

# Cells

- **All animals and plants are made of cells.**
- Animal cells and plant cells have features in common, such as a nucleus, cytoplasm, cell membrane, mitochondria and ribosomes.
- Plant cells also have a cell wall, and often have chloroplasts and a permanent vacuole.
- **Cells may be specialised to carry out a particular function.**
- Dissolved substances pass into and out of cells by *diffusion*. Water passes into and out of cells by *osmosis*.
- This table shows the function of cells which animal and plant cells have in common.

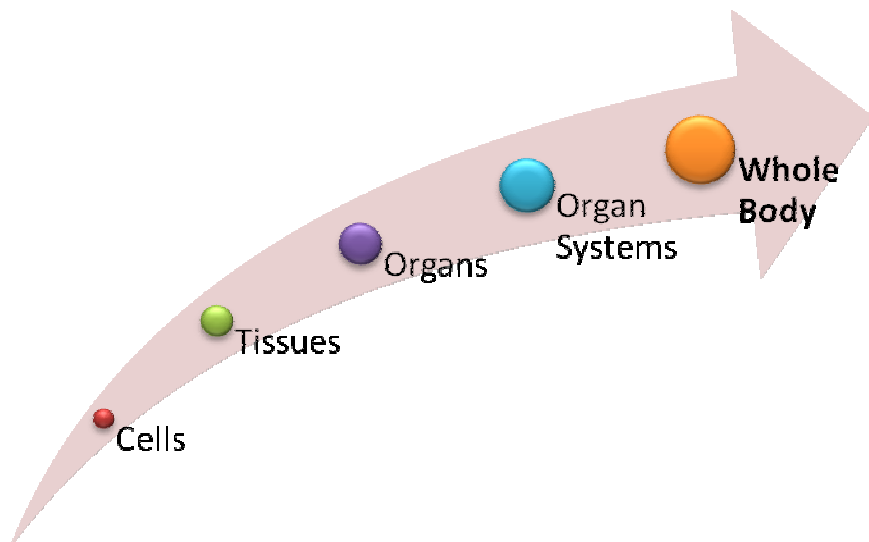
| Part          | Function(s)                                                     |
|---------------|-----------------------------------------------------------------|
| Nucleus       | Contains genetic material; controls the activities of the cell. |
| Cytoplasm     | Most chemical processes take place here; controlled by enzymes. |
| Cell Membrane | Controls the movement of substances into and out of the cell.   |
| Mitochondria  | Most energy is released by respiration here.                    |
| Ribosomes     | Protein synthesis happens here – i.e. where proteins are made.  |

- This smaller table shows that plant cells also have extra parts.

| Part              | Function(s)                                                         |
|-------------------|---------------------------------------------------------------------|
| Cell Wall         | Made of cellulose. Supports and strengthens the cell.               |
| Chloroplasts      | Contain chlorophyll, which absorbs light energy for photosynthesis. |
| Permanent Vacuole | Filled with cell sap (to help keep the cell turgid).                |

- Smallest living organisms are single cells – these can carry out all functions of life, from feeding and respiration to excretion and reproduction.
- Most organisms are bigger and are made up of lots of cells, some of these become specialised to carry out particular jobs.
- Good examples of **specialist cells** are sperm, eggs, red blood cells and nerve cells.
- For example, a sperm cell's function is to fertilise an egg cell:

- o The head contains genetic information and an enzyme to help penetrate the egg cell membrane.
  - o The middle section is packed with mitochondria for energy.
  - o The tail moves the sperm to the egg.
- Another example are red blood cells, which contain haemoglobin to carry oxygen to the cells:
  - o Thin outer membrane to let oxygen diffuse through easily.
  - o Shape increases the surface area to allow more oxygen to be absorbed efficiently.
  - o No nucleus, so the whole cell is full of haemoglobin.
- Below is a diagram showing how cells build up to form different stages of structure:



- **Diffusion** is the passive movement of particles from an area of high concentration to an area of low concentration.
- *This is how the smell of cooking travels around the house from the kitchen, for example.* Particles diffuse down a concentration gradient, from an area of high concentration to an area of low concentration.
- **Osmosis** is the movement of water molecules across a partially permeable membrane from a region of high water concentration to a region of low water concentration.
- In practice, when the concentration is the same on both sides of the membrane, the movement of water molecules will be the same in both directions. At this point, the net exchange of water is zero and there is no further change in the liquid levels.

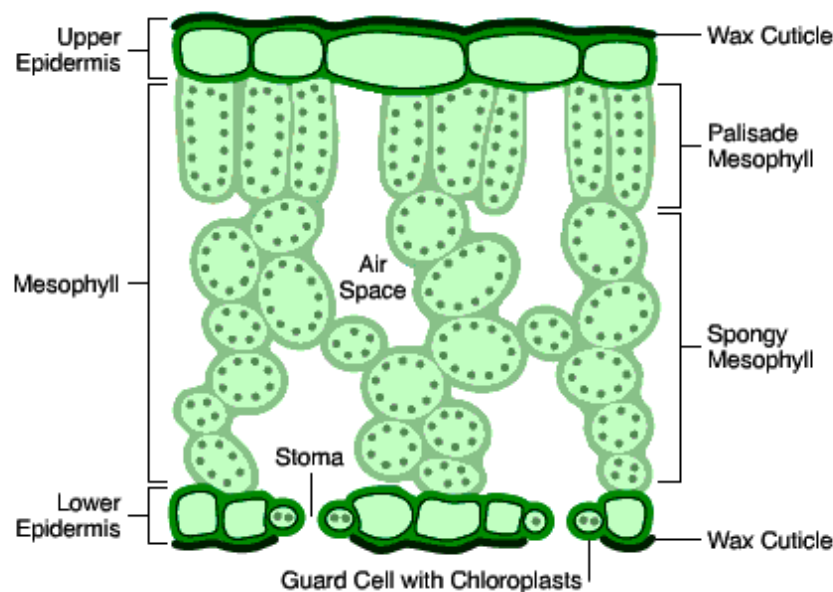
- *Osmosis is important to plants. They gain water by osmosis through their roots. Water moves into plant cells by osmosis, making them turgid or stiff so they are able to hold the plant upright.*

## Plants

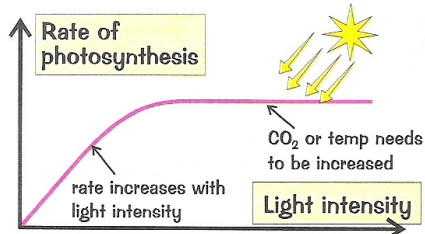
- Green plants absorb light energy using chlorophyll in their leaves. They use it to react carbon dioxide with water to make a sugar called glucose. The glucose is used in respiration, or converted into starch and stored. Oxygen is produced as a by-product.
- This process is called photosynthesis:

**carbon dioxide + water (+ light energy) → glucose + oxygen**

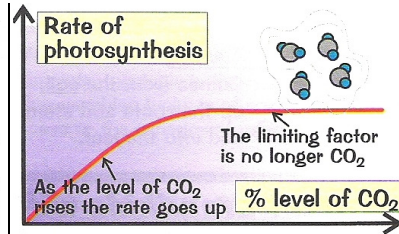
- Temperature, carbon dioxide concentration and light intensity are factors that can limit the rate of photosynthesis.
- Plants also need mineral ions, including nitrate and magnesium, for healthy growth. They suffer from poor growth in conditions where mineral ions are deficient.
- FOUR THINGS ARE NEEDED FOR PHOTOSYNTHESIS TO OCCUR:
  1. **Light** – from the sun.
  2. **Chlorophyll** – absorbs energy in sunlight and harnesses it to combine  $\text{CO}_2$  and  $\text{H}_2\text{O}$  to make  $\text{C}_6\text{H}_{12}\text{O}_6$ .
  3. **Carbon dioxide** – enters leaf from surrounding air.
  4. **Water** – comes from soil; up the roots and stems; into leaf.



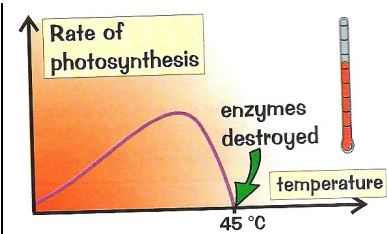
- Three factors can limit the speed of photosynthesis – light intensity, carbon dioxide concentration and temperature.
- There are three important graphs to show the rate of photosynthesis:



**Light provides energy needed for photosynthesis.** As the light exposure level is raised, the rate of photosynthesis increases steadily. As the graph flattens out, this shows that light intensity is no longer a limiting factor.



**CO<sub>2</sub> is one of the raw materials needed for photosynthesis.** The amount of CO<sub>2</sub> will only increase the rate of photosynthesis up to a point. As the graph flattens out, this shows that CO<sub>2</sub> is no longer a limiting factor.



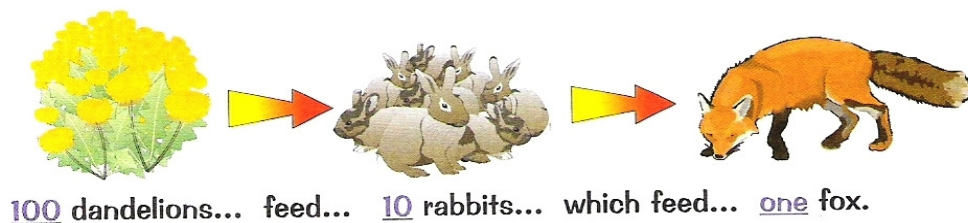
**The temperature has to be just right,** as if the temperature is the limiting factor, it is because it is too low – the enzymes needed for photosynthesis work more slowly at low temperatures.

- *Farmers can use their knowledge of these limiting factors to increase crop growth in greenhouses. They may use artificial light so that photosynthesis can continue beyond daylight hours, or in a higher-than-normal light intensity.*
- The use of **paraffin lamps** inside a greenhouse increases the rate of photosynthesis because the burning paraffin produces CO<sub>2</sub> and heat too.
- **Plants make glucose when they photosynthesise.** This glucose is vital for their survival. Some of the glucose produced during photosynthesis is immediately used by the cells of the plant. Once the plants have made the glucose, there are several ways they can use it.
  1. **RESPIRATION:** Plants manufacture glucose in their leaves, which they use for respiration, releasing energy, enabling them to convert the rest of the glucose into various other useful substances, which they can use to build new cells and grow.
  2. **MAKING FRUIT:** Glucose, along with another sugar called fructose is turned into sucrose for storing in fruits.
  3. **MAKING CELL WALLS:** Glucose is converted into cellulose for making cell walls.
  4. **MAKING PROTEINS:** Glucose is combined with nitrates to make amino acids, which are then made into proteins.

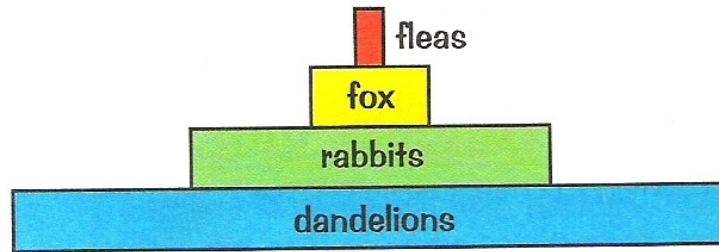
5. STORED IN SEEDS: Glucose is turned into lipids (fats and oils) for storing in seeds. Seeds also store starch.
  6. STORED AS STARCH: Glucose is turned into starch and stored in roots, stems and leaves, ready for use when photosynthesis isn't happening, like in the winter.
- **Plants need to take in a number of elements to stay alive. The most important are carbon, hydrogen and oxygen.**
  - Plants get hydrogen and oxygen from water in the soil, and carbon and oxygen from carbon dioxide and oxygen in the atmosphere.
  - Water and carbon dioxide are used to synthesise food during photosynthesis.
  - Oxygen is used to release energy from food during respiration.
  - In addition to these three elements, plants need a number of minerals for healthy growth. These are absorbed through the roots as mineral ions dissolved in the soil water. Two important mineral ions needed by plants are:
    - Nitrate** for making amino acids, which are needed to make proteins.
    - Magnesium** for making chlorophyll.
  - If a plant does not get enough minerals, its growth will be poor. It will suffer from deficiency symptoms:
    - Deficient in nitrate** – it will suffer from stunted growth.
    - Deficient in magnesium** – its leaves will turn yellow.

## Pyramids of Biomass

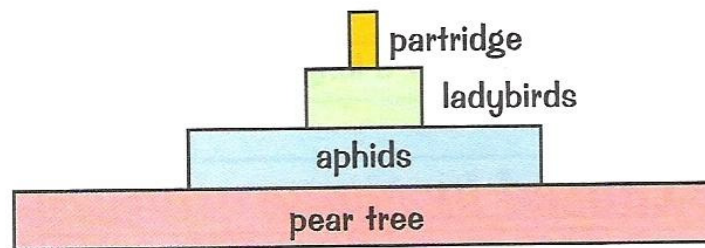
- **Pyramids of biomass reveal the mass of living material at each stage in a chain.**
- The amount of material and energy decreases from one stage to the next.
- Here is an example of constructing a pyramid of biomass:



- Each bar on a pyramid of biomass shows the mass of living material at that stage of the food chain – how much all the organisms at each level would “weigh” if you put them all together:



- The big bar along the bottom of the pyramid always represents the producer (i.e. a plant). The next bar will be the primary consumer (the animal that eats the plant), then the secondary consumer (the animal that eats the primary consumer), and so on up the food chain.
- An example of interpreting a pyramid of biomass would be...



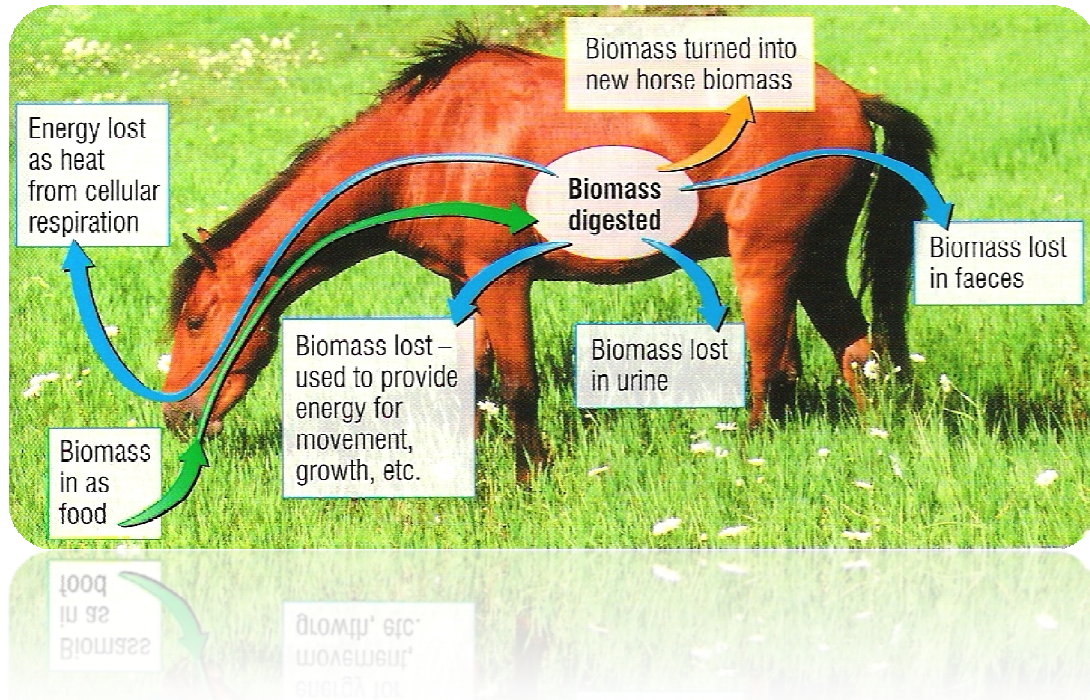
- There are probably thousands of aphids feeding on a few big pear trees. Quite a lot of ladybirds are then eating the aphids, and a few partridges are eating the ladybirds. *Biomass and energy are still decreasing as you go up the levels – it's just that one tree can have a very big biomass, and can fix a lot of the Sun's energy using all those leaves.*

## Energy Transfer

- Energy is transferred along food chains from one stage to the next.
- However, not all of the energy available to organisms at one stage can be absorbed by organisms at the next one. The amount of available energy decreases from one stage to the next.
- Some of the available energy goes into growth and the production of offspring. This energy becomes available to the next stage, but most of the available energy is used up in other ways:
  1. **Energy released by respiration is used for movement** and other life processes, and is eventually lost as heat to the surroundings.

2. **Energy is lost in waste materials**, such as faeces.

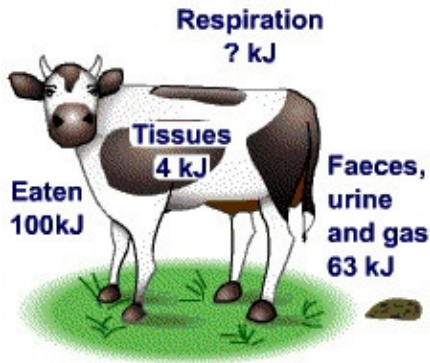
- All of the energy used in these ways returns to the environment, and is not available to the next stage.
- *Most food chains are fairly short – there are rarely more than four stages, because a lot of energy is lost at each stage.*



## Food Production

- **The efficiency of food production can be improved by reducing the amount of energy lost to the surroundings.** This can be done by:
  1. Preventing animals moving around too much.
  2. Keeping their surroundings warm.
- Mammals and birds maintain a constant body temperature using energy released by respiration. As a result, their energy losses are high.
- Keeping pigs and chickens in warm sheds with little space to move around allows more efficient food production.
- However, this raises moral concerns about the lives of such animals.
- In reality, **a balance must be reached between the needs of farmers and consumers and the welfare of the animals.**
- Calculating energy efficiency is important in food production. An example of how to do this is shown on the next page...

- A bullock has eaten 100 kJ of stored energy in the form of grass, and excreted 63 kJ in the form of faeces, urine and methane. The energy stored in its body tissues is 4 kJ. So how much has been used up in respiration?



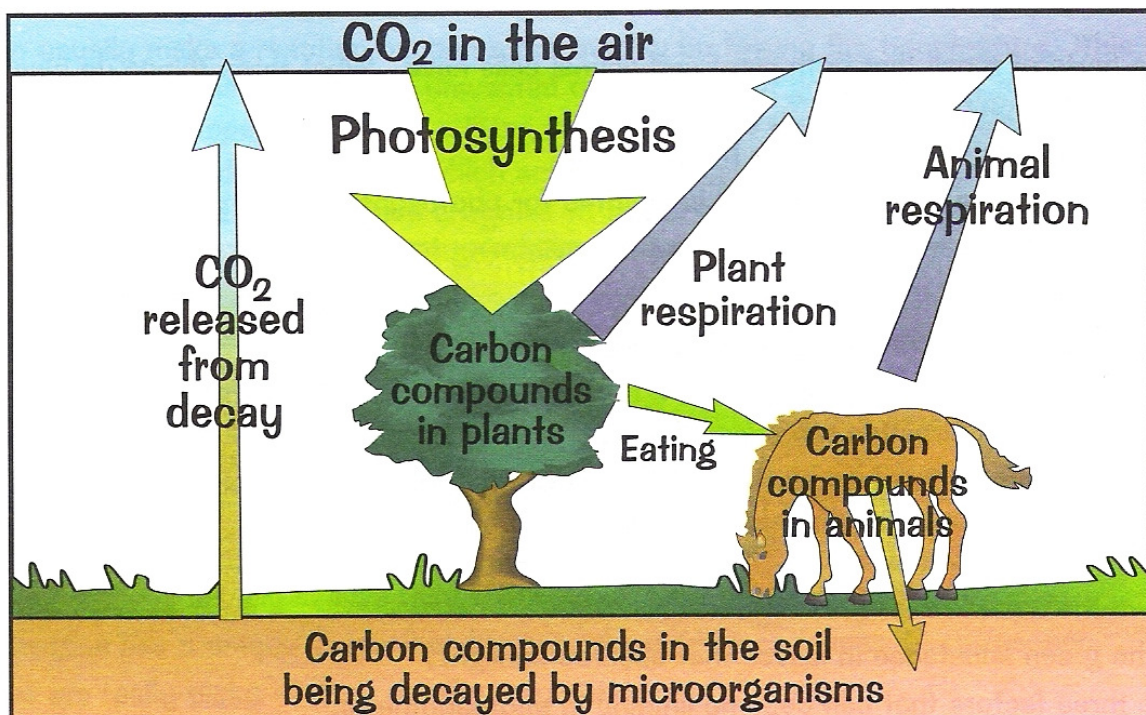
The energy released by respiration =  $100 - 63 - 4 = 33$  kJ.

Only 4 kJ of the original energy available to the bullock is available to the next stage, which might be humans.

Therefore, the efficiency of this energy transfer is  $(4 \div 100) \times 100 = \underline{4\%}$ .

## The Carbon Cycle & Decay

- All cells – whether animal, plant or bacteria – contain carbon, because they all contain proteins, fats and carbohydrates.
- Plant cell walls, for example, are made of cellulose – a carbohydrate.
- Carbon is passed from the atmosphere, as  $\text{CO}_2$ , to living things, passed from one organism to the next in complex molecules, and returned to the atmosphere as  $\text{CO}_2$ : this is known as the carbon cycle.

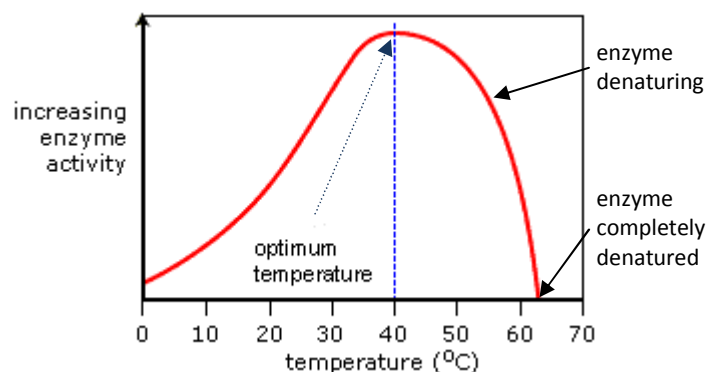


- Materials from living things decay because microorganisms (known as **detritus feeders**) digest them – this process happens faster in warm, moist conditions with plenty of oxygen.
- During the decaying process, CO<sub>2</sub> is released back into the atmosphere as these organisms respire.
- Decay can be very slow in cold, dry conditions, and when there is a shortage of oxygen.

## Enzymes & Digestion

- **Enzymes are biological catalysts.** There are optimum temperatures and pH values at which their activity is greatest. Enzymes are also proteins, and usually denatured above about 45°C.
- Enzymes are important in respiration and digestion. Aerobic respiration releases energy from glucose. Digestion is the breakdown of carbohydrates, proteins and fats into small soluble substances that can be absorbed into the blood.
- *Lipases and proteases are used in biological detergents, and enzymes are used in the manufacture of food and drink.*
- Enzymes are also proteins that are folded into complex shapes that allow smaller molecules to fit into them. The place where these substrate molecules fit is called the active site.
- If the shape of the enzyme changes, its active site may no longer work. We say the enzyme has been denatured. They can be denatured by high temperatures or extremes of pH.

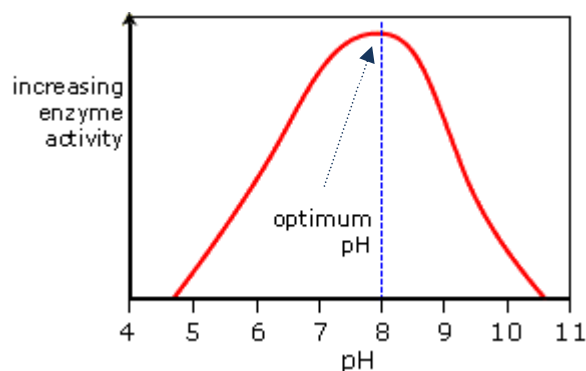
- **As the temperature increases, so does the rate of reaction.** Although very high temperatures denature enzymes.
- The graph shows the typical change in an enzyme's activity with increasing temperature. The enzyme activity gradually increases with temperature until around 37°C (body temperature). Then, as the temperature continues to rise; the rate of reaction falls rapidly, as heat energy denatures the enzyme.



- **Changes in pH alter an enzyme's shape.**

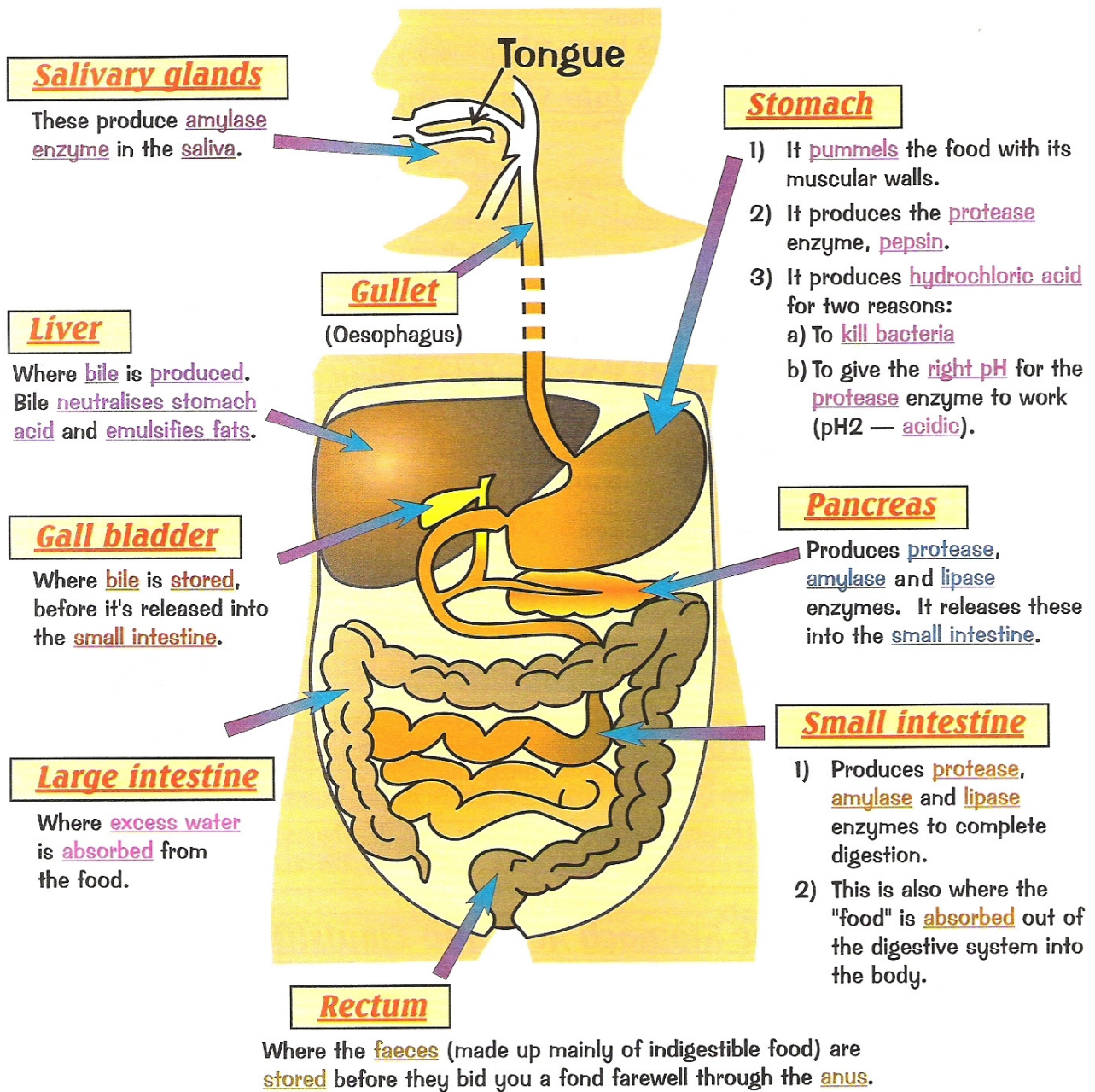
**Different enzymes work best at different pH values.** The optimum pH for an enzyme depends on where it normally works.

- However, for most enzymes, the optimum pH is around 7.



- Respiration is not the same thing as breathing – breathing is really ventilation. Instead, respiration is a chemical process in which energy is released from food substances, such as glucose – a sugar.
- **Aerobic respiration needs oxygen to work.** Most of the chemical reactions involved in the process happen in tiny objects inside the cell cytoplasm, called **mitochondria**.
- This is the equation for aerobic respiration:  
**glucose + oxygen → carbon dioxide + water (+ energy)**
- The energy released by respiration is used to make large molecules from smaller ones. In plants, for example, sugars, nitrates and other nutrients are converted into amino acids. Amino acids can then join together to make proteins.
- The energy is also used to...
  - Allow muscles to contract in animals.
  - Maintain a constant body temperature in birds and mammals.
- **Some enzymes work outside of cells.**
- The main group of these is the DIGESTIVE ENZYMES.
- Digestive enzymes are either produced by glands (which have specialised cells for the purpose) or by specialised cells lining the digestive tract (mainly the small intestine). The purpose of digestive enzymes is to speed up the breakdown of large molecules in food into smaller molecules which can then be absorbed into the blood.

| Enzyme              | Use(s)                                                                                             |
|---------------------|----------------------------------------------------------------------------------------------------|
| <b>Protease</b>     | Used to predigest proteins during the manufacture of baby foods.                                   |
| <b>Lipase</b>       | Biological detergents to break down substances in stains into smaller, water soluble substances.   |
| <b>Carbohydrase</b> | Used to convert starch syrup, which is relatively cheap, into sugar syrup, which is more valuable. |



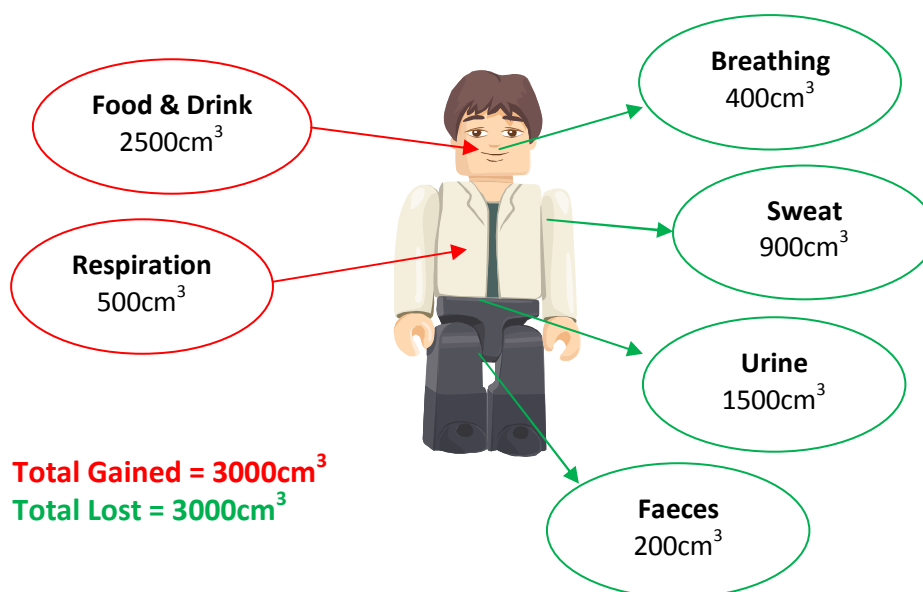
## Homeostasis

- Homeostasis literally means “staying the same”, and is the word used to describe how living things maintain a constant internal environment.
- In humans, there are three key areas that are controlled by homeostasis. These are:
  - Core body temperature.
  - Water balance/Ion content.
  - Blood glucose level.

- There is a **thermoregulatory centre** in the brain which acts as your own personal thermostat. It contains receptors that are sensitive to the temperature of the blood flowing through the brain.
- The thermoregulatory centre also receives impulses from the skin, providing information about skin temperature. If you're getting too hot or too cold, your body can respond to try and cool you down or warm you up.

| WHEN YOU'RE TOO HOT...                                                                                                                                                                                                                                                                                                                                     | WHEN YOU'RE TOO COLD...                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Hairs lie flat.</li> <li>• Sweat is produced by sweat glands and evaporates from the skin, which removes heat.</li> <li>• Blood vessels supplying the skin dilate so more blood flows close to the surface of the skin. This makes it easier for heat to be transferred from blood to the environment.</li> </ul> | <ul style="list-style-type: none"> <li>• Hairs stand up to trap an insulating layer of air.</li> <li>• No sweat is produced.</li> <li>• Blood vessels supplying skin capillaries constrict to close-off the skin's blood supply.</li> <li>• When you're cold you shiver too. This needs respiration, which releases some energy as heat.</li> </ul> |
| <b>VASODILATATION OCCURS</b>                                                                                                                                                                                                                                                                                                                               | <b>VASOCONSTRICTION OCCURS</b>                                                                                                                                                                                                                                                                                                                      |

- The amount of water gained by our bodies must be balanced by the amount of water lost by our bodies.
- The amount of water in our bodies is controlled by the kidneys, which reabsorb the necessary amount of water back into our blood.
- To maintain water balance the concentration of blood plasma is monitored by the brain.



- **Urea is one of the main waste products of the body. It is produced in the liver when excess amino acids are broken down.**
  - When you eat more protein than you need or when body tissues are worn out, the extra protein has to be broken down.
  - Amino acids cannot be used as fuel in the body.
  - But in your liver, the amino group is removed and converted into urea.
  - Urea is poisonous and if levels build-up in your blood, it will cause a lot of damage.
  - Fortunately, urea is filtered out of your blood by the kidneys, removed in urine along with any excess water.
- 
- It is important that the level of glucose in your blood is carefully kept within the “normal” upper and lower limits. If it goes above or below these values without being corrected then it can lead to very serious health problems.
  - The control of blood glucose level is down to the pancreas which produced the two hormones, insulin and glucagon which are used to control blood glucose levels.
  - **The pancreas monitors and controls the concentration of glucose in the blood. It produces a hormone called insulin.**
  - Insulin causes glucose to move from the blood into cells. It lowers the blood glucose concentration if it has become too high.
  - *This can happen after eating a meal that is rich in carbohydrates (for example, sweets, potatoes, bread, rice or pasta).*
  - If a person’s pancreas does not produce enough or any insulin then they suffer from DIABETES. This means that the level of glucose in their blood continues to fall below the ideal range and so the pancreas begins to secrete glucagon.
  - *There are two types of treatment for diabetes:*
    - *Careful monitoring of food intake, with particular care taken over carbohydrates – which are digested into glucose.*
    - *Injecting insulin into the blood before meals. The extra insulin causes glucose to be taken up by the liver and other tissues. Cells get the glucose they need for respiration, and the blood glucose concentration stays normal.*

## Cell Division

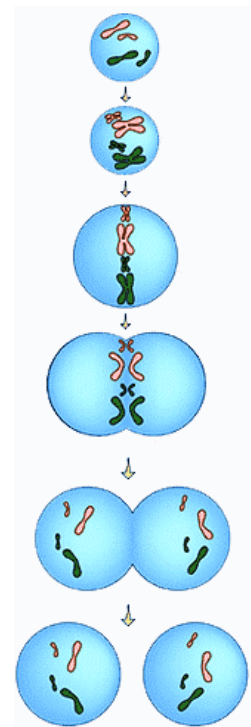
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- **Inside the nucleus of cells we have the genetic information.**
- This consists of DNA (Deoxyribose Nucleic Acid).
- Chromosomes are made of large molecules of DNA.
- On each chromosome are small sections of DNA called genes.

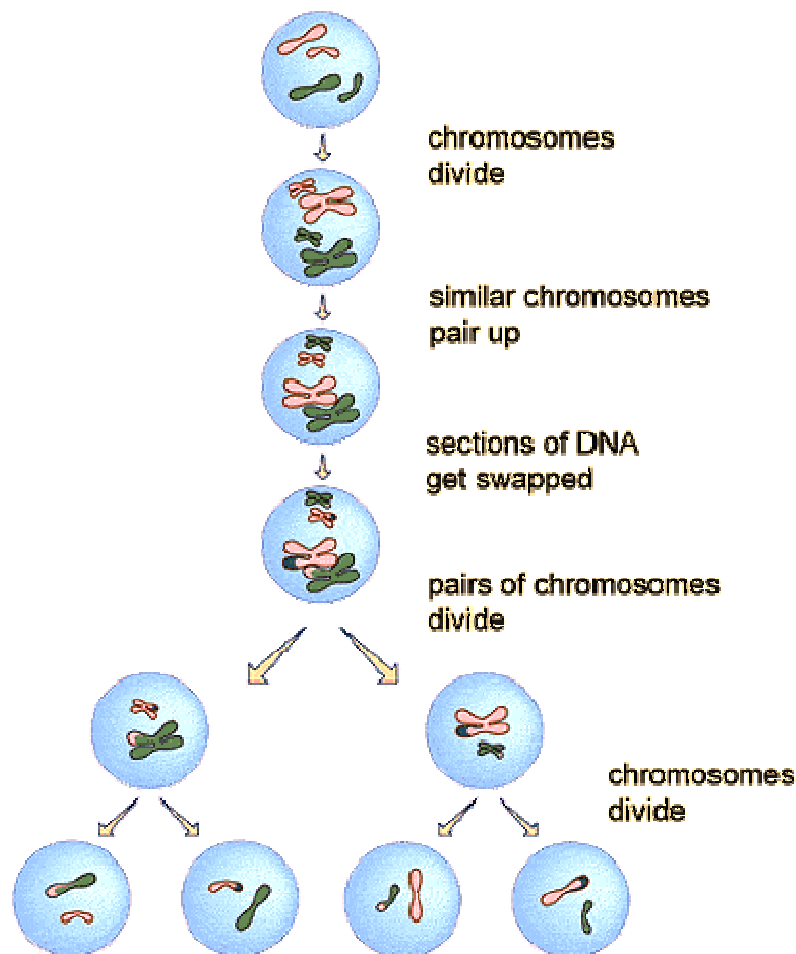
- Each gene is responsible for controlling one characteristic or feature – e.g. hair colour, eye colour etc.
- Different versions of the same gene are called ALLELES; i.e. brown eye allele = B and blue eye allele = b.
- **For each characteristic controlled by a gene, you will have to have two alleles that control it.**
- **Alleles can be described as:**
  - **Dominant:** this will control the characteristic/feature if only one of these alleles is present.
  - **Recessive:** will control the characteristic/feature only if both alleles are the recessive type; i.e. no dominant alleles present.
- Humans have 46 chromosomes arranged into 23 pairs (one set of 23 from your mum and 23 from your dad).
- 22 of these pairs contain the same genes (but different alleles).
- The 23<sup>rd</sup> pair are the sex chromosomes, either:
 

|                    |                   |
|--------------------|-------------------|
| <b>XX</b> = female | (from the mother) |
| <b>XY</b> = male   | (from the father) |
- Each person (apart from identical twins) has their own unique DNA. The process of DNA fingerprinting can be used to identify individuals due to this uniqueness: e.g. identifying suspects in crimes, identifying unknown/unrecognisable dead bodies.

- **Mitosis is the type of cell division that leads to growth or repair.**
- When a cell divides by mitosis:
  - Two new cells form.
  - Each cell is identical to the other one, and the cell they were formed from.
- Stages of mitosis:-
  1. Parent cell.
  2. Chromosomes make identical copies of themselves.
  3. They line up along the centre.
  4. They move apart.
  5. Two daughter cells form with identical chromosomes to the parent cell.



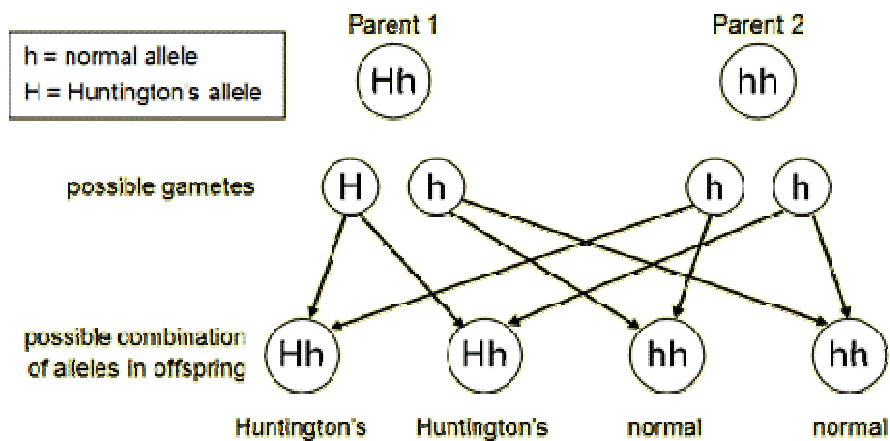
- **Gametes are formed** from cells in the reproductive organs by a type of cell division called **meiosis**.
- The cells that are formed by meiosis have half as many chromosomes as the cell that formed them. Human body cells contain 23 pairs of chromosomes, while human gametes contain 23 single chromosomes.
- The main features of meiosis are:
  - The chromosomes are copied.
  - The cell divides twice, forming four gametes.



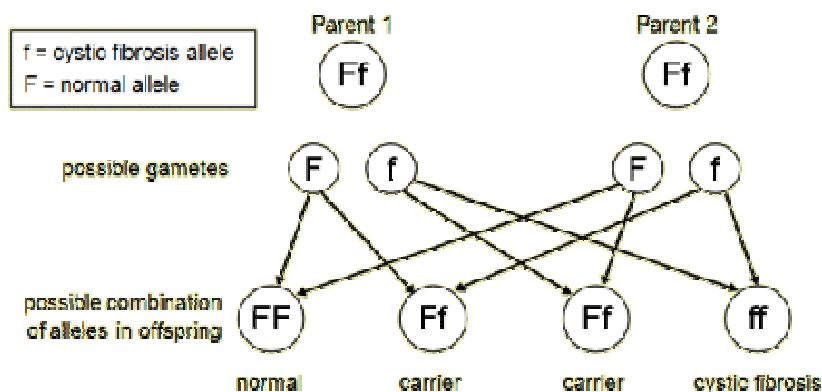
- **Stem cells are undifferentiated cells, which means they do not have features that allow them to carry out specific functions.**
- Adults produce stem cells, but adult stem cells can only differentiate into cells of the tissue that the stem cells came from.
- Scientists hope that stem cells from embryos might lead to a cure for many diseases/conditions, e.g. Alzheimer's, Parkinson's, spinal injury.

## Genetics (excluding the work of Mendel)

- **Genotype:** the combination of alleles that an individual has for that characteristic.
- **Phenotype:** the physical appearance/characteristic produced by a genotype.
- Genotypes can be either:
  - **Homozygous recessive:** has inherited 2 recessive alleles, i.e. both alleles are the same.
  - **Homozygous dominant:** has inherited 2 dominant alleles.
  - **Heterozygous:** it has inherited 2 different alleles, i.e. one recessive and one dominant.
- **Huntington's disease is an inherited disorder** that affects the nervous system. It is caused by a dominant allele. This means it can be passed on by just one parent if they have the disorder.
- The genetic diagram shows how this can happen:



- **Cystic fibrosis is another inherited disorder** that affects the cell membranes, causing the production of thick and sticky mucus. It is caused by a recessive allele. This means that it must be inherited from both parents.
- The genetic diagram shows how this can happen:



We can see that if **both parents are carriers**, then there is a **25% chance** of them having a child with cystic fibrosis.