

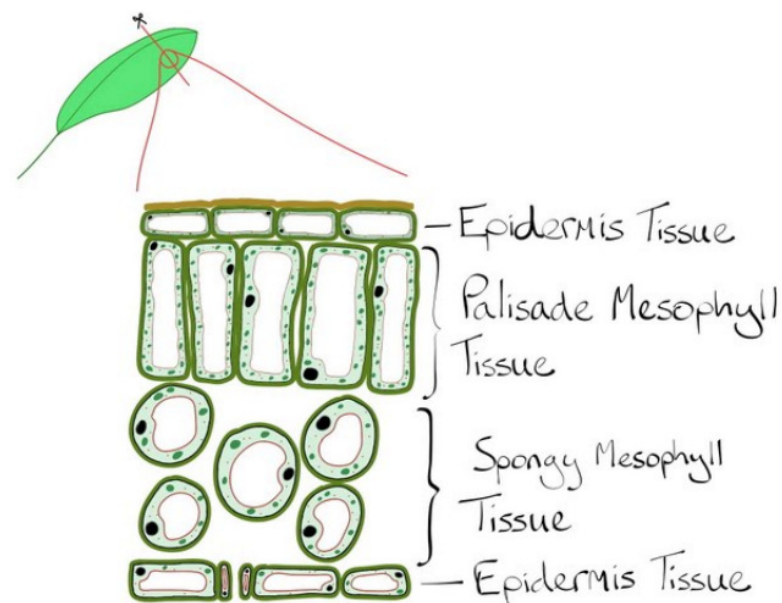
## National 5 Biology

### Unit 2 summary notes

#### 1. Cells, tissues and organs

Cells whose structure is adapted to carry out a specific function are called **specialised**. For example, red blood cells are a biconcave shape to increase their surface area for carrying oxygen. A **tissue** is a group of cells that are specialised to perform a particular function. For example, muscle cells join together to form muscle tissue which contracts to allow movement of our skeleton. Groups of tissues joining together to perform the same function are called **organs**. For example, our heart is made up of muscle and nerve tissues. Organs then join up to make organ **systems**, such as the digestive or respiratory systems. Finally, organ systems join up to make an **organism**.

Plants have specialised cells, tissues, organs and systems too. One example of a plant organ is a leaf.



- protects the leaf
- contains lots of chloroplasts containing chlorophyll to capture light for photosynthesis
- contain many spaces in between cells to allow gases (oxygen and carbon dioxide) to diffuse in and out of the leaf

## 2. Stem cells and meristems

Cells which are able to divide to create new cells are described as stem cells in animals. These cells divide by mitosis to create new cells. Stem cells which are formed immediately after fertilisation, called **embryonic stem cells**, can divide to produce cells which can go on to become any form of specialised cell. These stem cells are therefore crucial for **growth**. However, as the animal develops its stem cells become more restricted. Firstly, stem cells are restricted to producing groups of tissues and can eventually be restricted to only one tissue. In a fully grown animal, **adult stem cells** are restricted to producing cells of a particular tissue. For example, the stem cells which divide to replace your blood cells can only divide to become blood cells. Stem cells therefore are crucial for **repair**.

Arguments for stem cells include their many potential medical uses such as growing new organs / tissues for transplant, producing blood for transfusions and as an alternative to animal drug testing. Arguments against often focus on the killing of an embryo when stem cells are extracted which could be seen as taking a life.

Plants grow by a combination of cell division (mitosis) and cell elongation. Cell division in plants only occurs at **meristems**. Meristems can be found at the root and shoot tips which allows the stem and root to lengthen and also between xylem and phloem cells. Meristems divide to form unspecialised cells which can then become any specialised type of plant cell.

## 3. Control and communication

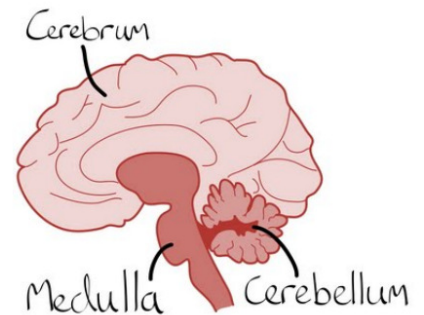
Multicellular organisms have groups of specialised cells such as tissues and organs which are physically distant from each other but need to communicate with each other. Therefore, we need a communication and control system.

### Nervous control

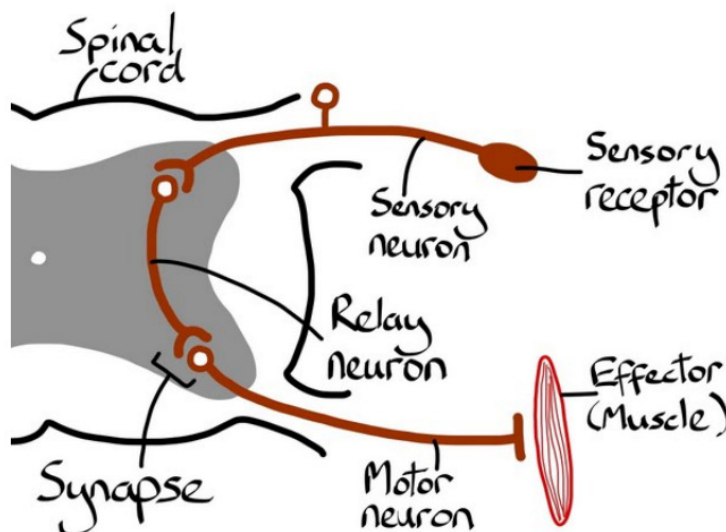
Animals have a system of neurons (nerve cells) which allows for quick communication and control of our body. Our **central nervous system (CNS)** is made up of two parts: the brain and the spinal cord. We also have neurons which join together to make nerves which connect the CNS with the rest of the body.

The brain can be divided into three main parts:

Structure	Function
cerebrum	controls thought, perception and personality
cerebellum	controls balance and co ordination
medulla	controls breathing rate and heart rate



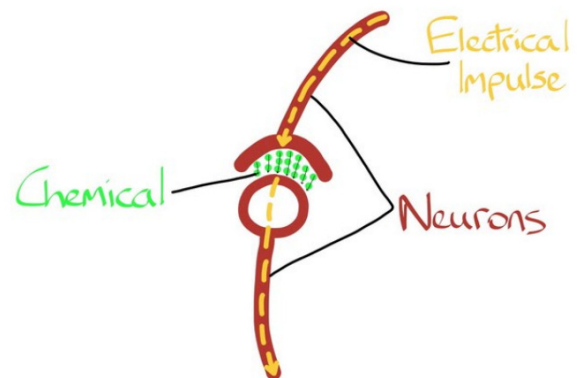
The spinal cord carries nerve impulses between the brain and the nerves, but it also carries out a control function. The spinal cord controls quite basic and primitive responses such as the **reflex** response. A reflex response is an **automatic** and **almost instantaneous** response to a stimulus. A reflex response normally occurs as a result of a stimulus which indicates potential harm to the organism. The response only travels as far as the spinal cord and not the brain, which makes it both **involuntary** and **quick**. The rapid reflex action occurs as a result of a **reflex arc**. The reflex arc consists of a series of neurons which pass through the spinal cord. The three neurons in the reflex arc are the **sensory neuron**, the **relay neuron** and the **motor neuron** as shown in the diagram below.



So, if you touch something very hot this **stimulus** is detected by sensory receptors in your skin. This triggers an **electrical impulse** which travels along the sensory neuron to the spinal cord. As an extreme temperature is likely to cause you harm, this stimulus will trigger a reflex response. The impulse therefore passes along the relay neuron to the motor neuron. The motor neuron carries the impulse to an **effector** (usually an organ/ gland) which brings about the response. In this example the effector would be the muscles in your arm

which would contract to move your arm away from the hot object. All of this occurs in a fraction of a second and without your conscious thought.

You will have noticed that there is a gap between each of the neurons in the diagrams above. These are called **synapses**. The **electrical impulse** which travels along a neuron cannot jump this gap. When the electrical impulse reaches the end of one neuron it stimulates the release of a chemical. This **chemical** diffuses across the gap between the two neurons. When the chemical reaches the second neuron it stimulates a new electrical impulse which then travels along this neuron.



## Hormonal control

Not all of the control and communication which occurs between tissues and cells in an animal are by electrical impulses. Some signals are sent using **chemical messengers** in the **blood** stream. These chemical messengers are called **hormones**. Tissues which produce hormones and release them into the blood are called **endocrine glands**.

Each hormone molecule carries out a particular function in the body. Cells of tissues have receptor molecules in their cell membranes which are specific to a certain hormone(s) which act on that tissue. So, if hormone molecules are present in the blood stream which a particular tissue doesn't have the **receptors** for, nothing will happen at that tissue. Only the tissues containing the correct receptors will detect each hormone presence and bring about the response.

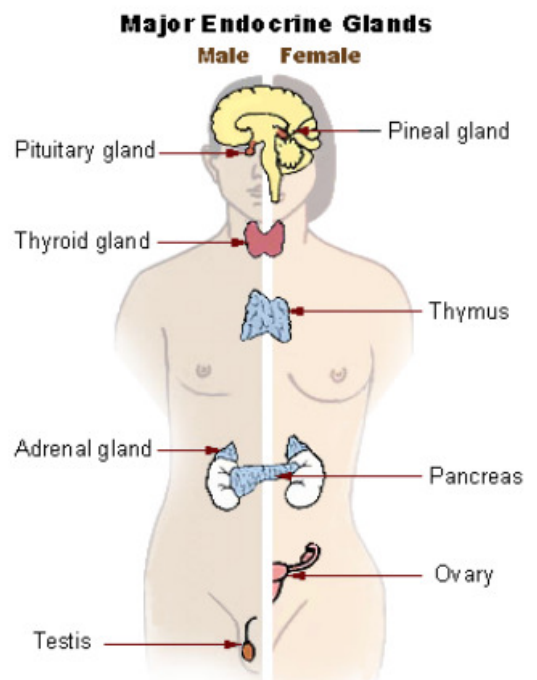
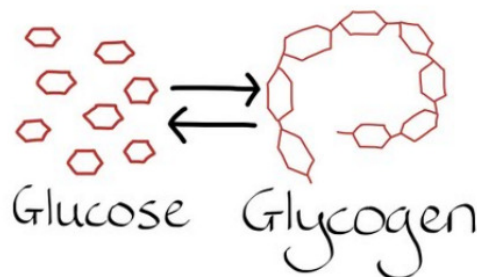


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## Control of blood glucose levels

Another example of a hormone system in our bodies is the way that we control the concentration of the sugar **glucose** in our **blood stream**. Why does the concentration of glucose in our blood stream matter? Too little glucose and our cells won't be able to carry out respiration to make energy, too much glucose in our blood stream and our cells will begin to lose water by osmosis. So, our bodies aim to have a relatively constant concentration of glucose in our blood stream by adding more glucose if it goes down and removing some if it goes up...this process is controlled by the hormones insulin and glucagon. Before we learn how these hormones control the concentration of glucose in our bloodstream, you first need to know how glucose can be stored. Glucose molecules are single sugars. Glucose can be stored by joining these single glucose molecules together to form long chains of glucose molecules. Plant cells form a type of long chain of glucose molecules called **starch** whereas animal cells instead produce **glycogen**. When an animal cell needs more glucose it can get it from breaking down glycogen.



Glucose is stored as glycogen in our bodies in the **liver**. Changes in blood glucose concentration are detected in the **pancreas**. As the liver and the pancreas are separate organs, hormones are required travel in the bloodstream to communicate between the pancreas and the liver to bring about the appropriate response.

**Insulin** is released by the pancreas into the bloodstream when the concentration of glucose in the blood rises, for example after eating a meal. Liver cells detect the presence of insulin in the blood which causes the conversion of glucose to glycogen. This lowers the concentration of glucose in the blood returning it to normal.

**Glucagon** is also a hormone released by the pancreas. Glucagon is released when the concentration of glucose in the blood falls, for example after exercise. When glucagon is detected by the liver cells they convert stored glycogen to glucose which raises the blood glucose concentration back to normal.

## Diabetes

Diabetes is a condition where our body cannot control its blood glucose levels. After eating, diabetic's glucose levels increase much higher and take much longer to come back normal than someone without diabetes. In Scotland, numbers of diabetics are rapidly increasing, particularly with type 2 occurring in younger people.

Type	Onset in life	Cause	Risk factors	Treatment
1	<b>Child hood</b>	Autoimmune disease - body attacks and destroys the pancreas	Close relative with type 1	Low sugar diet, insulin injections, exercise
2	<b>Usually adulthood</b>	Insulin resistance - body cells no longer responds to insulin	Obesity, age, high blood pressure, close relative with type 2	As above

## 4. Reproduction

You already know that chromosomes consist of DNA which carries our genetic information. But in order for a species to be successful, this genetic information needs to be passed onto future generations. The vast majority of cells in a multicellular organism can be described as **diploid**. A diploid cell contains **two copies** of each of the chromosomes for that species. For example, a healthy human cell consists of 23 different chromosomes. A diploid human cell therefore has 46 chromosomes, or 23 pairs:

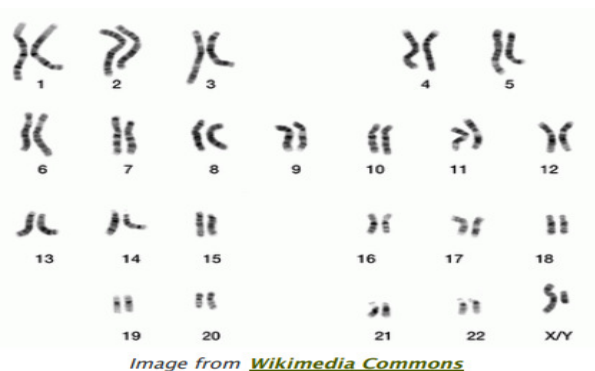
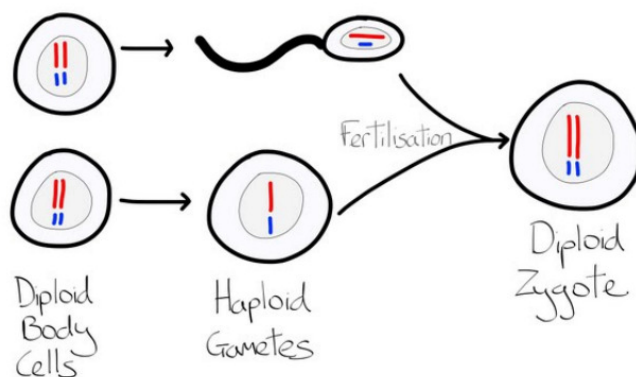


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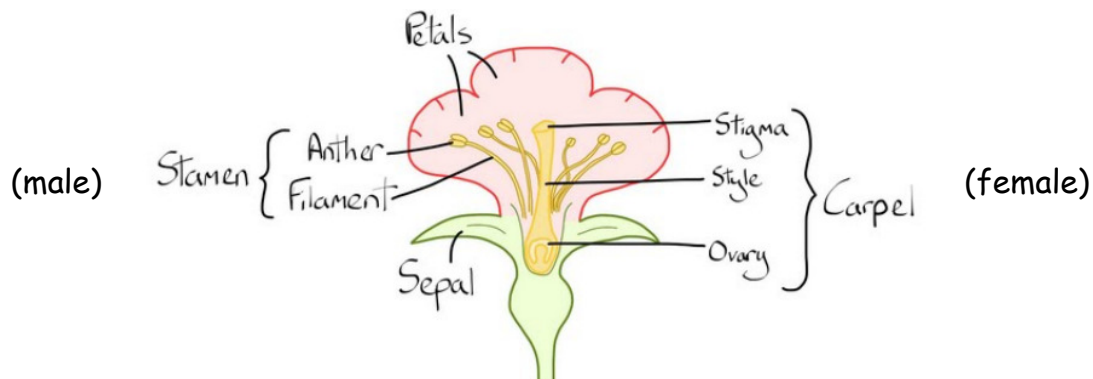
In order for sexual reproduction to occur, two cells must fuse to form the new individual. If two diploid cells were to fuse the number of chromosomes in the offspring would be double that of the parents. For most species, particularly animal species, this would be fatal. Multicellular organisms therefore need to reduce the chromosome complement of the cells involved in sexual reproduction by half. Cells which have only **one set** of the species' chromosomes are described as being **haploid**. In humans these haploid cells are egg and sperm cells, but they are pollen and ovule in plants. Collectively, these types of cells are known as gametes. During sexual reproduction, two haploid gametes fuse to form a new individual. This process is known as fertilisation and the new cell called a zygote contains **two sets** of chromosomes. It is described as being **diploid**. This process is summarised in the diagram below. To simplify the diagram, the diploid number in the diagram is 4 and the haploid number is 2. In reality, in humans this is 46 and 23.





## Reproduction in plants

There are many different types of plants and a great variety of methods of reproduction in the plant kingdom. Many plants can reproduce asexually, but many can also reproduce sexually. In order to reproduce sexually plants will need to produce haploid gametes which can fuse to form a diploid zygote. The organ of sexual reproduction for many plants is the flower.



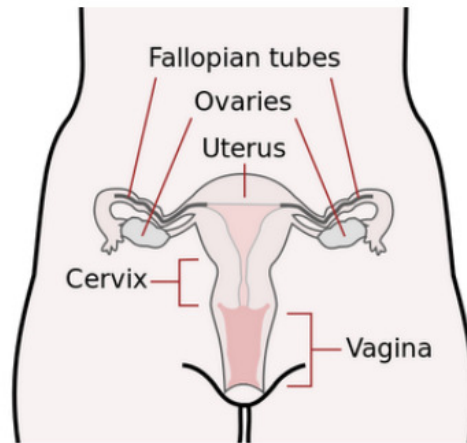
Structure	Function
petals	attract insects for pollination
anther	produces male gamete (pollen)
filament	stalk on which the anther sits
stigma	sticky, pollen lands here
style	connects stigma and ovary
ovary	produces female gamete (ovules)
sepal	protects bud

**Pollen** produced in the **anthers** are dispersed either by the wind or insects in a process called **pollination**. Once a pollen grain lands on the **stigma** of a flower the pollen grows a pollen tube which carries the pollen down the style in to the ovary where it fuses with an ovule through **fertilisation** to form a diploid zygote. This diploid zygote then develops into a seed which is then dispersed from the plant by various methods. These methods include being eaten by animals (**animal internal**), stuck to animals' coats (**animal external**) or being spread by the **wind**. This avoids the offspring competing with the parent plant for resources.



## Reproduction in animals

In animals, the haploid gametes in animals are **egg** cells produced by the **ovaries** and **sperm** cells produced by the **testicles**.



*Image from [Wikimedia Commons](#)*

When females reach puberty, they begin the process of releasing their own eggs, known as **ovulation**, normally at the rate of one per month. If sperm cells are present during or soon after ovulation, they travel up from the vagina then fertilisation can occur in the **fallopian tubes** (also called the oviduct) to form a diploid cell. This diploid cell, correctly called a **zygote**, will start to divide and grow as it travels down and **implants** into the uterus where it will stay during pregnancy. The uterus lining therefore thickens during the process of ovulation in preparation for pregnancy. If pregnancy is not achieved following ovulation, the lining of the uterus wall breaks down and is released from the body via the vagina - this is what is known as menstruation or "periods".

## 5. Variation and inheritance

### Variation

Differences you can see between organisms in a species is called **variation**. Variation can be grouped into two main categories: discrete and continuous. Variation which is measured in separate groups is called **discrete** variation. For example, our ability to roll our tongues is determined by just one gene. We can all either roll our tongue or not - there's nothing in between. Variation which is measured on a scale is called **continuous** variation, for example height and

weight. These types of variation often involve more than one gene - this is described as **polygenic** inheritance.

## Inheritance

Take our ability to roll our tongues, which is controlled by just one gene. As we each receive one copy of each gene from each parent (one in the egg, one in the sperm), we all have two copies of every gene in our body. Genes come in different forms, for example a tongue roller and a non roller. The different forms of a gene are called **alleles**. Each gene is allocated an individual letter and different forms of the gene are given either a capital or lower case version of the letter. The stronger form of the gene is called **dominant** and we always give it the capital letter. The weaker form of the gene is called recessive and we always give it the lower case. For example we can call the dominant 'can roll' version of the gene as 'R' and the recessive 'can't roll' version of the gene 'r'. So the possibilities are either RR, Rr or rr. If you have one or two copies of the dominant allele, RR or Rr, it means you can roll your tongue. If you have both recessive alleles, rr, you can't. The pair of alleles an organism has for each gene is called its **genotype**. The organism's physical appearance is called its **phenotype**.

We have two more words to introduce here before we can move on: heterozygous and homozygous. **Heterozygous** means that an organism has two different alleles, whereas **homozygous** means their two alleles gene are the same. In our tongue rolling example we would describe each of the genotypes as follows:

Genotype	Heterozygous/Homozygous	Phenotype
RR	Homozygous Dominant	Can Roll Tongue
Rr	Heterozygous	Can Roll Tongue
rr	Homozygous Recessive	Can't Roll Tongue

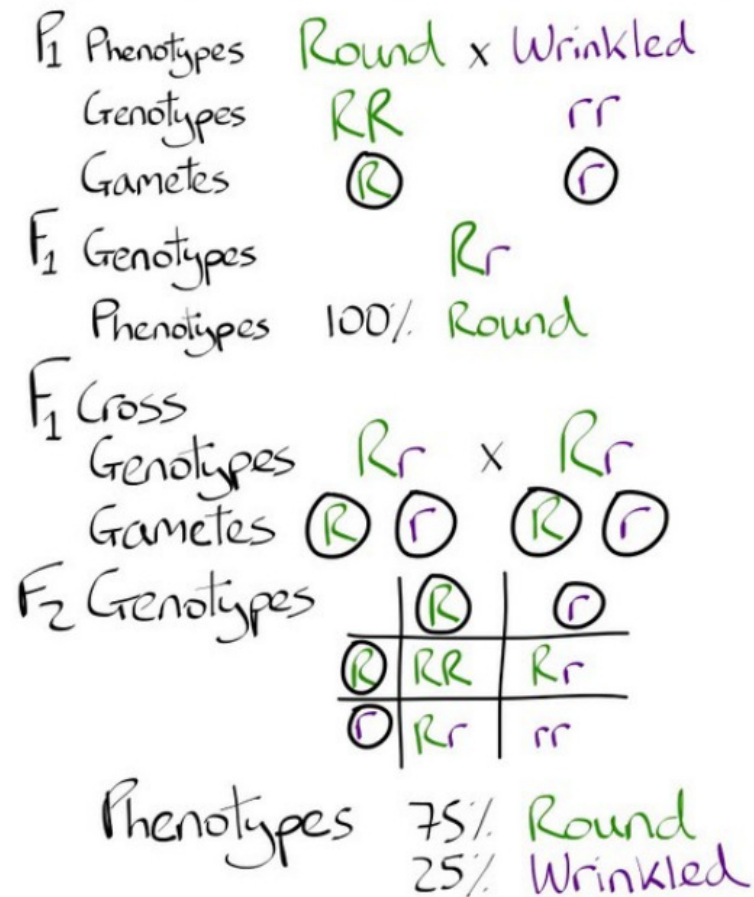
We can use this information to predict what we would expect the phenotypes of offspring from sexual reproduction to be by making up a punnett square. This works by adding the two alleles from one parent on one side of the square and the two alleles from the other parent on the other side of the square. We can then work out all possible combinations which could be made and the likelihood of each one occurring. The diagrams below show what we would expect the phenotypes of the children from parents with different genotypes for tongue rolling.

Parents'	Can Roll x Can Roll			
Phenotype	$Rr$ $Rr$			
Genotype	$R$ or $r$ $R$ or $r$			
Egg/Sperm	$R$ or $r$	$R$ or $r$		
Children	$R$	$r$	25% $RR$	
Genotypes	$RR$	$Rr$	50% $Rr$	
Phenotypes	$Rr$	$rr$	25% $rr$	
	75% Can Roll 25% Can't			

In this example where we have crossed two heterozygous parents (both  $Rr$ ), we would expect 25% of their children to be homozygous dominant ( $RR$ ), 50% to be heterozygous ( $Rr$ ) and 25% to be homozygous recessive ( $rr$ ). Because both  $RR$  and  $Rr$  have the same phenotype, the expected phenotypes would be 75% 'can roll' and 25% 'can't roll'. Our predicted ratios don't always match up to the exact numbers because **fertilisation is random**. Any egg could join with any sperm, so in theory, it would be possible to have 100%  $RR$ , just quite unlikely! Most of our genetic experiments are done with species which produce large numbers of offspring quickly, such as plants and fruit flies, to make our results more reliable.

For example, pea plants have a number of different characteristics which are controlled by one gene and can be easily studied. One such characteristic is the surface of the pea seeds. Again, for the pea surface there are two possible phenotypes: round or wrinkled. Round is dominant and wrinkled is recessive.

We can use the letter 'R' in this case to represent 'round' and 'r' to represent wrinkled. The basic sort of experiment you could do to investigate the inheritance of seed surface would be to cross two homozygous plants with different phenotypes. You could then cross two of the offspring plants together. We use a shorthand to indicate which of the generations we're discussing in such an experiment as you'll see in the following diagram. The parents we can refer to as 'P', the offspring of the parents as 'F1' (first generation) and the offspring of crossing two F1 as 'F2' (second generation). So what genotypes and phenotypes would we expect from this cross then?



As you can see from the diagram above, 100% of the  $F_1$  generation would have the genotype Rr and would have round seeds. The offspring of two  $F_1$  plants are shown in the  $F_2$  generation. We would expect 25% of the  $F_2$  generation to be RR, 50% to be Rr and 25% to be rr. Therefore, 75% of the  $F_2$  plants should be round and 25% should be wrinkled. The ratio of the two phenotypes is 'Round 3:1 Wrinkled'. Experiments such as these were first carried out by an Austrian monk named Gregor Mendel in the 19th Century.

Our understanding of genes has helped with the diagnosis of inherited diseases. For example, pedigree charts such as the one below can be used to help determine the inheritance of genes which are related to genetic diseases. This is called **genetic counselling**.

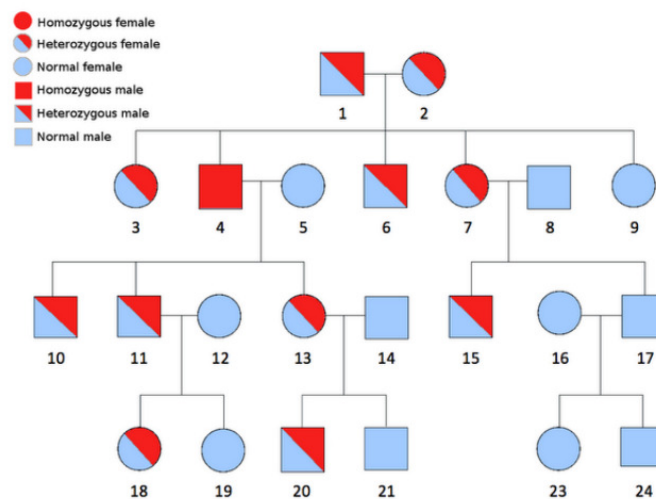


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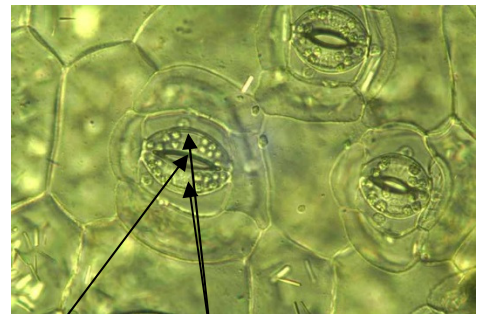
Quite often, the version of the gene which results in the disease is recessive and so individuals which are heterozygous have a copy of the gene, but are unaffected. These individuals are normally described as 'carriers'. In the example above, individuals 1, 2, 3, 6, 7, 10, 11, 13, 15, 18 and 20 are carriers. Without genetic testing, most of these individuals would not know if they were carriers for the condition or not. This is where a pedigree chart can be useful. Before couple 13 and 14 had their children they could have worked out that 13 must be a carrier for the disease as his father (4) had the condition and therefore must have been homozygous recessive and could only have passed on the disease-causing version of the gene.

## 6. Transport systems

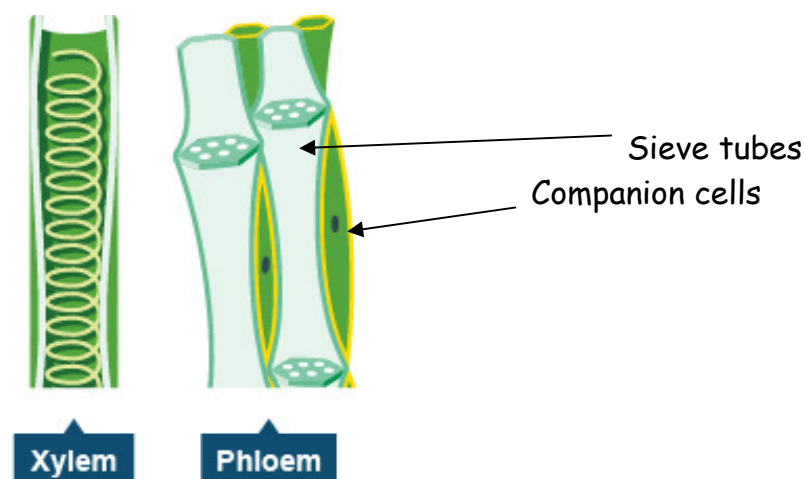
### Plants

Much of the transport systems of plants can be viewed from the perspective of photosynthesis. Photosynthesis requires a supply of water, therefore plants have a transport system which brings water up from the roots to the leaves. This water also carries other materials to the plant cells from the soil, such as minerals. Water and dissolved minerals enter the plant's roots and travel up tubes called **xylem**. Xylem tissues are made up of long, **dead** tubes supported by rings of a chemical called **lignin**.

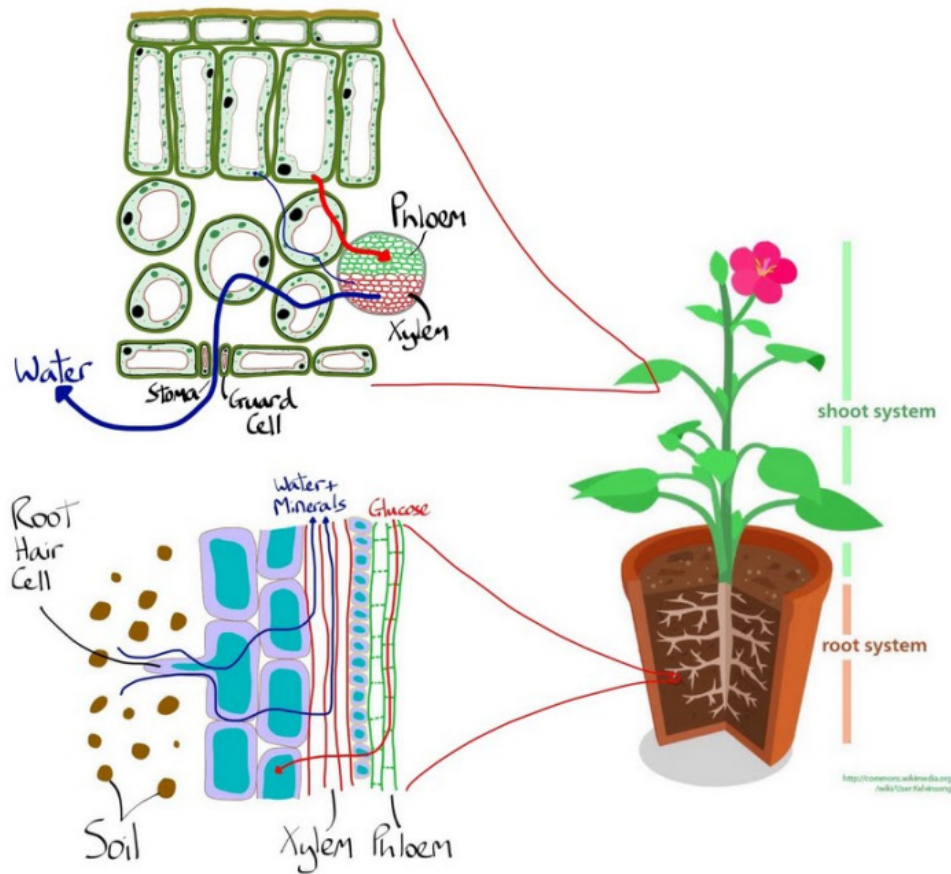
Photosynthesis also requires carbon dioxide. This enters the plant through holes on the underside of the leaf called **stomata**. These holes are controlled by cells on either side called **guard cells**. The stomata open during the day to let carbon dioxide in. As water can also be lost by **transpiration** through the stomata (and plants can't carry out photosynthesis at night as there is no light), they shut at night. Most plants also have a waxy layer on the surface of their leaves called the **cuticle** to further prevent water loss.



Plants also need to transport sugars. The sugar produced from photosynthesis in the leaves is needed by all the cells in the plant for energy, growth and storage. As this is mainly moving in the opposite direction to the water and minerals, plants have a separate transport system for the movement of sugar: **phloem**. Phloem tissue is **alive**. They are made up of sieve tubes which are tubes the sugars travels through and also companion cells which carry out many of the functions required to keep the phloem cells alive.





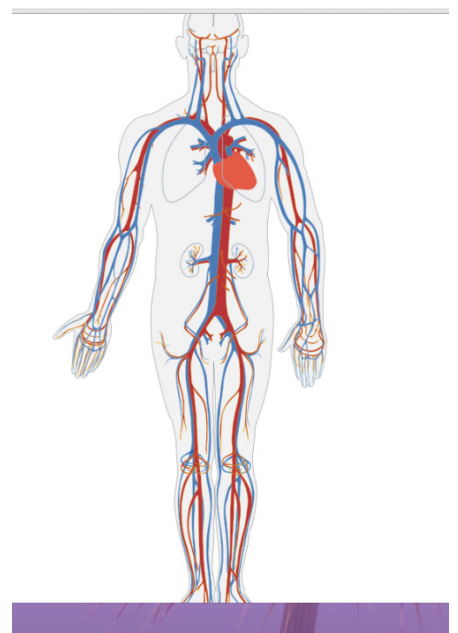


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## Animals

### Circulatory system

The circulatory system of animals consists of three main structures which you need to know about: the heart, the blood vessels and the blood





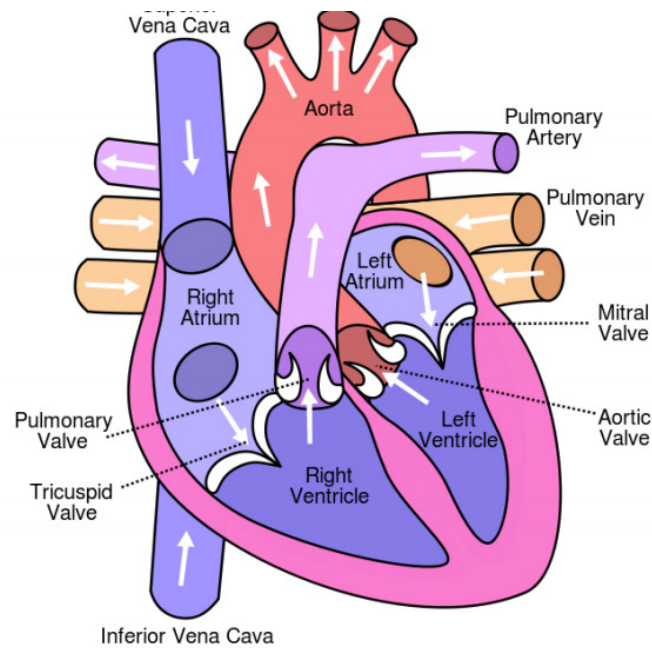


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The heart is the pump of our circulatory system. It is made up of cardiac muscle and is divided into 4 number of chambers. Although both sides of the heart contract simultaneously, the blood leaving the heart is going to different destinations depending on which side of the heart it is leaving. The right side of your heart pumps blood to the lungs to absorb oxygen and release the waste carbon dioxide. The left side of your heart has to work significantly harder by pumping the now oxygenated blood much further and throughout the whole of your body. As a result, the muscle of the left side is much thicker than the right.

As you can see from the diagram above, there is more complexity to the heart than simply the left and right side. The heart also consists of the upper two chambers, the atria, and the lower two chambers, or ventricles. Blood arriving at the heart arrives at the atria from a vein. The vein which brings the blood to the atria depends on what side of the heart it is. Blood arriving in the right atrium is coming from the body and is deoxygenated. This arrives in the **vena cava**. Blood arriving in the left atrium is coming from the lungs in the **pulmonary veins** and is oxygenated. From the atria, blood passes through valves into the ventricles. The **valves** prevent the backflow of blood, or prevent it from going in the wrong direction in other words. You don't need to know the names of the valves for this course. The ventricles make up the bulk of the structure of the heart and contract to push the blood out of the heart. The right ventricle pushes blood into the **pulmonary artery** to the lungs, whereas blood leaving the left ventricle enters the large artery known as the **aorta**.

Obviously, the heart muscle cells require a lot of energy themselves in order to contract and therefore carry out respiration too. The heart muscle therefore has its own blood supply, the **coronary artery**. This blood vessel is affected in people with heart disease.

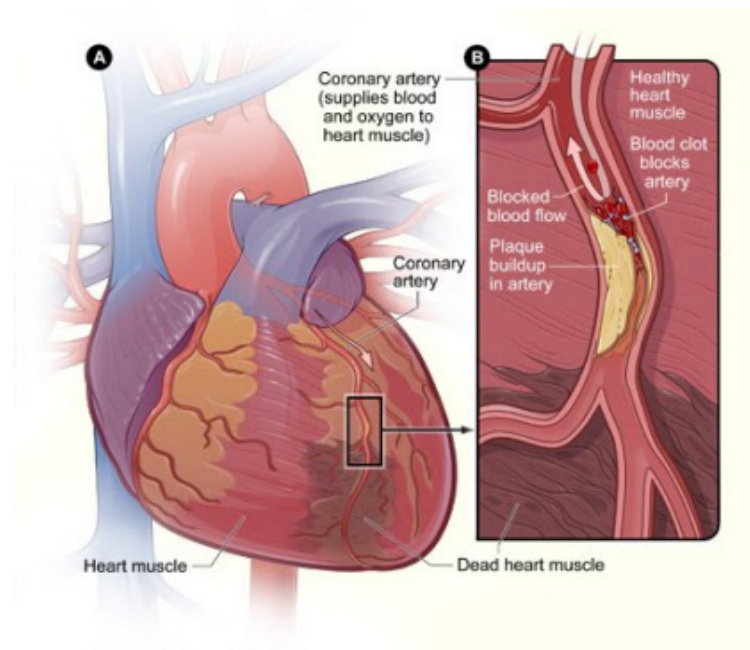


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As you may have noticed, there are a number of different blood vessels involved in carrying blood around the animal body. The blood vessels in your body can be categorised into one of three main types: arteries, veins and capillaries. Arteries carry blood away from the heart, veins carry blood back to the heart and capillaries connect the two allowing the exchange of substances between the blood and the surrounding tissues.

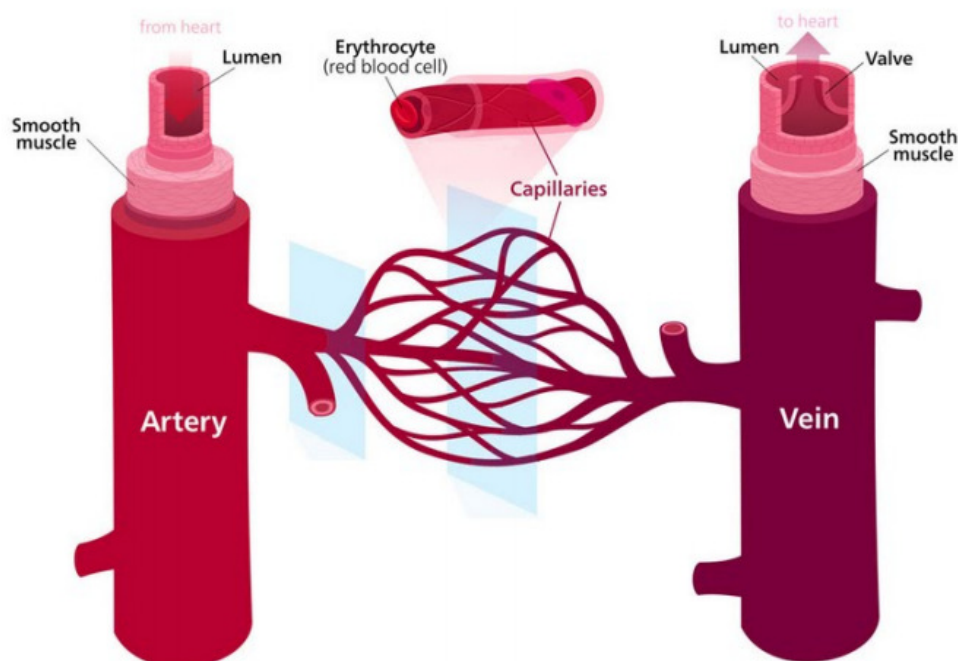
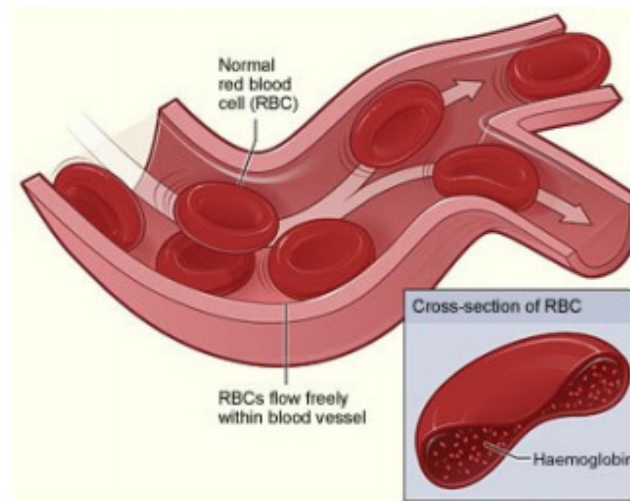


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Arteries carry blood away from the heart and therefore have thick, muscular walls as they carry blood under high pressure. Veins carry blood back to the heart under low pressure and have thinner walls. Veins also contain valves to prevent the backflow of blood. Capillaries form networks at organs and tissues. They are thin walled and have a large surface area, allowing the exchange of materials such as oxygen, carbon dioxide, glucose and amino acids. Most of the substances which are carried in the blood just dissolve in the fluid, but oxygen is different. Oxygen is carried by red blood cells which have specialised adaptations for this function.



*Image adapted from [Wikipedia](#)*

Red blood cells contain the chemical haemoglobin which binds reversibly to oxygen. Red blood cells absorb oxygen in the lungs and then release it again in the tissues. As you can see from the diagram above they have what we describe as a biconcave shape which increases the surface area for the absorption of oxygen and allows them to squeeze through the narrow capillaries which can be so narrow that only one red blood cell can pass through at a time.

## **Respiratory system**

As you will have already learned, the lungs are the organs where oxygen and carbon dioxide are exchanged between our blood and the air. The blood therefore has to come into close contact with the air in the lungs, this happens in the alveoli. Firstly though, the air has to get to the alveoli. The air we breathe in pass through a series of structures after our mouth and nose on their way to the alveoli as shown in the following diagram.

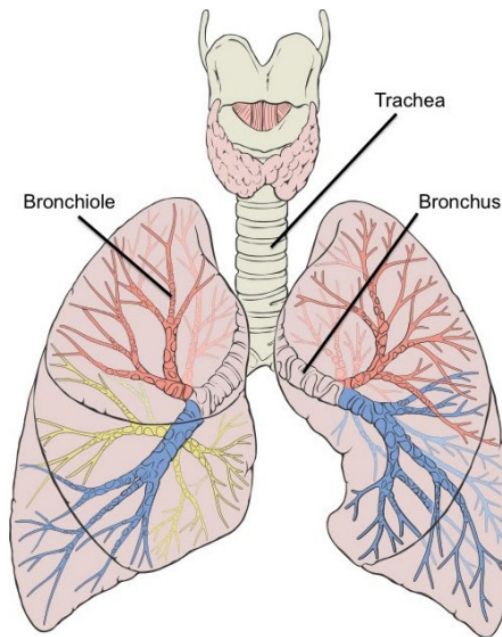


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Air passes through the trachea in your neck, which leads to two **bronchi**. Each series of ever smaller branching tubes called the **bronchioles** and at the end of these are the **alveoli**. These airways are surrounded by a rings of **stiff cartilage** to keep them open under the changing air pressures as you breathe in and out. This isn't dissimilar the hard rings on your vacuum cleaner's hose pipe! All of the above airways are lined with cells which have tiny hairs on them called **cilia** and other cells which produce **mucus**. The sticky mucus traps dirt and microorganisms carried into the lungs in the air. Cilia are little hairs on the cells lining the airways and these beat to move this mucus up out of the lungs and up to your throat to cough out or swallow.

The actual exchange of gases occurs in the alveoli which are found at the end of the bronchioles. These alveoli have adaptations to increase the efficiency of the exchange of oxygen and carbon dioxide between the air and the blood. These include a very large surface area, walls that are one cell thin and a good blood supply. As you can see from the diagram below, the alveoli are surrounded by complex networks of blood capillaries which bring the red blood cells in close proximity to the air. Oxygen diffuses from the air across the alveolar and capillary walls and into the passing red blood cells. At the same time, carbon dioxide is moving in the opposite direction out of the blood and into the air in the lungs to be exhaled. Once the blood has passed through the lungs it returns to the left atrium of the heart in the pulmonary artery.

## Digestive system

The other exchange system you need to know about is the digestive system. Blood interacts with the digestive system in order to absorb the nutrients required by the cells in the body, such as glucose and amino acids. But first, the food we eat must be broken down and digested from large insoluble molecules, to the small soluble molecules which can diffuse and dissolve in the blood. Our food therefore passes through a series of organs which carry out this digestion and absorption. These organs are also surrounded by a series of other organs which play a role in producing the enzymes involved in the digestion process. This system of organs is shown in the following diagram.

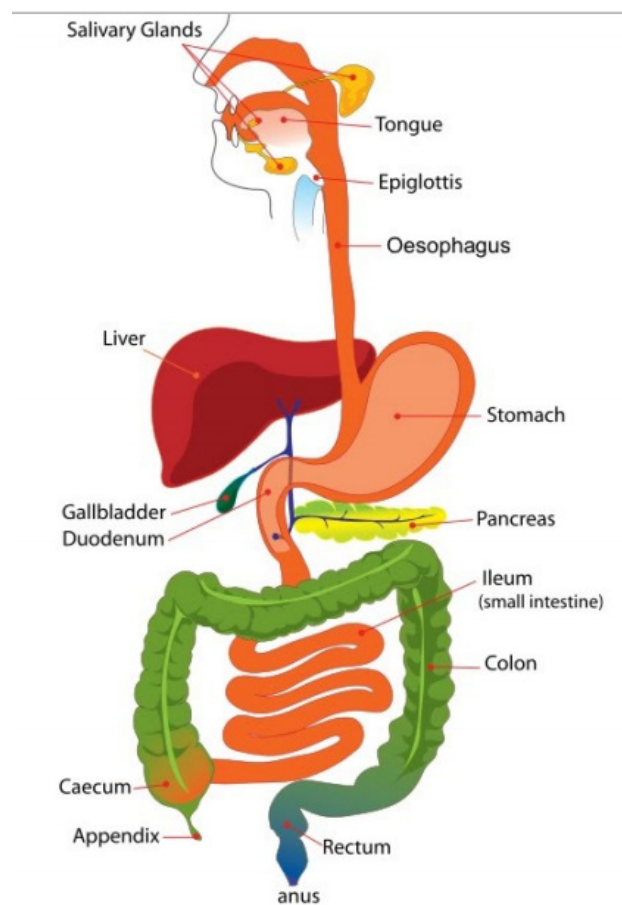


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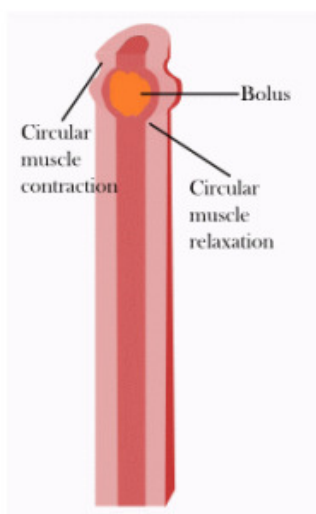


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Food is moved through the digestive system by **peristalsis**. Circular muscles contract behind the food and relax in front of the food which pushes it along.

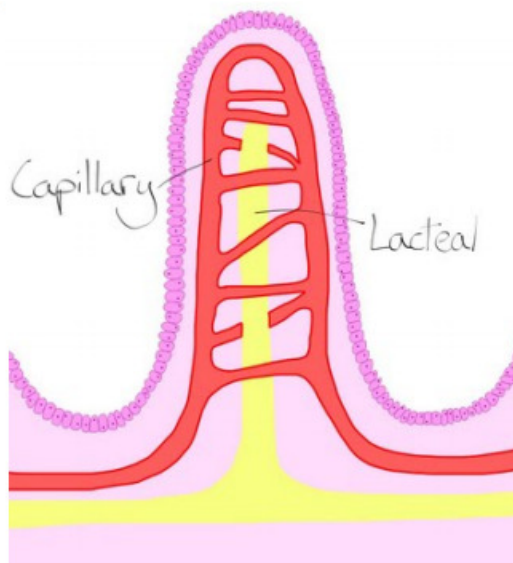


Once the food has been broken down, it needs to be passed by diffusion into the blood to be transported to all the cells in the body. This occurs in the small intestine. The wall of the small intestine consist of many finger-like projections called villi. These can be seen in the image below.



*Villi by Wellcome Images*

Villi have a large surface area, thin walls and a good blood supply to aid absorption. Notice the dense network of blood capillaries in each of the villi in the image above. These absorb the products of digestion such as glucose and amino acids and carry them to the rest of the cells in the body. What you can't see in the image above is the lacteals. Each villus also has a branch of the lymphatic system at its centre which absorbs the products of fat digestion. This is shown in the diagram below.



## **7. Effects of lifestyle choices**

Eating too much salt in your diet increases your blood pressure which in turn increases your likelihood of suffering a heart attack. Blood pressure which may be measured using a blood pressure meter.

Eating too many fatty foods may lead to obesity, which may lead to an increased likelihood of suffering a heart attack and possibly cancer. Obesity may be measured by calculating a body mass index (BMI).

Eating too many sugary foods / drinks can increase likelihood of suffering from type 2 diabetes. Diabetes may be confirmed by testing for glucose in the urine.

Moderate exercise will increase pulse and breathing rates and can reduce the likelihood of developing obesity and diabetes. It can also combat mental health by reducing stress.

All illnesses could be treated under the NHS which would reduce death rates and development of certain diseases in Scotland however would mean an increase in taxes.