture of plasma and blood cells. These cells come in three varieties: red, white and platelets.

Plasma

The **plasma** makes up most of the blood. It is mainly water but carries lots of other essential ingredients.

The following substances are carried in the plasma:

1. **Dissolved carbon dioxide:** This is the waste gas produced by respiration in cells
2. **Dissolved glucose and amino acids:** Food molecules for respiration, building and repairing cells
3. **Urea:** Waste product of digestion, this is lost from the kidney.
4. **Antibodies and antitoxins:** Chemicals that protect us from disease and poisons
5. **Hormones:** Chemicals that control some of our body functions

Plasma has a yellowish appearance. It sometimes oozes out of blisters. Nice!

Red Blood Cells

The best known of the cells are the red blood cells, correctly called **erythrocytes.**

Erythrocytes contain the oxygen carrying molecule haemoglobin; this is a special pigment that gives blood its red colour. Iron is needed in the production of haemoglobin; if your diet lacks this mineral you can develop the condition anaemia.

Red blood cells are unlike other cells in that they do not contain a **nucleus.** They are really just a bag containing the haemoglobin. The cells have a doughnut-shape with a flattened centre instead of a hole.

White Blood Cells

When blood picks up oxygen we say that it has been oxygenated. This happens because haemoglobin molecules form weak bonds with oxygen to make a new complex molecule called **oxyhaemoglobin.**

Platelets

Platelets are fragments of larger cells. Their job is to form part of a clot so that they plug a wound and stop too much blood being lost.

Nutrition

Food types

We eat all sorts of food. It all looks very different, but if we examine it closely we can spot different food types.

There are three main food types:

Carbohydrates: Used to give us energy and come from sugary or starchy foods

Proteins: Important for building up muscle and other cells.

Fats: Also used to give energy but have other uses too.

However, there are another four types of chemicals that are sometimes described as being 'food types'. **These include:**

Minerals: Simple ions (charged atoms) such as calcium, iron and fluoride.

Vitamins: More complex organic molecules.

Both Minerals and Vitamins are needed in only tiny amounts but have critical uses in the body and their absence causes disease.

Roughage: The indigestible bits of food that our body cannot cope with and so pass through unaffected.

Water: Also get this through drinks and in our food.

Food deficiencies

Without enough protein we cannot grow properly or be able to repair our cells. This problem is also seen in areas of the world suffering from famine - people can develop swollen abdomens from a disease called **kwashiorkor.**

Food Tests

We can test for protein using the **Biuret test.** This involves adding the piece of food to a copper sulphate solution with a little sodium hydroxide added. The light blue colour changes to purple if proteins are present.

Food contains fat if a white emulsion (tiny droplets of fat in water) is made after mixing the food with water and ethanol. This is called the **alcohol emulsion test.**

Carbohydrates come either as **starch** or **sugars.**

If you add a few drops of iodine to food it will go blue/black if starch is present.

For sugars we can use **Benedict's test.**

Digestion

The whole point of the digestive system is to **'digest'**, or break down, your food from large molecules small molecules that your cells can use for things such as respiration.

Starters: down to the stomach

The start of the process of digestion occurs in the mouth using the teeth and tongue.

There are four different types of human teeth:

1. Incisors for cutting.
2. Canines for piercing.
3. Pre-molars for cutting and crushing.
4. Molars for crushing and grinding.

All teeth have the similar features.

After the food has been mechanically broken up it is also mixed with **saliva** which moistens it and adds the enzyme **salivary amylase** which begins to digest **starch.**

The tongue helps to form the food into a small, moist ball called a **bolus**, which can be easily swallowed.

The bolus is squeezed down the **oesophagus (gullet)** by wavelike contractions of the surrounding muscle. This is called **peristalsis.**

Peristalsis occurs throughout the length of the **digestive system.**

Main course: stomach and beyond

In the stomach, the food is mixed up with **hydrochloric acid**, which acidifies the food, helping to soften it further and kill any nasty bugs. The acid conditions also allow a protease enzyme called **pepsin** to start to act on any proteins in the food.

The stomach continually churns up the food so that it is in a nice sloppy mess!

A ring of muscle called a **sphincter** is relaxed to allow the food out of the stomach. Next it passes into the small intestine, or if you want the fancy names, the **duodenum** and the **ileum** (both parts of the small intestine). In the duodenum the food is mixed with **bile**, which is made in the liver but stored in the **gallbladder**. This emulsifies any fats in the food, breaking them up into small globules and allows **lipase enzymes** to attack them.

The **pancreas** secretes alkali, protease, carbohydrase and lipase enzymes into the duodenum. These further digest all the food types into their smaller molecules.

Within the **ileum**, the main part of the small intestine, more enzymes act on any remaining large molecules.

Nerves and Hormones

The nervous and hormonal systems are critical in maintaining careful control of animal life.

Nervous System: uses receptors to gather information about the function of the body and the world outside. It then provides fast response to that information, by acting on glands or muscles.

Hormonal System: made up of a number of glands throughout the body, which secrete hormones directly into the blood stream. These control a wide range of functions within the body. The action of the system is slower than the nervous system but has a more widespread and longer-lasting action.

The body is a complex interconnection of many different systems.

Nervous System

Your nervous system is divided into two parts:

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

The **peripheral nervous system** is all the other nerve fibres that connect to it.

Receptors

Receptors are specialised nerve cells, which are adapted to respond to a stimulus.

Receptors pass electrical impulses to other neurones at tiny junctions called **synapses.**

These signals allow the nervous system to co-ordinate a response.

What happens at a synapse?

Neurones 'talk' by passing a small amount of a chemical messenger between them across the **synapse.** This **neurotransmitter** then sets up the electrical impulse in the second neurone, and so it carries on.

Drugs, poisons and other chemicals can affect synapses by interfering with how the neurotransmitter is dealt.

Reflex Action

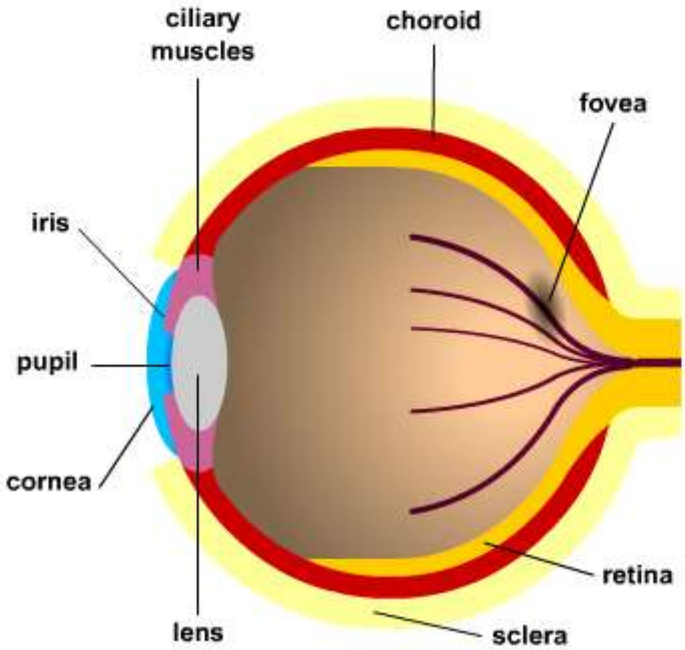
A **reflex** is a very fast, pre-programmed response to a stimulus. They are automatic so that you don't need to think about it beforehand. They act to protect the body.

The **stimulus** is picked up by a receptor, which transmits an impulse to a **sensory neurone.**

The Eye

The eye is a great example of a receptor and it also illustrates some reflex arcs too.

Structure of the eye



Hormonal System

The **hormonal system** is the second important control system in the body. It is closely connected with the nervous system, but is also distinct.

What are Hormones?

Hormones are proteins that act as chemical messengers.

They are secreted - that is they are released from glands into the blood stream. Hormones are then carried around the blood so that they can reach every cell.

Hormones in action

Hormones control a wide variety of things in the body including the amounts of water and glucose.

Hormones also control important functions including the production of eggs and sperm. They affect our growth, repair our cells, produce heat, and so on.

The **pituitary gland** controls the volume of water in the body by secreting anti-diuretic hormone (ADH) as part of homeostasis. The pituitary gland also controls other glands throughout the body.

Hormones form an essential part of our body's control system.

The Pancreas

The pancreas is a leaf-shaped organ just below the stomach. It has a complex function in the body. It secretes an **alkaline solution** containing enzymes into the digestive tract. But it also contains cells that **secrete hormones** into the blood stream.

Two of these are important in controlling the level of glucose in the blood stream.

Why is Glucose Important?

Glucose is the basic fuel for aerobic respiration and is needed by all cells. The heart and brain use glucose as their sole fuel supply.

Too little glucose

When there is too little glucose in the blood, it is detected. The pancreas secretes the hormone **glucagon.**

This causes the liver to convert glycogen back into glucose. When this gets back into the blood it returns the glucose level to normal.

Too much glucose

When we have too much glucose in our blood, we secrete **insulin** to store it for later.

Diabetes

Diabetes mellitus is a disease in which the pancreas cannot produce enough insulin.

As a result, a diabetic cannot store glucose as glycogen for later use. So they use up all the glucose in their blood and then go into a coma.

One treatment is to inject insulin after a meal. This stores the extra glucose as glycogen. Therefore they will have enough glucose for later on.

Diabetics have to test their blood regularly to monitor their blood glucose. When it gets too high they inject insulin. If it is too low, they eat something.

Defence against Disease

The Invaders

We often say that 'germs' cause diseases. What do we mean by this?

We mean that **microbes** invade our bodies and cause damage. The commonest types of microbes are **bacteria** and **viruses.**

Other microbes that rarely cause damage include some microscopic parasites and fungi.

Bacteria

Bacteria are fairly small cells and have a variety of different shapes.

These are:

Spheres known as 'cocci'.

Rods know as 'bacilli'.

Spirals know as 'spirilli'.

Unlike other cells, bacterial cells have **no nucleus.** Their genetic material (DNA) is free within the **cytoplasm.** They replicate themselves by dividing into two.

A **cell wall** surrounds bacterial cells but is not made of cellulose like plant cell walls. This cell wall gives protection to the bacterial cell membrane and shape to the cell.

Some bacteria have a small tail called a **flagellum** which is thrashed about to propel them. Others have multiple smaller versions of these called **cilia.**

Harmful bacteria make us ill by either damaging our cells or producing poisonous toxins.

But we are full of nice, friendly bacteria too which help to keep us healthy, for example in our digestive system.

Viruses

They are not cells; they are much tinier and cannot replicate themselves. Like bacteria, viruses come in all sorts of different shapes.

No matter what shape they are viruses share some common features. They have **no nucleus.** Instead they have a surrounding protein coat that gives them their unique shape. Inside this is a string of **DNA.**

The only way viruses can make us ill is to get themselves into our cells.

So viruses can get into our cells in a variety of ways including landing on our cells and injecting their DNA into them. Others break down the cell membranes then sneak inside. Once inside our cells they hijack them and make millions of copies of themselves. Each of these can go off and invade other cells.

How does the body fight back?

Passive Protection

Passive defences are those that are set up to stop bacteria or viruses entering the body. They act as roadblocks. They are found in those places where the invaders are most likely to try to the body.

Invaders try to get inside us via five main areas:

1. The Skin
2. The Eye
3. The Respiratory System
4. The Reproductive System
5. The Digestive System

Microbes also use another means of access. They hitch a ride on or inside another organism, called a **vector.**

Active Protection

Once the body's passive defences are breached there is another line of defence. The active system of cells goes and deals with the invaders directly. This is the **immune system.**

The most important of the cells in this defence system are the **white blood cells.**

White blood cells are obviously carried around in the blood, but they can also crawl out of blood vessels and get to any cell in the body. They can go anywhere!

The immune system cells act in 3 ways:

1. Consume the invaders
2. Produce antibodies
3. Produce antitoxins

Immunisation

Immunisation is giving dead or weakened forms of the disease causing **bacteria** to a person, usually as an injection. The injection does not cause the disease but the immune system responds and **creates antibodies.** Then if the person is infected with the live bacteria another time their immune system is ready to kill the bacteria

Antibiotics

Antibiotics like penicillin are chemicals that kill bacteria. They do not hurt body cells.

They are very useful for cleaning up infections but they are useless against viruses. So next time you have a cold or 'flu they won't be any use, I'm afraid.

Homeostasis

Homeostasis means keeping a constant internal environment. It is carried out around the whole body. Homeostasis reaches from every cell up to whole organs and systems.

If there was not a constant internal environment, our enzymes would not work properly. That would mean that nothing would operate correctly and we would die.

There are basically 6 things that are essential for health and that must be controlled:

1. Carbon Dioxide
2. Urea
3. Ions
4. Sugar
5. Water
6. Temperature

A cool way to remember these 6 things is by learning this...

- **W**hen (Water)
- **S**hall (Sugar)
- **I** (Ions)
- **C**lean (CO2)
- **T**he (Temperature)
- **U**tensils (Urea)

Which Organs are involved?

Hypothalumus: monitors water, temperature and carbon dioxide content of blood.

Pituitary gland: secretes a number of hormones, a key one is ADH which is important in regulating the water content of the body.

Liver: helps to control glucose content of the body by storing it as glycogen. It is also involved in temperature regulation, acting as the body's furnace by increasing the rate of respiration when we are cold.

Lungs: involved by getting rid of carbon dioxide from the body.

Pancreas: involved in maintaining a constant amount of glucose in the body through the actions of glucagon and insulin.

Muscles: of the body can help to maintain a stable body temperature as muscular activity and shivering help to generate heat.

kidney: are involved in controlling the amount of water in the body.

Skin: is the largest organ and has a central role in maintaining a constant temperature.

Controlling Temperature

Temperature control is important for the normal operation of enzymes and cells.

The brain has a key role in co-ordinating this function. Near the bottom of the brain is a place called the **hypothalamus**, which monitors a number of key things in the body, including temperature.

When the hypothalamus detects a change in the temperature of the blood it sends impulses down neurones to the skin.

The Skin's Jobs

The **skin** is described as the biggest organ in the body. An average person has about 2 square metres of skin.

The skin keeps our water in, has a layer of fat to keep us warm and is tough enough to keep out microbes that might cause disease. It is also a great place for nerve receptors.

In addition to all of this, the skin has some interesting mechanisms to help control temperature. It can alter blood flow, hair position and the amount of sweating.

Too Hot?

When we get too hot the hypothalamus sends impulses to the skin which cause 3 things to happen:

1. **Our hairs lie flat:** so letting more heat out.
2. **We sweat:** the evaporation of this cools us down.
3. **More blood goes through the skin:** this acts like a radiator to radiate out heat.

Too Cold?

If we get too cold the hypothalamus sends other impulses so that the reverse happens:

1. **Our hairs stand up:** this traps a layer of air which acts like an insulator.
2. **We stop sweating:** this stops the heat loss by evaporation.
3. **Less blood goes through the skin:** the skin will appear paler and colder.

Controlling Body Water

We have two kidneys, which are in your lower back just where your belt goes. Their job is to clean the blood by filtering out unwanted material such as **urea, excess water, salt** and **ions.**

They are wonderfully constructed organs and do some amazing work.

The Kidney

One job that they are involved in is reabsorbing excess water so that we don't dry out. But how do they do it?

Blood enters the kidney through the **renal artery.** It is filtered and the 'clean' blood leaves via the **renal vein.** Any waste material leaves through the **ureter**, then to the bladder and the world outside!

If you cut into a kidney you see two distinct parts, the dark red outer zone called the **cortex** and the lighter inner zone, the **medulla.** If you then use a microscope and look at the cortex you begin to see lots of structures called **nephrons**. There are about 750,000 of them in each kidney.

At one end is a cup-like structure called the **Bowman's capsule.** It encloses a knot of capillaries called the**glomerulus.** These capillaries are leaky and small molecules get filtered out and end up inside the Bowman's capsule. This process is called **ultrafiltration.**

If nothing else happens then the materials, such as water and urea, will end up going all the way through the nephron, down the ureter, through the bladder and into the toilet!

However, sometimes the body needs to grab back chemicals such as water and glucose which are still useful. This happens when they move out of the fluid in the nephron back into the capillary network that twists around the nephron.

This process is called **reabsorption.**

Reabsorption means that the useful chemicals are taken back into the blood out of the nephron. They do not end up in the urine and are not lost from the body.

Too Little Water

The chemical messenger between the brain and the kidney is the hormone **ADH, Anti-Diuretic Hormone.**

The important parts of the process involve:

1. The hypothalamus in the brain, which detects the lower blood water content.
2. The pituitary gland at the base of the brain, which releases the hormone ADH.
3. The kidney, which reabsorbs the water.

In order to get back to the normal level of water in the blood we absorb more water from the digestive system, feel thirsty, and so drink more.

Too Much Water

A similar sequence of events occurs when there is too much water in the body. This time, some of the details are reversed from what they were when there was too little water.

Dealing with Kidney Failure

Dialysis

Blood is taken out of a vein and pumped through a machine that cleans it. This cleaning is done by getting the waste materials like urea to diffuse across a selectively permeable membrane into a plasma-like fluid. The 'clean' blood is then returned to the patient.

This is an expensive and time-consuming process taking about 4-6 hours that must be repeated about three times a week.

Transplant

A better way is to have a kidney transplant. Here, a healthy kidney is taken from a donor, usually someone who has sadly been killed in an accident or illness.

The kidney is then sewn into place with all of the blood vessels and tubes connected. The success rate is about 80% if the tissue types are found to be the same between donor and patient.

However the patient must take antibiotics and anti-rejection drugs for the rest of their life! Quite a daunting prospect but at least they can lead a normal life otherwise.

It just shows why Organ Donor cards are such a good idea.

Drugs

Drugs

A **drug** is a chemical that has an effect on the body. Everybody thinks that drugs are just the illegal sort. But they also include useful medicines and also legal drugs.

Illegal Drugs

The drugs that society decides are dangerous or addictive are made illegal. Using these drugs is a crime.

These are the **'street'** drugs (cannabis, cocaine and heroin for example).

Different societies at various times have different views on which drugs should be illegal.

Legal Drugs

The most obvious are the medicinal drugs, such as Penicillin, that are designed to deal with medical conditions. These are always rigorously tested, checked and their use reviewed.

However other substances in common usage are drugs too:

Caffeine is a widely used drug, but its overuse can cause tissue damage.

Likewise **tobacco** and **alcohol** are legal drugs in most countries. Yet they too can have serious health effects.

Drugs that affect our nervous systems and our mood can become addictive or habit-forming.

However the word **'addictive'** is often seen as just relating to illegal drugs. Therefore the word dependence is seen as a better alternative.

Drug dependence has two features:

1. Chemical dependence
2. Psychological dependence

Chemical Dependence

This is where the body itself adapts to the presence of the drug. When the chemical is removed the body is no longer able to function normally.

The body then goes into withdrawal symptoms such as hallucinations, fevers, nausea (feeling sick) and shakes. These are real, physical signs.

Another term for chemical dependence is **physiological dependence. Physiology** is how the body functions normally.

Psychological dependence

This form of dependence is where the person feels a need for the drug. They may also feel unable to cope without the drug.

For example: some smokers need to chew sweets after they give up because they miss having a cigarette in their mouths.

Stimulants

A **stimulant** is a drug that increases the activity of the nervous system. It can raise the alertness, emotions or mood.

Caffeine is a mild stimulant found in tea and coffee. It is pretty harmless and most peoples' lives are not affected by it. Prolonged overuse may lead to problems with the heart, stomach and pancreas.

Amphetamine and **methedrine** are stronger stimulants. They induce a feeling of boundless energy but there is a deep depression after their use.

People think that they are performing better than they actually are. The person rapidly becomes dependent and needs the drugs to maintain the highs. Continued usage can lead to personality changes and serious depression.

Depressants

Depressants reduce the activity of the nervous system. They slow down your responses and make you sleepy.

Alcohol and **barbiturates** can cause slowed reaction times and poor judgement of speed and distance. They can lead to increased risk of accidents.

Barbiturates are used as tranquillisers. Overdosing can stop you breathing. Not a good idea.

Hallucinogens

A **hallucination** is a weird interpretation of the world around you. LSD and Ecstasy can cause these, usually only with higher doses of Ecstasy.

At lower doses Ecstasy gives a feeling of boundless energy and universal love, but this mood -changing effect can lead to a growing dependence.

The feeling of energy leads to a danger of overheating, dehydration and collapse.

Solvents

These include a variety of chemicals found in everyday things like paint, glue and gas canisters. They affect your nervous system and heart.

Solvents can cause hallucinations and can have very serious effects on body and personality. They cause damage to the kidneys, lungs, brain and liver. There is also a high risk of sudden death.

Pain Killers

These are useful medical drugs used by doctors to control patients' pain. They stop the impulses from pain receptors and neurones reaching the brain.

However they are often misused and lead to strong dependence and physical deterioration. Also their cost on the street leads many into committing crime to be able to afford to buy them.

Heroin and **morphine** are powerful painkillers. They provide a feeling of sleepiness and calm when first taken. Over time the person loses all motivation. They fail to look after themselves and rapidly deteriorate physically and mentally.

Falling into crime is a major problem, including prostitution and theft.

Aspirin is also a painkiller, a very mild one. However, people do overdose on it, usually accidentally. It has harmful effects, including stomach bleeding. Yeugh!

Alcohol

In many cultures alcohol has a welcome and socially acceptable place. In limited use it helps to relax us. However if misused it has serious problems.

Contrary to popular belief, **alcohol is a depressant.** Initially it depresses your inhibitions, but then it depresses your consciousness and finally your essential functions. In other words, it can kill you!

The depressant effect leads to a loss of judgement that can lead to accidents and taking life-threatening risks.

It has a poisonous effect on the brain, liver and other organs. Long-term abuse can lead to cancer, memory loss and so on. It doesn't help your sex life either!

Alcohol dependence can see a downward spiral into loss of income, job, friends, family and life.

Tobacco

Once it was seen as the sophisticated and cool thing to use. Some still see smoking as cool and grown up.

However is now known to have very serious health risks. It kills 20, 000 people a year in the UK alone. And you pay for the privilege!

If you spend £20 a week on tobacco it is costing you £1,040 a year. If you then smoke from the age of 16 until 65, you would have spent £51,000 on the habit. That's forgetting about inflation!

What about the health effects? The nicotine in tobacco affects the nervous system and is strongly addictive but does not really affect your mood. There's no 'high'.

There are also hundreds of cancer-causing chemicals in burning tobacco. These have been proved to cause lung cancers, heart and circulation problems.

The tar from tobacco clogs up your lungs and stops them working properly. This causes diseases like emphysema and bronchitis where the person has trouble getting enough breath.

The tar also stops the cilia that clear the lungs of mucus and bacteria from working. So you develop a lovely 'smokers cough' with all that yucky stuff in it.

Genes and Genetics

Variations

Some differences, or variations, cover a whole range of things and are called **continuous variations.**

Others differences have only a very few possible options, these are called **discontinuous variations.**

Continuous variation

Some of these differences vary over a whole range, for example the height, skin colour and weight of people. We call this type **continuous variation.**

So if you lined up a hundred people you would find a whole range of heights - within sensible limits! People don't just come in set heights like shoe sizes.

Discontinuous variation

However there are other differences where there are only a few possible forms. For example, I can't roll my tongue lengthways. Can you?

Try it now in a mirror. Don't try it if there are any big, strong aggressive people about! The only options are that you can or cannot roll your tongue; you can't half roll your tongue.

Other examples of discontinuous variation are blood groups and eye colour in humans. An example that could apply to plants and animals would be resistance to a particular disease.

But how do all the various differences arise?

Where do they come from in the first place?

The answers have been found only during the last one hundred years. Differences between animals or plants come about through either genetic variation or environmental variation.

The genetic code

The **genetic code** is carried by an amazing molecule called **Deoxyribonucleic acid**, or DNA to its friends. DNA is an amazingly long and complicated molecule.

The DNA is found in the nucleus of all cells. It is formed into X-shaped bundles called **chromosomes.** In human cells, except for eggs and sperm, there are 46 chromosomes. These are divided into 23 pairs.

Each chromosome has the appearance of two knitted sausages tied together in the middle. The more scientific description would be that a chromosome is made up of two chromatids held together in the middle by a centromere. You choose which is easier to remember!

What is the genetic code?

This **DNA** strand looks a bit like a ladder twisted into a double helix. The rungs of the ladder are made up of pairs of base molecules connected to each other.

It is the order of the bases (that form the rungs across it like on a ladder) that carry the actual genetic code.

To make things a bit easier for once, there are only 4 different types of bases.

Each is usually known by the first letter of its name:

Adenine (A),

Cytosine (C),

Guanine (G)

Thymine (T)

Even easier is the fact that the order the bases join up to form the 'rungs' is fixed.

Adenine and Thymine always join together, and Cytosine and Guanine always join.

Passing on the code

The genetic code contained in our chromosomes is of no real use unless it can be used to make new cells.

The code is passed on to the new cells using either of two processes, **mitosis** or **meiosis.**

Mitosis

Mitosis is the process used during growth to make new cells within a plant or animal. It is also used during asexual reproduction, in which an individual can clone itself to produce identical offspring.

However our body often has to make new cells to replace damaged ones or as we grow. So human cells also go through mitosis in the same way as animal and plant cells but they are for growth and repair.

The offspring cells have the same number of chromosomes as the parent cells, therefore they are **diploid.**

Meiosis

Meiosis is a slightly different process. It is used to create the gametes; these are the sperm or eggs, used in sexual reproduction. The offspring produced during sexual reproduction have characteristics, selected from those of the parents.

The main difference in meiosis as compared to mitosis is that the new cells have half the number of chromosomes as the diploid 'parent' cell. One chromosome comes from each homologous pair of chromosomes. So these offspring cells are **haploid** not diploid.

Genetic Crosses

Monohybrid crosses

In a **monohybrid cross** two plants or animals, which differ at only one gene, are bred together.

Useful Vocabulary

Homozygous and heterozygous

Chromosomes come in pairs. Each chromosome in a pair will have a gene at the same point on the chromosome. There can be more than one alternative form of the gene at that point. These alternative forms are called **alleles.**

Both chromosomes in a pair have one allele for the gene. If the two alleles are the same we say that the individual is '**homozygous**' for that gene. It they are different the individual is '**heterozygous**'.

Dominant and Recessive

HH = Homozygous dominant

hh = Homozygous recessive

Hh = Heterozygous

Genotype and phenotype

When you look at someone or at a plant, you can only consider what they look like. You can't work out which alleles they have for a particular gene. You are considering their **phenotype.** This is the outward effects of the genes - what you see.

Knowing their actual combination of alleles - for example, whether they are homozygous recessive - is to know their **genotype.** To know what genes they carry.

Generations

You would soon get confused about which plants or animals you are talking about. There are the parents, then their offspring, and their offspring, etc. etc.

So, to make it nice and easy we give each generation a name.

The first plants or animals bred together are called the **Parental generation,** or P1 generation.

Their offspring are called the **First Filial generation,** or F1 generation.

Their offspring are called the **Second Filial generation,** or F2 generation.

And so on. And so on.

Selective breeding

You choose your best animals (or plants) and breed them together.

Then choose the best animals in their offspring (F1 generation).

Breed these ones again to give an F2 generation.

Carry this on over many generations until you have the **'perfect animal'** - well, the one with the best characteristics or traits that you wanted.

Why selective breeding is useful

You can easily imagine that one big reason for selective breeding is **money.**

You can save a lot of wasted money if you weed out weaker individuals. For example, you could selectively breed for disease resistance. You can also ensure that you get the maximum output and therefore are more efficient. More potatoes grown on each plant means more money.

Inherited Diseases

As humans we don't consciously go in for selective breeding. We just follow our romantic feelings.

Usually this works out fine. However, there are occasions when people discover that one of their genes actually gives rise to an **inherited disease.**

Cystic fibrosis

Sufferers of this disease produce a thick, sticky mucus which coats their airways and lungs. If it is not cleared by daily massage and physiotherapy, and treated with antibiotics, the person can get serious chest infections.

The cause of the disease was discovered in 1989 as being a **recessive allele.** This allele is carried by about 1 in 20 of people.

Haemophilia

Haemophilia is a famous blood disease. Its fame comes from the children of Queen Victoria and their offspring.

The symptoms are that blood fails to clot. The smallest wound or tooth extraction can prove fatal. A bump will not lead to a bruise but large, internal bleeding.

Sickle cell anaemia

This inherited disease causes the red blood cells to change from their usual round shape to become pointed like a sickle.

This shape change means that they get stuck in blood vessels and cannot pick up oxygen properly from the lungs.

Huntington's chorea

This is also known as **Huntington's disease.** Chorea means dancing, that's where we get the word choreography.

The symptoms of Huntington's chorea are a series of uncontrolled, dance-like movements which do not appear until the sufferer is in their forties. There is also a severe mental damage which gets worse with increasing age.

Down's syndrome

Unlike the previous examples, Down's syndrome is caused by having an **extra whole chromosome.**

Therefore, Down's syndrome is a mutation in which an extra **chromosome 21** is passed into the same egg cell during meiosis. (The other egg cell created during the same meiotic division will have no chromosome 21 at all).

If the egg cell with two chromosomes 21 becomes fertilised, the zygote will end up with three chromosomes 21. It will have a total of 47 chromosomes instead of the usual 46. This causes **Down's syndrome.**

Cloning plants

There is both natural and artificial cloning. Both produce **clones,** plants that are genetically identical to the parent plants.

Natural Cloning

The cloning process occurs through cell division mechanism of **mitosis.** It therefore allows them to undergo this form of **asexual reproduction.**

However, these plants can also reproduce using sexual reproduction (that is releasing **gametes**). This is important as it allows for genes to be shared between different individuals and then on to their offspring. This avoids the loss of genetic variation, which is the main problem of cloning.

Artificial Cloning

A small piece of branch or stem is cut from a larger plant and is perhaps dipped into an **auxin** rooting powder. In a few weeks a new plant develops.

Little do these humble gardeners realise that they are carrying out a form of **micropropagation.** This is a high-tech version of the traditional cutting approach.

In **micropropagation,** cuttings are taken from a stem and cut into smaller sections. Each section is sterilised first before adding them to a growth medium containing rooting hormones. After each develops roots it grows into a plantlet. Finally, they are hardened up by being grown in a greenhouse.

Tissue culture is another new technique that has been used for cloning plants. Here, only a few plant cells are needed. These are then added to the growth medium and hormones. They will develop into a new plant.

Cloning animals

While cloning does occur naturally within animals, it is less common. Cloning is usually restricted to cells dividing by **mitosis**, and cells splitting, as is the case of identical twins.

Genetic engineering

This technique has already been used to produce large quantities of human **insulin** using bacteria. It has been a great help to sufferers of diabetes.

In genetic engineering the gene that you want is cut out of a human chromosome using **special enzymes.**

The gene is then **fitted** ('spliced') into a length of DNA from a bacterial cell and then reintroduced back into the bacterial cell.

The bacteria is tricked into carrying out the instructions on the human gene and producing the protein, insulin.

Once the bacteria has been **cultivated** so that it multiplies many times, enough insulin is produced so that it can be filtered off and collected.

This whole process is carried out on an **industrial scale** so that masses of insulin is produced in a continuous process.

Fertilisation

Making the Gametes

Fertilisation is all about getting the gametes together.

It may not sound very romantic but that's all there is to it really. In both plants and animals, the **male** and **female gametes** meet and join. They form the **zygote**, the fertilised egg that becomes the new organism as it divides, grows and develops. In plants it is all about the male gamete, the pollen, getting to the female gamete the **ovum.**

Making Sperm

Sperm are made in a continual process in the testes. Each testis is a series of tubes in which the sperm develop.

When they are ready they are stored in the widened start of the sperm duct. Then during sexual intercourse they are fired along the sperm duct towards the urethra - the tube that extends through the penis. This process of sperm emission is called **ejaculation** and is under reflex control using muscles.

As the sperm moves along into the **urethra** it gets mixed with the secretions from the prostate gland and the seminal vesicle. These give the sperm sugars and other chemicals to fuel them during their journey to the egg. This mixture of sperm and secretion is called **semen.**

Making eggs

Eggs are formed in the ovary. Then when they are ready they are released one at a time each month. This is called **ovulation.**

The egg travels down the oviduct towards the uterus. If it is not fertilised it will pass down through the uterus, past the cervix and out of the vagina.

Female Hormones

If you study the wall of the uterus you see a roughly **28 day cycle.** It begins with the start of the bleeding or menses; it is this that gives the cycle its name, the **menstrual cycle.**

The menstrual cycle has 4 stages to it:

1. The lining of the uterus breaks down and the bleeding starts.
2. Stretches from day 4 to day 14, this is when the lining is repaired.
3. On day 14 the egg is released from the ovary.
4. The maintenance stage when the uterus is maintained in case the egg is fertilised

The different stages of the cycle are controlled by a set of four hormones:

Follicle-stimulating hormone (FSH): stimulates the ovary to get the egg ready for release. It also gets the ovary to secrete oestrogen.

Oestrogen: causes the lining of the uterus to grow and get ready for the egg. It also helps to trigger the release of the egg.

Luteinizing hormone (LH): triggers the release of the egg from the ovary once it is ready and enough oestrogen has been produced.

Progesterone: maintains the uterus lining after the egg is released. When the level of progesterone falls the lining breaks down.

Using the hormones

By knowing about what the hormones do, doctors have been able to help women to control their egg release. This allows **fertility treatment** and **contraception.**

The **Pill** is a widely used means of contraception which contains both progesterone and oestrogen. This keeps the oestrogen levels high which stops further egg release.

If **FSH** is given to women who have problems ovulating (producing and releasing eggs) it triggers oestrogen release in the ovary and stimulates egg release.

Fertilisation

Fertilisation is when the sperm meets the egg. The **erectile tissue** within the penis is filled with blood as the man becomes sexually 'aroused'. The erect penis can then be placed into the woman's vagina.

During sexual intercourse the penis is moved back and forth until **ejaculation** occurs. This reflex involves muscles around the sperm duct squeezing out the semen in a series of contractions.

The **semen** gets fired up inside the vagina. From then on they are on their own - well all 500 million or so of them.

The embryo

As the **embryo** grows it becomes surrounded by a bag called the amnion. Inside this bag is amniotic fluid, this cushions and protects the embryo.

The embryo is supplied with food, water and oxygen via the **umbilical cord** that attaches it to the **placenta.** Waste materials such as **carbon dioxide** are also removed.

The placenta is a wonderful structure that is attached to the wall of the uterus and allows a very close meeting between the baby's blood and the mother's.

The two blood streams don't mix but molecules diffuse across a thin barrier between them.

Mutations

Most of the time everything from fertilisation to birth goes well, thankfully.

However sometimes things go wrong. There seem to be mistakes made in the development of cells. This can also happen in older organisms too, we call a lot of these mistakes cancer.

The changes that are seen in the genetic code are called **mutations.**

What are mutations?

Mutations are the changes in the DNA sequence. Or in other words, changes in parts of genes in chromosomes. The base sequences are messed up!

Sometimes as little as one base might be missing or it could be a few. On other occasions a couple of bases might be swapped around.

It is also possible that during **meiosis** parts of chromosomes get damaged.

If the genetic instructions are wrong what it does will also be wrong. It might end up making an enzyme the wrong shape so that it doesn't work. Anything could go wrong!

What causes mutations?

Mutations can occur naturally. However if you are exposed to things like **nuclear radiation** including **X rays** and **UV rays**, mutations are much more likely.

Other 'nasties' include chemicals known to cause mutations, known as **"mutagens"**. Cigarette and tobacco smoke contains many carcinogens, cancer-causing chemicals.

All of these things can damage your DNA. Women must be careful what they consume or take while they are pregnant. Many substances such as alcohol, bacteria, viruses and drugs can cross through the placenta to the baby. This could cause serious damage to the developing embryo.

What effect do mutations have?

Most mutations are harmful. In developing embryos they cause **abnormal development** and **may cause early death.**

In older tissue they can cause cells to keep on **dividing uncontrollably.** These cells develop into tumours, spread into other parts of the body and so become cancers.

However, rarely some mutations can be beneficial. For example a bacterial cell might mutate into a form that shows antibiotic resistance.

Bad news for us, good news for Mr. Bacterium. Or a plant might mutate so that it grows in poorer soil in which nothing else grows.

Natural selection is thought to be brought about by these rare, **beneficial mutations.**

Evolution

Fossils

Fossils are the remains of organisms that lived millions of years ago. Usually all the original tissue has gone and only the shape is left as a mineral cast.

What are the fossils made from?

Most of the fossils that you find are made from the **hard parts of animals.** They include such things as teeth, bones and shells.

Fossils are thought to have been buried in silt or mud and broken down only very slowly. Gradually they were replaced by minerals from the surrounding ground as the surrounding ground was turned to rock. So the rock-like substance of the fossil was formed but stays separate and distinct within the rock. It lies there until you dig it up!

Other fossils can be different in that they come from the softer parts of animals or plants. An example of this might be the **"petrified forests"** that have been found in coal mines.

Petrified means 'turned to stone'. The trees that used to be in a forest where the coal mines are were slowly turned into mineral fossils. They look like tree stumps and trunks made of coal.

But it is very rare as the conditions were not often right or the rate of decay slow enough.

Darwin's ideas

Charles Darwin is the one who is credited with coming up with the idea of natural selection, although there were others too, notably the American, Alfred Wallace.

Darwin noted four things from his observations:

1. All organisms produce an abundance of offspring, many more than is necessary
2. There is a fairly constant population size over time for any particular organism
3. Within a species there is a wide range of features, due to different alleles
4. Some variations are passed on and inherited by the offspring

From these Darwin decided that all organisms struggle for survival and so have to produce many offspring to ensure that some do survive.

He also concluded that for a species to survive, the best (or 'fittest') of them must survive long enough to reproduce and pass on their genes.

Lamarck's ideas

As usual, someone else had a different idea.

Jean Baptiste de Lamarck had the idea that plants and animals evolve features according to how much they use them.

Lamarck's idea means that giraffes evolved long necks by reaching up for leaves in trees. At one time they would have had short necks but then they got longer.

Extinction

Why do some animals 'die out' and become extinct? The dinosaurs, hairy mammoth, dodo and many others are all extinct.

There are 3 ways in which extinction can occur:

1. A rapid environmental change to which they can't adapt, this could be a natural change such as flooding or manmade such as the building of a city.
2. A new threat may occur, perhaps a new predator or disease kills them
3. Failure to compete successfully against a new species.

The theory of evolution

This theory is basically that all animals and plants on Earth gradually developed, or **'evolved'**, over millions of years from a common ancestor.

Life first began as simple organisms living in water. From there organisms became more complex and gradually moved onto the land and all over the Earth.

The process took only about 3 billion (3,000,000,000) years. Only!

Environment

Adaptation	Changes made in the structure or function of an organism to suit its environment.
Carnivore	Meat-eating animal.
Community	Groups of different species living in the same area.
Competition	Two or more species which require the same food or space to live in but do not eat each other.
Decomposer	Fungi or soil bacteria that break down dead plant or animal material.
De-nitrifying bacteria	Bacteria that convert nitrates back into atmospheric nitrogen gas. Not useful.
Efficiency	A measure in percentages of how much energy is passed on from one trophic level to another.
Energy transfer	When one organism is eaten by another some of the energy stored in its cells are passed on and used.
Food chain	Connection between organisms based on who eats whom.
Food web	A more complex system of connections based on predation, but links a number of food chains.
Haber process	Industrial chemical process which takes nitrogen and hydrogen gases and produces ammonia.
Herbivore	Plant-eating animal
Legume	A plant that has root nodules containing nitrogen-fixing bacteria. e.g. clover.
Migration	The movement, often seasonal, of animals or birds from one place to another.

Niche	The site or 'function' occupied by an individual organism in the environment.
Nitrates	Ion containing one nitrogen atom and three oxygen atoms. Used by plants and converted into many complex molecules.
Nitrifying bacteria	Convert ammonia and ammonium compounds into useful nitrates.
Nitrogen-fixing bacteria	Convert atmospheric nitrogen gas into useful nitrates. Many live in root nodules of Legume plants.
Omnivore	Animal that eats plants and other animals.
Photosynthesis	Process that produces glucose by combining carbon dioxide and water through the energy derived from the Sun.
Population	The total number of individuals of one species living in a particular location.
Predator	Animal that seeks out another animal for food.
Prey	Animal that is killed and eaten by a predator.
Primary consumer	A herbivore. An animal that eats a producer - a plant.
Producer	Plants. They produce the first glucose and other molecules by photosynthesis.
Putrefying bacteria	Decompose proteins and urea from animal and plant material into ammonia and ammonium compounds. Smelly!
Pyramid of biomass	Diagram that shows the total mass of all the organisms at each stage or level of a food chain or food web.
Pyramid of numbers	Diagram that shows the total numbers of organisms at each stage or level of a food chain or food web.
Secondary consumer	Animal that eats the primary consumer.

Tertiary consumer	Animal that eats the secondary consumer.
Top carnivore	The carnivore that eats other animals but is not itself eaten by a higher predator.
Trophic level	A stage in a food chain or food web.

Plant Growth

General Structure

Typical plants main features:

Roots: helps the plant to stand up in a strong wind and obtain water

Flower: attracts insects to pollinate it

Leaf: carries out most photosynthesis

Root Hairs: draw in the most water possible

Stem: carries material up and down and keeps it upright

Travelling Up and Down

Plants obtain their food through **photosynthesis** but not all parts of the plant can do this. For example, the roots do not get any light.

This system is made up of lots of tubes or vessels that branch throughout the plant, like our circulatory system.

Xylem (pronounced "zy-lem") vessels or tubes reach up to the leaves from the roots. They carry water and mineral nutrients to all parts of the plant, especially the leaves.

Water moves from the soil into the roots by **osmosis** and then flows steadily up the xylem. As water is lost from the leaf by **transpiration** more water is drawn up through the xylem to replace it. The roots have **root hairs** on them; this increases their surface area and so allows more water to be absorbed.

Phloem (pronounced "flo-em") tubes carry the sugars such as glucose made in the leaves to all parts of the plant, including the roots. This sugar can then be stored for example as starch in a potato.

The xylem and phloem tubes are often grouped together as they travel through plants into **veins** and **vascular bundles**. For example as they pass through leaves and up stems.

Nutrients

Nutrients are chemicals that plants need in small amounts but which are essential to keep them healthy. They are similar to the vitamins that we need.

Gardeners and farmers add **fertilisers** to plants in either organic material or as chemicals. Either way they contain the nutrients required. The best known of these nutrients are **nitrates, phosphates** and **potassium**. The relative amounts of these are often shown on bags of fertiliser as an **"NPK"** ratio.

Tropisms

Some people talk to plants. It is harmless, legal and they believe it helps them grow - although others disagree.

But plants are sensitive things. They do respond to certain stimuli. A **stimulus** is anything that could cause a response.

Such a growth response shown by a plant is called a **"tropism"**. It can involve all of the plant or just a small part of it.

Such a response involving light is **phototropism.**

However things are a bit more complicated than this - aren't they always! A growth response that is towards the stimulus is called a **"positive"** tropism, whereas one that is away from it is described as a **"negative"** tropism.

Plant hormones

A **hormone** is a chemical messenger, it causes changes in how a plant or the body of an animal works.

Plants release chemicals which control the tropisms. The best known of these **'plant hormones'** are the **"auxins".**

Auxins can make the shoot of a plant grow towards the sun. For example, by getting the cells on one side to grow larger and this pushes the whole shoot around. The auxins are released from the very tips of the shoots or roots.

Plant hormones work in the same way to get roots to bend down towards gravity or water in the soil.

Environmental Problems

Atmospheric pollution

The air is always around us but we pay it little attention. It contains 78% nitrogen, 20% oxygen and 0.04% carbon dioxide and is essential for our lives.

Yet we do not seem to be too bothered about it and go on pumping all sorts of nasty things into it.

The atmosphere is a complex thing, which we do not realise is important to us. Recently we have begun to realise just how important one part of it is to us, the **ozone layer.**

The Ozone Layer

Ozone is a molecule made up of three oxygen atoms. The oxygen molecules present in air has only 2 oxygen atoms in it. So what is so different about ozone?

If you go up to 12-30 miles above the Earth's surface you find a **layer of air** which contains small amounts of**ozone gas.** The ozone molecules absorb the **ultraviolet (UV)** rays that are emitted from the Sun and which are dangerous to all living things. UV rays can increase the risk of cancers forming, such as skin cancer.

So ozone gives us a **protective blanket** high above us that reduces the amount of UV rays that get through to the Earth's surface. Therefore ozone helps protect us.

However the atmosphere's protective effect is under threat from things we do.

CFC's

CFC's are **"Chloro-fluoro-carbons"** to their friends. Although nowadays they don't have many friends.

We thought that they were great molecules at one time. They used to do useful things like running cool machines such as 'fridges' and air-conditioning units. They were in aerosols and polystyrene foam.

However, we now know that they break up ozone molecules and so destroy the layer that protects us from UV rays from the Sun. Not a good idea!

Burning Fossil Fuels

We all burn fossil fuels. We do it directly by burning coal or driving cars. We also indirectly burn fossil fuels when we use electricity generated using them.

Our cars and power stations are responsible for most of the fossil fuel burning. The gases released include **carbon dioxide, sulphur dioxide** and oxides of **nitrogen** (NO_2, NO_3, etc.). Up in the atmosphere these gases are dissolved in water and cause acid rain.

The gases also mess up the atmosphere. The extra carbon dioxide causes the **greenhouse effect.**

Leaded petrol

Not only does our cars burn a fossil fuel but the older "4 star" petrol contains the element lead.

This leaded petrol was used because it made engines run smoothly. But when it was burned it released the lead into the air. When breathed in it could damage our nervous system. Not nice.

Thankfully, more modern engines can burn **"lead-free"** petrol and so there will be less lead in the air.

Greenhouse Effect

The **greenhouse effect** is where the temperature of the Earth increases. This happens as less heat is radiated back from the Earth than is received from the Sun.

The atmosphere becomes clogged up with **"greenhouse gases"** such as carbon dioxide from burning fossil fuels and methane. This lets the heat from the Sun in but stops some of it from be radiated back out again.

Carbon dioxide

Normally there is a balance in the amount of carbon dioxide in the atmosphere. It is produced by respiration and used up in photosynthesis. So across the whole planet there is a beautiful balance as part of the **"carbon cycle".**

Methane

The other common greenhouse gas is methane. Its molecules have one carbon and four hydrogen atoms.

Marshland and bogs produce methane naturally. It bubbles up from decaying plant material.

Acid Rain

Whenever we burn fossil fuels we release waste gases such as carbon dioxide, sulphur dioxide and various oxides of nitrogen. The main sources of these are **cars** and **power stations.**

Carbon dioxide is the main cause of the **greenhouse effect.**

Sulphur dioxide and the oxides of **nitrogen** will mix with rainwater in clouds and form acidic solutions. These then fall as **acid rain.**

The Effects

Acid rain has severe effects on the environment and individual ecosystems within it. The acid rain will **kill trees** and **damage buildings** made from limestone.

The water will also make lakes and **rivers more acidic**. This will kill fish and other aquatic life.

The increased acidity of the water also allows aluminium salts to dissolve more easily. The aluminium ions are very **poisonous** to fish and birds.

Overpopulation

Overpopulation occurs when there are more people than the land can sustain.

A lower death rate is a good thing. Modern medicine and farming techniques have allowed us to reduce deaths through starvation and disease.

However the birth rate has increased alarmingly. It has resulted in population rises that are out of control, many of these are in so-called '**under-developed**' countries.

Intensive Farming

Farming is often under-rated nowadays. Modern farming practices have radically increased the efficiency of farming, producing more food from the available land.

In a lifetime we have moved from not having enough to eat to having tons of food.

Despite this **"intensive farming"** providing us with masses of cheap food there are a number of problems.

Effects on animals

Strain can be placed upon domestic animals so that they produce the best possible food yield for us. Examples include the confinement of battery hens and veal calves.

Food chains are damaged by the use of pesticides to kill insects and animals that could damage crops. The chemicals used are indiscriminate, they kill any insect. So the links in food chains are wiped out and whole communities of animals can suffer.

Fields that are intensively farmed contain only single crop species, and the crowd of plants, insects, animals and birds that used to exist there are gone. Some face extinction.

Deforestation

Deforestation is the loss of trees due to demand for timber, land and so on.

It doesn't just occur in rainforests, the deforestation happens here too. We have virtually deforested our whole country over centuries, including our hedgerows.

The rainforests are the lungs of the Earth. The rapid rate of deforestation there has critical importance.

There are 4 main effects of deforestation:

1. **Decrease in rainfall:** less trees means less transpiration and photosynthesis.
2. **Soil erosion:** the exposed soil dries out under the Sun.
3. **Serious flooding:** rainwater runs off the exposed soil rather than soaking in as before.
4. **More carbon dioxide:** the trees that used to remove the gas are gone.

Bioaccumulation

Pesticides are used to kill animal pests, and herbicides are used to kill weeds. Both can be useful types of chemicals. However, their use has problems.

One problem is **"bioaccumulation"**. These chemicals are poisonous to other animal life. If the animals at the start of a food chain take up small amounts it becomes more and more concentrated higher up until it can kill the animals at the top - including humans.

Eutrophication

Eutrophication is what happens when too much chemical fertiliser is used on crops and it washes into rivers and streams.

Organic farming

Organic farming is a phrase often used to describe traditional farming practices. It is becoming increasingly used and with scientific knowledge it is more efficient that it used to be but without being intensive.

Biological pest control

Biological pest control includes any example where an animal is chosen which will eat the pest species.

Terms and conditions