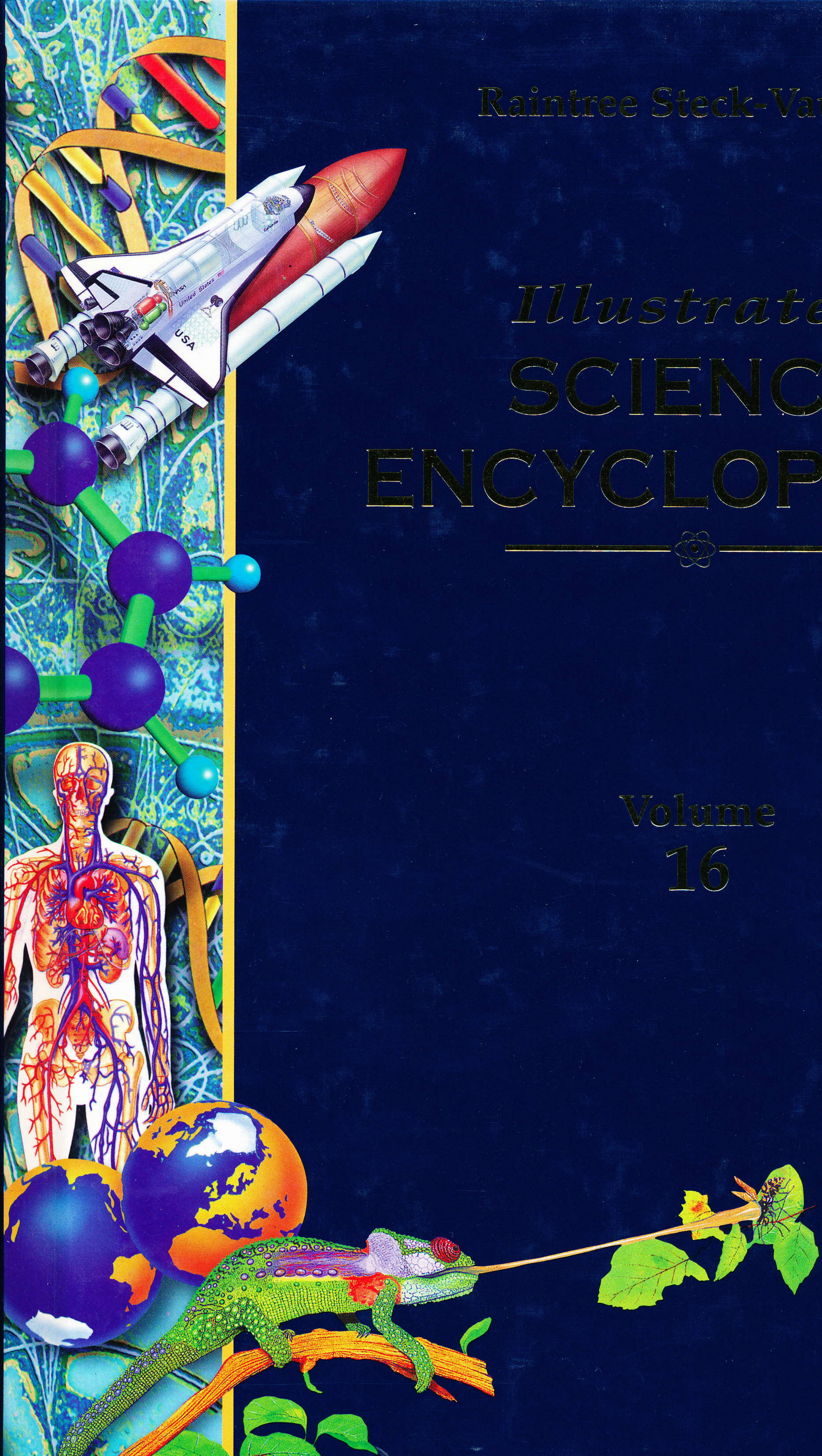
Raintree Steck-Vaughn

Illustrated SCIENCE ENCYCLOPEDIA

Volume
16



Raintree Steck-Vaughn

Illustrated SCIENCE ENCYCLOPEDIA

Volume 16

PIC – PRO

RAINTREE STECK-VAUGHN PUBLISHERS
The Steck-Vaughn Company
Austin, Texas

PICCARD, AUGUSTE (1884–1962) (pē kăr′, ō gyst′) Auguste Piccard was a Swiss scientist who was born in Basel. He had a twin brother, Jean Felix, who was also a scientist. In 1932, Auguste Piccard used a balloon to fly up to the stratosphere (the second layer of the atmosphere). In order to go this high, Piccard invented a pressurized cabin—that is, a cabin in which air pressure was kept at a normal level in spite of the altitude. He showed that flying at high altitudes was possible. Piccard reached an altitude of 52,657 ft. [16,050 m] (see ATMOSPHERE).

In 1945, Piccard made a spherical steel cabin called a bathyscaphe to help him go down to great depths in the ocean. The bathyscaphe protected him from the water pressure at these depths. Piccard's later bathyscaphe, the *Trieste*, reached a depth of 35,800 ft. [11,000 m] when piloted by his son Jacques in 1960.

See also BATHYSPHERE AND BATHYSCAPHE.

PICKEREL (pĭk′ər əl) A pickerel is a freshwater fish that belongs to the pike family, Esocidae, and is closely related to the northern pike (see PIKE). The three species of pickerels are the bulldog or barred pickerel, the mud or grass pickerel, and the chain pickerel. All these fishes have long, slender bodies; long, pointed snouts; and many sharp teeth. They are greenish in color.

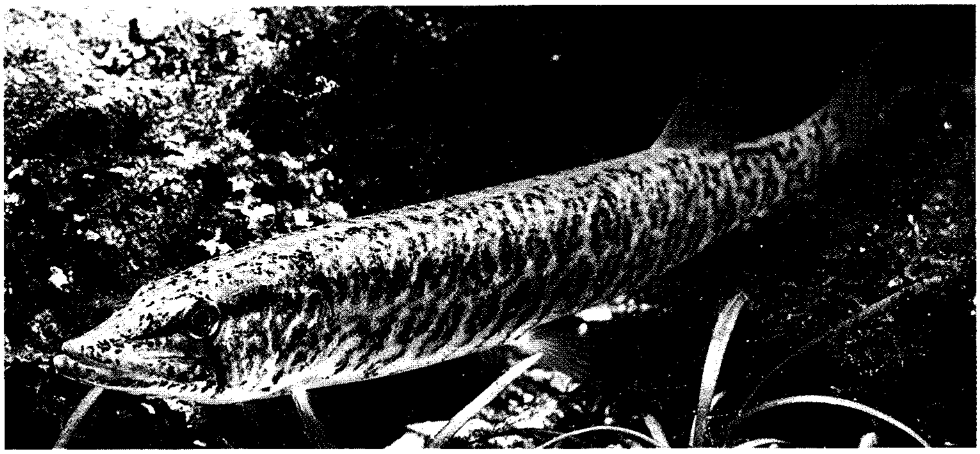
Pickerels live in shallow, weedy lakes or slow-moving rivers. They stay very still near a log or rock, waiting for a small animal to swim by. When one swims near, the pickerels dart out very quickly and take the prey in their teeth. Pickerels eat small fish, frogs, snakes, and insects.

Bulldog and mud pickerels rarely grow beyond 12 in. [30 cm] in length, so they are not often sought by fishers. The chain pickerel, however, grows to lengths over 24 in. [60 cm]. It is a popular game fish.

PIEZOELECTRIC EFFECT (pī ē′ zō ə lĕk trĭk ĭ fĕkt′) If certain crystals are pressed or stretched, an electric voltage develops across the crystal. This is called the piezoelectric effect. If a voltage is applied to a piezoelectric crystal, the crystal expands or contracts. This is called the reverse piezoelectric effect (see CRYSTAL; CURRENT, ELECTRIC; VOLT).

Piezoelectric crystals have many uses. The expansion or contraction of a crystal can be used to produce sound waves. Therefore, piezoelectric crystals can be used to convert electrical signals into sound waves and vice versa. For example, they could be used in telephone mouthpieces to convert sound into an electrical signal. In the earpiece of a telephone, the electrical signal could be converted back into sound by another piezoelectric crystal. Such crystals are used in microphones and in the pickup cartridge (which holds the needle) of record players.

Another important use for piezoelectric crystals is in sonar equipment. Sonar equipment is used on ships and submarines. Sonar makes sound waves under the water. The waves are used to find underwater objects. The waves are produced by the vibrations of a piezoelectric crystal. If an object is present, the waves are reflected off the object. A piezoelectric crystal then picks up the



PICKEREL

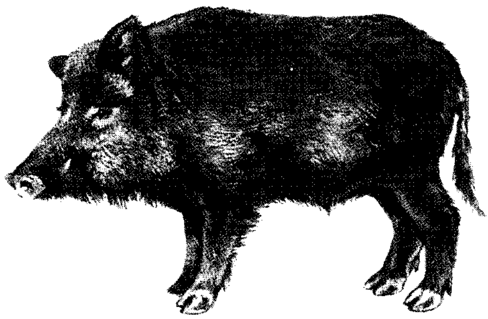
The pickerel is a pikelike fish that lives and hunts among the weeds of lakes and slow-flowing rivers. The larger species are popular with game fishers.

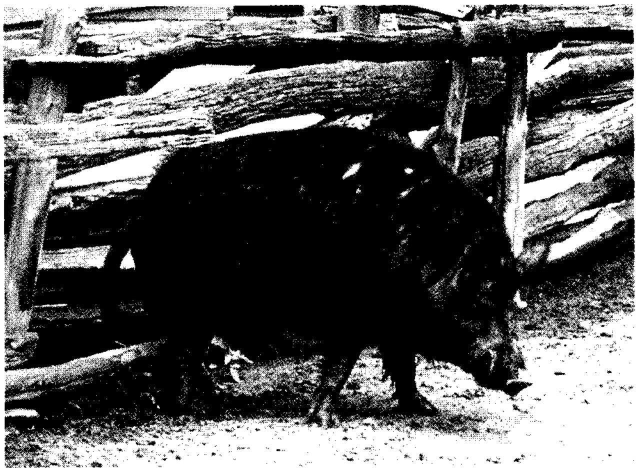
reflected wave and turns it into an electrical signal. In this way, objects under the water can be detected (see SONAR).

An alternating voltage is a voltage that varies. The voltage decreases in one direction to zero. Then it builds up in the opposite direction. It again decreases to zero and then increases in the original direction. If an alternating voltage is applied to a piezoelectric crystal, the crystal vibrates. It expands when the voltage goes in one direction. Then the crystal returns to its normal size as the voltage decreases to zero. The crystal contracts when the voltage goes in the opposite direction. The atoms in a crystal have a natural frequency of vibration. Frequency means the number of vibrations that occur per second (see FREQUENCY). If the frequency of the voltage is the same as the natural frequency of the crystal, then the crystal resonates (see RESONANCE). This means that it vibrates very strongly. This effect is used in radio broadcasting. Quartz crystals are used for broadcasting because they resonate at the required frequency. Quartz crystals are also widely used in other piezoelectric devices because they are very stable, even at high temperatures.
See also QUARTZ.

PIG Farmyard pigs, or hogs (also called swine), are descended from the wild boars that roamed throughout Asia, Europe, and north Africa thousands of years ago. Many scientists believe that people began taming pigs about 8,500 years ago. It is believed that such pigs were used as village scavengers, that is, to clean up rubbish. Pigs were useful as scavengers because they are omnivorous—they eat almost anything (see OMNIVORE).

The European wild boar is the animal from which many of today's domestic hogs are





PIG
Today's farmyard pigs are descended from the wild boar (top). Early breeds of domestic pig (above) resembled their wild ancestors in having most of their weight in the front part of their bodies. Pigs on today's farms (left) have been bred so that most of their weight is in their hindquarters, or hams.

descended. In the early 1800s, Spanish and French explorers brought domestic hogs to North and South America. Until the 1940s, United States farmers classified hog breeds as one of two kinds—lard type or meat type. Lard-type hogs had more fat in proportion to lean meat. Meat-packing plants made the fat into lard. This lard was used for cooking and other purposes. In the 1950s, shortening made from vegetable oils began to replace lard. Since then, farmers have raised hogs mainly for their meat.

Many different breeds of hogs have been developed in various parts of the world to meet local climate and pasture conditions (see BREEDING). Farmers in the United States raise about twenty breeds of hogs, including Landrace, Tamworth, and Yorkshire pigs.

A sow (adult female pig) gives birth to eight to twenty piglets (baby pigs) at a time, two or three times a year. Pigs reproduce rapidly and can be mated when about eight months old. Sows carry their young about 114 days before they farrow (give birth). A piglet weighs only about 2.5 lb. [1.1 kg] at birth but gains weight quickly, usually doubling its weight the first week. When it is only one year old, a piglet can weigh 250 lb. [113 kg]. The average boar (adult male pig) weighs from 350 to 500 lb. [159 to 230 kg]. The average sow weighs from 300 to 450 lb. [140 to 204 kg]. Most pigs are marketed when they are about six or eight months old, weighing from 180 to 240 lb. [82 to 109 kg]. Pigs kept beyond this age are usually used for breeding purposes.

The pig's snout has a flat, tough disk on the end that includes the nostrils. Pigs have canine teeth that develop into sharp tusks. These tusks serve as tools for digging and as weapons for fighting. They are much larger on males than on females.

Pork, ham, bacon, and spareribs all come from the meat of pigs. A pig's meat can be smoked or salted and then kept for a long time without spoiling. Pig intestines are used as the casing for sausages. Besides its use as food, the pig has other uses. The pig's hide, when tanned, becomes the leather known as pigskin. Pigskin is used to make such items as gloves and luggage. The stiff bristles from the pig's hide are made into brushes of various kinds. Pig's blood is used in animal feed, fertilizer, and medicine.

PIG IRON Pig iron is the name for all iron made in blast furnaces (see BLAST FURNACE; IRON). It is not pure iron, but usually contains about 95 percent iron, 3 or 4 percent carbon, and smaller

PIG IRON

This worker is raking impurities, called slag, off the surface of molten pig iron at the base of a blast furnace. The iron will then be used for making steel.

amounts of other elements, such as sulfur, phosphorus, and manganese.

In a pig-casting machine, the molten (liquid) iron flows into molds. The term *pig* comes from an early method of running hot iron into sand molds arranged around a main channel like a litter of pigs around the mother.

Today, most pig iron is used to make steel. The molten iron is carried from the blast furnaces to "mixers," which are huge heated tanks. Mixers keep the iron in liquid form until it is used by the steel-making furnaces.

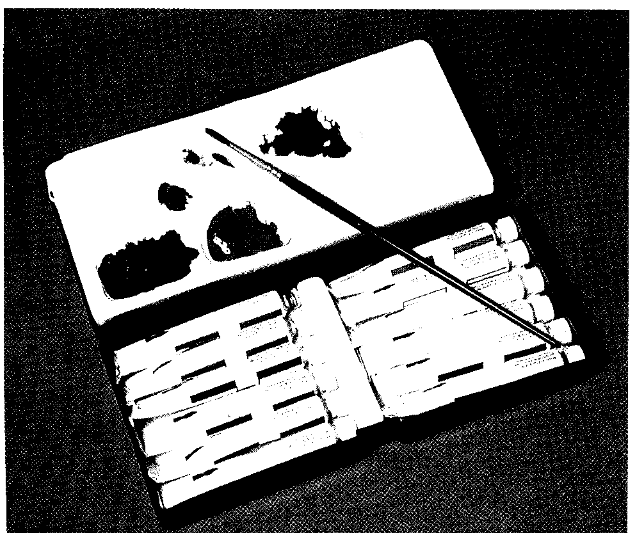
See also STEEL.

PIGMENT In chemistry, pigment is a substance, often in the form of a powder, that gives color to another material. Pigment colors a material in one of two ways—it is mixed in with the material or applied over its surface in a thin layer.

Pigment does not dissolve but rather remains suspended in a liquid. For example, when pigment is suspended in a certain kind of liquid, it forms paint (see PAINT). Colored substances that dissolve in liquids (giving color by staining) are called dyes (see DYE).

Pigments also occur in nature. In biology, a pigment is any substance that colors the tissues or cells of organisms.

See also ALBINO; COLOR; PIGMENTATION; SKIN.



PIGMENT
Watercolors are examples of paints made with brightly colored pigments.

PIGMENTATION The coloring of a living organism is nearly always caused by the presence of one or more coloring substances called pigments (see PIGMENT). In plants and animals, the pigments are in the cells of the organisms' outer layers.

The main pigment in human coloration is melanin. This dark-colored pigment is found in the skin and hair. The color of skin is determined by the amount of this pigment. People who are native to sunny regions tend to have large amounts of melanin and are dark brown or nearly black. The high melanin content has evolved in these people because it protects the underlying layers of skin from sunburn. People who are native to cooler and less sunny regions tend to have paler skins. With the exception of albinos, however, all people have some melanin in their skin (see ALBINO). People with light-colored skin can produce more melanin when their skin is exposed to extra sunlight. Their skin turns browner. This process is known as tanning.

Melanin is also responsible for hair color. Dark hair contains much melanin. Blond hair has only a little. Red-haired people, who often have pale skin, also have little melanin.

Many animals, such as chameleons, cephalopods, and flatfish, can change their appearance by altering the distribution of pigments in their skin. Nerves or hormones cause the pigment granules (small grains) to scatter or to collect in certain areas, thereby changing the color of the skin.

See also CAMOUFLAGE; HORMONE.

PIKA (pē'kə) The pika is a small, furry mammal related to the hare and rabbit (see MAMMAL). Pikas are found in Asia and North America. The animals often live among loose rock on mountainsides. Some kinds of pikas live together in large groups called colonies.

The American pika is frequently called a conie or a calling hare. American pikas are about 7 in. [18 cm] long, not including the tail. Their coat is grayish brown on the back with white or light brown covering the underside. American pikas resemble guinea pigs. Collared pikas are also found in North America. Like the American pika, the collared pika

PIKA
The pika is a small, furry animal often found in the loose rocks on mountainsides. Pikas spend much of their time collecting and storing plant material that they will eat during the winter months.

lives in the mountains. The collared pika, however, lives farther north than the American pika.

Pikas feed on plants. The animals spend much time collecting grasses and other plants to use during the winter months. Pikas dry these foods in the sun by stacking them in piles that look like small haystacks. Then they carry the dried material away and store it under rocks and fallen trees.
See also HARE; RABBIT.

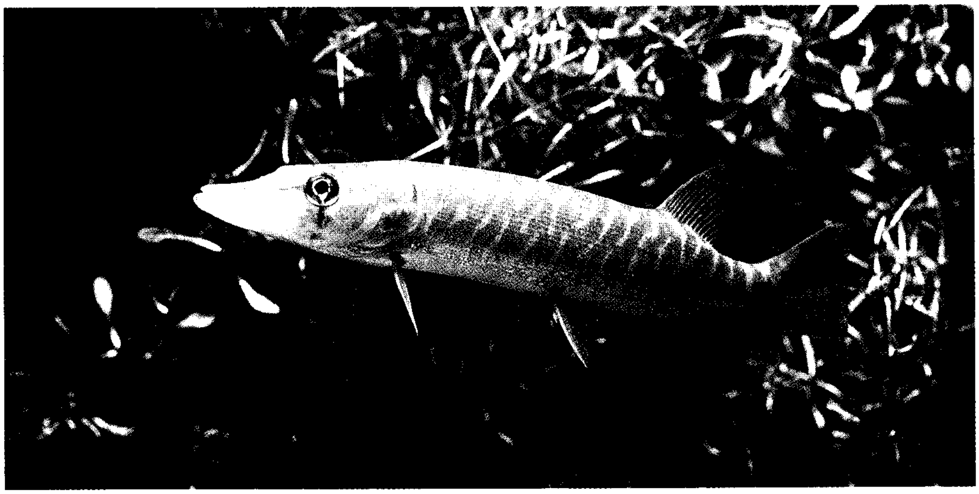
PIKE Pikes are freshwater fishes belonging to the pike family, Esocidae. Members of this family include the pickerels and the muskellunge (see MUSKELLUNGE; PICKEREL). Perhaps the best-known member is the northern pike. The northern pike is found in lakes and rivers of Europe, Asia, and North America. It hides in dense weeds or among submerged rocks, sitting very still. When an animal swims by, the pike darts out and grabs the prey in its sharp teeth. It feeds mainly on other fish and frogs, but sometimes snatches young ducklings from the surface.

The northern pike is one of the most popular game fishes in North America. It has been widely stocked into waters in which it did not previously live. The largest pike caught by a North American fisher was over 46 lb. [20 kg], but European specimens have been found up to 5 ft. [1.5 m] long and 77 lb. [35 kg] in weight. Like its relatives the muskellunge and pickerels, the northern pike is a very strong fighter.

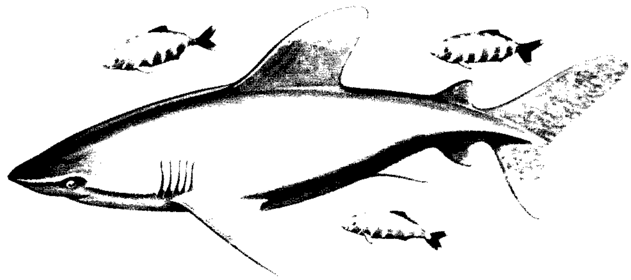
PILING Piling is a method of making a strong foundation for a building, bridge, or other large structure. Piling is used when the upper layers of soil are too weak to support an ordinary foundation. Piling is also used to support walls that help to retain water and soil—for example, to protect a beach from erosion (see EROSION).

Piles are long pieces of timber, concrete, or steel. They are usually driven into the ground, though concrete piles may be cast in position. A pile driver may use a weight to batter a pile into position. A vibrating pile driver shakes a pile into the ground.
See also BRIDGE; BUILDING CONSTRUCTION; SOIL MECHANICS.

PILOT FISH The pilot fish is a saltwater fish that belongs to the family Carangidae. It is white or pale blue with dark vertical bands on its sides. It is called a pilot fish because it is usually seen swimming near large fish and whales. It was once believed that the pilot fish guided the large animals to food. Ichthyologists—scientists who study fish—now believe that pilot fish swim near large



PIKE
The northern pike feeds mainly on other fish. It also eats frogs and young water birds. Pikes are strong fighters and popular with freshwater fishers.



PILOT FISH
Pilot fish usually swim near whales or alongside large fish, such as this shark.

fish because it is easier for them to swim in the currents caused by the large fish. The pilot fish grows to a length of about 24 in. [60 cm]. It is found in the Pacific and Atlantic oceans.

PILTDOWN MAN Piltdown man was the name given to the fossil remains of a supposed prehistoric human being. The fossils were discovered in 1912 in a gravel pit at Piltdown, England. In 1953, the fossils were proven to be fake.

The fossils consisted of a skull and jawbone. The braincase seemed very modern, while the jaw was quite apelike. Analyses completed in the 1950s proved that the skull was of a human being who had lived about 750 years before. The jaw was that of a modern ape. The jaw had been stained by chemicals to make it appear older, and the teeth had been artificially ground down to make them appear human.

For forty years, Piltdown man caused an amazing scientific uproar. The hoax did, however, have the positive effect of stimulating the development of new methods of finding the age of fossils.

See also DATING; FOSSIL; HUMAN BEING.

PINEAL GLAND The pineal (pĭn′ē əl) gland is an endocrine gland found in vertebrates (animals with backbones) near the center of the brain (see ENDOCRINE). The role of this pea-sized gland is unclear. The pineal gland is thought to secrete (give off) the hormone melatonin (see HORMONE). Melatonin has been found to affect the growth of the sex glands in some young animals. In certain adult animals, it seems to regulate the activity of the sex glands. In human beings, melatonin may determine when a person reaches sexual maturity. It may also help regulate the menstrual cycle in women (see MENSTRUAL CYCLE).

Some scientists have suggested that the pineal is a vestigial sense organ (see VESTIGIAL ORGAN). The exact function of the pineal gland in humans remains uncertain.

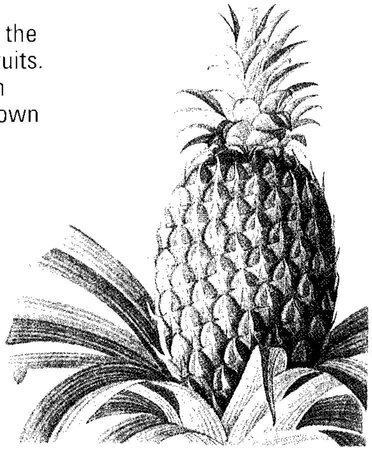
See also HORMONE.

PINEAL GLAND
The pineal gland forms a "third eye" on top of a lizard's head, where it may function to sense day length. Shown here is a western collared lizard from California.

PINEAPPLE The pineapple is a fruit-bearing plant belonging to the bromeliad family, Bromeliaceae. The plant probably originated in Brazil. It is grown today in tropical areas throughout the world.

The pineapple plant grows to heights of 2 to 3 ft. [60 to 90 cm]. Its leaves are sword-shaped and often very spiny. Purplish flowers grow in clusters on thick stalks (see INFLORESCENCE). Each of these flowers produces a small, fleshy fruitlet. These fruitlets fuse together to form one large fruit, the pineapple. The fruit weighs from 2 to 8 lb. [1 to 4 kg]. Its firm flesh is a light yellow color. The group of leaves at the top of the fruit is called the crown. The most popular variety, called smooth cayenne, is seedless, but some varieties have small brown seeds under the stem. Pineapples are eaten fresh or canned, and many are made into juice. Recent work has shown that an enzyme in the fruit can be of use in treating thrombosis.

Pineapple plants require a warm climate and a moderate amount of water. Chemicals are often spread over the area where pineapples are planted to prevent damage to the plants by parasitic worms (see PARASITE). Plastic strips are sometimes laid down between the plants to help the soil retain nutrients and water.



PINEAPPLE
The pineapple is one of the most popular tropical fruits. It probably originated in Brazil, but today it is grown in tropical regions throughout the world.

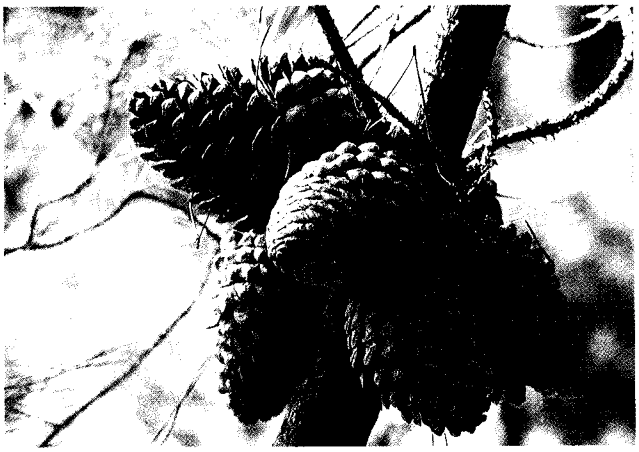
Nearly one-third of the pineapples produced each year are cultivated in Hawaii. Other important pineapple-producing areas are in Brazil, Malaysia, and Mexico.
See also FRUIT.

PINE FAMILY The pine family includes more than 250 species of coniferous trees (see CONIFER). Members of this family have needlelike leaves that grow in small clusters or in spirals around the stem. The male and the female reproductive structures are in different cones on the same plant (see MONOECIOUS). Pine trees, which belong to the genus *Pinus,* are among the most common trees in this family. Other members of the pine family include cedar, Douglas fir, fir, hemlock, larch, and spruce.

There are about one hundred species of pine trees. They grow throughout the cooler parts of the Northern Hemisphere. Huge forests of pine trees grow across Canada and the northern United States.

There are two main groups of pine trees: soft, or white, pines; and hard, or yellow, pines. The soft pines include the largest and the oldest pines. The sugar pines of California and Oregon sometimes grow to a height of 248 ft. [75 m]. The bristlecone pines are among the oldest living trees. Some are almost five thousand years old and are still alive.

The hard pines include some of the most valuable lumber trees in North America. Pine trees provide lumber that is important in the construction,



PINE FAMILY
Trees of the pine family are easy to recognize by their cones and needlelike leaves. Pictured here are the female cones (above left), male flowers (above right), and whole trees (left) of the Monterey pine.

furniture, and paper industries (see LUMBER; PAPER). Pines are also sources of oil, turpentine, charcoal, and fuel gases (by-products produced by distillation).
See also EVERGREEN; GYMNOSPERM.

PINK FAMILY The pink family includes about two thousand species of herbaceous plants. They are dicotyledons and grow throughout the world (see DICOTYLEDON; HERBACEOUS PLANT). The leaves grow in opposite pairs and have smooth margins (see LEAF). The stem is often swollen at the nodes, where the leaves attach. The flowers usually grow in clusters.

Genus *Gypsophila* includes fifty species of plants known as baby's breath. These plants produce tiny pink or white flowers, which are often added to bouquets of other flowers as trim. The most popular members of the pink family belong to genus *Dianthus*. This genus includes the carnations, sweet Williams, and pinks, many of which are sweetly scented.

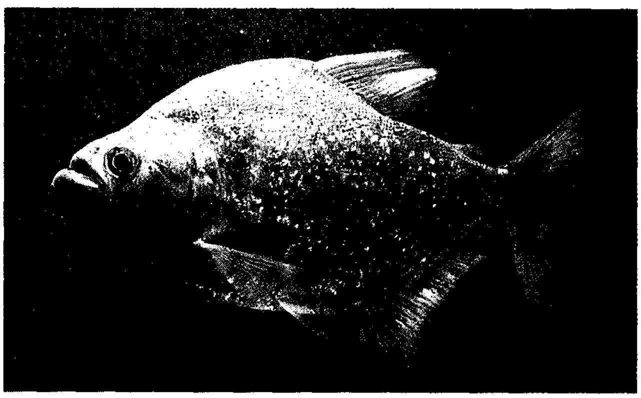
PINK FAMILY
Carnations (above), sweet-scented members of the pink family, belong to the genus *Dianthus*.

PIPEFISH A pipefish is a snakelike saltwater fish that belongs to the family Syngnathidae. It is related to the sea horse (see SEA HORSE). The pipefish has a long, thin body. Pipefish range in length from 1 to 20 in. [2.5 to 50 cm]. There are twenty-one species of pipefish in North America. They live in the coastal waters of both the Atlantic and Pacific oceans. Pipefish eat plankton, which they suck in through their slender snouts.
See also PLANKTON.

PIPETTE (pī pĕt′) A pipette is a piece of glass apparatus used in chemistry and biology. It is used for transferring an exact volume of a liquid from one container to another.

A pipette consists of a cylindrical glass bulb. At each end of the bulb there is a length of thin glass tubing. The lower end of the pipette has a thin tip. A rubber bulb is placed on the upper end of the pipette. The end without the rubber bulb is placed in the liquid to be transferred. The rubber bulb is squeezed and then released to draw the liquid up the pipette. The upper part of the tube has lines marked on it. The pipette is filled to the appropriate line. The pipette now holds an exact volume of the liquid. This can be transferred to another container.

PIRANHA (pĭ rän′ yə) A piranha is a sharp-toothed freshwater fish that belongs to the family Characidae. It is native to lakes and rivers throughout most of South America. Piranhas eat large amounts of prey and may attack land animals that



PIRANHA
The red-bellied piranha (above) lives in the waters of the Amazon River in Brazil.

fall into the water. Despite their reputation, they rarely attack people. Piranhas grow to be 24 in. [60 cm] long. They are often kept in the United States as aquarium pets, though it is illegal to do so in some states because of the danger of their being released into water bodies. They have been introduced into some North American rivers and lakes both by aquarium owners who tired of them and as game fish.

PISTIL The pistil is the female reproductive structure of a flower. It usually has three parts: stigma, style, and ovary. The stigma is at the top of the pistil. It has a sticky or feathery surface that will hold any pollen grains that land on it (see POLLINATION). The stigma leads to the tubelike style, which opens into the ovary. In some plants, the style is missing and the stigma sits directly on top of the ovary. Ovules are produced in the ovary. The ovules contain the female gametes, or eggs, which develop into seeds (see OVARY; OVULE).

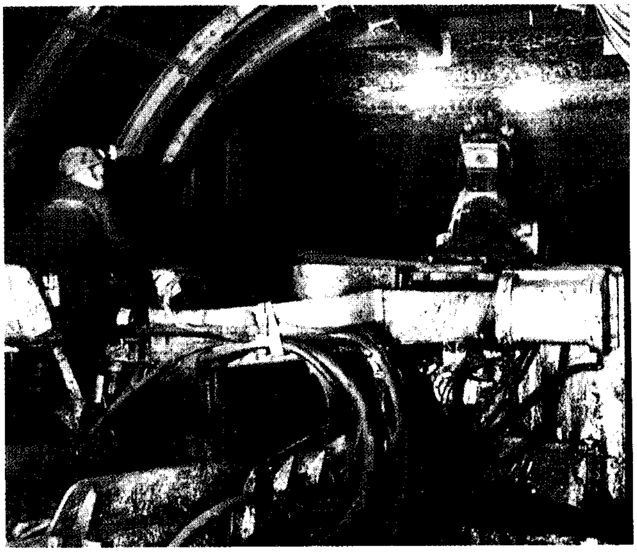
The number of pistils in a flower varies by species. Some flowers have many pistils; some have none. Some flowers have a compound pistil—actually several pistils fused into one.

See also FLOWER; FRUIT; REPRODUCTION.

PITCH Pitch is a black, gluelike substance that is left behind when petroleum or coal tar is distilled (see DISTILLATION). It is called asphalt in its natural form (see ASPHALT). Pitch is water repellent and highly adhesive (see ADHESION). It is used for roof coatings, highway paving, and waterproofing applications.

PITCHBLENDE Pitchblende is an important ore of the radioactive metal uranium. It occurs in igneous rocks, mainly granite, and in veins of iron, copper, lead, and tin minerals. Pitchblende is usually brown, black, or dark gray. It consists mainly of the compound uranium oxide ($2UO_3 \cdot UO_2$). It also contains small amounts of other elements, such as radium, thorium, and zirconium. Pitchblende is a type of uraninite.

See also COMPOUND; ELEMENT; MINERAL; ORE; ROCK; URANIUM.



PITCHBLENDE

Pitchblende is a major ore of uranium. This miner is drilling a tunnel in a pitchblende mine.

PITOT TUBE A pitot (pē′ tō) tube is used for measuring the velocity rate at which a gas or a liquid flows. For example, a pitot tube can be placed inside a pipeline to measure the rate at which a gas or a liquid flows through the pipeline. A pitot tube can also be fitted onto an airplane to measure the speed of the air flowing past the airplane. This lets the pilot determine how fast he or she is moving relative to the rate of flow of the air. This is called the air speed of the airplane.

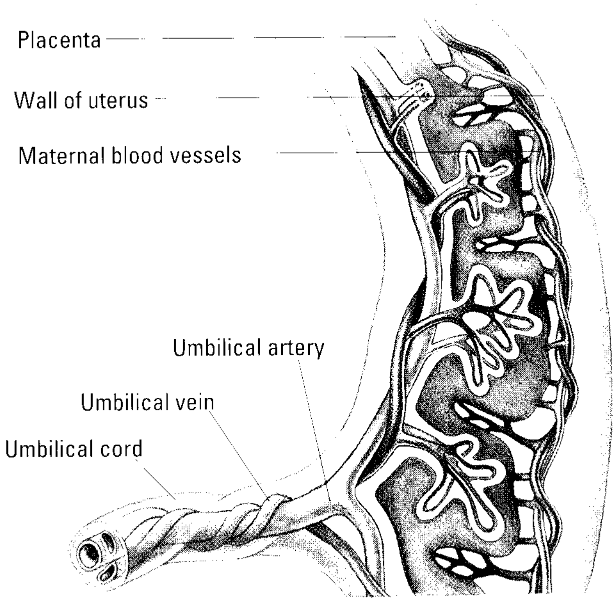
The pitot tube was invented by a French engineer, Henri Pitot, during the 1700s. A pitot tube is a narrow metal tube that is bent at a right angle. One end has a nozzle that faces into the fluid flow. Since the tube is small, it hardly disturbs the flow. In pipelines, the other end of the pitot tube is connected to a manometer. A manometer is an instrument that measures differences in pressure (see MANOMETER). The reading on this manometer is due to two different sorts of pressure in the pitot. One is called the dynamic pressure. This is caused by the gas or liquid moving through the pitot. There is also static pressure. This is the pressure exerted by the fluid even when it is not flowing. To calculate the rate of flow, only the dynamic pressure is needed. Therefore, the static pressure must be subtracted from the reading on the manometer. The static pressure is measured by another manometer. Then the rate of flow can be calculated.

PLACEBO (plə sē′ bō) A placebo is a "dummy treatment." It is any substance that has no activity against the illness for which it is being given, but which the patient believes will be effective. Placebos are used for two reasons. They may be given to improve the patient's well-being by helping the patient overcome symptoms that are psychological in origin (see PSYCHOSOMATIC DISORDER). The patient gets better because he or she believes in the power of the "drug." Placebos are also used to test the effects of a new drug. One group of people with a disease is given the new drug, and another group with the disease is given the placebo. Researchers can then determine the true effects of the real drug, balanced against any psychological effects caused by the patient's just believing the drug is working. The use of placebos in this way, however, is very carefully considered and monitored because of the ethical implications in withholding treatment.

PLACENTA (plə sĕn′tə) The placenta is an organ that is formed during pregnancy to allow substances to be exchanged between the blood of the mother and the fetus (the unborn young). Among all the members of the animal kingdom, only mammals have a placenta. The only mammals that do not develop a placenta are the pouched marsupials and the egg-laying monotremes (see MAMMAL; MARSUPIAL; MONOTREME).

In the placenta, the blood of the fetus comes very close to, but never mixes with, the blood of the mother. Digested food, water, oxygen, hormones, and antibodies move by diffusion from the mother's blood into the fetus's blood. Waste products diffuse from the fetus's blood into the mother's blood. In a sense, then, the mother eats, breathes, and removes wastes for her unborn child (see ANTIBODY; DIFFUSION; HORMONE).

The placenta forms from tissues surrounding the fetus and from some of the tissues in the mother's uterus. It is connected to the fetus by the umbilical cord (see UMBILICAL CORD). The placenta develops small, fingerlike projections called villi, which are surrounded by the mother's blood in her uterus. Blood flowing through the villi picks up food and oxygen from the mother's blood and then carries it back to the fetus. In human beings, the placenta is almost fully formed within the first two months of pregnancy. Throughout the pregnancy, the placenta also makes hormones that are needed for the pregnancy to continue and progress in a healthy manner.



PLACENTA
In its mother's uterus, the fetus, in effect, feeds, breathes, and excretes wastes through the placenta. The placenta is connected to the fetus by the umbilical cord.

Soon after the baby is born, the placenta is pushed out along with other membranes, all of which is called the afterbirth. However, some mammals do not force out the placenta, but instead take it back into their system.
See also PREGNANCY.

PLANCK, MAX (1858–1947) Max Planck was a German physicist famous for developing the quantum theory. He was born at Kiel and studied in Berlin. In 1900, while he was a professor in Berlin, Planck developed the theory that energy behaves as if it is given off as particles. He called these particles of energy quanta (plural of *quantum*). At first, Planck's idea was not taken seriously.

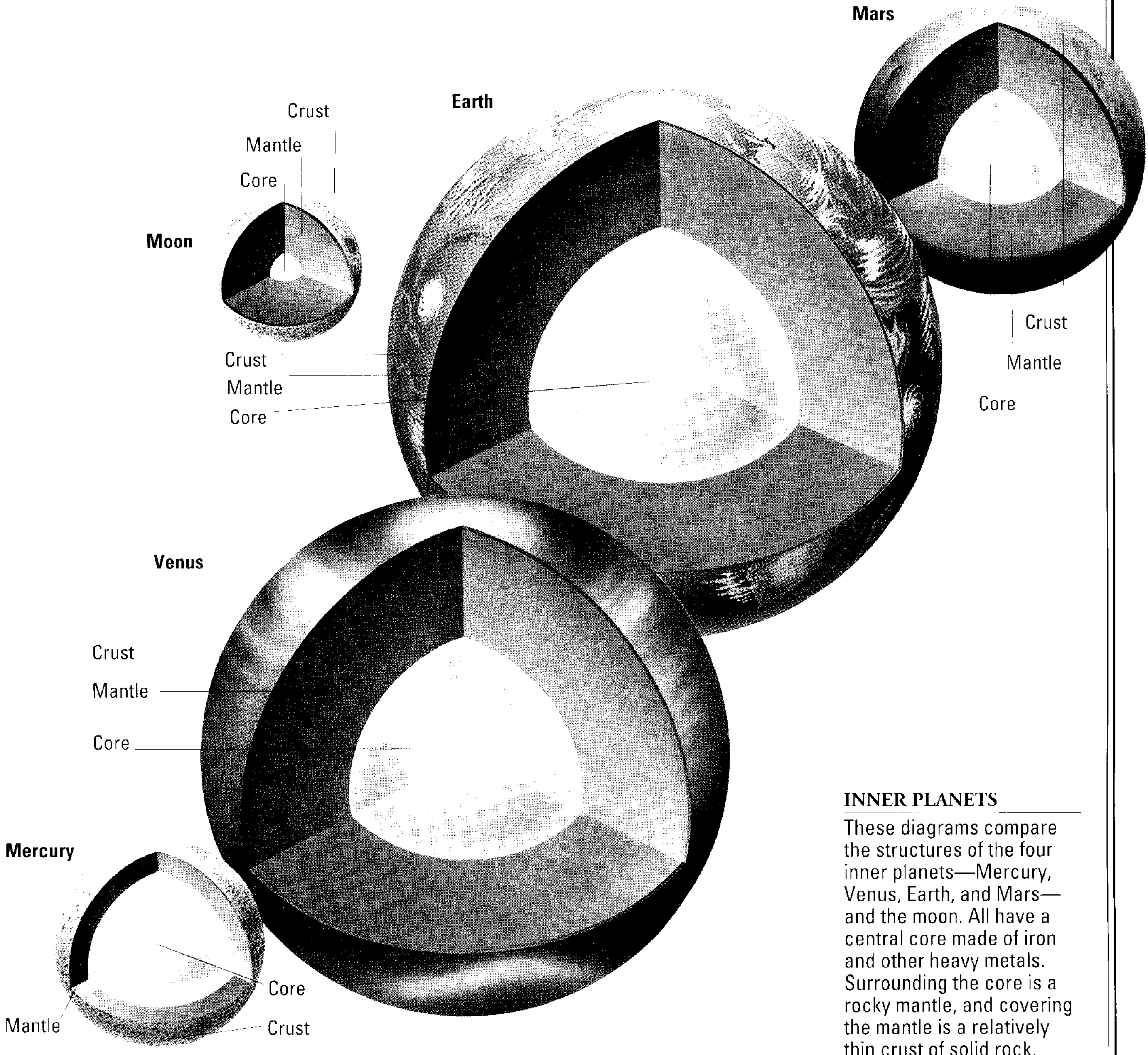
Gradually, scientists realized that the quantum theory helped explain things they could not explain any other way. In 1918, Planck was awarded the Nobel Prize for physics for his work.
See also LIGHT; PHOTON; QUANTUM THEORY.

PLANET

A planet is a body that revolves around a star. A planet gives off no light of its own. It can be seen because it reflects light from the star. It also receives most of its heat from the star (see ASTRONOMY; STAR).

The solar system There are nine major planets in orbit around the star called the sun, helping make up the solar system (see SOLAR SYSTEM; SUN). A major planet is different from a minor planet, such as an asteroid, because of its size and the shape of its orbit (see ASTEROID; ORBIT). In the order of the increasing average size of their orbits, the major planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. Except for Mercury and Pluto, they all orbit in approximately the same plane (level). The rest of this article will focus on these major planets.

A planet may be orbited by one or more smaller, solid bodies called satellites, or moons. Seven of the nine planets of the solar system are known to have moons (see MOON; SATELLITE).



INNER PLANETS
These diagrams compare the structures of the four inner planets—Mercury, Venus, Earth, and Mars—and the moon. All have a central core made of iron and other heavy metals. Surrounding the core is a rocky mantle, and covering the mantle is a relatively thin crust of solid rock.

Astronomers think that other stars in the universe may be orbited by one or more planets. In 1983, they found evidence that a star called Vega has a shell of solid particles surrounding it. These particles probably formed from the materials that formed the star. Many astronomers believe the solid particles may eventually form a solar system around Vega. However, the tremendous distance from Earth of this and other stars makes the search for other planets very difficult.

When viewed from Earth, other planets seem to give off a steady light, while stars twinkle. Because planets are relatively near Earth, their motion against the background of stars is noticeable. Because the stars are so distant, they appear to remain in the same position. Actually, the stars are moving thousands of times faster than any of the planets.

The planets are divided into two main groups: the terrestrial planets and the Jovian planets. The terrestrial planets—Mercury, Venus, Earth, and Mars—are similar in size and have solid, rocky surfaces. *Terrestrial* means "relating to Earth" (see EARTH; MARS; MERCURY; VENUS). The Jovian planets are Jupiter, Saturn, Uranus, and Neptune. The name *Jovian* means "relating to Jupiter." The planets are called Jovian because Saturn, Uranus, and Neptune—like Jupiter—consist largely of gases. The Jovian planets are also very large. Scientists put the farthest planet, Pluto, in a category by itself. Scientists know little about the surface of Pluto because it is so far away. However, they believe Pluto is made up of frozen gases. This makes Pluto's surface more similar to those of the terrestrial planets than those of the Jovian planets (see JUPITER; NEPTUNE; PLUTO; SATURN; URANUS).

Pluto and Neptune are too far from Earth to be seen without a telescope. The other planets can be seen in the night sky. Mercury, because of its closeness to the sun, is visible only briefly after sunset or before sunrise.

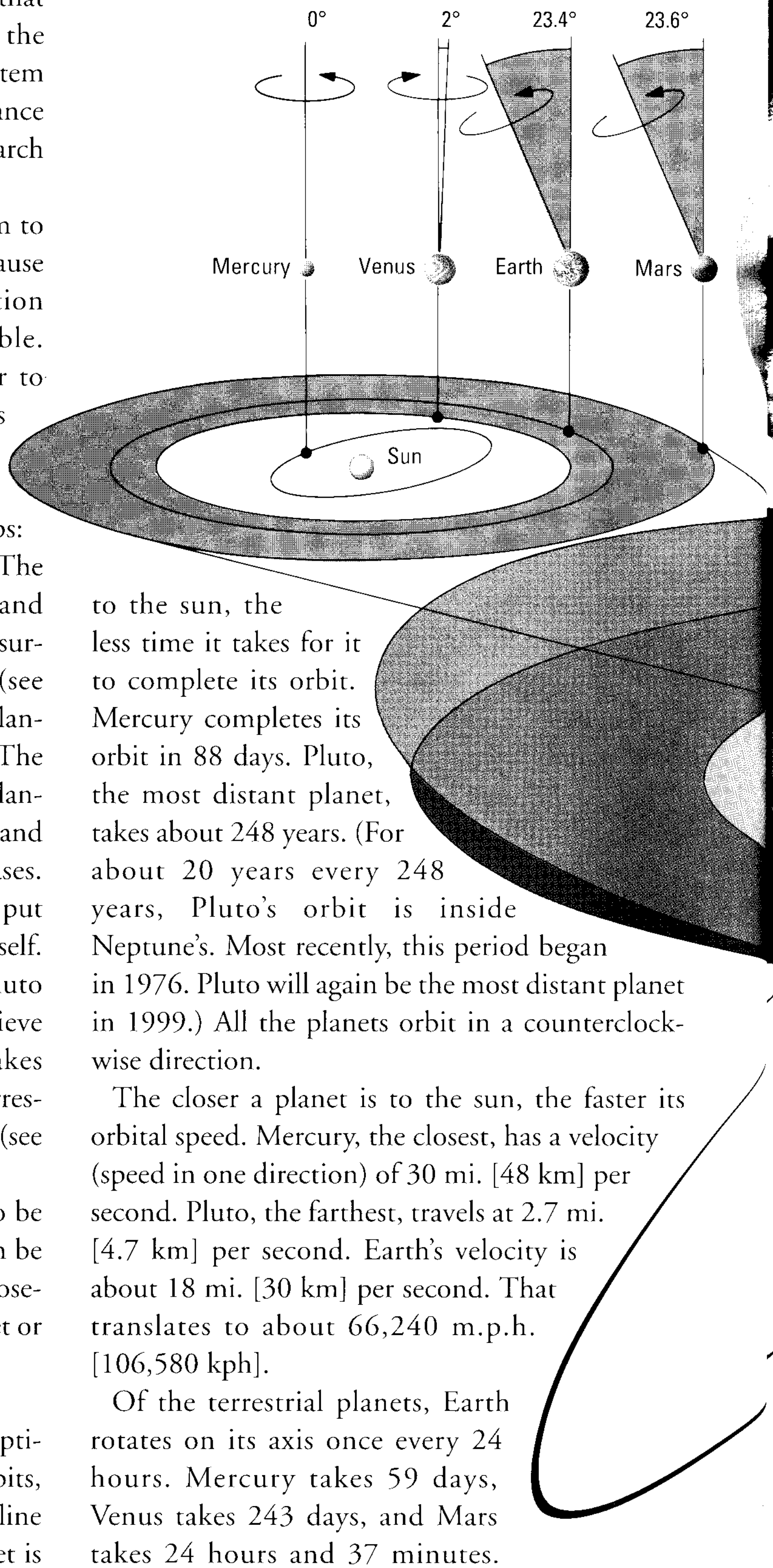
Planet movements Each planet follows an elliptical (oval) orbit around the sun. As a planet orbits, it turns, or rotates, on its axis (an imaginary line running through its center). The closer a planet is to the sun, the less time it takes for it to complete its orbit. Mercury completes its orbit in 88 days. Pluto, the most distant planet, takes about 248 years. (For about 20 years every 248 years, Pluto's orbit is inside Neptune's. Most recently, this period began in 1976. Pluto will again be the most distant planet in 1999.) All the planets orbit in a counterclockwise direction.

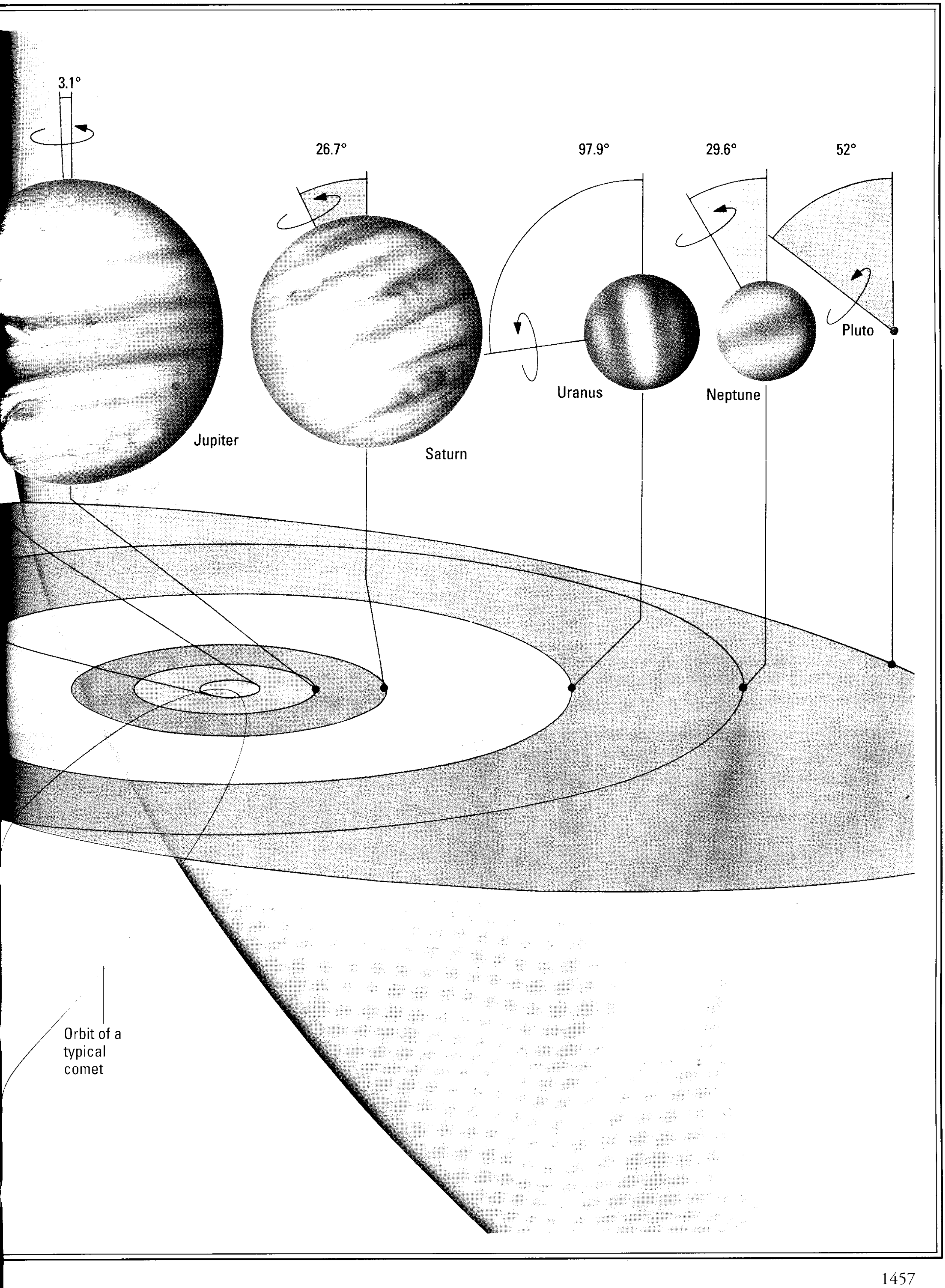
The closer a planet is to the sun, the faster its orbital speed. Mercury, the closest, has a velocity (speed in one direction) of 30 mi. [48 km] per second. Pluto, the farthest, travels at 2.7 mi. [4.7 km] per second. Earth's velocity is about 18 mi. [30 km] per second. That translates to about 66,240 m.p.h. [106,580 kph].

Of the terrestrial planets, Earth rotates on its axis once every 24 hours. Mercury takes 59 days, Venus takes 243 days, and Mars takes 24 hours and 37 minutes.

TILTED AXES

Except for Mercury, all the planets are tilted. Their axes (lines joining North and South poles) are not upright. The numbers in degrees show the angle of tilt for each planet.




3.1°
26.7°
97.9°
29.6°
52°
Jupiter
Saturn
Uranus
Neptune
Pluto
Orbit of a
typical
comet

Pluto takes 6 days, 9 hours, and 18 minutes. The other Jovian planets show less variation, ranging from about 10 to 18 hours. Venus and Uranus rotate clockwise. The other seven planets rotate counterclockwise.

All the planets except Mercury have a tilted axis. No two planets rotate on the same tilt. Earth's axis is tilted about 23° to the orbital plane. Uranus is tilted about 98° to the orbital plane.

Properties of the planets The characteristics of the planets are due in part to their distance from the sun. The planets closer to the sun have higher temperatures than the more distant planets. A planet's atmosphere also affects how much of the sun's light and heat are absorbed.

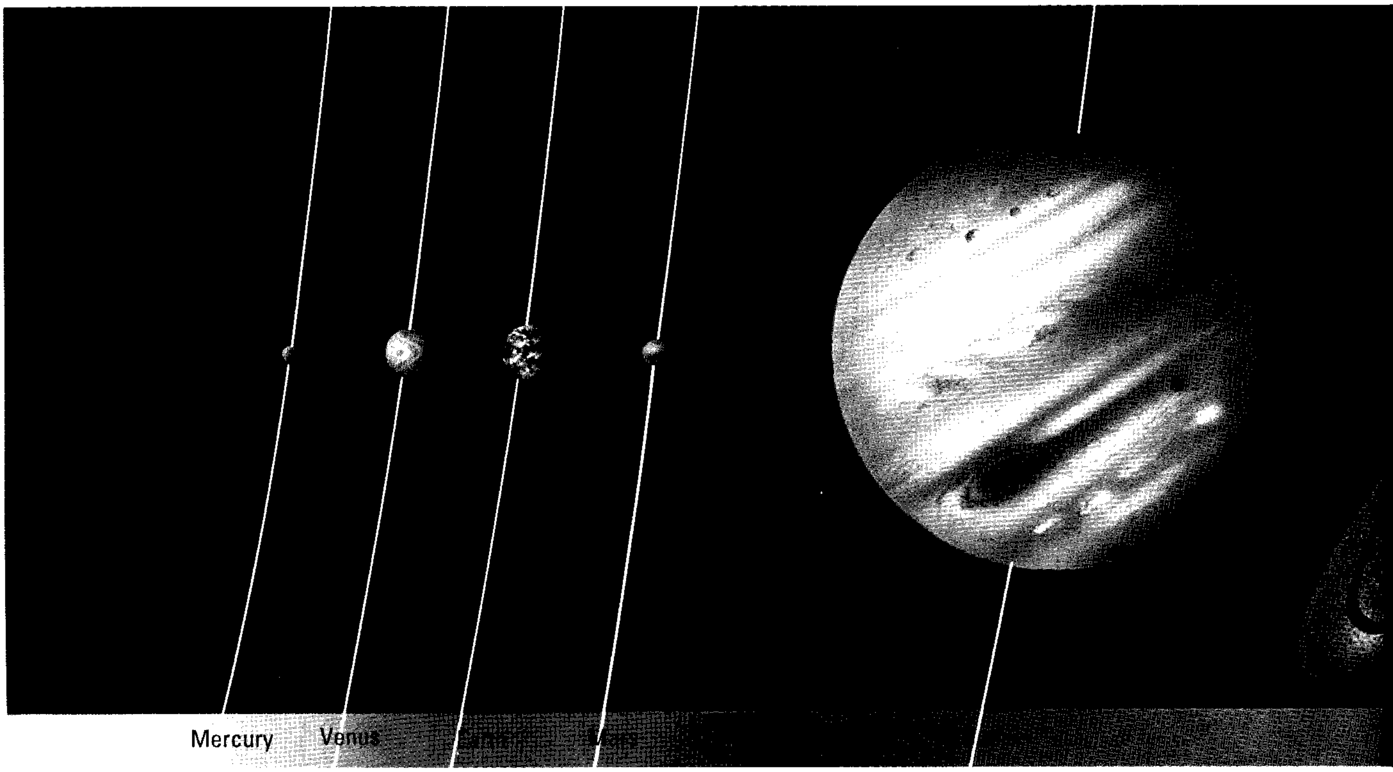
Earth is unlike the other planets in many ways. It is apparently the only planet that can sustain life as we know it. Earth is the only planet with an atmosphere that is rich in oxygen.

Of all the planets, Mercury orbits closest to the sun. Its orbit averages about 36 million mi. [57.9 million km] from the sun. Until recently, Mercury was believed to have no atmosphere. However, experiments have shown that Mercury probably has a very thin atmosphere that comes from the solar wind (see SOLAR WIND). The temperature on Mercury's surface reaches about 662°F [350°C] during the day. At night, the temperature falls to about -274°F [-170°C]. Photographs of Mercury's surface taken by space probes show it to be crater-marked rock. Space probes are unmanned spacecraft that are equipped with very advanced sensing, recording, and transmitting instruments (see SPACE EXPLORATION). In composition, Mercury seems to be more like our moon than like any of the other planets. There is no evidence that Mercury ever had a thicker atmosphere or any bodies of water.

Venus was once thought to be much like Earth. Space probes, however, have found it to be very different. The planet is surrounded by dense clouds of sulfuric acid (see SULFURIC ACID). Beneath the clouds, lightning flashes constantly, but no rain falls. The planet has the least elliptical orbit, but it rotates clockwise. This means that, on Venus, the sun appears to rise in the west. The clouds around Venus are in three layers. A clear atmosphere of

GIANT PLANETS

Compared to the inner planets, four of the outer planets—Jupiter, Saturn, Uranus, and Neptune—are giants. The exception is Pluto, which is a tiny planet smaller than Earth's moon.



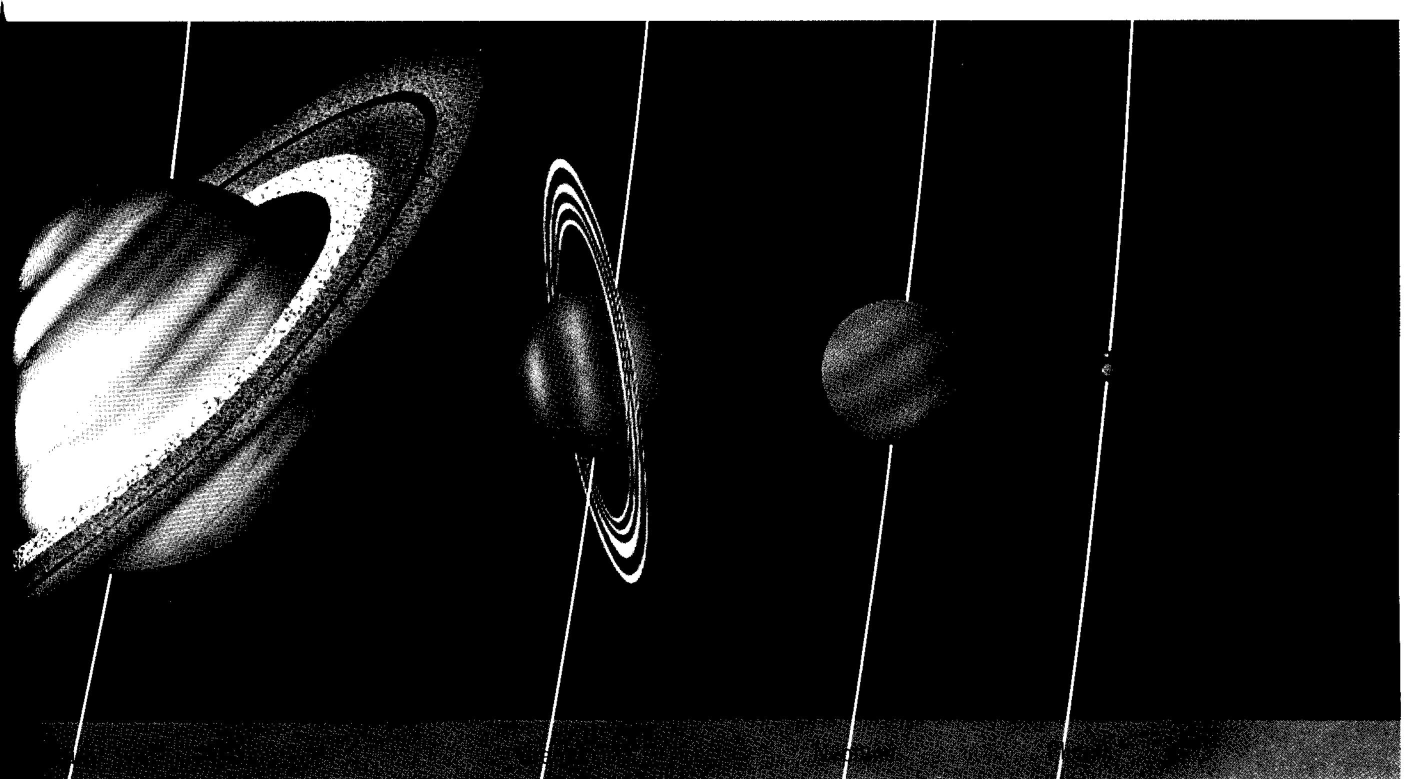
carbon dioxide extends from the planet's surface to the dense bottom cloud layer. This distance is about 30 mi. [50 km]. The other clouds of the atmosphere contain several gases, including nitrogen and water vapor. The planet's temperature is higher than the boiling point of sulfur, about 900°F [470°C]. The temperature is much cooler at the planet's poles, however. There is no measurable magnetic field and no seasonal change.

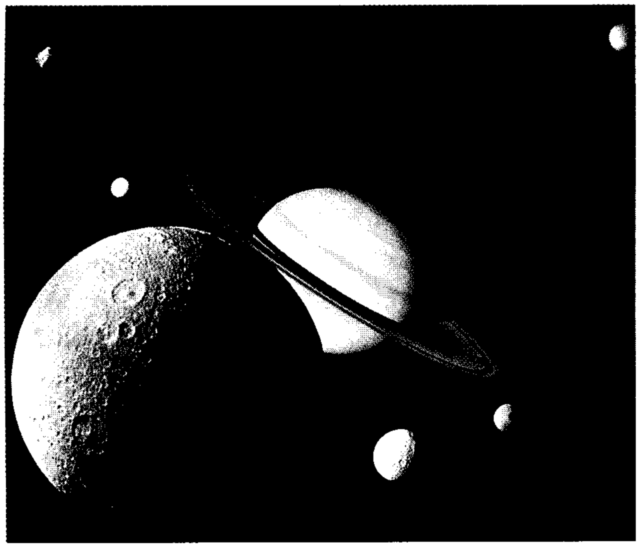
Venus's orbit is the closest to Earth. It is often the brightest object in the night sky other than the moon. Venus is often called the Evening Star or Morning Star because it is usually visible in the three hours after sunset or the three hours before sunrise.

Earth's other neighboring planet is Mars. Mars is barely more than half of Earth's diameter. A coating of dust stained by iron oxide gives the planet a reddish appearance when viewed through a telescope. Most of its surface is covered by sand dunes and rocks. Temperatures vary from near 70°F [21°C] at noon to about -150°F [-100°C] at night. Mars is the only other planet besides Earth that has water on its surface. However, the water on Mars is mostly in the form of ice caps at the poles. Mars has a very thin atmosphere, which includes a trace of water vapor. Astronomers think the cap at the south pole may be mostly frozen carbon dioxide (dry ice). Mars's surface is dotted with huge volcanoes that were active when the planet was young. Space probes and satellites have revealed traces of erosion that seems to have been caused by flowing water, but no sign of life has been found.

Jupiter, Saturn, Uranus, and Neptune are all much larger than any of the other planets. However, they are also much less dense than the other planets. They are mostly balls of helium and hydrogen. They all spin much more rapidly on their axes (plural of *axis*) than do the smaller planets. Jupiter spins the fastest of all the planets. All sides of each planet can be observed by telescope during a single night. All four planets are orbited by one or more rings. Jupiter's thin ring consists mainly of dust particles. Saturn has seven main rings, made up of particles and blocks of frozen gas, dust, and ice. Saturn's rings are much brighter than Jupiter's or Uranus's. Uranus has at least eleven semitransparent rings made up of chunks of unknown black material.

Neptune is a stormy planet. Above the planet, clouds of methane are pushed by winds of up to 1,500 m.p.h. [2,414 kph]. There is a permanent





SATURN'S MOONS
This picture shows Saturn (with rings) and six of its moons. The large moon in the foreground is called Dione.

storm system in Neptune's southern hemisphere that is as large as Earth. Scientists call this system "The Great Dark Spot." Scientists have recently learned that Neptune has four complete and several incomplete rings circling it.

Like the other Jovian planets, Pluto is very cold compared with Earth. In fact, Pluto is the coldest of all the planets. Astronomers think its surface temperature is near -459.67°F [-273.15°C], which is absolute zero (see ABSOLUTE ZERO).

The planets differ greatly in density and mass (see DENSITY; MASS). The density of Saturn is less than that of water. Pluto may have about the same density as water. The density of the other Jovian and the terrestrial planets is more than that of water. The largest of the Jovian planets, Jupiter, has 318 times the mass of Earth. The smallest planet, Pluto, has about 0.0017 times the mass of Earth. The planets also differ in gravity (see GRAVITY). Gravity does not affect the density or mass of an object. However, it does affect the weight of an object. An object weighs more if the force of gravity is stronger. For example, a person who weighs 120 lb. on Earth would weigh 46 lb. on Mercury or Mars, 109 lb. on Venus, and 304 lb. on Jupiter.

Space probes have helped scientists learn more about the planets than they could have ever learned from Earth. The *Mariner* and the *Viking* space probes that traveled through space in the 1960s and 1970s helped scientists learn about Mercury, Venus, and Mars. *Pioneer X* and *Pioneer-Saturn* were launched in the 1970s to study Jupiter and Saturn. All of those probes were launched by the United States. The *Venera* space probes, which were launched by the former Soviet Union in the 1960s, 1970s, and 1980s, studied Venus. In 1983, the *Pioneer X* space probe passed beyond the planets of Earth's solar system. However, it is still transmitting information. *Voyager 1* and *Voyager 2* were launched by the United States in 1977, in September and August respectively. *Voyager 1* sent back photographs of Jupiter and Saturn. *Voyager 2* proved to be one of the most successful space probes ever launched. *Voyager 2* sent back photographs of Jupiter, Saturn, Uranus, and Neptune. Both *Voyager 1* and *Voyager 2* have passed beyond the planets of Earth's solar system. However, both probes will continue to send information back to Earth. Scientists hope that these probes will find the outermost reach of the solar wind, called the heliopause. *Magellan* was launched by the United States in 1989. In 1990, it started sending back information about Venus. *Galileo*, also launched by the United States in 1989, was planned to begin orbiting Jupiter in 1995.

Scientists have also used orbiting space telescopes that send images back to Earth. The space telescopes are observatories designed to orbit around Earth, as opposed to space probes, which travel through the solar system and beyond. Between 1969 and 1988, the United States placed over seventy space telescopes in orbit around Earth. These telescopes studied the sun as well as the planets. Some of the telescopes that studied Earth sent back information about the movements of Earth's crust and the movements of weather patterns in Earth's atmosphere. The first large reflecting space telescope, the Hubble Space Telescope (HST), was launched into orbit in 1990. However, one of the mirrors of the HST was manufactured incorrectly. Because of this, some of the first images sent back to Earth were distorted. In 1993, the telescope was successfully repaired. The HST has since sent back clear images.

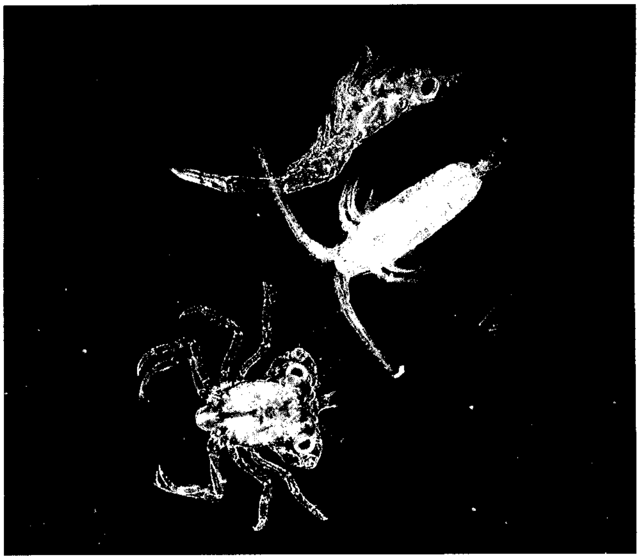
See also OBSERVATORY; TELESCOPE.

PLANETARIUM (plăn′ĭ târ′ē əm) A planetarium is a model or device that shows the positions and movements of certain heavenly bodies. The oldest type of planetarium is called an orrery. An orrery is a mechanical device that represents the sun as a large ball, the planets as slightly smaller balls, and moons as still smaller balls. These balls can be moved to portray the movements of the heavenly bodies (see MOON; PLANET).

Many museums and universities have planetariums where projectors are used to cast an image of the night sky onto a domed ceiling. In this way, the sky in different parts of the world or the skies during the different seasons can be shown. The projectionist, often an astronomer, may give a lecture describing the projection and discuss a wide range of astronomical phenomena.

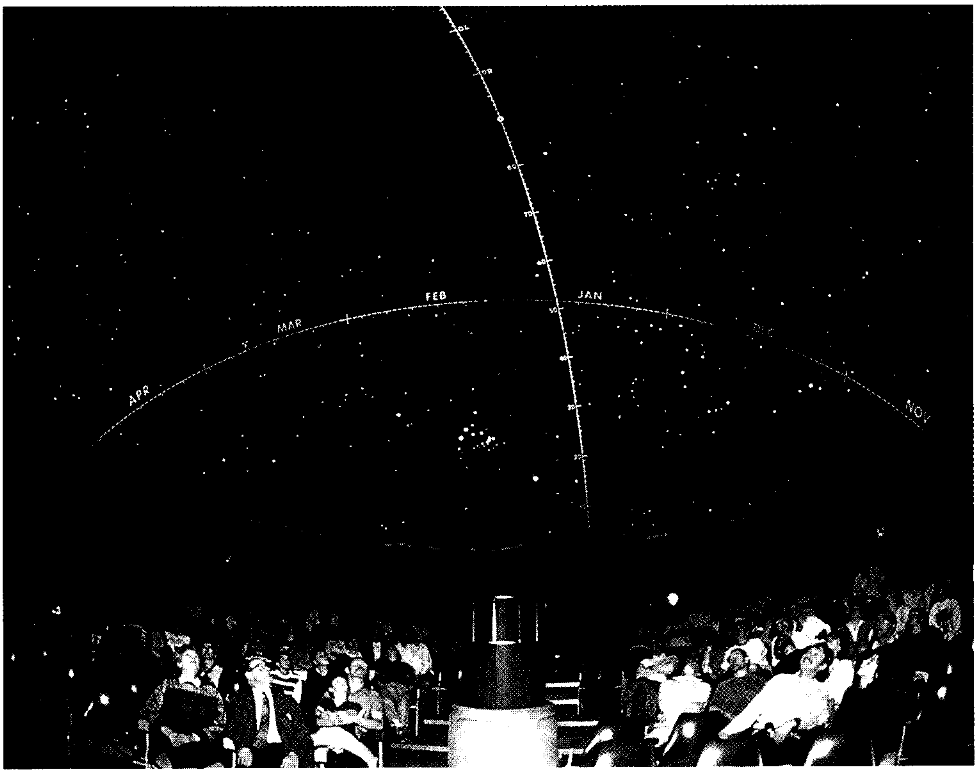
The Adler Planetarium in Chicago was one of the first planetariums constructed in the United States to use a projector that displays the moon, planets, stars, and sun on an overhead dome. The Adler Planetarium shows each object moving as it does in the natural sky. Since the Adler Planetarium was built, other cities have also constructed planetariums to teach astronomy.

See also ASTRONOMY.



PLANKTON
Zooplankton consists of tiny floating animals. Shown here are a crab larva (bottom), copepod (center), and shrimp larva (top).

PLANKTON Plankton includes all small, floating organisms that live in the sea and in bodies of fresh water. Algae and tiny floating plants are called phytoplankton. Phytoplankton accounts for most of the world's photosynthesis and releases large amounts of oxygen into the air (see PHOTOSYNTHESIS). Protozoans and tiny floating animals are called zooplankton. Fish eggs and larvae are also



PLANETARIUM
A planetarium has a complex, moving projector that casts images of planets, stars, and galaxies onto a domed ceiling. It can show the positions of stars and their constellations at various times of the year.

considered zooplankton. Zooplankton also includes larger animals such as jellyfish.

Some planktonic organisms, such as algae, spend their entire lives as plankton. Others, such as fish eggs and larvae, are part of plankton only until they are developed enough to swim off on their own (see NEKTON).

Plankton is a major source of food for many larger aquatic animals. As such, it is an important part of the aquatic food chain (see FOOD CHAIN). Many scientists believe that, in the near future, plankton may be cultivated as a major source of food for human beings.

See also BENTHOS.

PLANTAIN FAMILY The plantain (plăn'tən) family includes about 265 species of small, herbaceous plants. They are dicotyledons (plants with two seed leaves) and are found all over the world (see DICOTYLEDON; HERBACEOUS PLANT). The leaves are simple and usually grow in a rosette on the ground. From the middle of the rosette grows a leafless stalk. At the end of this stalk is a spike of tiny green or brown flowers. Long stamens hang from the flowers and scatter pollen in the breeze (see INFLORESCENCE; LEAF).

PLANTAIN FAMILY
Ribwort plantain, shown here, is a common weed in lawns.

Common plantain is a well-known plant that often grows in lawns. Its flowers make tiny nutlike fruits that are a popular food for birds.

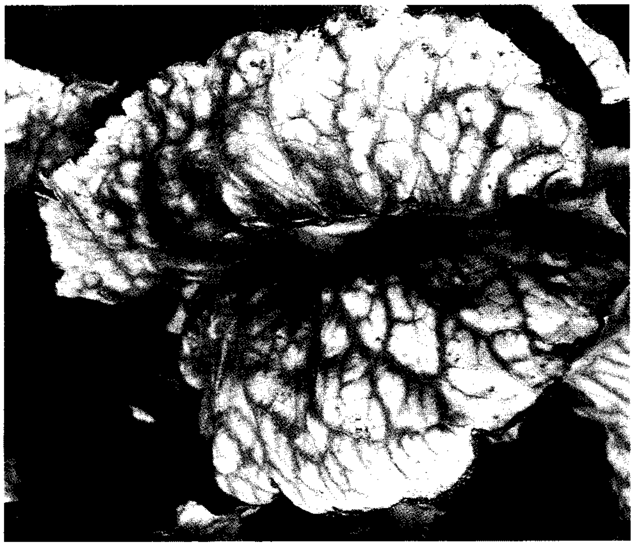
The tropical fruit that is called plantain is a kind of banana and not related to the plantain family (see BANANA).

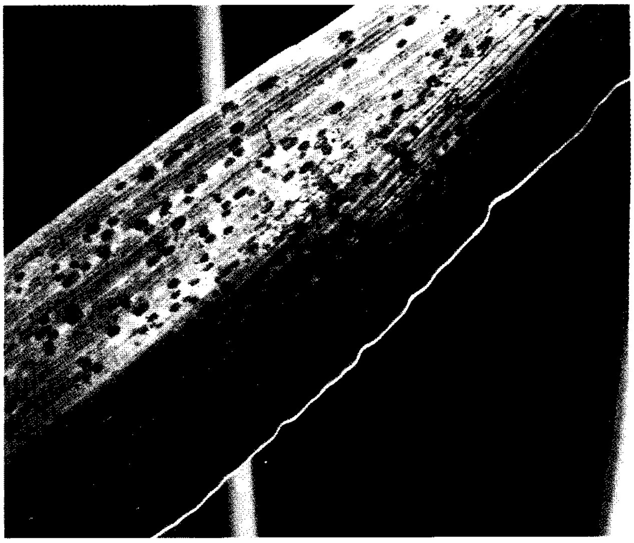
PLANT DISEASE A plant disease is anything that kills, weakens, or otherwise affects the normal growth of a plant. A great danger of plant diseases is that they will destroy plants that are necessary for people to live. A serious outbreak of a plant disease can cause a famine—widespread lack of food. Famine may result in the starvation and death of hundreds or thousands of people.

PLANT DISEASE—Smut and blight
Common diseases of crop plants include barley smut (above left) and potato blight (above right).

The causes of plant diseases can be divided into two major categories: nonliving causes and living causes. Nonliving causes usually involve a lack of one or more minerals.

Certain minerals or nutrients (nourishing substances) must be in the soil for a plant to grow properly. Some nutrients, such as nitrates and phosphates, are needed in fairly large amounts and are called macronutrients (the prefix *macro* means





PLANT DISEASE—
Affected leaves

The cabbage leaves (above) have turned yellow because of a virus, which is carried by aphids. The brown spots on the wheat leaf (above right) are caused by a type of fungus known as rust. The leaves of an apple tree (left) are affected by a type of mildew.

"large"). Micronutrients (the prefix *micro* means "small") are needed in smaller amounts. They include compounds of boron, copper, zinc, and many other elements. If the plant cannot get enough of any necessary nutrient, it will not grow properly. It is then said to be suffering from a deficiency disease. The leaves often turn yellow or blotchy, or become very spindly. Many times, farmers and gardeners increase the nutrient content of soil by adding fertilizers (see FERTILIZER). But they must be careful not to add too much. Too much nutrient can also upset the proper working of the plant's body.

The living causes of plant disease include fungi, bacteria, viruses, insects, and nematodes. Most plant diseases are caused by parasitic fungi (plural of *fungus*) (see FUNGUS; PARASITE). When a fungus spore lands on plant tissue, it grows hyphae (rootlike structures) into the plant. These hyphae feed on the plant's cells. Some of the main fungus diseases are blight, mildew, rust, and smut.

There are more than 170 known types of parasitic bacteria that cause diseases in plants (see BACTERIA). These bacteria are usually carried by insects from plant to plant. They destroy plant cells by digesting plant structures for food.

Viruses cause many plant diseases (see VIRUS). One of the most harmful viruses is the tobacco mosaic virus, which attacks tobacco and other members of the nightshade family, including tomatoes. These viruses may be spread by touch or be carried by insects, especially aphids, and other animals.

Nematodes are very small worms that sometimes live as parasites on plants (see NEMATODE). More than one hundred species of nematodes attack plant crops. Although nematodes usually hurt the plant's roots, sometimes they hurt or kill the part of the plant above the ground.

There are many signs of plant disease. These include changes in leaf color; enlarged areas on the stem, roots, or leaves; stunted growth (the plant stops growing); falling off or death of parts (flowers, fruits, leaves) of the plant; or the death of the entire plant.

Plant diseases can often be held off by biological or chemical means (see BIOLOGICAL CONTROL; FUNGICIDE; INSECTICIDE; PESTICIDE). They may also be fought by breeding plants that can hold off some kinds of diseases.

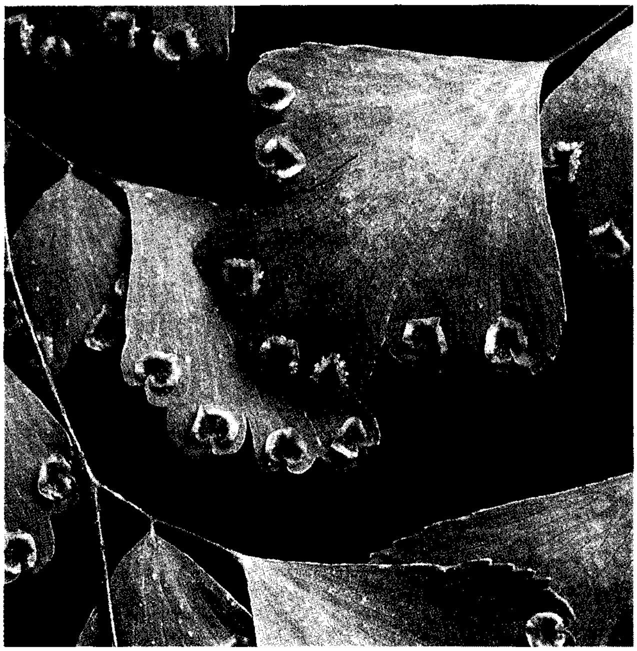
See also AGRONOMY; BREEDING.

PLANT KINGDOM

The plant kingdom includes all living and extinct (no longer living) plants. The members of the plant kingdom have many cells, and nearly all plants contain chlorophyll. Other organisms (such as bacteria, fungi, and algae) that were once classified as plants are now placed in separate kingdoms (see CLASSIFICATION OF LIVING ORGANISMS; KINGDOM).

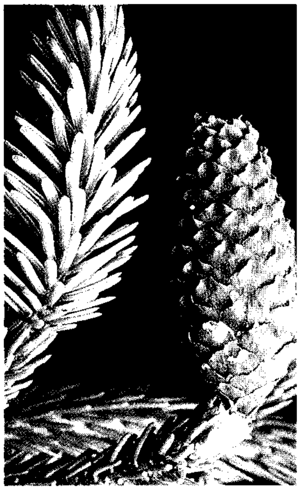
How plants differ from animals Plants are different from animals in many ways. Plants are able to make their own food by a process called photosynthesis. In order to make food, plant cells have chlorophyll, a green pigment that "traps" some of the energy from sunlight (see CHLOROPHYLL; PHOTOSYNTHESIS). Although most plants make more than enough food for themselves, some must depend on other organisms for part or all of their food (see PARASITE; SAPROPHYTE). However, all animals must depend on other organisms for their food. Some animals eat only plants and are called herbivores. Some animals eat only other animals and are called carnivores. Omnivores are animals that eat both plants and other animals (see CARNIVORE; HERBIVORE; OMNIVORE).

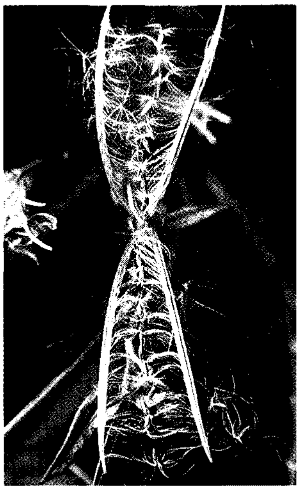
Most plants stay fixed in one place for their entire lives. Certain parts of the plant can move, but the plant itself does not move (see MOVEMENT OF PLANTS). Most animals, however, are able to move



LEAVES AND SEEDS

The leaves of simple ferns consist of fan-shaped segments. The leaves of maidenhead fern (above) bear "packets" of spores on their undersides. Watercress (above right) has leaves that grow out of the water. Seedcases vary widely in appearance. Shown here are a pine cone (right), seedcases of willow herb (center right), and fuchsia (far right).





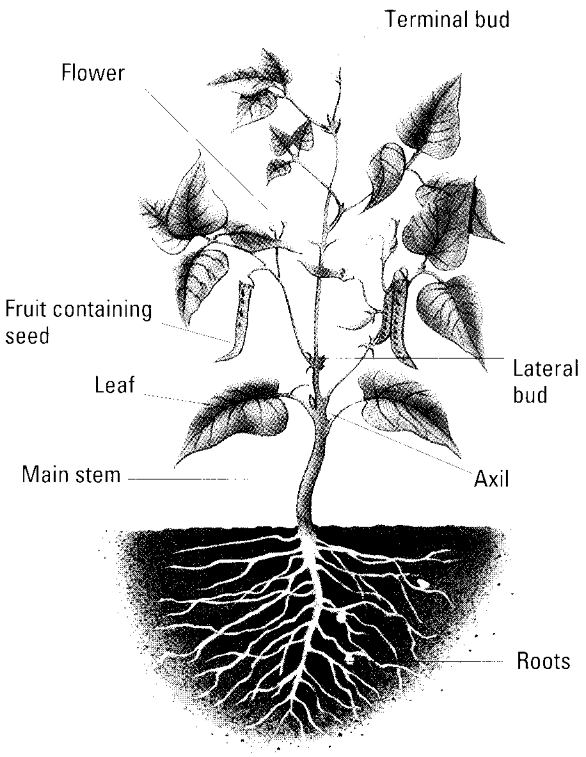
FLOWERS FROM BULBS
Tulips are grown for their showy, colorful blooms. Like many plants that grow from bulbs, tulips are monocotyledons—that is, plants that have only one seed leaf.

from one place to another under their own power.

It is possible for the growth of plants to be almost unlimited. Animals, however, are usually limited in size—they cannot grow beyond a certain size. A given kind of plant can also vary in shape—a tree, for example, varies according to where it grows—but a given species of animal is always the same shape.

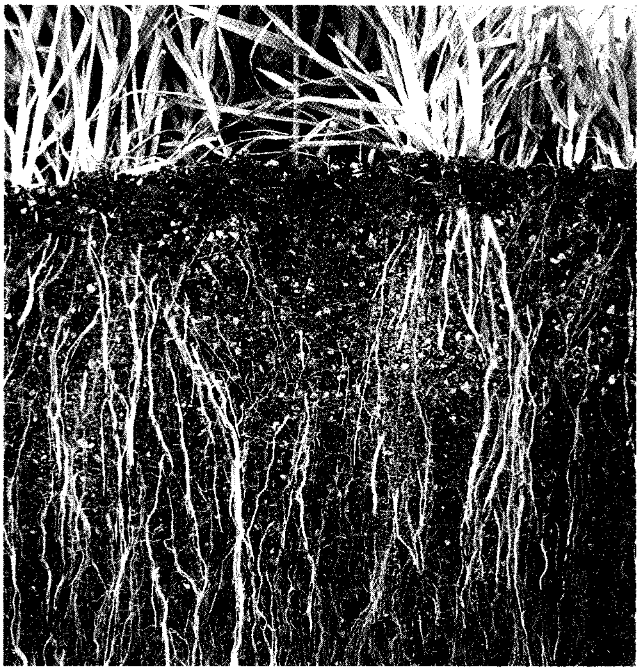
A plant cell is different from an animal cell (see CELL). Both the plant cell and animal cell have many similar structures. The plant cell, however, has a thick cell wall surrounding it, while the animal cell has only a thin cell membrane.

Divisions of plants There are over four hundred thousand different species of plants. They are grouped into several divisions (sometimes called phyla). Members of the division Bryophyta—liverworts, hornworts, and mosses—do not have special conducting tissues (xylem and phloem). They also do not have true roots, stems, or leaves (see BRYOPHYTE). The division Pteridophyta includes



PLANT PARTS

Most plants have a main stem that supports them, although some plants have several stems. The stem and side shoots bear leaves and flowers, which produce the seed-containing fruit. Roots supply water and nutrients to the plant.



BUDS AND ROOTS

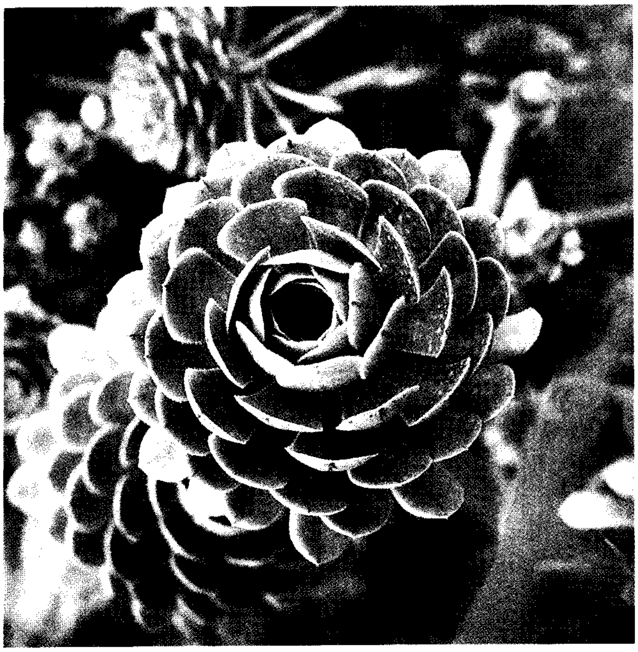
Flowers and shoots develop from buds, which often grow in axils at the junctions of leaf stalks and stems (top). Plants may have a single main tap root with side roots off it, like the plant pictured above left. Or there may be many fibrous roots all growing from the base of the plant, like the grasses in the photograph (above).

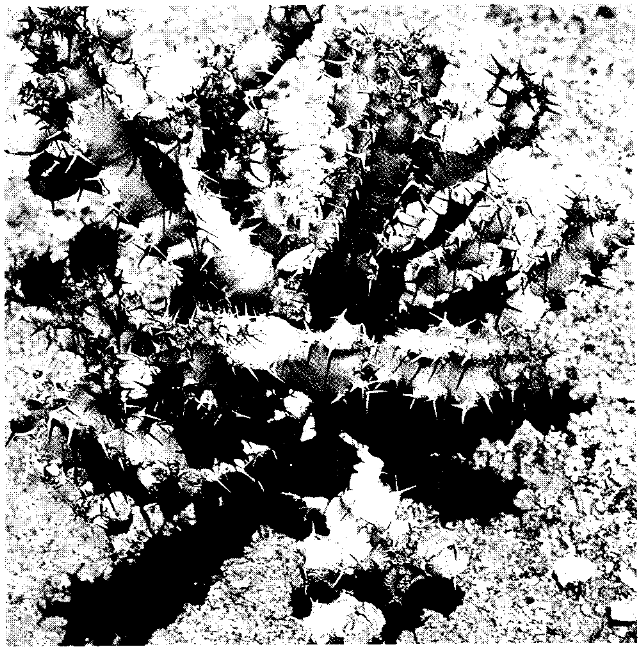
ferns, which have conducting tissues, roots, stems, and leaves but do not produce seeds (see PTERIDOPHYTE). The division Coniferophyta (conifers) includes the familiar evergreen trees that produce seeds in cones. They and the other plants that produce seeds that are not completely enclosed in a protective structure are called gymnosperms (see CONIFER; EVERGREEN; GYMNOSPERM). The division Anthophyta or Angiospermophyta includes all flowering plants, often called angiosperms. They produce seeds that are enclosed within a protective structure called a fruit (see ANGIOSPERM; FLOWER; FRUIT).

The bryophytes, pteridophytes, gymnosperms, and angiosperms are the main plant divisions. However, there are other, smaller divisions of plants as well. Club mosses and horsetails belong to two such divisions. Club mosses and horsetails were common prehistoric plants. They grew as tall as modern-day trees. A few small species of club mosses and horsetails still exist today (see CLUB MOSS; HORSETAIL).

Characteristics of different kinds of vascular plants Vascular plants are plants that have special tissue for conducting liquids (see VASCULAR PLANT). Ferns (pteridophytes) are among the simplest of the vascular plants. In prehistoric times, ferns grew as tall as trees. In tropical areas today, some ferns still grow 40 ft. [12 m] tall. However, most ferns do not grow taller than 3.3 ft. [1 m].

The gymnosperms include conifers, cycads, ginkgoes, and gnetales. Most conifers are evergreen trees





STORING WATER

Plants that grow in dry places have various ways of saving water. A succulent plant (above left) has thick, fleshy leaves that store moisture. A cactus (above right) has no leaves at all, only spines. Water is stored in the thick stems.

and shrubs with needlelike leaves. The cycads have large cones and fernlike leaves. The ginkgoes are gymnosperms with fanlike leaves. All but one species are now extinct. The gnetales are plants with some characteristics of gymnosperms and some of angiosperms. Gymnosperms are found throughout the world in almost every type of climate.

The angiosperms—flowering plants—are the most highly evolved, or developed, members of the plant kingdom. Most of the plants in the world today are angiosperms. They show great variety in size, appearance, and ways of life. Most live on land. Some, however, live in fresh water and a few live in salt water. Some live in hot, dry, desert areas. Some plants live in icy, arctic regions (see AQUATIC PLANT; EPIPHYTE; HALOPHYTE; XEROPHYTE). Angiosperms are divided into two classes according to the structure of the seed the plant makes: monocotyledons and dicotyledons. Monocotyledons have seeds with one seed leaf or cotyledon (see MONOCOTYLEDON). Dicotyledons have seeds with two cotyledons (see DICOTYLEDON).

Structure of a flowering plant Flowering plants have vegetative structures (roots, stems, leaves) and reproductive structures (flowers, fruits, seeds). The roots hold the plant in the ground and soak up water and minerals from the soil (see ROOT). Stems vary greatly in size, appearance, and structure (see STEM). Most stems are aerial—they grow above the ground. In general, aerial stems hold up the branches, leaves, and flowers. They also carry food, water, and minerals between the roots and other plant structures. Some stems are subterranean—they grow below the ground. Many underground stems have storage or rootlike structures such as corms and tubers (see BULB AND CORM; TUBER). Most stems have buds that make leaves, branches, or flowers (see BUD). The bud at the end of a stem is called the terminal bud. It controls the release of plant hormones that regulate growth (see HORMONE). Buds along the sides of the stem are called lateral buds. Each lateral bud forms in the axil of a leaf at a place on the stem called a node. Many stems have tiny openings called lenticels. The lenticels let gases pass into and out of the stem.

Leaves also show great variety in size and shape (see LEAF). Most photosynthesis takes place in the leaves. Most leaves are green because they include large amounts of the pigment (coloring substance) chlorophyll. Some leaves are large and fleshy, storing food and water. Some plants have leaves that have developed into needles, spines, or prickles. Deciduous trees and many herbaceous plants lose

DROUGHT-RESISTANT PLANTS
Cacti are adapted to grow in dry desert areas. They have no leaves (only spines), and thick fleshy stems to store water.

their leaves every year. Other plants, including the evergreen trees, have leaves year-round (see DECIDUOUS TREE).

The flower is the reproductive structure of an angiosperm. Most flowers have four regions: the calyx (sepals), the corolla (petals), the stamens (pollen-producing male structures), and the pistils (ovule-producing female structures). Although some of these parts may be missing, every flower must have at least one stamen or one pistil.

Fertilization occurs when a pollen cell reaches the egg (see FERTILIZATION; POLLINATION). This takes place in an ovule within the ovary of the pistil. The fertilized egg develops into an embryo (see EMBRYO). The ovule develops into a seed, and the ovary develops into a fruit (see SEED). The function of the fruit is to help scatter the seeds of the plant (see DISPERSION OF PLANTS). It is possible for each normal seed to germinate (sprout) and develop into a new plant.

Plant evolution and adaptation Scientists believe that the first plants were algaelike and lived in the oceans over three billion years ago during the Precambrian time (see EVOLUTION; PRECAMBRIAN TIME). The first land plants were probably the primitive psilophytes (see PSILOPHYTE). These plants probably evolved from the algaelike plants about 400 million years ago during the Paleozoic era (see PALEOZOIC ERA). By about 340 million years ago, there were forests of club mosses, horsetails, and ferns. By the beginning of the Mesozoic era, about 245 million years ago, when dinosaurs roamed the earth, gymnosperms had become the most widespread of the land plants. Angiosperms evolved during the Mesozoic era (see MESOZOIC ERA). By the beginning of the Cenozoic era, about 65 million years ago, angiosperms had spread throughout the world (see CENOZOIC ERA).

As evolution continued, many plants developed lifestyles or special structures to help them grow and reproduce efficiently. Some plants grow, reproduce, and die in one year (see ANNUAL PLANT). Some plants grow for one year, then reproduce and die in the second year (see BIENNIAL PLANT). Many plants live for more than two years, usually reproducing every year (see PERENNIAL PLANT). Some plants have developed structures to protect them from being eaten by animals. In some of these plants, the leaves have been modified (changed) as spines or thorns for protection. In others, the plant has a bad-tasting or poisonous fluid in the roots, stems, leaves, flowers, or fruits.

Many plants have evolved special structures to help them store food. Bulbs, corms, tubers, fleshy stems, and fleshy leaves are all food-storing structures. Some plants have haustoria, specialized rootlike structures that grow into a host and soak up food and water. Some plants have even evolved special structures for catching insects so that the plants can get the minerals they need (see CARNIVOROUS PLANT). Other plants have developed a lifestyle in which they live symbiotically with other organisms (see SYMBIOSIS).

Uses of plants Plants are the most important living things on Earth. Without plants, there would be no other forms of life. It is believed that plants were the original source of all the oxygen in the earth's early atmosphere. Plants are also the main source of oxygen in the air today. They help maintain the carbon dioxide and oxygen levels in the air.

Plants are the source of all food needed by animals. They are vital links in the food chain (see FOOD CHAIN). Plants are important in practically every cycle in nature—the carbon cycle, the nitrogen cycle, the oxygen cycle, and so forth.

Plants provide many useful nonfood products for people. They provide lumber for construction, fibers for clothing, chemicals for medicines, and hundreds of other substances that have become common parts of everyday life.

See also BOTANY; ECOLOGY; PLANT DISEASE; REPRODUCTION.

PROJECT 67, 68, 69, 72

AQUATIC PLANTS

Most seaweeds grow in shallow water near the seashore. Unlike most plants, they can tolerate salt. They are covered by the sea except at low tide.

PLASMA Plasma is the straw-colored liquid part of the blood that carries the solid parts of blood—red and white cells and platelets (see BLOOD). Plasma is made of water, salt, protein, and other materials.

Plasma carries food that has been dissolved to all parts of the body. It picks up waste material from body cells and carries it to organs that remove waste from the body (see EXCRETION).

Plasma contains hundreds of proteins that are essential for the proper functioning of the body (see PROTEIN). One of the proteins found in plasma is fibrinogen. Fibrinogen helps make it possible for the blood to clot (thicken and lump together) and seal off a wound. If it were not for fibrinogen, a person could bleed to death from the smallest cut. Globulins are another type of protein found in plasma. Globulins are mostly antibodies that help the body's immune system fight disease (see ANTIBODY; IMMUNITY). A third type of protein found in plasma is albumin. Albumin helps keep the blood pressure and blood volume normal and helps transport certain substances in the blood.

During the 1930s, researchers found that plasma could be separated from whole blood by using a machine called a centrifuge (see CENTRIFUGE). After plasma has been separated from whole blood, it can be frozen and will keep for a long period of time. Plasma is used in blood transfusions (transferring blood from one person to another person) to restore blood that has been lost due to injury or disease.

See also BLOOD TRANSFUSION.

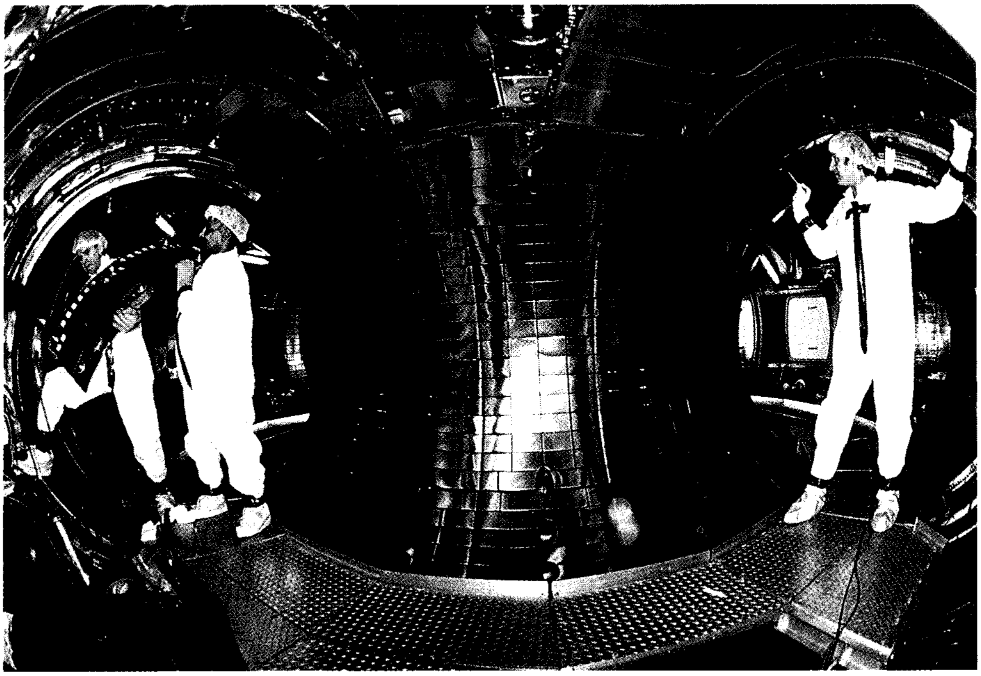
PLASMA (PHYSICS) Plasma is a fourth state of matter (see STATES OF MATTER). Solids, liquids, and gases are called states of matter. If a solid is heated, it melts and turns into a liquid. At a higher temperature, the liquid boils to form a gas. The fourth state of matter, plasma, is made by heating a gas to above 90,000°F [50,000°C]. Plasmas can also be made by passing electricity through a gas.

All atoms have small particles called electrons (see ATOM; ELECTRON). In a plasma, some of the electrons are separated from the atoms. When an atom loses (or gains) an electron, it is called an ion (see IONS AND IONIZATION). Plasma contains many ions.

Plasmas usually give off light. The light comes mostly from the electrons and the ions coming into contact, or touching. Arc lamps and fluorescent lamps give off light because they contain plasmas (see ELECTRIC LIGHT). The Van Allen belts around the earth and the corona around the sun are also made of plasmas (see CORONA; VAN ALLEN BELTS).

PLASMA

Plasma is the part of blood that carries red and white blood cells and platelets. Plasma can be separated from whole blood, frozen, and stored (left) for long periods until it is needed for life-saving transfusions.



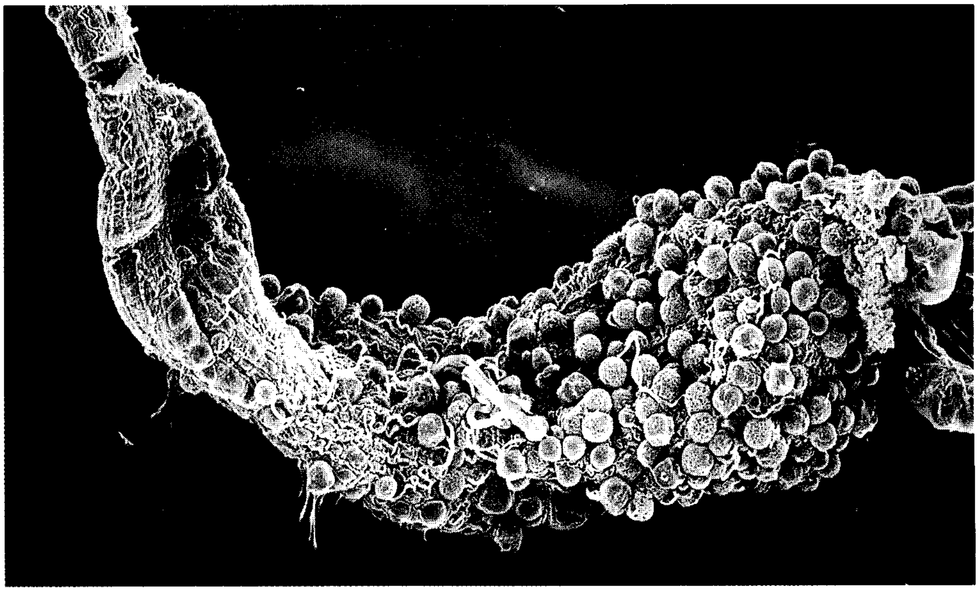
PLASMA (PHYSICS)
Nuclear fusion is a process in which atoms join together and give off very large amounts of heat energy. For nuclear fusion to take place, the atoms have to be in the form of a plasma, which is contained inside a doughnut-shaped vessel using magnets. Here technicians inspect the inside of an experimental fusion reactor at Princeton University.

Plasmas are good carriers of electricity. They are strongly affected by magnetic fields.
See also MATTER.

PLASMODIUM (plăz mō′ dē əm) A plasmodium is a shapeless mass of protoplasm that has many nuclei (plural of *nucleus*) but lacks a firm cell wall (see CELL). It moves by oozing from one place to another in what is called ameboid movement. A plasmodium is the normal body form of slime molds and some fungi (plural of *fungus*) (see FUNGUS; SLIME MOLD). *Plasmodium* is also the name of malaria-causing protozoans that live as parasites in mosquitoes. The mosquitoes pass on the parasites when they bite humans, causing malaria (see MALARIA; PROTOZOAN).

PLASTER OF PARIS Plaster of Paris is a white powder that is a form of calcium sulfate ($CaSO_4 \cdot \frac{1}{2}H_2O$). It is made by removing water from the mineral gypsum ($CaSO_4 \cdot 2H_2O$) when the mineral is heated to 482°F [250°C]. When water is added to plaster of Paris, it sets in a few minutes to form a hard mass of gypsum. This makes it an ideal material for casts, molds, and pottery.
See also GYPSUM.

PLASMODIUM
Plasmodium is a type of protozoan that causes the disease malaria. This photograph, taken using an electron microscope, shows the stomach of an *Anopholes* mosquito. The small round lumps are cysts containing immature *Plasmodium*.



Plastic

Plastics are synthetic (human-made) materials. They are easily molded into shapes, usually by applying heat and pressure. Plastic objects have many different uses. In the home, plastic is used in floor tiles, nonstick cooking pans, and heat-proof surfaces in the kitchen. Curtains, carpets, and light fixtures may be made from plastic. Drip-dry shirts, non-iron dresses, and many types of shoes have plastic in them.

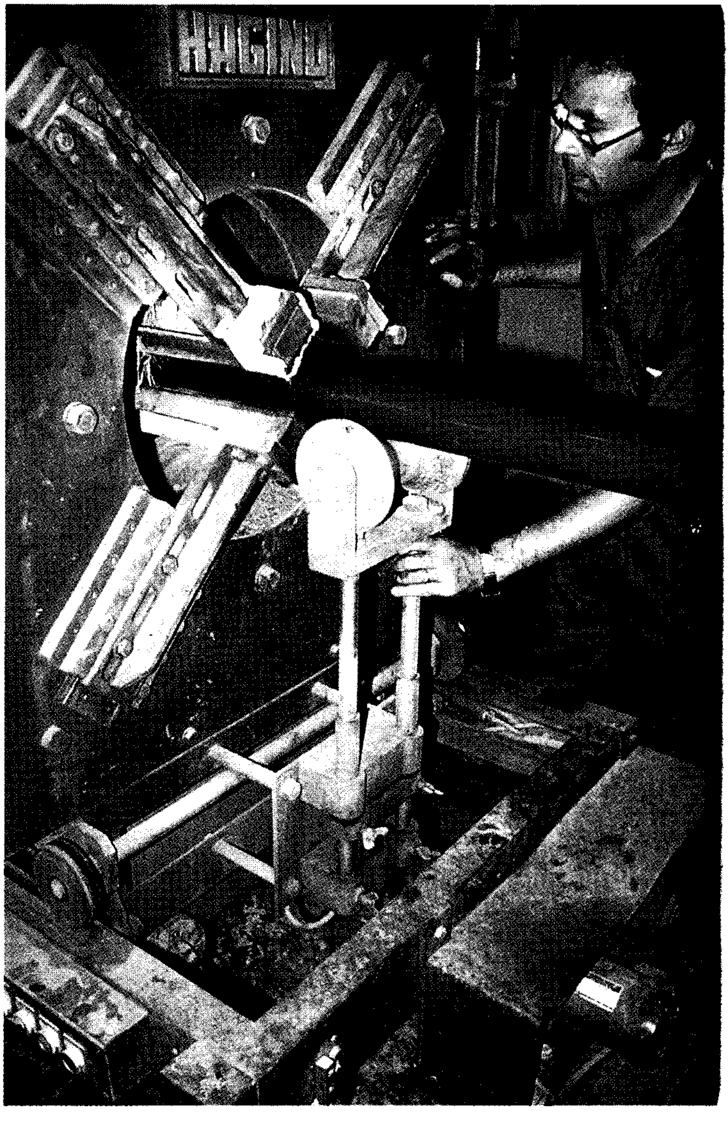
Plastics are also very important in industry and medicine. For example, plastic tubes are used in surgery for replacing blood vessels that are no longer working as they should. The plastic used is inert. This means that the body will not have a reaction to the tubing. Few other materials could be used in this way (see PROSTHETICS).

Most common plastics belong to a group of chemical compounds called synthetic resins (see RESIN). Plastics are made of long, chainlike molecules called polymers (see POLYMER). Some of the polymers used to make plastics are found in nature. For example, celluloid is made by treating cellulose, a naturally occuring polymer, with a mixture of sulfuric and nitric acids (see CELLULOSE).

Types of plastic There are two main groups of plastics: thermoplastics and thermosets. Thermosets are hard and rigid. Thermoplastics are softer and more flexible than thermosets. These two types of plastics act differently when they are heated. Thermosets tend to resist heat. They cannot be remelted and reshaped. For example, a hot pan from the stove can be placed on top of a thermoset plastic without hurting the plastic. A hot pan, however, would melt most thermoplastics. Thermoplastics soften and melt at fairly low temperatures. Melting does not damage them, however, and they harden again when they are cooled. This process of melting and cooling a thermoplastic can be repeated many times.

Thermosets and thermoplastics are different from each other because their molecules are arranged differently. In thermoplastics, the long chain molecules are mostly separate from each other. There is very little linkage between the chains. This is why thermoplastics are flexible, especially when they are warmed. In thermoset plastics, the long chain molecules are linked together. The linkage of molecules in thermosets makes these materials hard and rigid. When a thermoset is heated, even more linkages form. This is why thermosets do not melt when they are heated (see MOLECULE).

Most of the well-known plastics are thermoplastics. Besides nylon and polyethylene, they include polystyrene, polyvinyl chloride (PVC), acrylic, polyacetal, and polytetrafluoroethylene (PTFE)

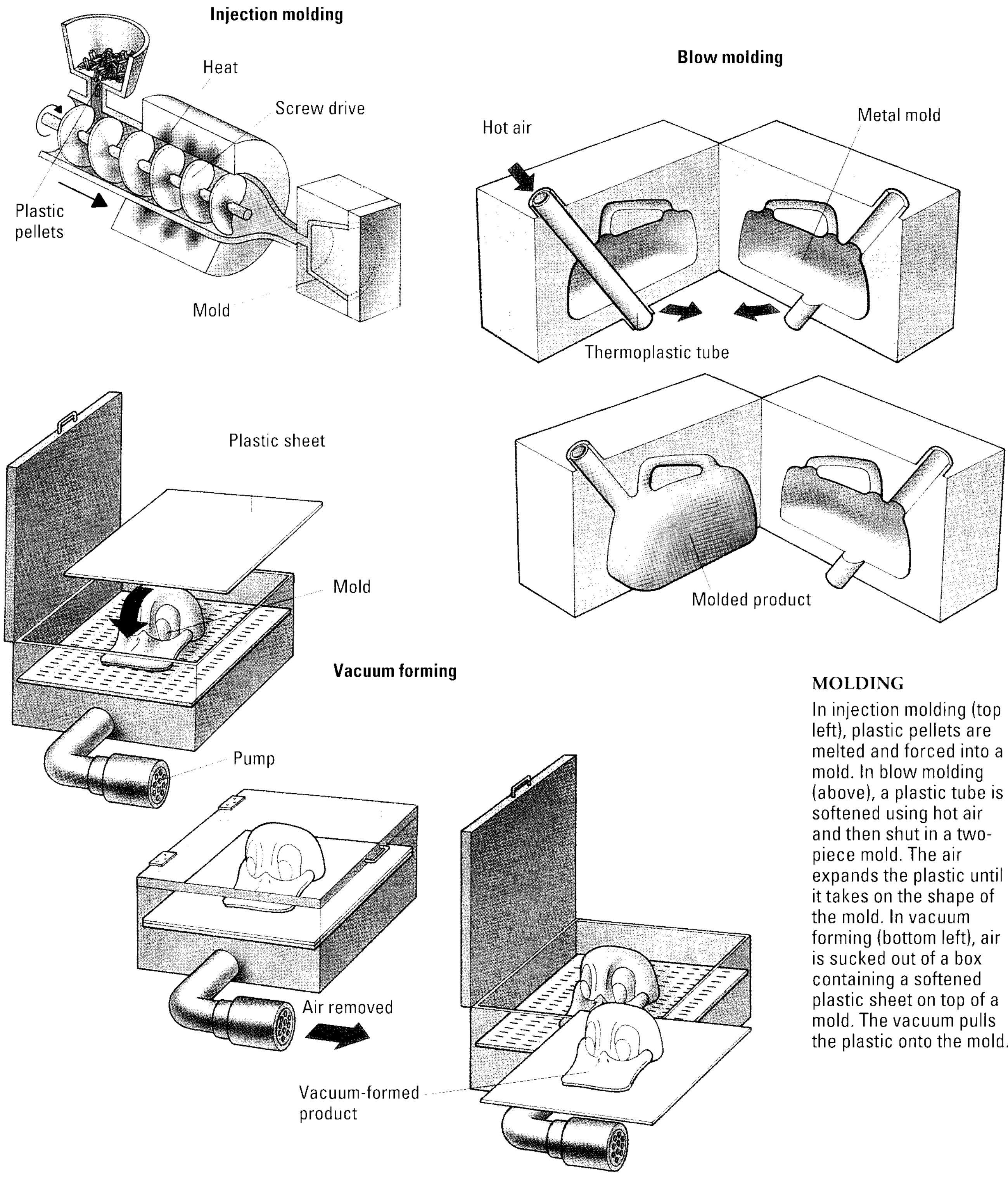


EXTRUSION MACHINE
This machine is making plastic pipes by extrusion, which involves forcing melted plastic through a die.

(see ACRYLIC; NYLON). Common thermosetting plastics include Bakelite, epoxy resins, urea-formaldehyde resin, polyurethane, and silicones (see BAKELITE; EPOXY RESIN; SILICONE).

Some plastics can be either thermosetting or thermoplastic. An example is polyester. Thermoplastic polyester is used in fabrics and to make fiberglass (see FIBERGLASS). New plastics that can conduct electricity have been developed.

Making and shaping plastics Plastics are made by a process called polymerization. In polymerization, small molecules called monomers are linked together to make the long chainlike molecules



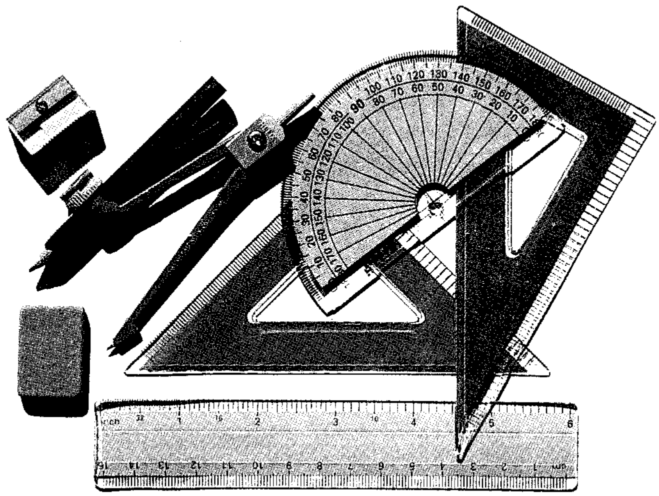
MOLDING

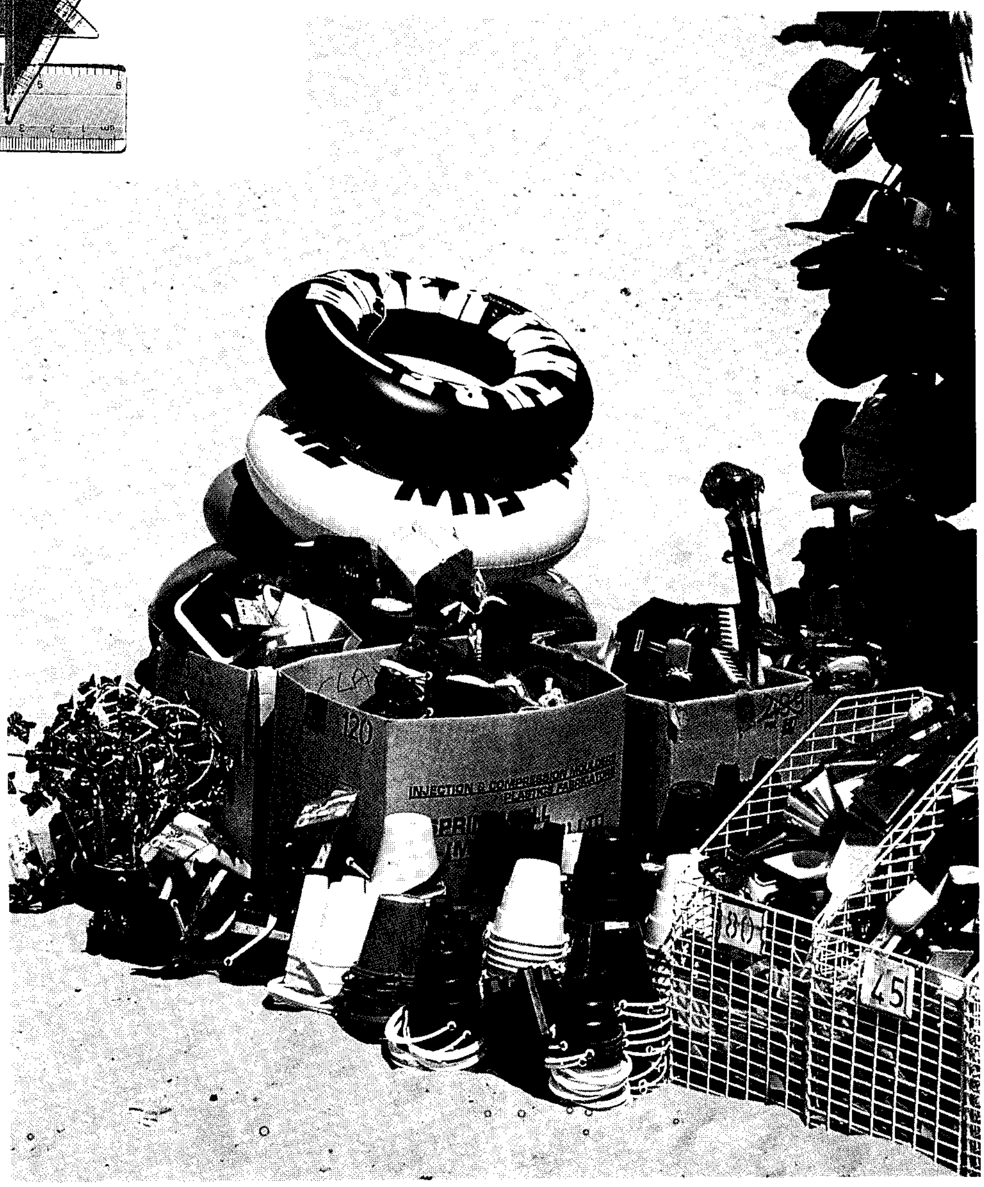
In injection molding (top left), plastic pellets are melted and forced into a mold. In blow molding (above), a plastic tube is softened using hot air and then shut in a two-piece mold. The air expands the plastic until it takes on the shape of the mold. In vacuum forming (bottom left), air is sucked out of a box containing a softened plastic sheet on top of a mold. The vacuum pulls the plastic onto the mold.

called polymers. For polymerization to happen, a catalyst is usually needed to speed the polymers in linking up (see CATALYST).

In order to make plastic articles, the plastic has to be shaped. The most common way of shaping plastic is by molding it. Different processes are used for thermosets and thermoplastics. Objects made of thermoset plastic are produced by compression molding. In this process, plastic pellets are placed in the bottom half of a hot mold. The top half of the mold is moved down on top of the bottom half with a great deal of pressure. This melts the plastic, causing it to flow into the shape of the mold. Under these conditions of high pressure and temperature, the molecules link up, and the plastic sets, or molds.

Thermoplastics are much easier to shape than thermosets. This is because thermoplastics can be kept molten (melted) for a long time. There are several different methods of molding thermoplastics. A very common method is called injection molding. Plastic pellets are melted in a heated chamber. A piston, or screw drive, then forces the





PLASTIC GOODS
Many everyday articles are made of plastic, from drawing instruments (above) to things to use at the beach (right).

molten plastic through a nozzle into a mold that is kept cool. The plastic cools and sets in the shape of the mold. The mold then opens automatically, and the object is taken out of the mold. Another method is called blow molding. Molten thermoplastic is placed inside a mold. The mold is kept cool by water. Air is then blown into the plastic to force it into the right shape. This method is used for making plastic bottles and other hollow articles.

Another common method for shaping thermoplastic is called extrusion (see EXTRUSION). In this method, molten plastic is forced through a hole in the shape of the object to be made. For example, a circular hole is used for making rods and a slit for making films. Synthetic fibers are made this way. Molten plastic is forced through very tiny holes in a special device called a spinneret. This method is used for nylon and polyester (see FIBER).

The heat-resistant countertops used in kitchens are made by a different process called laminating. Layers of cloth or paper are soaked in a resin such as urea-formaldehyde. The resin makes the structure strong and rigid. The layers are then clamped in a press and heated to set the resin. This forms the thick plastic countertop. Some plastic materials are made in the form of a foam. Such plastics are used for insulation in the home and in factories, and also to package fast foods.

Plastics and the environment Even though plastics have become a "wonder material," they pose great problems for the environment. For example, plastics are made from a nonrenewable natural resource—petroleum (see NATURAL RESOURCE; NONRENEWABLE RESOURCE; PETROLEUM). The manufacture of plastics releases poisons into the air and creates hazardous waste (see WASTE DISPOSAL). These liquid and solid wastes can cause cancer in humans and other animals if they are poorly disposed of and leak into the soil or water. Plastic products also make up close to one-fifth of the solid waste in the United States. Because they do not biodegrade (break down), they take up valuable space in landfills and other disposal sites forever (see BIODEGRADABILITY). Also, improperly discarded plastic materials can cause damage to many organisms. For example, rings that hold cans together, fishing lines, and fishing nets can strangle sea animals. Sea turtles can choke on plastic bags they mistake for jellyfish.

Some manufacturers claim their plastic grocery and trash bags are biodegradable. However, the process of making these bags involves bonding small plastic pieces together with cornstarch (see STARCH). The cornstarch decomposes, but the plastic pieces do not. These claims may cause harm if they lead people away from researching how plastics can be recycled.

See also RECYCLING.

PLASTIC TOYS
Plastics have revolutionized the toy industry. Today, most toys are made of plastic (left) rather than metal or wood.

PLASTIC SURGERY Plastic surgery is the surgical repair or rebuilding of body tissues (see SURGERY). Plastic surgeons treat physical defects (something that is wrong with the body) that existed when a person was born (congenital defects) or defects that were caused by injury or disease. Often, a natural body part does not work as it should. In such cases, the surgeon does reconstructive plastic surgery to improve the body part's function and appearance. This often requires grafting. In grafting, skin, muscle, bone, or cartilage is transplanted from a healthy part of the body to the part that is hurt or damaged. Sometimes, reconstructive surgery involves reattaching severed limbs, rebuilding damaged tissues, or restoring damaged blood vessels and nerves.

People who want to make their appearance better sometimes have cosmetic plastic surgery. The most common types of cosmetic surgery are face-lifts to take away wrinkles from the face and neck and rhinoplasties to change the shape of the nose.

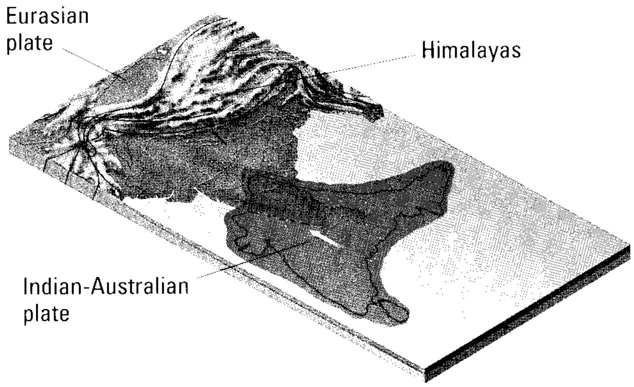
See also IMPLANTATION; TRANSPLANTATION.

PLATELET (plāt'lĭt) Platelets are tiny, colorless disks found in blood plasma that help blood clot. When a person receives a cut, clotting is the mechanism that prevents excessive blood loss, which may cause death. Platelets measure about 0.00008 to 0.00016 in. [0.002 to 0.004 mm] in diameter. They are produced by bone marrow (see BLOOD; BONE MARROW; PLASMA). Platelets live for about eight days. They cannot move on their own and are carried by the bloodstream.

When a blood vessel is cut, platelets stick to the damaged edges and to each other. They form a temporary seal over the injury. As the platelets pile up, they release a chemical that combines with other substances in plasma. This reaction produces the chemical called thromboplastin. Thromboplastin changes a blood chemical called prothrombin into thrombin. Thrombin acts on another blood chemical called fibrinogen. Thrombin changes fibrinogen so that it takes the form of threads. The threads form a permanent seal called a clot that stops the escape of blood through the wound.

Platelets occur only in mammals (see MAMMAL). In other vertebrates (organisms with a backbone) and some invertebrates, cells called thrombocytes perform a similar function.

PLATE TECTONICS (plat tĕk tŏn'ĭks) Plate tectonics is the theory that the earth's surface consists of plates (big, movable, flat pieces of rock). Some of these plates include continents, while others include both continents and oceans. According to this theory, the movement and interaction of these plates causes continental drift (the slow movement of the continents), volcanoes, mountain building, and earthquakes (see CONTINENTAL DRIFT).



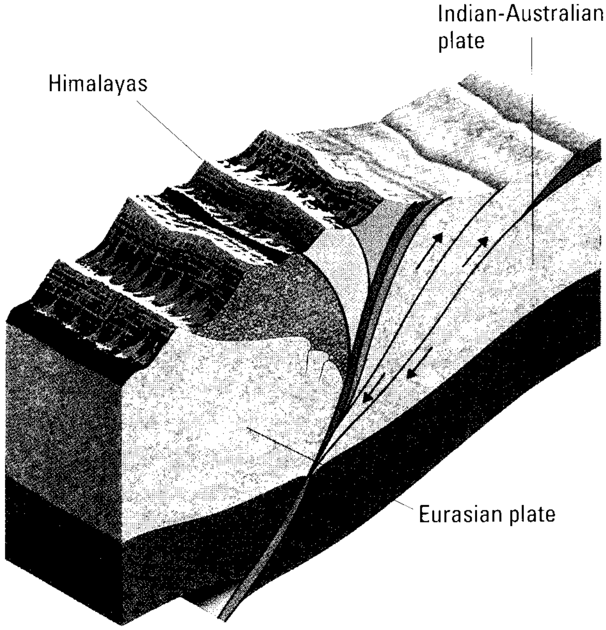


PLATE TECTONICS—Mountain building
The mighty Himalayas were created by plate movements. Millions of years ago, the plate carrying India drifted northward and collided with the Eurasian plate. Rocks from the ocean floor were pushed up to form the range of mountains.

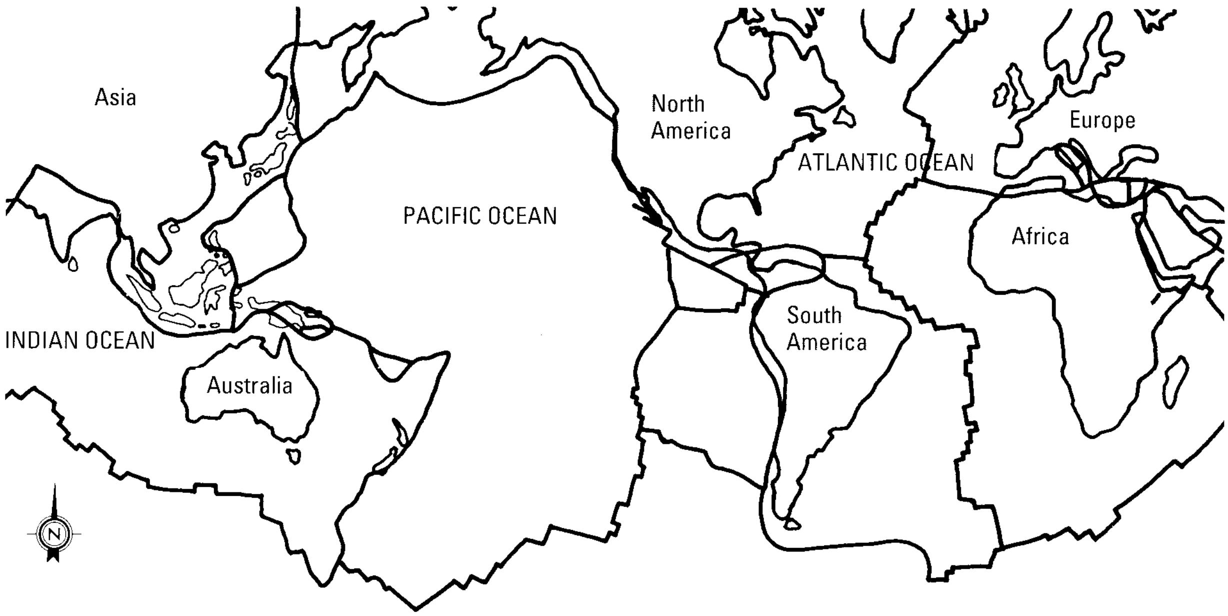


PLATE TECTONICS—Interlocking plates
The red lines on this map show the edges of the plates that make up the earth's lithosphere.

The San Andreas fault in California is where the North American plate meets the Pacific plate. The area around this fault line is very likely to have earthquakes. Earthquakes are also likely to occur along plate edges in other parts of the world. Volcanoes also are likely to occur along the edges of plates (see EARTHQUAKE; FAULT; SAN ANDREAS FAULT; VOLCANO).

Convection currents are forces beneath the earth's crust that carry molten (melted) material from the inside of the earth to the surface. These occur in the soft portion of the earth's interior—the asthenosphere. The movements carry the solid center portion—the lithosphere—in the form of individual plates. Convection currents have played a part in the formation of the Mid-Atlantic ridge. Along this ridge, new rock is always being formed from the molten material. The new rock forces the two plates that meet at this ridge to spread apart. This tectonic activity is slowly moving the American continents away from Europe and Africa.

Tectonic activity also explains how mountain ranges have formed (see MOUNTAIN). For example, millions of years ago, the plate carrying the Indian peninsula crashed into the Eurasian plate. This caused the Himalayas to rise up.

The plate tectonic theory provides an explanation for many of the unusual geological events that have happened during the last several billion years. *See also* EARTH; PANGAEA.

PLATINUM (plăt'n əm) Platinum (Pt) is a rare, silvery metallic element (see ELEMENT). Platinum is found as grains or nuggets in igneous rocks (see ROCK). It is a hard metal and is resistant to (not hurt by) heat and many chemicals. For these reasons, it is used to make surgical instruments, chemical equipment, and electrodes (see ELECTRODE). It is also easily shaped into a new form. Platinum is used

PLATINUM
Platinum, shown here made into wedding rings, is a silvery metal valued for its rarity and beauty.

in a number of different alloys. An alloy is a mixture of different metals (see ALLOY). Alloys of platinum and silver are used in dentistry. Alloys of platinum with the metal iridium are used for making electrical parts and bearings. Platinum's resistance to heat allows it to be used as a coating in nose cones of missiles and in fuel nozzles for jet engines. Platinum is used to make fine jewelry. It is also an important catalyst in many chemical reactions. A catalyst is a substance that speeds up a chemical reaction (see CATALYST).

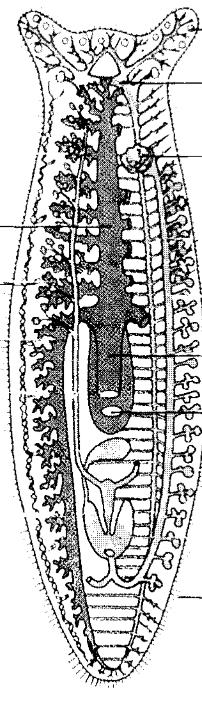
Platinum's atomic number is 78, and its relative atomic mass is 195.08. Platinum melts at 3,222°F [1,772°C] and boils at about 6,900°F [3,800°C]. Its relative density is 21.5.

See also RELATIVE DENSITY.

PLATYHELMINTHES (plăt′ ē hĕl mĭn′ thēz) Platyhelminthes is a phylum of animals that includes a large class of free-living flatworms and two classes of parasitic flatworms, the flukes and the tapeworms (see PARASITE; TAPEWORM). These invertebrate animals have soft, flat bodies. They have no skeleton, respiratory system, or circulatory system. Oxygen simply seeps into their bodies from the surroundings.

The platyhelminths have simple nervous and excretory (waste-removal) systems. Most have digestive systems with a single opening. Digested food seeps out of the gut and into the cells of the body. The most common nonparasitic flatworms are the freshwater planarians that can often be seen gliding over the mud or even just under the surface of the water.

See also INVERTEBRATE; SCHISTOSOMIASIS; WORM.



PLATYHELMINTHES
This diagram shows the body plan of a planarian flatworm, a member of the animal phylum *Platyhelminthes*.

PLATYPUS
The platypus uses its ducklike bill to hunt underwater for shellfish, worms, and aquatic insects.

PLATYPUS (plăt′ĭ pəs) The platypus, or duckbill, is a primitive mammal found in parts of Australia (see MAMMAL). The animal is often called a duckbill because of its ducklike bill. The platypus uses its bill to hunt for shellfish, worms, and various insects on the bottom of streams. Adult platypuses have no teeth. Instead, they use the horny plates in their upper and lower jaws to chew food.

The platypus is about 2 ft. [61 cm] long, not including the tail. The tail, which is 6 in. [15 cm] long, is shaped like a paddle. It helps the animal swim.

Although the platypus lays eggs instead of bearing its young alive, it is a mammal. It is classified in the order Monotremata (see MONOTREME). Like other mammals, the platypus nurses its young—that is, feeds them with milk from the mother's breast. The female usually lays from one to three eggs in a burrow in the riverbank. When they are hatched, she uses her tail to hold the young close to her body while nursing them.

Platypuses were once killed in great numbers for their thick, soft fur. Hunting platypuses is now against the law in Australia.

PLEISTOCENE EPOCH (plī'stə sēn' ĕp'ək) The Pleistocene epoch is the division of the Quaternary period in the earth's history that began 1.64 million years ago and ended about 10,000 years ago. Modern humans emerged during the Pleistocene epoch.

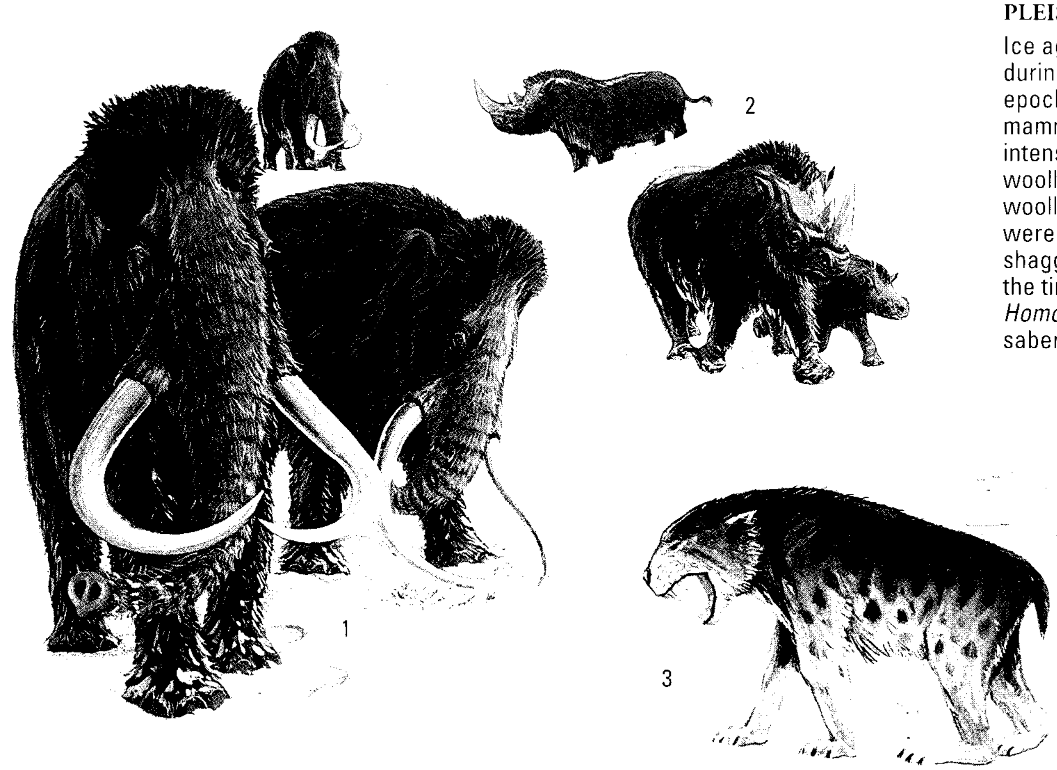
The Pleistocene epoch was marked by several ice ages—periods of time when much of the earth was covered with ice (see ICE AGE). During the ice ages, there was less water in the oceans than there is now because of the large amount of frozen water in the glaciers (large bodies of ice). Land bridges (connections formed by land over a body of water), such as the Bering Strait, were uncovered. This may have given animals and people the chance to move from the Eastern Hemisphere into the Western Hemisphere. When the glaciers melted, the landscape of the northern land areas was changed (see GLACIATION; GLACIER).

Most modern mammals appeared during the Pleistocene. Toward the end of this epoch, huge mammals such as the mammoths, mastodons, and woolly rhinoceroses became extinct (no longer existed) (see EXTINCTION; MAMMOTH; MASTODON). The reason for the extinction of these large mammals has not yet been determined.

See also EVOLUTION; GEOLOGICAL TIME SCALE; QUATERNARY PERIOD.

PLIMSOLL LINE The Plimsoll (plĭm'səl) line is a mark on the side of a ship that shows how low in the water the ship can safely sit when it is fully loaded. If the Plimsoll line is below the water level, the ship is too full. A ship that is too full can sink in stormy seas.

The Plimsoll line is named after the British politician Samuel Plimsoll. Plimsoll helped improve the laws for ship safety. A Plimsoll line is now necessary by law on ships of all nations. It is sometimes called the International Load Line. PROJECT 3



PLEISTOCENE EPOCH
Ice ages were common during the Pleistocene epoch. Among the mammals that survived the intense cold were (1) the woolly mammoth and (2) the woolly rhinoceros. Both were plant eaters with long, shaggy coats. Predators of the time included (3) *Homotherium*, a heavy saber-toothed cat.

PLIOCENE EPOCH (plī′ə sēn′ ĕp′ək) The Pliocene epoch, the last division of the Tertiary period in the earth's history, began about 5.2 million years ago and lasted about 3.5 million years. The Pliocene is the shortest epoch of the Tertiary period (see TERTIARY PERIOD).

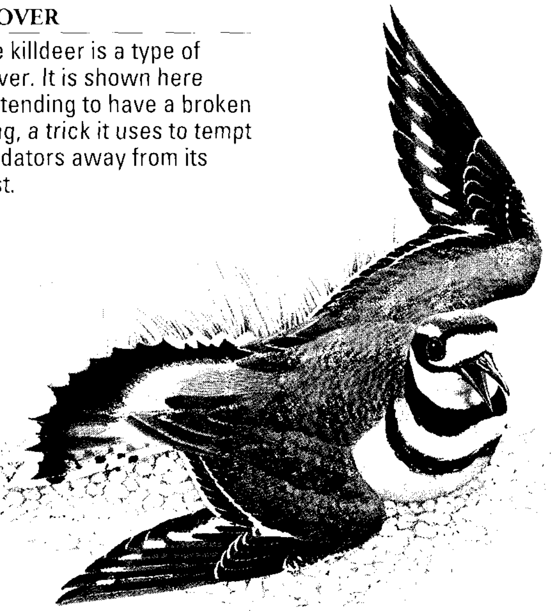
The Pliocene epoch was cooler and drier than the previous epochs. Pliocene mammals began to grow to a larger size. There were many species of camels and horses that were bigger than today's species. Mastodons (elephantlike mammals) that could live in the new environment began to evolve. Primates were also evolving rapidly (see PRIMATE). The rhinoceroses of North America became extinct (no longer existed) (see EXTINCTION). Pliocene sea life was quite similar to that of today. During the Pliocene epoch, the mountain ranges known as the Alps and the Himalayas were rising.

See also GEOLOGICAL TIME SCALE.

PLOVER (plŭv′ər) A plover is a bird that belongs to the family Charadriidae. It has a short, straight bill; a short tail; and long, pointed wings. Many plovers are shorebirds. They are most often seen walking along the shoreline, feeding on insects and small water animals. Other plovers feed in grasslands and meadows some distance from the water.

There are twelve species of plovers in North America. One of the most common plovers is the killdeer. It grows to about 8 in. [20 cm] long.

PLOVER
The killdeer is a type of plover. It is shown here pretending to have a broken wing, a trick it uses to tempt predators away from its nest.



Killdeer have brown wings, white bellies, and two black bands around their necks. All plovers are strong fliers. The American golden plover, a bird about the size of a robin, spends the summer in the Arctic but flies to southern South America for the winter. This is one of the longest bird migrations known.

See also BIRD; MIGRATION.

PLUM
Plums are a popular food, as are dried plums, called prunes. In the United States, most plums are grown in California.

PLUM The plum is a fruit-bearing tree belonging to the rose family, Rosaceae (see ROSE FAMILY). Its fruit, which can be as large as a peach, is round or oval and contains a single seed enclosed in a woody stone or pit. The thin skin may be purple, blue, red, yellow, or green. The flesh of the plum can be eaten fresh. The plum tree, which grows in temperate regions around the world, can be low and shrubby or grow to 30 ft. [9 m] high. The flowers are white or pink.

Almost two thousand varieties of plum are known. The five most common plums are the European plum, the Japanese plum, the American plum, the damson plum, and the ornamental plum. Some of these varieties are used to make jellies, jams, and plum butter. Dried plums are known as prunes. Prunes have a high sugar content.

In the United States, most plums and prunes are grown in California. Oregon, Washington, Idaho, and Michigan are other states where plums are grown for market.

PLUTO

Pluto is the planet next to Neptune. It is normally the farthest planet from the sun (see PLANET). Percival Lowell, an American astronomer, believed there was a planet beyond Neptune. He based his belief on Neptune's unusual orbit. In 1930, Pluto was discovered by Clyde Tombaugh, an assistant to Lowell (see LOWELL, PERCIVAL; TOMBAUGH, CLYDE WILLIAM). Pluto cannot be seen without a strong telescope.

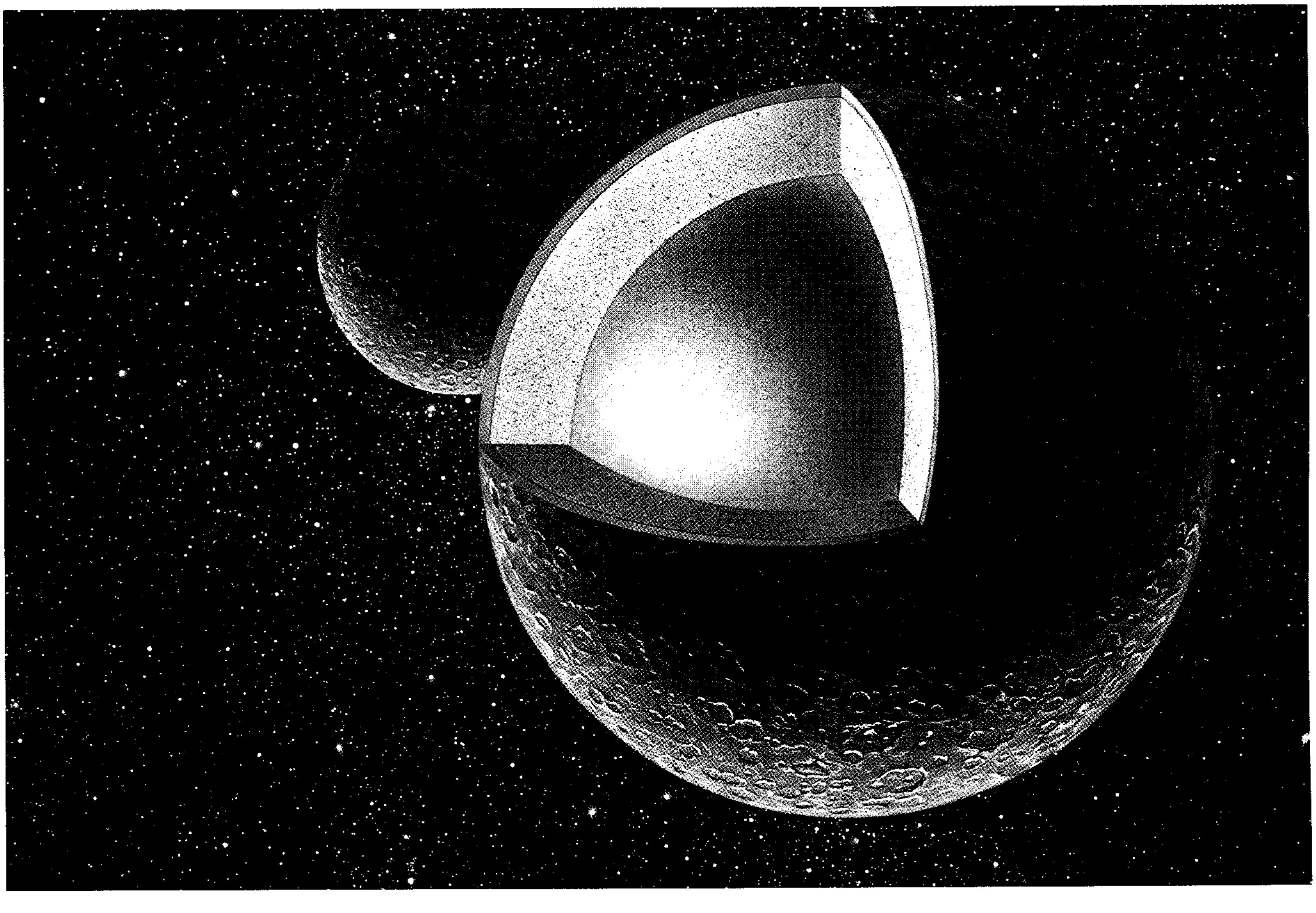
Pluto is the smallest planet. Pluto's diameter is between 1,500 and 1,800 mi. [2,400 and 2,900 km]. Pluto is, on average, about 3.66 billion mi. [5.89 billion km] from the sun. Pluto takes a little more than 248 years to make a full orbit around the sun. For about 20 years every 248 years, Pluto's orbit is inside Neptune's. Most recently, this period began in 1976. Pluto will again be the most distant planet in 1999.

Very little is known about the surface of Pluto. Its tiny size and great distance from the earth make Pluto the most difficult planet for astronomers to study. Pluto consists largely of gases. Scientists believe that the average temperature of Pluto is near absolute zero, which is -459.67°F [-273.15°C]. This low temperature would cause most of the gases on Pluto to be frozen.

Until 1978, Pluto was thought to have no natural satellites. However, on June 22, 1978, James W. Christy, an American astronomer, discovered that Pluto has a moon. Christy named the moon Charon. Charon has a diameter of 500 to 600 mi. [800 to 965 km]. It orbits Pluto every 6.4 earth-days, the same time it takes Pluto to make a complete spin on its axis. Charon is about 12,000 mi. [19,300 km] from Pluto. Some astronomers regard Pluto and Charon as a binary planet system.

COMPOSITION OF PLUTO

Pluto is the smallest planet and the planet that is normally farthest from the sun. Astronomers believe that Pluto probably has a rocky core covered by a thick layer of ice with a thin crust of frozen (solid) methane. Charon, Pluto's moon, is a little less than half the size of Pluto and very close to it. The pair are sometimes regarded as a binary planet system.



PLUTONIUM (plo͞o tō'nē əm) Plutonium (Pu) is a radioactive metallic element (see ELEMENT; RADIOACTIVITY). Plutonium is the only transuranic element that occurs naturally (see TRANSURANIC ELEMENT). Before this fact was discovered, a team of American scientists headed by Edwin McMillan made the element artificially in 1940.

Fifteen isotopes of plutonium have been discovered (see ISOTOPE). The longest-lasting plutonium isotope is plutonium-239. It takes 24,100 years for half of a given amount of this isotope to decay (see HALF-LIFE). Plutonium is used as a fuel in some nuclear reactors as well as in nuclear weapons (see NUCLEAR ENERGY; NUCLEAR WEAPONS). Plutonium-238 was used as a power source for equipment placed on the moon during the Apollo missions (see APOLLO PROJECT).

Plutonium isotopes are extremely poisonous and radioactive. Therefore, disposal of waste products from nuclear reactors and nuclear weapons that use plutonium poses grave problems.

Plutonium's atomic number is 94. It melts at 1,184°F [640°C] and boils at 6,260°F [3,460°C]. Its relative density is 19.8.
See also RELATIVE DENSITY.

PNEUMATICS (no͞o măt'ĭks) Pneumatics is the branch of mechanics that deals with the behavior of compressed gases. In the seventeenth century, the Italian scientist Evangelista Torricelli studied the effects of atmospheric pressure. As a result of Torricelli's work, practical air pumps that could compress air were built. Modern pneumatic devices that work with compressed air include riveting hammers, jackhammers, sandblasting equipment, auto garage tools, and dental drills. Compressed air is also used in some vehicle braking systems and to fill tires.
See also BRAKE; GAS; MECHANICS.

PNEUMATICS
The pneumatic wrench, used for tightening nuts and bolts, is an example of the many industrial tools that work using compressed air.

PNEUMONIA (no͞o mōn'yə) Pneumonia is a lung disease that is usually caused by pathogens such as bacteria or viruses (see PATHOGEN). It may also be caused by exposure to radiation, such as X rays, or by breathing in chemical fumes or powders. Pneumonia causes the alveoli (air sacs) of the lungs to become irritated and inflamed (see INFLAMMATION; LUNG). When this happens, white blood cells enter the alveoli to fight the infection. The symptoms of pneumonia include chills, fever, chest pain, coughing, and difficulty in breathing. Frequently, a person with pneumonia coughs up rust-colored phlegm—mucus that contains blood from the irritated lung tissues. The symptoms usually last for a week to ten days until the body's immune system gets the infection under control (see IMMUNITY). Antibiotics have greatly reduced the number of deaths due to pneumonia (see ANTIBIOTIC).

Pneumonia is most commonly caused by bacteria called *Streptococcus pneumoniae,* also called pneumococci (see BACTERIA). Pneumococci are present in the bodies of many healthy persons, but the immune system usually can keep such bacteria under control. If the body becomes weakened because of surgery, exhaustion, or illness, the pneumococci can quickly overcome the body's defenses and cause pneumonia. Another bacterium (singular of *bacteria*), called *Mycoplasma pneumoniae,* also causes pneumonia. The body develops an immunity to this bacterium, so it does not usually affect a person more than once.

Pneumonia is a serious disease that should always be treated by a doctor. The patient should get plenty of rest, fluids, and fresh air. In addition, he or she should avoid contact with other people.

Viral and bacterial pneumonia are very contagious (catching). The pathogens become airborne when a person who has pneumonia coughs, sneezes, or spits. As a result, pneumonia can quickly become epidemic.
See also DISEASE; EPIDEMIC; INFECTION; VIRUS.

POISON (poi'zən) A poison is a substance that causes irritation, injury, sickness, and possibly death. The study of poisons is called toxicology.

Corrosive poisons—poisons that slowly eat away at something—kill living tissue that they touch. A person who swallows this type of poison may destroy the lining of the mouth or throat. Lye (sodium hydroxide) is an example of a corrosive poison (see CORROSION; LYE).

Irritant poisons cause swelling and soreness of the mucous membranes, such as in the nose, stomach, and intestines (see MUCOUS MEMBRANE). Irritant poisons may also damage nerves (see NERVOUS SYSTEM).

Systemic poisons attack the nervous system and other important organs, such as the liver and heart. For example, strychnine damages the nervous system, causing convulsions (sudden, uncontrolled muscle movements) and making it difficult for a person to swallow (see CONVULSION). Many drugs, taken in large doses, are also systemic poisons (see DRUG).

Poisonous gases make it hard for a person to breathe and can sometimes cause death. Some gases irritate the eyes, nose, or skin. Carbon monoxide is a particularly dangerous poisonous gas because it has no odor and does not cause irritation and so is difficult to detect (see CARBON MONOXIDE). Carbon monoxide can cause a person to lose consciousness and die.

Food poisoning can come from eating certain chemicals or organisms and their poisons. For example, chemicals such as insecticides can cause food poisoning. When organisms make a poison, the poison is called a toxin. Botulism is poisoning caused by a toxin that certain bacteria make. Botulism can cause paralysis and death (see BOTULISM; FOOD POISONING; TOXIN).

All cases of poisonings are serious medical emergencies. A physician or poison control center should always be consulted as soon as possible when poisoning is suspected. There are many treatments for poisoning. Each is effective for specific types of poisons (see FIRST AID).

Treatment sometimes includes giving an antidote to the victim. An antidote blocks or weakens the effects of the poison. Some antidotes, such as ipecac syrup, cause a person to vomit. This rids the stomach of the poison. However, if a person has swallowed a corrosive poison, such as lye, vomiting will cause additional damage to the lining of the esophagus, throat, and mouth. In such cases, patients are sometimes advised to eat food that will absorb the poison.

The United States has over one hundred regional poison control centers. Trained specialists at poison control centers answer emergency calls twenty-four hours a day. Most phone books list emergency phone numbers for the nearest poison control center.

The strongest poisons are not usually found in the home or other everyday surroundings. However, over 92 percent of the over 2 million poisonings each year occur at home. The misuse of common household substances—such as alcoholic beverages, cleaning products, cough and cold remedies, cosmetics, prescription medicines, and vitamins—causes many poisonings.

POISONOUS PLANT There are about seven hundred species of poisonous (poi'zə nəs) plants in the United States and Canada. Some are harmful only if they are eaten. Others give off poisonous substances when they are merely touched (see POISON). Some spread pollen or other substances that cause an allergic reaction in certain people (see ALLERGY). In some poisonous plants, the whole plant is harmful, while in others, only parts of the plant are poisonous. For example, the leaf stalks of rhubarb are a popular vegetable. The leaf blades, however, are poisonous (see RHUBARB).

Many poisonous plants have a bad taste or smell, and it is easy to recognize and keep away from them. Others, though, are very pretty and are often grown as decorative plants. The mountain laurel, for example, has beautiful pink or white flowers. This flower is the state flower of both Connecticut and Pennsylvania. However, the flower is poisonous.

Although many plant families have poisonous species, the main ones are the crowfoot, nightshade, and spurge families (see CROWFOOT FAMILY; NIGHTSHADE FAMILY; SPURGE FAMILY). Many of the poisons in these plants are alkaloids (see ALKALOID). Frequently, these poisons are very useful as medicines if used in small amounts.

The most deadly of the poisonous plants is the rosary pea. It is often used as a bead in making bracelets or rosary beads. If a person eats even one seed from this plant, he or she can die. The oleander plant has been known to kill people who used it as a stick to hold meat when cooking over a fire. The poison can pass from the stick into the meat. Many kinds of mushrooms, which are actually fungi rather than plants, also are deadly poisonous (see MUSHROOM).

Several plants belonging to the group of plants called sumacs are poisonous (see SUMAC). The best-known poisonous sumacs include poison ivy, poison oak, and poison sumac. Poison ivy grows in the eastern and central United States. Poison oak grows on the northwest coast of the United States. Poison sumac grows in the United States from New England to Minnesota and from Georgia to Texas.

Poison ivy and poison oak look similar. Both plants have three notched leaflets on each leaf stalk. Two of these leaflets form an opposite pair near the end of the stalk. The third leaflet is at the end of the stalk (see LEAF). The leaflets are red in the spring, shiny green in the summer, and reddish orange in the fall. The poison sumac plant has many leaflets on each leaf stalk. Its leaves are dark green and turn reddish orange in the fall. All three plants grow small flowers and white berries.

The tissues of the plants produce a poisonous oil. If it is not washed off the skin within an hour or two after the person touches the plant, the oil may cause itchy inflammation (redness and soreness) that may last for more than two weeks. If the plants are burned and the smoke is breathed in, the oil may cause serious irritation of the lungs.

Many poisonous plants look similar to plants that are not poisonous. It is best not to touch or eat any plant unless you are certain it is not poisonous.

POISONOUS PLANT

Plants that are poisonous include the foxglove (above) and yew (top left). Both contain toxins that affect the heart. The leaves of rhubarb (left) contain poisonous oxalic acid.

POLAR BEAR The polar bear is a large, white bear living in cold arctic regions such as Alaska, Canada, Greenland, and Siberia (see BEAR). The male polar bear may grow as tall as 8.25 ft. [2.5 m] and weigh as much as 1,000 lb. [455 kg]. This bear has thick, white fur, which serves both as camouflage and as protection from the cold (see CAMOUFLAGE). The bear also has a thick layer of fat to keep it warm and to help it float. It spends a lot of time in the sea. The head of the polar bear is small in comparison with its long neck. These features help the bear swim efficiently—3 to 6 m.p.h. [5 to 10 kph]. The polar bear has pads of hair on its feet. This hair helps the bear walk on ice and protects the feet from the cold.

The polar bear is a very good hunter. It can spot prey (something that is to be killed for food) from a great distance. It is able to run 25 m.p.h. [40 kph]. This is fast enough to catch up with most prey on land or on the ice. Unlike other bears, the polar bear almost always eats meat. Its diet is made up of seals, walruses, fish, and any dead sea animals that may have washed ashore.

Female polar bears give birth to one or two cubs (babies) during the spring. By the end of the summer, these cubs can take care of themselves in most ways. However, before they are independent, the mother is very protective and will try to kill anyone or anything that she thinks might hurt her cubs.

Polar bears have been hunted for their meat, hides (skins), and bones. By the early 1970s, they were declared an endangered species—a species in danger of becoming extinct (see ENDANGERED SPECIES). The United States, Canada, and other countries now have laws against the hunting of polar bears.

POLAR BEAR
Polar bears are large bears that live in arctic regions, such as Alaska, Canada, Greenland, and Siberia.

POLAR FRONT A polar front is where the cold air of a polar region that is flowing toward the equator meets the warmer air that is closer to the equator and flowing toward the pole. Polar fronts form near both the North Pole and the South Pole and are cloudy, rainy areas. Winds known as jet streams form above them (see JET STREAM; WIND).

The cold polar air stays close to the ground because it is denser than the warmer air, which rises above it. As the air masses pass one another, they form complex frontal systems (see AIR MASS). In the Northern Hemisphere, the cold polar winds from the northeast meet the warm tropical winds from the southwest. Much of the weather of North America and northern Europe is determined by this constant activity. *See also* COLD FRONT; FRONT; WARM FRONT.

POLARIZED LIGHT Polarized (pō'lə rīzd') light is composed of orderly waves that vibrate in one direction only. In this way, polarized light is different from ordinary light. In ordinary light, disorderly waves vibrate in all directions at right angles to the light beam (see LIGHT; WAVE).

In the sea, waves move across the surface of the water. However, the water just bobs up and down as the wave moves over it. The water itself does not move forward or backward. If the waves are moving in a straight line across, and the water is moving in a straight line up and down, the two lines meeting make a right angle. This kind of wave motion is called transverse wave motion. Light also travels in a transverse wave. It vibrates (moves from side to side) in a plane (an imaginary flat surface) at right angles to its direction of motion. Usually, the vibrations are in any direction in that plane. However, sometimes the light vibrates in one direction only. It is then called plane, or linearly, polarized light.

Plane polarized light can be made in different ways. When light hits glass, part of it is reflected (thrown off), and part of it goes into the glass (see REFLECTION OF LIGHT). The light that goes into the glass is bent through an angle. This is called

POLARIZED LIGHT
Much of the light reflected from a window (far left) is polarized. By putting a polarizing filter in front of the camera lens, the photographer can block polarized light and take a photograph that has no reflections (left).

refraction (see REFRACTION OF LIGHT). The ray that goes into the glass is called the refracted ray. If the reflected and refracted rays are at right angles to each other, then the reflected ray is plane polarized. Certain materials polarize light that passes through them. An example is Polaroid plastic sheet. This plastic lets through only light that vibrates in a certain direction. Because of this, the light is polarized when it leaves the Polaroid sheet. Polaroid sheet is used in sunglasses to lessen the glare of the sun and in camera filters to make clouds stand out clearly against the sky.

There are other kinds of polarization besides plane polarization. Sometimes, the direction of light vibration moves around in a circle as the light wave moves along. This is called circular polarization. The vibration can also move in an oval shape called an ellipse. This is elliptical polarization.

POLAROID CAMERA (pō′lə roid′ kăm′ər ə) The Polaroid camera takes, develops, and prints its own photographs in a matter of seconds or minutes. This "instant" camera was invented by Edwin H. Land of the United States. The first Polaroid camera was sold in 1948. It took only black-and-white photos. Later, another model was built that could take, develop, and print color photos.

Polaroid cameras are loaded with a double picture roll. One part is a negative roll of film and the other is a positive roll of special printing paper. Small pods (containers) of chemicals are joined to the positive roll. After exposure to light through the lens of the camera, the negative and positive rolls are made to pass through a pair of rollers inside the camera that break the chemical pods. The chemicals flow over the exposed portion of the negative roll and develop a negative image on the roll. More chemical reactions happen between the pod chemicals and chemicals that coat the positive roll, and a positive photograph is made. This process takes about ten seconds for a black-and-white photo and up to a minute for a color photo. Early Polaroid models needed more developing and printing time than one minute.

There are now many different models of Polaroid cameras. Polaroid film has also been developed that can be used in cameras made by other manufacturers. The original Polaroid films consisted of a double roll of negative and positive sheets. More recently Polaroid film packs and sheet films have been developed. Because of the speed with which photographs can be developed, Polaroid cameras and film are widely used by both professional and amateur photographers.

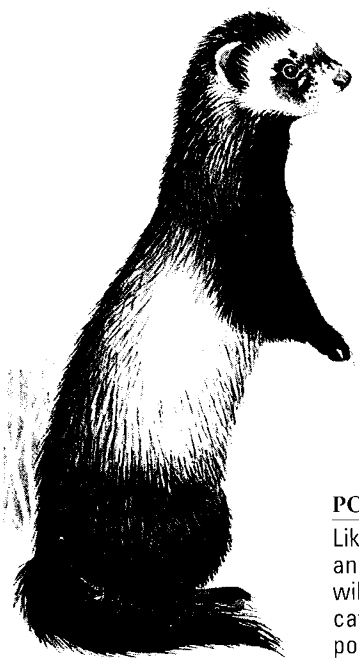
See also CAMERA; PHOTOGRAPHY.

POLE The word *pole* has many scientific meanings. The two points where a planet's axis of rotation intersect the planet's surface are called the geographic poles. The celestial poles are the points in the sky where the earth's axis, if continued, would pass through the celestial sphere (see CELESTIAL SPHERE). In the Northern Hemisphere, the celestial pole is located near the North Star. A magnetic pole is a point where magnetic lines of force leave the magnet or the magnetically charged object. Opposite magnetic poles attract each other, while like magnetic poles repel each other.

See also MAGNETISM.

POLECAT The polecat is a mammal belonging to the weasel family, Mustelidae (see MAMMAL). It is native to Europe and Asia, but it is closely related to the North American weasel and mink (see MINK; WEASEL). Like the mink, the polecat can discharge a strong odor at will.

The polecat prefers wooded country. However, it sometimes lives on coastal sand dunes and on open hillsides. The polecat makes its home in a hole in the ground or in a tree. The animal's main food is rabbit. However, the polecat also eats rats, mice, eels, frogs, snakes, birds, and eggs. The male polecat is about 22 in. [56 cm] long, including its tail. Female polecats are a little shorter. European polecats have long, blackish purple, shiny fur and a white pattern on the face. At one time, polecats were common throughout Europe. However, many polecats are killed because they attack some farm animals and game birds. Ferrets are domesticated polecats with paler fur. They were once used for hunting rabbits but are now kept as pets.



POLECAT

Like its relatives the mink and the weasel, the polecat will eat anything it can catch. Domesticated polecats are called ferrets.

POLIOMYELITIS (pō′lē ō mī′ə lī′tĭs) Poliomyelitis, or polio as it is commonly called, is a disease caused by a virus (see VIRUS). Usually, people who are infected have few symptoms or none at all. Some people may have a headache or a sore throat and feel as though they have a cold. In about 10 percent of people, however, the disease becomes very serious. The virus attacks the nervous system (see NERVOUS SYSTEM). It may attack motor nerves (the nerves of movement) where they leave the spinal cord. Because of this, groups of muscles may become paralyzed (see PARALYSIS). The virus may damage the brain instead or as well. If polio only affects the spinal cord, it is called spinal polio. If the disease affects only the brain, it is called bulbar polio. In its most serious form, polio affects both regions. This is spinobulbar polio.

When the spinal cord is damaged, body movements below the neck are affected. All groups of muscles are not paralyzed at one time. There may be paralysis of the arms only, the legs only, or of just one limb. When the nerve centers of the brain are attacked, the muscles of breathing and swallowing may be paralyzed. People with breathing difficulties were once helped by means of the "iron lung," a kind of artificial respirator in which the person was placed. Today, improved kinds of artificial respirators help the person breathe.

People with paralysis can be helped by physical therapy (see PHYSIOTHERAPY). Paralyzed limbs may be held up by splints. Sometimes, surgery can help relieve paralysis. Many times, the paralysis disappears or partially disappears on its own, a few weeks or months after the onset of the disease.

Before vaccines were developed to give protection, as many as 58,000 people were affected by polio in a single year. The first polio vaccine was made by Dr. Jonas E. Salk in 1955. Later, Dr. Albert B. Sabin developed vaccines that could be swallowed rather than taken by injection (see SABIN, ALBERT BRUCE; SALK, JONAS EDWARD; VACCINATION). These and other types of polio vaccines have been used to give immunity to most of the people in the world (see IMMUNITY). Today, fewer than five hundred people a year are infected with polio.

See also DISEASE; INFECTION.

POLLEN Pollen is a yellowish powder that is made up of pollen grains that produce the male gametes of flowering plants and conifers (see GAMETE). The pollen grains are made in the anther of the stamen, which is the male part of a flower, or in pollen-bearing cones (see CONIFER; FLOWER). In sexual reproduction, a male gamete, produced by a pollen grain, fertilizes an egg produced within an ovule (see FERTILIZATION).

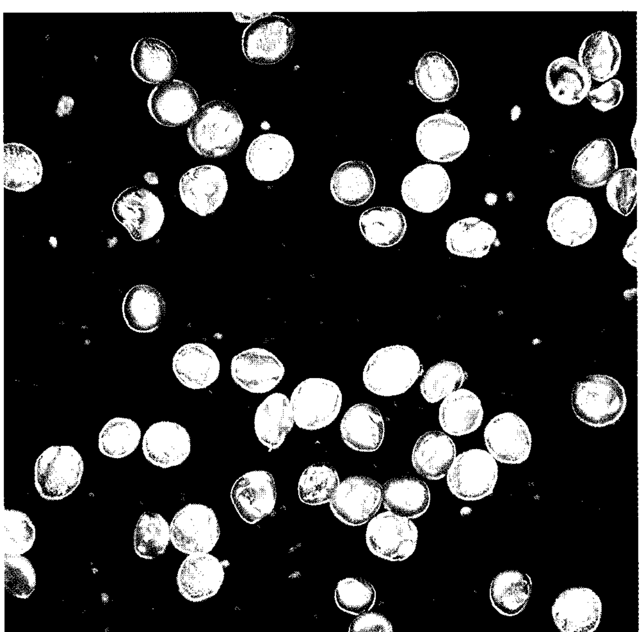
The shape and structure of pollen grains are different in each species. All the pollen grains made by any one species, however, are alike.

Pollen grains vary in size from about 0.0002 to 0.01 in. [0.005 to 0.25 mm] in diameter. They have thick walls that are resistant to chemicals as well as to very high or low temperatures. This allows the pollen grains to survive harsh environmental conditions for long periods of time. Some pollen grains have been able to pollinate plants after having been stored for more than ten years.

Many types of pollen are scattered by the wind. The grains are usually lightweight and are made in great numbers. Some grains have been found as high as 3 mi. [5 km] in the air and more than 100 mi. [160 km] away from the plant that made them. A single male (staminate) flower may make more than 50 million pollen grains. Although most of these pollen grains are lost in the wind, their great numbers make it almost certain that some will reach and pollinate other flowers (see POLLINATION). Pollen grains floating in the air are the cause of many cases of hay fever. Hay fever is an allergy to airborne pollen (see HAY FEVER).

See also ALLERGY; ANGIOSPERM; GYMNOSPERM.

PROJECT 62



POLLEN

Pollen contains microscopic grains that are the male gametes (sex cells) of flowering plants. Pictured here are pollen grains of the larch (shown greatly magnified, above), and also sticking to the petals of female larch flowers (left).

POLLINATION

Pollination is the transfer of pollen from the male structure to the female structure of the same plant or a different plant of the same species (see POLLEN). In angiosperms (flowering plants), pollination is the transfer of pollen from the anther to the stigma of a flower (see ANGIOSPERM; FLOWER). The anther is the pollen-producing part of the stamen, the male reproductive structure. The stigma is the sticky upper part of the pistil, the female reproductive structure.

Pollination is part of sexual reproduction in plants (see REPRODUCTION). It is usually followed by fertilization and later by the formation of a seed (see FERTILIZATION; SEED).

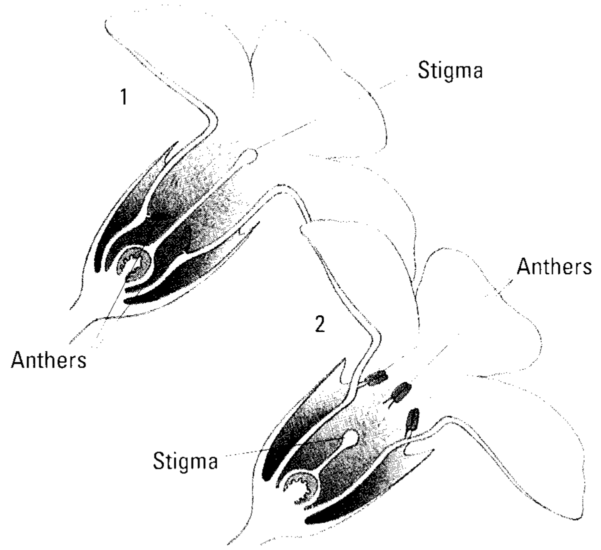
When a pollen grain lands on a stigma of the right kind, a chemical reaction takes place. This causes the pollen grain to form a pollen tube. The pollen tube grows through the style (a part of the pistil) and into the ovary to an ovule (see OVARY; OVULE). Two male gametes called sperm nuclei travel through the tube. One fertilizes the egg, and the other joins with two structures called polar nuclei in a process called triple fusion. Triple fusion results in the formation of the endosperm. The fertilized egg develops into an embryo that gets food from the endosperm. Together, the embryo and endosperm make up a seed (see EMBRYO; ENDOSPERM).

There are two types of pollination: self-pollination and cross-pollination. Self-pollination is the transfer of pollen from the anther of a flower to the stigma of the same flower. In many cases, self-pollination happens before the blossom even opens. Cross-pollination is the transfer of pollen from the anther of one flower to the stigma of another flower of the same species. Cross-pollination makes stronger offspring than those made by self-pollination.

Many plants have developed ways of ensuring cross-pollination. In some plants, the anthers are below the stigmas, making self-pollination difficult. In some flowers, the stamens and pistils ripen at different times. Some plants have a chemical

CROSS-POLLINATION
Most grasses, such as the cocksfoot grass shown left, are cross-pollinated when pollen from the anther (male part) of one flower reaches the stigma (female part) of another flower.

MALE CATKINS
Some plants are monoecious—that is, they bear both male flowers and female flowers. An example is the silver birch. Shown here are male silver birch catkins (flowers) releasing a shower of pollen. The wind will then carry the pollen to the female flowers.

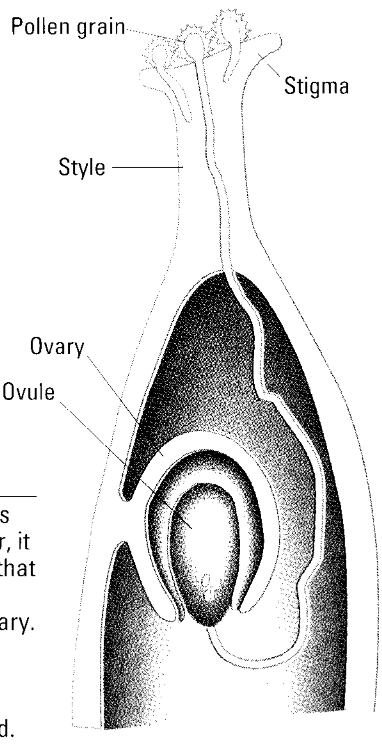


FLOWER STRUCTURE
The structure of a flower determines whether it is cross-pollinated or self-pollinated. (1) If the stigma is longer than the pollen-bearing anthers, self-pollination is difficult and the flower has to be cross-pollinated. (2) If the anthers are above the stigma, self-pollination happens readily.

ATTRACTIVE FLOWERS
Many plants have colorful or scented flowers that attract insects such as bees. When a bee visits the flower, it picks up pollen on its body and legs. It then moves on and carries the pollen to another flower, where pollination takes place.

barrier that prevents pollen from the same flower from growing if it gets on the stigma. Some plants make only staminate (male) flowers or pistillate (female) flowers.

Cross-pollination may occur in many ways. Many trees and shrubs and most grasses, for example, depend on the wind to carry pollen from one flower to another. Wind-pollinated flowers are not brightly colored and do not normally have nectar. They usually make large amounts of lightweight pollen. Since many of the pollen grains are lost in the wind, the large numbers help ensure that at least a few will reach stigmas of other flowers.



FERTILIZATION
After a pollen grain lands on the stigma of a flower, it sends out a pollen tube that grows down the style to reach an ovule in the ovary. A sperm gamete that travels along the tube fertilizes the egg, which later forms part of a seed.

Birds and insects are common carriers of pollen. When a bird feeds on the nectar (sweet liquid) of a flower, some pollen rubs off on its body. As the bird flies from flower to flower, it spreads pollen. Some birds, such as hummingbirds, have adaptations for pollinating certain flowers (see ADAPTATION). Hummingbirds have long, thin beaks that can get into tube-shaped flowers. This allows the bird to feed on nectar at the base of the flower. The pollen gets deposited on the hummingbird's beak when it visits one flower. Then, when the hummingbird feeds on another flower, the pollen on its beak is transferred to that flower.

Insects are among the most common carriers of pollen. They may be attracted to a flower by its scent or coloring. Some flowers, such as members of the orchid family, have developed petals that look like female insects (see MIMICRY; ORCHID FAMILY). When a male insect tries to mate with these flowers, it spreads pollen. Some flowers need a specific insect for pollination. The yucca, for example, can be pollinated only by the yucca moth (see YUCCA). Some flowers, such as some members of the honeysuckle family, open at night to attract moths (see HONEYSUCKLE FAMILY; NOCTURNAL BEHAVIOR).

Pollination also happens in gymnosperms, most of which make gametes in cones (see GYMNOSPERM). The male cone is soft and small and makes pollen. The female cone is usually larger and makes ovules. Pollen from the male cone is carried by the wind to the female cone where it is held by a sticky substance near the ovules. The pollen grain then grows a pollen tube in which sperm cells form. One sperm cell fertilizes an egg within an ovule. The ovule develops into a seed, which then matures and falls to the ground. There it may germinate (sprout) and develop into a new plant.

Scientists often use artificial methods to cross-pollinate plants. They carefully take away pollen from one plant and brush it on the stigma or female cone of another plant. In this way, they are able to make different varieties (see BREEDING). Artificial cross-pollination also has helped geneticists learn more about heredity.

See also GENETICS; HEREDITY; MENDEL, GREGOR.

PROJECT 62

In general, pollution is the contamination of the environment—air, water, and land—with wastes from human activities. Environmental pollution has become a major worldwide problem. It obstructs naturally beautiful scenery. It interferes with normal cycles in nature, such as the food chain, carbon cycle, nitrogen cycle, and oxygen cycle. Because there are so many complex interrelationships in the environment, a pollutant that harms one part almost always affects other parts (see ECOSYSTEM; ENVIRONMENT). As a result, pollution damages or destroys plant and animal life. Pollution also causes sickness and death among human beings.

People have always polluted the environment. When most people lived in rural areas and there were no factories or cars, pollution was not much of a problem. With the industrial revolution in the late 1700s, the growth of cities and technology in general in the 1800s, and the widespread use of motor vehicles in the 1900s, however, pollution has become a major problem.

Air pollution Polluted air damages plants, animals, and other organisms. It has also been shown to be a cause of many human illnesses, such as cancer and many lung diseases. Most air pollution is caused by burning fuels to release energy. Few Americans still rely on open fires for heating and cooking. However, the electricity that people often do use, which seems so "clean" in the home, is usually produced by burning coal or petroleum products. This process releases gases and tiny particles called particulates into the air. Many of these gases and particulates are harmful types of air pollution. Factories also produce large amounts of air pollution every day.

Pollution continues to grow as the population grows (see POPULATION GROWTH). Areas that are densely populated and have much industry often have the most serious air pollution.

AIR POLLUTION

Smoke and chemicals from vehicle exhausts can accumulate over cities and cause air pollution, which can be dangerous to health. This picture shows polluted air over New York City.

CARELESS FIRE
Air can become polluted even in rural areas by careless human activity. Here a fire in a tire dump spreads clouds of black smoke across the fields.

Although it is easy to blame other sources for air pollution, the major cause of air pollution is the automobile. The exhaust produced by internal combustion engines contains carbon dioxide, carbon monoxide, nitrogen oxides, and sulfur dioxide. Nitrogen dioxide and sulfur dioxide contribute to acid rain (see ACID RAIN). Acid rain has damaged forests and bodies of water all over the world. One problem in controlling acid rain is that the pollutants it contains can travel long distances. Thus, pollution produced in one region can affect other areas that otherwise would not have pollution problems.

Carbon dioxide, mainly from automobile exhaust, is the main gas responsible for the greenhouse effect. Measurements taken in Hawaii suggest that the concentration of carbon dioxide in the atmosphere is increasing by about 0.2 percent every year (see GREENHOUSE EFFECT). In the greenhouse effect, pollution in the atmosphere helps trap the sun's heat above the earth. This may cause the temperature of the earth's atmosphere to rise.

Also, automobile air conditioners release chlorofluorocarbons (CFCs) into the atmosphere (see CHLOROFLUOROCARBON). CFCs from automobile air conditioners and from other sources destroy the ozone layer (see ATMOSPHERE; OZONE LAYER). The ozone layer protects the earth from the sun's ultraviolet rays.

Since the mid-1970s, the U.S. federal government has tried to control the pollution released from automobiles. For example, the government has required that new cars use unleaded fuel to reduce the amount of pollution released in exhaust. Pollution-control devices have been added to car engines to further reduce pollution. Car owners in certain areas also must have their cars tested periodically to determine the amount of pollutants being released in their exhaust (see AUTOMOBILE).

Nevertheless, air pollution continues to contaminate the air in many places. Weather conditions can make air pollution in some places worse. In a condition called a thermal inversion, a layer of warm air traps a layer of cold air near the ground. This keeps polluted air from dispersing into the upper atmosphere. Dense smog is the result (see SMOG). A thermal inversion caused the 1952 London smog, which killed more than four

thousand people. In the United States, the city most severely affected by smog is Los Angeles, California. Every year, polluted air causes dozens of people to be hospitalized. Laws have been passed in Los Angeles to help control pollution. These laws include banning the use of old cars that release large amounts of pollution in their exhaust.

The air inside buildings can also become polluted. The major source of indoor air pollution is cigarette smoke. However, machinery, such as photocopying machines, and chemicals, such as solvents, can also cause indoor air pollution. Better filtering systems and tighter regulations about indoor pollution could help reduce the health problems associated with indoor pollution.

Water pollution Oceans and other bodies of water provide one of the earth's richest environments for animal and plant life. However, pollution threatens the delicate balance of life in the oceans, because pollution changes the water's ability to support life.

Most water pollution comes from factories, farms, and homes. Chemicals, human and animal wastes, and many other substances are dumped into rivers, lakes, and oceans each year. Many large cities treat sewage before it is released into a body of water (see SEWAGE TREATMENT). However, even this treated sewage may contain harmful pollutants. Sometimes, the pollutants cause an unnatural increase in the numbers of certain microorganisms in a lake. This may speed up the lake's natural death (see MICROORGANISM; SUCCESSION). Fertilizers are now the main pollutants responsible for this problem.

Thermal pollution is caused by adding hot water to a cooler body of water. This kills many living organisms in the area. Thermal pollution is a major problem near nuclear power plants (see NUCLEAR ENERGY). In order to control nuclear reactions in these power plants, large amounts of water are heated to a high temperature. Although partially cooled, this waste water is usually much hotter than the water into which it is poured. The warm water kills off many organisms.

Petroleum (oil) is another major source of water pollution. More than 13,000 oil spills involving varying amounts of oil occur in the United States each year. Oil released into oceans threatens and kills ocean life, including birds, fish, and plants. Recreation areas are also harmed by oil that washes up on beaches. Each year, nearly 5,510,000 tons [5,000,000 metric tons] of oil are released into the oceans. Most of this oil comes from industries near coastlines that dump oil and other wastes into the

WATER POLLUTION

Garbage and chemical waste dumped in rivers pollute the water and may kill fish. Artificial fertilizers used on farmland may be washed into rivers, causing the rapid growth of plants and using up the oxygen in the water. The result is the same—the fish die.

ocean. Leaks from offshore oil drilling and oil tankers that accidentally spill the oil they are transporting also add significant amounts of oil to the water. The oil that spills into the ocean forms a film on the water called an oil slick. One of the largest recent oil spills occurred in March 1989. A tanker named the *Exxon Valdez* spilled 11,000,000 gallons [41,624,000 liters] of oil into the water near northern Alaska. In June 1990, another major oil spill occurred. A Norwegian oil tanker exploded 60 mi. [97 km] off Galveston, Texas, in the Gulf of Mexico. The explosion resulted in an oil slick that was 30 mi. [48 km] long. Permanent oil slicks now can be found in many parts of the oceans, mostly along the main routes of oil tankers.

Land pollution Much land pollution is caused by the use of pesticides and other chemicals. Often, a pesticide poisons many more organisms than those for which it was intended. Some of these poisons are passed through the food chain, eventually reaching and harming human beings (see FOOD CHAIN; PESTICIDE).

Strip mining and careless farming, construction, and other practices lead to soil erosion (see SOIL EROSION). Eroded soil often leads to other troubles, such as floods or famine (widespread starvation).

Solid wastes are another major cause of land pollution. Billions of tons of solid wastes are produced each year. For example, cars, aluminum cans, papers, plastics, and scrap metal end up on roadsides or in landfills. In the late 1980s, every person in the United States produced over 3.6 lb. [1.6 kg] of solid waste per day. By the mid-1990s, household, municipal, and commercial wastes in the United States totalled around 249,000,000 tons [226,000,000 metric tons] each year. This amounts to 6.8 lb. [3.1 kg] per person per day. Some of these wastes are biodegradable, meaning they can decay and become part of the soil (see BIODEGRADABILITY). Others, such as aluminum cans and plastics, do not decay and will remain as garbage for hundreds or thousands of years (see WASTE DISPOSAL).

OIL SPILLS
Oil spilled from tankers pollutes the oceans. The oil can clog the feathers of sea birds. This bird has been rescued from the beach and is being cleaned using a detergent.

Other kinds of pollution In many places, noise is a major form of pollution. Noise is produced by airplanes, cars, construction equipment, and many other things. Installing storm windows and absorbent material in walls helps reduce noise pollution. Light pollution results from streetlights and lighted signs. Light pollution prevents observation of the stars and planets and interrupts the blooming cycles of some plants and the sleeping cycles of some animals.

Pollution also exists in space. For example, thousands of pieces of space equipment are in orbit around the earth. This equipment includes old rocket boosters and satellites and empty fuel tanks. There are also clouds of burned rocket propellant. Space pollution interferes with working space equipment and the visibility of astronauts. Some possible solutions include designing rocket boosters to fall so that they burn up in the earth's atmosphere (see SPACE EXPLORATION).

Pollution control Pollution control involves several steps. Special techniques and equipment are needed to measure the amount of pollution in the air, land, or water. Standards have to be set regarding the levels of pollution that are harmful to life. Sources of pollution have to be identified and monitored. Existing pollution has to be cleaned up.

Some parts of the environment are so polluted that they may have been permanently damaged.

DUMPING AT SEA
These piles of trash have been brought in by the tide and left on the shore when the tide went out. Most of the items have been thrown overboard from ships at sea.

Much of this pollution occurred before people really knew the harm they were doing. As scientists, politicians, and other people have become more aware of the problems caused by pollution, there has been an attempt to limit future pollution and to clean up the pollution that already exists. The United States Environmental Protection Agency (EPA), formed in 1970, has the power to set pollution standards and to enforce them. Many state and local governments have established similar agencies to control pollution. For example, some local governments are trying to limit pollution from cars by encouraging people to use their cars less. Bicycles, public transportation, ride sharing, and walking are all ways to prevent pollution.

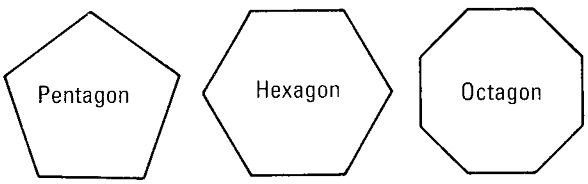
Scientists are experimenting with ways to reduce pollution. For example, at a laboratory in Bay St. Louis, Mississippi, water hyacinths have been used to clean waste water from homes and industries. Water hyacinths grow extremely fast and form thick, matted root systems. As sewage is slowly filtered through the root systems, the roots excrete substances that partly or completely kill pathogens (disease-causing microorganisms). In addition, the root systems provide a good environment for protozoans that also feed on pathogens (see PATHOGEN; PROTOZOA). About 15 acres [6 hectares] of water hyacinths can clean up to 141,000 cu. ft. [3,990 cu. m] of water per day.

There are many private groups and citizens' organizations that deal with pollution problems. Perhaps the most important way to fight pollution is through the efforts of individuals. If each person makes an effort to limit his or her activities that cause pollution, problems can be greatly reduced. For example, much of the garbage that people throw away, including aluminum cans, glass, motor oil, paper and cardboard, tires, scrap metal, and some plastics, can be recycled (see RECYCLING). When something is recycled, it is used again either in the same form or a different one. Some recycling centers pay people to bring in certain wastes.

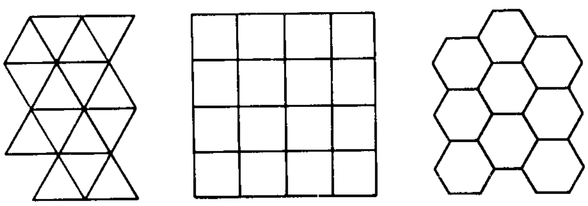
See also AIR; CONSERVATION; ECOLOGY.

POLYGON AND POLYHEDRON A polygon (pŏl′ē gŏn′) is any flat shape that has straight edges. A more precise definition is that a polygon is any flat, closed geometric figure that is bounded by straight line segments.

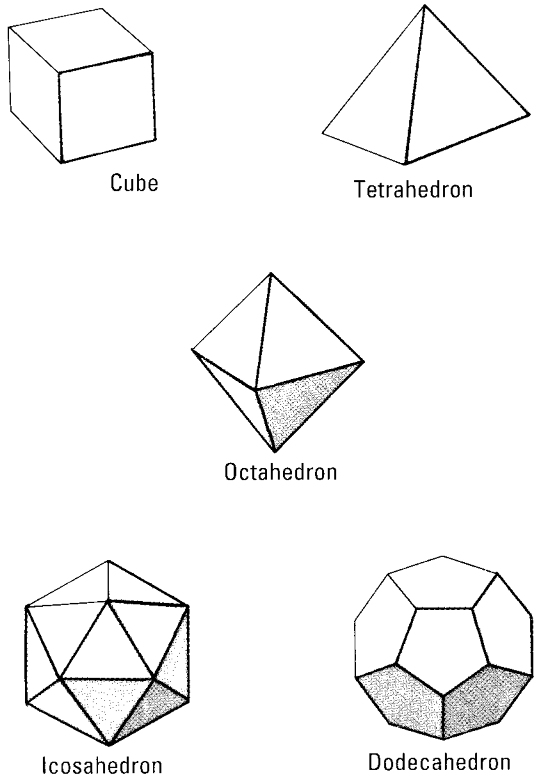
The simplest polygon is a triangle. A triangle has three straight edges. A polygon with four straight edges is called a quadrilateral. A polygon with five edges is called a pentagon. A hexagon is a polygon with six sides, and an octagon has eight sides.



If all the sides are the same length, the polygon is called a regular polygon (as in the ones illustrated). A square is a regular polygon. Certain polygons can be fitted together exactly, without leaving spaces between them. This is called tessellation. Examples of tessellation can be seen in tile patterns. The only regular polygons that tessellate are the triangle, the square, and the hexagon.



A polyhedron (pŏl′ē hē′drən) is the solid (three-dimensional) equivalent of a polygon. Its faces are all flat and are polygons. If the faces are regular polygons, the polyhedron is called a regular polyhedron. A common example of a regular polyhedron is a cube. Its faces are all squares. There are five regular polyhedra (plural of *polyhedron*). Three have triangular faces: the tetrahedron (four faces), the octahedron (eight faces), and the icosahedron (twenty faces). The other two are the cube, which has six square faces, and the dodecahedron, which has twelve pentagonal faces.



POLYHEDRON

Pictured here are five polyhedrons. The simplest are the cube, with six faces, and the tetrahedron (a triangular-based pyramid), with four faces. An octahedron (resembling two square-based pyramids base to base) has eight faces. An icosahedron has twenty triangular faces, and a dodecahedron has twelve pentagonal faces.

A polyhedron can be made by drawing the faces on a flat surface. The faces have to be drawn so that they join in the right way. The figure can then be cut out and folded to make a polyhedron.

An interesting relationship exists between the faces, vertices, and edges of a polyhedron. Vertices are the points on the polyhedron. If the number of faces is F, the number of vertices V, and the number of edges E, then

$$F + V = E + 2$$

For example, a cube has 6 faces and 8 vertices, and this makes 14. A cube has 12 edges, and 12 + 2 is also 14. This law holds for all polyhedra.

POLYMER

A polymer (pŏl′ə mər) is a compound (chemical substance made up of two or more elements) formed by the process of polymerization (see POLYMERIZATION). Polymerization is a chemical reaction that links many smaller molecules, called monomers, into a larger chainlike molecule, called a polymer. Most polymers contain carbon because carbon allows molecules to link together in chains more readily than other elements.

Starch, cellulose, and protein are examples of polymers that occur in nature. Nylon and synthetic (human-made) resins, such as polyester, are examples of polymers that people make. Most common plastics, such as polyethylene, Teflon, polyethylene derivatives, polystyrene, and polyurethane, are synthetic resins (see NYLON; PLASTIC; RESIN).

Polyethylene Polyethylene is a common synthetic polymer. Low-density polyethylene is made by heating ethylene gas to about 392°F [200°C] at very high pressure, usually more than a thousand

POLYETHYLENE
Thin polyethylene tubing for making plastic bags and sheets is made by shaping a tube (bottom right of photograph) using hot air. The tube dries rapidly and can be folded.

times that of atmospheric pressure. The resulting polymer is a molecule that is made up of short chains with many branches. Low-density polyethylene is used to make plastic wraps and bags for food. Low-density polyethylene is also used to make buckets, bowls, and "squeeze" bottles.

High-density polyethylene is a heavier, more rigid type. High-density polyethylene is produced at fairly low temperatures (158°F [70°C]) in the presence of a catalyst. The pressure is only slightly more than atmospheric pressure. High-density polyethylene is a molecule that is made up of long chains with few branches. It is used to make bottles for liquid bleaches and buckets and bowls that must withstand boiling water.

Teflon Teflon is the trade name for another polymer made from ethylene called polytetrafluoroethylene (PTFE). If all the hydrogen atoms in ethylene are replaced by fluorine atoms, then tetrafluoroethylene is formed. When tetrafluoroethylene is polymerized, polytetrafluoroethylene is formed. PTFE is used to make nonstick coatings for certain cookware. PTFE coatings on tools, such as sawblades, help keep them from sticking to the materials on which they are being used. PTFE coatings are also used to help insulate the roofs of large structures, such as sports arenas, without adding much extra weight.

Polyethylene derivatives A chemical derivative is a substance obtained from another substance or substances. Polyethylene derivatives are formed when ethylene is polymerized with other substances. Polyvinyl chloride (PVC) is one polyethylene derivative. It is formed by polymerizing ethylene with a chloride. A chloride is a compound that contains chlorine with one other element, usually a metal. By itself, PVC is brittle. If a substance called a plasticizer is added, PVC becomes flexible. Flexible PVC is used to make dolls, floor coverings, raincoats, shower curtains, and wire insulation. If only a small amount of plasticizer is added, the PVC is more rigid. Rigid forms of PVC are used to make plumbing pipes and siding for buildings. PVC can be used as an insulator for electrical wiring (see INSULATION).

PVC also resists attack by acids or bases and so is used to make pipes and basins for the chemical industry (see ACID; BASE).

Polyester Polyester is formed by the reaction of two compounds, ethylene glycol (an alcohol) and terephthalic acid (an organic, or carbon-containing, acid). Alcohols and organic acids react to make compounds called esters (see ESTER). When the ester compounds are polymerized, polyester is formed. The polyester molecule can be melted and passed through a spinneret. A spinneret is a machine that contains very small holes, from which the polyester can be drawn into long fibers (see EXTRUSION; FIBER). Polyester fabric does not wrinkle easily. If it is heated and pressed at the same time, polyester forms a permanent crease. It is widely used to make clothing. Polyester is not affected by sunlight, so it makes a good material for curtains that would otherwise fade in the sunlight.

Polyester resins are also used to make fiberglass, a strong, rigid material used in making surfboards and the bodies of boats and cars (see FIBERGLASS).

Polystyrene Polystyrene is a polymer made from the joining of styrene molecules. Styrene is made from two compounds—ethylene and benzene (see BENZENE). In the presence of a catalyst, these react to form the compound ethyl benzene. Ethyl benzene is heated and brought into contact with a metal oxide (a metal combined with oxygen). Some hydrogen atoms from ethyl benzene are removed, leaving the compound styrene.

Polystyrene is used to make plastic measuring cups and some clear kitchenware. High-impact polystyrene is polystyrene mixed with artificial rubber. It is used to line refrigerators. Expanded polystyrene, also called polystyrene foam, has tiny air bubbles trapped inside it, making it very lightweight and useful for packaging material and insulation. Many types of ceiling tiles are made from polystyrene.

Restaurants and cafeterias often use polystyrene foam cups, trays, and containers. This type of

NONSTICK PAN
The nonstick coating on cookware (above) is made of polytetrafluroethylene (PTFE), better known by its trade name Teflon.

WATERPROOF FABRIC
This little girl, who is peeping out from behind her toy, is wearing a raincoat made from flexible polyvinyl chloride (PVC), a completely waterproof fabric. The child's boots are also made from a polymer, in this case a type of artificial rubber.

polystyrene foam is often called by its trade name, Styrofoam. The manufacture and use of some polystyrene foam gives off chlorofluorocarbons (CFCs), which destroy the protective ozone layer of the earth's stratosphere (see ATMOSPHERE; CHLOROFLUORCARBON; OZONE LAYER). Since the 1980s, some manufacturers have changed their processes, so that CFCs are not given off. Another problem with disposable polystyrene foam, as with other plastics, is that they do not decay. Scientists hope to find ways to reuse polystyrene foam and other plastics. Construction began on the first recycling plant for polystyrene foam products in 1989 (see RECYCLING).

Polyurethane Polyurethane is a plastic polymer that is made by combining certain organic compounds with other compounds such as glycols. A glycol is a type of alcohol. Polyurethane has several forms. One type is a light, stretchable foam. It is used in clothing and upholstery. The other type of polyurethane is a hard foam. It can be made into furniture and used to insulate buildings.

POLYMERIZATION (pŏl′ə mər ĭ zā′ shən) Polymerization is a chemical process in which small molecules join together to form much larger molecules called polymers (see MOLECULE; POLYMER). Polymerization of natural products, such as the conversion of glucose into starch or of amino acids into proteins, takes place by the elimination of water as a by-product of the process. Polymerization of small molecules into synthetic larger polymers, such as polystyrene, takes place by adding one molecule to the other without eliminating a by-product.

Natural polymers are formed at ordinary temperatures by the action of catalysts called enzymes (see CATALYST; ENZYME). Synthetic (human-made) polymers frequently require high temperatures, high pressures, and catalysts for their formation.
See also ATOM; COMPOUND.

POLYMORPHISM (pŏl′ē môr′fĭz′əm) Polymorphism is the existence of two or more distinct forms of a single species of organism in the same population. The best examples are the social insects, such as bees, ants, and termites. Each community contains queens, males, and one or more kinds of workers. Polymorphism also occurs among other insects, bacteria, jellyfish, molds, and protozoans. The differences between the forms may be the result of genetic or environmental factors, or both (see HEREDITY).

Dimorphism is a type of polymorphism in which there are two distinct forms. The most common example is sexual dimorphism, in which the male and the female of a species are markedly different in appearance. Different breeds or races of any one species of organism are not considered to be examples of polymorphism because they do not live together.
See also BREEDING.

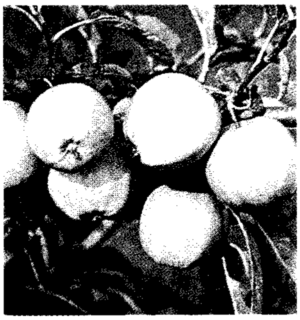
POLYP (pŏl′ĭp) A polyp is the shape that certain animals, such as those belonging to the phylum Cnidaria, have during all or part of their lives (see CNIDARIA). Polyps are shaped like a vase, with an opening at the top. Food goes into, and waste products leave by, this opening, or mouth. The mouth is surrounded by arms called tentacles. There may be stingers called nematocysts on the tentacles. The nematocysts are used for protection and for capturing prey. Adult sea anemones, corals, and hydra are polyps.

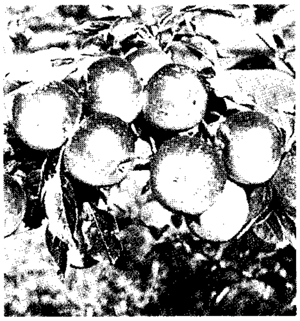
The other body shape that members of the phylum Cnidaria have is called a medusa. This shape is like that of a polyp turned upside-down and shortened. Adult jellyfish have this shape. Many young jellyfish go through a polyp stage.

POLYMORPHISM

Marked differences between males and females of the same species is called sexual dimorphism, which is one type of polymorphism. Shown here are female and male European golden orioles (above) and black lemurs (right), of which only the male is really black.

POME (pōm) A pome is a fleshy fruit in which the flesh is formed by the swollen receptacle (see FLOWER). The central part of the fruit is the core, a tough, leathery structure that grows from the ovary of the flower and contains the seeds. Several members of the rose family, such as apples, pears, and hawthorns, produce pomes.
See also FRUIT; ROSE FAMILY.





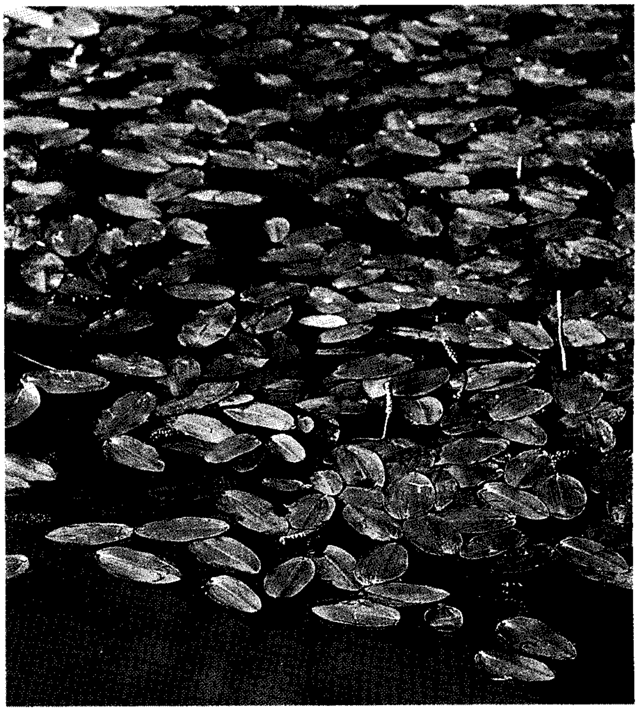
POME
Apples are the best-known fruits that are examples of pomes. Shown here are three varieties of apples: Golden Delicious (top left), Granny Smith (top right), and Jonathan (right).

POMEGRANATE (pŏm′grăn′ĭt) The pomegranate is the fruit of a deciduous tree native to warmer areas of Europe and Asia (see DECIDUOUS TREE). This tree grows to a height of 20 ft. [6 m]. It has simple, sword-shaped leaves that are arranged in opposite pairs (see LEAF). The flowers have a waxy tube-shaped calyx and five to seven scarlet petals (see FLOWER). The fruit is a large berry with a hard rind and many seeds. The pulp, which is fleshlike and sweet, can be eaten. It is usually golden red in color.
See also BERRY; FRUIT.

POMEGRANATE
The pomegranate is a fruit native to Europe and Asia. The fruit is a large berry with a hard rind and many seeds.

PONDWEED Pondweeds are monocotyledonous plants that live in water (see AQUATIC PLANT; MONOCOTYLEDON). There are about 100 species, all in the genus *Potamogeton.* The pondweeds usually live in freshwater ponds or slow-moving streams. They have roots and thick rhizomes in the mud. The flowers are very tiny and grow above the top of the water, either singly or in spikes.

Many types of pondweeds have small, thin leaves, all of which are underneath the surface. Some other kinds also have large, flat leaves that float on the top of the water. Pondweeds serve as food for water birds and provide surface cover and oxygen for fish. Pondweeds are often grown in aquariums to provide oxygen.



PONDWEED
The broad-leaved pondweed, shown here, is one of the types of pondweed that have flat leaves floating on the water.

POPLAR The poplars are deciduous trees that belong to genus *Populus* of the willow family (see DECIDUOUS TREE; WILLOW FAMILY). There are about 30 species, and they grow to heights of over 100 ft. [30 m]. The leaves are simple and pear-shaped or triangular with toothed margins (see LEAF). The flowers hang in red or yellow catkins and are pollinated by the wind. Male and female catkins grow on different trees.
See also CATKIN.

POPLAR
Poplar flowers (above) take the form of catkins. Male and female flowers grow on different trees.

POPPY FAMILY The poppy family includes about two hundred species of dicotyledonous plants, most of which are herbaceous (see DICOTYLEDON; HERBACEOUS PLANT). They have alternate leaves and large flowers. The flowers have two sepals, which fall when the flowers open, and twice as many petals. They usually have many stamens around two or more joined pistils (see FLOWER; LEAF). The seeds grow in capsules (cases around the seeds of a plant), which open in dry weather after the seeds are grown (see DISPERSION OF PLANTS; SEED). These capsules also hold a milky juice that contains a poison called an alkaloid (see ALKALOID).

The Oriental poppy is a popular garden plant. It is grown in temperate and subtropical climates for its large, reddish flowers. The opium poppy is the source for opium and other narcotic drugs (see DRUG; NARCOTIC). The plant reaches a height of 3.3 to 16.5 ft. [1 to 5 m] and has white flowers. The juice from the flowers' capsules is used as a drug itself, or it can be made into narcotics such as heroin, morphine, and codeine.

POPPY FAMILY
Many kinds of poppies grow wild on unused land and along roadsides. They can be troublesome weeds in fields of cereal crops. They spread quickly because of their efficient method of dispersing seeds.

POPULATION In the natural world, a population is a group of plants or animals, all of the same species, living in a particular area. The word can refer to the minnows in a small pond, the robins in a patch of woodland, or even the blue whales in the Pacific Ocean. The size of a population depends greatly on the amount of food available in the area and on the number of suitable breeding sites. A small island, for example, can support only a certain number of rabbits. If the population gets too big, there will not be enough grass for all the rabbits to eat, and many will die. Predators and other enemies also play an important role in regulating the size of a population (see PREDATORS AND PREY).

Populations that are completely separated from each other—on different islands, for example—often develop slightly different characteristics. Each population may evolve into different geographic races or subspecies, and eventually into different species (see EVOLUTION; SPECIES).

See also GALÁPAGOS ISLANDS.

POPULATION GROWTH Population growth is any increase in the number of people in the world or a smaller area. This growth has been especially rapid in the past one hundred years and has become a cause for concern. In 1800, the world population was less than 1 billion. By 1900, it had risen to 1.7 billion. By 1950, the world population had crept up to 2.5 billion. By 1980, it had nearly doubled, to about 4.5 billion. By 1994, the population had reached 5.6 billion. Scientists predict that the world's population will double again before the year 2015.

The main factor behind the tremendous population growth of the twentieth century is prolonged life due to improved diet, more sanitary living conditions, and modern medicine. Modern medicine has been especially important because it has helped combat the major killing diseases of the past, such as cholera, smallpox, tuberculosis, and the bubonic plague (black death) (see CHOLERA; SMALLPOX; TUBERCULOSIS). In the 1300s, for example, these diseases killed over 40 percent of the world's population.

The problem with rapid population growth is that the world's natural resources, such as land, minerals, plants, and water, are limited. A population cannot survive if it uses up its resources faster than they can be renewed. The world's natural resources directly affect its food supply. Scientists predict that the current level of world food supply will only feed about one-third of the world's population by the time the population doubles again.

Many governments around the world have started programs to encourage people to limit the number of children they have. Most modern methods of population control involve contraception (see CONTRACEPTION). If every family raised only two children, population growth would drop to zero, because each parent would replace only himself or herself.

See also NATURAL RESOURCE.

PORCUPINE (pôr′kyə pīn′) The porcupine is a large rodent known for its strong, stiff quills (see RODENT). The quills are modified hairs that the porcupine uses to defend itself. Contrary to popular belief, porcupines do not throw out quills from their bodies. However, an attacker that tries to grab the porcupine usually gets a mouthful of quills.

There are two main groups of porcupines: Old World (family Hystricidae) and New World

PORCUPINE—New World
The short quills of the North American porcupine are normally concealed by its long fur.

PORCUPINE—Old World

The adaptable African porcupine lives in deserts, grasslands, and forests.

(family Erethizontidae). The Old World porcupines range throughout south Asia, Africa, and Indonesia. There are also some in Italy. They feed mainly on bark, fruit, and other plant matter. The largest Old World porcupine is the African crested porcupine. When provoked, this porcupine shakes its long quills in warning, making a rattling sound. As a last resort, it attempts to protect itself by running backwards into its attacker. The quills then get stuck in the attacker's skin.

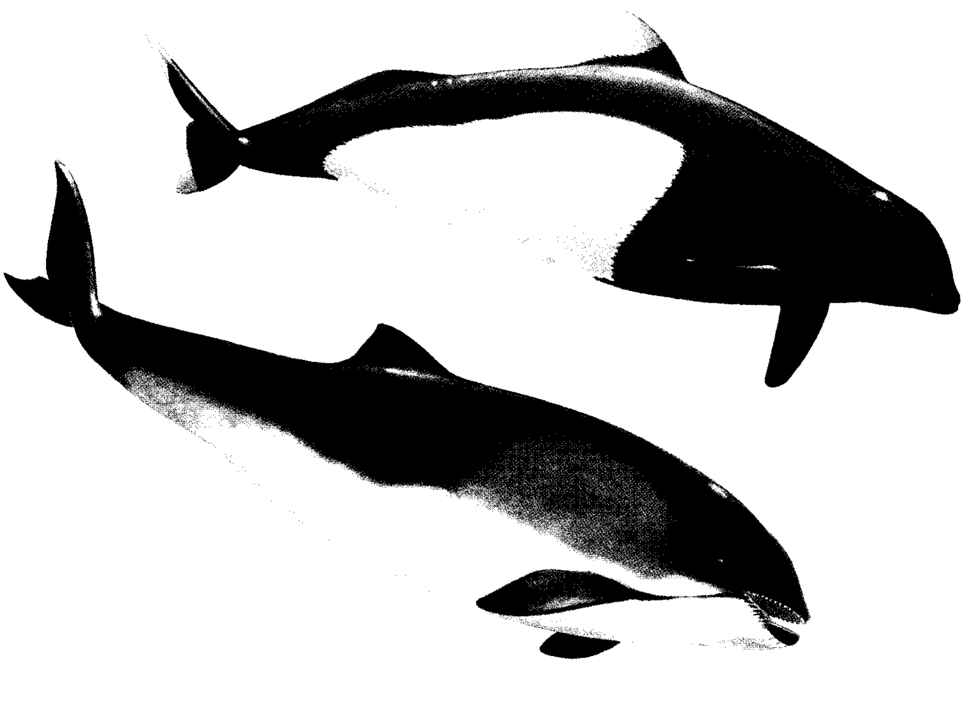
The only New World porcupine found in North America is the North American porcupine. This porcupine is about 3 ft. [90 cm] long and averages about 20 lb. [9 kg] in weight. Its yellow-white quills are about 2 to 3 in. [5 to 8 cm] long and concealed in the fur. When it needs to defend itself, it rams its enemies with its tail. The quills are then forced into the attacker's skin. The North American porcupine lives in trees and eats bark, buds, and green plants.

PORPOISE (pôr'pəs) The porpoise is a small member of the whale order, Cetacea (see WHALE). Porpoises are related to dolphins, and many scientists do not distinguish between the two kinds of animals. However, many porpoises have spoon-shaped teeth and a snout that does not form a beak. Many dolphins have cone-shaped teeth and a snout that is shaped like a beak.

The common porpoise has a gray back and white underside. It grows to about 6 ft. [1.8 m] long and may weigh up to 200 lb. [90 kg] although it is usually only 110 to 143 lb. [49.9 to 65.3 kg]. The common porpoise is found along the coasts of North America, South America, Europe, Africa, and Asia. Common porpoises travel in small groups of two to five animals. Porpoises feed on herring, mackerel, other fish, crustaceans, and squids. *See also* DOLPHIN.

PORPOISE

Dall's porpoise (right, top) lives off the Pacific coast of North America and in northern European seas. It sometimes looks yellowish in color because of tiny plants (algae) that grow on its fin and flippers. The common porpoise (right, bottom) swims along the coasts of the Americas, Europe, Africa, and Asia.



PORTLAND CEMENT Portland cement is a type of cement that hardens under water. Its main use is in the making of concrete. Concrete is a hard material that is made of cement mixed with sand or gravel and water (see CEMENT AND CONCRETE).

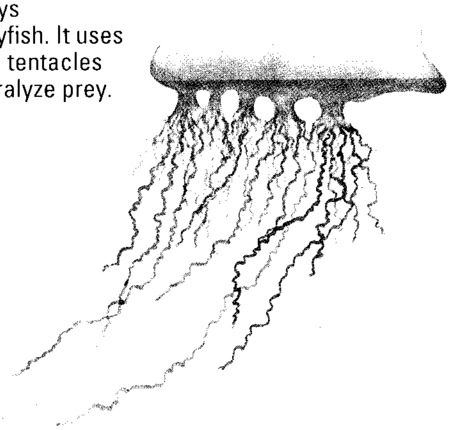
Portland cement is made up of 60 percent limestone, 25 percent silica, 10 percent alumina, and small amounts of gypsum and iron oxide. These materials are crushed, ground, and burned in a complex process to make cement. The finished product is strong and lasts for a long time. The United States leads the world in producing Portland cement.

Portland cement was invented by Joseph Aspdin, an English bricklayer, in 1824. He named his invention Portland cement because it was the same color as a type of limestone found on the Isle of Portland in Britain.

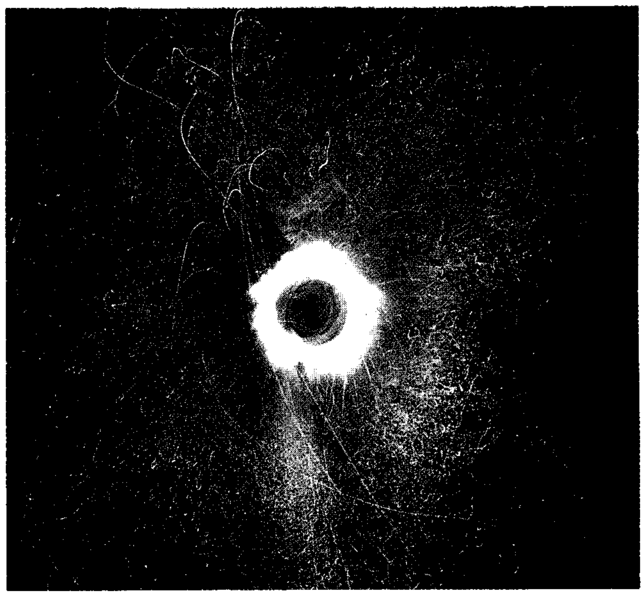
PORTUGUESE MAN-OF-WAR The Portuguese (pôr′chə gēz′) man-of-war is a marine animal that floats on the surface of tropical seas and on the Gulf Stream of the North Atlantic Ocean. It is not really a single animal, but rather a colony of animals, each of which has a specialized function that helps the man-of-war survive. The Portuguese man-of-war belongs to the phylum Cnidaria (see CNIDARIA).

The Portuguese man-of-war consists of a blue, balloonlike part called a float and a number of polyps hanging beneath it (see POLYP). The full-grown float is about 8 in. [20 cm] long. It is filled with gas that allows it to float. Long, stringlike tentacles hang down from the float. These tentacles are covered with powerful stinging cells and are used to capture prey, such as small fish. The stinging cells contain a poison that paralyzes the prey. Having trapped the prey, the tentacles then pull it up to the feeding polyps under the float, where it is digested.

The Portuguese man-of-war is dangerous to humans. Swimmers touching them get painful lumps, a fever, or even respiratory or heart problems.



PORTUGUESE MAN-OF-WAR
The Portuguese man-of-war is really a colony of animals that in many ways resembles a jellyfish. It uses its long, stinging tentacles to catch and paralyze prey.



POTASSIUM
This spinning pinwheel is one of the many types of fireworks that are made using potassium chlorate.

POTASSIUM (pə tăs′ē əm) Potassium (K) is a soft, silvery metallic element. It is one of the alkali group of elements (see ALKALI METAL; ELEMENT).

Potassium was discovered in 1807 by the British scientist Sir Humphry Davy (see DAVY, SIR HUMPHRY). Salts of potassium are found in many different minerals. Potassium is separated from these minerals by the process of electrolysis (see ELECTROLYSIS; MINERAL; SALTS). Potassium is necessary to many forms of life. Nerves need potassium to send messages (see NERVE CELL). Plants also need potassium for chemical reactions in their cells.

Potassium is one of the most reactive of all elements. It combines very quickly with the oxygen in the air and has to be stored under oil. It bursts into flame when placed in water. Potassium itself has few uses, but many of its compounds are very important (see COMPOUND). Potassium bromide and iodide are used in medicine and photography. Potassium chlorate is used to make fireworks and matches. Potassium hydroxide, which is also known as caustic potash, is used in making soap and textiles.

Potassium's atomic number is 19, and its relative atomic mass is 29.0983. Potassium melts at 146°F [63°C] and boils at 1,410.8°F [766°C]. It is lighter than water, with a relative density of 0.86.
See also RELATIVE DENSITY.

POTATO The potato is a plant of the nightshade family (see NIGHTSHADE FAMILY). It has over one thousand close relatives in the genus *Solanum*. These include the tomato and the capsicums. The potato plant has star-shaped flowers with five white or pink petals and five yellow stamens forming a cone at the center (see FLOWER). The plant stores starch in a swollen underground stem called a tuber. The tuber is either round or oval and has a thin brown or red skin. The flesh is white. People eat the tuber as a vegetable (see TUBER).

The tuber, or potato, is about 80 percent water and 20 percent solid matter. About 85 percent of the solid matter is starch. About 10 percent is protein. The potato also contains the vitamins thiamine, riboflavin, niacin, ascorbic acid, and a small amount of vitamin A. Many other elements are also present, including calcium, iron, magnesium, phosphorus, potassium, and sodium (see MINERAL; PROTEIN; STARCH; VITAMIN). A potato is not fattening, though many people believe it is. A medium-sized new potato has about 70 calories.

About 11 billion bushels of potatoes are grown throughout the world each year. They are eaten baked, boiled, or fried. Manufacturers use billions of bushels each year to make potato chips and frozen french-fried potatoes. Many schools and other large institutions use dehydrated potato powder to make mashed or whipped potatoes. This is done by adding water or milk when cooking. Millions of bushels of potatoes are also used each year to make alcohol, flour, and other products.

The former Soviet Union, with a yearly production of 2 billion bushels, is the leading grower of potatoes in the world. China and Poland are the next largest growers. The United States grows more than 500 million bushels of potatoes a year. Idaho is the leading potato-growing state. Washington, Oregon, Maine, and California also grow large crops.

The potato was first grown in South America.

POTATO—An American plant
The potato was first grown in South America and taken to Europe by Spanish explorers in the 1550s. Today, it is a staple food in many countries. About 11 billion bushels of potatoes are grown throughout the world each year, with the former Soviet Union being the largest producer.

POTATO—Earthing up
Potato tubers that grow too near the surface of the soil turn green and, because the green parts are poisonous, cannot be eaten. To prevent this from happening, commercial potato growers heap soil around the plants as they grow. This is known as "earthing up."

Spanish explorers took the potato with them on a return trip to Europe around 1550. In Ireland, potatoes grew so well that they became the country's main food. Potatoes were introduced into the United States in 1719 by Irish immigrants who settled in Londonderry, New Hampshire. The common white potato then became known as the Irish potato.

POTENTIAL (pə tĕn'shəl) *Potential* is a term used to describe several different quantities used in physics. In order to lift an object a certain distance, work has to be done. Work is a form of energy. When you lift an object, energy is transferred from you to the object. You lose energy because you are doing work. The object gains energy because it is being lifted. When the object has been lifted, it has energy because of its position. This energy is called potential energy. When the object falls, this energy is changed into energy of movement, called kinetic energy (see POTENTIAL ENERGY; KINETIC ENERGY).

An object near or on the earth's surface has gravitational potential energy because it is in the earth's gravitational field (see FIELD; GRAVITY). Any object placed in this field is pulled downward by gravity.

In the same way, an electric charge sets up an electric field in the area around it (see CHARGE). This electric field attracts or repels other charges. (If two charges have the same sign, either both positive or both negative, they repel each other—they are not attracted to each other. If they have opposite signs, such as a negative charge and a positive charge, they attract each other.) The electric potential in this electric field can be calculated for each point in the field.

The difference in potential between two points in an electric field is called the potential difference. This is equal to the work that must be done in moving a charge of one coulomb from one point to the other. Another name for potential difference is voltage. Electric potential is measured in units of joules per coulomb, also called volts (see COULOMB; JOULE; VOLT). When a battery is rated at six volts, this means that six joules of energy are required to move a charge of one coulomb from one battery terminal to the other.

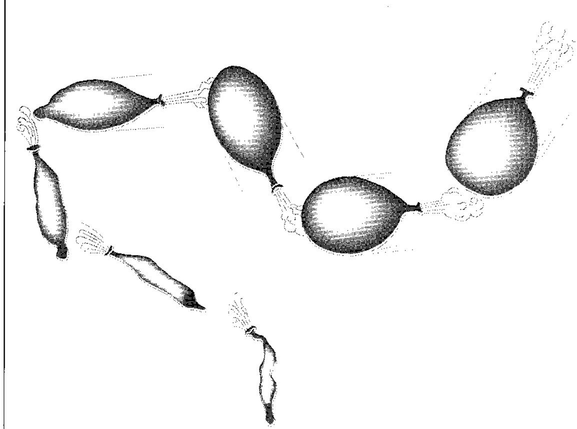
POTENTIAL ENERGY Potential energy is energy that an object has because of its position or state of stress (see ENERGY). When you lift an object, energy is transferred from you to the object. You lose energy because you are doing work in lifting the object. The object gains energy because it is being lifted. After the object has been lifted, it has energy because of its raised position. This energy is called potential energy. When the object falls, the potential energy is changed into energy of movement, or kinetic energy (see KINETIC ENERGY).

When an archer draws a bow, the drawn bow has potential energy because of its stretched position. When the archer releases the stretched string, the potential energy is changed into energy of movement, or kinetic energy. In the same way, a wound watch spring has potential energy because of its tightly wound position.

There are several types of potential energy: gravitational potential energy (a raised object such as water behind a dam), elastic potential energy (a squashed or stretched elastic material such as a watch spring), electrical potential energy (an electrically charged object near an electric charge), and magnetic potential energy (a magnetic material near a magnet).

PROJECT 35

ACTIVITY *Using potential energy*



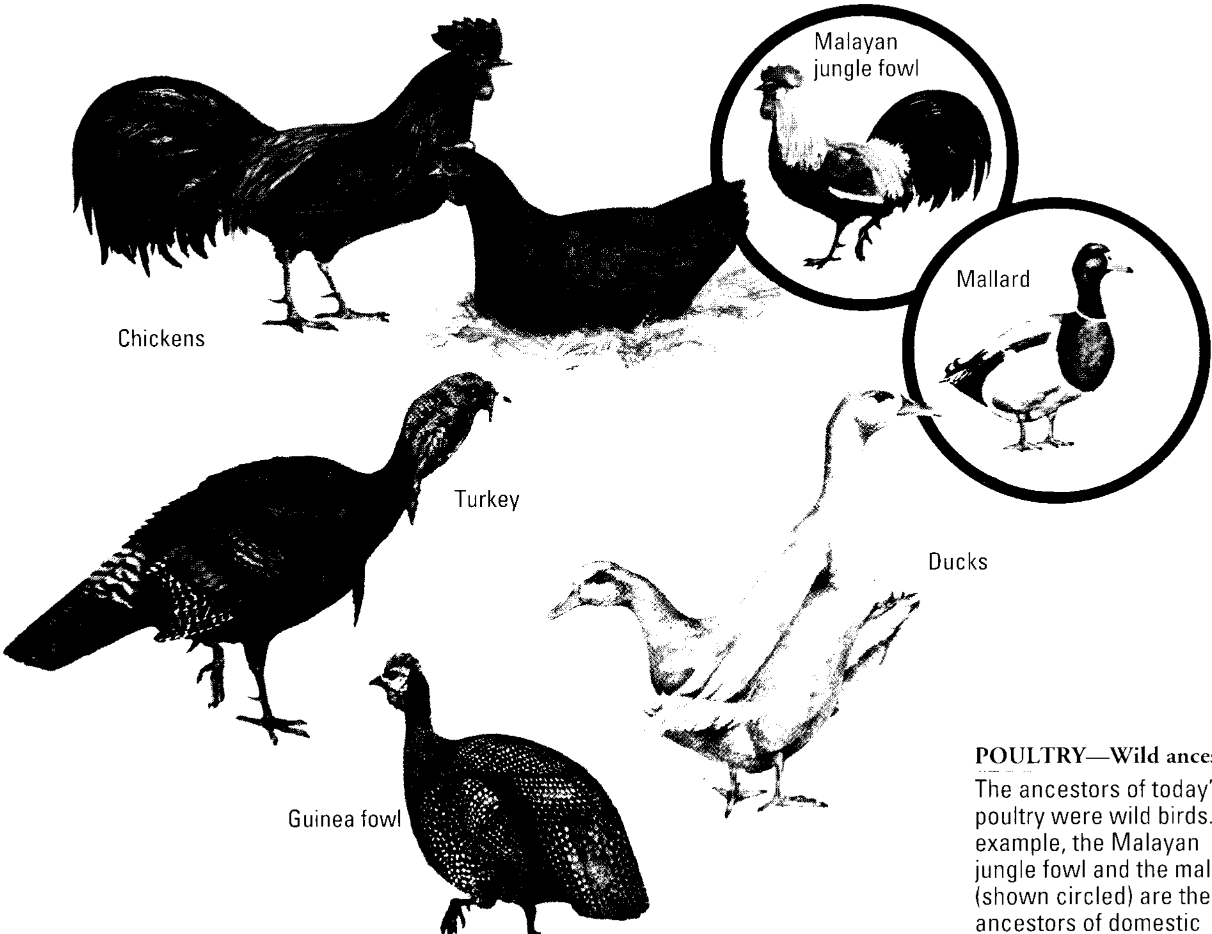
Blow up a balloon and then release the neck, so that the balloon flies through the air. The inflated balloon has potential energy because it is stretched. This energy changes to kinetic energy when the balloon is released.

POULTRY (pōl′trē) *Poultry* is the name for the various kinds of birds raised for their meat or their eggs. Chickens and turkeys are the most common types of poultry. Other kinds of poultry include ducks, geese, pheasants, pigeons, quail, and guinea fowl.

Many different breeds of chickens exist today. They are divided into two main groups: those raised for their eggs and those raised for their meat. Laying hens are female chickens raised to produce eggs. They start laying eggs when they are about twenty-two weeks old. Usually, the birds are kept in long, low buildings called laying houses. One laying house may hold as many as fifty thousand hens. Chickens raised only for their meat are called broilers or fryers. Most such chickens also are raised indoors. They eat and drink from automatic feeders and water containers.

It takes more space to raise turkeys than chickens, because turkeys are larger. Most turkeys are raised outdoors in pens or fields.

POULTRY—Large-scale farming
Chickens are farmed on a large scale to meet the demand—each American eats an average of more than 41 lb. [18 kg] of chicken meat per year. Pictured here are Rhode Island Reds.



POULTRY—Wild ancestors
The ancestors of today's poultry were wild birds. For example, the Malayan jungle fowl and the mallard (shown circled) are the wild ancestors of domestic chickens and ducks.

Diseases and parasites are a major problem of poultry farms (see PARASITE). To prevent disease among their poultry, farmers often vaccinate their birds, add antibiotics to the feed or drinking water, and try to keep their flocks clean (see ANTIBIOTIC; VACCINATION).

Each person in the United States eats an average of about 55 lb. [25 kg] of poultry per year. More than 75 percent of this meat comes from chickens, and about 15 percent comes from turkeys. The rest comes from ducks, pheasants, geese, and other fowl. Besides being used for food, poultry also provides other by-products. The feathers of ducks and geese are sometimes used to stuff pillows and to insulate clothing and quilts. Poultry manure is used as fertilizer. Eggs, aside from their use as food, are used in making paint and other products.

See also EGG.

POWDER METALLURGY (pou'dər mĕt'l ûr'jē) Powder metallurgy is the way in which articles are made from metal powders. Sometimes, nonmetallic substances are used in the powder.

There are several ways of making powders. The most widely used method starts with a metal oxide in powder form. An oxide is a compound of oxygen and one other element (see OXIDE). Through a reaction called a reduction reaction, the metal oxide is reduced to just the metal (see OXIDATION AND REDUCTION). The metal is in powder form because the oxide was in powder form. Another method is called atomization. In this method, a thin stream of molten (melted) metal is broken down by a blast of air.

The first stage in making an article using powder metallurgy is to mix the powder with a lubricant. The lubricant helps the powder pack tightly. The powder is then forced by pressure into a mold or die (see DIE). The pressure can be as much as 50 tons per sq. in. [7,000 kg per sq. cm]. The pressed powder is called a compact. It is then heated in a furnace to three-fourths of the melting point of the metal. This process is called sintering. Sometimes the metal has many tiny pores, or holes. The pores can be removed by sintering twice. Another way of removing the pores is to add a small amount of another metal with a lower melting point than the main metal. The second metal melts during sintering and fills up the pores. This is called infiltration.

Sometimes, however, the pores are necessary. For example, porous bronze can be made to soak up oil. It is used as a self-lubricating material for bearings. The pores slowly release the oil, which then acts as a lubricant.

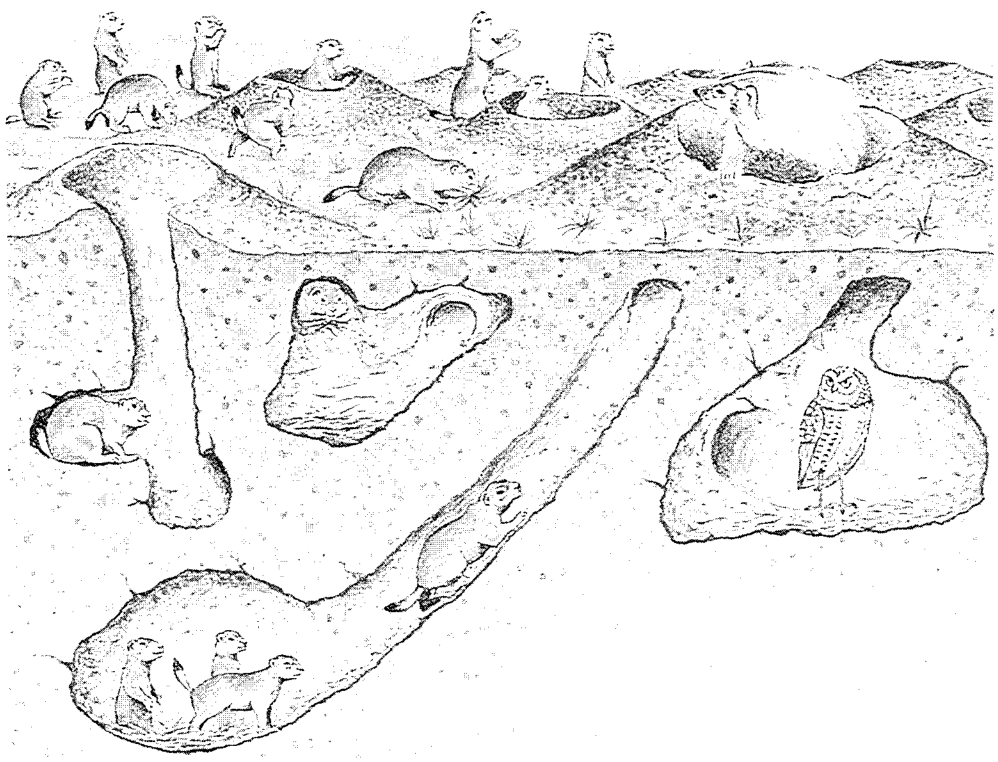
See also METAL AND METALLURGY.

POWER In physics, *power* is defined as the rate of doing work. For example, if you lift an object of a certain mass through a certain distance, you are doing work (see MASS). The faster you lift the object, the more power you use. In the metric system, work is measured in units called joules, and power is measured in joules per second. Another name for joules per second is *watts.*

See also JOULE; WATT.

PRAIRIE DOG The prairie (prâr'ē) dog is not a dog at all. It is a burrowing rodent belonging to the squirrel family, Sciuridae (see RODENT; SQUIRREL). The prairie dog got its name from its barking call. Prairie dogs inhabit the open plains and plateaus of North America from Canada to Mexico. The prairie dog grows to about 1 ft. [30 cm] long, not including its short, flat tail. The

PRAIRIE DOG—Burrowing rodent
Prairie dogs are burrowing rodents that belong to the squirrel family. They live on open plains throughout North America.



PRAIRIE DOG—Colony
Prairie dogs live in tunnels and chambers in underground colonies. Badgers may invade the tunnels looking for prey. Burrowing owls may take over old prairie dog tunnels and use them as nests.

animal has coarse gray and brown fur. It is stout and has short legs.

The prairie dog is a highly social animal. It lives in large colonies, or groups. The animal builds a maze of burrows by digging about 12 ft. [3.7 m] underground. At the bottom of the tunnel, several different chambers may be hollowed out—one for sleeping, one for storing food, and so on. The prairie dog makes a mound of earth at the entrance to each hole. The mound keeps water from entering the hole. Their underground homes give the prairie dogs protection from enemies such as coyotes, badgers, weasels, hawks, and eagles.

Prairie dogs feed on grass and other plants. Farmers consider prairie dogs pests. Not only do these animals eat crops, but a horse or cow that steps into a prairie dog's home could break a leg. Therefore, farmers have used poison to reduce the numbers of prairie dogs in farm fields and on grazing land. However, the prairie dog is protected in several national parks in the United States, including Badlands National Park in South Dakota.

PRECAMBRIAN TIME Precambrian (prē kăm'brē ən) time is the name that scientists have given to the earliest division of the earth's history. Precambrian time began about 4.6 billion years ago, the same time that the earth's crust probably formed. It ended about 570 million years ago. Thus, Precambrian time includes approximately 80 percent of the earth's history.

Huge outcrops of Precambrian rock are located in various parts of the world. These outcrops, called continental shields, are most obvious in Canada, Greenland, and Scandinavia. The continental shields acted as cores around which the continents formed. Most geologists agree that large glaciers formed at the end of the Precambrian time (see GLACIER).

Precambrian time is often divided into three eras: the Azoic era, Archeozoic era, and Proterozoic era. During the early part of the Azoic era, the earth formed. The atmosphere probably formed later on during the Azoic era. Evidence suggests that the earth's crust melted and hardened several times during this time.

Fossil evidence indicates that the first forms of life evolved during the Archeozoic era. Blue-green algae and bacteria evolved. Fossils of these organisms have been found in rocks dating to this era. The heat, pressure, and chemical processes within the earth's crust caused the formation of such

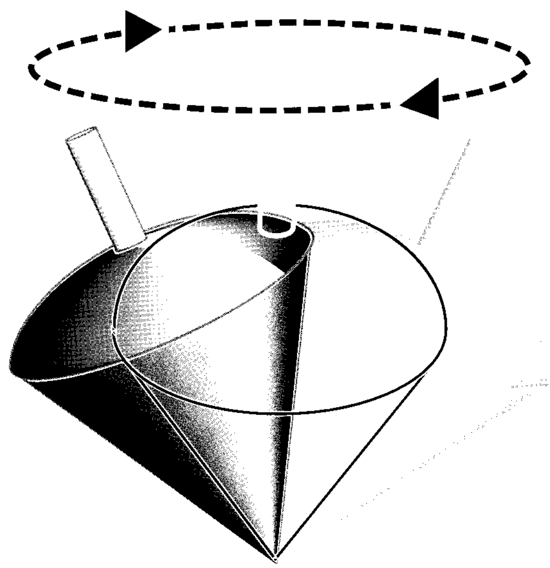
PRECAMBRIAN TIME
Precambrian life forms preserved as fossils include invertebrate animals, such as worms, and simple plants, such as algae.

metamorphic rocks as marble and slate. Large bodies of granite also formed during the Archeozoic era. Volcanic activity was widespread (see ROCK; VOLCANO).

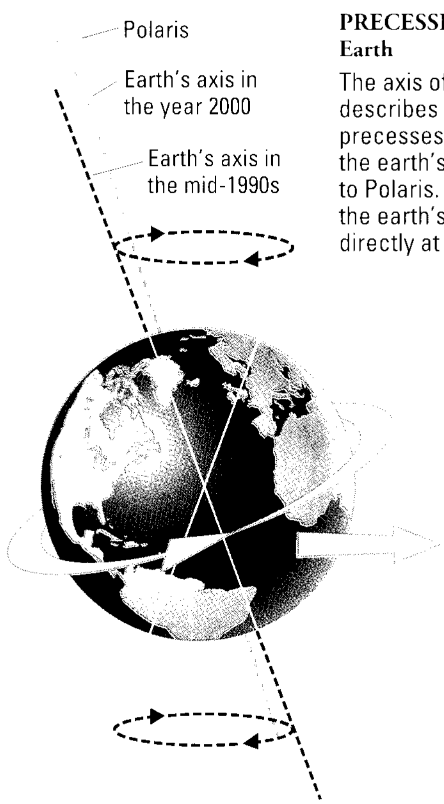
Proterozoic rocks have large amounts of iron ore. A greater variety of life, including jellyfish, sponges, and worms, evolved during the late Proterozoic era.
See also ARCHEOZOIC ERA; FOSSIL; GEOLOGICAL TIME SCALE; GEOLOGY; PROTEROZOIC ERA.

PRECESSION (prē sĕsh'ən) Precession is the tendency of a rotating (spinning) object to change the direction of its axis of rotation when a force is applied to it. The earth provides an example of precession. The earth spins around its axis, an imaginary line that connects the North and South poles. It completes one rotation every day. The sun and moon exert a force of gravity on the earth (see GRAVITY). This force causes the earth's axis to move slowly around in a circle. It takes 25,800 years for the earth's axis to complete the circle.

One effect of the earth's precession is a change in which star is the North Star. The North Star is the star that lies nearest to due north. The present North Star is Polaris. As the earth precesses and the earth's axis changes position, Polaris will no longer be the North Star. Another star will be nearest to due north. Similarly, 14,000 years ago, the bright star Vega was the North Star.
See also GYROSCOPE.



PRECESSION—Spinning top
The axis of a spinning top shows precession as the top slows down. The path the handle follows is shown by the dashed line.



PRECESSION—Spinning Earth
The axis of the spinning earth describes a double cone as it precesses. In the mid-1990s, the earth's axis points almost to Polaris. In the year 2000, the earth's axis will point directly at Polaris.

Precious Stone and Gem

A precious (prĕsh′əs) stone or gem is any naturally occuring mineral that is used for jewelry or other decorative purposes and that is considered valuable (see MINERAL). The word *gem* comes from the Latin word *gemma,* which means "bud." Just as a bud forms into a lovely flower, dull lumps of a mineral can be cut and polished into brilliant (sparkling) gems. Several different gems may come from the same mineral. For example, ruby and sapphire are both formed from the mineral corundum (see CORUNDUM; RUBY; SAPPHIRE).

Some gems do not come from minerals. The pearl is an example. It is taken from a mollusk, usually an oyster (see MOLLUSCA; OYSTER; PEARL). Amber, another gem, is a hard substance formed from the resin of trees that grew millions of years ago (see AMBER; RESIN). Coral, which is often used in necklaces, is made by tiny sea animals (see CORAL).

Imitation gems are often made of a soft glass called paste, or strass. This glass is very clear and brilliant. Imitation gems made from this paste can be scratched easily. Other imitation gems are made from plastics.

Synthetic gems are made of the same material as natural gems, but they are made in the laboratory instead of being found in nature. For example, rubies and sapphires have been made by melting aluminum oxide in a flame from oxygen and hydrogen gases. It is hard to tell the difference between good-quality synthetic gems and natural gems.

Qualities of precious gems There are various properties used to identify gem minerals. One is the shape of the crystals, which differs with each mineral. All the crystals in any one mineral have the same type of pattern in which their atoms are arranged. For example, diamonds crystallize in the isometric system (see CRYSTAL; DIAMOND).

Color is also an important factor in identifying gems. There are two types of color in precious stones. Essential color is the color of the mineral in its pure state (without impurities). Nonessential color comes from some impurity.

Another factor in identifying gems is how the gem affects light that is reflected (thrown back) from it or that passes through it (see REFLECTION OF LIGHT). When light passes from air to a denser substance, the speed of light is slowed down. The ratio of the speed of light in air to its speed in the gem is the gem's index of refraction (see REFRACTION OF LIGHT). Minerals with a high index of refraction sparkle and glitter. Minerals with a low index of refraction usually appear dull. The amount of refraction also varies with the color of the light that passes through the mineral. For example, blue rays are refracted more than yellow rays

OPAL
Opal is a precious stone that consists of non-crystalline silica. This miner is looking for opals underground in New South Wales, Australia, one of the world's major producers of opals.

and yellow rays more than red. Beams of white light passed through some gems become separated into various colored rays. This is called dispersion (see DISPERSION OF LIGHT).

Cleavage is the tendency of some minerals to split along certain directions, producing an even surface. Each mineral has a certain cleavage direction that helps identify the mineral.

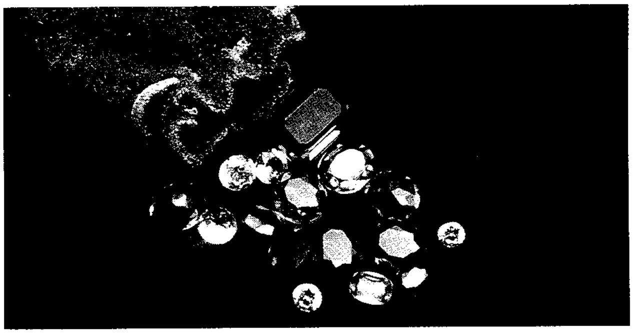
Experts also identify gem minerals by specific gravity. Specific gravity, or relative density, is a comparison of the weight of an equal amount of pure water (see RELATIVE DENSITY). Each gem has a unique relative density.

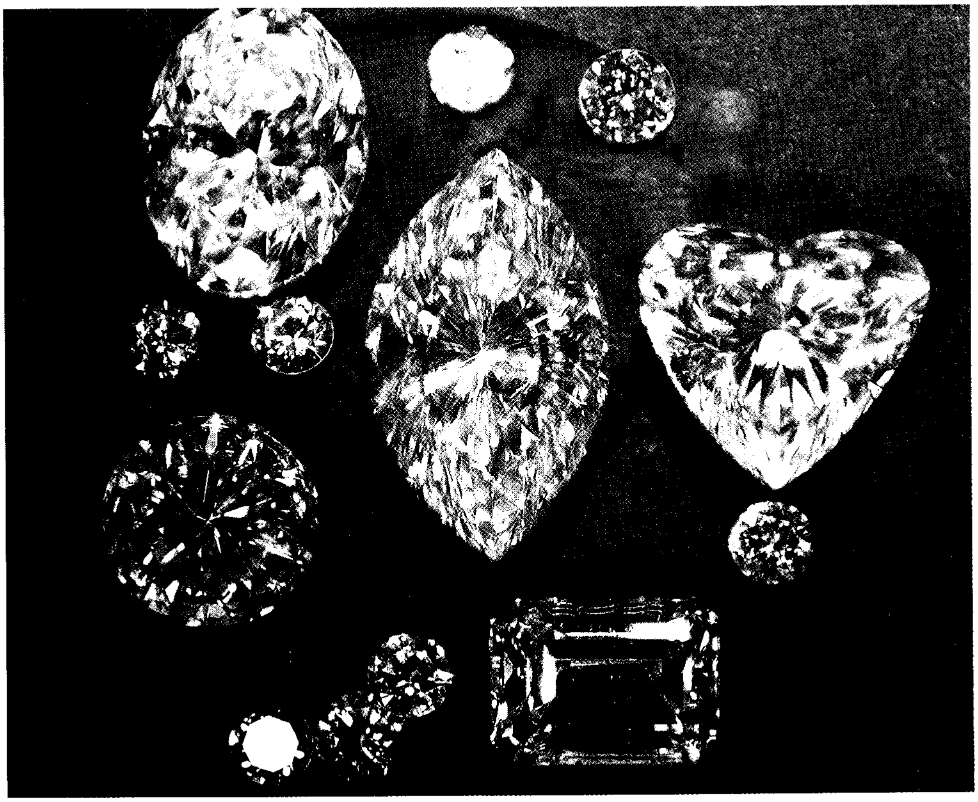
Hardness is an important quality of gem minerals. Few minerals can serve as gems unless they will last for a long time. However, some gems, such as opals, are fairly soft (see HARDNESS).

Cutting The tools used for cutting gems depend on the hardness of the mineral. Proper cutting brings out the brilliance and color of gems. Also, flaws (imperfections) are removed. Transparent gems, such as diamonds, are usually faceted—that is, their surfaces are cut into a series of small square or triangular faces (sides) that reflect and refract (bend) light. Nontransparent gems, such as rubies (which are often flawed), are generally cut with a rounded surface. This is called cabochon cutting. After a gem has been cut, it is polished. This helps bring out the gem's brilliance and natural beauty.

Value of gems Diamonds are generally the most prized gems because they surpass all others in hardness and brilliance. Besides hardness and brilliance, other factors determine the value of gems, such as color, rarity, and demand. For example, the value of sapphires depends on the quality of the blue color. Rubies are more valuable than sapphires, because rubies are rarer. Certain emeralds, because they are in high demand, may be more valuable than some diamonds.

See also EMERALDS.





COLOR

Gems come in a variety of colors (above). Color is an important factor in identifying specific gems. Diamonds (left) are among the world's most expensive gems. Chemically, they are crystalline carbon—the same element in charcoal and graphite. Pictured here are stones of various colors and various cuts, chosen to make the gems sparkle with reflected light.

PRECIPITATE (prĭ sĭp′ĭ tāt′) A precipitate is a substance that separates out from a solution. A precipitate can form because of chemical change. When two solutions are mixed together, they sometimes react to form different substances. If one of the substances is insoluble (cannot be dissolved), then it forms solid particles. These are called a precipitate. For example, many metal hydroxides are insoluble in water. Suppose a solution of sodium hydroxide is mixed with a solution of copper sulfate. A blue precipitate of copper hydroxide, a metal hydroxide, is immediately formed.

Precipitates can also form when the temperature of a solution changes. The amount of a substance that can dissolve in a fixed amount of liquid increases as the temperature increases. If the temperature is lowered, this amount decreases, and a precipitate can form.

Most precipitates are made of many small particles. However, a precipitate may also occur as flakes. This is called a flocculent precipitate. A precipitate may also be jellylike.

See also CHEMICAL REACTION; SOLUTION AND SOLUBILITY.

PRECIPITATION (prĭ sĭp′ĭ tā′shən) Precipitation is the descent (coming down) of liquid or solid water particles from clouds to the ground. The word also refers to the water itself. Forms of precipitation include drizzle, rain, freezing rain, sleet, snow, and hail.

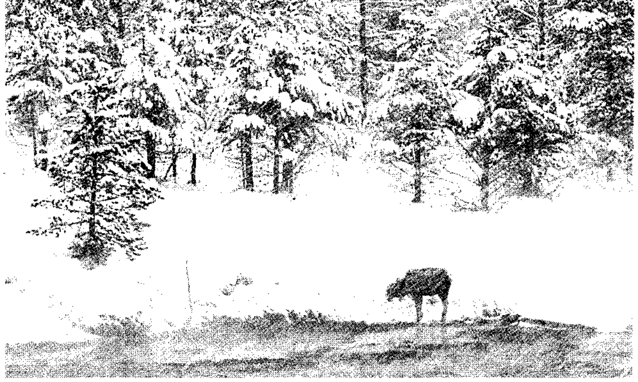
Precipitation occurs because of the way air acts at different temperatures. As air rises, it cools and cannot hold as much water vapor as it can at warmer temperatures (see VAPOR). At a temperature known as the dew point, the water vapor condenses around tiny particles in the air. These particles, called condensation nuclei, include dust particles and sea salt. The condensation of water vapor around such particles forms water droplets (see CONDENSATION; DEW POINT). The water droplets aggregate (collect) together, forming clouds. If the water droplets become supercooled (remain liquid below the freezing point, 32°F [0°C]), the droplets combine and may be heavy enough to fall to the ground as rain or snow (see SUPERCOOLING).

If precipitation is in the form of very small water droplets, it is called drizzle. The water droplets that make up drizzle have diameters ranging from 0.008 to 0.02 in. [0.2 to 0.5 mm]. The total amount of precipitation that comes from drizzle is often hardly worth noting.

Water droplets larger than those of drizzle are called rain. The maximum diameter of a raindrop is about 0.25 in. [6 mm]. The largest raindrops usually fall during heavy storms. Freezing rain happens when the raindrops fall through a layer of air colder than 32°F [0°C]. Freezing rain presents a danger to motorists and pedestrians alike because it coats roadways and walkways with a thin glaze of ice.

Snow is frozen water that remains in the solid state. It only falls when the temperature is near or below freezing. Winter snowstorms are commonplace in many parts of the United States. Snowfall is classified by the accumulated (collected) amount that falls on the ground. Sleet is either mixed rain and snow or partially frozen ice particles. Hail is frozen precipitation that falls only from cumulonimbus (thunderhead) clouds during thunderstorms.

See also ACID RAIN; AIR; CLOUD; HAIL; RAIN; SNOW.



PRECIPITATION
Snow is a type of precipitation. The picture shows snow falling on lodgepole pine trees in Yellowstone National Park, Wyoming. An elk is in the foreground.

PREDATORS AND PREY

Predators are animals that hunt other animals, known as prey, for food. Carnivores, or meat-eaters, are predators (see CARNIVORE). Insectivores, or insect-eaters, are also predators (see INSECTIVORE).

Predators include many different kinds of animals. Some predators, such as the fox, eat almost anything that they can catch. Others are much more choosy about their food. The snail kite of the Florida Everglades, for example, feeds only on a particular kind of water snail.

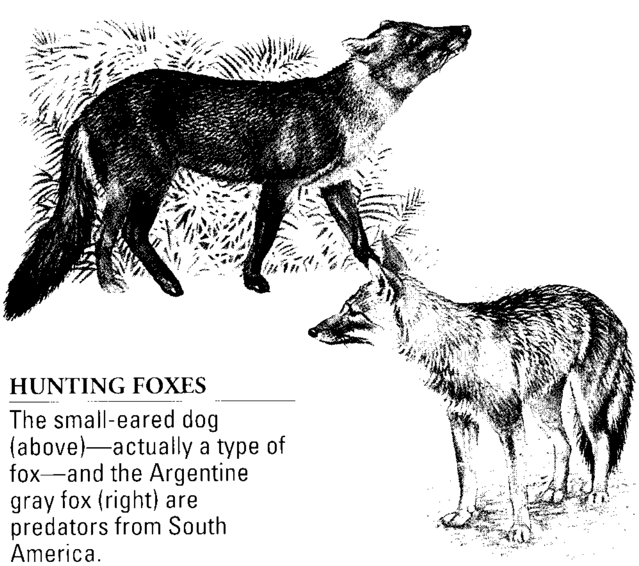
Each kind of predator has its own method of capturing its prey. These methods fall into three main groups: ambushing, trapping, and hunting. Ambushing involves lying in wait for the prey to come along. Ambushers seem to know good places to wait, and they are often so well camouflaged that their victims never see them until it is too late. Praying mantises and crab spiders are masters of the ambush (see MANTIS; SPIDER). They often hide among flowers and wait for their insect prey to arrive.

Spider webs are the best known of the traps set by animals, although not all spiders actually weave webs. The webs are made with silk from the spiders' bodies. There are many different designs. The webs are designed to catch flying, crawling, and jumping insects. Most of the webs contain gum-covered threads to which the insects stick firmly. Some ant lion larvae dig conical pits in sandy soil and lie in wait at the bottom. When ants or other small insects fall in, they are grabbed by the ant lion larva. Adult ant lions are delicate insects related to the lacewing (see LACEWING).

PREDATORY BIRD

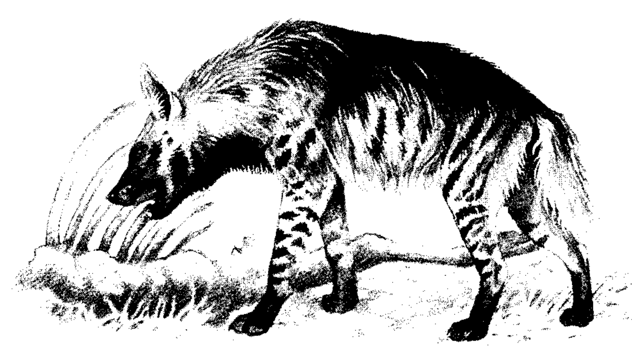
Eagles are skillful hunters and belong to the general group known as birds of prey. Pictured here is an eagle feeding its chick.

Spiders and ant lions do not lure their prey into their traps, but some animals do. The anglerfish dangles a long spine over its mouth. A flap of skin at the end looks like bait on a fishing line, and any small fish that mistakes it for food is quickly engulfed in the angler's huge mouth. Some deep-sea fishes have similar baits that shine in the inky blackness. The alligator snapping turtle lives in



HUNTING FOXES

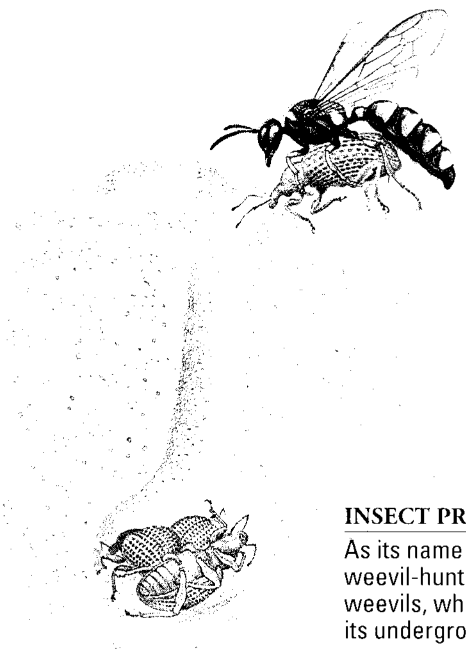
The small-eared dog (above)—actually a type of fox—and the Argentine gray fox (right) are predators from South America.



SCAVENGER

The striped hyena of Africa generally lives by scavenging off animals killed by other hunters. Even so, it is usually regarded as a predator.

muddy rivers in the eastern parts of the United States and lies in the water with its mouth open. It waves a pink, wormlike flap on the end of its tongue, and, like the anglerfish, it snaps up any small fish that comes to investigate.



INSECT PREDATOR

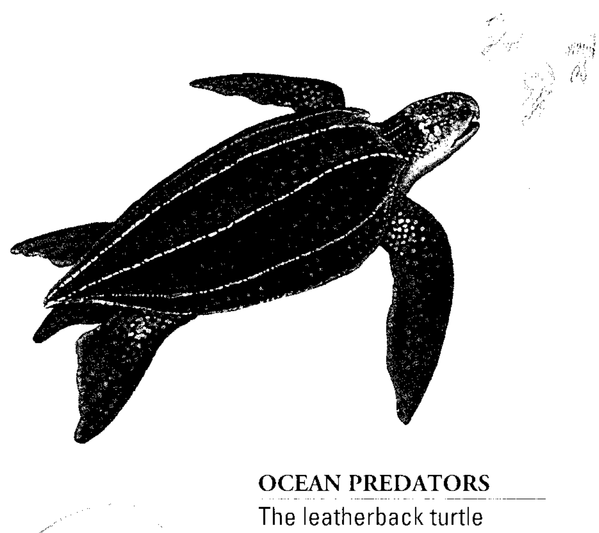
As its name implies, the weevil-hunting wasp kills weevils, which it stores in its underground nest.

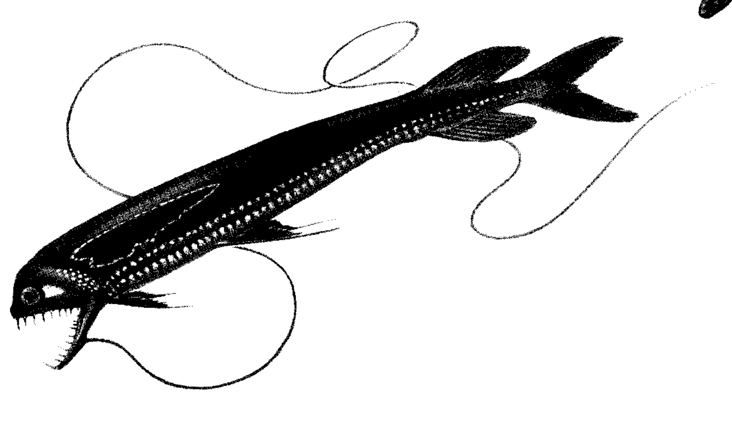
AMBUSH

The common pearly nautilus (left) lies in wait for its prey. When a small fish strays too close, the nautilus seizes it by shooting out more than thirty tentacles.

True hunting animals are those that chase their prey. They include many spiders and other small animals as well as the better-known hunters, such as lions and cheetahs on the land, owls and other birds of prey in the air, and sharks in the sea. The hunters need efficient eyes or other sense organs to tell them where the prey is. Many also need good speed to be able to overtake their prey. The cheetah, for example, is the fastest animal on four legs, and the peregrine falcon is the fastest in the air (see CHEETAH; FALCON). Hunters also need efficient weapons to kill their prey when they catch it. Strong claws and teeth are the main weapons, but some hunters also use poison to kill or paralyze their victims.

Predators might seem cruel or bloodthirsty, but they are simply following an instinct to survive by catching and killing their prey (see INSTINCT). They rarely kill more than they need. If they did, they would soon run out of food. Predators control the populations of their prey very efficiently. They may even help the prey population by catching and killing the weakest individuals in each generation and leaving the fittest to survive and breed.





OCEAN PREDATORS

The leatherback turtle (above) feeds mainly on jellyfish, although it will eat crustaceans such as shrimp. The dragonfish (left) lives in the deep ocean and lures its prey with the aid of a long "fishing line" that grows from its chin.

PREGNANCY (prĕg'nən sē) Pregnancy is the period of time that a female carries a baby inside her body before giving birth. Pregnancy begins when a fertilized egg attaches itself to the lining of the uterus (womb), but in humans is usually counted from the first day of the last menstrual period (see FERTILIZATION; IMPLANTATION).

Pregnancy is also called gestation. For most women, gestation lasts about nine months. The length of the gestation period varies among other mammals. It can be as short as a few days or longer than a year (see GESTATION PERIOD).

In human pregnancy, the developing baby is called an embryo during the first two months of pregnancy (see EMBRYO). After the second month until birth, the developing baby is called a fetus. In early pregnancy, certain structures form in the uterus. Such structures make it possible for the developing baby to live within the mother's body. The placenta is one of the most important of these structures (see PLACENTA). By means of the placenta, food and oxygen pass from the mother's bloodstream to the embryo or fetus.

After two months of development, the human fetus is only about 1 in. [2.5 cm] in length. However, it can move its head, mouth, arms, and legs. A technique called ultrasound imaging can be used at different times throughout a pregnancy to show the size and position of the fetus (see ULTRASOUND).

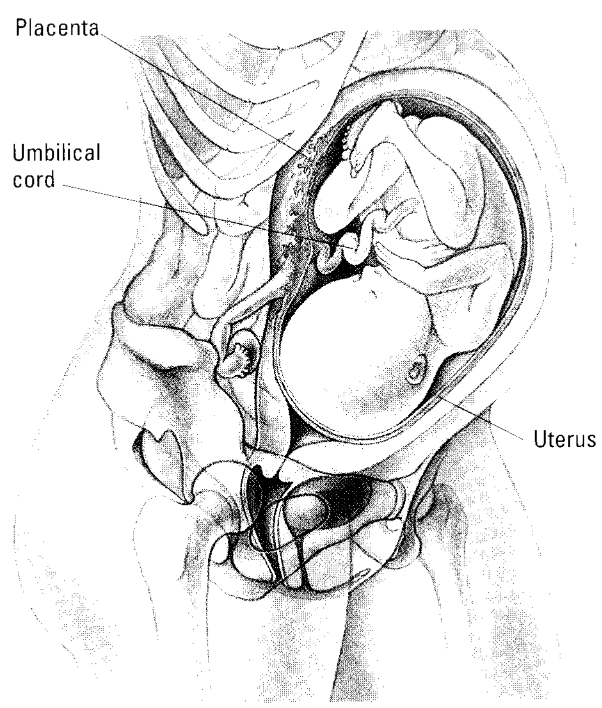
During the fourth to fifth month, the mother can usually begin to feel the fetus moving inside her. In the sixth month, the fetus measures roughly 1 ft. [30 cm] long, and weighs about 1 to 1.5 lb. [0.5 to 0.7 kg]. Most of the fetus's organs can function. During the final few months of pregnancy, the mother's bloodstream gives the fetus various immunities. These immunities help protect the baby from the various diseases for a short period after birth (see IMMUNITY).

As the fetus undergoes development through pregnancy, pregnancy also causes bodily and emotional changes in women. Menstruation stops, morning sickness (vomiting) may occur, weight is gained, and the breasts change (see MENSTRUAL CYCLE). The bodily changes make it possible for the fetus to grow and for the mother to nurse the baby after it is born. Pregnancy causes changes in hormone levels (see HORMONE). Such changes may make some women feel moody during pregnancy.

To prevent harm to the developing baby, doctors advise pregnant women not to smoke or take alcohol or certain drugs.

Spontaneous abortion, also known as miscarriage, is an early ending of pregnancy by a natural or accidental cause (see ABORTION). Medical treatment throughout pregnancy can help prevent miscarriages. Such medical treatment also helps ensure that the mother stays healthy throughout pregnancy. This makes it more likely that the baby will be born healthy. If a problem occurs with the fetus, prompt medical attention can sometimes save its life. In severe cases of fetal injury, surgeons can sometimes even operate on the fetus to correct problems before birth. Medical advances continue to improve the chances of women having healthy pregnancies and healthy babies.

See also REPRODUCTION; REPRODUCTIVE SYSTEM.



PREGNANCY

A human baby, known as a fetus after two months of pregnancy, develops in its mother's uterus (womb). Food and oxygen travel to the fetus from the mother's bloodstream via the placenta and umbilical cord.

PREHISTORIC PEOPLE Prehistoric people are humans who lived before people started making written records, about 7,000 years ago.

The classification of these human cultures is based on the type of technology that people had. The first is the Paleolithic, or Old Stone Age (see STONE AGE). At this time, people used tools—knives and spear points—chipped from stone. Paleolithic people were hunters.

In the Mesolithic, or Middle Stone Age, society was becoming a little more settled, and much finer tools were made.

In the Neolithic, or New Stone Age, the people had learned how to farm and domesticate animals. The first settled communities developed. The people still used tools made from stone, but the New Stone Age tools were much more sophisticated and finely polished, and other materials such as bone and wood were also used.

The New Stone Age progressed into the Bronze Age, which was when people produced the first metal tools. The final phase of metalwork development before the beginning of written history was the Iron Age (see IRON AGE).

These ages do not have strict boundaries, and the transitions between them differed in different areas. For example, the Iron Age began in the Near East about 1200 B.C., but did not begin in northern Europe until about 500 B.C. In Africa, cultures developed from the New Stone Age directly into Iron Age without passing through a Bronze Age.

See also HOMO ERECTUS; PREHISTORY.

PREHISTORY (prē hĭs'tə rē) Prehistory is the time before human beings developed methods for writing about their lives (see PREHISTORIC PEOPLE). It generally includes all time before about 7,000 years ago. Around this time, written records began to be kept in certain parts of the world, such as the Middle East.

The knowledge we have of prehistory comes from the study of animal and human fossils, ancient tools and other evidence of human beings, and rocks. Geologists, anthropologists, and

PREHISTORY

Prehistoric mammals date from the beginning of the Tertiary period, 65 million years ago. All modern groups—plant-eaters, insect-eaters, and meat-eaters—were present.

paleontologists all strive toward a fuller understanding of the prehistoric earth and its life forms.
See also ANTHROPOLOGY; FOSSIL; GEOLOGICAL TIME SCALE; GEOLOGY; PALEONTOLOGY.

PRESERVATIVES Preservatives are substances that prevent or slow down the growth of microorganisms such as bacteria, fungi, and viruses. These organisms live in organic matter, such as food and wood, where they often produce chemicals that cause food to spoil or wood to rot. Common food preservatives include sulfur dioxide, organic and inorganic acids, phosphates, and nitrates.

Preservatives are used in many processed, packaged, and prepared foods. Many people are becoming concerned about their use and are demanding better labeling of foods that identify the preservatives used.
See also FOOD PROCESSING.

PRESSURE Pressure occurs when force acts over the surface of a body. Pressure is defined as force divided by the area over which it acts (see FORCE).

To understand pressure, it is helpful to think of an example. Suppose that you are carrying a heavy package by its string. In a short while the string starts to cut into your hand. The weight is much easier to carry if the package is in a bag with a handle. Both the string and the handle exert a pressure on your hand. However, the pressure of the string is much greater than the pressure of the handle. That is why the string quickly starts to hurt. The force, or weight, of the package, is the same in each case. However, because the string is thin, the area of contact with your hand is very small. This means that the pressure is very large. The handle covers a much greater area of your hand because it is wider. Therefore, the handle's pressure is much less than the pressure exerted by the string.

Different substances react differently to pressure. When you press your hands against wood, the wood is not noticeably affected. However, when you press against clay, the clay changes shape. This is because the forces between the molecules in wood are strong. In clay, they are not as strong. In fact, they are not strong enough to resist the pressure of your hand (see MOLECULE).

The forces between the molecules in a liquid are weaker than those between molecules in a solid. Therefore, liquids are very easily distorted by pressure. In a gas, the forces are weaker still. In fact, a gas can be compressed by pressure.

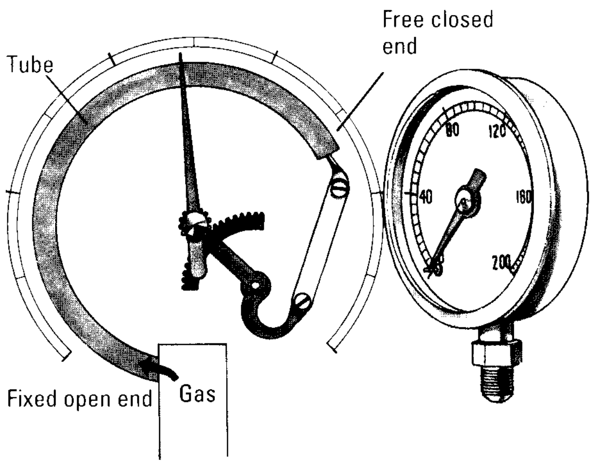
Gases and liquids are together known as fluids. The branch of physics that studies the pressures in still fluids is called hydrostatics (see HYDRAULICS; HYDROSTATICS). At any point inside a fluid, the pressure is the same in all directions. This is true for the air in the atmosphere. The air above us exerts a pressure on us. The pressure is about 14.7 pounds per sq. in. [101,600 newtons per sq. m]. Over the area of your hand, this is equal to a weight of about 150 lb. [70 kg]. This is the weight of a person. However, the pressure acts in all directions. It acts on both sides of your hand. For this reason, you do not notice the pressure of the air on your hand.

A gas can be easily compressed because the forces between its molecules are very weak. If the pressure on a gas is doubled, then the volume is roughly halved. This law is called Boyle's law (see BOYLE'S LAW). At very high pressures, the molecules in a gas are very close together, and Boyle's law no longer applies.

PROJECT 22, 26, 57, 58

PRESSURE GAUGE (prĕsh′ər gāj) A pressure gauge is an instrument that measures pressure (see PRESSURE). Such gauges are widely used in industry and scientific research. There are many different types of pressure gauges. For example, the manometer has a U-shaped tube containing a liquid. One end of the tube is connected to the pressurized system. The other end is left open. The pressure forces the liquid down one side of the tube and up the other. The difference in the two levels is used to calculate the pressure (see MANOMETER).

The Bourdon gauge is another common type of pressure gauge. It can measure fairly high pressures. It contains a C-shaped coil. The coil is a tube with thin walls. It is closed at one end. The open end is connected to the pressurized system. The pressure



PRESSURE GAUGE
The Bourdon gauge is often used with steam boilers. When pressure inside the boiler increases, the tube straightens out, and the needle on the dial moves up.

forces the tube to straighten. This causes the free end of the coil to move, which, in turn, moves a pointer on a dial.

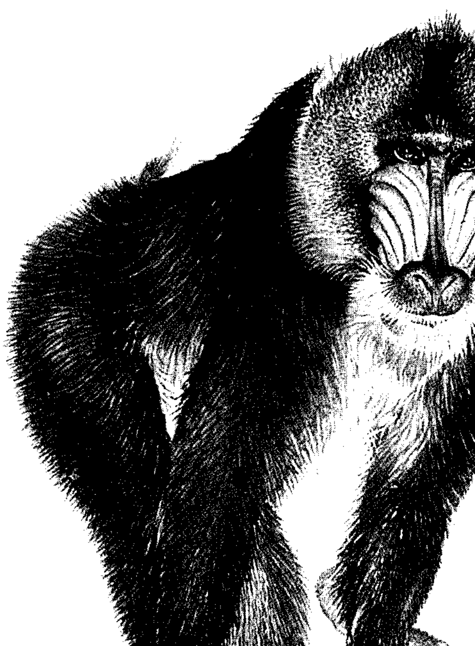
There are also bellow-shaped gauges. The "bellows" are made out of a metal tube with corrugated walls—that is, walls with wavelike folds. One end of the tube moves under pressure, while the other end is kept still. The aneroid barometer works in a similar way. It is used for measuring the pressure of the atmosphere (see BAROMETER).

All these instruments measure pressure directly. However, they are not sensitive enough to measure very low pressures. In this case, some quantity is measured that varies with pressure. For example, the ionization of a substance may be measured (see IONS AND IONIZATION). Then this measurement is correlated with pressure.

PRIESTLEY, JOSEPH (1733–1804) Joseph Priestley (prēst′ lē) was an English scientist best known for his discovery of the gas called oxygen. Priestley was originally a preacher. He became involved with science soon after meeting the great American scientist, Benjamin Franklin (see FRANKLIN, BENJAMIN). Priestley did experiments with electricity. He deduced the inverse square law for electrical attraction (see ELECTROSTATICS; INVERSE SQUARE LAW).

Priestley also investigated and discovered many other gases. He was the first person to dissolve the gas carbon dioxide in water. This is how soda water is made. He also investigated the gases hydrogen chloride and ammonia. In 1774, he produced oxygen by heating the compound mercuric oxide (see OXIDE). He did experiments to show the relationship between oxygen and living things.
See also OXYGEN.

PRIMATES make up the order of mammals that includes human beings (see MAMMAL). This order also includes more than two hundred species of other animals. Except for human beings, most primates live in trees in tropical or subtropical areas. Primates have large, well-developed brains and eyes that give them good vision. Most primates have hands with four fingers and an opposable thumb. This means they can touch their thumb to any of the four fingers. This gives primates the ability to pick up, hold, and grasp objects easily. Many primates have a similar arrangement of toes on the feet. The fingers and toes usually have nails instead of claws. Most primates live in social groups. They



PRIMATES—Colorful baboon
The mandrill is a type of baboon, an anthropoid primate. Its ridged muzzle and rump are brightly colored red and blue.

PRIMATES—Tree-living primates

The slender loris of southeast Asia (above left) and the potto of Africa are prosimian primates that spend their lives among the branches of trees.

communicate with each other by sounds, touch, and smell.

The primates are divided into two main groups: the prosimians and the anthropoids. The prosimians include the aye-ayes, galagos, lemurs, lorises, pottos, tarsiers, and tree shrews (see LEMUR; TARSIER). The anthropoids include human beings, apes, and monkeys (see ANTHROPOID; APE; HUMAN BEING; MONKEY). In general, the anthropoids are larger and more intelligent than the prosimians. It is believed that the anthropoids evolved from the prosimians.

See also EVOLUTION.

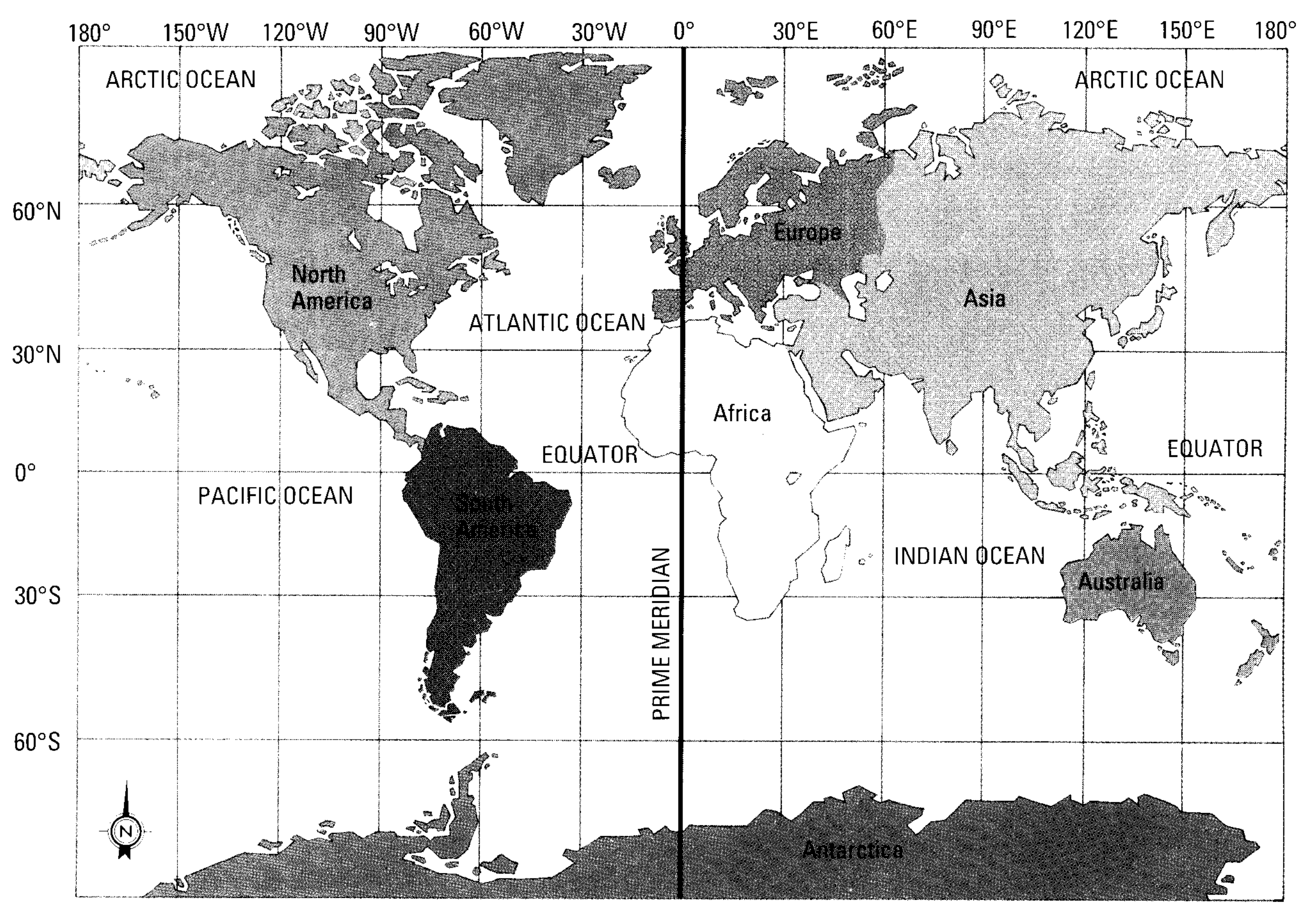
PRIME MERIDIAN (prīm mə rĭd′ē ən) The prime meridian is the imaginary north-south line that represents 0° longitude on maps of the world (see LATITUDE AND LONGITUDE). It is also called the Greenwich meridian because it passes through Greenwich, England.

One hundred and eighty degrees of longitude are drawn both east and west of the prime meridian. The lines of 180° west longitude and 180° east longitude make up the same line. The prime meridian was established by a conference of astronomers in 1884.

See also INTERNATIONAL DATE LINE.

PRIME MERIDIAN

The prime meridian is 0° longitude. All other longitudes are measured east or west of the prime meridian. It passes through Greenwich, England, and for this reason it is also known as the Greenwich meridian.



PRIME NUMBER A prime number is any integer (whole number) that can be evenly divided only by itself and by the number one (see NUMBER). Some examples of prime numbers are two, three, and five. A number that is not a prime number can be evenly divided by itself, by the number one, and by another number or numbers. For example, the number six can be evenly divided by one, two, three, and six.

The ancient Greek mathematician Euclid proved that there is an infinite (unending) number of prime numbers. Euclid also discussed what is known today as the fundamental theorem (statement) of mathematics. This theorem says that any positive integer can be written as a product of prime numbers. A product is the result achieved from multiplication. For example, twelve is the product when two is multiplied by two and then by three.

See also MATHEMATICS.

PRIMROSE FAMILY The primrose family includes about a thousand species of herbaceous dicotyledons (see DICOTYLEDON; HERBACEOUS PLANT). Most are perennials and grow in cooler areas of the Northern Hemisphere (see PERENNIAL PLANT). The leaves are simple, with toothed margins. They usually grow in a rosette on the ground but may be opposite or whorled on a stem (see LEAF). The flowers have five petals that are fused at the base to form a short tube. There are five stamens growing opposite the spreading petals. The fruits are dry capsules that open when ripe (see FLOWER; FRUIT).

The common primrose has flowers that are yellowish white in color. Each flower grows at the top of a leafless stalk. This species has given rise to many cultivated varieties of the beautiful and colorful flowering plants known as polyanthus.

PRIMROSE FAMILY

The common primrose (above) blooms in late spring. The cowslip (left) also belongs to the primrose family.

PRINTING

Printing is the process by which images—such as letters, numbers, drawings, and photographs—are reproduced on paper, plastic, or some other material. Printing is done using electronic, mechanical, and photographic devices (see ELECTRONICS; PHOTOGRAPHY). The goal of printing is to reproduce many copies of a master, or original document.

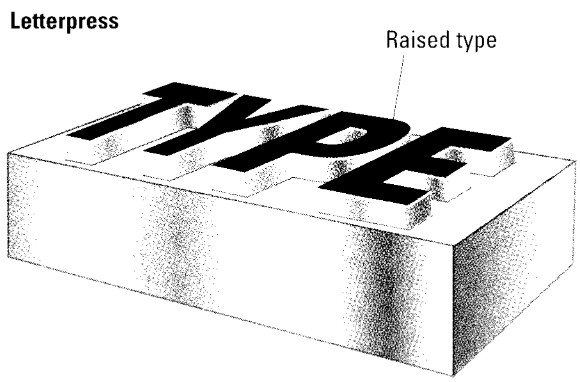
Printing is one of the most important ways of communicating with large numbers of people (see COMMUNICATION). Books, magazines, and newspapers are obvious examples of things that are printed. However, printed items also include such things as billboard signs, calendars, food and beverage containers, ruled writing tablets, and wallpaper.

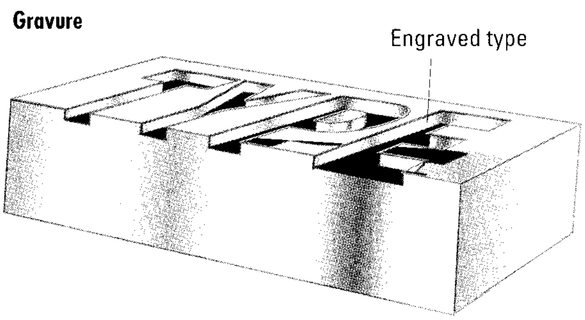
Printing began in China around the year A.D. 500 with the use of simple hand-carved wooden printing blocks called woodcuts. The Europeans later also discovered this method. Printing as we know it today was not invented until 1440. It was then that Johannes Gutenberg of Germany invented printing with movable type. He made separate pieces of metal, each with a raised letter on it. The letters could be combined in any number of ways and used over and over again to print many different books.

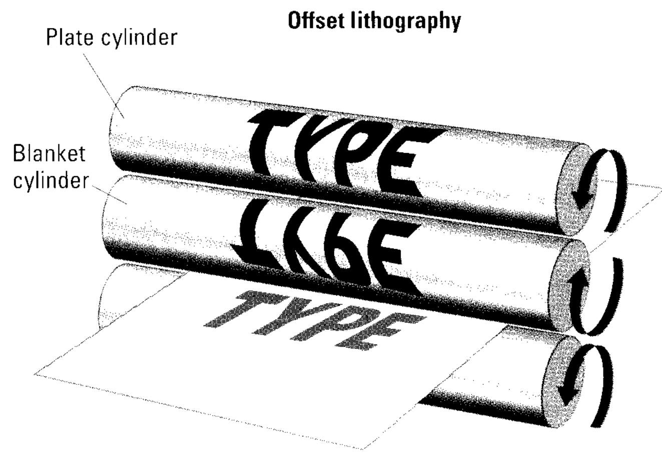
With the invention of movable type, printing spread throughout the world and became the first means of mass communication. It put more knowledge into the hands of more people at a faster rate than ever before. Gutenberg's invention was the start of modern printing.

Preparing materials to be printed Today, before a book, newspaper, or any other material can actually be printed on a large machine called a press, there must be a process of preparation. Different parts of a printed material are prepared in different ways. For example, the letters, numbers, and other non-illustration symbols, called type, that will be printed on the page must first be "set." Today, most type is set on machines called laser typesetters. A laser typesetter is a computer that uses lasers to produce different styles and sizes of type very quickly (see LASER; COMPUTER).

The typesetting process begins when an operator







BASIC PRINTING PROCESSES

Three common kinds of printing are letterpress, gravure, and offset lithography. In letterpress printing, ink is transferred from a raised surface directly to the paper. In gravure printing, the ink is also transferred directly, but it is transferred from an etched surface. In offset lithography, printing takes place from a flat surface, using a plate cylinder and a blanket cylinder.

enters the information into the typesetter. This is done by pressing certain letters, numbers, or other symbols on a keyboard. The operator also presses keys that give the typesetter information about the size and style of type. As the operator presses the keys, the typesetter converts the information into a form that can be understood by the machine. This information is then sent to the part of the typesetter that contains a laser. The laser then "draws" the type in the form of many tiny dots on light-sensitive film or paper. The film or paper is then developed by means of a chemical process.

Illustrations also have to be prepared for printing. Many illustrations contain only a single color, such as black, green, or red. There are two kinds of such single-color illustrations—line art and halftones. Line art is illustrations, such as diagrams or charts, that contain only solid lines and large solid areas. Halftones are illustrations, such as photographs, that contain various tones, or shades, of a color, such as gray. The process of printing line art begins by taking a photograph of it. The photographic negative is then used later in the preparation process to make a printing plate.

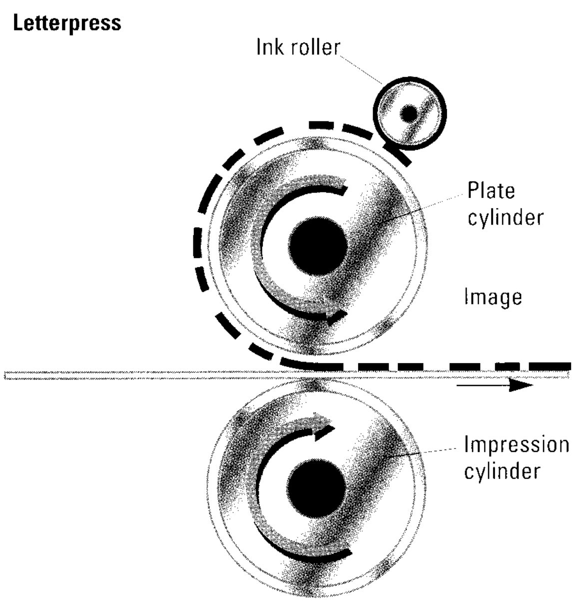
The process for producing halftones is similar. However, to allow the printing press to produce the various tones, the photograph of the illustration is taken through a clear plastic screen. The screen has a regular pattern of thousands of tiny dots. These tiny dots appear on the negative. The dots are large and close together in the dark areas and small and farther apart in the light areas of the illustration. As with line art negatives, the halftone negative is used later to make a printing plate. When the image from the halftone is printed, the viewer's eyes and brain blend the dots to see the dark and light areas that were in the original image.

Illustrations, such as color photographs, that are more than one color must be prepared for printing in a different manner than one color line art or halftones. Usually, the color illustration is first passed through a machine called a color scannner. Color scanners use lasers to break the color drawing or photograph into four separate negatives, one for each of the four main colors. These negatives are called separations. In each separation, the image is broken down into many different-sized dots. The larger these dots are, the denser the color will be when printed. The four different separations are used to make four different printing plates.

After the type has been set and negatives made of the illustrations, the next step in preparing for printing is to make a paste-up. To make the paste-up, a person called a designer follows a layout sheet. A layout sheet is a sketch of how each page should look, showing where the type and illustrations should be placed. The designer places the developed paper containing the type in the appropriate position on a piece of white paper. The paper containing the type has been trimmed to the appropriate length and has had a sticky substance applied to its back. The actual negatives of the illustrations are not part of the paste-up. There are markings, however, showing where each illustration is to be placed, and there may be photocopies or photostats

INK TRANSFER

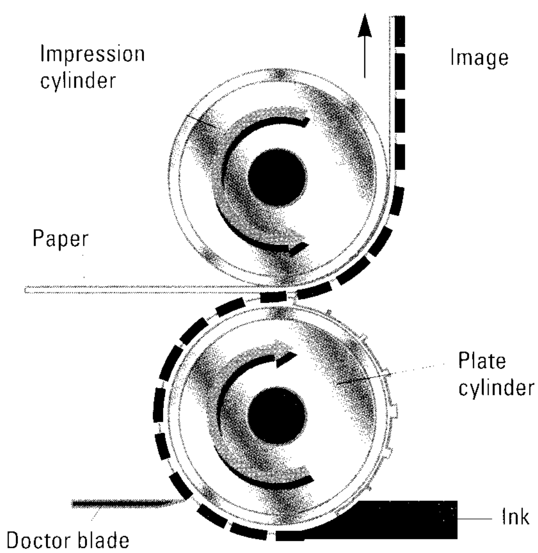
In letterpress printing, ink is transferred onto the raised image on the plate cylinder. The impression cylinder presses the paper onto the ink as the paper passes through the press. In gravure printing, the ink is deposited in "pits" in the plate cylinder. A doctor blade removes excess ink before the ink is transferred to the paper. In offset lithography, greasy ink sticks to the image on a smooth plate. The rest of the plate is covered with a thin film of water. The ink is then transferred to a blanket cylinder, which in turn transfers the ink to the paper. The plate cylinder therefore offsets, or transfers the image, which gives this method its name.



of the illustrations pasted down as "placeholders." A photograph is then taken of the paste-up, producing a negative. The negative of the paste-up and any negatives of black line art or black separations are then stripped—that is, taped together in their precise positions to form a negative for the entire page. This negative is called a flat. If the illustrations are color, the other separations are each made into flats as well. For each color, a separate printing plate is made. The plate—made of metal, plastic, or paper coated with a light-sensitive material—and its flat are pressed together and are exposed to strong light. The light shines through the negative onto the plate. The flat is removed, and the exposed plate is developed. The plate is then ready to be used on the printing press.

In many cases, this traditional method of preparing for printing is being replaced by a method called desktop publishing. In this method, a computer is used to perform the typesetting, design, and paste-up. The page is then printed out on a sheet of paper, using a special kind of printer called a laser printer. This paper is the master. Generally, the master is then photographed, and the negative is used in traditional stripping and plate making. Some modern printing equipment can make a printing plate directly from the computer.

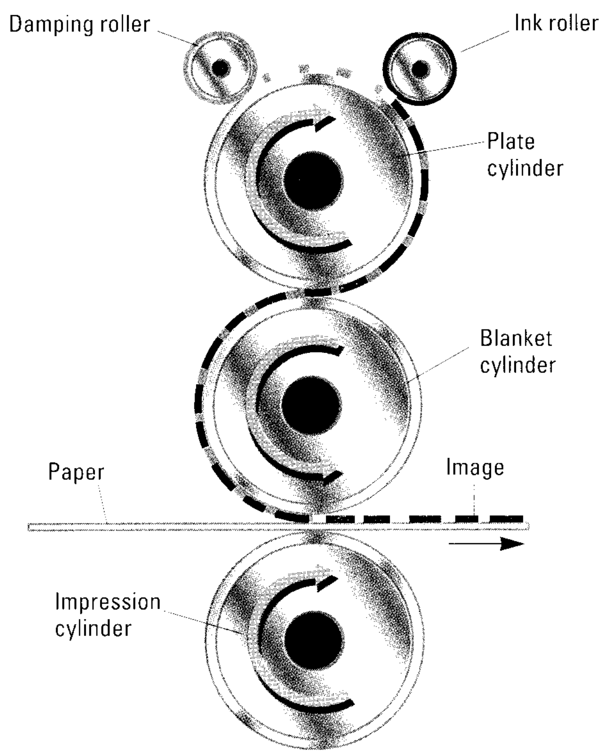
Gravure



Offset lithography Once the materials have been prepared and the printing plates made, one of several printing processes can be used. The most common is called offset lithography. *Offset* refers to using a rubber-covered cylinder to transfer ink from the printing plate to paper. *Lithography* refers to printing from a flat surface rather than a raised or etched surface. In offset lithography, the flat surface is the printing plate. Offset lithography is based on the fact that grease (oily matter) and water do not mix. This fact was discovered in 1798 by Alois Senefelder, a German. Senefelder drew a design on a smooth, flat stone with a greasy crayon. He then dampened the stone. The water stuck only to the parts not covered by the design. Next, he inked the stone, and the greasy ink stuck only to the design. He then pressed paper against the stone, transferring the image of the design to the paper.

Today, the same principle is used in offset lithography. In offset lithography, the printing plates have been treated with a substance called a lacquer (see LACQUER). A lacquer sticks only to the image areas of the plate—that is, the areas with type or

Offset lithography



illustrations. The printing plates are bent to fit around plate cylinders. As the plate cylinders spin, they press against damping rollers. The damping rollers wet the nonimage areas of the plate. The plate cylinders next pass against ink rollers. The greasy ink sticks only to the image areas of the plate; the wet nonimage areas repel the ink. Finally, the plate cylinder offsets, or transfers, the image onto the rubber-covered cylinder, called a blanket. The blanket, in turn, transfers the inked image onto the paper.

The printing press used in offset lithography is a kind of rotary press called a blanket-to-blanket press. A rotary press involves spinning cylinders. A rotary press can print on single sheets of paper or on a long roll of paper called a web. Rotary presses usually use webs. In the blanket-to-blanket press, there are at least two sets of cylinders that each contain a plate cylinder and a blanket cylinder. The paper passes between the blanket cylinders, so that both sides of the paper are printed at the same time. Once it has been printed, the web passes through a heated tunnel. There, the ink dries. However, in the tunnel, the web becomes very hot. It then has to pass through a cooling unit. The heat of the tunnel also has dried the web to the point that it becomes brittle. Another part of the press adds a slight layer of moisturizers to make the web flexible again. As the web leaves the press, it is folded or cut into complete publications or sections of publications, called signatures.

Rotary presses that print by offset lithography can also be used to print more than one color. Instead of having only two sets of cylinders, there are as many sets of cylinders as there are plates for each side of the paper. Most color printing uses four different plates—one each for yellow, magenta (red), cyan (greenish blue), and black. This means that each plate cylinder offsets one of these colors on its accompanying blanket cylinder. Some rotary presses can print only one color at a time. Therefore, to print in full color, a sheet of paper or a web must be fed through the press as many times as there are colors. As the paper moves through the press, it passes from plate to plate. Each time it does so, a pattern of colored dots is printed on the paper. The combination of different-colored dots reproduces the colors of the original illustrations. Many modern presses can print four colors on both sides of the web at the same time, so that only one pass through the press is required for full-color reproduction. Presses that print on both sides of the paper at the same time are called perfecting presses.

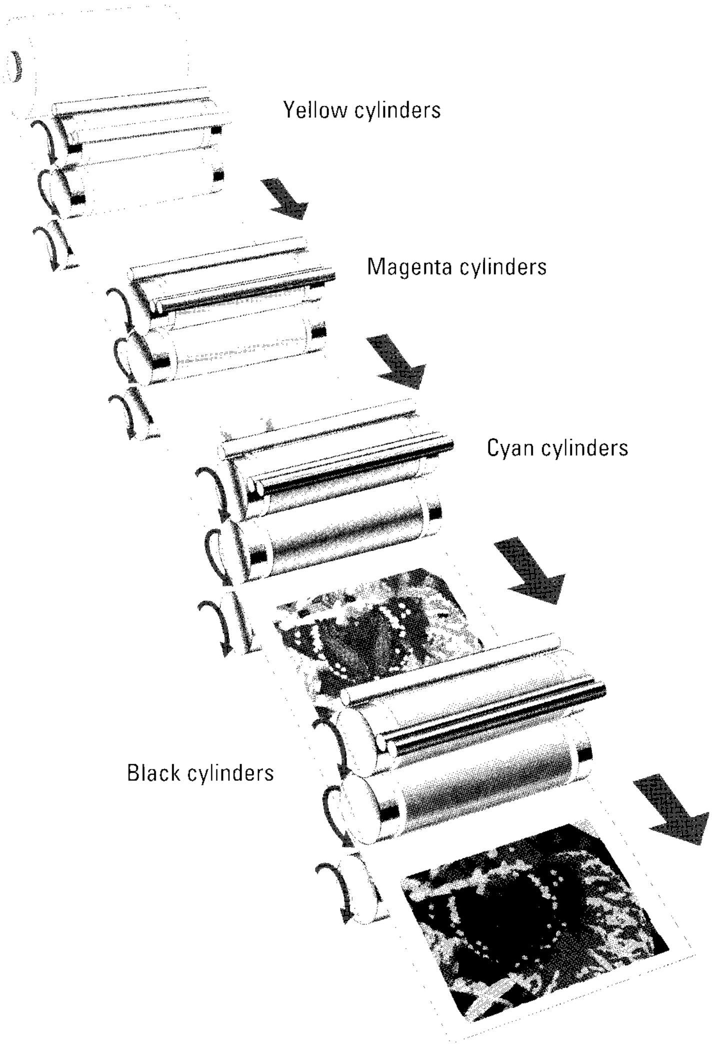
An advantage of a blanket-to-blanket press is that it is very fast. For this reason, it is often used to print magazines and newspapers. An advantage of offset lithography is that the flexible blanket can easily pass on the image to many kinds of surfaces, such as rough paper or plastic.

Other printing processes There are several other printing processes that are used in different situations. These processes include gravure, letterpress, silk-screen, and ink-jet.

In gravure, after the printing plate has been made from the negative, the plate is placed in acid. The acid etches the image from the negative into the plate. During the printing process, the ink fills in the etched areas. The ink in the etched areas is then transferred to the paper. Gravure printing can be done with a kind of rotary press called a rotogravure press. In a rotogravure press, the plate cylinder spins in a container of ink. A blade continually scrapes the ink from the non-etched areas of the plate cylinder. The paper passes between the plate cylinder and an impression cylinder. The impression cylinder presses down on the paper, leaving an ink image on the paper. Gravure is often used for printed material requiring heavy ink coverage, such as magazine or advertising inserts for newspapers. A rotogravure press is as fast as an offset press.

Letterpress is one of the oldest printing processes. In letterpress printing, the image on the printing plate is raised. In the past, the raised image was made by pouring melted metal into molds. The molds were then assembled in a frame, and the frame was used to print from.

A new method of making letterpress plates involves using light-sensitive plastic with a metal



COLOR PRINTING

A rotary color printing press using a web (paper wound off a roll) has four sets of cylinders, one set each for yellow, magenta, cyan, and black.

base. When light is shone on the negative and the plastic during the plate-making stage, the image areas harden in the plastic. The nonimage areas remain soft. They are then removed by different means, such as water or blasts of air. However, this new method produces printed material of poorer quality than those printed with the old method.

A flatbed press may be used in letterpress printing. In a flatbed press, the printing plate or frame is placed on a flat area called a "bed." The bed moves back and forth between inking rollers and an impression cylinder. The inking rollers and the impression cylinder are side by side. The first position of the bed is under the inking rollers, where ink is applied. The bed then moves under and past the cylinder. As the bed goes back under the cylinder, a sheet of paper is fed over the cylinder and falls on top of the bed. The bed and sheet of paper pass under the cylinder. The cylinder presses down on the paper and the bed, leaving an ink image on the paper. Just before the bed passes under the inking rollers again, the paper is lifted up and released by the action of the cylinder.

Letterpress using a flatbed press is slow because of the back-and-forth action of the bed. Also, materials that are printed using letterpress are of lower quality than materials printed by offset. For example, the pressure from the raised images often leaves a dent in the paper. The plate or the molds in the frame may become worn toward the end of a printing job. This means that the final printed copies are of lower quality than the earlier printed copies. However, letterpress is still used for smaller printing jobs, where the look of traditional printing is preferred, such as for certain art books.

There are several other printing processes that are used for specialized purposes. For example, silk-screen printing is sometimes used to print colored designs on fabric, wood, plastic, or metal. It is also used for limited printings of fine art. In silk-screen printing, a stencil (pattern) is made of the design. If the design has more than one color, a stencil is made for each color in the design. The stencil or stencils are then glued onto a fine silk mesh. A mesh is a fabric with tiny holes. The silk mesh is then placed over the surface to be printed. Ink is forced over the mesh by a rubber blade called a squeegee. The ink passes through the areas of the mesh where there is no stencil but cannot pass through the areas where the stencil is attached. This produces the design on the paper.

In ink-jet printing, tiny nozzles spray ink on a surface, usually paper, to form letters, numbers, or other images. The nozzles are controlled by a computer. Ink-jet printing is often used for printing jobs in which some of the information changes. For example, ink-jet printing is often used to print form letters in which the name and address changes.

PRISM (prĭz'əm) A prism is a transparent object that bends light and breaks it up into rainbow colors (see COLOR; LIGHT). Prisms can have many different shapes. The most common kind has two end faces that are triangles. Joining these end faces are three oblong faces.

Prisms made from glass are used in optical instruments. Sometimes, they are used for reflecting light (see REFLECTION OF LIGHT). More often, they are used for dispersing light. If light hits the side of a glass prism at an angle, it bends as it passes into the prism. The amount that the light is bent depends on its color. For example, red light is bent less than blue light. White light is a mixture of colors of light. When white light enters a prism, it becomes separated into its various colors. This is called dispersion (see DISPERSION OF LIGHT).

Prisms are used for dispersing light in instruments called spectroscopes (see SPECTROSCOPE). In microscopes, prisms are used for changing the direction of light and for splitting up the light. The splitting is done by shining a beam of light onto an edge of the prism. Part of the beam is reflected from one face and part from the other. Prisms are also used for beam splitting in binoculars.

See also BINOCULARS; MICROSCOPE. PROJECT 52

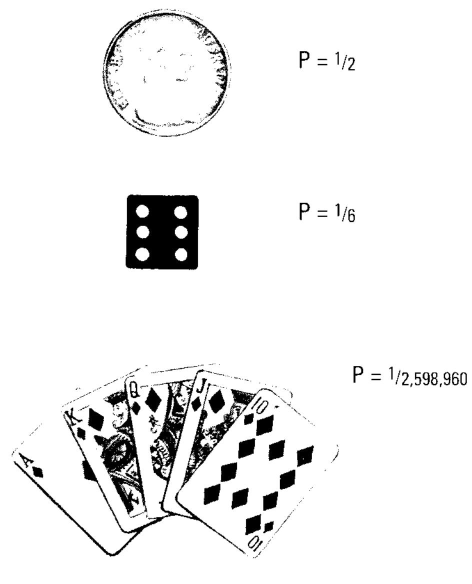
PROBABILITY (prŏb'ə bĭl'ĭ tē) Probability is a branch of mathematics that deals with the laws of chance. A simple example of the laws of chance is tossing a coin. The coin can turn up either heads or tails. Both are equally likely. Therefore, the probability of heads is $\frac{1}{2}$, and the probability of tails is $\frac{1}{2}$. If you toss two coins, the situation is a little more complicated. There are now four possibilities: head-head, head-tail, tail-head, and tail-tail. All four situations are equally likely. Therefore, the probability of each is $\frac{1}{4}$. Head-tail is the same as tail-head. Therefore, the probablity of getting heads once and tails once is $\frac{1}{2}$. The probabilities then are head-head ($\frac{1}{4}$), tail-tail ($\frac{1}{4}$), and head-tail (or tail-head) ($\frac{1}{2}$). The total probability for all events always adds up to one.

The probability of one coin turning up heads is $\frac{1}{2}$, and the probability of tossing a coin twice and getting two heads is $\frac{1}{4}$. This shows that probabilities are combined by multiplying them together, since $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$. In the same way, suppose that you toss a coin ten times. The probability of getting ten heads is $\frac{1}{2}$ multiplied by itself ten times. This is $\frac{1}{1,024}$. Therefore, there is one chance in 1,024 that heads will come up ten times in a row.

Probability never tells what will happen in any particular case. It only predicts the likelihood of particular events. For example, it is equally likely that a coin will land heads or tails up. However, suppose that it lands heads up the first time. This does not mean that it will definitely land tails up the second time. The probability of heads coming up on any particular toss is always $\frac{1}{2}$.

What is the probability of drawing a heart from an ordinary deck of cards? The number of possible outcomes is fifty-two (the number of cards in a deck), of which thirteen are hearts. Therefore, the probability of getting a heart is $13/52 = \frac{1}{4}$.

Probability is used in many fields in which the chance of a certain event's happening needs to be calculated. Insurance companies use probabilities to calculate the amount that they charge their customers. Probability is also used in physics. For example, the behavior of a certain electron in an atom can never be accurately predicted. However,



PROBABILITY

To calculate the probability (P) of an event happening, divide 1 by the number of ways in which the event can happen. A coin can fall in 2 ways and a die in 6 ways. Some probabilities can be extremely small. The probability of choosing 5 particular cards from a deck of 52 cards is 1 in 2,598,960.

the likelihood of certain kinds of behavior can be calculated. The laws of probability are used to calculate the likelihood of such behaviors.

PROBOSCIS MONKEY
The male proboscis monkey has a huge proboscis, or nose, that hangs down over its mouth.

PROBOSCIS MONKEY (prō bŏs′ĭs mŭng′ kē) The proboscis monkey lives in the swamps of the South Pacific island of Borneo and is a good swimmer. The male has a huge proboscis, or nose, that hangs down over his mouth. It is used like a trumpet to produce a loud, howling alarm call. The female's nose is smaller. A large male may grow 30 in. [75 cm] long and have a tail at least that long. The male may weigh as much as 55 lb. [26 kg]. The female is smaller and lighter. Both sexes have reddish brown hair with light tan hair on the belly.

Proboscis monkeys are herbivores and usually eat leaves (see HERBIVORE). They live in groups of about twenty. The female gives birth to one offspring once or twice a year.
See also MONKEY.

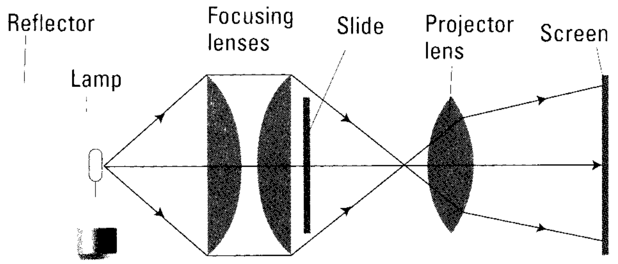
PROCAINE Procaine is a synthetic (human-made), organic (carbon-containing) chemical that is used in dentistry and surgery as a local anesthetic. It is commonly known by its trade name, Novocain (see ANESTHETIC). When injected, procaine deadens nearby nerves without harming them. Its effects wear off after a short time. Unlike some anesthetics, procaine is not poisonous or addictive.

Procaine was introduced in 1905 as a substitute for the then-popular anesthetic, cocaine (see COCAINE). In recent years, procaine has been replaced, in large part, by two new drugs, lidocaine and mepivacaine. These drugs are faster, stronger, and longer lasting than procaine.
See also DRUG.

PRODUCER In the natural world, a producer is an organism that can make food from simple materials. Green plants and algae are the main producers on Earth (see ALGAE; PLANT KINGDOM). They make food from water and carbon dioxide with the aid of sunlight. This process is called photosynthesis (see PHOTOSYNTHESIS). Some bacteria can also make food by photosynthesis and by other chemical processes (see BACTERIA). Animals cannot make food. They have to get their food from plants, so animals are called consumers (see CONSUMER). Primary consumers get their food by eating plants. Secondary consumers get their food by eating animals that have already eaten plants.
See also FOOD CHAIN.

PROJECTOR A projector is a device used to show enlarged pictures on a screen or a wall. Projectors are most commonly used to show photographic slides and movies.

The simplest projector consists of a light source, a reflector that focuses the light, a focusing lens, and a projector lens. A powerful light is needed to project images onto a screen. Most projectors use an incandescent bulb of about one thousand watts (see INCANDESCENCE; LIGHT; WATT). The reflector, located behind the bulb, is a concave (inward-curving) mirror. It focuses the light rays forward through a thick focusing lens. The focusing lens is flat on the side facing the bulb, and convex (outward-curving) on the other side. Light rays entering the lens are bent inward and brought together. The concentrated rays then pass through a photographic slide or film that is placed so that its image is upside down. The final lens, the projector lens, reverses and enlarges the picture, which appears right side up on a screen or a wall.



PROJECTOR
A slide projector has a lamp, reflector, and various lenses.

Slide projectors are used by teachers and business people to illustrate subjects being discussed. Lecturers also often use projectors in this way. Movie projectors have electrically powered reels that move the film between the bulb and projecting lens at high speed.
See also MOTION PICTURE.

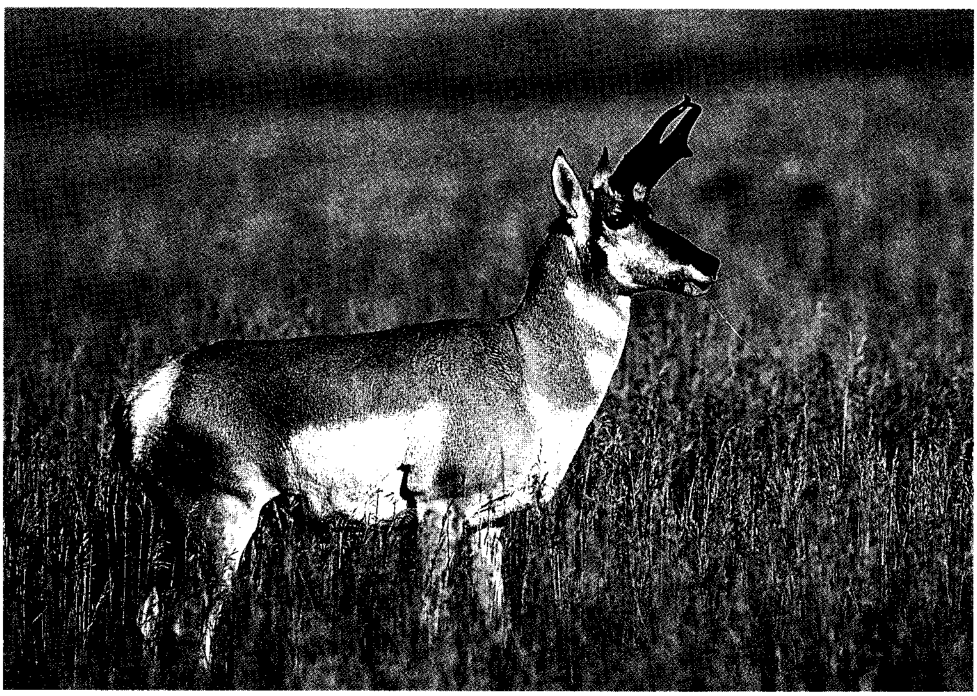
PRONGHORN The pronghorn is an ungulate (hoofed mammal) sometimes called the American antelope (see UNGULATE). However, the pronghorn, which has branched horns, is not a true antelope. It has no close relatives. Pronghorns live in North America, from Canada to Central Mexico and from Iowa to near the Pacific coast.

The pronghorn has a thick body, large ears, and thin legs. It varies in color from tan to reddish brown. The animal has white markings on its underparts, rump, head, and throat. The buck (male) stands about 35 to 41 in. [89 to 104 cm] at the shoulder. It weighs 100 to 140 lb. [45 to 64 kg]. The animal's horns average 1 ft. [30 cm] long, although some are 20 in. [50 cm] long, and have a black covering. The pronghorn is the only animal in the world that regularly sheds the covering of its horns.

Pronghorns are grazers that live on open grassland. Each buck often lives with several does (females). Pronghorns usually bear twins in the late spring of each year.

Pronghorns are social animals that gather in large herds, especially in winter. Herds may contain several hundred animals. They are probably the fastest large mammals of North America. They are known to run at a rate of 40 m.p.h. [64 kph]. Once an endangered species, pronghorns are now estimated to number at least 250,000. In several western states, hunting of the pronghorn is now legal.
See also ANTELOPE; ENDANGERED SPECIES.

PROPANE Propane (C_3H_8) is a colorless flammable gas (see FLAMMABLE; GAS). It is a hydrocarbon (see HYDROCARBON). Propane occurs in natural gas (see NATURAL GAS). It is used as a fuel, often mixed with another hydrocarbon, butane. It



PRONGHORN
The pronghorn is an antelopelike animal that lives in North America. It is not a true antelope—true antelopes live in Africa and Asia.

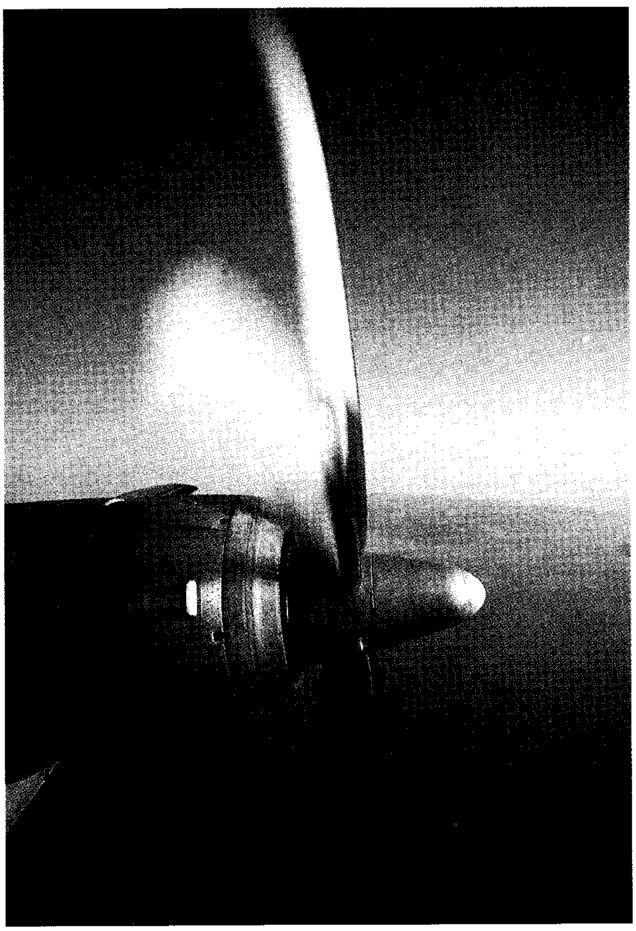
is also used for manufacturing other chemicals—ethene and propene, for example. These chemicals are used to make the plastic polyethylene.
See also PLASTIC.

PROPELLER A propeller is a fanlike device for producing motion that is mounted on a power-driven shaft. A propeller moves a ship or airplane forward by the action of its blades in water or air.

Marine propellers range in diameter from 10 in. [25 cm] for small boats to 8 ft. [2.4 cm] for the average large ship. Large tankers have propellers nearly 25 ft. [7.5 m] in diameter. A marine propeller bites into the water much the way a screw bites into wood. Water flows over the surface of the blades, and because of their shape, a force is produced that is parallel to the axis of the rotation of the propeller. The force, called thrust, drives the ship forward. The same principle applies to propellers on airplanes.

The pitch of a propeller is the angle that the blades are set on the hub. Pitch also means the distance the propeller would advance (move forward) with each rotation if it were cutting into something solid, like wood. However, the marine propeller does not advance this full distance because water does not offer as much resistance as a solid would. The difference between the pitch and the actual distance the propeller does advance in water is called slip. Slip usually amounts to about 15 percent, even with the most efficient marine propeller.

Outboard motors and other marine engines used in small pleasure crafts usually have two-bladed propellers. Larger crafts have three- or four-bladed propellers. Propellers on ships with a single engine rotate in a clockwise direction, when seen from the rear. Twin-engine vessels usually have propellers that rotate in opposite directions. The propeller on the right side rotates in a clockwise direction, and the propeller on the left side rotates in a counterclockwise direction. Ships with one propeller that turns clockwise tend to veer to the right because of the direction of the propeller rotation. Ships' pilots



PROPELLER
This airplane propeller (above) is a variable-pitch type—the angle of the blades can be adjusted in flight for maximum engine efficiency. The large four-bladed ship's propeller (right) is located just in front of the rudder, to give maximum maneuverability. The worker is cleaning barnacles off the ship in the repair yard.

overcome this tendency with a slight correction in the steering. Twin-engine vessels are easier to handle than single-engine ones.

Airplane propellers have two or more blades fixed to a central hub. A fixed-pitch propeller is one in which the pitch, or angle of the blades, is fixed. Most airplanes with propellers today have variable-pitch propellers. In constant-speed propellers, the angle of the blades is adjusted continually to allow efficient operation at every flight speed. The angle of the blades can be adjusted while the propeller is spinning. The adjustment is done either manually by the pilot or automatically to give the most efficient blade angle for different conditions of flight. Some propellers can be "feathered." This means that, in the event of engine failure, the blades can be adjusted so that their leading and trailing edges are parallel to the path of flight. This lessens air resistance and prevents engine damage. Propeller-driven airliners and cargo planes have reversible-pitch propellers. The blades can be adjusted so that the propeller produces reverse thrust. This helps heavy airplanes slow down and stop on short or icy runways where wheel brakes are not very effective.
See also AIRPLANE; SHIPS AND SHIPBUILDING.

PROPRIOCEPTION (prō′prē ō sĕp′shən) Proprioception means "awareness of self." It is the internal sense through which the brain constantly receives information about the body's position, balance, and internal condition. Most animals have proprioceptors of some kind. Vertebrates (animals with backbones) have "position" receptors located in striated muscles and on the surfaces of tendons (see MUSCLE; TENDON). These position receptors sense muscle length and tension. For example, proprioceptors in humans keep the brain aware of the position of the arms. The brain can then send the proper signals to the muscles in each arm so that the arm moves in the desired way. Arthropods, such as insects, and some other invertebrates (animals without backbones) also have "position" receptors. They are located on the outside surfaces of the muscles and in the joints and are particularly important in keeping flying insects on a steady course.

In order for an animal to keep its balance, it has proprioceptors that respond to gravity (see GRAVITY). Many invertebrates have a balancing structure called a statocyst. The statocyst is a fluid-filled chamber with tiny hairs and free-floating, sandlike granules. When the animal changes position, the granules float against the hairs, sending a signal to the brain. Most vertebrates have a similar structure in the ear (see EAR).

In human beings and many other animals, the proprioceptors send signals to a part of the brain called the cerebellum (see BRAIN). The cerebellum also processes the signals traveling from the brain to the muscles. The cerebellum brings together all these signals in order to coordinate all of the voluntary (conscious) movements of the body. Because of this, the organism is able to keep its balance and move in a coordinated way.
See also NERVOUS SYSTEM.

PROSPECTING Prospecting is searching for deposits of minerals and certain other valuable substances (see MINERAL). In the United States, early prospectors were enchanted by the promise of rich discoveries of gold, silver, and other precious metals. These people traveled throughout the west, often leading lonely lives and suffering terrible hardships. Most early prospectors had no scientific training. They depended mainly on luck to discover deposits. Their simple equipment included picks, shovels, and pans.

Modern prospecting Prospectors today are usually qualified geologists who have been trained in chemistry and physics (see GEOLOGY). They use a wide range of scientific equipment. They also use geological maps. These maps show rock outcrops on the earth's surface and also indicate how rock layers dip beneath the surface. Geologists can therefore use these maps to get information about underground structures (see GEOLOGICAL MAP). Aerial photographs, including infrared pictures from spacecraft, show features that cannot easily be seen on the ground. Geologists can also analyze samples of rocks and determine their relative ages from fossils (see FOSSIL). In recent years, these

PROSPECTING

A prospector is a person, usually a geologist, who looks for signs of deposits of minerals and other valuable substances in the earth. While some prospecting is still done on foot (right), airplanes and helicopters filled with scientific instruments are now often used to prospect for natural gas, petroleum, and other substances.

scientists have been able to find out much about the rocks beneath the surface using geophysical and geochemical methods. All this information helps geologists figure out whether particular areas are likely to contain valuable substances.

Particular substances are found under particular conditions. For example, petroleum (oil) and natural gas are found mostly in sedimentary rocks, including sandstone and limestone. Large quantities of these fuels build up in special rock structures called structural traps. A very common type of trap is an upfold in rocks called an anticline (see ANTICLINE; NATURAL GAS; PETROLEUM; SEDIMENTARY ROCK). Geophysical prospecting and geochemical prospecting help geologists identify specific conditions under which particular substances might be found.

Geophysical prospecting Geophysical prospecting includes seismology, the scientific study of earthquakes (see SEISMOLOGY). Seismology is especially important in the search for oil and gas. Geophysicists set up explosives in the ground and so generate small shock waves. Using an instrument called a seismograph, the geophysicists record the path of the waves as they travel through the earth's crust. Because rock layers of differing densities reflect (throw off) and refract (bend) waves in different ways, seismic studies give much information about rock structures under the ground.

Another geophysical method involves the study of local variations in gravity (see GRAVITY). Using instruments called gravity meters, geophysicists can discover variations in rock densities and information about rock structures. Magnetometers are used to find minerals with magnetic properties (see MAGNETISM). Magnetometer surveys are often carried out by aircraft. Measurements of electrical conductivity are especially useful in locating metals, which are usually better conductors of electricity than nonmetals (see CONDUCTION OF ELECTRICITY).

The chief instruments used in geophysical prospecting for radioactive substances, such as uranium, are Geiger counters. Geiger counters measure the amounts of radioactive substances in rocks (see GEIGER COUNTER; RADIOACTIVITY).

Geochemical prospecting Geochemical prospecting applies the study of chemistry to the search for valuable substances. For example, geochemists may find clues to important reserves from a chemical analysis of water, soil, or plants. The presence of trace elements at the ground surface may point out large deposits under the ground. (Trace elements are chemical elements in very small amounts).

After collecting information by all available methods, prospectors analyze the information and determine places that desired substances are most likely to be found. Next, they drill holes in likely areas. This helps them determine the richness and extent of deposits before extraction (removal) begins. Most searching is done for deeply buried deposits, because most surface deposits have been discovered. Such prospecting is undertaken only after careful study because of the expense of drilling deep underground.
See also GEOCHEMISTRY; GEOPHYSICS; MINING.

PROSTAGLANDIN (prŏs'tə glăn'dĭn)

Prostaglandins are a group of chemicals found in the bodies of mammals, including human beings (see MAMMAL). Prostaglandins play an important role in regulating the body's control systems, including the endocrine system and the nervous system (see ENDOCRINE; NERVOUS SYSTEM). Many scientists consider the prostaglandins to be hormones or hormonelike substances (see HORMONE). Since prostaglandins were discovered in the early 1930s, at least sixteen different kinds have been identified. All are types of fatty acids (see FAT).

Prostaglandins affect many different bodily processes in many different ways. They help regulate blood pressure, pulse rate, smooth muscle contraction, stomach acid production, and the use of fat stored in the body. Prostaglandins also help regulate production of hormones by various glands of the endocrine system, including the pituitary, thyroid, and adrenal glands.

In the near future, prostaglandins may be used as drugs to treat many disorders, such as asthma, arthritis, high blood pressure, and stomach ulcers. They stimulate contractions of the uterus in pregnant women. Thus, they are sometimes used to induce labor in childbirth.

PROSTATE (prŏs'tāt')

The prostate is a gland of the reproductive system of all male mammals (see MAMMAL). It is located at the base of the bladder and partially surrounds the urethra. The bladder stores urine before it is eliminated from the body through the urethra. The urethra also eliminates sperm (male sex cells) from the body. The sperm are originally stored in the testicles and in the epididymides, which are tubes that rest on top of the testicles. The sperm travel from the epididymides to the urethra through other tubes called vasa deferentia. Before sperm enter the urethra, they are mixed with a whitish fluid from the prostate gland and from structures called the seminal vesicles. The fluid helps the sperm live and travel once they are deposited inside the female's vagina. The combination of this fluid and sperm is called semen (see GLAND; REPRODUCTIVE SYSTEM; TESTICLE).

The prostate is reddish brown and is normally slightly larger than a walnut. It is made up of three rounded parts lying side by side within a casing of fibrous tissue. The prostate's growth and function are controlled by androgens, hormones found in both males and females. However, males usually have larger amounts of androgens than females (see HORMONE).

As males grow older, their prostates tend to enlarge. By age seventy, there is a 50 percent chance that a man's prostate is enlarged. By age eighty, there is an 80 percent chance. This condition can be dangerous because of the prostate's location. Because it partially surrounds the urethra, which carries urine as well as semen out of the male's body, an enlarged prostate can interfere with the rate that urine leaves the body. Infections can result.

Prostate cancer is also very common in older males. By the time a man reaches age seventy, there is a 50 percent chance he will have prostate cancer. Prostate cancer can be treated with hormones and radiation. The prostate is also sometimes removed.
See also CANCER; RADIATION THERAPY.

PROSTHETICS (prŏs thĕt'ĭks) Prosthetics is the branch of medicine that deals with the use of prostheses (plural of *prosthesis*). A prosthesis is an artificial structure, often made of ceramic, plastic, or stainless steel, that replaces a missing or defective part of the body. Prostheses are also sometimes used for cosmetic purposes. An artificial tooth or arm is an example of a prosthesis that replaces a missing body part. Artificial blood vessels, bones, heart valves, and joints are prostheses that replace defective body parts. A nose that was damaged and rebuilt is an example of a cosmetic prosthesis. Some prostheses do not replace the body part but instead perform the part's function. For example, an artificial pacemaker implanted in the body does the work of the body's natural pacemaker. A pacemaker controls the beating of the heart (see PACEMAKER). A kidney dialysis machine, which is periodically attached to the outside of the body, does the work of the kidneys (see DIALYSIS).

Besides medicine, prosthetics also involves other areas of science, such as engineering. As technology has progressed, prostheses have become more natural in their use as well as their appearance. For example, natural-looking artificial limbs may be set in motion by electric motors. The motors are controlled by electric signals picked up from the nerves in the patient's body. With new surgery techniques, prostheses are also now being implanted and used in very delicate areas, such as the inner ear.

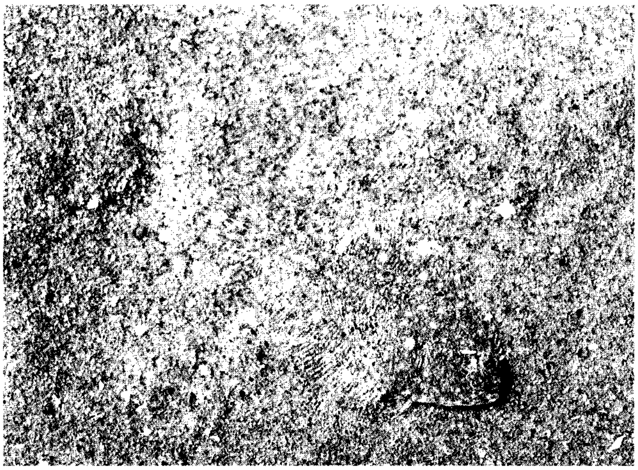
A relatively new area of prosthetics involves biologic prostheses. A biologic prosthesis is implanted in the body to give the body a chance to replace a missing or defective body part on its own. For example, synthetic (human-made) hydroxyapatite can be implanted in the body. Hydroxyapatite is the basic mineral compound that makes up bone and tooth enamel (see BONE; COMPOUND; MINERAL; TEETH). By supporting the structure of a damaged bone or tooth, the synthetic hydroxyapatite gives natural bone or tooth tissue a chance to grow back. A fabriclike implant is used in a similar way to give natural skin a chance to grow back after damage due to burns or other causes.

See also IMPLANTATION; MEDICAL ENGINEERING; PLASTIC SURGERY.

PROSTHETICS
Artificial limbs and other modern prosthetic devices allow many people, such as the girl above, to do more than they could otherwise.

PROTECTIVE COLORATION Protective coloration is a color or pattern that makes an organism less visible to its enemies. Many animals have colors that blend in with their surroundings and make them difficult to see. These animals are said to be camouflaged (see CAMOUFLAGE).

There are many different types of protective coloration. In countershading, the lower part of the animal's body is light colored, and the upper part is dark colored. In bright sunlight, this arrangement reduces the differences between the shadows and the animal's body and allows it to blend in even more effectively with its surroundings. In object resemblance, also called protective resemblance, an animal looks like something else, such as a rock, a twig, or perhaps a dead leaf. It is then ignored by its enemies. Disruptive coloration consists of bold



PROTECTIVE COLORATION
This young plaice's protective coloration allows it to blend into its environment, hiding it from enemies. The fish has the type of coloration known as object resemblance.

patterns of colors that break up an animal's outline and confuse its enemies.
See also MIMICRY; WARNING COLORATION.

PROTEIN A protein is a complex chemical compound that is made of a chain of amino acids (see AMINO ACID; COMPOUND). Proteins are necessary for the survival of every living organism. They work in many different ways. An important group of proteins, called enzymes, affect many of the chemical reactions that make up an organism's metabolism (see ENZYME; METABOLISM). Another important class of proteins are the structural proteins. Collagen is one of the most important of the structural proteins. It is found in almost all organs and gives strength to bone, cartilage, and tendons (see COLLAGEN).

A protein that is foreign and potentially harmful to the body is called an antigen. The effects of an antigen are offset by a protein called an antibody (see ANTIBODY). Some hormones, such as insulin, are also proteins (see HORMONE).

Each amino acid in proteins has carbon, nitrogen, oxygen, and hydrogen in it. Some amino acids also have small amounts of other elements. Plants make their own amino acids, so they can also make their own proteins. Animals (including human beings) are able to make some, but not all, of the necessary amino acids. The amino acids that animals cannot make themselves are called the essential amino acids. Animals must get the essential amino acids from the food they eat.

Milk, meat, nuts, and certain types of beans and peas are examples of foods rich in proteins (see NUTRITION). When an animal eats protein-rich food, the proteins are broken down into individual amino acids (see DIGESTION). The amino acids are then used by the body to make different kinds of proteins through a series of complicated chemical reactions known as protein synthesis (see RNA). Protein-rich food is necessary for the well-being of an organism. Because humans cannot store amino acids, protein-rich food should be eaten every day. Insufficient protein may cause brain damage, mental retardation, and other unhealthy conditions.
See also DEFICIENCY DISEASES; DIET; FOOD.

PROTEIN
Milk and other dairy products are among the foods that are high in proteins.

PROTEROZOIC ERA (prŏt′ər ə zō′ĭk ĕr′ə) The Proterozoic era is the final division of Precambrian time in the earth's history (see PRECAMBRIAN TIME). Although the starting date of the Proterozoic era is disputed, many scientists agree that it began about 1.85 billion years ago. It ended about 570 million years ago, when the Cambrian period began. It is the time when some kind of primitive life existed on the earth (see CAMBRIAN PERIOD).

No Proterozoic animals had shells, and so fossils are very rare. Proterozoic fossils include jellyfish, worms, and other primitive invertebrates (animals without backbones).
See also FOSSIL; GEOLOGICAL TIME SCALE.