

Biology
Student Summary Notes
(Int 2)

4178

Autumn 1998

HIGHER STILL

Biology

Student Summary Notes

Intermediate 2

Support Materials



INTRODUCTION

The student summary notes for Intermediate 2 Biology are intended to provide students with all the information they will require to know for external assessment in a summary form. It is intended that they will be issued to students as an aid to revision in preparing for the external examination and also for end of unit tests.

In addition teachers and lecturers may find them useful as exemplification of the notes section in the Arrangements document providing an indication of the appropriate depth of treatment.

Intermediate 2 Biology
Student Summary Notes
Unit: Environmental Biology
and Genetics

ECOSYSTEMS

Energy flow

Components of an ecosystem

Ecology is the study of living organisms in relation to their environment.

A **community** is made up of the populations of plants, animals and micro-organisms found in a particular habitat. A **population** is a group of living organisms of the same species. The place where an organism lives, for example bark of tree or tree canopy is known as its **habitat**. By studying an individual species in its habitat, its relationship with other community members and its way of life in general, it is possible to work out its **niche**, that is, its status and its part played in the pattern of the community.

All the energy in an ecosystem comes from the **sun**. Green plants convert **light** energy from the sun into **chemical** energy during **photosynthesis**. As a result of being able to make their own food green plants are known as **producers**. All other living organisms which use the producers as a food source are known as **consumers**.

Food chains and food webs

By considering the organisms in the diagram below we can study energy flow and consumers in more detail.

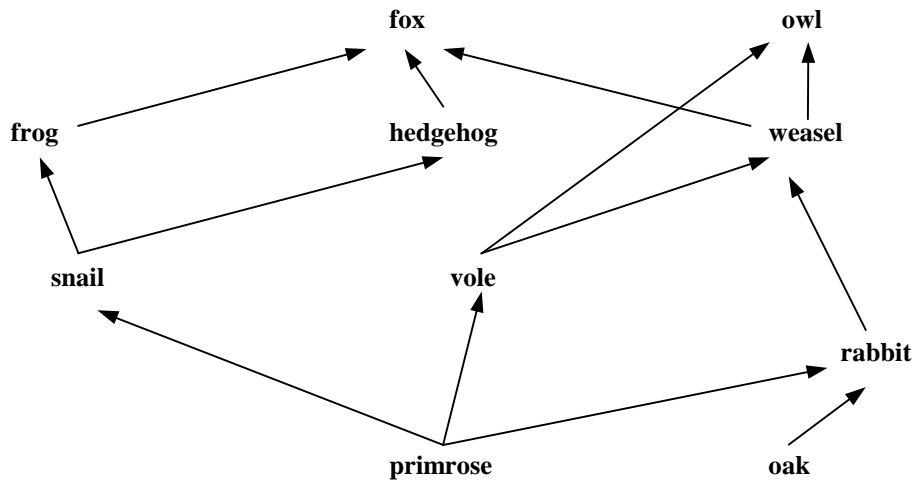
primrose → vole → weasel

The primrose uses the energy from the sun to make its own food. The animals all eat other organisms and are called consumers. The vole is the first consumer and is called the **primary consumer**. The weasel is the second consumer and is called the **secondary consumer**.

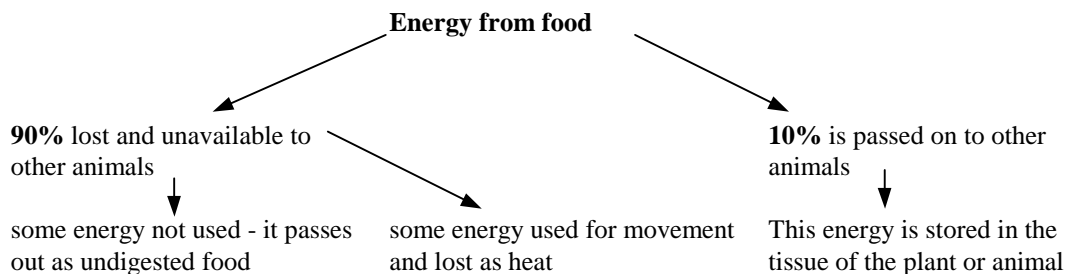
These organisms can be described in other ways. The vole eats only plant material and therefore is called an **herbivore**. The weasel eats only other animals and is called a **carnivore**. The weasel is the **predator** of the vole and the vole is the **prey** of the weasel.

Energy is transferred in the form of chemical energy in food from green plants to the primary consumer and then on to the secondary consumer. This feeding relationship is called a **food chain**. The **arrows** in a food chain point from food to feeder and show **the direction of energy flow**.

A feeding relationship is never as simple as the one shown above. Food chains interconnect at many points. This interconnection of food chains is called a **food web**.



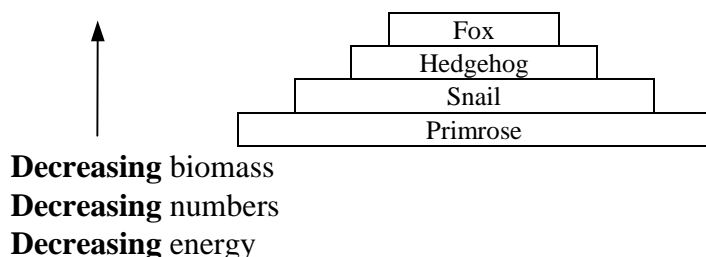
Not all the energy available at each step in a food chain is passed onto the next step. Some of the energy is **lost**. The snail eats a leaf from the primrose. Some of the energy present in the leaf passes out of the snail in **undigested food**. The snail uses some of the energy it gets from the leaf to **move, grow, feed** and **produce heat**. The rest of the energy the snail gets from the leaf is **stored** in the body of the snail and only this stored energy is available to the next animal in the food chain.



The diagram above shows that only **10%** of the energy taken in by one organism is passed on to the next in a food chain.

The energy loss at each link in the food chain limits the mass of living matter that can be supported at the next level. The **biomass** of a population is its total mass of living matter. The biomass **decreases** at each level and represents the actual quantity of animal and plant material at each level. This can be represented by a pyramid and is called the **pyramid of biomass**.

In most food chains there is a greater number of producers than primary consumers and a greater number of primary consumers than secondary consumers and so on. The final consumer is the least numerous. This numerical relationship is called a **pyramid of numbers**.



There are other organisms involved in food chains. They feed on dead animals and plants and are known as **decomposers**. These decomposers are **bacteria** and **fungi**. They bring about the **decay** of dead animals, plants and waste materials releasing chemicals which go into the soil and help keep it fertile.

Factors affecting the variety of species in an ecosystem

A **species** is a group of similar animals that is able to **interbreed** to produce **fertile** offspring. This means that two members of the group can mate to produce young similar to themselves and the young, in turn, have the ability to produce young of their own.

The importance of biodiversity at species level

Biodiversity

Within an ecosystem there is a variety of **habitats**. Within each habitat there is a range of populations of plants, animals and micro-organisms. As well as being adapted to the habitat each population of organisms is adapted to a particular **niche** in the pattern of the community. As an ecosystem develops over time the range of habitats and niches it contains increases. This gives rise to a wide **diversity of species** in every ecosystem.

Over a period of time ecosystems develop until the population in the community become stable. Ecosystems which are stable have a wide diversity of species. It is this biodiversity and the checks and balances within it that make the ecosystem stable. For example, a change in the population of one species is less likely to have an effect in a complex food web with many inter actions than in a simple food web with a few.

Changes in Biodiversity

Factors such as **pollution** and **grazing** reduce the variety of species in an ecosystem. They act selectively on populations by disadvantaging some species and allowing others to thrive by eliminating their competition.

Human activity can reduce biodiversity through the **destruction of habitats** whose plant and animal communities are then lost.

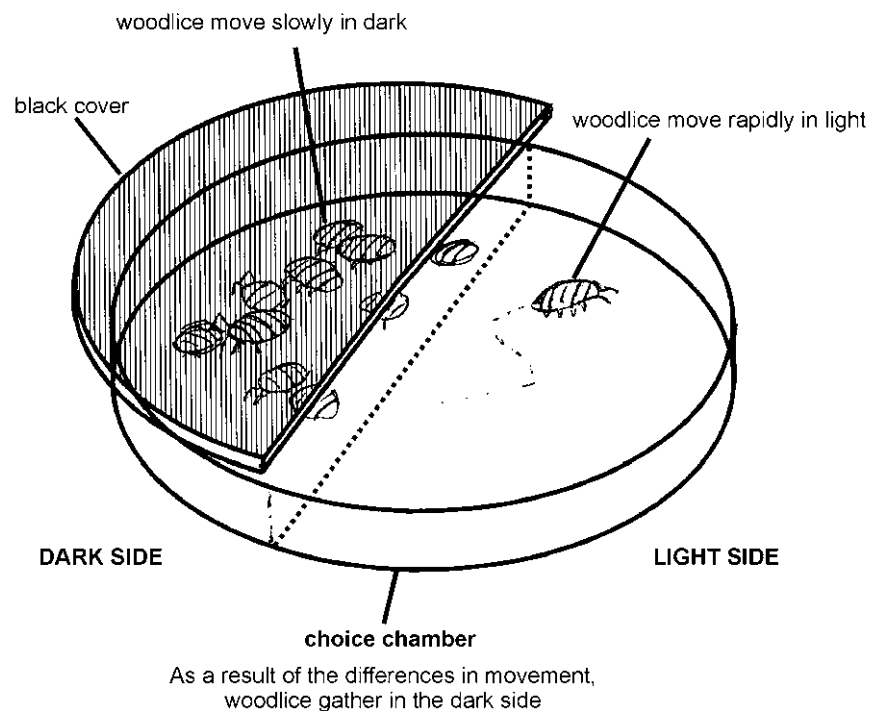
When **food webs are disrupted** by, for example, the removal of one species or the introduction of an exotic species not normally found in the ecosystem there are changes to the other populations of species that form the food web often resulting in a loss of biodiversity.

Behavioural adaptations in animals

Animals are continually being subjected to signs or signals coming from the environment around them. Environmental signals are called **stimuli** and animals will **respond** to them in a variety of ways. Some examples of stimuli might be:

- light
- humidity.

The responses of animals to different stimuli can be investigated in a number of ways. One example is a choice chamber which can be used to show whether woodlice prefer light or dark conditions. The diagram below shows how this would be set up.



The way in which an animal responds to stimuli from the environment makes up an animal's behaviour. This behaviour is important for an animal's survival. Woodlice, for example, are found under stones and bits of wood where it is damp and dark. This protects them from predators and from drying out because their breathing system needs to be moist to enable them to breathe.

Competition

The total number of one kind of organism in an ecosystem is called a population. The size of a population is controlled by many factors, some of these are:

- space
- availability of food
- disease
- predators

In most populations the numbers may go up and down from year to year but over a period of years the numbers will stay approximately the same. Only in ideal growing conditions when the birth rate is much greater than the death rate will there be a dramatic increase. In unfavourable conditions when the death rate is bigger than the birth rate will there be a decrease in numbers. These changes can lead to changes in the variety of species in the ecosystem.

Competition occurs when two or more organisms of the same or different species need the same resource. Plants compete for **light** and **minerals** from the soil. Animals compete mainly for **food, water, shelter** and **shelter**.

FACTORS AFFECTING VARIETY IN A SPECIES

Fertilisation

Gamete (sex cell) production

For sexual reproduction to occur an organism must produce **gametes**. Gametes are another name for sex cells.

Male mammals produce sex cells called **sperm**, female mammals produce sex cells called **eggs**. Males produce sperm in their **testes** and females produce eggs in their **ovaries**.

Flowering plants can also reproduce sexually. The male part of the flower is termed the **anther** and produces **pollen** which contains the male sex cell. The female part of the flower which contains the sex cells called **egg cells** is called the **ovary**.

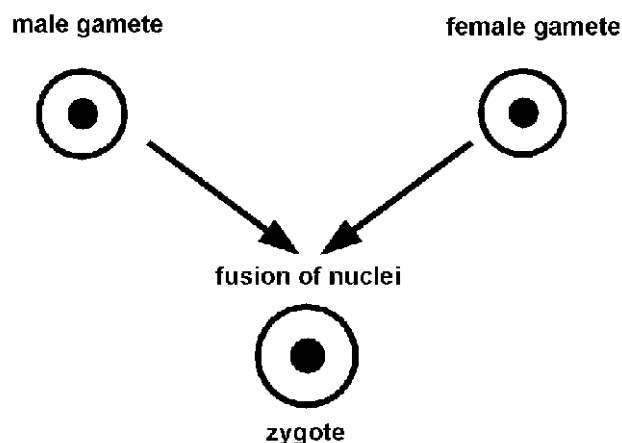
Organism	male sex cell	site of production	female sex cell	site of production
mammal	sperm	testes	egg	ovary
flowering plant	in pollen grain	anther	egg cell	ovary

Fusion of nuclei

For a new individual to be formed a male sex cell must fuse with a female sex cell, allowing the nuclei of the two cells to fuse.

The single cell resulting from this fusion of parental gametes is termed the **zygote**.

It is the random combination of the sex cells from each parent which produces variety in the offspring.

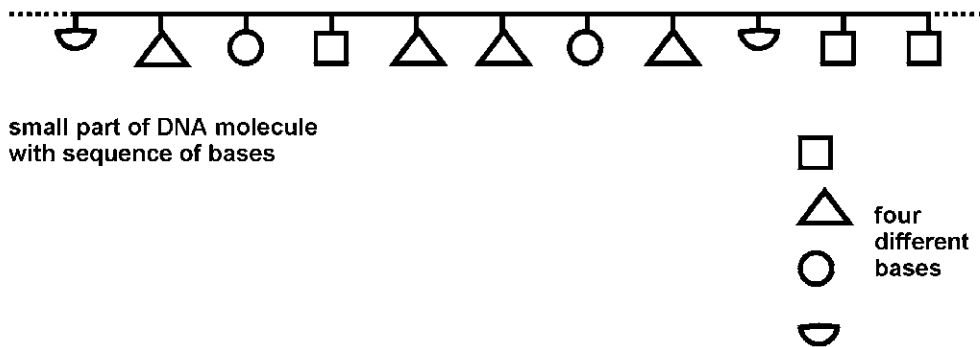


Genetics

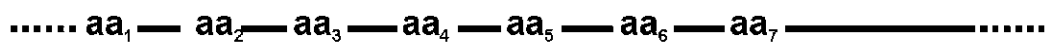
Chromosome structure

Chromosomes are made DNA. DNA is a very long chain molecule made of smaller sub units which have a DNA bases as part of their structure. There are four different bases which are found in a DNA molecule.

It is the sequence of these bases that encode the information for making proteins.



Protein molecules are also long chain molecules made of smaller amino acid sub units. Different sequences of amino acids make different proteins. The structure and function of protein molecules is determined by their sequence of amino acids. When the protein is being made in the cell the sequence of amino acids is determined by the sequence of the bases in the cell's DNA.



**small section of a protein molecule
with sequence of amino acids**

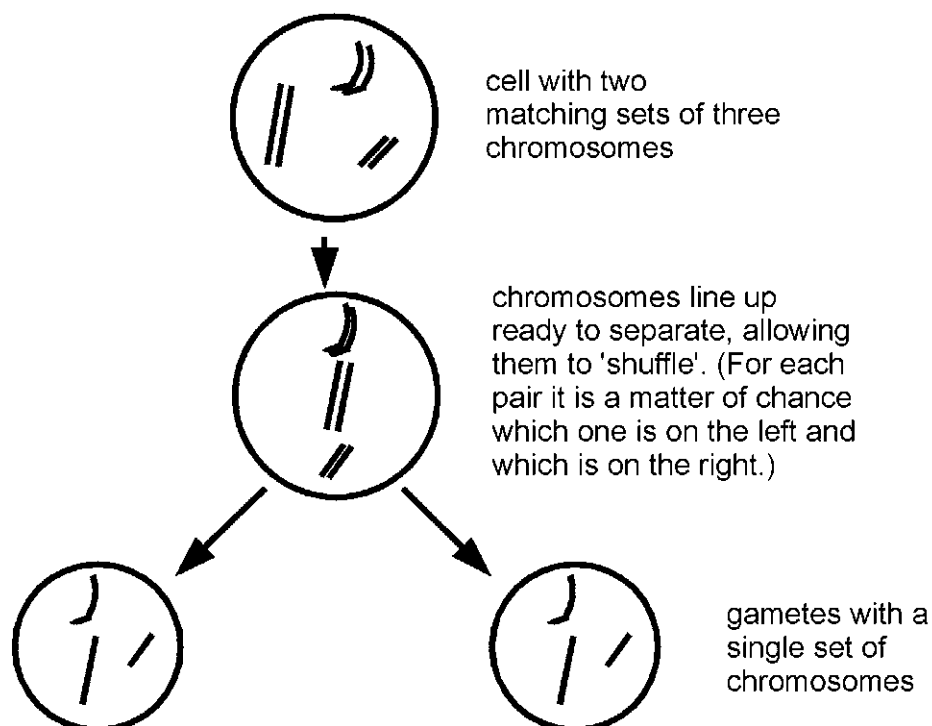
Division of the nucleus in gamete production

Chromosomes are thread like structures made of DNA found in the nucleus of all cells. Chromosomes occur in matching pairs in body cells so that each cell has two matching sets of chromosomes (e.g. humans have 46 chromosomes i.e. 23 pairs of chromosomes).

During gamete formation chromosomes pair up and then separate from each other. This reduces the chromosome number by half in the gametes (one from each pair). For example, in humans, sperm have 23 chromosomes and eggs have 23 chromosomes.

When the gamete nuclei fuse the zygote receives a single set of chromosomes from each parent to restore the complete number of chromosomes (in humans 46).

Also the chromosomes can line up in pairs in a variety of ways before they separate providing a variety of gametes. Remember that each parent has contributed one from each pair of chromosomes. When they line up just before separating it is as if the chromosomes which were from each parent originally are shuffled each time. It is this 'shuffling' that leads to the gametes all being different.



Sex determination

Of the 23 pairs of chromosomes in humans, one pair is known as the **sex chromosomes**. Females have two **X** sex chromosomes (**XX**), males have one **X** and one **Y** sex chromosome (**XY**). Female gametes have an X chromosome, male gametes can have an X or Y chromosome. If an egg cell is fertilised by a sperm with an X sex chromosome the child will be female (**XX**). However, if an egg cell is fertilised by a sperm with a Y chromosome the child will be male (**XY**).

Characteristics controlled by forms of a gene called alleles

Genetic information passed on from parents to offspring is carried on the **chromosomes**. Sections of these chromosomes are called **genes**. These are tiny units which carry information to make one characteristic and many are found along the length of the chromosome. Some characteristics are determined by a pair of genes, one found on each chromosome of a pair. For each characteristic there can be different forms of the gene. These different forms of the same gene are called **alleles**.

During gamete formation the chromosomes are reduced to a single set and subsequently, only one allele for each gene. The exception will be those genes found on the section of the X chromosome not represented on the Y chromosome. The genes on that section will not be present in sperm containing the Y chromosome.

At fertilisation an egg cell from the mother is fertilised by a sperm cell from the father. Each of these gametes will have a single set of chromosomes and alleles but the resulting zygote will have a double set of chromosomes and both alleles for each of the gene.

Genotype and phenotype

The outward appearance of a characteristic in an organism is known as its **phenotype**. A characteristic can be described in terms of its genes, this is known as its **genotype**. When two identical genes are present in the genotype for a characteristic, we describe the organism as **homozygous**. When different alleles are present in the genotype for a characteristic, we describe the organism as **heterozygous**. In heterozygous individuals the dominant form of the gene will always be expressed in the phenotype.

Characteristics controlled by the alleles of more than one gene are said to show **polygenic inheritance**. The greater the number of genes involved, the higher the number of intermediate phenotypes of the particular characteristic.

Letters of the alphabet are used to represent the two forms of a particular gene. A **capital** letter is used to represent the dominant allele and a **small** letter to represent the recessive allele. In humans, tongue rolling is dominant to non-rolling. The alleles can be represented as shown below:

T = tongue rolling t = non-rolling

The table below shows the possible combinations of these alleles (genotype) and the corresponding appearance of the person (phenotype).

Table

genotype	description of genotype	phenotype
TT	homozygous dominant	tongue rolling
Tt	heterozygous dominant	tongue rolling
tt	homozygous recessive	non-rolling

The way in which inherited characteristics are passed on from parents to offspring follow a pattern. The simplest cross which involves one characteristic and is called a **monohybrid** cross. In addition to the symbols for genes, the following symbols are used in a monohybrid cross:

- **P** - parent generation
- **F 1** - first generation
- **F 2** - second generation

The following cross shows the pattern of inheritance for tongue rolling between two individuals who are true breeding. This means that if they are self-fertilised they will produce offspring which are identical to the parent. One parent has the homozygous dominant genotype and one who has the homozygous recessive genotype.

parents phenotype	tongue rolling	X	non-rolling
parents genotype	TT		tt
gametes	T		t
F1 genotype		all Tt	
F1 phenotype		all tongue rolling	

If two individuals of the F1 generation go on to reproduce, this is the pattern:

F1 phenotype	tongue rolling	X	tongue rolling
F1 genotype	Tt		Tt
gametes	T or t		T or t

These two sets of gametes can combine in four possible ways during fertilisation. A **Punnet square** can be used to show this:

	T	t
T	TT	Tt
t	Tt	tt

The above table shows the possible genotypes in the **F₂ generation**. There is one homozygous dominant, one homozygous recessive and two heterozygous. There are three tongue rolling and one non-rolling, thus a **phenotypic ratio of 3:1**.

The **predicted** 3:1 ratio in the F₂ generation of a monohybrid cross is unlikely to occur unless huge numbers of offspring are produced. In addition, fertilisation is a random process involving an element of chance.

In some cases one allele of a gene is not completely dominant over the other allele and both are expressed equally. In such cases, the heterozygote has a phenotype different from both of the homozygotes. This is known as **co-dominance**.

Environmental impact on phenotype

Variation in the final appearance of an organism (phenotype) may be due to the effect of the environment and not the result of genotype alone. Genetically identical plants grow very differently when given varying amounts of light and soil nutrients. These characteristics resulting from the influence of the environment will not be passed onto the next generation. Variation resulting from changes to the genotype of an organism is much more important to the process of evolution.

Evolution and natural selection

Natural selection can bring about evolution, the process by which new species are formed from existing ones over a period of time. By natural selection organisms which are better suited to their environment survive and breed, passing their genes onto their offspring. Those less well adapted fail to survive and their genes are lost. The environment exerts a selection pressure which determines which characteristics are passed to succeeding generations and these organisms have a selective advantage. In this way new kinds of organisms evolve.

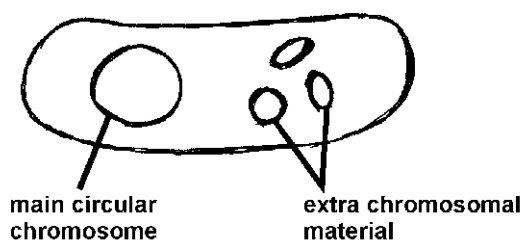
Genetic engineering

New genotypes can be created by either selective breeding or genetic engineering. Both methods create the best organism for a particular function.

Selective breeding involves identifying good qualities in plants or animals and allowing these organisms to breed. By careful cross breeding the good features of two different varieties can be combined in their offspring. However selective breeding is a lengthy process which may not always produce the desired results.

Genetic engineering is a much faster more reliable process which can produce new genotypes in one generation. In this process the genotype of an organism is altered artificially by the insertion of desired genes. New varieties of rapidly growing bacteria are “engineered” to make useful products in large amounts.

Bacterial cells contain chromosomal material (DNA) with essential genes for controlling cell activities.



DNA from different organisms can be transferred into bacteria to change their genotype. This extra chromosomal material causes the bacteria to produce large quantities of a desirable product normally manufactured by the original organism.

The sequence of events in the genetic engineering of human insulin used to prevent diabetes are outlined below.

Stages in the genetic engineering of insulin

1. Identification of required gene which controls the production of the desired product (human insulin).

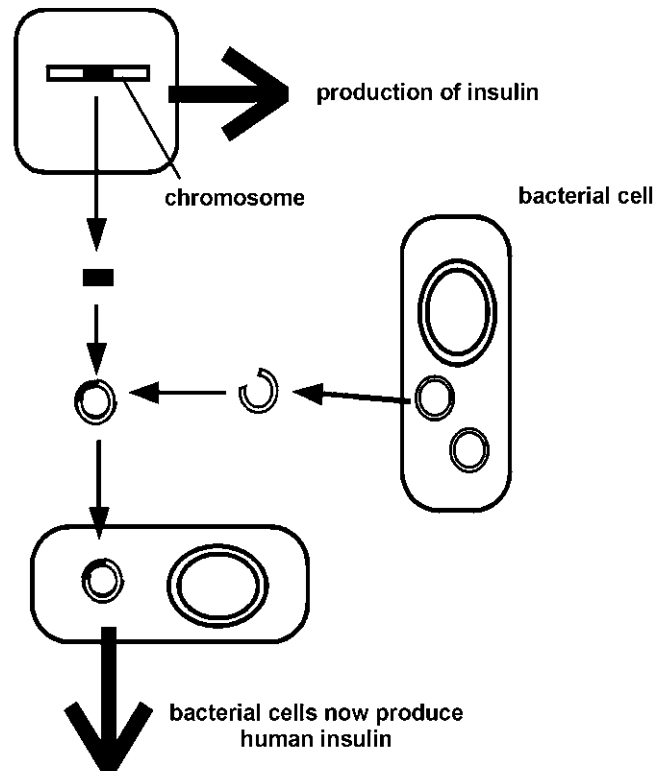
2. Removal of the piece of DNA containing the insulin gene.

3. Insertion of DNA into bacterial chromosomal material which has been cut open.

4. Insertion of chromosomal material into the host bacterial cell.

5. Replication of the bacteria and synthesis of the desired product.

6. Separation of the product from the bacterial cells.



This technique can be used to make a range of chemicals used to treat diseases and disorders.

Intermediate 2 Biology
Student Summary Notes
Unit: Living Cells

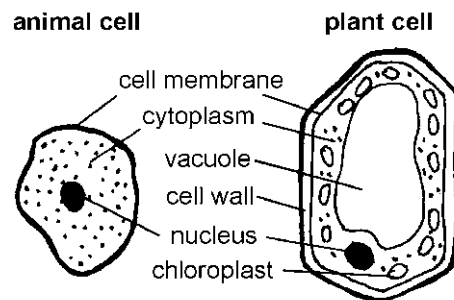
THE STRUCTURE AND FUNCTION OF A VARIETY OF CELLS

The Cell

If you look at living tissue under the microscope you will see that it is made up of small units. These are **cells**. The cell is the basic unit of life. Every living organism is made up of one or more cells.

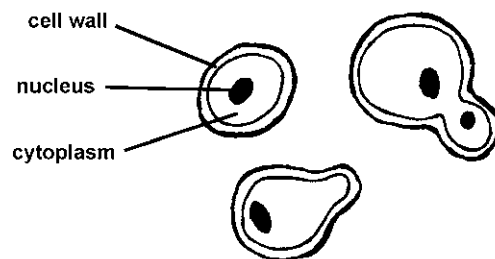
Plant and animal cells

When plant and animal cells are compared, differences in structure can be seen. This is shown in the diagram below.



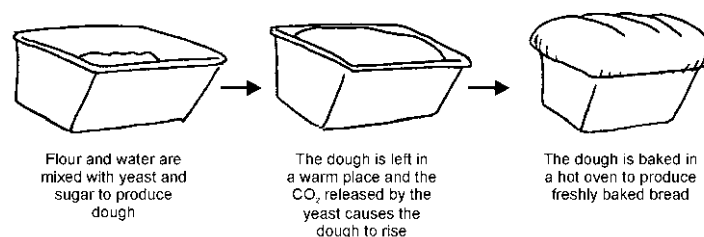
The uses of cells in industry

For thousands of years man has used living cells to make useful products. **Yeast** is a tiny, single-celled fungus which is used in baking, brewing, wine-making and alternative fuel production.



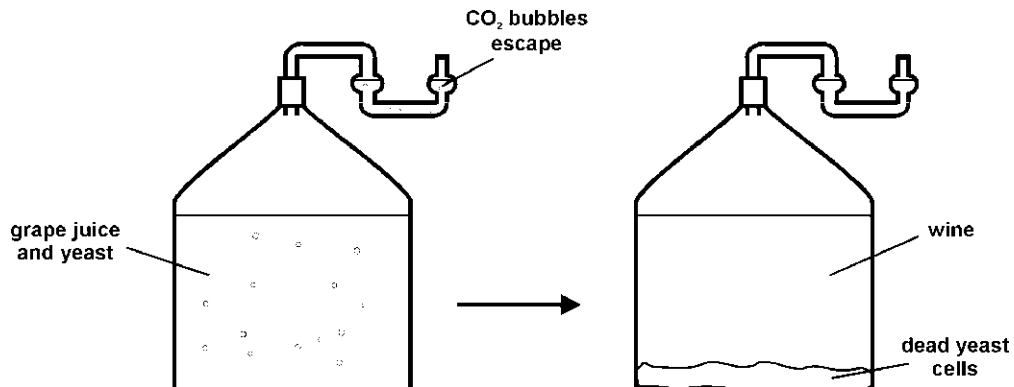
Yeast in baking

In baking, yeast is mixed with the dough which is then left in a warm place. The bubbles of carbon dioxide gas given off by the yeast make the dough rise. The dough is then baked in a hot oven which kills off the yeast.



Making alcoholic drinks

In **wine making**, yeast is added to the juice extracted from crushed grapes. The grape juice contains sugars which the yeast use to grow. The sugars are changed by the yeast into alcohol and carbon dioxide gas.



Barley is used to make beer. The barley grains are first germinated to convert the starch in the grains to sugar. Yeast is then added and fermentation begins when the yeast changes the sugar into alcohol and carbon dioxide. This process is known as **brewing**.

The use of yeast in fuel production

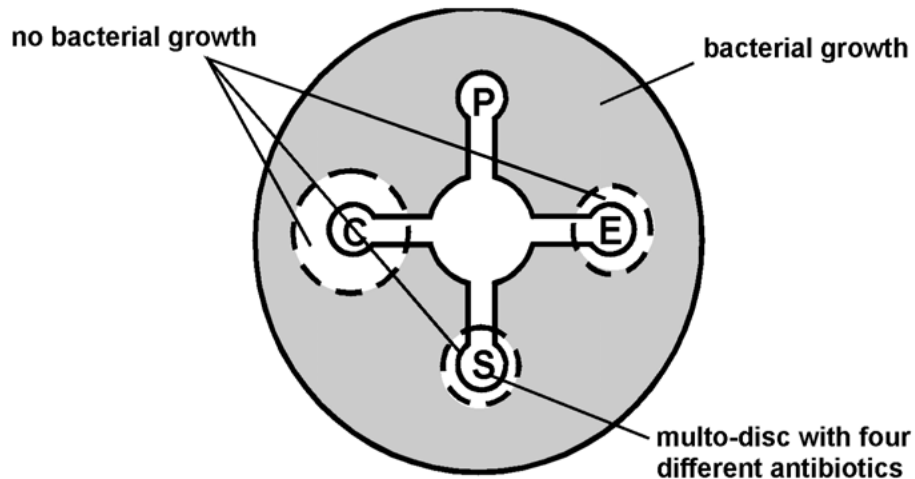
When yeast ferments sugar, **alcohol** is produced, but in small amounts. The alcohol can be separated from the fermentation mixture by **distillation**. Alcohol is flammable and can therefore be used as a **fuel**.

In some countries such as Brazil, alcohol is used as a fuel for cars, either on its own, or mixed with petrol as gasohol. The advantages of using alcohol as a fuel are that it is a **renewable** energy source.

Making antibiotics

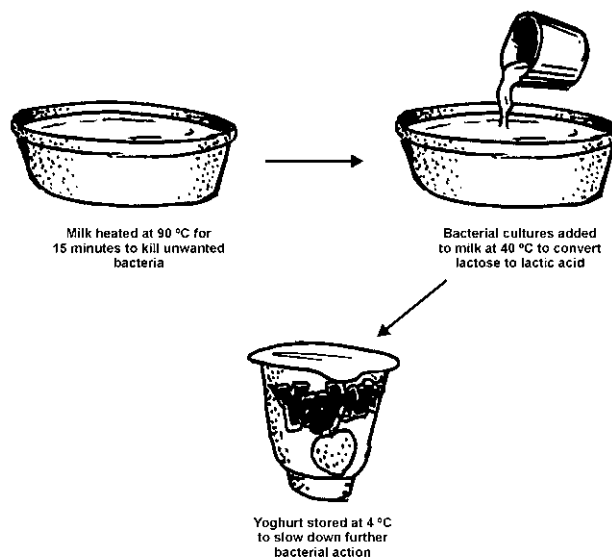
An **antibiotic** is a substance produced by a micro-organism which kills or inactivates another micro-organism.

The most famous antibiotic is **penicillin** which is made by a fungus and inhibits the growth of bacteria. Many other antibiotics have now been discovered. They are used to treat bacterial and fungal diseases. The diagram below shows the effect of four different antibiotics, (C, P, E and S) on the growth of one type of bacteria. Antibiotic C is the most effective against this bacteria.



Yoghurt production

Special strains of **bacteria** convert the milk sugar **lactose** to **lactic acid**. This causes the milk to curdle. **Yoghurt** is made in this way. Other strains of bacteria make the yoghurt more creamy and improve the taste. Fruit juices can also be added to give different flavours. The yoghurt is then refrigerated to slow down bacterial growth.



DIFFUSION AND OSMOSIS IN PLANT AND ANIMAL CELLS

Diffusion

Many substances enter and leave cells by **diffusion**. Diffusion is the movement of substances from a region of high concentration to a region of low concentration, that is, **along a concentration gradient**. This movement continues until the concentrations are equal.

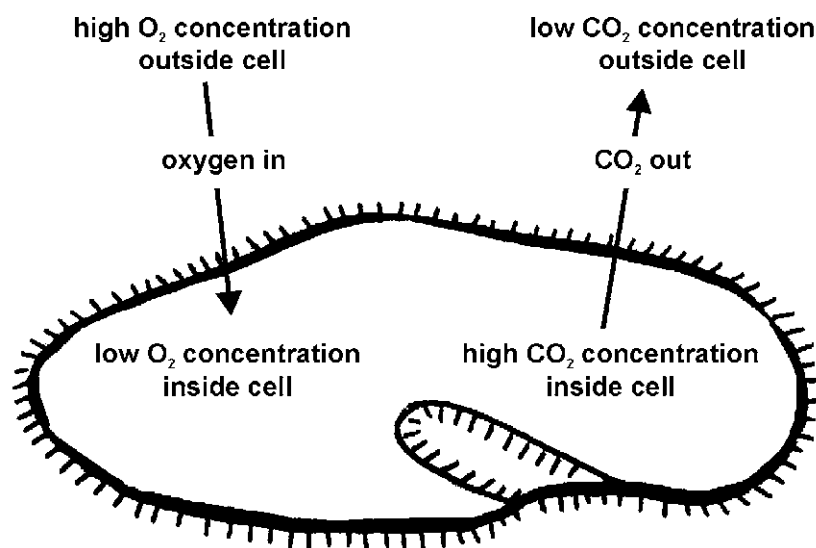
Oxygen and dissolved foods such as glucose enter a cell by diffusion. Carbon dioxide leaves a cell by diffusion.

The importance of diffusion in organisms

In **unicellular** organisms such as *Paramecium*, **oxygen** is constantly being used up. This means that the oxygen concentration inside the cell is lower than the oxygen concentration outside the cell, so oxygen **enters** the cell by diffusion.

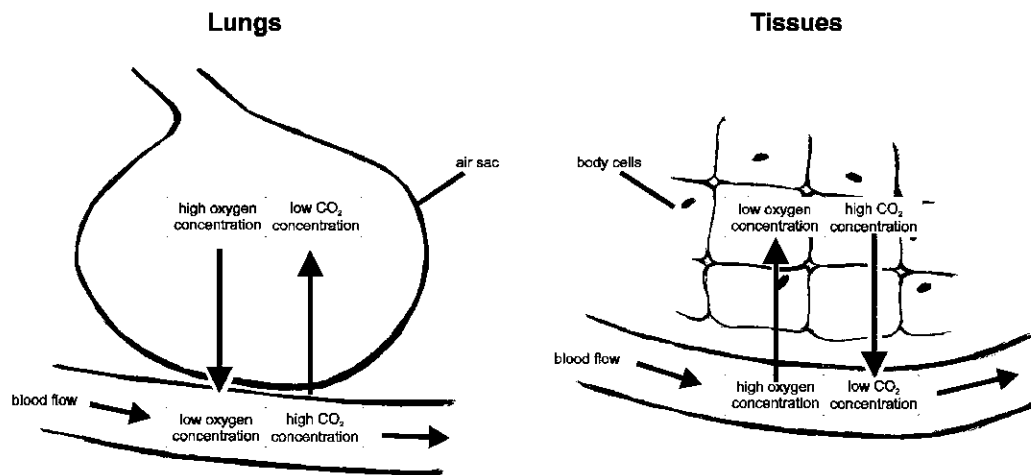
Carbon dioxide is a waste product made by the cell. The carbon dioxide concentration inside the cell is therefore greater than the concentration outside, so carbon dioxide **leaves** the cell by diffusion.

Diffusion, therefore, is the means by which unicellular organisms obtain oxygen from their surroundings, and get rid of wastes such as carbon dioxide.



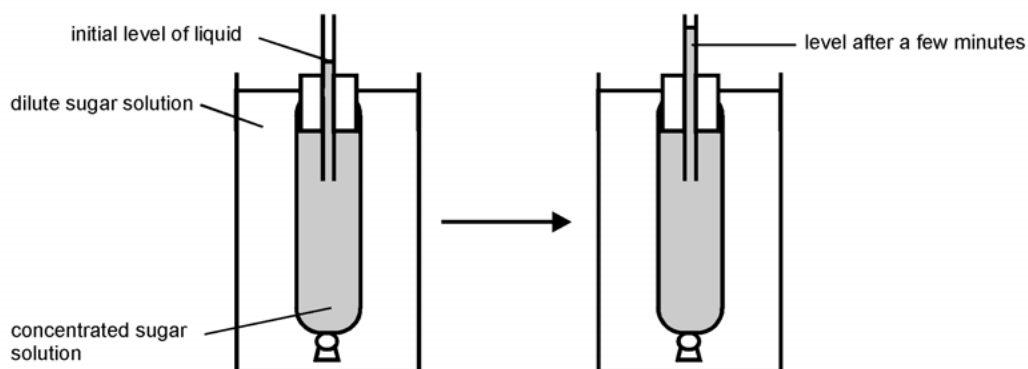
In **multicellular** organisms e.g. mammals, diffusion plays an important role in the movement of **oxygen** in the lungs from a high concentration in the air sacs to a low concentration in the blood capillaries. In the tissues the blood has a higher oxygen concentration than the body cells so oxygen moves from the capillaries to the cells by diffusion.

Carbon dioxide moves in the opposite direction in the lungs and tissues by diffusion, since the concentration gradient is in the opposite direction.



Osmosis

Osmosis is a special case of diffusion of water across a **selectively permeable** membrane. A selectively permeable membrane allows water and some other molecules to pass through it but not others. In the experiment shown below, the visking tubing acts as a selectively permeable membrane. After a few minutes water moves from a high water concentration (outside the bag), to a low water concentration (inside the bag), that is along a water concentration gradient, causing the level of the liquid to rise.

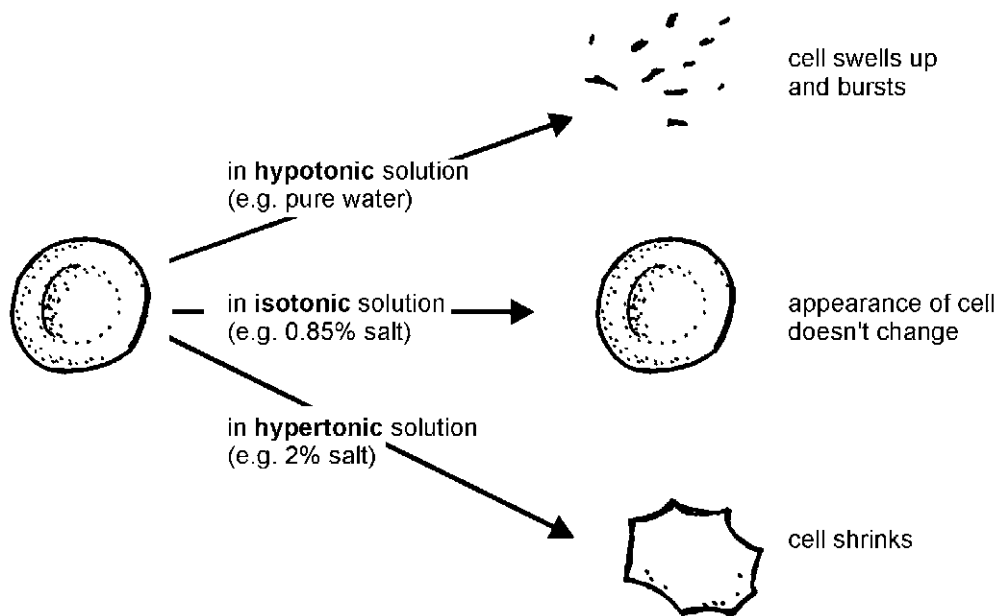


Osmosis in animal cells

Human red blood cells will swell up and burst if they are placed in **pure water**. Water has a higher water concentration than the cell contents, therefore water moves along the concentration gradient and enters the cell by osmosis until the cell bursts. Because water has a lower concentration of dissolved salts than the cell contents it is described as a **hypotonic** solution.

A solution of **0.85% salt** has the same water concentration and salt concentration as the cell contents and is described as an **isotonic** solution. There is no concentration gradient and therefore no net movement of water into or out of the cell. The appearance of the cell doesn't change.

A **2% salt** solution, has a lower water concentration than red blood cells. The cells have a higher water concentration than the 2% salt solution and therefore water moves along the concentration gradient and leaves the cell by osmosis causing the cells to shrink. Because the 2% salt solution has a higher concentration of dissolved salts than the cell contents it is described as a **hypertonic** solution.

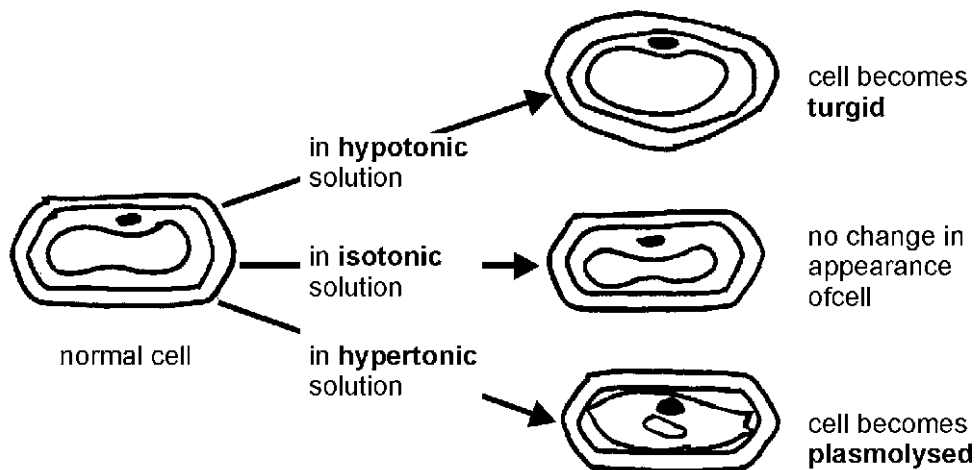


Osmosis in plant cells

Plant cells have a **cell wall** which is fully permeable to water outside the cell membrane. When a plant cell is placed in a **hypotonic** solution, for example water, water moves along a water concentration gradient from the solution to the cell. The cell gains water by osmosis but does not burst, however. The vacuole swells and pushes the cytoplasm against the cell wall which stretches slightly but does not break. A cell in this condition is described as **turgid**. Young land plants depend on the turgidity of their cells for support.

When a plant cell is placed in an **isotonic** solution, for example a dilute sugar solution, there is no concentration gradient and therefore no net movement of water.

When a plant cell is placed in a **hypertonic** solution, for example a concentrated sugar solution, water moves along a concentration gradient from the cell to the solution. The cell loses water by osmosis, the cell contents shrivel and pull away from the cell wall. A cell in this condition is described as **plasmolysed**. Plant tissue containing plasmolysed cells appears limp and wilted and is described as **flaccid**.



ENZYME ACTION

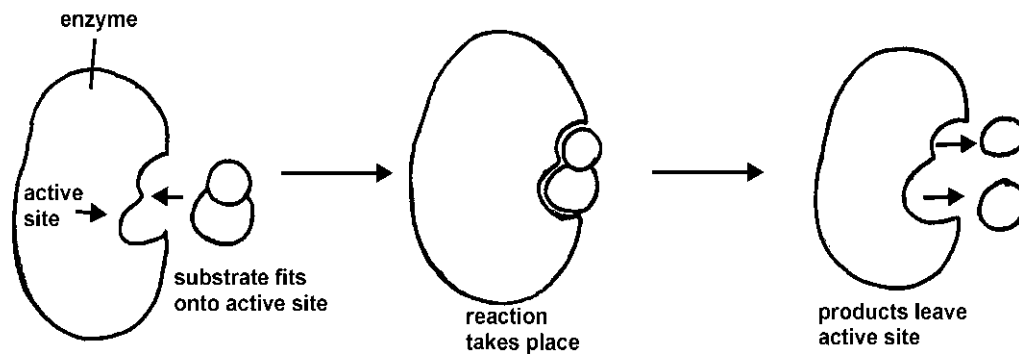
Enzyme properties

Enzymes as catalysts

The many chemical reactions which take place in living cells are controlled by naturally occurring protein molecules called **enzymes**. Enzymes are biological **catalysts** which lower the energy required for reactions to occur and in doing so speed up the reactions. For example, the enzyme catalase can break down six million molecules of hydrogen peroxide every minute! Although enzymes take part in chemical reactions they are unchanged by the reactions. Enzymes are necessary for the functioning of all living cells.

Enzyme specificity

An enzyme can only act on one type of substance (its substrate). The enzyme amylase, for example, is only able to promote the breakdown of starch and no other substance. Each enzyme is therefore said to be **specific** to its substrate. The shape of the substrate fits exactly onto a part of the enzyme surface known as the **active site**, in much the same way as a key fits exactly into a lock.

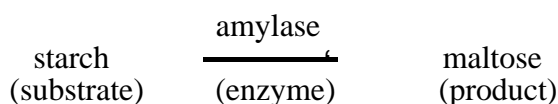


Breakdown and synthesis

Some enzyme reactions involve the chemical breakdown of complex molecules into simpler ones, while other enzyme reactions involve the synthesis of complex molecules from simpler ones. These types of reaction are illustrated by the enzymes amylase, which promotes the breakdown of starch, and phosphorylase, which promotes the synthesis of starch.

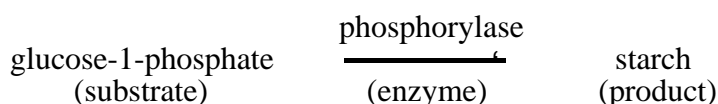
Amylase

The enzyme amylase, found in animals and plants, acts on the substrate starch, breaking it down to the simple sugar, maltose. The reaction is summarised in the following equation:



Phosphorylase

The enzyme phosphorylase, which is found in potato, promotes the synthesis of starch from a type of glucose called glucose-1-phosphate. The reaction is summarised in the following equation:



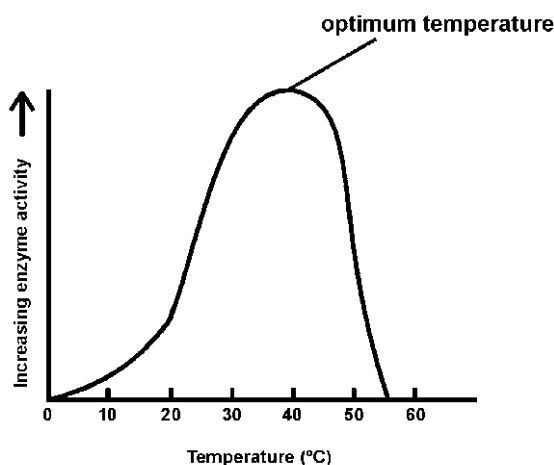
Factors affecting activity

Temperature

Most enzymes will not work at temperatures above 50°C. This is because they are destroyed (**denatured**) at high temperatures. The high temperature alters the shape of the enzyme's active site so that the substrate no longer fits. At low temperatures, for example 2°C, enzymes are inactive (but not destroyed).

The temperature at which an enzyme is most active is known as its **optimum** temperature and is around 35°C to 40°C for most enzymes.

The graph below shows the effect of temperature on an enzyme.

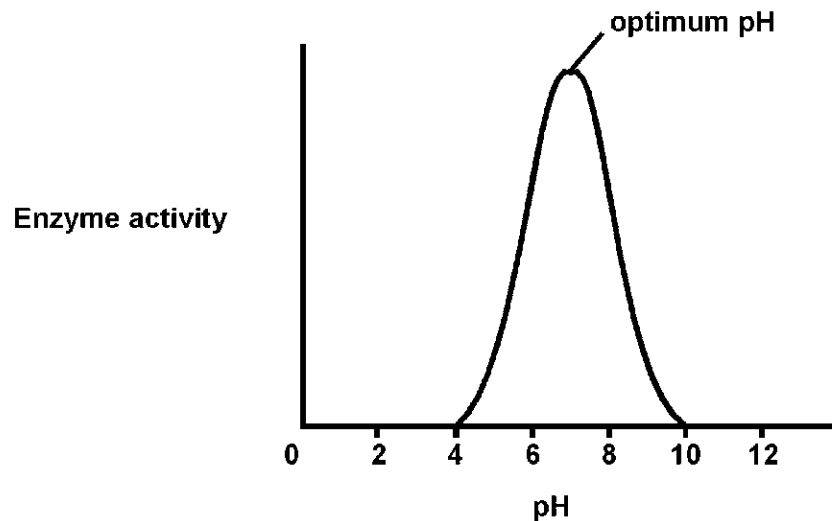


pH

Enzymes work in solution and the pH (acidity or alkalinity) of the solution affects the activity of enzymes. All enzymes have a working pH range within which they are active, and outside this working range enzymes are inactive. At pH values outside the working range enzymes become **denatured** due to the pH altering the shape of the active site so that the substrate no longer fits.

All enzymes have a particular pH they work best at, known as the **optimum pH**.

The graph below shows the effect of pH on the enzyme plant amylase.



AEROBIC AND ANAEROBIC RESPIRATION

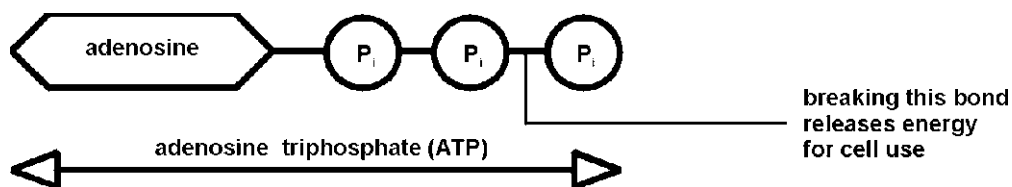
Energy release

Glucose as a source of energy

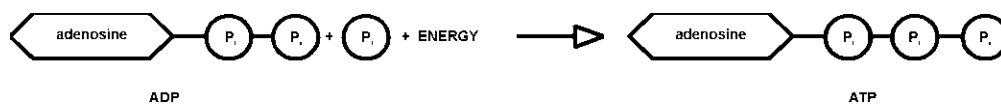
Glucose from food diffuses into cells. The chemical energy stored in glucose is a source of energy in cells. The chemical energy from the glucose is not all released at once in cells as it is when glucose burns. The energy is released gradually in stages in a series of enzyme controlled reactions called **respiration**. Some energy is released as heat from cells during respiration while the rest is used to drive chemical processes within the cell.

Role of ATP

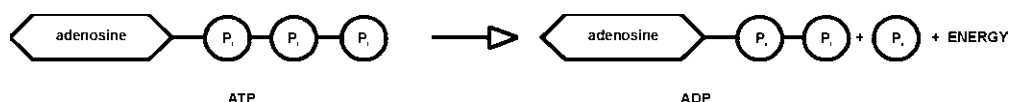
The energy released when glucose is broken down in living cells is not used directly but is used to synthesise the chemical **adenosine triphosphate (ATP)**. ATP can provide energy for cell processes such as contraction of muscle cells, immediately when energy is needed.



ATP is built up from the adenosine diphosphate (ADP) using the energy from respiration to add on another phosphate group (P_i).



The energy stored in the ATP molecule is released when that phosphate group is removed and the ADP regenerated. ATP can therefore be used as a source of energy for the cells needs.



Comparison of energy yield in aerobic and anaerobic respiration

The complete breakdown of glucose in the presence of oxygen releases a great deal of energy used to produce 38 molecules of ATP. This breakdown of glucose in the **presence** of oxygen is called **aerobic respiration**.

When oxygen is not available to a cell glucose can be partly broken down. This releases only enough energy to produce 2 molecules of ATP. This breakdown of glucose in the **absence** of oxygen is called **anaerobic respiration**.

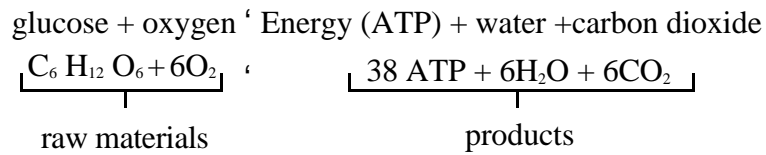
Products

Aerobic respiration

Glucose is a carbohydrate with the formula C₆H₁₂O₆.

In aerobic respiration glucose is broken down by living things using up oxygen (O₂).

This process releases energy, carbon dioxide (CO₂) and water (H₂O) and is summarised in the following equation:

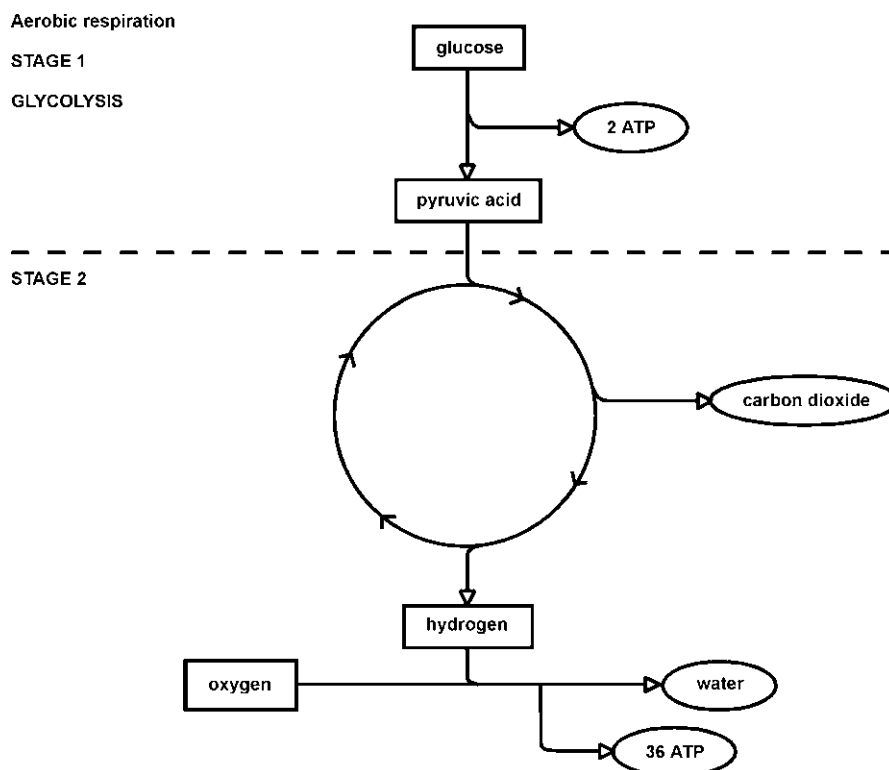


The process of energy release is not as simple as the equation suggests. It involves many small steps, all controlled by specific enzymes, which make sure that the energy is released in a gradual and controlled way. Hydrogen is removed from the glucose molecule and the carbon and oxygen atoms are released as carbon dioxide. The hydrogen joins with the oxygen from the air to produce water. The energy released is used to build up ATP.

This process can be divided into two stages.

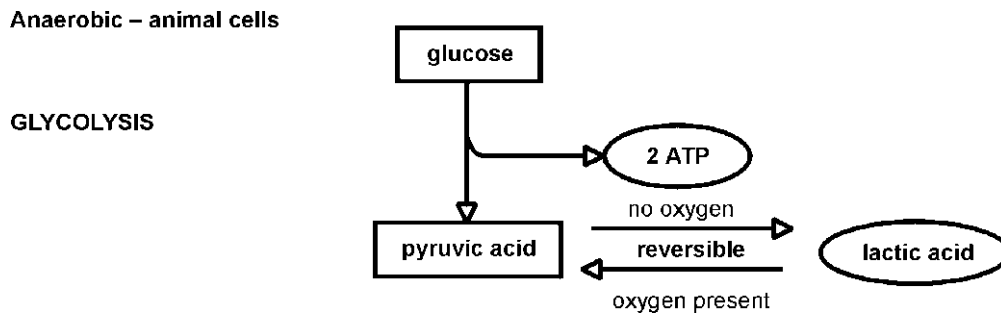
In **glycolysis** the **glucose** molecule is broken down into two molecules of **Pyruvic acid**. This stage proceeds without the presence of oxygen and produces 2ATP.

Pyruvic acid is needed for the next stage which involve a series of enzyme controlled reactions and requires the presence of oxygen. During this stage oxygen is used to break down **pyruvic acid** to **carbon dioxide** and **water** releasing sufficient energy to make 36 more molecules of ATP.

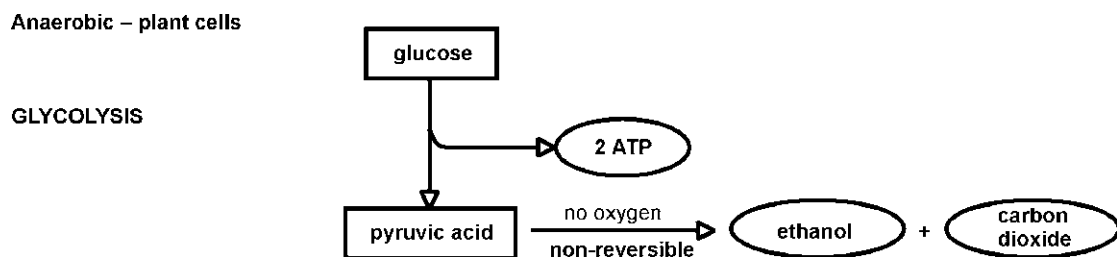


Anaerobic respiration

If not enough oxygen is available glucose can still be broken down partially to release some energy. Glycolysis proceeds and produces **pyruvic acid** which in animal cells such as muscle is converted into the **lactic acid**. Lactic acid is a poison which causes muscles to ache. The anaerobic conversion of pyruvic acid to lactic acid is **reversible**. When oxygen becomes available to the cell again lactic acid is converted back to pyruvic acid which can be completely broken down to release the rest of the energy in aerobic respiration.



In plants and yeast anaerobic respiration allows glycolysis to proceed but the pyruvic acid produced is **irreversibly** converted into **ethanol** and **carbon dioxide**.



PHOTOSYNTHESIS

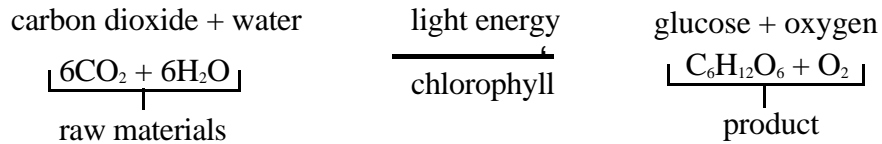
Energy fixation

Sunlight as the source of energy

The process by which plants make their own food is called **photosynthesis**. Photosynthesis consists of a series of enzyme controlled-reactions which use light energy from the sun as a source of energy. The green substance chlorophyll, found in the chloroplasts of plant cells, captures light energy which is converted into chemical energy in the form of ATP. ATP is then used to provide the energy for the synthesis of food.

Summary equation for photosynthesis

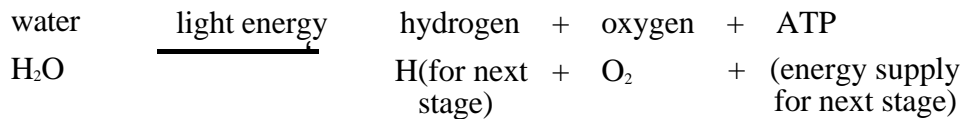
In photosynthesis a green plant uses up carbon dioxide (CO_2) from the air and water (H_2O) from the soil. These substances are turned into glucose ($\text{C}_6\text{H}_{12}\text{O}_6$) and oxygen (O_2). The oxygen is released into the air as a by-product. The essential energy for this synthesis comes from sunlight captured by green chlorophyll.



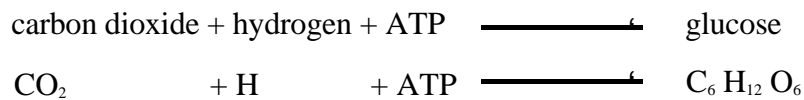
Photosynthesis occurs in two stages: photolysis and carbon fixation

Photosynthesis occurs in two stages.

In the first stage water (H_2O) is split into oxygen and hydrogen. This is called **photolysis**. Only this first stage needs light energy. The function of photolysis is to provide the hydrogen and the chemical energy in ATP needed for the second stage. The oxygen from water splitting is a by-product.

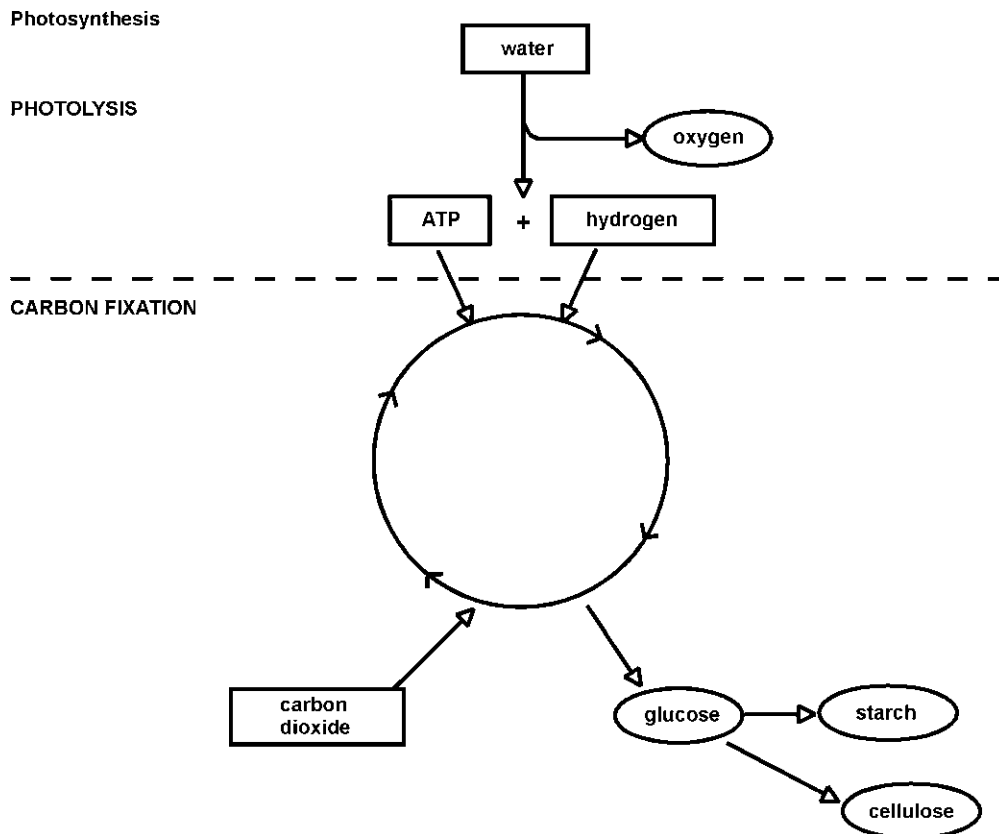


The second stage does not need light energy. This stage involves a series of enzyme controlled reactions in which the hydrogen from the water combines with carbon dioxide to form the carbohydrate, glucose. This stage is known as **carbon fixation**.



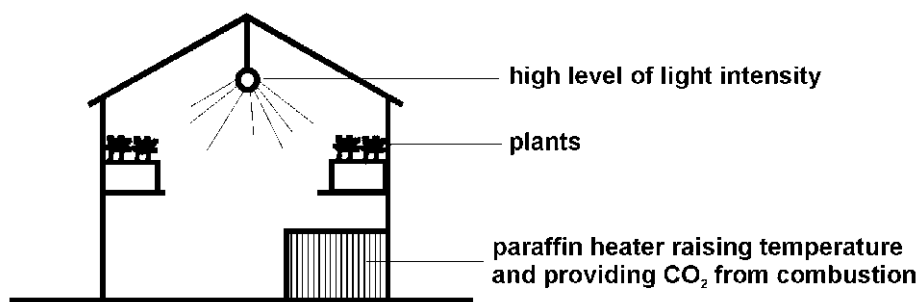
Conversion of Glucose to other carbohydrates

The glucose that is not needed as a source of energy for the plant can be used in other ways. Glucose, a simple sugar is used by the plant to build up more complex carbohydrates like starch and cellulose. **Starch** is a large, insoluble carbohydrate which is **stored in plant cells**. Starch can be change back into glucose if the plant needs it . **Cellulose** is also a large carbohydrate which is a **component of plant cell walls**.



Factors affecting the rate of photosynthesis

As can be seen from the summary equation for photosynthesis, carbon dioxide, water and light are all required for the process. A suitable temperature is also required. As water is always in plentiful supply any shortage of the other three will reduce the rate of photosynthesis. Because of this the **concentration of carbon dioxide, levels of light and temperature** are said to be **limiting factors** on the rate of photosynthesis.



The growth of glasshouse crops in winter can be increased by raising the temperature, using supplementary artificial lighting and enriching the atmosphere with extra carbon dioxide. This increases the rate of photosynthesis.

Intermediate 2 Biology
Student Summary Notes
Unit: Animal Physiology

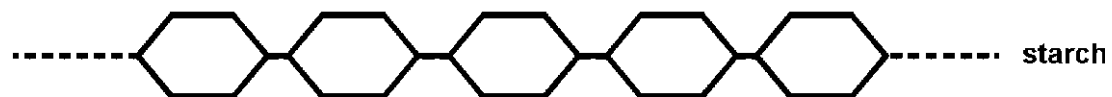
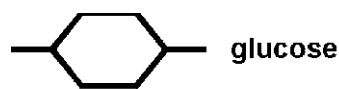
MAMMALIAN NUTRITION

Breakdown of food

Requirement for food

The main food groups which mammals eat are carbohydrates, proteins, fats, vitamins and minerals.

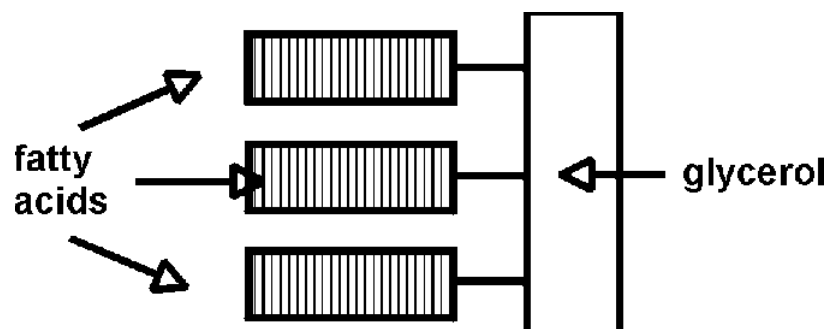
Carbohydrates contain the elements carbon (C), hydrogen (H) and oxygen (O). These elements are combined together into molecules of simple sugars such as glucose. More complex carbohydrates are built up from repeating units of these simple sugars.



Proteins contain the elements carbon (C), hydrogen (H), oxygen (O) and nitrogen (N). These elements are combined together into molecules called amino acids. There are about twenty different types of amino acid which can be joined together in different sequences and numbers to make proteins.



Fats contain the elements carbon (C), hydrogen (H) and oxygen (O). These elements are combined together into molecules of fatty acids and glycerol. Fat molecules are made up of molecules of fatty acids and glycerol.



Food Group

	carbohydrates	proteins	fats
chemical elements present	CHO	CHON	CHO
structural units	simple sugars	amino acids	fatty acids and glycerol

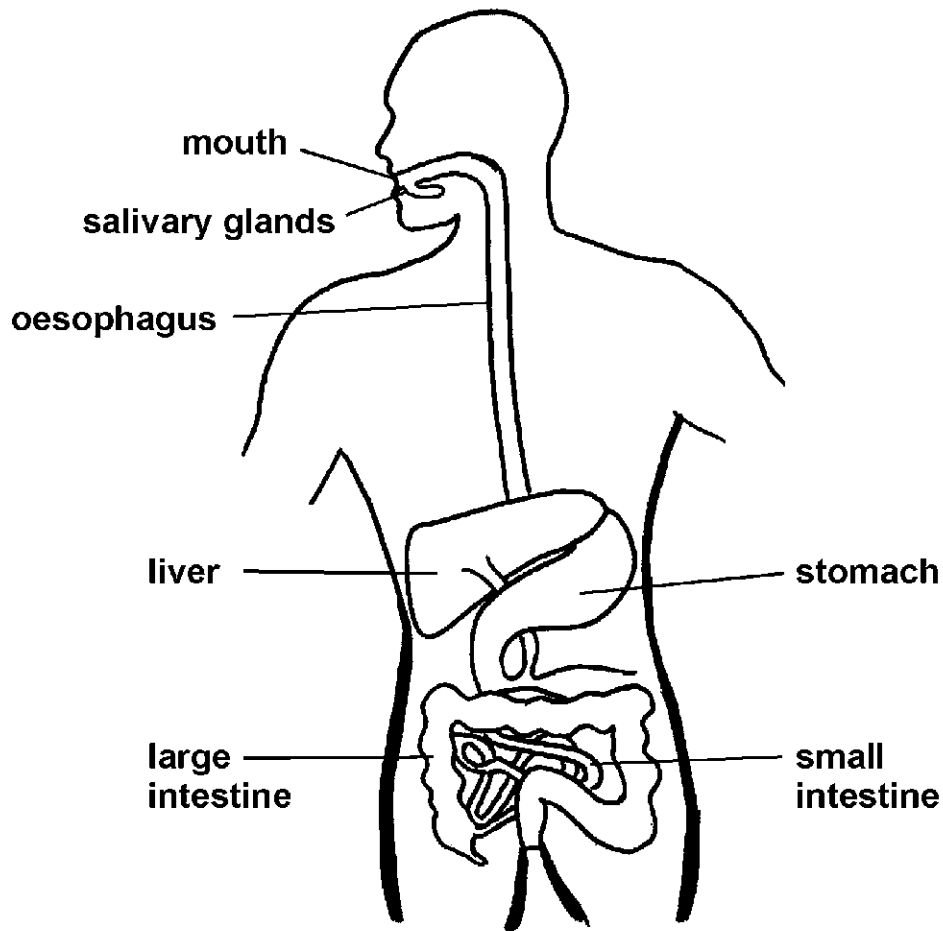
The need for digestion

Food that is eaten contains large insoluble molecules such as starch, proteins and fats. Digestion of food involves breaking down the large insoluble food molecules into small soluble molecules. Small soluble molecules can pass through the small intestine and into the bloodstream.

This breakdown will occur in the mouth, stomach and small intestine. Enzymes are produced and act on the large insoluble molecules, breaking them down into small soluble molecules.

Function of the alimentary canal and associated organs

The diagram below shows the human alimentary canal and some associated structures.

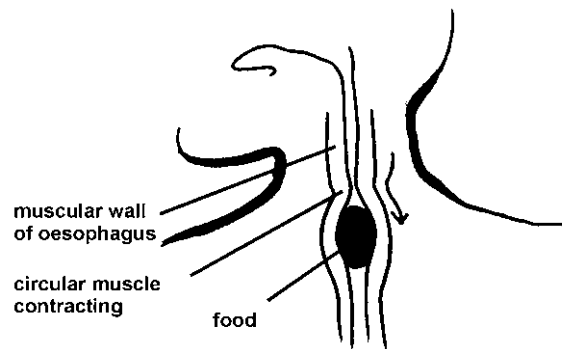


Part	Function
mouth	food is chewed and broken into smaller pieces
salivary glands	saliva digests food and mucus produced helps lubricate mouth and food to aid swallowing
oesophagus	food is moved by peristalsis to stomach
stomach	food is churned and mixed with gastric juice
small intestine	final digestion followed by absorption
large intestine	reabsorbs water and eliminates waste

The mouth, salivary glands and oesophagus

In the **mouth** food is first broken up by the mechanical action of teeth. The **salivary glands** produce saliva which contains an enzyme which starts the digestion of the food. Chewing breaks the food into smaller pieces and mixes it with mucus making it easier to swallow.

The **oesophagus** is a muscular tube running from the mouth to the stomach. Food is passed along by peristalsis. Peristalsis is a wave of muscular contractions behind the food which pushes it along the length of the gut.

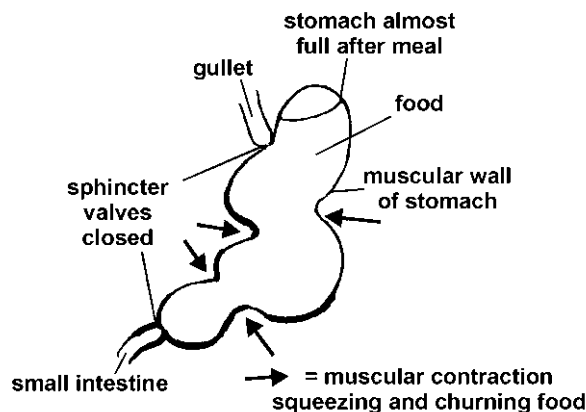


The role of the stomach

Once food has entered the stomach sphincter muscles at either end of the stomach contract to prevent the food leaving the stomach. Food is churned in the stomach by the actions of longitudinal and circular muscles. These contractions also mix the food thoroughly with gastric juice which is released from gastric glands in the stomach lining.

There are three types of cell in the gastric glands : - mucus-secreting cells, enzyme-secreting cells and acid secreting cells. The secreted enzyme continues the chemical breakdown of food, the secreted acid provides a suitable pH for the enzyme action and the mucus protects the stomach from the action of the enzyme and acid.

The thorough mixing of the food with the secretions of the gastric glands assists the chemical breakdown of the food by the secreted enzyme.



The role of the small intestine in the absorption and transport of food

The small intestine is designed to complete the digestive process and then absorb the soluble food products into the bloodstream. It has the following features:

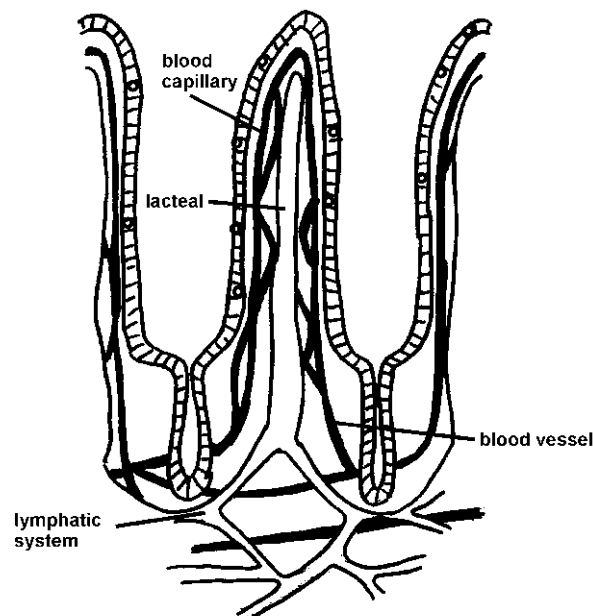
1. it is very long
2. the inner surface is folded to increase the surface area for absorption
3. it has very thin walls to allow easy diffusion of the digested food products
4. it has a rich blood supply to absorb the digested food products and transport them elsewhere in the body

The folds in the inner surface of the small intestine are called villi (singular - villus). These increase the surface area for absorption. Inside each villus is a dense network of blood capillaries, and a single lacteal or lymph vessel. It is into these two kinds of vessel that the digested food products pass.

The soluble products - sugars, amino acids, vitamins and minerals pass into the blood capillaries. These blood capillaries then join to form a large blood vessel called the hepatic portal vein which carries the soluble food products to the liver.

The lacteal absorbs fatty acids and glycerol and passes them into the main lymphatic system.

Diagram of villus



The blood capillaries of the villi join to form a larger blood vessel called the **hepatic portal vein** which carries the products of digestion to the liver. The products of digestion are transported in the blood plasma.

The lacteals of the villi drain into the lymphatic system which later drains into the blood system.

The fate of absorbed materials

Glucose is used in cells for respiration, releasing energy to drive chemical reactions. Glucose not immediately required can be converted to glycogen and stored in the liver and muscles. Excess glucose not stored as glycogen is converted to fat and stored.

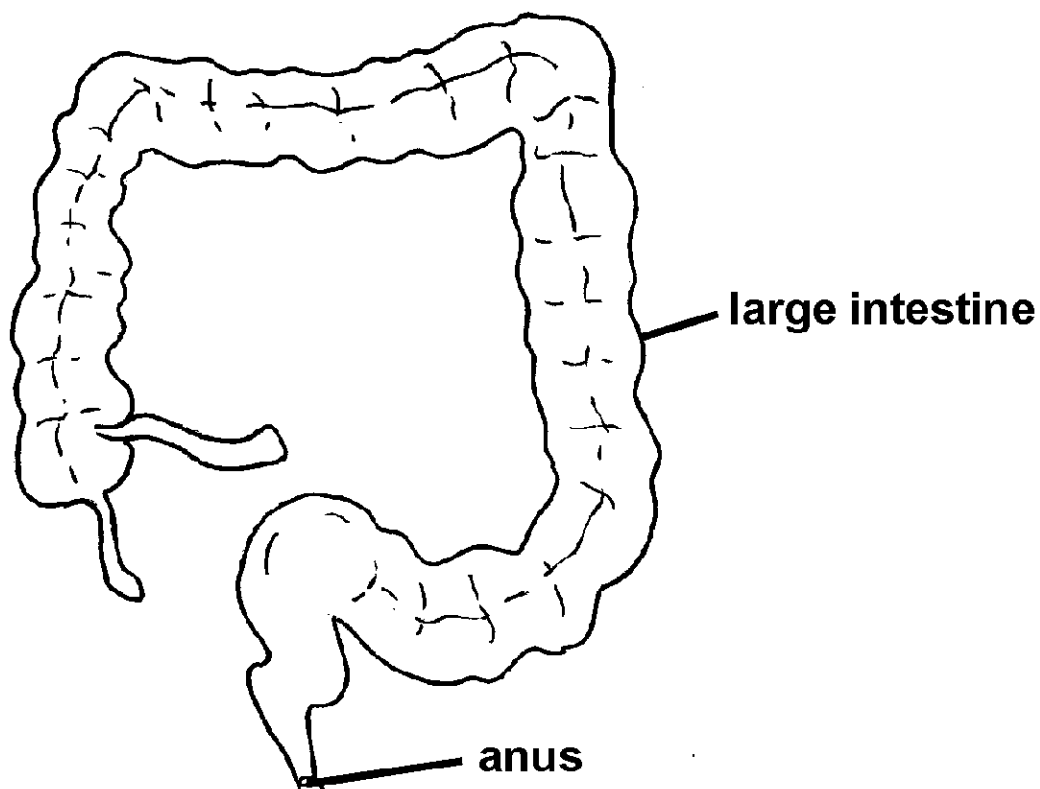
Amino acids are absorbed by cells and reassembled to make new proteins. Excess amino acids cannot be stored and are broken down in the liver in a process called deamination.

Fats can be used in some cell structures and also act as an energy store.

The role of the large intestine in water absorption and elimination of undigested material

Indigestible material (mainly plant fibres and cellulose) from the small intestine passes into the large intestine. As material passes along the large intestine water and salts are absorbed from it. This semi solid waste (called faeces) is periodically eliminated through the anus.

Diagram of large intestine



CONTROL OF THE INTERNAL ENVIRONMENT

The role of the mammalian kidney in osmoregulation

Mammals gain and lose water in a variety of ways.

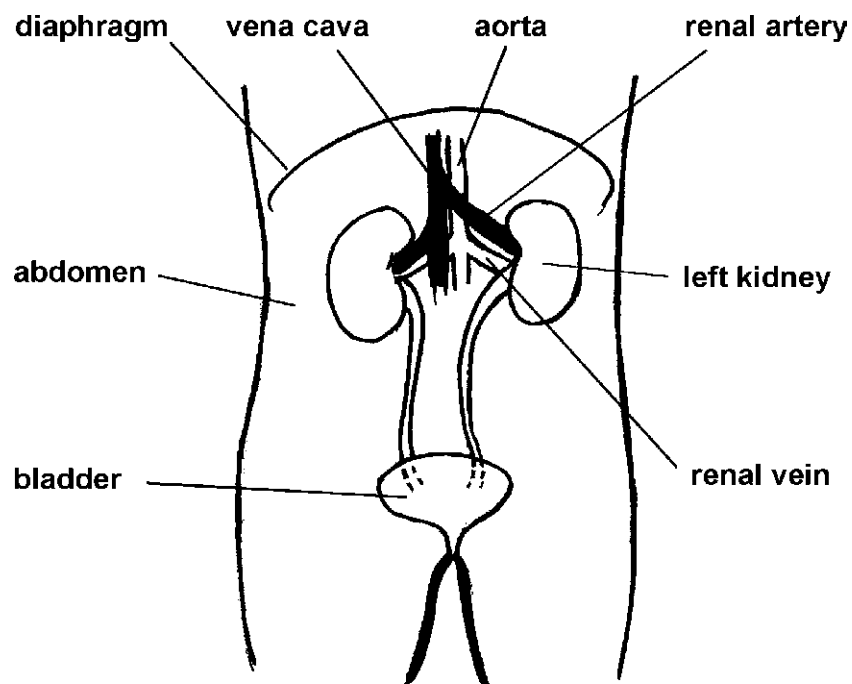
Methods of Water Gain	Methods of Water Loss
drinking	urine
food	exhaled breath
metabolic water (water produced in cells by aerobic respiration)	sweat

The kidneys are the main organs responsible for controlling the water content of the blood. They regulate the volume of water lost in the urine and thus keep the blood's solute concentration steady, i.e. they are the organs of osmoregulation.

The kidneys are also organs of excretion, they remove unwanted substances (e.g. urea) from the body.

The kidneys are bean-shaped organs located in the abdominal cavity. The diagram below shows their approximate position and some of the associated structures.

Blood is transported into the kidneys via the renal arteries. The renal veins take the blood away from the kidneys.



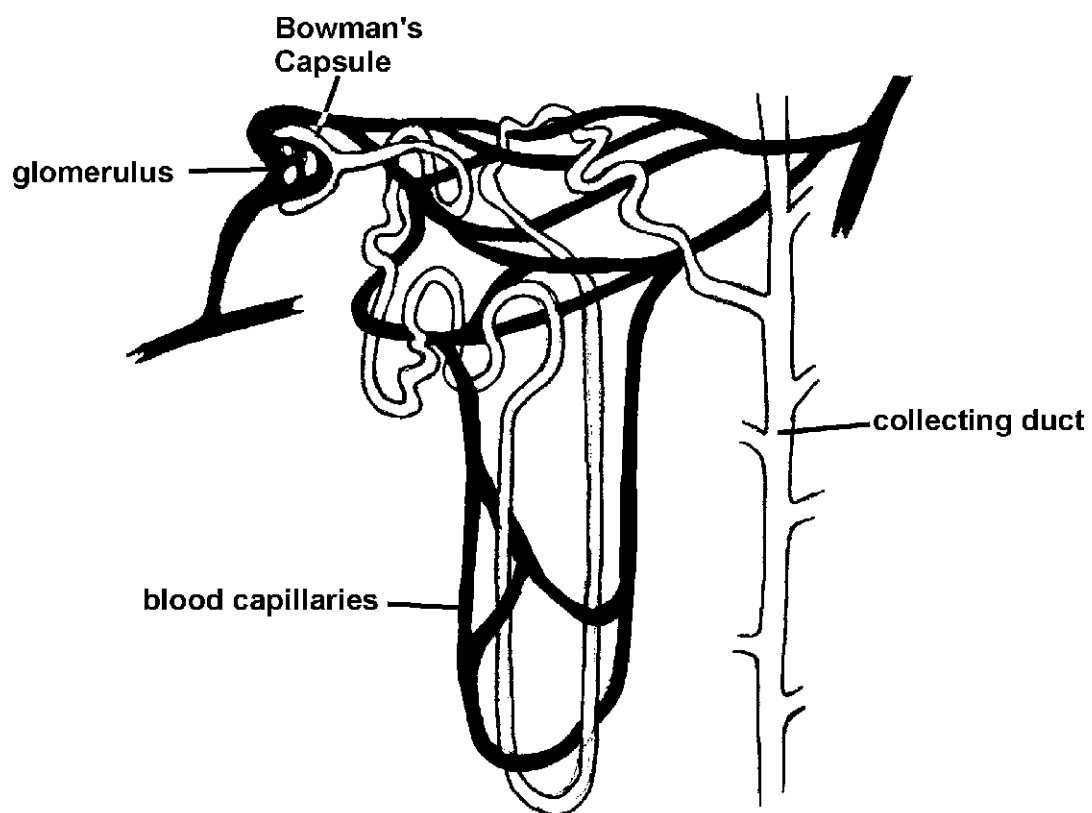
The kidneys maintain water balance excrete waste substances by the processes of **filtration** and **reabsorption**.

Nephrons, the structural units of the kidney carry out these processes.

Filtration - as the blood passes through the glomerulus small molecules e.g. water, glucose and urea filter out to enter the cavity of the Bowman's capsule.

Reabsorption - as the filtrate flows through the tubule water, glucose and other useful substances are reabsorbed into the blood in the capillaries which surround the tubule.

Diagram of nephron



Formation of urea - Excess amino acids cannot be stored and are broken down to urea in the liver. Urea is released into the blood. The kidney nephrons extract urea from the blood during the filtration process and excrete it from the body in the urine. This is the body's method of excreting nitrogenous waste.

Osmoregulation in marine and freshwater bony fish

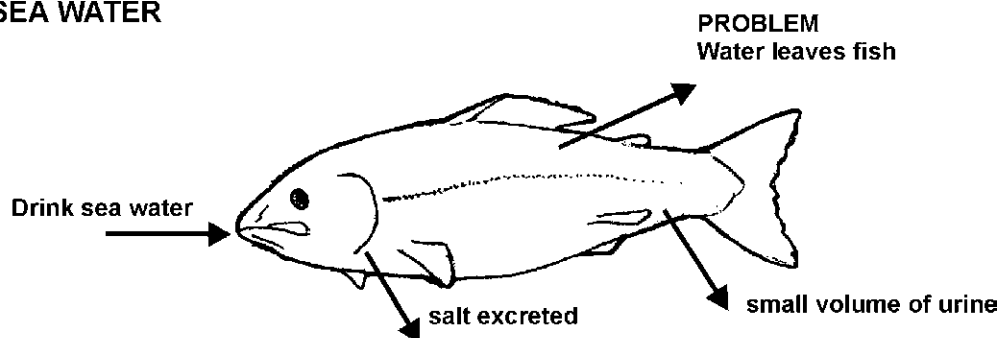
Marine bony fish live in the sea which has a higher salt concentration than the cells of the fish. The fish cells are said to be **hypotonic** to the surrounding sea water i.e the cells are higher in water concentration and lower in solute concentration than the surrounding sea water.

Freshwater bony fish live in rivers and freshwater lochs which have a lower salt concentration than the cells of the fish. The fish cells are **hypertonic** to the surrounding freshwater i.e. the cells are lower in water concentration and higher in solute concentration than the surrounding water.

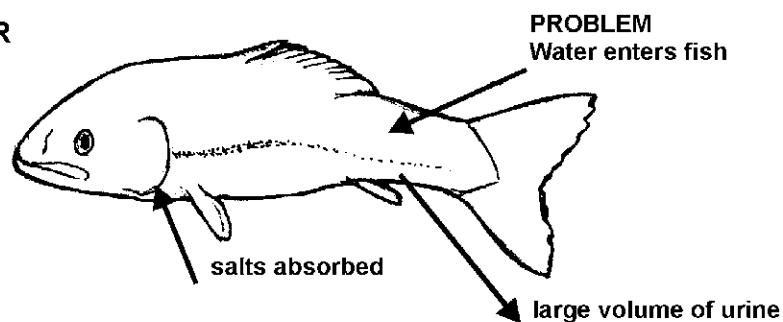
Both these environments pose problems for the fish which have adaptations to allow them to maintain their water balance. This control of their water balance is termed **osmoregulation**.

Environment	Problem	Methods of Overcoming Problem
sea water	water loss (dehydration)	<ul style="list-style-type: none"> • drink sea water • excrete small volume of urine • gills excrete salt to compensate for salt taken in when drinking sea water
fresh water	water gain	<ul style="list-style-type: none"> • excrete large volume of very dilute urine • gills absorb salt to compensate for salts lost in urine

IN SEA WATER



IN FRESH WATER

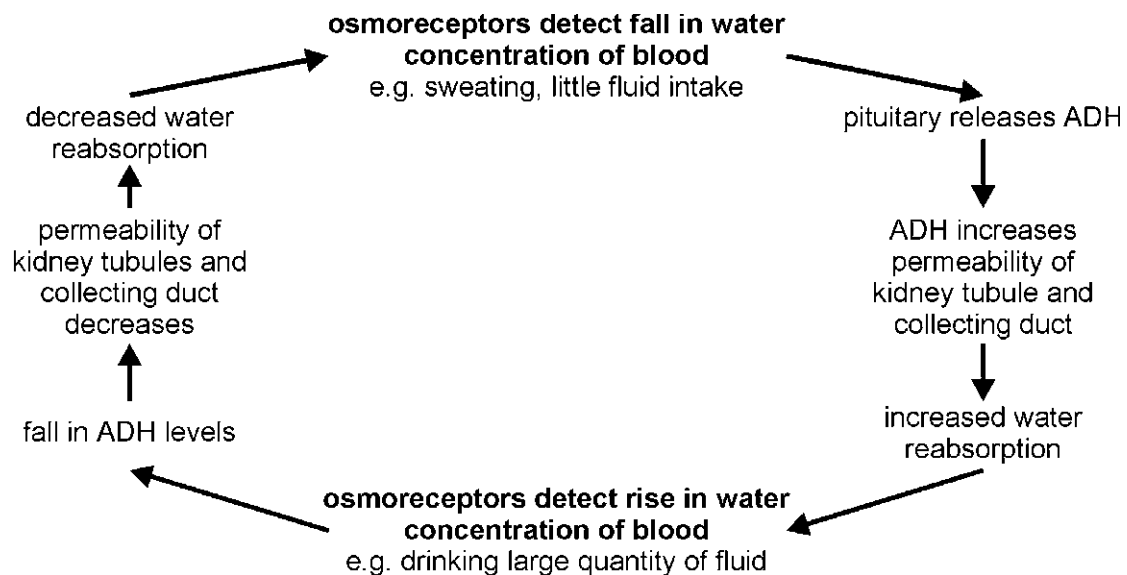


Negative feedback control by ADH

Anti diuretic hormone (ADH) is a hormone released from the pituitary gland at the base of the brain. It travels in the bloodstream to affect the kidney tubules and collecting ducts - making them more permeable to water reabsorption into the bloodstream. Thus urine volume is decreased and water conserved to combat dehydration.

Cells in the hypothalamus are sensitive to the water/solute concentration of the blood and are thus termed osmoreceptors. These osmoreceptors send messages to the pituitary gland to release ADH when the water concentration of the blood falls.

When the water concentration of the blood rises less ADH will be released and less water reabsorbed from the kidney tubule into the bloodstream. Thus urine volume is increased and excess water is lost.



CIRCULATION AND GAS EXCHANGE

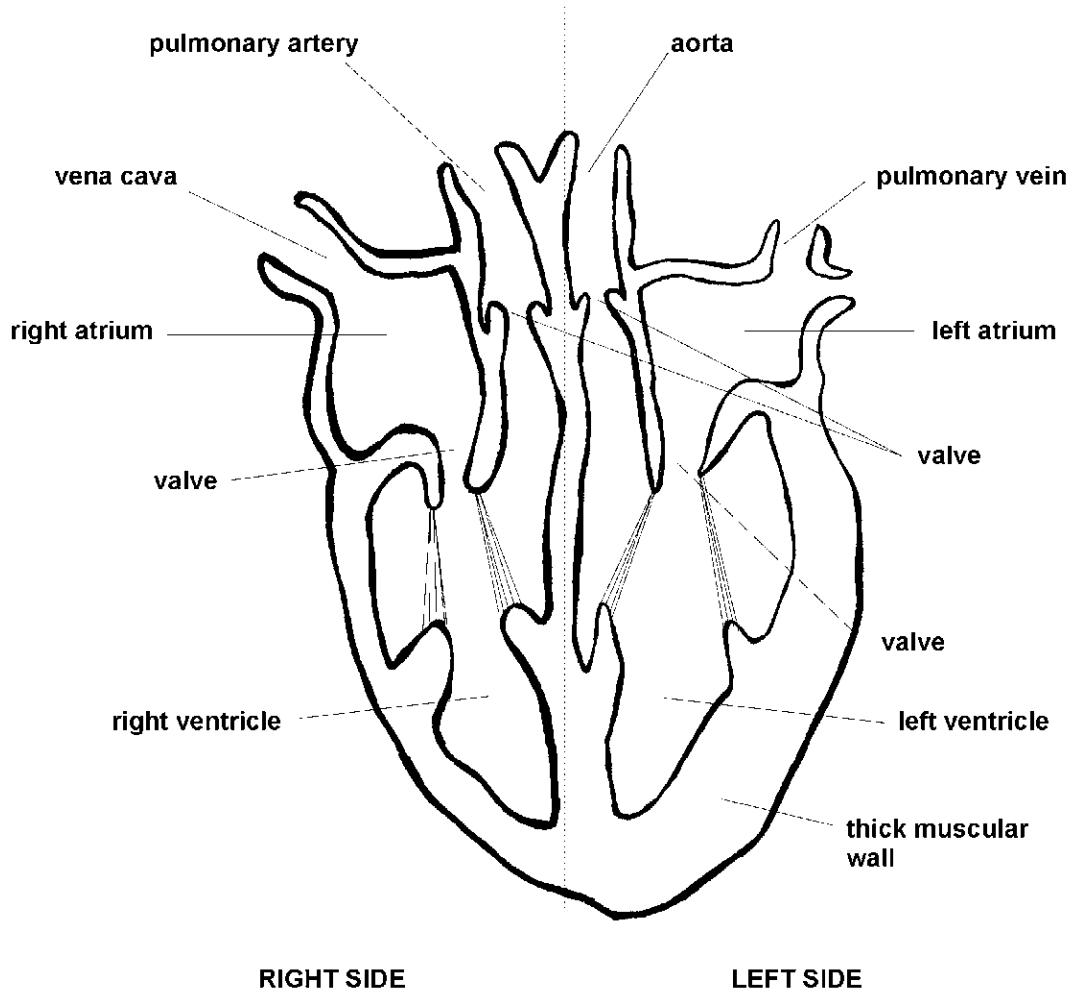
The Function of the Heart and Blood Vessels

Heart Structure

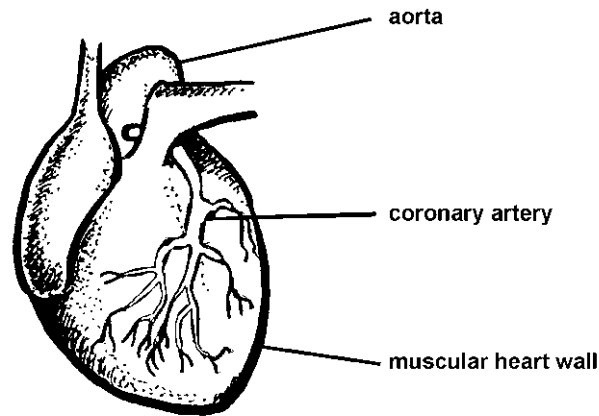
The heart has 4 chambers. The 2 upper chambers are called **atria** and the 2 lower chambers are called **ventricles**.

The position and function of the heart **valves** are shown in the table below.

Position	Function
Aorta Pulmonary artery	to prevent backflow of blood into the heart
between atria and ventricles	to prevent backflow of blood from ventricle to atrium



The main artery supplying the heart muscle is the **coronary artery**



Heart function

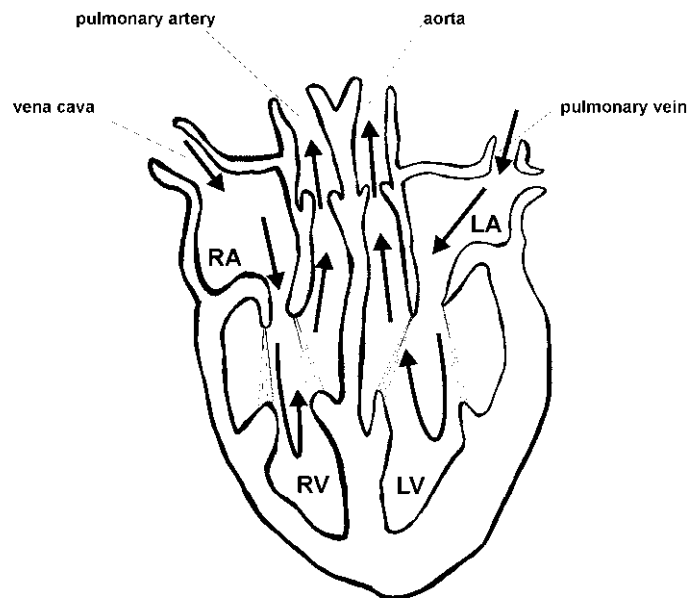
The heart is a **muscular pump** which pumps blood **to all body cells** and **to the lungs**.

The **left ventricle** is much **thicker and more muscular** than the right ventricle because it must pump blood to all body cells.

The **right ventricle** pumps blood to the lungs, so it does not need to have as thick a muscle.

Coronary arteries supply the heart muscle with the food and oxygen it requires to function efficiently.

The path of blood flow through the heart



Blood leaves the heart in arteries, flows through capillaries and returns to the heart in veins.

Oxygenated blood from the lungs enters the left atrium and passes to the left ventricle where it is pumped to the body tissues via the aorta. Deoxygenated blood from the tissues returns to the right atrium and passes to the right ventricle where it is pumped to the lungs via the pulmonary artery.

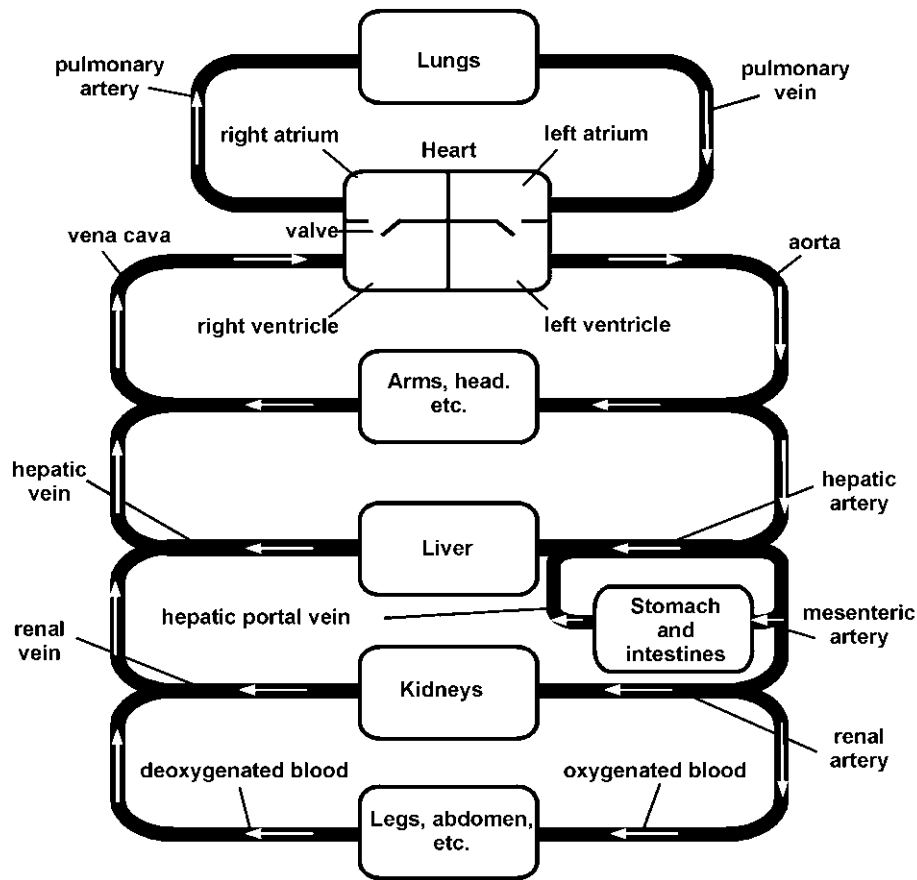
Blood vessels

Differences between arteries and veins:

Arteries	Veins
Carry blood away from the heart	Carry blood back to the heart
Thick muscular walls to maintain blood pressure	Thin muscular walls
No valves	Valves to prevent backflow
Have a pulse which indicates the pumping of blood from the heart	No pulse

Capillaries are a network of tiny blood vessels flowing through tissues. Capillaries have permeable walls to allow fluid to bathe the tissues and to allow the exchange of materials between the tissues and the blood.

Main blood vessels of the body are shown in diagram below:

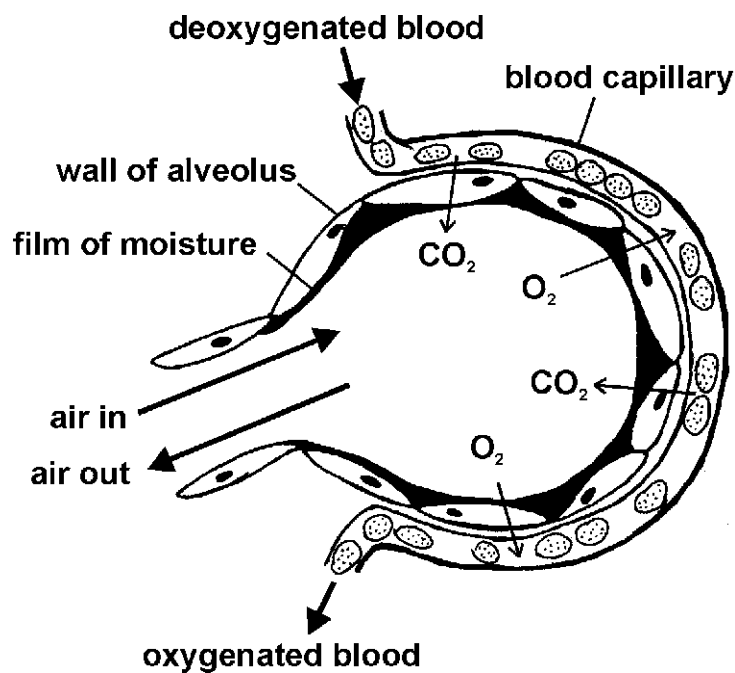
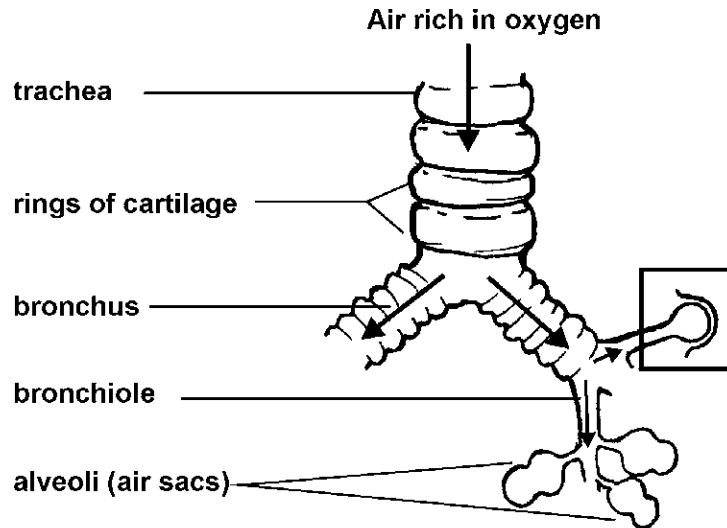


Blood vessel	Function
aorta	takes oxygenated blood to the tissues
vena cava	returns deoxygenated blood from the tissues
pulmonary artery	takes deoxygenated blood to the lungs
pulmonary vein	returns oxygenated blood to the heart
hepatic artery	carries blood to the liver
hepatic vein	returns blood from the liver
mesenteric artery	carries blood to the gut
hepatic portal vein	carries blood from the gut to the liver
renal artery	carries blood to the kidneys
renal vein	returns blood from the kidneys

Lungs and the capillary network

Lung structure

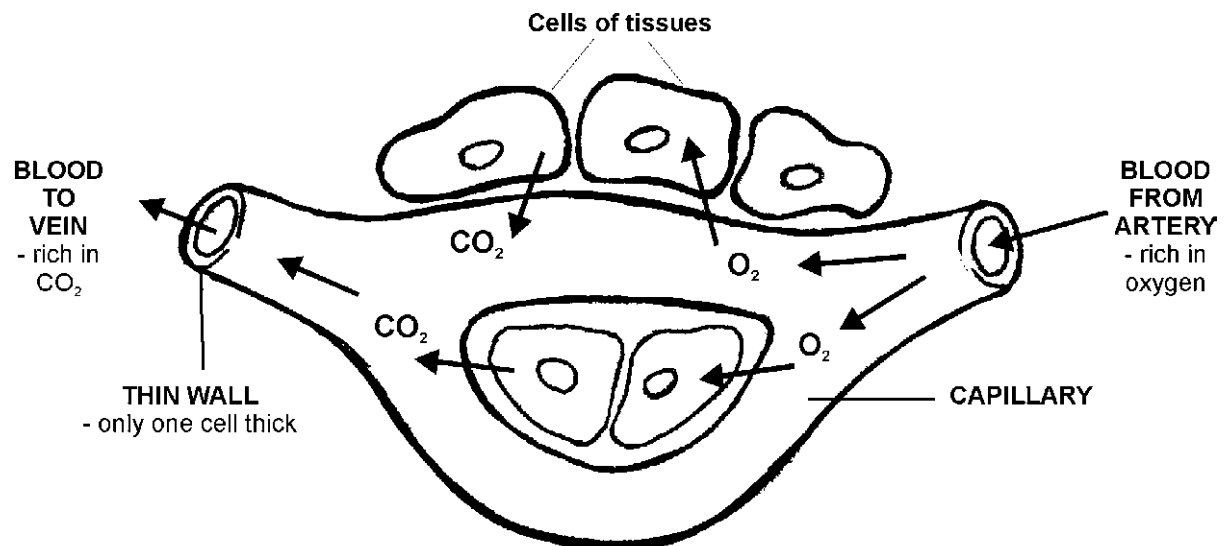
Gas exchange takes place in the lungs. Each lung consists of numerous branching bronchioles each ending in an alveolus or air sac. The trachea, bronchi and bronchioles are surrounded by rings of cartilage which keep the air passages open and air flowing freely in and out of the lungs.



Lungs as efficient gas exchange structures

Feature	Function
Numerous alveoli providing a large surface area	absorb maximum oxygen
Walls of alveoli moist	allows oxygen to dissolve before diffusion
Thin walls of alveoli	easy diffusion of oxygen into blood capillaries
Network of blood capillaries surrounds alveoli	take up oxygen from alveoli for transport in blood to cells

Structure of capillaries



Capillaries as efficient gas exchange structures

Feature	Function
Numerous and tiny, providing a large surface area	to reach all cells for gas exchange
Walls only one cell thick	easy diffusion of oxygen and carbon dioxide into and out of tissues

Blood

Red blood cells

Red blood cells contain **haemoglobin**, a molecule which combines with oxygen when the oxygen concentration is high and forms **oxyhaemoglobin**. This happens in the **capillaries surrounding the alveoli of the lungs** where the oxygen concentration is **high**.

Oxyhaemoglobin releases its oxygen in the **capillaries of the body tissues** where oxygen concentration is **low**.

Plasma

Plasma is the watery fluid in which blood cells are carried. It contains dissolved substances such as glucose, amino acids, plasma proteins, useful ions, a little oxygen and carbon dioxide.

Transport of carbon dioxide

A small amount of carbon dioxide is carried in solution in the plasma. Carbon dioxide combines with water to form carbonic acid. This causes an increase in acidity which limits the amount of carbon dioxide carried in this way. The majority of the carbon dioxide carried by the blood enters the red blood cells to be transported.

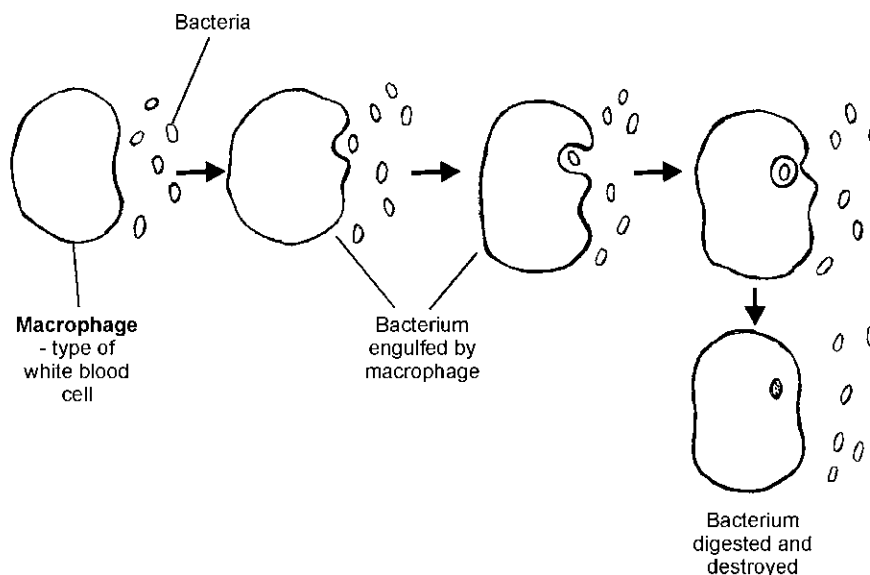
White blood cells

White blood cells are involved in the destruction of foreign bodies such as bacteria and viruses.

types of white blood cells

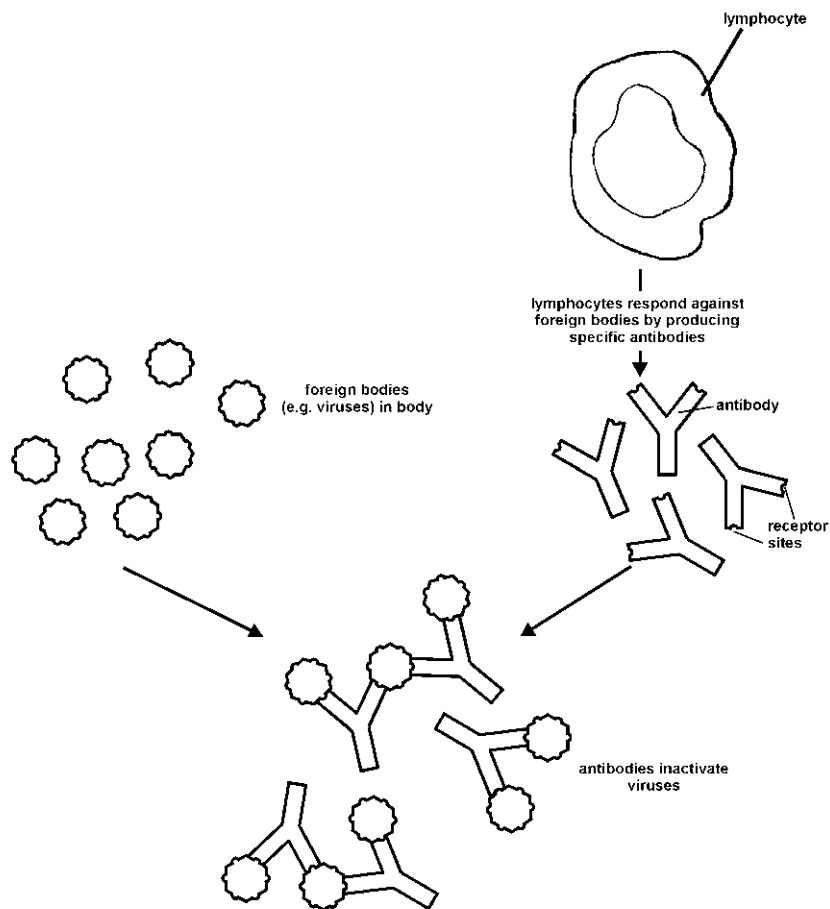
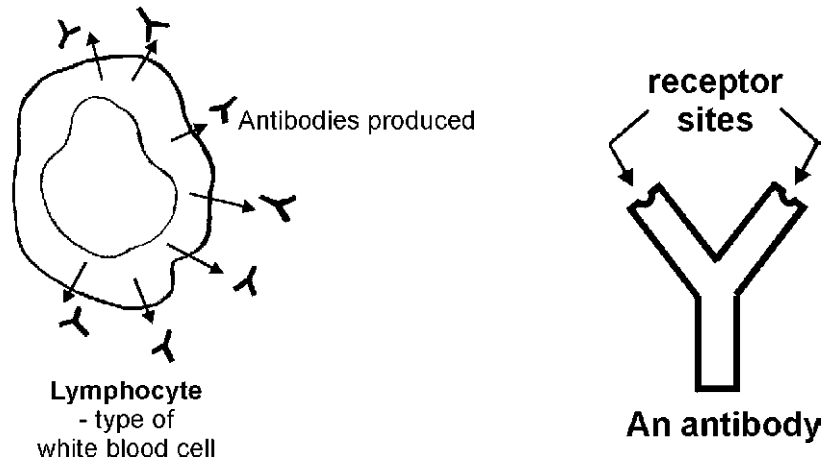
macrophages	lymphocytes
destroy foreign bodies by phagocytosis	destroy foreign bodies by production of antibodies
are non-specific	are specific - they only destroy one type of foreign body

Phagocytosis



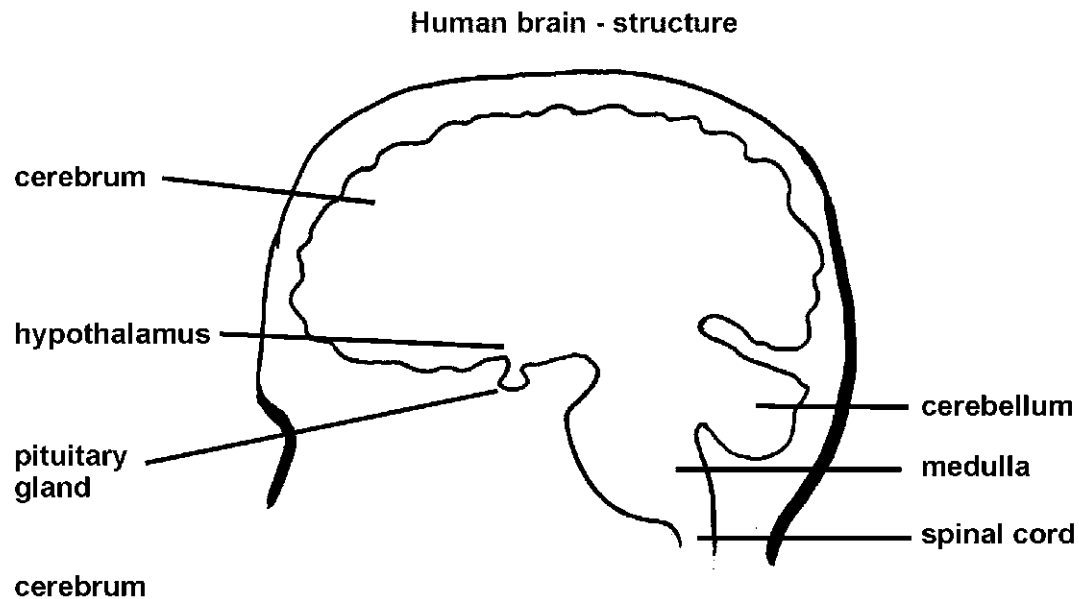
Antibody production

Lymphocytes circulate in the blood and produce antibodies which have receptor sites. These sites respond to a **specific** foreign body (bacteria or virus). The receptor sites become attached to the bacteria or virus to inactivate it.



SENSORY MECHANISMS AND PROCESSING INFORMATION

The Brain



Functions of the brain

The brain:

- receives impulses from all sensory organs of the body
- sends motor impulses to muscles and glands to control their function
- co-ordinates bodily activities
- stores informatio

The **cerebrum**:

- consists of two cerebral hemispheres
- co-ordinates activities in all parts of the body
- responsible for intelligent behaviour and consciousness of our own activitie

The **medulla** is the centre for bodily functions which are not under conscious control such as breathing and heart rate.

The **hypothalamus**:

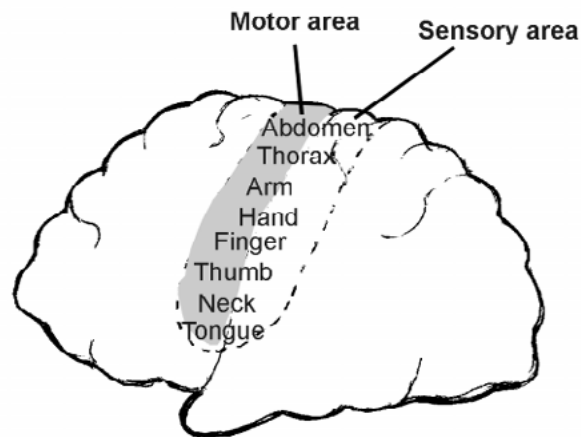
- is a regulatory centre lying above the pituitary gland
- detects changes such as water content of the blood and temperature
- reacts to these changes by producing nerve impulses which then respond to control these changes

The **cerebellum**:

- receives impulses from sensory organs involved in movement
- co-ordinates balance and muscular movement

Different areas of the brain have specific functions

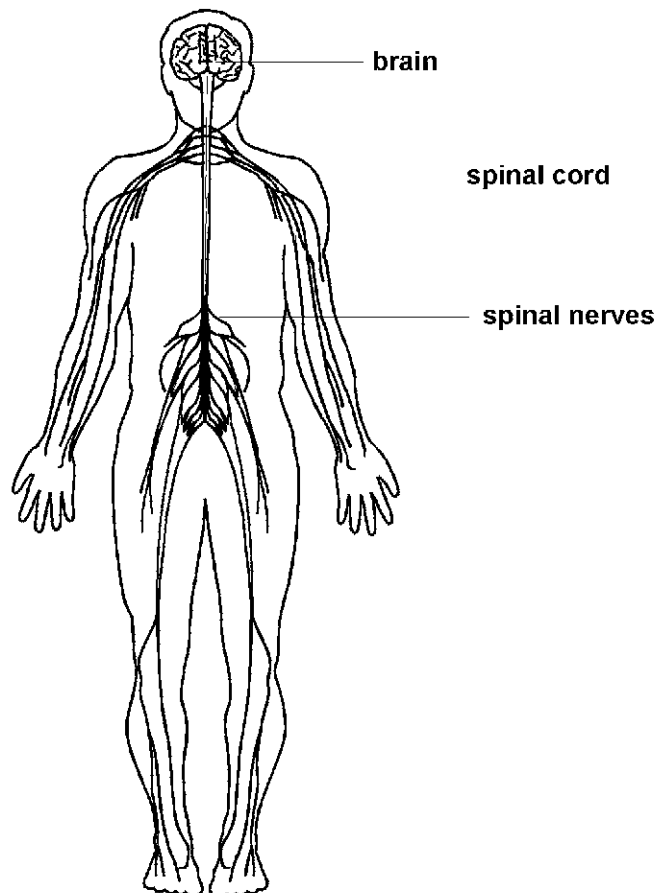
Different areas of the brain are responsible for controlling different parts of the body. Motor and sensory information are controlled by separate areas.



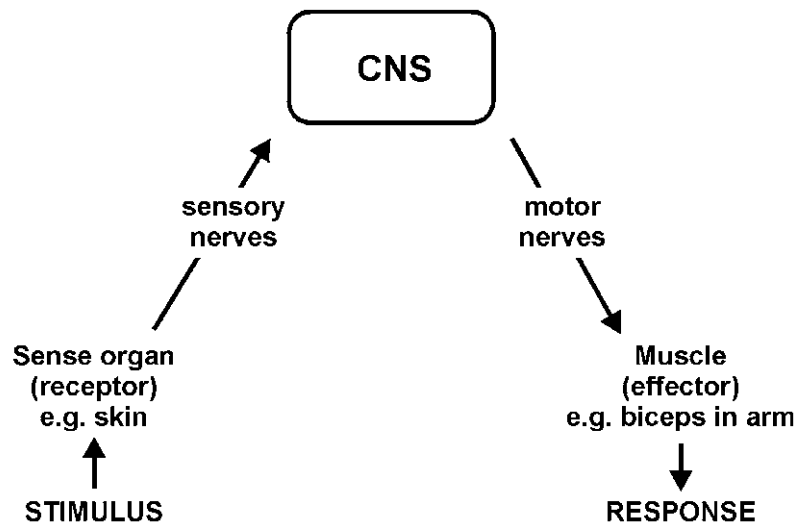
The Nervous System

Structure

The nervous system consists of the **brain, spinal cord and nerves.**



Nerve pathways carry nerve impulses from the sense organs (receptors) to the central nervous system (CNS), and from the central nervous system to the muscles.



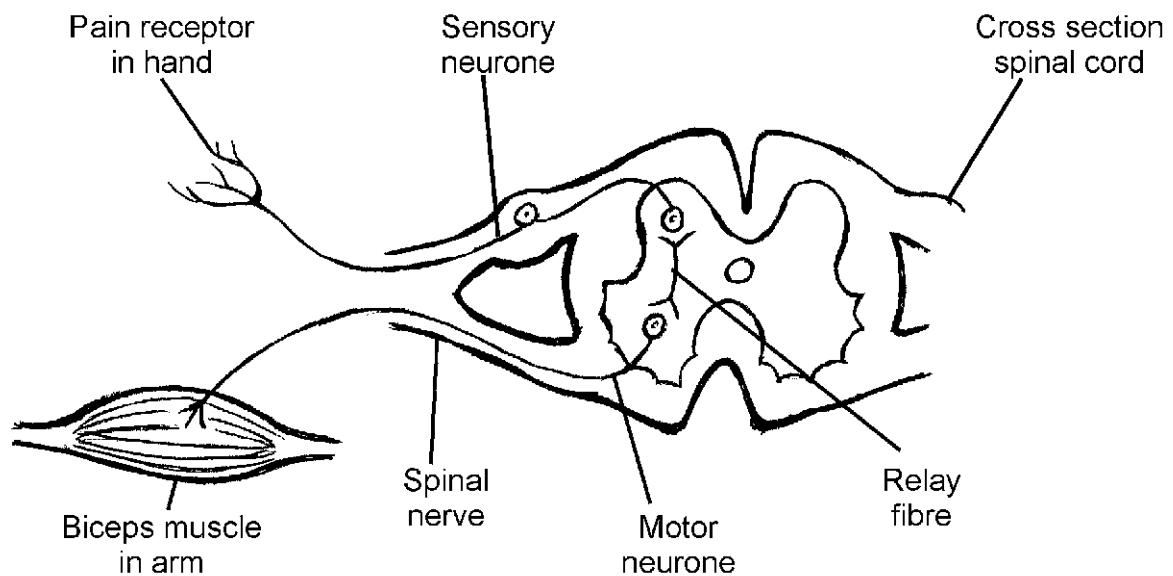
The reflex arc

A reflex action is a rapid, automatic, involuntary response to a stimulus. They do not require conscious control by the brain so they can work very quickly. As a result, reflex actions protect the body from damage.

Examples of reflex actions are:

- blinking
- decrease in the size of the pupil of the eye in response to bright light
- withdrawal of the hand in response to touching a hot surface

The **reflex arc** consists of a **sensory neurone**, **relay fibre** and **motor neurone**.

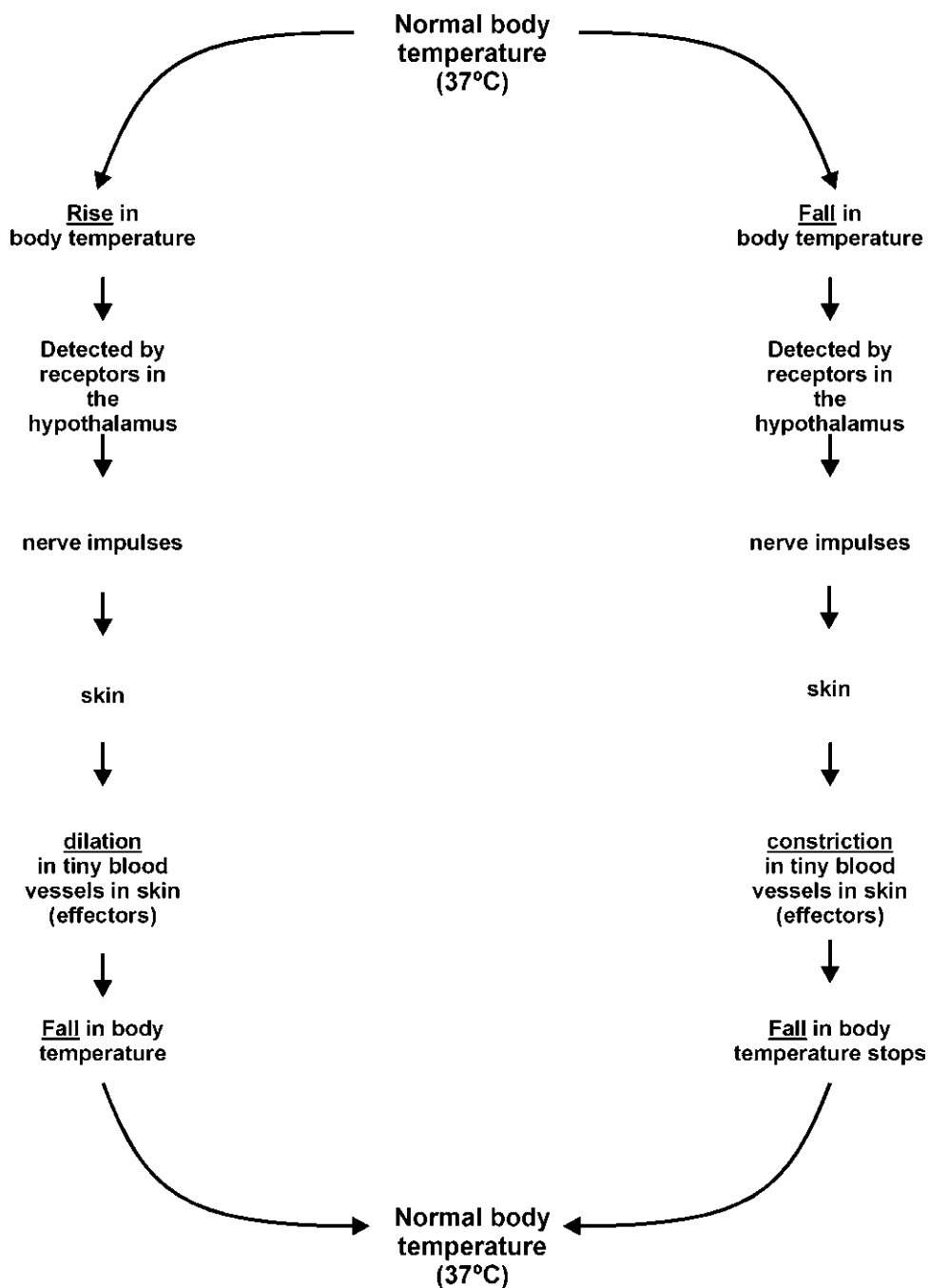


The role of the central nervous system (CNS)

The brain and spinal cord make up the central nervous system. The **CNS** is connected to all parts of the body by the **spinal nerves**. This means that the functioning of all parts of the body are coordinated by the CNS. Because the brain is highly complex, it has overall control of all functions.

Temperature regulation (an example of control by negative feedback)

The brain controls the internal environment of the body. An example of this is the control of body temperature. The blood must be maintained at around 37°C so that the enzymes in the cells can function properly. The mechanism which maintains the blood at this temperature is called **negative feedback**. This is shown in the following diagram:-

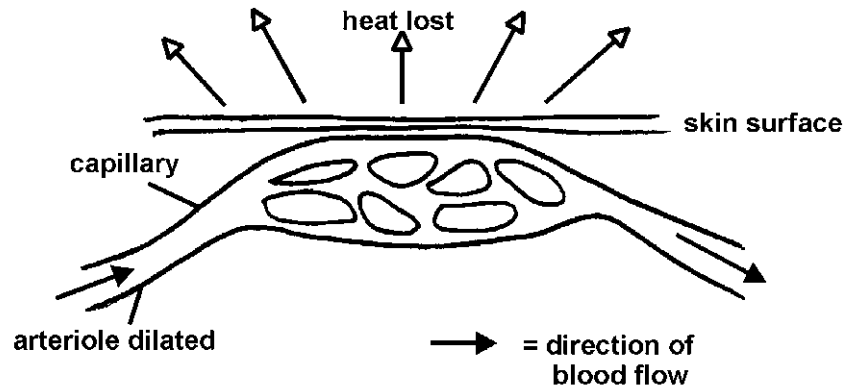


How temperature is controlled by the blood vessels in the skin

Heat loss through the skin is controlled by the tiny blood vessels in the skin called arterioles.

To decrease body temperature:

- Arterioles **dilate**
- More blood flows near the surface of the skin radiating heat
- Body temperature **falls**



To increase body temperature:

- Arterioles **constrict**
- Less blood flows near the surface of the skin reducing heat loss
- Body temperature **rises**

