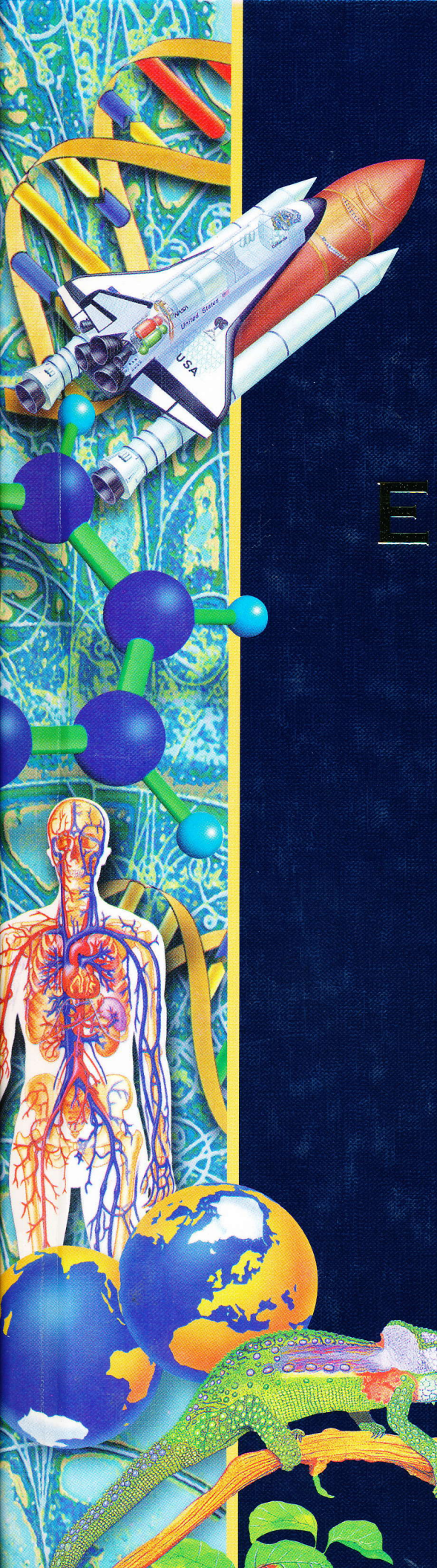
Raintree Steck-Vaughn



Illustrated SCIENCE ENCYCLOPEDIA

Volume 6

Raintree Steck-Vaughn

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DAI – EBO

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DAISY The daisy is any of several flowering plants belonging to the composite family. The name *daisy* comes from the phrase *day's eye,* which refers to the round, yellow center of the flower and the fact that the flowers open in the morning and close at night (see MOVEMENT OF PLANTS). The flower is made up of disk florets surrounded by petallike ray florets. It grows on a leafless stem that grows up from a ground-level rosette (circle) of leaves. The familiar American daisy is actually a chrysanthemum. The black-eyed Susan is a popular wild daisy. Daisies are sometimes called whiteweed, marguerite, and oxeye.

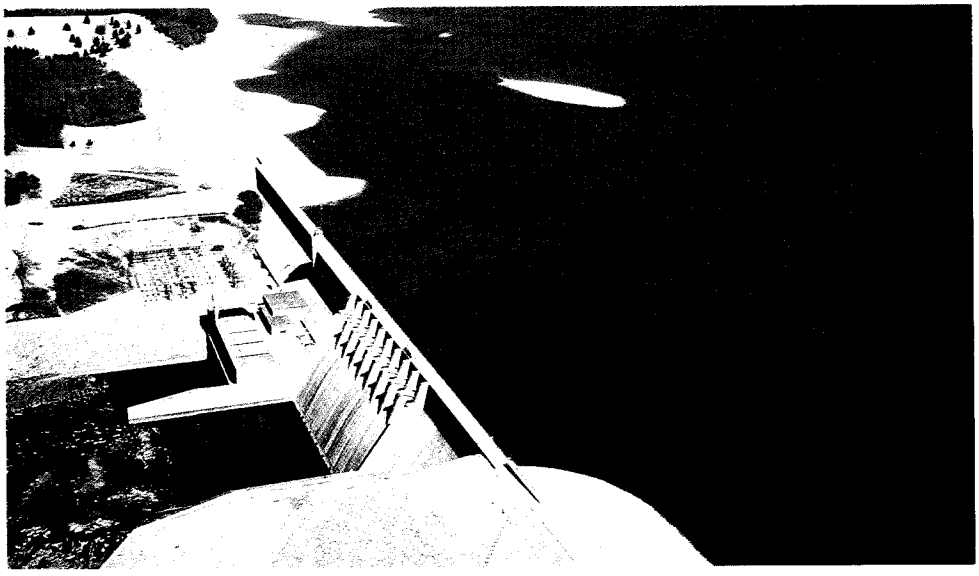
See also CHRYSANTHEMUM; COMPOSITE FAMILY.

DAISY
This cultivated form of black-eyed Susan is often called the gloriosa daisy.

DALTON, JOHN (1766–1844) John Dalton, a British chemist, is known for several scientific achievements. He discovered the law of partial pressures in 1802. This law, also known as Dalton's law, states that the total pressure of a gas mixture equals the sum of the pressures each gas would exert alone in the same volume as the mixture (see PRESSURE). Dalton is best known for the atomic theory of matter that he first proposed in 1803. His theory became one of the foundations of chemistry. Dalton believed that substances are made up of particles that cannot be divided or broken down. He called the particles *atoms,* a name first used in ancient Greece by Democritus (see DEMOCRITUS). In his atomic theory, Dalton stated that all the atoms of an element are exactly the same. He said that the atoms of different elements differ only in mass. Dalton also suggested that all compounds are made up of atoms that are combined in simple, numerical proportions. Dalton also made the first table of atomic weights (see ATOM; COMPOUND; ELEMENT; RELATIVE ATOMIC MASS).

In another field of study, Dalton, who was colorblind, was the first person to describe color blindness. Color blindness is also known as Daltonism (see COLOR BLINDNESS).

DAM A dam is a barrier that prevents the flow of water. Dams are used to prevent flooding, to provide a permanent water supply for an area, and to produce electricity (see HYDROELECTRIC POWER).



DAM
The water behind this dam wall is allowed to flow in a controlled way through turbines connected to electricity generators.

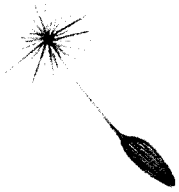
The design of a dam depends on its purpose, the site, and the materials available for construction. Before a dam can be built, the water path must be changed so the construction site will not be flooded. Dams must be strong enough to withstand the weight of the water behind them.

There are two main types of dams: concrete dams and earth dams. One kind of concrete dam is a gravity dam. A gravity dam depends on its weight to stay up. Every part of the dam is strong enough to withstand the water pressure on it. Sometimes, steel is added to the concrete for extra strength. An arch dam is a kind of concrete dam that depends on its shape for strength. Arch dams are built against the sides of a valley. They curve toward the water in the shape of an arch. Because of this design, the water pressure is greatest against the sides of the valley, instead of against the dam itself.

Earth dams are made of soil, gravel, rock, or sand. They are often reinforced with concrete and steel. Earth dams are the most common and least expensive type of dam.

See also DIKE.

DANDELION The dandelion is a bright yellow flower belonging to the composite family. It grows throughout temperate regions of the world and, although the flower is very pretty, it is often considered a weed by farmers and home owners. The flower is made up of ray florets. Unlike most other plants, the dandelion produces pufflike fertile seeds without being pollinated (see POLLINATION). The flower grows at the top of a straight, hollow stem. The root is long and goes down as much as 3 ft. [90 cm] into the ground. Cutting off the top of the plant without removing the root causes the dandelion plant to spread because the broken root can send up a lot of new shoots.



DANDELION
Each dandelion floret produces a seed that has a feathered, cottony "parachute" to carry it away on the breeze. The proper name for the parachute is *pappus*.

The name *dandelion* comes from the French *dent de lion,* or "tooth of a lion," referring to the leaves with their deep, toothlike notches. The young leaves are often used in food, such as salads and soups. The flowers can be used to make wine, and the roots can even be used as a substitute for coffee.

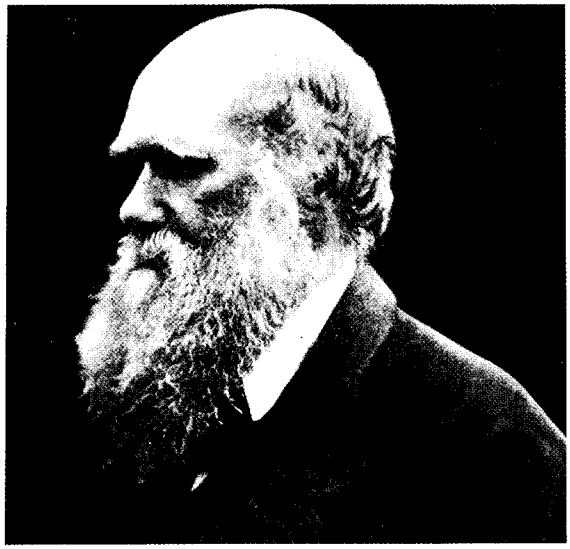
See also COMPOSITE FAMILY; DISPERSION OF PLANTS.

DARTER A darter is a small, colorful fish that belongs to the perch family, Percidae. It has a small, narrow body; large eyes; and wide fins. Darters live on the bottom of streams in North America that are east of the Rocky Mountains. Most species prefer fast-flowing streams. There are over one hundred species of darters. New species are still being discovered. In the spring, darters develop bright spawning colors, just as birds develop new, bright feathers before nesting (see SPAWNING). The names of some darters—bluebreast, goldstripe, greenthroat, rainbow, and seagreen—indicate the many colors of darters.

Many species of darters are found only in small areas. In 1973, a new species that was named the snail darter was discovered in the Little Tennessee River in Tennessee, upstream from where the huge Tellico dam was being built. Completion of the $100 million dam was delayed because biologists feared that it would threaten the survival of the snail darter. Another colony of the fish was found, however, and construction was allowed to resume.

The name *darter* is also given to some long-billed, fish-eating water birds.

DARWIN, CHARLES (1809–1882) Charles Darwin was the British naturalist who became famous for his theories on evolution. Darwin proposed a theory of evolution based on natural selection, or "survival of the fittest." After Darwin graduated from college, he took a position as the naturalist aboard the British ship H.M.S. *Beagle.* While on the voyage, Darwin became aware of the possibility that plants and animals must adapt to their ecosystem (see ECOSYSTEM). For example, Darwin noticed that the birds were slightly different on each of the Galápagos Islands. This led Darwin to believe that the birds had adapted to



CHARLES DARWIN
Charles Darwin became famous for his theories on biological evolution.

their particular ecosystem. Through the process of natural selection, the birds who had specific traits were able to survive and pass those traits to their offspring.

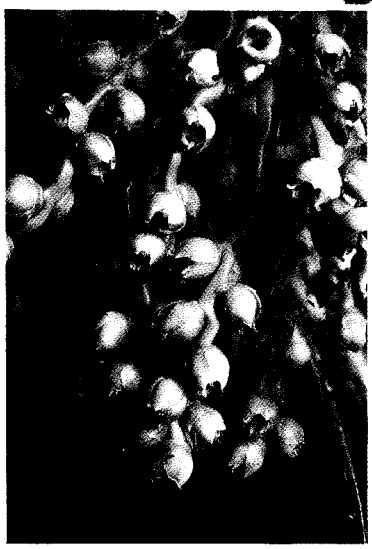
After his return to England, Darwin received a letter from the naturalist Alfred Russel Wallace. Wallace had similar beliefs about evolution. A joint paper by Darwin and Wallace was read in 1858, and then Darwin wrote his famous book, *On the Origin of Species.* In this book, he presented theories on evolution and adaptation. The book caused an uproar when it was first published. Today, Darwin's theories are widely accepted.

See also EVOLUTION.

DATE PALM The date palm is a tall tree that belongs to the palm family (see PALM FAMILY). It produces a valuable fruit and was probably the first tree cultivated, more than five thousand years ago. The date palm is native to countries with a hot, dry climate, such as Egypt and Iraq. Most of the dates grown for use in the United States are from California and Arizona.

The date palm grows to be as tall as 100 ft. [30 m] and has a tall, straight stem. The large leaves grow only at the top of the stem. The flowers are small, but they produce a tasty fruit. Each tree may produce 110 to 220 lb. [50 to 100 kg] of dates each year. The date fruit can be eaten raw, dried, or cooked. The seeds can be roasted and used as a coffee substitute, or they can be squeezed for their oil.

The date palm bears male and female flowers on separate trees. Only female trees can produce fruit, so date growers grow mainly female trees. A few male trees are needed to produce the pollen to pollinate the female flowers.



DATE PALM
Ripe dates can be seen hanging in large clusters under the leaves of this date palm (far right). The fruit is a staple food crop throughout the Middle East and North Africa. The flowering parts of female flowers (inset, right) produce the fruits.

DATING

Dating is the process of determining the age of a fossil or rock (see FOSSIL). This can be done in several ways. The simplest method of dating a fossil is called dendrochronology, or tree-ring dating. Each year, an extra layer of wood grows on a tree, so that the number of rings equals the age of the tree. The size of the ring and characteristics of the tree cells can also tell what the climate was like when the tree was growing (see ANNUAL RING).

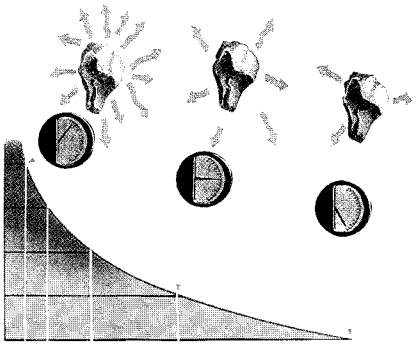
Rocks and sediment can be dated by examining the layers of sediment deposited by melting glaciers (huge, slow-moving sheets of ice). The amount of sediment also gives climatic information (see SEDIMENTARY ROCK).

In pollen-count dating, the number of grains of each kind of pollen found with fossils shows what kind of plants were living at that time. From that information, the climate can be determined. Paleobotanists use the climate to estimate the date of the fossils (see PALEOBOTANY).

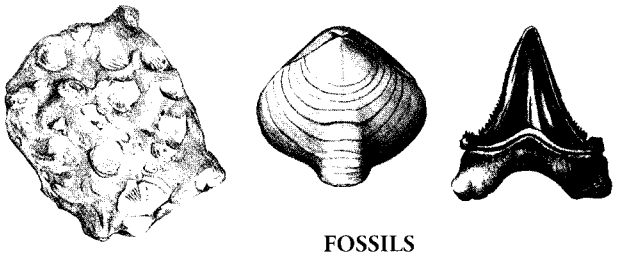
One of the most widely used methods of dating is radiocarbon dating. Radiocarbon dating is also called carbon-14 dating. Because all living matter is made of carbon, radiocarbon dating is used to date organic (carbon-containing) materials, such as bones, cloth, peat (partially decayed plants), shells, and wood. When an organism dies, the radiocarbon that it has absorbed from the atmosphere begins to break down. By finding out how much radiocarbon remains in the organism, an archeologist can determine when the plant or animal died. If a fossil is older than 45,000 years, however, radiocarbon dating does not work. Almost all the radiocarbon the organism absorbed from the atmosphere has broken down. Recently, methods of dating have been developed for fossils older than 45,000 years. These methods involve testing for uranium, which decays into thorium.

Radiometric dating determines the age of the rocks that compose the earth's crust. This method compares the rates of decay (breakdown) of atoms of various elements. Geologists can then determine the approximate age of rocks that date back billions of years. The age of moon rocks and meteorites also can be determined using this method.

See also ARCHEOLOGY; GEOLOGICAL TIME SCALE.



RADIOACTIVITY
The "half life" of a radioactive element is the time taken for its radioactivity to decay to half its former level. This can be used for rock dating.



FOSSILS
Geologists can date rocks by their fossils. The limestone with brachiopods imbedded in it and the fossil of the brachiopod shell (above left) are from the Silurian period. The fossil of the shark tooth (above right) is from the Cenozoic era.

LAYERED ROCK
A basic rule in dating rocks is the "law of superposition." This states that in any sequence of layered rocks, the oldest rock lies at the bottom and the youngest at the top.

DAVY, SIR HUMPHRY (1778–1829) Sir Humphry Davy, a British chemist, is famous for several reasons. At the age of twenty, he experimented with nitrous oxide, commonly called laughing gas. He found a use for it as an anesthetic (see ANESTHETIC). At twenty-four, Davy became professor of chemistry at the Royal Institution in London, where his experiments and lectures made him widely known.

Davy discovered many elements. At twenty-nine, he was the first person to isolate sodium and potassium. Davy also discovered magnesium, calcium, and barium. He was the first to isolate strontium, though the element was already known to exist. Davy also showed chlorine to be an element (see ELEMENT).

Davy was also an inventor. His best-known invention was a miner's safety lamp. Perfected in 1815, the Davy lamp greatly reduced the risks of coal mine explosions. This oil-burning lamp did not ignite the flammable gases in mines.

DAY A day is the time taken by the earth to make one complete turn on its axis, the imaginary line that runs through the North and South Poles. This period may be measured in relation to the stars, in which case it is called the sidereal day. (*Sidereal* means "to do with stars.") The sidereal day is always equal to twenty-three hours, fifty-six minutes, and four seconds.

A slightly different period of time is called the solar day. (*Solar* means "to do with the sun.") It is the time taken for the earth to turn once in relation to the sun. That is, it is the time between one noon and the next. The solar day varies in length throughout the year. The mean, or average, solar day lasts twenty-four hours.

The term *day* also refers to the hours of sunlight in a twenty-four hour period. In the Northern Hemisphere, June 21 is usually the longest day, and December 21 is usually the shortest day. In the Southern Hemisphere, December 21 is usually the longest day, and June 21 is usually the shortest day. In both hemispheres, day and night are of equal length on or about March 21 and September 21. These days are known as the equinoxes (see EQUINOX).

DEATH Death is the end of life. Scientists agree that all organisms will die. People have kept records of the life span of different kinds of organisms. *Life span* means the average period of existence for individuals of a given species. For example, a life span is about 0.2 years for the housefly, 10 years for the cat, 35 years for the horse, 70 years for a human being, and 4,000 years for the giant sequoia tree.

The work of biological and medical scientists is focused on finding new knowledge about human disease and death—and how to delay the two. In a normal healthy person, all cells are dying continuously. Except for nerve cells, all cells that die are replaced by new cells. For example, old skin cells die and flake off, while new skin cells form underneath them.

Cells can die prematurely because of accidents, disease, poisons, and other causes. For example, a blood clot can block the flow of blood to part of the heart. This can stop the supply of oxygen to certain heart cells, causing them to die. However, the person can go on living if the remaining cells take over the pumping work for the cells that died. New medicines are being developed to unblock clogged arteries (blood vessels) quickly after a heart attack, so that fewer heart cells die from lack of blood and oxygen.

When a cell dies, its internal chemical processes stop. When all of the cells in certain organs, such as the heart and the lungs, stop working, the person is said to be clinically dead. However, emergency methods may start the blood pumping and lungs breathing, and the person may be brought back to life. Such emergency action must take place within three minutes, or the heart cells will begin to die and the brain will be starved of oxygen.

Because physicians can restart and maintain a heartbeat and breathing with special machines, there has been a redefining of death in terms of brain activity. The current thought is that when the brain is dead, the person is dead. Physicians can tell whether a brain is dead by measuring its electrical activity on a machine called an electroencephalograph (see ELECTROENCEPHALOGRAPH). The breathing and heartbeat of the individual whose brain is thought to be dead may be kept going for

twenty-four hours or longer. During this period, the physician determines whether there is a possibility of recovery. For example, recovery may occur if the brain's activity was actually only slowed due to the use of certain drugs or exposure to extremely cold temperatures.

DEATHWATCH BEETLE The deathwatch beetle is a small brown beetle that causes extensive damage to old building timbers, especially oak and other hardwoods. The beetle produces a larva that tunnels through the timber, eating as it goes and gradually reducing the timber to dust. Many ancient buildings in Europe, including cathedrals and castles, have been seriously damaged by the pest. It also damages furniture, and in the wild it feeds on dead trees. The larva develops into a pupa and then an adult (see METAMORPHOSIS).

The deathwatch beetle gets its name from the fact that it knocks its head against the walls of its burrow, producing a knocking sound. Although meant to attract a mate, this sound has been regarded by superstitious people as a warning that someone in the house will die soon.

See also BEETLE.

DECAY Decay is the gradual rotting or breaking down of dead plants and animals, and of any materials coming from them, including timber and animal waste. Many beetles and fly maggots attack dead matter, but the main agents of decay are fungi and bacteria. These organisms cause chemical changes in the materials and then use some of the new products in their own bodies (see BACTERIA; FUNGI). The decaying material may pass through several different stages. It may be eaten and passed out by several different animals, but eventually it is almost all converted to carbon dioxide gas and simple minerals, which can be used again by plants (see CYCLING OF NUTRIENTS).

Decay is a very important process, for without it we would be buried in dead plant and animal material. If there were no decay, all the food materials would be locked up in the dead plants and animals and not be available for new plants and animals to use.

DECIBEL (dĕs'ə bəl') The decibel (dB) is a unit that is used in both electricity and sound. In electricity, it is used to compare the power of two energy sources. In sound, the decibel compares the intensity of two sound sources. A decibel is one-tenth of a larger unit, the bel. The bel is named for Alexander Graham Bell, the inventor of the telephone (see BELL, ALEXANDER GRAHAM).

In sound, the decibel is not the unit of loudness. Loudness is measured in a unit called the phon. Loudness measured in phons depends on both the

EFFECTS OF SOUND BY DECIBEL LEVELS

dB	Source	Sense	Irreversible hearing loss
150	Jet plane taking off	Painful	Immediate loss of some hearing
130 110 100 90	Loudest rock concerts Drilling, riveting Thunder (nearby) Train Motorcycle or boat motor	Uncomfortably loud	Gradual hearing loss with repeated exposure
80 70 	Garbage disposer Vacuum cleaner Traffic	Loud	Possible hearing loss after long exposure
60 40 20 15 0	Air conditioner Conversation Wind in the leaves Soft whispering Barely audible sounds	Comfortable	No hearing loss

intensity of the sound in decibels and on its frequency. This is because the sensitivity of the human ear depends on the frequency of the sound. The decibel scale is set up so that 0 dB is the least intense sound the normal ear can hear. A sound of 10 dB transmits 10 times as much energy as sound with 0 dB. A sound of 20 dB transmits 100 times as much energy as a 0 dB sound. Ordinary speech at a distance of a few feet is about 40 dB. The intensity of sound of city traffic at a busy intersection is around 70 dB. The sound in a factory can reach 110 dB. A rock music concert may produce sound as high as 130 dB. This level of sound can cause permanent damage to a person's hearing, depending on the length of the exposure. The loudest noise created in a laboratory is 210 dB. A beamed sound of this intensity can be used to bore a hole through solid materials.

DECIDUOUS TREE A deciduous (dĭ sĭj′o͞o əs) tree is any kind of tree that loses its leaves at a certain time of the year and later grows new leaves. The leaves, which produce food for the tree, die when temperatures starts to fall. In many regions, the leaves turn bright red, orange, or yellow when they die. The dry leaves then fall to the ground.

DECIDUOUS TREE—Winter
Bare deciduous trees in winter.

DECIDUOUS TREE—Summer
The same deciduous trees look totally different with their leaves in the summer.

The tree spends the winter without any leaves and lives off stored food. New leaves grow in the spring.

Deciduous trees are found mostly in temperate climates. Deciduous trees include the beech, maple, many oaks, and other broad-leaved trees. Most conifers, which have needlelike leaves, have leaves all year. One member of the pine family, however, is deciduous. The larch loses its needles each fall and grows new ones in the spring. Some desert shrubs are also deciduous, dropping their leaves at the start of the dry season to save water.

See also CONIFER; PHOTOSYNTHESIS.

DECOMPOSITION *Decomposition* is a term used in chemistry. It means the breakdown of chemical compounds into simpler substances by physical or chemical means. Heat, electricity, and light are physical factors that cause decomposition. For example, heat decomposes red mercuric oxide into its elements of oxygen and bright metallic mercury. An electric current decomposes water into its elements of hydrogen and oxygen. Light decomposes silver salts into silver and other elements. This process is the basis of photography.

Many substances are decomposed by the action of chemicals. For example, starch is broken down into

DECOMPOSITION
The white pattern on this leaf is caused by a fungus. Fungi are important in the decomposition of living things after they die.

a simple sugar, called glucose, by the action of a boiling, dilute acid. Decomposition may also be caused by the action of enzymes and catalysts. For example, the enzymes in yeast ferment sugar into simple products. Catalysts are used to break down petroleum into light fuels in a process called cracking (see CATALYST; CRACKING; FERMENTATION).

Decomposition that occurs in nature is also known as putrefaction. For example, dead animals and plants undergo putrefaction when attacked by microorganisms such as bacteria (see MICROORGANISM). The decomposition of animals and plants is important in geology. For instance, coal and petroleum were formed from marsh plants that were buried in swamps and later decayed.

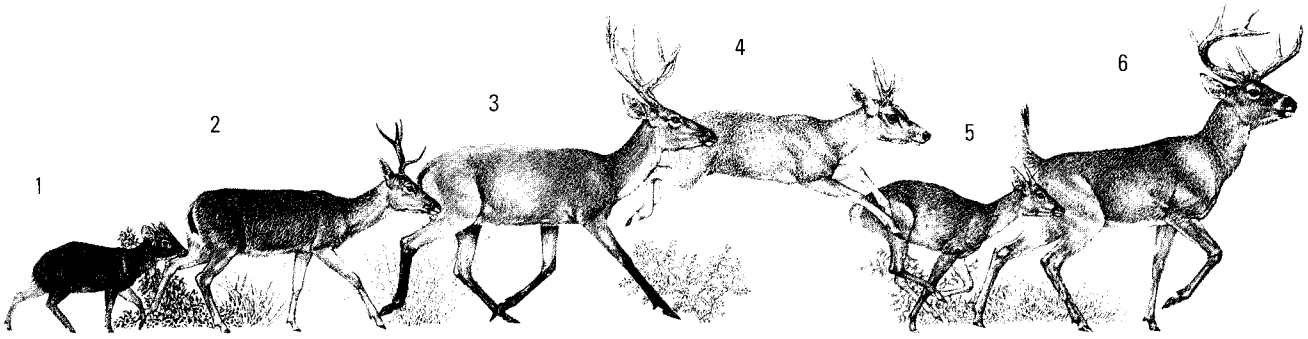
DEER Deer are a family of over forty species of hoofed mammals (see MAMMAL). Deer are the only animals with antlers. Antlers are bony outgrowths from the head. They are different from horns, which are hard layers of skin. The antlers are usually branched and are used in fighting for mates or for leadership of the herd. In most species of deer, only the males have antlers. However, both male and female caribou and reindeer have antlers (see ANTLER). The antlers of most deer are lost in the winter and regrown in the spring. Two species of deer, the Asian musk deer and the Chinese water deer, do not have antlers.

The largest species of deer is the North American moose. A moose may grow to be 7.9 ft. [2.4 m] tall at the shoulder and weigh 1,804 lb. [820 kg]. The smallest deer is the pudu of South America, which stands 15 in. [37 cm] tall and weighs 20 lb. [9 kg]. All deer have strong legs and walk on the tips of their two center toes. The other two toes are smaller and are located on the back of the leg above the other toes. These back toes, called dewclaws, are not used in standing, walking, or running. Some deer can run as fast as 40 m.p.h. [65 kph] and can jump as far as 30 ft. [9 m].

A deer has large eyes on the sides of its head, but it relies mostly on its senses of hearing and smell to tell if enemies are present. Deer graze on grasses and other low-growing plants and also browse on trees. Like cattle, they are ruminants and chew their food two separate times before digesting it (see RUMINANT). Also like cattle, deer have front teeth only in the bottom jaw and have back teeth in both jaws for chewing.

The male deer mates with the female deer once a year. The female gives birth to one or two fawns,

DEER
Deer of South America include (1) the pudu, (2) the pampas deer, (3) the swamp deer, (4) the huemel, and (5) the red brocket. The pudu is the smallest of all deer. It is only about 15 in. [38 cm] high. The best-known deer in North America is (6) the white-tailed deer.

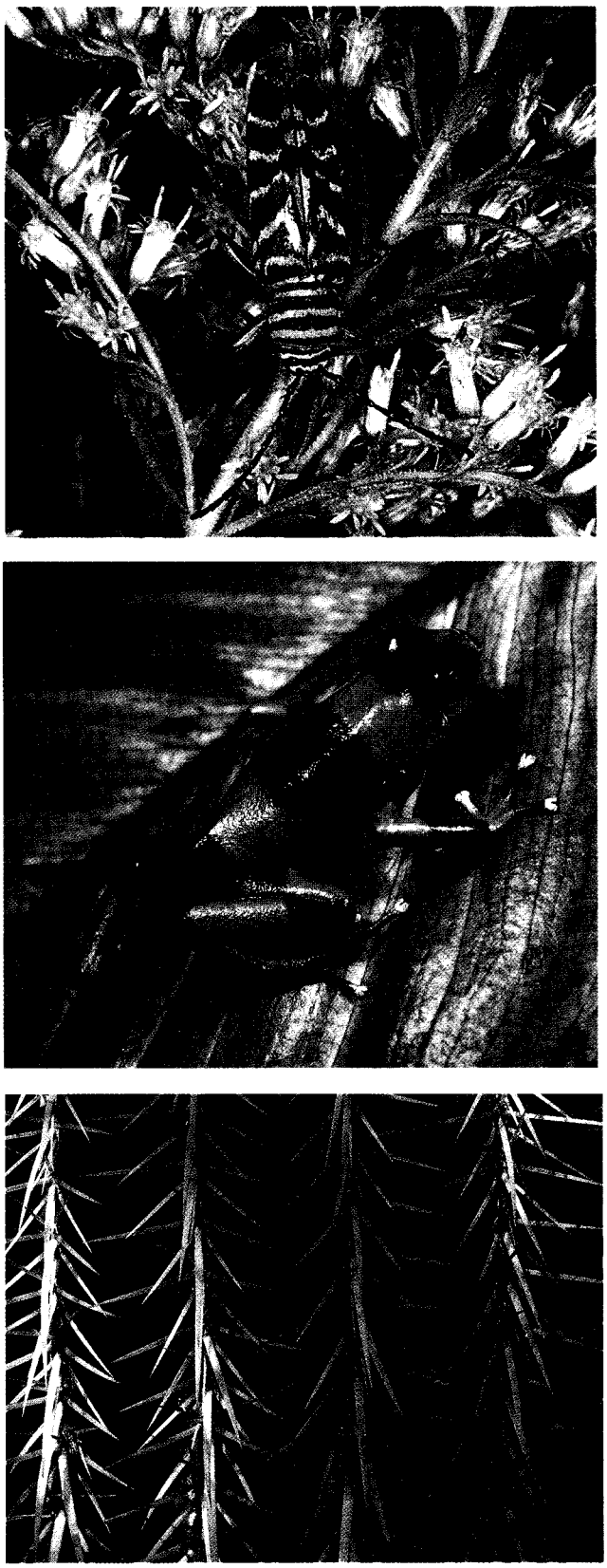


which she hides until they are able to walk. A fawn is able to walk a few hours to several days after birth, depending on the species. Deer usually live to be ten to twenty years old in the wild. Most deer live in forests or on mountains and rarely establish a permanent home. For example, some species, such as caribou, migrate great distances every year in search of food (see MIGRATION). Most species, though, stay within a fairly limited area, called the home range.

The most common species of deer in North America are the white-tailed deer, mule deer, caribou, wapiti, and moose. Of these, the white-tailed deer are the best known. White-tailed deer are 3.3 ft. [1 m] tall at the shoulder and weigh 198 lb. [90 kg]. They get their name from the fact that they have tails about 1 ft. [30 cm] long, with white hair underneath. Other species of deer are found in all areas of the world except in Africa, where they are replaced by antelopes. There are no native deer in Australia or New Zealand, but several species have been introduced. Several species of deer are considered endangered species, meaning they are in danger of extinction (see ENDANGERED SPECIES). Many countries, including the United States, have laws limiting or prohibiting hunting. Special areas called game refuges have been set aside to protect deer and other wildlife.

DEFENSE MECHANISM A defense mechanism is a method used by an organism to protect itself from its enemies. Nearly every organism has some type of defense mechanism. For example, some organisms may hide by using a defense mechanism called camouflage (see CAMOUFLAGE). An animal or plant that is camouflaged has coloring that blends in with the surrounding area so that enemies cannot see it. Animals that run away, such as an antelope, may be very fast. Others, such as a rabbit, may dodge back and forth. Birds can escape most enemies by flying away.

Animals have developed many ways to fight. Many mammals have sharp claws and teeth to protect themselves against enemies. Snakes bite, bees sting, and skunks squirt an unpleasant-smelling liquid. Many animals have developed defense



DEFENSE MECHANISM
The locust-borer beetle (top) is protected by its resemblance to a stinging yellow jacket. The arrow-poison frog (middle) has a foul-tasting and very poisonous skin. Its brilliant colors warn predators of this. The spines of the cactus (bottom) give it good protection against grazing animals.

mechanisms that discourage an enemy from attacking. The quills of a porcupine make it very difficult to attack the animal without being injured. The puffer fish can swell up like a balloon when it is attacked. This makes it difficult for another fish to swallow it. Many poisonous or distasteful animals have very bright colors. This is called warning coloration. Enemies that attack the poisonous creatures might get bitten or stung, or get a mouthful of poison that makes them sick. They soon learn that the bright colors are a warning, and they leave the brightly colored animals alone (see PROTECTIVE COLORATION; WARNING COLORATION). Many nonpoisonous animals also have bright colors and often look very like the poisonous ones. This kind of defense mechanism is called mimicry (see MIMICRY). Predators who have already learned that brightly colored animals can taste bad leave the harmless ones alone as well.

Plants also have defense mechanisms. The cactus has long spines that will prick animals that try to eat it. Many vines have thorns to keep animals away. Some plants are poisonous and will make an animal sick if it eats or touches the plant (see POISONOUS PLANT).

DEFICIENCY DISEASES Deficiency diseases are caused by a lack of essential nutrients—proteins (or amino acids), vitamins, and minerals that the body cannot make from other foods (see VITAMIN).

Ten of the twenty amino acids are essential. Deficiency in any one of them will cause anemia, gastrointestinal disturbances, and eventually wasting of body tissue. The body needs about fifteen minerals to keep healthy. The most common vitamin and mineral deficiency diseases are given in the table below.

ESSENTIAL NUTRIENT	DEFICIENCY DISEASE	FOOD SOURCES
Vitamins		
A	Night blindness, lowered resistance to skin infections.	Fish-liver oil, dairy foods, liver, broccoli, cabbage, carrots, apricots.
B_1 (thiamine)	Beriberi (*see* BERIBERI).	Yeast, whole grains, liver, nuts, potatoes.
B_2 (riboflavin)	Skin disorders.	Yeast, dairy foods, liver, greens.
B_6 (pyridoxine)	Infant convulsions, anemia (*see* ANEMIA; CONVULSION).	Yeast, whole grains, fish, liver, legumes.
B_{12}	Anemia.	Dairy foods, liver, beef, pork.
Biotin	Skin disorders.	Found in all common foods.
Folic acid	Anemia.	Yeast, liver, kidney, leafy greens, fruit.
Niacin	Pellagra—skin breakdown, mental deterioration.	Yeast, liver, lean meats, whole-grain bread, cereals.
C	Scurvy (*see* SCURVY).	Citrus fruits, green vegetables, potatoes.
D	Rickets (*see* RICKETS).	Fish-liver oils, eggs, butter, liver, yeast.
E	Abnormal reproduction or muscle development.	Eggs, vegetable oils, wheat germ, greens.
K	Abnormal blood clotting.	Vegetable oils, leafy vegetables, liver, pork.
Minerals		
Calcium	Rickets.	Milk products, leafy green vegetables.
Copper	Anemia.	Most foods contain enough.
Iodine	Abnormal thyroid activity (*see* THYROID).	Seafood, cereals.
Iron	Anemia.	Meat.
Magnesium	Irritability, convulsions, depression (*see* DEPRESSION (MENTAL)).	Most foods contain enough.

DE FOREST, LEE (1873–1961) Lee De Forest was an American inventor who developed a kind of vacuum tube called an audion in 1906 (see VACUUM TUBE). This tube was probably the most important discovery leading to wireless radio and telephone communication. The tube added a third electrode to the two-electrode tubes of the day (see ELECTRODE). This allowed the audion, or "triode" tube, to be used as an amplifier or as an oscillator (see AMPLIFIER; OSCILLATOR). In order to publicize his developments, De Forest broadcast the voice of Italian opera singer Enrico Caruso from the Metropolitan Opera House in New York City in 1910. In 1916, he broadcast the first radio news. In 1923, he introduced his sound-on-film "talking movies."

Often considered the father of radio, De Forest patented more than three hundred inventions in the areas of telegraph, radio telephone, sound movie films, television, and radiation therapy.

See also ELECTRONICS; RADIO.

DEFORESTATION

Deforestation threatens the survival of many plant and animal species. It destroys important sources of natural herbs, medicines, and other products. It may also result in soil erosion. Without plant roots to hold the soil together, it is washed away by rain. Illegal forest clearance, as shown here in Costa Rica, is a particularly serious problem.

DEFORESTATION Deforestation is the large-scale clearing of trees. Heavy deforestation occurred in Europe and North America during the Industrial Revolution as forests were cleared for industry and agriculture. By the early twentieth century, governments began protecting forest resources against deforestation. However, forests in the United States are still disappearing because the rate of cutting trees continues to increase. Almost all old-growth forests have been cleared from private lands. Old-growth forests are forests that have been in existence long enough to develop very diverse plant and animal life. The U.S. government owns millions of acres of old-growth forests that are from two hundred to one thousand years old. The government, however, currently sells 70,000 acres [28,329 hectares] of old-growth forest each year to the timber industry. The clearing of forests threatens many plants and animals. In 1990, after fifteen years of effort by biologists and environmental groups, the government placed a species of spotted owl on the endangered species list (see ENDANGERED SPECIES). In order to protect the owl, forest cutting would have to be banned in a large area that covers parts of Washington, Oregon, and northern California. However, this ban would mean the loss of 28,000 jobs in the timber industry during the 1990s.

The problem of deforestation is most serious in tropical rain forests of the world. Besides threatening many plants and animals, deforestation of tropical rain forests also causes the loss of many foods and other products for human use, such as tropical fruits and medicinal herbs. Another problem is that the soil is no longer protected by the trees and may erode (see EROSION). This erosion may cause areas that were once forests to become desertlike. Also, the soil from cleared areas may wash into water supplies, clogging them for human use and threatening water plants and animals. Deforestation has other effects on the environment. For example, because forests absorb carbon dioxide, a main gas involved in the greenhouse effect, deforestation may help raise the temperature of the earth.

See also GREENHOUSE EFFECT; FORESTRY; RAIN FOREST.

DEGREE Degree is a name given to various small units of measure. In science, the scales on thermometers are marked in degrees. For example, one degree on the Fahrenheit scale is 0.0056 of the difference between the temperatures of melting ice and boiling water. One degree on the Celsius scale of temperatures is 0.01 of the same difference (see CELSIUS SCALE; FAHRENHEIT SCALE).

In mathematics, degrees are used to measure angles and arcs of circles. A complete turn in a circle is a turn through an angle of 360 degrees (360°). A half-turn is 180°, and a one-quarter turn, or right angle, is 90°. The degree used for the measurement of angles is divided into minutes and seconds. There are 60 minutes (60') in one degree, and 60 seconds (60") in one minute (see GEOMETRY). Because latitude and longitude lines are circles, they are also measured in degrees (see LATITUDE AND LONGITUDE).

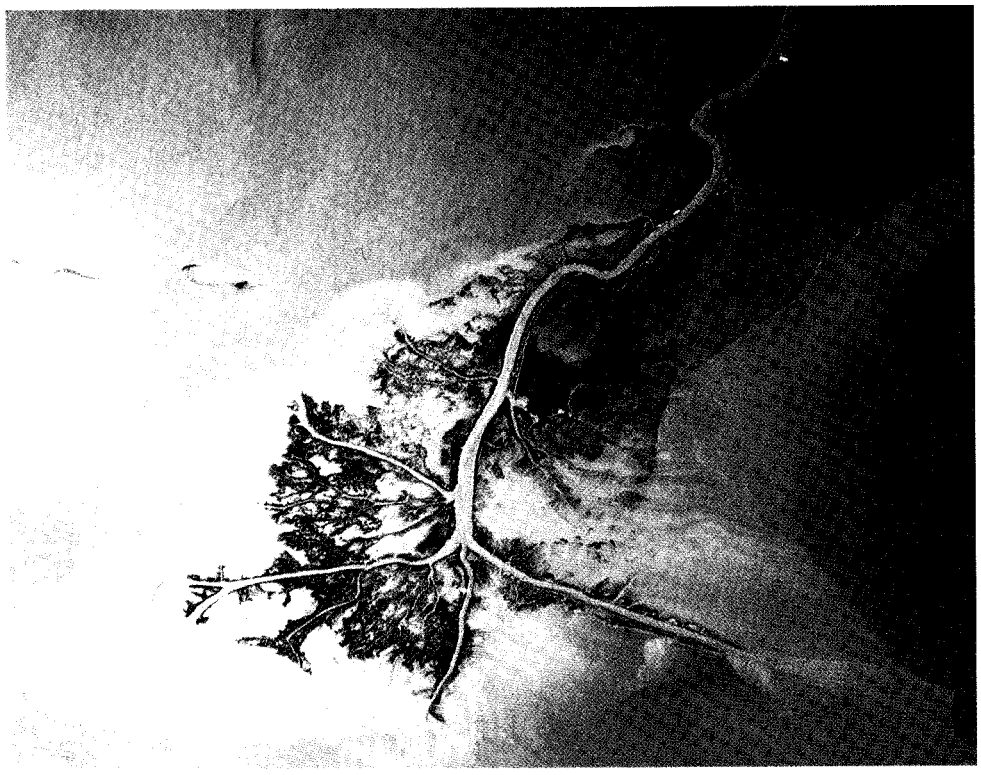
DEHISCENCE (dĭ hĭs'əns) Dehiscence is the splitting open of a fruit to release the seeds inside it. Some fruits, including the pods of the pea family and the capsules of touch-me-nots, break open so violently that the seeds are thrown for several meters. The word *dehiscence* is also used to describe the splitting open of the spore capsules of ferns and similar plants.

See also DISPERSION OF PLANTS; INDEHISCENCE.

DEHISCENCE
The foxglove and the pea pod capsule are both dehiscent fruits, splitting open when they are ripe so that their seeds can escape. The foxglove seeds are very small and are blown away by the wind.

DELTA A delta is an area of land formed by mud and sand that is deposited at the mouth of a river. The size of the delta depends on the river's current and the amount of material being carried by the river.

A fast-moving river transports sand and other material toward the water body into which the river empties. If the water currents are not strong enough to carry away all the sand and other material, the material is deposited at the river's outlet. Over a long period of time, these deposits build up



DELTA
One of the most famous deltas is that of the Mississippi River. Sediment is brought down from a vast area of the United States and deposited in the Gulf of Mexico. The currents there are not strong enough to carry it away and so it builds up into a series of banks cut by river channels.

to form the delta. Delta gets its name from the Greek letter *delta,* because both are shaped like triangles.

Deltas are usually fertile areas with large populations. However, deltas can be hazardous because of the frequent flooding that occurs on them. The two largest deltas in the world are the Nile River delta in Egypt and the Mississippi River delta in the United States.

See also RIVER.

DELTOID In the human body, the deltoid is a large, triangular muscle that covers the shoulder. The deltoid is used to raise the upper arm and move it forward, backward, and out to the side. The deltoid also helps rotate the upper arm inward and outward. Its origin (attachment to unmoving bone) is in the clavicle, or collarbone, and in the scapula, or shoulder blade. Its insertion (attachment to the bone that it moves) is near the middle of the humerus, the bone of the upper arm. The deltoids are used when walking to swing the arms backward and forward.

See also MUSCLE.

DEMENTIA (dĭ mĕn'shə) Dementia is a general, gradual loss of a person's intellectual abilities, with accompanying changes in personality, and loss of memory and judgment. This may eventually make the person dependent on others for daily care.

Dementia has a large number of causes. Some of these cause dementia that can be cured (reversed) and others cause dementia that is incurable (progressive or irreversible), but they all cause widespread damage to the brain. The commonest cause of dementia is Alzheimer's disease (see ALZHEIMER'S DISEASE). Dementia can also be caused by small blockages in blood vessels in the brain; by damage to the white matter of the brain (see BRAIN); by infections such as AIDS (see AIDS); by toxins such as aluminum in the fluids used in dialysis (see DIALYSIS); by epilepsy (see EPILEPSY); and by repeated blows to the head.

Dementia is not an inevitable part of old age, that is, it does not always happen as people grow older. Dementia is not always incurable.

DEMOCRITUS (about 470 B.C.–380 B.C.) Democritus was a Greek philosopher who developed many theories on the nature of matter. He believed that all matter is made up of extremely small particles that cannot be broken down or divided. He called these particles atoms. Democritus thought that all existing things differ from each other because of the arrangement, position, and shape of their atoms. The behavior of atoms, Democritus reasoned, was regulated by natural, unchangeable laws. Democritus' theories were no more than ideas. He had no evidence to support them. Few people believed Democritus during his lifetime. In fact, his theories on matter were nearly forgotten until John Dalton included some of Democritus' ideas in an atomic theory he published in the early 1800s.

See also ATOM; DALTON, JOHN.

DENSITY The density of a substance is the amount of mass (matter) it contains for each unit of its volume (amount of space it occupies). The density of a substance is calculated by dividing its mass by its volume:

$$\text{density} = \text{mass} \div \text{volume}$$

In the customary system of measurement, density is measured in pounds per cubic inch or in pounds per cubic foot. In the SI (Système Internationale) system of measurement, the metric system, density is measured in kilograms per cubic meter.

Most substances expand in volume when they are heated. Therefore, when such substances are heated, their density decreases. Water behaves differently. It contracts, or takes up less volume, when heated from 32°F [0°C] to 39°F [4°C], and its density increases. Above 39°F [4°C], water expands when heated, and its density decreases.

Most substances contract when they freeze. In such substances, the density of the solid is higher than the density of the liquid. Again, water is an exception. It expands when it freezes; its density decreases. Ice floats on water because lower-density substances float in liquids of higher density.

See also RELATIVE DENSITY. PROJECT 2, 4, 12, 40

DENTISTRY

Dentistry is the branch of medicine dealing with the teeth, gums, and other parts of the mouth. People throughout history have been concerned with their teeth, especially when diseases of the teeth or mouth caused pain. Gold artificial teeth dating back to at least 500 B.C. have been found in Italy. In the Middle Ages, barbers acted as dentists, usually by removing troublesome teeth. In 1783, Josiah Flagg, the first American-born dentist, introduced the use of gold foil to fill a decayed tooth. In 1840, a dental school was opened in Baltimore, Maryland. This established dentistry as a medical science. In 1844, anesthesia was first used to prevent pain during an extraction (removal of a tooth) (see ANESTHETIC). In 1895, X rays were first used to examine the inside of a tooth (see X RAY). In 1910, English dentists William Hunter and Kenneth Goodly proved that an infection in a tooth could cause infections in other parts of the body. Electric drills have been used since the early 1900s to remove decay. In the 1950s, high-speed drills were introduced, making the treatment of decayed teeth faster and less painful. More recently, there has been experimental use of lasers and ultrasound to replace the drill as a way of removing decay (see LASER; ULTRASOUND).

There are several branches of dentistry. They include general dentistry, oral surgery, orthodontics, prosthodontics, periodontics, pedodontics, and endodontics. General dentists must be skilled in many areas of dentistry. The other specialists deal with specific dental problems.

Much of a general dentist's time is spent preventing mouth diseases. Such dentists help patients establish good habits that keep teeth and gums healthy. In many dental offices, dental hygienists help the dentist. A dental hygienist is a licensed professional who may clean and examine teeth and gums. The hygienist may also provide instructions on how to maintain healthy teeth and gums.

HYGIENE
A dentist gives a patient a shot of painkiller before drilling to fill a cavity. The assistant sucks out excess saliva to allow a clearer view and reduce the amount of swallowing by the patient. Dentist and assistant wear gloves to prevent the spread of diseases such as hepatitis.

X RAYS
A dentist examines an X ray of the entire mouth. Such X rays can show signs of disease that may not be visible by examining the mouth directly. Areas filled with amalgam show up more brightly on an X ray than a normal tooth surface.

EDUCATION
A dental hygienist shows a young patient the correct way to brush the teeth.

General dental treatment also includes filling cavities that result from caries (tooth decay), removing teeth, and replacing lost teeth (see CARIES). More and more general dentists are also offering services to help their patients improve the appearance of their teeth.

Oral surgery uses surgery to treat deformities or diseases of the mouth. Orthodontics corrects problems associated with the growth of teeth and jaws. Braces are often used to treat malocclusion, or "bad bite," resulting from crowded or irregular teeth. Prosthodontics uses false teeth to replace lost or missing teeth. Bridges and partial dentures replace one or several teeth, while full dentures replace all the teeth in one or both jaws. An alternative to dentures is dental implants. These are permanently attached false teeth. Prosthodontics also deals with the reconstruction of jawbones and other facial bones that are injured. Periodontics treats diseases that affect the gums or jaw. Periodontal disease is a disease in which the gums and tooth sockets become infected, loosening teeth. Periodontal disease causes adults to lose more teeth than all other reasons combined. Pedodontics is general dentistry for children and is concerned mostly with preventive techniques. Examples of preventive techniques include fluoride treatments and sealants. Sealants are substances applied to the back teeth to prevent caries. Endodontics treats diseases of the pulp, or inside of the tooth. Removal of the pulp, with its nerves and blood vessels, is called root-canal therapy. It is a way of saving an otherwise hopelessly diseased tooth.

All dentists must attend a dental school after college. After completing dental school, many dentists continue their studies in order to specialize. Each state also requires a dentist to pass a special examination before he or she can practice dentistry in that state. Dentists may have a degree of D.D.S. (Doctor of Dental Surgery) or D.M.D. (Doctor of Dental Medicine).

See also AMALGAM.

DEPOSITION (dĕp´ə zĭsh'ən) Deposition is the process by which rocks, minerals, or other materials are laid down by water, ice, or wind. The material laid down is called a deposit. Deposition happens in many different ways.

In the upper reaches of a river, rocks and stones from the river banks and river bed are swept along. Here the river is steep and shallow, and the water must push against the stones in the river to make its way downstream. Further downriver the water does not push as strongly against each stone or pebble on its bed. Here the river deposits the larger stones and only moves the smaller particles downstream. As the river approaches the sea, it carries only mud and silt (see SILT). The mud and silt in the river water gradually settle out where the river water mixes with the sea. River deltas are often covered with rich agricultural soil formed from the silt deposited by the river (see DELTA).

Underground water forms deposits in the cracks and caverns through which it flows. It deposits substances that were dissolved in the water but could not stay dissolved because of changes in conditions such as temperature (see CRYSTAL; GEODE; ORE; STALACTITES AND STALAGMITES).

The ocean floor is covered with sediment, which is material that drifts down and settles on the bottom. Much of it consists of the bodies of countless plants and animals, most of them tiny. Small particles of rock carried into the sea from the land by rivers, or worn away from the coasts by waves, form part of the sediment. Volcanic ash launched into the air from volcanoes adds to the sediment. And chemicals dissolved in the water that come out of solution also add to it. The bottom layers of sediment are crushed by increasing pressure as they are covered by more and more sediment, and turn into solid sedimentary rock (see SEDIMENTARY ROCK).

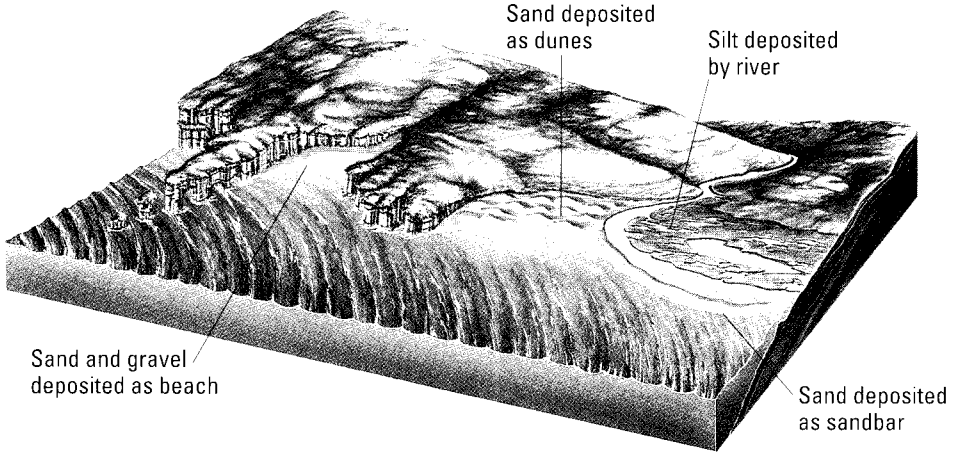
Glaciers flow down mountainsides or toward the sea from ice sheets such as on Greenland and Antarctica (see GLACIER). As they do this, sediment, including large pieces of rock, becomes mixed with the ice in the sides and base of glaciers. Most of the sediment is carried along in the ice at the base of the glacier, or on its surface, and is released as the ice melts.

The wind can blow fine silt particles much farther than sand because each particle is smaller and has less mass (see MASS). This silt settles over large areas as sediment called loess. Soils that are particularly good for farming often form on the loess. Loess deposits occur all around the world. They are especially common near the edges of the great ice sheets or glaciers that formed on several continents during the last ice age. Glaciers grind and break rocks into smaller pieces and deposit them at their edges. The wind may remove this fine rock powder and deposit it elsewhere as loess.

DEPRESSION A depression is an area of low atmospheric pressure. Depressions in North America usually form along the polar front, where cold, arctic air meets the warmer air from the south. The dense, heavier cold air pushes under the warmer air. As the warm air rises, an area of low atmospheric pressure, or depression, forms. The winds spiral into the depression in a cyclonic, or counterclockwise, direction. If this same situation

DEPOSITION

The entire landscape of the earth is undergoing either erosion or deposition. Weathering breaks down existing rocks to smaller fragments and erosion carries them away. Deposition occurs when the eroded fragments come to rest, or are laid down as seabeds, beaches, plains, or swamps. These deposits may later be transformed into new rocks.



occurs in the Southern Hemisphere, the winds move in a clockwise direction. Depressions that form along the polar front often develop into cyclones (see ATMOSPHERE; CYCLONE).

Depressions can be recognized on a weather map by the shape of the isobars. Isobars are lines that join points of equal pressure. The isobars usually form a circle or oval around the depression. The innermost isobar shows the lowest pressure in the depression (see ISOBAR AND ISOTHERM).

A tropical depression is an area of low atmospheric pressure that has the potential to become a hurricane.

See also FRONT; HURRICANE; METEOROLOGY; WEATHER.

DEPRESSION (MENTAL) Depression is a mental disorder. A person suffering from depression has long periods of sadness, hopelessness, or other negative feelings. A depressed person may also have extreme mood changes, may often feel angry or anxious, and may lose interest in normal activities. Other signs of depression include weight loss or energy loss, sleeping either too much or too little, slowness in action, and trouble concentrating. A depressed person may think about suicide often. He or she may actually commit suicide.

Short-term depression can be a natural reaction to certain life events, such as the death of a family member. However, depression that lasts for a long period of time affects about one out of every ten people in the United States. Both men and women get depressed, but depression is more commonly noticed in women. Depression can be treated by therapy with a psychologist or psychiatrist. A psychologist studies how people relate to one another and their environment. A psychologist analyzes the situation a person is in and how he or she feels about it. Psychologists plan treatment without drugs. A psychiatrist is a medical doctor who specializes in the treatment of mental disorders. During psychiatric therapy, the depressed person talks about his or her feelings and works to regain a feeling of self-worth. Therapy may also involve the use of certain antidepressant drugs. Severely depressed persons who do not respond to any of these kinds of therapy may be helped by electroshock therapy. In electroshock therapy, an electric current is passed through the patient's brain for a fraction of a second. About half of depressed persons recover completely.

See also MENTAL ILLNESS; PSYCHIATRY; PSYCHOLOGY.

DESALINATION (dē săl′ə nā′shən) Desalination is the process of removing salt from seawater to make fresh water. A person can safely drink water that contains a small amount of salt. However, seawater contains too much salt to drink. A person can die of thirst by drinking seawater because his or her body dehydrates while trying to remove the excess salt. Seawater cannot be used in agriculture or in most industries. It kills crops and quickly rusts most machinery.

Only about 3 percent of all the water in the world is fresh water. People have been fascinated for years with the prospect of obtaining an almost endless supply of fresh water by converting seawater. However, desalination accounts for only a small percentage of the fresh water used in the world because it is an expensive process that uses a great deal of energy.

The main desalination, or desalting, processes are distillation, electrodialysis, reverse osmosis, and freezing (see DISTILLATION; FREEZING AND FREEZING POINT). Distillation is the oldest and most common desalination method. The simplest version of distillation involves boiling seawater and then piping its steam into a cool bottle. The steam rises, leaving the salt behind, and then condenses into fresh water in the bottle (see CONDENSATION). Solar distillation is another old and simple process. It was used over two thousand years ago by Roman troops in Egypt to obtain drinking water. Solar distillation involves using the sun's heat to convert water in a covered basin into vapor (see VAPOR). The vapor collects on the cover and then runs down into collecting troughs. Solar distillation, however, is a slow process.

A faster method used today is called multistage flash distillation. Hot seawater flows into a chamber where the pressure is low. The low pressure causes some of the water to flash (turn quickly) into

DESALINATION
In hot, dry countries, such as Saudi Arabia, fresh water is in short supply. Saudi Arabia has a sea coast and several large installations to desalinate seawater.

steam. The steam is then condensed into fresh water in another chamber.

Electrodialysis is a process that is used chiefly to desalinate brackish groundwater (water that is slightly salty). It is based on the idea that when salt is dissolved in water, it breaks up into ions (electrically charged particles) of sodium and chloride (see IONS AND IONIZATION). Sodium ions have a positive electric charge, and chloride ions have a negative electric charge. Electrodialysis takes place in a large chamber that is divided into several compartments by thin plastic sheets called membranes. Two types of membranes are used in alternating order. One type allows only positively charged ions to pass through it. The other type allows only negatively charged ions to pass through. Positive and negative electrodes are located at either end of the chamber (see ELECTRODE). When an electric current is passed through salty water in the chamber, the positive ions travel through the positive membranes to the positive electrode. The negative ions travel through the negative membranes to the negative electrode. Fresh water is left behind.

Reverse osmosis "squeezes" fresh water from seawater by forcing it through a special membrane that separates the water from the salt (see OSMOSIS). Freezing seawater produces ice crystals that are pure water in solid form. The salt is separated in the freezing process, and trapped between the ice crystals. The ice crystals are then washed in fresh water to separate the salt from the ice.

Other recent desalination research centers on using large nuclear-power plants. These plants would desalt water cheaply and produce electric power as a by-product.

See also WATER.

DESCARTES, RENÉ (1596–1650) René Descartes was a French philosopher, mathematician, and scientist. He is regarded as a founder of epistemology, which is the study of the beginning, the limitations, and the methods of human knowledge. Descartes sought knowledge by starting with a basic, simple statement that could not be doubted. His statement was *"Cogito ergo sum,"* which means, "I think, therefore I am." All Descartes's statements were based on those things he could be absolutely certain about. Beginning with such a certain, simple statement, Descartes set about to develop his understanding of humans and the universe in accordance with geometry and mechanical laws (see GEOMETRY).

Descartes invented analytic (or coordinate) geometry, which brought algebra and geometry together (see ALGEBRA). This made it possible for geometric lines and figures to be developed using a system of coordinates. Problems could then be solved using algebra. Descartes also added to the knowledge of music and optics.

See also OPTICS.

DESERT

A desert is a region of the earth's surface where there is less than 10 in. [254 mm] of precipitation (rainfall and snowfall) a year, and where the rate of evaporation is greater than this. Little or no water is stored in the soil of a desert. Only a few kinds of animals and plants that are especially adapted to the dry conditions can live there.

There are deserts in both cold and hot regions of the world. The Arctic and Antarctic are really deserts, since there is very little precipitation there (see ANTARCTIC; ARCTIC).

A belt of deserts runs around the globe in the tropical and warm latitudes of the Northern Hemisphere. These include the deserts of western North America, such as the Mojave and Sonoran Deserts; the Sahara Desert of North Africa; the Arabian Desert; and the Gobi Desert of Mongolia and China.

In the Southern Hemisphere, on the Tropic of Capricorn, lie the Kalahari Desert of southern Africa, and the Great Sandy Desert and other deserts of central Australia. Farther south, at the southern end of South America, is Patagonia, where the low-lying parts are desert.

These deserts are formed because the air there is dry. *Dry* here means that the air contains much less water vapor than it is capable of holding. Air can hold more water vapor when it is warmer, less when it is cooler. Warm air rises, so air rises from the equatorial regions. It cools as it rises, and moisture condenses out as clouds and rain. The air circulates away from the equator and descends again. It warms as it descends, so that it can hold more moisture. There is little precipitation from this dry air, and moisture already on and in the ground evaporates. This is how the land over which this circulating, atmospheric air descends may become a desert.

Air masses can be dried in other ways. When winds blow from cold ocean over warm land, the air is warmed, and so becomes drier. Thus, deserts can be right next to oceans, such as the Atacama Desert of South America.

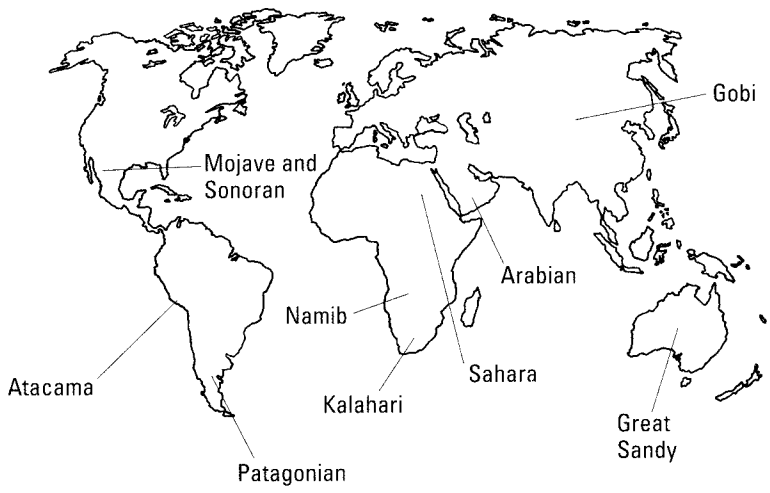
Air becomes drier as it moves long distances over land. Deserts can be found in the centers of continents, far from the ocean. An example is the Gobi Desert.

Air is forced to rise and cool when it meets mountains. It sheds its moisture and is dry as it flows down the other side. For example, air flowing from the Pacific Ocean sheds its water over the Andes Mountains. The air is dry when it reaches the eastern side of the mountains and causes the aridity (dryness) of Patagonia east of the Andes mountain range.

Because there is little cloud cover in the sky to trap heat at night or to shade the earth during the day, tropical and subtropical deserts become quite cool at night, but very hot during the day. There can also be a large contrast between summer and winter temperatures. In the Gobi Desert, the

MAP OF DESERTS

Deserts lie in areas of low rainfall. Along the tropics the wind brings only dry air to the Mojave, the Sahara, and Arabian deserts in the north, and the Kalahari and the Great Sandy deserts in the south. Continental deserts, such as the Gobi, lie far from the ocean. "Rain shadow" deserts form in the lee of mountains, like the Patagonian Desert. Coastal deserts such as the Atacama in Chile and the Namib in Namibia occur because cold ocean currents prevent rain from falling nearby.



LANDSCAPES
The dryness and the great difference in temperature between day and night break down the exposed desert rocks. With no plant roots to hold them together, the smallest particles blow in the wind, forming sand dunes. The typical desert landscape consists of steep, jagged rocks and shifting sands.

average temperature in the summer can reach over 105°F [41°C]. In winter, temperatures fall below freezing. In tropical deserts, temperatures can rise as high as 130°F [54°C].

Only a small part of the world's deserts are covered by sand. The rest are rocky. Sometimes large, low-lying areas are covered by glistening white salt flats, which are beds of salt and other minerals left behind by the evaporation of water that flows onto the surface after heavy rains.

Life in the desert Desert plants have roots that spread wide to capture the rare rainfall, or go deep to tap underground water. The plants do not give off large amounts of water vapor as plants do elsewhere, but store water in their fleshy bodies. Plants in temperate regions have broad leaves that trap sunlight and give off large amounts of water vapor (see PHOTOSYNTHESIS; TRANSPIRATION). But in cacti, leaves have become adapted to the desert by evolving into spines, which discourage animals from eating the plants (see ADAPTATION; CACTUS FAMILY). This is especially necessary since the body of the plant is a store of water that would attract animals. The leaves give off no water vapor, and the sun's energy is trapped by chlorophyll in the body of the plant (see CHLOROPHYLL). Other desert plants also have small leaves, and their pores (stomata) close during the day to save water. Desert plants save water by limiting their activity. Many flower for only a few days when rain has fallen. Years may pass before this happens.

Desert animals are often nocturnal, that is, they become active at night. During the day they sleep in cool burrows or shady places. They get water by eating plants or other animals. Some animals even make water chemically from their food. Desert animals keep water in their bodies by giving out little in their body wastes. Food is scarce in the desert, so when animals such as camels get a chance to eat, they eat as much as possible, converting the food into fat that can provide energy later (see CAMEL). In addition to the camel, animals as large as antelopes and jackals can live in deserts.

Are deserts spreading? Deserts make up a fifth of the land area of the earth. There are fears that deserts might be spreading. In 1977 a major United Nations conference was held on the issue of "desertification." Land that borders deserts must have plants to stop the sand blown by the wind. These plants also help to hold water in the soil. It is thought that farming methods in these areas have a bad effect on the ability of the soil to support these plants. For example, vegetation may be destroyed by poor farmers who have little choice of places to feed their livestock or gather firewood.

But it has also been claimed that some spreading of deserts, as in the southern fringe of the Sahara from 1982 to 1984, has been due to drought (see DROUGHT). These increases in desert can reverse when rains return, and did so in the same areas in the three following years. Satellite data have to be carefully interpreted to identify desert areas. The data should eventually show whether or not the deserts are spreading.

DESICCATOR A desiccator is a device used in chemistry to dry substances. It is made up of a container with a perforated shelf. An object that is perforated has holes in it. A drying agent, called a desiccant, is placed in the bottom of the container. The substance to be dried is placed on the perforated shelf. The desiccator is closed with a greased lid to keep it airtight. The substance to be dried loses its moisture into the air. The drying agent steadily absorbs moisture from the air. In this way, the substance gradually becomes dry.

DESICCATOR
A desiccator is used for drying materials. A simple desiccator is a box or jar containing a chemical called a desiccant that absorbs moisture. The desiccators shown here can be attached to a vacuum pump to suck the air and moisture out.

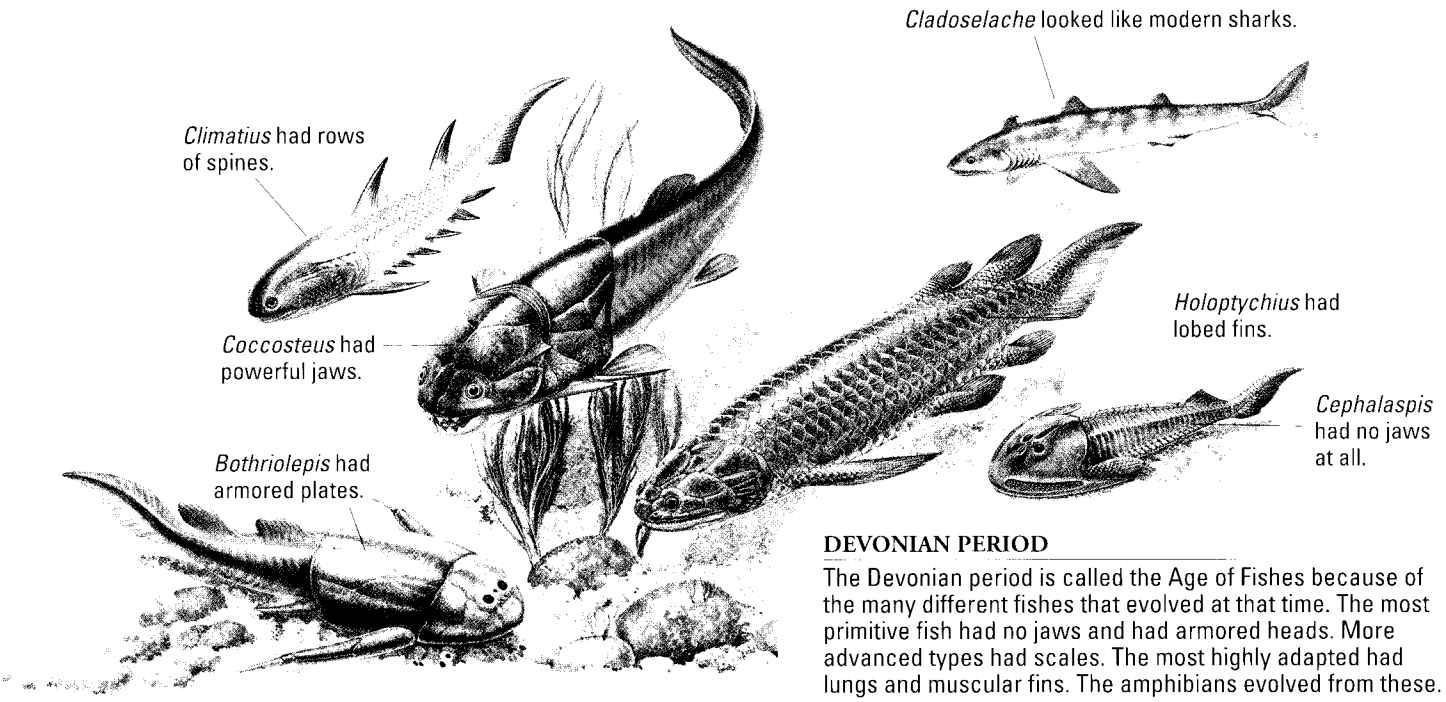
DETERGENT The word *detergent* usually refers to an organic (carbon-containing) chemical substance made of carbon, oxygen, sulfur, and hydrogen compounds that combines with water to clean soiled materials (see COMPOUND). Soap has a different chemical makeup but is considered a detergent in the sense that it is a substance that cleans soiled materials. Household detergents are used mainly in clothes and dish washing. They come in powder, flake, or liquid form. Detergents contain a basic cleaning agent called a surfactant, or surface active agent. Surfactants are molecules that attach themselves to dirt particles in soiled materials, such as cloth. They pry the dirt particles from the cloth and surround the particles with a layer of water that allows them to be carried away. Surfactants increase the wetting ability of water by lowering its surface tension. Surface tension is the force that keeps water molecules clinging to one another (see MOLECULE; SURFACE TENSION). Surfactants also help detergents create lather and suds. Contrary to popular belief, lather and suds have very little to do with the cleaning ability of a detergent.

Most detergents contain other agents besides surfactants, including bleaches, fabric brighteners, and stabilizers. They also contain antiredeposition agents that prevent removed dirt from returning to the clean material.

The first detergent was developed in 1916 by Fritz Gunther, a German scientist. In 1933, household detergents were introduced into the United States. During World War II (1939–1945), ingredients for making soap were scarce, and detergents came into wide use for the first time. In the early 1960s, it was discovered that used detergents flushed down sewer systems were not biodegrading, or breaking down. Normally, bacteria living in waterways, such as streams, rivers, and lakes, break down foreign substances. However, detergents entering waterways through sewer systems were clogging waterways with huge mounds of lather and suds. This was killing fish and other aquatic life and severely hampering commerce and recreation.

In 1965, the detergent industry developed nonsudsing and low-sudsing detergents. In the 1970s, another water pollution problem involving detergents arose. Phosphates, chemical substances used in detergents, were observed to be causing a condition called eutrophication (see PHOSPHATE; SUCCESSION). Eutrophication occurs because certain substances, such as phosphates, overfertilize algae and cause them to grow at a tremendous rate (see ALGAE). The algae clog waterways, and the decomposition of dead algae uses up the oxygen in the water. Eutrophication can cause the death of fish and other aquatic life.

State and local governments banned the use of detergents with phosphates. The detergent industry has since developed detergents that are phosphate-free.

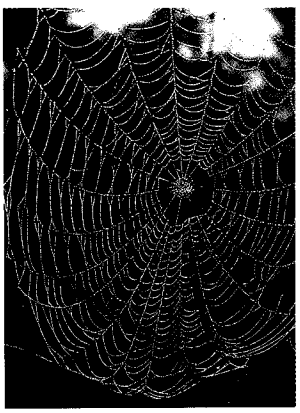


DEVONIAN PERIOD
The Devonian period is called the Age of Fishes because of the many different fishes that evolved at that time. The most primitive fish had no jaws and had armored heads. More advanced types had scales. The most highly adapted had lungs and muscular fins. The amphibians evolved from these.

DEVONIAN PERIOD The Devonian period in the earth's history began about 409 million years ago and lasted almost 46 million years. During that time, seas covered most of the land. Fish became the dominant creatures on Earth, which is why the Devonian period is often called the Age of Fishes. Sharks developed during the Devonian period and have remained almost unchanged since then. Amphibians began to evolve before the end of the period (see EVOLUTION). On land, early plants, including seed plants, began to develop, and the earliest known insects and spiders appeared.

The Devonian period is named after Devon, a county in England. It was there that rocks of the period were first studied.

See also GEOLOGICAL TIME SCALE.



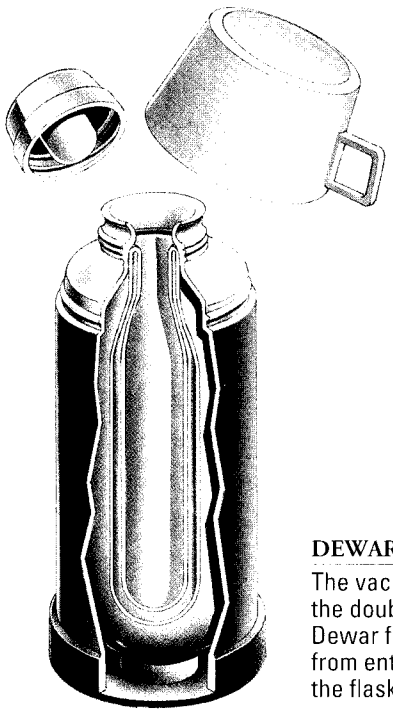
DEW
Dew forms on spider webs, grass and leaves, and other objects.

DEW Dew is water vapor that condenses on objects as small water droplets, usually at night. On a warm day, evaporation increases the amount of water vapor in the air. On a clear, cool night, the air temperature may drop to the dew point. The dew point is the temperature below which water vapor condenses out of the air into dew. Frost is frozen dew.

See also CONDENSATION; DEW POINT; EVAPORATION; FROST; VAPOR.

DEWAR FLASK The Dewar flask is a bottle-shaped container designed to keep its contents at a steady temperature. It does this by greatly reducing the exchange of heat between the inside of the flask and the outside. This exchange of heat may take place through the processes of conduction, convection, and radiation (see CONDUCTION, HEAT; CONVECTION; RADIATION). Dewar flasks are used to store hot drinks, such as tea or coffee; cold drinks; or ice. They are carried on scientific expeditions and are used in the handling of certain chemicals and drugs.

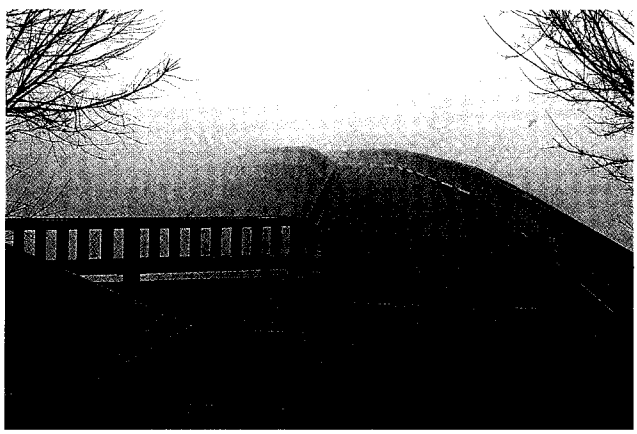
The Dewar flask has an inner container that is made of glass. This inner container is like a bottle within a bottle, sealed at the top by melting the glass edges together. Air is removed from the space



DEWAR FLASK
The vacuum between the double walls of a Dewar flask stops heat from entering or leaving the flask.

between the two bottles, producing a vacuum. Both the glass and the vacuum are poor conductors of heat. The vacuum between the two walls of glass also slows down the transfer of heat by convection. To reduce the transfer of heat by radiation, the two walls are covered with a silvery coating of aluminum that reflects any radiation striking it. The flask is usually sealed by a cork or a hollow plastic stopper. Both are poor conductors of heat.

In 1885, Sir James Dewar invented the Dewar flask. He sold it under the trade name *Thermos,* meaning "heat." The Dewar flask, therefore, is sometimes called the Thermos bottle (or flask) or vacuum bottle (or flask).



DEW POINT
Fog may form when the air temperature drops to the dew point.

DEW POINT The dew point is the temperature at which air becomes saturated with water vapor. The dew point changes according to the amount of water in the air. If there is a large amount of water in the air, the dew point is high. If the air is dry, the dew point is low. When the air temperature drops to the dew point, condensation occurs in the form of fog, dew, or frost.

See also CONDENSATION; DEW; FOG; FROST; HUMIDITY; VAPOR; WEATHER.

DIABETES (dī'ə bē'tēz) Diabetes is the common name for two diseases: diabetes mellitus and diabetes insipidus.

Diabetes mellitus This form of diabetes occurs when the body is unable to use glucose, a sugar, properly. Sugar is produced when food is digested. Sugar moves from the digestive tract into the blood, which transports nutrients to the body cells. Sugar must enter the cells for it to be used. People with diabetes mellitus cannot transport sugar into their cells. This results in an excess of glucose in the blood (hyperglycemia), which, in turn, causes too much glucose in the urine (glucosuria). Many cases of diabetes have been discovered by routine urine tests.

Diabetes mellitus occurs because of either the lack of or the body's inability to use insulin. Insulin is a hormone produced by the pancreas. It allows the body to use and store sugar. In some people who have diabetes, the pancreas does not produce enough insulin. Others with diabetes produce enough insulin, but their bodies cannot use it (see INSULIN).

People who have diabetes mellitus are usually warned by a number of symptoms. In the milder form, called noninsulin-dependent diabetes mellitus (NIDDM), the symptoms include excessive urination, thirst, hunger, weakness, and weight loss. This form of diabetes most frequently develops in overweight people over forty years old. The symptoms are sometimes mild and may go unnoticed until the patient has a physical examination. There is a more serious form of diabetes that usually strikes young people, called insulin dependent diabetes mellitus (IDDM). The symptoms include excessive urination, thirst, nausea, vomiting, and

breathing problems. If not treated, the patient may lapse into a coma and die.

People with diabetes mellitus often can control their disease by responsibly following a routine of self-care. In some mild cases, weight loss and a restricted diet is all that is necessary. Sometimes, drugs taken by mouth can control the disease. In the more serious cases, diabetes mellitus can be controlled by daily injections of insulin. The amount of insulin taken by the diabetic must be carefully monitored by the patient and his or her doctor and balanced by diet and exercise. If not enough insulin is taken, the glucose in the blood may increase to harmful levels, and the patient may experience a serious condition called diabetic ketoacidosis, which may result in coma.

On the other hand, if too much insulin is taken, the blood glucose is reduced to a dangerously low level. This condition is called hypoglycemia. Hypoglycemia is often sensed by the patient. Common symptoms are shakiness and confusion. The condition may be corrected by quickly drinking orange juice or eating candy or some other suggested food. Those who know a person with diabetes mellitus should be aware of these symptoms, so that they can help the person suffering from hypoglycemia get something to eat or seek medical help if the condition continues.

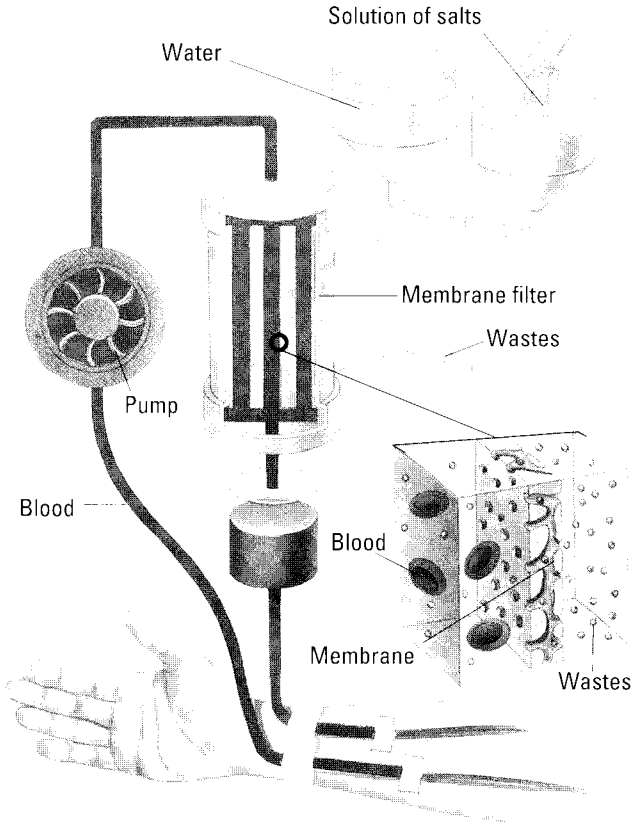
Diabetes insipidus Diabetes insipidus is due to a lack of or the body's inability to use the hormone vasopressin. When there is not enough of this hormone in the body, the kidneys cannot regulate the proper amount of water required by the body. This causes the patient to urinate excessively. A disease or injury to the part of the brain called the hypothalamus, which may occur after a blow to the head, can cause this form of diabetes. Also, an inherited disorder or certain drugs may act on the kidneys to cause diabetes insipidus. The disease is usually controlled by taking vasopressin.

See also HORMONE.

DIALYSIS (dī ăl'ĭ sĭs) In medicine, dialysis describes the process by which the kidneys purify, or clean, the blood of wastes. Dialysis can also be done artificially when the kidneys are damaged or diseased. In artificial dialysis, the person's blood is taken out of an artery in the arm, passed through a kidney machine where waste materials are removed, and put back into an arm vein. The kidney machine has a membrane to filter the blood (see MEMBRANE). The blood is passed through tubes made of this membrane which are placed in a tank containing fluid that takes the waste away after it has been filtered. The tubes allow smaller waste molecules, salts, and water to pass through but hold back larger molecules of glucose, fatty acids, and amino acids so they stay in the blood (see AMINO ACIDS; GLUCOSE). The fluid around the membrane contains the same amounts of salts as the blood to keep blood salt levels from dropping in dialysis.

Another type of dialysis uses the body's own abdominal lining, the peritoneum, as a membrane. Fluid with the same salt level as blood is placed into the abdomen through a tube. The peritoneum then acts as the filter between this fluid and the blood in the abdomen.

See also KIDNEY.



DIALYSIS
A dialysis machine performs the same work as the kidneys.

DIAMOND

A diamond is the hardest substance known that occurs in nature. It is also one of the most valuable and long lasting substances. Diamonds are a crystalline form of carbon. Diamond is closely related to the mineral graphite, which is also a form of carbon. Graphite, however, is a very soft substance. In graphite, the atoms of carbon are arranged in sheets that are stacked on top of one another. When graphite is treated with high pressure and temperature, the sheets of carbon atoms are broken up. The atoms are forced together into a much more tightly packed structure. Scientists believe diamonds were formed underground millions of years ago from carbon that was subjected to high temperature and pressure (see CARBON; GRAPHITE).

Diamonds may vary in color from white or nearly colorless to green, brown, yellow, pink, and sometimes black. The color is caused by impurities.

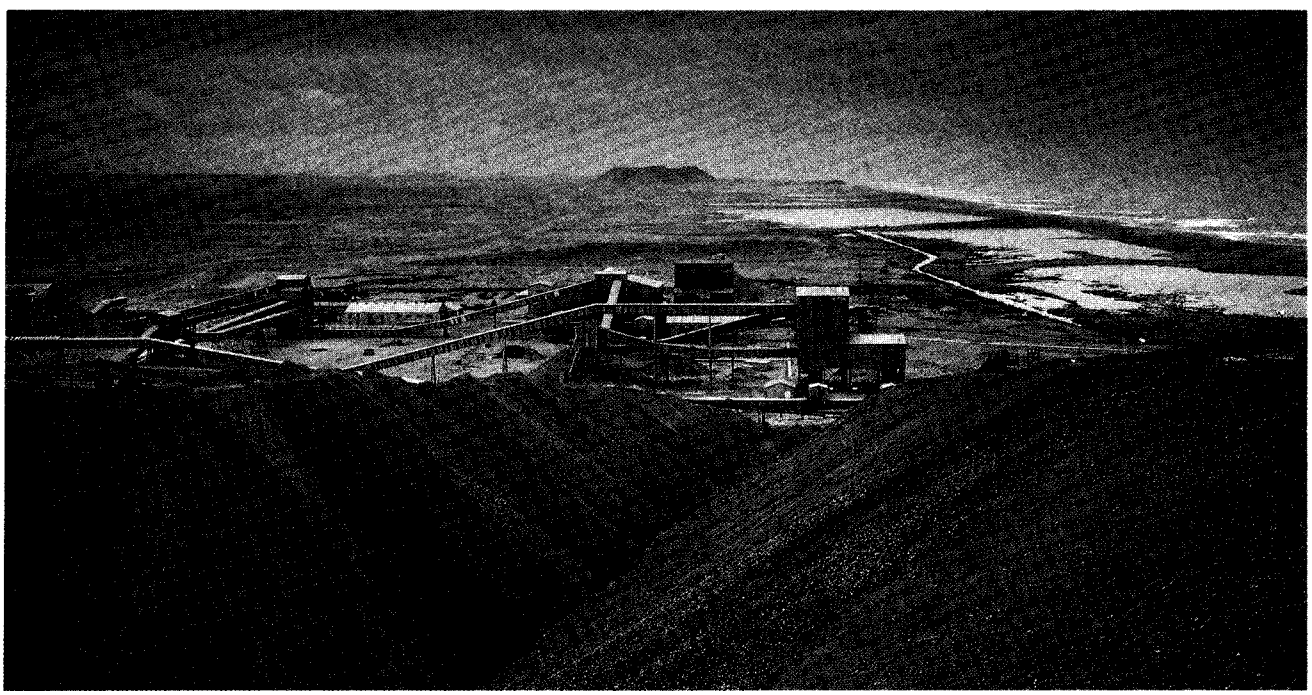
Where diamonds are found Diamonds are believed to have been first discovered in stream beds in India. India, however, produces few diamonds today. A high proportion of the world's current supply of diamonds comes from Africa. South Africa provides most of the high-quality diamonds that are used for jewelry. Zaire, in central Africa, is a main source of diamonds used in industry. Russia is an important source of diamonds. Its deposits are in Siberia. South America, especially Brazil, is another important source of diamonds. In the United States, the only diamond mine is located in Arkansas.

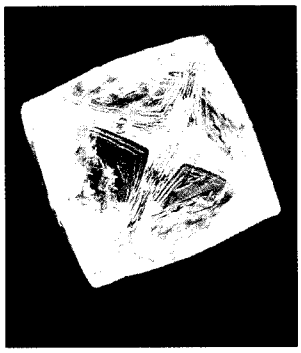
The first diamonds, known as alluvial diamonds, were found in the sand and gravel of stream beds (see ALLUVIUM). Later, diamonds were found in rocks deep in the earth. The rock containing diamonds is called blue ground. Many tons of blue ground must be taken from deep in the earth, then crushed and sorted, to obtain one small diamond. Even in the richest deposits of South Africa, an average of only 1 carat [0.007 oz. or 200 mg] of diamond is found for every 3 tons [2.7 metric tons] of blue ground mined.

Diamonds as gems Diamonds are able to reflect light, bend rays of light, and break up light into all colors of the rainbow. To produce the

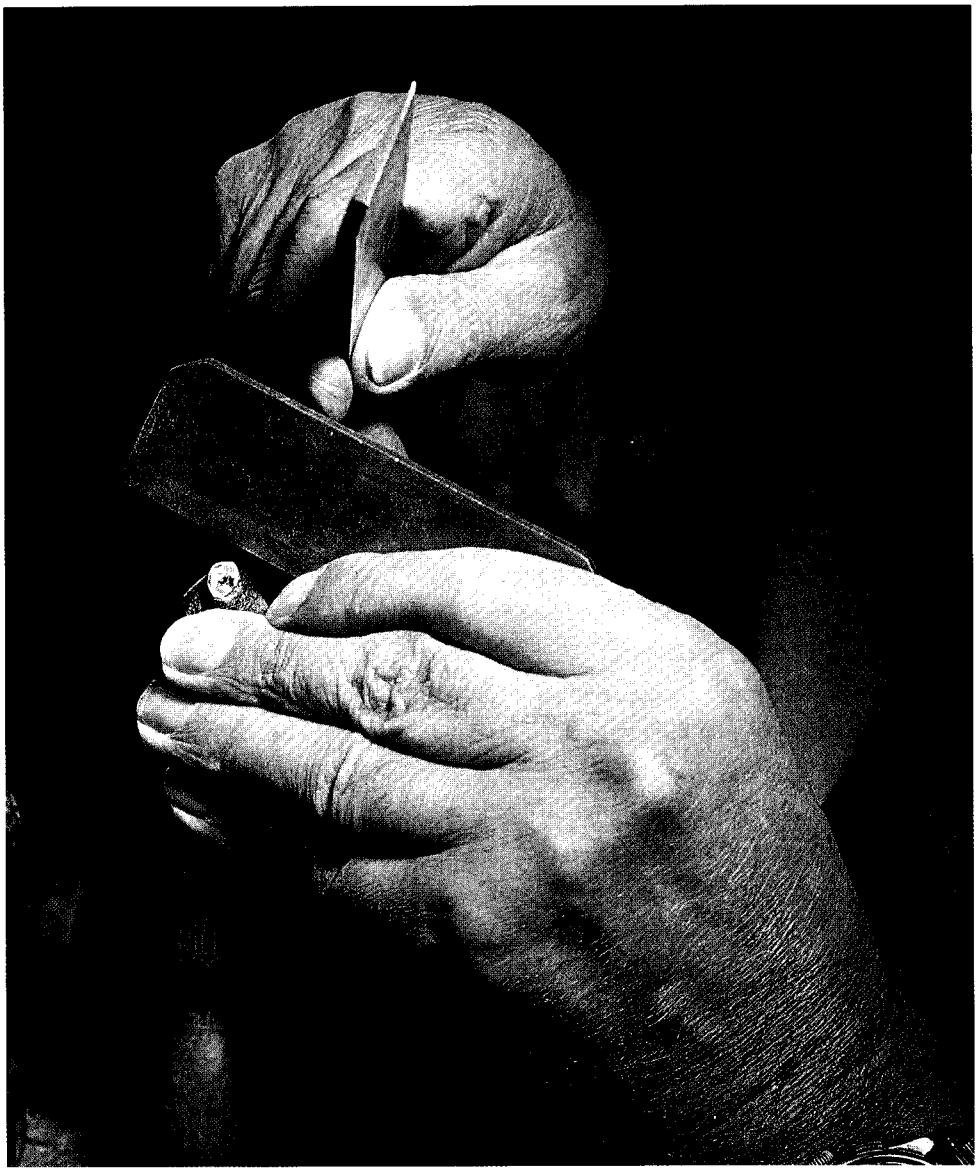
SEARCHING FOR DIAMONDS

Diamonds are so precious that it is worthwhile to move vast quantities of rock in order to find them. This huge operation, where thousands of tons of coastal sand is being sifted for the precious crystals, is in Namibia on the southwest coast of Africa.





CRYSTALS
A good crystal of a diamond is octahedral in shape. It has eight faces (above). Within this crystal the carbon atoms are so tightly bound together that they are very difficult to dislodge from one another. This makes diamond the hardest of all minerals.

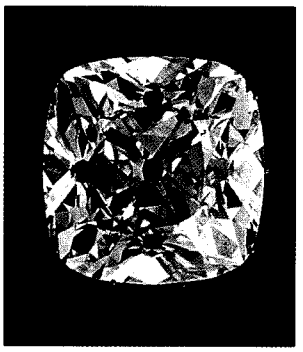


ROUGH DIAMONDS
Rough diamonds need a great deal of treatment before they can be used as jewelry. The crystal must be cut down to a useful size and shape. This is done by cleaving, during which a skilled worker splits the crystal along its lines of weakness (right).

greatest brilliance, many little sides, called facets, must be cut and polished on a diamond. Each facet must be exactly the right size and shape and placed exactly at the correct angle. Usually, a chisel-like blade is used to cut a rough diamond. Cutters then use the lopping method to grind facets. Lopping involves carefully pressing the diamond against a rotating wheel coated with diamond dust. The style of cut often seen today is the round shape with fifty-eight facets, known as the brilliant cut.

Gem diamonds are graded according to weight, color, purity, and cut. The weight of the diamond is measured in carats. One carat weight is 0.007 oz. [200 mg]. The color of most diamonds in jewelry has a faint tint of yellow. Very few diamonds are colorless. A few contain a slight blue tint. Diamonds can be a number of other colors, but such diamonds are usually not as valuable. The value of a diamond can be lessened by many kinds of flaws. These flaws include the presence of foreign material (which may affect the color), small bubbles, and small cracks. The cracks are called fissures, or sometimes feathers. The cut of a diamond also affects its value. Diamonds that are not properly cut do not have as much brilliance as ones that are.

Famous diamonds There are hundreds of famous diamonds, each with an interesting history. Many diamonds are the property of royalty or governments. The largest cut diamond in existence was once part of the Cullinan, a stone that weighed 3,106 carats, or about 1.3 lb. [0.6 kg]. The



THE REGENT DIAMOND
The sparkle of a well-cut and polished diamond is evident in this photograph of the famous Regent Diamond, sometimes called the Pitt Diamond (above). It weighs 410 carats and was found in India in 1701. It can now be seen in the Louvre Art Gallery in Paris, France.

THE HOPE DIAMOND
The Hope Diamond is one of the most famous diamonds in the world (left). It weighs 112 carats and was found in India some time before 1642. It has been cut and mounted in a necklace along with smaller diamonds, and is on display in the Smithsonian Institution in Washington, D.C.

Cullinan was purchased by the Transvaal Government of South Africa and presented to King Edward VII of Britain. Cutters in Amsterdam later trimmed the Cullinan into nine large stones and ninety-six smaller stones.

Diamonds used in industry Industrial diamonds include stones that are not of gem quality. Such diamonds are used to cut, grind, and bore very hard materials. Sometimes, whole rough diamonds are set into tools. Other times, the diamonds are crushed, mixed with a binder, and baked onto a tool surface.

Artificial diamonds There is not a large enough supply of natural diamonds to meet the needs of industry. For this reason, industry depends on artificial diamonds. The first artificial diamonds were made in 1955 by scientists at the General Electric Research Laboratory. Tiny diamonds, no larger than a grain of sand, were made by subjecting carbon to extremely high pressure and temperatures. Today, several companies manufacture industrial diamonds. In 1970, the General Electric Company produced the first artificial diamonds of gem quality and size. Artificial diamonds are not sold as jewelry. They cost too much to produce—much more than natural diamonds themselves.

Imitation diamonds Imitation diamonds, made from several substances under various trade names, are made into gemstones that resemble genuine diamonds. Imitation diamonds do not have the hardness of real diamonds and soon show scratches and other signs of wear.

See also PRECIOUS STONE AND GEM.

DIAPHRAGM In the human body, the diaphragm is a sheet of muscle located between the chest and abdominal cavities. It is the main muscle of breathing.

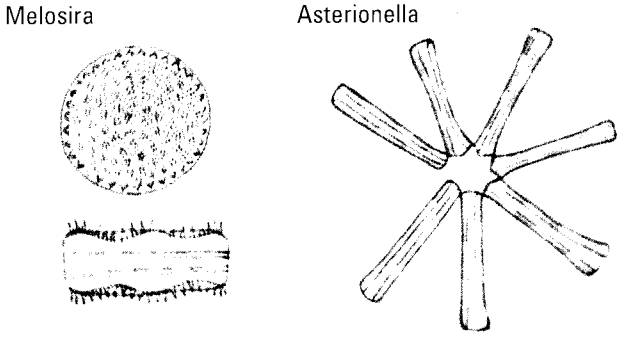
When relaxed, the diaphragm rises up and is curved at the center, allowing the lungs to exhale, or move air out. When the diaphragm contracts, it falls and flattens, which increases the volume of the chest. During contraction, the diaphragm causes air to be drawn in as the lungs inhale. This action of moving air in and out of the lungs by contraction and relaxation of the diaphragm is called breathing.

See also BREATHING. PROJECT 64

DIATOM The diatoms are a class of more than five thousand species of single-celled algae (see ALGAE). They live in salt or fresh water and some live in damp soil. They may live in groups or alone. Some diatoms are able to move from one place to another by a series of jerky or creeping motions. Their cell walls contain large amounts of silica, which forms a protective coat like a glass shell (see SILICA).

Diatoms are an important part of plankton, which serves as a major food source for many sea animals. The shells of diatoms collect and form thick layers at the bottoms of some seas and lakes. This deposit, called diatomite, is used as insulation, a filtering agent for swimming pools, an abrasive, and as part of some explosives.

See also PLANKTON.



DIATOM

Melosira (left) and Asterionella (right) are just two of the thousands of different kinds of diatoms. The glassy cell walls of many diatoms are in two halves. They fit together like the lids and bases of tiny boxes, as you can see in the lower picture of the Melosira (left).

DICOTYLEDON (dī'kŏt'l ēd'n) Dicotyledons are one of two major classes of flowering plants. The other class is monocotyledons (see MONOCOTYLEDON). The more than 250,000 species of dicotyledons are characterized by seeds that have two cotyledons or seed leaves (see COTYLEDON).

Branching is more common in dicotyledons than in monocotyledons. The leaves are usually broad with a network of veins. Flower parts (petals, sepals, stamens, and carpels) are usually in multiples of four or five.

See also ANGIOSPERM; FLOWER. PROJECT 61, 72

DICOTYLEDON

The four petals of the clematis flower and the broad leaves with branching veins clearly show that it is a dicotyledon.

DIE A die is a kind of tool used in shaping, cutting, trimming, and casting various materials. Many manufactured products require the use of dies. For example, many types of dies are used in the manufacture of automobiles. The body parts of cars are formed in dies. These dies are built so that the top and bottom parts are of the same shape. There is only enough space between the top and bottom sections of the die to allow for a sheet of metal. When the metal is placed in the die, pressure is applied. The sheet takes the form of the die.

After the body of the car is formed, it is removed and trimmed in a blanking die. A blanking die is like a pair of scissors. One blade passes another so that it cuts the metal instead of shaping it.

In making automobile trim, an extrusion die is used. The metal is forced through a hole in the die. The strip of metal that is pulled through is the shape of the opening in the die. Other trim parts are made of die castings (see CASTING).

Automobile making is only one example of the many uses of dies. A cookie cutter is a simple type of die. The pictures impressed on coins are formed with dies. Buttons, plastic toys, doorknobs, and certain jars are other products that are shaped with dies.

DIESEL (dē′zəl) A diesel engine is a type of internal combustion engine that is used for heavy-duty work. A diesel engine usually has a longer life than a gasoline engine. For fuel, it uses a low-grade oil that is less expensive than gasoline. Railroad locomotives, trailer trucks, buses, tractors, and road-building equipment are powered by diesel engines. Ships and electric-power-generating stations also use diesel engines. Small models are used to power some automobiles. The diesel engine was developed in 1897 by Rudolf Diesel, a German engineer (see ENGINE).

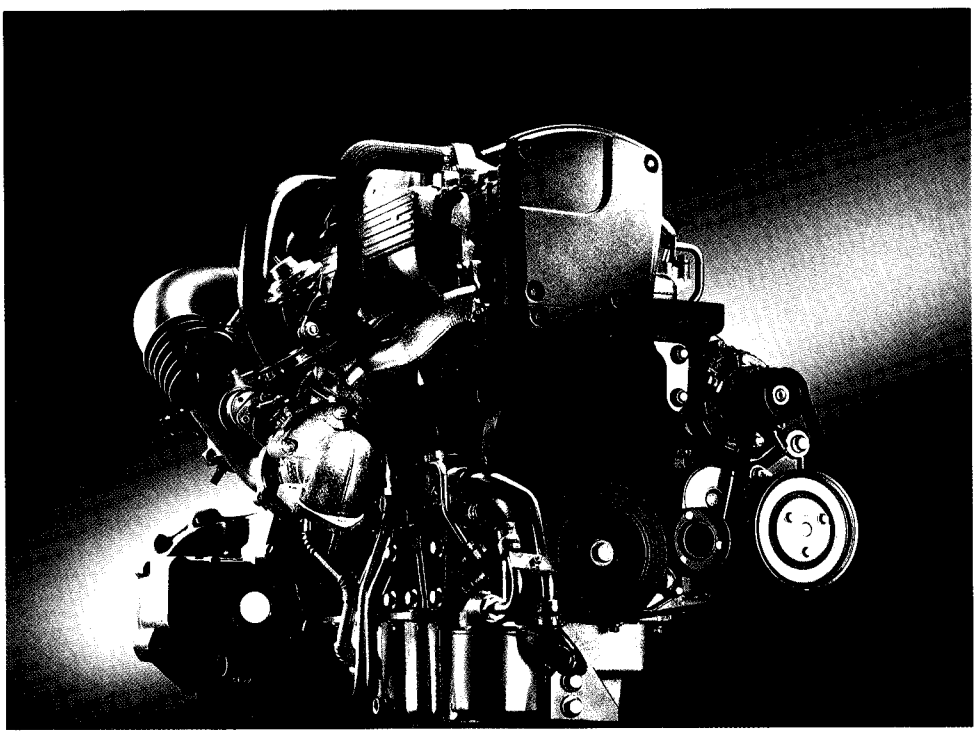
The diesel is a compression-ignition engine, whereas the gasoline engine is a spark-ignition engine. In a diesel engine, air is compressed (squeezed) in each cylinder, causing its temperature to rise. Fuel is then injected into the cylinders. The heat of the air causes the mixture to ignite and explode. Gasoline engines use electric sparks to ignite the fuel-and-air mixtures in the cylinders.

The pressure in the cylinder and the subsequent explosion, or combustion, forces the piston downward. The piston turns the crankshaft. Cylinder walls and most other parts of diesel engines are thicker and stronger than those parts in gasoline engines, so they can stand extra strains and stresses.

There are two main kinds of diesel engines: the four-stroke engine and the two-stroke engine. In the larger and more powerful four-stroke model, each piston moves down, up, down, and up to complete a cycle. The first downstroke draws air into the cylinder. The first upstroke compresses the air. The second downstroke is the power stroke. The second upstroke exhausts the gases produced by combustion.

In a two-stroke diesel engine, the exhaust and intake of air occur through openings in the cylinder near the end of the power stroke. The one upstroke is the compression stroke. The downstroke is the power stroke. Two-stroke engines are used for applications that require high power in a small engine.

See also LOCOMOTIVE.



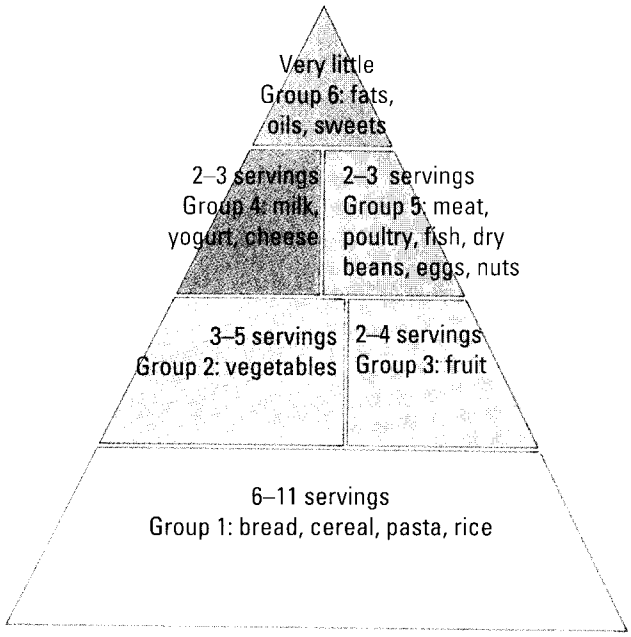
DIESEL
A diesel engine looks similar to a gasoline engine. The main difference is that the diesel engine does not need an electric circuit to send pulses of electricity to spark plugs in each cylinder to ignite the fuel inside it. Instead, pressure alone ignites the fuel.

DIET

Diet is all the food and drink that a person normally consumes on a regular, daily basis. Food contains substances called nutrients, which are needed to build and maintain body tissues, to provide a source of energy for all body functions, and to help regulate the processes of the body. A person's dietary needs vary according to age, weight, physical condition, body metabolism, amount of activity, and the climate (see METABOLISM).

The energy content of food, as well as the amount of energy expended by the body, are measured in units called calories. If a person consumes more calories than he or she uses, he or she will gain weight. If the person consumes fewer calories than he or she uses, he or she will lose weight (see CALORIE). Because a balanced diet provides all the necessary nutrients in the proper amounts, a person following such a diet should neither gain nor lose weight. A balanced diet must include proteins, carbohydrates, fats, minerals, vitamins, and water.

Proteins are complex chemical compounds that are needed to build and repair tissues and to help in the production of hormones and enzymes (see COMPOUND; ENZYME; HORMONE). Proteins consist of and must be broken down into amino acids before they can be used by the body. The human body itself produces several amino acids, but the other, essential amino acids must be supplied by foods in the diet. Meat, fish, seafood, eggs, and dairy products are good sources of most or all of the essential amino acids. Vegetables, grains, dried beans and peas, and nuts also provide the essential amino acids, but they must be varied and eaten in larger quantities if they alone are to meet the body's protein needs (see AMINO ACID; DIGESTIVE SYSTEM; PROTEIN).



FOOD GUIDE PYRAMID

U.S. agricultural and health agencies have developed this pyramid. It divides food into six groups, and recommends the daily servings of foods in each group. The foods contained in each group are illustrated on pages 515 to 518.

Carbohydrates are the main source of energy for the body. Although they supply fewer calories per unit weight than do fats, carbohydrates are broken down more easily. Carbohydrates become simple sugars through the process of digestion. Fruits, vegetables, cereal, bread, and pasta are major sources of carbohydrates (see CARBOHYDRATE).

Fats, or lipids, are used for energy and for other functions. Fats are broken down into fatty acids and glycerol. Because the body tends to use carbohydrates for energy before using fats, fats are often stored in the body. A person who consumes large amounts of fats in his or her diet may store more fat and, thus, be overweight. The two main kinds of fats in the diet are saturated fats and unsaturated fats. Saturated fats are those that are usually in solid form at room temperature, while unsaturated fats are usually liquid at room temperature. Saturated fats are found in meat, eggs, dairy products, and tropical oils such as coconut oils. Unsaturated fats are found in vegetable oils such as olive oil and safflower oil (see FAT).

Minerals are important in the diet (see MINERAL). They help regulate the body and are elements in many vital chemical compounds used by the body. Some of the most important minerals are calcium, phosphorus, iron, sodium, potassium, chlorine, and iodine. Calcium and phosphorus are used in building bones and teeth and in regulating body processes. Leafy green vegetables and milk products are good sources of these minerals. Iron is needed

GROUP 1
Group 1 contains bread, cereal, pasta, and rice. The Food Guide Pyramid recommends 6–11 servings from this group each day.

for hemoglobin in the blood (see HEMOGLOBIN). Sources of iron include meat, eggs, dried beans, and leafy green vegetables. Sodium, potassium, and chlorine all function in the regulation of cellular activity. Most foods, and table salt, supply these minerals (see SODIUM CHLORIDE). Iodine, which is found in seafood, is needed for the proper functioning of the thyroid gland. Iodine is often added to table salt.

Vitamins have many important regulatory functions in the body. Vitamins are found in most foods, though only a carefully balanced diet can supply the necessary vitamins in the proper amounts (see VITAMIN). Fresh fruits and vegetables are excellent sources of vitamins.

Water makes up most of the human body. Most body processes and functions require water. Water is found in all foods except those that are specially dehydrated (see WATER).

The Food Guide Pyramid The U.S. Department of Agriculture (USDA), supported by the U.S. Department of Health and Human Services (USHHS), developed the Food Guide Pyramid. The Pyramid replaces the "four basic food groups" and offers practical information for planning a healthful diet.

The Bread, Cereal, Rice, and Pasta Group forms the large base of the Pyramid, and is made up of foods that come from grains. The USDA and USHHS recommend 6–11 servings a day. A serving may consist of a slice of bread, an ounce of cereal, or a half-cup of cooked rice or pasta.

The Vegetable Group and the Fruit Group are the two groups which form the next level of the Pyramid. This level includes whole foods that come from plants. The Vegetable Group calls for 3–5 servings of vegetables per day. A serving from this group may be a cup of raw, leafy vegetables or a half-cup of other types of raw or cooked vegetables. The Fruit Group calls for 2–4 servings of fruit per day, and a serving may consist of a medium apple, banana, or orange. A serving from this group may also include 3/4 cup of pure fruit juice.

Two groups make up the next level of the Pyramid. The Milk, Yogurt, and Cheese Group calls for 2–3 servings per day. In this group, a serving may be one cup of milk or yogurt, or 1 1/2 ounces of natural cheese. The Meat, Poultry, Fish, Dry Beans, Eggs, and Nuts Group also calls for 2–3 servings per day. In this group, a serving may consist of 2–3 ounces of cooked lean meats, poultry, or fish. One-half cup of cooked dry beans or one egg are also considered servings.

The smallest level of the Food Guide Pyramid, like any other pyramid, is always the top level. The Fats, Oils, and Sweets Group forms this level. Butter and margarine, salad dressings and oils,

GROUP 2
Group 2 contains vegetables. The Food Guide Pyramid recommends 3–5 servings each day from this group. The vegetables may be eaten raw or cooked.

sugar, and foods containing significant amounts of these ingredients make up this level. These foods are usually loaded with calories and offer little nutritional benefits. The USDA and USHHS recommend that people eat these foods in small amounts and use these ingredients sparingly.

A healthy diet contains a variety of foods from each of these groups. It is possible, however, to have a balanced diet even though one of these groups is eliminated. For example, vegetarians who eat carefully planned meals are able to consume all the necessary nutrients without eating meat.

Special diets Although people's food needs are generally similar, certain people need special diets. These diets should be planned and supervised by a doctor or a dietitian, a person who studies diets and dietary needs.

Children and teenagers need more calories than adults need. They use more calories because they are growing, and, in general, are more active than adults. Expectant and nursing mothers, elderly people, and people with certain illnesses all have special dietary requirements. A person with diabetes mellitus, for example, must regulate his or her calorie intake (see DIABETES). People with heart, circulatory, or kidney problems are usually put on a low-sodium diet. People who are allergic to or are unable to digest certain foods must eliminate these foods from their diets (see ALLERGY).

A person who is underweight can gain weight by increasing his or her calorie intake. An overweight person must reduce his or her calorie intake to lose weight. In recent years, there have been hundreds of "fad" or "miracle" weight-loss diets. In spite of all claims, the only way a diet can be effective is if it combines decreasing calorie intake with increasing calorie use through increased exercise. Fewer than 5 percent of the people who lose weight by following a fad diet are able to keep the weight off for at least a year. Some scientists have presented evidence for a "fat gene," a hereditary condition in which a person may be more likely to be overweight.

People in many countries suffer from diseases caused by a deficiency of one or more of the vital nutrients in the diet. Diets in developing countries are sometimes deficient in protein. Some countries have had deficiencies of one or more minerals, which has resulted in birth defects and diseases. The diets of some people in the United States are deficient in certain nutrients. "Junk food," high in calories but low in nutritional value, is thought to be a major reason for this problem.

Dietetics is the study of diets and dietary needs. As the dietary needs of the growing world population become better defined, scientists and dietitians are seeking new ways of meeting these needs. They are exploring potential new food sources, as well as trying to increase the productivity of current food sources.

Dietary guidelines The USDA and the USHHS suggest seven dietary guidelines for Americans as the framework for a good diet.

1. Eat a variety of foods.

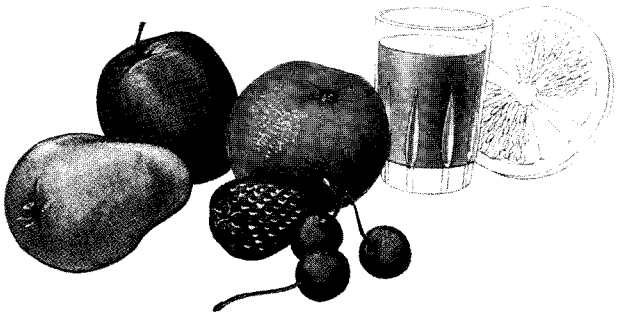
A person should eat a variety of foods to get all the necessary nutrients. Each day, foods should be selected from each of the food groups. Also, a variety of foods from within the groups should be selected.

2. Maintain healthy weight.

A healthy weight can be achieved by balancing food intake with sufficient exercise. Those who are overweight increase their chances of developing certain chronic disorders. For example, obesity is associated with high blood pressure, heart disease, stroke, the most common type of diabetes, and certain cancers.

3. Choose a diet low in fat, saturated fat, and cholesterol.

Cholesterol is a fatty substance made in the bodies of human beings and other animals. People with a high level of cholesterol may increase their risk for heart attack and certain types of disease. High intakes of saturated fat, calories, and cholesterol (which is found only in foods from animal sources, such as meat, eggs, and dairy products) will increase blood cholesterol in many people. Of these, saturated fat has the greatest influence. The relationship between cholesterol in the blood and heart disease depends on how the cholesterol travels throughout the body. Cholesterol that travels as a low-density lipoprotein (LPL) increases the risk of heart disease. On the other hand, cholesterol that travels as a high-density lipoprotein (HDL) lowers the risk of heart disease.



GROUP 3

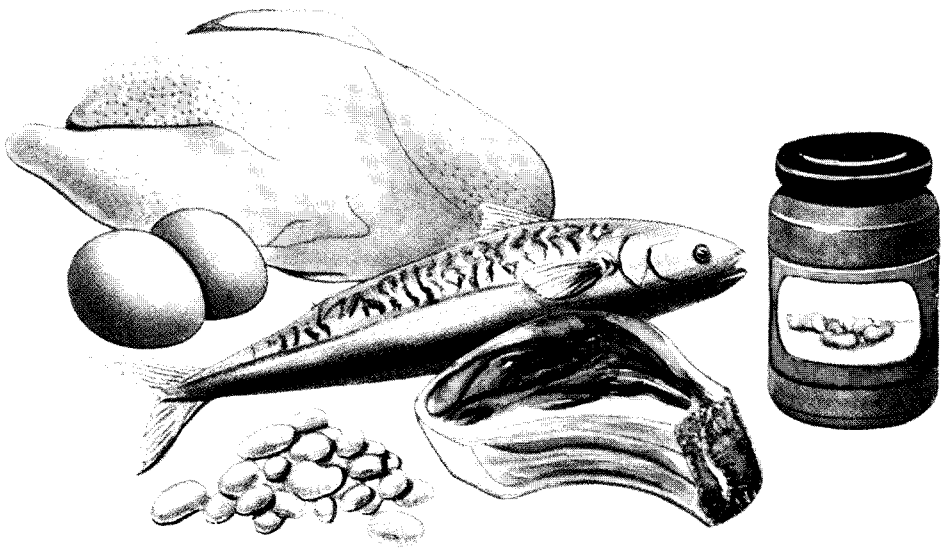
Group 3 of the Food Guide Pyramid contains fruits. It is recommended that people eat 2–4 servings of fruit each day.

4. Choose a diet with plenty of vegetables, fruits, and grain products.

Such foods are high in starch and fiber. Foods high in starch contain essential nutrients and relatively few calories (see STARCH). Examples of high-starch foods are breads, dried beans, dried peas, and

GROUP 4

Group 4 of the Food Guide Pyramid includes milk, yogurt, and cheeses. Two to three servings each day are recommended for foods in this group.



GROUP 5

Group 5 contains high-protein foods such as meat, poultry, fish, eggs, nuts, and beans. Two to three servings each day are recommended in the Food Guide Pyramid.

potatoes. *Dietary fiber* is a term used to describe parts of plant foods that are generally not digestible by humans (see FIBER). Whole-grain breads and cereals and fruits and vegetables are good sources of fiber. Eating foods high in fiber has been found to reduce symptoms of chronic constipation and some colon disease, and diets low in fiber may increase the risk of developing colon cancer.

5. Use sugars only in moderation.

Eating too much sugar can result in a significant health problems such as dental caries, or tooth decay. The risk of caries is not simply a matter of how much sugar and sugar-containing foods are eaten, but how often they are eaten and how often the teeth are brushed (see CARIES).

6. Use salt and sodium only in moderation.

Table salt contains sodium. While sodium is essential in the diet, excess sodium is a hazard for persons who have high blood pressure. At present, there is no good way to predict who will develop high blood pressure, though certain groups, such as African-Americans, have a higher risk than other groups. Maintaining a low-sodium diet may help prevent high blood pressure.

Many Americans eat more sodium than necessary, and may want to consider reducing sodium intake. Several good ways are to use less table salt, read food labels carefully, and eat sparingly foods with large amounts of sodium.

7. Those who drink alcoholic beverages should do so in moderation.

Alcoholic beverages are high in calories and low in nutrients. Although there is some evidence that drinking alcohol in moderation *may* protect against heart disease, heavy drinkers frequently develop nutritional deficiencies as well as more serious diseaseses, such as alcoholism and cirrhosis (see CIRRHOSIS). Alcohol consumption by pregnant women may cause birth defects or other problems during pregnancy. Because alcohol impairs judgment and various abilities needed for safe driving, those who drink should not drive.

See also NUTRITION.

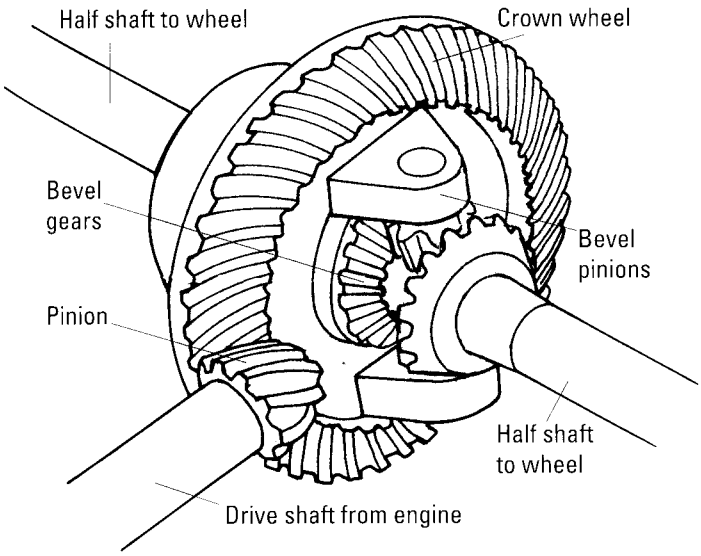
GROUP 6

Candy, sweet snacks, and fried foods are included in Group 6, at the top of the Food Guide Pyramid. It is recommended that very little of these foods be eaten.

DIFFERENTIAL The differential is a system of gears that is mounted between the drive wheels of a vehicle. The drive wheels make the vehicle go. They may be the rear wheels, the front wheels, or all four wheels. The gears make it possible for one drive wheel to turn faster than the other wheel when the vehicle goes around a corner. The differential gears are located inside a metal housing. They are turned by the drive shaft from the engine. Axles, or half shafts, connected to the gears extend out from each side of the housing to the wheels.

When the vehicle moves straight ahead, the differential gears divide the driving force equally between or among the drive wheels. This keeps each wheel turning at the same speed. However, when the car turns a corner, the gears permit the outside wheel, which has farther to travel, to turn faster than the inside wheel. Also, when a car gets stuck in snow or mud, the differential gears allow one wheel to spin while the other does not move. The differential principle was developed in the early 1900s by Charles S. Mott and H. H. Timken, two American inventors.

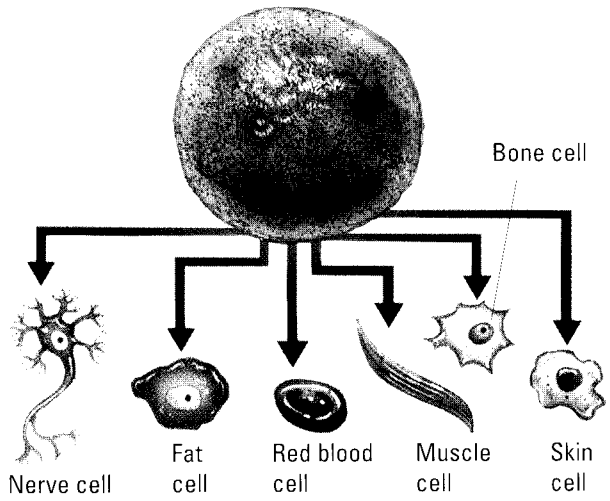
See also AUTOMOBILE; GEAR.



DIFFERENTIAL

A vehicle's differential is a set of interlinked gearwheels that allows the vehicle's wheels to turn at different speeds for cornering.

DIFFERENTIATION, CELLULAR (sĕl′yə lər dĭf′ə rĕn′shē ā′shən) Cellular differentiation is a process that occurs in multicellular organisms. In this process, one cell develops into many distinct types of cells in the growing embryo. A fertilized egg cell (zygote) or a spore becomes a fully developed organism by dividing many times in a process called mitosis (see MITOSIS; SPORE; ZYGOTE). As the number of cells increases, the cells begin to develop into distinct types of cells with specific functions. The controlling process of differentiation, which determines whether a certain cell becomes a muscle cell or a nerve cell, for example, is not understood.



DIFFERENTIATION

Although all the cells derived from a fertilized egg contain the same genetic makeup and all look the same in the early stages of embryonic development, they eventually produce the many very different kinds of cells that make up the body.

It is known that heredity accounts for an organism's producing other organisms similar to itself. For example, a cat will always give birth to another cat, not to a dog or a rabbit. Heredity is ultimately controlled by DNA (see DNA). Each cell of an organism has exactly the same kind of DNA molecule with exactly the same genetic code as every other cell. For some reason, the DNA directs certain cells to develop in certain ways. Because the DNA in every cell of that organism is exactly the same, however, it is difficult to understand why cells are different from one another. This mystery is especially interesting when considering that there are billions and billions of cells in the human body. These cells perform thousands of different functions, yet they all have the same DNA code.

See also ASEXUAL REPRODUCTION; CHROMOSOME; CLONE; GENE; GENETICS; GROWTH; HEREDITY; REPRODUCTION.

DIFFRACTION

Diffraction (dĭ frăk'shən) is the spreading out of waves as they pass by the edge of an obstacle, which is anything that stands in the way of the waves. Diffraction is also the spreading out of waves as they pass through an opening.

Diffraction happens as water waves spread out in all directions after passing through a narrow channel. Diffraction also explains why sound can be heard around a corner, even though there is no straight path from the source of the sound to the ear.

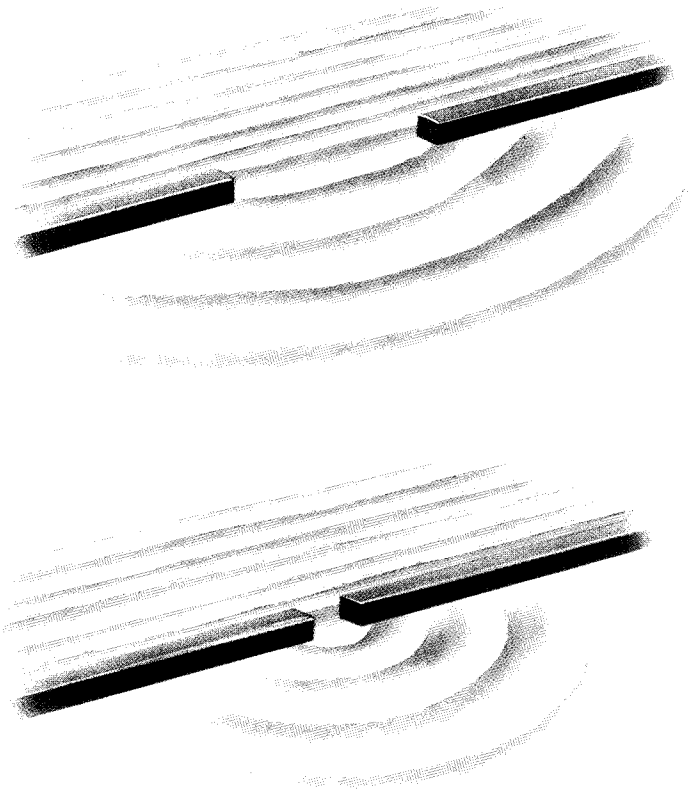
Diffraction of light differs from that of sound because diffraction is most evident when the obstacle is about the same size as the wavelength diffracted. Visible light waves have wavelengths of less than 0.000028 in. [0.0007 mm]. Therefore, light waves can be noticeably diffracted only by very small objects. Sound waves audible to humans have wavelengths of about 1 yd. [0.9 m]. For this reason, sound waves can be diffracted by ordinary objects.

When light passes the edge of an obstacle, and then falls onto a screen, a sharp-edged shadow does not appear. A bending in the light appears to take place at the edge of the obstacle. This spreads light into what otherwise would be a dark shadow. This is, however, a very small effect and is difficult to observe.

The occurrence of diffraction has been used as a test to see whether or not certain things are waves. For example, diffraction of X rays by crystals convinced scientists that X rays are waves.

A diffraction grating is a small glass plate with lines ruled on it at very small, equal intervals. Light can pass only through the openings between the lines. The openings are about as wide as a wavelength of light. If a beam of white light strikes the grating, a pattern of light of the various spectrum colors appears on a screen behind the grating. The colors appear because white light is made up of different colors. These colors have different wavelengths, and the longer wavelengths are diffracted at greater angles. Scientists can identify a substance by the pattern of colors produced when light from the heated substance passes through a diffraction grating or a prism.

See also INTERFERENCE; SPECTROSCOPE; SPECTRUM; WAVE.



SPREADING WAVES
Diffraction occurs, for example, when water waves spread out in all directions after passing through a narrow channel. The narrower the channel, the more the waves curve. This is shown here with a wide channel at the top and a narrow channel at the bottom.

DIFFUSION (dĭ fyo͞o′zhən) Diffusion is the process of substances mingling with each other without mechanical mixing or stirring. It occurs readily in gases and liquids. For example, when a small amount of sugar is placed in a glass of water, it begins to dissolve. The sugar molecules move about in all directions, being jostled by each other and by water molecules. Soon, all the sugar has dissolved, and the sugar molecules are spread evenly throughout the solution.

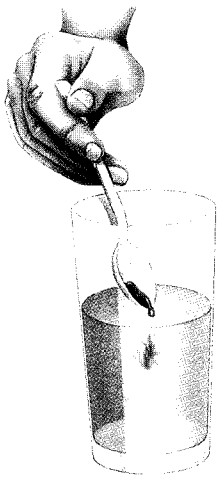
The molecules in gases, such as air, are farther apart than the molecules in liquids and solids, and they have higher speeds. Therefore, diffusion occurs more rapidly in gases than in liquids. If a bottle of perfume is opened in a room, the odor is soon spread throughout the room. The same thing is true of the smell of many flowers. These odors come from gases whose molecules have mixed with the molecules of the other gases in the air.

In plants, diffusion occurs when sap passes through cell walls (see OSMOSIS).

Thermal diffusion is a special process in which heavy atoms or molecules in a gas move toward colder regions. Diffusion through a porous plate is used in the nuclear industry to separate isotopes of uranium. When light shines on a rough surface, the rays are diffused, or reflected in many directions. Diffused light is good light to read under because it does not give off much glare.

See also ISOTOPE; MOLECULE.

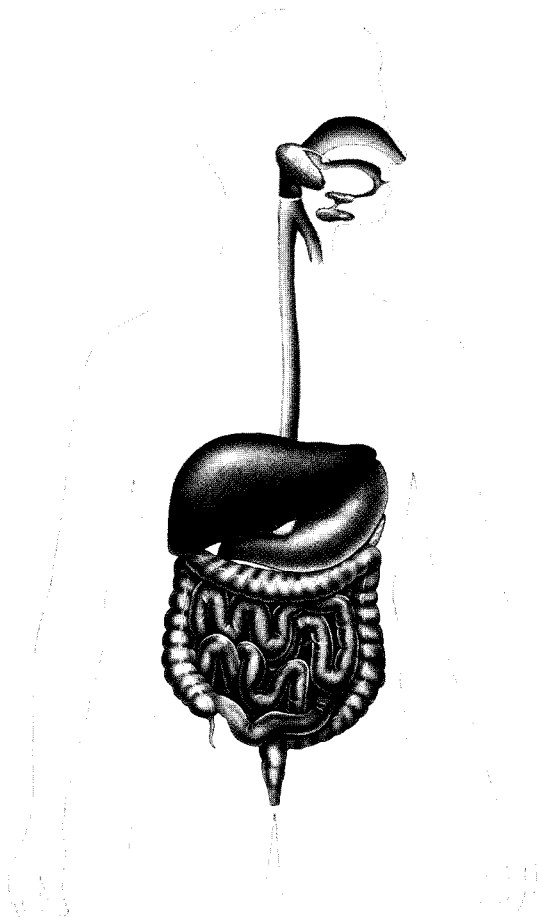
ACTIVITY *Test diffusion times*



Half fill a 10-oz. water glass with cold water. Wait 5 minutes or until the water stops moving. Carefully put in 2 drops of red food coloring. Compare how the color has spread in the water after 5 minutes, 10 minutes, 20 minutes, 30 minutes, and 1 hour.

DIGESTIVE SYSTEM All organisms that do not produce their own food—including all animals—must eat food in order to live. The food is used as fuel in the cells to produce energy. Food must be eaten and converted to the proper form so that the cells can use it. This conversion, which takes place inside the organism, is called digestion. In single-celled animals, digestion takes place in small cavities called vacuoles. Members of the phylum Cnidaria bring food in and take waste out of the same opening. Advanced animals, such as humans, have a complex digestive system. Food enters through the mouth, and wastes leave through the anus. Digestion occurs between these two places (see ALIMENTARY CANAL).

In the human body, digestion begins in the mouth. Chewing makes food soft and breaks it into small pieces. The saliva in the mouth helps break down some carbohydrates in foods into sugars.



DIGESTIVE SYSTEM

Over 22 ft. [6.5 m] long in an adult human, the digestive system breaks down and absorbs thousands of different foods using hundreds of chemical reactions.

Saliva also makes the food slippery, so it can slide down the throat and esophagus easily (see ESOPHAGUS). A wavelike muscle contraction called peristalsis pushes the food down the esophagus to the stomach (see STOMACH). Churning of the stomach changes the food into a semiliquid mass called chyme. Gastric juices, produced by the stomach wall, continue the digestive process. Liquid food passes out of the stomach and into the first part of the small intestine, the duodenum (see DUODENUM; INTESTINE). Digestion is aided by juices from the pancreas, liver, and gallbladder that contain enzymes and bile salts, which are added to the food in the small intestine (see BILE; ENZYME). Most of the food is broken down in the small intestine into its simplest forms: sugar, amino acids, and fatty acids and glycerol. These nutrients are absorbed by little fingerlike projections on the inside of the small intestine called microvilli. From there, the nutrients enter the blood and are carried throughout the body to every cell (see CIRCULATORY SYSTEM).

Not all of the material that is eaten is absorbed by the body as nutrients. Some of it is unusable to the body. As it passes into the large intestine, water is removed and saved by the body. The rest of the waste product is passed out of the body as feces through the anus.

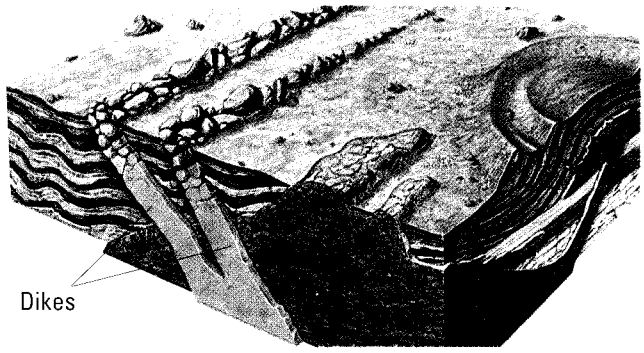
After the food is eaten, several hours pass before its nutrients are in the cells. The body provides enough nutrients to each cell to meet its present need. If there is more food than is necessary, it is stored as fat. If a person always eats more than his or her body needs, his or her body will store a lot of fat. The person will be overweight. When a person does not eat enough food, his or her body will use up stored fat. If a person always eats less food than his or her body needs, the person will be underweight.

See also RESPIRATION.

DIKE The word *dike* has more than one meaning. In the Netherlands, dikes are dams that hold back the sea. They allow land to be used that would otherwise be covered by water.

In geology, dikes are bands of igneous rocks. They cut across the preexisting rock surrounding them. Dikes have a wide range of sizes. When there is a large number of dikes in an area, they are called a dike swarm. A similar band of rock that lies between the preexisting rock beds is called a sill.

See also DAM; IGNEOUS ROCK; SILL.



DIKE

Dikes form when cracks in the rock strata are filled with molten rock that then solidifies.

DINGO The dingo is a wild dog found only in Australia. It was probably introduced to the continent about ten thousand years ago by Aborigines from New Guinea and Asia. It is thought that dingoes were once tame dogs that escaped and reverted to their wild state. Dingo puppies, however, can be trained. The dogs make good pets.

Like all dogs, the dingo is a carnivorous mammal (see CARNIVORE; MAMMAL). It stands about 20 in. [50 cm] tall at the shoulder and has an alert face, erect ears, and a bushy tail. Its fur is usually yellowish brown but may vary from light yellow to black.

Dingoes usually howl instead of barking. They hunt alone or in small family groups. They prey on various marsupials, such as the wallaby, and have been partly responsible for the disappearance of some marsupial species. Because the dingoes sometimes attack sheep, the Australian government considers them pests and has tried to control them.

See also DOG.

DINGO

Dingoes hunt in family groups and attack sheep as well as many of Australia's native marsupials.

DINOSAUR

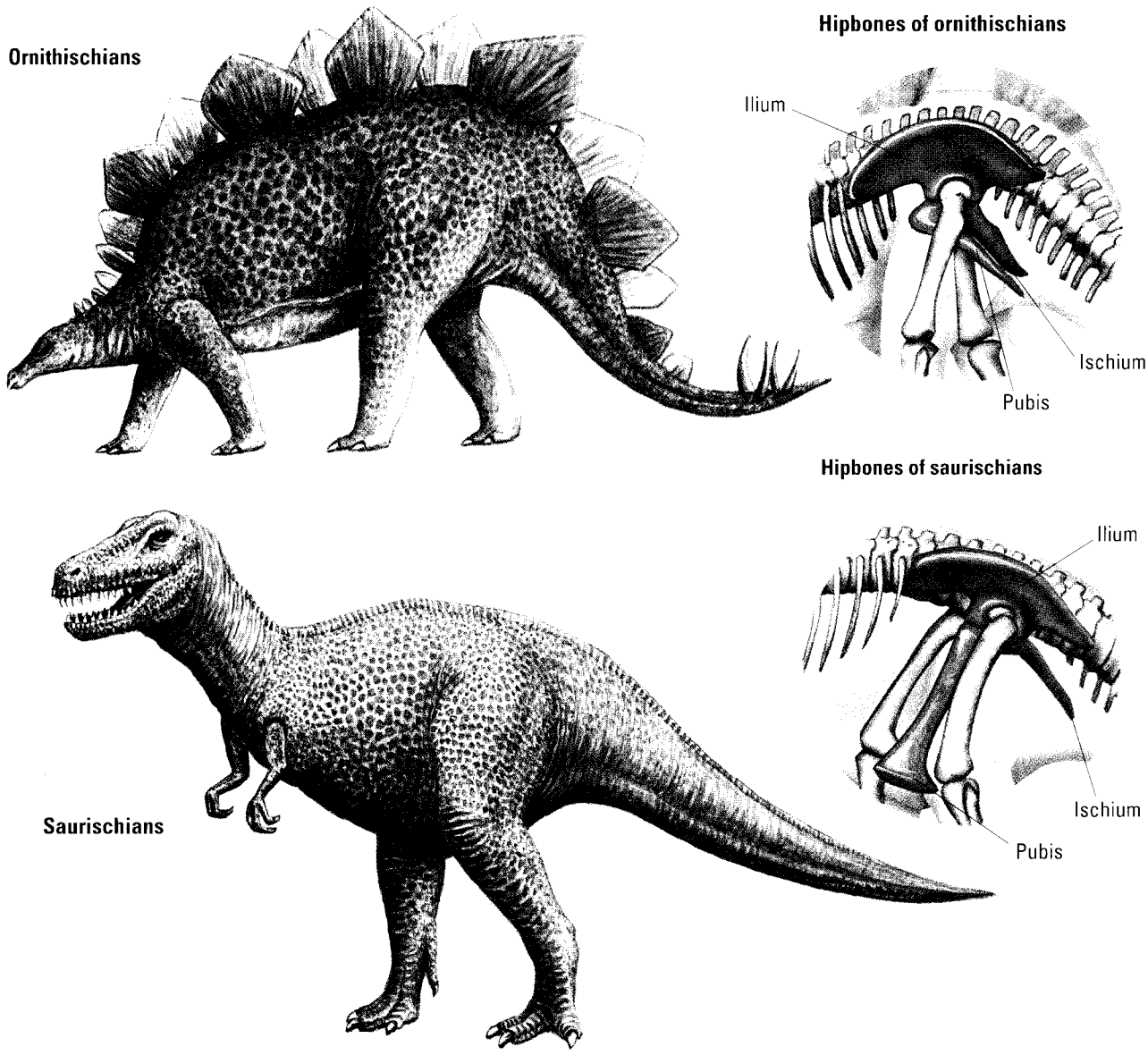
Dinosaur is the name for a kind of land-dwelling reptile that lived millions of years ago (see REPTILE). The word *dinosaur* comes from the Greek words meaning "terrible lizard."

The British scientist Richard Owen coined the term *dinosaur* in 1841 to name the enormous fossil bones and footprints that had been found in England. Dinosaur fossils have since been found all over the world, including the western United States (see FOSSIL). Previously, there had been various explanations for the fossils. One explanation for the large bones was that they were the remains of an extinct race of giant humans. Other people said the bones were left by giant lizards. Some people who found fossil dinosaur footprints thought they were left by giant birds.

It was not until the 1840s that the idea of a gigantic, slow-moving creature called a dinosaur was generally accepted. Today, scientists know that even this idea is not totally correct. For example, though some dinosaurs could be considered giant,

CLASSIFICATION

Dinosaur classification is based on the hipbones. One group of dinosaurs, the saurischians (bottom), had hipbones arranged like those of a lizard. Such dinosaurs were the meat eaters and long-necked plant eaters. The other group, the ornithischians (top), had hipbones arranged like those of a bird. These reptiles were all plant eaters, and the position of the hipbones allowed for the much larger volume of intestine needed for digesting plant food.



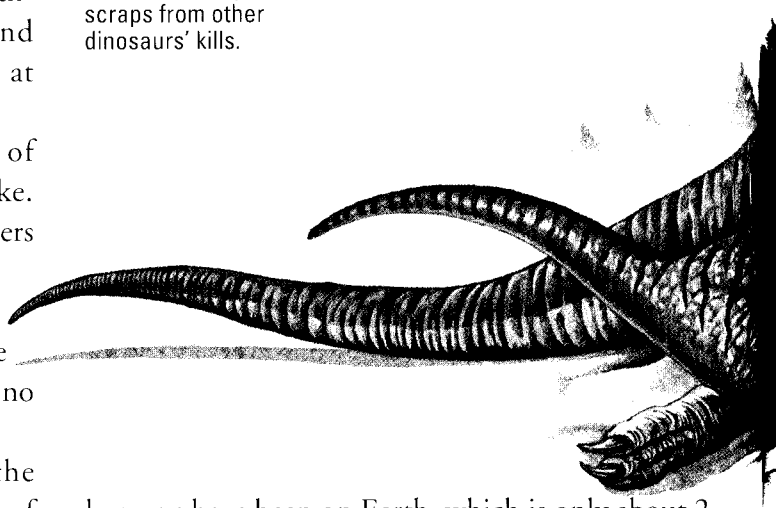
others were very small. The mighty plant-eating *Diplodocus* reached a length of 90 ft. [27 m] and weighed as much as 15 tons [13,608 kg]. However, the meat-eating *Compsognathus* reached only 2 ft. [0.6 m] long and probably weighed no more than a chicken, about 6 lb. [3 kg]. As for being slow moving, some dinosaurs, such as the plant-eating *Stegosaurus,* may have poked along. However, others, such as the meat-eating *Deinonychus* and *Allosaurus,* may have charged after their prey at high speeds.

These differences hint at the difficulty of describing what a typical dinosaur looked like. Some dinosaurs had very small skulls, while others had skulls that were more in balance with the rest of their bodies. Some had short, thick necks, while others had long, thin necks. Some dinosaurs had very sharp teeth, while others had no teeth at all. Some dinosaurs even had beaks.

Scientists are certain about one thing: the dinosaurs lived for a long time many millions of years ago. Dinosaurs are thought to have evolved about 225 million years ago, during the Triassic period (see GEOLOGICAL TIME SCALE; TRIASSIC PERIOD). The dinosaurs became extinct (died out completely) during the Cretaceous period, about 65 million years ago (see CRETACEOUS PERIOD; EXTINCTION). That means dinosaurs roamed the earth for about 160 million years. That is a very long time when compared with the length of time humans have been on Earth, which is only about 2 million years.

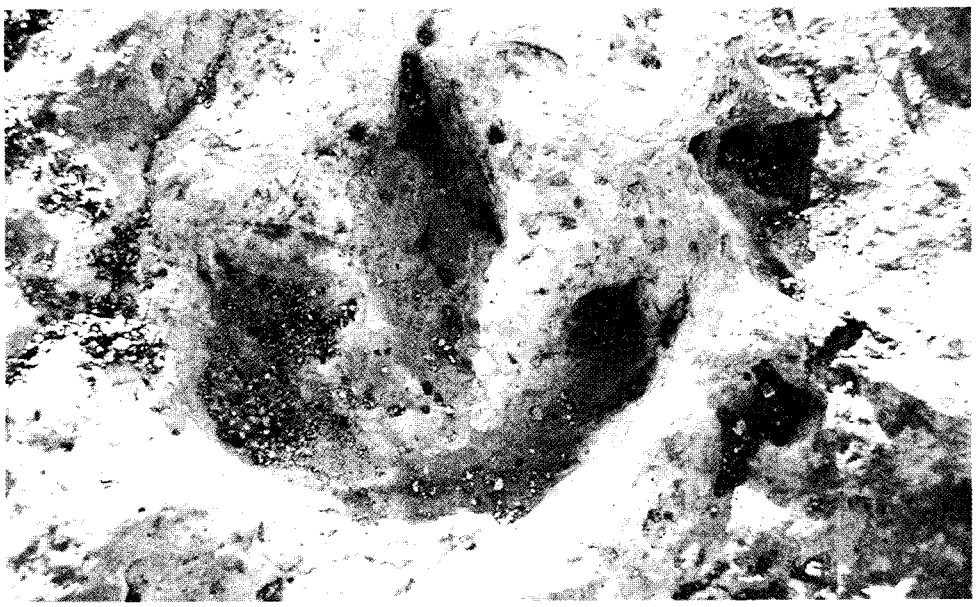
MEAT-EATING DINOSAURS

The meat-eating dinosaurs came in all shapes and sizes. Big *Allosaurus* may have fought and killed large plant eaters. Medium-sized *Ceratosaurus* may have hunted in packs. Tiny *Ornitholestes* hunted small animals, or may have stolen scraps from other dinosaurs' kills.



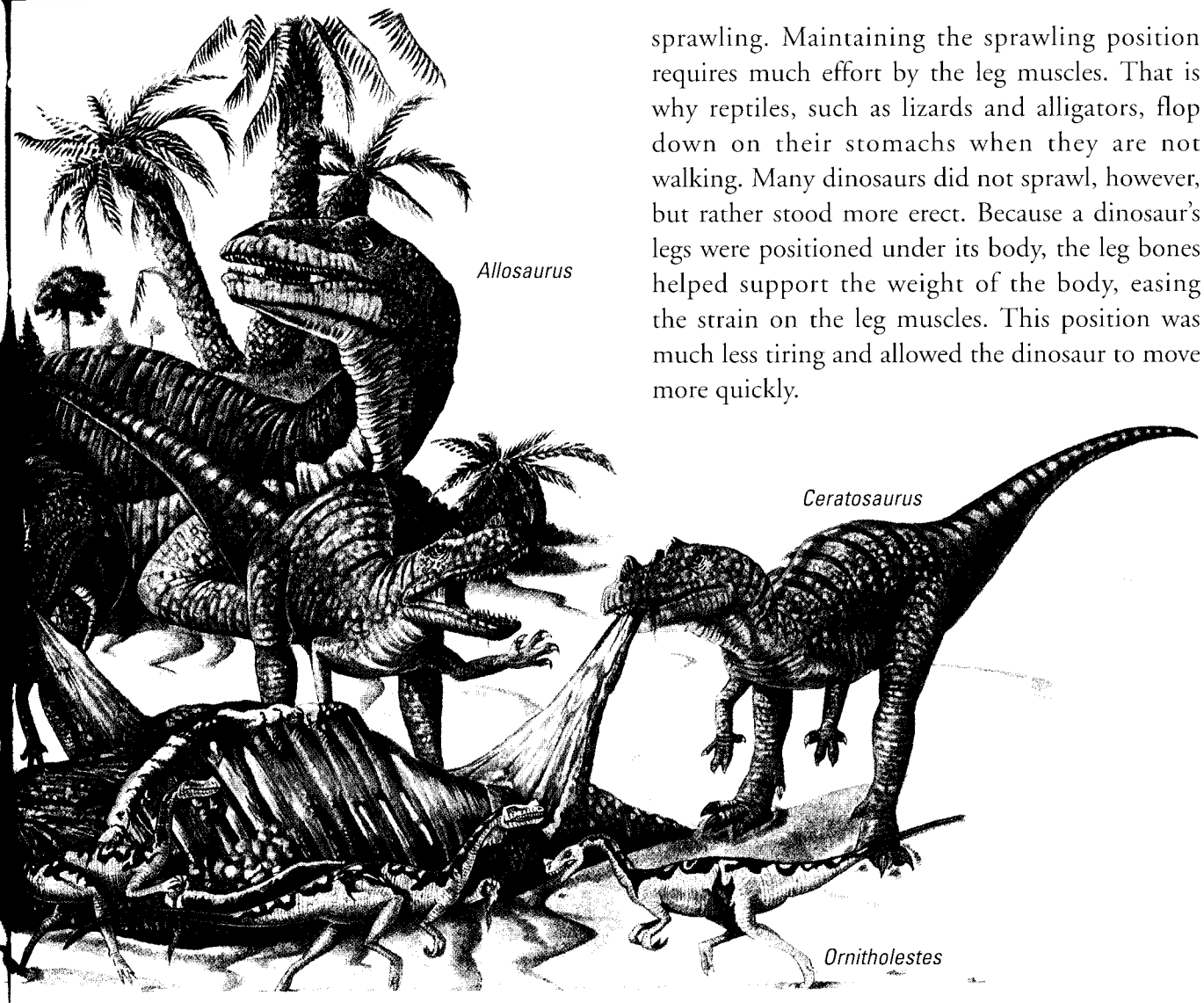
Grouping dinosaurs Dinosaurs belong to the class of animals called reptiles. Examples of modern reptiles include alligators, crocodiles, lizards, snakes, and turtles. The time period during which the dinosaurs lived is often referred to as the Age of Reptiles.

Many other reptiles lived along with the



FOOTPRINTS

It is not just the remains of the bones that tell us about dinosaurs and how they lived. Footprints, like this one in Arizona, can tell us how dinosaurs walked, their speed, the terrain on which they lived, and whether they lived singly or in herds.



sprawling. Maintaining the sprawling position requires much effort by the leg muscles. That is why reptiles, such as lizards and alligators, flop down on their stomachs when they are not walking. Many dinosaurs did not sprawl, however, but rather stood more erect. Because a dinosaur's legs were positioned under its body, the leg bones helped support the weight of the body, easing the strain on the leg muscles. This position was much less tiring and allowed the dinosaur to move more quickly.

dinosaurs in the warm, moist climate that dominated many parts of the world at that time. However, only one particular group of the land-dwelling reptiles are called dinosaurs. An example of a flying reptile is the pterosaur. One pterosaur, the *Quetzalcoatlus,* had wings that spanned 40 ft. [12 m] from tip to tip. That is about the same size as the wingspan of a modern, two-seater airplane. While the pterosaurs ruled the skies, the plesiosaurs and other swimming reptiles made their home in the oceans. Some plesiosaurs were about as big as a modern-day whale and gobbled down fish that weighed close to 200 lb. [91 kg] each.

Many dinosaurs were different from other reptiles in an important way—posture. The legs of most modern-day reptiles stick out from the sides of their bodies. The resulting posture is called

Scientists use another part of the dinosaurs' anatomy, the hips, to divide them into two major groups: the ornithischians and the saurischians. The ornithischians are called the bird-hipped dinosaurs because their hipbones were arranged similarly to the hipbones of today's birds. The saurischians are called the lizard-hipped dinosaurs because their hipbones were arranged similarly to those of today's lizards. All animals with backbones have three hipbones. The ilium is the large upper bone that forms part of the pelvis. The other two bones, the pubis and the ischium, protrude downward from the ilium. In the ornithischians, the pubis and the ischium pointed to the rear and lay parallel to each other. In the saurischians, on the other hand, the pubis pointed forward and away from the ischium.

How the dinosaurs lived After many years of research, scientists are now starting to understand how the dinosaurs actually lived. For example, scientists have a general idea about what dinosaurs ate by studying the shape and arrangement of their teeth. Dinosaurs probably were similar to today's animals in that some were vegetarians, or plant eaters, while others were carnivores, or meat eaters. All of the ornithischians were plant eaters. Saurischians included both meat eaters and plant eaters. Other saurischians were omnivores, which means they ate both plants and animals. Some saurischians also might have been insectivores, meaning they ate only insects.

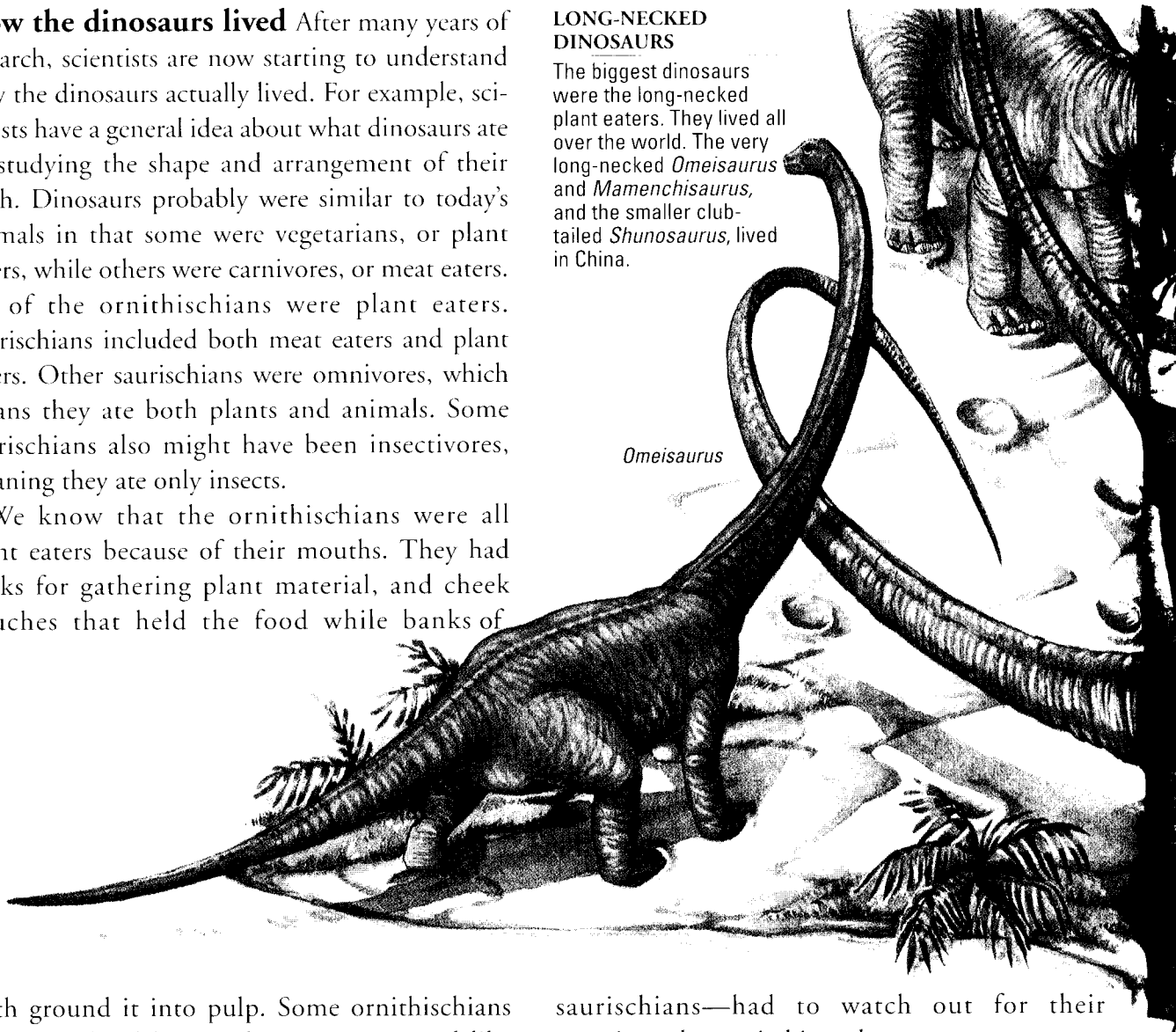
We know that the ornithischians were all plant eaters because of their mouths. They had beaks for gathering plant material, and cheek pouches that held the food while banks of teeth ground it into pulp. Some ornithischians moved on hind legs. Others were armored like *Ankylosaurus*, covered with plates like *Stegosaurus*, or had horns like *Triceratops*. These ornithischians were too heavy for a two-footed existence and moved on all fours.

The plant-eating saurischians were all four-footed animals and had long necks. Their teeth were not made for chewing, but for combing leaves and conifer needles from branches and twigs. They also swallowed stones that ground up the plant material in the stomach so that chewing was not necessary. Many modern birds do this. The plant-eating saurischians were the biggest land animals that ever lived. One, *Seismosaurus*, was about 150 ft. [45 m] long and must have weighed about 100 tons [90,000 kg].

All of these—ornithischians and the plant-eating saurischians—had to watch out for their enemies—the saurischians that ate meat.

The meat eaters were probably similar to today's lions and tigers in that when they were not hunting, they were probably sleeping. Some may have hunted in packs, but others probably hunted alone. Scientists believe some meat eaters did not hunt, but instead were scavengers, feeding on the bodies of dead animals. One of the smaller meat-eating dinosaurs was *Compsognathus*. *Compsognathus* had long, powerful hind legs that helped it overtake and catch its prey. *Compsognathus* had short front legs. Its forelimbs had claws that helped grab and kill its prey. One *Compsognathus* skeleton had the skeleton of a lizard in its belly, showing what its last meal had been.

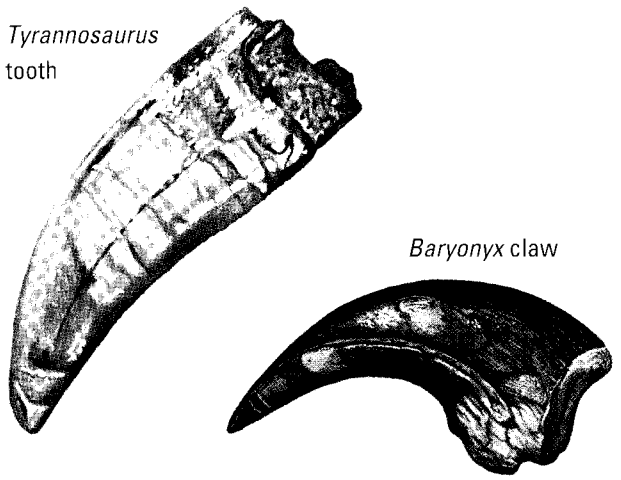
Among the most fierce of all the meat eaters was *Tyrannosaurus*. *Tyrannosaurus* was 40 ft. [12 m]



LONG-NECKED DINOSAURS
The biggest dinosaurs were the long-necked plant eaters. They lived all over the world. The very long-necked *Omeisaurus* and *Mamenchisaurus*, and the smaller club-tailed *Shunosaurus*, lived in China.

long from its nose to the end of its tail, weighed over 14,000 lb. [6,350 kg], and was the largest carnivore ever to walk the earth. Armed with dagger-like teeth sometimes 6 in. [14 cm] long, *Tyrannosaurus* probably could kill any prey it wished. However, some scientists believe these giant meat eaters were only scavengers.

Caring for the young Today's reptiles provide little care for their young. Once these reptiles have laid their eggs or, in a few cases, given birth to live young, they then generally leave the young to fend for themselves. Scientists once assumed dinosaurs followed this same pattern of parenthood. Recently, however, scientists have found fossilized

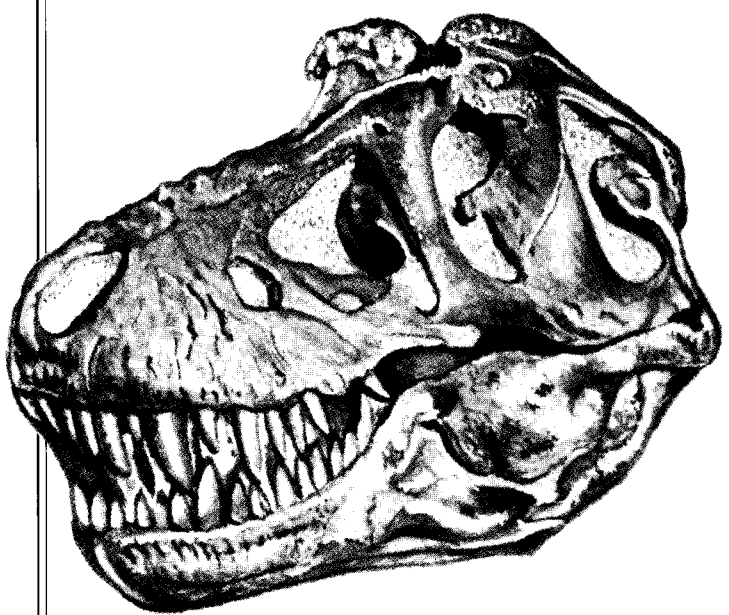


TEETH AND CLAWS
The fierceness of some of the meat eaters can be seen from their teeth and claws. The serrated tooth of the biggest meat eaters, *Tyrannosaurus*, was 6 in. [15 cm] long and used for tearing flesh. The 12 in. [30 cm] long claw of *Baryonyx* was probably used for catching fish.

dinosaur nests. Inside the nests were fossilized skeletons at different stages of growth. This discovery suggests some dinosaurs protected the eggs and cared for the young after they hatched.

Warm-blooded or cold-blooded? Modern reptiles are cold-blooded, which means their body temperatures are determined by the temperature of their surroundings. If the surroundings are warm, the reptiles are warm. If the surroundings are cool, the reptiles are cool. Mammals, such as humans, cats, and dogs, are warm-blooded, which means their body temperatures are controlled internally. Animals that are cold-blooded face special difficulties. For example, when the surroundings are cool, such as in the early morning or night, the body temperatures of cold-blooded animals drop, and they are sluggish. This sluggishness makes it easier for warm-blooded animals to catch them. Cold-blooded animals also have a hard time catching prey when they are sluggish. Scientists once assumed that all dinosaurs were cold-blooded. Recently, however, some scientists are challenging this idea. They believe that because some dinosaurs were very fast movers, they were more likely to be warm-blooded than cold-blooded.

SKULL OF A DINOSAUR
The skull of the fearsome *Tyrannosaurus* shows that its eyes pointed forward—just right for hunting. It killed with its huge toothed jaws, powered by massive muscles.



Reasons for extinction Scientists have debated for many years the reason behind the sudden disappearance of the dinosaurs 65 million years ago. Many scientists today believe that a change in the earth's environment is the reason behind the dinosaurs' disappearance. Such a change would not only have harmed the dinosaurs, but it also would have killed off much of the plant life on which many of them fed. The dinosaurs would have starved to death. The cause of the change remains a mystery. Some scientists feel a large meteorite might have struck the earth. This theory, which was originated by Luis and Walter Alvarez, says such a meteorite would have blasted enormous amounts of dust into the atmosphere (see ALVAREZ, LUIS). This dust would have blocked the sun's heat and light. Other scientists believe ash from a volcanic eruption blocked the sun's heat and light. Still others think that the cooling was caused by continental drift (see CONTINENTAL DRIFT). In this theory, the plates on which the continents rest drifted toward the cooler regions of the earth. Some scientists think that this movement brought different groups of dinosaurs into contact with one another, leading to the spread of disease. The disappearance of the dinosaurs will probably continue to be one of science's most puzzling riddles.

DIOXIN Dioxin is the general name for a group of 75 different chemical compounds. All of them consist of the elements carbon, hydrogen, oxygen, and chlorine. The term *dioxin* is usually used to refer to only one of these compounds, TCDD. Some scientists believe dioxin, or TCDD, is one of the most poisonous chemicals ever made. Dioxin is produced as a by-product during the manufacture of certain weedkillers and some other chemicals such as bactericides. It is found in the smoke when plastic, paper, or wood is burned.

Dioxin does not break down in soil or in water. It is difficult to dispose of safely, except by burning it at a very high temperature. Soil and water in certain areas of the United States, Canada, and Europe have been contaminated with dioxin. Environmentalists have lobbied against its use and for its proper disposal.

Dioxin appears to affect the way some hormones behave, producing a wide range of changes in the body. Nonhuman animals exposed to dioxin have developed cancerous tumors. Humans exposed to dioxin have developed headaches, stomachaches, and severe skin rashes. The chemical may also cause cancer in humans. Dioxin was present in the weed killer called Agent Orange that U.S. forces used during the Vietnam War (1957–1975).

See also CANCER; HORMONE.

DIPHTHERIA (dĭf thîr'ē ə) Diphtheria is an infectious disease caused by the bacterium *Corynebacterium diphtheriae* (see DISEASE; INFECTION). It affects the upper respiratory system and occasionally the skin (see RESPIRATORY SYSTEM). Two to five days after infection, a heavy discharge develops in the nose. This grows into a thin layer of tissue in the upper respiratory system. A toxin (poison) is produced by the bacterium. The poison circulates through the blood and affects the heart, circulatory system, and nervous system (see CIRCULATORY SYSTEM; HEART; NERVOUS SYSTEM). Diphtheria can last up to eight weeks. The sufferer can become very ill or die.

Thousands of people were killed every year from diphtheria until about 1920. At that time, immunization (protection) programs were introduced. Today many people are protected from a young age because they receive an injection of killed diphtheria bacteria. This causes the body to produce an antitoxin that neutralizes, or cancels, the poison, making the person immune to the disease (see ANTITOXIN; IMMUNITY). If an unimmunized person catches the disease, he or she can be cured by taking antitoxins and antibiotics (see ANTIBIOTIC).

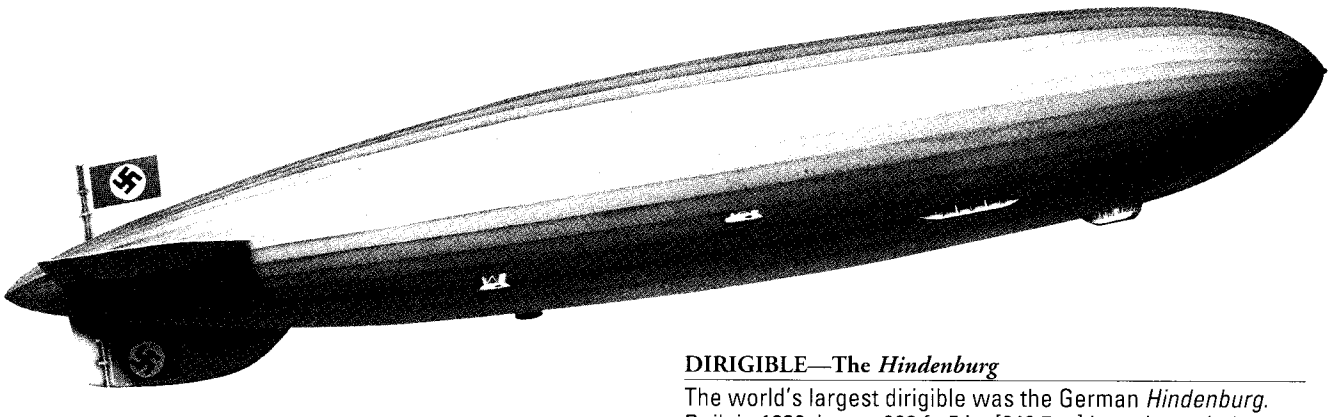
DIRECT CURRENT Direct current is electric current that always flows in one direction. It is produced by batteries and direct current (DC) generators (machines that produce electricity). Direct current operates automobile electric systems, locomotives, and some types of motors used in industry. Radios, television sets, and other electronic devices use alternating current as their primary source of power. However, they also need some direct current to operate internal circuits. Devices called rectifiers change alternating current into direct current for these circuits.

See also ALTERNATING CURRENT; DYNAMO; GENERATOR, ELECTRICAL; RECTIFIER.

DIRIGIBLE (dĭr'ə jə bəl) A dirigible is a rigid, lighter-than-air aircraft shaped like a football. Dirigibles were built and flown in many countries during the early 1900s. They were driven by gasoline-engine-powered propellers, and they could be steered in any direction by means of rudders.

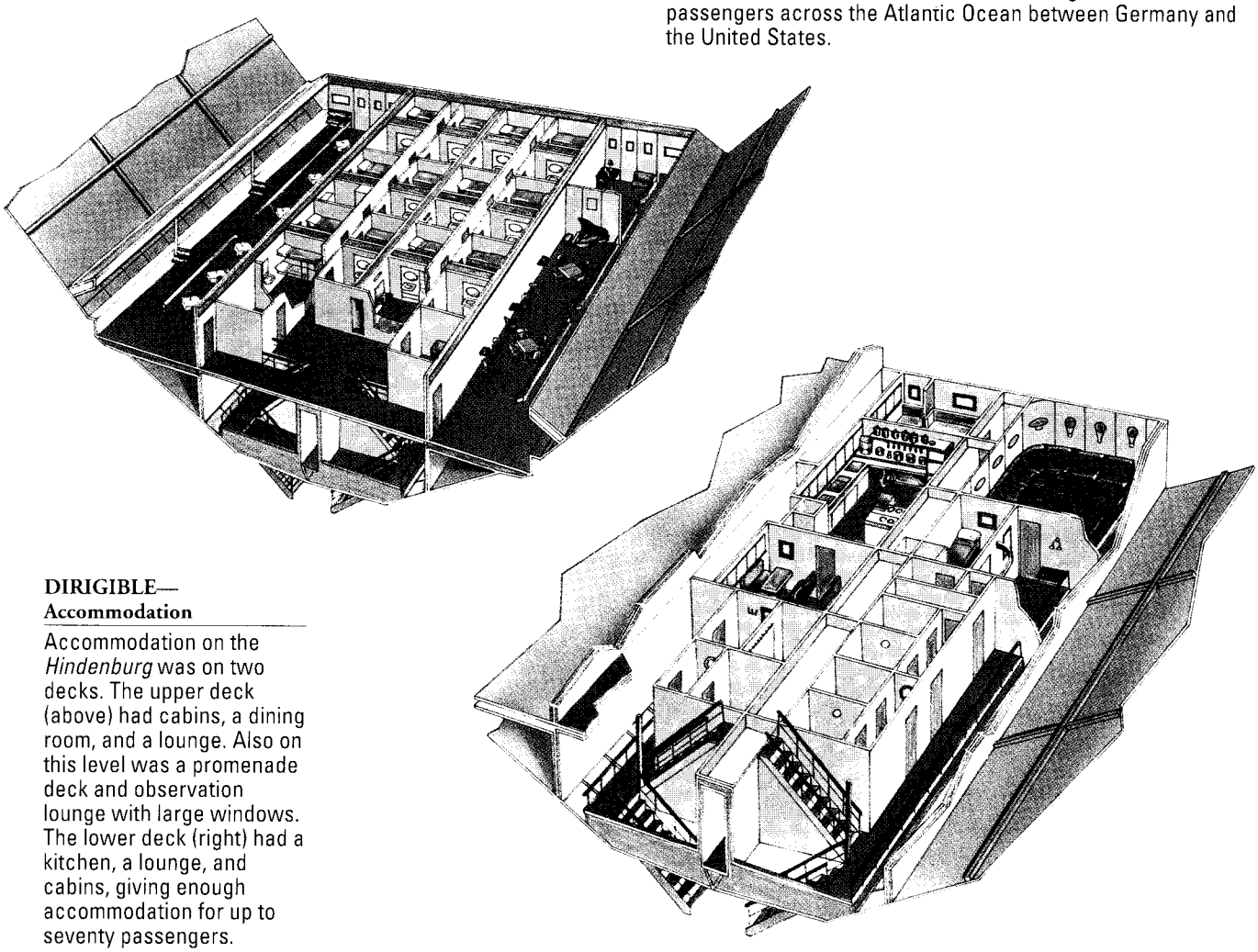
Along with their crew, dirigibles were used to carry passengers and freight. Some dirigibles, especially those built in Germany, were very large. Some were about 800 ft. [244 m] long with diameters of up to 135 ft. [41 m]. Dirigibles had frameworks of aluminum covered by cloth, which contained large bags of hydrogen gas. Hydrogen gas, which is lighter than air, provided the lift the dirigibles needed to get off the ground. Generally, stationary dirigibles were tied to towers while still floating in the air. The crew and passengers climbed the tower to board it. They rode in a passenger car attached to the bottom of the dirigible's body.

During World War I (1914–1918), Germany used dirigibles to drop bombs on English cities. In 1936, the Germans built the *Hindenburg*. Over



DIRIGIBLE—The *Hindenburg*

The world's largest dirigible was the German *Hindenburg*. Built in 1936, it was 809 ft. 5 in. [246.7 m] long. It carried passengers across the Atlantic Ocean between Germany and the United States.

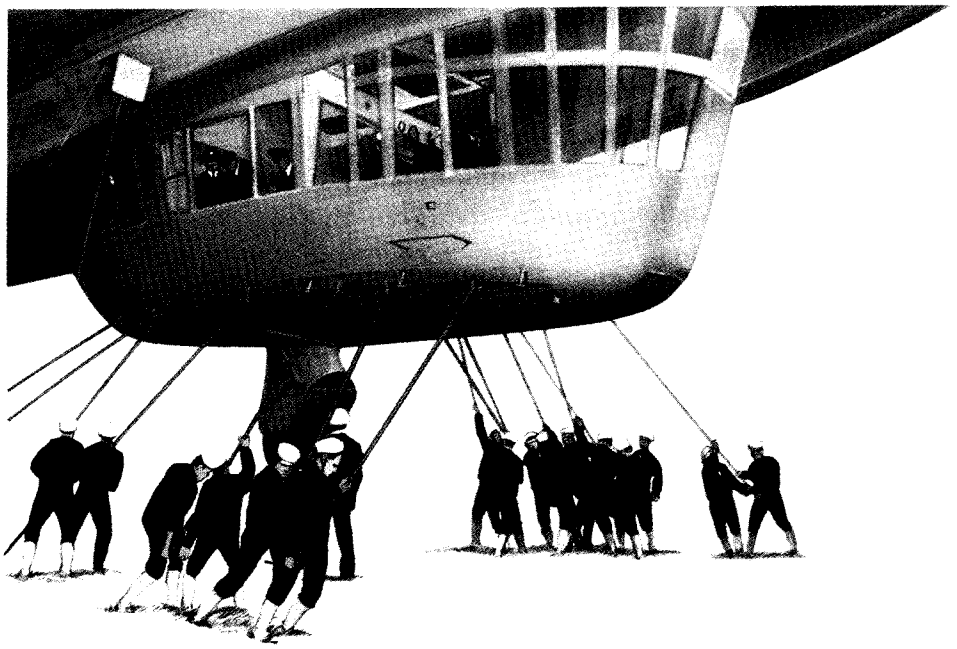


DIRIGIBLE—Accommodation

Accommodation on the *Hindenburg* was on two decks. The upper deck (above) had cabins, a dining room, and a lounge. Also on this level was a promenade deck and observation lounge with large windows. The lower deck (right) had a kitchen, a lounge, and cabins, giving enough accommodation for up to seventy passengers.

800 ft. [244 m] long, it was the largest dirigible ever built. The *Hindenburg* made thirty-six flights across the Atlantic Ocean from Germany to the United States. In 1937, while the dirigible was landing in New Jersey, the highly flammable hydrogen inside caught fire. The *Hindenburg* burst into flames and was destroyed. More than thirty people were killed in the disaster.

The *Hindenburg* tragedy ended passenger service aboard dirigibles. In the 1970s, aviation experts again talked about building dirigibles using helium gas, which is not flammable. Helium was not used originally because it was too expensive. However, by the 1970s, helium could be produced more economically and was readily available. In spite of this renewed interest, no new commercial dirigibles



DIRIGIBLE—Mooring
When a large dirigible like the *Hindenburg* landed, the ground crew used long crutches to hold the craft steady so that passengers could get on and off.

have been built. However, a similar kind of aircraft—a non-rigid airship, or blimp—is used today for advertising and as airborne platforms for television cameras filming aerial views.
See also AVIATION.

DISEASE A disease is a condition of a living thing that prevents it from functioning in a normal way. When your body does not seem to be working normally and you feel sick, you may have a disease.

When you see a doctor about feeling sick, he or she looks for signs that show what kind of disease you might have. The doctor is doing a kind of detective work for which he or she has been specially trained. When the doctor finds out what is wrong, your disease has been diagnosed.

Doctors can group different diseases together according to what causes them. Infectious diseases are those that are caused by organisms called pathogens. Many kinds of bacteria, viruses, and fungi can be pathogens (see BACTERIA; FUNGUS; INFECTION; PATHOGEN; VIRUS).

Bacteria cause diseases such as strep throat, whooping cough, and scarlet fever. Bacterial diseases are treated with antibiotics, and many can be prevented by vaccines (see ANTIBIOTIC; SCARLET FEVER; STREP THROAT; VACCINATION).

Viruses cause many diseases, including AIDS, measles, mumps, influenza ("flu"), and poliomyelitis ("polio"). Some viral diseases can be prevented by vaccines. However, antibiotics will not cure diseases caused by viruses (see AIDS; INFLUENZA; MEASLES; MUMPS; POLIOMYELITIS).

Several diseases, such as ringworm, are caused by fungi. These skin diseases can be difficult to treat (see RINGWORM).

Many infectious diseases, such as measles, are contagious. This means they can be spread from one person to another through the air or by direct contact with a sick person or secretions from his or her body, such as saliva. Some infections are not contagious. They must be carried from person to person by insects or other animals. Typhus and bubonic plague are spread by certain lice and fleas. Malaria can be carried only by certain kinds of mosquitoes. Other types of infectious diseases can be caused by larger organisms, such as worms. These organisms that live inside other organisms, called hosts, are called parasites. One type of parasite that attacks people is the tapeworm. It grows in the intestines and can reach 15 ft. [4.6 m] in length. The tapeworm eats the person's food, depriving the person of nutrition and causing weakness (see FLEA; LICE; MALARIA; MOSQUITO; PARASITE; TAPEWORM; TYPHUS).

Many diseases, called noninfectious diseases, result from the failure of organs in the body, such as the heart, lungs, or kidneys, to work properly.

Noninfectious diseases can also be due to neoplasms, also called tumors. These are growths of body tissue that are not normal. Tumors can be benign or malignant. *Benign* means the tumor will not spread or harm nearby structures. A malignant tumor is called a cancer. Cancers are very serious because they can kill other tissues and spread throughout the body to various organs. A cancer can kill the person, unless it is diagnosed early and treated successfully (see CANCER).

An allergy is a type of noninfectious disease caused by an abnormal reaction to a substance a person breathes, touches, or eats. Many people are allergic to bee stings or dust, but can be treated with the proper drugs (see ALLERGY).

Certain noninfectious diseases are inherited by a child from parents who are carriers for that disease (see CARRIER). In many cases, doctors are not certain how important heredity is in the development of a disease (see HEREDITY).

DISINFECTANT (dĭs' ĭn fĕk'tənt) A disinfectant is a chemical that kills microorganisms on nonliving objects. Disinfectants are used in hospitals to sterilize instruments and other equipment to prevent infections in patients (see INFECTION; STERILIZATION). Disinfectants are also used in homes, particularly in kitchens and bathrooms. Household disinfectants are often mixed with detergents to help them clean while killing microorganisms (see DETERGENT). Some countries add disinfectants to sewage systems and water supplies to help prevent epidemics (see EPIDEMIC).

DISINFECTANT
Many home disinfectants are perfumed, and may be combined with detergents and used for cleaning bathrooms and kitchens. They kill germs that could cause illness.

Some common disinfectants are alcohol, ammonia, chlorine bleach, hexachlorophene, and iodine. Iodine and other substances that are used to kill microorganisms on living tissue are called antiseptics.

See also ANTISEPTIC; ASEPSIS; INFECTION; MICROORGANISM.

DISLOCATION A dislocation occurs when something moves out of the position it would normally occupy. A bone becomes dislocated if it is pushed out of its socket or joint.

A dislocation is also a defect in a crystal (see CRYSTAL). Crystals are formed of atoms arranged in regular patterns (see ATOM). When a crystal is growing, the atoms pile up on one another to form flat, smooth surfaces. Sometimes a sheet of atoms stops growing and ends in the middle of the crystal. This is called an edge dislocation. Atoms that spiral upward instead of lying in flat sheets form a corkscrew dislocation. Dislocations can move through a crystal if pressure is applied.

In geology, a dislocation is a fault in the earth's crust caused by a fracture in the rock. If a geological dislocation moves suddenly, an earthquake results (see EARTHQUAKE).

DISPERSION OF LIGHT When a beam of white light passes through a prism, the different wavelengths of light disperse, or spread apart, into a band of colors called the spectrum. This dispersion of light occurs because white light is actually made up of lights of various colors, each of which has a different wavelength. The different wavelengths of light travel at different speeds when they pass through a prism. The angle at which each light wave is refracted (bent) as it passes into the prism depends on the speed of the wave. Therefore, different wavelengths are refracted at different angles, causing them to disperse.

See also ABERRATION; COLOR; LENS; LIGHT; PRISM; REFRACTION OF LIGHT; SPECTRUM. PROJECT 52

DISPERSION OF PLANTS

Plants are fixed in one place for most of their lives, and therefore need efficient methods of scattering their seeds or spores. If the seeds or spores simply fell underneath the parent plants, they would not have enough room to grow properly. The spores of ferns and mosses are extremely light and can be carried long distances on the breeze. Some seeds, including those of orchids, are also very light and easily carried away, but most fruits and seeds have special features to ensure that the seeds are well scattered (see FRUIT; SEED; SPORE).

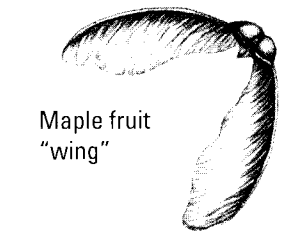
Many fruits split open so that the individual seeds can escape. These fruits are called dehiscent fruits (see DEHISCENCE). Examples include the milkweeds and the willowherbs, whose seeds are fluffy and carried away by the wind. Poppy fruits or capsules also split open when they are ripe. Their seeds are dispersed through small holes when the stalks sway in the breeze. Tumbleweeds use the wind in a very different way. The plants grow in hot, dry areas, and they break away from their roots when they die. Seeds fall out as the dead plants are rolled or tumbled across the land by the wind. Some fruits explode quite violently and their seeds are thrown several yards away. Examples include many members of the pea and mustard families and most members of the balsam family. The latter are often called touch-me-nots because the fruits explode as soon as they are touched and the seeds can sting your face if you get in the way.

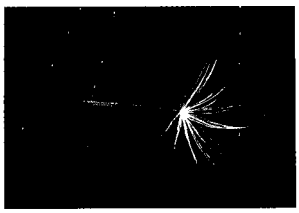
Many other fruits do not open to release their seeds. They are called indehiscent fruits and the whole fruit is carried away by wind, animals, or water (see INDEHISCENCE). Wind-dispersed fruits include those of dandelions and many grasses, which have fluffy outgrowths to keep them aloft like parachutes. Grass seeds have been seen drifting more than 3,300 ft. [1,000 m] above the ground. The fruits of ash, maple, and elm all have winglike outgrowths that keep them aloft for a time after they fall from the trees.

The coconut is dispersed by water. It has a light, waterproof outer covering and floats easily on the sea. Shortly after a new island was formed by an underwater volcano in the Pacific Ocean, coconut palms were found growing on its shores. The coconut seed germinates inside the fruit and eventually bursts through to the outside. The same

DRIFTING COCONUTS

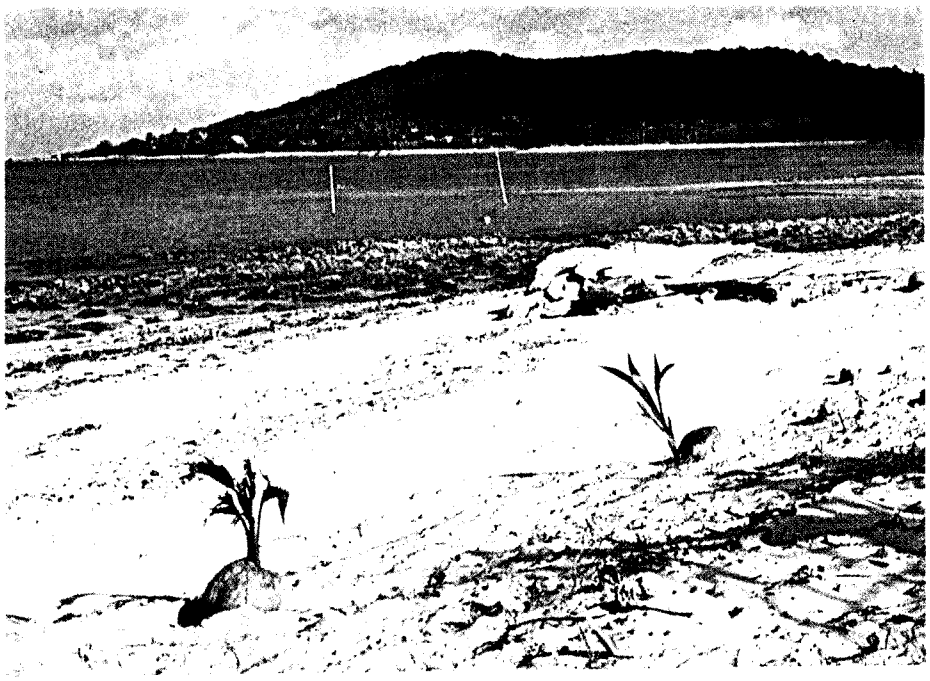
Many tropical beaches are fringed with coconut palms. The fruits can drift all over the ocean and then germinate quickly when washed up on warm, sandy shores.





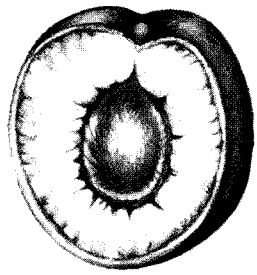
WINGS AND PARACHUTES

"Wings" enable the maple fruit to drift far from the parent tree before coming to land (top). The "parachute" of the dandelion (above) does the same job and can carry the fruit for many miles.



thing happens with the wind-dispersed indehiscent fruits already mentioned (see GERMINATION).

Fruits and seeds can be dispersed by animals in several ways. Some fruits have burrs or hooks that attach to fur (or the clothing of humans). They can be carried great distances before falling off. Some seeds are enclosed in juicy, tasty fruits that are attractive to birds and other animals. When a bird or other animal eats these fruits, some seed may stick to its feet, mouth, or body and may then be carried away. Even when the seeds are swallowed, they are not affected by the digestive system. The seeds are then passed out of the body in the feces. The seeds of many plants, such as grape, mulberry, pear, and others, are dispersed this way. Seeds of clover and cereal crops are often dispersed by grazing animals, such as cattle and sheep. Human beings often disperse seeds by discarding apple cores, peach pits, and other inedible parts from juicy fruits. People frequently and unknowingly carry seeds great distances by airplane, automobile, or boat. The seeds may be hidden in clothing or baggage. Many other seeds travel around the world on wool, timber, and other commercial products.

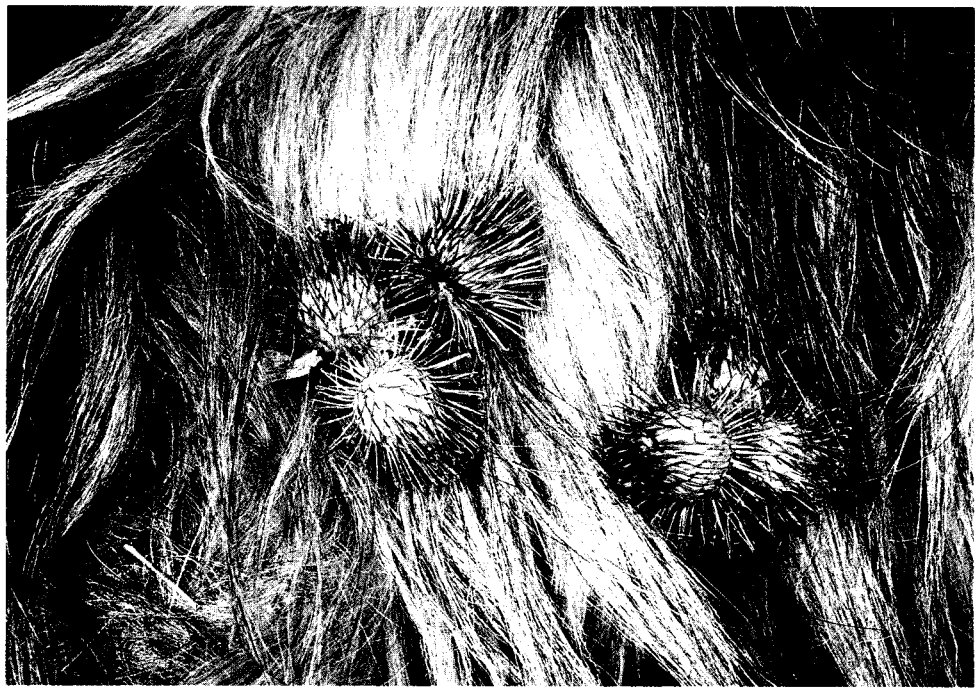


PLUM FRUIT SEEDS

Juicy fruits like this plum attract birds, which eat the flesh of the fruit and scatter the stony pits containing the seeds.

SEEDS CARRIED BY BIRDS

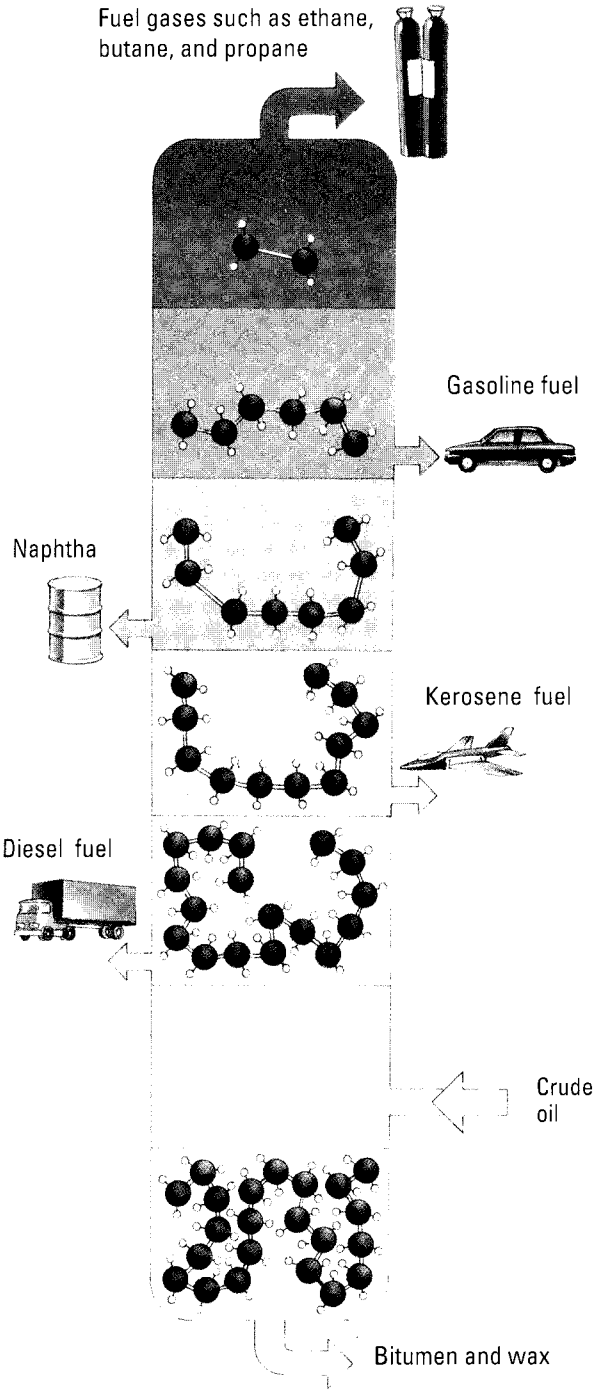
This waxwing is eating a rosehip containing many small seeds. The bird cannot digest the hard seeds, so they pass out with its droppings, often a long way from the parent plant.



SEEDS THAT TRAVEL ON ANIMALS

The hooked burdock fruits or burrs clinging to this dog's fur are full of seeds that will gradually fall out as the dog moves about.

DISTILLATION Distillation is a process that is used to separate liquids from solids or from other liquids. It is also used to purify a liquid. It works because liquids boil at different temperatures. The mixture is heated and vapor from the liquid rises to the top of the apparatus and is condensed to its liquid form (see CONDENSATION). There are three main types of distillation: simple distillation, fractional distillation, and destructive distillation.



DISTILLATION
Crude oil is converted into a variety of more useful materials by distilling it in a fractionating tower. The oil is heated by steam to make it evaporate. The vapor rises through bubble caps at each level of the tower and condenses into a liquid. The lightest materials, such as gasoline, come from near the top of the tower. Heavier materials, such as wax and diesel oil, come from near the bottom.

Simple distillation is used to obtain a pure solvent (a substance that dissolves another substance) from a solution (see SOLUTION AND SOLUBILITY). The solution is boiled, and the vapor that condenses consists of the pure solvent. Distilled water is obtained in this way (see VAPOR).

In fractional distillation, a mixture of liquids is separated in order to obtain each liquid. The liquid mixture is heated to the temperature at which one of the liquids boils. The resulting vapor is cooled until it condenses to give one pure liquid. This process is repeated until all the liquids in the mixture have been separated. A water-alcohol mixture is subjected to fractional distillation when making distilled liquors, such as whiskey. Fractional distillation is an important procedure in the refinement of petroleum, as well (see PETROLEUM).

In destructive distillation, solid substances are heated without air, and the resulting vapors are condensed. This method of distillation is used to make charcoal. A carbon-rich substance, such as wood, is placed in an airtight oven. It is heated so that the hydrogen, nitrogen, and oxygen are removed. The black substance remaining at the end of the process is charcoal.

See also CHARCOAL; COKE; SEPARATION. PROJECT 9

DIURETIC (dī'ə rĕt'ĭk) A diuretic is a chemical that causes an increase in the amount of urine released from the kidneys (see KIDNEY; URINE). Many natural substances are diuretics, such as tea and coffee. Diuretic drugs are prescribed by doctors for conditions that cause more fluid to be held in the body than is normal. This is called edema. Edema can be present on its own or because of high blood pressure (hypertension) due to heart disease, kidney disease, or respiratory disease (see HEART DISEASE; KIDNEY; RESPIRATORY DISEASE). Diuretics reduce the swelling and hypertension by increasing the fluid output from the kidneys.

Some diuretics cause salts to be lost with the

fluid output, which affects the amount of salts in the blood. Diuretics also can cause fluid to drain from body areas such as the eyeball or spinal cord. Doctors may prescribe diuretics to relieve pressure, produced by the edema, in these areas. However, too much salt loss can be harmful, so extra salts may be prescribed with the diuretic.

DIVING Diving is the way that people enter the underwater world. For thousands of years, people have explored oceans, lakes, and rivers by short dives beneath the surface. Today, underwater breathing devices allow people to stay beneath the surface for long periods of time.

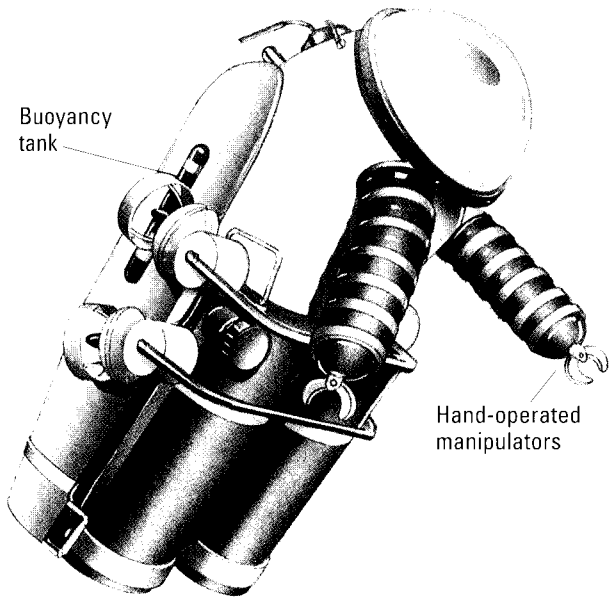
For centuries, divers have been using breathing tubes. The top of a breathing tube, now called a snorkel, remains above the water. This allows divers who are just below the surface of the water to breathe in air. Another method of staying underwater involves being lowered under the water in a watertight metal container. The trapped air inside the container allows the diver to breathe.

Both of these diving techniques are still used today. Some improvements have been made on the watertight container method. The container, now called a diving bell, has compressed air pumped in from above the surface. The diving bell is of limited use because divers can reach objects below them but not above them.

Diving suits are used by some divers because they reduce the loss of body heat and allow the diver to stay underwater for longer periods. The helmet diving suit consists of a copper helmet attached to a waterproof suit. Air is pumped from the surface through a tube. Even though the diver wears weighted boots to keep upright, movement is restricted and clumsy.

Scuba divers can spend the most time underwater. *Scuba* stands for "self-contained underwater

DIVING—Photography
Waterproof cameras allow divers to take underwater photographs. Some of these cameras have special flash units and pressurized cases so that they can be used at great depths.



DIVING—Atmospheric diving suit
An atmospheric diving suit allows a diver to go deeper and stay down longer. The rigid suit, which has its own air supply, totally encases the diver, who breathes air at normal pressure.

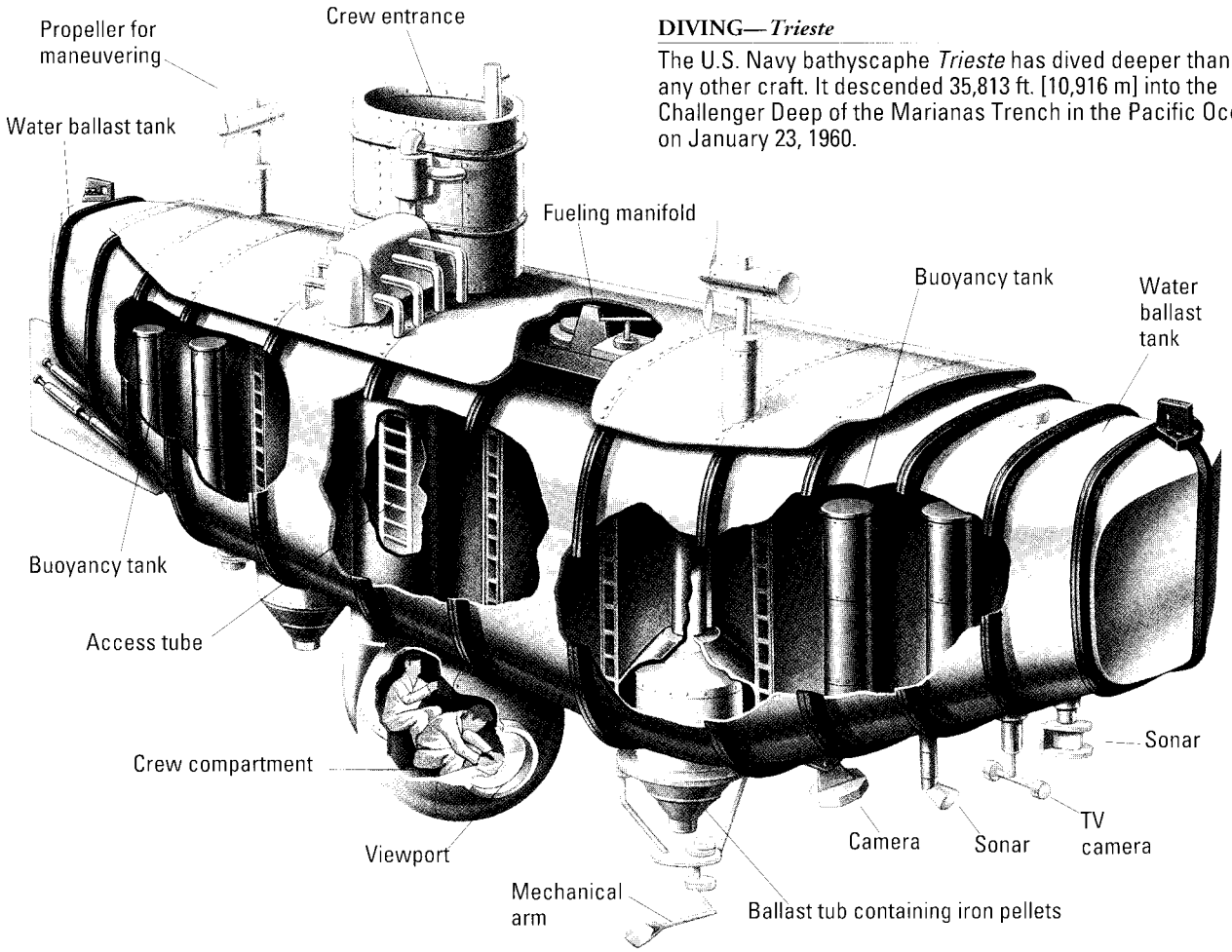
breathing apparatus." Scuba divers have a tank of compressed air on their back and breathe the air through a mouthpiece. They also wear flippers on their feet to help them swim, and a facemask to see more clearly.

Divers avoid coming up to the surface quickly because of a condition called caisson disease, or the bends. If a diver surfaces too quickly, the reduced water pressure causes nitrogen bubbles to form in his or her bloodstream. This results in horrible pain, paralysis, and sometimes death. By coming to the surface slowly, divers can avoid this condition.

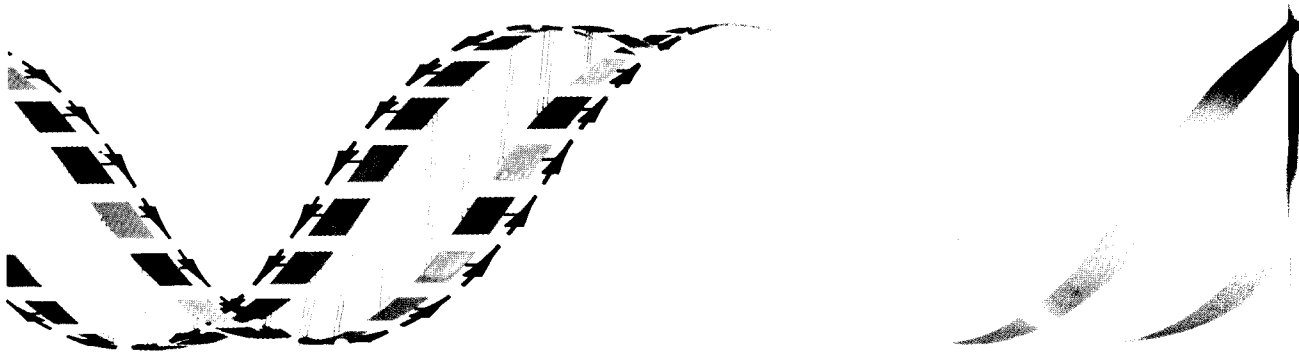
Divers do many important jobs. For example, they are needed for the construction and repair of oil rigs. They also study plant and animal life beneath the surface. Diving is also a sport that almost everybody, regardless of age, can enjoy.

See also BATHYSPHERE AND BATHYSCAPHE; CAISSON DISEASE; COUSTEAU, JACQUES-YVES.

DIVING—*Trieste*
The U.S. Navy bathyscaphe *Trieste* has dived deeper than any other craft. It descended 35,813 ft. [10,916 m] into the Challenger Deep of the Marianas Trench in the Pacific Ocean on January 23, 1960.



DNA

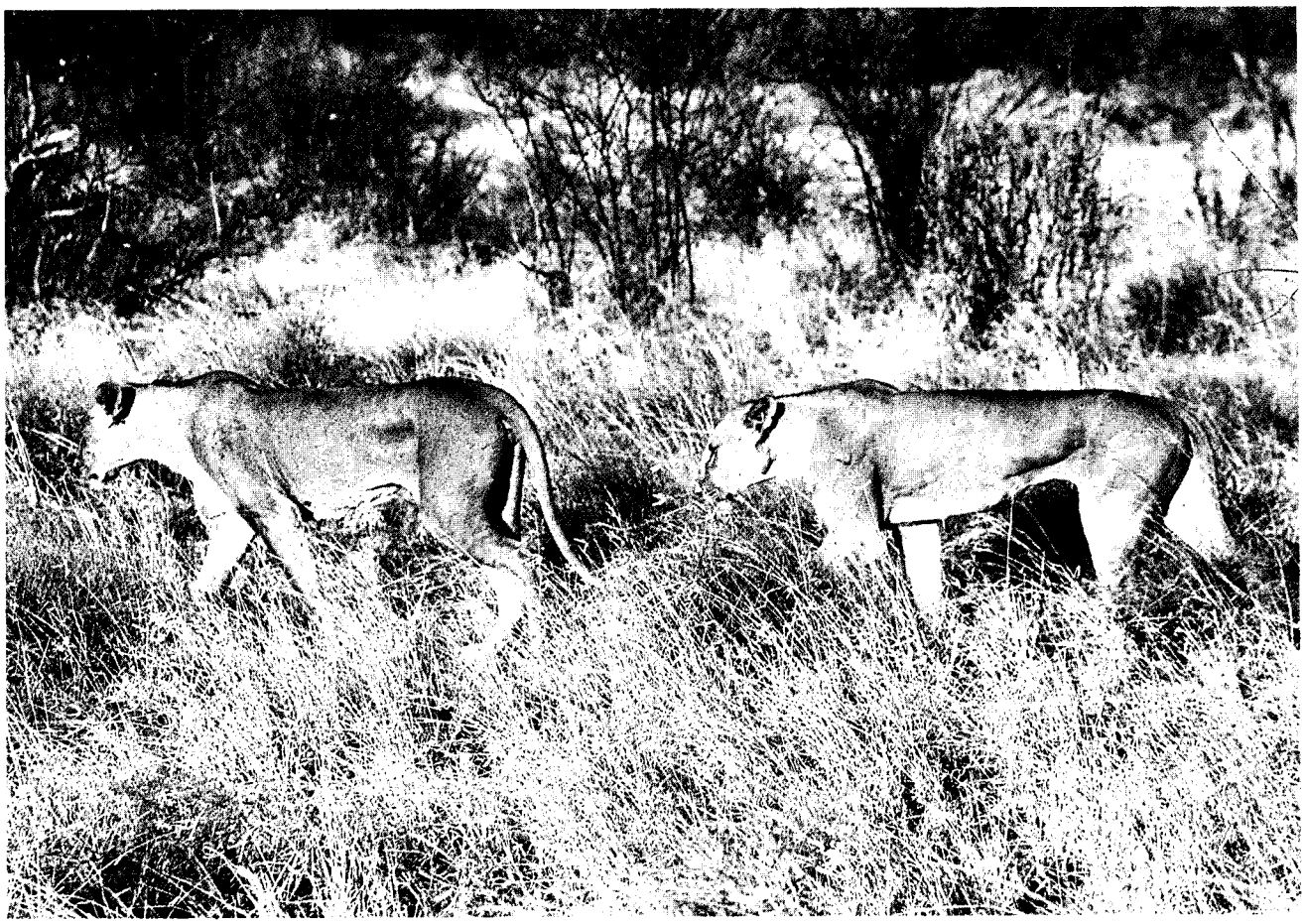


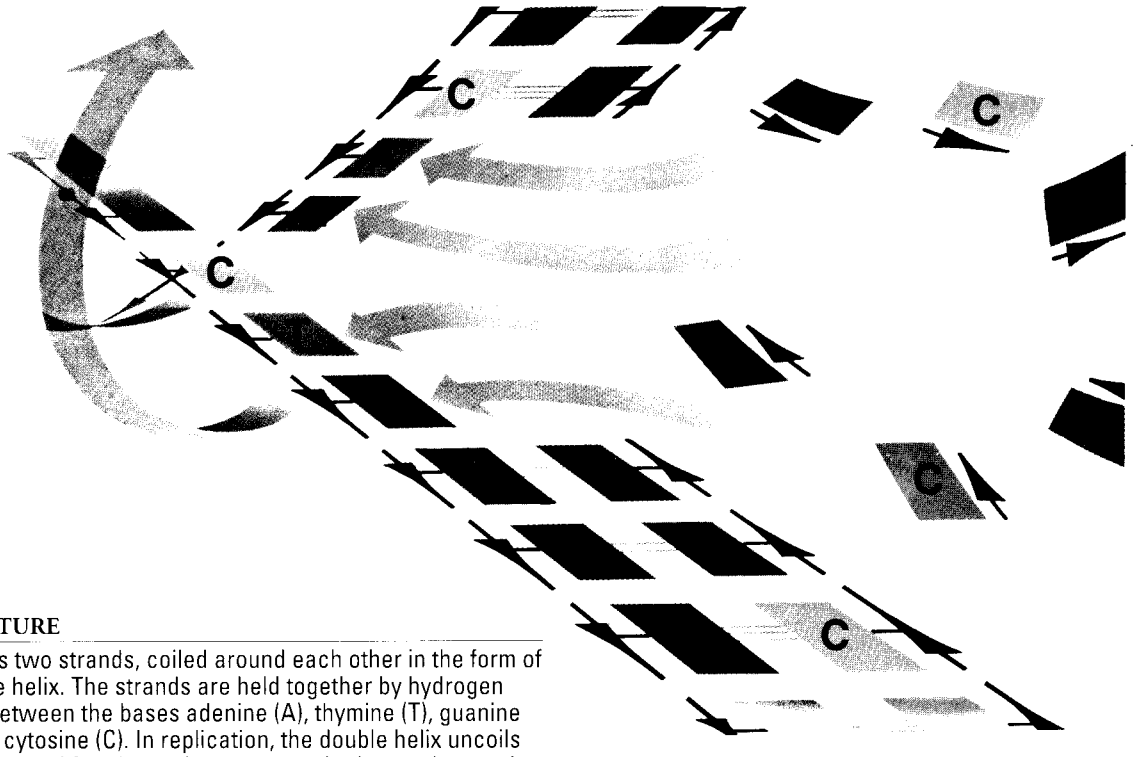
The initials *DNA* stand for deoxyribonucleic acid. DNA is the carrier of genetic information in cells. DNA forms genes. Genes are located on the chromosomes of cell nuclei (plural of *nucleus)* and in certain cell organelles, such as mitochondria. DNA also occurs in some viruses (see CELL; CHROMOSOME; GENE; VIRUS).

DNA is a nucleic acid (see NUCLEIC ACID). A nucleic acid is made of chains of units called nucleotides. Each nucleotide in DNA contains phosphate (a salt of phosphoric acid), a sugar called deoxyribose, and compounds called bases (see BASE). There are two main kinds of bases in DNA: purines and pyrimidines. There are two kinds of purine bases: adenine (A) and guanine (G). There

SPECIFIC DNA

DNA has been called the "blueprint of life." All cells contain chromosomes, which control inheritance, made up of DNA. All animals, from lice to lions (below), have their own specific DNA. So do grapes, grasses, and all other plants.





STRUCTURE

DNA has two strands, coiled around each other in the form of a double helix. The strands are held together by hydrogen bonds between the bases adenine (A), thymine (T), guanine (G), and cytosine (C). In replication, the double helix uncoils and splits, and free bases become attached to each strand as shown, to make new DNA.

are also two kinds of pyrimidine bases: cytosine (C) and thymine (T).

Two long nucleotide chains coil around each other to form the DNA molecule. This coiled structure is known as a double helix. A double helix resembles a circular staircase or a twisted ladder. The sides of the DNA "ladder" consist of alternating sugar (deoxyribose) and phosphate molecules. Each "rung" of the DNA ladder consists of a purine base connected to a pyrimidine base.

Only certain combinations of purine and pyrimidine bases may occur in DNA. Adenine (A) can only combine with thymine (T), while guanine (G) can only combine with cytosine (C). Any other combination does not work. Therefore, the rungs of the DNA ladder can be any of four combinations: A-T, G-C, T-A, and C-G. There are hundreds of these combinations in every gene. The sequence, or order, in which they appear on the double helix determines the genetic information of the cell.

When a cell divides, this genetic information is passed on by the DNA replicating, or reproducing, itself. In replication, the double helix uncoils and splits along its center. So-called free purine and pyrimidine bases from within the cell nucleus connect with the appropriate bases on the original chains. Again, the only possible combinations are A-T, G-C, T-A, and C-G. Sugar and phosphate from the cell form a second side for each new ladder. In this way, two new identical DNA molecules are formed. Each molecule then coils into the double helix structure.

In recent years, new forms of DNA have been created in laboratories through genetic engineering. Genetic engineers split DNA crosswise at the point where certain bases connect. One part of the split DNA is then combined with DNA from another organism that has also been split crosswise. The bases of the two DNAs combine. This new DNA is called recombinant DNA. It can then be inserted into an organism. The organism will then have characteristics from both DNAs. Scientists have also used recombinant DNA to create artificial hormones, such as insulin.

See also BREEDING; GENETICS; HORMONE; INSULIN; RNA.

DOCTOR A doctor is a person who has successfully completed an extensive program of advanced study at a college or university. The degree of "doctor" is the most advanced degree awarded in many fields. For example, scientists may hold a doctoral degree (Ph.D.) in specialized areas, such as biochemistry, microbiology, or physics. The training includes extensive coursework beyond the four-year college education and the completion of a significant research project. The research is defended orally before a committee of experts and submitted in written form as a thesis or dissertation. In medical fields, the major degrees are in medicine (M.D.), dental surgery (D.D.S.), dental medicine (D.M.D.), and veterinary medicine (D.V.M.).

DOCTOR
A doctor examines a young patient using a stethoscope (an instrument used for listening to internal bodily sounds).

DODO The dodo was a large, flightless bird that is now extinct (see EXTINCTION). The dodo was about the size of a turkey and had a large beak, short legs, and small wings. It lived on the island of Mauritius in the Indian Ocean. Until European sailors arrived in the 1500s, the dodo had no enemies. Because it was so clumsy and had no fear, the dodo was easily captured and killed for food. Animals, such as dogs and rats, arrived with the sailors and destroyed many dodo eggs. With no defenses, the dodo was soon endangered and by 1681 was extinct.

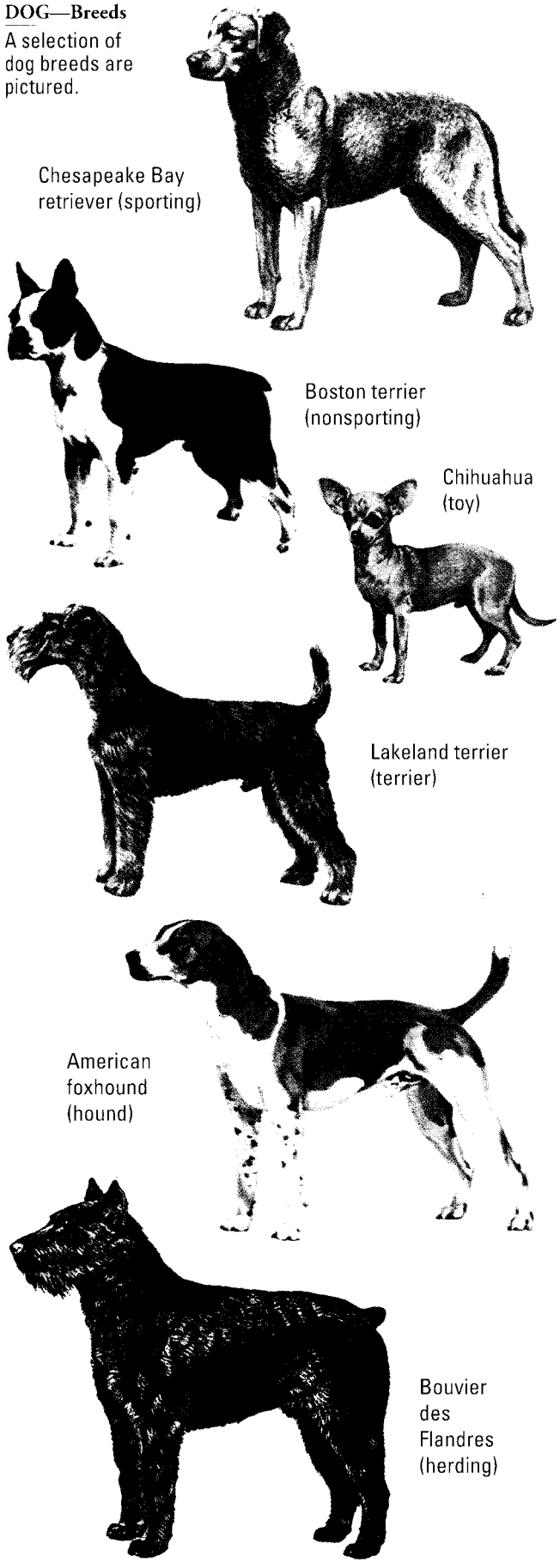
See also BIRD.

DODO
The dodo was a turkey-sized relative of today's pigeons. The last one is thought to have died in about 1681. Biologists estimate that another eighty species of birds have become extinct since then, mostly as a result of hunting and loss of habitat.

DOG The dog is a carnivorous (meat-eating) mammal that was probably the first animal to be domesticated (see MAMMAL). Dogs can be trained as hunters, guards, livestock herders, guides for people who are blind or deaf, and, most frequently, as pets. The domesticated dog of today probably descended mostly from the wolf. Bones show that dogs lived with prehistoric people at least twenty thousand years ago.

There are many different breeds of dogs. Some dogs, called crossbreds, have known parents of two different breeds. Others, called mongrels or mutts, cannot be recognized as being from any particular breed. Purebreds are dogs with a father (sire) and a

DOG—Puppy
Puppies are blind when they are born, but their eyes open after a few days and they soon become very playful.



DOG—Breeds
A selection of dog breeds are pictured.

mother (dam) of the same breed. The American Kennel Club recognizes over one hundred pure breeds of dogs. These are divided into seven different groups—sporting dogs, hounds, terriers, working dogs, herding dogs, toy dogs, and non-sporting dogs.

Even the tamest dog has many of the instincts of its wild cousins and ancestors. There are several types of wild dogs, which usually roam in packs. These include the coyote, dingo, jackal, and wolf (see COYOTE; DINGO; JACKAL; WOLF).

Dogs vary widely in appearance and size. For example, the Chihuahua is the smallest dog. It is only 4 in. [10 cm] tall at the shoulder and weighs 1.1 lb. [0.5 kg]. The Irish wolfhound is the tallest of all dogs. It is 3 ft. [90 cm] tall at the shoulder and weighs 130 lb. [59 kg]. The St. Bernard, which weighs 220 lb. [100 kg] and stands 2 1/2 ft. [76 cm] tall, is the heaviest of all dogs.

Most dogs have an outer coat of hair to protect them from snow and rain, and an inner, fluffy coat for warmth. The inner coat grows thick in the winter and is usually shed in the summer. Some dogs are hairless. Most dogs have strong, muscular legs with five claws on the front paws and four claws on the hind paws. They have two large, stabbing eye-teeth in each jaw, used for tearing meat. A dog drinks by lapping liquid into its mouth with its tongue.

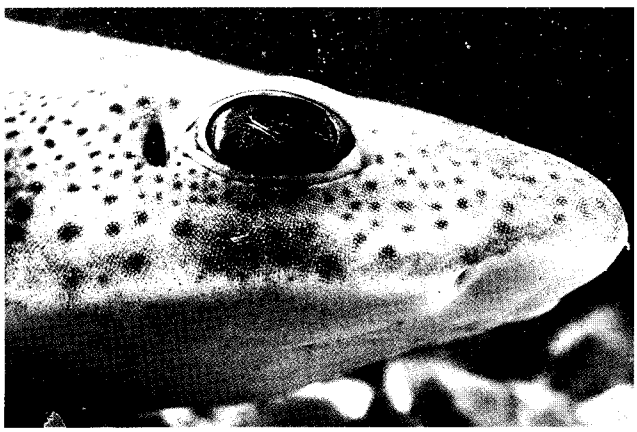
Dogs are color-blind but otherwise have good eyesight (see COLOR BLINDNESS). They also have good hearing and an excellent sense of smell. Dogs lick their noses to keep them moist. This helps them detect odors. Contrary to popular belief, a warm, dry nose does not mean the dog is sick. A dog can turn its ears to "catch" sounds that may be too faint or too high a frequency for a human being to hear. A dog's normal body temperature is about 101°F [38°C]. Its heart beats irregularly, at 70 to 120 times per minute. When overheated or excited, a dog pants in order to cool off its body. It loses heat from its tongue and the lining of its mouth. Although dogs rarely perspire, they do have sweat glands on their noses and feet.

A female dog mates only when she is in heat, a state of sexual readiness that lasts for about two

weeks every six months. This is the only time a female dog can become pregnant. After mating, the female is pregnant for about nine weeks before giving birth to a litter of one to twelve puppies. She then feeds her puppies milk for four or five weeks. Most dogs live to be twelve or thirteen years old, though some live to be eighteen or twenty.

DOGFISH A dogfish is a small shark found in shallow, coastal waters in most oceans. There are eight species in North America. Dogfish grow to 4 ft. [1.2 m] in length. They are dark gray above and pale gray to white below and have very rough skin. Dogfish eat small fishes and invertebrates (animals without backbones).

See also SHARK.



DOGFISH

This European lesser-spotted dogfish shows the rough skin found in this group of fishes.

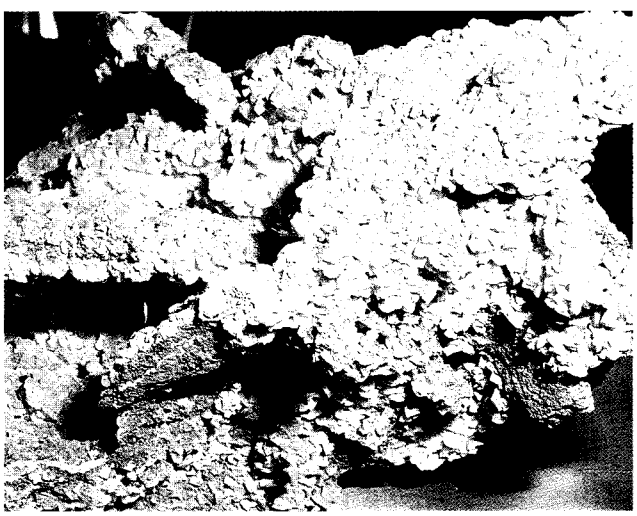
DOGWOOD Dogwoods are trees belonging to the family Cornaceae. Several species grow wild in North America. The Pacific dogwood is a magnificent tree up to about 100 ft. [30 m] high, but most of the others are quite small, short-lived trees. They include the alternate-leaved dogwood, the rough-leaf dogwood, and the flowering dogwood. The latter has beautiful clusters of pink or white flowers in the spring and is a popular tree for parks and gardens. Plant breeders have also produced many lovely hybrids for growing in gardens. Dogwoods have shiny red or black berries that ripen in the fall and provide food for many birds. The leaves also take on brilliant colors in the fall, and some dogwoods have brightly colored twigs as well.

DOGWOOD

Flowering dogwood, with several large-flowered cultivated varieties, is a popular garden shrub. It also has fine foliage in the fall.

DOLOMITE (dŏl'ə mīt') Dolomite is a mineral consisting of calcium carbonate and magnesium carbonate. Dolomite is the main source of the magnesium obtained from the earth's crust (see MAGNESIUM). Pure dolomite varies in shades from white to yellow. Impurities, such as manganese or iron, may give dolomite a pink or brown color. Because of its luster, dolomite is sometimes called pearl spar.

The term *dolomite* also refers to rock consisting chiefly of dolomite. Much dolomite rock contains fragments of fossils. Many mountain ranges in Europe, such as the Dolomite Alps, have great masses of dolomite rock. The rock also exists in various parts of the United States.



DOLOMITE

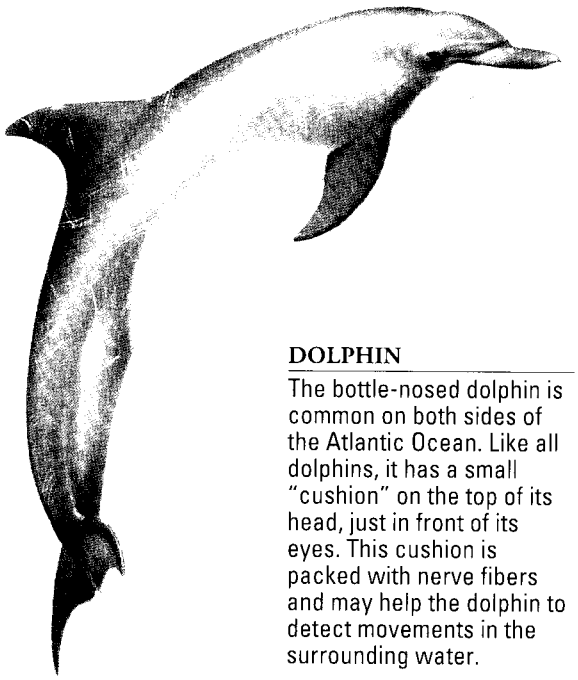
The mineral dolomite is named for the French chemist Dolomieu, 1750–1801, who first studied its properties.

Dolomite is used in industry by iron and steel manufacturers. They use it in the smelting process (see SMELTING). Finely ground dolomite is used as a filler in rubber, putty, and paint. Marble made of dolomite crystals may have unusual colors. It is sometimes used as a building material. Dolomite is also an important source of lime. Farmers use lime to neutralize soil and help their plants grow.

DOLPHIN The dolphin is a mammal that lives in all of the oceans and in some rivers. Dolphins are toothed whales (see WHALE) belonging to several families. There are about 50 species and they feed mainly on fish. The dolphin has a blowhole at the top of its head through which it breathes. As it blows air through its blowhole, it can make sounds that include whistles, clicks, and yelps. Scientists believe that dolphins communicate with each other by making these different sounds. People have tried to communicate with them but have not been successful.

Scientists believe the dolphin is one of the most intelligent of animals. The bottle-nosed dolphin has sharp vision, excellent hearing, and a good sense of taste. It is different from other mammals in that it has no sense of smell.

Two of the most common dolphins are the bottle-nosed dolphin and the common dolphin. Bottle-nosed dolphins are the kind that can be seen in aquariums. They learn tricks that they perform for audiences, such as leaping high into the air to get a fish from a trainer's hand. They are extremely fast swimmers and can make sharp turns and sudden stops.



DOLPHIN
The bottle-nosed dolphin is common on both sides of the Atlantic Ocean. Like all dolphins, it has a small "cushion" on the top of its head, just in front of its eyes. This cushion is packed with nerve fibers and may help the dolphin to detect movements in the surrounding water.

The bottle-nosed dolphin grows to 13 ft. [4 m] in length and weighs as much as 880 lb. [400 kg]. It is grayish in color, and its back is darker than its belly.

The common dolphin lives in temperate and warm ocean waters all over the world. It can grow to a length of 7 ft. [2.1 m] or more. It can weigh over 220 lb. [100 kg], although most adults weigh much less than this. The common dolphin is black on its back and white underneath. It has gray and brown markings on its sides.

Often, large groups of dolphins play around ships. For hundreds of years, sailors believed that their presence meant that the voyage would be a smooth one.

See also PORPOISE.

DOMINANCE *Dominance* has three meanings in biology. In heredity, genes controlling inherited characteristics are received from both parents. A dominant characteristic shows up in the offspring if the gene for that characteristic is dominant. A dominant gene produces a dominant characteristic regardless of whether it is combined with another dominant gene or with a recessive gene. For example, the gene for brown eyes (B) is dominant over the recessive gene for blue eyes (b). A person with brown eyes can have either one or two dominant "brown eye" genes (Bb or BB). A person with blue eyes, however, must have two recessive "blue eye" genes (bb). An offspring from two blue-eyed parents will almost always have blue eyes because neither parent has the dominant "brown eye" gene. An offspring from two brown-eyed parents, or one brown-eyed and one blue-eyed parent, can have either brown or blue eyes, but is most likely to have brown eyes (see GENE; GENETICS; HEREDITY).

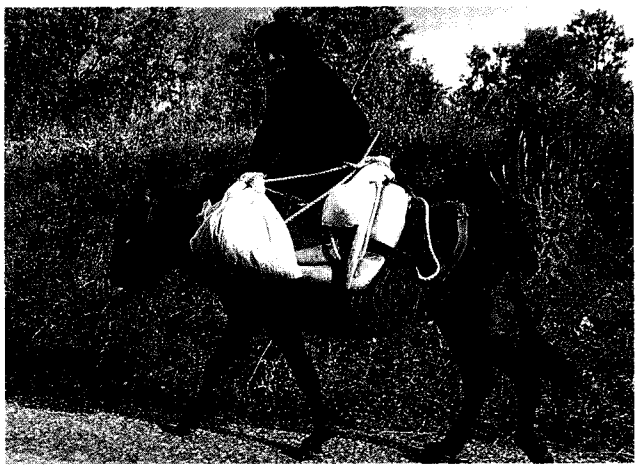
In ecology, the dominant species in a particular community is the most prominent species, controlling to a great extent the other species there. For example, pine trees are dominant in many northern

forests. Animals often establish dominance in a certain area, protecting their territory from any potential invaders. For example, a dog may establish its territory as its master's yard and will attack other dogs in its territory. It will not, however, bother animals in surrounding territories or yards.

Within a species, animals often fight to establish leadership and a dominance hierarchy, or pecking order. In a dominance hierarchy, the dominants have their choice of food, mates, and shelter. The other animals, called subordinates, must accept whatever is left. Once the dominance hierarchy has been established, a subordinate rarely challenges a dominant. A dominance hierarchy helps reduce fighting within a group of animals of the same species and helps set definite duties for each member of that group.

Evolutionary change, or natural selection, is also a result of dominance (see EVOLUTION). According to the concept of survival of the fittest, when an environment cannot support large numbers of a given species, only the best or fittest specimens of that species, the dominants, will survive.

DONKEY The donkey is a horselike mammal descended from the wild ass of Ethiopia and northern Africa (see ASS; MAMMAL). This sure-footed animal stands about 4 ft. [1.2 m] at the shoulder and usually has gray or brown hair. First trained several thousand years ago, the domesticated donkey is used for riding, carrying loads, or pulling carts.



DONKEY
The donkey is still widely used for carrying loads in Greece and other Mediterranean countries.

The donkey is well suited for hot, dry climates such as those in southern Europe and Asia and northern Africa. Donkeys were first introduced into the United States in 1848. If a male donkey (jack) mates with a female horse, the offspring will be a mule. If a female donkey (jenny) mates with a male horse, the offspring will be a hinny. Burros are small donkeys often used as pack animals.

DOPPLER EFFECT The Doppler effect is the apparent change in frequency of sound, light, or radio waves caused by motion. For example, when an approaching train blows its whistle, the pitch of the whistle seems higher as the train comes toward you. The pitch seems lower when the train passes and goes away from you. The actual pitch of the sound remains the same. The cause of this effect was first studied in 1842 by Christian Doppler, an Austrian physicist.

To understand the Doppler effect, it is necessary to know that sound travels in waves. The pitch of a sound depends on its frequency. Frequency can be thought of as the number of sound waves striking the ear each second. When the source of sound is approaching, each wave sent out by the source has a shorter distance to travel than the wave that was sent out previously. Each wave reaches the listener a little sooner than it would have if the source had not been moving. The waves seem to have a higher frequency and thus a higher pitch. As the train moves away, each wave starts a little farther away and so seems to have a lower frequency, or pitch.

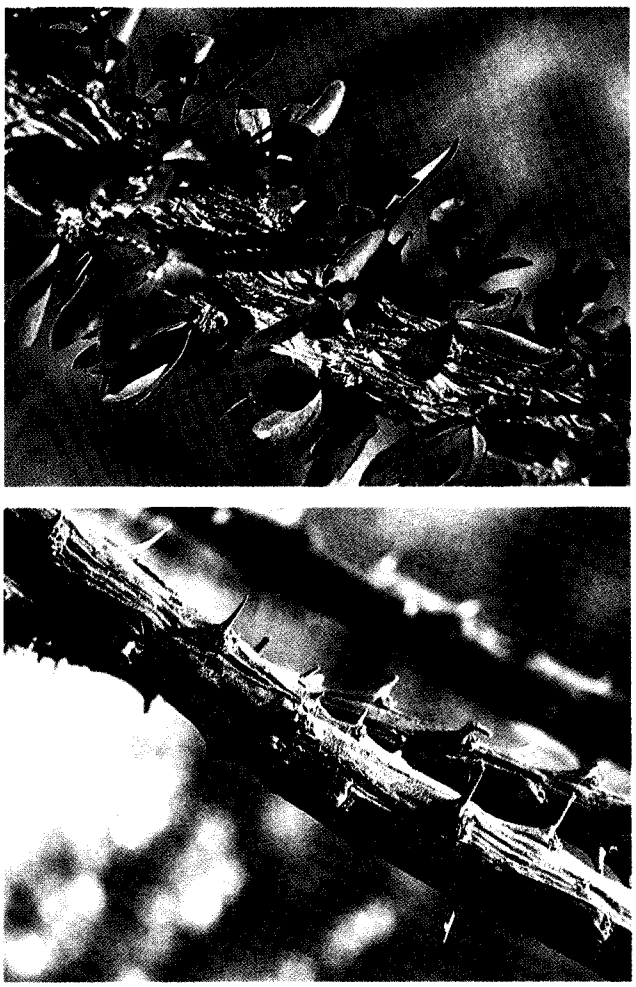
The same thing happens with any other wave motion. Astronomers study the motion of a star by measuring the apparent change in the frequency of light waves due to motion.

See also RADAR; RED SHIFT; SOUND; SPECTRUM.

DORMANCY Dormancy is a state of rest or inactivity in living things that is marked by greatly reduced metabolic activity (see METABOLISM). Dormancy usually occurs during or just before periods of unfavorable environmental conditions, such as a cold season. In temperate regions, most amphibians and reptiles and many other animals become dormant or hibernate during the winter

(see HIBERNATION). Most insects have a dormant stage in their development (see METAMORPHOSIS). Many shrubs and trees lose their leaves in the fall and remain dormant until the spring, when new buds begin to form (see DECIDUOUS TREE). Many fruit trees require long periods of dormancy before they can bear fruit. Biennial and perennial herbaceous plants lose their stems in the fall, with the roots remaining dormant through the winter (see HERBACEOUS PLANT). The seeds of many plants are dormant for several months, usually during the winter, until environmental conditions are favorable for germination. Some seeds have survived dormancies of more than one thousand years. The delay in the growth of an embryo plant during its dormancy is called "after ripening." Some bacteria and members of the kingdom Protista form a thick, protective coat and remain inactive during unfavorable times.

If there is a sudden, unexpected, and unusual change in environmental conditions, the dormancy of an organism may be broken. When conditions return to normal, the organism may not be able to survive. For example, if there is a midwinter thaw, many trees will begin to form buds. When temperatures return to normal, subfreezing levels, the buds will die. As a result, the trees will produce few, if any, leaves and may not survive the following growing season.



DORMANCY

The ocotillo grows in the deserts of North America. It puts out its leaves after rain (top), but at the first hint of drought the leaves all fall and the plant remains dormant until the next rains arrive (bottom). Its spiky stems make the ocotillo a popular hedging plant.

DORMOUSE (dôr'mous') The dormouse is a small rodent with a long and often very bushy tail (see RODENT). It is not a true mouse. Several species live in Europe and Asia and in parts of Africa. The largest species is the edible dormouse, also called the glis-glis. It is about 12 in. [30 cm] long, including its bushy tail. It was a favorite food in Roman times. The Romans used to keep the animals in earthenware jars and fatten them up before eating them. Dormice feed mainly on fruits and seeds, but also nibble buds and bark. They are sometimes pests in orchards. They feed at night. In the fall the dormice go into a long sleep or hibernation and do not wake up until the spring.

See also HIBERNATION.

DORMOUSE

The edible dormouse looks like a small gray squirrel. It lives in Europe and western Asia.

DOS The disk operating system (DOS) is a computer program that manages the operation of all parts of the computer. It is called a disk operating system because many of its tasks involve using the computer's disk drive. The DOS transfers information from a floppy disk or a hard disk into the computer's memory, or from the memory to the disk. It also accepts instructions given to the computer by a person who presses keys on the keyboard. Computer programs, such as word processing or games, have to be loaded into the computer's memory each time they are needed. The DOS remains in the computer's memory all the time, however, even when the computer is switched off. Programs that are loaded into the computer's memory cannot work without the DOS because they depend on it to do all the most basic jobs within the computer.
See also COMPUTER.

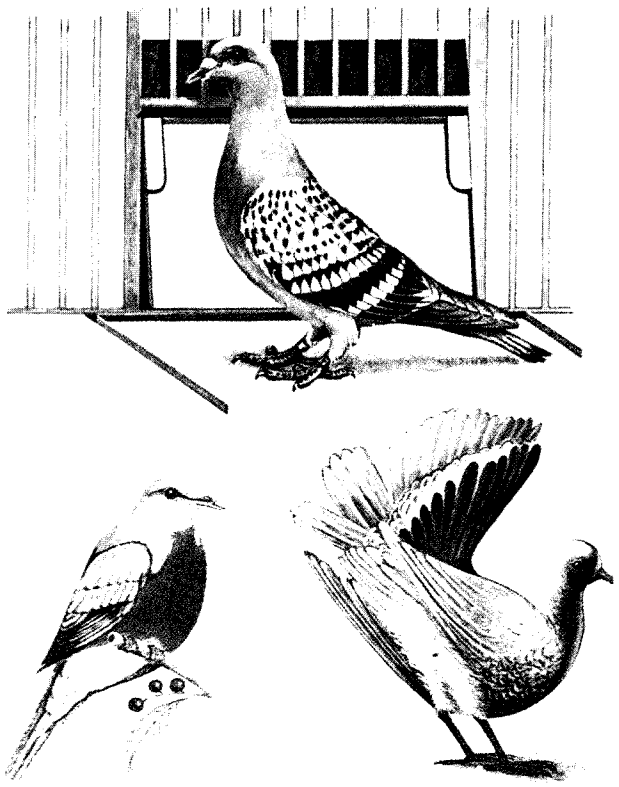
DOUGLAS FIR The Douglas fir is one of the largest and most valuable conifers in the world. Native to western North America, this member of the pine family may reach a height of 330 ft. [100 m] with a trunk 6 ft. [1.8 m] in diameter. It has soft, flat needles about 1 in. [2.5 cm] long and seed-filled cones up to 4 in. [10 cm] long. The Douglas fir provides most of the lumber used in North America.
See also CONIFER; FIR; PINE FAMILY.

DOVE AND PIGEON The dove and the pigeon are members of the same family, Columbidae. There are about 300 species. They have well-developed flight muscles and can fly fast. The largest is about 25 in. [63 cm] long. Doves are generally smaller than pigeons.

Doves and pigeons eat fruit and seeds and some eat leaves. Some species are serious farm pests. They feed their young with a milky secretion from the lining of the crop (see CROP).

Doves and pigeons have always been a source of food for people, and they have also been kept as pets. People started to keep the European rock dove in captivity a very long time ago and many different breeds have been produced. Some of them have

DOUGLAS FIR
The tall, straight trunks of the Douglas fir yield strong, durable, and very valuable building timbers.



DOVE AND PIGEON
Pictured are a carrier pigeon (top), a fruit pigeon (above left), and a fantail pigeon (above right).

very unusual shapes and colors and the breeders, often called pigeon fanciers, display them proudly at shows. Carrier pigeons have been used to carry messages, especially in wartime, and many people now keep racing pigeons. These are specially trained to find their way home from distant places. The first one home is the winner. Many birds have escaped from captivity over the years and they have given rise to the town pigeons that now live in towns and cities all over the world.

See also BIRD.

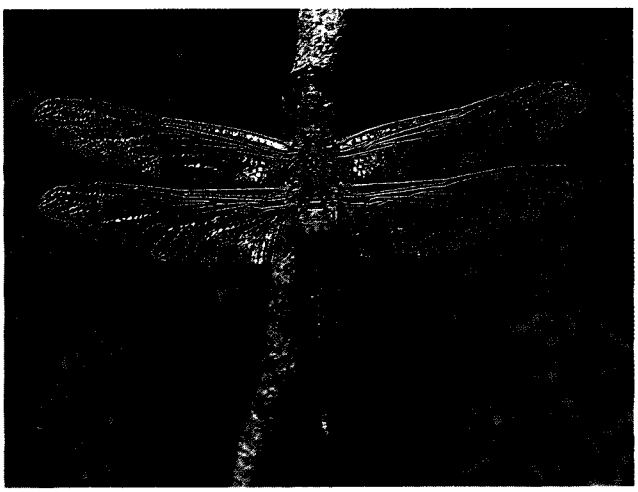
DRAG Drag is the resistance force that affects an object when it moves through a fluid (liquid or gas). The drag slows the object. Drag increases rapidly as speed increases. If the speed doubles, the drag increases by four times.

The drag that affects an aircraft moving through the air causes a great waste of power and fuel, so aircraft are streamlined (smoothly shaped) to reduce drag (see POWER). Cars are also streamlined to reduce drag. Boats are streamlined to reduce the drag of the water they move through. The fastest boats are hydrofoils (see HYDROFOIL). The hull of a hydrofoil lifts out of the water when it moves, which greatly reduces drag. Sometimes drag can be useful. Spacecraft, such as the space shuttle, are slowed by the drag of the air when they re-enter the atmosphere.

DRAG COEFFICIENT (drăg kō′ə fĭsh′ənt) The total drag force that affects a car depends on its speed, the car's front area, and a number, or coefficient, called the drag coefficient (Cd). A small front area and a low drag coefficient help reduce drag.

If air flows easily around a car and does not resist the car's movement too much, there is not a lot of drag and the car has a low Cd. If it is difficult for the air to flow around the car, there is a lot of drag and the car has a high Cd. Car producers try to lessen the drag on cars to reduce slowness and save fuel. They do this by manufacturing cars with a smooth underside and a smooth, rounded front.

DRAGONFLY Dragonflies are slender, long-bodied insects belonging to the order Odonata. The adult has four large, glassy wings with a network of supporting veins. The wingspan of dragonflies ranges from 1.5 to 7.2 in. [4 to 18 cm]. The head is large and is occupied almost entirely by compound eyes (see EYE AND VISION). The antennae are small, and the dragonfly relies mostly on sight to find prey (see ANTENNAE). The dragonfly

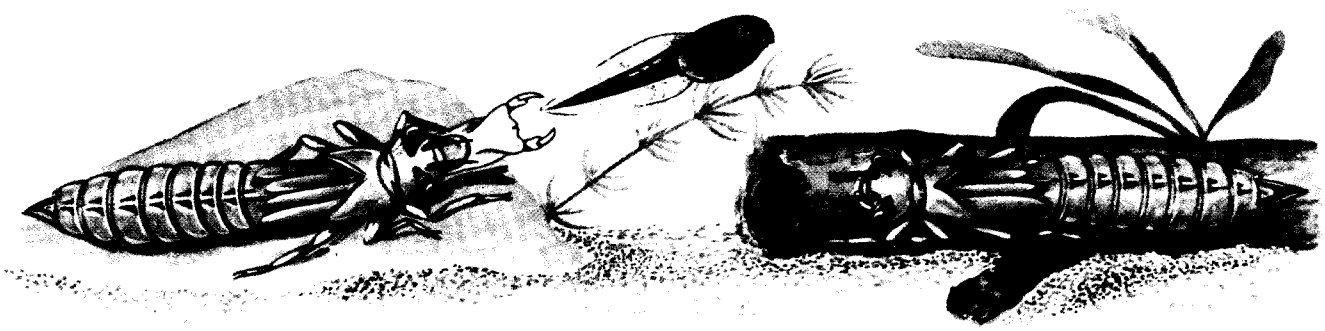


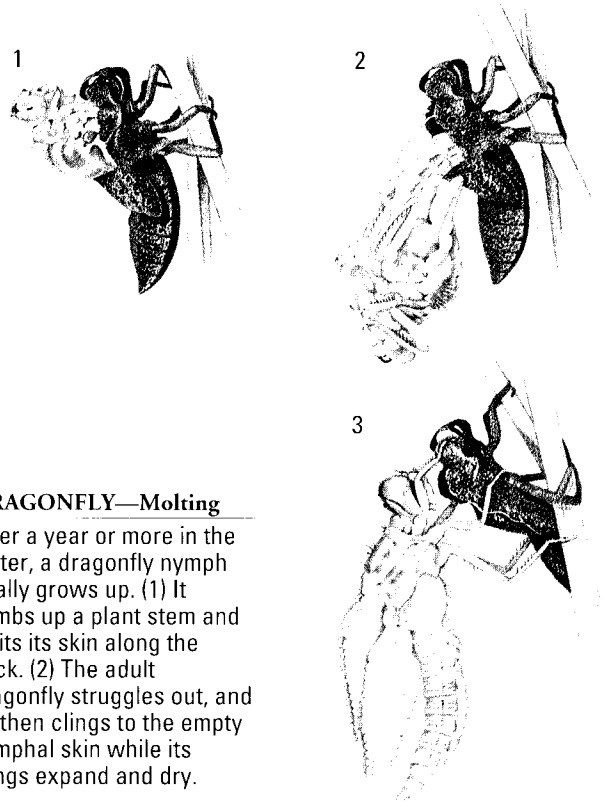
DRAGONFLY—The red skimmer

A red skimmer dragonfly rests in typical pose, but is always ready to dart off and snatch up a passing insect.

DRAGONFLY—Nymphs

Dragonfly nymphs (below) live in water, feeding on tadpoles and other small animals that they capture by shooting out their lower lips. Their wings develop gradually on their back and can be seen as small fingerlike flaps, but they do not become fully formed until the nymph crawls out of the water for its final molt.





DRAGONFLY—Molting
After a year or more in the water, a dragonfly nymph finally grows up. (1) It climbs up a plant stem and splits its skin along the back. (2) The adult dragonfly struggles out, and (3) then clings to the empty nymphal skin while its wings expand and dry.

uses its long, bristly legs as a basket to trap mosquitoes and other small insects in midair. A dragonfly cannot walk but is able to fly as fast as 60 m.p.h. [100 kph].

After mating, the female dragonfly deposits her eggs in the water or on aquatic plants. The eggs usually hatch within about four weeks, although some remain unhatched through the winter and do not hatch until the spring—several months after they were laid. Nymphs emerge from the eggs and live in the water for as long as five years (see NYMPH). They breathe through gills and capture insects and small water animals with their masks, which are really long, hinged lower lips. The nymph matures into an adult through a series of twelve molts (see METAMORPHOSIS; MOLTING). The adult usually lives for only a few weeks.
See also INSECT.

DREAM Dreams are activities of the mind that occur while a person is asleep. Dream experiences are said to be imaginary, but they can be related to real experiences in the person's life.

Scientists have shown that almost everyone does dream, sometimes two or three times during each night. In order to show this, scientists use a technique that records eye movements of the person as he or she goes through the process of falling asleep, sleeping deeply, and waking up. During periods of dreaming, the person's eye movements become faster and constant, as if the eyes were following the action in the dream. These periods are called rapid eye movement (REM) sleep. The REM usually lasts about fifteen to twenty minutes. During REM periods, the pattern of the person's brain waves changes.

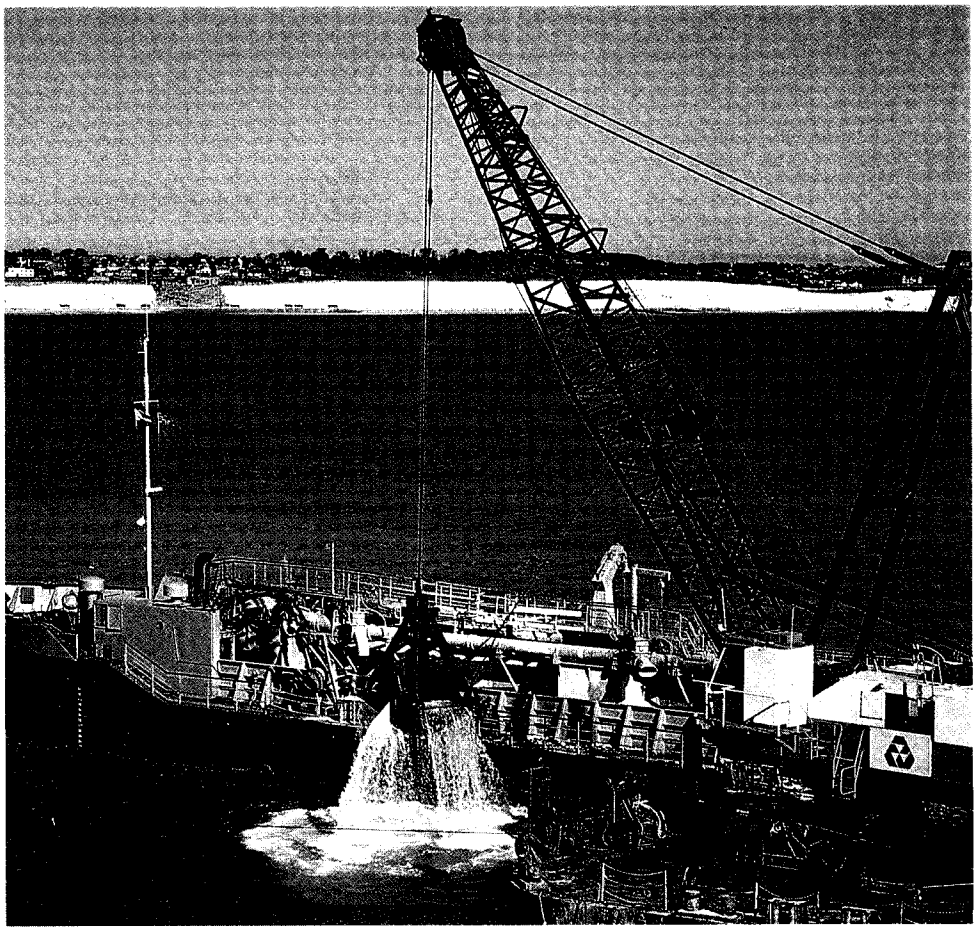
Some people say they do not dream, because they cannot recall anything about their dreams. Others are able to remember their dreams in great detail. Dreams can be pleasurable, uneventful, or very frightening. Frightening dreams are called nightmares.

Scientists do not know why people dream, but they believe dreams are important. Ancient peoples thought that dreams had meanings. People who dealt in magic claimed to be able to interpret the meaning of dreams. Some people believed that dreams could tell what would happen in the future.

Sigmund Freud, a famous Austrian doctor, studied dreams to understand why people have mental illness (see FREUD, SIGMUND). His method for treatment of mental illness, called psychoanalysis, is sometimes used today. In this method, the patient is often asked to try to remember his or her dreams and to talk to an analyst about them. This discussion is supposed to help the patient better understand his or her feelings when awake. Some psychologists believe that dreaming is a period during which the brain clears itself of thoughts in preparation for the next day's activities.
See also PSYCHOANALYSIS; SLEEP.

DREDGING *Dredging* generally refers to the clearing out of silt, sediment, and other deposits from the bottoms of bodies of water, such as rivers and harbors. Erosion washes the deposits into the water (see EROSION). These deposits eventually settle to the bottom of the water. If dredging were not done, the water would become more and more shallow, and ships would not be able to pass through.

Dredging is also performed in the cutting of new



DREDGING
This dredge is digging sand and mud out of the bottom of a channel to ensure that the water is deep enough for ships to pass through safely. Without dredging, ships could be in danger of running aground.

waterways. Sometimes, when a waterway is being cut through rock, the material that is removed, known as spoil, is used for building. In projects that restore land, spoil from the sea is pumped ashore to build up the ground level.

Machines that do dredging are called dredges. Dredges move material underwater in much the same way that mechanical shovels move material on land. There are several types of dredges. Different dredges are used depending on the material being dug out and the condition of the underwater area being excavated.

The dipper dredge has a large scoop shovel called a dipper. The dipper is shaped like a box. It hangs on a chain from a derrick, or long steel beam. The dipper and derrick can be raised, lowered, or swung in a circle. The dipper dredge drags across the bottom of the body of water and scoops up soil. The dipper full of soil is raised above the water and swung above a barge. The soil is emptied into the barge by opening the door at the bottom of the dipper.

Grab dredges are used in deeper water than dipper dredges. Grab dredges have buckets that are shaped like big clam shells hinged at the top. The buckets are attached to a long cable. When lowered to the bottom, the bucket is opened at the bottom, filled, closed, and then raised.

Dredging is also used in mining (see MINING). The bucket or ladder dredge is used to mine gold and tin. It has a series of buckets attached to an endless moving chain. The chain is supported by a long beam called a boom. The buckets scrape up soil from the bottom of the body of water. The buckets empty the soil into a long chute when they turn over at the top of the boom. The chute carries the material to a place where it is discharged.

The hydraulic dredge, or suction dredge, is used for moving large amounts of beach or river sand. A suction pipe carries the sand and water to a pump. A discharge pipe leads from the pump to a barge or disposal area. The deposits from this process, called hydraulic fill, are used for dams, dikes, or building sites.

See also EXCAVATION.

DREW, CHARLES RICHARD (1904–1950) Charles Richard Drew was an African-American medical doctor and teacher who founded and directed the world's first blood bank using blood plasma. A blood bank is an institution that stores blood that people donate for future use. Drew was born in Washington, D.C. He received his medical and surgical degrees from McGill University in Canada. In 1938, Drew attended Columbia University in New York City to continue his training in surgery and to study blood. Drew discovered that blood plasma could be used in place of whole blood in transfusions (see BLOOD; BLOOD TRANSFUSION). This discovery was important because plasma can be stored easily for months or even frozen. Whole blood, on the other hand, spoils quickly.

In 1940, Drew set up and directed a blood bank, which collected plasma in New York City and sent it to Europe to aid people injured in World War II (1939–1945). In 1941, the American Red Cross appointed Drew to direct a project to collect and bank the blood of 100,000 donors. However, at that time, the U.S. Army and Navy insisted that the blood of black donors be refused. Drew argued against this practice. Eventually, he resigned from the project in protest. He then taught surgery at Howard University in Washington, D.C.

In 1950, Drew was injured in an automobile accident in North Carolina. The hospital to which he was taken did not have any blood plasma. Drew died of his injuries. Had plasma been available, he might have lived.

DRILLING Drilling is a process used for making holes in rock, metal, wood, plastic, or other materials. The tools used to make these holes are called drills. Most drills work by a rotary, or spinning, action. The part of the drill that cuts the holes is called the bit. The bit drills deeper into the material as it spins.

Twist drills are a widely used type of drill. The bit of a twist drill has two cutting edges at the tip. Flutes, or spiral grooves, lead from the tip. The flutes allow cut material to pass back from the hole. Twist drills are used in home workshops and in industry. In industry, twist drills are inserted in machine tools called drill presses. The drill press has a platform with one or several drills mounted above it. The drills are lowered by a lever to the object placed on the platform. These drills work at very high speeds, so their bits get hot. For this reason, bits are made of hard, heat-resistant material, such as steel. The bits are cooled and lubricated by oils, which flow over the bits during drilling.

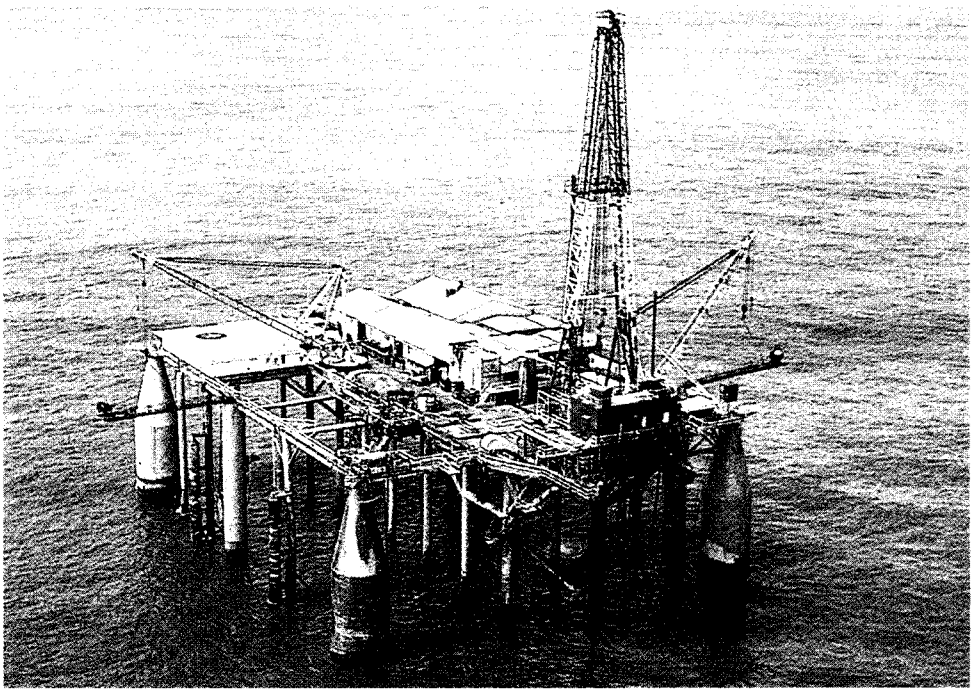
Another type of drill is an auger. Augers are used by carpenters and geologists. Augers have a screw in front of the cutting edge. The screw eases the cutting edge into the soft material, such as wood, soil, or soft rocks.

Drills are used to find petroleum. In the usual method of rotary drilling, a tough bit with a diamond tip is rotated at the end of a long drill pipe. A drilling rig, called a derrick, up to 200 ft. [61 m] in height is needed to work with the long lengths of pipes that are used.

Rock drills, which are used for drilling holes in mining operations, are usually run by compressed air that drives a chisel-shaped point. Some rock drills have cutting edges like those on twist drills.

DRILLING—Hand drills

One of the most useful power tools is the electric drill. Drill bits of different sizes can be clamped in the chuck at one end. Pressing a trigger starts an electric motor that spins the chuck and drill at high speed. Electric drills are powered from a nearby wall socket, by built-in batteries, or can be rechargeable.



DRILLING—Oil rig
An oil rig is a platform standing on legs that rest on the seabed. A long drilling pipe is supported by a derrick (tower) on the platform. Motors turn the pipe so that it drills through the rocky sea floor to reach the oil underneath.

In the ultrasonic drill, a special bit is made to vibrate rapidly. The bit does not rotate and can be used to cut holes of any shape (see ULTRASOUND). High-energy electron beams and high-energy light beams from lasers are sometimes used to make holes in very hard materials, such as diamond. Laser beams are also being used experimentally in dentistry to remove decay (see LASER).

Boring is similar to drilling. However, borers usually have only one cutting edge. Reaming is a process for making holes larger. Reamers may have straight or spiral cutting edges. Both boring and reaming require rotary bits.

DROUGHT (drout) A drought is a long period of very dry weather. A region experiencing a drought has precipitation far below normal. Some droughts can last for years. The extreme lack of rain during a drought can cause serious damage to plants and animals and greatly increases the danger of forest fires.

The new ring that forms each year in trees provides an accurate record of annual rainfall. In a dry year, the ring is narrow. In a wet year, the ring is wider. By studying these rings, scientists have determined that periods of drought alternate with periods of wet weather (see ANNUAL RING).

One of the worst droughts in the history of the United States occurred from 1931 to 1938 in the Great Plains region. Lack of rain meant that few crops could be grown, and food throughout the United States became scarce. For many years, farmers in the Great Plains had used practices that did little to protect the soil. The erosion from these practices was made worse by the drought, which dried out the soil. Also, strong winds blew through this area during the 1930s, causing great dust storms. The areas where the dust storms were the worst were called the Dust Bowl.

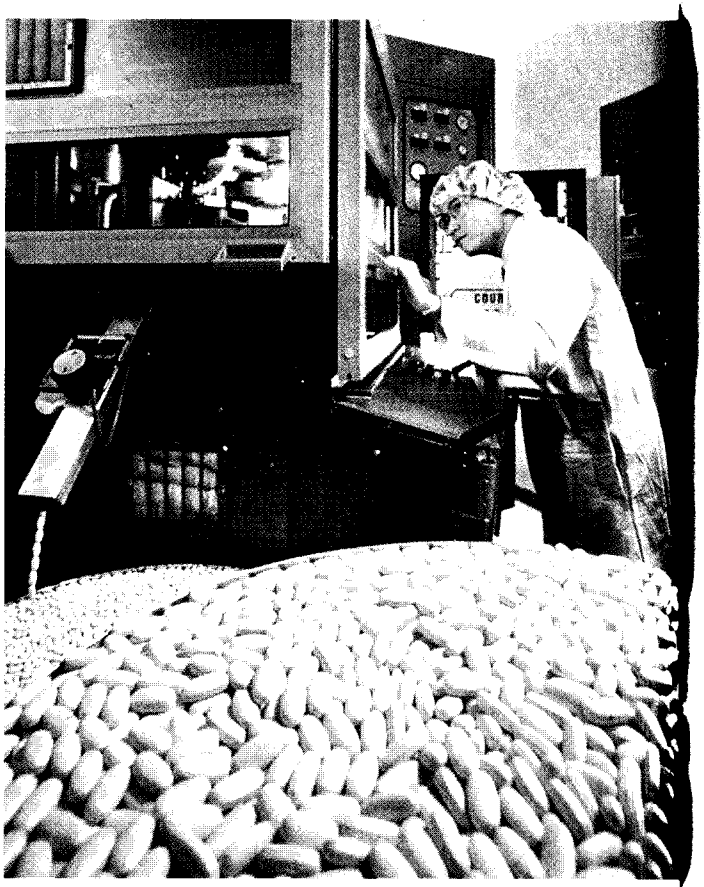
See also CLIMATE; EROSION; SOIL EROSION; WEATHER.

DROUGHT
A drought dried up this lake and left its mud bottom shrunken and cracked.

DRUG

A drug is any substance or mixture of substances that has an effect on the physiology of a living thing. *Physiology* refers to the actions of structures in the body (see PHYSIOLOGY). By definition, many things, such as the chemicals in air pollution, can be considered drugs. However, the word *drug* usually refers to a substance that is taken for medical reasons or to attain some desired nonmedical mental or physical effect. Drugs may be prescription medicines, "over-the-counter" medicines, or illicit drugs. Prescription medicines are ordered by a physician. Over-the-counter medicines do not need to be ordered by a physician and are usually used to treat such minor illnesses as colds. Illicit drugs are illegally obtained and are often used for nonmedical purposes. Illicit drugs have become a national health and safety concern. In addition to these three groups of drugs, there are drugs that are legal (in some cases, only for adults) but that are used for nonmedical purposes. These include caffeine (found in cocoa, coffee, tea, and some soft drinks), nicotine (found in tobacco products), and alcohol (found in beer, wine, and liquor). Pharmacology is the branch of science that studies the effects of drugs on organisms (see PHARMACOLOGY).

Drugs are useful in the prevention, diagnosis, and treatment of diseases (see DISEASE). Drugs that prevent disease are called vaccines, and their use is called vaccination (see VACCINATION). Vaccination involves placing dead or weakened pathogens (disease-causing microorganisms) of a certain kind into a patient's body. This causes the body to produce substances called antibodies to fight the pathogens (see ANTIBODY). The antibodies help a person develop a resistance to the disease. Iodine is a drug that is used during diagnosis. Iodine is used as a contrast medium during angiography. Angiography is an X-ray procedure that examines the body's blood vessels (see ANGIOGRAPHY). Iodine helps highlight blood vessels, making them easier to see on the television monitor that is connected to the X-ray machine. An example of drugs used to treat disease is the group of drugs used against hypertension, or high blood pressure. If this disease is untreated, heart failure, kidney damage, or a stroke may result. By giving certain drugs, however, the doctor can lower his or her patient's blood pressure to close to normal levels. In doing so, the conditions that might have resulted are prevented.



MANUFACTURE

Drugs are produced in a multibillion dollar industry on a vast scale and to a very high quality.

Some drugs cause a loss of feeling. These drugs, called anesthetics, are often given during surgery (see ANESTHETIC). General anesthetics cause a loss of feeling in the entire body, and the patient becomes unconscious. Local anesthetics cause a loss of feeling only in a particular area. Anesthetics can be given as an injection, a gas that the patient breathes in, or a solution that is applied to a particular area on the skin.

Other drugs work to relieve pain, help people sleep, or help mental illness. Unfortunately, most drugs produce side effects that may be harmful to the patient. For example, the drug penicillin may kill the bacteria causing strep throat, but it may also

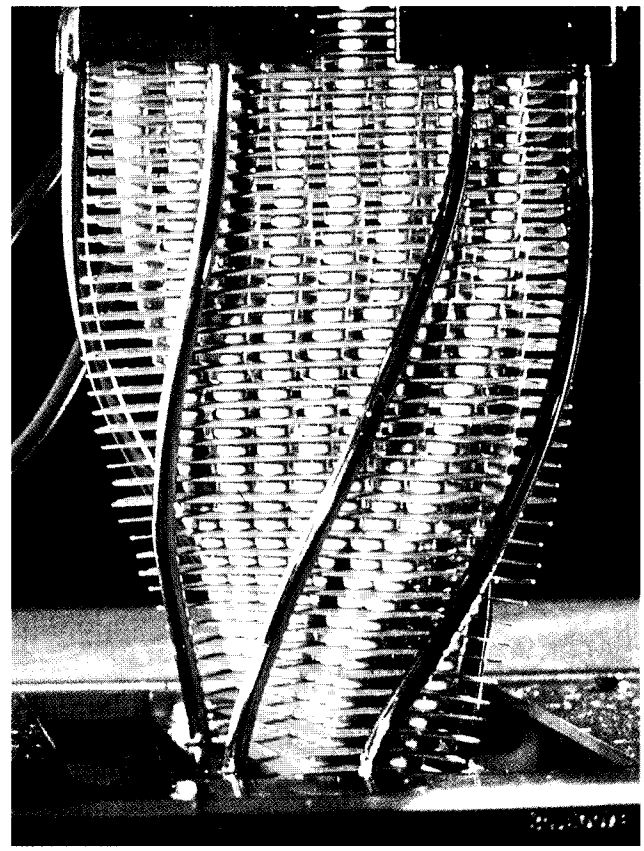
cause an allergic reaction (see ALLERGY; BACTERIA; PENICILLIN; STREP THROAT).

Drugs come in various forms, including capsules, inhalants, ointments, tablets, and liquids to be injected or taken by mouth. Drugs are produced in a variety of ways. Some are made by pharmacologists. These are called synthetic (human-made) drugs. Others can be found in nature. For example, digitalis is made from the leaves of the foxglove plant. Digitalis is used to treat certain heart diseases (see FOXGLOVE; HEART DISEASE).

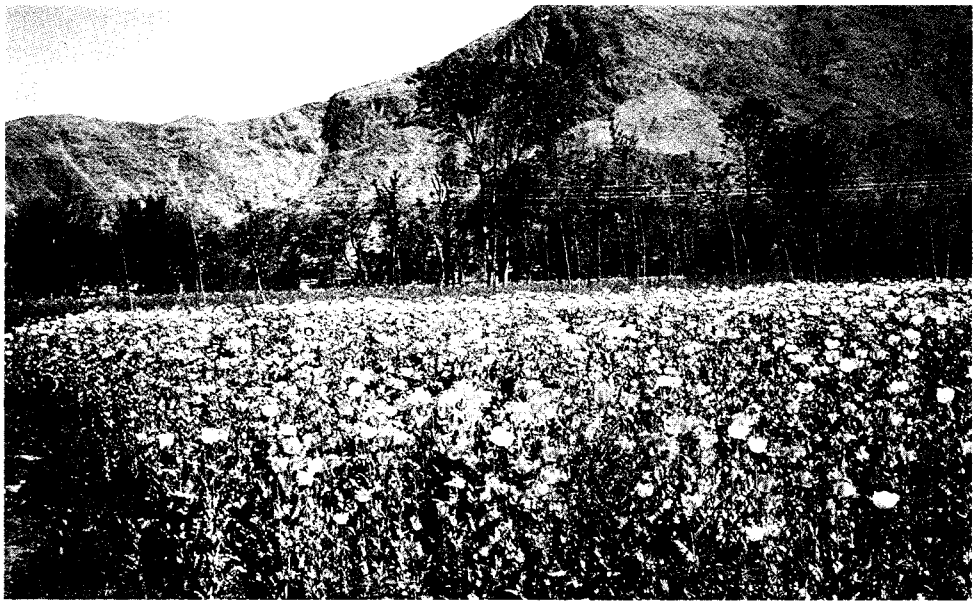
History Drugs have been used by humans for thousands of years. Scientists believe that prehistoric humans ate certain plants to produce desired effects in the body. The oldest known written record of drug use is a clay tablet from the ancient Sumerian civilization in the Middle East. This tablet, made in the twenty-first century B.C., lists about a dozen drug prescriptions.

The ancient Greeks and Romans were fairly advanced in their use of drugs. For example, they used opium from the opium poppy to relieve pain. Other ancient civilizations also used drugs. The Egyptians used castor oil as a laxative (see LAXATIVE). The Arabs burned the water organisms called sponges and had patients suffering from goiter eat them (see HORMONE).

During the 1500s and 1600s, scientists performed many experiments with drugs. Important basics in pharmacology were developed during this time. In the 1700s, digitalis was discovered. Near the end of the 1700s, Edward Jenner gave the first smallpox vaccine (see JENNER, EDWARD).



PACKAGING
Drugs must be carefully prepared and transported. Direct human contact is kept to a minimum. Drugs can be in the form of pills (above and left) and as a liquid.



POPPY FIELDS
This field of opium poppies is growing in Pakistan. In many parts of Asia, poppies are grown illegally as a lucrative cash crop, providing opium and its derivatives.

In the early 1800s, drug development exploded. Pharmacology became a well-established science. Scientists learned more and more about how to separate chemicals that could be used as drugs from plants in which they were found. The 1800s also brought about the development of synthetic drugs. In 1860, acetylsalicylic acid (aspirin) was first made (see ASPIRIN). In 1922, Frederick Banting, a Canadian physician, discovered insulin. Insulin is a hormone produced by the body to help in the use of sugar and starches (see INSULIN). Today, synthetic insulin is used to treat diabetes (see DIABETES). The science of microbiology developed in the early 1900s, as bacteria were found to be a major cause of disease (see MICROBIOLOGY). Doctors began treating the causes of disease rather than just the symptoms. The first antibiotic to be discovered was penicillin, in 1928. In 1952, chlorpromazine was first used to treat a mental illness called schizophrenia (see MENTAL ILLNESS). Antidepressants (drugs that fight depression) were also developed around this time. The major efforts of drug researchers today center on finding cures for diseases that have not yet been conquered. These diseases include AIDS and cancer (see AIDS; CANCER).

How drugs work In the body, many drugs work by binding with a special protein, called a receptor (see PROTEIN). Receptor proteins are shaped in different ways. This means that a particular drug can only fit into certain receptors. The binding between the drug and the receptor often leads to a long chain of reactions. For many drugs, scientists know the entire series of reactions, from the drug receptor binding to the final effect. For example, scientists know that certain drugs that are used to treat hypertension bind with a receptor in heart cells. When the drug is bound with the receptor, it prevents certain body chemicals from binding with the same receptor. These chemicals are ones that can cause the heart to beat quickly and forcefully. With the chemicals unable to bind with the receptors, fast, strong heartbeats are prevented. Therefore, the blood pressure is lowered. However, for other drugs, scientists know only the effect, not the series of steps that leads to the effect.

Some drugs work similarly to the receptor process, only they cause just one reaction instead of a long chain of reactions. Other drugs work by changing the structure of cell membranes or by being toxic (poisonous) to cancer cells or pathogens.

In order for drugs to treat injury or disease, they must get to the part of the body that is injured or diseased. Some drugs, such as ointments to relieve muscle pain, are applied directly to the affected body part. Most drugs, however, travel throughout the bloodstream before reaching the affected part of the body. Drugs that are swallowed get into the blood stream from the stomach and intestines

during digestion. Other drugs are injected directly into veins. Once in the bloodstream, drugs generally travel to all parts of the body, though the body prevents some drugs from reaching the brain. A drug in the bloodstream will work on the injured or diseased part of the body, but it may also have effects throughout the body. For example, morphine is one of a group of drugs called narcotics. Morphine is given to patients in severe pain, such as cancer victims (see NARCOTIC). Morphine decreases the patient's awareness of pain, but it also causes sleepiness. A doctor must decide before giving a drug whether the benefits of giving the drug will outweigh any side effects it might cause.

Types of drugs There are many ways in which drugs may be grouped. Drugs may be grouped by physical properties, such as by being a gas, liquid, or solid. Another way to group drugs is by how they are given—by mouth or by injection, for example. Probably the best way to group drugs is by what part of the body they are targeted to affect. Affected parts of the body include the circulatory system, nervous system, digestive system, and immune system.

Nitroglycerin is an example of a drug that affects the circulatory system. Nitroglycerin is given to patients who have angina pectoris. Angina results because the blood vessels that supply the heart muscle with blood become too narrow. Nitroglycerin causes these vessels to open wider, allowing more blood to reach the heart.

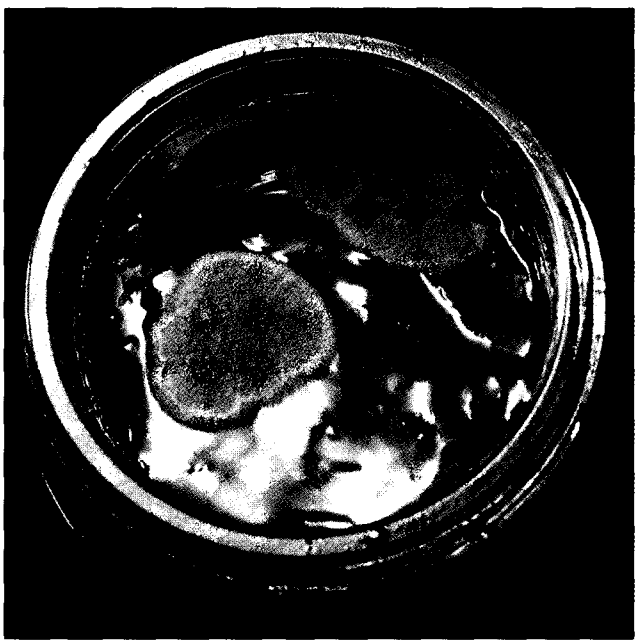
Morphine is a drug that affects the nervous system. Morphine binds to particular receptor proteins called opioid receptors. This binding decreases the patient's awareness of pain, but it does not decrease the pain itself.

Some problems of the digestive system, such as ulcers, can be treated with a drug called cimetidine. An ulcer is an open sore in the skin or mucous membrane. The best-known kinds of ulcers occur in the stomach or intestines. They are often caused by stress or the use of tobacco. These two factors can cause the stomach to overproduce acids, which dissolve part of the mucous membrane lining in the stomach or intestines. Cimetidine prevents a certain body chemical from causing acid to be secreted in the stomach. This helps an ulcer heal faster.

Drug testing Before any drug becomes legal for people to use, it must be tested by the U.S. Food and Drug Administration (FDA). The FDA is the government agency responsible for setting rules for developing and testing drugs. Testing often takes years to complete. It determines both the good and bad effects of a drug. The drug industry spends millions of dollars each year developing and testing new drugs.

Once preliminary drug tests are complete, testing begins on humans. Human tests first involve a small group of volunteers and then a larger group. After both the preliminary tests and the human tests are completed, the FDA may approve the drug. Unfortunately, the tests sometimes do not show all the harmful effects of a drug. Some drugs have been removed from the market years after the FDA approved the drug, because harmful effects showed up in patients.

Drug abuse and addiction Drugs can be abused. Drug abuse may involve overuse of a legal drug, such as alcohol, or use of a medicinal drug,



PENICILLIUM

The fungus *Penicillium*, shown growing in a Petri dish, produces the antibiotic drug penicillin, which was the first antibiotic to be discovered.

such as a narcotic, for nonmedicinal purposes. Drug abuse often leads to harm to the body and emotional difficulties. These difficulties may affect job performance and relationships with family and friends and may even lead to the drug abuser breaking the law.

Several terms describe different aspects of drug abuse. For example, *physical dependence* refers to the inability of a drug abuser to function without the drug in his or her body. Such dependence can be seen in those people who abuse the drug cocaine (see COCAINE). Over time, cocaine abusers need the drug to maintain normal body functions. Without the drug, the abuser's body enters a stage called withdrawal. During withdrawal, certain body changes may occur. For example, the abuser may feel shaky or nauseous or have stomach pains. An abuser may also experience *psychological dependence.* In psychological dependence, an abuser's mood and behavior are altered by the drug. The abuser feels unable to cope with everyday life without the drug. When a person is psychologically or physically dependent on a drug, he or she is said to be *addicted.* Those who are addicted to a drug often develop a tolerance to it. This means that the abuser's body requires an increasing amount of the drug to achieve the same effect (see ADDICTION).

People abuse many drugs, including alcohol, marijuana, nicotine, narcotics, sedatives, and stimulants (see ALCOHOLISM; MARIJUANA; SEDATIVE; STIMULANT). Many people abuse drugs to try to get a feeling of well-being, often called a "high." Adolescents often start abusing drugs because they are curious about the drugs' effects or because their friends are using drugs. Many drug abusers are people who have not developed healthy ways of dealing with the normal pressures of life. They often feel lonely and inadequate, and they abuse drugs to mask these feelings.

Laws control the use of various drugs. In the United States, Canada, and many other countries, some drugs are illegal for any use, medical or nonmedical. The narcotic drug heroin is an example of an illegal drug. It was once used for medical purposes but no longer is. Other narcotics are legal to use with a doctor's prescription. Certain sedatives and stimulants also require a prescription. In spite of these laws, drug abuse continues to be a tremendous problem. Many people believe that solving the problem of drug abuse requires cooperation among law-enforcement officials, politicians, teachers, parents, and adolescents. Recently, there has been an increase in educational programs about the use and abuse of drugs.

Rules for safe drug use Drugs are important in medical practice, but even medicines can be dangerous. For example, if the wrong amount of a medicine is taken, permanent physical damage or death may result. For this reason, there are several rules on the proper use of drugs as medicines.

1. Do not take a drug that was prescribed for someone else. A drug that works for one person may not work for or may be harmful to someone else.

2. Do not reuse a prescription drug. A drug that may have helped an illness at one time may not work a second time.

3. Do not use any drug if the expiration date has passed. Drugs change chemically over time. This is why all drugs are labeled with a date that tells when the drug may no longer be good.

4. Read and follow all instructions on drug labels. The label tells how much of a drug to take and how often. Drug package inserts may also tell what side effects are likely to occur and what to do in case of an accidental overdose.

5. Report unpleasant effects to your doctor.

6. Keep all drugs in a safe place that children cannot reach.

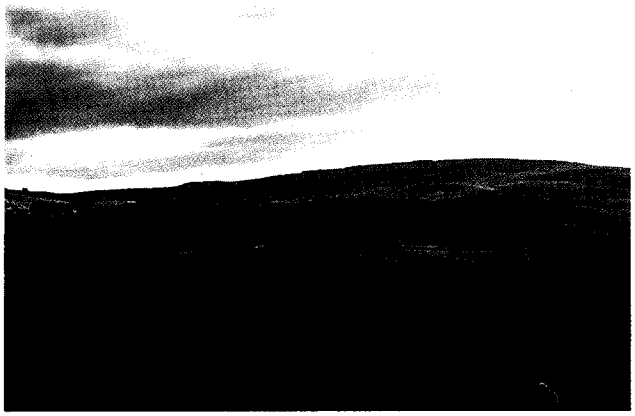
7. Do not take more than one drug at a time unless your doctor recommends it. Many drugs cause unexpected effects when combined with other drugs.

Drugs can help people tremendously. Drugs help cure and prevent many diseases. Drugs can help relieve pain and tension. Doctors hope that drugs may someday prevent or cure diseases such as AIDS and cancer. However, drugs may also be abused. Millions of people in the United States are addicted to drugs because they started to abuse them.

DRUMLIN (drŭm'lĭn) Drumlins are low, smooth hills formed by glacial movements (see GLACIATION). They range in height from 25 to 250 ft. [8 to 75 m] and are usually 0.25 to 0.50 mi. [400 to 800 m] long. The longest part of the hill is usually parallel to the direction of the ice flow.

Drumlins formed when the glaciers of the last ice age moved across the land. The glaciers scooped up rock and other debris from the ground and deposited it elsewhere. These deposits formed drumlins. They often appear in clusters called drumlin fields.

See also EROSION; ICE AGE.



DRUMLIN

Mounds of sand, gravel, and clay dropped by a glacier may form a hummocky landscape called a "basket of eggs" topography.

DRUPE (drōōp) A drupe is a kind of fruit. It contains a single seed, which is enclosed in a hard, woody "stone." The stone is surrounded by juicy matter called the pulp.

DRUPE

Drupes are fleshy fruits such as the peach, plum, and cherry (left to right) that have single seeds inside a hard "stone." The half cherry shows the drupe structure. Drupes are also called stone fruits.

The best-known examples of the drupe are the plum, the cherry, the peach, and the apricot. Blackberries and raspberries are made up of a number of small drupes called drupelets.

See also FRUIT.

DRY CLEANING Dry cleaning is a process that removes dirt and stains from fabrics without the use of water. However, dry cleaning is not really "dry," because liquid solvents (substances that dissolve other substances) are used.

Many garments, including most of those made of wool or silk, must be dry-cleaned to prevent shrinkage, fading, or other damage from water. However, some materials, such as vinyl, should not be dry-cleaned because it can cause them to crack and split. Leather and fur products are also not dry-cleaned but instead are cleaned by other specialized methods.

Dry cleaning began in France in the mid 1800s. The process was called French cleaning when it was first introduced to the United States in the early 1900s. Today, the dry-cleaning industry is one of the largest service industries in the United States.

DUCK Ducks are water birds related to geese and swans. Some live in fresh water—in rivers and lakes or in prairie and mountain marshes. Others live in coastal waters (see GOOSE; SWAN).

Ducks have short legs, webbed feet, and flattened beaks called bills. Their legs and webbed feet serve as paddles. Some bills have comblike or toothed edges, which the duck uses for sifting food from the water and the mud and for holding fish. The ducks with shorter bills use them to pry off snails from rocks and to pull clams off the bottom of a lake or pond.

There are two main kinds of ducks: surface feeders and divers. Surface feeders eat by extending their necks under water, leaving their tails sticking out. Divers submerge completely and swim under the water. Both are good fliers. Surface feeders can fly directly into the air. Divers must flap across the water before they can become airborne.

The plumage of the duck consists of a layer of down feathers and an outer layer of waterproof

feathers. The down is very fine and soft. It is next to the bird's skin and helps keep the bird warm. The outer feathers help keep the down layer dry. The outer feathers are covered with a waxy oil that comes from a gland at the base of the tail and is applied to the feathers with the bill. The oil waterproofs the feathers. The male duck, called a drake, usually has brightly colored outer feathers. They are arranged in simple patterns, and can be green, chestnut brown, blue, black, and white. The female, called simply a duck, has plain feathers. This allows her to hide easily when she is incubating her eggs or taking care of her young ducklings. In the fall, ducks molt (see MOLTING). The drake loses his bright feathers and comes to look like the female. At other times it is often hard to realize that the male and female belong to the same species (see POLYMORPHISM).

After molting, many ducks migrate to winter feeding grounds in a warmer area (see MIGRATION). They may use the same feeding grounds year after year. The drakes and female ducks may mate at their winter feeding grounds but not until the drakes have grown new, colored feathers that attract the females. Drakes are territorial and drive away other males of the same species.

When the ducks migrate back during springtime, the male flies with his new mate. Very often, they return to the place where she was born. The female duck makes a nest on the ground, in places such as a clump of grass or another animal's burrow. The female then lays from five to twelve eggs. The duck sits on the nest, while the drake wanders away. The ducklings are hatched in about a month. They have feathers from the start. Most ducklings can run, swim, and find food the day they are hatched.

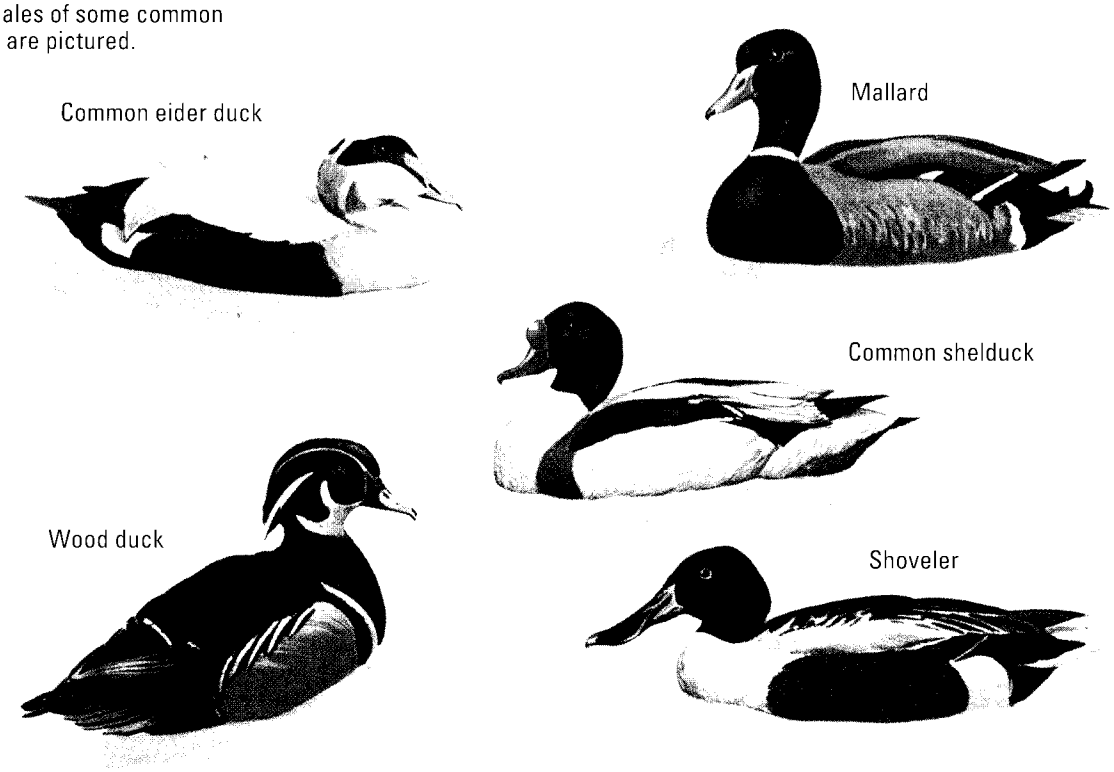
Most ducks live in flocks during migration and at winter feeding grounds. You can see them in the fall flying in a *V* formation. One or two are at the pointed end of the *V*, and the rest form two lines trailing on both sides.

Wild ducks are protected by hunting laws and cannot be sold as food. Domestic ducks, the kind farmers raise, can be sold in markets and are served in restaurants. The most common commercially raised ducks in the United States are the white Pekin ducks.

See also BIRD.

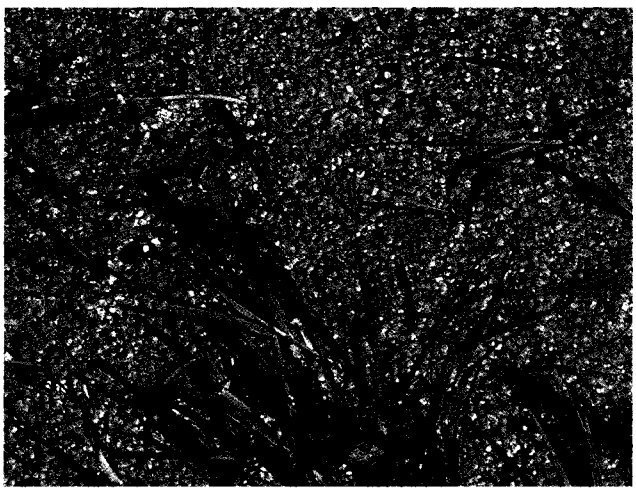
DUCK

The males of some common ducks are pictured.



DUCKWEED The duckweeds are a family of perennial aquatic plants that float on ponds and slow-moving streams in temperate regions (see PERENNIAL PLANT). Duckweeds are the smallest flowering plants known, producing flowers and fruits that are almost microscopic in size.

Duckweeds grow very fast, and some kinds can double their number every two and a half days or so by producing long detachable buds. They often cover stagnant bodies of water completely. Many kinds of water birds and fish, such as ducks and large goldfish, feed on duckweed. This helps keep the plants' growth under control. In the fall, the duckweeds sink to the bottom and remain there until the spring.



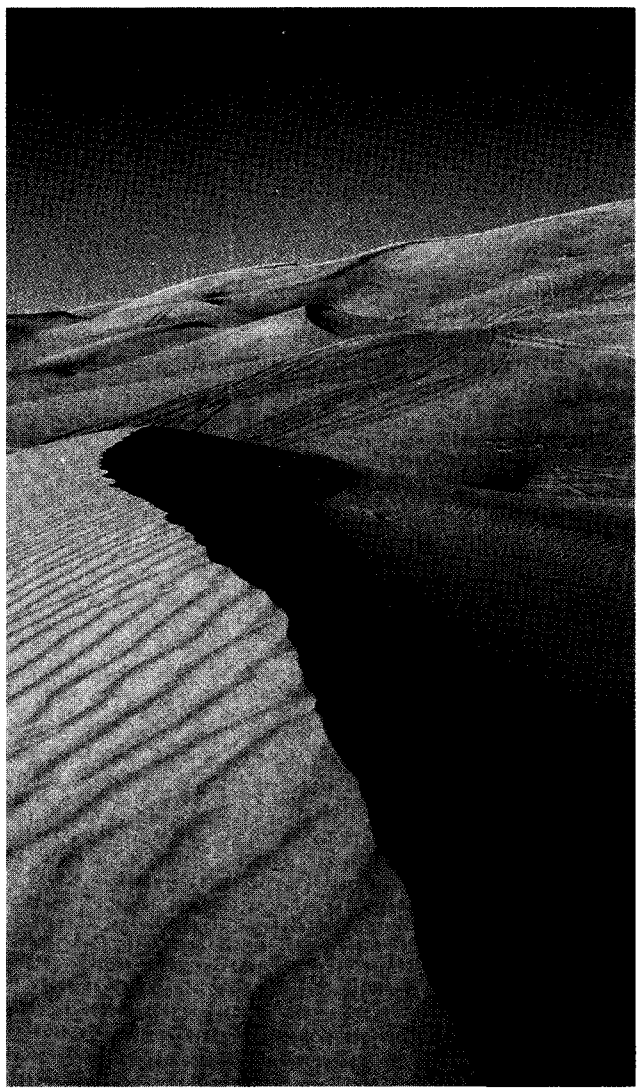
DUCKWEED
This colony of duckweed has completely covered the water surface.

DUCTILITY (dŭk′tĭl′ĭ tē) Ductility is the capacity of certain solid substances to undergo permanent changes in shape without breaking. Soft metals, such as copper and gold, can be drawn out into wire finer than a human hair without being heated. Such metals are highly ductile. Ductility is a valuable property of many other metals, such as aluminum, iron, nickel, and silver. The term *malleability* is often used in place of *ductility* to describe the property of metals that allows them to be hammered into thin sheets (see MALLEABILITY).

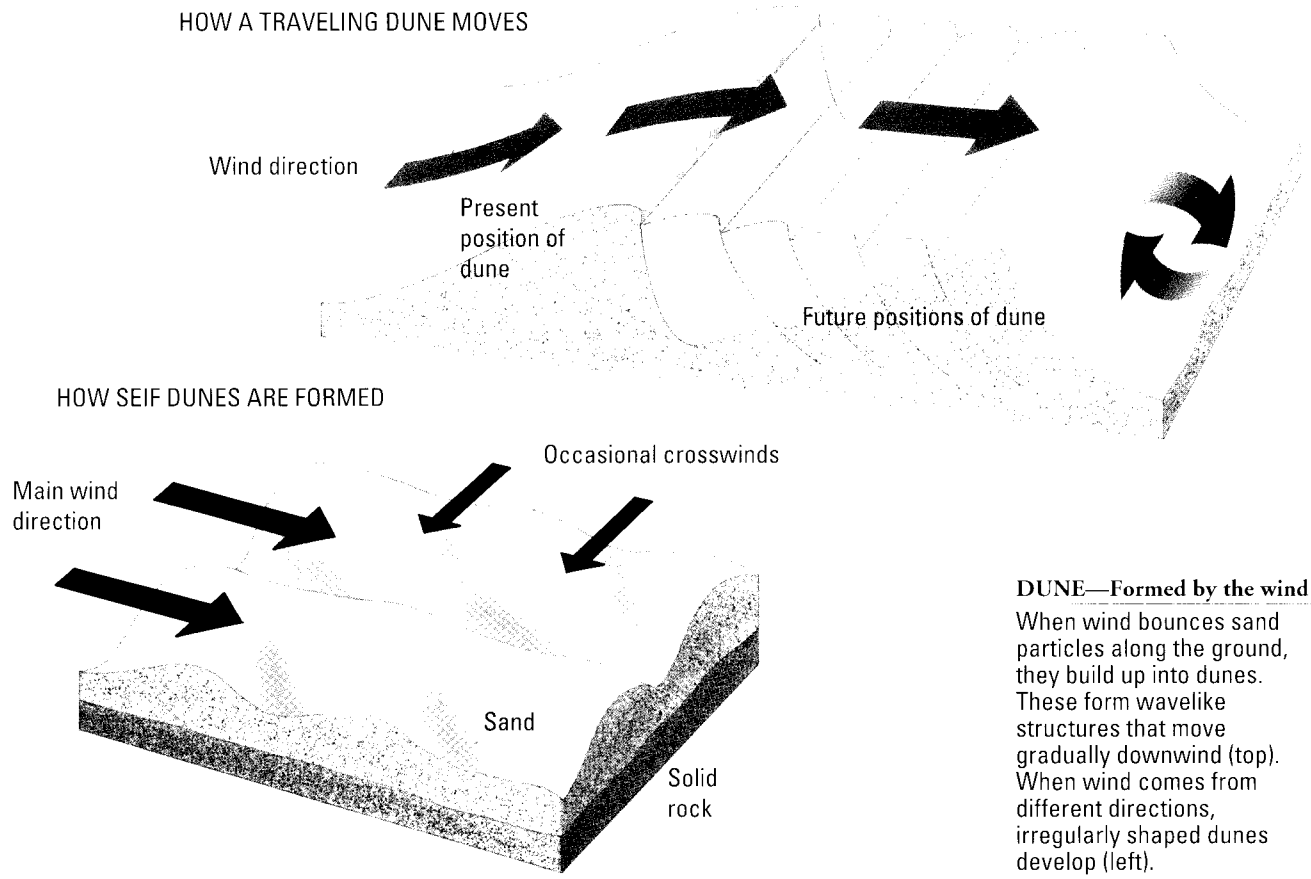
Some metals are not ductile. Cast iron, for example, fractures quickly when even slightly drawn out to a greater length. Cast iron is called a brittle metal.

Metals are not the only ductile substances. For example, modeling clay is a ductile, nonmetallic substance.

DUNE A dune is a hill or mound of sand made by the wind. Dunes are found in sandy regions, such as in deserts and along ocean coastlines (see DESERT). A large dune may be 500 to 600 ft. [150 to 180 m] high, but most are much lower than that. Dunes usually have a gentle slope on the side toward the wind and a steep slope on the side away from the wind. Crescent-shaped dunes are called barchan dunes. Seif dunes are long, steep-sided ridges of sand lying in the direction of the main wind movement.



DUNE—Sand
The constantly moving sands of the desert produce small dunes that creep over the sides of larger dunes.



DUNE—Formed by the wind
When wind bounces sand particles along the ground, they build up into dunes. These form wavelike structures that move gradually downwind (top). When wind comes from different directions, irregularly shaped dunes develop (left).

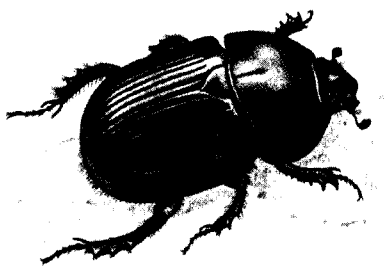
A traveling dune may move across the desert. It loses sand on one side while it gains sand on the other. Some dunes make sounds when the grains of sand are blown by the wind. They are called singing dunes in some parts of the world. Dunes with unusual shapes can be found in Dunes State Park in Indiana. Other areas noted for sand dunes are Cape Cod in Massachusetts, the coastline of the Gulf of California, and the eastern shore of Lake Michigan.

Many ancient Egyptian cities and religious shrines were buried by sand dunes. Grass and trees are often planted to keep dunes from moving into farmlands and inhabited areas.

DUNG BEETLE Dung beetles are stocky beetles that feed on animal dung. Some of them use their shovel-shaped heads and broad, spiky legs to roll the dung into balls. Each insect then buries its ball and feeds on it. A dung beetle is able to eat more than its own weight in dung every twenty-four hours. Females also lay their eggs in the balls of dung. The eggs develop into larvae, which feed on the dung as they progress through the stages of metamorphosis (see METAMORPHOSIS). Dung beetles perform a useful service. They help to speed up the decay of the dung and its conversion to simple nitrogen-containing compounds that can be used by other organisms (see NITROGEN CYCLE).

There are over two thousand species of dung beetles. Most are very dark in color and they range from about 0.1 in. to 1.2 in. [2–30 mm] in length. In some species, the male has one or more elaborate curved "horns" on its head or thorax, which it uses to fight and overturn rival males.

See also BEETLE; SCARAB.



DUNG BEETLE
The dung beetle digs a number of underground chambers and fills them with dung for its larvae to eat.

DUODENUM (dōō'ə dē'nəm) The duodenum is the first part of the small intestine (see INTESTINE). It is approximately 10 in. [25 cm] long in an adult. It accepts chyme (partly digested food) from the stomach and receives fluids called secretions from the liver and the pancreas. It also secretes (or releases) juices from its own walls (see LIVER; PANCREAS; STOMACH). The pancreatic and intestinal juices contain enzymes (see ENZYME). These break up starch, fat, and protein into nutrients of sugar, fatty acids, glycerol, and amino acids. Bile fluid from the liver is alkaline. It neutralizes stomach acids and also breaks up oil droplets to make them easier to digest.

The duodenum contains many small projections called villi. These increase the surface area of the duodenum. The lining of each villus is very thin. This enables nutrients to be absorbed easily. The duodenum is well supplied with blood and lymph vessels to carry food to the rest of the body (see DIGESTIVE SYSTEM; LYMPHATIC SYSTEM). Absorption of small molecules that do not need digesting, such as iron and calcium, also takes place in the duodenum.

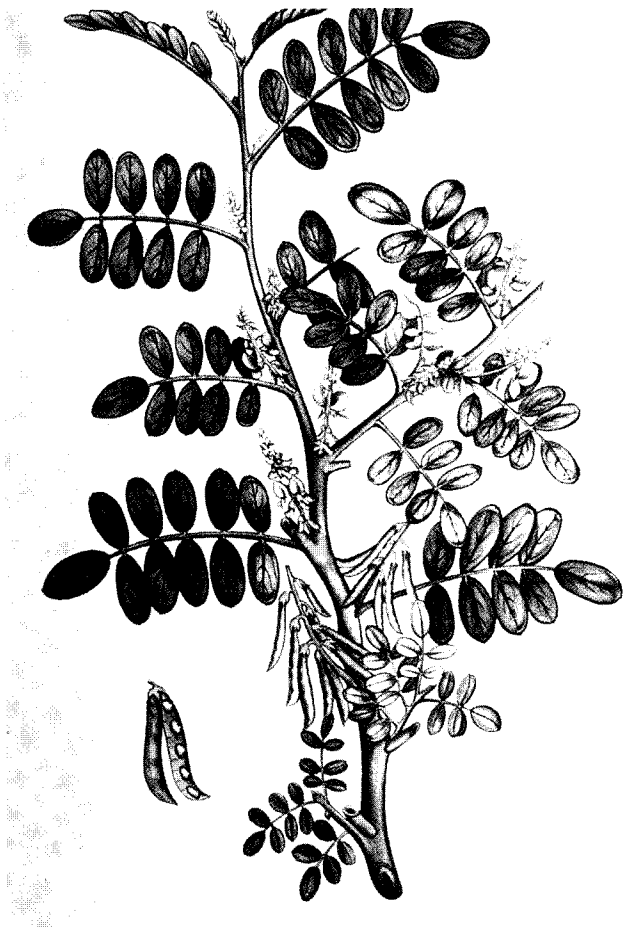
DWARF STAR There are two main kinds of stars: dwarfs and giants. Dwarfs are small stars and giants are large stars. Stars range in size from less than one tenth the mass of the sun to more than fifty times the mass of the sun. Dwarfs are the most common type of star. They make up 90 percent of the stars in the universe.

Brown dwarfs are very small, starlike objects that do not have enough mass to burn long enough to become stars. A red dwarf is a small star that actually has begun to burn, in a process called nuclear fusion. The majority of stars found throughout the galaxy are cool, red dwarfs. The sun is a little larger than a red dwarf and is called a yellow dwarf star. Another type of dwarf star, called a white dwarf, is much smaller than these others. A white dwarf is the dying remains of a small star that occurs when most of the nuclear fuel inside a star has been consumed. These white dwarfs result from stars that may have collapsed from something the size of the sun to something only as large as the earth. They are extremely dense and extremely hot, which is why they appear white. In about six billion years the sun will start on its way to becoming a white dwarf star.

See also STAR.

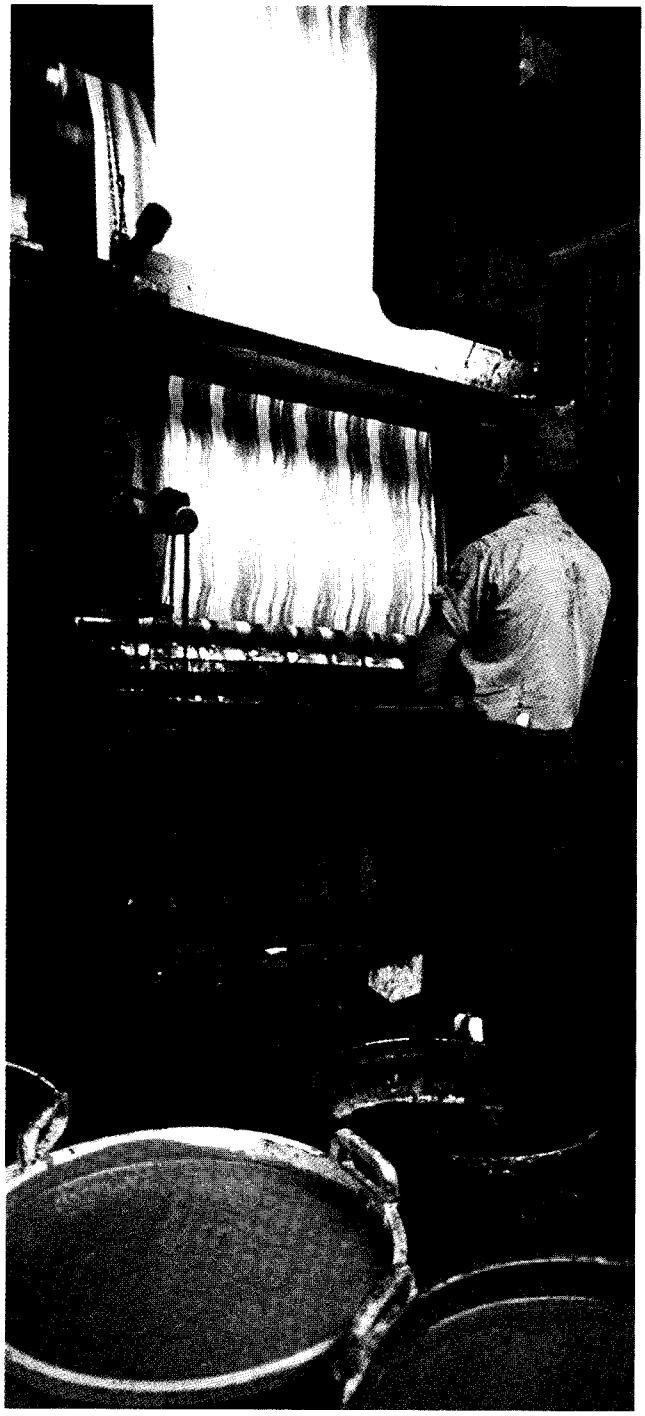
DYE A dye is a chemical compound used to color materials. People have used dyes to color textiles (fabrics) and other materials for more than five thousand years. Until the 1850s, dyes came only from a handful of animals and plants. In 1856, William H. Perkin, a British chemist, made the first synthetic dye from a product of coal tar.

Until World War I (1914–1918), Germany was the largest producer of the world's dyes. Since then, the dye industry in the United States has grown rapidly. Today, United States industries use about eight thousand different synthetic dyes.



DYE—Indigo shrub

The indigo shrub, *Indigofera tinctoria*, ranges from 4 to 6 ft. [1.2 to 1.8 m] in height and grows wild in southern Asia. The indigo dye can be extracted from the shoots with water. Indigo was used to dye cotton a deep blue color.



DYE—Textile printing
A sheet of cloth is being dyed by running it through a textile printing press. Large vats of dye are standing in front of the press.

Dyeing During dyeing, textiles are placed in a dye solution called a dye bath. The textile fibers absorb the dye molecules. Dyed textiles vary widely in their ability to hold color. A colorfast fabric does not usually change color. Substances called mordants are often added to dye baths to make fabrics more colorfast. Fabrics can have other properties also. For example, a lightfast fabric does not fade in sunlight. A washfast fabric keeps its color after washing and drying.

Textiles are dyed in different stages. If the fibers are dyed before being spun into a yarn, the process is called stock dyeing. In yarn dyeing, also called skein dyeing, the fibers are dyed after they are made into a yarn. Most stock and yarn dyeing occurs in large vats. In piece dyeing, dye is applied after the yarn is made into cloth. Some dyeing machines pull the cloth through the dye bath. Others operate by squeeze rolls, which force the dye into the cloth.

Types of dye The two main types of dye are natural and synthetic. Most natural dyes come from parts of plants, such as bark, berries, leaves, flowers, and roots. The madder plant, indigo plant, and the crocus plant once supplied dyes. Logwood and henna, which is obtained from a shrub that grows in North Africa and the Middle East, are still used as dyes today.

Synthetic dyes have largely replaced natural dyes. There are several kinds of synthetic dyes. Acid dyes dissolve in acid solutions and are used to color nylon, silk, and wool. Basic dyes dissolve in alkaline solutions and color acrylic, wool, and other fibers (see ACID; ALKALI). Direct dyes color material without the help of a mordant. They are used on cotton and rayon. Premetalized dyes contain metals that improve colorfastness. These dyes are often used on nylon, wool, and acrylic. Disperse dyes dissolve only at high temperatures. Disperse dyes color acetate, acrylic, nylon, and polyester. Reactive dyes form a chemical bond with certain fabrics, including cotton and rayon. Sulfur dyes dissolve in alkaline solutions. Fibers colored with such dyes are treated with oxygen to help fix the dyes. Vat dyes, processed in a way similar to the sulfur dyes, are among the most colorfast dyes. Sulfur and vat dyes are used chiefly on cotton and rayon.

Dyes are also used by manufacturers in printing designs on fabrics. A machine applies different colors to various areas by means of screens or engraved rolls.

See also FIBER; TEXTILE.

DYNAMICS

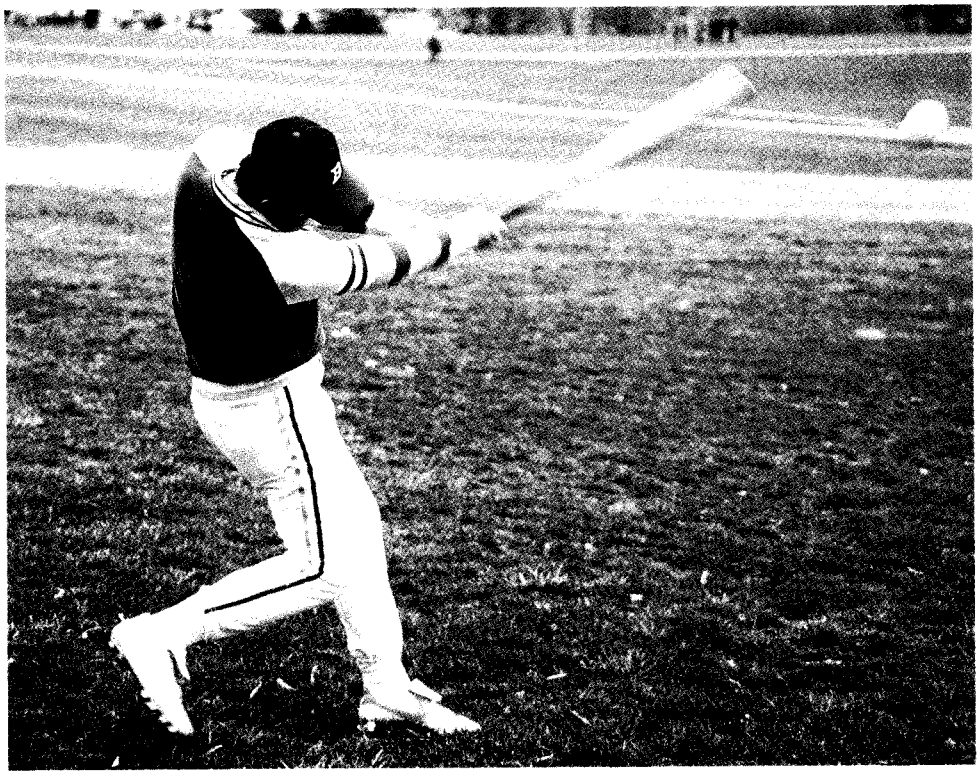
Dynamics is the branch of physics that is the study of movement. There are three very important laws in dynamics. They are called Newton's laws of motion, after Sir Isaac Newton. Newton was an English physicist who lived three hundred years ago. He was the first person to codify these laws (see MECHANICS; NEWTON, SIR ISAAC; PHYSICS).

The first law of motion An object will remain at rest unless a force acts on it. Also, an object moving in a straight line will continue to move in a straight line unless acted upon by a force. When a body is moving, it has a velocity. Velocity is the rate of motion in a particular direction. Speed is the rate of motion in any direction. Velocity will only change if a force acts on the body (see SPEED; VELOCITY).

The second law of motion When a body speeds up or slows down, it accelerates. Acceleration is the rate of change of velocity. Suppose a body's velocity increases by 6.5 ft. [2 m] per second, every second. Then, its acceleration is 6.5 feet per second per second. A force causes a body to accelerate. The size of the force acting on a body of constant mass and its acceleration are proportional to each other. That is, if the force on a body is doubled, so is its acceleration. The acceleration also depends on the mass of the body. The larger the mass, the smaller the acceleration it will have for a particular force (see ACCELERATION; MASS).

An example of Newton's second law of motion is when a person hits a ball with a bat. When this is done, a force is acting on the ball. If the ball is hit twice as hard, it will go twice as far. However, suppose the ball is twice as heavy. Then it has to be hit twice as hard to make it go the same distance.

The third law of motion Every force creates a reaction. This reaction is as big as the force and acts in the opposite direction. When a person pushes his or her hand on a table, the table pushes back against the person's hand. The pushing is called the action and the pushing up is the table's reaction. Without this reaction, pressure from the hand would push the table down. This does not seem like a law of motion, but it is. Without it, jet



HITTING A BALL
Hitting a baseball illustrates Newton's second law. The ball changes its direction of motion as the result of a force applied by the bat. The greater the force applied (the harder the ball is hit), the greater is the acceleration given to the ball.

airplanes would not be able to fly. The jet plane's forward movement is the reaction to the action of exhaust being thrown backward from the plane's engine.

Moving in a circle Imagine whirling a stone around on the end of a string. There is a force keeping the stone moving in a circle. This force is the tension in the string. It is the same with a spacecraft orbiting the earth. The force keeping it moving in a circle is gravity. This pull is called the centripetal force (see CENTRIPETAL FORCE). According to Newton's laws of motion, a force produces an acceleration. These objects do not seem to be accelerating, but they are. Their speeds stay the same, but the direction of their motion changes. This means that their velocities change. They are, in fact, accelerating. The stone is accelerating toward the person's hand, and the spacecraft is accelerating toward the earth. However, this acceleration is offset by the object's tendency to move in a straight line. This means that the rocket or stone tend to move away from the earth or the person's hand. Therefore, the rocket or stone stay as they are, going around in a circle.

Movement and energy All moving bodies have energy. This energy is called kinetic energy (see KINETIC ENERGY). The amount of energy depends on the mass of the body and its velocity. If a moving ball hits a still one, then the still ball moves. Some of the kinetic energy from the moving ball has been transferred to the still ball. However, the total of the energy of motion of the two balls before and after the collision is the same. This is an example of the law of conservation of energy. In practice, of course, a little of the energy of the moving ball will be lost as friction and in heating up the still ball during collision. This is because the collision will not be completely elastic—that is, some of the kinetic energy will be absorbed by the balls themselves. There is another quantity that remains the same. It is called the momentum. The momentum of a body is its mass times its velocity. When two balls collide, some of the momentum is transferred. However, the total momentum of the two balls remains the same. This is called the law of conservation of momentum (see MOMENTUM).

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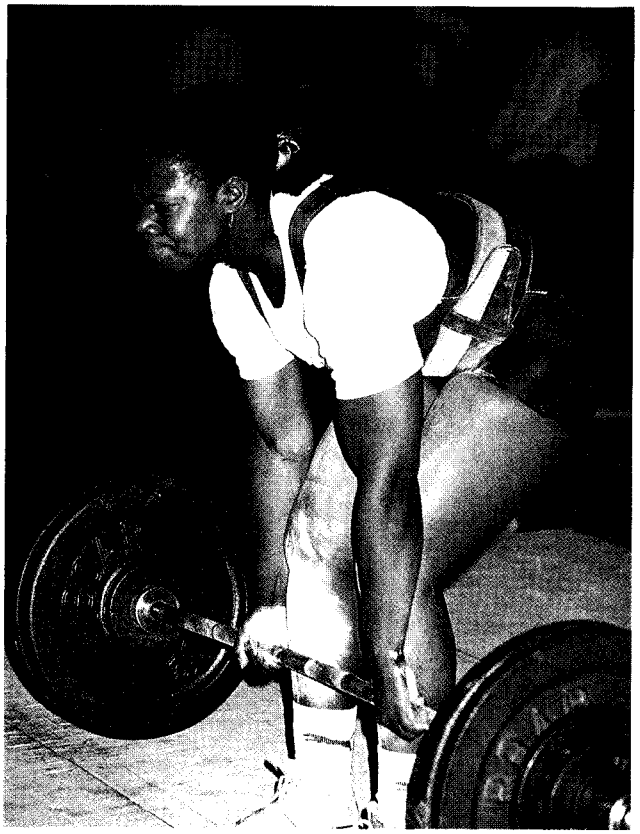
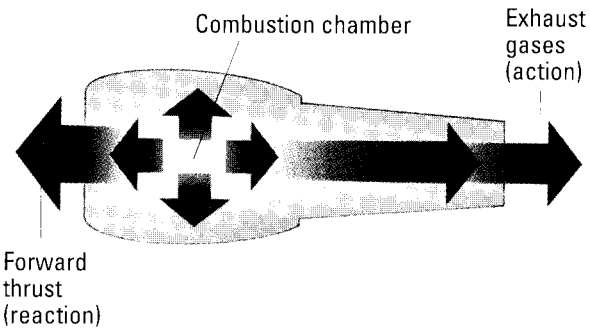


LIFTING WEIGHTS

Lifting a weight involves all of Newton's laws. Before the athlete applies a force, the weight does not move (in accordance with the first law). The weight only moves when a force is applied and the greater the force, the greater the acceleration of the lift (in accordance with the second law). When holding the weight aloft, the athlete experiences the downward force of the weight and an equal upwards reaction force produced by the floor (in accordance with the third law).

ROCKET ENGINES

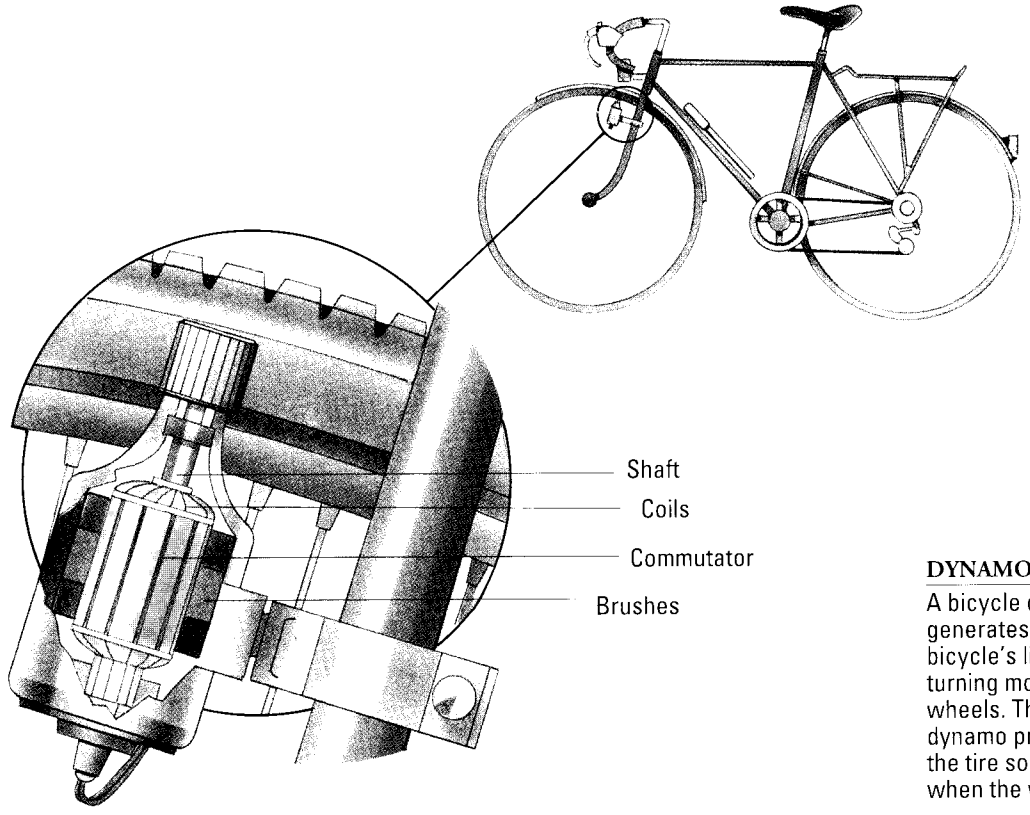
A rocket engine illustrates Newton's third law. Hot gases produced in the combustion chamber expand, forcing the exhaust gases backwards from the engine. An equal but opposite thrust force is developed which drives the engine forward.



DYNAMITE Dynamite is an explosive. It is used to blast rock out of quarries and mines, and to make space for foundations for buildings. Dynamite is also used to demolish (knock down) buildings and other structures such as bridges. Dynamite was invented in 1864 by the Swedish inventor Alfred Nobel. He made it from an oily liquid explosive called nitroglycerin absorbed into a powdery earth called kieselguhr. Nobel's dynamite was not as powerful an explosive as nitroglycerin on its own, but it was much more stable and therefore safer to handle than nitroglycerin. Dynamite was so successful that Nobel made a great fortune from its sales. Modern dynamite contains sodium or ammonium nitrate with nitroglycerin absorbed into wood pulp. To use dynamite, a detonator is inserted into one end of a cartridge full of the explosive. A detonator is a device that sets off an explosion. When everyone is at a safe distance, an electric current is sent down a pair of wires to the detonator. The detonator explodes and sets off the main charge of dynamite.
See also EXPLOSIVE; NOBEL, ALFRED.

DYNAMO A dynamo is a machine designed to change mechanical energy into electrical energy. It is an electrical generator. The simplest dynamo consists of a coil of wire, called an armature, rotating between the poles of a magnet. The magnetic field causes an electric current to flow through the wire (see MAGNETIC FIELD). When the coil has rotated halfway around, the direction of the electric current flowing in the coil reverses.

In practice, the armature consists of many coils of wire rotating inside a powerful electromagnet. The ends of each armature coil are connected to segments of a ring called a commutator (see COMMUTATOR). The commutator spins with the armature. Blocks of carbon, called brushes, rest against the spinning commutator and lead the electric current from it to an outside circuit. The commutator ensures that the electric current generated by the dynamo always flows in the same direction. This is a direct-current (DC) generator. The commutator may be replaced by two continuous rings on each coil. This makes the current reverse direction with every half turn of the armature. This is an alternating-current (AC) generator, also called an alternator (see ALTERNATING CURRENT).
See also ELECTROMAGNETISM; GENERATOR, ELECTRICAL.



DYNAMO
A bicycle dynamo generates electricity for the bicycle's lights from the turning motion of one of its wheels. The top of the dynamo presses against the tire so that it turns when the wheel turns.

E

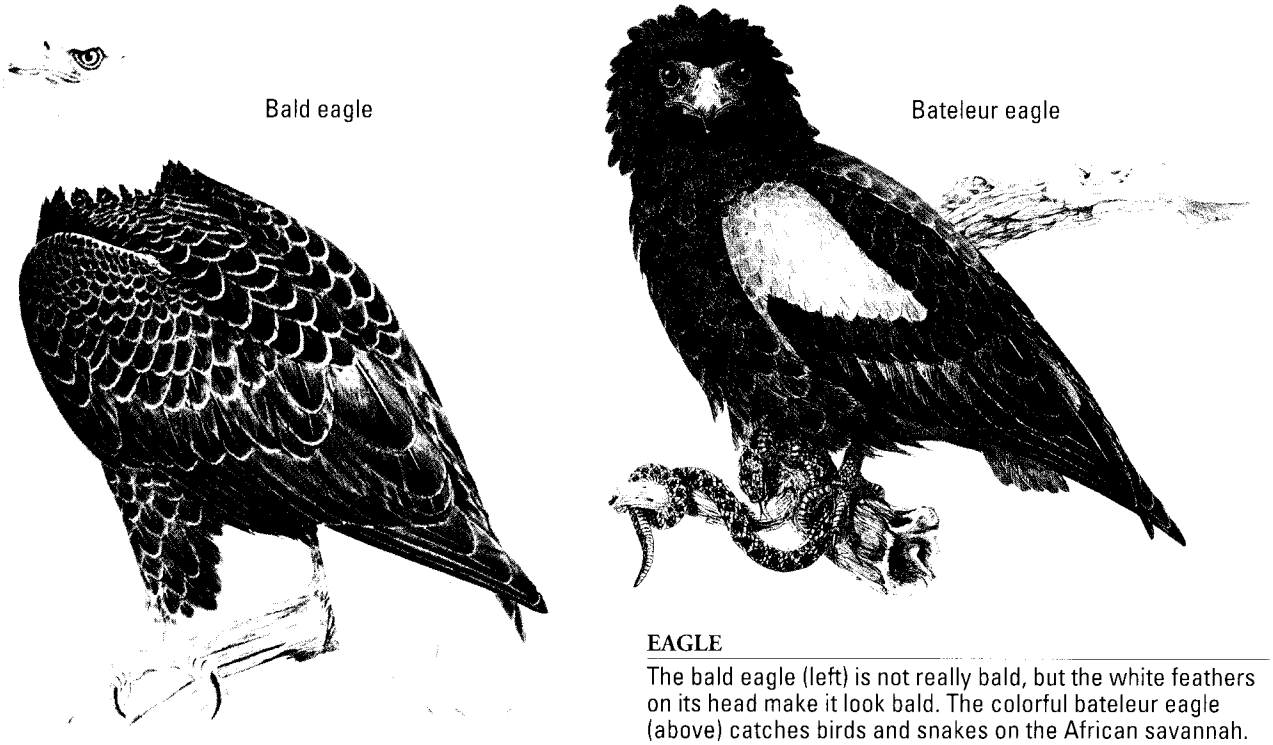
EAGLE Eagles are large birds of prey found throughout the world except in Antarctica. They have long symbolized power, freedom, and greatness. Among the largest eagles, the bald eagle *(Haliaeetus leucocephalus)* and the golden eagle *(Aquila chrysaetos)* grow to a length of 36 in. [90 cm], weigh 13 lb. [6 kg], and have a wingspan of 6.6 ft. [2 m]. As with most birds of prey, the female is larger than the male.

Eagles have large heads, with large, very keen eyes. They have rectangular wings that they use to soar gracefully through the air in search of food. The beak is strong, about 2 in. [5 cm] long, with the upper part curving over the lower part and ending in a sharp point. The legs and feet are very strong, and the toes end in sharp, clawlike talons. Eagles are carnivores (meat eaters) and usually eat rodents and other small animals, though some eagles prey on larger animals such as goats, small antelopes, and livestock weighing as much as 22 lb. [10kg]. Eagles are aggressive predators, hunting during the day by swooping down on prey, grabbing it and killing it with their talons.

An eagle usually makes a nest, called an aerie, in the top of a tall tree. One nest usually serves an eagle for its entire life (twenty to fifty years) and may be as deep as 20 ft. [6 m] and as wide as 10 ft. [3 m]. Eagles begin to mate in the spring of their fourth year and keep the same mate for life. At breeding time, a pair of eagles establishes its territory and prevents all other eagles from entering. The female lays one or two large eggs, about 3 in. [8 cm] long and weighing about 5.4 oz. [150 g], and stays with them for thirty-five to forty-five days, until they hatch. During this time, the male brings food to the female in the nest. If there are two eggs, the eaglet that hatches first is usually larger, and it often kills the other eaglet.

Of the forty-eight different kinds of eagles, only the bald eagle and the golden eagle are native to North America. Others, such as the serpent eagles, harpy eagles, monkey-eating eagles, and sea eagles, live in widely varied parts of the world. Because eagles sometimes prey on livestock, they are often hunted by ranchers and farmers. Eagles in many parts of the world (including the United States) face extinction from hunting and from poisoning by insecticides and pesticides. Many countries have established laws to protect eagles.

See also BIRD; EXTINCTION.



EAGLE
The bald eagle (left) is not really bald, but the white feathers on its head make it look bald. The colorful bateleur eagle (above) catches birds and snakes on the African savannah.

EAR

The ear is the organ of hearing and equilibrium, or balance. With our ears, we hear sounds. Because we have two ears, we are able to locate sounds in space. We learn to talk by imitating speech sounds reaching us through the ears. The ears also have special parts that help us keep our balance.

The ear is a complicated and sensitive organ. It detects the vibration of sound waves in the air and changes them into nerve signals that reach the brain (see SOUND). The ear is divided into three parts: the outer ear, the middle ear, and the inner ear.

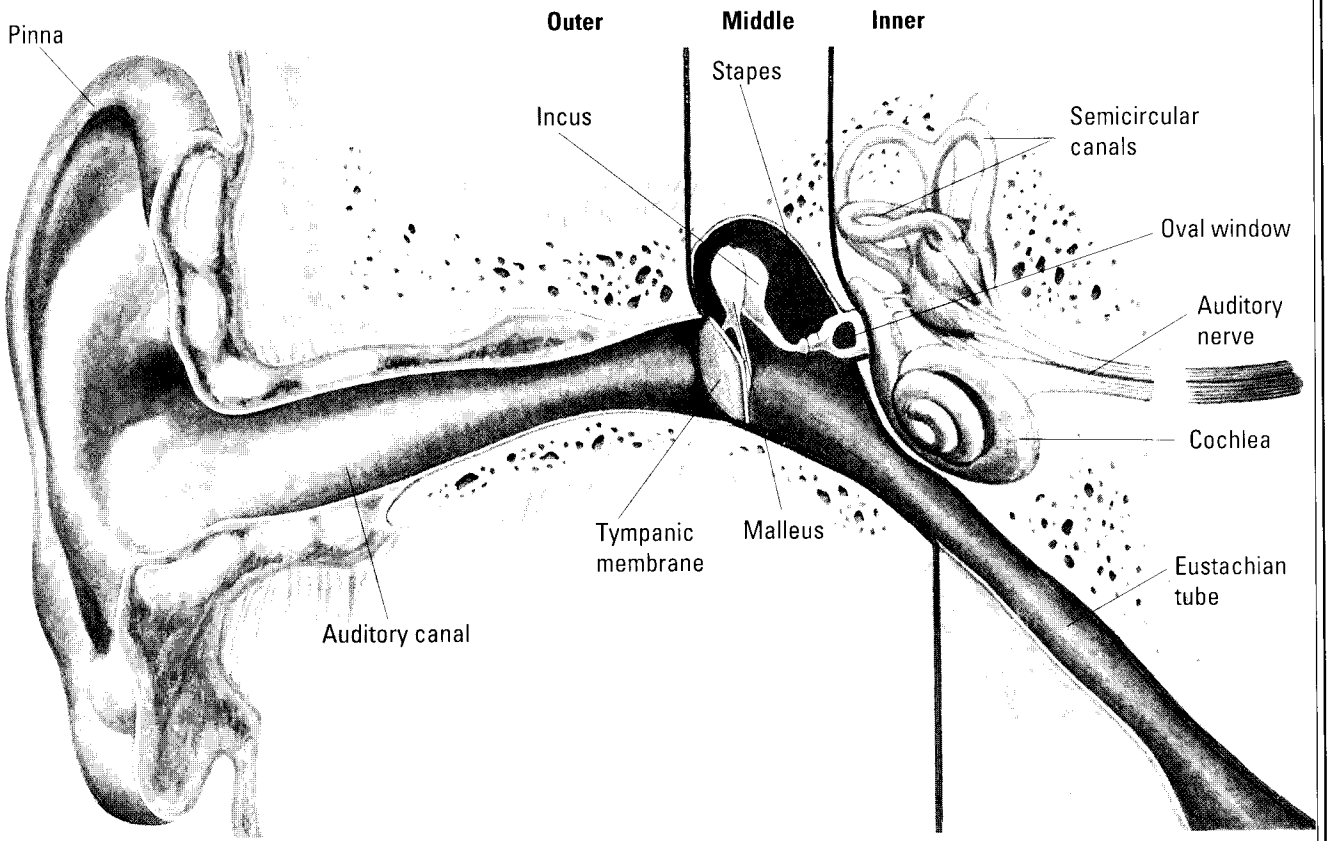
The outer ear includes the fleshy part on the outside of the head. This part is also called the auricle or pinna. Its main function is to collect sound waves so that they can travel along the external auditory canal to the middle ear. In humans, the pinna lies close to the head and cannot move around. Certain other animals, including the horse, the dog, and the cat, can move their pinnas around to gather sounds more efficiently.

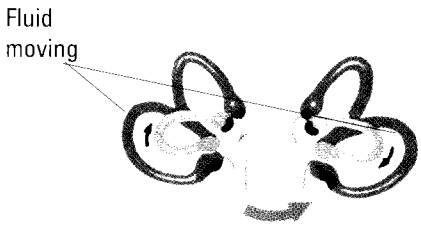
The external auditory canal is about 1 in. [2.5 cm] in length and ends at the tympanic membrane, or eardrum, which is a thin sheet of tissue about 0.25 in. [6 mm] across. Sound waves reaching the tympanic membrane cause it to vibrate and to pass the waves on to the middle ear. The external auditory canal is lined with fine hairs and very small glands that produce wax. The hairs and wax protect the ear by keeping out dust and insects.

The middle ear begins with the inner side of the tympanic membrane and ends at another membrane, called the oval window. Within the middle ear are three small bones. The first, called the malleus, or hammer, is attached to the inner surface of the tympanic membrane. The malleus is then hinged to the incus, or anvil. Finally, the incus connects to the stapes, or stirrup, which is attached to

HUMAN EAR

The outer, middle, and inner divisions of the ear are shown. This small organ distinguishes between millions of different sounds and keeps the entire body balanced.





SEMICIRCULAR CANALS

The semicircular canals keep the body balanced by sending nerve impulses to the brain according to the way in which fluid moves along them. They can detect the smallest movement in any direction. If they are affected by disease, vertigo or dizziness is the result.

the membrane of the oval window. These three hinged bones can move freely when the tympanic membrane vibrates due to sound waves. This movement transmits the sound wave vibrations to the oval window membrane and into the inner ear.

The inner ear contains the cochlea. The cochlea is a spiral-shaped cavity. The cochlea is filled with a fluid and a thin length of tissue called the basilar membrane. Attached to this membrane is the organ of Corti. The organ of Corti contains many tiny hair cells that respond to sound waves. These hairs change the sound vibrations into nerve impulses, which are sent along to the brain through the auditory nerve.

The inner ear also contains the three semicircular canals. The canals contain fluid. Whenever a person's head tilts or turns, the movement causes the fluid in the canals to move in different directions. This movement results in nerve impulses being sent to the brain. The brain then gives instructions to the body on how to keep its balance.

The air pressure on either side of the tympanic membrane must be equalized so that the membrane can vibrate freely. Air can get to the middle ear side of the tympanic membrane through a narrow tube, called the eustachian tube, which connects with the back of the throat. Hearing can be disturbed if this tube becomes clogged—for example, when a person has a cold. The middle ear is usually the part that is infected when people get an earache. Earaches are more common in children than in adults because children's eustachian tubes become blocked more easily than those of adults.

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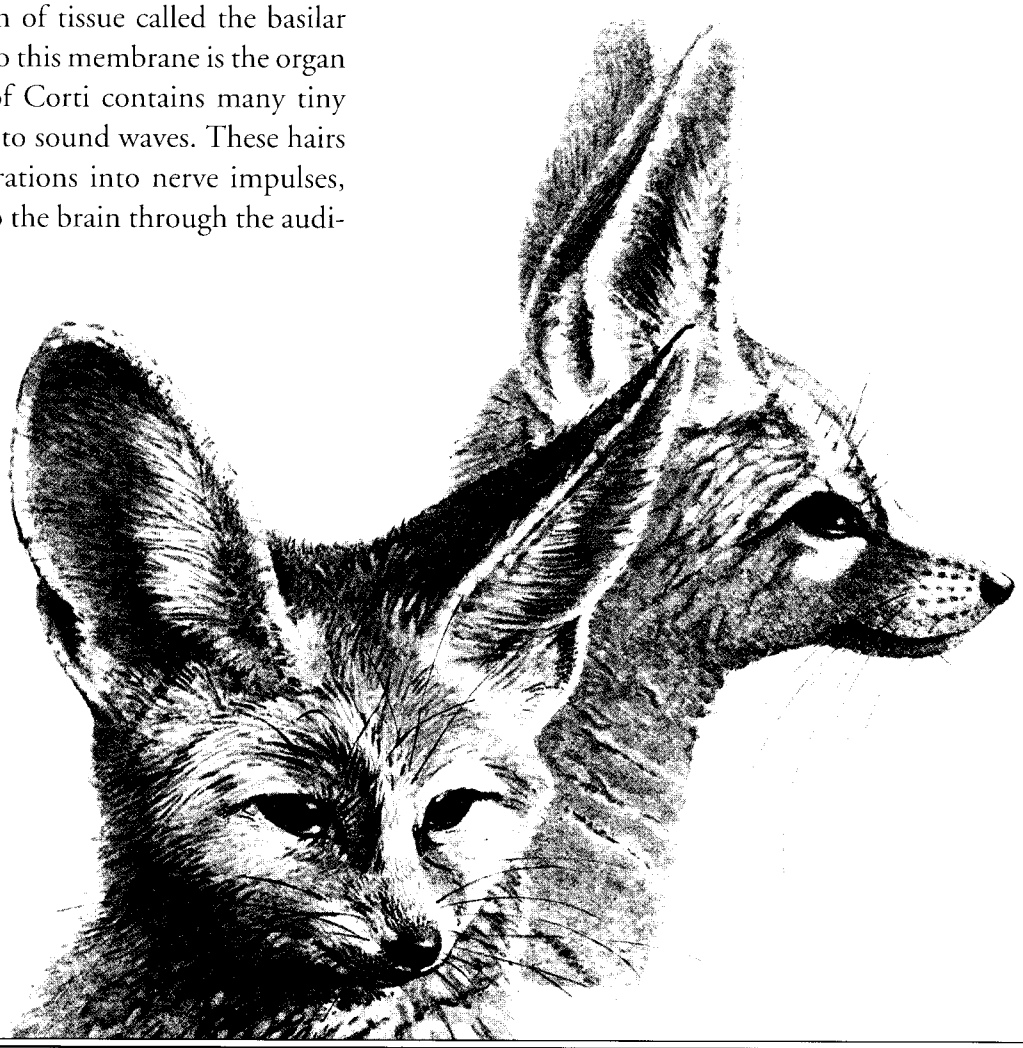


FENNEC

The fennec, or desert fox, hunts mainly at night. Instead of using eyesight, the fennec uses its sensitive hearing to locate prey in the dark. Its large ears help collect the quietest sounds.

EARTH

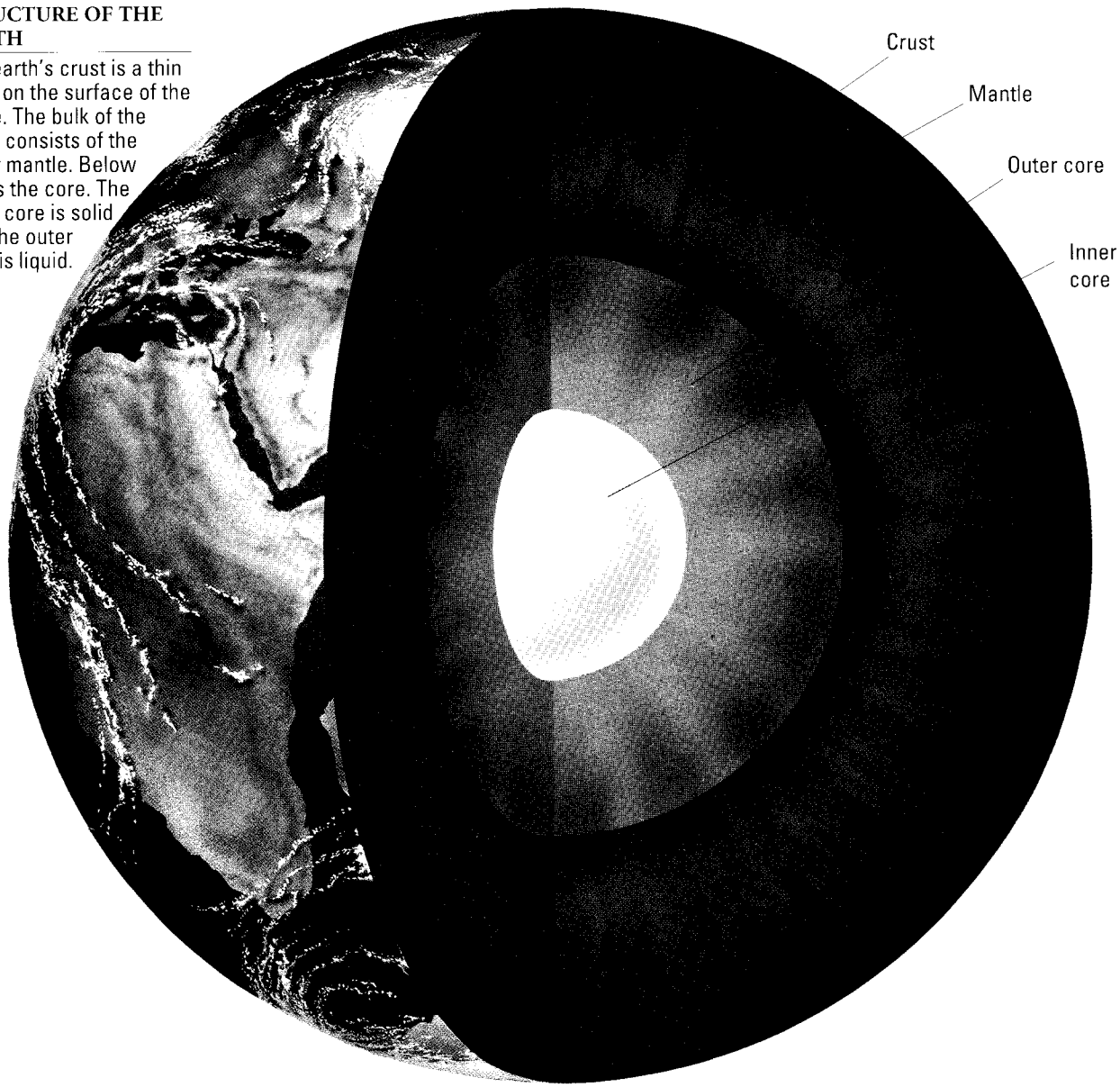
The earth is the planet on which we live, the third planet from the sun. The earth has developed an environment suited for supporting life. The oceans, continents, and atmosphere formed over a period of billions of years. Organisms as tiny as bacteria and as large as dinosaurs have evolved, flourished, and died on earth. The unique characteristics of the earth have allowed life to evolve here (see EVOLUTION).

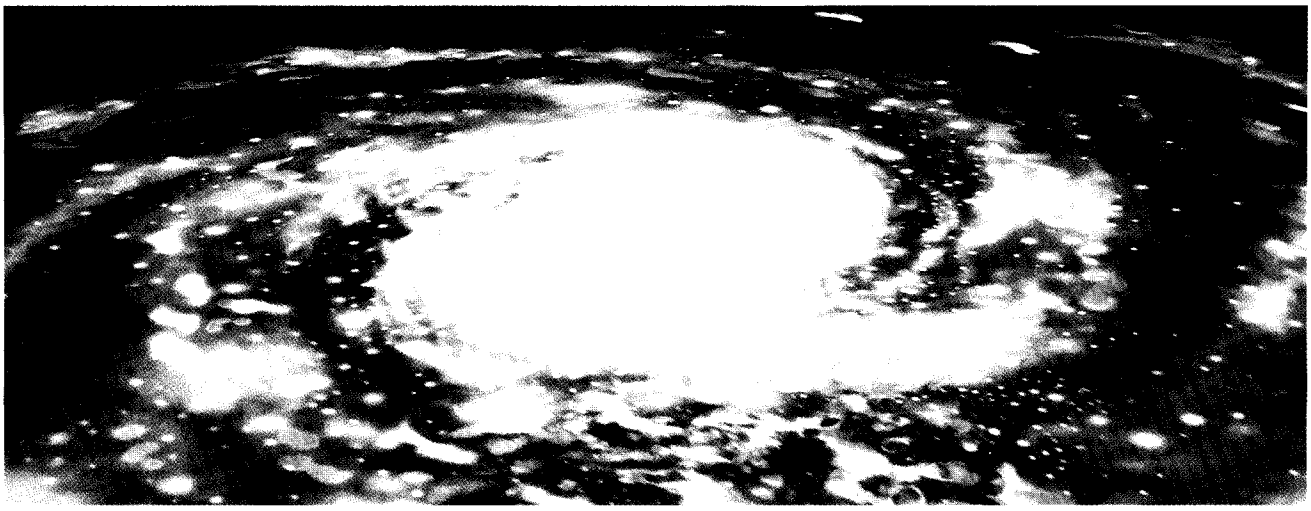
The earth and the universe The earth is one of nine known planets that revolve around the sun (see SOLAR SYSTEM). Of these nine planets, the earth is the fifth largest. It has a diameter of almost 8,000 mi. [13,000 km] and a surface area of about 200,000,000 sq. mi. [500,000,000 sq. km]. Water covers about 70 percent of the earth's surface area.

The earth is always moving in four ways. It spins on its axis (an imaginary line running through the north and south poles), causing day and night. It takes the earth slightly less than one day (twenty-four hours) to make a complete turn. The earth also revolves around the sun, taking about one year for a complete revolution. The axis of the earth also shifts or wobbles, like that of a spinning top beginning to slow down. Finally, with the rest of the solar

STRUCTURE OF THE EARTH

The earth's crust is a thin layer on the surface of the globe. The bulk of the earth consists of the stony mantle. Below this is the core. The inner core is solid and the outer core is liquid.





MILKY WAY GALAXY

The sun is just one of the 100 billion stars in the Milky Way galaxy, which is slowly rotating. The earth, with the rest of the solar system, moves around the center of the Milky Way galaxy once every 225 million years.

system, the earth swings around the center of the Milky Way galaxy. This trip takes about 225 million years (see MILKY WAY).

The earth's axis is tilted at 23½° toward a line perpendicular (at a right angle) to its path around the sun. The movement of the earth around the sun and the tilt of the earth's axis cause the seasons (see SEASON).

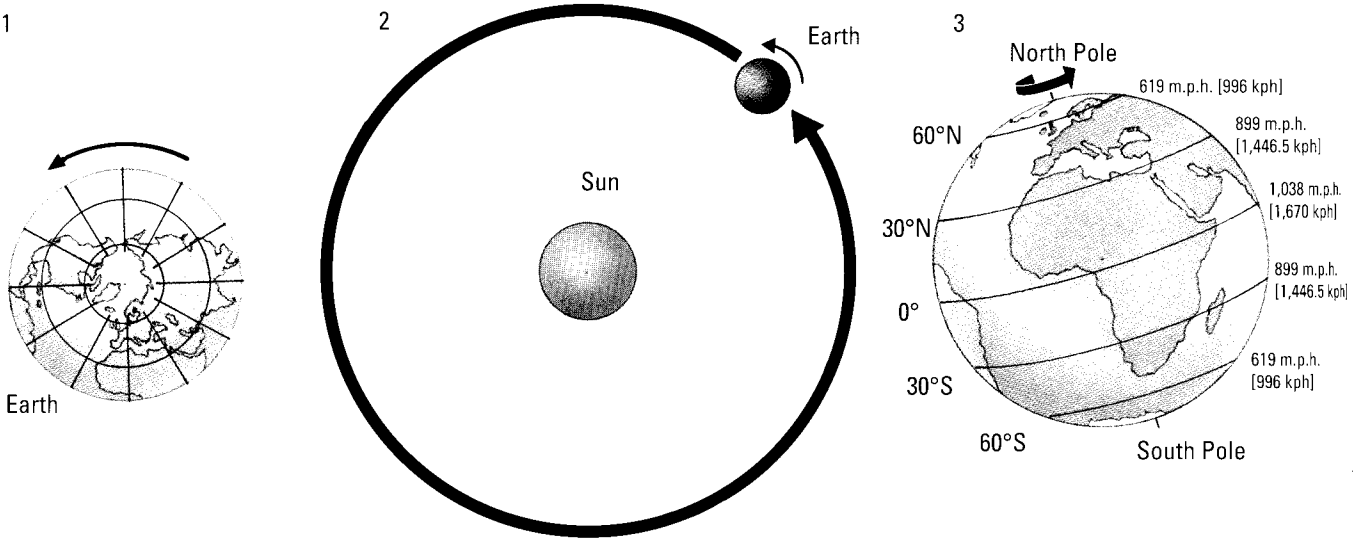
Gravity holds the earth, and the eight other known planets of the solar system, in their orbits around the sun. Gravity also holds the moon in orbit around the earth (see GRAVITY).

Earth zones The earth is divided into three main zones: the atmosphere, the hydrosphere, and the solid earth. The atmosphere is like a gas envelope surrounding the earth. It provides the air necessary for life and protects the earth from extreme heat and cold. Physical changes in the atmosphere are responsible for the weather. A large percentage of the oxygen in the atmosphere comes from photosynthetic plants (see ATMOSPHERE; PHOTOSYNTHESIS).

The hydrosphere consists of the water and ice on earth. Water is essential for all life on earth. The

MOVEMENTS OF THE EARTH

The main movements of the earth are illustrated below. (1) The earth spins on its axis, making one rotation each 24 hours. (2) The earth revolves around the sun, making one orbit in a year. (3) Due to the rotation of the earth, places at the equator are moving at over 1,000 m.p.h. [1,600 kph].



solid earth consists of three parts: an iron-rich core, a stony mantle, and a thin crust. The theory that the earth's crust is not rigid, but rather consists of a number of plates, is known as plate tectonics. Some of the plates have oceans on top of them, while other plates have both continents and oceans. The movement and interaction of these plates causes earthquakes and volcanic action and builds mountains (see PLATE TECTONICS).

The three types of rocks found in the earth's crust are classified by how they were formed. They are igneous rock, metamorphic rock, and sedimentary rock (see ROCK). The earth's crust varies in thickness from 3 mi. [5 km] under the oceans to about 55 mi. [90 km] under the continents. Beneath the crust is the mantle, which is about 1,800 mi. [2,900 km] thick. Mantle rocks are far more dense than those of the crust (see DENSITY). At the center of the earth is the core. The earth's core is thought to be solid at the center, but surrounded by a liquid envelope.

The age and history of the earth It is generally accepted that the earth formed around 4.6 billion years ago from a vast cloud of dust and gases. The rest of the solar system also formed from this cloud around the same time.

By studying fossils, scientists have been able to unravel some of the history of life on earth. Methods have been developed that can determine the age of fossils and rocks (see DATING; FOSSIL).

The history of the earth is divided into four main time periods: the Precambrian era, the Paleozoic era, the Mesozoic era, and the Cenozoic era. The Precambrian era covers the first four billion years of the earth's history. During this time, the crust of the earth melted and cooled, and the atmosphere formed. Around 3.8 billion years ago, the oceans began to form. Scientists have found fossils of primitive organisms that floated in the seas about 3.5 billion years ago. These are the oldest life forms known to have existed on earth.

The Paleozoic era began 570 million years ago and lasted about 325 million years. During this period, organisms made up of many cells evolved. These include fish, amphibians, and reptiles. Insects and plants also appeared. The Paleozoic era also saw the formation of the Appalachian Mountains.

The Mesozoic era began about 245 million years ago and lasted 180 million years. This was the age of reptiles, including the dinosaurs. Cone-bearing plants (conifers) were the main type of plants, though flowering plants developed near the end of the Mesozoic. Birds and mammals also evolved.

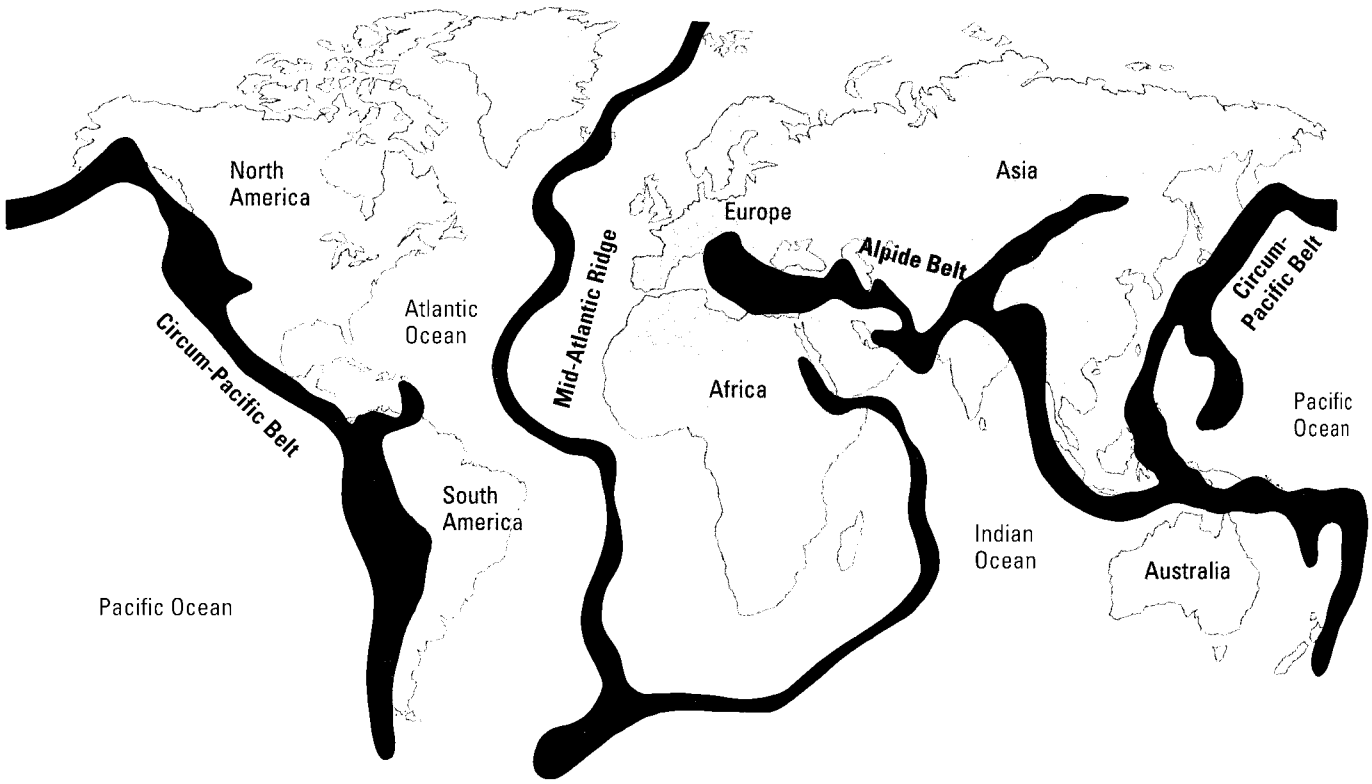
The Cenozoic era started 65 million years ago and extends to the present. During this time, the ice ages—in which huge sheets of ice called glaciers moved across the continents—occurred (see ICE AGE). In the beginning of this era, flowering plants, such as the ones that exist today, became plentiful. Mammals became the dominant land animal. Landforms such as the Alps, Himalayas, and Coast Ranges developed.

Human beings have evolved only recently in the earth's history. The first humanlike creatures appeared more than 4 million years ago. Modern human beings developed about 2 million years ago. *See also* GEOLOGICAL TIME SCALE. PROJECT 28

THE EARTH

Diameter:	7,926 mi. [12,756 km] at equator
Circumference:	24,901 mi. [40,074 km] at equator
Surface temperature:	
Minimum recorded	-127°F [-88°C]
Maximum recorded	136°F [58°C]
Gases in the atmosphere by volume:	
Nitrogen	78.09 percent
Oxygen	20.95 percent
Argon	0.93 percent
Carbon dixoide and other gases in small quantities	
Composition of the earth's crust by weight:	
Oxygen	46.60 percent
Silicon	27.72 percent
Aluminum	8.13 percent
Iron	5.00 percent
Calcium	3.63 percent
Sodium	2.83 percent
Potassium	2.59 percent
Magnesium	2.09 percent
Others	1.41 percent

EARTHQUAKE



EARTHQUAKE ZONES

The map above shows the world's earthquake-prone regions. Most earthquakes occur along the Circum-Pacific and Alpide belts. Others occur along mid-oceanic ridges beneath the oceans.

An earthquake is a movement of the earth's crust that causes the ground to shake or vibrate. Of the thousands of earthquakes that occur each year, only a few are felt or cause major damage.

The most destructive earthquakes are those that occur near cities or other populated areas. Most casualties associated with earthquakes are caused by buildings or other artificial structures collapsing. However, when an earthquake occurs in a large city, fire is frequently one of the major causes of damage. Fires often spread in an area hit by an earthquake because of broken gas lines and electrical short circuits. For example, in the San Francisco earthquake of 1906, three-fourths of the damage to the city was caused by fire.

Earthquakes are detected by sensitive instruments called seismographs (see SEISMOLOGY). The strength of an earthquake is measured on the Richter scale (see RICHTER SCALE).

Powerful earthquakes may cause huge sea waves called tsunamis. These waves cause heavy damage when they hit the coast.

Earthquake zones The zones along which earthquakes are most common coincide with the lines along which the various tectonic plates of the earth's surface meet (see PLATE TECTONICS). These may lie along the edges of continents, such as around the rim of the Pacific Ocean, or along chains of islands, such as the East Indies, or beneath oceans along the oceanic ridges.

Cause of earthquakes The earth's crust is made up of about twenty plates that are always moving and rubbing against each other. When the

edges of two plates become jammed, tension builds up. The tension is relieved by a sudden movement of the plates, causing an earthquake. Sometimes one plate is forced beneath the other to cause an earthquake.

As tension between two plates builds up, large amounts of energy also build up. When the force finally is released in an earthquake, it is transmitted to the surrounding areas in several waves. The first two waves are the compression waves and shear waves. These travel rapidly through the earth but cause little damage on the surface. The third type of wave, called the long wave, travels slowly over the earth's surface. It is this wave that causes the damage.

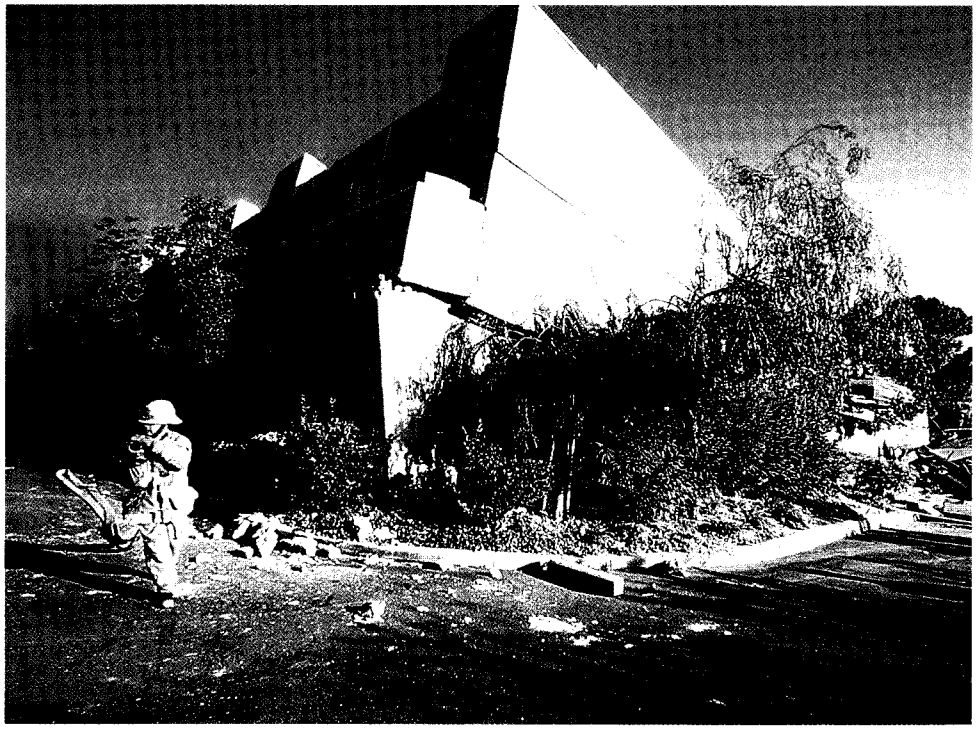
The San Andreas fault in western California is thought to be the edge between two plates. A shift in the San Andreas fault caused a major earthquake in San Francisco in 1906 (see FAULT; SAN ANDREAS FAULT).

Other fault lines that could result in earthquakes in the United States are in Hawaii, Missouri, New Jersey, and New England. A series of quakes in 1811–1812 in the town of New Madrid, Missouri, may have been the worst in American history. The first quake was felt as far away as Boston, Massachusetts. The series of earthquakes near New Madrid raised about 25 sq. mi. [65 sq. km] of ground 20 ft. [6 m]. It caused a new lake to form, and it made the Mississippi River run backward for a time. Such earthquakes are called "intra plate earthquakes" because they occur a long way from the edge of a tectonic plate. The faults that cause them usually lie deep below the earth's surface.

Accurate earthquake forecasts could save many lives. Few successful predictions have been made in recent years. The most notable was in China in February 1975. Because of the advance warning,

DEVASTATION

In 1886 an earthquake in Charleston, South Carolina, devastated the city. This earthquake was caused by motion between the Caribbean and North American tectonic plates. In those days buildings were not designed and constructed to withstand earthquakes.



RECENT EARTHQUAKES

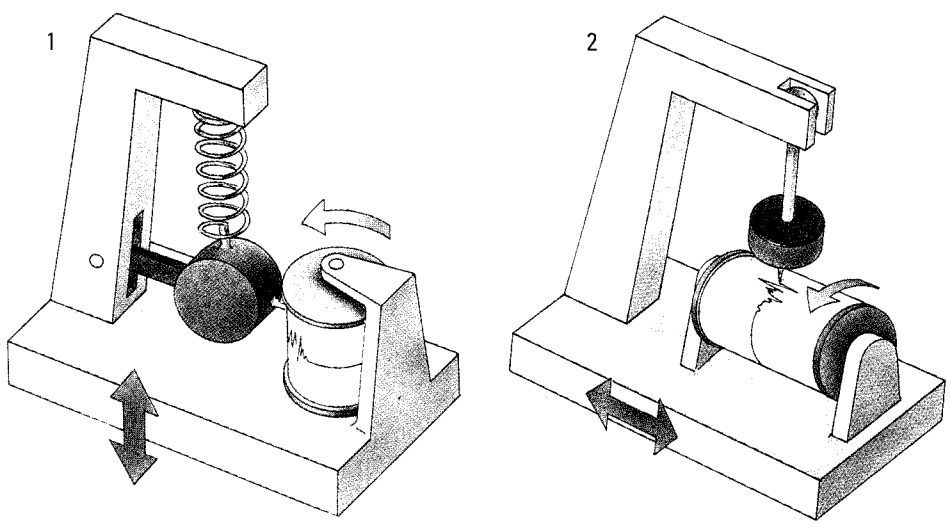
The earthquake that struck California on January 17, 1994, was one of many that plague the area. Buildings designed to withstand the shocks and frequent earthquake emergency drills are reducing the casualties caused by earthquakes.

officials evacuated people and animals to open ground, and thousands of lives were saved in the severe earthquake that followed. However, in 1976, an unpredicted earthquake destroyed the city of Tangshan, killing 650,000 people.

One way scientists are trying to make better earthquake predictions is through observing animals. Animals sometimes act strangely in the hours before an earthquake strikes. Animals may well be more sensitive than humans to physical changes that precede a quake. These changes include a shift in the angle or height of ground surfaces, ionization of the air, the presence of radon gas, vibrations, shifts in the earth's magnetic field, and the rise or fall of lake, pond, or river levels (see IONS AND IONIZATION).

With special photographs made by satellites, scientists can measure the actual distance that the earth's crust is moving. From photographs taken at altitudes of 600 mi. [965 km], scientists know that the two sides of the San Andreas fault are moving past each other at the rate of about 3.5 in. [9 cm] per year.

See also CONTINENTAL DRIFT.



SEISMOGRAPHS

Earthquake magnitudes are estimated by using a seismograph. A suspended weight tends to remain still while the rest of the instrument, as well as the whole observatory, is shaken around it. The relative movement is traced out on a revolving drum. Seismographs are mounted (1) vertically and (2) horizontally, to record the movements in any direction.

EARTHWORM An earthworm is any of 1,800 species of segmented worms belonging to the phylum Annelida (see ANNELIDA). The most common earthworm, *Lumbricus terrestris*, is found in moist soil in temperate regions throughout the world. Earthworms vary in size from 0.04 in. [1 mm] to 11 ft. [3.3 m]. The earthworm has a simple brain and nervous system, allowing it to respond to heat, light, chemicals, or touch (see NERVOUS SYSTEM). Each segment, except the first and last, has four pairs of stiff bristles called setae. The setae are made of a tough material called chitin (see CHITIN). The earthworm uses its setae for movement.

The earthworm has a complete digestive system (see DIGESTIVE SYSTEM). Its alimentary canal runs the entire length of its body with a mouth in the first segment and an anus in the last. As the earthworm moves, it swallows the soil along with any digestible decaying plant matter contained in it (see HUMUS). Gardeners and farmers consider the earthworm an important animal. As earthworms tunnel through the soil, they create air space. These air spaces help break up the soil, enabling roots of plants to grow more easily.

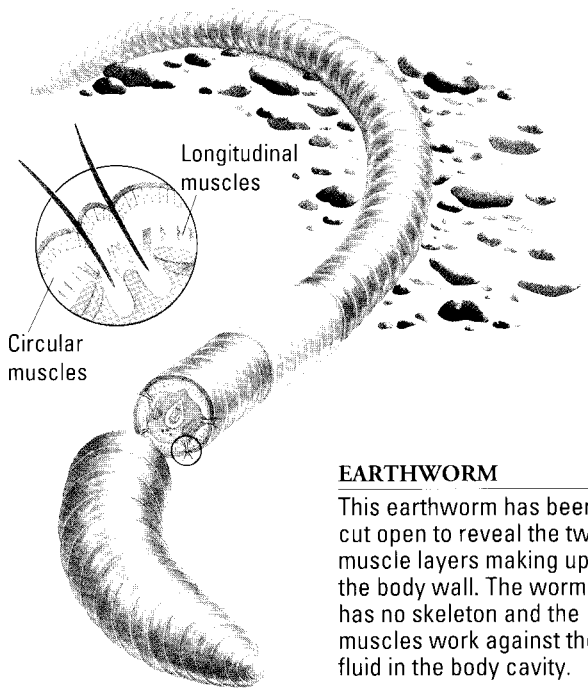
The earthworm moves by stretching out its front part, sticking its setae into the soil, then pulling up its rear part. In order to do this, the earthworm has evolved two sets of muscles. Circular muscles surround each segment and can make the worm thinner and longer. Longitudinal muscles extend the length of the worm and make the worm short and fat when they contract.

The earthworm has excretory structures called nephridia in each segment (see EXCRETION). The earthworm has a heartlike pump to push blood through two major blood vessels. The earthworm breathes through its skin. Oxygen from the air spaces in the soil diffuses through the worm's smooth, moist skin into the blood (see DIFFUSION). When it rains hard, these air spaces may become filled with water, and the earthworm will drown unless it comes to the surface. If the weather is too hot and dry, the earthworm's skin loses some of its moisture, and air cannot diffuse into the worm as easily. This often results in the death of the earthworm.

Earthworms are hermaphrodites, meaning they have both male and female reproductive structures. They cannot fertilize themselves, however (see HERMAPHRODITE). During mating, two earthworms surround themselves with mucus. This sticky fluid binds the two earthworms together as they exchange sperm. After sperm are exchanged, the earthworms move away from each other. A few days later, each worm detaches a cylinder of skin from its clitellum, which is the swollen band on the front half of the body. Eggs from the worm's own body and sperm received from the other worm are passed into the cylinder as the worm wriggles out of it. The ends of the cylinder then close up around the eggs and sperm to form a cocoon. The eggs are then fertilized and they develop into baby worms, which leave the cocoon when they are ready.

Because earthworms often come to the surface at night when their natural enemies, such as birds, are not hunting, they are sometimes called night crawlers.

PROJECT 75



EARTHWORM
This earthworm has been cut open to reveal the two muscle layers making up the body wall. The worm has no skeleton and the muscles work against the fluid in the body cavity.

EARWIG An earwig is any of 1,200 species of insects belonging to the order Dermaptera and characterized by pincers at the rear of the body. These pincers are used to capture prey, for defense, for fighting, in mating, or to help fold the hindwings under the forewings. The earwig's hindwings

are semicircular and very thin. Its forewings are small leathery flaps that protect the hindwings. However, some species of earwigs are wingless or have vestigial wings (see VESTIGIAL ORGAN). Some species can fly, but even those with fully developed wings rarely take to the air.

Earwigs have flat, brownish bodies ranging in length from 0.25 to 2 in. [0.6 to 5 cm]. They live in dark, moist places such as in decaying plant matter or under stones. Most species are tropical. Fewer than twenty species of earwigs live in the United States.

Earwigs are active at night. They are omnivores, feeding on both plant and animal matter. Although some earwigs cause damage to fruits and flowers, many also eat animals that humans consider pests, such as caterpillars, slugs, snails, and thrips.

One worldwide species of earwig is able to defend itself by squirting a foul-smelling liquid from a special gland in the abdomen. Other types of earwigs are parasites on rodents and bats (see PARASITE). Earwigs get their name from the superstition that they enter a sleeping person's ear. However, earwigs are no more likely than any other insects to crawl into people's ears.

EASTMAN, GEORGE (1854–1932) George Eastman was an American manufacturer and inventor. His development of an inexpensive, easy-to-use camera and roll film made it possible for millions of Americans to become amateur photographers.

Eastman's first contribution to photography was in simplifying the preparation process for taking photographs. Early cameras did not use film but glass plates that had to be coated with a light-sensitive mixture of chemicals. Eastman invented a machine for coating the glass plates. Before Eastman invented this machine, in 1879, the coating process had to be done by hand.

In 1884, Eastman introduced an inexpensive roll film and a roll holder for winding the film in the camera. Film was a big improvement over the fragile glass plates. Eastman's big breakthrough came in 1888, when he began manufacturing a small, light camera called the Kodak. Kodaks sold for $25, and thousands of people bought them. In 1900, Eastman came out with a $1 model. It sold in the millions and created a tremendous boom in amateur photography in the United States.

See also CAMERA; PHOTOGRAPHY.

EBONY Ebony is a very hard wood from a tree of the genus *Diospyros.* Ebony trees grow mainly in tropical regions, such as the Philippines, India, Sri Lanka, Africa, the islands of the Caribbean, and South America.

The outer wood, called sapwood, is white and often tinged with a gray or pink shade. The inner wood, called heartwood, is dark brown or black. A hard gum fills the heartwood cells. This gum probably adds to the property of ebony that makes the wood easy to work and carve. Ebony is used mainly for black piano keys, flutes, knife and brush handles, cabinets, and furniture.

The persimmon trees of the United States and Asia belong to the same genus, *Diospyros,* as the other trees from which ebony is obtained. However, persimmon trees have very little black heartwood. Therefore, the persimmon tree produces little ebony. Nevertheless, the hard sapwood of the American persimmon tree is used to make wooden heads for golf clubs.

EBONY
The dense, black heartwood seen in this log is ebony, a popular wood for carving. However, the trees are now becoming rare.