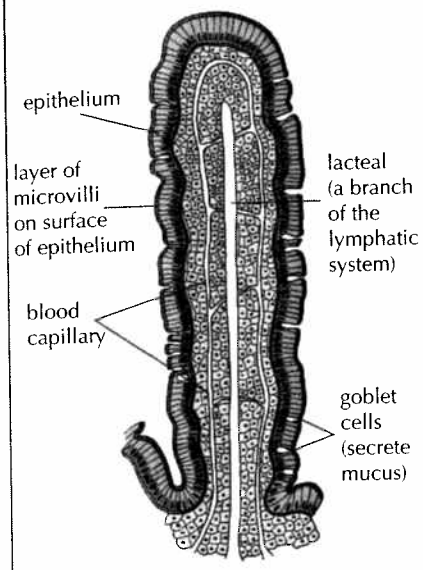
TAKING IN FOOD

Humans take food into their digestive system through the mouth and the esophagus. However, this food is not truly inside the body until it has passed through a layer of cells into the body's tissues. This happens in the small intestines and is called **absorption**. Small finger-like projections from the wall of the small intestine called villi are specially adapted to absorb food molecules. The structure of a villus is shown below. After food has been absorbed it is **assimilated** – it becomes part of the tissues of the body.

Structure of a villus



RELATIONSHIP BETWEEN STRUCTURE OF A VILLUS AND ITS FUNCTION

- Villi increase the surface area over which food is absorbed.
- An epithelium, consisting of only one thin layer of cells, is all that foods have to pass through to be absorbed.
- Protrusions of the exposed part of the plasma membranes of the epithelium cells increase the surface area for absorption. These projections are called microvilli.
- Protein channels in the microvilli membranes allow rapid absorption of foods by facilitated diffusion and pumps allow rapid absorption by active transport.
- Mitochondria in epithelium cells provide the ATP needed for active transport.
- Blood capillaries inside the villus are very close to the epithelium so the distance for diffusion of foods is very small.
- A lacteal (a branch of the lymphatic system) in the centre of the villus carries away fats after absorption.

THE NEED FOR DIGESTION

The food that humans eat contains substances made by other organisms, many of which are not suitable for human tissues. They must therefore be broken down and reassembled in a form that is suitable.

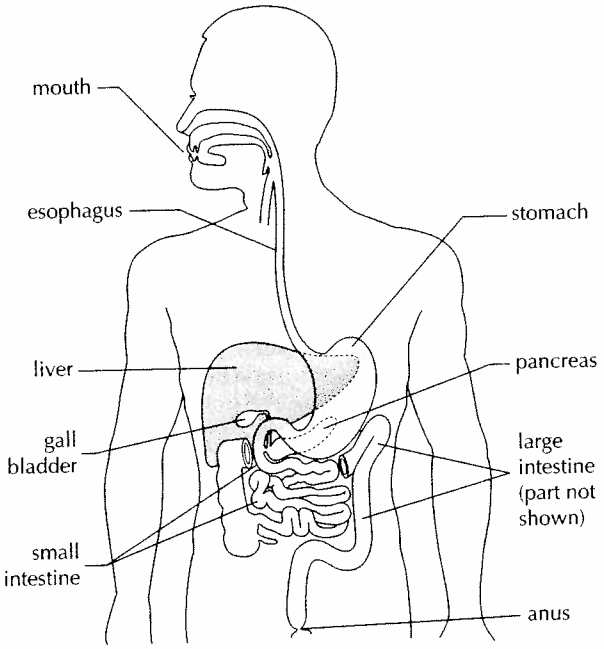
A second reason for digestion is that many of the molecules in foods are too large to be absorbed by the villi in the small intestine. These large molecules have to be broken down into small molecules that can then be absorbed by diffusion, facilitated diffusion or active transport. The three main types of food molecule that need to be digested are starch, protein and triglycerides (fats and oils).

Digestion of these large molecules happens naturally at body temperature, but only at a very slow rate. Enzymes are essential to speed up the process.

Enzymes of digestion

	Amylase	Protease	Lipase
Example of this enzyme	Salivary amylase	Pepsin	Pancreatic lipase
Source	Salivary glands	Wall of stomach	Pancreas
Substrate	Starch	Proteins	Triglycerides (fats or oils)
Products	Maltose	Small polypeptides	Fatty Acids and Glycerol
Optimum pH	pH 7	pH 1.5	pH 7

The human digestive system



FUNCTIONS OF THE STOMACH AND INTESTINES

Digestion of proteins begins in the stomach, catalysed by pepsin. Bacteria, which could cause food poisoning, are mostly killed by the acid conditions of the stomach. The acidity also provides optimum conditions for pepsin to work.

Enzymes secreted by the wall of the small intestine complete the process of digestion. The end products of digestion are absorbed by the villi protruding from the wall of the small intestine.

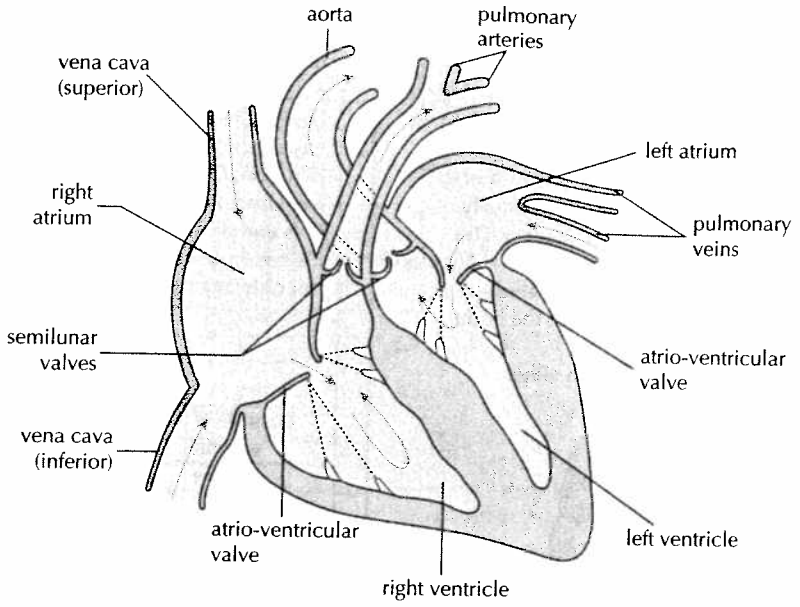
The indigestible parts of the food, together with a large volume of water, pass on into the large intestine. Water is absorbed here leaving solid feces, which are eventually egested through the anus.

The cardiovascular system

HEART STRUCTURE

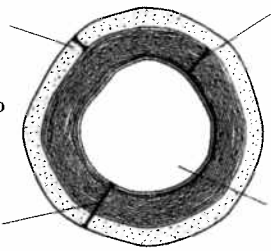
The heart is a double pump, with the right side pumping blood to the lungs and the left side pumping blood to all other organs. The walls of the heart are composed of cardiac muscle. Contraction of cardiac muscle is **myogenic** – it can contract on its own, without being stimulated by a nerve. There are many capillaries in the muscular wall of the heart. The blood running through these capillaries is supplied by the coronary arteries, which branch off the aorta, close to the semilunar valve. The blood brought by the coronary arteries brings nutrients. It also brings oxygen for aerobic cell respiration, which provides the energy needed for cardiac muscle contraction.

Structure of the heart

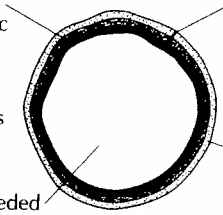


BLOOD VESSELS

Arteries

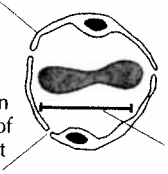


Veins



N.B. veins have valves to prevent back-flow

Capillaries



THE ACTION OF THE HEART

The atria are the collecting chambers – they collect blood from the veins. The ventricles are the pumping chambers – they pump blood out into the arteries at high pressure. The valves ensure that the blood always flows in the correct direction. Every heartbeat consists of a sequence of actions.

1. The walls of the atria contract, pushing blood from the atria into the ventricles through the atrioventricular valves, which are open. The semilunar valves are closed, so the ventricles fill with blood.
2. The walls of the ventricles contract powerfully and the blood pressure rapidly rises inside them. This rise in pressure first causes the atrioventricular valves to close, preventing back-flow of blood to the atria and then causes the semilunar valves to open, allowing blood to be pumped out into the arteries. At the same time the atria start to refill as they collect blood from the veins.
3. The ventricles stop contracting and as pressure falls inside them the semilunar valves close, preventing back-flow of blood from the arteries to the ventricles. When the ventricular pressure drops below the atrial pressure, the atrioventricular valves open. Blood entering the atrium from the veins then flows on to start filling the ventricles.

The next heartbeat begins when the walls of the atria contract again.

THE CONTROL OF THE HEART BEAT

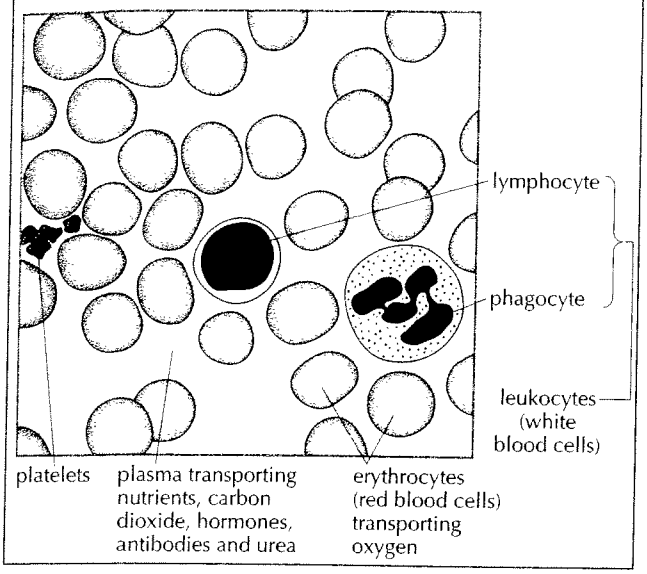
Heart muscle tissue has a special property – it can contract on its own without being stimulated by a nerve. One region is responsible for initiating each contraction. This region is called the pacemaker and is located in the wall of the right atrium. Each time the **pacemaker** sends out a signal the heart carries out a contraction or beat. Nerves and hormones can transmit messages to the pacemaker.

- One nerve carries messages from the brain to the pacemaker that tell the pacemaker to speed up the beating of the heart.
- Another nerve carries messages from the brain to the pacemaker that tell the pacemaker to slow down the beating.
- Adrenalin, carried to the pacemaker by the bloodstream, tells the pacemaker to speed up the beating of the heart.

Blood, transport and infections

THE COMPOSITION OF BLOOD

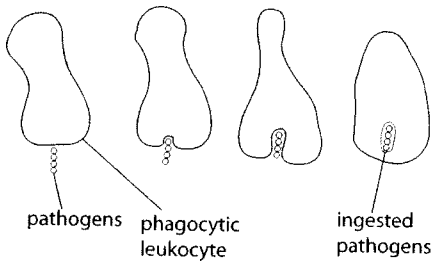
Blood is composed of plasma, erythrocytes (red blood cells), leukocytes and platelets. The figure below shows the appearance of blood as seen using a light microscope. Two types of leukocyte are shown.



PHAGOCYTES

Some of the leukocytes in blood are phagocytes. These cells can identify pathogens and ingest them by endocytosis. *A pathogen is an organism or virus that causes disease.* The pathogens are then killed and digested inside the cell by enzymes from lysosomes. Phagocytes can ingest pathogens in the blood. They can also squeeze out through the walls of blood capillaries and move through tissues to sites of infection. They then ingest the pathogens causing the infection. Large numbers of phagocytes at a site of infection form pus.

Some pathogens are able to avoid being killed by phagocytes, so another defence is needed.



FUNCTIONS OF BLOOD

Blood has two main functions: transport and defence against infectious disease.

Red blood cells transport oxygen from the lungs to respiring cells.

Blood plasma transports

- nutrients
- carbon dioxide
- hormones
- antibodies
- urea.

The blood also transports heat from parts of the body that produce it, to the skin, where it is lost to the environment.

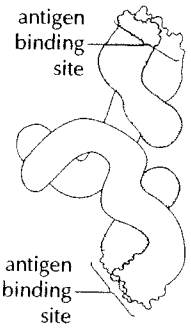
Leukocytes (white blood cells) defend the body against infectious diseases. The roles of phagocytes and leukocytes are described on this page and the next page.

ANTIBODIES

Antibodies are proteins that recognize and bind to specific antigens. Antigens are foreign substances that stimulate the production of antibodies.

Antibodies usually only bind to one specific antigen. Antigens can be any of a wide range of substances including cell walls of pathogenic bacteria or fungi and protein coats of pathogenic viruses.

Antibodies defend the body against pathogens by binding to antigens on surface of a pathogen and stimulating its destruction. The figure (on page 50) shows how antibodies are produced.



Antibody molecule made up of four polypeptides

BARRIERS TO INFECTION

The skin and mucous membranes form a barrier that prevents most pathogens from entering the body. The outer layers of the skin are tough and form a physical barrier. Sebaceous glands in the skin secrete lactic acid and fatty acids, which make the surface of the skin acidic. This prevents the growth of most pathogenic bacteria.

Mucous membranes are soft areas of skin that are kept moist with mucus. Mucous membranes are found in the nose, trachea, vagina and urethra. Although they do not form a strong physical barrier, many bacteria are killed by lysozyme, an enzyme in the mucus. In the trachea pathogens tend to get caught in the sticky mucus and cilia then push the mucus and bacteria up and out of the trachea.

Despite these barriers to infection, pathogens do sometimes enter the body so another defence is needed.

ANTIBIOTICS

Antibiotics are chemicals produced by microorganisms, to kill or control the growth of other microorganisms. For example, *Penicillium* fungus produces penicillin to kill bacteria.

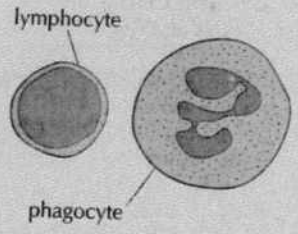
Most bacterial diseases in humans can be treated successfully with antibiotics. For example, tuberculosis has been treated with streptomycin. There are many differences between human cells and bacterial cells and so there are many antibiotics that block a process in bacterial cells without causing any harm to human cells.

Viruses carry out very few processes themselves. They rely instead on a host cell such as a human cell to carry out the processes for them. It is not possible to block these processes with an antibiotic without also harming the human cells. For this reason virus diseases cannot be treated with antibiotics.

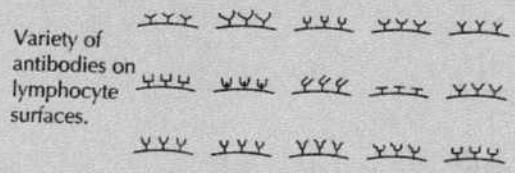
Antibodies and AIDS

PRODUCTION OF ANTIBODIES

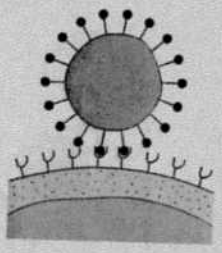
① Antibodies are made by lymphocytes, one of the two main types of leukocyte.



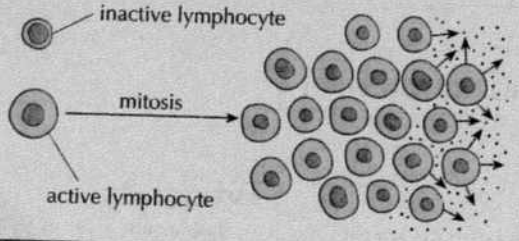
② A lymphocyte can only make one type of antibody so a huge number of different lymphocyte types is needed. Each lymphocyte puts some of the antibody that it can make into its plasma membrane with the antigen-combining site projecting outwards.



③ When a pathogen enters the body, its antigens bind to the antibodies in the plasma membrane of one type of lymphocyte.



④ When antigens bind to the antibodies on the surface of a lymphocyte, this lymphocyte becomes active and divides by mitosis to produce a clone of many identical cells.



⑤ The clone of cells starts to produce large quantities of the same antibody – the antibody needed to defend the body against the pathogen.

AIDS – A SYNDROME CAUSED BY A VIRUS

AIDS shows how vital the body's defences against disease are. Destruction of the immune system leads inevitably to death. AIDS is an example of a syndrome. A syndrome is a group of symptoms that are found together. Individuals with acquired immunodeficiency syndrome (AIDS) have low numbers of one type of lymphocyte together with weight loss and a variety of diseases caused by viruses, bacteria, fungi and protozoa. These diseases weaken the body and eventually cause death.

Cause

HIV (human immunodeficiency virus) causes AIDS. The virus infects a type of lymphocyte that plays a vital role in antibody production. Over a period of years these lymphocytes are destroyed and antibodies cannot then be produced. Without a functioning immune system, the body is vulnerable to pathogens that would normally be controlled easily.

Transmission

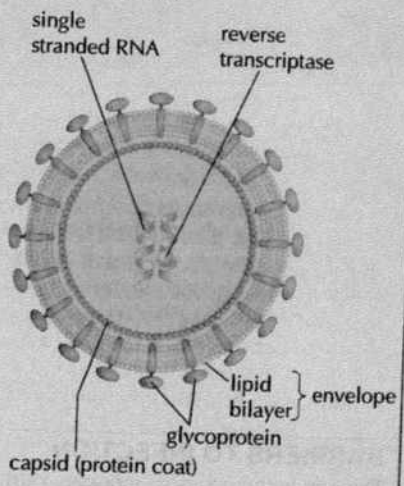
HIV does not survive for long outside the body and cannot easily pass through the skin. Transmission involves the transfer of body fluids from an infected person to an uninfected one.

- Through small cuts or tears in the vagina, penis, mouth or intestine during vaginal, anal or oral sex.
- In traces of blood on a hypodermic needle that is shared by intravenous drug abusers.
- Across the placenta from a mother to a baby, or through cuts during childbirth or in milk during breast-feeding.
- In transfused blood or with blood products such as Factor VIII used to treat hemophiliacs.

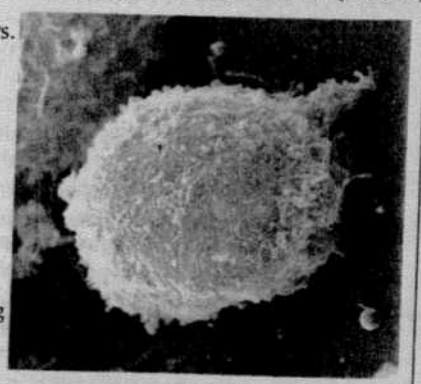
Social implications

- Families and friends suffer grief.
- Families become poorer if the individual with AIDS was the wage earner and is refused life insurance.
- Individuals infected with HIV may become stigmatized and not find partners, housing or employment.
- Sexual activity in a population may be reduced because of the fear of AIDS.

Structure of HIV



T-lymphocyte infected with HIV(× 3500)

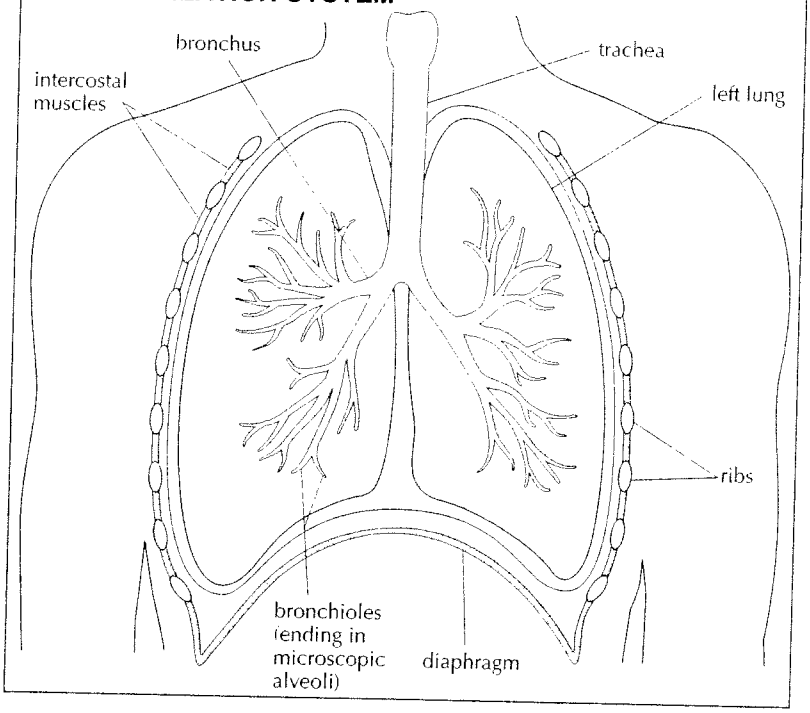


Gas exchange

THE NEED FOR GAS EXCHANGE AND VENTILATION IN HUMANS

Cell respiration happens in the cytoplasm and mitochondria of cells and releases energy in the form of ATP for use inside the cell.
In humans oxygen is used in cell respiration and carbon dioxide is produced. Humans therefore must take in oxygen from their surroundings and release carbon dioxide. This process of swapping one gas for another is called **gas exchange**.
Gas exchange happens in the alveoli of human lungs. Oxygen diffuses from the air in the alveoli to the blood in capillaries. Carbon dioxide diffuses in the opposite direction. The figure (below) shows the adaptations of the alveolus for gas exchange. Diffusion of oxygen and carbon dioxide happens because there are concentration gradients of oxygen and carbon dioxide between the air and the blood. To maintain these concentration gradients, the air in the alveoli must be refreshed frequently. The process of bringing fresh air to the alveoli and removing stale air is called **ventilation**.

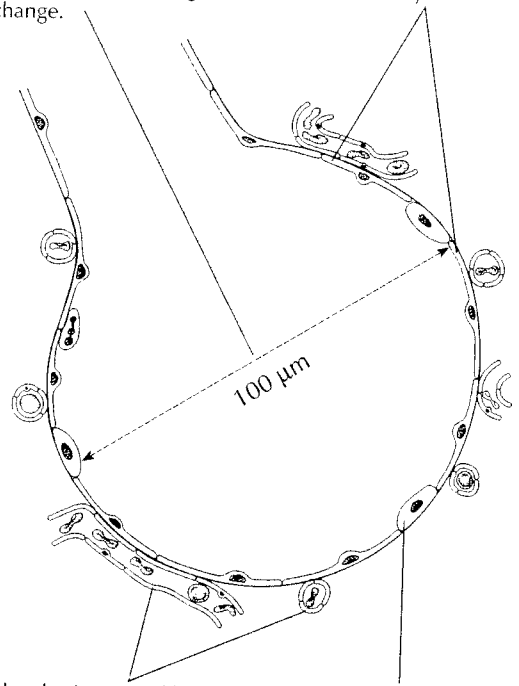
THE VENTILATION SYSTEM



ADAPTATIONS OF THE ALVEOLUS TO GAS EXCHANGE

Although each alveolus is very small, the lungs contain hundreds of millions of alveoli in total, giving a huge overall surface area for gas exchange.

The wall of the alveolus consists of a single layer of very thin cells. The capillary wall also is a single layer of very thin cells, so the gases only have to diffuse a very short distance.



The alveolus is covered by a dense network of blood capillaries with low oxygen and high carbon dioxide concentrations. Oxygen therefore diffuses into the blood and carbon dioxide diffuses out.

Cells in the alveolus wall secrete a fluid which keeps the inner surface of the alveolus moist, allowing the gases to dissolve. The fluid also contains a natural detergent, which prevents the sides of the alveoli from sticking together.

VENTILATION OF THE LUNGS

Air is inhaled into the lungs through the trachea, bronchi and bronchioles.
It is exhaled via the same route. Muscles are used to lower and raise the pressure inside the lungs to cause the movements of air.

Inhaling

- The external intercostal muscles contract, moving the ribcage up and out
- The diaphragm contracts, becoming flatter and moving down
- These muscle movements increase the volume of the thorax
- The pressure inside the thorax therefore drops below atmospheric pressure
- Air flows into the lungs from outside the body until the pressure inside the lungs rises to atmospheric pressure

Exhaling

- The internal intercostal muscles contract, moving the ribcage down and in
- The abdominal muscles contract, pushing the diaphragm up into a dome shape
- These muscle movements decrease the volume of the thorax
- The pressure inside the thorax therefore rises above atmospheric pressure
- Air flows out from the lungs to outside the body until the pressure inside the lungs falls to atmospheric pressure

Neurons and synapses

ORGANIZATION OF THE NERVOUS SYSTEM

The nervous system is composed of cells called neurons. These cells are often very elongated and can carry messages at high speed in the form of electrical impulses.

There are two parts of the nervous system

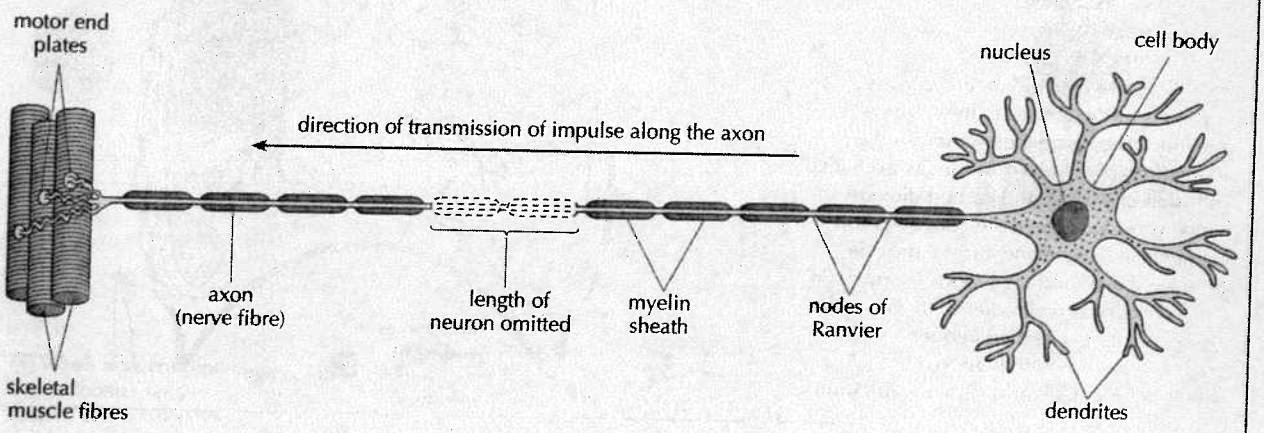
- the central nervous system (CNS), consisting of the brain and spinal cord
- peripheral nerves that connect all parts of the body to the central nervous system.

SENSORY AND MOTOR NEURONS

Neurons carry electrical impulses long distances in the body, using elongated structures called nerve fibres (axons).

- Sensory neurons carry nerve impulses from receptors (sensory cells) to the CNS.
- Motor neurons (below) carry impulses from the CNS to effectors (muscle and gland cells).
- Relay neurons carry impulses within the CNS, from one neuron to another.

Structure of a motor neuron



SYNAPSES

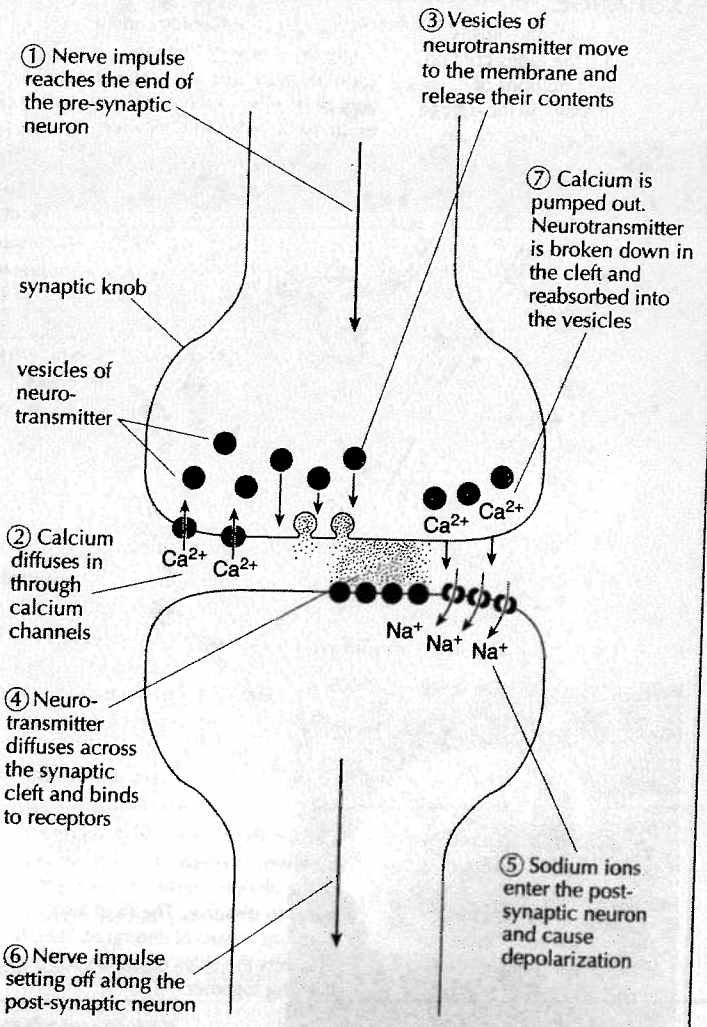
A synapse is a junction between two neurons. The plasma membranes of the neurons are separated by a narrow fluid-filled gap called the synaptic cleft. Messages are passed across the synapse in the form of chemicals called **neurotransmitters**. The neurotransmitters always pass in the same direction from the pre-synaptic neuron to the post-synaptic neuron.

Many synapses function in the following way.

1. A nerve impulse reaches the end of the pre-synaptic neuron.
2. Depolarization of the pre-synaptic membrane causes voltage-gated calcium channels to open. Calcium ions diffuse into the pre-synaptic neuron.
3. Influx of calcium causes vesicles of neurotransmitter to move to the pre-synaptic membrane and fuse with it, releasing the neurotransmitter into the synaptic cleft by exocytosis.
4. The neurotransmitter diffuses across the synaptic cleft and binds to receptors in the post-synaptic membrane.
5. The receptors are transmitter-gated ion channels, which open when neurotransmitter binds. Sodium and other positively charged ions diffuse into the post-synaptic neuron. This causes depolarization of the post-synaptic membrane.
6. The depolarization passes on down the post-synaptic neuron as an action potential.
7. Neurotransmitter in the synaptic cleft is rapidly broken down, to prevent continuous synaptic transmission. For example, acetylcholine is broken down by cholinesterase in synapses that use it as a neurotransmitter. Calcium ions are pumped out of the pre-synaptic neuron into the synaptic cleft.

The figure (right) shows the events that occur during synaptic transmission.

Stages in synaptic transmission



Nerve impulses

RESTING POTENTIALS

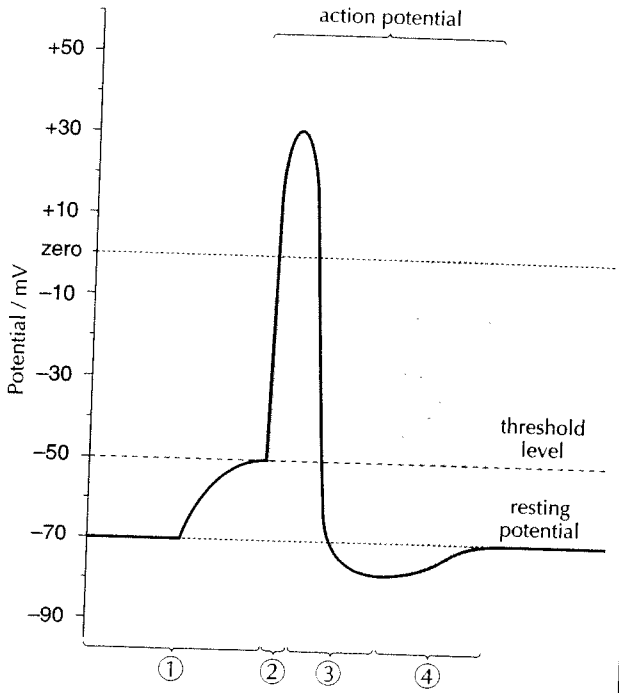
The resting potential is the electrical potential across the plasma membrane of a cell that is not conducting an impulse.

Neurons pump ions across their plasma membranes by active transport. Sodium is pumped out of the neuron and potassium is pumped in. Concentration gradients of both sodium and potassium are established across the membrane. The inside of the neuron develops a net negative charge, compared with the outside, because of the presence of chloride and other negatively charged ions. There is therefore an electrical potential or voltage across the membrane. This is called the **resting potential**.

ACTION POTENTIALS

An action potential is the reversal and restoration of the electrical potential across the plasma membrane of a cell, as an electrical impulse passes along it (depolarization and repolarization).

When an impulse passes along the neuron, sodium and potassium ions are allowed to diffuse across the membrane, through voltage-gated ion channels. The electrical potential across the membrane is initially reversed but is then restored. This is called an **action potential**. The figure (right) shows the changes in membrane polarization that occur during an action potential. The way in which action potentials pass down nerve fibres is explained below.



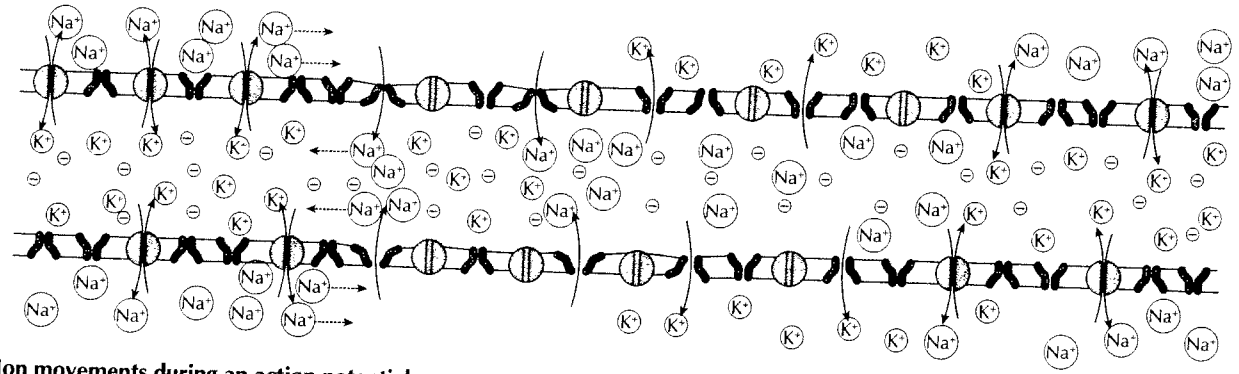
STAGES IN THE PASSAGE OF A NERVE IMPULSE

(1) An action potential in one part of a neuron causes an action potential to develop in the next section of the neuron. This is due to diffusion of sodium ions between the region with an action potential and the region at the resting potential. These ion movements, local currents, reduce the resting potential. If the potential rises above the threshold level, voltage-gated channels open.

(2) Sodium channels open very quickly and sodium ions diffuse into the neuron down the concentration gradient. This reduces the membrane potential and causes more sodium channels to open. The entry of positively charged sodium ions causes the inside of the neuron to develop a net positive charge compared to the outside – the potential across the membrane is reversed. This is called **depolarization**.

(3) Potassium channels open after a short delay. Potassium ions diffuse out of the neuron down the concentration gradient through the opened channels. The exit of positively charged potassium ions cause the inside of the neuron to develop a net negative charge again compared with the outside – the potential across the membrane is restored. This is called **repolarization**.

(4) Concentration gradients of sodium and potassium across the membrane are restored by the active transport of sodium ions out of the neuron and potassium ions into the neuron. This restores the resting potential and the neuron is then ready to conduct another nerve impulse. As before, sodium ions diffuse along inside the neuron from an adjacent region that has already depolarized and initiate depolarization.



Ion movements during an action potential

Maintaining the internal environment

HOMEOSTASIS

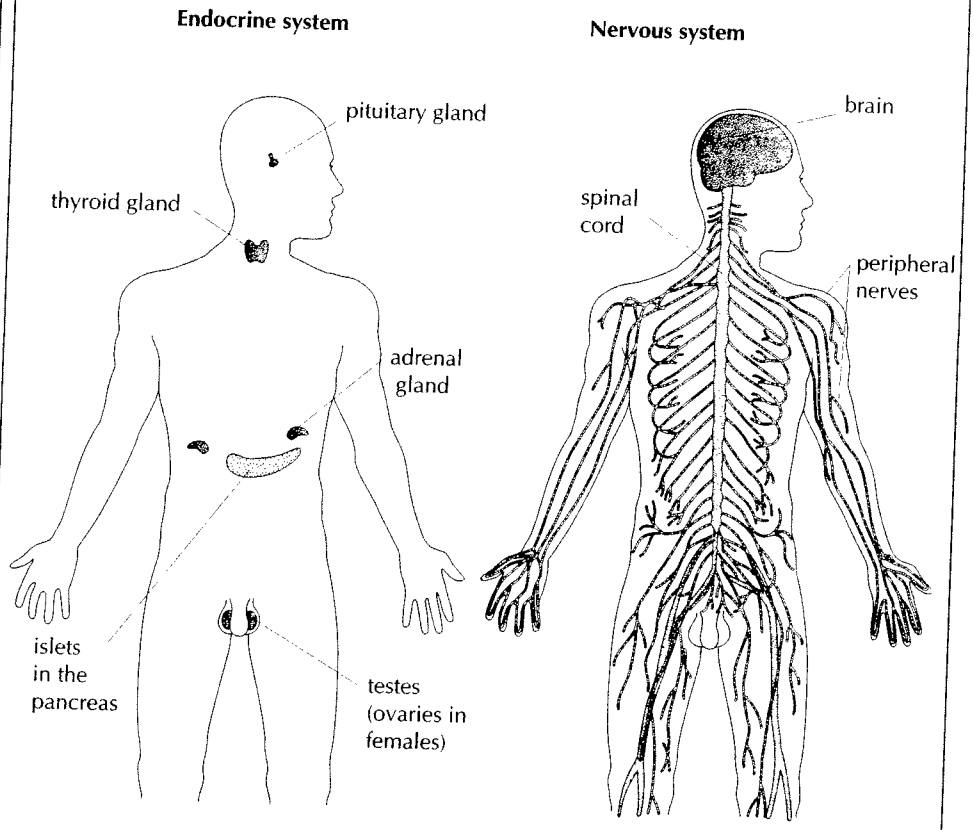
Blood, and tissue fluid derived from blood, flow around or close to all cells in the body. Blood and tissue fluid form the internal environment of the body. This internal environment is controlled and varies very little despite large variations in the external environment. The control process is called **homeostasis**. *Homeostasis is maintaining the internal environment of the body between limits.*

The parameters controlled include

- body temperature
- blood pH
- carbon dioxide concentration
- blood glucose concentration
- water balance

The nervous system and the endocrine system are both involved in controlling the internal environment. The endocrine system consists of glands, which release hormones that are transported in the blood.

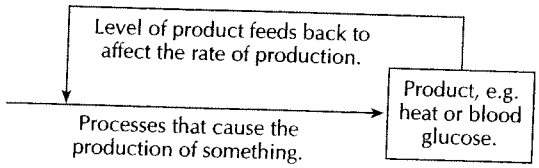
The endocrine and nervous systems



CONTROLLING LEVELS BY NEGATIVE FEEDBACK

1. **Feedback**

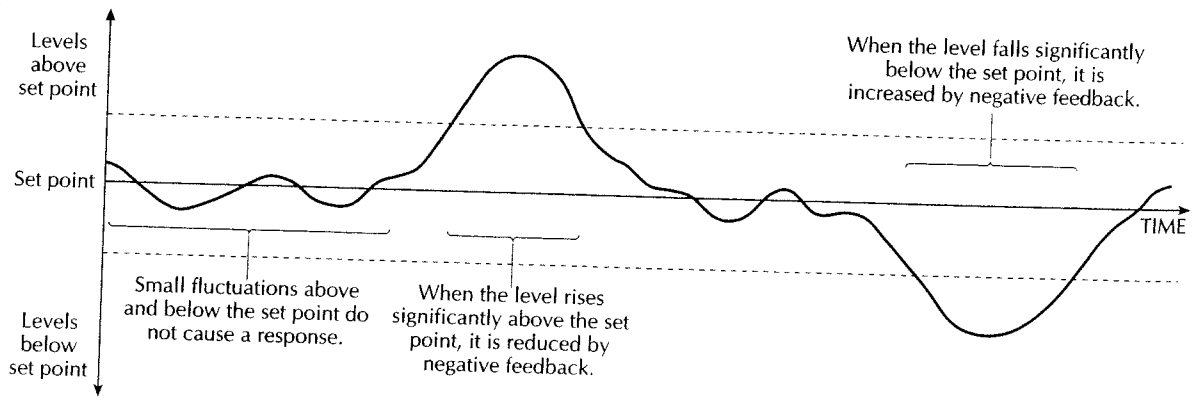
In feedback systems, the level of a product feeds back to control the rate of its own production.



2. **Negative feedback**

Negative feedback has a stabilizing effect because a change in levels always causes the opposite change. A rise in levels feeds back to decrease production and reduce the level. A decrease in levels feeds back to increase production and raise the level. These are both negative feedback.

3. **Monitoring levels**

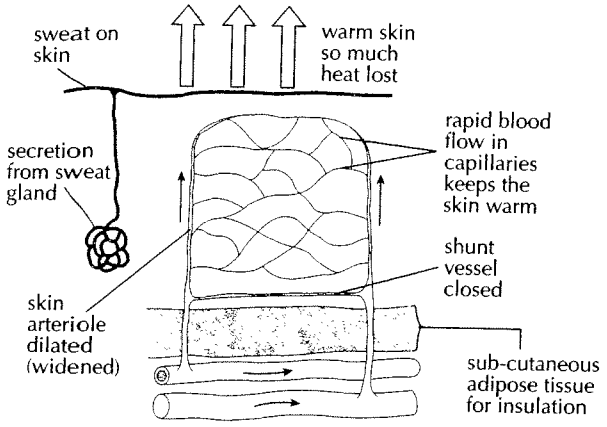


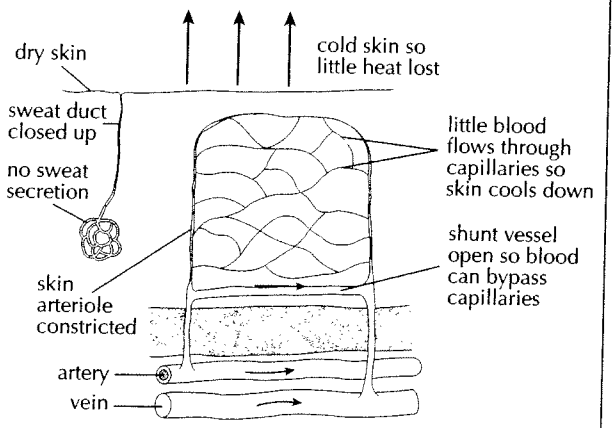
Body temperature and blood glucose

CONTROL OF BODY TEMPERATURE

The hypothalamus of the brain monitors the temperature of the blood and compares it with a set point, usually close to 37°C. If the blood temperature is lower or higher than the set point the hypothalamus sends messages to parts of the body to make them respond and bring the temperature back to the set point – negative feedback. These messages are carried by neurons. The responses affect the rate at which heat is produced, the rate at which it is transferred between parts of the body in the blood, or the rate at which it is lost from the body.

Responses to overheating	Responses to chilling
Skin arterioles become wider, so more blood flows through the skin. This blood transfers heat from the core of the body to the skin. The temperature of the skin rises, so more heat is lost from it to the environment.	Skin arterioles become narrower and they bring less blood to the skin. The blood capillaries in the skin do not move, but less blood flows through them. The temperature of the skin falls, so less heat is lost from it to the environment.
Skeletal muscles remain relaxed and resting so that they do not generate heat.	Skeletal muscles do many small rapid contractions to generate heat. This is called shivering.
Sweat glands secrete large amounts of sweat making the surface of the skin damp. Water evaporates from the damp skin and this has a cooling effect.	Sweat glands do not secrete sweat and the skin remains dry.





CONTROL OF BLOOD GLUCOSE

Blood glucose concentration cannot be kept as steady as body temperature. Instead it is usually kept between 4 and 8 millimoles per dm^3 of blood. Cells in the pancreas monitor the concentration and send hormone messages to target organs when the level is low or high. Responses by the target organs affect the rate at which glucose is loaded into the blood or unloaded from it. The mechanisms involved are another example of negative feedback.

Responses to high blood glucose levels	Responses to low blood glucose levels
β cells in the pancreatic islets produce insulin.	α cells in the pancreatic islets produce glucagon.
Insulin stimulates the liver and muscle cells to absorb glucose from the blood and convert it to glycogen. Granules of glycogen are stored in the cytoplasm of these cells. Other cells are stimulated to absorb glucose and use it in cell respiration instead of fat. These processes lower the blood glucose level.	Glucagon stimulates liver cells to break glycogen down into glucose and release the glucose into the blood.
	This raises the blood glucose level.

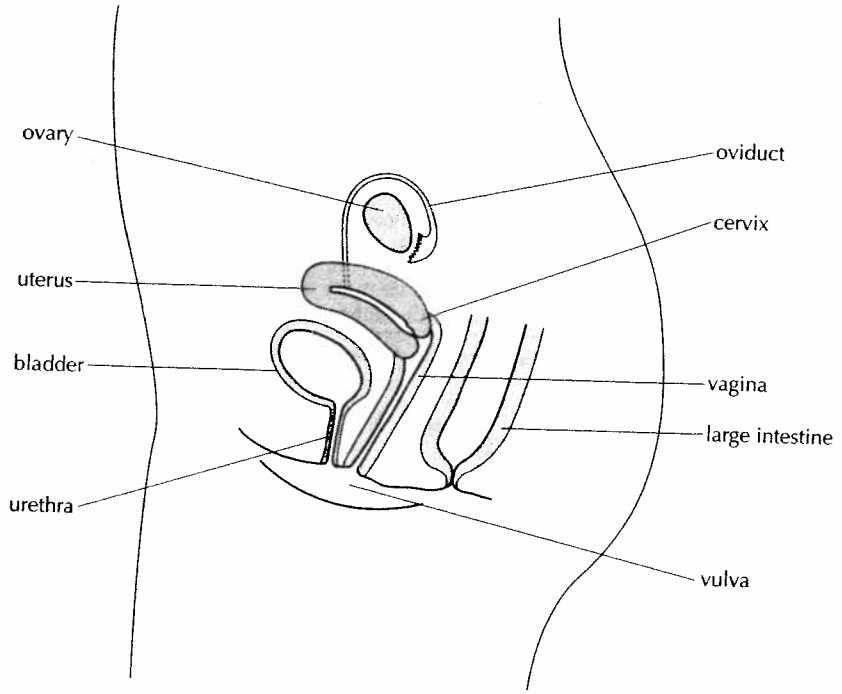
DIABETES

In some people the control of blood glucose does not work effectively and the concentration can rise or fall beyond the normal limits. The full name for this condition is **diabetes mellitus**. There are two forms of this condition, which are compared in the table below:

Type I diabetes	Type II diabetes
The onset is usually during childhood.	The onset is usually after childhood.
α cells produce insufficient insulin.	Target cells become insensitive to insulin.
Insulin injections are used to control glucose levels.	Insulin injections are not usually needed.
Diet cannot by itself control the condition.	Low carbohydrate diets usually control the condition.

Reproductive systems

THE FEMALE REPRODUCTIVE SYSTEM



FEMALE SEX HORMONES

The pituitary gland produces FSH and LH. These two hormones affect processes in the ovary. FSH stimulates the development of follicles –fluid filled sacs that contain an egg cell. LH stimulates follicles to become mature, release their egg (ovulation) and then develop into a structure called the corpus luteum.

The ovary produces estrogen and progesterone. These two hormones stimulate the development of female secondary sexual characteristics during puberty. They also stimulate the development of the uterus lining that is needed during pregnancy. Unless a woman is pregnant the levels of the female sex hormones rise and fall according to a cycle, which is described on page 57.

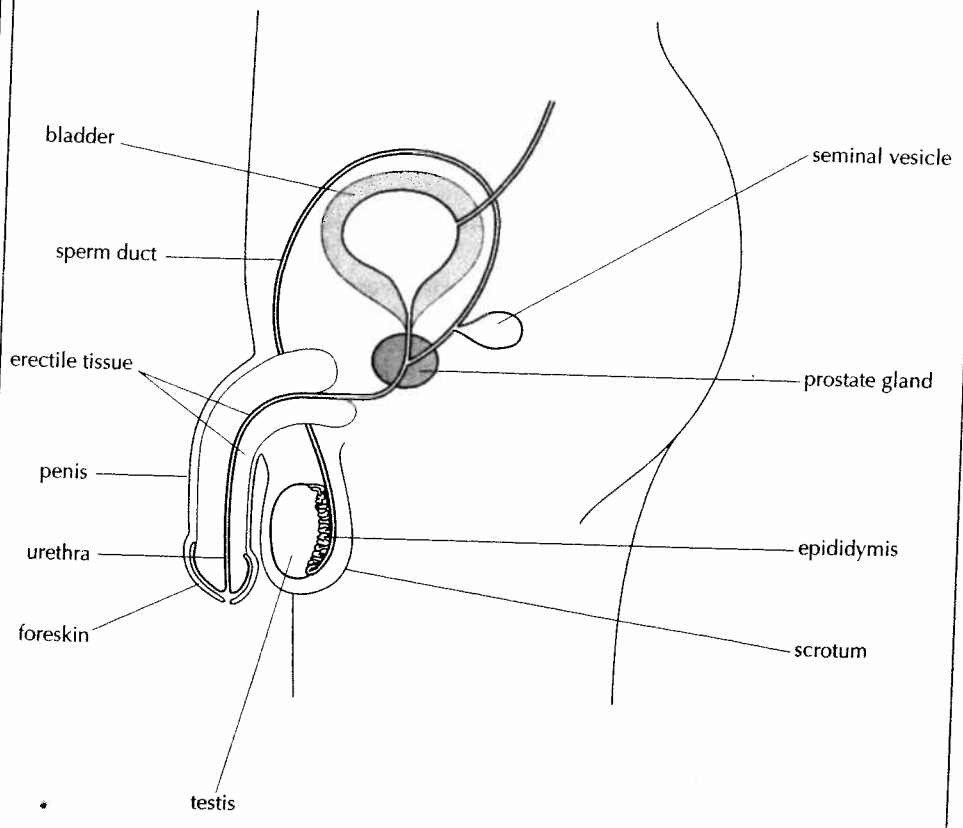
TESTOSTERONE

Cells in the testes of males produce testosterone – the male sex hormone. Testosterone has several roles.

- The developing testes of a male fetus secrete testosterone, which causes male genitalia, including a penis, to develop in the fetus
- Levels of testosterone rise during puberty and cause male secondary sexual characteristics to develop – pubic hair, an enlarged penis and growth of skeletal muscles for example
- During adulthood, testosterone maintains the sex drive, the instinct which encourages men to have sexual intercourse and therefore pass on their genes to offspring.

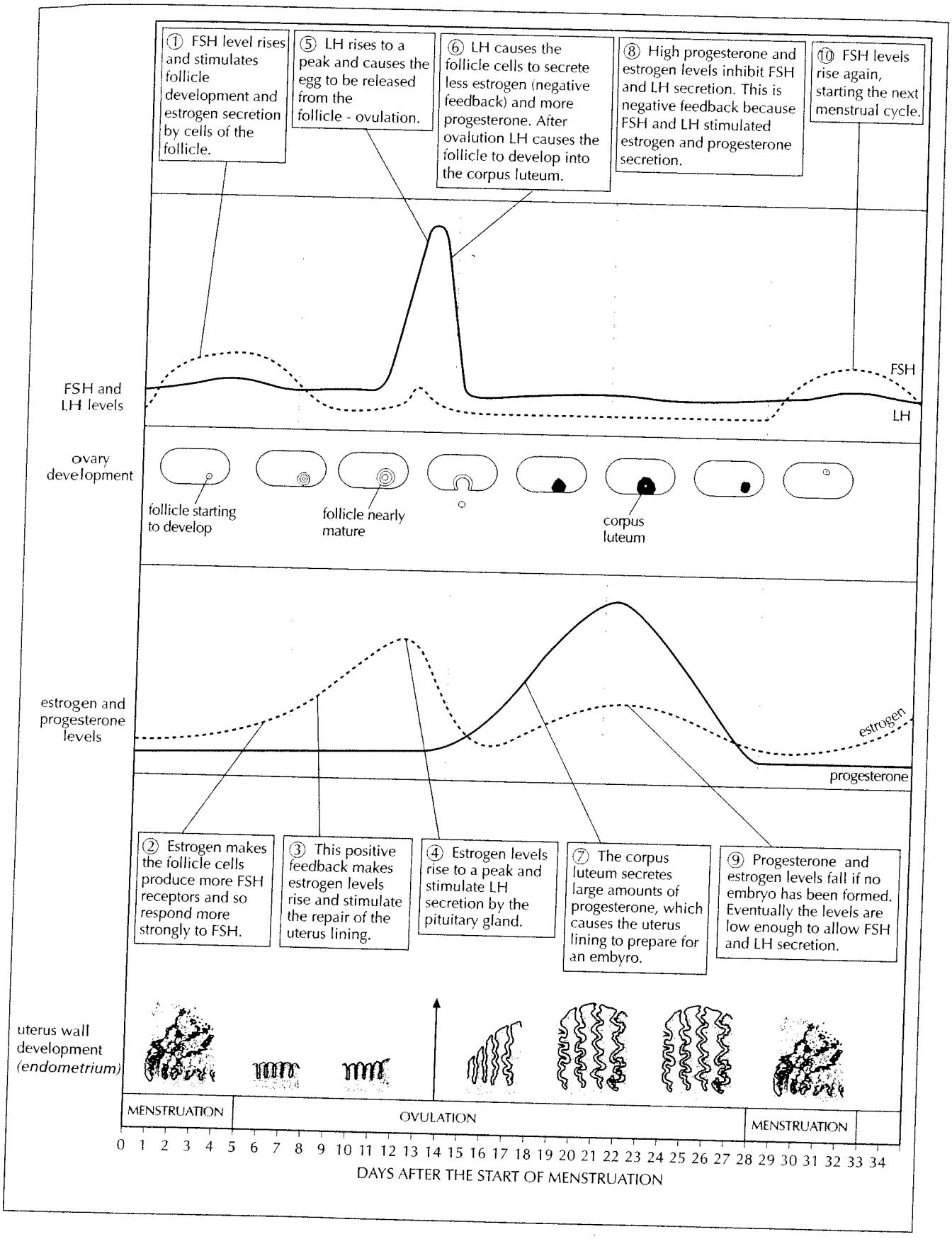
Testosterone is also one of the hormones needed to stimulate sperm production by the testes.

THE MALE REPRODUCTIVE SYSTEM



The menstrual cycle

Between puberty and the menopause, women who are not pregnant follow a cycle called the menstrual cycle. This cycle is controlled by hormones FSH and LH produced by the pituitary gland and estrogen and progesterone produced by the ovary. The figure below shows the levels of these hormones during the menstrual cycle. It also shows the changes in the ovary and in the uterus.



In vitro fertilization

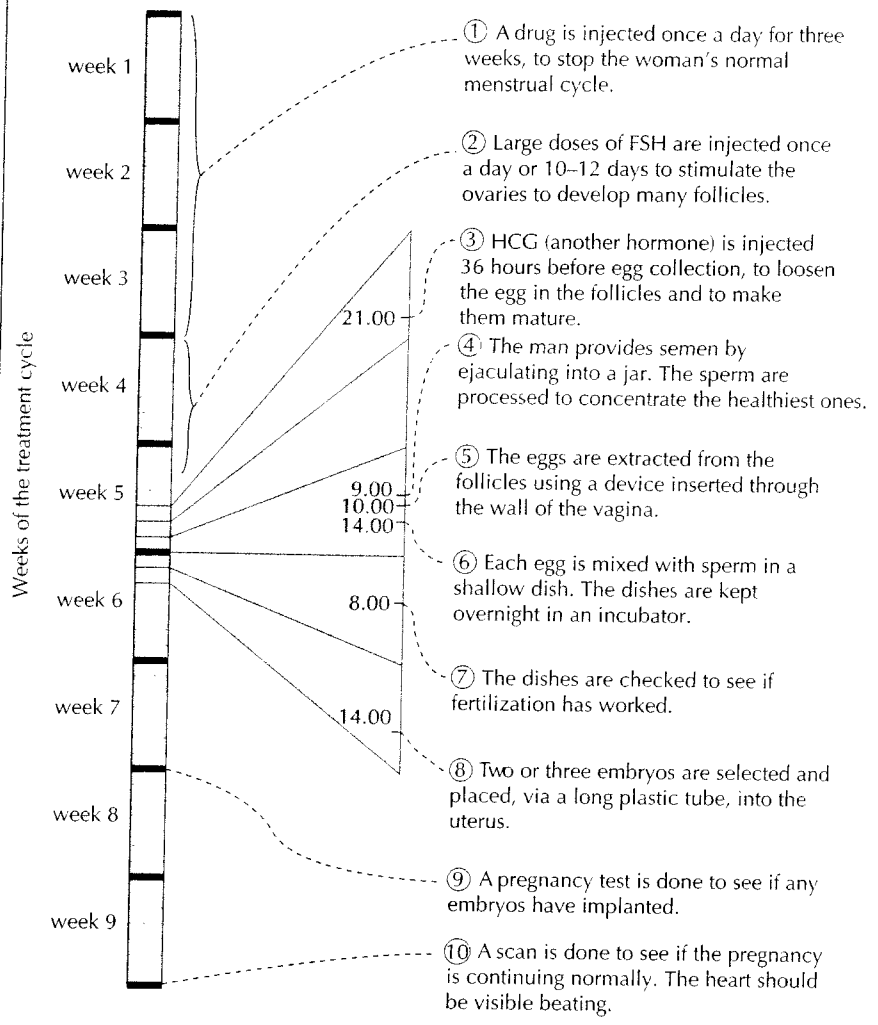
INFERTILITY

Some couples do not achieve fertilization and pregnancy when they wish to, despite sexual intercourse during the period in the middle of the menstrual cycle when ovulation usually occurs. This is called infertility. It may be temporary, because the causes can be resolved, or permanent.

Approximately one in six couples have some experience of temporary or permanent infertility. Many of these couples can be helped to have a child by *in vitro* fertilization – IVF. For example, blocked oviducts in a woman prevent conception, but IVF can overcome this problem. Other problems cannot be resolved by IVF, for example low or zero sperm counts in men.

The process of IVF is outlined (right).

Timetable for IVF



ETHICAL ISSUES ASSOCIATED WITH IVF

Some issues are controversial and around the world the views held by people may vary considerably. Ethical issues involve questioning whether something is wrong or right. Decisions cannot be made using scientific methods, but scientists have an obligation to consider ethical issues.

Ethical arguments against IVF

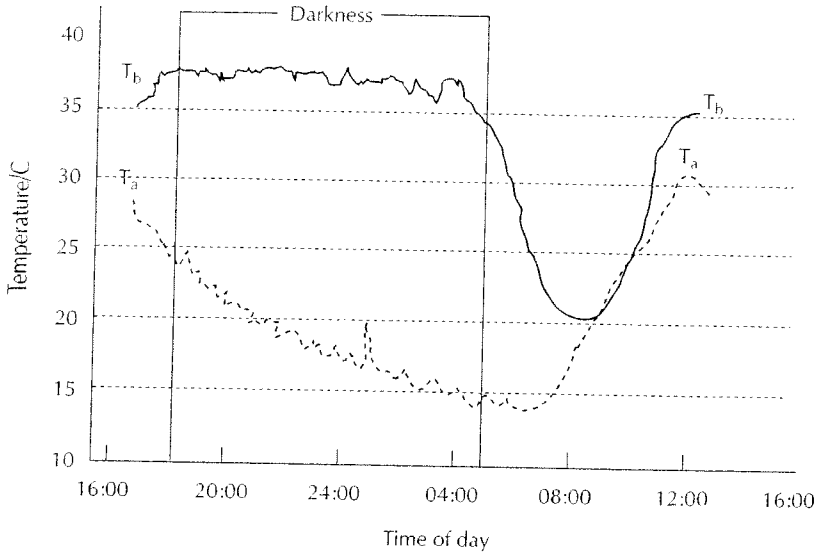
- Inherited forms of infertility might be passed on to children, which means that the suffering of the parents is repeated in their offspring.
- More embryos are often produced than are needed and the spare embryos are sometimes killed, denying them the chance of life.
- Embryologists select embryos to transfer to the uterus, so humans are deciding whether new individuals survive or die.
- IVF is an unnatural process, carried out in laboratories, in contrast to natural conception occurring as a result of an act of love.
- Infertility should be accepted as the will of God and it is wrong to try to circumvent it by using IVF to have a child.

Ethical arguments for IVF

- Many forms of infertility are due to environmental factors, so offspring will not inherit them.
- Any embryos that are killed during IVF are unable to feel pain or suffer, because their nervous system has not developed.
- Suffering due to genetic disease could be reduced if embryos were screened before being transferred to the uterus.
- Parents willing to go through the process of IVF must have a strong desire for children and so are likely to be loving parents.
- Infertility brings great unhappiness to parents who want to have children, which in some cases can be overcome by IVF.

1 Respiration in humans and other mammals generates heat which can be used to keep the body temperature above that of the surroundings.

Many mammals found in the southern hemisphere, including marsupials, vary their body temperature according to a daily cycle. The mouse lemur (*Microcebus myoxinus*) is an example of such a mammal. To investigate this daily cycle, *M. myoxinus* was studied in its native habitat in Madagascar. Data-loggers which recorded body temperature (T_b) over 24-hour periods were implanted in the bodies of several of these mammals. Air temperature (T_a) was recorded at the same time. A typical set of results is shown in the graph below.



[Source: Cossins and Barnes. Nature (1996), 384, page 582]

a) Using only the data in the graph, state two differences between T_a and T_b during the hours of darkness. [2]

b) T_b rises from 08:00 to 12:00. Explain briefly how this temperature rise occurs. [2]

c) Predict, with a reason, whether *M. myoxinus* is active in the hours of daylight or the hours of darkness. [1]

2 a) (i) State the function of phagocytic leukocytes. [1]

(ii) Outline where in the body phagocytic leukocytes carry out their function. [2]

b) Explain briefly the need for small numbers of many types of B-lymphocyte in the body. [2]

3 The diagram right shows part of the human gas exchange system.

a) State the name of the parts labelled I and II. [2]

b) I and II allow the lungs to be ventilated. Explain briefly the need for ventilation. [2]

c) Draw and label a diagram of alveoli. [3]