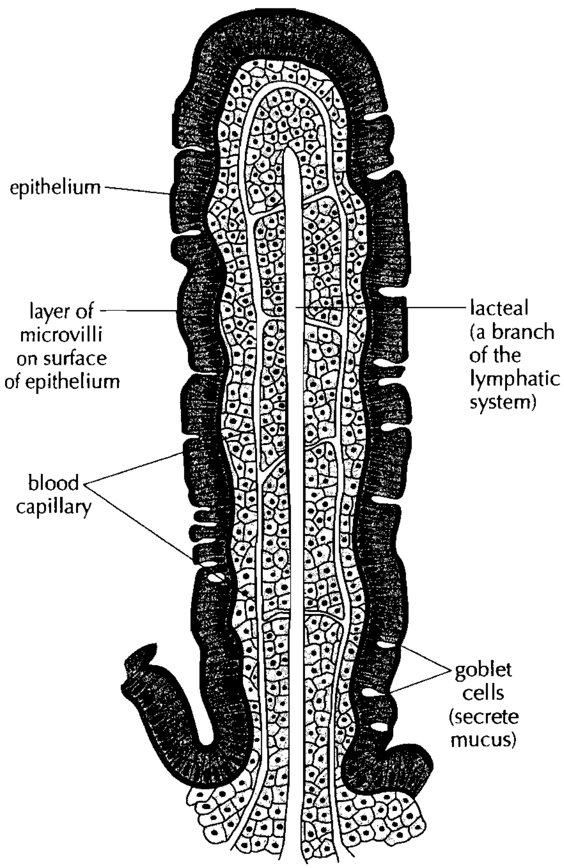
Digestion

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 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.

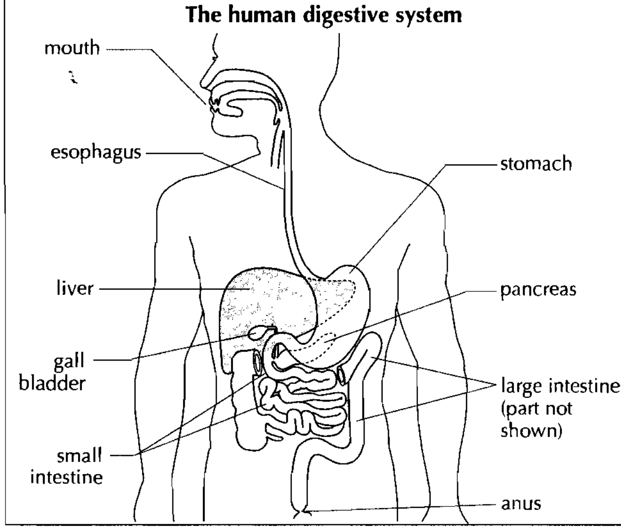
A second reason for digestion is that many of the molecules in foods are too large to be absorbed by the villi in the small intestine. These large molecules have to be broken down into small molecules that can then be absorbed by diffusion, facilitated diffusion or active transport. The three main types 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

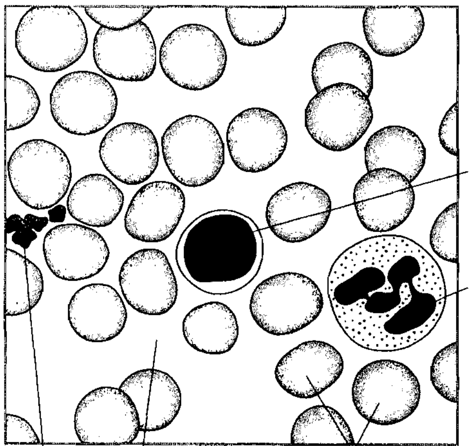
Digestion of proteins begins in the stomach, catalysed by pepsin. Bacteria, which could cause food poisoning, are mostly killed by the acid conditions of the stomach. The acidity also provides optimum conditions for pepsin to work. Enzymes secreted by the wall of the small intestine complete the process 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 blood system

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.



THE ACTION OF THE HEART

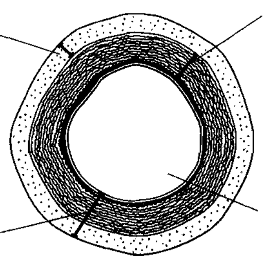
The atria are the collecting chambers – they collect blood from the veins. The ventricles are the pumping chambers – they pump blood out into the arteries at high pressure. The valves ensure that the blood always flows in the correct direction. Every heartbeat consists of a sequence of actions.

1. The walls of the atria contract, pushing blood from the atria into the ventricles through the atrio-ventricular valves, which are open. The semi-lunar 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 atrio-ventricular valves to close, preventing back-flow of blood to the atria and then causes the semi-lunar 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 semi-lunar 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.

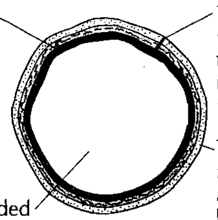
The next heartbeat begins when the walls of the atria contract again.

BLOOD VESSELS

Arteries

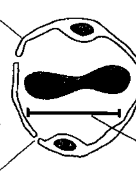


Veins

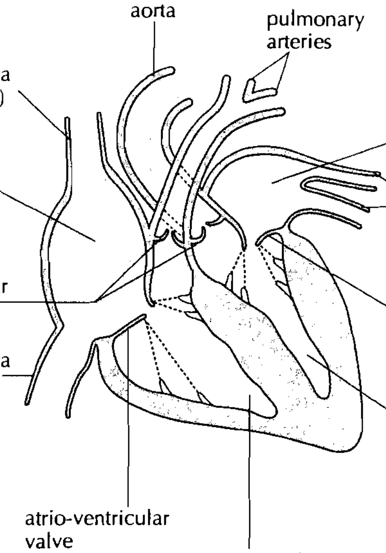


N.B veins have valves to prevent back-flow

Capillaries



STRUCTURE OF THE HEART



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.

PATHOGENS

Humans sometimes develop diseases because a living organism or a virus gains entry and reproduces inside the body, causing harm. The human is called the **host** and organism that enters the body and causes harm is called the **pathogen.** *A pathogen is an organism or a virus that causes a disease.* Many types of organism can act as pathogens in humans. Six examples are shown in the table below.

Disease	Type of pathogen
Influenza	Viruses
Tuberculosis	Bacteria
Thrush (oral or vaginal)	Fungi
Malaria	Protozoa
Schistosomiasis (bilharzia)	Flatworms
Hookworm	Roundworms

Robert Koch's drawing of a culture of *Mycobacterium tuberculosis*

TRANSMISSION OF PATHOGENS

One of the main problems in the life of a pathogen is how to reach a new host and gain entry to the body. There are various possible methods.

- **Contact** – contagious diseases are transmitted when an uninfected person touches an infected person as the pathogen can enter the body through the skin.
- **Cuts** – pathogens enter the body when the skin is cut or punctured by any object that is contaminated with pathogens
- **Droplets** – diseases of the human ventilation system can be transmitted when an infected person coughs or sneezes out droplets containing pathogens, which are breathed in by an uninfected person.
- **Food or water** – pathogens in contaminated food or water enter the body through the soft gut wall.
- **Sexual intercourse** – sexually transmitted diseases gain entry through the soft mucous membranes of the penis and vagina during sexual intercourse.
- **Insects** – blood-sucking insects inject their mouthparts though the skin and can transmit pathogens that they sucked out of an infected person.

TUBERCULOSIS –AN EXAMPLE OF A BACTERIAL DISEASE

Cause

Tuberculosis is caused by *Mycobacterium tuberculosis,* a rod-shaped bacterium (left). Malnutrition, overcrowding and stress all increase the chance of infection.

Transmission

The most common form of tuberculosis is spread by droplet infection. People who have advanced tuberculosis tend to cough frequently and spread droplets containing the bacteria. Another person can become infected if they breathe in the droplets. The bacteria enter the lungs and start to grow and divide there.

A rarer form of tuberculosis is transmitted from cattle to humans in infected milk. Most milk is now pasteurized or sterilized to kill the bacteria and prevent this method of transmission.

Effects

Phagocytes move to the areas of infection in the lungs and take in the bacteria by endocytosis. The bacteria are usually able to survive and breed inside the phagocytes. Small rounded swellings containing these infected phagocytes form in the lungs. These are called tubercles and give the disease its name. In X-ray photographs the tubercles are clearly visible as white patches (below). The infection usually remains confined to the lungs and gradually becomes less severe. However if the person becomes re-infected, a chronic form of the disease usually develops. Lung tissue is gradually destroyed. The person develops a fever and loses their appetite, so becomes very thin. They develop a persistent cough and often cough up blood. The infection can spread from the lungs to the lymph nodes, bones and gut. Over three million deaths each year in the world are caused by tuberculosis.

X-ray of lungs affected by tuberculosis

TREATMENT OF DISEASES WITH ANTIBIOTICS

Most bacterial diseases 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.

Defence against infectious disease

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.

PHAGOCYTES

Some of the leukocytes in blood are phagocytes. These cells can identify pathogens and ingest them by endocytosis. 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.

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 (below) shows how antibodies are produced.

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.

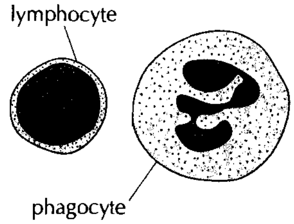
- Through small cuts or tears in the vagina, penis, mouth or intestine during vaginal, anal or oral sex.
- In traces of blood on a hypodermic needle that is shared by intravenous drug abusers.
- Across the placenta from a mother to a baby, or through cuts during childbirth or in milk during breast-feeding.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

Social implications

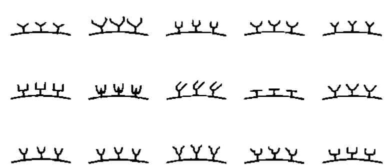
- Families and friends suffer grief.
- Families become poorer if the individual with AIDS was the wage earner and is refused life insurance.
- Individuals infected with HIV may become stigmatized and not find partners, housing or employment.
- Sexual activity in a population may be reduced because of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

PRODUCTION OF ANTIBODIES

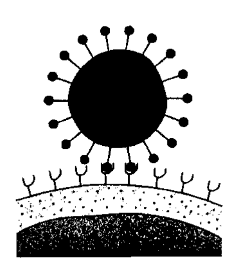
① Antibodies are made by lymphocytes, one of the two main types of leukocyte.



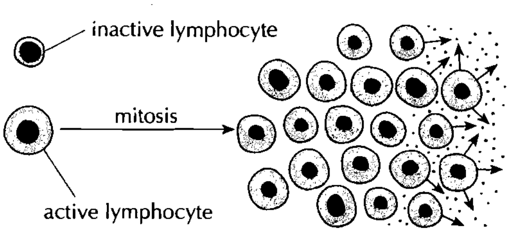
② A lymphocyte can only make one type of antibody so a huge number of different lymphocyte types is needed. Each lymphocyte puts some of the antibody that it can make into its cell surface membrane with the antigen-combining site projecting outwards.



③ When a pathogen enters the body, its antigens bind to the antibodies in the cell surface 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.



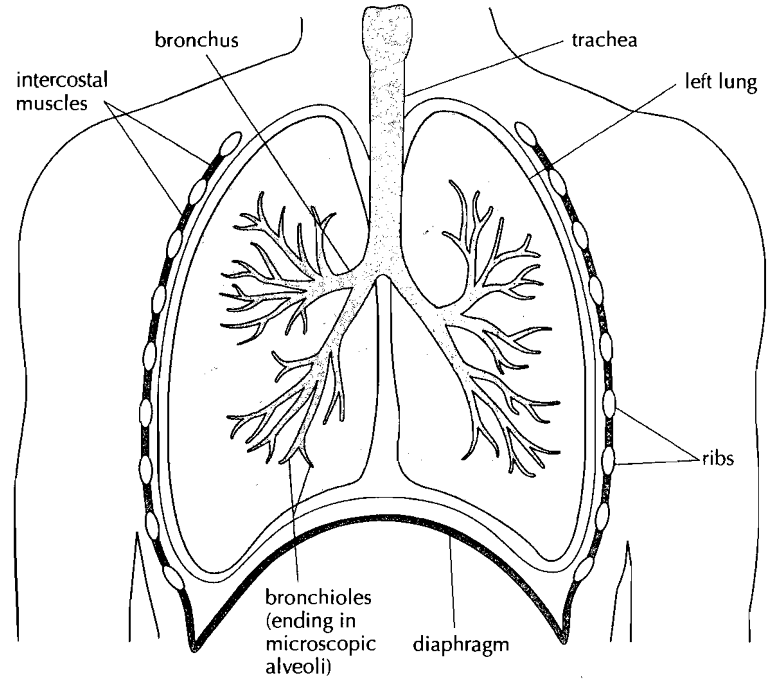
⑤ The clone of cells starts to produce large quantities of the same antibody – the antibody needed to defend the body against the pathogen.

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**.

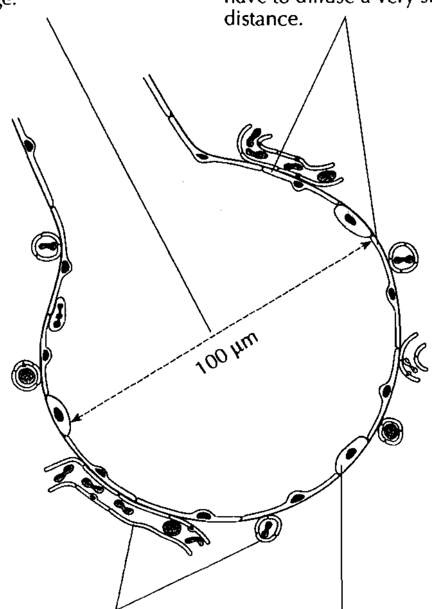
THE VENTILATION SYSTEM



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

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 at constant levels or between narrow limits.*

The parameters controlled include:

- temperature
- blood pH
- oxygen and carbon dioxide concentrations
- blood glucose concentration
- water/solute balance.

Two systems in the body play a major part in homeostasis – the nervous system and the endocrine system.

THE NERVOUS AND ENDOCRINE SYSTEMS

The nervous system is composed of cells called neurones. 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, consisting of the brain and spinal cord
- the peripheral nervous system, consisting of the peripheral nerves that connect all parts of the body to the central nervous system.

The endocrine system is composed of glands that secrete hormones. These hormones are secreted directly into the blood and are carried by the blood throughout the body.

EXCRETION

All body cells produce waste substances that have to be removed, because they can damage the body – they are toxic. These waste substances are the products of **metabolism**. Metabolism consists of all of the chemical reactions that occur inside the cells of the body. There are useful products of metabolism, but also waste products. For example, carbon dioxide is a waste product of aerobic cell respiration. The process of removing waste products is **excretion**. *Excretion is the removal from the body of the toxic waste products of metabolism.*

THE ROLE OF THE KIDNEYS

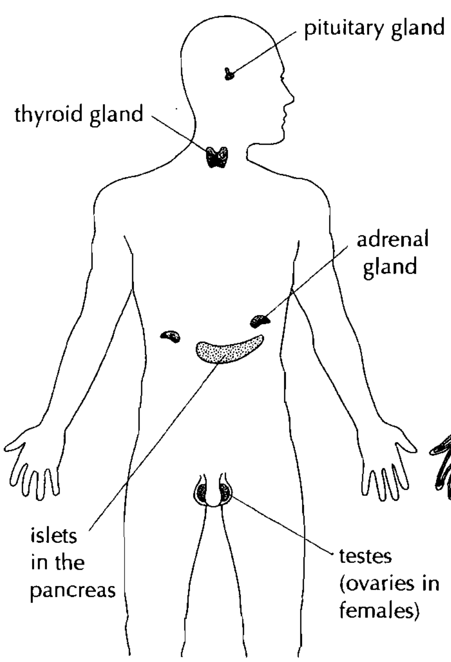
The kidneys have a major role in excretion. Waste products of metabolism are carried from body cells to the kidneys by the blood system. Urea is one of the main waste products. The kidneys remove the waste products from the blood and produce urine containing them. This is stored in the bladder and then passes out through the urethra.

The kidneys also have a role in homeostasis. By varying the composition and volume of urine, the kidneys help to keep the water and salt content of the blood and tissue fluid constant. If there is too much water or too little salt inside the body, the kidneys produce a large volume of urine with a low salt concentration. If there is too little water or too much salt inside the body, the kidneys produce a small volume of urine with a high salt content.

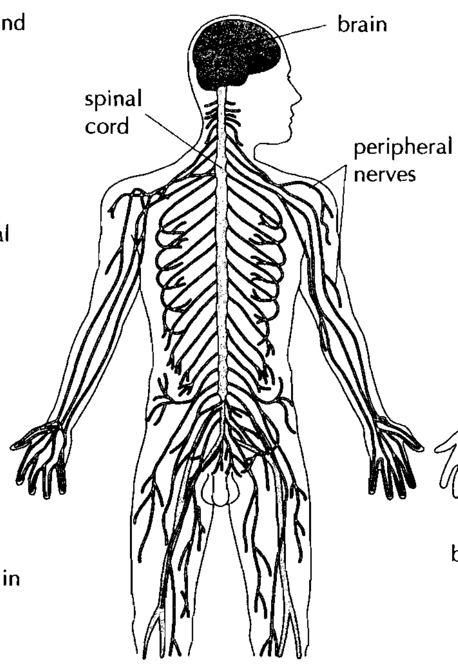
ORGAN SYSTEMS THAT MAINTAIN THE INTERNAL ENVIRONMENT

Each of the diagrams below shows organs that form part of an organ system.

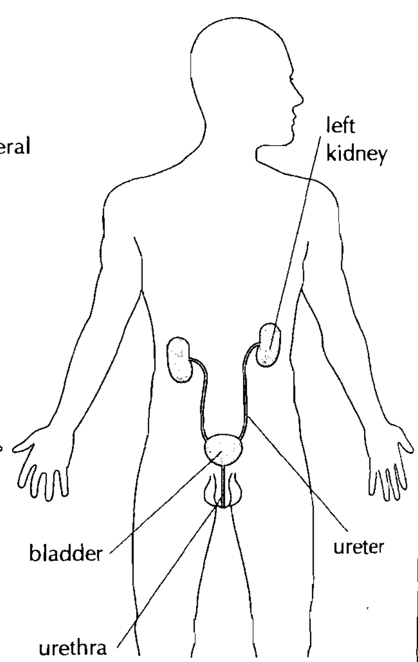
Endocrine system



Nervous system



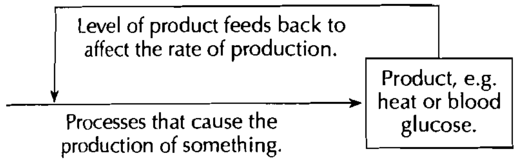
Excretory system



CONTROLLING LEVELS BY NEGATIVE FEEDBACK

1. Feedback

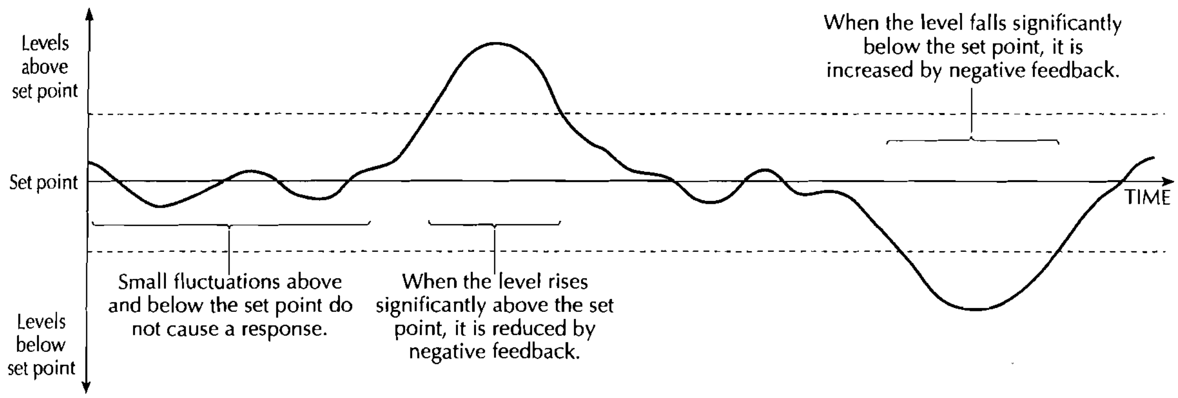
In feedback systems, the level of a product feeds back to control the rate of its own production.



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



CONTROL OF BODY TEMPERATURE

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 brain 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 neurones. The responses all affect the rate at which heat is produced or the rate at which it is lost from the body.

Responses to chilling	Responses to overheating
Skin arterioles become narrower and they bring less blood. 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	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
Skeletal muscles do many small rapid contractions to generate heat. This is called shivering	Skeletal muscles remain relaxed and resting, so that they do not generate heat
Sweat glands do not secrete sweat and the skin remains dry	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

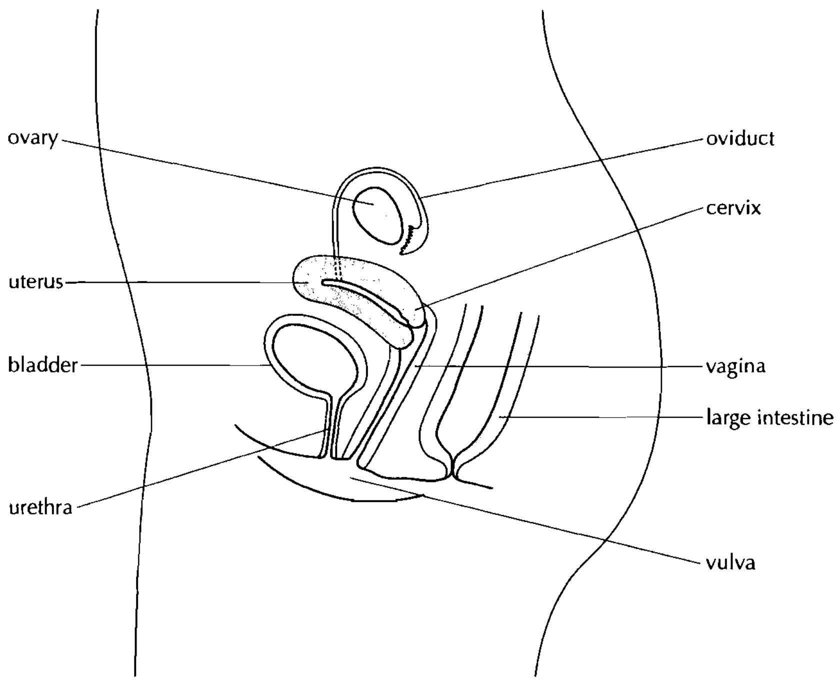
CONTROL OF BLOOD GLUCOSE LEVEL

Cells in the pancreas monitor blood glucose level and compare it with a set point, usually close to 90 mg glucose per 100 ml of blood. If the blood glucose is higher or lower than the set point the pancreas sends messages to target organs to make them respond and bring the blood glucose level back to the set point – negative feedback. These messages are carried by hormones. The responses all affect the rate at which glucose is loaded or unloaded to and from the blood.

Responses to high blood glucose levels	Responses to low blood glucose levels
ß 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

Reproductive systems

THE FEMALE REPRODUCTIVE SYSTEM



PUBERTY IN GIRLS

Over a period of about 4 years in the life of a girl, the amount of estrogen secreted by the ovaries rises. Estrogen causes girls to develop the female secondary sexual characteristics.

- The vagina and uterus grow larger.
- The vagina begins to secrete fluid.
- The breasts grow larger.
- Pubic and armpit hair start to grow.
- The pelvis grows larger.
- Fat is deposited under the skin of the buttocks and thighs.

Girls also start to follow the menstrual cycle and to release eggs.
These changes in the body and the life of girls are called puberty.

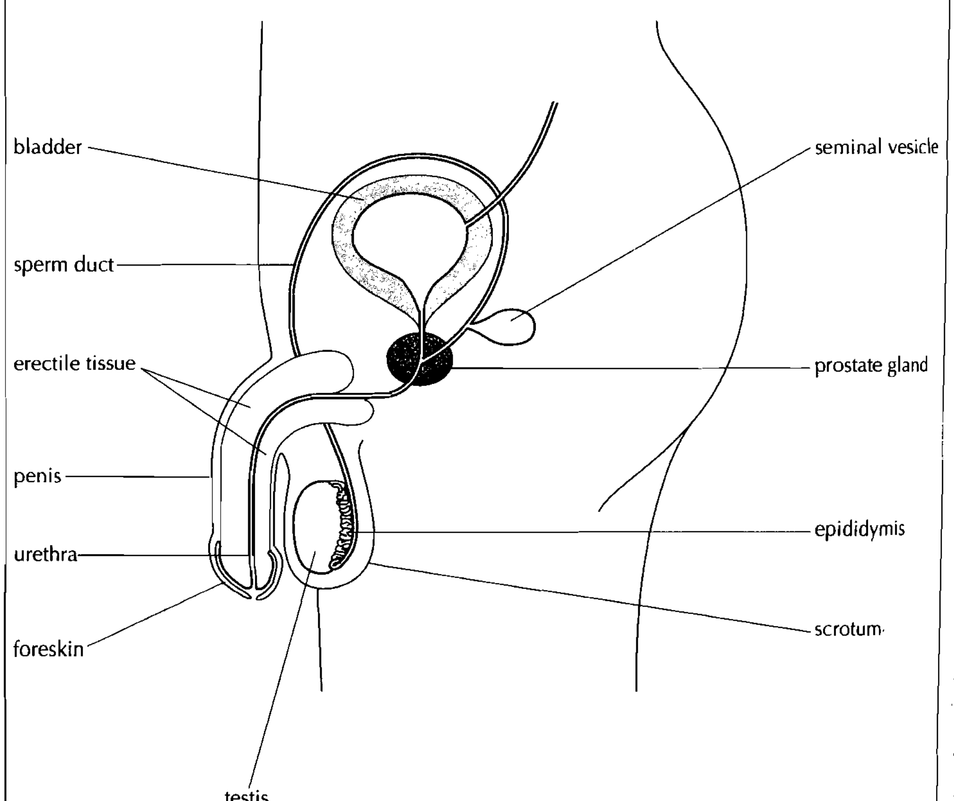
PUBERTY IN BOYS

Over a period of about 4 years in the life of a boy, the amount of testosterone secreted by the testes rises. Testosterone causes boys to develop the male secondary sexual characteristics.

- The penis and testes grow larger.
- The prostate gland and the seminal vesicles begin to secrete fluid.
- The larynx grows larger causing the voice to become deeper.
- Pubic and armpit hair start to grow.
- Facial hair starts to grow.
- Skeletal muscles grow larger.

Boys also start to produce sperm and release them during ejaculation.
These changes in the body and the life of boys are called puberty.

THE MALE REPRODUCTIVE SYSTEM

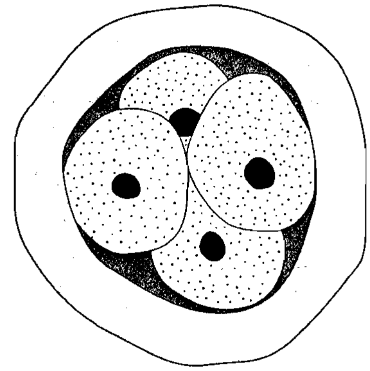


FERTILIZATION AND EARLY EMBRYO DEVELOPMENT

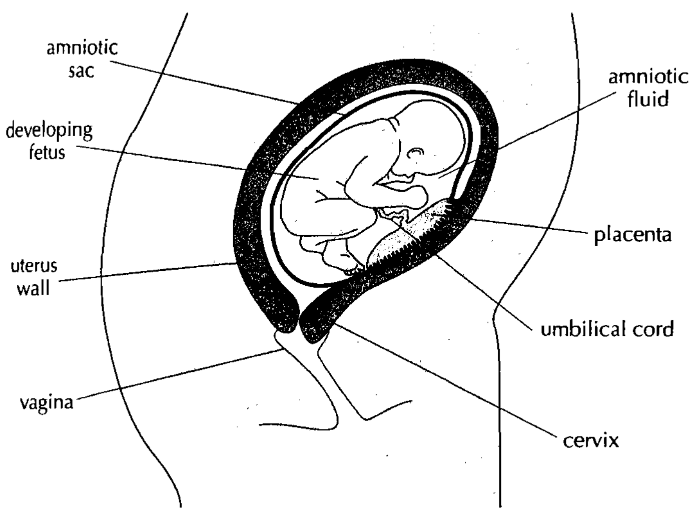
If a couple want to have a child, they have sexual intercourse without using any method of contraception. The biological term for sexual intercourse is **copulation.** During copulation, semen is ejaculated into the vagina. Sperm swim through the cervix, up the uterus and into the oviducts. If there is an egg in the oviducts, a sperm can fuse with it to produce a zygote. The fusion of an egg with a sperm is called **fertilization**.

The zygote produced by fertilization in the oviduct is a new human individual. It starts to divide by mitosis to form a 2-cell embryo, then a 4-cell embryo (right) and so on until a hollow ball of cells called a blastocyst is formed. While these early stages in the development of the embryo are happening, the embryo is transported down the oviduct to the uterus. When it is about 7 days old, the embryo implants itself into the wall of the uterus, where it continues to grow and develop.

4-cell embryo



Female reproductive system during pregnancy



DEVELOPMENT OF THE FETUS

By the time that embryo is about 8 weeks old, it starts to develop bone tissue and is known from then onwards as a **fetus**. The fetus develops a placenta and an umbilical cord (left). The placenta is a disc-shaped structure, with many projections called placental villi embedded in the uterus wall. In the placenta the blood of the fetus flows close to the blood of the mother in the uterus wall. Materials are exchanges between maternal and fetal blood. For example, oxygen passes from maternal to fetal blood and carbon dioxide passes from fetal to maternal blood. The fetus also develops around itself an amniotic sac containing amniotic fluid. The fetus floats in this amniotic fluid and is supported by it. The delicate tissues of the fetus are protected from injury by the amniotic fluid, which acts as a shock absorber. This is needed if an everyday event or an accident causes an impact to the mother's abdomen.

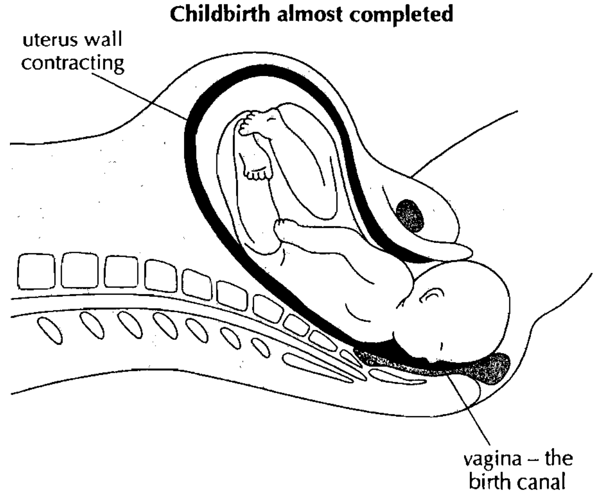
A sample of fluid can be taken from the amniotic sac by inserting a hypodermic needle through the abdomen wall. This procedure is known as **amniocentesis**. The fluid contains fetal cells which can be cultured to make them divide. The chromosomes of the dividing cells can be examined to test for chromosomal abnormalities such as Down's syndrome.

CHILDBIRTH

Through the 9 months of pregnancy, the hormone progesterone ensures that the uterus develops and sustains the growing fetus. The level of progesterone in the mother becomes increasingly high. The end of pregnancy is signalled by a fall in progesterone level. This allows the mother's body to secrete another hormone – oxytocin. Oxytocin causes the muscle in the uterus wall to contract. Uterine contractions stimulate the secretion of more oxytocin. The uterine contractions therefore become stronger and stronger. This is an example of **positive feedback**.

While the muscle in the wall of the uterus is contracting, the cervix relaxes and becomes wider. The amniotic sac bursts and the amniotic fluid is released. Finally, often after many hours of contractions, the baby is pushed out through the cervix and the vagina. The umbilical cord is cut and the baby begins its independent life. Contractions continue for a time until the placenta is expelled as the afterbirth.

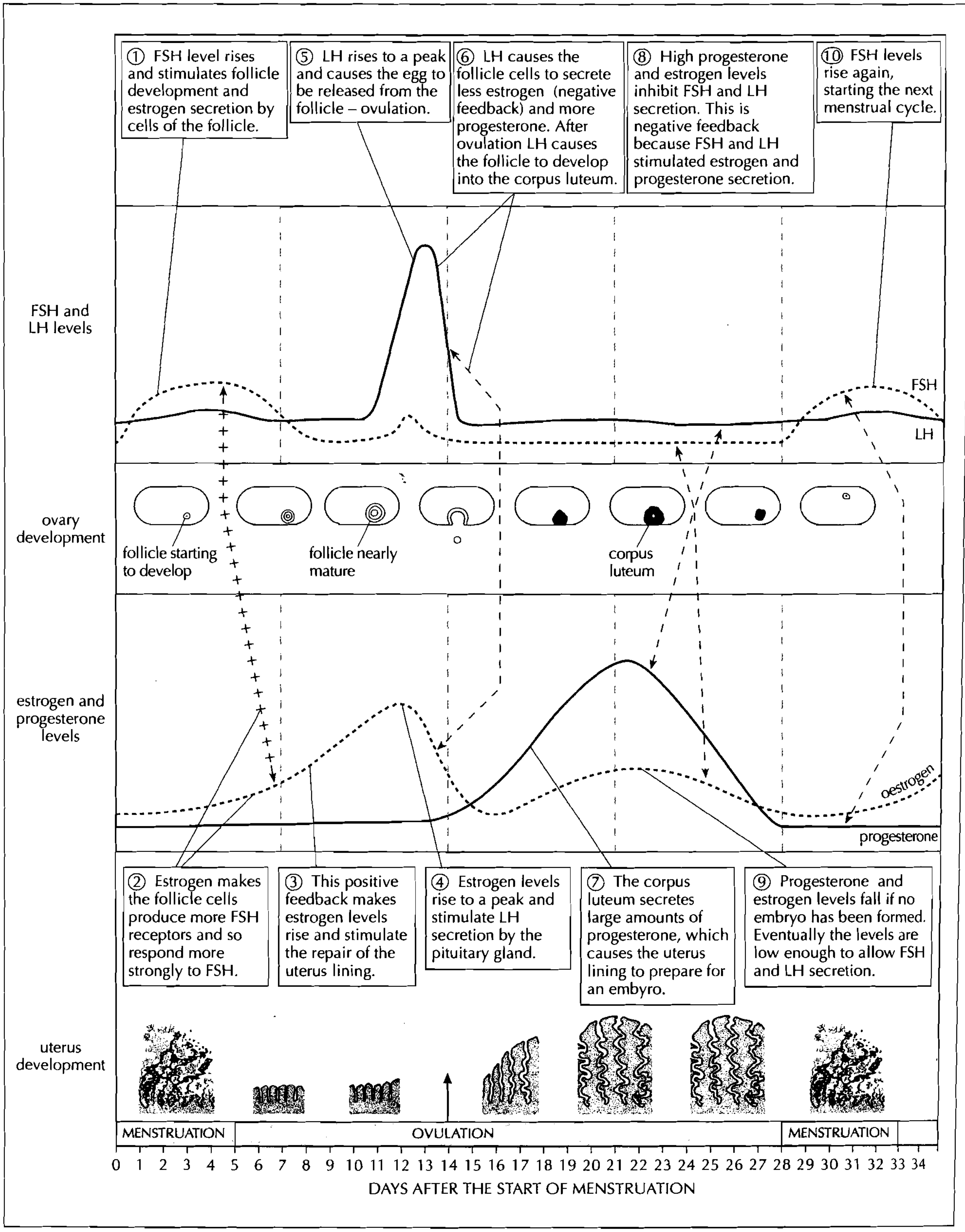
Childbirth almost completed



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 oestrogen 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. Control of the cycle involves negative and positive feedback mechanisms, indicated by arrows.

(- - - - - - - -> = negative feedback + + + + + + + + +> = positive feedback)

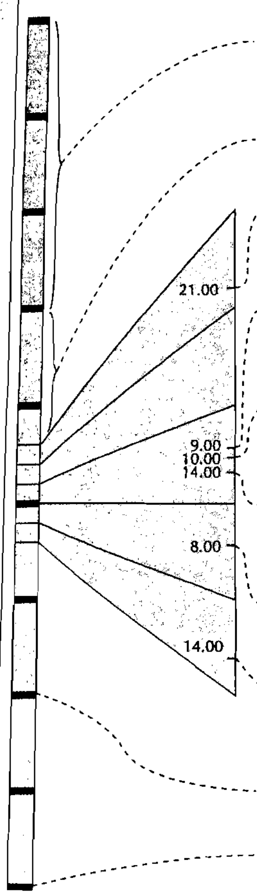


Human fertility can now be controlled in many ways. There are also many different views about whether it is right or wrong to control it. It is important to understand the views of different people and also how the methods work.

IN VITRO FERTILIZATION

Some couples do not achieve fertilization and pregnancy as a result of sexual intercourse. One possible cause is blocked oviducts. Many of these couples can be helped to have a child by in vitro fertilization – IVF.

Timetable for IVF



① A drug is injected once a day for three weeks, to stop the women's normal menstrual cycle.

② Large doses of FSH are injected once a day for 10–12 days to stimulate the ovaries to develop many follicles.

③ HCG (another hormone) is injected 36 hours before egg collection, to loosen the egg in the follicles and to make them mature.

④ The man provides semen by ejaculating into a jar. The sperm are processed to concentrate the healthiest ones.

⑤ The eggs are extracted from the follicles using a device inserted through the wall of the vagina.

⑥ Each egg is mixed with sperm in a shallow dish. The dishes are kept overnight in an incubator.

⑦ The dishes are checked to see if fertilization has worked.

⑧ Two or three embryos are selected and placed, via a long plastic tube into the uterus.

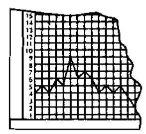
⑨ A pregnancy test is done to see if any embryos have implanted.

⑩ A scan is done to see if the pregnancy is continuing normally. The heart should be visible beating.

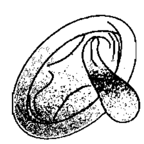
FAMILY PLANNING AND CONTRACEPTION

Family planning involves couples discussing and deciding how many children they want to have and when, if possible, they want to have them. During one period in the menstrual cycle, sexual intercourse can lead to fertilization and pregnancy. Couples who want a child should have sexual reproduction during this period.

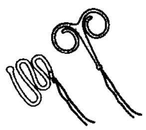
Family planning may also involve contraception. Contraception is used when a couple want to have sexual intercourse but do not want to have a child. Methods of contraception can be divided into two types, mechanical methods such as condoms, diaphragms and IUDs and chemical methods such as the contraceptive pill. The ways in which four methods work are shown below, but not detailed instructions for their use.



The rhythm method – behavioural
The couple try to develop a rhythm of having intercourse only on 'safe' days in the cycle. Temperature changes or tests for the LH surge help to find when ovulation has occurred, which helps to identify safe days.



Condom – a mechanical method
A thin but strong sheath of rubber or plastic is unrolled over the erect penis before intercourse. A teat at the end catches the semen. The condom is removed after withdrawing the penis from the vagina.



IUD – a mechanical method
Intra-uterine devices are plastic or metal objects, which are placed in the uterus and left there for months or years. It causes irritation in the uterus and prevents implantation of embryos into the uterus lining.

Contraceptive pills – a chemical method
Female contraceptive pills contain hormones, that either prevent ovulation or prevent implantation of embryos by altering the uterus lining. One contraceptive pill is taken orally each day.

ETHICAL ARGUMENTS FOR IVF

- Some childless couples are able to have children.
- Suffering due to genetic disease could be reduced if embryos were screened before being transferred to the uterus.

ETHICAL ARGUMENTS AGAINST IVF

- Inherited forms of infertility might be passed on the children, which means that the suffering the parents endured is repeated in their offspring.
- More embryos are often produced than are needed and the spare embryos are sometimes killed although they are new human lives.
- Embryologists select the embryos that are transferred to the uterus, so humans are deciding whether new individuals survive or die.
- Multiple births, which carry the risk of various health problems for the children, are more likely with IVF than with natural conception.

ETHICAL ARGUMENTS FOR FAMILY PLANNING AND CONTRACEPTION

- Prevents the birth of unwanted and therefore probably unloved children
- Couples who are carriers of genetic disease can avoid the birth of children with the genetic disease.
- Women should have the right to choose whether they become pregnant or not.
- Human impacts on the biosphere will be reduced if fewer human babies are born.

ETHICAL ARGUMENTS AGAINST FAMILY PLANNING AND CONTRACEPTION

- Many religions teach that it is wrong to intervene in a natural process.
- Promiscuity might be encouraged.
- Some methods involve the death of zygotes or young embryos, which are new human lives.