NEW ENCYCLOPEDIA OF SCIENCE

new encyclopedia of SCIENCE

volume 7

heating – jenner

Purnell Reference Books
Milwaukee • Toronto • Melbourne • London

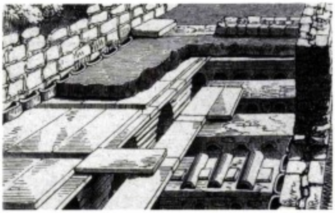
Library of Congress Cataloging in Publication Data
New Encyclopedia of Science
1. Science - Dictionaries, Juvenile
I. Osman, Tony
503 Q123 79-41530
ISBN 0-85613-998-X

Consultant Editor: Tony Osman, MSc, BSc, ARCS
Executive Editor: Vivian McCorry
Scientific Editor: Christopher Cooper, BSc, ARCS
Editorial Director: Brian Innes, BSc, MIOP, ASIA
Assistant Editor: Jennifer Sullings, BA

Printed and bound in Spain
by Graficromo, S.A.-Córdoba

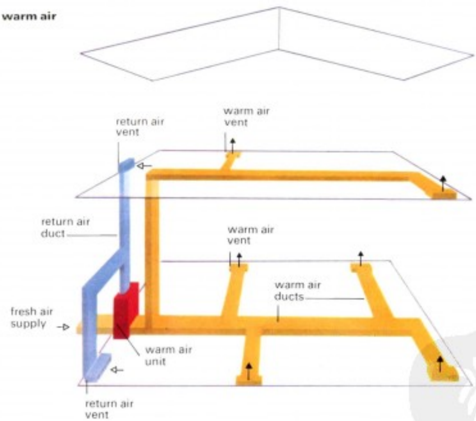
new encyclopedia of SCIENCE

heating systems

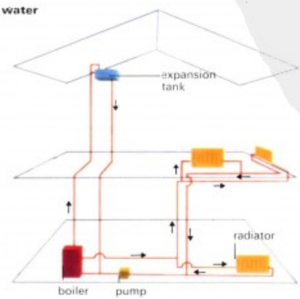


The hypocaust — Roman heating system — of a Roman villa found at Woodchester, in Gloucestershire. Air heated by a furnace, was circulated through a system of channels under the floor, so warming the rooms above

warm air



hot water



Home heating systems:
△ Air heated by the warm air unit is blown by fans along ducts to all the rooms. It goes through vents in the floor or walls into the rooms. Vents can be closed in rooms not used, or adjusted to control the amount of heat. Return air vents take the air back to the heater.
▷ Hot water is pumped along pipes to radiators in the rooms. The water in the boiler may be heated by gas or electricity, and regulated by a time-clock and thermostat. The expansion tank allows for overflow of water from the boiler. Radiators can be closed off in rooms where heat is not wanted

Most of us today take the heat in our homes and workplaces for granted. We expect hot water to emerge from a hot water tap. We expect the radiators or registers of a home heating system to keep out the chill of winter. But we seldom concern ourselves with the engineering behind our heating.

Complicated systems for warming houses were in use before the time of Christ. The Romans were masters of these systems. The Roman heating system was known as a hypocaust. From a furnace room hot air passed along channels beneath the floor, warming the rooms above. It was drawn away through chimneys. Sometimes this kind of heating was used for baths, and in the hot rooms around the baths.

Heat can travel from one place to another in three ways. It can be passed from atom to atom through a material like the top of a stove. This is called conduction. Or it can travel by radiation across empty space in the form of waves. Heat from the Sun reaches us in this way, and so does most of the heat we can feel a campfire sending out. (See: *radiation*.)

In a liquid or gas, heat can move in a third way, called convection. In a water tank, for example, the heated part of the water rises, and its place is taken by cold water. The warm water rises because, when heated, it expands. So it is lighter than an equal volume of cold water, and starts to rise.

After the decline of the Roman Empire this kind of home heating became a forgotten art. Until the present century, most homes were heated by open fires burning coal, peat or wood. Today, home heating uses electricity, oil, gas and coal.

Home heating systems make use mainly of convection. The household water boiler is heated by coal, oil, gas or electricity. The heated water rises and sets up a flow of water in the house's hot-water pipes. The hot water flows to radiators throughout the house. (Electric pumps are often used to help the flow.)

The radiators that actually warm the rooms are badly named. They send out only a little heat by radiation. Their most important effect is to heat air by direct contact. This hot air rises and is replaced by cool air. The heat is spread around the room.

Rooms can also be heated by hot air travelling by convection currents through ducts – like the Roman hypocaust. Or the air can be blown through the ducts by fans. Electrical wiring can also be set in floors and ceilings to radiate heat into the room.

Steam is often used for heating. In many areas of high density housing, offices, and college campuses, steam for heating comes from a local power station. The steam is led to the buildings to be heated through pipes that are heavily insulated to avoid heat loss. Waste heat from power stations is normally carried away in river water. This can destroy river life. Using this waste heat for warming buildings is helpful to man, and also protects our rivers.

See: *energy*, *heat*, *power*.

◁A frightened hedgehog curled into a ball with its legs and head in the middle. You can just distinguish its ears. Only its coat of sharply pointed spines is exposed to the enemy

▽ The tree porcupine lives in North and South America. Some types are 90 centimetres (three feet) long, including 30 centimetres of tail. The short spines on its back are often hidden by long fur. With spines raised it turns its back on an enemy

hedgehog

The name hedgehog means different things to different people. To you hedgehogs are small plump animals with bodies 18 to 25 centimetres (seven to ten inches) long. They have short legs, soft fur on face and belly, and spines on the back. To an American, a hedgehog is a large spiny animal that lives in the forest. It is more correctly known as a porcupine.

Although they have spines like the American porcupine, European hedgehogs are a very different kind of animal. They are insectivores – mammals that eat insects (see: *insectivore*). Moles and shrews are related to them. The American porcupine is more closely related to rats and squirrels.

Hedgehogs are found in Africa and Asia, as well as in Europe. They do not live in North America. They are called hedgehogs because they are often found under hedgerows, and the snout looks like a hog's snout. The fur on the back is specially adapted to form an armour of sharp prickly spines. They are a hedgehog's natural defence.

When it is disturbed or threatened by another animal the hedgehog immediately sticks its spines up and rolls into a tight ball. The armour of sharp spines, pointing in all directions, that is presented to the enemy is usually enough to send it away. But sometimes a hungry badger or fox will roll the hedgehog over or even throw it into water where it uncurls at once. Then the enemy can attack its soft underparts.

The long sharp quills of the porcupine and the body armour of the South American armadillo are also examples of natural defences.

Hedgehogs like to sleep in quiet places during the day. Their favourite haunts are under hedges

or piles of dead leaves, or in burrows in banks. They are nocturnal animals which means that they are active mainly at night. Bats and owls are also night-time animals.

When twilight falls, hedgehogs come out to feed. They have a varied diet. They like insects, snails, slugs and worms. They also eat mice, rats, frogs, snakes and birds' eggs. And if all these are scarce they will even eat plant material like acorns and berries. They use their strong claws to dig up ants' nests and worms. And their sharp teeth are very efficient in breaking the hard outer skeleton of insects. They hunt by listening and smelling out their prey. Their eyesight seems to be poor.

During the cold part of the year a hedgehog retires for its winter sleep. This is called hibernation. It makes a nest for itself in a sheltered place, lines it with dry leaves, and settles down to sleep. Fat that has been stored in the body during the summer months is absorbed as food during this time. This fat is usually enough to last the animal for the whole winter. It does not need as much food as usual because it is not active.

During hibernation the body is working at a much slower rate than normal. The heart beat and the breathing rate are much slower. The body can also tolerate a much lower temperature than usual – often it is just a few degrees above freezing point. But should the body temperature drop too low, the hedgehog immediately becomes active, warming up its body. Then it sleeps again. (See: *hibernation*.)

Hedgehogs breed in summer. They may have one or two litters of young a year, with three to seven in each litter. A newborn hedgehog is about six centimetres (2-3 inches) long. It is deaf, blind and quite helpless. It has a thin coat of soft spines. These bend easily and are no protection against enemies. Soon a new layer of spines grows and in eleven days the young hedgehog can roll up into a tight ball just like its parents can. The eyes open a few days later and the coat of spines gets thick and prickly.

The mother nurses the young hedgehogs for their first four weeks. Then they start to find their own food which at this stage consists of soft things like insect larvae, worms and plants. When two years old, hedgehogs find a mate and produce young of their own.

See: *porcupine*.

Hedgehogs are born about six centimetres long with sparse rubbery spines. They cannot curl up until they are 11 days old

helicopter

A helicopter is able to fly in any direction, even backwards. It can rise straight up from the ground, hover at any height, and land on a clear area beneath. It can go where no ordinary airplane can.

It is able to do all this because, unlike an airplane, it does not have wings fixed to the cabin. Instead, it has a 'rotor' of two, three or four blades mounted on a shaft above the roof of the cabin. An engine is used to turn these blades horizontally. By rotating they are able to lift the cabin off the ground. The way they do this is similar to the way the wings lift an airplane.

The top of an airplane's wing is more curved than the bottom. Air passing over the top has farther to go than air going underneath. So when the airplane moves forwards (driven by its engine) air passing over the top of the wing moves faster. When a stream of air is made to go faster, its pressure is reduced as a result. (See: *aerodynamics*.) So the pressure of the air above the wing becomes less than that of the air beneath the wing. The wing rises because of this pressure difference, which increases as the airplane gathers speed. The wings are forced up and carry the plane with them.

The forward movement of the plane, therefore, makes the pressure difference needed to lift it. So it needs a runway to speed along until it has liftoff. A runway is also needed for its gradual slowing down after landing.

In a helicopter, the rotor blades are curved more on the top then on the bottom. The rotation of these blades creates the pressure difference needed to lift the craft.

As the blades rotate, their path traces a disc horizontally over the cabin. If each blade is tilted up at the front edge, it is then at an angle to the horizontal. This angle at which the blades cut through the air is called the pitch. By changing the pitch of the blades, the amount of lift can be altered.

When the engine is started up, the blades rotate. The throttle, which controls the speed of the blades, is on the 'collective pitch' stick at

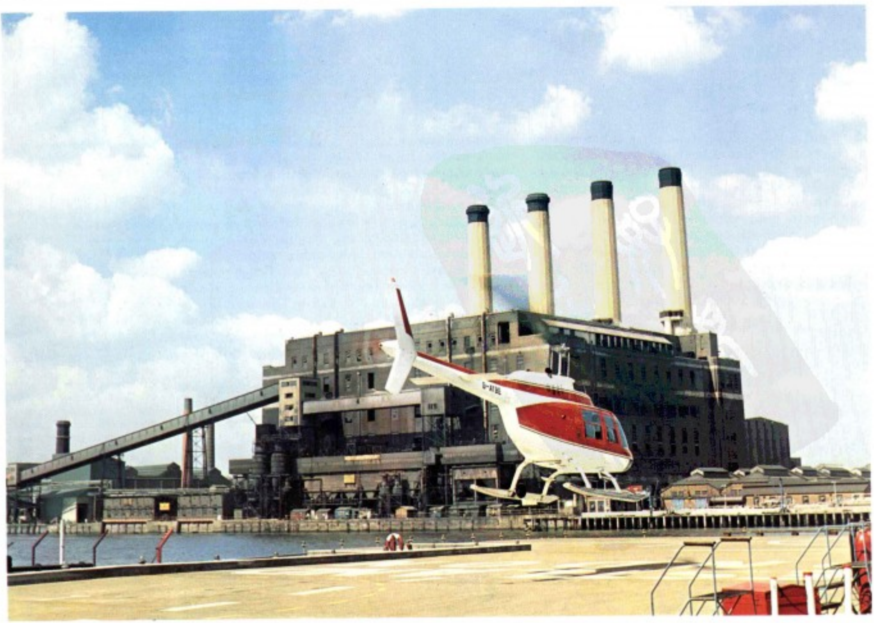
The helicopter hovers while goods are lowered to an isolated centre in the Arctic. Helicopters need no runway. They can land straight down on a clear area beneath. They are useful for reaching areas difficult to get to by any other means, such as this centre

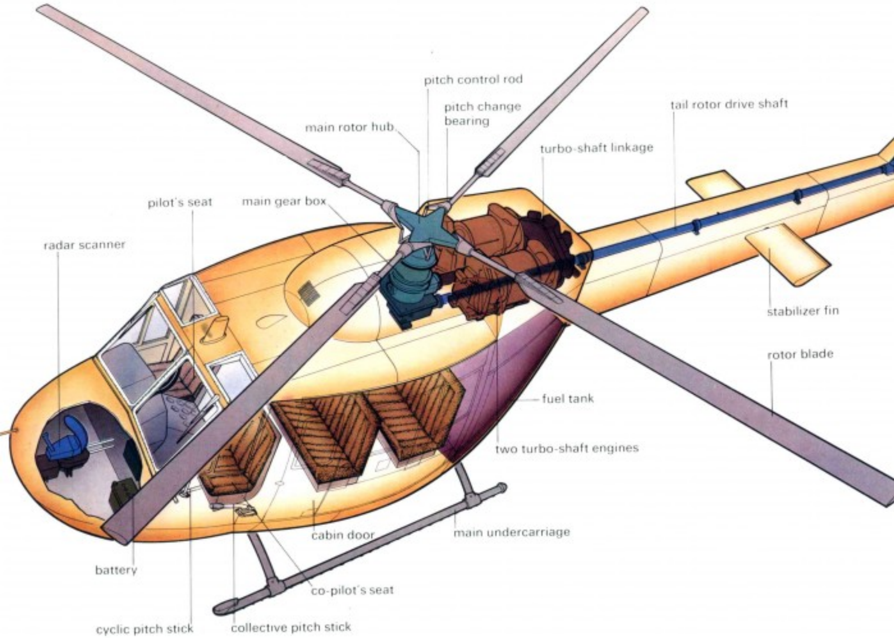

ARMY

◁ Bell 'Sioux' helicopters. These are principally working machines. Because they can be used in areas inaccessbile to ordinary aircraft, helicopters are often used in military operations, for search and rescue, and for surveying and transportation into undeveloped areas. The Bell helicopter gives wide vision useful for such operations.

▷ Helicopters can also provide recreation for the wealthy. This Bensen 'one man' helicopter is open to the air to give the sensation of flying. Such one-man helicopters could be everyday transport of the future. One type, the Hiller Aircraft 'Rotorcycle' is collapsible for easy transport on the ground.

▽ A Bell Jet Ranger helicopter takes off from London's heliport. In Los Angeles, where more people use helicopters for private transport, the tops of many tall buildings are used as heliports.





the pilot's side. This stick also controls the pitch of all the blades together. Increasing the pitch increases the lift. The blades can rotate, while the cabin remains still on the ground, until there is enough lift to pull the cabin up.

When the pilot wants to descend, he uses the collective pitch stick to decrease the pitch of all the blades, and at the same time he reduces the speed of the engine. If the engine stalls, the helicopter will not suddenly fall to the ground but will slowly descend because the blades still turn, like a windmill, and create some lift.

Once in the air, the pilot can hold the helicopter in one position, so that it hovers. In order to move horizontally, the pilot pushes another lever, the 'cyclic pitch' stick, or 'go-stick', in front of him. This stick tilts each blade separately.

When he pushes the go-stick forward, the pitch of each blade is increased as it passes over the back of the cabin. The pitch is reduced again as each blade passes over the front. There is more lift at the back and the disc traced out by the blades is tilted forward, pulling the cabin forward with it. By moving the go-stick in the direction he wishes to go, the pilot is able to direct the helicopter wherever he wishes.

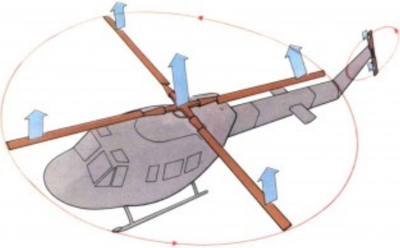
The rotation of the blades tends to make the cabin turn in the opposite direction. A small rotor turning vertically is therefore fitted to the back of the cabin. When its blades rotate a force is produced that balances the force of the main rotor. The cabin is thus prevented from spinning and held steady.

In other helicopter designs different methods are used to steady the cabin. The tandem helicopter has two large main rotors. These both rotate horizontally, but in opposite directions so that the cabin does not spin. As they are both used for lifting, greater lift is possible and a larger cabin can be attached. One rotor is fitted at the front of the craft, the other at the back. The rotors are at different heights, so that the blades do not collide with each other. Thus the tandem can carry an uneven load. If there is more weight at the back, for example, the amount of lift created by this rotor can be increased. Tandem helicopters are too big for rescue purposes but are ideal for transportation of people and cargo.

Helicopters cannot fly as fast as ordinary planes, but modern machines can reach speeds of nearly 500 kph (300 mph).

Successful helicopters could not be developed until the petrol engine was invented. In the 1920s the gyroplane, or autogyro, was invented by the Spaniard Juan de la Cierva. This was like an ordinary plane, but as well as wings and a propeller it had rotors. The rotors were not

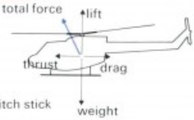
△ A passenger-carrying helicopter. The main rotors trace a horizontal disc above the cabin (red arrows, *top right*). The tail rotor traces a vertical disc and helps steer the aircraft. The curve of the rotor blades cutting through the air causes the lift. By altering the angle, or pitch, of the blades the direction of the thrust is changed. Increasing the pitch at the back will move the helicopter forward in the direction of the blue arrow (*middle right*). The cyclic and collective pitch sticks (*bottom right*) control the angle of the blades. The throttle alters their speed. The pilot uses his feet to work the tail rotor control

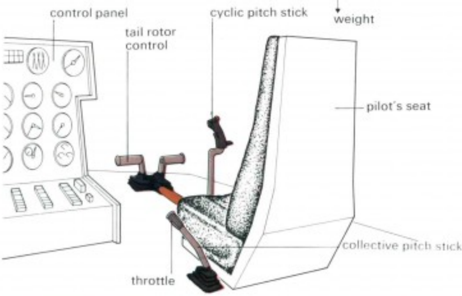


powered by the engine. The craft's forward movement made them turn. The rotors assisted in take-off, so that the autogyro needed less than 30 metres (100 feet) of runway. However, its top speed was only 130 kph (80 mph).

Then, in 1939, the Russian-born American Igor Sikorsky made and flew the first single-rotor helicopter. In 1941, he was able to remain airborne for 92 minutes.

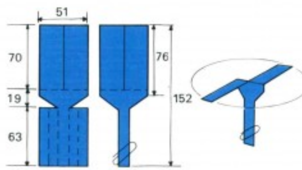
See: *aerodynamics*, *airplane*.





Find out by doing

You can make a simple rotor to see what happens as it spins through the air. On a piece of stiff card mark out lines as shown in the picture. Then, cut along the straight lines so that you have an oblong cut in half at one end with two triangles cut out of the sides. Fold along the dotted lines at the other end to form the shaft. Weight this with something such as a paper-clip. Fold along the remaining dotted line to form the two 'rotor blades'. Now, hold it by the shaft as high as you can with the rotor blades at the top, and let it fall. At first it falls quite fast. But as soon as it starts to spin it slows down. In a similar way a helicopter will 'windmill' to the ground if its engine fails. Lengths are in mm.



heliograph

Three signallers, during the Boer War in Africa, flashing messages by heliograph to other troops. Messages are sent by long and short flashes of reflected sunlight

A ship out at sea must have some way to communicate with the mainland or other ships. Before the radio was invented, messages were sent by signalling with flags or a heliograph.

In this instrument a mirror is used to reflect sunlight in flashes over the sea. On a clear day these flashes can be seen up to 80 kilometres (50 miles) away.

This method was used in a crude way in Ancient Greece, but the heliograph was developed properly as a precision instrument in 1869 by Henry Mance, a British engineer. By then Samuel Morse had invented his code which could be applied to the flashes (see: *Morse*).

A mirror is mounted so that it can be turned and inclined at any angle to the Sun to reflect light precisely in any direction. Light from the mirror is lined up with the centre of a disc on a sighting rod (rather like lining up a rifle). This rod is positioned directly in line with the receiving station. Flashes are made by pressing a switch. The switch may cause the angle of the mirror to change briefly. Or it may open a shutter covering the mirror.

As the position of the Sun moves, the mirror is adjusted slightly to keep the reflected light in line with the receiving station.

A second mirror is used to reflect light onto the first if the flash is to be sent in a direction opposite the Sun.

In Rudyard Kipling's poem *A Code of Morals* he explains how the heliograph was used by the British army in India.

See: *communication*, *light*.

helium

Helium is a rare gas which has no colour, taste or smell. Helium was unknown until 1868. Then Sir Joseph Lockyer, an English astronomer, and Pierre Janssen, a French astronomer, found that it exists on the Sun. The gas was called helium after *helios* – the Greek word for Sun. Now we know there is helium on our planet Earth too.

Both scientists found helium when studying an eclipse of the Sun by the Moon (see: *eclipse*). When the Sun is in eclipse the hot gases of its outer atmosphere can be clearly seen on Earth. These burning gases can be studied with a 'spectroscope'. A spectroscope is a special instrument that tells one substance from another by the light it gives out when it is hot. Janssen's and Lockyer's spectroscopes showed that an unknown gas was present on the Sun. This was the substance they named helium.

△ Helium gas becomes liquid when cooled but will not solidify. It is useful for research at low temperatures and for refrigeration. It cools water vapour in air to a visible mass of water droplets.

▽ Hot gases of the Sun's atmosphere are visible when the Sun is blocked out (eclipsed). Helium was discovered in these gases by the light it gives out

Twenty-seven years later, Sir William Ramsay, a Scottish chemist, obtained helium by treating the mineral 'cleveite' with acid. Cleveite is a radioactive form of the chief ore of uranium. Later, scientists found out that there is a little helium in the air we breathe. There is only one helium atom for every 186,000 molecules of our air. But there is much more helium in the Sun's atmosphere. So it is not surprising that helium was first noticed on the Sun. In the universe as a whole, helium is the next most common element to hydrogen. Scientists have estimated that helium atoms represent about nine per cent of all the atoms that exist.

Helium is a member of the group of elements called 'inert gases' (see: *element*). Inert gases do not easily react with other elements. That means they do not burn and cannot be identified by a 'chemical test'. (See: *chemistry*.)

Helium is a very light gas. Only hydrogen is lighter. Helium is safer than hydrogen for filling airships and weather balloons because it does not catch fire. And an artificial air made of helium and oxygen is safer than real air for deep sea diving. Divers using this mixture can work longer under water and at greater depths. The helium replaces the gas nitrogen in the real air. Nitrogen is the cause of 'bends' (see: *bends*). Bubbles of nitrogen gas form in the diver's blood and block the circulation of his blood. The diver may become paralyzed and die. Helium does not dissolve so easily in the blood as nitrogen, and it passes out of the lungs more quickly (see: *deep sea diving*).

A helium-oxygen mixture is sometimes given in hospital to patients who have difficulty in breathing. The mixture of gases can be passed through obstructions more easily than can air.

Helium is present in the natural fuel gas that we extract from the ground. This may contain from one to eight per cent helium. Most helium comes from Texas, New Mexico or Kansas.

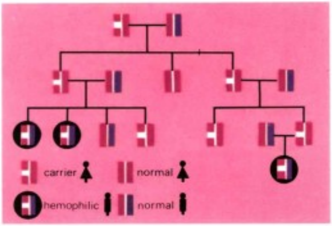
Helium gas can be made liquid by first cooling it, then compressing it at very high pressures and finally letting it expand rapidly. The sudden expansion cools it so it becomes liquid. Liquid helium behaves in a most extraordinary way. Other liquids freeze solid if they are made cold enough. Helium stays liquid at the lowest temperatures we can make. Liquid helium is very useful for cooling things to very low temperatures.

Zero absolute temperature is the lowest temperature of all (see: *heat*). No substance can reach it. When liquid helium is nearly at zero absolute temperature, it turns into a superfluid. Helium superfluid is unlike any other substance on Earth.

The superfluid will climb up the sides of a beaker and overflow. It can find its way through a hole too small to allow even the molecules of a gas to pass through. And it can flow without any measurable friction. If a wave motion is started in a tank of helium superfluid it will continue to slop back and forth for an extremely long time. This is because there is no friction to slow it down.

See: *chemistry*, *gas*.

hemophilia



How hemophilia is passed on. Men have an X (red) chromosome and a Y (blue) chromosome. Women have two X chromosomes; one of them is abnormal (red and white) in carriers of hemophilia. If a boy child inherits a normal X from his mother he will not have the disease. If he inherits an abnormal X chromosome he will have hemophilia. A girl child will not because she has a normal X chromosome from her father (unless he has hemophilia)

Hemophilia is an inherited disease that usually shows up only in males. The blood of a hemophilic person does not clot or will clot only very slowly. If he cuts himself he will probably need a blood transfusion to replace the blood he has lost.

The bleeding occurs inside his body too. A bump may cause bleeding in a joint area or inside the abdomen. The pool of blood presses on the joint or internal organ. It causes pain and may cause damage.

There are at least 12 factors, or ingredients, in the blood that must work together to form a clot. When you cut yourself, these factors start a series of reactions. One of the most important reactions affects the factor fibrinogen (factor I). Fibrinogen forms solid threads of fibrin.

The fibrin threads form a net that traps the cells that float in the blood. The net, loaded with cells, becomes a clot. As the bleeding slows, the clot hardens into a scab.

The blood of a hemophilic person lacks one of these clotting factors. Slight clotting can occur in blood that lacks factor VIII, for instance. But it lacks the fibrin network, so the clots are easily pushed away by the oozing blood. Bleeding may stop for a while, then begin again. Diseases similar to hemophilia may be due to lack of one of the other clotting factors. If more than one factor is lacking the disease is more severe and difficult to treat.

Hemophilia is an inherited sex-linked disease. There are two types of human sex chromosomes, X and Y. Every cell in a female's body has two X chromosomes. Every cell in a male's body has an X and a Y chromosome. You inherit one of the chromosome pairs from each parent. If you are a girl, you inherited an X from your mother and an X from your father. If you are a boy, you inherited an X from your mother and a Y from your father (see: *chromosomes and genes*).

The instructions for making factor VIII are on the X chromosome. No such instructions occur on the Y. So if a male inherits an abnormal X, his blood lacks factor VIII and does not clot. If a female inherits an abnormal X, the other X will usually be normal and will carry the clotting instructions. Her blood clots normally, but she may pass the abnormal X on to her children. So she is a 'carrier'. Hemophilia is carried by women, but shows up only in men. However, if a woman carrier married a male hemophiliac, the disease could affect some of their daughters. (See: *heredity*.)

In many parts of the world, only one kind of treatment for hemophilia is available. This is to give blood transfusions to replace the blood lost. A better treatment is to inject pure factor VIII. This temporarily makes the person's blood able to clot normally. The factor can be extracted from blood given by donors. The liquid part of the blood, containing the factor, is stored in a deep freezer. It is thawed and injected when needed. It may take five or more pints of blood to produce enough factor VIII to stop bleeding. Since the factor lasts only a few hours in the body it may have to be given many times. Days may pass before the wound heals.

Hemophilia brings many social problems. The person must always be careful not to get hurt. He often needs medical care. Even when good care is available, a hemophilic person's life is not easy. A hemophilic person, or a carrier of the disease, also has to consider that any children he or she might have are likely to inherit this condition.

See: *disease*, *heredity*.

Treatment of a hemophiliac: *1* This boy is given blood factor VIII to make his blood clot. He goes to an ordinary school but visits a hemophilia clinic when bleeding starts. *2* Joints swollen by bleeding in them must be rested. Legs weak from lack of use are strengthened by physiotherapy. *3* A splint protects a leg after severe bleeding, until it is stronger. *4* X-ray of the knee shows damage caused by bleeding

1

2

3

4

△ Wild horses in the long grass on which they feed. Herbivores have special teeth to break up their fibrous food

herbivore

When you sit down to a meal you probably expect to find some meat, vegetables and dairy products on the table. Human beings have an omnivorous diet, meaning that they eat both plant and animal foods. But many animals have a more specialized diet. Some eat only plant material like grass, fruits, leaves, nuts and bark. Such animals are called herbivores. Cows, horses, squirrels, mice, butterflies and many snails are herbivores.

Animals that eat other animals are called carnivorous, meaning flesh-eating. Wolves, lions, snakes and dragonflies are carnivorous (see: *carnivore*).

Cows and horses and other animals that eat tough fibrous grass have special teeth to deal with their food. The incisor teeth (at the front of the mouth) act like pincers and crop the grass. Then the molars (at the back of the mouth) and the premolars (just in front of the molars) crush and grind it up into small pieces. The jaws can move sideways as well as up and down so that the teeth can grind. The teeth of many herbivores are continually growing. So they are not worn down. And they are covered with hard 'cement' and ivory to protect them.

Food must be broken down before it can be used by the body. Not only do animals grind their food by chewing it. They also make digestive juices, or enzymes which break down its chemical structure (see: *enzyme*). These juices are released in the digestive tract and digest, or break down, the food into simple chemical compounds. These are then absorbed by the cells of the body to give nourishment. (See: *digestion*.)

But plants are made mainly of a material called cellulose. And this cannot be broken down by digestive juices. So how do herbivores digest their food and get the nourishment they need to live?

In the digestive tract of all herbivores, there are tiny one-celled creatures called bacteria and protozoans. These break down cellulose into simple chemical compounds that can be used by the herbivore. In fact most animals, no matter what they eat, have bacteria in their digestive tracts. But because herbivores eat only plants, they specially need the bacteria. This kind of relationship is called symbiosis, meaning 'life together'. The herbivore and bacteria depend on each other for their existence. The bacteria, in the process of breaking down the food the herbivore has eaten, get some food themselves. And the herbivore gets its food digested. (See: *symbiosis*.)

Because plant material is difficult to digest, it must be thoroughly chewed up into small pieces before it passes to the stomach. This makes the work done by the bacteria and the herbivore's digestive juices possible.

Most herbivores have complex stomachs and very long intestines so that they can thoroughly digest plant food. The intestine of the hippopotamus is 60 metres (200 feet) long. Some herbivores have stomachs with four chambers to deal with their plant diet. These animals are called ruminants. Cows and sheep, as well as the African gnus and impala antelopes, and the North American bison are ruminants. They all ruminate, or chew the cud. Rumination is very important for their digestion (see: *ruminant*).

When a cow swallows, its food enters the first stomach or rumen. The bacteria here break down the cellulose material of the plants. The partly digested food then passes back up into the mouth a bit at a time, and is chewed over again. This is the familiar chewing-the-cud action. When the food is thoroughly chewed, it is re-swallowed and passes into the other

▽ Sharp front teeth cut into vegetation. This beaver cuts pieces of bark for food, and for its nest. *(Right)* The back teeth of a herbivore have a wide ridged surface for cutting and grinding on

Despite its appearance, the white rhinoceros is a placid vegetarian, browsing on leaves and grass. It uses its horns as defence against predators, but its size is usually sufficient deterrent

▷Sheep are ruminants. They prefer the sparser grass of hill and mountain sides where their sureness of foot also makes them safe from predators. These wild sheep have a long outer coat of hair. Beneath this is a fine undercoat of wool. In domestic breeds, the wool has been developed and the hair coat bred out.

▽The giraffe is also a ruminant. Giraffes browse from trees and so do not compete with the grass-eating antelope and zebra that share their environment. The giraffe defends itself by powerful kicks from its legs

chambers of the stomach. In these the digestive juices are released and the food is completely broken down. It then passes into the intestine where useful chemical compounds and water are absorbed.

Horses and zebras do not have four-chambered stomachs like ruminants. But digestion is carried out by bacteria in the stomach also.

On the grasslands of Africa, there are many kinds of herbivores, all feeding on plants. How can they all survive, eating the same diet and in the same area? The answer is that although they all eat plants, they eat different ones and even different parts of the same plants. For example, zebras prefer tall fibrous kinds of grass, and gnus like shorter grasses. Gazelles (small antelopes) eat the very short tufty grasses and other antelopes prefer dry stalks. So although all these herbivores are eating grasses in the same area, they do not compete with each other because each prefers a different type of grass.

Herbivores also move from one area of grassland to another. In this way they do not eat out an area. And also it gives the grasses time to grow again.

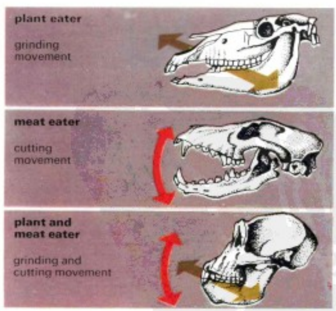
There are many more examples of herbivores. Reindeer and caribou feed on the thin cover of lichens and mosses in the tundra (treeless plains) of Canada and northern Eurasia. In winter, the ground is covered with snow. Large herds of animals then migrate southwards so they can find food to survive on during these hard months.

Some herbivores have very specialized diets. For example, the koala bear of Australia eats only the leaves of eucalyptus trees.

Fruits are the favourite food of many animals that live in the tropics, such as bats and monkeys. Many insects, such as bees and butterflies, feed on the nectar of flowers. They have very long tongues so they can reach down to the nectaries at the base of the flowers (see: *insect*). Snails and slugs, as farmers well know, are also herbivores. They can cause much damage to crops.

See: ***carnivore, cattle, elephant, food chain, grass, ruminant.***

△ Like other herbivores, the graceful impala of Africa lives in herds and has long legs for running fast from danger. (*Above left*) Herbivores that live in cold climates, like the deer, feed on the leaves of evergreen trees when snow covers the ground



◁ Jaw movement varies with type of food. Herbivores chew with a side-to-side movement that grinds their plant food against the ridges on their back teeth

▽ Herbivores need not compete for food. For example, zebras like tall grass, gnus, shorter grass, gazelles low grass, and hartebeestes dryish stalks. They can all survive in one area on different grasses